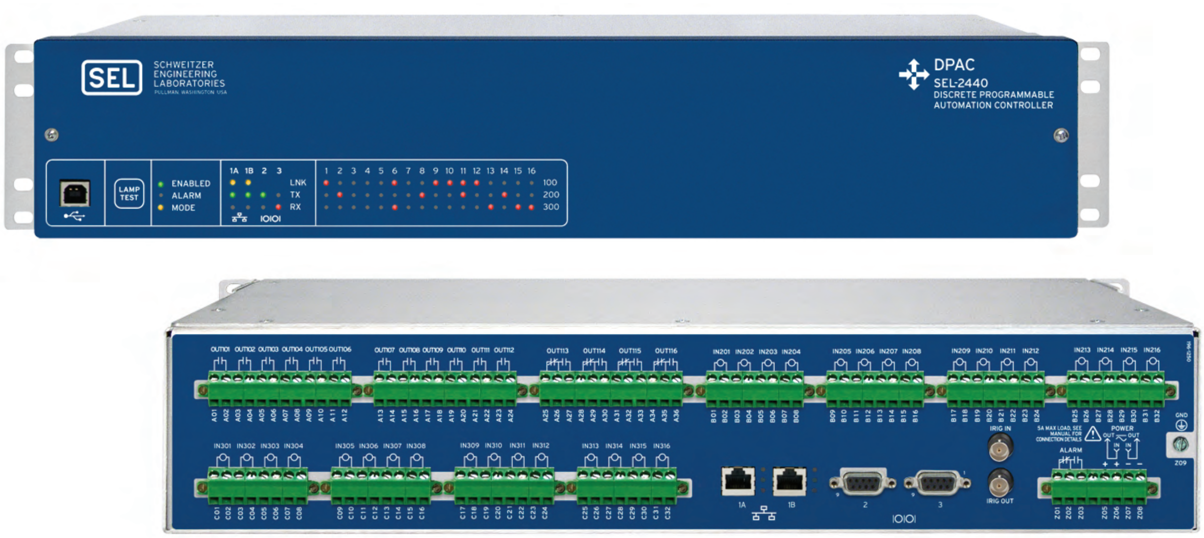
SEL-2440

Discrete Programmable Automation Controller DPAC

Instruction Manual



20250228

SEL SCHWEITZER ENGINEERING LABORATORIES

Part Number: PM2440-01

Table of Contents

Appendix A: Firmware and Manual Versions

Appendix B: Firmware Upgrade Instructions

Appendix C: SEL Communications Processors

Appendix D: DNP3 Communications

Appendix E: Modbus Communications Protocol

Appendix F: IEC 61850 Communications

Appendix G: MIRRORED BITS Communications

Appendix H: Device Word Bits

Appendix I: Cybersecurity Features

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Preface

Safety Information

⚠CAUTION
To ensure proper safety and operation, the equipment ratings, installation instructions, and operating instructions must be checked before commissioning or maintenance of the equipment. The integrity of any protective conductor connection must be checked before carrying out any other actions. It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner specified in this manual. If misused, any safety protection provided by the equipment may be impaired.

Dangers, Warnings, and Cautions

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

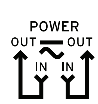
⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

⚠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
	Power input/output terminals	Les bornes d'entrée/sortie d'alimentation
	Instruction manual	Manuel d’instructions

Safety Marks

The following statements apply to this device.

General Safety Marks

For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature shall not exceed 40°C (104°F).	La température de l'air ambiant ne doit pas dépasser 40°C (104°F).
Terminal Ratings Wire Material Copper Wire Size 12–26 AWG Tightening Torque I/O and Power Terminal Blocks: 0.6–0.8 Nm (5–7 in-lb) Serial Ports: 0.6–0.8 Nm (5–7 in-lb)	Spécifications des bornes Type de filage Cuivre Calibre de fil 12–26 AWG Couple de serrage Borniers d'entrée/sortie et de puissance : 0,6–0,8 Nm (5–7 livres-pouce) Ports Série : 0,6–0,8 Nm (5–7 livres-pouce)
⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Rayovac no. BR1632 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 BR1632 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.

Other Safety Marks (Sheet 1 of 2)

⚠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.
⚠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.
⚠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 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 De-energize the device and all external connections before disconnecting any terminal blocks or modifying the wiring on any terminal blocks.	⚠AVERTISSEMENT Retirer l'alimentation du module et débrancher tous les raccordements externes avant de déconnecter les bornes de raccordement ou d'en modifier le filage.

Other Safety Marks (Sheet 2 of 2)

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

General Information

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor
Maximum Altitude	2000 m
Relative humidity	5% to 95%
Overvoltage	Category II
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

Laser/LED Emitter

The SEL-2440 is a Class 1 LED Product and complies with IEC 60825-1:1993 + A1:1997 + A2:2001.

The following table shows LED information specific to the SEL-2440 for the location of **Port 2**, the port using these LEDs, on the device.

SEL-2440 LED Information

Item	Detail
Mode	Multimode
Wavelength	820 nm
Source	LED
Connector type	ST
Maximum output power	–3 dBm

Safety Warnings and Precautions

- Do not look into the end of an optical cable connected to an optical output.
- Do not look into the fiber ports/connectors.
- Do not perform any procedures or adjustments that are not described in this manual.

- ➤ During installation, maintenance, or testing of the optical ports only use test equipment classified as Class 1 laser products.
- ➤ Incorporated components such as transceivers and laser/LED emitters are not user serviceable. Units must be returned to SEL for repair or replacement.

Wire Sizes and Insulation

Wire sizes for grounding (earthing) and contact connections are dictated by the terminal blocks and expected load currents. You may use the following table as a guide in selecting wire sizes.

Connection Type	Minimum Wire Size	Maximum Wire Size
Grounding (Earthing) Connection	14 AWG (2.5 mm^2)	10 AWG (4 mm^2)
Contact I/O	18 AWG (0.8 mm^2)	14 AWG (2.5 mm^2)
Other Connection	18 AWG (0.8 mm^2)	14 AWG (2.5 mm^2)

You should use wire with 0.4 mm thick insulation for high-voltage connections to allow for contact between adjacent wires. If possible, use 0.4 mm insulated wires for all connections. Recommended strip length for the wires is 8 mm (0.31 in). The use of an 8 mm wire ferrule is also recommended.

Instructions for Cleaning and Decontamination

Use care when cleaning the SEL-2440. Use a mild soap or detergent solution and a damp cloth to clean the chassis. Do not use abrasive materials, polishing 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

Section 1
Introduction and Specifications

Overview

The SEL-2440 Discrete Programmable Automation Controller (DPAC) provides the features shown in *Figure 1.1* to give you the most powerful utility rated discrete I/O solution in the world:

- DNP3 serial and DNP3 LAN/WAN communications
- Absolute timing
- Ready-to-go distributed I/O
- Bonus features
  - Flexible SELOGIC® control equations
  - SER with inputs timed to the microsecond
  - Analog signal profiling
  - SEL Event Messenger points for SEL-3010 compatibility
  - SEL ASCII communications
  - SEL Fast Message communications
  - SEL MIRRORED BITS® communications
  - Modbus RTU and Modbus TCP/IP communications
  - IEC 61850 communications

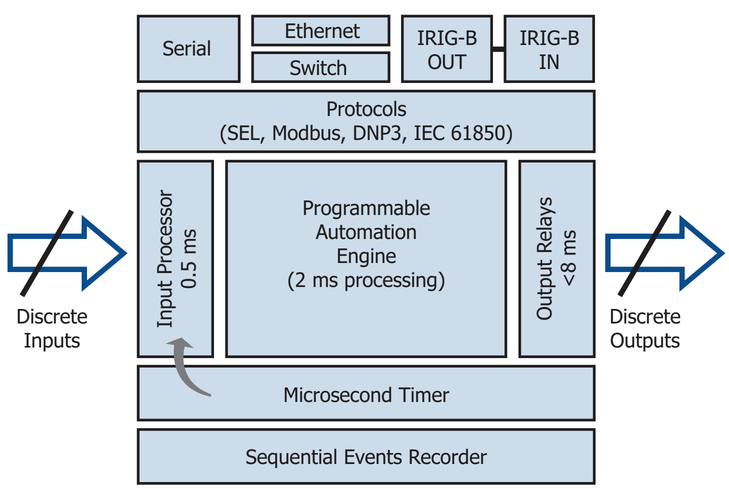


Figure 1.1 Block Diagram

Features

Physical

Standard
Isolated dry inputs (16, 32, or 48)
Electromechanical outputs (32, 16, 10, or 0)
One front USB port
Two 10/100BASE-T Ethernet ports
One rear EIA-232 serial port
IRIG-B input and output
One rear port available as an EIA-232, EIA-485, or ST fiber port

Monitoring

Standard
Record trend data through the use of the analog signal profile feature
Record state changes through the use of the Sequential Event Recorder (SER) report feature
Compatible with the SEL-3010 Event Messenger

Automation and Control

Standard
Programmable Boolean operators (such as AND, OR, and NOT)
Programmable math operators (add, subtract, multiply, and divide)
Programmable logic functions (timers, counters, and latches)
Programmable analog comparisons
Programmable rising and falling edge trigger
Digital output logic to assign logic outputs to digital outputs
Control based on date and time
Remote control to close digital outputs and reset latched indicators from remote locations

Metering

Standard
Math variable and remote analog metering
Analog signal profiling

Communications Protocols

SEL Protocols	Serial	Ethernet
SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, Fast SER, and Fast Message	Yes	
SEL MIRRORED BITS	Yes	
Industry Protocols		
DNP3	Yes	Yes (LAN/WAN)
FTP and Telnet		Yes

IEC 61850		Yes
Modbus	Yes (RTU)	Yes (TCP/IP)
SNTP		Yes
PTP		Yes

Models, Options, and Accessories

Models

This manual does not provide complete ordering information. For complete information, see the latest SEL-2440 Model Option Table (MOT) at selinc.com.

Options

I/O Quantity Options	Inputs	Outputs
Standard	32	16 (12 Form A, 4 Form C)
Option 1	16	32 (28 Form A, 4 Form C)
Option 2	48	0
Option 3	16	32 (12 Form A, 4 Form C, 16 High-Current Interrupting Form A)
Option 4	16	26 (12 Form A, 4 Form C, 10 Fast High-Current Form A)
Option 5	32	10 (10 Fast High-Current Form A)
Mounting		
Rack		
Panel		
Surface		
Digital Input Rating		
24 Vac/Vdc		
48 Vac/Vdc		
110 Vac/Vdc		
125 Vac/Vdc		
220 Vac/Vdc		
250 Vac/Vdc		
Port 1 Physical Interface		
10/100BASE-T (Copper)		
100BASE-FX (Fiber)		
Port 2 and 3 Physical Interface		
EIA-232		
EIA-485		
ST fiber		

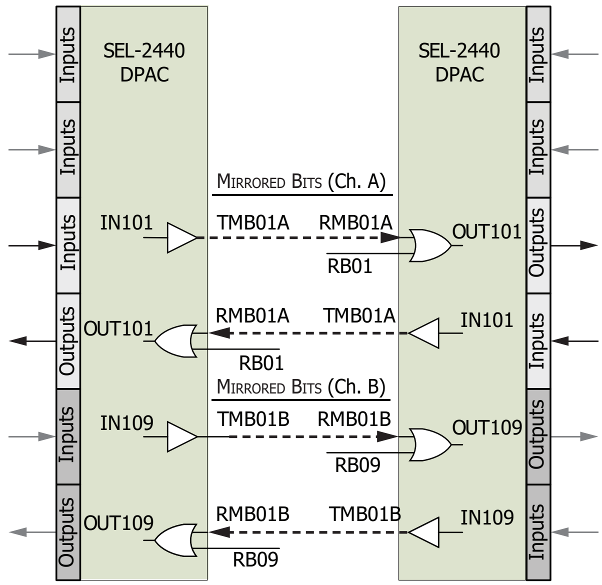
Accessories

For all DPAC mounting accessories, including adapter plates, visit selinc.com/accessories/. Contact your Technical Service Center or the SEL factory for additional details and ordering information for all other accessories.

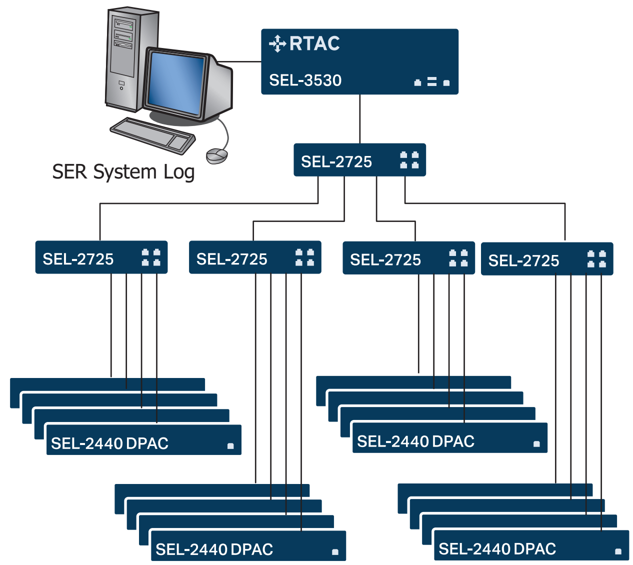
Table 1.1 Optional Accessories

Product	Description
SEL-2401	Precise Timing Source—Satellite-Synchronized Clock
SEL-2890	Ethernet Transceiver—Send email from SEL-3010
SEL-3010	Event Messenger—Automatic Voice Notification
SEL-3021	Secure Communications—Serial Encrypting Transceiver
SEL-2925	Secure Communications—Bluetooth® Encrypting Transceiver
SEL-2810	Fiber-Optic Transceiver (compatible with serial port)
SEL-2812	Fiber-Optic Transceiver (compatible with fiber-optic port)
SEL-2814	Fiber-Optic Transceiver (compatible with serial port)
300-0710	Single 14 AWG Wire Ferrules
920-0209	Dual 14 AWG Wire Ferrules
915900221	90-Degree Connector Kit
915900237	SEL-2440 Wetting Voltage Jumper Kit, Eight 4-Prong and Three 6-Prong Jumpers
915900241	Wetting Voltage Jumpers Bulk, 100 pack 4-Prong Jumpers
915900242	Wetting Voltage Jumpers Bulk, 100 pack 6-Prong Jumpers

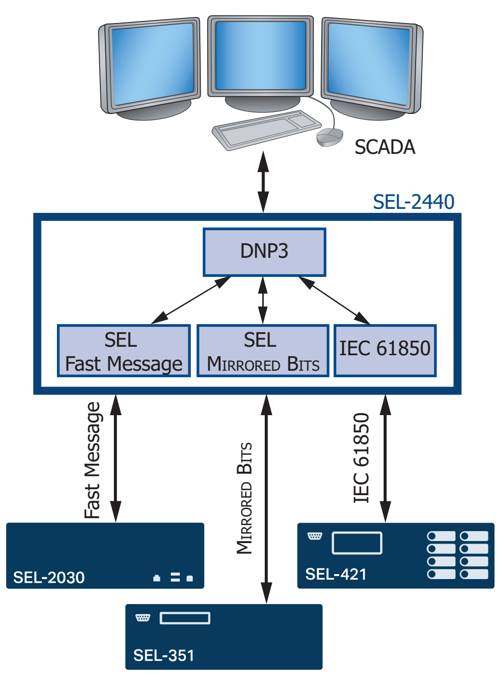
Applications



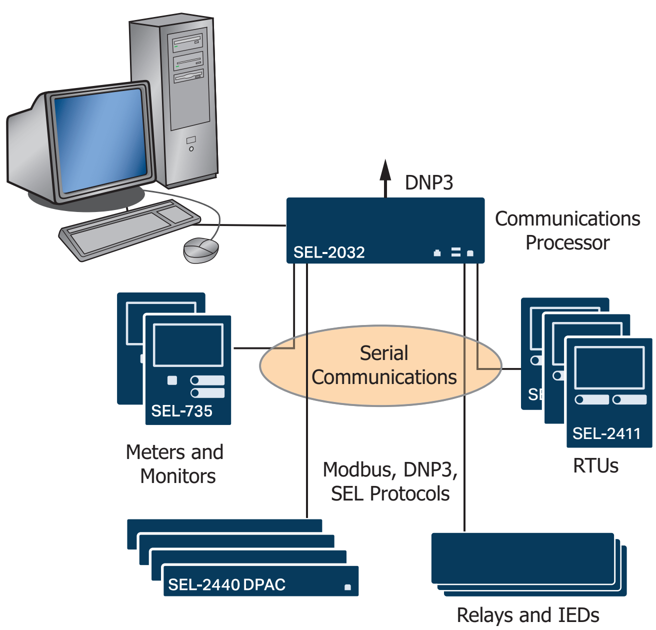
Replace Field Wiring With Mirrored Bits



Build High-Density Discrete I/O



Replace a Protocol Converter With Resident Protocols



Add Discrete I/O to Legacy Systems

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards (File E220228; NRAQ, NRAQ7)
Note: DC output ratings not evaluated by UL61010.

CE Mark

UKCA Mark

RCM Mark

Note: 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.

General

Operating Temperature Range

–40° to +85°C (–40° to +185°F)
(not applicable to UL installations. UL rated 40°C)

When Powered by 24 V, the SEL-2440 Supports the Following Conditions:

70°C:	Operate 32 outputs and 2.5 W max on +5 V pin (Port 2/3)
Conformal Coated:	Derate operating temperature by 10°C.

Operating Environment

Pollution Degree:	2
Overvoltage Category:	II
Insulation Class:	1
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude:	2000 m

Weight

2.0 kg (4.4 lb)

Inputs

Optoisolated Control Inputs

When Used With DC Control Signals:

250 V	ON for 200–275 Vdc	OFF below 150 Vdc
220 V	ON for 176–242 Vdc	OFF below 132 Vdc
125 V	ON for 100–135.5 Vdc	OFF below 75 Vdc
110 V	ON for 88–121 Vdc	OFF below 66 Vdc
48 V	ON for 38.4–52.8 Vdc	OFF below 28.8 Vdc
24 V	ON for 15–30 Vdc	OFF below 5 Vdc

When Used With AC Control Signals:

250 V	ON for 170.6–275 Vac	OFF below 106 Vac
220 V	ON for 150.3–264 Vac	OFF below 93.2 Vac
125 V	ON for 85–150 Vac	OFF below 53 Vac
110 V	ON for 75.1–132 Vac	OFF below 46.6 Vac
48 V	ON for 32.8–60 Vac	OFF below 20.3 Vac
24 V	ON for 14–27 Vac	OFF below 5 Vac

Current Draw at Nominal DC Voltage:	2–6 mA (except for 24 V, 8 mA)

Outputs

Mechanical Durability

10 M no-load operations

DC Output Ratings

Standard Output Option

Rated Operational Voltage:	24–250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C; 4 A @ 85°C
Thermal:	50 A for 1 s
Contact Protection:	360 Vdc, 40 J MOV protection across open contacts
Operating Time (Coil Energization to Contact Closure, Resistive Load):	Pickup/Dropout time ≤ 8 ms typical

Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974:	24 V	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 V	0.20 A	L/R = 40 ms
Cyclic Capacity (2.5 Cycles/Second) per IEC 60255-0-20:1974:	24 V	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 V	0.20 A	L/R = 40 ms

High-Current Interrupting Output Option

Rated Operational Voltage:	24–250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	330 Vdc/145 J
Pickup Time:	Less than 5 ms
Dropout Time:	Less than 8 ms, typical

Breaking Capacity (10,000 Operations):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989.
Note: Do not use high-current interrupting output contacts to switch ac control signals. These outputs are polarity-dependent.
Note: Breaking and Cyclic Capacity per IEC 60255-0-20:1974.

Fast High-Current Interrupting Output Option

Rated Operational Voltage:	24–250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C; 4 A @ 85°C
Continuous Carry (UL/CSA Derating With All Outputs Asserted):	5 A @ < 60°C; 2.5 A 60 to 70°C
Thermal:	50 A for 1 s

Contact Protection:	330 Vdc, 145 J MOV protection across open contacts

Operating Time (Coil Energization to Contact Closure, Resistive Load)

Pickup Time:	~16 µs at 250 Vdc, 22 µs at 125 Vdc, 85 µs at 19.2 Vdc typical (results with 100 kΩ resistive load)
Dropout Time:	< 8 ms typical

Inductive Breaking Capacity (100,000 Operations) per IEC 60255-0-20:1974

24 Vdc	10 A	L/R = 40 ms
48 Vdc	10 A	L/R = 40 ms
125 Vdc	10 A	L/R = 40 ms
250 Vdc	10 A	L/R = 20 ms

Cyclic Capacity (4 Cycles/Second Followed by 2 Minutes Idle Thermal Dissipation) per IEC 60255-0-20:1974

24 Vdc	10 A	L/R = 40 ms
48 Vdc	10 A	L/R = 40 ms
125 Vdc	10 A	L/R = 40 ms
250 Vdc	10 A	L/R = 20 ms

AC Output Ratings

Standard Output Option

Rated Operational Voltage:	110–240 Vac
Rated Voltage Range:	19.2–264 Vac
Rated Insulation Voltage:	270 Vac
Rated Frequency:	50/60 ± 5 Hz
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Contact Protection:	270 Vac, 40 J
Continuous Carry:	6 A @ 70°C; 4 A @ 85°C
Continuous Carry (UL/CSA Derating With All Outputs Asserted):	5 A @ < 60°C; 2.5 A 60–70°C
Operating Time (Coil Energization to Contact Closure):	Pickup/Dropout Time: ≤ 8 ms
Electrical Durability Make VA Rating:	3600 VA, cosϕ = 0.3
Electrical Durability Break VA Rating:	360 VA, cosϕ = 0.3

Fast High-Current Output Option

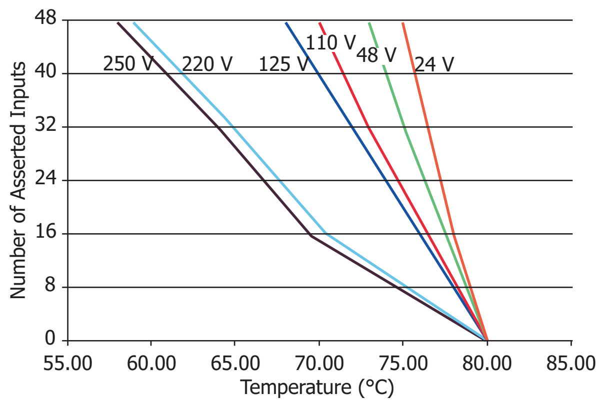
Rated Operational Voltage:	110–240 Vac
Voltage Range:	19.2–250 Vac
Rated Insulation Voltage:	250 Vdc
Rated Frequency:	50/60 ± 5 Hz
Make:	30 A @ 240 Vac
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Continuous Carry:	6 A @ 70°C; 4 A @ 85°C
Continuous Carry (UL/CSA Derating With All Outputs Asserted):	5 A @ < 60°C; 2.5 A 60 to 70°C
Thermal:	50 A for 1 s
Contact Protection:	250 Vac, 145 J MOV protection across open contacts

Operating Time (Coil Energization to Contact Closure, Resistive Load)

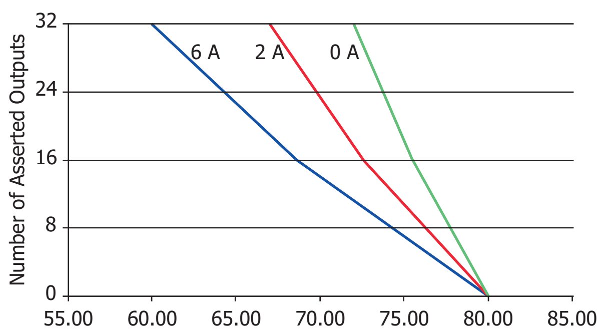
Pickup Time:	~16 µs at 250 Vac, 22 µs at 125 Vac, 85 µs at 19.2 Vac typical (results with 100 kΩ resistive load)
Dropout Time:	< 8 ms typical

Note: Per IEC 60255-23:1994, using the simplified method of assessment.
Note: Making rating per IEEE C37.90-1989.

48DI Input Derating Curve:



32DO/16DI Output Derating Curve:



Time-Code Input (Demodulated IRIG-B)

On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ
Accuracy:	microsecond

Time-Code Input (SNTP)

High-Priority Server Accuracy:	±1 ms (in an ideal network)
Low-Priority Server Accuracy:	±25 ms

Time-Code Input (PTP)

IEEE 1588-2008 Firmware-Based Accuracy:	±1 ms

Time-Code Output (Demodulated IRIG-B)

On (1) State:	$V_{oh} \geq 2.4$ V
Off (0) State:	$V_{ol} \leq 0.8$ V
Load:	50 Ω

Communications

Communications Ports

USB 2.0 Port:	Port F; front-panel port
Ethernet Ports:	Port 1A, 1B; rear-panel 10/100BASE-T or 100BASE-FX ports
Optional Port:	300–115200 bps Port 2; rear panel available as: EIA-232 with IRIG-B EIA-485 with IRIG-B ST fiber with IRIG-B
EIA-232 Port:	300–115200 bps Port 3; rear-panel port with IRIG-B

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength:	1300 nm
Data Rate:	100 Mbps
Optical Connector Type:	LC
Fiber Type:	Multimode
Link Budget:	16.1 dB
Typical TX Power:	–15.7 dBm
Min RX Sensitivity:	–31.8 dBm
Fiber Size:	50–200 µm
Approximate Range:	~6.4 km
Typical Fiber Attenuation:	–2 dBm/km

Port 2 Serial ST (SEL-2812 Compatible)

Baud Rate:	300–115200 bps
Wavelength:	850 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Link Budget:	16 dBm
Min TX Power:	–13 dBm
Max TX Power:	–3 dBm
Min RX Sensitivity:	–29 dBm
Fiber Size:	50–200 µm
Approximate Range:	~4 km with 62.5 µm ~1 km with 200 µm
Typical Fiber Attenuation:	–4 dBm/km

Communications Protocols

Modbus Slave (TCP and RTU)
DNP3 Level 2 Outstation (LAN/WAN and Serial)
IEC 61850 communications
FTP
SNTP
PTP (firmware based)
Telnet
SEL MIRRORED BITS
Ymodem file transfer on the front and rear port
Xmodem file transfer on the front port
SEL ASCII and Compressed ASCII
SEL Fast Meter
SEL Fast Operate
SEL Fast SER
SEL Fast Message unsolicited write
SEL Fast Message read request
SEL Event Messenger points

Maximum Concurrent Connections

Modbus Slave:	2
DNP3 Level 2 Outstation:	5[a]
Ethernet FTP:	2
Telnet:	2
IEC 61850 MMS:	7
IEC 61850 Goose:	16 incoming 8 outgoing

[a] Maximum in any combination of serial and/or LAN/WAN links.

Power Supply

Input Voltage

Rated Voltage:	24–250 Vdc 110–230 Vac, 50/60 Hz
Voltage Range:	19.2–275 Vdc 85–264 Vac
Inrush Current:	< 20 A pk

Power Consumption

AC:	< 50 VA
DC:	< 20 W

Interruptions:	10 ms @ 24 Vdc 25 ms @ 48 Vdc 125 ms @ 125 Vdc 160 ms @ 120 Vac 600 ms @ 250 Vdc 1000 ms @ 230 Vac
Fuse Rating:	3.15 A, high breaking capacity, time lag T, 250 V (5 x 20 mm, T3.15AH 250 V)

Sampling and Processing Specifications

Digital Inputs

Sampling Rate:	2 kHz

Contact Outputs

Refresh Rate:	2 kHz
Logic Update:	Every 4 ms

Timer Accuracy

±2 ms and ±0.001% of settings

Processing Specifications

Processing Interval:	2 ms
Control Processing:	2 ms (except for math variables and, with default settings, remote analogs which are processed at 100 ms)

Product Standards

Electrical Equipment for Measurement, Control, and Laboratory Use:	IEC 61010-1:2013 UL 508:2018 C22.2 No. 61010-1:12 IEC 61010-2-201:2013 UL 61010-2-201:2017 C22.2 No. 61010-2-201:14
Measuring Relays and Protection Equipment:	IEC 60255-26:2013 IEC 60255-27:2013

Type Tests

Note: To ensure good EMI and EMC performance, type tests were performed using shielded copper Ethernet cables with the shell grounded at both ends of the cable. Additionally, digital inputs were configured with 4 millisecond pickup and dropout time settings. Double-shielded cables and 4 millisecond or greater pickup and dropout times are recommended for best EMI and EMC performance.

Environmental Tests

Enclosure Protection:	IEC 60529:1989 + A1:1999 + A2:2013 IP4X Front IP2X Product **Note:** If rear terminals are accessible during normal use, the product must be mounted in a locked enclosure or restricted area accessible by trained maintenance or operation personnel only.
Vibration Endurance:	Class 2
Response:	Class 2
Shock Withstand:	Class 1
Response:	Class 2
Bump Withstand:	Class 1
Seismic Response:	Class 2
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 40°C, 93% relative humidity, 4 days
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25°C–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 85°C, 16 hours

Power Interruption Tests

AC Power:	61000-4-11:2004
DC Power:	61000-4-29:2001

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-27:2013 IEEE C37.90-2005 3.6 kVdc on power supply 2.5 kVac on contact I/O 1.5 kVac on Ethernet/IRIG IN
Impulse:	IEC 60255-27:2013 5 kV on power supply, contact I/O 2.2 kV on Ethernet

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 Severity Level: 2, 4, 6, 8 kV contact discharge 2, 4, 8, 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2006 + A1:2007 + A2:2010 10 V/m IEEE C37.90.2-2004 20 V/m
Fast Transient, Burst Immunity:	IEC 61000-4-4:2012 4 kV @ 5 kHz on power supply and contact I/O 2 kV @ 5 kHz for communication ports
Surge Immunity:	IEC 61000-4-5:2005 1 kV on power supply, contact I/O 2 kV on power supply, contact I/O, Ethernet and serial ports, IRIG
Surge Withstand Capability:	IEC 61000-4-18:2006 + A1:2010 Severity Level: Power supply and contact I/O 2.5 kV peak common mode 1.0 kV peak differential mode Communication ports 1.0 kV peak common mode IEEE C37.90.1-2012 2.5 kV oscillatory, 4 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2013, 10 Vrms
Power Frequency Magnetic Field:	IEC 61000-4-8:2009 1000A/m for 3 s 100A/m for 1 min
Pulse Magnetic Field:	IEC 61000-4-9:2016 1000 A/m
Damped Oscillatory Magnetic Field:	IEC 61000-4-10:2016 100 A/m

EMC Emissions

Note: Test performed using serial cables with shield grounded at both ends.

Conducted and Radiated Severity Level:	Class A EN 55011:2009 + A1:2010 EN 55022:2010 + AC:2011 EN 55032:2012 + AC:2013 CISPR 11:2009 + A1:2010 CISPR 22:2008 CISPR 32:2015 ANSI C63.4:2014 Canada ICES-001 (A) / NMB-001 (A)

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Section 2
Installation

Overview

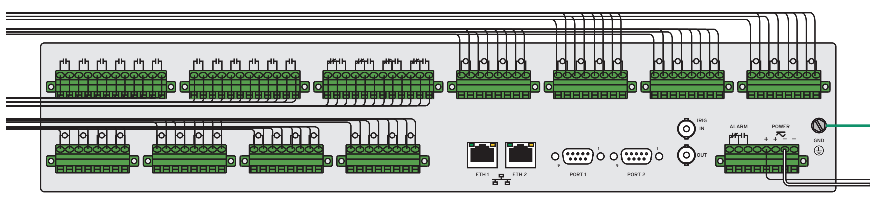
The first steps in applying the SEL-2440 Discrete Programmable Automation Controller (DPAC) are installing and connecting the device. This section describes common installation features and requirements. To install and connect the device safely and effectively, you must be familiar with device configuration features and options.

Unpack and Inspect

- ➤ Remove the packing slip.
- ➤ Slit the tape and remove DPAC.
- ➤ Verify that the DPAC has not been damaged.

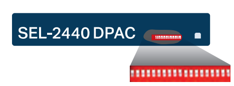
Wire It

Wire the terminals as described in *Connections*.



Configure Control (DIP) Switches

Configure the protocol, speed, and address for **PORT 2** and **PORT 3** with control DIP (dual in-line package) switches (see *Easy Mode on page 3.1*). For more sophisticated applications, see *Flexible Mode on page 3.4*.



Verify Device Status

Connect to power and verify that the **ENABLED** LED illuminates and the **ALARM** LED extinguishes. Use the other LEDs to verify correct communications and I/O operations.

Press the **LAMP TEST** pushbutton briefly and verify that all of the LEDs illuminate. Press the **LAMP TEST** pushbutton for more than four seconds to verify the control (DIP) switch positions (e.g., port address) in Easy Mode and the IRIG-B time. The **ALARM** LED will flash when the LEDs are displaying these data. If an alarm has occurred and the LED is already illuminated, the **ALARM** LED will stay illuminated and will not flash. After about one minute the device will return to normal status.

Verify I/O Status

Verify operation by reading inputs and controlling outputs with a polling master.

Device Placement

Physical Location

NOTE: If rear terminals are accessible during normal use, product must be mounted in a locked enclosure or restricted area accessible by trained maintenance or operation personnel only.

You can mount the DPAC in a sheltered indoor environment (a building or an enclosed cabinet) that does not exceed the temperature and humidity ratings for the device.

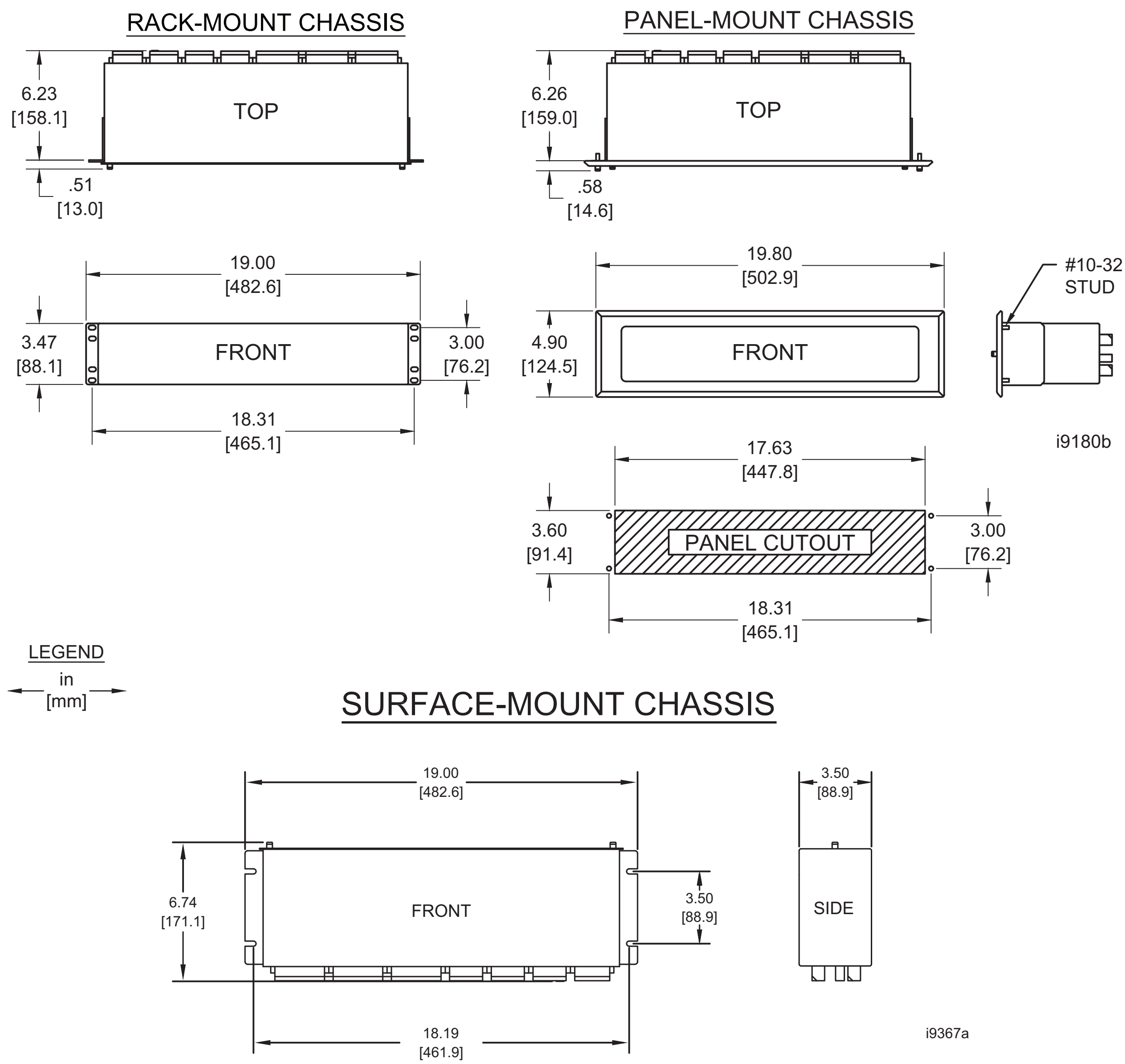


Figure 2.1 Rack-, Panel-, and Surface-Mount Dimensions

Front- and Rear-Panel Drawings

Figure 2.2 through *Figure 2.4* show the front-panel status LEDs provided to simplify system troubleshooting and the rear-panel connectors used for communications and wiring.

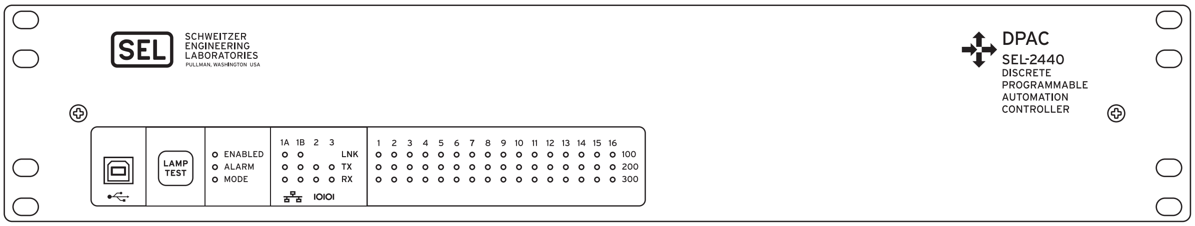


Figure 2.2 Rack-Mount Drawing

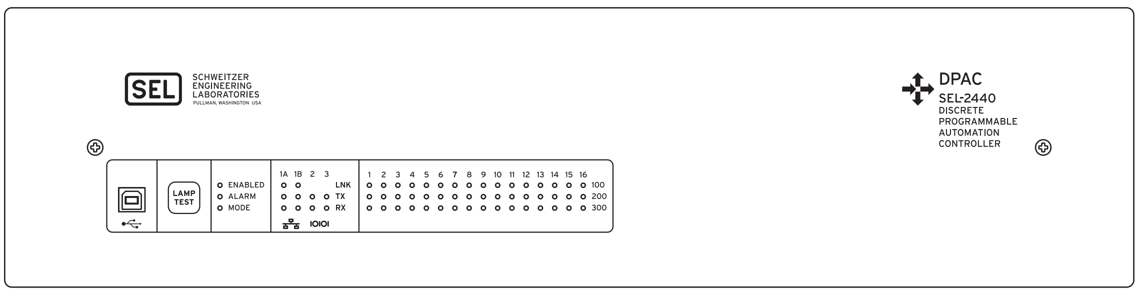


Figure 2.3 Panel-Mount Drawing

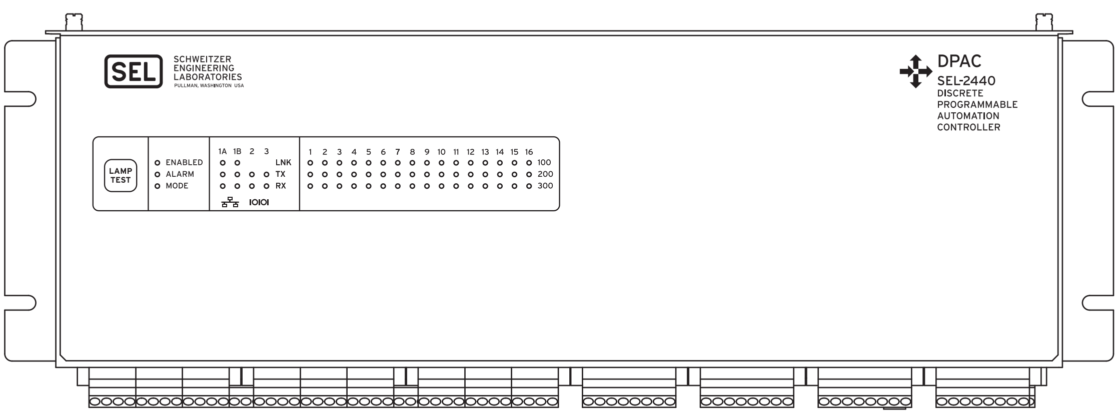


Figure 2.4 Surface (Left) Mount Drawings

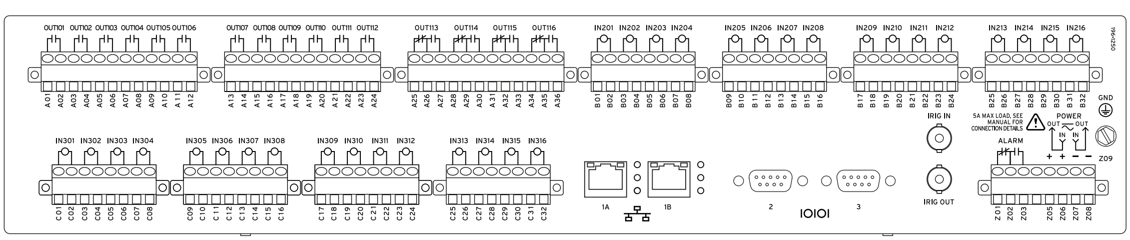


Figure 2.5 32 Input, 16 Output Rear-Panel Drawing

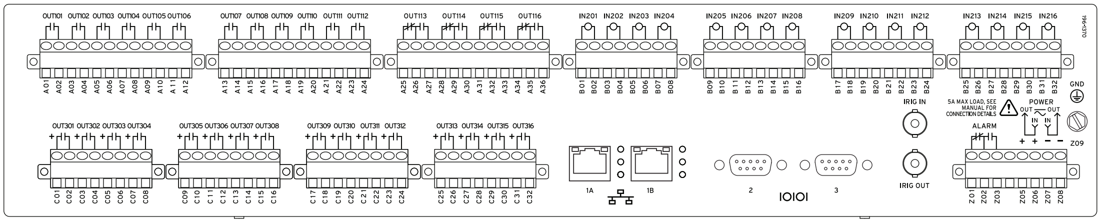


Figure 2.6 High-Current Interrupting Option Rear-Panel Drawing

High-current interrupting outputs are polarity sensitive. This is indicated with a + next to the contact on the overlay to indicate the positive side of the contact.

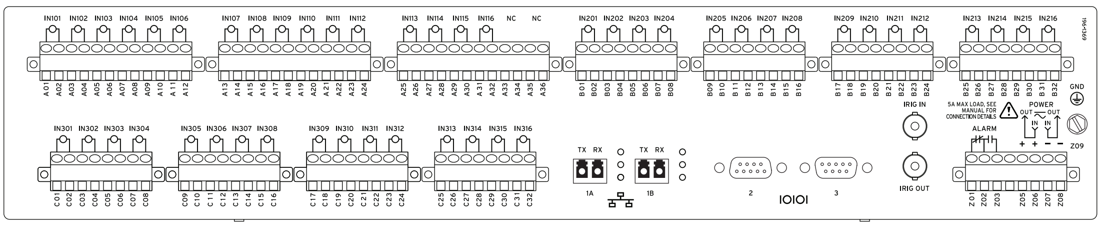


Figure 2.7 Port 2 EIA-485 and Fiber-Optic Ethernet Option Rear-Panel Drawing

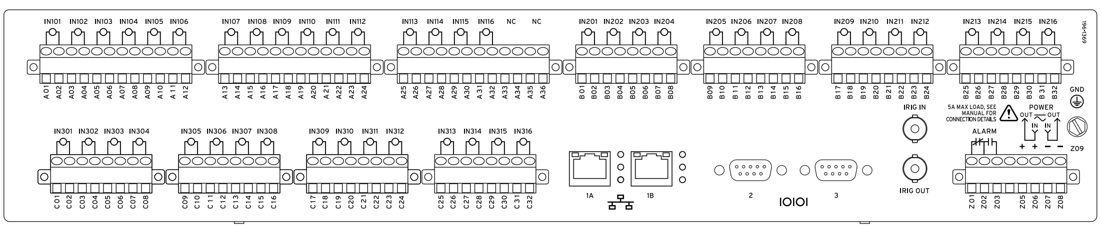


Figure 2.8 48DI Option Rear-Panel Drawing

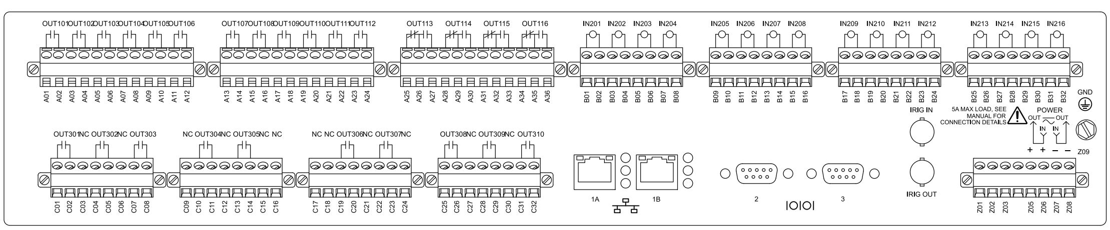


Figure 2.9 16 Input, 16 Standard Output, and 10 Fast High-Current Output Rear-Panel Drawing

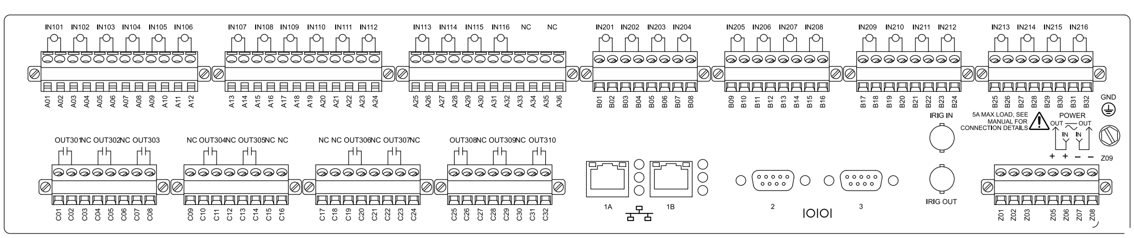


Figure 2.10 32 Input and 10 Fast High-Current Output Rear-Panel Drawing

Connections

Power

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

The **POWER** terminals on the rear panel (**Z06(+/H)** and **Z07(–/N)**) must connect to 120–230 Vac or 24/48/125/220/250 Vdc with the proper polarity. The extra power terminals are bridged internally, **Z05(+/H)** bridged with **Z06(+/H)** and **Z07(–/N)** bridged with **Z08(–/N)**, to provide a parallel power connection for another device not to exceed 5 A. The **POWER** terminals are isolated from chassis ground. Use 16–14 AWG (1.5–2.5 mm2) wire of sufficient current capacity and insulation voltage rating to connect to the **POWER** terminals. Be sure to use wire rated for 90°C operation.

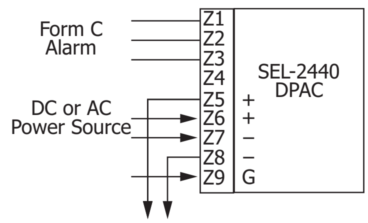


Figure 2.11 Power Connections

Grounding (Earthing)

Connect the ground terminal labeled **GND (Z09)** on the rear of the panel to a rack frame or switchgear ground for proper safety and performance. Use less than 2 m (6.6 ft) of 14 AWG (2.5 mm^2) wire of sufficient current capacity and insulation voltage rating for the ground connection. Be sure to use wire rated for 90°C operation.

Communications Ports

Figure 2.12 and *Table 2.1* show cables that should fit your application.

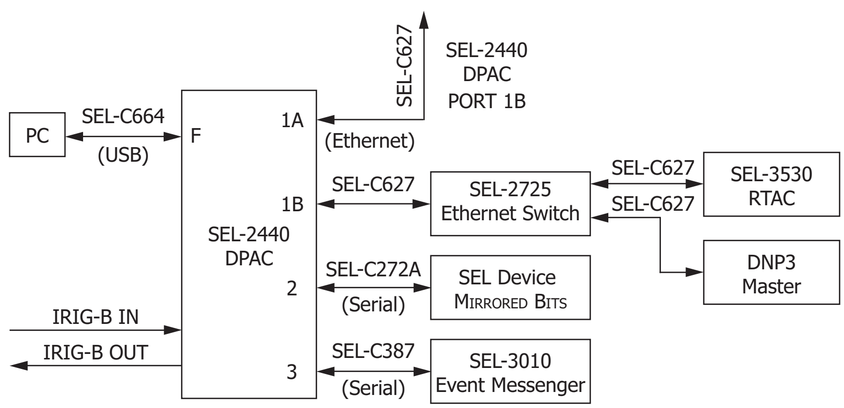


Figure 2.12 Communications Ports

Table 2.1 Port Characteristics (Sheet 1 of 2)

Port Type	Port Interface	Cables
PORT F (serial)	USB to Serial Bridge	SEL-C664
PORT 1A, **1B** (Ethernet)	10/100BASE-T (RJ45 for Copper)	SEL-C627
PORT 2 and **Port 3** (serial)	EIA-232 (Nonisolated)	SEL-C234A, SEL-C272A, and SEL-C387 are popular selections. The cable shield must be connected to the SEL-2440 to pass emissions. Cables such as the SEL-C323 are connected on both ends for ease of installation.
PORT 2 (serial)	EIA-485	
PORT 2 (serial)	ST fiber	ST terminated SEL-C807 Cable (< 4 km) or SEL-C805 Cable (< 1 km), compatible with SEL-2812 Fiber-Optic Transceiver

Table 2.1 Port Characteristics (Sheet 2 of 2)

Port Type	Port Interface	Cables
IRIG-B Input	Female BNC	SEL-C256
IRIG-B Output	Female BNC	SEL-C256

Inputs

The DPAC optoisolated inputs are not polarity dependent. Refer to *Section 1: Introduction and Specifications* for optoisolated input ratings and *Figure 2.5–Figure 2.10* for terminal assignments. Inputs can be configured to respond to ac or dc control signals.

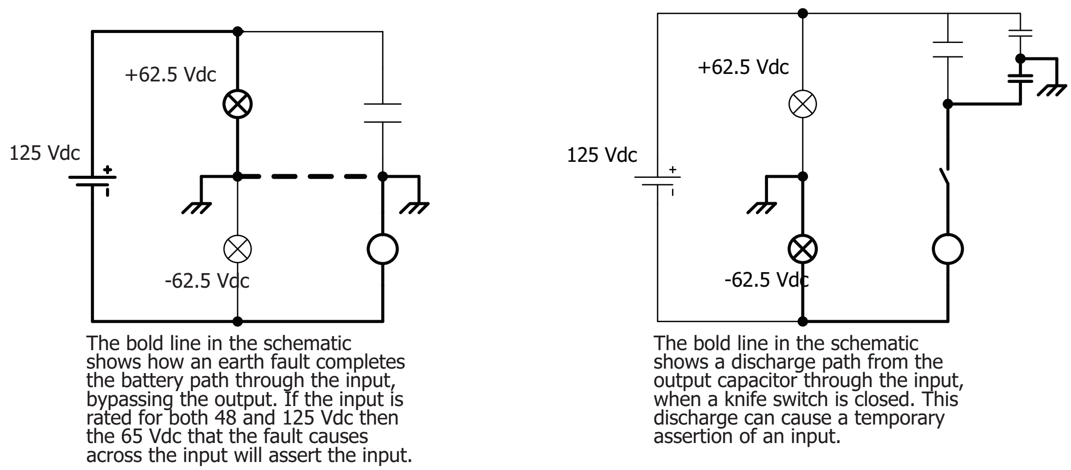


Figure 2.13 Designed Against False Assertions

Outputs

Refer to *Section 1: Introduction and Specifications* for output contact ratings and *Figure 2.5–Figure 2.10* for terminal assignments.

The following figure shows that a trip coil has a resistive and inductive component. After a trip output has been closed for a long time the current will settle to a steady-state value. When the trip output is opened it tries to interrupt the inductive current that wants to continue to flow (V = L di/dt), which causes a large voltage spike that can turn into an arc. When the contacts bounce during the arc they often weld closed. SEL outputs have been designed, tested and specified for this application so they do not weld. See *Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974: on page 1.6* in the specifications section.

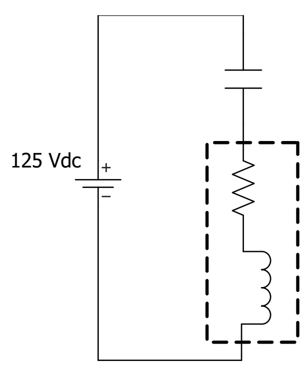


Figure 2.14 Inductive Interrupt of a Trip Output

Field Serviceability

The DPAC firmware may be upgraded in the field (see *Appendix B: Firmware Upgrade Instructions*). Configure an output contact to create a diagnostic alarm for a self-test failure as explained in *Section 4: Logic Functions*. Refer to *Section 8: Testing and Troubleshooting* for detailed testing and troubleshooting information.

The only field replaceable components are the power supply fuse and the real-time clock battery. A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Rayovac no. BR1632 or equivalent. At room temperature (25°C), the battery will operate nominally for 10 years at rated load. When the device is powered from an external source, the battery experiences a low self-discharge rate. Thus, battery life may extend well beyond 10 years. The battery cannot be recharged.

Fuse Replacement

⚠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.

⚠CAUTION
The device contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.

To replace the power supply fuse, perform the following steps:

Step 1. De-energize and disconnect the device.

Step 2. Place the device on a flat, clean, grounded surface for maintenance.

Step 3. Remove the ground screw, plug-in connectors, and device panel.

Step 4. Carefully disconnect the HMI ribbon cable when removing the device panel.

Step 5. Disconnect the connector that secures the upper I/O printed circuit board ribbon cable to the upper I/O printed circuit board.

Step 6. Remove the upper printed circuit board.

Step 7. Locate the fuse on the lower printed circuit board, near the power supply connector.

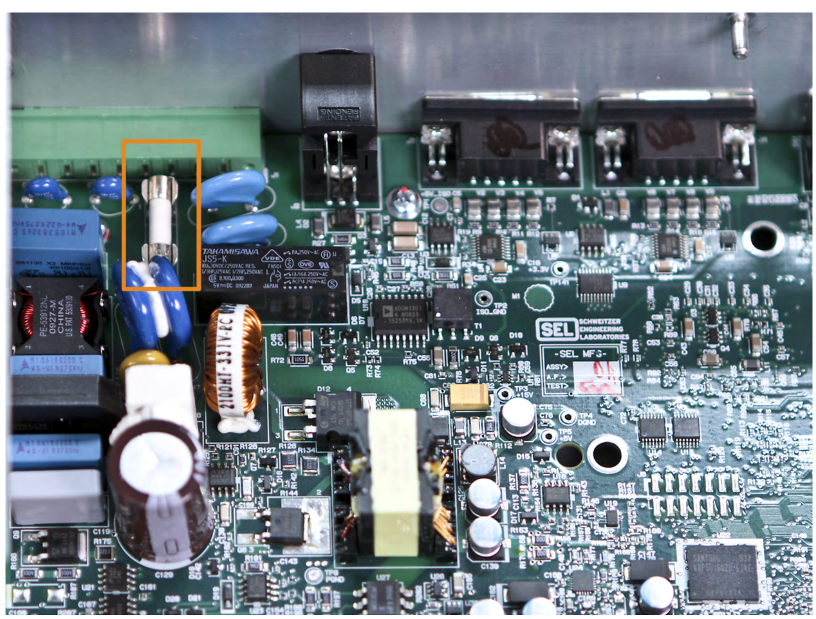


Figure 2.15 Fuse Location

Step 8. Remove the fuse from the fuse holder.

Step 9. Ensure fuse holder has not been damaged, bent, or deformed.

Step 10. Be sure to reform the fuse holder to ensure proper contact with the new fuse.

Step 11. Replace the fuse with a time delay, 5 x 20 mm, 3.15 A, high breaking capacity, 250 V fuse (T315H 250 V).

Step 12. Reinstall the upper printed circuit board.

Step 13. Replace the device front panel, reinstall all screws and connectors, and energize the unit.

Real-Time Clock Battery Replacement

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with Rayovac no. BR1632 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.

To replace the real-time clock battery, perform the following steps:

Step 1. De-energize and disconnect the device.

Step 2. Place the device on a flat, clean, grounded surface for maintenance.

Step 3. Remove the ground screw, plug-in connectors, and device panel.

Step 4. Carefully disconnect the HMI ribbon cable when removing the device panel.

Step 5. Disconnect the connector that secures the upper I/O printed circuit board ribbon cable to the upper I/O printed circuit board.

Step 6. Remove the upper printed circuit board.

Step 7. Locate the battery clip (holder) on the lower printed circuit board.

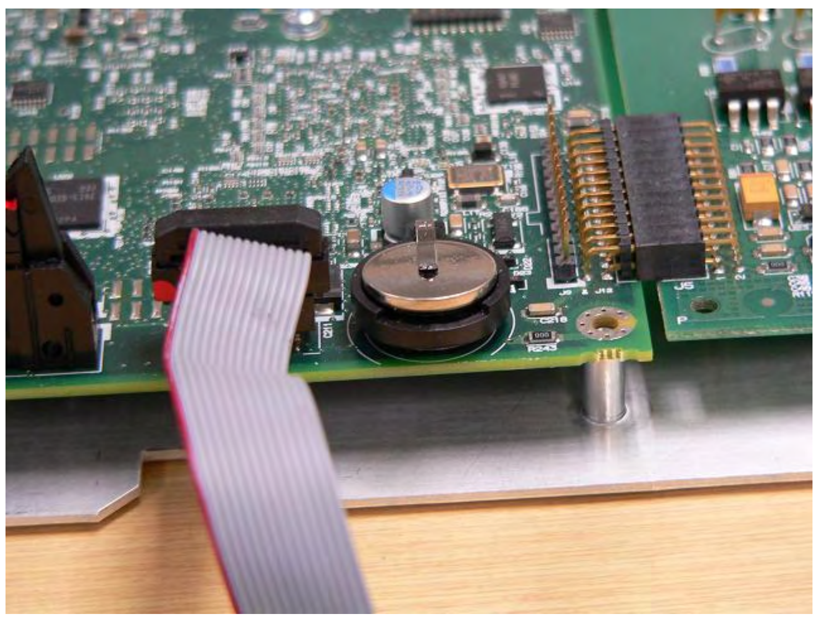


Figure 2.16 Battery Location

Step 8. Carefully remove the battery from beneath the clip. Properly dispose of the old battery.

Step 9. Install the new battery with the positive (+) side facing up.

Step 10. Reinstall the upper printed circuit board.

Step 11. Replace the device front panel, reinstall all screws and connectors, and energize the unit.

Step 12. Set the device date and time.

Section 3
Getting Started

Overview

NOTE: +5 Vdc port power is configured with control (DIP) switch settings for both Easy and Flexible Modes.

Configure the SEL-2440 Discrete Programmable Automation Controller (DPAC) using one of the following modes:

➤ **Easy.** In Easy Mode, all settings are configured with control (DIP) switches accessible on the back of the DPAC front panel.

➤ **Flexible.** In Flexible Mode, all settings are configured with ACSELERATOR QuickSet® SEL-5030 Software or with a terminal emulator by using the DPAC command line interface.

Front-Panel Indicators

Indicators (LEDs) are provided to simplify commissioning and troubleshooting. Each LED function is shown in *Figure 3.1*. The **MODE** indicator illuminates when Flexible Mode is selected and flashes when Easy Mode is selected.

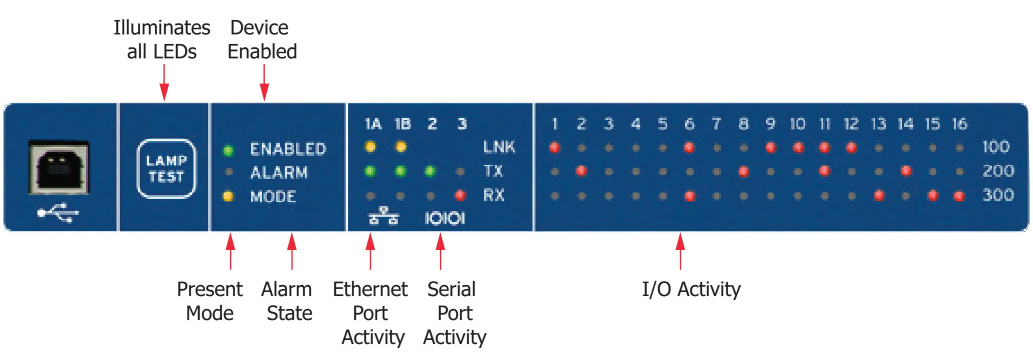


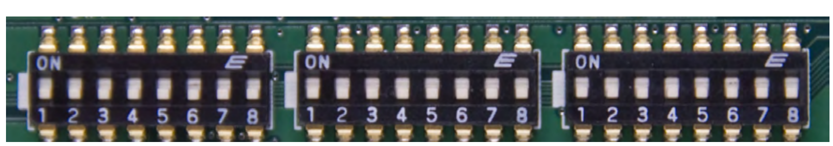
Figure 3.1 Front-Panel Indicators

Easy Mode

NOTE: In Easy Mode, settings that cannot be configured with control (DIP) switches are automatically set to their default value. In addition, the **SET** and **SHO** commands are disabled and the Port settings cannot be edited.

NOTE: Performing a firmware upgrade is only possible in Flexible Mode. Refer to *Appendix B: Firmware Upgrade Instructions*.

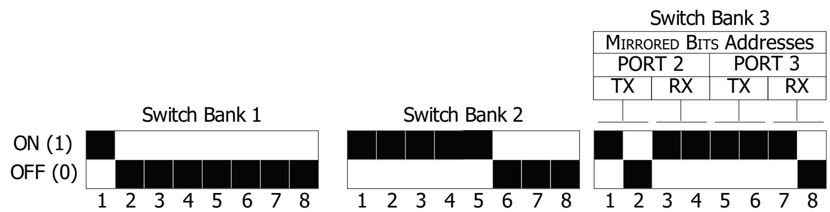
DPAC Easy Mode settings are configured with control (DIP) switches located behind the front panel as shown below. To access these switches, disconnect input power from the DPAC, then remove the front panel by loosening the two captive screws located on the front panel; use these same steps in reverse to restore the DPAC to operation.



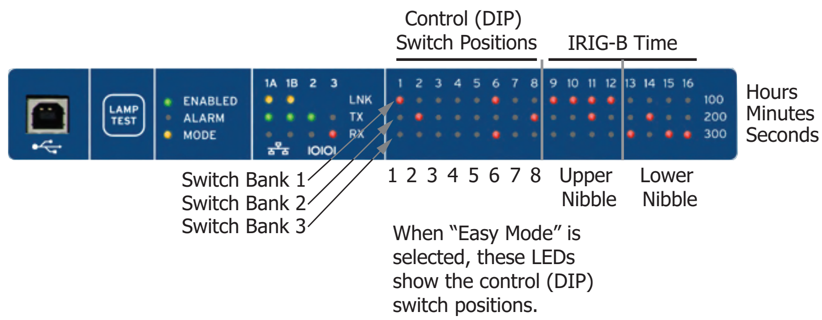
Add I/O to Replace Field Wiring With MIRRORED BITS

Set the switches as shown below (see *Table 3.1* for details on configuring control [DIP] switches):

- Select Easy Mode
- Select MIRRORED BITS® for **PORT 2** and **PORT 3**
- Select 38400 bps for both ports
- Set MIRRORED BITS addresses: PORT 2 TX = 3, RX = 4; PORT 3 TX = 4, RX = 3



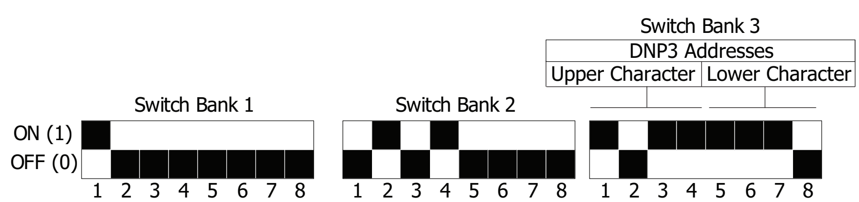
Attach one DPAC **PORT 2** to another DPAC **PORT 3** and vice versa by using an SEL-C273A cable.



Add I/O to Legacy DNP3 Serial Systems

Set the switches as shown below to:

- Select Easy Mode
- Select DNP3 for **PORT 2** and **PORT 3**
- Select 38400 bps for both ports
- Set DNP3 addresses to 190 decimal (BE hex)



Control (DIP) Switch Configuration

Table 3.1 Switch Configuration Descriptions

Switch	Function	Configuration
Switch Bank 1 (S1)		
1	Setting Mode	OFF (0) = Flexible (Factory Default) ON (1) = Easy
2	Password Override	OFF (0) = Passwords Enabled (Factory Default) ON (1) = Passwords Disabled
3–4	Reserved	OFF (0) = N/A (Factory Default) ON (1) = N/A
5	SELBOOT Override at Power Up	OFF (0) = Normal (Factory Default) ON (1) = Force SELBOOT at Power Up
6–8	Reserved	OFF (0) = N/A (Factory Default) ON (1) = N/A
Switch Bank 2 (S2)		
1–2	PORT 2 Protocol	OFF (0), OFF (0) = SEL ASCII (Factory Default) OFF (0), ON (1) = DNP3 ON (1), OFF (0) = Modbus ON (1), ON (1) = MIRRORED BITS (MB8A)
3–4	PORT 3 Protocol	OFF (0), OFF (0) = SEL ASCII (Factory Default) OFF (0), ON (1) = DNP3 ON (1), OFF (0) = Modbus ON (1), ON (1) = MIRRORED BITS (MB8B)
5	PORT Speed (Parity = N, Data Bits = 8, Stop Bits = 1)	OFF (0) = 9600 bps (Factory Default) ON (1) = 38400 bps
6	PORT Power (+5 Vdc)	OFF (0) = Disabled (Factory Default) ON (1) = Enabled
7–8	Reserved	OFF (0) = N/A (Factory Default) ON (1) = N/A
Switch Bank 3 (S3)		
1–8	Address (Hex) Last IP Octet (00–FF hex, 0–255 decimal; 192.168.0.*n* with default IP address) DNP3 Address (00–FF hex, 0–255 decimal) Modbus Slave Address (1–F7 hex, 1–247 decimal) MIRRORED BITS: 1, 2 PORT 2 TX 3, 4 PORT 2 RX 5, 6 PORT 3 TX 7, 8 PORT 3 RX	

NOTE: Factory-default setting for all control (DIP) switches is OFF (0).

Flexible Mode

> **NOTE:** Set Control (DIP) Switch 1 in Switch Bank 1 to Flexible.

DPAC Flexible Mode settings are configured with either SEL-5030 ACSELERATOR QuickSet or SEL ASCII commands with terminal emulation software. QuickSet provides the ability to:

- ➤ Configure connection parameters
- ➤ Edit (new, read, open) settings
- ➤ Send/receive settings
- ➤ Manage settings databases
- ➤ Receive/view HMI information
- ➤ View communications with terminal emulation
- ➤ Get help

Install

Install the DPAC as described in *Overview on page 2.1* and install QuickSet on your personal computer. Once QuickSet is installed, launch the application and a launchpad similar to that shown in *Figure 3.2* will be displayed.

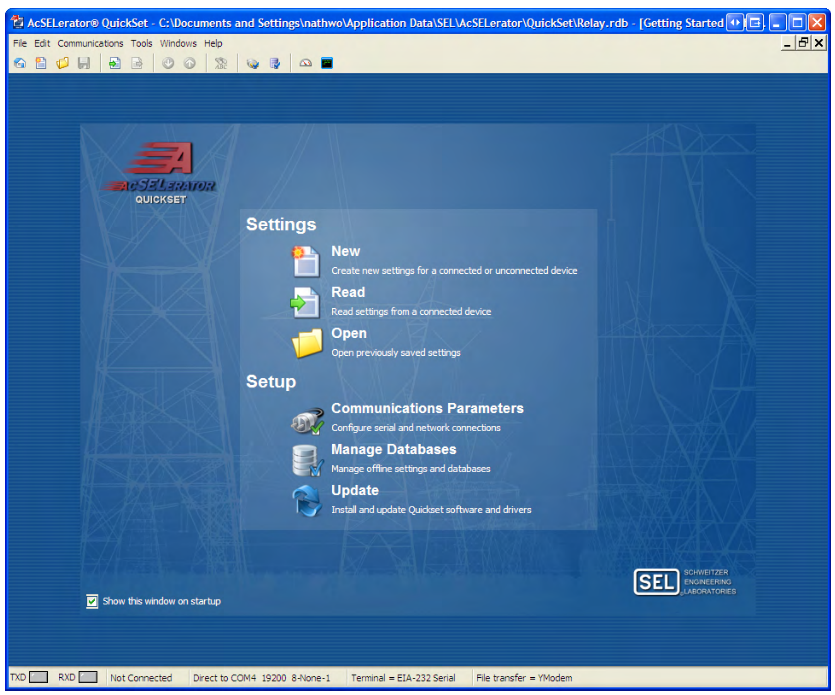


Figure 3.2 QuickSet Launchpad

Connection Parameters

The **Connection Parameters** launchpad selection is a shortcut to the **Communications** > **Parameters** selection on the menu bar. Configure the QuickSet communications parameters and passwords to match those in the DPAC. The DPAC default passwords are shown in *Table 3.2*.

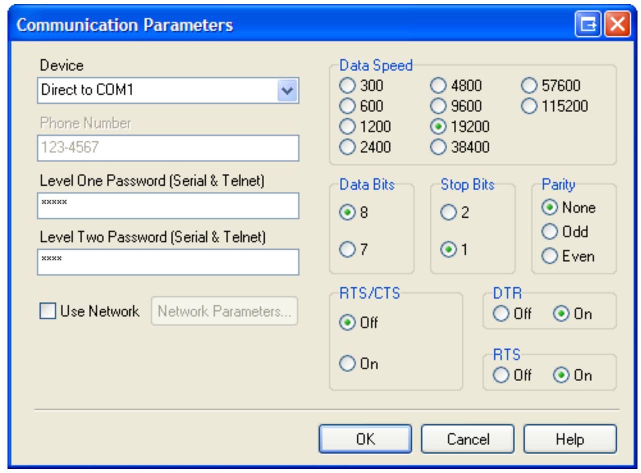


Table 3.2 Factory-Default Passwords

Access Level	Password
0	N/A
1	OTTER
2	TAIL
C	CLARKE

Manage Databases

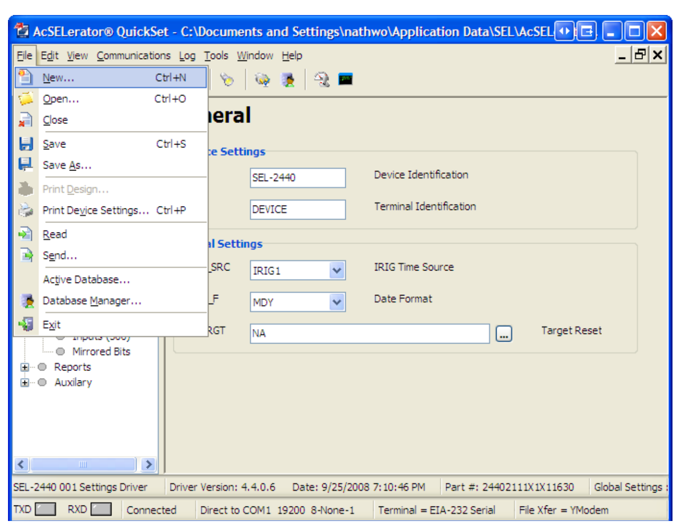
Select **File** > **Database Manager** on the main menu bar to open the database manager or **Manage Databases** from the launchpad. With the manager you can create, copy, and manage databases and manage records within existing databases. The manager gives you access to the **New Database** button and the **Copy/Move Settings Between Databases** tab.

Update

Select **Update** from the launchpad to update the QuickSet application, add support for new products (drivers), or update the support for existing products (drivers). This selection will launch SEL Compass®, the SEL software and literature management application.

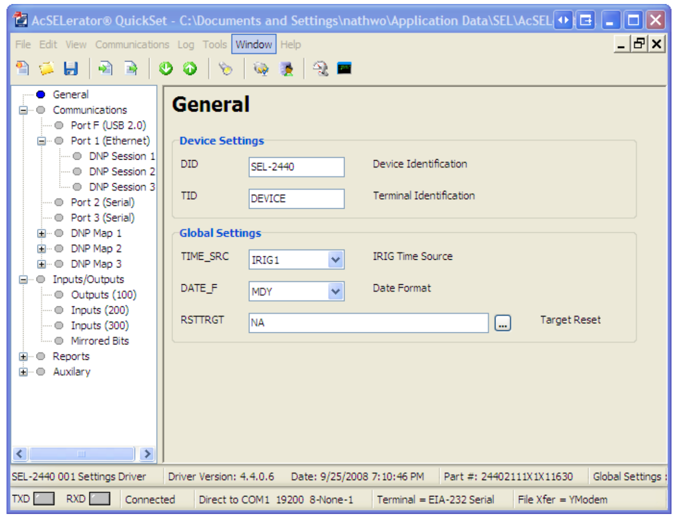
Edit (New, Open, Read) Settings

Begin the settings process by selecting **New**, **Open**, or **Read** from the launchpad shown in *Figure 3.1*, QuickSet launchpad, or by selecting **File** > **New**, **File** > **Open**, or **File** > **Read** from the menu bar.



General Settings

NOTE: With terminal emulation, use the **SET** command to access the device settings and **SET G** to access the Global settings.

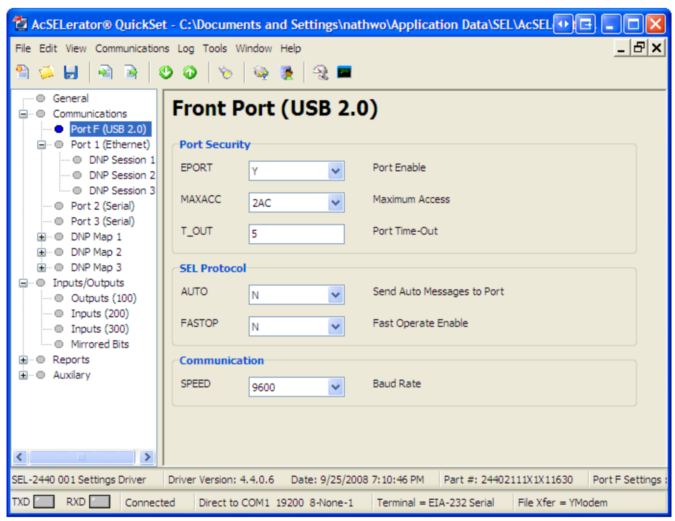


Time-Synchronization Source

Use the Time-Synchronization Source Setting (TIME_SRC) to declare the source of the IRIG input. The SEL-2440 accepts IRIG input from the IRIG-BNC connector, Port 2, or Port 3.

USB 2.0 Settings (PORT F)

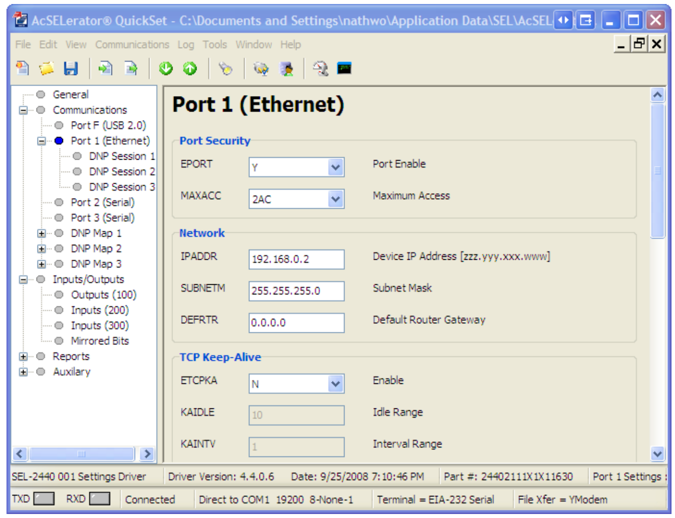
NOTE: With terminal emulation, use the **SET P F** command to access the front-panel USB port settings.



Network Settings (PORT 1)

NOTE: With terminal emulation, use the **SET P 1** command to access the Ethernet network port settings.

Select the **Network** node on the QuickSet tree. *Table 3.3* describes the Ethernet network port settings and *Table 3.6* describes the DNP3 settings.



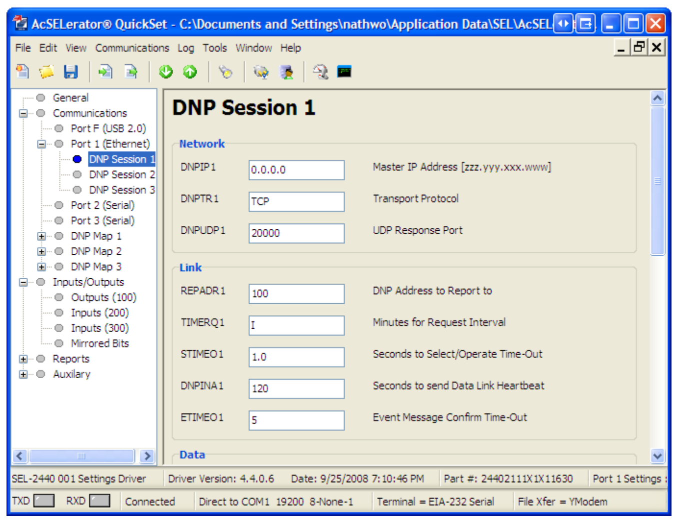


Table 3.3 Ethernet Network Settings (Sheet 1 of 2)

Description	Range	Name	Default
Security Setting			
Port Enable	Y, N	EPORT	Y
Maximum Access Level	ACC, 2AC	MAXACC	2AC
Ethernet Network Settings			
IP Address	zzz.yyy.xxx.www	IPADDR	192.168.0.2
Subnet Mask	zzz.yyy.xxx.www	SUBNETM	255.255.255.0
Default Router	zzz.yyy.xxx.www	DEFRTR	192.168.0.1
Operating Mode	FIXED, FAILOVER, SWITCHED, PRP	NETMODE	FAILOVER
Fail Over Time Out	OFF, 0.10–65.00 s	FTIME	1.00
Primary Network Port	A, B, D	NETPORT	A
PRP Entry Timeout	400–10000 ms	PRPTOUT	500
PRP Destination Address LSB	0–255	PRPADDR	0

Table 3.3 Ethernet Network Settings (Sheet 2 of 2)

Description	Range	Name	Default
PRP Supervision TX Interval	1–10 s	PRPINTV	2
Network Port A Speed	AUTO, 10, 100	NETASPD	AUTO
Network Port A Speed	AUTO, 10, 100	NETBSPD	AUTO
Enable TCP Keep-Alive	Y, N	ETCPKA	N
TCP Keep-Alive Idle Range	1–20 s	KAIDLE	10
TCP Keep-Alive Interval Range	1–20 s	KAINTV	1
TCP Keep-Alive Count Range	1–20 s	KACNT	6
Enable Telnet	Y, N	ETELNET	Y
TELNET Port	23, 1025–65534	TPORT	23
TELNET Time-Out	1–30 min	TIDLE	15
Enable FTP	Y, N	EFTP	Y
FTP User Name	20 characters	FTPUSER	FTPUSER
Enable IEC 61850 Protocol	Y, N	E61850	N
Enable IEC 61850 GSE (Y, N)	Y, N	EGSE	N
Enable Modbus	0–2	EMODBUS	0
Enable DNP Sessions	0–5	EDNP	1
Enable SNTP Client	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP	OFF
SNTP Primary Server IP Address		SNTPPSIP	192.168.1.1
SNTP Backup Server IP Address		SNTPBSIP	192.168.1.1
SNTP IP (Local) Port Number	1–65534	SNTPPORT	123
SNTP Client Request Update Rate	15–3600	SNTPRATE	60
SNTP Client Response Timeout	5–20	SNTPTO	5
PTP Settings			
Enable PTP	Y, N	EPTP	N
PTP Profile	DEFAULT, C37.238	PTPPRO	DEFAULT
PTP Transport Mechanism	UDP, LAYER2	PTPTR	UDP
PTP Domain Number	0–255	DOMNUM	0
PTP Path Delay Mechanism	P2P, E2E, OFF	PTHDLY	E2E
Peer Delay Request Interval	1, 2, 4, 8, 16, 32, 64	PDINT	1
PTP Number of Acceptable Masters	1–5, OFF	AMNUM	OFF
PTP Acceptable Master [*n*][a]	zzz.yyy.xxx.www	AMIP[*n*]	192.168.1.12[*n*]
PTP Alternate Priority for Master (*n*) MAC	xx-xx-xx-xx-xx-xx	AMMAC[*n*]	00-03-A7-00-00-0[N][b]
PTP Alternate Priority for Master (*n*)[a]	0–255	ALTPRI[*n*]	0
PTP VLAN Identifier	1–4094	PVLAN	1
PTP VLAN Priority	0–7	PVLANPR	4

[a] [*n*] = 1 to 5

[b] [N] = *n* + 9 for conversion to Hexadecimal

Network Connection Using PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure. The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings in Port 1 to configure the DPAC for PRP mode.

- NETMODE := PRP
- PRPTOUT := desired timeout for PRP frame entry
- PRPADDR := PRP destination MAC address LSB 01-15-4E-00-01-XX
- PRPINTV := desired supervision frame transmit interval

Serial Port Settings (PORT 2 and PORT 3)

NOTE: With terminal emulation, use the **SET P 2** and **SET P 3** commands to access the Serial Port 2 and Port 3 settings respectively.

Select the Port 2 or Port 3 node on the QuickSet tree. *Table 3.4* describes the serial port settings and *Table 3.6* describes the DNP3 settings.

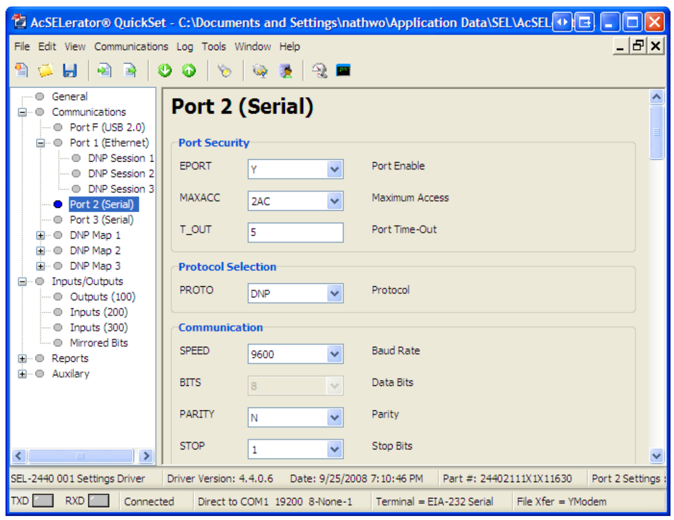


Table 3.4 Serial Port Settings (Sheet 1 of 2)

Description	Range	Name	Default
Security Settings			
Enable Port	Y, N	EPORT	Y
Maximum Access Level	ACC, 2AC	MAXACC	2AC
Protocol Selection			
Protocol	SEL, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB, DNP, EVMSG	PROTO	DNP (Port 2) SEL (Port 3)
Communications Settings			
Baud Rate	300–115,200[a] bps	SPEED	9600
Data Bits	7, 8 bits	BITS	8
Parity	O, E, N	PARITY	N
Stop Bits	1, 2 bits	STOP	1
Enable Hardware Handshaking	Y, N	RTSCTS	N
SEL Protocol Settings			
Port Time-Out	0–30 min (*0 disables port time-out*)	T_OUT	5
Enable Auto Messages	Y, N	AUTO	N

Table 3.4 Serial Port Settings (Sheet 2 of 2)

Description	Range	Name	Default
Enable Fast Operate Messages	Y, N	FASTOP	N
MIRRORED BITS Protocol Settings			
MB Transmit Identifier	1–4	TXID	2
MB Receive Identifier	1–4	RXID	1
MB RX Bad Pickup Time	1–10000	RBADPU	60
PPM MB Channel Bad Pickup	1–10000	CBADPU	1000
MB Receive Default State	8 characters	RXDFLT	XXXXXXXX
RMB[x] Pickup Debounce Messages	1–8	RMB[x]PU	1
RMB[x] Dropout Debounce Messages	1–8	RMB[x]DO	1
Modbus Protocol Settings			
Modbus Slave ID	1–247	SLAVEID	1

[a] Baud rates of 57,600 and 115,200 bps are reserved for Millisecond MIRRORED BITS, and cable length is limited to 7.62 m (25 ft).

Table 3.5 Modbus Settings

Description	Range	Name	Default
Modbus Protocol Settings			
Enable Modbus Sessions	0–2	EMODBUS	0
Modbus *n* Settings (Where *n* Denotes Modbus Session Number 1–2)			
Modbus TCP Port	1–65534	MODNUM*n*	502
Seconds to Communications Time-Out[a]	0–3600	MOD_TO*n*	30
Modbus Time-Out[b]	15–900	MTIMEO*n*	15
Serial Modbus Settings			
Modbus Slave ID	1–247	SLAVEID	1

[a] Setting for communication time-out indication.
[b] Time-Out setting for TCP connection.

Table 3.6 DNP3 Settings (Sheet 1 of 2)

Description	Range	Name	Default
DNP3 Protocol Settings			
Enable DNP Sessions	0–5	EDNP	1
DNP TCP and UDP Port	1–65534	DNPNUM*n*	20000
DNP Address	0–65519	DNPADR	1
Port Time-Out	1–30 min	T_OUT	5
Master n Settings (Where n Denotes DNP Master Number 1–5)			
IP Address	15 characters	DNPIP*n*	0.0.0.0
Transport Protocol	UDP, TCP	DNPTR*n*	TCP
UDP Response Port	REQ, 1–65534	DNPUDP*n*	20000
DNP Address to Report to	0–65519	REPADR*n*	100
DNP Map (1–3)	1–3	DNPMAP*n*	1
Analog Input Default Variation	1–6	DVARAI*n*	4
Frozen Counter Default Variation	1, 2, 5, 6, 9, 10	DVARFC*n*	6
Class for Binary Event Data	0–3	ECLASSB*n*	1

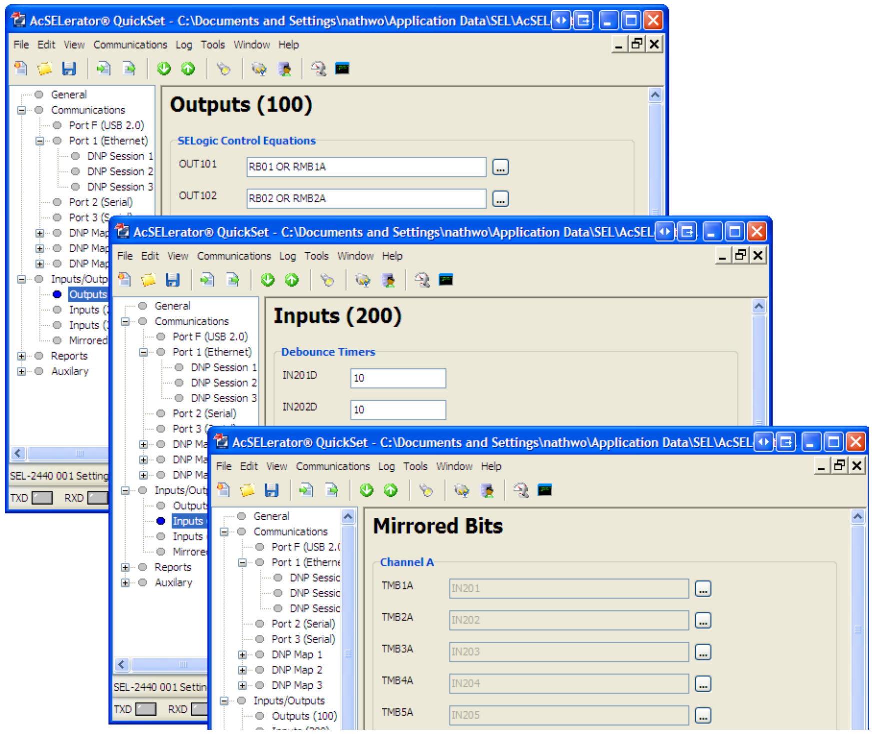
Table 3.6 DNP3 Settings (Sheet 2 of 2)

Description	Range	Name	Default
Class for Counter Event Data	0–3	ECLASSC*n*	0
Class for Frozen Counter Event Data	0–3	ECLASSF*n*	0
Class for Analog Event Data	0–3	ECLASSA*n*	0
Misc Data Scaling Decimal Places	0–3	DECPLM*n*	1
Misc Data Reporting Dead-Band Counts	0–32767	ANADBM*n*	100
Minutes for Request Interval	I, M, 1–32767	TIMERQ*n*	I
Seconds to Select/Operate Time-Out	0.0–30.0	STIMEO*n*	1.0
Seconds to send Data Link Heartbeat	0–7200	DNPINA*n*	120
Data Link Retries	0–15	DRETRY*n*	0
Seconds to Data Link Time-Out	0–5	DTIMEO*n*	1
Event Message Confirm Time-Out	1–50 s	ETIMEO*n*	5
Default Counter Reporting	RUNNING, FROZEN, ALL	DCNTRPT*n*	ALL
Enable Unsolicited Reporting	Y, N	UNSOL*n*	N
Enable Unsolicited Reporting at Power-Up	Y, N	PUNSOL*n*	N
Number of Events to Transmit On	1–200	NUMEVE*n*	10
Oldest Event to Tx On	0.0–99999.0	AGEEVE*n*	2.0
Unsolicited Message Max Retry Attempts	2 … 10	URETRY*n*	3
Unsolicited Message Offline Time-Out	OFF, 1–5000	UTIMEO*n*	60
Serial DNP3 Settings			
Minimum Seconds from DCD to TX	0.00–1.00	MINDLY	0.05
Maximum Seconds from DCD to TX	0.00–1.00	MAXDLY	0.10
Settle Time from RTS On to TX	OFF, 0.00–30.00	PREDLY	0.00
Settle Time from TX to RTS OFF	0.00–30.00	PSTDLY	0.00
DNP3 Modem Settings			
Modem Connected to Port	Y, N	MODEM	N
Modem Startup	As many as 30 characters	MSTR	“E0X0&D0S0=4”
Phone Number for Dial-Out	As many as 30 characters	PH_NUM1	“”
Phone Number for Dial-Out	As many as 30 characters	PH_NUM2	“”
Retry Attempts for Phone 1 Dial-Out	1–20	RETRY1	5
Retry Attempts for Phone 2 Dial-Out	1–20	RETRY2	5
Time to Attempt Dial	5–300	MDTIME	60
Time Between Dial-Out Attempts	5–3600	MDRET	120

I/O Settings

NOTE: With terminal emulation, use the **SET L** command to access these logic settings.

Select the **I/O Logic** node on the QuickSet tree.



Digital Input Debounce

To comply with different control voltages, the SEL-2440 offers dc debounce as well as ac debounce modes. Therefore, if the control voltage is dc, select the dc mode of operation, and if the control voltage is ac, select the ac mode of operation. Debounce mode ac or dc is an independent setting for each input. In general, debounce refers to a qualifying time delay before processing the change of state of a digital input. Normally, this delay applies to both the processing of the debounced input when used in device logic, as well as to the time stamping in the SER. However, in some cases, it is also important to record the time of first assertion of the input. This information is useful to time-align events from two unsynchronized devices when one device operated on receipt of the output from the other device. To this end, the SEL-2440 provides both the time of first assertion information as well as the delayed time information as separate Device Word bits when set to the dc debounce mode. Following is a description of the two modes.

DC Mode Processing (DC Control Voltage)

Figure 3.3 shows the logic for the dc debounce mode of operation. To select the dc mode of debounce, set IN101D to any number between 0 and 65000 ms. In the figure, Input IN101 becomes IN101R (internal variable), after analog-to-digital conversion. On assertion, IN101R starts Debounce Timer 1, producing Device Word bit IN101 after the debounce time delay, and Device Word bit IN101E from the edge detection logic. The debounce timer is a pickup/dropout combination timer, with debounce setting IN101D applying to both pickup (pu) and dropout (do) timers of both Debounce Timer 1 and Debounce Timer 2, i.e., you cannot set any timer individually. For example, a setting of IN101D = 20 ms delays processing of the input signal by 20 ms (pu) and maintains the output of the timer (do) for 20 ms. Device Word bit IN101 is the output of the debounce timer. If you do not want to debounce a particular input, still use Device Word bit IN101 in logic programming, but set the debounce time delay to 0 (IN101D = 0).

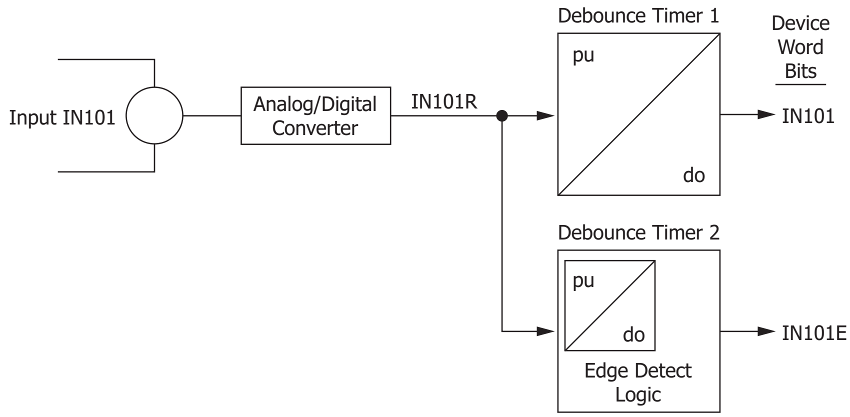


Figure 3.3 DC Mode Processing

Figure 3.4 shows a timing diagram when IN101R changes from the deasserted state to the asserted state. At the first assertion of IN101R, the following takes place:

- ➤ Device Word bit IN101E asserts
- ➤ Debounce Timer 2 starts
- ➤ All edge changes are ignored

If you want to record the time of first assertion of IN101, be sure to enter Device Word bit IN101E in the SER. While Debounce Timer 2 is timing, the device ignores all edge changes. At the end of this timing period, the device evaluates the status of IN101R (either logical 0 or logical 1) and sets Device Word bit IN101E to this value. In the example shown in *Figure 3.4*, IN101R has a status of logical 1 and Device Word bit IN101E remains at logical 1.

Device Word bit IN101 asserts only if IN101R stays asserted for the complete duration of Debounce Timer 1. If IN101R deasserts at any point while Debounce Timer 1 is running, Debounce Timer 1 resets and starts timing from the beginning at the next rising edge.

When changing from the asserted state to the deasserted state, the inverse operation applies, as shown in *Figure 3.5*.

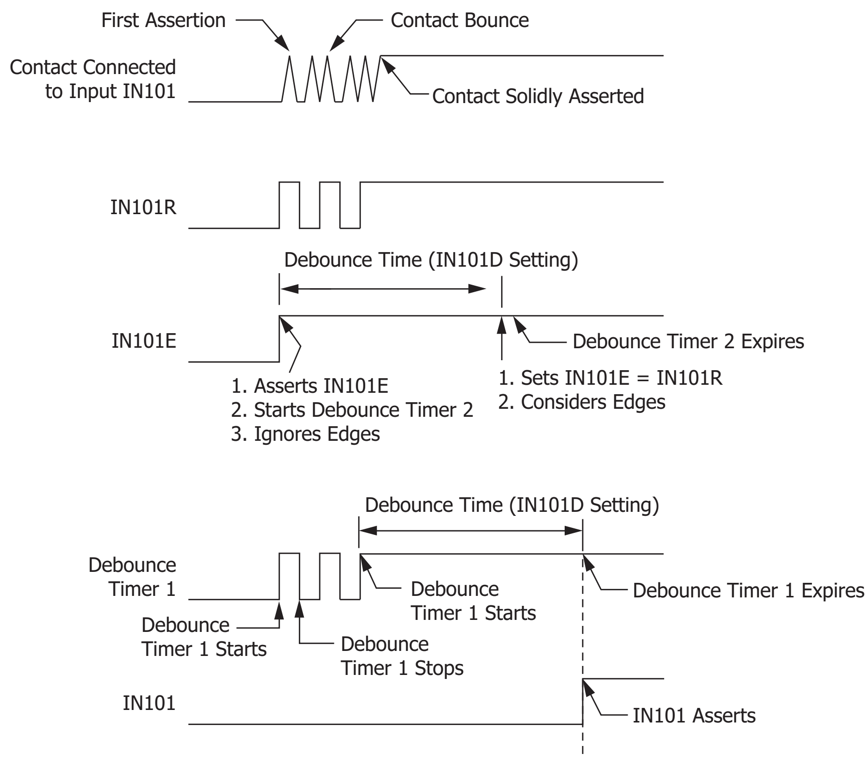


Figure 3.4 Timing Diagram When IN101R Changes From the Deasserted State to the Asserted State

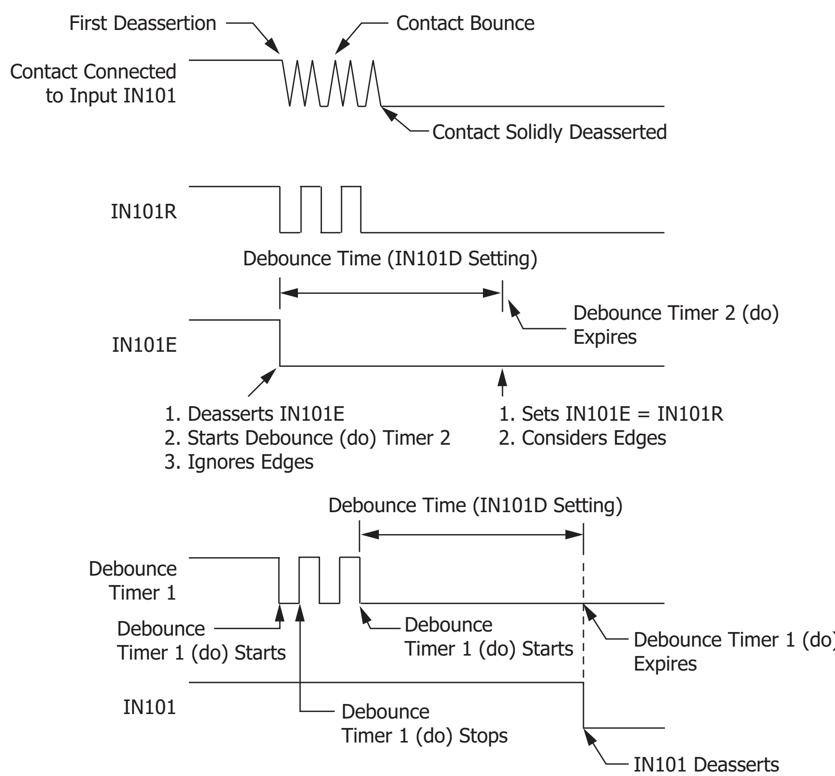


Figure 3.5 Timing Diagram When Input IN101 Changes From the Asserted State to the Deasserted State

AC Mode Processing (AC Control Voltage)

Figure 3.6 shows IN101R from Input IN101 applied to a pickup/dropout timer. Different from the dc mode, only the delayed time information is available in the ac mode. There are also no time settings for the debounce timer in the ac mode: the pickup time delay is fixed at 2 ms, and the dropout time is fixed at 16 ms. Device Word bit IN101 is the output of the debounce timer. To select the ac mode of debounce, set IN101D = AC.

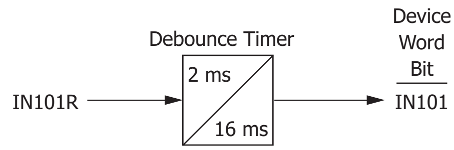


Figure 3.6 AC Mode Processing

Figure 3.7 shows a timing diagram for the ac mode of operation. On the rising edge of IN101R, the pickup timer starts timing (points marked 1 in *Figure 3.7*). If IN101R deasserts (points marked 2 in *Figure 3.7*) before expiration of the pickup time setting, Device Word bit IN101 does not assert and remains at logical 0. If, however, IN101R remains asserted for a period longer than the pickup timer setting, then Device Word bit IN101 asserts to a logical 1.

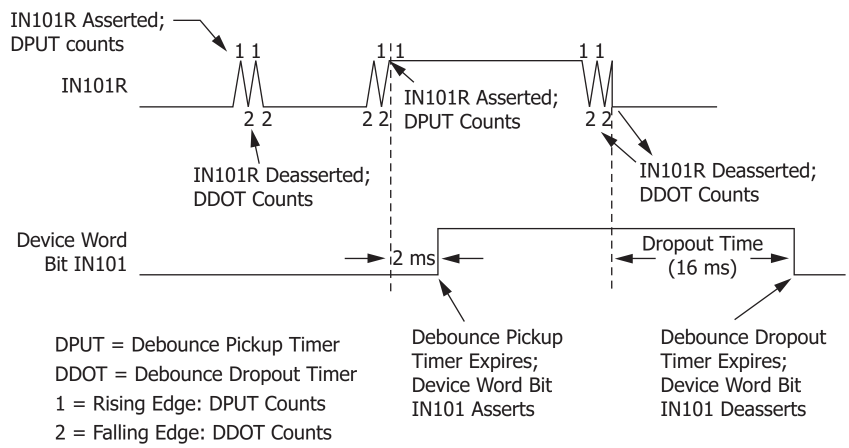
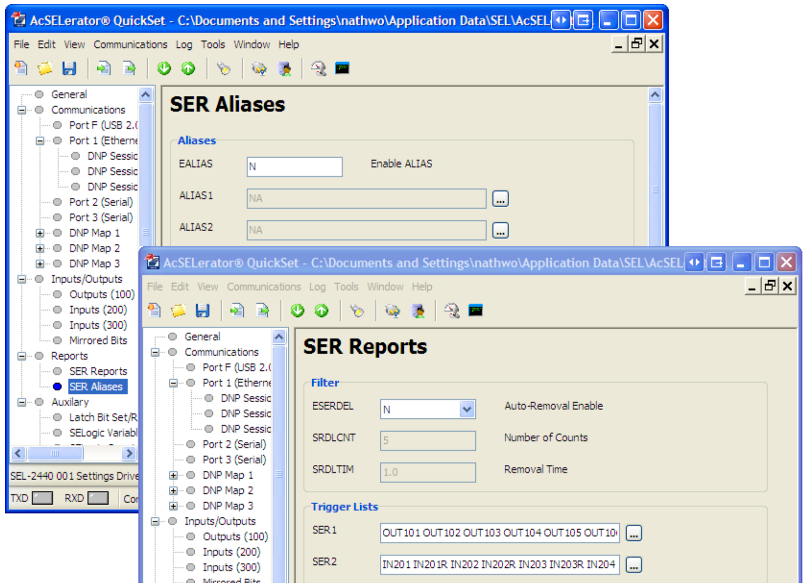


Figure 3.7 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

Deassertion follows the same logic. On the falling edge of IN101R, the dropout timer starts timing. If IN101R remains deasserted for a period longer than the dropout timer setting, then Device Word bit IN101 deasserts to a logical 0.

Reporting

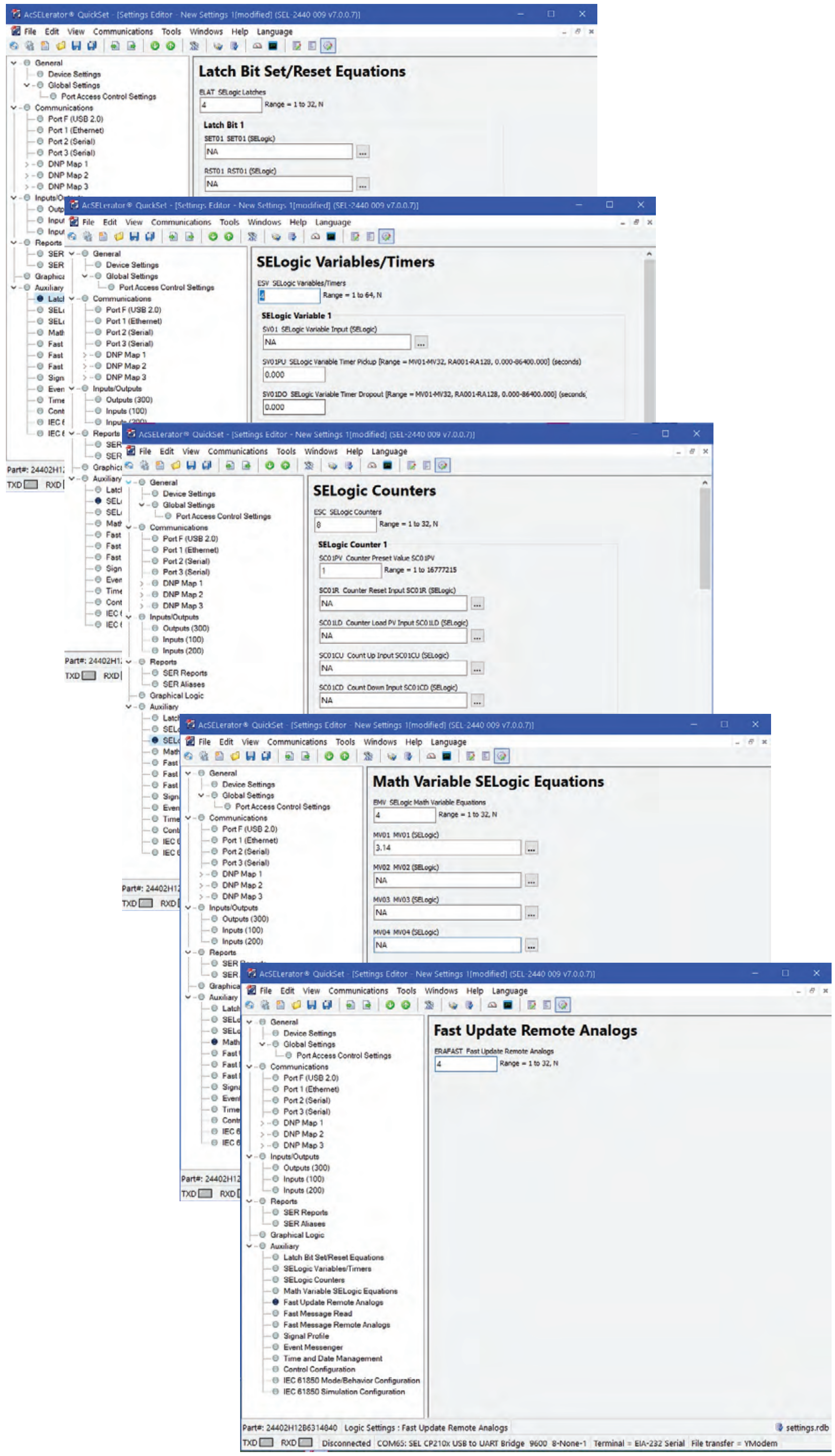
Use Enable SER Chatter to enable automatic filtering of excessive state changes. When a Device Word bit changes state more than the SER Chatter Count in a SER Chatter Time, the device automatically removes these Device Word bits from SER recording (logging) until the criteria are no longer met. Use aliases to simplify the review of SER records. *Section 7: Analyzing Events* provides details on SER recording and reporting capabilities.



SELogic Settings

Flexible digital logic (variables, latches, timers, and counters; Boolean and edge detect operators) and analog logic (math variables; comparison and equality operators) provide the ability to customize solutions. *Section 4: Logic Functions* describes these capabilities in more detail.

NOTE: With terminal emulation, use the **SET L** command to access these logic settings.



Local/ Remote Control

The SEL-2440 supports local/remote control supervision function through the LOCAL Device Word bit. The supervision can be enabled or disabled with Global setting EN_LRC.

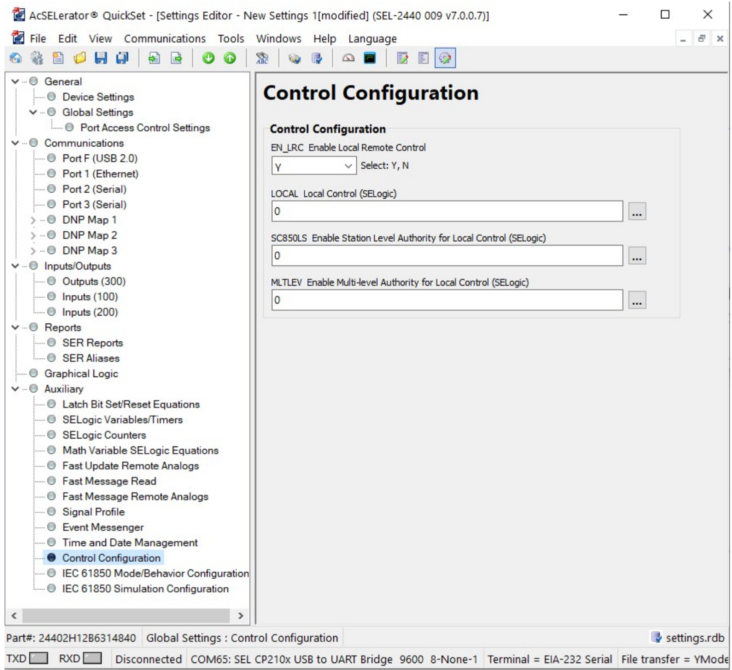


Table 3.7 Local/Remote Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE LOC REM CON	Y, N	EN_LRC := N
LOCAL CONTROL[a]	SELOGIC	LOCAL := 0

[a] This setting is hidden when EN_LRC := N.

To enable the supervision, set EN_LRC := Y. When EN_LRC := Y, the LOCAL SELOGIC control equation is available. For example, to toggle the Local/Remote on the device by pressing Pushbutton **01**, use the following Global and Logic settings.

Global Settings:

EN_LRC := Y

LOCAL := LT01

Logic Settings:

SET01 := R_TRIG RB03 AND NOT LT01

RST01 := F_TRIG RB03 AND LT01

Use the LOCAL Device Word bit to implement custom logic to operate in local mode or remote mode. For example, *Figure 3.8* shows the output contact OUT101 being controlled by custom logic when LOCAL := 1 or by remote bit, RB01 when LOCAL := 0.

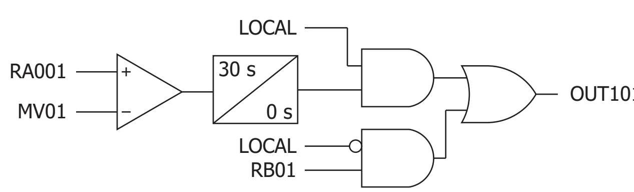


Figure 3.8 OUT101 Logic

As seen in *Figure 3.8*, in Local mode, OUT101 asserts when RA001 exceeds the math variable setting for at least 30 s. In Remote mode, OUT101 is controlled by the Remote bit.

Multilevel Local/ Remote Control

The SEL-2440 supports implementation of multilevel Local/Remote Control supervision through the LOCSTA and MLTLEV Device Word bits. Enable multi-level supervision through global settings SC850LS and MLTLEV.

Table 3.8 Additional Local/Remote Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable Station Level Authority for Local Control	0, SELOGIC	SC850LS := 0
Enable Multilevel Authority for Local Control	0, SELOGIC	MLTLEV := 0

The SC850LS setting controls the Device Word bit that indicates the local station supervision, LOCSTA. The multilevel supervision setting, MLTLEV controls the Device Word bit MLTLEV.

For example, *Figure 3.9* extends the implementation shown in *Figure 3.8* to allow controls from the station level and remote level. Use the following Global and Logic settings to control OUT101 from multiple levels.

Global Settings:

SC850LS := LT02

MLTLEV := LT03

Logic Settings:

SET02 := R_TRIG RB04 AND NOT LT02

RST02 := F_TRIG RB04 AND LT02

SET03 := R_TRIG RB05 AND NOT LT03

RST03 := F_TRIG RB05 AND LT03

NOTE: Although multilevel supervision can be implemented using SELOGIC and communications protocols, the IEC61850 MMS implementations are simpler. Over MMS, depending on the local/remote Device Word bits, the device blocks the operation of controls based on the originator categories. See *Local/ Remote Control Authority on page F.9*.

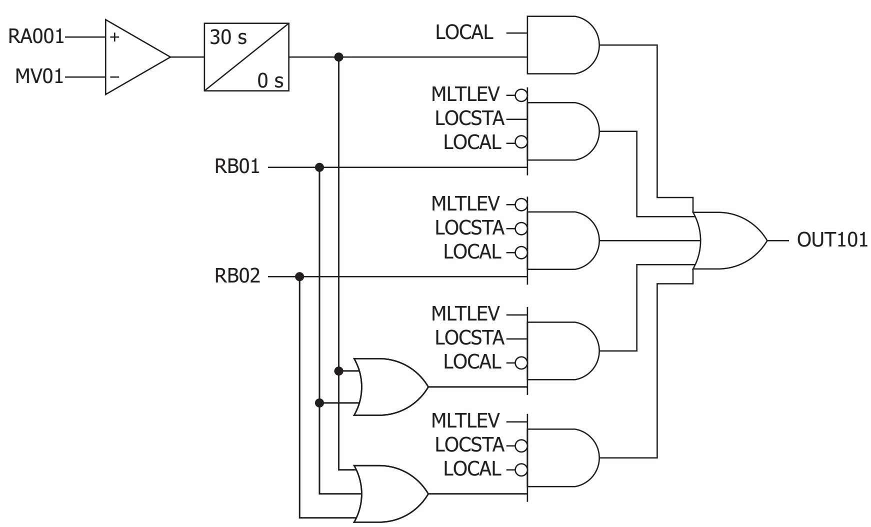
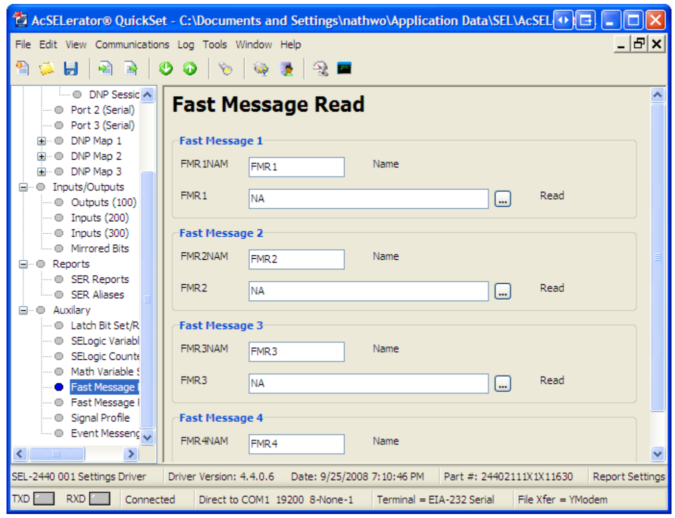


Figure 3.9 In the Local mode (Bay level) OUT 101 asserts when RA001 exceeds MV01 for at least 30s. RB01 is controlled by a station level device while RB02 is controlled by a Remote level device.

Fast Message Read Settings

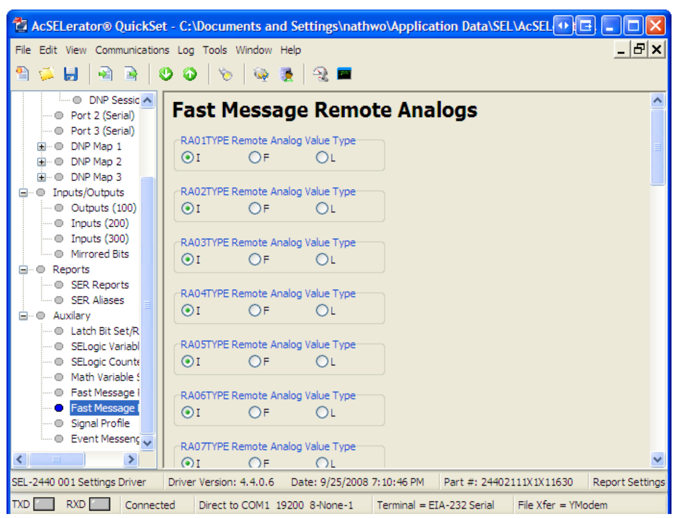
Remote devices with SEL Fast Message are able to read analog quantities from the DPAC. Specify the analog quantities (FMR1–FMR4) by entering as many as 24 analog quantities, separated by spaces or commas, in each setting. Choose from the analog quantities in *Table 4.11*.



Fast Message Remote Analogs Settings

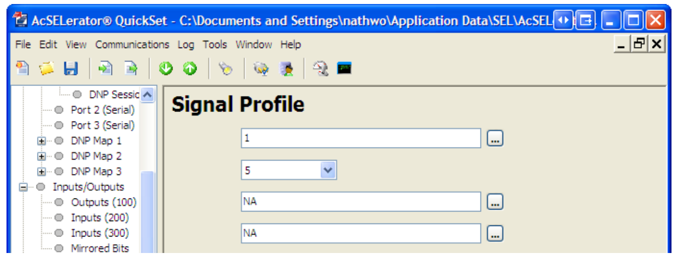
NOTE: When Type is set to Float, you cannot write the maximum value of 99999.99 to a remote analog. Instead, use 99999.98 as the maximum number. Similarly, use -99999.98 instead of -99999.99.

Remote devices are able to write analog quantities into the DPAC by using protocols such as Modbus and DNP3 (RA001 through RA128) and SEL Fast Message (RA01 through RA32). These analog quantities are available for use in Math Variable equations. If the SEL Fast Message protocol is used, the data type must be declared for each analog quantity (RA01TYPE through RA32TYPE).



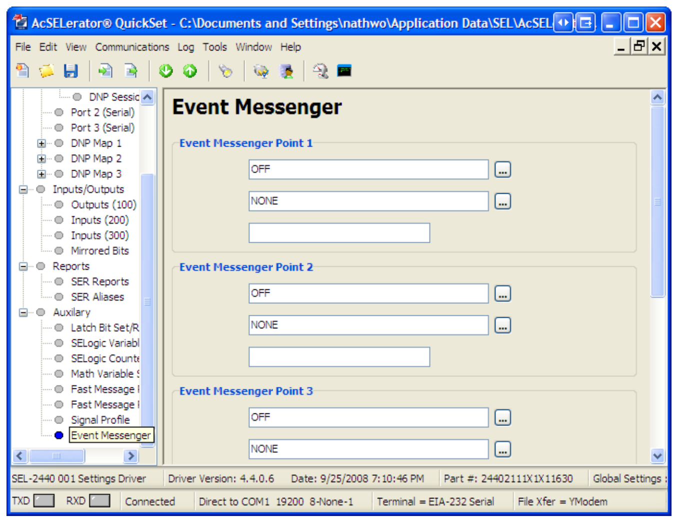
Analog Signal Profile Settings

Trend analog quantities at the specified rate by entering as many as 16 names in each signal profile list.



Event Messenger Settings

The DPAC can be configured to send automatically an ASCII message on a communications port when a trigger condition is satisfied. This feature is designed to send messages to the SEL-3010 Event Messenger.



NOTE: When Event Messenger points are selected for the desired port, all other communications on the selected port are disabled.

Use MPTX*x* to construct the desired message. MPAQ*x* is an optional setting and can be used to specify an analog quantity to be formatted into a single message. It will be added at the end of the message, rounded to the nearest integer value (see *Example 3.1*).

EXAMPLE 3.1 Setting MPTXx By Using Default Analog Location

MPTX1 := THE LOAD CURRENT IS

MPAQ1 value = 157.44

Message: The load current is 157

Location and resolution of the analog quantity value within the message can be specified by using "%.pf", where,

- % defines location of the value
- p defines number of digits (as many as 6, defaults to 6 if omitted)
- f indicates floating point value (use %d if nearest whole number is desired)

EXAMPLE 3.2 Setting MPTXx By Using Specified Analog Location

MPTX1 := THE LOAD CURRENT IS %.2f AMPERES

MPAQ1 value = 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157.44 AMPERES

MPTX1 := THE LOAD CURRENT IS %d AMPERES

MPAQ1 value = 157.44

Message: THE LOAD CURRENT IS 157 AMPERES

Time and Date Management Settings

NOTE: The UTC_OFF setting only applies to time synchronization with SNTP. IRIG-B time is not modified by this setting.

NOTE: With terminal emulation, use the **SET G** command to set the time and date management settings.

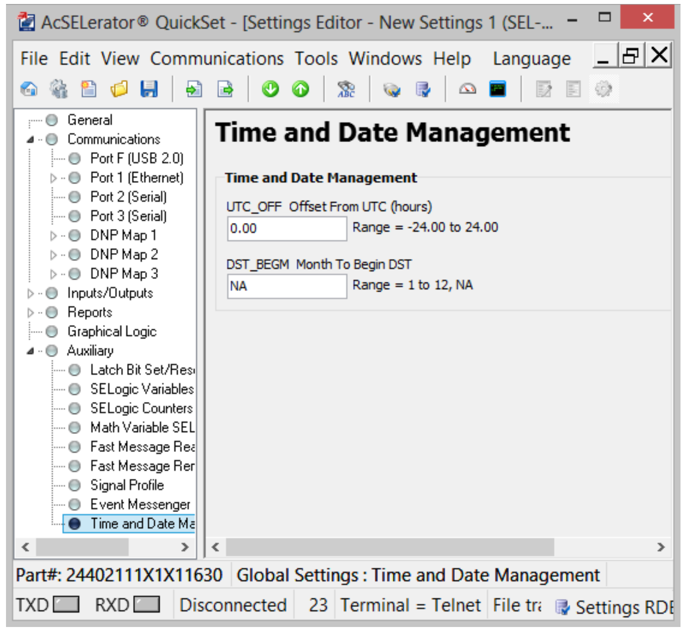


Table 3.9 shows the time and date management settings that are available in the Global settings.

Table 3.9 Time and Date Management Settings

Description	Range	Name	Default
Offset from UTC	–24.00 to 24.00 hours, rounds up to nearest 0.25 hour	UTC_OFF	0.00
Month to begin DST	OFF, 1–12	DST_BEGM	OFF
Week of the month to begin DST	1–3, L	DST_BEGW	2
Day of the week to begin DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_BEGD	SUN
Local hour to begin DST	0–23	DST_BEGH	2
Month to end DST	1–12	DST_ENDM	11
Week of the month to end DST	1–3, L	DST_ENDW	1
Day of the week to end DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_ENDD	SUN
Local hour to end DST	0–23	DST_ENDH	2

Coordinated Universal Time (UTC) Offset Setting

The SEL-2440 has a Global setting UTC_OFF, settable from –24.00 to 24.00 hours, in 0.25 hour increments. The device also uses the UTC_OFF setting to calculate local (device) time from the UTC source when configured for Simple Network Time Protocol (SNTP) updating via Ethernet. When a time source other than SNTP is updating the device time, the UTC_OFF setting is not considered because the other time sources are defined as local time.

Automatic Daylight-Saving Time Settings

The SEL-2440 can automatically switch to and from daylight-saving time, as specified by the eight Global settings DST_BEGM through DST_ENDH. The first four settings control the month, week, day, and time that daylight-saving time shall commence, while the last four settings control the month, week, day, and time that daylight-saving time shall cease.

Once configured, the SEL-2440 changes to and from daylight-saving time every year at the specified time. Device Word bit DST asserts when daylight-saving time is active.

The SEL-2440 interprets the week number settings DST_BEGW and DST_ENDW (1–3, L = Last) as follows:

- The first seven days of the month are considered to be in week 1.
- The second seven days of the month are considered to be in week 2.
- The third seven days of the month are considered to be in week 3.
- The last seven days of the month are considered to be in week “L”.

This method of counting of the weeks allows easy programming of statements like “the first Sunday”, “the second Sunday”, or “the last Tuesday” of a month.

As an example, consider the following settings:

DST_BEGM := 3

DST_BEGW := L

DST_BEGD := SUN

DST_BEGH := 2

DST_ENDM := 10

DST_ENDW := 3

DST_ENDD := WED

DST_ENDH := 3

With these example settings, the device enters daylight-saving time on the last Sunday in March at 0200 h, and leave daylight-saving time on the third Wednesday in October at 0300 h. The device asserts Device Word bit DST when DST is active.

When you use an IRIG-B time source, the device time follows the IRIG-B time, including daylight-saving time start and end, as commanded by the time source. If there is a discrepancy between the daylight-saving time settings and the received IRIG-B signal, the device follows the IRIG-B signal.

QuickSet Graphical Logic Editor

Use the QuickSet Graphical Logic Editor to create SELOGIC settings easily just by creating a logic diagram with standard logic gates.

QuickSet Design Templates

The licensed version of QuickSet allows you to create personalized templates for device applications. Use design templates within QuickSet to implement such various schemes as transformer protection or fan control quickly. Design templates hide settings you do not want to change (e.g., SELOGIC control equations) while making visible the minimum necessary settings (e.g., timer and pickup settings) to implement the scheme. All settings can use aliases and allow mathematical manipulation for simple end-user interfacing. Create design templates that include the most commonly used device features and settings for your application.

Design templates are stored locally on the DPAC. This ensures that users connecting with different computers will retrieve the correct template.

SEL-2440 Settings Sheets

These settings sheets include the definition and input range for each setting in the device. You can access the settings from the serial ports.

- Some settings require an optional module (see *Section 4: Logic Functions* for details).
- Some of the settings ranges may be more restrictive than shown, because of settings interdependency checks performed when new settings are saved. The settings are not case sensitive.

Device Settings (SET Command)

Device Settings

Device Identification (16 characters)	**DID**	:=
Terminal ID (16 characters)	**TID**	:=

Logic Settings (SET L Command)

SELOGIC Enables

SELOGIC Latches (N, 1–32)	**ELAT**	:=
SELOGIC Variables/Timers (N, 1–64)	**ESV**	:=
SELOGIC Counters (N, 1–32)	**ESC**	:=
SELOGIC Math Variables Equations (N, 1–64)	**EMV**	:=
SELOGIC Fast Update Remote Analogs (N, 1–32)	**ERAFAST**	:=

Latch Bit Set/Reset Equations

SET01	:=
RST01	:=
SET02	:=
RST02	:=
SET03	:=
RST03	:=
SET04	:=
RST04	:=
SET05	:=
RST05	:=
SET06	:=
RST06	:=
SET07	:=
RST07	:=
SET08	:=
RST08	:=
SET09	:=
RST09	:=

SET10	:=
RST10	:=
SET11	:=
RST11	:=
SET12	:=
RST12	:=
SET13	:=
RST13	:=
SET14	:=
RST14	:=
SET15	:=
RST15	:=
SET16	:=
RST16	:=
SET17	:=
RST17	:=
SET18	:=
RST18	:=
SET19	:=
RST19	:=
SET20	:=
RST20	:=
SET21	:=
RST21	:=
SET22	:=
RST22	:=
SET23	:=
RST23	:=
SET24	:=
RST24	:=
SET25	:=
RST25	:=
SET26	:=
RST26	:=
SET27	:=
RST27	:=
SET28	:=
RST28	:=
SET29	:=
RST29	:=
SET30	:=
RST30	:=
SET31	:=
RST31	:=
SET32	:=
RST32	:=

SELOGIC Variable/Timer Settings

SELOGIC Variable Input (SV)	**SV01**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV01PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV01DO**	:=
SELOGIC Variable Input (SV)	**SV02**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV02PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV02DO**	:=
SELOGIC Variable Input (SV)	**SV03**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV03PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV03DO**	:=
SELOGIC Variable Input (SV)	**SV04**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV04PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV04DO**	:=
SELOGIC Variable Input (SV)	**SV05**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV05PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV05DO**	:=
SELOGIC Variable Input (SV)	**SV06**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV06PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV06DO**	:=
SELOGIC Variable Input (SV)	**SV07**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV07PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV07DO**	:=
SELOGIC Variable Input (SV)	**SV08**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV08PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV08DO**	:=
SELOGIC Variable Input (SV)	**SV09**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV09PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV09DO**	:=
SELOGIC Variable Input (SV)	**SV10**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV10PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV10DO**	:=

SELOGIC Variable Input (SV)	**SV11**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV11PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV11DO**	:= ________
SELOGIC Variable Input (SV)	**SV12**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV12PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV12DO**	:= ________
SELOGIC Variable Input (SV)	**SV13**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV13PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV13DO**	:= ________
SELOGIC Variable Input (SV)	**SV14**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV14PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV14DO**	:= ________
SELOGIC Variable Input (SV)	**SV15**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV15PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV15DO**	:= ________
SELOGIC Variable Input (SV)	**SV16**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV16PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV16DO**	:= ________
SELOGIC Variable Input (SV)	**SV17**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV17PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV17DO**	:= ________
SELOGIC Variable Input (SV)	**SV18**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV18PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV18DO**	:= ________
SELOGIC Variable Input (SV)	**SV19**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV19PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV19DO**	:= ________
SELOGIC Variable Input (SV)	**SV20**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV20PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV20DO**	:= ________
SELOGIC Variable Input (SV)	**SV21**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV21PU**	:= ________

SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV21DO**	:= ________
SELOGIC Variable Input (SV)	**SV22**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV22PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV22DO**	:= ________
SELOGIC Variable Input (SV)	**SV23**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV23PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV23DO**	:= ________
SELOGIC Variable Input (SV)	**SV24**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV24PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV24DO**	:= ________
SELOGIC Variable Input (SV)	**SV25**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV25PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV25DO**	:= ________
SELOGIC Variable Input (SV)	**SV26**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV26PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV26DO**	:= ________
SELOGIC Variable Input (SV)	**SV27**	:= ________
SELOGIC Variable Timer Pickup(0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV27PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV27DO**	:= ________
SELOGIC Variable Input (SV)	**SV28**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV28PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV28DO**	:= ________
SELOGIC Variable Input (SV)	**SV29**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV29PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV29DO**	:= ________
SELOGIC Variable Input (SV)	**SV30**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV30PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV30DO**	:= ________
SELOGIC Variable Input (SV)	**SV31**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV31PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV31DO**	:= ________

SELOGIC Variable Input (SV)	**SV32**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV32PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV32DO**	:=
SELOGIC Variable Input (SV)	**SV33**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV33PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV33DO**	:=
SELOGIC Variable Input (SV)	**SV34**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV34PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV34DO**	:=
SELOGIC Variable Input (SV)	**SV35**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV35PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV35DO**	:=
SELOGIC Variable Input (SV)	**SV36**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV36PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV36DO**	:=
SELOGIC Variable Input (SV)	**SV37**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV37PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV37DO**	:=
SELOGIC Variable Input (SV)	**SV38**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV38PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV38DO**	:=
SELOGIC Variable Input (SV)	**SV39**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV39PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV39DO**	:=
SELOGIC Variable Input (SV)	**SV40**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV40PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV40DO**	:=
SELOGIC Variable Input (SV)	**SV41**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV41PU**	:=
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV41DO**	:=
SELOGIC Variable Input (SV)	**SV42**	:=
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV42PU**	:=

SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV42DO**	:= ________
SELOGIC Variable Input (SV)	**SV43**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV43PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV43DO**	:= ________
SELOGIC Variable Input (SV)	**SV44**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV44PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV44DO**	:= ________
SELOGIC Variable Input (SV)	**SV45**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV45PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV45DO**	:= ________
SELOGIC Variable Input (SV)	**SV46**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV46PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV46DO**	:= ________
SELOGIC Variable Input (SV)	**SV47**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV47PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV47DO**	:= ________
SELOGIC Variable Input (SV)	**SV48**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV48PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV48DO**	:= ________
SELOGIC Variable Input (SV)	**SV49**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV49PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV49DO**	:= ________
SELOGIC Variable Input (SV)	**SV50**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV50PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV50DO**	:= ________
SELOGIC Variable Input (SV)	**SV51**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV51PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV51DO**	:= ________
SELOGIC Variable Input (SV)	**SV52**	:= ________
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV52PU**	:= ________
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV52DO**	:= ________

SELOGIC Variable Input (SV)	**SV53**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV53PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV53DO**	:= ______
SELOGIC Variable Input (SV)	**SV54**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV54PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV54DO**	:= ______
SELOGIC Variable Input (SV)	**SV55**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV55PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV55DO**	:= ______
SELOGIC Variable Input (SV)	**SV56**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV56PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV56DO**	:= ______
SELOGIC Variable Input (SV)	**SV57**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV57PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV57DO**	:= ______
SELOGIC Variable Input (SV)	**SV58**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV58PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV58DO**	:= ______
SELOGIC Variable Input (SV)	**SV59**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV59PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV59DO**	:= ______
SELOGIC Variable Input (SV)	**SV60**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV60PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV60DO**	:= ______
SELOGIC Variable Input (SV)	**SV61**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV61PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV61DO**	:= ______
SELOGIC Variable Input (SV)	**SV62**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV62PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV62DO**	:= ______
SELOGIC Variable Input (SV)	**SV63**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV63PU**	:= ______

SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV63DO**	:= ______
SELOGIC Variable Input (SV)	**SV64**	:= ______
SELOGIC Variable Timer Pickup (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV64PU**	:= ______
SELOGIC Variable Timer Dropout (0.000–86400.000 s, MV*nn*, RA*nnn*)	**SV64DO**	:= ______

SELOGIC Counter Settings

Counter Preset Value SC01PV (1–65000)	**SC01PV**	:= ______
Counter Reset Input SC01R (SELOGIC)	**SC01R**	:= ______
Counter Load PV Input SC01LD (SELOGIC)	**SC01LD**	:= ______
Count Up Input SC01CU (SELOGIC)	**SC01CU**	:= ______
Count Down Input SC01CD (SELOGIC)	**SC01CD**	:= ______
Counter Preset Value SC02PV (1–65000)	**SC02PV**	:= ______
Counter Reset Input SC02R (SELOGIC)	**SC02R**	:= ______
Counter Load PV Input SC02LD (SELOGIC)	**SC02LD**	:= ______
Count Up Input SC02CU (SELOGIC)	**SC02CU**	:= ______
Count Down Input SC02CD (SELOGIC)	**SC02CD**	:= ______
Counter Preset Value SC03PV (1–65000)	**SC03PV**	:= ______
Counter Reset Input SC03R (SELOGIC)	**SC03R**	:= ______
Counter Load PV Input SC03LD (SELOGIC)	**SC03LD**	:= ______
Count Up Input SC03CU (SELOGIC)	**SC03CU**	:= ______
Count Down Input SC03CD (SELOGIC)	**SC03CD**	:= ______
Counter Preset Value SC04PV (1–65000)	**SC04PV**	:= ______
Counter Reset Input SC04R (SELOGIC)	**SC04R**	:= ______
Counter Load PV Input SC04LD (SELOGIC)	**SC04LD**	:= ______
Count Up Input SC04CU (SELOGIC)	**SC04CU**	:= ______
Count Down Input SC04CD (SELOGIC)	**SC04CD**	:= ______
Counter Preset Value SC05PV (1–65000)	**SC05PV**	:= ______
Counter Reset Input SC05R (SELOGIC)	**SC05R**	:= ______
Counter Load PV Input SC05LD (SELOGIC)	**SC05LD**	:= ______
Count Up Input SC05CU (SELOGIC)	**SC05CU**	:= ______
Count Down Input SC05CD (SELOGIC)	**SC05CD**	:= ______
Counter Preset Value SC06PV (1–65000)	**SC06PV**	:= ______
Counter Reset Input SC06R (SELOGIC)	**SC06R**	:= ______
Counter Load PV Input SC06LD (SELOGIC)	**SC06LD**	:= ______
Count Up Input SC06CU (SELOGIC)	**SC06CU**	:= ______
Count Down Input SC06CD (SELOGIC)	**SC06CD**	:= ______
Counter Preset Value SC07PV (1–65000)	**SC07PV**	:= ______
Counter Reset Input SC07R (SELOGIC)	**SC07R**	:= ______
Counter Load PV Input SC07LD (SELOGIC)	**SC07LD**	:= ______

Count Up Input SC07CU (SELOGIC)	**SC07CU**	:= ________
Count Down Input SC07CD (SELOGIC)	**SC07CD**	:= ________
Counter Preset Value SC08PV (1–65000)	**SC08PV**	:= ________
Counter Reset Input SC08R (SELOGIC)	**SC08R**	:= ________
Counter Load PV Input SC08LD (SELOGIC)	**SC08LD**	:= ________
Count Up Input SC08CU (SELOGIC)	**SC08CU**	:= ________
Count Down Input SC08CD (SELOGIC)	**SC08CD**	:= ________
Counter Preset Value SC09PV (1–65000)	**SC09PV**	:= ________
Counter Reset Input SC09R (SELOGIC)	**SC09R**	:= ________
Counter Load PV Input SC09LD (SELOGIC)	**SC09LD**	:= ________
Count Up Input SC09CU (SELOGIC)	**SC09CU**	:= ________
Count Down Input SC09CD (SELOGIC)	**SC09CD**	:= ________
Counter Preset Value SC10PV (1–65000)	**SC10PV**	:= ________
Counter Reset Input SC10R (SELOGIC)	**SC10R**	:= ________
Counter Load PV Input SC10LD (SELOGIC)	**SC10LD**	:= ________
Count Up Input SC10CU (SELOGIC)	**SC10CU**	:= ________
Count Down Input SC10CD (SELOGIC)	**SC10CD**	:= ________
Counter Preset Value SC11PV (1–65000)	**SC11PV**	:= ________
Counter Reset Input SC11R (SELOGIC)	**SC11R**	:= ________
Counter Load PV Input SC11LD (SELOGIC)	**SC11LD**	:= ________
Count Up Input SC11CU (SELOGIC)	**SC11CU**	:= ________
Count Down Input SC11CD (SELOGIC)	**SC11CD**	:= ________
Counter Preset Value SC12PV (1–65000)	**SC12PV**	:= ________
Counter Reset Input SC12R (SELOGIC)	**SC12R**	:= ________
Counter Load PV Input SC12LD (SELOGIC)	**SC12LD**	:= ________
Count Up Input SC12CU (SELOGIC)	**SC12CU**	:= ________
Count Down Input SC12CD (SELOGIC)	**SC12CD**	:= ________
Counter Preset Value SC13PV (1–65000)	**SC13PV**	:= ________
Counter Reset Input SC13R (SELOGIC)	**SC13R**	:= ________
Counter Load PV Input SC13LD (SELOGIC)	**SC13LD**	:= ________
Count Up Input SC13CU (SELOGIC)	**SC13CU**	:= ________
Count Down Input SC13CD (SELOGIC)	**SC13CD**	:= ________
Counter Preset Value SC14PV (1–65000)	**SC14PV**	:= ________
Counter Reset Input SC14R (SELOGIC)	**SC14R**	:= ________
Counter Load PV Input SC14LD (SELOGIC)	**SC14LD**	:= ________
Count Up Input SC14CU (SELOGIC)	**SC14CU**	:= ________
Count Down Input SC14CD (SELOGIC)	**SC14CD**	:= ________
Counter Preset Value SC15PV (1–65000)	**SC15PV**	:= ________
Counter Reset Input SC15R (SELOGIC)	**SC15R**	:= ________
Counter Load PV Input SC15LD (SELOGIC)	**SC15LD**	:= ________

Count Up Input SC15CU (SELOGIC)	**SC15CU**	:= ______________
Count Down Input SC15CD (SELOGIC)	**SC15CD**	:= ______________
Counter Preset Value SC16PV (1–65000)	**SC16PV**	:= ______________
Counter Reset Input SC16R (SELOGIC)	**SC16R**	:= ______________
Counter Load PV Input SC16LD (SELOGIC)	**SC16LD**	:= ______________
Count Up Input SC16CU (SELOGIC)	**SC16CU**	:= ______________
Count Down Input SC16CD (SELOGIC)	**SC16CD**	:= ______________
Counter Preset Value SC17PV (1–65000)	**SC17PV**	:= ______________
Counter Reset Input SC17R (SELOGIC)	**SC17R**	:= ______________
Counter Load PV Input SC17LD (SELOGIC)	**SC17LD**	:= ______________
Count Up Input SC17CU (SELOGIC)	**SC17CU**	:= ______________
Count Down Input SC17CD (SELOGIC)	**SC17CD**	:= ______________
Counter Preset Value SC18PV (1–65000)	**SC18PV**	:= ______________
Counter Reset Input SC18R (SELOGIC)	**SC18R**	:= ______________
Counter Load PV Input SC18LD (SELOGIC)	**SC18LD**	:= ______________
Count Up Input SC18CU (SELOGIC)	**SC18CU**	:= ______________
Count Down Input SC18CD (SELOGIC)	**SC18CD**	:= ______________
Counter Preset Value SC19PV (1–65000)	**SC19PV**	:= ______________
Counter Reset Input SC19R (SELOGIC)	**SC19R**	:= ______________
Counter Load PV Input SC19LD (SELOGIC)	**SC19LD**	:= ______________
Count Up Input SC19CU (SELOGIC)	**SC19CU**	:= ______________
Count Down Input SC19CD (SELOGIC)	**SC19CD**	:= ______________
Counter Preset Value SC20PV (1–65000)	**SC20PV**	:= ______________
Counter Reset Input SC20R (SELOGIC)	**SC20R**	:= ______________
Counter Load PV Input SC20LD (SELOGIC)	**SC20LD**	:= ______________
Count Up Input SC20CU (SELOGIC)	**SC20CU**	:= ______________
Count Down Input SC20CD (SELOGIC)	**SC20CD**	:= ______________
Counter Preset Value SC21PV (1–65000)	**SC21PV**	:= ______________
Counter Reset Input SC21R (SELOGIC)	**SC21R**	:= ______________
Counter Load PV Input SC21LD (SELOGIC)	**SC21LD**	:= ______________
Count Up Input SC21CU (SELOGIC)	**SC21CU**	:= ______________
Count Down Input SC21CD (SELOGIC)	**SC21CD**	:= ______________
Counter Preset Value SC22PV (1–65000)	**SC22PV**	:= ______________
Counter Reset Input SC22R (SELOGIC)	**SC22R**	:= ______________
Counter Load PV Input SC22LD (SELOGIC)	**SC22LD**	:= ______________
Count Up Input SC22CU (SELOGIC)	**SC22CU**	:= ______________
Count Down Input SC22CD (SELOGIC)	**SC22CD**	:= ______________
Counter Preset Value SC23PV (1–65000)	**SC23PV**	:= ______________
Counter Reset Input SC23R (SELOGIC)	**SC23R**	:= ______________
Counter Load PV Input SC23LD (SELOGIC)	**SC23LD**	:= ______________

Count Up Input SC23CU (SELOGIC)	**SC23CU**	:=
Count Down Input SC23CD (SELOGIC)	**SC23CD**	:=
Counter Preset Value SC24PV (1–65000)	**SC24PV**	:=
Counter Reset Input SC24R (SELOGIC)	**SC24R**	:=
Counter Load PV Input SC24LD (SELOGIC)	**SC24LD**	:=
Count Up Input SC24CU (SELOGIC)	**SC24CU**	:=
Count Down Input SC24CD (SELOGIC)	**SC24CD**	:=
Counter Preset Value SC25PV (1–65000)	**SC25PV**	:=
Counter Reset Input SC25R (SELOGIC)	**SC25R**	:=
Counter Load PV Input SC25LD (SELOGIC)	**SC25LD**	:=
Count Up Input SC25CU (SELOGIC)	**SC25CU**	:=
Count Down Input SC25CD (SELOGIC)	**SC25CD**	:=
Counter Preset Value SC26PV (1–65000)	**SC26PV**	:=
Counter Reset Input SC26R (SELOGIC)	**SC26R**	:=
Counter Load PV Input SC26LD (SELOGIC)	**SC26LD**	:=
Count Up Input SC26CU (SELOGIC)	**SC26CU**	:=
Count Down Input SC26CD (SELOGIC)	**SC26CD**	:=
Counter Preset Value SC27PV (1–65000)	**SC27PV**	:=
Counter Reset Input SC27R (SELOGIC)	**SC27R**	:=
Counter Load PV Input SC27LD (SELOGIC)	**SC27LD**	:=
Count Up Input SC27CU (SELOGIC)	**SC27CU**	:=
Count Down Input SC27CD (SELOGIC)	**SC27CD**	:=
Counter Preset Value SC28PV (1–65000)	**SC28PV**	:=
Counter Reset Input SC28R (SELOGIC)	**SC28R**	:=
Counter Load PV Input SC28LD (SELOGIC)	**SC28LD**	:=
Count Up Input SC28CU (SELOGIC)	**SC28CU**	:=
Count Down Input SC28CD (SELOGIC)	**SC28CD**	:=
Counter Preset Value SC29PV (1–65000)	**SC29PV**	:=
Counter Reset Input SC29R (SELOGIC)	**SC29R**	:=
Counter Load PV Input SC29LD (SELOGIC)	**SC29LD**	:=
Count Up Input SC29CU (SELOGIC)	**SC29CU**	:=
Count Down Input SC29CD (SELOGIC)	**SC29CD**	:=
Counter Preset Value SC30PV (1–65000)	**SC30PV**	:=
Counter Reset Input SC30R (SELOGIC)	**SC30R**	:=
Counter Load PV Input SC30LD (SELOGIC)	**SC30LD**	:=
Count Up Input SC30CU (SELOGIC)	**SC30CU**	:=
Count Down Input SC30CD (SELOGIC)	**SC30CD**	:=
Counter Preset Value SC31PV (1–65000)	**SC31PV**	:=
Counter Reset Input SC31R (SELOGIC)	**SC31R**	:=
Counter Load PV Input SC31LD (SELOGIC)	**SC31LD**	:=

Count Up Input SC31CU (SELOGIC)	**SC31CU**	:=
Count Down Input SC31CD (SELOGIC)	**SC31CD**	:=
Counter Preset Value SC32PV (1–65000)	**SC32PV**	:=
Counter Reset Input SC32R (SELOGIC)	**SC32R**	:=
Counter Load PV Input SC32LD (SELOGIC)	**SC32LD**	:=
Count Up Input SC32CU (SELOGIC)	**SC32CU**	:=
Count Down Input SC32CD (SELOGIC)	**SC32CD**	:=

Math Variable SELOGIC Equations

MV01 :=
MV02 :=
MV03 :=
MV04 :=
MV05 :=
MV06 :=
MV07 :=
MV08 :=
MV09 :=
MV10 :=
MV11 :=
MV12 :=
MV13 :=
MV14 :=
MV15 :=
MV16 :=
MV17 :=
MV18 :=
MV19 :=
MV20 :=
MV21 :=
MV22 :=
MV23 :=
MV24 :=
MV25 :=
MV26 :=
MV27 :=
MV28 :=
MV29 :=
MV30 :=
MV31 :=
MV32 :=

Output Contacts (DO Units)

Group 1

OUT101	:=	
OUT102	:=	
OUT103	:=	
OUT104	:=	
OUT105	:=	
OUT106	:=	
OUT107	:=	
OUT108	:=	
OUT109	:=	
OUT110	:=	
OUT111	:=	
OUT112	:=	
OUT113	:=	
OUT114	:=	
OUT115	:=	
OUT116	:=	

Group

OUT301	:=	
OUT302	:=	
OUT303	:=	
OUT304	:=	
OUT305	:=	
OUT306	:=	
OUT307	:=	
OUT308	:=	
OUT309	:=	
OUT310	:=	
OUT311	:=	
OUT312	:=	
OUT313	:=	
OUT314	:=	
OUT315	:=	
OUT316	:=	

MIRRORED BITS

TMB1A	:=	
TMB2A	:=	
TMB3A	:=	
TMB4A	:=	
TMB5A	:=	
TMB6A	:=	
TMB7A	:=	
TMB8A	:=	

TMB1B	:=
TMB2B	:=
TMB3B	:=
TMB4B	:=
TMB5B	:=
TMB6B	:=
TMB7B	:=
TMB8B	:=

Global Settings (SET G Command)

General Settings

Date Format (MDY, YMD, DMY)	**DATE_F**	:=

Input Debounce Settings (Group 1)

IN101 Debounce (AC, 0–65000 ms)	**IN101D**	:=
IN102 Debounce (AC, 0–65000 ms)	**IN102D**	:=
IN103 Debounce (AC, 0–65000 ms)	**IN103D**	:=
IN104 Debounce (AC, 0–65000 ms)	**IN104D**	:=
IN105 Debounce (AC, 0–65000 ms)	**IN105D**	:=
IN106 Debounce (AC, 0–65000 ms)	**IN106D**	:=
IN107 Debounce (AC, 0–65000 ms)	**IN107D**	:=
IN108 Debounce (AC, 0–65000 ms)	**IN108D**	:=
IN109 Debounce (AC, 0–65000 ms)	**IN109D**	:=
IN110 Debounce (AC, 0–65000 ms)	**IN110D**	:=
IN111 Debounce (AC, 0–65000 ms)	**IN111D**	:=
IN112 Debounce (AC, 0–65000 ms)	**IN112D**	:=
IN113 Debounce (AC, 0–65000 ms)	**IN113D**	:=
IN114 Debounce (AC, 0–65000 ms)	**IN114D**	:=
IN115 Debounce (AC, 0–65000 ms)	**IN115D**	:=
IN116 Debounce (AC, 0–65000 ms)	**IN116D**	:=

Input Debounce Settings (Group 2)

IN201 Debounce (AC, 0–65000 ms)	**IN201D**	:=
IN202 Debounce (AC, 0–65000 ms)	**IN202D**	:=
IN203 Debounce (AC, 0–65000 ms)	**IN203D**	:=
IN204 Debounce (AC, 0–65000 ms)	**IN204D**	:=
IN205 Debounce (AC, 0–65000 ms)	**IN205D**	:=
IN206 Debounce (AC, 0–65000 ms)	**IN206D**	:=
IN207 Debounce (AC, 0–65000 ms)	**IN207D**	:=
IN208 Debounce (AC, 0–65000 ms)	**IN208D**	:=
IN209 Debounce (AC, 0–65000 ms)	**IN209D**	:=
IN210 Debounce (AC, 0–65000 ms)	**IN210D**	:=
IN211 Debounce (AC, 0–65000 ms)	**IN211D**	:=
IN212 Debounce (AC, 0–65000 ms)	**IN212D**	:=

IN213 Debounce (AC, 0–65000 ms)	**IN213D**	:=
IN214 Debounce (AC, 0–65000 ms)	**IN214D**	:=
IN215 Debounce (AC, 0–65000 ms)	**IN215D**	:=
IN216 Debounce (AC, 0–65000 ms)	**IN216D**	:=

Input Debounce Settings (Group 3)

IN301 Debounce (AC, 0–65000 ms)	**IN301D**	:=
IN302 Debounce (AC, 0–65000 ms)	**IN302D**	:=
IN303 Debounce (AC, 0–65000 ms)	**IN303D**	:=
IN304 Debounce (AC, 0–65000 ms)	**IN304D**	:=
IN305 Debounce (AC, 0–65000 ms)	**IN305D**	:=
IN306 Debounce (AC, 0–65000 ms)	**IN306D**	:=
IN307 Debounce (AC, 0–65000 ms)	**IN307D**	:=
IN308 Debounce (AC, 0–65000 ms)	**IN308D**	:=
IN309 Debounce (AC, 0–65000 ms)	**IN309D**	:=
IN310 Debounce (AC, 0–65000 ms)	**IN310D**	:=
IN311 Debounce (AC, 0–65000 ms)	**IN311D**	:=
IN312 Debounce (AC, 0–65000 ms)	**IN312D**	:=
IN313 Debounce (AC, 0–65000 ms)	**IN313D**	:=
IN314 Debounce (AC, 0–65000 ms)	**IN314D**	:=
IN315 Debounce (AC, 0–65000 ms)	**IN315D**	:=
IN316 Debounce (AC, 0–65000 ms)	**IN316D**	:=

Time-Synchronization Source

TIME_SRC IRIG Time Source (IRIG1, IRIG2)	**TIME_SRC**	:=

Event Messenger Points

MESSENGER POINT TRIGGER (OFF, 1 Device Word bit)	**MPTR1**	:=
MESSENGER POINT AQ (NONE, 1 analog quantity)	**MPAQ1**	:=
MESSENGER POINT TEXT (148 characters)	**MPTX1**	:=
MESSENGER POINT TRIGGER (OFF, 1 Device Word bit)	**MPTR2**	:=
MESSENGER POINT AQ (NONE, 1 analog quantity)	**MPAQ2**	:=
MESSENGER POINT TEXT (148 characters)	**MPTX2**	:=
MESSENGER POINT TRIGGER (OFF, 1 Device Word bit)	**MPTR3**	:=
MESSENGER POINT AQ (None, 1 analog quantity)	**MPAQ3**	:=
MESSENGER POINT TEXT (148 characters)	**MPTX3**	:=
MESSENGER POINT TRIGGER (OFF, 1 Device Word bit)	**MPTR4**	:=
MESSENGER POINT AQ (NONE, 1 analog quantity)	**MPAQ4**	:=
MESSENGER POINT TEXT (148 characters)	**MPTX4**	:=
MESSENGER POINT TRIGGER (OFF, 1 Device Word bit)	**MPTR5**	:=
MESSENGER POINT AQ (NONE, 1 analog quantity)	**MPAQ5**	:=
MESSENGER POINT TEXT (148 characters)	**MPTX5**	:=

Time and Date Management Settings

Month To Begin DST (NA, 1–12)	**DST_BEGM**	:=
Offset from UTC (–24.00 to 24.00 hours)	**UTC_OFF**	:=

Month To Begin DST (NA,1–12)	**DST_BEGM**	:= ___________
Week Of The Month To Begin DST (1–3, L)	**DST_BEGW**	:= ___________
Day Of The Week To Begin DST (SUN, MON, TUE, WED, THU, FRI, SAT)	**DST_BEGD**	:= ___________
Local Hour To Begin DST (0–23)	**DST_BEGH**	:= ___________
Month To End DST (1–12)	**DST_ENDM**	:= ___________
Week Of The Month To End DST (1–3, L)	**DST_ENDW**	:= ___________
Day Of The Week To End DST (SUN, MON, TUE, WED, THU, FRI, SAT)	**DST_ENDD**	:= ___________
Local Hour To End DST (0–23)	**DST_ENDH**	:= ___________

Control Configuration

Enable Local Remote Control (Y, N)	**EN_LRC**	:= ___________
Local Control (SELOGIC)	**LOCAL**	:= ___________
Enable Station Level Authority for Local Control (SELOGIC)	**SC850LS**	:= ___________
Enable Multi-level Authority for Local Control (SELOGIC)	**MLTLEV**	:= ___________

IEC 61850 Mode/Behavior Configuration

IEC 61850 Blocked Mode Control Equation (SELOGIC)	**SC850BM**	:= ___________
IEC 61850 Test Mode Control Equation (SELOGIC)	**SC850TM**	:= ___________
		:= ___________

IEC 61850 Simulation Configuration

IEC 61850 Process Simulated GOOSE Messages Control Equation (SELOGIC)	**SC850SM**	:= ___________

Port Access Control Settings

Enable ACC Access (SELOGIC)	**EACC**	:= ___________
Enable 2AC Access (SELOGIC)	**E2AC**	:= ___________

Port Settings (SET P Command)

Port F

Port Enable (Y, N)	**EPORT**	:= ___________
Maximum Access (ACC, 2AC)	**MAXACC**	:= ___________
Port Access Control Enable (Y, N)	**EPAC**	:= ___________
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:= ___________
Data Bits (7, 8 bits)	**BITS**	:= ___________
Parity (O, E, N)	**PARITY**	:= ___________
Stop Bits (1, 2 bits)	**STOP**	:= ___________
Minutes to Port Time-Out (0–30 min)	**T_OUT**	:= ___________
Send Auto Messages to Port (Y, N)	**AUTO**	:= ___________
Enable Hardware Handshaking (Y, N)	**RTSCTS**	:= ___________
Fast Operate Enable (Y, N)	**FASTOP**	:= ___________

Port 1 (Ethernet Port)

All Ethernet settings are hidden if an Ethernet option is not available.

Port Enable (Y, N)	**EPORT**	:= ___________
Maximum Access (ACC, 2AC)	**MAXACC**	:= ___________

Port Access Control Enable (Y, N)	**EPAC**	:=
ENABLE ETHERNET FIRMWARE UPGRADE (Y, N)	**EETHFWU**	:=
IP ADDRESS (zzz.yyy.xxx.www)	**IPADDR**	:=
Subnet Mask (zzz.yyy.xxx.www)	**SUBNETM**	:=
Default Router Gateway (zzz.yyy.xxx.www)	**DEFRTR**	:=
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	:=
TCP Keep-Alive Idle Range (1–20 sec) (*Hidden if ETCPKA := N*)	**KAIDLE**	:=
TCP Keep-Alive Interval Range (1–20 sec) (*Hidden if ETCPKA := N*)	**KAINTV**	:=
TCP Keep-Alive Count Range (1–20 sec) (*Hidden if ETCPKA := N*)	**KACNT**	:=
Operating Mode (FIXED, FAILOVER, SWITCHED, PRP) (*Hidden if not dual redundant Ethernet port option*)	**NETMODE**	:=
Fail Over Time-Out (OFF, 0.10–65.00 sec) (*Hidden if not dual redundant Ethernet port option or if NETMODE is not FAILOVER*)	**FTIME**	:=
Primary Netport (A, B, D) (*Hidden if not dual redundant Ethernet port option*)	**NETPORT**	:=
PRP Entry Timeout (400–10000 ms)	**PRPTOUT**	:=
PRP Destination Address LSB (0–255)	**PRPADDR**	:=
PRP Supervision TX Interval (1–10 s)	**PRPINTV**	:=
Network Port A Speed (Auto, 10, 100 Mbps)	**NETASPD**	:=
Network Port B Speed (Auto, 10, 100 Mbps) (*Hidden if not dual redundant Ethernet port option*)	**NETBSPD**	:=
Enable Telnet (Y, N)	**ETELNET**	:=
Telnet Port (23,1025–65534)	**TPORT**	:=
Telnet Port Timeout (1–30 min)	**TIDLE**	:=
Enable FTP (Y, N)	**EFTP**	:=
File Transfer User Name (20 characters)	**FTPUSER**	:=
Enable ICMP Ping Responses (Y, N)	**EPING**	:=
Enable Modbus (0–2)	**EMODBUS**	:=
Modbus TCP Port 1 (1–65534) (*Hidden if EMODBUS < 1*)	**MODNUM1**	:=
Modbus TCP Port 2 (1–65534) (*Hidden if EMODBUS < 2*)	**MODNUM2**	:=
Seconds to Communications Time-Out (0–3600 seconds) (*Hidden if EMODBUS < 1*)	**MOD_TO1**	:=
Seconds to Communications Time-Out (0–3600 seconds) (*Hidden if EMODBUS < 2*)	**MOD_TO2**	:=
Enable IEC 61850 Protocol (Y, N) (*Hidden if 61850 not supported*)	**E61850**	:=
Modbus Time-Out (15–900 sec)	**MTIMEO1**	:=
Modbus Time-Out (15-900 sec)	**MTIMEO2**	:=
Enable MMS File Transfer Services (Y, N) *(Hidden if 61850 := N)*	**EMMSFS**	:=
Enable IEC 61850 GSE (Y, N) (*Hidden if E61850 := N*)	**EGSE**	:=
Enable 61850 Mode/Behavior Control (Y, N) (*Hidden if E61850 := N*)	**E850MBC**	:=
Enable Goose Tx In Off Mode (Y, N) (*Hidden if E61850 := N*)	**EOFFMTX**	:=
Enable DNP Sessions (0–5) (*Hidden if DNP not supported*)	**EDNP**	:=
Enable SNTP Client (OFF, UNICAST, MANYCAST, BROADCAST)	**ESNTP**	:=
SNTP Primary Server IP Address (zzz.yyy.xxx.www)	**SNTPPSIP**	:=
SNTP Backup Server IP Address (zzz.yyy.xxx.www)	**SNTPBSIP**	:=
SNTP IP (Local) Port Number (1–65534)	**SNTPPORT**	:=
SNTP Client Request Update Rate (15–3600)	**SNTPRATE**	:=
SNTP Client Response Time-out (5–20)	**SNTPTO**	:=
Enable PTP (Y, N)	**EPTP**	:=

PTP Profile (DEFAULT, C37.238)	**PTPPRO**	:=
PRP Transport Mechanism (UDP, LAYER2)	**PTPTR**	:=
PTP Domain Number (0–255)	**DOMNUM**	:=
PTP Path Delay Mechanism (P2P, E2E, OFF)	**PTHDLY**	:=
Peer Delay Request Interval (1, 2, 4, 8, 16, 32, 64)	**PDINT**	:=
PTP Number of Acceptable Masters (1–5, OFF)	**AMNUM**	:=
PTP Acceptable Master [*n*] IP (zzz.yyy.xxx.www) (*[n] = 1 to 5*)	**AMIP[*n*]**	:=
PTP Alternate Priority for Master [*n*] MAC (xx-xx-xx-xx-xx-xx) (*[n] = 1 to 5*)	**AMMAC[*n*]**	:=
PTP Alternate Priority for Master [*n*] (0–255) (*[n] = 1 to 5*)	**ALTPRI[n]**	:=
PTP VLAN Identifier (1–4094)	**PVLAN**	:=
PTP VLAN Priority (0–7)	**PVLANPR**	:=

Port 2

Port Enable (Y, N)	**EPORT**	:=
Maximum Access (ACC, 2AC)	**MAXACC**	:=
Port Access Control Enable (Y, N)	**EPAC**	:=
Protocol (SEL, DNP, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB, EVMSG)	**PROTO**	:=
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:=
Data Bits (7, 8 bits)	**BITS**	:=
Parity (O, E, N)	**PARITY**	:=
Stop Bits (1, 2 bits)	**STOP**	:=
Seconds to Communications Time-Out (*0–3600 seconds*)	**PROTO_TO**	:=
Minutes to Port Time-out (0–30 min) *(0 is only valid for SEL protocol to disable the time-out)*	**T_OUT**	:=
Send Auto Messages to Port (Y, N)	**AUTO**	:=
Fast Operate Enable (Y, N)	**FASTOP**	:=
Modbus Protocol Settings (*Hidden if PROTO is not MOD*)	**SLAVEID**	:=

Port 3

Port Enable (Y, N)	**EPORT**	:=
Maximum Access (ACC, 2AC)	**MAXACC**	:=
Port Access Control Enable (Y, N)	**EPAC**	:=
Protocol (SEL, DNP, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB, EVMSG)	**PROTO**	:=
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:=
Data Bits (7, 8 bits)	**BITS**	:=
Parity (O, E, N)	**PARITY**	:=
Stop Bits (1, 2 bits)	**STOP**	:=
Seconds to Communications Time-Out (*0–3600 seconds*)	**PROTO_TO**	:=
Minutes to Port Timeout (0–30 min) *(0 is only valid for SEL protocol to disable the timeout)*	**T_OUT**	:=
Send Auto Messages to Port (Y, N)	**AUTO**	:=
Enable Hardware Handshaking (Y, N)	**RTSCTS**	:=
Fast Operate Enable (Y, N)	**FASTOP**	:=
Modbus Protocol Settings (*Hidden if PROTO is not MOD*)	**SLAVEID**	:=

Mirrored Bits

MB Transmit Identifier (1–4)	**TXID**	:= ________
MB Receive Identifier (1–4)	**RXID**	:= ________
MB RX Bad Pickup Time (0–10000 seconds)	**RBADPU**	:= ________
PPM MB Channel Bad Pickup (1–10000)	**CBADPU**	:= ________
MB Receive Default State (8 character string of 1s, 0s, or Xs)	**RXDFLT**	:= ________
Transmission Mode (P, N) (*The device automatically sets this*)	**TXMODE**	:= ________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU**	:= ________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO**	:= ________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU**	:= ________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO**	:= ________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU**	:= ________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO**	:= ________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU**	:= ________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO**	:= ________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU**	:= ________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO**	:= ________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU**	:= ________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO**	:= ________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU**	:= ________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO**	:= ________
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU**	:= ________
RMB8 Dropout Debounce Messages (1–8)	**RMB8DO**	:= ________

Report Settings (SET R Command)

SER Chatter Criteria

Auto-Removal Enable (Y, N)	**ESERDEL**	:= ________
Number of Counts (2–20)	**SRDLCNT**	:= ________
Removal Time (0.1–90.0 seconds)	**SRDLTIM**	:= ________

SER Trigger Lists

Enter as many as 24 Device Word elements separated by spaces or commas in each of the four lists.
Use NA to disable setting.

SER1 := ________________________________

SER2 := ________________________________

SER3 := ________________________________

SER4 := ________________________________

Device Word Bit Aliases

15 character maximum per string. Device Word **Bit > Alias–String > Asserted–String > DEASS–String**

Enable ALIAS Settings	**EALIAS**	:= ________
ALIAS 1	**ALIAS01**	:= ________

ALIAS 2	**ALIAS02**	:=
ALIAS 3	**ALIAS03**	:=
ALIAS 4	**ALIAS04**	:=
ALIAS 5	**ALIAS05**	:=
ALIAS 6	**ALIAS06**	:=
ALIAS 7	**ALIAS07**	:=
ALIAS 8	**ALIAS08**	:=
ALIAS 9	**ALIAS09**	:=
ALIAS 10	**ALIAS10**	:=
ALIAS 11	**ALIAS11**	:=
ALIAS 12	**ALIAS12**	:=
ALIAS 13	**ALIAS13**	:=
ALIAS 14	**ALIAS14**	:=
ALIAS 15	**ALIAS15**	:=
ALIAS 16	**ALIAS16**	:=
ALIAS 17	**ALIAS17**	:=
ALIAS 18	**ALIAS18**	:=
ALIAS 19	**ALIAS19**	:=
ALIAS 20	**ALIAS20**	:=

Fast Message Read Settings

Enter as many as 24 Analog Quantities separated by spaces or commas in each of the four lists.
Use NA to disable setting.

FMR1 NAME (9 characters) **FMR1NAM** :=

FMR1 :=

FMR2 NAME (9 characters) **FMR2NAM** :=

FMR2 :=

FMR3 NAME (9 characters) **FMR3NAM** :=

FMR3 :=

FMR4 NAME (9 characters) **FMR4NAM** :=

FMR4 :=

Fast Message Remote Analog Settings

I = Integer, F = Float, L = Long

Remote Analog Value Type (I, F, L)	**RA01TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA02TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA03TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA04TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA05TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA06TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA07TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA08TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA09TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA10TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA11TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA12TYPE**	:=

Remote Analog Value Type (I, F, L)	**RA13TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA14TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA15TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA16TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA17TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA18TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA19TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA20TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA21TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA22TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA23TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA24TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA25TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA26TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA27TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA28TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA29TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA30TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA31TYPE**	:=
Remote Analog Value Type (I, F, L)	**RA32TYPE**	:=

Signal Profile Settings

Enter as many as 16 Analog Quantities separated by spaces or commas in each list. Use NA to null.

Signal Profile List	**SPLIST1**	:=
Signal Profile List	**SPLIST2**	:=
SP Acquisition Rate (1, 5, 10, 15, 30, 60 min)	**SPAR**	:=
Signal Profile Enable (SV)	**SPEN**	:=

DNP3 Settings (SET P 1, 2, or 3 Command)

DNP3 Communications (hidden if DNP not supported)

Enable DNP Sessions (0–5)	**EDNP**	:=
Device DNP Address (0–65519)	**DNPADR**	:=

Session 1 Settings

IP Address (zzz.yyy.xxx.www) NOTE: Set DNPIP1 to 0.0.0.0 for anonymous connections.	**DNPIP1**	:=
DNP TCP and UDP Port (1–65534)	**DNPNUM1**	:=
Transport Protocol (UDP, TCP)	**DNPTR1**	:=
UDP Response Port (REQ, 1–65534)	**DNPUDP1**	:=
DNP Address to Report to (0–65519)	**REPADR1**	:=
DNP Map (1–3)	**DNPMAP1**	:=
Analog Input Default Variation (0–6)	**DVARAI1**	:=
Analog Change Event Default Variation (1–8)	**DVARAIE1**	:=
Frozen Counter Default Variation (1, 2, 5, 6, 9, 10)	**DVARFC1**	:=
Counter Default Variation (1, 2, 5, 6)	**DVARC1**	:=

Class for binary event data (0–3)	**ECLASSB1**	:=
Class for counter event data (0–3)	**ECLASSC1**	:=
Class for analog event data (0–3)	**ECLASSA1**	:=
Class for Frozen Counter Event Data (0–3)	**ECLASSF1**	:=
Misc Data Scaling Decimal Places (0–3)	**DECPLM1**	:=
Misc Data Reporting Deadband Counts (0–32767)	**ANADBM1**	:=
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:=
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:=
Seconds to Communications Time-Out (0–3600 seconds)	**DNP_TO1**	:=
Seconds to send Data Link Heartbeat (0.0–120)	**DNPINA1**	:=
Data link retries (0–15) (*Hidden if port is on Ethernet*)	**DRETRY1**	:=
Data link time-out, seconds (0.0–5.0) (*Hidden if port is on Ethernet*)	**DTIMEO1**	:=
Event message confirm time-out, seconds (1–50) (*Hidden if port is on Ethernet*)	**ETIMEO1**	:=
Default Counter Reporting (RUNNING, FROZEN, ALL)	**DCNTRPT1**	:=
Analog Input Event Reporting (MOST_RECENT, SOE)	**AI_RPT1**	:=
Enable unsolicited reporting (Y, N)	**UNSOL1**	:=
Enable unsolicited reporting at power up (Y, N)	**PUNSOL1**	:=
Number of events to transmit on (1–200)	**NUMEVE1**	:=
Oldest event to transmit on, seconds (0.0–99999.0)	**AGEEVE1**	:=
Unsolicited messages maximum retry attempts (2–10)	**URETRY1**	:=
Unsolicited messages offline timeout, seconds (OFF, 1–5000)	**UTIMEO1**	:=

Session 2 Settings

IP Address (zzz.yyy.xxx.www) **NOTE:** Set DNPIP2 to 0.0.0.0 for anonymous connections.	**DNPIP2**	:=
DNP TCP and UDP Port (1–65534)	**DNPNUM2**	:=
Transport Protocol (UDP, TCP)	**DNPTR2**	:=
UDP Response Port (REQ, 1–65534)	**DNPUDP2**	:=
DNP Address to Report to (0–65519)	**REPADR2**	:=
DNP Map (1–3)	**DNPMAP2**	:=
Analog Input Default Variation (0–6)	**DVARAI2**	:=
Analog Change Event Default Variation (1–8)	**DVARAIE2**	:=
Frozen Counter Default Variation (1, 2, 5, 6, 9, 10)	**DVARFC2**	:=
Counter Default Variation (1, 2, 5, 6)	**DVARC2**	:=
Class for binary event data (0–3)	**ECLASSB2**	:=
Class for counter event data (0–3)	**ECLASSC2**	:=
Class for analog event data (0–3)	**ECLASSA2**	:=
Class for Frozen Counter Event Data (0–3)	**ECLASSF2**	:=
Misc Data Scaling Decimal Places (0–3)	**DECPLM2**	:=
Misc Data Reporting Deadband Counts (0–32767)	**ANADBM2**	:=
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ2**	:=
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO2**	:=
Seconds to Communications Time-Out (0–3600 seconds)	**DNP_TO2**	:=
Seconds to send Data Link Heartbeat (0.0–120)	**DNPINA2**	:=
Data link retries (0–15) (*Hidden if port is on Ethernet*)	**DRETRY2**	:=
Data link time-out, seconds (0.0–5.0) (*Hidden if port is on Ethernet*)	**DTIMEO2**	:=
Event message confirm time-out, seconds (1–50) (*Hidden if port is on Ethernet*)	**ETIMEO2**	:=

Default Counter Reporting (RUNNING, FROZEN, ALL)	**DCNTRPT2**	:= ________
Analog Input Event Reporting (MOST_RECENT, SOE)	**AI_RPT2**	:= ________
Enable unsolicited reporting (Y, N)	**UNSOL2**	:= ________
Enable unsolicited reporting at power up (Y, N)	**PUNSOL2**	:= ________
Number of events to transmit on (1–200)	**NUMEVE2**	:= ________
Oldest event to transmit on, seconds (0.0–99999.0)	**AGEEVE2**	:= ________
Unsolicited messages maximum retry attempts (2–10)	**URETRY2**	:= ________
Unsolicited messages offline timeout, seconds (OFF, 1–5000)	**UTIMEO2**	:= ________

Session 3 Settings

IP Address (zzz.yyy.xxx.www) NOTE: Set DNPIP3 to 0.0.0.0 for anonymous connections.	**DNPIP3**	:= ________
DNP TCP and UDP Port (1–65534)	**DNPNUM3**	:= ________
Transport Protocol (UDP, TCP)	**DNPTR3**	:= ________
UDP Response Port (REQ, 1–65534)	**DNPUDP3**	:= ________
DNP Address to Report to (0–65519)	**REPADR3**	:= ________
DNP Map (1–3)	**DNPMAP3**	:= ________
Analog Input Default Variation (0–6)	**DVARAI3**	:= ________
Analog Change Event Default Variation (1–8)	**DVARAIE3**	:= ________
Frozen Counter Default Variation (1, 2, 5, 6, 9, 10)	**DVARFC3**	:= ________
Counter Default Variation (1, 2, 5, 6)	**DVARC3**	:= ________
Class for binary event data (0–3)	**ECLASSB3**	:= ________
Class for counter event data (0–3)	**ECLASSC3**	:= ________
Class for analog event data (0–3)	**ECLASSA3**	:= ________
Class for Frozen Counter Event Data (0–3)	**ECLASSF3**	:= ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM3**	:= ________
Misc Data Reporting Deadband Counts (0–32767)	**ANADBM3**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ3**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO3**	:= ________
Seconds to Communications Time-Out (0–3600 seconds)	**DNP_TO3**	:= ________
Seconds to send Data Link Heartbeat (0.0–120)	**DNPINA3**	:= ________
Data link retries (0–15) (*Hidden if port is on Ethernet*)	**DRETRY3**	:= ________
Data link time-out, seconds (0.0–5.0) (*Hidden if port is on Ethernet*)	**DTIMEO3**	:= ________
Event message confirm time-out, seconds (1–50) (*Hidden if port is on Ethernet*)	**ETIMEO3**	:= ________
Default Counter Reporting (RUNNING, FROZEN, ALL)	**DCNTRPT3**	:= ________
Analog Input Event Reporting (MOST_RECENT, SOE)	**AI_RPT3**	:= ________
Enable unsolicited reporting (Y, N)	**UNSOL3**	:= ________
Enable unsolicited reporting at power up (Y, N)	**PUNSOL3**	:= ________
Number of events to transmit on (1–200)	**NUMEVE3**	:= ________
Oldest event to transmit on, seconds (0.0–99999.0)	**AGEEVE3**	:= ________
Unsolicited messages maximum retry attempts (2–10)	**URETRY3**	:= ________
Unsolicited messages offline timeout, seconds (OFF, 1–5000)	**UTIMEO3**	:= ________

Session 4 Settings

IP Address (zzz.yyy.xxx.www) NOTE: Set DNPIP4 to 0.0.0.0 for anonymous connections.	**DNPIP4**	:= ________
DNP TCP and UDP Port (1–65534)	**DNPNUM4**	:= ________

Transport Protocol (UDP, TCP)	**DNPTR4**	:=
UDP Response Port (REQ, 1–65534)	**DNPUDP4**	:=
DNP Address to Report to (0–65519)	**REPADR4**	:=
DNP Map (1–3)	**DNPMAP4**	:=
Analog Input Default Variation (0–6)	**DVARAI4**	:=
Analog Change Event Default Variation (1–8)	**DVARAIE4**	:=
Frozen Counter Default Variation (1, 2, 5, 6, 9, 10)	**DVARFC4**	:=
Counter Default Variation (1, 2, 5, 6)	**DVARC4**	:=
Class for binary event data (0–3)	**ECLASSB4**	:=
Class for counter event data (0–3)	**ECLASSC4**	:=
Class for analog event data (0–3)	**ECLASSA4**	:=
Class for Frozen Counter Event Data (0–3)	**ECLASSFA**	:=
Misc Data Scaling Decimal Places (0–3)	**DECPLM4**	:=
Misc Data Reporting Deadband Counts (0–32767)	**ANADBM4**	:=
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ4**	:=
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO4**	:=
Seconds to Communications Time-Out (0–3600 seconds)	**DNP_TO4**	:=
Seconds to send Data Link Heartbeat (0.0–120)	**DNPINA4**	:=
Data link retries (0–15) (*Hidden if port is on Ethernet*)	**DRETRY4**	:=
Data link time-out, seconds (0.0–5.0) (*Hidden if port is on Ethernet*)	**DTIMEO4**	:=
Event message confirm time-out, seconds (1–50) (*Hidden if port is on Ethernet*)	**ETIMEO4**	:=
Default Counter Reporting (RUNNING, FROZEN, ALL)	**DCNTRPT4**	:=
Analog Input Event Reporting (MOST_RECENT, SOE)	**AI_RPT4**	:=
Enable unsolicited reporting (Y, N)	**UNSOL4**	:=
Enable unsolicited reporting at power up (Y, N)	**PUNSOL4**	:=
Number of events to transmit on (1–200)	**NUMEVE4**	:=
Oldest event to transmit on, seconds (0.0–99999.0)	**AGEEVE4**	:=
Unsolicited messages maximum retry attempts (2–10)	**URETRY4**	:=
Unsolicited messages offline timeout, seconds (OFF, 1–5000)	**UTIMEO4**	:=

Session 5 Settings

IP Address (zzz.yyy.xxx.www) NOTE: Set DNPIP5 to 0.0.0.0 for anonymous connections.	**DNPIP5**	:=
DNP TCP and UDP Port (1–65534)	**DNPNUM5**	:=
Transport Protocol (UDP, TCP)	**DNPTR5**	:=
UDP Response Port (REQ, 1–65534)	**DNPUDP5**	:=
DNP Address to Report to (0–65519)	**REPADR5**	:=
DNP Map (1–3)	**DNPMAP5**	:=
Analog Input Default Variation (0–6)	**DVARAI5**	:=
Analog Change Event Default Variation (1–8)	**DVARAIE5**	:=
Frozen Counter Default Variation (1, 2, 5, 6, 9, 10)	**DVARFC5**	:=
Counter Default Variation (1, 2, 5, 6)	**DVARC5**	:=
Class for binary event data (0–3)	**ECLASSB5**	:=
Class for counter event data (0–3)	**ECLASSC5**	:=
Class for analog event data (0–3)	**ECLASSA5**	:=
Class for Frozen Counter Event Data (0-3)	**ECLASSF5**	:=
Misc Data Scaling Decimal Places (0–3)	**DECPLM5**	:=

Misc Data Reporting Deadband Counts (0–32767)	**ANADBM5**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ5**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO5**	:= ________
Seconds to Communications Time-Out (0–3600 seconds)	**DNP_TO5**	:= ________
Seconds to send Data Link Heartbeat (0.0–120)	**DNPINA5**	:= ________
Data link retries (0–15) (*Hidden if port is on Ethernet*)	**DRETRY5**	:= ________
Data link time-out, seconds (0.0–5.0) (*Hidden if port is on Ethernet*)	**DTIMEO5**	:= ________
Event message confirm time-out, seconds (1–50) (*Hidden if port is on Ethernet*)	**ETIMEO5**	:= ________
Default Counter Reporting (RUNNING, FROZEN, ALL)	**DCNTRPT5**	:= ________
Analog Input Event Reporting (MOST_RECENT, SOE)	**AI_RPT5**	:= ________
Enable unsolicited reporting (Y, N)	**UNSOL5**	:= ________
Enable unsolicited reporting at power up (Y, N)	**PUNSOL5**	:= ________
Number of events to transmit on (1–200)	**NUMEVE5**	:= ________
Oldest event to transmit on, seconds (0.0–99999.0)	**AGEEVE5**	:= ________
Unsolicited messages maximum retry attempts (2–10)	**URETRY5**	:= ________
Unsolicited messages offline timeout, seconds (OFF, 1–5000)	**UTIMEO5**	:= ________

Serial Port Settings

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 seconds)	**PREDLY**	:= ________
Settle time from TX to RTS off (0.00–30.00 seconds)	**PSTDLY**	:= ________

DNP3 Serial Modem Settings

Modem connected to port (Y, N)	**MODEM**	:= ________
Modem startup string (Up to 30 characters)	**MSTR**	:= ________
Phone number for dial-out (Up to 30 characters)	**PH_NUM1**	:= ________
Secondary phone number for dial-out (Up to 30 characters)	**PH_NUM2**	:= ________
Retry Attempts for Phone 1 Dial-Out (1–20)	**RETRY1**	:= ________
Retry Attempts for Phone 2 Dial-Out (1–20)	**RETRY2**	:= ________
Time from initiating call to failure due to no connection, seconds (5–300)	**MDTIME**	:= ________
Time between dial-out attempts (5–3600)	**MDRET**	:= ________

Section 4
Logic Functions

Overview

The SEL-2440 Discrete Programmable Automation Controller (DPAC) provides digital logic capabilities that operate on physical inputs and outputs and virtual inputs and outputs, as shown in *Figure 4.1* and *Figure 4.2*. The DPAC operates by periodically reading physical inputs, evaluating logic (settings), and writing physical outputs.

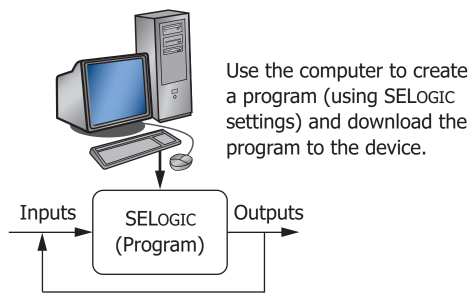


Figure 4.1 Program Model Overview

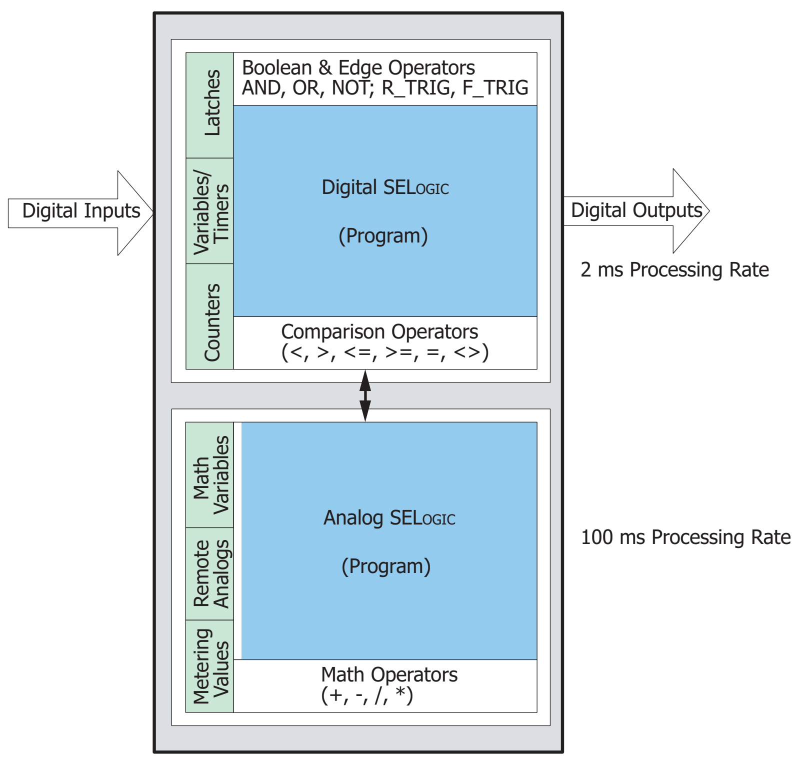


Figure 4.2 Detailed Program Model

Logical Operators

Logical operators can be used in any SELOGIC equation; they are shown in *Table 4.1*. See *SELOGIC Control Equation Operators on page 4.6* for more details. R_TRIG and F_TRIG only function with individual word bits.

Table 4.1 Logical Operators

Operation	Operator
Boolean	
Boolean AND	AND
Boolean OR	OR
Complement	NOT
Edge Detection	
Rising edge trigger/detect	R_TRIG
Falling edge trigger/detect	F_TRIG
Comparison	
Greater than	>
Greater than or equal	>=
Equality	=
Less than or equal	<=
Less than	<
Inequality	<>

Mathematical Operators

Mathematical operators can only be used in SELOGIC Math Variables; they are shown in *Table 4.2*. See *SELOGIC Control Equation Operators on page 4.6* for more details.

Table 4.2 Mathematical Operators (Use in Math Variables)

Operation	Operator
Negation	–
Multiply	*
Divide	/
Add	+
Subtract	-

Function Blocks

Function block outputs can be used in any SELOGIC equation; they are shown in *Table 4.3*. Each function block is described in more detail in *General Logic Functions on page 4.3*.

Table 4.3 Function Blocks

Function	Output
Latches	LT01–LT32
Variables	SV01–SV64
Timers	SV01T–SV64T
Counters	SC01–SC32

General Logic Functions

SELOGIC Enables

Enable settings are provided for latch bits (ELAT), SELOGIC control equations (variables/timers) (ESV), counters (ESC), Math Variables (EMV), and Fast Update Remote Analogs (ERAFAST). This helps limit the number of settings that you need to make. For example, if you need six timers, only enable six timers.

Remote Bits

There are 32 non-retentive remote bits in the SEL-2440. Remote bits are asserted and deasserted via a communications protocol. Use remote bits as SELOGIC variables or to remotely control output contacts. Remote bits are primarily used for SEL Fast Messaging communications. Refer to *Appendix C: SEL Communications Processors* for remote bit addressing using SEL Fast Messaging.

The user has the ability to locally test the remote bits. Use the **CONTROL** command to set, clear, or 2 ms pulse the desired remote bit.

Table 4.4 CONTROL Remote Bit Command

Command	Description	Access Level
CON RB*xx*[a] S	Sets (asserts) the specified remote bit	2
CON RB*xx*[a] C	Clears (de-asserts) the specified remote bit	2
CON RB*xx*[a] P	Pulses the specified remote bit for one processing interval	2

[a] xx is a number from 01–32 that represents RB01 through RB32.

Control Bits

There are 128 non-retentive control bits in the SEL-2440. Control bits are asserted and deasserted via a communications protocol. Use control bits as SELOGIC variables or to remotely control output contacts. Control bits are controlled via the Modbus RTU, Modbus TCP, DNP3 serial, DNP3 LAN/WAN, or IEC 61850 communications protocols. Refer to the appropriate communications appendix for control bit addressing.

The user has the ability to locally test the control bits. Use the **CONTROL** command to set, clear, or 2 ms pulse the desired control bit.

Table 4.5 CONTROL Control Bits Command

Command	Description	Access Level
CON CB*xxx*[a] S	Sets (asserts) the specified control bit	2
CON CB*xxx*[a] C	Clears (deasserts) the specified control bit	2
CON CB*xxx*[a] P	Pulses the specified control bit for one processing interval	2

[a] xxx is a number from 001–128 that represents CB001 through CB128.

Virtual Bits

There are 128 non-retentive virtual bits. Virtual bits are asserted and deasserted via IEC 61850 messages. Use virtual bits as SELOGIC variables or to remotely control output contacts. Use ACSELERATOR Architect® SEL-5032 Software to assign control points to the virtual bits. Refer to *Appendix F: IEC 61850 Communications* for virtual bit addressing.

Latches

SELOGIC latches replace traditional latching devices (see *Figure 4.3*). The DPAC latches retain state even when power to the device is lost. If the latch is set to a programmable output contact and power to the device is lost, the state of the latch is stored in nonvolatile memory, but the device de-energizes the output contact.

When power to the device is restored, the programmable output contact will go back to the state of the latch after device initialization. Pulse the set input to close (set) the latch or pulse the reset input to open (reset) the latch. The external contacts wired to the latching device inputs are often from remote control equipment (e.g., SCADA, RTU).

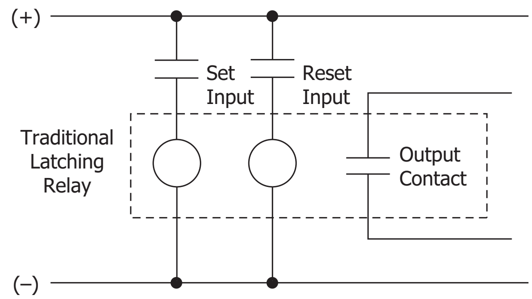


Figure 4.3 Schematic Diagram of a Traditional Latching Device

Thirty-two latches are provided by the DPAC. *Figure 4.4* shows the logic diagram of a latch switch. The output of the latch is a Device Word bit (LT01 through LT32) called a latch bit.

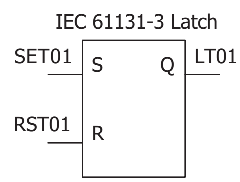


Figure 4.4 Logic Diagram of a Latch Switch

Settings Change

If individual settings are changed, the latch states are retained. If an individual setting change causes a change in a set or reset SELOGIC control equation setting, the retained states of the latch bits can be changed, subject to the newly enabled settings SET*n* or RST*n*.

Latches Settings

Latch states are stored in battery-backed RTC SRAM. An operational battery in the real-time clock is necessary to ensure that latch settings are not compromised.

Variables/Timers

Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 4.5*. Timers SV01T through SV64T in *Figure 4.5* have a setting range of 0.000–86400.00 seconds. This timer setting range applies to both pickup and dropout times (SV*n*PU and SV*n*DO; *n* = 1–64). You can enter as many as 15 elements per SELOGIC equation.

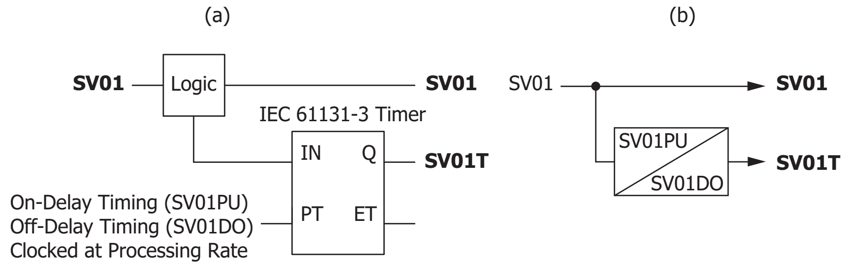


Figure 4.5 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV64T

Run-Time Configurable Timers

Run-time configurable timers function just like standard SELOGIC variables/timers except the PU and DO settings are set dynamically by using specific analog quantities. Convert any SELOGIC variable timer to a run-time configurable timer by assigning a math variable or remote analog to it's pickup or dropout settings. The device supports as many as 64 run-time configurable timers.

Table 4.6 Run-Time Configurable Timer Settings

Setting	Description
SV*n*	SELOGIC Variables 1–64
SV*n*PU	SELOGIC pickup threshold. A constant value or the analog quantities: MV*xx* or RA*xxx*
SV*n*DO	SELOGIC dropout threshold. A constant value or the analog quantities: MV*xx* or RA*xxx*

SV*n*PU and SV*n*DO are clamped between 0.000 and 86400.000 (86400.000 is a PU or DO of 24 hours). If a variable assigned to SV*n*PU or SV*n*DO exceeds these limits, they will be clamped to these values.

Counters

NOTE: These counter elements conform to the standard counter function block #3 in IEC 61131-3 First Edition 1993-03 International Standard for Programmable Controllers—Part 3: Programming Languages.

NOTE: If setting SCnnCD is set to NA, the entire counter nn is disabled.

SELOGIC counters are up- or down-counting elements, updated every processing interval. Each counter element consists of one count setting, four control inputs, two digital outputs, and one analog output. *Figure 4.6* shows Counter 01, the first of 32 counters available in the device.

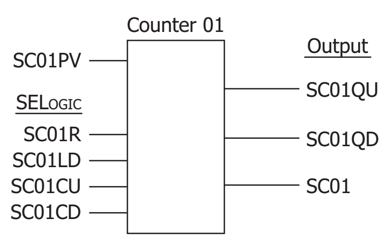


Figure 4.6 Counter 01

Table 4.7 describes the counter operation. Control input precedence is first followed by SC*nn*R, SC*nn*LD, SC*nn*CU, and SC*nn*CD.

Table 4.7 Counter Input/Output Description (Sheet 1 of 2)

Name	Type	Description
SC*nn*LD	Active high input	Load counter with the preset value to assert the output (SC*n*QU) (SELOGIC setting). When SC*nn*LD is asserted, SC*nn*CU and SC*nn*CD are ignored.
SC*nn*PV	Input value	This preset value is loaded when SC*n*LD pulsed. This preset value is the number of counts before the output (SC*n*QU) asserts (SELOGIC setting). The counter will not increment higher than this value.

Table 4.7 Counter Input/Output Description (Sheet 2 of 2)

Name	Type	Description
SC*nn*CU	Rising edge input	Count-up increments the counter (SELOGIC setting). When SC*nn*CU has a rising edge, a rising edge on SC*nn*CD is ignored (unless SC*nn* is already at the maximum value SC*nn*PV), in which case SC*nn*CU is ignored and SC*nn*CD is processed.
SC*nn*CD	Rising edge input	Count-down decrements the counter (SELOGIC setting). Setting this to NA disables the counter.
SC*nn*R	Active high input	Reset counter to zero (SELOGIC setting). When SC*nn*R is asserted, SC*nn*LD, SC*nn*CU, and SC*nn*CD are ignored.
SC*nn*QU	Active high output	This count-up output asserts when the preset value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 32).
SC*nn*QD	Active high output	This count-down output asserts when the counter is equal to zero (SC*n* = 0, *n* = 01 to 32).
SC*nn*	Output value	This counter output is an analog value that may be used with analog comparison operators in a SELOGIC control equation and viewed by using the **COU** command.

When a counter is disabled by setting, the present count value is forced to 0 (SC*nn* := 0), causing Device Word bit SC*nn*QD to assert, and Device Word bit SC*nn*QU to deassert.

Math Variables

NOTE: Math variables have a lower range than remote analogs. Therefore, the device limits the range to lower values when remote analogs are assigned to math variables.

The executed result of a math SELOGIC control equation is stored in a math variable. The storage format of the math variable is a 32-bit fixed-point signed integer. Twenty-four bits represent the integer portion, seven bits represent the fractional portion, and one bit represents the sign. The smallest and largest values a math variable can represent are –16777215.99 and +16777215.99, respectively. If the executed result exceeds these limits, it will be clipped at the limit value. For example, when MV01 := executed result is –16777219.00, MV01 will be –16777215.99. Similarly, when MV02 := executed result is +16777238.00, MV02 will be +16777215.99.

Device Word bits provided for math are shown in *Table 4.8*.

Table 4.8 Math Device Word Bits

Device Word Bit	Description
MATHSTRT	Pulses for one processing interval pulse when math starts.
MATHTSK	Asserts while math is running.
MATHERR	Asserts when a math error occurs.

Output Contacts

The DPAC provides the ability to use SELOGIC control equations to map logic outputs to the physical outputs. If you do not want to configure an output contact enter 0 as the setting, which is the default setting.

SELOGIC Control Equation Operators

Boolean SELOGIC control equation settings use logic similar to Boolean algebra logic, combining Device Word bits together with one or more of the Boolean operators listed in *Table 4.9*. Math SELOGIC control equation settings operate on numerical values, using one or more of the mathematical operators listed in *Table 4.9*. These numerical values can be mathematical variables or actual real numbers. R_TRIG and F_TRIG only function with individual word bits.

Operator Precedence

When you combine several operators and operands within a single expression, the DPAC evaluates the operators from left to right, starting with the highest precedence operators and working down to the lowest precedence.

Table 4.9 SELOGIC Control Equation Operators (Listed in Operator Precedence)

Operator	Function	Function Type (Boolean and/or Mathematical)
( )	Parentheses	Either (highest precedence)
–	Negation	Mathematical
NOT	NOT	Boolean
R_TRIG	Rising edge trigger/detect	Boolean
F_TRIG	Falling edge trigger/detect	Boolean
* /	Multiply Divide	Mathematical Mathematical
+ -	Add Subtract	Mathematical Mathematical
<, >, <=, >=	Comparison	Boolean
= <>	Equality Inequality	Boolean Boolean
AND	AND	Boolean
OR	OR	Boolean (lowest precedence)

Parentheses Operator ( )

You can use more than one set of parentheses in a SELOGIC control equation setting. Use as many as 14 sets of parentheses in a single SELOGIC control equation setting. The parentheses can be "nested" (parentheses within parentheses).

Boolean Rising-Edge Operator (R_TRIG)

Apply the rising-edge operator, R_TRIG, to individual Device Word bits only; you cannot apply R_TRIG to groups of elements within parentheses. When the Device Word bit asserts, R_TRIG asserts to logical 1 for one processing interval.

Boolean Falling-Edge Operator (F_TRIG)

Apply the falling-edge operator, F_TRIG, to individual Device Word bits only; you cannot apply F_TRIG to groups of elements within parentheses. When the Device Word bit deasserts, F_TRIG asserts to logical 1 for one processing interval, as shown in *Figure 4.7*.

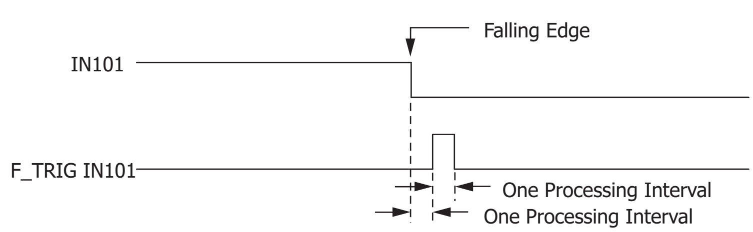


Figure 4.7 Result of Falling-Edge Operator on a Deasserting Input

Math Arithmetic Operators (*, /, +, and –)

Device Word bits (which are effectively Boolean resultants, equal to logical 1 or logical 0) may be used in mathematical operations; they are treated as numerical values 0 and 1.

Boolean Comparison Operators (<, >, <=, and >=)

Comparisons are mathematical operations that compare two numerical values, with the result being a logical 0 or logical 1. Thus, what starts out as a mathematical comparison ends up as a Boolean resultant.

Boolean Equality (=) and Inequality (<>) Operators

Equality and inequality operators operate similarly to the comparison operators.

Other Operators

Table 4.10 shows other operators and values that you can use in writing SELOGIC control equations.

Table 4.10 Other SELOGIC Control Equation Operators/Values

Operator/Value	Function	Function Type
0	Set SELOGIC control equation directly to logical 0	Boolean
1	Set SELOGIC control equation directly to logical 1	Boolean
#	Characters entered after the # operator are not processed and deemed as comments	Boolean and Mathematical
\	Indicates that the preceding logic should be continued on the next line (“\” is entered only at the end of a line)	Boolean and Mathematical

Analog Quantities

Table 4.11 Available Analog Quantities

Analog Quantity	Description
RA001–RA128	Remote analog inputs
MV01–MV32	Math Variables
SC01–SC32	SELOGIC counters
HOUR	Hour (0–23)
MIN	Minute (0–59)
SEC	Second (0–59)
YEAR	Year number (0000–9999)
DAYY	Day of year number (1–366)
WEEK	Week number (1–52)
MONTH	Month number (1–12)
DAYM	Day of month (1–31)
DAYW	Day of week number (1–7, where 1 is Sunday, 2 is Monday)
MINSM	Minutes since midnight
MS	Milliseconds after the Second

Section 5

Metering and Monitoring

Metering

Remote Analogs

NOTE: Setting ERAFAST enables updating RA001–RA032 at the SELOGIC processing interval, of 2 ms, instead of the standard 100 ms analog processing interval.

NOTE: The SEL-2440 supports a range of –16777215.99 and +16777215.99 for remote analogs over all communication protocols except MODBUS. The device restricts the range to -9999999 to +9999999 over MODBUS.

Use analog metering to verify the values received from an external device, as many as 128 variables. *Fast Message Remote Analogs Settings on page 3.20* shows how to enter remote analog settings. *Figure 5.1* shows the device response to the **METER RA** command.

```
=>>MET RA <Enter>

SEL-2440                                  Date: 02/15/2005   Time: 13:42:23
DEVICE                                    Time Source: External

RA01       1.00
RA02 -32767.00
RA03      -1.00
RA04       0.00
RA05    1000.59
RA06   -1000.61
RA07    2411.01
RA08    2410.99
RA09   98303.00
RA10  -98303.00
RA11  -38400.00
RA12  -65536.00
RA13       0.00
RA14       0.00
RA15       0.00
 •          •
 •          •
 •          •
RA126      0.00
RA127      0.00
RA128      0.00

=>>
```

Figure 5.1 Device Response to the MET RA Command

Math Variable Metering

Use Math Variable metering to determine the values of as many as 32 Math Variables. *Figure 5.2* shows the device response to the **METER MV** (math variable) command with MV01–MV08 enabled.

```
=>>MET MV <Enter>

SEL-2440                                  Date: 02/15/2005   Time: 14:15:43
DEVICE                                    Time Source: Internal

MV01        1.00
MV02   -32767.00
MV03       -1.00
MV04        0.00
MV05     1000.59
MV06    -1000.61
MV07     2411.01
MV08     2410.99

=>>
```

Figure 5.2 Device Response to the MET MV Command

Analog Signal Profiling

IMPORTANT: All stored signal data are lost when changing either SPLIST1 or SPLIST2 settings.

Analog signal profiling records and tracks values of as many as 32 analog channels. This function provides human-readable data in ASCII format (**PRO** command) and machine-readable data in CASCII format (**CPR** command), which import directly into applications like spreadsheets.

Signal Profile Settings

Enter as many as 16 analog quantities, separated by spaces or commas, into either SPLIST1 or SPLIST2 settings, for a total of 32 analog quantities. *Table 5.1* shows the settings for the signal profile list.

Table 5.1 Signal Profile List Settings

Settings Prompt	Description	Setting Range	Default Settings
SPLIST1	Signal profile list	As many as 16 quantities	NA
SPLIST2	Signal profile list	As many as 16 quantities	NA
SPAR	Signal profile acquisition rate	5, 10, 15, 30, 60 min	5
SPEN	Signal profile enable	SV	1

At the data acquisition rate of 5 minutes, the DPAC stores at least 10 days of all analog signals selected for profiling in nonvolatile memory. The report includes the time of acquisitions and the magnitude of each selected analog quantity. By defining conditions in the signal profiling enable SELOGIC® variable setting (SPEN), you can record analog values only at particular periods or conditions of interest.

Because the profile report is optimally formatted for machine-to-machine compatibility, use software such as Microsoft Excel to display it. *Figure 5.3* shows the data and graphed data after importing the data (comma-delimited) into an Excel spreadsheet. Use the **PRO C** (clear) command to clear all profile data.

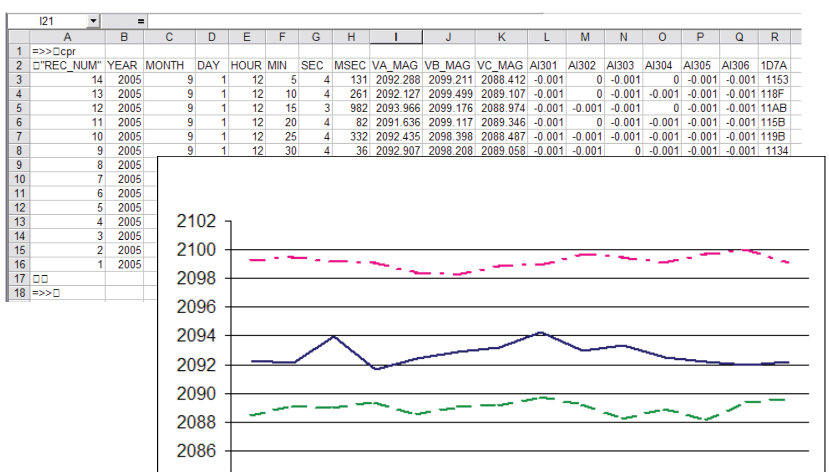


Figure 5.3 Profile Data in an Excel Spreadsheet and Graph

Section 6
Communications

Overview

A communications interface and protocol are necessary for communicating with the device. A communications interface is the physical connection on a device. Once you have established a physical connection, you must use a communications protocol to interact with the device.

The first part of this section describes communications interfaces and protocols available with the device, including communications interface connections.

The remainder of the section lists commands (ASCII and CASCII formats) you can use to communicate with the device to obtain information, reports, data, or perform control functions. You enter all commands on a keyboard when communicating via the serial port.

Commands, command options, and command variables to enter are shown in bold. Lowercase italic letters and words in a command represent command variables that are determined based on the application. Command options appear with brief explanations about the command function. Refer to the references listed with the commands for more information on the control function corresponding to the command or examples of the control response to the command.

You can simplify the task of entering commands by shortening any command to the first three characters; for example, **ACCESS** becomes **ACC**.

Communications Interfaces

Communications Ports

Table 6.1 shows the physical interfaces of the SEL-2440 Discrete Programmable Automation Controller (DPAC). Several options are available to provide alternative physical interfaces, including EIA-485 and fiber-optic cable (see *Section 2: Installation* for more information).

Table 6.1 Communications Port Physical Interfaces

Port Type	Port Interface	Usage
Port 1A, 1B (Ethernet)	10/100BASE-T (Copper)	*Table 6.9* shows the available Ethernet protocols. Use Telnet to emulate serial communications in a network environment.
Port 2, 3 (Serial)	EIA-232 (Nonisolated)	Use the EIA-232 port for communications distances of ≤ 15 m (50 ft) in low-noise environments.
Port 2 (Serial)	EIA-485	Use the EIA-485 port for communications distances ≤ 1200 m (4000 ft). For maximum performance, ensure proper line termination at the receiver.
Port 2 (Serial)	ST fiber	Use the fiber-optic port for safety (electrical isolation) and large communications distances (500 m to 4 km) with an SEL-2812.

Device Word bits provided for Ethernet ports are shown in *Table 6.2*.

Table 6.2 Ethernet Port Device Word Bits

Device Word Bit	Description
LINKA	Dual Ethernet link status for Port A.
LINKB	Dual Ethernet link status for Port B.
LINKFAIL	Dual Ethernet active port link status failure indicator. LINKFAIL asserts if connections fail on both ports for SWITCHED and FAILOVER operating modes. LINKFAIL asserts if the connection fails on the primary port for FIXED operating mode.
PASEL	Dual Ethernet active **Port A** indicator.
PBSEL	Dual Ethernet active **Port B** indicator.

Serial (EIA-232 and EIA-485) Port

Use the EIA-232 port for communications distances as far as 15 m (49 ft) in low noise environments. Use the optional EIA-485 port for communications distances as far as 1200 m (3937 ft) maximum distance (to achieve this performance, ensure proper line termination at the receiver).

To connect a PC serial port to the device front-panel serial port and enter device commands, you need the following:

- A personal computer equipped with one available EIA-232 serial port
- A communications cable to connect the computer serial port to the device serial ports
- Terminal emulation software to control the computer serial port
- An SEL-2440 Device

Some of the SEL devices available for integration or communications system robustness are as follows:

- SEL-3505, SEL-3530, SEL-3555, and SEL-3560 Real-Time Automation Controllers, SEL-2240 Axion ®
- SEL-2800 series fiber-optic transceivers
- SEL-2890 Ethernet Transceiver
- SEL-3010 Event Messenger
- SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to device fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the device

A variety of terminal emulation programs on personal computers can communicate with the device. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are as follows:

Data Rate = 9600

Data Bits = 8

Parity = N

Stop Bits = 1

To change the port settings, use the **SET P** command using QuickSet (see *Network Settings (PORT 1) on page 3.7*).

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control). To enable hardware handshaking, set RTSCTS := Y. Disable hardware handshaking by setting RTSCTS := N.

- ➤ If RTSCTS := N, the device permanently asserts the RTS line.
- ➤ If RTSCTS := Y, the device deasserts RTS when it is unable to receive characters.
- ➤ If RTSCTS := Y, the device does not send characters until the CTS input is asserted.

Fiber-Optic Serial Port

Use the optional fiber-optic port (Port 2) for safety and communications distances as far as 1 km. For communications distances as far as 4 km, use an SEL-2812 transceiver on Port 3. Although Port 2 and the SEL-2812 are compatible, Port 2 is less sensitive than the SEL-2812, which limits the distance to 1 km.

Telnet

NOTE: Telnet works with other NETMODE settings also, but NETMODE = SWITCHED is easiest to begin communication. The device hides setting NETMODE when equipped with a single Ethernet port.

Factory-default settings for the Ethernet ports disable all Ethernet protocols except Telnet and PING. Command **SET P 1** accesses settings for both Ethernet ports on the device: Port 1A and Port 1B. Use the **SET P 1** command or QuickSet to set the following settings:

- ➤ IPADDR := IP address assign by network administrator
- ➤ DEFRTR := Default router IP address assigned by network administrator
- ➤ NETMODE := SWITCHED (available with dual Ethernet ports)
- ➤ ETELNET := Y

Leave all other settings at their default values. Connect an Ethernet cable between your PC or a network switch and any Ethernet port on the device. Verify that the amber link LED illuminates on the connected device port. Many computers and most Ethernet switches support autocrossover, so nearly any Cat 5 Ethernet cable with RJ45 connectors, such as an SEL-C627 cable will work. When the computer does not support autocrossover, use a crossover cable, such as an SEL-C628 cable. If your device is equipped with dual Ethernet ports, connect to either port. Use a Telnet application or QuickSet on the host PC to communicate with the device. To terminate a Telnet session, use the **EXIT** command from any access level.

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. SEL-2440 Ethernet port choices include single or dual copper or fiber-optic configurations. With dual Ethernet ports, the unit has an unmanaged Ethernet switch. Redundant configurations support automatic failover switching from the primary to the backup network if the device detects a failure in the primary network. The basic concept in the Parallel Redundancy Protocol (PRP) mode of operation is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel. The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure. In addition to failover and PRP modes, the unit can operate in a “fixed connection (to netport) mode” or in a “switched mode” (as an unmanaged switch).

You should carefully design your Ethernet network to maximize reliability, minimize system administrator efforts, and provide adequate security. SEL recommends that you work with a networking professional to design your substation Ethernet network.

Several settings control how the device with the optional Ethernet card operates on an Ethernet network. These settings include deviceIP addressing information, network port failover options, and network speed.

Use the network configuration settings shown in *Table 3.3* to configure the device for operation on an IP network and to set other parameters affecting the physical Ethernet network interface operation.

Figure 6.1 shows an example of a simple Ethernet network configuration, *Figure 6.2* shows an example of an Ethernet network configuration with dual redundant connections, and *Figure 6.3* shows an example of an Ethernet network configuration with ring structure.

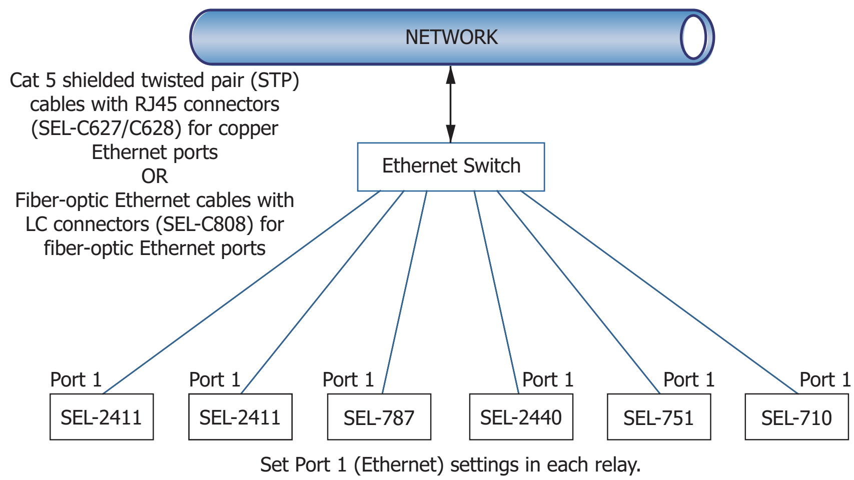


Figure 6.1 Simple Ethernet Network Configuration

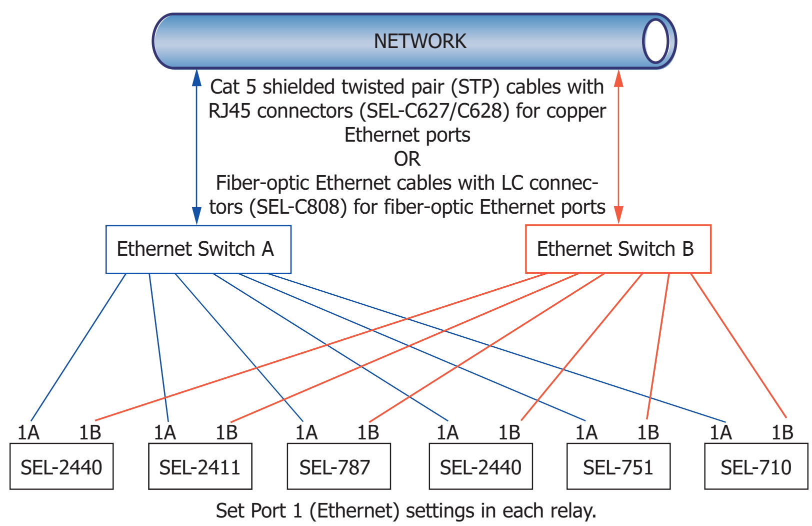


Figure 6.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

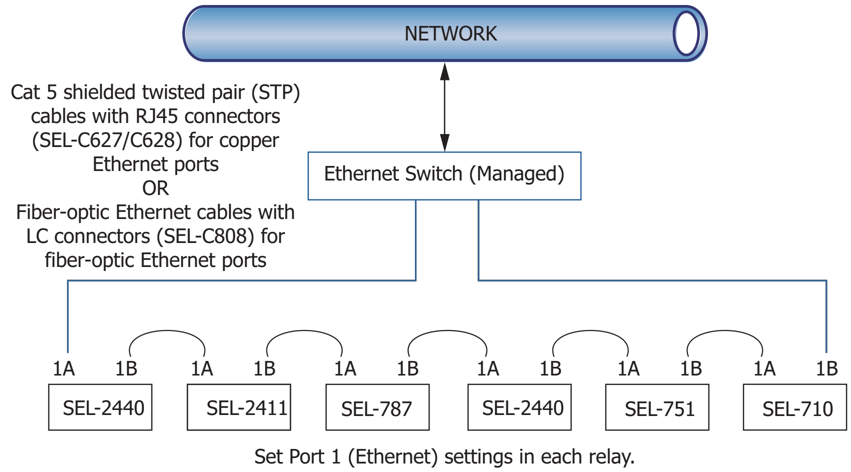


Figure 6.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-2440 dual Ethernet port option has two network ports. Network port failover mode enables the dual Ethernet port to operate as a single network adapter with a primary and standby physical interface. You can connect the two network ports to the same network or to different networks depending on your specific Ethernet network architecture.

Failover Mode

In the failover mode operation, the device determines the active port. To use failover mode, proceed with the following steps.

NOTE: If you change settings for the host port in the device and the standby network port is active, the device resets and returns to operation on the primary port.

Step 1. Set NETMODE to **FAILOVER**.

Step 2. Set FTIME to the desired network port failover time (0.10–65.00 seconds or OFF).

Step 3. Set NETPORT to the network interface you prefer.

On startup, the device communicates via NETPORT (primary port) selected. If the device detects a link failure on the primary port, it activates the standby port after the failover time, FTIME, elapses. If the link status on the primary link returns to normal before the failover time expires, the failover timer resets and uninterrupted operation continues on the primary network port.

Setting FTIME := OFF allows fast port switching (with no intentional delay). Fast port switching can occur within one processing interval (typically 100 ms) and can help with IEC 61850 GOOSE performance.

After failover, while communicating via standby port, the device checks the primary link periodically and continues checking until it detects a normal link status. The device continues to communicate via the standby port even after the primary port returns to normal. The device reevaluates the port of choice for communication upon a change of settings, at failure of the standby port, or upon reboot. The device returns to operation on the primary link under those conditions if it detects a normal link status. When the active and backup links both fail, the device alternates checking for the link status of the primary and standby ports.

Unmanaged Switch Mode

If you have a network configuration where you want to use the device as an unmanaged switch, set NETMODE to SWITCHED. In this mode, both links are enabled. The device responds to the messages it receives on either port. All the messages received on one network port that are not addressed to the device are transmitted out of the other port without any modifications. In this mode, the device ignores the NETPORT setting.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates, and the other port is disabled.

PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure.

The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings for Port 1 to configure the device for PRP mode.

- NETMODE = PRP
- PRPTOUT = desired timeout for PRP frame entry
- PRPADDR = PRP destination MAC address LSB (least significant byte of "01-15-4E-00-01-*XX*," converted to decimal and entered as 0–255)
- PRPINTV = desired supervision frame transmit interval

When NETMODE is not set to PRP, the following settings are hidden.

Table 6.3 PRP Settings

Setting Prompt	Setting Description	Setting Range	Setting Name := Factory Default
PRP ENTRY TIMEOUT	PRP Entry Timeout	400–10000 ms	PRPTOUT := 500
PRP DESTINATION ADDR LSB	The multicast MAC address of PRP supervision frames is 01-15-4E-00-01-*XX* where *XX* is specified by this setting in decimal notation as 0–255	0–255	PRPADDR := 0
PRP SUPERVISION TX INTERVAL	PRP Supervision TX Interval	1–10 s	PRPINTV := 2

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports can autonegotiate to determine the link speed and duplex mode. Accomplish this by setting the NETASPD and NETBSPD (network speed) to AUTO. You can also set single or dual copper ports to specific speeds so that you can apply them in networks with older switch devices. The device fixes the single and dual fiber Ethernet ports to work at 100 Mbps and full duplex mode.

The speed and mode of an established link is dependent on the settings on both ends of the link. For all settings of network speed (AUTO,10, or 100) on the SEL-2440 and with auto negotiation set on the other end, the devices establish a full duplex mode link at the corresponding speed. However, if the device on the other end does not support auto negotiation, or if auto negotiation is disabled, the devices establish a half duplex mode link at the set speeds. Such a mismatched state can lead to packet collisions, delays, or even packet loss. Use custom logic to set alarms when the devices fail to establish the speed and mode required for your application through the Device Word bits listed in *Table 6.4*.

Table 6.4 Device Word Bits to Monitor Network Speed and Duplex Mode

Device Word Bit	Description
SPD1[a]	Port1 Speed. Asserts for 100 Mbps and deasserts for 10 Mbps
SPD1B[b]	Port1B Speed. Asserts for 100 Mbps
SPD1A[b]	Port1A Speed. Asserts for 100 Mbps and deasserts for 10 Mbps
DUP1[a]	Port1 Duplex Mode. Asserts for full duplex and deasserts for half duplex
DUP1B[b]	Port1B Duplex Mode. Asserts for full duplex and deasserts for half duplex
DUP1A[b]	Port1A Duplex Mode. Asserts for full duplex and deasserts for half duplex

[a] The Device Word bit is available only when a single Ethernet port is available.
[b] The Device Word bit is available only when a dual Ethernet port is available.

NETPORT Selection

The NETPORT setting gives you the option of selecting the primary port of communication in failover or fixed communications modes.

TCP Keep Alive

The ETCPKA setting, along with the KAIDLE, KAINTV, and KACNT settings, can be used to verify that the computer at the remote end of a TCP connection is still available. If ETCPKA is enabled and the device does not transmit any TCP data within the interval specified by the KAIDLE setting, the device sends a keep-alive packet to the remote computer. If the device does not receive a response from the remote computer within the time specified by KAINTV, the keep-alive packet is re-transmitted as many as KACNT times. After this count is reached, the relay considers the remote device no longer available, so the device terminates the connection without waiting for the idle timer (TIDLE or FTPILE) to expire.

The device monitors MMS inactivity to identify and disconnect MMS clients that have stopped communicating. You can set it from 0 to 4,200,000 seconds via the IED Properties MMS Settings in ACSELERATOR Architect SEL-5032 Software. The MMS inactivity default value is either 120 seconds or 900 seconds, depending on the device firmware version. Setting this value to 0 disables the MMS inactivity timer. If enabled, the device starts a timer for an MMS session after it receives an MMS request from the client on that session. It resets the timer whenever it receives a new MMS request from that client. When the timer runs out, the device disconnects the MMS session, making it available for other MMS clients. This feature was implemented in addition to the TCP keep-alive timer to specifically handle MMS clients that do not disconnect properly. As there are a limited number of MMS sessions available, this ensures that misbehaving MMS clients do not take up multiple MMS sessions. Note that the MMS inactivity time-out can still disconnect an MMS session even if the device receives TCP keep-alive messages from that MMS client.

IRIG-B

NOTE: IRIG-B000 extensions are not processed by the DPAC.

Several demodulated IRIG-B input physical interfaces are provided by the DPAC: BNC, **Port 2**, and **Port 3**. Select with the TIME_SRC setting.

Device Word bits provided for IRIG-B are shown in *Table 6.5*.

Table 6.5 IRIG-B Device Word Bits

Device Word Bit	Description
IRIGOK	Signal meets “normal accuracy” requirements.
TSOK	Signal meets “high accuracy” requirements, or device timekeeping is in holdover if IRIGOK := 0.
TSYNC	Device is synchronized to the time source reference.
TOS	Asserts for 2 ms at the top-of-second.

+5 Vdc Power Supply

NOTE: Although the +5 Vdc power supply is available at more than one port, the total 5 V load from any combination of ports cannot exceed 0.5 A.

The SEL-2440 provides a +5 VDC serial port power with as much as 0.5 A on pin 1 of Port 2 (with the EIA-232 option) and Port 3. Some SEL communications devices require the +5 VDC power supply. Pin 1 is enabled with Control (DIP) Switch 6 on Switch Bank 2. Recycle power on the device after changing +5 Vdc control (DIP) switch settings, to make the settings active.

Communications Cables

Table 6.6 shows the pin functions for the EIA-232 serial ports.

Table 6.6 EIA Serial Port Pin Functions

Pin	EIA-232	EIA-485
1	+5 Vdc	+TX
2	RXD	–TX
3	TXD	N/C
4	IRIG+	+IRIG-B
5	GND	Shield
6	GND	Shield
7	RTS	+RX
8	CTS	–RX
9	GND	Shield

Table 6.7 Communications Cables (Sheet 1 of 2)

Interface	Device 1 (SEL-2440)	Device 2	Connection Description	Cable
EIA-232	DTE: 9-Pin Male D	DTE: 9-Pin Male D	Comm. Proc. without IRIG-B	SEL-C272A
EIA-232	DTE: 9-Pin Male D	DTE: 9-Pin Male D	Comm. Proc. with IRIG-B	SEL-C273A
EIA-232	DTE: 9-Pin Male D	DTE: 9-Pin Female D	Computer	SEL-C234A
EIA-232	DTE: 9-Pin Male D	DTE: 25-Pin Female D	Computer	SEL-C227A
EIA-232	DTE: 9-Pin Male D	DCE: 9-Pin Male	Wireless encrypting transceiver	SEL-C285
EIA-232	DTE: 9-Pin Male D	DCE: 9-Pin Female D	Serial encrypting transceiver	SEL-C245A
EIA-232	DTE: 9-Pin Male D	DCE: 25-Pin Female D	Modem	SEL-C222
Ethernet	RJ45 Ethernet	RJ45 Ethernet	Copper Ethernet	SEL-C627
IRIG-B	DTE: 9-Pin Male D	BNC Female	Demodulated IRIG-B	SEL-C256

Table 6.7 Communications Cables (Sheet 2 of 2)

Interface	Device 1 (SEL-2440)	Device 2	Connection Description	Cable
USB 2.0	DTE: 9-Pin Male D	USB Type A	EIA-232 to USB adapter	SEL-C662
USB 2.0	USB Type B	USB Type A	Computer	SEL-C664

Time-Out Indication

The SEL-2440 provides communication time-out indication for DNP and Modbus sessions. These are timers that indicate when a DNP or Modbus client stops communicating with the device.

Set the communication time-out in seconds for serial port using PROTO_TO. When the SEL-2440 does not receive a valid DNP or Modbus message on Serial Port *x* for PROTO_TO seconds, the device will assert the P*x*_TO Device Word bit until it receives a valid message (where *x* = 2 or 3 representing Serial Ports 2 or 3, respectively).

Set the TCP communication time-out for DNP sessions on Port 1 using DNP_TO*k* (where *k* = 1–5 representing DNP Sessions 1–5). When DNP_TO*k* seconds transpires without receiving a DNP message for Session k, the SEL-2440 will assert the DNP*k*_TO Device Word bit until it receives a valid DNP message.

Set the TCP communication time-out for Modbus sessions on Port 1 using MOD_TO1 or MOD_TO2. When MOD_TO1 or MOD_TO2 seconds transpire without receiving any Modbus messages on Port 1, the SEL-2440 will assert the MOD1_TO or MOD2_TO Device Word bits, respectively.

Communications Protocols

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control).

Port Setting	Effect
RTSCTS := N	Disables hardware handshaking. Permanently asserts the RTS line.
RTSCTS := Y	Deasserts RTS when unable to receive characters. Blocks character transmission until the CTS input is asserted.

Protocols

A rich collection of protocols is available with the DPAC; however, not all protocols are available on all ports.

Table 6.8 Serial Port Protocols (Sheet 1 of 2)

Protocol	Description
SEL Communications Protocols	
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human readable with an appropriate terminal emulation program.
Compressed ASCII	This protocol provides compressed versions of some of the ASCII commands. See *Appendix C: SEL Communications Processors* for details.
Fast Meter	This protocol supports binary messages to transfer metering and digital element messages.
Fast Operate	This protocol supports binary messages to transfer operation messages.
Fast SER	This protocol is used to receive binary Sequential Events Recorder unsolicited responses.

Table 6.8 Serial Port Protocols (Sheet 2 of 2)

Protocol	Description
Fast Message Read	This protocol uses binary messages to transmit data to an SEL Communications Processor. See *Appendix C: SEL Communications Processors* for details.
Fast Message Unsolicited Write	This protocol uses binary messages to receive data from an SEL Communications Processor. See *Appendix C: SEL Communications Processors* for details.
Other SEL Communications Protocols	
MIRRORED BITS®	This protocol is a direct device-to-device (peer-to-peer) communications protocol that allows IEDs to exchange information quickly, securely, and with minimal expense for functions such as intertripping, remote control, and remote sensing. See *Appendix G: MIRRORED BITS Communications* for details.
Event Messenger	This protocol supports transmitting messages to SEL-3010 Event Messenger. See *Event Messenger Settings on page 3.21* for details.
Industry Standard Communications Protocols	
Modbus	Modbus is a simple manufacturer-developed, hardware independent communications protocol. See *Appendix E: Modbus Communications Protocol*.
DNP3	DNP3 is an object-oriented manufacturer-developed, hardware independent communications protocol. See *Appendix D: DNP3 Communications*.

Ethernet Protocols (Port 1A, 1B)

A wide collection of Ethernet protocols is available with the DPAC; *Table 6.9* shows protocols available on the Ethernet ports.

Table 6.9 Ethernet Protocols

Protocol	Sessions/ Messages	Description
FTP Server	2	Use FTP to access the following files: ➤ CFG.XML (Configuration RO file) ➤ CFG.TXT (Configuration RO file) ➤ ERR.TXT (Error RO file) ➤ SET_61850.CID (IEC 61850 CID RO file) ➤ SET_*xx*.TXT (Setting RW files) FTP is a standard TCP/IP protocol for exchanging files.
Telnet Server	2	Use Telnet to connect to the device to use SEL protocols (SEL ASCII, Compressed ASCII, Fast Meter, and Fast Operate). Telnet is a terminal connection across a TCP/IP network that operates in a manner very similar to a direct serial port connection to one of the device ports. As with FTP, Telnet is a part of TCP/IP.
Ping Server	1	Use a ping client with the device ping server to verify that your network configuration is correct. ping is an application based on ICMP over an IP network.
Industry Standard Communications Protocols		
Modbus	2	Modbus is a simple manufacturer-developed, hardware-independent communications protocol. See *Appendix E: Modbus Communications Protocol*.
DNP3	5	DNP3 is an object-oriented, manufacturer-developed, hardware-independent communications protocol. See *Appendix D: DNP3 Communications*.
IEC 61850	MMS: 7 GOOSE: 16 Incoming 8 Outgoing	Use as MMS over a TCP network to exchange data with the device. Use GOOSE to do real-time data exchange. For more details on the IEC 61850 protocol, see *Appendix F: IEC 61850 Communications*.

Device Access

Change the Default Passwords

It is extremely important that you change the factory-default passwords programmed in the SEL-2440. Setting unique passwords for the device access levels increases the security of your substation and the power system.

Access Levels

To provide security, commands are available on different password-protected access levels. Each command description throughout this section indicates the access level at which the command is available. There are four access levels in the device that offer varying levels of control, as shown in *Table 6.10*.

Table 6.10 Access Level

Level	Prompt	Capability[a]
0	=	Access Level 0 commands are at the lowest security level and they support SEL Communications Processors and the **ACC** command. Entering the **ACC** command at the Access Level 0 prompt takes the DPAC to Access Level 1.
1	=>	Access Level 1 commands are primarily for reviewing information, not changing it. Entering the **2AC** command at the Access Level 1 prompt takes the DPAC to Access Level 2.
2	=>>	Access Level 2 commands are primarily for changing device settings, resetting accumulated device information, or resetting saved data.
C	==>	Access Level C commands should be used under direction of SEL only.

[a] See *SEL-2440 DPAC Command Summary* at the end of this manual for the commands available at a particular level.

Access Commands (ACCESS and 2ACCESS)

The **ACC** and **2AC** commands provide entry to the multiple access levels, as shown in *Table 6.11*. Different commands are available at the different access levels, as shown in the *SEL-2440 DPAC Command Summary* at the end of this manual. Commands **ACC** and **2AC** are explained together because they operate similarly. The alarm contact closes for one second upon entry of **2AC** and if the incorrect password is entered three times for any access level.

Table 6.11 Access Commands

Command	Description	Access Level
ACC	Moves from Access Level 0 to Access Level 1	0
	Moves from Access Level 2 to Access Level 1	2
	Moves from Access Level C to Access Level 1	C
2AC	Moves from Access Level 1 to Access Level 2	1
	Moves from Access Level C to Access Level 2	C
CAL	Moves from Access Level 2 to Access Level C	2

Password Requirements

After enabling the password function, you need to enter passwords to access each access level. See *PASSWORD Command (View/Change Passwords) on page 6.21* for the list of default passwords and for more information on changing and disabling passwords.

Port Access Control

Port access control provides a flexible way to manage access permissions on designated ports. For example, a remote administrator (e.g., SCADA) can use this feature to grant temporary or limited access to personnel in the field. Set port setting EPAC = Y to enable access control on a particular port. Use the Global SELOGIC equations EACC and E2AC to define the access criteria for all EPAC enabled ports. If EACC and E2AC evaluate to 0, all access requests are denied. If EACC evaluates to 1, Access Level 1 requests are permitted. If E2AC evaluates to 1, all access level requests are permitted (see *Figure 6.4*). Note that passwords are still required to escalate privilege.

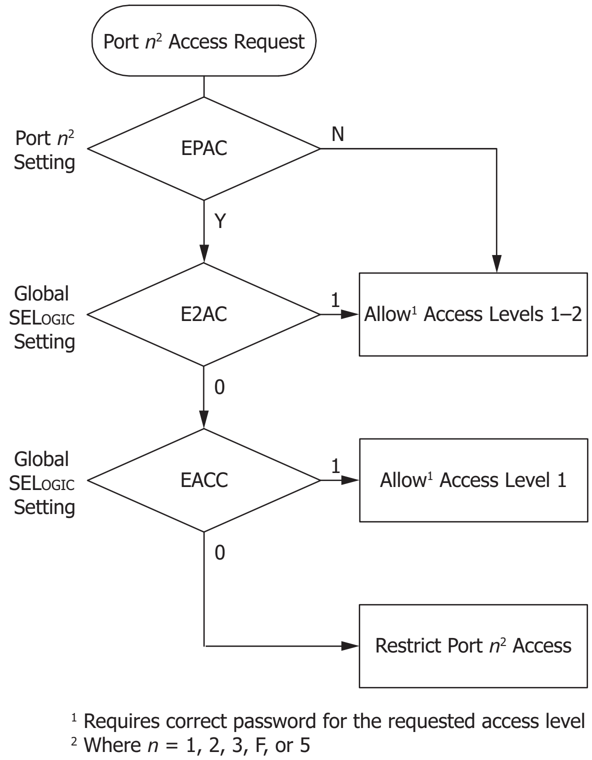


Figure 6.4 Port Access Control Flow Chart

Port access control does not apply when the device is disabled, the password jumper is installed (PASSDIS = 1), or when EPAC = N, nor can it be used to decrease a user's current access level or exceed the MAXACC setting level of the port.

ASCII Commands

The following is an alphabetical listing and discussion of all the ASCII commands available in the DPAC.

CAL Command

Use the **CAL** command to gain access to Access Level C. See *Access Levels on page 6.11* for more information. Only go to Level C to modify the default password or under the direction of an SEL employee. The additional commands available at Level C are not intended for normal operational purposes.

Table 6.12 CAL Command

Command	Description	Access Level
CAL	Go to Access Level C.	2, C

CASCII Command (Compressed ASCII)

Use the **CAS** command to produce the Compressed ASCII configuration message. This configuration instructs an external computer on the method for extracting data from other Compressed ASCII commands, as shown in *Table 6.13*. This command is only available as Compressed ASCII response.

Table 6.13 CASCII Command

Command	Description	Access Level
CAS	Return the Compressed ASCII configuration message.	0

COMMUNICATIONS Command

The **COM *x*** command displays communications statistics for the MIRRORED BITS communications channels. For more information on MIRRORED BITS communications, see *Appendix G: MIRRORED BITS Communications*. The summary report includes information on the failure of ROKA or ROKB. The last error field displays the reason for the most recent channel error, even if the channel was already failed. We define failure reasons as one of the following error types: device disabled, framing error, parity error, overrun, re-sync, data error, loopback, and underrun.

Table 6.14 COMMUNICATIONS Command

Command	Description	Access Level
COM S A or **COM S B**	Return a summary report of the last 255 records in the communications buffer for either MIRRORED BITS communications Channel A or Channel B when only one channel is enabled.	1
COM A	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.	1
COM C A	Clears all communications records for Channel A.	1
COM C B	Clears all communications records for Channel B.	1

COM PTP Command

The **COM PTP** command provides a report of the PTP data sets maintained by the device as well as statistics for the measured time offsets with the parent (master) clock. The PTP data sets contain information about the state, identity, and configuration of the local, parent, and grandmaster clocks in addition to properties of the time being distributed by the grandmaster clock.

Table 6.15 COM PTP Command

Command	Description	Access Level
COM PTP[a,b]	Displays the PTP data sets and offset statistics for the active PTP slave port or for the last active PTP slave port.	1
COM PTP C or **R**[a,b]	Clears or resets the PTP offset statistics for all ports.	1

[a] If EPTP := N the device responds with `PTP not enabled`.

[b] If there is a temporary resource shortage, settings change in progress, or the PTP component is not initialized the device responds with `Command is not available`.

NOTE: When the PTP statistics are cleared while the device is not synced to a PTP source, the time stamp for the report will be calculated in UTC using the local time and the local UTC offset on the device.

The statistics can be cleared via the ASCII command, a Port 1 settings change, or a power up. The time stamp of the most recent PTP statistic clearing event is provided in the COM PTP response.

The COM PTP response organizes the statistics into data sets. A description of each PTP data set is provided in *Table 6.16*.

Table 6.16 PTP Data Set Descriptions (Sheet 1 of 4)

Type of Data Set	Information Field	Description
Settings	PTP Profile	This value is the same as PTPPRO.
	Transport Mechanism	This value is the same as PTPTR.
	Path Delay	This value is the same as PTHDLY.
Default	Two Step	For the default data, this is set to TRUE. A two-step clock provides time information using the combination of an event message and a subsequent general message. A one-step clock provides times information using a single event message.
	Clock Identity	This is an 8-octet number that uniquely identifies the clock on the network. It is derived from the Ethernet MAC address.
	Number of Ports	This is the number of Ethernet ports used to communicate PTP messages. It is always 1 for the device.
	Clock Quality	This contains information about clock class, accuracy, and variance for the device.
	Priority1	This is the first priority in the default BMCA. It is always set to 255.
	Priority2	This is the second priority in the default BMCA. It is always set to 255.
	Domain Number	This value is the same as DOMNUM. It is the PTP domain number that the clock is part of.
	Slave Only	This is always TRUE.
Current	Steps Removed	This is the number of communications paths between the device and the grandmaster clock. A communication path is the link between a master and a slave port. Hence, links to transparent clocks do not count as separate paths. The values range from 1–65535.
Parent	Parent Port Identity	This contains the clock identity and port number of the adjacent clock to which the device clock is synchronized. The port number identifies the specific port on the adjacent clock from which the device is receiving PTP messages.
	Grandmaster Clock Identity	This is the clock identity of the grandmaster clock that the device is synchronized to.
	Grandmaster Clock Quality	This contains the class, accuracy, and variance of the grandmaster clock.
	Grandmaster Clock Class	This field displays an ASCII message based on the received clock class code described as follows:

Code (decimal)	Message
68–122, 133–170, 216–232	Profile specific value
6	Synchronized with PTP timescale
7	Holdover with PTP timescale
13	Synchronized with ARB timescale
14	Holdover with ARB timescale
52	Holdover degrade A with PTP timescale
58	Holdover degrade A with ARB timescale
187	Holdover degrade B with PTP timescale
193	Holdover degrade B with ARB timescale
248	Default
255	Slave only
All other codes	Reserved with decimal code value (xxx)

Table 6.16 PTP Data Set Descriptions (Sheet 2 of 4)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>Grandmaster Clock Accuracy</td><td>This field displays an ASCII message based on the received clock accuracy enumeration value described as follows:
<table>
<tr><th>Value (Hex)</th><th>Message</th></tr>
<tr><td>20</td><td>Within 25 ns</td></tr>
<tr><td>21</td><td>Within 100 ns</td></tr>
<tr><td>22</td><td>Within 250 ns</td></tr>
<tr><td>23</td><td>Within 1 µs</td></tr>
<tr><td>24</td><td>Within 2.5 µs</td></tr>
<tr><td>25</td><td>Within 10 µs</td></tr>
<tr><td>26</td><td>Within 25 µs</td></tr>
<tr><td>27</td><td>Within 100 µs</td></tr>
<tr><td>28</td><td>Within 250 µs</td></tr>
<tr><td>29</td><td>Within 1 ms</td></tr>
<tr><td>2A</td><td>Within 2.5 ms</td></tr>
<tr><td>2B</td><td>Within 10 ms</td></tr>
<tr><td>2C</td><td>Within 25 ms</td></tr>
<tr><td>2D</td><td>Within 100 ms</td></tr>
<tr><td>2E</td><td>Within 250 ms</td></tr>
<tr><td>2F</td><td>Within 1 s</td></tr>
<tr><td>30</td><td>Within 10 s</td></tr>
<tr><td>31</td><td>Greater than 10 s</td></tr>
<tr><td>80–FD</td><td>Profile specific value (0xyy)</td></tr>
<tr><td>FE</td><td>Unknown</td></tr>
<tr><td>All other codes</td><td>Reserved (0xyy)</td></tr>
</table></td></tr>
<tr><td></td><td>Grandmaster Priority1</td><td>This is the priority1 value set in the grandmaster clock. If the setting ALTPRIn > 0, its value is used as the reported priority1 value for Grandmaster n. The expected value is between 0 to 255.</td></tr>
<tr><td></td><td>Grandmaster Priority2</td><td>This is the priority2 value set in the grandmaster clock. The expected value is between 0–255.</td></tr>
<tr><td></td><td>C37.238 TLV Information</td><td>This is the C37.238 TLV information received. It is valid only in the Power profile. In the case of the Default profile, this section is hidden.</td></tr>
<tr><td>Time Properties</td><td>Current UTC Offset</td><td>This is the current number of leap seconds between TAI and UTC.</td></tr>
<tr><td></td><td>Current UTC Offset Valid</td><td>This attribute is TRUE if the current UTC Offset is valid and should be used. Otherwise, it is FALSE.</td></tr>
<tr><td></td><td>Leap59</td><td>This is set to TRUE if there is an impending leap second removal, i.e., the last minute of the current day contains 59 seconds.</td></tr>
<tr><td></td><td>Leap61</td><td>This is set to TRUE if there is an impending leap second insertion, i.e., the last minute of the current day contains 61 seconds.</td></tr>
<tr><td></td><td>Time Traceable</td><td>This indicates if the time being served is traceable to UTC reference time.</td></tr>
<tr><td></td><td>Frequency Traceable</td><td>This indicates if the frequency being distributed is traceable to a primary source.</td></tr>
<tr><td></td><td>PTP Timescale</td><td>This is TRUE if the time being served uses the PTP/UTC timescale. Otherwise, it is FALSE.</td></tr>
</table>

Table 6.16 PTP Data Set Descriptions (Sheet 3 of 4)

Type of Data Set	Information Field	Description
	Time Source	This shows the source of the time being distributed based on the value of the timeSource enumeration as show in the following table. Code (decimal) — Message 10 — ATOMIC_CLOCK 20 — GPS 30 — TERRESTRIAL_RADIO 40 — PTP 50 — NTP 60 — HAND_SET 90 — OTHER A0 — INTERNAL_OSCILLATOR F0–FE — PROFILE SPECIFIC VALUE (0xyy) All other codes — RESERVED (0xyy)
	Local Time Offset	This is the offset of local time from UTC and information about impending change in the offset.
Port	Port Identity	This contains the clock ID and port number of the device on the PTP network.
	Port State	This is the synchronization state of the device: LISTENING, SLAVE, UNCALIBRATED, or FAULTY. The device is synchronized if the state is SLAVE.
	Log Delay Request Interval	If the end-to-end delay mechanism is enabled, then this is the logarithm to base 2 of the delay request intervals (in seconds) received from the master clock. If the peer-to-peer (P2P) delay mechanism is enabled, these data are hidden. Also, these data are hidden when the delay mechanism is set to OFF.
	Log Pdelay Request Interval	If the peer-to-peer (P2P) delay mechanism is enabled, this is the logarithm to base 2 of the configured peer delay request intervals (PDINT). If the end-to-end delay mechanism is enabled, these data are hidden. Also, these data are hidden when the delay mechanism is set to OFF.
	Peer Mean Path Delay	If the peer-to-peer (P2P) delay mechanism is enabled, this is the measured mean peer delay on the device. If the peer-to-peer (P2P) delay mechanism is not selected (PTHDLY ≠ P2P), these data are hidden.
	Announcement Receipt Timeout	This value is always 4 announce intervals.
	Path Delay Mechanism	This is the same value as PTHDLY.
	Failed to Receive Response	The value is TRUE if no response is received after 5 consecutive Delay or Pdelay Requests from the port. Otherwise, the value is FALSE. These data are hidden if PTHDLY = OFF.
	Received Multiple Pdelay Responses	This is set to TRUE if a response is received from more than one clock to a Pdelay request from the device. The port state will transition to FAULTY when this happens. The value is reset to FALSE when only one clock responds to Pdelay requests from the device. These data are hidden if PTHDLY ≠ P2P.

Table 6.16 PTP Data Set Descriptions (Sheet 4 of 4)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>Reason for Nonsynchronization</td><td>If the device is failing to synchronize, this will provide one of the following reasons for the failure: incorrect domain number, clock not in the acceptable master table, or missing TLV in Announce messages. Otherwise, the string is empty.
<table>
<tr><th>#</th><th>Reason for Nonsynchronization Display Strings</th></tr>
<tr><td>1</td><td>Received Announce message for a different domain: <domain number></td></tr>
<tr><td>2</td><td>Received Announce message from an unacceptable master: <MAC or IP address></td></tr>
<tr><td>3</td><td>Required TLV is missing or incorrectly formatted by clock <clock id></td></tr>
</table></td></tr>
<tr><td></td><td>Port Status</td><td>This displays the Port 1A and 1B time synchronization status. If the port is not synchronized to a PTP master, NA is displayed. If a port is in the SLAVE state and it is chosen as a master, ACTIVE is displayed.
Additional port status indications are available via Device Word bits PTPA, PTPB, PASEL, and PBSEL. When Ethernet Port 1A is active, PASEL asserts. Similarly, when Ethernet Port 1B is active, PBSEL asserts. If the operating mode of Port 1 of the device is PRP, then PTPA asserts if PTP is enabled and the device is receiving PTP messages on Port 1A. Similarly, in PRP mode, PTPB asserts if PTP is enabled and the device is receiving PTP messages on Port 1B.</td></tr>
</table>

CONTROL Command (Control Remote Bit)

Use the **CON** command to control remote bits (Device Word bits RB01–RB32) and control bits (CB001–CB128). You can select the control operation from three states: set, clear, or pulse, as described in *Table 6.18*.

Table 6.17 CONTROL Command

Command	Description	Access Level
CON RB*nn*[a] *k*	Use this command for control by setting, clearing, or pulsing the specified remote bit.	2

[a] Parameter nn is a number from 01 to 32, representing RB01 through RB32. k is S, C, or P.

Table 6.18 CONTROL Remote Bits Command

Command	Description	Access Level
CON RB*xx*[a] S	Sets (asserts) the specified remote bit	2
CON RB*xx*[a] C	Clears (deasserts) the specified remote bit	2
CON RB*xx*[a] P	Pulses the specified remote bit for one processing interval	2

[a] xx is a number from 01–32 that represents RB01 through RB32.

Table 6.19 CONTROL Control Bits Command

Command	Description	Access Level
CON CB*xxx*[a] S	Sets (asserts) the specified control bit	2
CON CB*xxx*[a] C	Clears (deasserts) the specified control bit	2
CON CB*xxx*[a] P	Pulses the specified control bit for one processing interval	2

[a] xxx is a number from 001–128 that represents CB001 through CB128.

COUNTER Command (Counter Values)

The device generates the values of the 32 counters in response to the **COU** command, as shown in *Table 6.20*.

Table 6.20 COUNTER Command

Command	Description	Access Level
COU *n*	Display the values of the SELOGIC® counters *n* times.	1

CSER Command (Compressed SER Report)

The **CSER** command generates the SER report in the Compressed ASCII format, as shown in *Table 6.21* and *Table 6.22*.

Table 6.21 CSER Command (Compressed SER Report)

Command	Description	Access Level
CSER	Use the **CSER** command to display a chronological progression of all available SER rows (as many as 512 rows). Row 1 is the most recent triggered row and Row 512 is the oldest.	1
CSER *row1* **CSER *row1 row2*** **CSER *date1*** **CSER *date1 date2***	Use the **CSER** command with parameters (*row* or *date*) to display a chronological or reverse chronological subset of the SER rows—see *Table 6.22*.	1

Append **TERSE** to any of the commands in *Table 6.21* to generate reports without labels (e.g., **CSER 5 2 TERSE** to generate a report without labels from Rows 5 to 2).

If the requested SER report rows do not exist, the device responds with the following:

```
"No Data Available", "0668"
```

Table 6.22 CSER Command Format

Parameter	Description
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **CSER 5** to return the first five rows.
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **CSER 1 10** to return the first ten rows in numeric order, or **CSER 10 1** to return the same items in reverse numeric order.
date1	Append *date1* to return all rows with this date. For example, use **CSER 1/1/2021** to return all records for January 1, 2021.
date1 date2	Append *date1* and *date2* to return all rows between *date1* and *date2*, beginning with *date2* and ending with *date1* (i.e., the newest records are listed first). Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression of rows. Date entries are dependent on the date format setting DATE_F. For example, with DATE_F set to MDY (Month Day Year), **CSER 1/5/2021 1/7/2021** returns all records for January 5, 6, and 7, 2021.

DATE Command (View/Change Date)

Use the **DAT** command to view and set the device date, as shown in *Table 6.23*. The device can overwrite the date entered by using other time sources such as IRIG. Enter the **DAT** command with a date to set the internal clock date. Separate the month, day, and year parameters with slashes. Set the year in 4-digit form (for dates 2000–2099). Global setting DATE_F sets the date format.

Table 6.23 DATE Command

Command	Description	Access Level
DAT	Display the internal clock date.	1
DAT ***date***	Set the internal clock date to *date* (DATE_F set to MDY, YMD, or DMY).	1

ETHERNET Command

NOTE: Units built with R214 or older can be upgraded to firmware versions R215 or newer, but the unit will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

The **ETH** command displays the status report of both Ethernet ports, including settings and performance.

```
=>>ETH <Enter>

SEL-2440
MOT Tst2

MAC:   00-30-A7-DD-28-F3
IP ADDRESS:   10.203.41.47
SUBNET MASK:   255.255.240.0
DEFAULT GATEWAY: 10.203.32.1

              Link     SPEED     DUPLEX     MEDIA
PORT 1A       Up       100M      Full       TX
PORT 1A       Up       100M      Full       TX

=>>
```

Figure 6.5 ETH Command Example

FILE Command (Manage Settings Files)

The **FIL** command provides a safe and efficient means of transferring settings files between intelligent electronic devices (IEDs) and external support software (ESS). Use the **FIL** commands for sending settings to the DPAC and receiving settings from the device, as shown in *Table 6.24*.

Table 6.24 FILE Command

Command	Description	Access Level
FIL DIR	Return a list of files.	1
FIL READ ***filename***	Transfer settings file *filename* from the device to the PC.	1
FIL WRITE ***filename***	Transfer settings file *filename* from the PC to the device.	2
FIL SHOW ***filename***	Displays the contents of the file *filename*.	1

GOOSE Command

Transmit and receive GOOSE messaging information, which can be used for troubleshooting, is displayed with the **GOO** command. The **GOO** command variants and options are shown in *Table 6.25*.

Table 6.25 GOOSE Command Variants

Command Variant	Description	Access Level
GOO	Display Goose information.	1
GOO ***count***	Display GOOSE information *count* times.	1

HELP Command

In response to the **HEL** ***XXX*** command, the device displays a short description of the ASCII command. Parameter ***XXX*** is any ASCII command, **HEL CON** for example.

IRIG Command

Read the demodulated IRIG-B time code at the serial port or IRIG-B input with the **IRI** command. The **IRI** command also forces immediate synchronization of the internal clock with the IRIG-B signal (see *Table 6.26*). If an IRIG-B signal is present at the serial port or IRIG-B input, the device automatically synchronizes the internal clock with the IRIG-B signal in a time period not exceeding one minute. It is not necessary to issue the **IRI** command for this automatic one-minute synchronization. If you are testing the device and do not want to wait for the one-minute synchronization, then issue the **IRI** command to immediately force the device to synchronize with the IRIG-B signal. You can also use the **IRI** command to determine if the device is properly reading the IRIG-B signal.

Table 6.26 IRIG Command

Command	Description	Access Level
IRI	Force synchronism of internal control clock to IRIG-B time-code input.	1

LOOPBACK Command

The **LOO** command is used for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix G: MIRRORED BITS Communications*. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be deasserted. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK will assert if error-free data are received. The **LOO** command with just the channel specifier enables looped back mode on that channel for 5 minutes, while the inputs are forced to the default values.

Table 6.27 LOOPBACK Command

Command	Description	Access Level
LOO *n*	Enable loopback testing of both MIRRORED BITS channels for the next *n* minutes, where *n* is 5 minutes if unspecified or is 1–5000 minutes.	2
LOO A *n*	Enable loopback on MIRRORED BITS Channel A.	2
LOO B *n*	Enable loopback on MIRRORED BITS Channel B.	2

Include the **DATA** parameter to allow the modification of the RMB values. To disable loopback and return to normal operation before the selected number of minutes, issue the **LOO R** command.

MAC Command

NOTE: Units built with R214 or older can be upgraded to firmware versions R215 or newer, but the unit will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

MAC addresses of PORT 1 are displayed with the **MAC** command.

```
=>>MAC <Enter>
Port 1 (IP) MAC Address: 00-30-A7-67-32-10
Port 1 (GOOSE) MAC Address: 00-30-A7-78-10-20
=>>
```

Figure 6.6 MAC Command Example

MAP Command (Display DNP3 Maps)

The **MAP** command is only available if DNP3 has been selected as the protocol on a serial or Ethernet port. Issue the **MAP** command with the *port* parameter (from 1 to 4) to view the DNP3 settings for that port. If you specify port number 1, you must also specify the *session* (from 1 to 5). For example, to observe Port 1 DNP3 maps and settings for session 1, type **MAP 1 1 <Enter>**.

METER Command (Metering Data)

Metering data retrieval and display is described in the following subsections. See *Section 5: Metering and Monitoring* for details on metering.

MET RA (Remote Analog Metering)

Remote analog values sent by a remote device are displayed with the **MET RA** command.

Command	Description	Access Level
MET RA *n*	Display Remote Analog (RA) values.	1

MET M (Math Variable Metering)

Calculated Math Variable values are displayed with the **MET M** command.

Command	Description	Access Level
MET M *n*	Display Math Variable (MV) values.	1

NET Command (Network Status)

The **NET** command displays the state of TCP and UDP ports that are open on the SEL-2440. See *Table 6.28* for more information.

Table 6.28 NET Command

Command	Description	Access Level
NET	Displays the local IP address, foreign (remote device) IP address, ports, and the status of the port connection. If a port is open but no remote device is connected to that port, the device displays an empty foreign address.	1, 2

If no TCP or UDP ports are enabled for protocols, the NET command responds with the following:

```
"No Data Available", "0668"
```

The following is a sample NET command response for SEL-2440 on for Eth 1.

```
SEL-2440                                         Date: 11/06/2024   Time: 14:14:06.465
DEVICE                                           Time Source: Internal

Proto  Local Address                  Foreign Address                     State
TCP    0.0.0.0:23                                                         LISTEN
TCP    192.168.2.240:23               192.168.2.10:59296                  LISTEN
```

PASSWORD Command (View/Change Passwords)

Set passwords with the **PAS** command, as shown in *Table 6.29* and *Table 6.30*.

Table 6.29 PASSWORD Command

Command	Description	Access Level
PAS *level new password*	Set a *new password* for Access Level *level*. Parameter *level* represents the device Access Levels 1 or 2.	2

Table 6.30 Factory-Default Passwords

Access Level	Password
1	OTTER
2	TAIL

> ⚠**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.

To change the password for Access Level 2 from the default password TAIL to new password Ot3579, enter the following:

```
=>>PAS 2 <Enter>
Old PW: ? **** <Enter> (Enter TAIL)
New PW: ? ****** <Enter>  (Enter Ot3579)
Confirm PW: ? ****** <Enter>  (Enter Ot3579)
Password Changed

CAUTION: This password can be strengthened.  Strong passwords do not include a
name, date, acronym, or word.  They consist of the maximum allowable
characters, with at least one special character, number, lower-case letter, and
upper-case letter.  A change in password is recommended.

=>>
```

Similarly, use **PAS 1** to change Access Level 1 passwords.

Passwords can contain as many as 12 characters. Uppercase and lowercase letters are treated as different characters. Strong passwords consist of 12 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.

Table 6.31 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	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

PING Command

With the **PING** command, the DPAC sends ping messages to the remote node until interrupted by pressing **Q** (if you want ping statistics) or **<CTRL+X>** (if you do not want ping statistics) on the keyboard. The DPAC will support only one ping command per IED from any available port. Command options for the **PING** command are shown in *Table 6.32*.

Table 6.32 PING Command

Command	Description	Access Level
PING *addr*	Ping the IP address represented by *addr* every second.	2
PING *addr n*	Ping the IP address once every *n* seconds, where *n* is a value from 1–255.	2

PROFILE Command (Signal Profile Values)

Display or clear analog signal profile data with the **PRO** command, as shown in *Table 6.33*.

Table 6.33 PROFILE Command

Command	Description	Access Level
PRO	Display analog signal profile data.	1
PRO C	Clear analog signal profile data.	1

PULSE Command (Test Outputs)

Pulse the state of an output contact for 1 second with the **PUL** command. This command overrides the present settings for the particular output under test, as shown in *Table 6.34*.

Table 6.34 PULSE Command

Command	Description	Access Level

PUL *n*	Pulse output contact *n* for 1 second, as shown below:
	`=>PUL OUT101 <Enter>`
	`Pulse Output`
	`Are you sure (Y,N)? Y <Enter>`
	
	`=>`
		2

QUIT Command

Revert to Access Level 0 from either Level 1 or Level 2 with the **QUIT** command, as shown in *Table 6.35*.

Table 6.35 QUIT Command

Command	Description	Access Level
QUI	Go to Access Level 0.	0

Access Level 0 is the lowest access level; the DPAC performs no password check to descend to this level (or to remain at this level).

SER Command (Sequential Events Recorder Report)

View and manage the Sequential Events Recorder report with the **SER** commands, as shown in *Table 6.36* and *Table 6.37*.

Table 6.36 SER Command (Sequential Events Recorder Report)

Command	Description	Access Level
SER	Use the **SER** command to display a chronological progression of all available SER rows (as many as 512 rows). Row 1 is the most recent triggered row and Row 512 is the oldest.	1
SER *row1* **SER *row1 row2*** **SER *date1*** **SER *date1 date2***	Use the **SER** command with parameters (*row* or *date*) to display a chronological or reverse chronological subset of the SER rows—see *Table 6.37*.	1
SER C	Use this command to clear/reset the SER records.	2

Table 6.37 SER Command Format

Parameter	Description
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first ten rows in numeric order, or **SER 10 1** to return the same items in reverse numeric order.
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2005** to return all records for January 1, 2005.
date1 date2	Append *date1* and *date2* to return all rows between *date1* and *date2*, beginning with *date2* and ending with *date1* (i.e., the newest records are listed first). Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression of rows. Date entries are dependent on the date format setting DATE_F. For example, with DATE_F set to MDY (Month Day Year), **SER 1/5/2005 1/7/2005** returns all records for January 5, 6, and 7, 2005.

SET Command (Change Settings)

The **SET** command is for viewing or changing the device settings, as shown in *Table 6.38*. Append **TERSE** to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the **TERSE** option. The alarm contact closes for one second when the SEL-2440 saves new settings.

Table 6.38 SET Command

Command	Description	Access Level
SET *s* TERSE	Set Device settings.	2
SET L *s* TERSE	Set Logic settings.	2
SET G *s* TERSE	Set Global settings.	2
SET P *n s* TERSE	Set serial port settings. Depending on the device configuration, *n* specifies either Port F or Ports 2 through 4; defaults to the active port if not listed.	2
SET R *s* TERSE	Set SER report settings.	2
SET DN *s* TERSE	Set DNP settings.	2

Append *s*, the specific setting name you want to change, to the **SET** command to immediately jump to the setting.

When you issue the **SET** command, the device presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting, as shown in *Table 6.39*.

Table 6.39 SET Command Editing Keystrokes

Press Key	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

SHOW Command (Show/View Settings)

When showing settings, the device displays the settings label and the present value from nonvolatile memory for each setting class as shown in *Table 6.40*.

Table 6.40 SHOW Command

Command	Description	Access Level
SHO *s*	Show Device settings.	1
SHO L *s*	Show Logic settings.	1
SHO G *s*	Show Global settings.	1
SHO P *n s*	Show serial port settings, where *n* specifies either Port F or Ports 1 through 4; defaults to the active port if not listed.	1
SHO R *s*	Show report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	1
SHO DN *s*	Show DNP settings.	1

Append *s,* the specific setting name you want to view, to the **SHO** command to immediately jump to the setting. If the setting name is not included, the device presents settings beginning with the first one in the group.

STATUS Command (Device Self-Test Status)

Table 6.41 shows how the **STA** command displays the status report. *Table 8.1* shows the status report definitions and message formats for each self-test. As with all microprocessor devices, increasing the number of functions increases the processor burden. Use the **STA S** command to see the remaining processor capacity.

Table 6.41 STATUS Command (Device Self-Test Status)

Command	Description	Access Level
STA *n*	Displays the device self-test information *n* times (*n* = 1–32767). Defaults to 1 if *n* is not specified.	1
STA S	Displays the memory and execution utilization for the SELOGIC control equations.	1
STA R or **C**	Restarts the device and clears self-test warning and failure status results.	2

TARGET Command (Display Device Word Bit Status)

The **TAR** command displays the status of Device Word bits, whether these Device Word bits are asserted or deasserted, as shown in *Table 6.42*.

Table 6.42 TARGET Command

Command	Description	Access Level
TAR	Use without parameters to display Device Word row 0.	1
TAR *n k*	Show Device Word row number *n* (0–140) and heading, and repeat the status (0 or 1) of the eight Device Word bits in row *n k* times (1–32767). See *Table H.1* for the Device Word bit table.	1
TAR … ROW	Adding ROW to the command displays the Device Word Row number at the start of each line.	1
TAR R	Reset front-panel trip/target LEDs.	1

The elements are represented as Device Word bits and are listed in rows of eight, called Device Word rows. All Device Word rows are shown in *Table H.1*. Device Word bits are used in SELOGIC control equations. The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL products.

Test DB Command

Use the **TEST DB** command to override analog and/or digital values over communications interfaces for protocol testing.

A device with IEC 61850 communications enabled and E850MBC := Y supports test DB commands only when the Mode/Behavior is set to the On mode. The device removes all overrides and exits TEST DB mode when you change the Mode/Behavior from On.

Table 6.43 TEST DB Commands (Sheet 1 of 2)

Command	Description	Access Level
TEST DB	Displays the present status of digital and analog overrides.	2
TEST DB A *name value*	Forces the protocol analog element *name* to override *value*.	2
TEST DB D *name value*	Forces the protocol digital element *name* to override *value*.	2
TEST DB *name* OFF	Clears (analog or digital) override for element *name*.	2
TEST DB A OFF	Clears all analog overrides.	2

Table 6.43 TEST DB Commands (Sheet 2 of 2)

Command	Description	Access Level
TEST DB D OFF	Clears all digital overrides.	2
TEST DB OFF	Clears 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.

NOTE: The **TEST DB** command does not support digital points for the SEL Fast Message protocol.

The **TEST DB** command provides a method to override Device Word bits or analog values to aid in the testing and commissioning of communications interfaces only and should not be used on an energized system. The command overrides values in the communications interfaces (ASCII, SEL Fast Message, DNP3, Modbus, and IEC 61850) only. The actual values used by the device for monitoring 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.

The device automatically exits the test mode if you clear all the overrides or do not issue a **TEST DB** command for 30 minutes.

TIME Command (View/Change Time)

The **TIME** command returns information about the DPAC internal clock, shown in *Table 6.44*. You can also set the clock if you specify hours and minutes (seconds data are optional). Separate the hours, minutes, and seconds with colons.

Table 6.44 TIM Command

Command	Description	Access Level
TIME	Display the present internal clock time.	1
TIME *hh:mm*	Set the internal clock to hh:mm.	2
TIME *hh:mm:ss*	Set the internal clock to hh:mm:ss.	2

Simple Network Time Protocol (SNTP)

When ESNTP is enabled (Port 1 setting ESNTP is not OFF), the device internal clock conditionally synchronizes to the time of day served by a Network Time Protocol (NTP) server. The device uses a simplified version of NTP called the Simple Network Time Protocol (SNTP). SNTP is not as accurate as IRIG-B. The device can use SNTP as a less accurate primary time source, or as a backup to the higher accuracy IRIG-B time source.

SNTP As Primary Or Backup Time Source

If an IRIG-B time source is connected and either Device Word bits TSOK or IRIGOK assert, then the device synchronizes the internal time-of-day clock to the incoming IRIB-G time code signal, even if SNTP is configured in the device and an NTP server is available. If the IRIG-B source is disconnected (IRIGOK deasserted) then the device synchronizes the internal time-of-day clock to the NTP server if available. In this way, an NTP server acts as either the primary 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 Device

To enable SNTP in the device, make Port 1 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 6.45* shows each setting associated with SNTP.

Table 6.45 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 6.27*.
SNTPRAT[a]	SNTP Request Update Rate (15–3600 s)	15–3600 s	60	Determines the rate at which the relay asks for updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the time the relay will wait for an NTP broadcast when ESNTP = BROADCAST.
SNTPTO	SNTP Timeout (5–20 s)	5–20 s	5	Determines the time the relay will wait for the NTP master to respond when ESNTP = UNICAST or MANYCAST
SNTPPSIP	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
SNTPBSIP	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 unicast mode of operation, the SNTP client in the device requests time updates from the primary (IP address setting SNTPPSIP) or backup (IP address setting SNTPBSIP) NTP server at a rate defined by setting SNTPRAT. If the NTP server does not respond with the period defined by the sum of setting SNTPTO and SNTPRAT, then the device tries the other SNTP server. When the device successfully synchronizes to the primary NTP time server, Device Word bit TSNTPP asserts. When the device successfully synchronizes to the backup NTP time server, Device Word bit TSNTPB asserts.

ESNTP = MANYCAST

In manycast mode of operation, the device initially sends an NTP request to the broadcast address contained in setting SNTPPSIP. The device continues to broadcast requests at a rate defined by setting SNTPRAT. When a server replies, the device considers that server to be the primary NTP server, 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 device deasserts TSNTPP and begins to request time from the broadcast address again until a server responds.

ESNTP = BROADCAST

Setting SNTPPSIP = 0.0.0.0 while ESNTP = BROADCAST, the device will listen for and synchronize to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the device will listen for and synchronize to only NTP server broadcasts from that address. When synchronized, the device asserts Device Word bit TSNTPP. Device Word bit TNSTPP deasserts if the device does not receive a valid broadcast within the SNTPT0 setting value after the period defined by setting SNTPRAT.

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 device.

When installed on a network with low burden configured with one Ethernet switch between the device and the SNTP Server, and when using ESNTP = UNICAST or MANYCAST, the device time-synchronization error to the SNTP server is typically less than ±5 milliseconds.

Precision Time Protocol (PTP)

Configuring PTP in the Device

The SEL-2440 supports firmware-based PTP. If the EPTP setting is available and set to Y, then the device supports PTP Version 2 (PTPv2) as a slave-only clock as defined by IEEE 1588-2008 on Ports 1A and 1B. *Table 6.46* shows the settings associated with PTP.

Table 6.46 Settings Associated With PTP (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default	Description
ENABLE PTP	Y, N	EPTP := N	When set to Y, the device becomes a slave PTP clock
PTP PROFILE	DEFAULT, C37.238	PTPPRO := DEFAULT	Sets the PTP profile
PTP TRANSPORT MECHANISM	UDP, LAYER2	PTPTR := UDP	Transport mechanism for PTP messages
PTP DOMAIN NUMBER	0–255	DOMNUM := 0	PTP domain number of the clock
PTP PATH DELAY MECHANISM	P2P, E2E, OFF	PTHDLY := E2E	Path delay measurement method to be used on the PTP network
PEER DELAY REQUEST INTERVAL	1, 2, 4, 8, 16, 32, 64 s	PDINT := 1	Duration of time between transmissions of peer delay request messages
PTP NUMBER OF ACCEPTABLE MASTERS	1–5, OFF	AMNUM := OFF	Number of acceptable PTP masters
PTP ACCEPTABLE MASTER *n*[a] IP	*zzz.yyy.xxx.www*	AMIP*n* := 192.168.1.12*n*	Acceptable master IP addresses
PTP ACCEPTABLE MASTER *n*[a] MAC	*xx:xx:xx:xx:xx:xx*	AMMAC*n* := 00-30-A7-00-00-0*m*[b]	Acceptable master MAC addresses
PTP ALTERNATE PRIORITY1 FOR MASTER *n*[a]	0–255	ALTPRI*n* := 0	If the acceptable master table option is enabled and this setting value is not zero, the Priority 1 value received in the Announce message from the specified master will be replaced by this value and used in the Best Master Clock Algorithm (BCMA)

Table 6.46 Settings Associated With PTP (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default	Description
PTP VLAN IDENTIFIER	1–4094	PVLAN := 1	VLAN ID for a C37.238 Ethernet frame
PTP VLAN PRIORITY	0–7	PVLANPR := 4	VLAN priority for a C37.238 Ethernet frame

[a] *n* = 1–5.
[b] *m* = A–E.

To achieve the best accuracy (<1 ms), it is necessary to have one or more PTP master clocks and that all intervening equipment (e.g., Ethernet switches) be IEEE 1588-aware (i.e., all intervening network devices need to be transparent or boundary clocks).

In PTP, a clock that provides time to other devices, typically based on GPS input, is a master clock. The intervening switches are transparent clocks. You can connect networks together and pass time from one network to another using boundary clocks. Transparent and boundary clocks are important because they provide time correction in the PTP messages that pass through them, whereas devices that are not IEEE 1588-aware do not provide this correction. Because it is possible for a network to have multiple master clocks, PTP clocks implement algorithms to select the best available clock. The one selected for use by an end device is the grandmaster clock. You can learn more about configuring a PTP network in these application guides:

- “Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality in a Redundant Network Topology” (AN2015-07)
- “Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality to Isolated Ethernet Networks” (AN2015-06)

The device supports both one-step and two-step clocks. A one-step clock provides time information using a single event message. A two-step clock provides time information using the combination of an event message and a subsequent general message.

Within PTP, there are multiple clock profiles available. A profile defines the set of PTP features available in a specific application domain. SEL-2440 supports two profiles: Default and Power (C37.238-2011).

The Default profile has many optional features and is intended to address common applications. The Default profile supports both UDP or Layer 2 (802.3) Ethernet transport, and can use either the end-to-end (E2E) or the peer-to-peer (P2P) delay mechanism. Grandmaster clocks can send Announce, Sync, and Delay request messages over a wide range of intervals. A Default profile network can consist of boundary clocks or transparent clocks anywhere between the grandmaster and the end devices. The only performance requirement for the Default profile is that a master clock must maintain frequency accuracy to within 0.01 percent.

The Power profile has minimal optional features to facilitate interoperability and performance predictability. The Power profile is only supported on Layer 2 networks and exclusively uses the peer-to-peer delay mechanism. All messages must be sent at 1-second intervals, have 802.1Q VLAN tags, and include grandmaster ID and (maximum) inaccuracy fields in the Announce message. Transparent clocks are mandatory in a Power profile network and boundary clocks are not allowed. Select the profile by using the PTPPRO setting.

PTP defines a logical grouping of clocks in a network as a clock domain. This allows a logical separation between clocks that participate in different application domains to coexist on the same network. Domains are identified by domain numbers.

The SEL-2440 supports transport of PTP messages over UDP or Layer 2 (Ethernet). This needs to match the transport mechanism used in the master clocks.

NOTE: High-accuracy synchronization may not be achievable across the WAN, so it is left to you to determine if the accuracy meets the needs of your application.

When using the UDP transport mechanism, the device uses Ports 319 or 320 for PTP messages. Except for peer delay messages, the SEL-2440 sets the time allowed to live (TTL) value in the UDP/IP header of PTP messages to 64. This allows you to use routers across a WAN to synchronize to a PTP master.

The Power profile only supports Layer 2 transport and peer-to-peer mechanism. When using the Power profile, the VLAN settings are available for Ethernet frames, choose unique VLAN settings for each protocol.

PTP defines two methods for calculating and correcting the communications path delay between the SEL-2440 and the master clock: end-to-end (Delay Request Response) and peer-to-peer (Peer Delay Request Response). The end-to-end mechanism calculates the total path delay between the SEL-2440 and the master clock. The peer-to-peer mechanism calculates the total path delay as the sum of the delays between peers in the path. SEL recommends the use of this method because it is more accurate. The device periodically initiates path delay calculations.

NOTE: SEL recommends using a specified list of allowable masters for additional security.

By default (with AMNUM := OFF), the device synchronizes to any clock on the network that it evaluates to be the best clock based on the BMCA. If AMNUM is set to a value other than OFF, the number of allowable masters must be identified in accordance with the PTP transport chosen, i.e., MAC address for Layer 2 or IP address for UDP transport. The device will not synchronize to any master clock that is not in the list.

Virtual File Interface

You can retrieve and send data as files through the device virtual file interface. Devices with embedded computers can also use the virtual file interface. When using serial ports of virtual terminal links, use the **FILE DIR** command to access the file interface.

Send and receive files using the following three protocols:

Protocol	Port Availability
FTP	Ethernet only
MMS	Ethernet only
Ymodem	Serial and Ethernet

FTP and MMS File Structure

The Ethernet FTP and the IEC 61850 MMS have a two-level file structure. Files are available at the root level and in subdirectories. *Table 6.47* shows the directories and their contents.

Table 6.47 FTP and MMS Virtual File Structure

Directory	Contents
/ (Root)	Files: CFG.TXT, CFG.XML, ERR.TXT, and SET_61850.CID, Directories: SETTINGS, REPORTS, and UPGRADE
/SETTINGS	Device settings
/REPORTS	SER and signal profile reports
/UPGRADE	Firmware and SELBOOT upgrade files

Root Directory

CFG.TXT File (Read-Only). The CFG.TXT file contains general configuration information about the device and each settings class. External support software retrieves the CFG.TXT file to interact automatically with the device.

```
[INFO]
RELAYTYPE=SEL-2440
FID=SEL-2440-R300-V0-Z009004-D20221111
BFID=SLBT2440-R600-V0-Z000000-D20220621
PARTNO=24402H12B6314840
[CLASSES]
PF,"Port F Settings"
P2,"Port 2 Settings"
P3,"Port 3 Settings"
P1,"Port 1 Settings"
G,"Global Settings"
1,"Device Settings"
L,"Logic Settings"
R,"Report Settings"
D1,"DNP Map 1 Settings"
D2,"DNP Map 2 Settings"
D3,"DNP Map 3 Settings"
```

CFG.XML (Read-Only), ERR.TXT (Read-Only) and SET_61850.CID Files.

These files are only present if the device is ordered with the IEC 61850 protocol option. The CFG.XML file describes the IED configuration such as firmware identification, settings class names, and Ethernet port information. The SET_61850.CID file contains the encrypted IEC 61850 configured IED description. ACSELERATOR Architect® SEL-5032 Software generates and then sends this file to the device. See *Appendix F: IEC 61850 Communications* for more information. The ERR.TXT file contents are based on the most recent SET_61850.CID file written to the device. If there are no errors on writing the CID file, the ERR.TXT file is empty.

Settings Directory (Available for FTP and MMS)

You can access the device settings through files in the SETTINGS directory.

Table 6.48 Settings Directory Files

File Name	Settings Description
SET_1.TXT	Group
SET_D*n*.TXT	DNP3 Map; *n* in range 1–3
SET_G.TXT	Global
SET_L.TXT	Logic
SET_P*n*.TXT	Port; *n* in range 1, 2, 3, F
SET_R.TXT	Report
SET_ALL.TXT	All instances of all settings classes
ERR.TXT	Error log for most recently written settings file

SET_ALL.TXT File (Read-Only). The SET_ALL.TXT file contains the settings for all of the settings classes in the device. Calibration settings are included only when the file is read at Access Level C.

SET_cn.TXT Files (Read and Write). There is a file for each instance of each setting class. *Table 6.48* summarizes the settings files. The settings class is designated by *c*, and the settings instance number is designated by *n*.

ERR.TXT (Read-Only). The ERR.TXT file contents are based on the most recent SET_*cn*.TXT file written to the device. If there were no errors, the file is empty. If the errors occurred, the device logs these errors in the ERR.TXT file.

The device only allows you to write to the individual SET_*cn* files, where *c* is the settings class code and *n* is the settings instance. Except for the SET_61850 CID file, changing settings with external support software involves the following steps:

Step 1. Read the CFG.TXT and the SET_ALL.TXT files from the device.

Step 2. Modify the settings for each settings class and send the corresponding SET_*cn*.TXT file to the device.

Step 3. Read the ERR.TXT file from the device. If the ERR.TXT file is empty, the device detected no errors in the SET_*cn*.TXT file and it is accepted.

Step 4. For any detected errors, fix the SET_*cn*.TXT file as indicated by the ERR.TXT file and send the SET_*cn*.TXT file to the device.

Step 5. Repeat *Step 2* to *Step 4* for each setting class that you want to modify.

Step 6. After all setting changes are complete, test and commission the device.

Reports Directory (Read-Only) (Available for FTP and MMS)

Use the REPORTS directory to retrieve files that contain the reports shown in *Table 6.49*. Note that the device provides a report file that contains the latest information each time you request the file. Each time you request a report, the device stores its corresponding command response in the designated text file.

Table 6.49 Reports Directory Files

File Name	Description	Equivalent Command Response
CPRO.TXT	Compressed ASCII Analog Signal Profile Report	CPRO
PRO.TXT	ASCII Analog Signal Profile Report	PRO
CSER.TXT	Compressed Sequence of Events	CSER
SER.TXT	Sequence of Events	SER

UPGRADE Directory (Read and Write) (Available Only for FTP)

Use the UPGRADE directory to write firmware and SELBOOT upgrade files over FTP and read upgrade error information. See *Table 6.50* for all the files available in the UPGRADE directory. See *Appendix B: Firmware Upgrade Instructions* for firmware upgrade over FTP information.

Table 6.50 Upgrade Directory Files

File Name	Description
RELAY.ZDS	Signed firmware upgrade file
SLBT.ZDS	Signed SELBOOT upgrade file
ERR.TXT	Error log for firmware upgrades

Ymodem File Structure

All the files available (see *Table 6.51*) for Ymodem protocol are in the root directory. See *FILE Command (Manage Settings Files) on page 6.19* for a response to the **FIL DIR** command.

Table 6.51 Files Available for Ymodem Protocol

File Name	Description	Read Access Level	Write Access Level
CFG.TXT	See *Root Directory on page 6.31*	1, 2, C	N/A
ERR.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	N/A
SET_ALL.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	N/A
SET_1.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	2, C
SET_D*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	2, C
SET_G.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	2, C
SET_L*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	2, C
SET_P*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	2, C
SET_R.TXT	See *Settings Directory (Available for FTP and MMS) on page 6.31*	1, 2, C	2, C
CPRO.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 6.32*	1, 2, C	N/A
PRO.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 6.32*	1, 2, C	N/A
CSER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 6.32*	1, 2, C	N/A
SER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 6.32*	1, 2, C	N/A

Batch File Access

Files can be accessed as a batch by using the supported wild card character, *.

FTP and MMS Wild Card Usage

Table 6.52 shows examples using supported wild cards. Note that these wild cards may be appended to a directory path (e.g., /specified_directory/*.txt).

Table 6.52 FTP and MMS Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files and/or subdirectories in a specified directory whose name (including extension) ends with xyz.	/*.TXT	List all files with the .TXT extension
abc*	Lists all files and/or subdirectories in a specified directory whose name begins with abc.	/SETTINGS/SET*	List all settings files that start with SET.
mno	Lists all files and/or subdirectories in a specified directory whose name contains mno.	/SETTINGS/*ET_*	List all files that have ET_ in the name.

Ymodem Wild Card Usage

Event, report, and diagnostic files can also be accessed as a batch by using wild cards.

Table 6.53 Ymodem Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files that end with xyz.	FILE DIR*.TXT	Lists all of the text files
abc*	Lists all files whose name begins with abc.	FILE READ SET	Retrieves all of the settings files

Section 7
Analyzing Events

Overview

The SEL-2440 Discrete Programmable Automation Controller (DPAC) provides a Sequential Events Recorder (SER) report that records as many as 512 state changes of as many as 96 Device Word bits that are timed to the microsecond. SER reports give you detailed information on device element state changes over an extended period of time. The SER captures and time tags state changes of Device Word bits and device conditions to analyze the cause of device operations.

All reports are stored in nonvolatile memory, ensuring that a loss of power to the DPAC will not result in lost data.

Sequential Events Recorder (SER) Report

Inputs

The SER is timed to the microsecond for physical inputs.

Chatter Filtering

The SER includes an automatic deletion and reinsertion function to prevent overfilling of the SER buffer with chattering information. Each processing interval the device checks the Device Word bits in the four SER reports for any changes of state.

When detecting a change of state, the device adds a record to the SER report containing the Device Word bit(s), new state, time stamp, and checksum. When detecting oscillating SER items, the device automatically deletes these oscillating items from SER recording. *Table 7.1* shows the auto-removal settings.

Table 7.1 Auto-Removal Settings

Settings Prompt	Setting Range	Factory Default
Auto-Removal Enable	Y, N	ESERDEL := N
Number of Counts	2–20 counts	SRDLCNT := 5
Removal Time	0.1–90.0 seconds	SRDLTIM := 1.0

To use the automatic deletion and reinsertion function, proceed with the following steps:

Step 1. Set Report setting ESERDEL (Enable SER Delete) to **Y** to enable this function.

Step 2. Select values for the setting SRDLCNT (SER Delete Count) and the setting SRDLTIM (SER Delete Time) that mask the chattering SER element.

Setting SRDLTIM declares a time interval during which the device qualifies an input by comparing the changes of state of each input against the SRDLCNT setting. When an item changes state more than SRDLCNT times in an SRDLTIM interval, the device automatically removes these Device Word bits from SER recording. Once deleted from recording, the item(s) are ignored for the next nine intervals. At the ninth interval, the chatter criteria are again checked and, if the point does not exceed the criteria, it is automatically reinserted into recording at the starting of the tenth interval. You can enable or disable the autodeletion function via the SER settings. Any autodeletion notice entry is lost during changes of settings. The deleted items can be viewed in the SER Delete Report (command **SER D**—refer to *Section 6: Communications* for additional information).

SER Triggering

To capture element state changes in the SER report, enter the Device Word bit into one of the four SER (SER1 through SER4) trigger equations. Each of the four programmable trigger equations allows entry of as many as 24 Device Word bits separated by spaces or commas; the SER report accepts a total of 96 Device Word bits.

The device also adds a `Relay Powered Up` and `Relay Settings Changed` message to the SER when appropriate.

Each entry in the SER includes the SER row number, date, time, element name, and element state.

SER Aliases

Aliases are provided for the name, asserted state, and deasserted state of Device Word bits selected for SER recording. These aliases simplify analysis of sequences. As many as 96 Device Word bits can be selected as triggers and as many as 96 of these can be assigned aliases.

Define the alias by using the following format, where each field can be as many as 15 characters long: name assert deassert. You can use capital letters (A–Z), numbers (0–9), and the underscore character (_) within each string. Do not use a space within a string because the device will interpret a space as the break between two strings. If you wish to clear a string, simply type **NA**.

Viewing and Clearing SER Reports

The device displays the SER records in ASCII format. To retrieve SER information, type **SER <Enter>** at Access Level 1 or higher to see a report similar to that shown in *Figure 7.1*.

Example SER Report

Figure 7.1 shows the data contained in the SER report.

Terminal Identification
Device Identification
Report Date
Report Time

```
SEL-2440                                              Date: 09/23/2008   Time: 12:13:51
DEVICE

Serial No = 000000000000001
FID = SEL-2440-R001-V0-Z001001-D20081010                       CID = B12D

 #      DATE          TIME             ELEMENT                 STATE
150  09/23/2008  12:13:41.000000  TOS                          Asserted
149  09/23/2008  12:13:41.002000  TOS                          Deasserted
148  09/23/2008  12:13:41.224180  52_1_Closed                  Asserted
147  09/23/2008  12:13:41.224180  IN215R                       Asserted
146  09/23/2008  12:13:41.224180  Fan_Running                  Asserted
145  09/23/2008  12:13:41.224180  IN213R                       Asserted
144  09/23/2008  12:13:41.224180  IN212R                       Asserted
143  09/23/2008  12:13:41.224180  IN211R                       Asserted
142  09/23/2008  12:13:41.224180  IN210R                       Asserted
141  09/23/2008  12:13:41.224180  IN209R                       Asserted
140  09/23/2008  12:13:41.224180  IN208R                       Asserted
139  09/23/2008  12:13:41.224180  IN207R                       Asserted
138  09/23/2008  12:13:41.224180  IN206R                       Asserted
137  09/23/2008  12:13:41.224180  IN205R                       Asserted
```

SER Number
SER Date
SER Time
Element or Condition
Element State

Figure 7.1 Sample SER Report

Each entry in the SER includes the SER row number, date, time, element name, and element state. In the SER report, the oldest information has the highest number, i.e., the newest information is the Number 1 entry (RB01 in *Figure 7.1*). When using a computer terminal you can change the order of the SER records in the SER report. See *SER Command (Sequential Events Recorder Report) on page 6.23* for more information.

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Section 8
Testing and Troubleshooting

Overview

This section provides information on installation and periodic testing for the SEL-2440 Discrete Programmable Automation Controller (DPAC). Because the DPAC is equipped with extensive self-tests, traditional periodic test procedures may be eliminated or greatly reduced. Should a problem arise during either installation or periodic tests, the section on *Troubleshooting on page 8.3* provides a guide to isolating and correcting the problem.

Testing

Because the DPAC is equipped with extensive self-tests, the most effective periodic maintenance task is to view the status report after a self-test failure.

The DPAC does not require specific routine tests, but your operation standards may require some degree of periodic device verification. If you need or want to perform periodic device verification, the following checks are recommended.

Configuration

Check the DPAC control (DIP) switch configuration settings. Ensure that the transmit address matches the receive address of the remote device and that the baud rate is identical.

Device Status Verification

The **ENABLED** LED should be illuminated. The b form of the ALARM contact should be open. Press the **LAMP TEST** pushbutton. All LEDs should illuminate. When you release the pushbutton, the LEDs should extinguish.

Use the serial port **STATUS** command to verify that the device self-tests have not detected any FAIL conditions.

Input Verification

Use the front-panel status LEDs to check the input status in the device. As you apply rated voltage to each input, the LED corresponding to that input should change from extinguished (OFF) to illuminated (ON).

Output Verification

For each output contact, set the input to logical 1. This causes the output contact to close. For example, setting OUT101 = 1 causes the output **OUT101** contact to close. Repeat the process for all contact outputs. Make sure that each contact closure behaves correctly in the annunciation, control, or trip circuit associated with that contact closure.

SER Command

The device provides a Sequential Events Recorder (SER) report that time-tags changes in device and input/output contact states. The SER report provides a convenient means to verify the pickup/dropout of any element in the device. *Table 6.36* shows the **SER** commands to view and manage the Sequential Events Recorder report.

TARGET Command

Use the **TAR** command to view the state of device inputs, outputs, and elements during a test. The **TAR** command displays the status of Device Word bits, as shown in *Table 6.42*. The bits are listed in rows of eight, called Device Word rows, which are described in *Table H.1*.

Self-Test

The DPAC runs a variety of self-tests. Two Device Word bits, HALARM and SALARM, indicate self-test problems. SALARM is pulsed for software-programmed conditions such as settings changes, access level changes, and three consecutive unsuccessful password entry attempts. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures.

NOTE: After a device failure, all digital output contacts revert to their de-energized state, i.e., all normally open contacts (Form A) open and all normally closed contacts (Form B) close.

Table 8.1 lists hardware self-tests. In the Alarm Status column, Latched indicates that HALARM is continuously asserted, Not Latched indicates that HALARM is pulsed for 5 seconds, and NA indicates that HALARM is not asserted. All hardware self-test failures disable the device and generate a message that is automatically sent to the serial port.

Table 8.1 Device Self-Tests (Sheet 1 of 2)

Self-Test	Description	Monitoring Disabled on Failure	Alarm Status	Status Command
Main Board FPGA (power up)	Fail if main board Field Programmable Gate Array does not accept program or the version number is incorrect	Yes	Latched	FPGA OK/FAIL
Main Board FPGA (run time)	Fail on lack of data acquisition interrupts or on detection of a CRC error in the FPGA code	Yes	Latched	FPGA OK/FAIL
Front-Panel HMI (power up)	Fail if ID registers do not match expected or if FPGA programming is unsuccessful	No	Not Latched	HMI OK/WARN
External RAM (power up)	Performs a read/write test on system RAM	Yes	Latched	RAM OK/FAIL
External RAM (run time)	Performs a read/write test on system RAM	Yes	Latched	RAM OK/FAIL
Internal RAM (power up)	Performs a read/write test on system CPU RAM	Yes	Latched	RAM OK/FAIL
Internal RAM (run time)	Performs a read/write test on system CPU RAM	Yes	Latched	RAM OK/FAIL
Code Flash (power up)	SELBOOT qualifies code with a checksum	NA	NA	NA
Code Flash (run time)	Checksum is computed on the entire code base	Yes	Latched	ROM OK/FAIL
Data Flash (power up)	Checksum is computed on critical data	Yes	Latched	NON_VOL OK/FAIL
Data Flash (run time)	Checksum is computed on critical data	Yes	Latched	NON_VOL OK/FAIL

Table 8.1 Device Self-Tests (Sheet 2 of 2)

Self-Test	Description	Monitoring Disabled on Failure	Alarm Status	Status Command
Critical RAM (settings)	Performs a checksum test on the active copy of settings	Yes	Latched	CR_RAM OK/FAIL
Critical RAM (run time)	Verifies instruction (code) matches Flash image	Yes	Latched	CR_RAM OK/FAIL
Clock Battery	Check battery voltage level	No	Not Latched	CLKBAT OK/WARN
Clock Chip	Unable to communicate with clock or fails time keeping test	No	Not Latched	CLOCK OK/WARN
Clock Chip RAM	Clock chip static RAM fails	No	Not Latched	CLOCK OK/WARN
CID (Configured IED Description) file (access)	Fail if unable to access/read the file	NA	NA	CID_FILE[a] OK/FAILOVER/FAIL
+15 V Fail	Monitor +15 V power supply	Yes	Latched	+15 V OK/FAIL
Exception Vector	CPU Error	Yes	Latched	NA
Processor Fail	Processing Failure	Yes	Latched	PROC FAIL

[a] CID only appears when the IEC 61850 option is installed and enabled.

Troubleshooting

Refer to the following table for troubleshooting instructions.

Problem	Possible Cause	Solution
The device **ENABLED** front-panel LED is dark.	Input power is not present or a fuse is blown. Self-test failure.	Verify that input power is present. Issue **STA** command from Access Level 1 to verify system self-tests are OK. Issue **VEC D** command from Access Level 2 to verify there are no system vectors.
The device does not respond to commands from a device connected to the serial port.	Cable is not connected. Cable is the incorrect type. The device or communicating device has communications mismatch(es). The device serial port has received an XOFF, halting communications.	Verify the cable connections. Verify the cable pinout. Verify device communications parameters. Type **<Ctrl+Q>** to send the device XON and restart communications.

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Appendix A
Firmware and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front panel. The status report displays the Firmware Identification (FID) number.

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.

A standard release is identified by a change in the R-number of the device FID number.

Existing firmware:

FID=SEL-2440-**R100**-V0-Z001001-Dxxxxxxxx

Standard release firmware:

FID=SEL-2440-**R101**-V0-Z001001-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID number.

Existing firmware:

FID=SEL-2440-R100-**V0**-Z001001-Dxxxxxxxx

Point release firmware:

FID=SEL-2440-R100-**V1**-Z001001-Dxxxxxxxx

The date code is after the D. For example, the following is firmware version number R100, date code December 10, 2003.

FID=SEL-2440-R100-V0-Z001001-**D20031210**

Revision History

Table A.1 lists the firmware versions for R300-series firmware, revision descriptions, and corresponding instruction manual date codes. *Table A.2* lists the firmware versions for R200-series firmware (see *Table A.3* for R100 series firmware). The most recent firmware version is listed first.

When upgrading from R200-series firmware versions to R300 or later, the device SELBOOT version must be updated. For detailed information on this upgrade process, see *Special Instructions for Upgrading to R300 Series Firmware on page B.2*.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with “[Cybersecurity]”. Improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with “[Cybersecurity Enhancement]”.

Table A.1 Firmware Revision History for R300 Series Firmware (Sheet 1 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2440-R301-V0-Z009004-D20250228	➤ [Cybersecurity] Resolved an issue where the MMS server did not lock the user out after three failed password attempts within one minute. ➤ Updated IEC 61850 protocol implementation to IEC 61850 Edition 2.1. ➤ Improved processing of pulsed remote bits by adding support for pulse configuration attributes cmdQual, onDur, offDur, and numPls according to IEC 61850-7-3. ➤ Extended LPHD logical node to include IEC 61850 library version (SelLibId). ➤ Added support for indexed unbuffered and buffered MMS reports. ➤ Added support for the sAddr attribute to replace the esel:datasrc attribute in ICD files to improve compatibility with third-party system configuration tools. ➤ Added support to allow the relay to accept GOOSE data with questionable or invalid validity. ➤ Added support for deadband configuration, including the dbRef, dbAngRef, zeroDbRef, and zeroDb attributes, according to IEC 61850-7-3 Edition 2.1. ➤ Added support for attributes valImport and valKind according to IEC 61850-6 for compatibility with third-party system configuration tools. ➤ Added the **NET** command. ➤ Added MODE Device Word bit that asserts when the device is in Flexible mode. ➤ Improved support for IEC 61850 Edition 1 MMS clients. ➤ Resolved an issue with the reporting of the quality data attribute in IEC 61850 OFF mode. ➤ Enhanced the relay firmware to retain the IP address, subnet mask, and default router settings after a **R_S** command is issued. ➤ Resolved an issue with the processing of multicast and broadcast messages in failover mode. ➤ Resolved an issue introduced in R300-V0 where the device may not apply PREDLY setting of OFF correctly. ➤ Resolved an issue introduced in R300-V0 where the settings for ALTPRI2 and ALTPRI3 were tied. ➤ Resolved an issue where entering a special character for a settings value via the terminal session may cause the device to interpret the setting as 0.	20250228
SEL-2440-R300-V0-Z009004-D20221110	➤ [Cybersecurity Enhancement] Added support for zipped and digitally signed (.zds) firmware files. These files require the SELBOOT firmware version to be upgraded to R600 first. Firmware files with the .s19 and .z19 extensions cannot be sent to relays with SELBOOT firmware R600. ➤ [Cybersecurity Enhancement] Added the ability to upgrade relay firmware remotely over an Ethernet network. ➤ [Cybersecurity Enhancement] Added EACC, E2AC, and EPAC settings to support port access control using SELOGIC control equations. ➤ [Cybersecurity Enhancement] Enhanced SER to record “Relay Settings Changed” on a port settings change. ➤ [Cybersecurity Enhancement] Enhanced SALARM behavior to pulse for 1 second on a port setting change. ➤ Added run-time configurable timers and more variables/timers. ➤ Added communication time-out indication for DNP and Modbus.	20221110

Table A.1 Firmware Revision History for R300 Series Firmware (Sheet 2 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Added the **TEST DB** command to support relay testing. ➤ Added SELOGIC variable SC850SM for IEC 61850 simulation mode. ➤ Added support for IEC 61850 mode/behavior. ➤ Added support for fast analog processing (ERAFAST setting). ➤ Added support for IEEE 1588-2008 firmware-based Precision Time Protocol (PTP) for time synchronization. ➤ Added support for the IEC 61850 Local/Remote control feature defined in the IEC 61850-7-4 standard. ➤ Added support for MMS file transfer. ➤ Added support for virtual file interface. ➤ Added support for analog input event buffers for DNP. ➤ Added support for setting analog change event variation (DVARAIE*n*) for DNP. ➤ Added Device Word bits to indicate speed and duplex mode for established Ethernet links. ➤ Enhanced Time Source status to allow for reporting SNTP, DNP, and PTP time sources. ➤ Enhanced status report to display “FAILOVER” when the device fails to parse the current CID file and has reverted to using the default CID file. ➤ Improved timer accuracy and expanded setting ranges for variables/ timers. ➤ Resolved an issue where the err.txt file may report an incorrect element when the ENABLED word bit is included in the SER report. ➤ Resolved an issue where the IRIGOK word bit may occasionally deassert while the device is receiving IRIG-B time through the fiberoptic port 2 or from an SEL-2812 fiber-optic transceiver through port 3. ➤ Resolved an issue where the device may not correctly update Remote Analogs in the analog processing interval. ➤ Resolved an issue where the device may allow duplicate names for SEL aliases. ➤ Resolved an issue where a counter’s active low and active high outputs would not assert after a restart until the counter value changed at least once. ➤ Removed raw inputs from default SER settings. ➤ Resolved an issue where the device may not properly close a DNP TCP connection after the connection timeout has expired. ➤ Removed RSTTRGT from the global settings.	

Table A.2 Firmware Revision History for R200 Series Firmware (Sheet 1 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2440-R216-V3-Z008004-20220128	Includes all the functions of SEL-2440-R216-V2-Z008004-D20211021 with the following addition: ➤ Resolved an issue introduced in R216-V2 that may prevent firmware upgrades from succeeding on devices manufactured before December 21, 2021.	20220128
SEL-2440-R216-V2-Z008004-D20211021	Includes all the functions of SEL-2440-R216-V1-Z008004-D20190315 with the following addition: ➤ Revised firmware for FPGA part replacement. **Note**: Units built after December 21, 2021, are no longer compatible with firmware versions R216-V1 and earlier.	20211021
SEL-2440-R216-V1-Z008004-D20190315	Includes all the functions of SEL-2440-R216-V0-Z008004-D20180926 with the following addition: ➤ Improved backward compatibility with certain MMS clients.	20190315
SEL-2440-R216-V0-Z008004-D20180926	➤ Revised hardware for IEC 60255-26 and IEC 60255-27. ➤ Added support for 10 FHCDO board option. ➤ Added support for Millisecond MIRRORED BITS. **Note**: Units built after September 26, 2018, are no longer compatible with firmware versions R215-V0 and earlier.	20180926
SEL-2440-R215-V0-Z007004-D20180131	➤ Added support for IEC-61850 Edition 2. ➤ Added a dedicated MAC address to improve GOOSE processing performance. **Note**: Units built with R214 or older can be upgraded to firmware versions R215 or newer, but the unit will not have the GOOSE performance improvements (dedicated MAC address).	20180330
SEL-2440-R214-V3-Z007004-D20180801	Includes all the functions of SEL-2440-R214-V2-Z007004-D20170116 with the following addition: ➤ Resolved an issue introduced in R214-V0 that could prevent receipt of new GOOSE messages after a heavy storm of GOOSE messages.	20180801
SEL-2440-R214-V2-Z007004-D20170116	Includes all the functions of SEL-2440-R214-V1-Z007004-D20160210 with the following additions: ➤ Resolved an issue introduced in R214-V0 that prevented SNTP time synchronization from functioning when using PRP. ➤ Resolved an issue introduced in R214-V0 that prevented GOOSE VLAN tags from being applied when using PRP.	20170114
SEL-2440-R214-V1-Z007004-D20160210	Includes all the functions of SEL-2440-R214-V0-Z007004-D20151120 with the following addition: ➤ Resolved an issue introduced in R208 that could cause the device to momentarily disable during a startup sequence.	20160210
SEL-2440-R214-V0-Z007004-D20151120	➤ Added Parallel Redundancy Protocol (PRP). ➤ Increased the number of DNP binary outputs from 32 to 64. ➤ Increased the number of SER aliases from 20 to 96. ➤ Modified the behavior of STSET to assert after a setting download.	20151120
SEL-2440-R213-V1-Z006004-D20150707	Includes all the functions of SEL-2440-R213-V0-Z006004-D20141027 with the following addition: ➤ Resolved an issue that caused SELOGIC timers to drop out after a temporary dropout of the input that was less than the timer's dropout time setting.	20150707

Table A.2 Firmware Revision History for R200 Series Firmware (Sheet 2 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2440-R213-V0-Z006004-D20141027	➤ Enhanced device self-diagnostics to prevent false clock, 15 V, and battery warnings. ➤ Resolved an issue on Port F setting transfers by using YMODEM that prevented QuickSet from knowing the transfer completed. ➤ Resolved an issue that could vector the unit when attempting to transfer system files with FTP. ➤ Added default setting for DNP frozen counters. ➤ Added DAYM and MONTH analog time quantities.	20141027
SEL-2440-R212-V0-Z005003-D20131217	➤ Resolved handling of unrecognized Ethertype frames that can cause Ethernet to stop responding.	20131217
SEL-2440-R211-V0-Z005003-D20130503	➤ Resolved an issue introduced in R210 with the initial Gratuitous ARP that prevented the relay from initializing when the Ethernet port is disabled.	20130503
SEL-2440-R210-V0-Z005003-D20130418	➤ Resolved an issue in Port 1 Failover mode that could cause it to not switch ports in the event of a cable loss. ➤ Resolved an issue with the initial Gratuitous ARP request not being sent for as long as five minutes after startup.	20130418
SEL-2440-R209-V0-Z005003-D20121107	➤ Resolved an issue that prevented SNTP time sources from time stamping IEC 61850 tags. ➤ Resolved an issue that caused improper behavior of SNTP MANYCAST mode.	20121107
SEL-2440-R208-V0-Z005003-D20111128	➤ Added support for SNTP time synchronization. ➤ Added 32 additional SELOGIC variables. ➤ Made the SEL-2440 series Flash driver more robust to prevent unintended writes or erasures.	20111128
SEL-2440-R206-V0-Z004002-D20110819	➤ Resolved an issue where state of the output contacts may change during the device warm start that follows a settings change.	20110819
SEL-2440-R205-V0-Z004002-D20100917	➤ Added support for storage of Designer Templates. ➤ Enhanced device self-diagnostic capabilities.	20100917
SEL-2440-R204-V0-Z003002-D20100428	➤ Resolved an error on Port 2 EIA-485 option that rendered DNP communications inoperable. ➤ Increased timestamp accuracy when using IEC 61850. ➤ Enhanced DNP security by verifying entire request when processing controls. ➤ Resolved possible memory allocation failures during IEC 61850 configuration.	20100428
SEL-2440-R203-V0-Z003002-D20100115	➤ Resolved an occasional IEC 61850 communications defect where the firmware incorrectly reads an opcode from Flash memory and results in a vector. ➤ Added support for 48 DI option. ➤ Added DNP controls/pulse controls and DNP frozen counters. ➤ Added support for as many as five DNP sessions and control bits with pulse control. ➤ Added Modbus force multicoil capability. ➤ Added ability to disable Telnet, FTP, and Modbus over Ethernet port.	20100115

Table A.2 Firmware Revision History for R200 Series Firmware (Sheet 3 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2440-R201-V0-Z002002-D20091119	➤ Resolved IRIG-B signal inversion and loss-of-time sync when serial Port 2 is configured with the ST Fiber or EIA-485 option for the IRIG-B time source. ➤ Corrected erroneous assertion of digital outputs for approximately 1 second on unit power-up.	20091119
SEL-2440-R200-V0-Z002002-D20091005	➤ No functional changes. Revised firmware for processor update. Previous versions cannot be upgraded to R200.	20091005

Table A.3 Firmware Revision History for R100 Series Firmware

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2440-R105-V1-Z002002-D20150805	Includes all the functions of SEL-2440-R105-V0-Z002002-D20131004 with the following addition: ➤ Resolved an issue that caused SELOGIC timers to drop out after a temporary dropout of the input that was less than the timer's dropout time setting.	20151020
SEL-2440-R105-V0-Z002002-D20131004	➤ Resolved an Ethernet Failover Switching issue for dual Ethernet models. ➤ Resolved an issue with the initial Gratuitous ARP request not being sent for as long as five minutes after startup.	20131004
SEL-2440-R104-V0-Z002002-D20090716	➤ Removed potential loss of SER data on raw contact inputs (IN101R, IN102R, etc.).	20090716
SEL-2440-R103-V0-Z002002-D20090224	➤ Added support for 32 DO/16 DI (Option 1) configuration. ➤ Updated Analog Quantity Support to include MS (millisecond). ➤ Improved IEC 61850 security.	20090224
SEL-2440-R101-V0-Z001001-D20081030	➤ Updated IEC 61850 firmware to streamline MMS processing and improve TCP/IP connections. ➤ Improved security.	20081030
SEL-2440-R100-V0-Z001001-D20081010	➤ Initial version.	20081010

SELBOOT Firmware Version and Device Firmware Compatibility

The SELBOOT version and compatible device firmware versions are listed in *Table A.4*. Older versions are not listed for simplicity. SELBOOT firmware versions R600 and later ensure that the device firmware upgrade file is digitally signed by SEL using a secure hash algorithm and that the file has been provided by SEL and that its contents have not been altered.

Firmware version R300-V0 or later requires that the SELBOOT firmware be upgraded to R600 or later.

Table A.4 SELBOOT Firmware Revision History

Boot Firmware Identification Number	SEL-2440 Firmware Versions Supported	Date Code
SLBT2440-R600-V0-Z000000-D20220621[a]	R300 and higher	20220621
SLBT24XX-R600-V0-Z000000-D20210430[a]	R300 and higher	20210430
SLBT-2440-R300-V0-Z000000-D20180926[b]	R216	20180926
BOOTLDR-R501-V0-Z000000-D20140224	R213–R216	20140224
BOOTLDR-R500-V0-Z000000-D20090925	R200–R216	20090925

[a] The SELBOOT upgrade file (with filename pattern: slbtldr_rxx-vx24xx.s19) will upgrade the SELBOOT Firmware depending on the currently installed version. For example, slbtldr_r600-v224xx.s19 will upgrade devices with SLBT-2440-R300 to SLBT2440-R600, and BOOTLDR-R50x to SLBT24XX-R600.

[b] The supported firmware versions for this SELBOOT version are hardware dependent. See *Table A.2* for more details.

ICD File

Issue the SEL ASCII command **ID** to find the ICD revision number (configVersion) in your device.

The configVersion appears in the following format in the responses.

configVersion = ICD-2440-R110-V0-Z000000-D20180412

The ICD revision number follows the R (e.g., 110) and the date code follows the D (e.g., 20180412). This revision number is not related to the relay firmware revision number.

configVersion = ICD-2440-R**110**-V0-Z000000-D**20180412**

Beginning with the R111 ICD file version, the Z-number is non-zero. In the new format, the first three digits following the Z represent the minimum IED firmware required to be used with the ICD (e.g., 200).

configVersion = ICD-2440-R110-V0-Z**200**000-D20180412

The last three digits represent the ICD ClassFileVersion (

configVersion = ICD-2440-R110-V0-Z200**006**-D20180412

The ICD file version is used to create the CID file that is loaded in the relay.

See *Table A.5* for the ICD file revision history.

Table A.5 ICD File Revision History (Sheet 1 of 2)

configVersion	Summary of Revisions	Minimum Relay Firmware	ClassFileVersion
ICD-2440-R112-V0-Z301010-D20250228	➤ Initial ICD file release with Edition 2.1 support and compatibility. ➤ Updated ClassFileVersion to 010. ➤ Added support for pulse configuration attributes cmdQual, onDur, offDur, and numPls according to IEC 61850-7-3. ➤ Added support for deadband data attributes dbRef, dbAngRef, zeroDbRef, and zeroDb according to IEC 61850-7-3 Edition 2.1. ➤ Added support for attributes valImport and valKind according to IEC 61850-6 for compatibility with third-party system configuration tools. ➤ Extended LPHD logical node to include IEC 61850 library version (SelLibId). ➤ Added support for sAddr attribute to replace esel:datasrc attribute in ICD files to improve compatibility with third-party system configuration tools. ➤ Conformance-related changes.	R301	010
ICD-2440-R111-V0-Z300006-D20221014	➤ Added system logical nodes LGOS, LTIM, LTMS, and LCCH. ➤ Added the device main board version numbers to the IEC 61850 LPHD logical node.	R300	006

Table A.5 ICD File Revision History (Sheet 2 of 2)

configVersion	Summary of Revisions	Minimum Relay Firmware	ClassFileVersion
	➤ Added the IEC 61850 LTRK logical node for service tracking. ➤ Added support for the IEC 61850 Functional Naming Feature. ➤ Added support for PRBGGIO logical node for pulsing remote bits. ➤ Added support for No Operation by allowing NOOP as data source for IEC 61850 Data objects.		
ICD-2440-R110-V0-Z000000-D20180412	➤ Added support for IEC 61850 Edition 2. ➤ Certified by KEMA for IEC 61850 conformance.	R215	006
ICD-2440-R107-V0-Z000000-D20111101	➤ Added Conformance Enhancements.	R207	004
ICD-2440-R105-V0-Z000000-D20091123	➤ Renamed GAIO logical node classes as GGIO.	R104	003
ICD-2440-R101-V0-Z000000-D20081014	➤ Initial release of the SEL-2440 ICD file for firmware R100 or higher.	R100	002

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table A.6 lists the instruction manual versions and revision descriptions. The most recent instruction manual version is listed first.

Table A.6 Instruction Manual Revision History (Sheet 1 of 8)

Date Code	Summary of Revisions
20250228	Preface ➤ Updated *SEL-2440 LED Information*. Section 1 ➤ Updated *Specifications*. Settings Sheets ➤ Removed *Event Report Settings*. Section 6 ➤ Updated *Table 6.8: Serial Port Protocols* and *Table 6.9: Ethernet Protocols*. ➤ Added *CASCII Command (Compressed ASCII), CSER Command (Compressed SER Report)*, and *NET Command (Network Status)*. ➤ Updated *Table 6.45: Settings Associated With SNTP*. ➤ Updated *ESNTP = UNICAST, ESNTP = MANYCAST*, and *ESNTP = BROADCAST*. Appendix A ➤ Updated *Revision History*. ➤ [Cybersecurity] Updated for firmware version R301-V0. ➤ Updated for ICD version R112-V0. Appendix E ➤ Updated *Table E.17: Modbus Register Map*.

Table A.6 Instruction Manual Revision History (Sheet 2 of 8)

Date Code	Summary of Revisions
	Appendix F ➤ Updated *Features*. ➤ Added *Introduction to IEC 61850*. ➤ Updated *Object Models, Control, File Services*, and *Reports*. ➤ Added *Deadband Configuration and Functionality*. ➤ Updated *GOOSE Processing, NamPlt, Standard Logical Nodes*, and *Logical Nodes.* ➤ Added *SEL Nameplate Data, Architect Flexible Server Model (FSM),* and *Potential Client and Automation Application Issues With Ed2 and 2.1 Upgrades.* Appendix H ➤ Updated *Table H.1: SEL-2440 Device Word Bits* and *Table H.2: Device Word Bit Definitions.*
20221221	Section 1 ➤ Added UKCA to *Specifications*.
20221110	General ➤ Updated phrasing from relay to device. Section 1 ➤ Updated *Communications Protocol* in *Features*. ➤ Updated *Time-Code Input (SNTP)*, *Processing Specifications*, and *Communications Protocols* in *Specifications*. ➤ Added *Time-Code Input (PTP)* and *Sampling Processing Specifications* in *Specifications*. Section 2 ➤ Updated *Power* in *Connections*. ➤ Updated *Figure 2.11: Power Connections*. Section 3 ➤ Updated *Table 3.3: Ethernet Network Settings*. ➤ Added *Table 3.5: Modbus Settings*. ➤ Updated *Table 3.6: DNP3 Settings*. ➤ Updated *SELogic Settings* in *Getting Started*. ➤ Added *Local/Remote Control* in *Getting Started*. ➤ Added *Multilevel Local/Remote Control* in *Getting Started*. ➤ Updated *Time and Date Management Settings* in *Getting Started*. ➤ Added *SEL-2440 Settings Sheets*. Section 4 ➤ Updated SELOGIC *Enables* and *Variables/Timers* in *General Logic Functions*. ➤ Added *Run-Time Configurable Timers* in *General Logic Functions*. ➤ Added note under *Math Variables* in SELOGIC *Control Equation Operators*. ➤ Moved *Table 4.11: SEL-2440 Device Word bits* to *Appendix H: Device Word Bits*. Section 5 ➤ Added notes under *Remote Analogs* in *Metering*. Section 6 ➤ Updated *Overview*. ➤ Updated *Communication Interfaces*. ➤ Added *Serial (EIA-232 and EIA-485) Port* in *Communication Interfaces*. ➤ Added *Ethernet Port* in *Communication Interfaces*. ➤ Updated *+5 Vdc Power Supply* in *Communications Interfaces*. ➤ Added *Time-Out Indication* in *Communications Interfaces*. ➤ Updated *Table 6.10: Access Level* and *Table 6.11: Access Commands*. ➤ Added *Port Access Control* in *Device Access*. ➤ Added *COM PTP Command* in *ASCII Commands*. ➤ Updated *TARGET Command (Display Device Word Bit Status)* in *Simple Network Time Protocol (SNTP)*. ➤ Added *TEST DB Command* and *Precision Time Protocol (PTP)* in *Simple Network Time Protocol (SNTP)*. ➤ Added *Virtual File Interface*.

Table A.6 Instruction Manual Revision History (Sheet 3 of 8)

Date Code	Summary of Revisions
	Section 8 ➤ Updated *Table 8.1: Device Self-Tests*. Appendix A ➤ Added SELBOOT *Firmware Version and Device Firmware Compatibility*. ➤ Added *ICD File*. Appendix B ➤ Updated *Overview*. ➤ Added *Upgrade the Firmware Using a Terminal Emulator*, *Upgrade the Firmware Using ACSELERATOR QuickSet*, *Upgrade the Firmware Using File Transfer Protocol*, *Upgrade the Firmware Via Terminal Emulator Using the FILE Command Over Telnet*, and *IEC 61850 CID File Upgrade Instructions*. Appendix E ➤ Updated *Table E.17: Modbus Register Map*. Appendix F ➤ Updated *Features*, *IEC 61850 Configuration*, and *Logical Nodes*. ➤ Added *IEC 61850 Operation*, *IEC 61850 Simulation Mode*, *IEC 61850 Mode/Behavior*, *Common Logical Nodes*, *Protocol Implementation Conformance Statement*, and *ACSI Conformance Statements*. Appendix G ➤ Updated *Overview*. ➤ Updated *Message Transmission* in *Operation*. Appendix H ➤ Added *Appendix H: Device Word Bits*. Appendix I ➤ Added *Appendix I: Cybersecurity Features*. Index ➤ Updated *ASCII Commands*.
20220902	Section 1 ➤ Updated *Inputs* in *Specifications*.
20220128	Appendix A ➤ Updated for firmware version R216-V3.
20211021	Appendix A ➤ Updated for firmware version R216-V2.
20210831	Section 1 ➤ Updated *Type Tests* in *Specifications*.
20190315	Appendix A ➤ Updated for firmware version R216-V1.
20180926	Section 1 ➤ Updated Specifications. Section 2 ➤ Updated *Front- and Rear-Panel Drawings*. Section 3 ➤ Updated *Serial Port Settings*. Appendix A ➤ Updated for firmware version R216-V0.
20180801	Appendix A ➤ Updated for firmware version R214-V3.
20180330	Section 1 ➤ Updated *Specifications*.

Table A.6 Instruction Manual Revision History (Sheet 4 of 8)

Date Code	Summary of Revisions
	Section 3 ➤ Added *Time-Synchronization Source*. Section 6 ➤ Updated *Table 6.4: EIA Serial Port Pin Functions*. ➤ Updated *MAC Command*. Section 7 ➤ Updated *Chatter Filtering*. Appendix A ➤ Updated for firmware version R215-V0.
20170120	Appendix A ➤ Revised R214-V2 revision history.
20170114	Appendix A ➤ Updated for firmware version R214-V2.
20160325	Preface ➤ Updated *Safety Information*. Section 1 ➤ Updated *Specifications*. Appendix A ➤ Updated point release information. Appendix B ➤ Updated point release information.
20160210	Appendix A ➤ Updated for firmware version R214-V1.
20151120	Section 3 ➤ Updated *Network Settings* for PRP. Appendix A ➤ Updated for firmware version R214.
20151020	Appendix A ➤ Updated for firmware version R105-V1.
20150714	Appendix A ➤ Added details on description of firmware point releases. Appendix B ➤ Added examples to show the difference between firmware standard releases and firmware point releases.
20150707	Preface ➤ Updated *Safety Marks*. Appendix A ➤ Updated for firmware version R213-V1.
20150116	Preface ➤ Updated *Safety Information*. Section 1 ➤ Renamed *Certifications* to *Compliance* and moved to the beginning of *Specifications*.
20141027	Preface ➤ Updated *Wire Sizes and Insulation* information in *Safety and General Information*. Section 3 ➤ Added *Time and Date Management* heading, note, and figure in *Flexible Mode*. ➤ Updated *Table 3.4: Serial Port Settings*. ➤ Updated *Table 3.5: DNP3 Settings*.

Table A.6 Instruction Manual Revision History (Sheet 5 of 8)

Date Code	Summary of Revisions
	Section 4 ➤ Updated *Latches Settings* information in *General Logic Functions*. ➤ Updated *Table 4.10: Available Analog Quantities*. Section 6 ➤ Added note under *IRIG-B* in *Communications*. Appendix A ➤ Updated for firmware version R213.
20140717	Preface ➤ Moved caution, warning, and danger statements from front cover to *Preface*. ➤ Added warning stating that users should de-energize the device and all external connections before disconnecting any terminal blocks or modifying the wiring on any terminal blocks.
20131217	Section 2 ➤ Updated *Figure 2.9: Power Connections*. Section 4 ➤ Updated *Table 4.11:* SEL-2440 *Device Word Bits*. Appendix A ➤ Updated for firmware version R212. Appendix D ➤ Added *Ethernet Operation* and *Table D.2: DNP-IP Specific Settings*.
20131004	Appendix A ➤ Updated for firmware version R105. ➤ Added *Table A.2: Firmware Revision History for R100 Series Firmware*. ➤ Moved R100 series firmware information from *Table A.1* to *Table A.2*.
20130503	Appendix A ➤ Updated for firmware version R211.
20130418	Section 1 ➤ Updated *Table 1.1: Optional Accessories*. Appendix A ➤ Updated for firmware version R210.
20121107	Section 6 ➤ Added *Simple Network Time Protocol (SNTP)*. Appendix A ➤ Updated for firmware version R209.
20120601	Section 1 ➤ Updated *Specifications*.
20111128	Section 2 ➤ Updated UL listing in *Specifications*. ➤ Added SNTP accuracy in *Specifications*. Section 3 ➤ Added SNTP settings. Section 4 ➤ Updated logic and word bits for 32 additional SELOGIC variables and SNTP. Appendix A ➤ Updated for firmware version R208. Appendix D ➤ Updated *Table D.5 SEL-2440 DNP Object List*.

Table A.6 Instruction Manual Revision History (Sheet 6 of 8)

Date Code	Summary of Revisions
	Appendix E ➤ Updated *Table E.17 Modbus Register Map*. Appendix F ➤ Updated *Table F.1 Logical Device: ANN (Annunciation)*.
20110819	Appendix A ➤ Updated for firmware version R206.
20100917	Section 2 ➤ Added description of parallel power connection. Section 3 ➤ Added note to Easy Mode that Firmware upgrade is only possible in Flexible Mode. ➤ Added Graphical Logic Editor and Designer Template Storage to Getting Started. ➤ Added OFF to UTIMEO*n* range setting. Section 6 ➤ Added description of alarm contact behavior for access levels and setting change. Section 8 ➤ Added to description of FPGA Self-Tests. Appendix A ➤ Updated for firmware version R205. Appendix B ➤ Added steps to ensure that DPAC is in Flexible Mode for firmware updates. Appendix D ➤ Added description of the effect of setting UTIMEO*n* to OFF.
20100730	Section 1 ➤ Added UL/cUL certification. ➤ Added 220/250 Vdc Input Specifications Section 2 ➤ Included additional rear-panel drawings. ➤ Clarified *Table 2.1: Port Characteristics.* Section 3 ➤ Added more detailed description of Digital Input Debounce Settings. Section 6 ➤ Removed cable C675 from *Table 6.5: Communications Cables.* Appendix D ➤ Added *Table D.9 R202 or Previous Example Object 12 Trip/Close or Code Selection Operation* for legacy firmware.
20100629	Section 7 ➤ Changed description about timestamps in the SER. Appendix E ➤ Increased the range of the relay word in the Modbus map to accommodate Control Bits 1–128.
20100428	Appendix A ➤ Updated for firmware version R204.
20100115	Section 1 ➤ Added 110 V input option to *Options*. ➤ Updated *Specifications*. Section 3 ➤ Added Ethernet enable settings for FTP, Telnet, and Modbus to *Table 3.3: Ethernet Network Settings*. ➤ Updated *Table 3.5: DNP3 Settings*.

Table A.6 Instruction Manual Revision History (Sheet 7 of 8)

Date Code	Summary of Revisions
	Section 4 ➤ Added *Remote Bits*, *Control Bits*, and *Virtual Bits* descriptions. ➤ Expanded *Math Variables* description. Section 6 ➤ Changed TOS duration from 4 ms to 2 ms in *Table 6.3: IRIG-B Device Word Bits*. ➤ Clarified **CONTROL** command. ➤ Added **CONTROL control_bits** command. Section 8 ➤ Clarified troubleshooting steps. Appendix A ➤ Updated for firmware version R203. Appendix D ➤ Updated DNP3 description. ➤ Updated *Table D.4: DPAC DNP3 Device Profile, Table D.5: SEL-2440 DNP3 Object List*, and *Table D.6: DNP3 Reference Data Map*. Appendix E ➤ Updated Modbus description ➤ Updated *Table E.1: DPAC Modbus Functions* and *Table E.3: DPAC Inputs*. ➤ Added *0Fh Multicoil Write Command*. Appendix F ➤ Updated *Table F.1: Logical Device: ANN (Annunciation)*.
20091119	Section 1 ➤ Added third option for I/O Quantity in *Options*. ➤ Updated *Specifications* to include High-Current Interrupting Output Option, and clarified Fiber-Optic Ports Characteristics. Section 3 ➤ Clarified factory-default control (DIP) switch position in *Table 3.1: Switch Configuration Descriptions*. Appendix A ➤ Updated for firmware version R201. Appendix D ➤ Corrected point label counters in *Table D.7: DNP3 Default Data Map*. Appendix E ➤ Updated *Table E.3: DPAC Inputs* and *Table E.4: 05 Force Single Coil Command*.
20091005	Section 8 ➤ Updated *Table 8.1: Device Self Tests*. Appendix A ➤ Updated for firmware version R200.
20090716	Appendix A ➤ Updated for firmware version R104.
20090402	Section 3 ➤ Updated *Specifications*.
20090224	Section 3 ➤ Corrected *Figure 3.2*. Section 4 ➤ Modified *Table 4.8* and *Table 4.9* to support the 16 input, 32 output option. Appendix A ➤ Updated for firmware version R103.

Table A.6 Instruction Manual Revision History (Sheet 8 of 8)

Date Code	Summary of Revisions
	Appendix D ➤ Modified *Table D.6* to support the 16 input, 32 output option. Appendix E ➤ Modified *Table E.2*, *Table E.4*, and *Table E.5* to support the 16 input, 32 output option. Appendix F ➤ Modified *Table F.1* to support the 16 input, 32 output option.
20081214	Section 1 ➤ Added information about I/O options. Section 2 ➤ Corrected description of LAMP TEST operation, cable number in *Figure 2.7*, and added PORT F to *Table 2.1*. Section 4 ➤ Added table describing Math Device Word bits and added I/O options to Device Word table. Section 6 ➤ Added tables describing Ethernet and IRIG-B Device Word bits. Appendix D ➤ Corrected index of STFAIL, STSET, and ENABLED in the DNP3 default map.
20081030	Appendix A ➤ Updated for firmware version R101.
20081010	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

These instructions guide you through the process of upgrading firmware in the device. 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) number.

Existing firmware:

FID=SEL-2440-**R100**-V0-Z001001-Dxxxxxxxx

Standard release firmware:

FID=SEL-2440-**R101**-V0-Z001001-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID number string.

Existing firmware:

FID=SEL-2440-R100-**V0**-Z001001-Dxxxxxxxx

Point release firmware:

FID=SEL-2440-R100-**V1**-Z001001-Dxxxxxxxx

The date code is after the D. For example, the following is firmware version number R100, date code December 10, 2003.

FID=SEL-2440-R100-V0-Z001001-**D20031210**

SEL occasionally offers firmware upgrades to improve the performance of your device. The SEL-2440 stores firmware in flash memory. Therefore, changing physical components for the firmware upgrade is unnecessary. Upgrade the device firmware by downloading a file from a personal computer to the device via the Ethernet port through FTP or via Telnet. You can also use the front-panel serial port through ACSELERATOR QuickSet SEL-5030 Software or a terminal emulator, as outlined in the following sections. For devices with the IEC 61850 option, verify the IEC 61850 protocol after the upgrade (see *IEC 61850 CID File Upgrade Instructions on page B.11*).

Table B.1 details the available firmware upgrade methods. Available methods depend on your existing firmware and the firmware version to which you are upgrading.

Table B.1 Firmware Upgrade Method

Existing Firmware	Upgrade Version	SELboot Upgrade Required?	Firmware Upgrade Methods Supported	
			Serial	Ethernet
R1*xx*	R1*xx*	No	Terminal emulator QuickSet	--
R1*xx*	R2*xx*	--	Cannot be upgraded	--
R2*xx*	R2*xx*	No	Terminal emulator QuickSet	--
R2*xx*	R3*xx*	Yes[a]	Terminal emulator QuickSet	--
R3*xx*	R3*xx*	No	Terminal emulator QuickSet	Terminal emulator FTP

[a] When upgrading from firmware versions R2*xx* to R3*xx* or higher, fist perform the *Special Instructions for Upgrading to R300 Series Firmware on page B.2* and then follow the Upgrade instructions for the desired method.

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- PC
- Terminal emulation software that supports Xmodem/CRC or 1 k Xmodem/CRC protocol
- Serial communications cable (SEL-C234A or equivalent, or a null-modem cable) or Ethernet cable
- Disk containing the firmware upgrade file (e.g., SEL2440-R*xxx*-V*x*.s19, SEL2440-R*xxx*-V*x*.z19, or SEL2440-R*xxx*-v*x*.zds)
- QuickSet software

Digitally Signed Firmware Files

NOTE: The device pulses the SALARM bit and writes an entry to the device SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring the SALARM bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

The SEL-2440 supports digitally signed firmware files for firmware versions R300 and higher. These firmware files are compressed to reduce file transfer times and are digitally signed by SEL using a secure hash algorithm. The signature ensures that the file has been provided by SEL and that its contents have not been altered. Once the firmware is uploaded to the device, the signature of the firmware is verified with a public key that is stored on the device from the factory. If the device cannot verify the signature, it rejects the file. The name of the digitally signed firmware file is of the form SEL-2440-R*xxx*-V*x*.zds, where R*xxx*-V*x* is the firmware revision number, 2440 indicates the device type, and .zds is the file extension reserved for digitally signed files. Firmware files with the .s19 or .z19 extension are not available for firmware versions R300 and higher.

Ethernet Firmware Upgrades

You can upgrade firmware over an Ethernet connection by sending the .zds firmware upgrade files via File Transfer Protocol (FTP) or Telnet protocols to a device running SELBOOT version R600 or newer and a device firmware version identified in *Table B.1*. FTP and Telnet are plain text protocols and do not inherently support message encryption (e.g., device passwords, etc.). Because of this, SEL strongly recommends you use a security gateway between your device and your network that provides encrypted communications along with SEL Software Defined Networking (SDN) technology to harden your network cybersecurity.

Special Instructions for Upgrading to R300 Series Firmware

The SELBOOT firmware in devices shipped with firmware versions R216-V3 or earlier must be upgraded before you can use digitally signed firmware files that have versions R300 or later. The SELBOOT firmware can be upgraded from version R50*x* or SLBT-2440-R300 to version R600 by uploading a special SELBOOT Loader firmware to the device.

NOTE: Make sure that the device firmware and SELBOOT firmware revisions are compatible. Refer to *Appendix A: Firmware and Manual Versions* in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the device firmware.

The following instructions assume you have a working knowledge of your PC terminal emulation software.

Step 1. If the device is in service, open the device control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present device settings.

Use the following steps to save and restore the settings:

a. To display the settings files issue the following command at the ASCII prompt: **FILE DIR**.

b. Record all the settings for possible re-entry after the firmware upgrade.

For example, to save the Device Settings, issue the **FILE READ SET_1.txt** command. Then, receive the file to the PC via YMODEM transfer.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

We recommend that you save all data, including events, stored in the device before the upgrade.

Step 4. Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 5. Enter a current SELBOOT.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

```
Disable device to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The device sends the !> prompt.

Step 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing SELBOOT and device firmware cand be erased.

Step 8. Press any key (e.g., **<Enter>**) when the device sends a prompt.

Step 9. Send the special SELBOOT Loader firmware (e.g., SLBTLDR-24XX-R600-V2.s19) to the device. The special SELBOOT Loader firmware erases the existing SELBOOT and device firmware and loads the SELBOOT firmware.

The file transfer typically takes less than 5 minutes at 9600 bps, depending on the product. After the transfer is complete, the device reboots and displays the SELBOOT !> prompt.

After the SELBOOT upgrade is complete, upgrade your device firmware by using a terminal emulator (see *Upgrade the Firmware Using a Terminal Emulator on page B.4*). It is not necessary to save the device settings and other data again during the firmware upgrade process if you saved them before upgrading SELBOOT. Proceed to *Step 5*.

Figure B.1 shows the entire special SELBOOT upgrade process.

```
=>>1_d
Disable device to receive firmware (Y,N)? Y
Are you sure (Y,N)? Y
Device Disabled

BFID=BOOTLDR-R501-V0-Z000000-D20140224
!>bau 9600
!>rec
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware (Y,N)?
Press any key to begin transfer and then start transfer at the terminal.C
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
!>
```

Figure B.1 Special SELBOOT Upgrade Process

Upgrade the Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your PC terminal emulation software.

NOTE: Make sure that the device firmware and SELBOOT firmware revisions are compatible. Refer to *Appendix A: Firmware and Manual Versions* in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the device firmware.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

Step 1. If the device is in service, open the device control circuits.

Step 2. Connect the PC to the front-panel serial and enter Access Level 2.

Step 3. Save the present device settings.

Use the following steps to save and restore the settings:

a. To display the settings files, issue the following commands at the ASCII prompt: **FILE DIR**

b. Record all the settings for possible reentry after the firmware upgrade.

For example, to save the Device Settings, issue the **FILE READ SET_1.txt** command. Then, receive the file to the PC via YMODEM transfer.

We recommend that you save all stored data in the device, including events, before the upgrade.

Step 4. Enter SELboot to upgrade firmware.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

`Disable device to receive firmware (Y/N)?`

c. Type **Y <Enter>** at the following prompt:

`Are you sure (Y, N)?`

The device sends the !> prompt.

If you are using an Ethernet port, proceed to *Step 6*.

Step 5. Change the data rate, if necessary.

a. Type **BAU 115200 <Enter>**.

This changes the data rate of the communications port to 115200 bps.

b. Change the data rate of the PC to 115200 bps to match the device.

Step 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing firmware can be erased.

Step 8. Press any key (e.g., **<Enter>**) when the device sends a prompt.

Step 9. Start the file transfer.

Use the Xmodem protocol to send the file that contains the new firmware (e.g., SEL-2440-R*xxx*-V*x*.s19, SEL-2440-R*xxx*-V*x*.z19, or SEL-2440-R*xxx*-V*x*.zds). Firmware files for firmware versions R1*xx* and R2*xx* have .s19 or .z19 extensions. Firmware files for firmware versions R300 or higher have .zds extensions. Firmware files with .s19 or .z19 extensions are not available for firmware versions R300 and higher.

The file transfer typically takes less than 6 minutes at 115200 bps. After the transfer is complete, the device reboots and returns to Access Level 0.

Figure B.2 shows the entire upgrade process.

```
=>>1_d
Disable device to receive firmware (Y,N)? Y
Are you sure (Y,N)? Y
Device Disabled
In SELBoot from L_D
Validating Firmware. Standby...
Firmware validated.
!>bau 115200
!>rec
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.
Are you sure you want to erase the existing firmware (Y/N)?
Press any key to begin transfer and then start transfer at the terminal.
OKC
Validating firmware. Please stand by.
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
Starting Application
Are you sure you want to erase the existing firmware (Y,N)?
Press any key to begin transfer and then start transfer at the terminal.C
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
!>
```

Figure B.2 Special SELBOOT Upgrade Process

Step 10. The device front-panel **ENABLED** LED illuminates if the device settings are retained through the download.

If **ENABLED** LED is illuminated, proceed to *Step 11*.

If **ENABLED** LED is not illuminated or the front panel displays STATUS FAIL Non_Vol Failure, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

   The device then reboots with the factory-default settings.

d. Enter Access Level 2.

e. Issue the **STATUS** command.

   If the device is enabled, go to *Step f*.

   If the STATUS report shows option card `FAIL` and `RELAY DISABLED` and the message:

   ```
   Confirm Hardware Config
   Accept & Reboot (Y/N)?
   ```

   Enter **Y**. This saves the device calibration settings.

   The device reboots and comes up enabled.

f. Restore device settings back to the settings saved in *Step 3*.

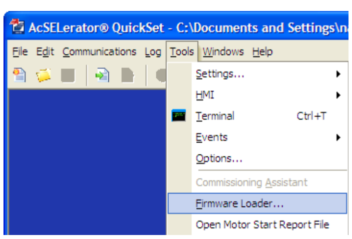
Step 11. Change the data rate of the PC to match that of the device prior to *Step 4*, and enter Access Level 2.

Step 12. Issue the **STATUS** command; verify all device self-test results are OK.

Step 13. Configure the SEL communications processor port to restore port settings to re-establish previous connections.

Upgrade the Firmware Using ACSELERATOR QuickSet

Select **Tools** > **Firmware Loader** from the ACSELERATOR QuickSet® SEL-5030 Software menu bar to launch a wizard that walks you through the steps to load firmware into your SEL device.



Firmware Loader will not start if:

➤ The device is unsupported by QuickSet.
➤ The device is not connected to the computer with a communications cable.
➤ The connected port does not support SELBOOT.
➤ The device is disabled.

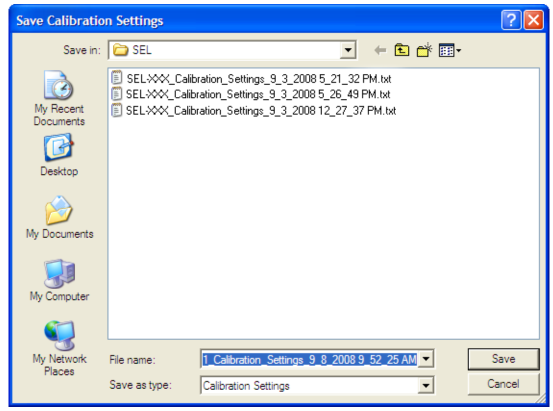
Step 1: Prepare Device

a) Select the firmware to be loaded by using the browse control and select whether you want to save calibration settings, device settings, and event report files. Select **Next** to continue the wizard.

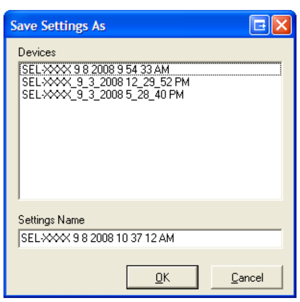
NOTE: If you are downgrading firmware, be certain to save device settings as they can be lost during a downgrade. Additionally, you may need to use the PART command to restore some MOT fields after a downgrade.

NOTE: Be certain to save SERs before upgrading or downgrading firmware, because they can be lost during the process.

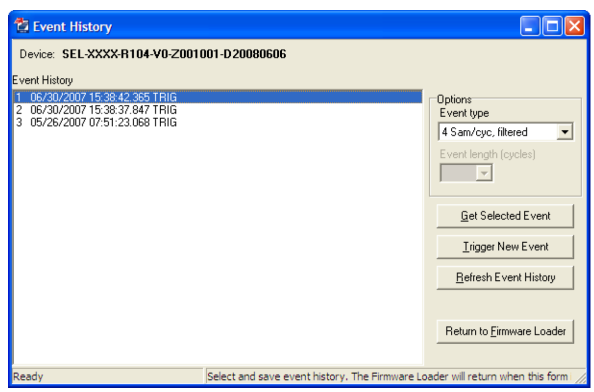
b) Select a file name and path to save the settings or accept the defaults as shown. Click **Save**.



c) After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.

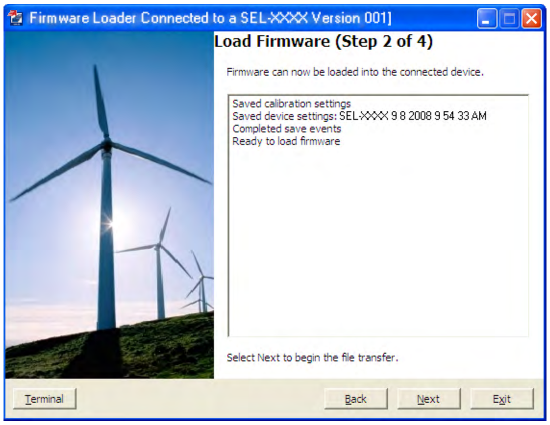


d) Select events and click **Get Selected Event** to save any events. After saving all events, select **Return to Firmware Loader**.

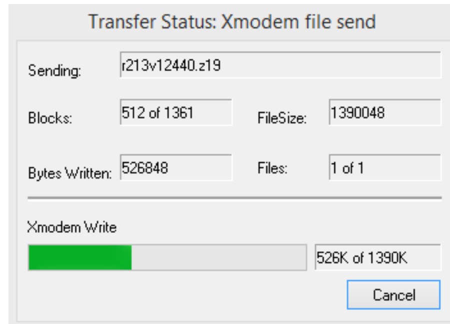


Step 2: Transfer Firmware

Click **Next** to begin the firmware transfer.

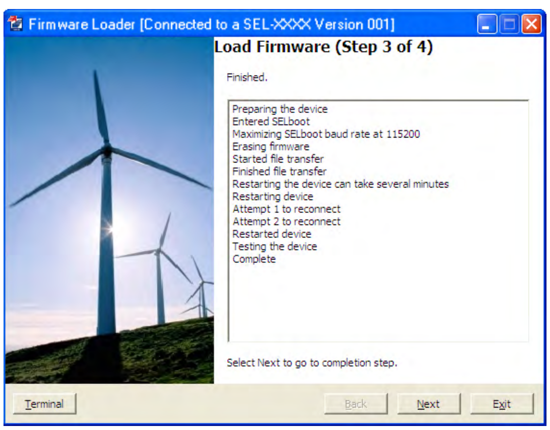


The **Transfer Status: Xmodem file send** window shows the transfer progress of the firmware file. Clicking **Cancel** will stop the transfer.



Step 3: Prepare Device

During this step, the device will be put in SELboot. The transfer speed will be maximized and the firmware transfer will begin.



Step 4: Verify Device

Four verification options are provided and when enabled these options perform as follows.

Test Device Communications. If the device cannot be restarted then device power should be cycled and the device reset. Once the device is enabled, this option will reconnect and re-initialize the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings saved to the database to the device; settings will be converted automatically if needed.

Load Firmware into Another Device. Returns the wizard to *Step 1: Prepare Device* to repeat the firmware loading process with another device.

Upgrade the Firmware Using File Transfer Protocol

NOTE: Make sure that the device firmware and SELBOOT firmware revisions are compatible. Refer to Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the device firmware.

NOTE: The device pulses SALARM bit and writes an entry to the device SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring the SALARM bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: File name RELAY.zds is not case sensitive.

To upgrade firmware using FTP, the firmware in your device must be R300 or higher. The firmware is designated with a .zds extension.

To upgrade device firmware using FTP, set the Port 1 setting **EETHFWU:= Y**. If EETHFWU is set to N, you cannot upgrade the firmware over Ethernet.

The following instructions assume you have a working knowledge of the Windows command prompt.

Step 1. Ensure that the device is not in service.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present device settings.

Use the following steps to save and restore the settings:

a. Issue the following commands at the ASCII prompt:

SHO, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

We recommend that you save all stored data in the device, including events, before the upgrade.

Step 4. Rename the SEL-2440-R*xxx*-V*x*.zds file as RELAY.zds.

Step 5. Create an FTP session to connect to the device using the device IP address.

Step 6. Enter your FTP username and password.

Step 7. Issue the **CD UPGRADE** command to switch the present device directory to the UPGRADE directory.

Step 8. Issue the **PUT RELAY.ZDS** command to place the RELAY.zds file in the UPGRADE directory and to send the file to the device.

When the download is complete, the device reboots and comes up enabled. During this upgrade process, you will lose the FTP connection, and you must reestablish the FTP connection after the upgrade is complete. Then navigate to the device UPGRADE directory and review the ERR.txt file for any error messages. If the firmware upgraded properly, no errors occurred during the upgrade process and the file will contain `Firmware upgrade succeeded. Date: MM/DD/YYYY Time: HH:MM:SS.sss`.

```
Microsoft Windows [Version 10.0.10042.985]
(c) Microsoft Corporation. All rights reserved.

Z:\>ftp
ftp> open 10.203.116.73
Connected to 10.203.116.73.
220 SEL-2440 FTP SERVER:
User (10.203.116.73:(none)): FTPUSER
331 User name okay, need password.
Password:
230 User logged in, proceed.
ftp> cd UPGRADE
250 CWD requested file action okay, completed.
ftp> CWD
Invalid command.
ftp> PWD
257 "/UPGRADE" is current directory.
ftp> PUT RELAY.zds
200 PORT Command okay.
150 File status okay; about to open data connection.
Connection closed by remote host.
ftp>
```

Figure B.3 Firmware Upgrade Via FTP

Upgrade the Firmware Via Terminal Emulator Using the FILE Command Over Telnet

To upgrade firmware using the **FILE** command over Telnet, the firmware in your device must be R300 or higher. The firmware is designated with a .zds extension.

NOTE: Make sure that the device firmware and SELBOOT firmware revisions are compatible. Refer to *Appendix A: Firmware and Manual Versions*. If needed, upgrade the SELBOOT firmware prior to upgrading the device firmware.

To upgrade device firmware using the **FILE** command over Ethernet, set the Port 1 setting:

EETHFWU := Y. If EETHFWU is set to N, you cannot upgrade the firmware over Ethernet.

The following procedure assumes that you have a working knowledge of the software being used to upgrade the firmware via **FILE** command.

Step 1. Ensure that the device is not in service.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present device settings.

Use the following steps to save and restore the settings:

a. Issue the following commands at the ASCII prompt:

SHO, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

We recommend that you save all stored data in the device, including events, before the upgrade.

NOTE: The device pulses SALARM bit and writes an entry to the device SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring the SALARM bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

4. Rename the SEL-2440-R*xxx*-V*x*.zds file as RELAY.zds.
5. Save the RELAY.zds file to a directory.
6. Update the active directory to be the directory where the RELAY.zds file is saved.

7. Issue the FILE WRITE RELAY.ZDS command to the device.

NOTE: File name RELAY.zds is not case sensitive.

8. Send the RELAY.zds file to the device via Ymodem transfer. When the upgrade is complete, the device reboots and comes up enabled.

IEC 61850 CID File Upgrade Instructions

Verify or Restart IEC 61850 Operation (Optional)

SEL-2440 series devices with optional IEC 61850 protocol require the presence of one valid CID file to enable the protocol. You should only transfer a CID file to the device if you want to implement a change in the IEC 61850 configuration or if new SEL-2440 firmware does not support the current CID file version. If you transfer an invalid CID file, the device will disable the IEC 61850 protocol, as it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the device.

Perform the following steps to verify that the IEC 61850 protocol is still operational after an SEL-2440 firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating an SEL-2440 firmware upgrade.

Step 1. Establish an FTP connection to the SEL-2440 Ethernet port.

Step 2. Open the ERR.TXT file for reading.

If the ERR.TXT file contains error messages relating to CID file parsing, this indicates that the device has disabled the IEC 61850 protocol. If this file is empty, the device found no errors during CID file processing and IEC 61850 should remain enabled. Skip to *Step 3* if ERR.TXT is empty.

If the IEC 61850 protocol has been disabled because of an upgrade-induced CID file incompatibility, you can use ACSELERATOR Architect® SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the Architect software upgrade that supports your required CID file version.

b. Run Architect and open the project that contains the existing CID file for the device.

c. Download the CID file to the device.

Upon connecting to the device, Architect will detect the upgraded SEL-2440 firmware and prompt you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the device to re-enable the IEC 61850 protocol in its original configuration.

Step 3. In the Telnet session, type **GOO <Enter>** or you can also execute **GOO** from a **2AC** prompt on a serial port connection.

Step 4. View the GOOSE status and verify that the transmitted and received messages are as expected.

Appendix C
SEL Communications Processors

SEL Communications Protocols

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the device 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 device, collect data, and issue commands.

SEL Compressed ASCII Commands

The SEL-2440 Discrete Programmable Automation Controller (DPAC) 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 device can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor needed to interpret nondelimited messages.

Table C.1 lists the Compressed ASCII commands and contents of the command responses.

Table C.1 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 Level 1 and above	1
CSTATUS	Device status	1
DNAME	ASCII names of digital I/O reported in Fast Meter	0
ID	Device identification	0
SNS	ASCII names for SER data reported in Fast Meter	0

Interleaved ASCII and Binary Messages

SEL devices have two separate data streams that share the same physical serial port. Human data communications with the device consist of ASCII character commands and reports that you view through use of 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 interleaved with short bursts of binary data to support fast acquisition of SCADA data.

SEL Communications Processor

SEL communications processors 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*.

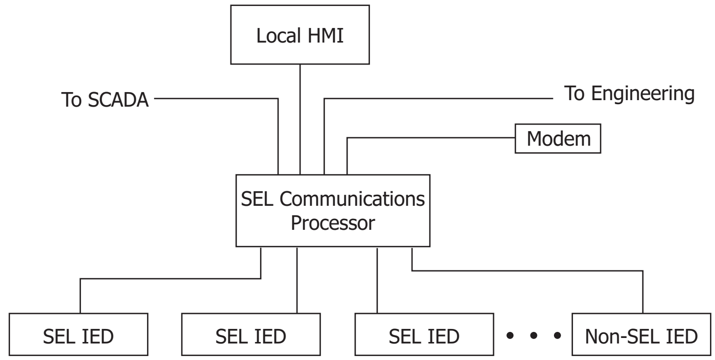


Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1*, the SEL communications processor offers the following substation integration functions: collection of real-time data; calculation, concentration, and aggregation of real-time data; engineering access; and distribution of demodulated IRIG-B signal.

SEL communications processors have 16 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*.

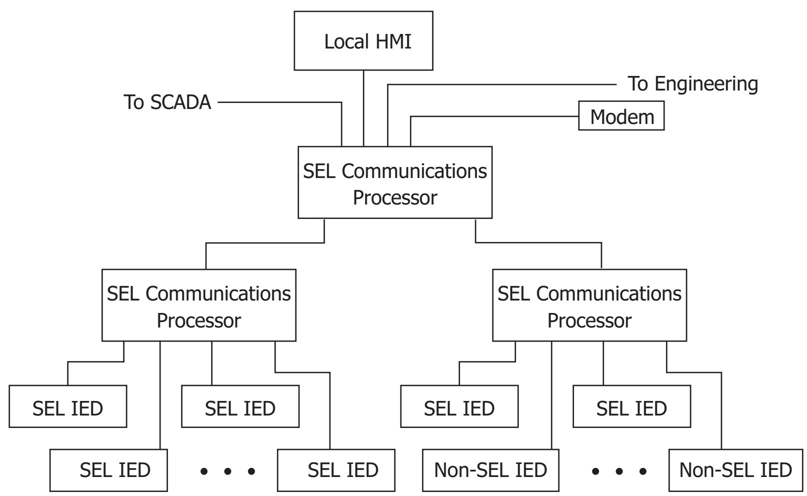


Figure C.2 Multitiered SEL Communications Processor Architecture

SEL Communications Processor Example

This example demonstrates the data and control points available in the SEL communications processor when you connect a DPAC. This example connects the communications processor **Port F** to a personal computer and **Port 1** to the DPAC.

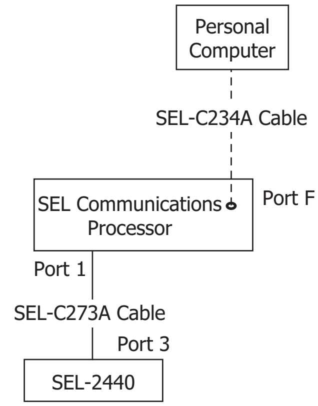


Figure C.3 Example SEL Device and SEL Communications Processor Configuration

Table C.2 shows the Port 1 settings for the SEL communications processor.

Table C.2 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	Device 1	Name of connected device[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	N	Hardware flow control enabled
TIMEOUT	30	Idle timeout that terminates transparent connections of 30 seconds

[a] Automatically collected by the SEL communications processor during autoconfiguration.

Data Collection

Configure the SEL communications processor to collect DPAC Device Word bits through use of the **20TARGET** command; *Table C.3* shows the associated automessage (**SET A**) settings. The Device Word bits will be collected using a Fast Meter binary message and stored in the D1 data region.

Table C.3 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 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	1	Two automessages
ISSUE1	P00:00:01.0	Issue Message 1 every second
MESG1	20TARGET	Collect Device Word bit data
ARCH_EN	N	Archive memory
USER	0	No USER region registers reserved

Device Word Bits Information

Table C.4 lists the Device Word bit data available in the SEL communications processor TARGET data region 2 (D2).

Table C.4 Communications Processor TARGET Region

Address	Device Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h				STSET				
2805h	See *Table H.1*, Row 0							
2806h	See *Table H.1*, Row 1							
2807h	See *Table H.1*, Row 2							
2808h	See *Table H.1*, Row 3							
2809h	See *Table H.1*, Row 4							
280Ah	See *Table H.1*, Row 5							
280Bh	See *Table H.1*, Row 6							
280Ch	See *Table H.1*, Row 6							
280Dh	See *Table H.1*, Row 8							
280Eh	See *Table H.1*, Row 9							
280Fh	See *Table H.1*, Row 10							
• • •	• • •							
2861h	See *Table H.1*, Row 92							

Control Points

The SEL communications processor can automatically pass control messages, called Fast Operate messages, to the DPAC. Enable Fast Operate messages by using the FASTOP setting in the DPAC port settings. Also enable Fast Operate messages in the SEL communications processor by setting SEND_OPER equal to Y.

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the device for changes in remote bits RB1 through RB16 on the corresponding SEL communications processor port.

Appendix D
DNP3 Communications

Overview

The SEL-2440 Discrete Programmable Automation Controller (DPAC) provides a Distributed Network Protocol Version 3.0 (DNP3) Level 2 Outstation interface for direct serial and LAN/WAN network connections to the device.

The DNP Users Group maintains and publishes DNP3 standards. See the DNP Users Group website, www.dnp.org, for more information on standards, implementers, and tools for working with DNP3.

Objects

DNP object types, commonly referred to as objects, specify the type of data the object carries. An object can include a single value or more complex data.

If there can be more than one instance of an object type, then each instance has an index that makes it unique. Each object also includes multiple versions called variations. A master initiates all DNP message exchanges except unsolicited data, with all points described from the perspective of the master.

Function Codes

Each DNP message includes a function code. Each object has a limited set of function codes that a master may use to manipulate the object. The most common DNP function codes are listed in *Table D.1*.

Table D.1 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the remote
2	Write	Send data to the remote
3	Select	First part of a select-before-operate operation
4	Operate	Second part of a select-before-operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP remote.

Ethernet Operation

NOTE: Firmware versions R300 and later limit the range of DNPINA*n* to 0–120 seconds to ensure proper closing of unresponsive TCP connections. Earlier versions allowed a range of 0–7200 seconds.

The DNP-IP response is identical to the serial response, but it requires the communications-specific settings shown in *Table D.2*.

Table D.2 DNP-IP Specific Settings

Setting	Definition	Range	Default Value
EDNP	Enable DNP Sessions	0–5	0
DNPADR	DNP Address	0–65519	1
DNPIP*n*	Master IP Address	zzz.yyy.xxx.www	192.168.0.3 for Master 1 192.168.0.4 for Master 2 192.168.0.5 for Master 3 192.168.0.6 for Master 4 192.168.0.7 for Master 5
DNPTR*n*	Transport Protocol	UDP, TCP	TCP
DNPNUM*n*	DNP TCP and UDP Port	1–65534	20000
DNPUDP*n*	UDP Response Port	REQ, 1–65534	20000
REPADR*n*	DNP Address to Report to	0–65519	100
DNPMAP*n*	DNP Map	0–3	1
TIMERQ*n*	Minutes for Request Interval	I, M, 1–32767	I
STIMEO*n*	Seconds to Select/Operate Time-Out	0.0–60.0 seconds	1
DNP_TO*n*	Seconds to Communications Time-Out	0–3600 seconds	30
DNPINA*n*	Seconds to send Data Link Heartbeat	0–120	120
DRETRY1[a]	Data Link Retries	0–15	0
DTIMEO1[a]	Seconds to Data Link Time-Out	0–5	1
ETIMEO*n*	Event Message Confirm Time-Out	1–300	5
AI_RPT*n*	Analog Input Event Reporting	MOST_RECENT, SOE	MOST_RECENT
UNSOL*n*	Enable Unsolicited Reporting	Y, N	N
PUNSOL*n*	Enable Unsolicited Reporting at Power-Up	Y, N	N
NUMEVE*n*	Number of Events to Transmit On	1–200	10
AGEEVE*n*	Oldest Event to Tx On	0.0–99999.0	2
URETRY*n*	Unsolicited Message Max Retry Attempts	2–10	3
UTIMEO*n*	Unsolicited Message Offline Time-Out	OFF, 1–5000 seconds	60

[a] Available on serial ports only with PROTO = DNP.

If the UNSOL setting is set to Y, the SEL-2440 transmits unsolicited data when either of the following is true:

- Initialization is complete and DNPTR = UDP, or
- The master has established a session, if DNPTR = TCP.

Control the Classes for reporting event data and their formats using the settings as shown in *Table D.3*.

Table D.3 DNP Link Settings

Setting	Definition	Range	Default Value
DVARAI[*k*]	Analog Input Default Variation	1–6	4
DVARAIE[*k*]	Analog Change Event Default Variation	1–8	4
DVARC[*k*]	Counter Default Variation	1, 2, 5, 6	6
DVARFC[*k*]	Frozen Counter Default Variation	1, 2, 5, 6, 9, 10	6
ECLASSB[*k*]	Class for Binary Event Data	0–3	1
ECLASSC[k]	Class for Counter Event Data	0–3	0
ECLASSA[*k*]	Class for Analog Event Data	0–3	2
ECLASSF[*k*]	Class for Frozen Counter Data	0–3	0
DECPLM[*k*]	Misc Data Scaling Decimal Places	0–3	1
ANADBM[*k*]	Misc Data Reporting Deadband Counts	0–32767	100
DCNTRPT[*k*]	Free Running Counters, Frozen Counters, or All Counters	RUNNING, FROZEN, ALL	ALL

DNP3 in the SEL-2440

The DPAC is a DNP3 Level 2 Outstation device. See *DNP3 Communications* for additional documentation describing DNP3.

Data Access

Table D.4 lists DNP data access methods along with corresponding DPAC settings. You must select a data access method and configure each DNP master for polling as specified.

NOTE: Because unsolicited messaging is problematic in most circumstances, SEL recommends using the polled report-by-exception access method to maximize performance and minimize risk of configuration problems.

NOTE: In the settings below, the suffix n represents the DNP3 session number from 1 to 5. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table D.4 DNP Access Methods

Access Method	Master Polling	SEL-2440 Settings
Polled static	Class 0	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to 0; UNSOL*n* to No
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; UNSOL*n* to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* to Yes and PUNSOL*n* to Yes or No
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* and PUNSOL*n* to Yes.

If the master does not acknowledge the unsolicited data with an Application Confirm, the device will resend the data until it is acknowledged. It will wait for ETIMEO*n* seconds and then repeat the unsolicited message. To prevent clogging of the network with unsolicited data retries, the DPAC uses the URETRY*n* and UTIMEO*n* settings to increase retry time when the number of retries set in URETRY*n* is exceeded. After URETRY*n* has been exceeded, the DPAC pauses

UTIMEO*n* seconds and then transmits the unsolicited data again. *Figure D.1* provides an example with URETRY*n* = 2. If UTIMEO*n* is set to OFF, the retry interval will be 10*ETIMEO*n*.

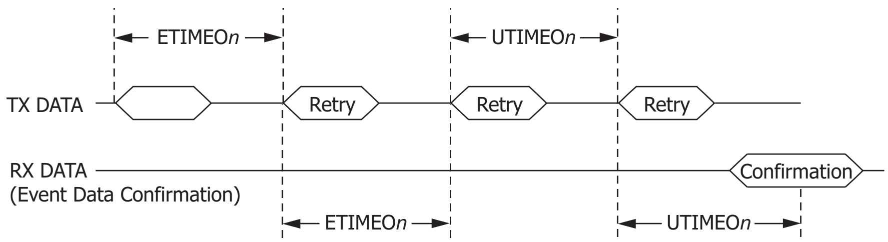


Figure D.1 Application Confirmation Timing With URETRY*n* = 2

Collision Avoidance

If your application uses unsolicited reporting on a serial network, you must select a half-duplex medium or a medium that includes carrier detection to avoid data collisions. EIA-485 two-wire networks are half-duplex. EIA-485 four-wire networks do not provide carrier detection, while EIA-232 systems can support carrier detection. DNP LAN/WAN uses features of the IP suite for collision avoidance.

The DPAC uses Application Confirmation messages to guarantee delivery of unsolicited event data before erasing the local event data buffer. Data collisions are typically resolved when messages are repeated until confirmed.

The DPAC pauses for a random delay between the settings MAXDLY and MINDLY when it detects a carrier through data on the receive line or the CTS pin. For example, if you use settings of 0.05 and 0.10 s, the DPAC will insert a random delay of 50 to 100 ms as shown in *Figure D.2*.

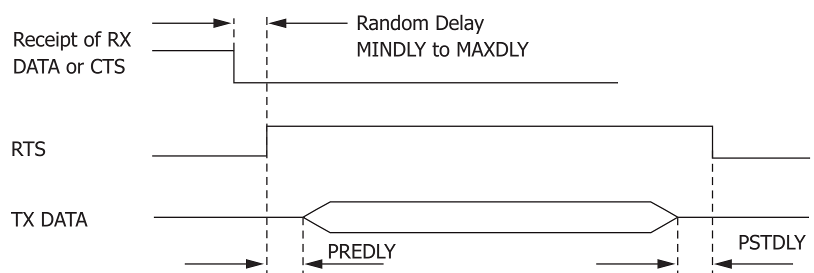


Figure D.2 Message Transmission Timing

Transmission Control

NOTE: PREDLY and POSTDLY settings are only available for EIA-232 and EIA-485 serial port sessions.

If you use a media transceiver (for example, EIA-232 to EIA-485) or a radio system for your DNP network, you may need to adjust data transmission properties. Use the PREDLY and POSTDLY settings to provide a delay between RTS signal control and data transmission (see *Figure D.2*). For example, an EIA-485 transceiver typically requires 10 to 20 ms to change from receive to transmit. If you set the pre-delay to 30 ms, you will avoid data loss resulting from data transmission beginning at the same time as RTS signal assertion.

Event Data

DNP event data objects contain change-of-state and time-stamp information that the DPAC collects and stores in a buffer. Points assigned in the Binary Input Map that are also assigned in the Sequential Events Recorder (SER) settings carry the time stamp of actual occurrence. Binary input points not assigned in the SER settings will carry a time stamp based on the DNP map scan time. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. The DNP map is scanned approximately once per second to generate events. You can configure the DPAC to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests it with an event poll message.

The DPAC uses the NUMEVE*n* and AGEEVE*n* settings to decide when to send unsolicited data to the master. The device sends an unsolicited report when the total number of events accumulated in the event buffer for master *n* reaches NUMEVE*n*. The device also sends an unsolicited report if the age of the oldest event in the master *n* buffer exceeds AGEEVE*n*. The DPAC has the buffer capacities listed in *Table D.5*.

Table D.5 DPAC Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	100
Counters	32

Time Synchronization

By default, the DPAC accepts and ignores time set requests (TIMERQ*n* = I). (This mode allows the DPAC to use a high accuracy, IRIG time source, but still interoperate with DNP masters that send time synchronization messages.) It can be set to request time synchronization periodically by setting the TIMERQ*n* setting to the desired period. It can also be set to not request, but accept time synchronization (TIMERQ*n* = M).

Configurable Data Mapping

One of the most powerful features of the DPAC implementation is the ability to remap DNP data and, for analog values, specify per-point scaling and dead bands. Dead bands are applied to the scaled value. Remapping is the process of selecting data from the reference map and organizing it into a data subset optimized for your application. The DPAC uses object and point labels, rather than point indices, to streamline the remapping process. This enables you to quickly create a custom map without having to search for each point index in a large reference map.

You may use any of the three available DNP maps simultaneously with as many as five unique DNP masters. Each map is initially populated with default data points, as described in *Default Data Map on page D.11*.

Device Profile

Table D.6 contains the standard DNP device profile information. Rather than check boxes in the example Device Profile in the DNP3 Subset Definitions, only the relevant selections are shown.

Table D.6 DPAC DNP Device Profile (Sheet 1 of 2)

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-2440
Highest DNP request level	Level 2
Highest DNP response level	Level 2
Device function	Slave

Table D.6 **DPAC DNP Device Profile** (Sheet 2 of 2)

Parameter	Value
Notable objects, functions, and/or qualifiers supported	Analog Dead-Band Objects (object 34)
Maximum data link frame size transmitted/ received (octets)	292
Maximum data link retries	Configurable, range 0–15
Requires data link layer confirmation	Configurable by setting
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
Complete application fragment time-out	None
Application confirm time-out	Configurable
Complete Application response time-out	None
Executes control WRITE binary outputs	Always
Executes control SELECT/OPERATE	Always
Executes control DIRECT OPERATE	Always
Executes control DIRECT OPERATE-NO ACK	Always
Executes control count greater than 1	Always
Executes control Pulse On	Always
Executes control Pulse Off	Always
Executes control Latch Off	Configurable
Executes control Latch On	Configurable
Executes control Queue	Always
Executes control Clear Queue	Always
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
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 6
Counter roll-over	No roll-over. Max. value 65,000
Sends multifragment responses	No

Object List

Table D.7 lists the objects and variations with supported function codes and qualifier codes available in the DPAC. The list of supported objects conforms to the format laid out in the DNP3 specifications and includes both supported and unsupported objects. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table D.7 SEL-2440 DNP Object List (Sheet 1 of 4)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
0	242	Device Attributes—Device manufacturer's software version	1	0	129	0, 17
0	243	Device Attributes—Device manufacturer's hardware version	1	0	129	0, 17
0	246	Device Attributes—User assigned ID code/number	1	0	129	0, 17
0	248	Device Attributes—Device serial number	1	0	129	0, 17
0	250	Device Attributes—Device manufacturer's product name and model	1	0	129	0, 17
0	252	Device Attributes—Device manufacturer's name	1	0	129	0, 17
0	254	Device Attributes—Non-specific all attributes request	1	0, 6		
0	255	Device Attributes—List of attribute variations	1	0, 6	129	0, 17
1	0	Binary Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
1	1	Binary Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
1	2[e]	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[e]	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		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	0	Control Block—All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block—Not Supported				
12	3	Pattern Mask—Not Supported				
20	0	Binary Counter—All Variations	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28		
20	1	32-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	2	16-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	6[e]	16-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter—All Variations	1	0, 1, 6, 7, 8, 17, 28		
21	1	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	3	32-Bit Frozen Delta Counter	1		129	
21	4	16-Bit Frozen Delta Counter	1		129	
21	5	32-Bit Frozen Counter With Time of Freeze	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28

Table D.7 SEL-2440 DNP Object List (Sheet 2 of 4)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
21	6	16-Bit Frozen Counter With Time of Freeze	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	7	32-Bit Frozen Delta Counter With Time of Freeze	1		129	
21	8	16-Bit Frozen Delta Counter With Time of Freeze	1		129	
21	9	32-Bit Frozen Counter Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	10	16-Bit Frozen Counter Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
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[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event—All Variations	1	6,7, 8		
23	1	32-Bit Frozen Counter Event Without Time	1	6,7, 8	129	17, 28
23	2	16-Bit Frozen Counter Event Without Time	1	6,7, 8	129, 130	17, 28
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
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
23	7	32-Bit Delta Counter Change Event With Time				
23	8	16-Bit Delta Counter Change Event With Time				
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[e]	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
30	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				

Table D.7 SEL-2440 DNP Object List (Sheet 3 of 4)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
31	7	Short Floating Point Frozen Analog Input				
31	8	Long Floating Point Frozen Analog Input				
32	0	Analog Change Event—All Variations	1	6, 7, 8		
32	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32	2[e]	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	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32	8	Long Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Short Floating Point Frozen Analog Event With Time				
33	8	Long Floating Point Frozen Analog Event With Time				
34	0	Analog Dead Band—All Variations				
34	1[e]	16-Bit Analog Input Reporting Dead-Band Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Dead-Band Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Dead-Band Object	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	129	
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	3	Short Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	4	Long Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2[e]	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				
50	1	Time and Date	1, 2	7, 8 index=0	129	07, quantity=1
50	2	Time and Date With Interval				
50	3	Time and Date Last Recorded	2	7, 8		
51	0	Time and Date CTO—All Variations				

Table D.7 SEL-2440 DNP Object List (Sheet 4 of 4)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO			129	07, quantity=1
52	0	Time Delay—All Variations				
52	1	Time Delay, Coarse				
52	2	Time Delay, Fine			129	7, quantity=1
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1, 20, 21	6, 7, 8		
60	2	Class 1 Data	1, 20, 21	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
70	2	Authentication Object				
70	3	File Command Object				
70	4	File Command Status Object				
70	5	File Transport Object				
70	6	File Transport Status Object				
70	7	File Descriptor Object				
80	1	Internal Indications	1, 2	0, 1 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
110	all	Octet String				
111	all	Octet String Event				
112	All	Virtual Terminal Output Block	2	6	129	
113	All	Virtual Terminal Event Data	1	6	129, 130	17, 28
N/A		No object required for the following function codes: 13 cold start;14 warm start; 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.

Reference Data Map

Table D.8 shows the DPAC reference data map. The reference map shows the data available to a DNP master. You can use the default map or the custom DNP mapping functions of the DPAC to retrieve only the points required by your application.

NOTE: Dead-band changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 dead bands after a warm (**STA C**) or cold start (power cycle).

The DPAC scales analog values by the indicated settings or fixed scaling indicated in the description. Analog dead bands for event reporting use the indicated settings, or ANADBM if you have not specified a setting.

Table D.8 DNP Reference Data Map[a]

Object	Labels	Description	
Binary Inputs			
01, 02	STFAIL	Device Diagnostic Failure	
01, 02	STWARN	Device Diagnostic Warning	
01, 02	STSET	Device Settings Changed Warning	
01, 02	ENABLED	Device Word Elements, Row 0, Targets (see *Table H.1*)	
01, 02	SALARM to VB128	Device Word Elements, Row 1 to Row 119 (see *Table H.1*)	
Binary Outputs			
10, 12	RB*xx*	Remote Bits (RB01 to RB32) and Control Bits (CB001 to CB128)	
Counters			
20, 21, 22, 23	SC*xx*	SELOGIC Counter Values (SC01 to SC32)	
Analog Inputs			
30, 32, 34	RA*xxx*	Remote Analogs (RA001 to RA032)	
30, 32, 34	RA*xxx*	Remote Analogs (RA033 to RA064)	
30, 32, 34	RA*xxx*	Remote Analogs (RA065 to RA096)	
30, 32, 34	RA*xxx*	Remote Analogs (RA097 to RA128)	
Analog Outputs			
40, 41	N/A	N/A	

[a] Although not shown as part of the reference maps, you may use any Device Word bit label when creating custom maps.

Default Data Map

The default data map is an automatically generated subset of the reference map. All data maps are initialized to the default values, based on the DPAC part number. *Table D.9* shows the DPAC default data map. If the default maps are not appropriate, you can also use the custom DNP mapping commands **SET DN** and **SHO DN** to create the map required for your application.

Table D.9 DNP3 Default Data Map

Object	Default Index	Point Label
01, 02	0–15	IN201–IN216
01, 02	16–31	IN301–IN316
01, 02	32	STFAIL
01,02	33	STSET
01, 02	34	ENABLED
10, 12	0–31	RB01–RB32 Remote Bits
20, 22	0–31	SC01–SC08 Counters
40, 41	0–31	RA001–RA008 Remote Analogs

Control Point Operation

You can define any two remote bit to control bit points as a pair for Trip/Close or Code Selection operations with Object 12 control device output block command messages. The DPAC assigns some special operations to the code portion of the control device output block command. *Table D.10* demonstrates how you can use this functionality for both paired and non-paired points with firmware revision R203 or later. Because the DPAC with firmware revision R201 or previous allows only one control bit to be pulsed at a time, you should send consecutive control bits in consecutive messages. *Table D.11* demonstrates how you can use this functionality for both paired and non-paired points on a DPAC with R201 or previous firmware. Pulse operations for remote bits provide a pulse with a duration of one protection-processing interval.

Table D.10 R203 or Later Example Object 12 Trip/Close or Code Selection Operation

Control Points	Trip/Close		Code Selection Operation		
	Close/PULSE_ON	Trip/PULSE_ON	Null/LATCH_ON	Null/LATCH_OFF	Null/PULSE_ON
RB01:RB02	PULSE ON RB02	PULSE ON RB01	NOT_SUPPORTED	NOT_SUPPORTED	NOT_SUPPORTED
RB03	PULSE ON RB03	PULSE ON RB03	SET RB03	CLEAR RB03	PULSE ON RB03
CB001:CB002	PULSE ON CB002	PULSE ON CB001	NOT_SUPPORTED	NOT_SUPPORTED	NOT_SUPPORTED
CB003	PULSE ON CB003	PULSE ON CB003	SET CB003	CLEAR CB003	PULSE ON CB003

Control bits will follow on time, off time, and count in the DNP control message as defined in the timing diagram shown in *Figure D.3*. The duration of the pulse is checked every processing interval allowing for accurate pulse durations as short as 2 ms. If the control duration of a point is not completed, and an additional control is received for the same point, it will be rejected. It is possible to cancel an active control by sending a cancel control to the active point.

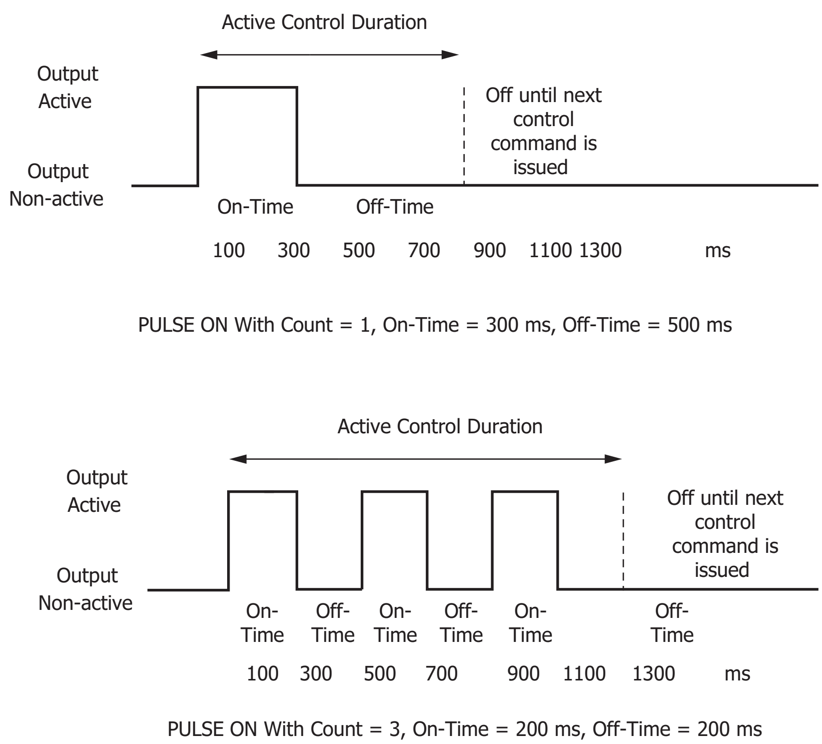


Figure D.3 PULSE ON With Count = 3

Table D.11 R201 or Previous Example Object 12 Trip/Close or Code Selection Operation

Control Points	Trip / Close		Code Selection Operation			
	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RB01:RB02	PULSE ON RB02	PULSE ON RB01	PULSE ON RB02	PULSE ON RB01	PULSE ON RB02	PULSE ON RB01
RB03	SET RB03	CLEAR RB03	SET RB03	CLEAR RB03	SET RB03	CLEAR RB03
RB04	SET RB04	CLEAR RB04	SET RB04	CLEAR RB04	SET RB04	CLEAR RB04
RB05:RB06	PULSE ON RB06	PULSE ON RB05	PULSE ON RB06	PULSE ON RB05	PULSE ON RB06	PULSE ON RB05
RB07	SET RB07	CLEAR RB07	SET RB07	CLEAR RB07	SET RB07	CLEAR RB07
RB08	SET RB08	CLEAR RB08	SET RB08	CLEAR RB08	SET RB08	CLEAR RB08
RB14:RB15	PULSE ON RB15	PULSE ON RB14	PULSE ON RB15	PULSE ON RB14	PULSE ON RB15	PULSE ON RB14
RB18:RB21	PULSE ON RB21	PULSE ON RB18	PULSE ON RB21	PULSE ON RB18	PULSE ON RB21	PULSE ON RB18

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Appendix E
Modbus Communications Protocol

Overview

This appendix describes Modbus RTU and Modbus TCP communications features supported by the SEL-2440 (DPAC). Complete specifications for the Modbus protocol are available from the Modbus website at www.modbus.org.

Modbus TCP is automatically available with the Ethernet port. Modbus TCP uses the device IP address as the Modbus identifier and accesses the data in the DPAC by using the same function codes and data maps as Modbus RTU. The TCP port for Modbus TCP is 502.

Modbus Queries

Modbus RTU master devices initiate all exchanges by sending a query. The SEL-2440 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, each slave device must have a different address.

Modbus Responses

The slave device sends a response message after it performs the action the query specifies. If the slave device cannot execute the query command for any reason, it sends an error response. Otherwise the slave device response is formatted 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 DPAC supports the Modbus function codes shown in *Table E.1*.

Table E.1 DPAC Modbus Function Codes

Codes	Modbus Description	Device Description
01h	Read Discrete Output Coil Status	Read the status of the digital output and remote bits.
02h	Read Discrete Input Status	Read the status of the digital inputs.
03h	Read Holding Registers	Read data from the Modbus map.
04h	Read Input Register	Read data from the Modbus map similarly to function code 03.
05h[a]	Force Single Coil	Control the status of the digital outputs, remote bits, and control bits.
06h[a]	Preset Single Register	Write data directly to a single register in the Modbus map.
08h	Diagnostic Command	Test the Modbus communications channel.
0Fh	Force Multiple Coils	Control the status of multiple digital outputs, remote bits, and control bits simultaneously.
10h[a]	Preset Multiple Register	Write data directly to multiple registers at the same time in the Modbus map.

[a] The DPAC supports the Broadcast function on these functions.

Modbus Exception Responses

The SEL-2440 sends an exception code under the conditions described in *Table E.2*.

Table E.2 SEL-2440 Modbus Exception Codes

Exception Code	Error Type	Description
1	Illegal Function Code	The received function code is either undefined or unsupported.
2	Illegal Data Address	The received command contains an unsupported address in the data field.
3	Illegal Data Value	The received command contains a value that is out of range.
4	Device Error	The SEL-2440 is in the wrong state for the function a query specifies.
6	Busy	The device is unable to process the command at this time, because of a busy resource.

In the event that any of the errors listed in *Table E.2* occur, the device assembles a response message that includes the exception code in the data field. The device sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the required data.

Cyclical Redundancy Check

For Modbus RTU communications, the SEL-2440 calculates a 2-byte CRC value through use of the device address, function code, and data region. It appends this value to the end of every Modbus RTU response. When the master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-2440, the master device uses the data received. If there is no match, the check fails and the message is ignored. The devices use a similar process when the master sends queries.

Function Code Details

01h Read Discrete Output Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils) shown in *Table E.17*. You can read the status of as many as 2000 bits per query by using the fields shown in *Table E.2*. Note that the DPAC 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 towards the high order end of this byte and from low order to high order in subsequent bytes.

Table E.3 01h Read Discrete Output Coil Status Command

Bytes	Field
Requests from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the first bit
2 bytes	Number of coils to read
2 bytes	CRC-16[b]
A successful response from the slave will have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (01h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

Table E.4 01h DPAC Outputs

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description
0–15	0–0F	01h	OUT101–OUT116
16–31	10–1F	01h	OUT301–OUT316
32–47	20–2F	01h	RB01–RB16
48–63	30–3F	01h	RB17–RB32
64–191	40–BF	01h	CB001–CB128
192–207	C0–CF	01h	Pulse RB01–RB16
208–223	D0–DF	01h	Pulse RB17–RB32

To build the response, the SEL-2440 calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros to make an even byte. The device responses to errors in the query are shown in *Table E.2*.

02 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 by using the fields shown in *Table E.5*. The input status is packed one input per bit of the data field. The LSB of the first data byte contains the starting input address in the query. The other inputs follow towards the high order end of this byte, and from low order to high order in subsequent bytes. In each row, the input numbers are assigned from the right-most input to the left-most input.

Table E.5 02h Read Input Status Command

Bytes	Field
Requests from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
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[b]
A successful response from the slave will have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

Table E.6 includes the coil address in decimal and hex and lists all possible inputs (Device Word bits) available in the device. Device Word bit assignments are found in *Table H.1*.

Table E.6 DPAC Inputs

Coil Address in Decimal[a]	Coil Address in Hex	Function Code Supported	Coil Description
0–7	0–7	02h	Device Word Row 0
8–15	8–F	02h	Device Word Row 1
16–699	10–260	02h	Device Word Row 2–120

[a] Coil address in decimal is (8*Row_Number) + Bit_Number.

To build the response, the SEL-2440 calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros to make an even byte. The device responses to errors in the query are shown in *Table E.2*.

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.17*.

You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. For five-digit addressing, add 40001 to the standard database address.

Table E.7 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
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[b]
A successful response from the slave will have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

The device responses to errors in the query are shown in *Table E.2*.

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table E.17*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. For five-digit addressing, add 40001 to the standard database address.

Table E.8 04h Read Input Register Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
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[b]
A successful response from the slave will have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address

Table E.8 04h Read Input Register Command (Sheet 2 of 2)

Bytes	Field
1 byte	Function Code (04h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

The device responses to errors in the query are shown in *Table E.2*.

05h Force Single Coil Command

Use function code 05h to set or clear a coil. *Table E.10* lists the coil numbers supported by the DPAC. Coil addresses start at 0000 (i.e., Coil 1 is located at Coil address 0000). Responses to the 05h command are identical to the request.

Table E.9 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
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[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

Table E.10 05 Force Single Coil Command Addresses

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description
0–15	0–0F	01h	OUT101–OUT116[a]
16–31	10–1F	01h	OUT301–OUT316[a]
32–47	20–2F	01h	RB01–RB16
48–63	30–3F	01h	RB17–RB32
64–191	40–BF	01h	CB001–CB128
192–207	C0–CF	01h	Pulse RB01–RB16
208–223	D0–DF	01h	Pulse RB17–RB32

[a] Pulse output for 1 second.

The device responses to errors in the query are shown in *Table E.2*.

06h Write Single Register Command

The DPAC uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Register Map in *Table E.17* for a list of registers that can be written to by using this function code. For six-digit addressing, add 400001 to the standard database addresses. Responses to the 06h command are identical to the request.

Table E.11 06h Write Single Register Command

Bytes	Field
Queries from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

0Fh Multicoil Write Command

Use function code 0Fh to simultaneously set or clear as many as 32 control bits. *Table E.13* lists the coil addresses and coil descriptions supported by this command.

Table E.12 0Fh Multicoil Write Command (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (0Fh)
2 bytes	Starting Coil Address
2 bytes	Number of Coils
1 byte	Number of Bytes of Data (02)
2 bytes	Data
2 bytes	CRC[b]
A successful response from the SEL-2440 will have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (0Fh)
2 bytes	Starting Coil Address

Table E.12 0Fh Multicoil Write Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Number of Coils
2 bytes	CRC[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

Table E.13 0Fh Multicoil Write Command Addresses

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description
64–191	40–BF	0Fh	CB001–CB128

10h Write Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, as many as 100 per operation. Refer to the Modbus Register map in *Table E.17* for a list of registers that can be written to by using this function code. For six-digit addressing, add 400001 to the standard database addresses.

Table E.14 10h Read Multiple Registers Command

Bytes	Field
Queries from the master must have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16[b]
A successful response from the slave will have the following format:	
2 bytes	Transaction Identifier[a]
2 bytes	Protocol Identifier[a]
2 bytes	Data Length[a]
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16[b]

[a] Only present in Modbus TCP communications.
[b] Only present in Modbus RTU communications.

The device responses to errors in the query are shown in *Table E.2*.

Command Codes

The DPAC Modbus Register Map (*Table E.17*) includes three fields that allow a Modbus master to force the device to perform a variety of operations. Use Modbus function codes 06h or 10h to write the appropriate command codes and parameters into the registers shown in *Table E.15*. If function code 06h is used to write to a command code that has parameters, the parameters must be written before the command code. After issuing a command, parameters 1 and 2 are cleared and must be rewritten prior to the next command. *Table E.15* defines the command code functions and parameter(s).

Table E.15 Command Codes, Functions, and Parameters

Command Code in Decimal	Command Code in Hex	Function	Parameter 1	Parameter 2
0–1	1–2	Reserved	[a]	N/A
3–18	3–12	Pulse OUT101–OUT116	[a]	N/A
19–34	13–22	Pulse OUT301–OUT316	[a]	N/A
35	23	Reset Data Regions	[b]	N/A
36	24	Control RB01–RB16	[c]	[d]
37	25	Control RB17–RB32	[c]	[d]

[a] Pulse output for 1–30 s, default is 1 s.
[b] Use 01 to clear the Modbus communications counters.
[c] This parameter determines the type of operation with the following values: 01 Set, 02 Clear, 03 Pulse (one processing interval).
[d] This parameter is bitmasked for the remote bits. If more than one bit occurs in the parameter, then the highest numbered bit will be controlled. For example, for a parameter 2 value of 0003h, only RB02 will be controlled.

Table E.16 DPAC Modbus Command Region

Parameter 2 for Command Code 24h	Parameter 2 for Command Code 25h
0000 0000 0000 0001—RB01	0000 0000 0000 0001—RB17
0000 0000 0000 0010—RB02	0000 0000 0000 0010—RB18
0000 0000 0000 0100—RB03	0000 0000 0000 0100—RB19
0000 0000 0000 1000—RB04	0000 0000 0000 1000—RB20
0000 0000 0001 0000—RB05	0000 0000 0001 0000—RB21
0000 0000 0010 0000—RB06	0000 0000 0010 0000—RB22
0000 0000 0100 0000—RB07	0000 0000 0100 0000—RB23
0000 0000 1000 0000—RB08	0000 0000 1000 0000—RB24
0000 0001 0000 0000—RB09	0000 0001 0000 0000—RB25
0000 0010 0000 0000—RB10	0000 0010 0000 0000—RB26
0000 0100 0000 0000—RB11	0000 0100 0000 0000—RB27
0000 1000 0000 0000—RB12	0000 1000 0000 0000—RB28
0001 0000 0000 0000—RB13	0001 0000 0000 0000—RB29
0010 0000 0000 0000—RB14	0010 0000 0000 0000—RB30
0100 0000 0000 0000—RB15	0100 0000 0000 0000—RB31
1000 0000 0000 0000—RB16	1000 0000 0000 0000—RB32

Modbus Register Map

Table E.17 Modbus Register Map (Sheet 1 of 5)

Address in Decimal	Address in Hex	Function Code	Conversion	Min	Max	Default	Name/Enums
Character Strings							
0–21	00–15	03h, 04h	12				FID Char (1–44)
22–43	16–2Bh	03h, 04h	12				BFID Char (1–44)
44–45	2C–2D	03h, 04h	12				CID Char (1–4)
46–53	2E–35h	03h, 04h	12				DEVID Char (1–16)
54	36	03h, 04h	1				DEVCODE
55–64	37–40	03h, 04h	12				Part Number Char (1–20)
65–67	41–43	03h, 04h					Config (1–6)
68–99	44–63	03h, 04h	5	8000	8000	8000	Reserved = 8000h
100	64	03h, 04h	0	0	1	1	FPGA Status
101	65	03h, 04h	0	0	1	1	RAM Status
102	66	03h, 04h	0	0	1	1	ROM Status
103	67	03h, 04h	0	0	1	1	CR_RAM Status
104	68	03h, 04h	0	0	1	1	NON_VOL Status
105	69	03h, 04h	0	0	1	1	CLK_BAT Status
106	6A	03h, 04h	0	0	1	1	CLOCK Status
107	6B	03h, 04h	0	0	1	1	ENABLED
108	6C	03h, 04h	0	0	1	1	CID FILE Status
109	6D	03h, 04h	0	0	1		15V Status
110	6E	03h, 04h	0	0	1		PROC Status
111	6F	03h, 04h	0	0	1		HMI Status
112–199	6E–C7	03h, 04h	5	0	0	1	Reserved = 8000h
Math Variables							
200–231	C8–E7	03h, 04h	15	-1677721599	+1677721599	0	MV01 [0: UW], [1: LW] to MV16 [0: UW], [1: LW]
232–263	E8–107	03h, 04h	15	1677721599	+1677721599	0	MV17 [0: UW], [1: LW] to MV32 [0: UW], [1: LW]
264–399	108–18F	03h, 04h	5	8000	8000	8000	Reserved = 8000h
Device Date/Time							
400	190	03h, 04h, 06h, 10h	1	0	59		ss
401	191	03h, 04h, 06h, 10h	1	0	59		mm
402	192	03h, 04h, 06h, 10h	1	0	23		HH
403	193	03h, 04h, 06h, 10h	1	1	31		DD
404	194	03h, 04h, 06h, 10h	1	1	12		MM

Table E.17 Modbus Register Map (Sheet 2 of 5)

Address in Decimal	Address in Hex	Function Code	Conversion	Min	Max	Default	Name/Enums
405	195	03h, 04h, 06h, 10h	1	2000	2999		YY
406–409	196–1F3	03h, 04h	5	8000	8000	8000	Reserved = 8000h
410	19A	3, 4	13	0	4294967295	0	Port F Settings CRC
411	19B	3, 4	13				
412	19C	3, 4	13	0	4294967295		Port 2 Settings CRC
413	19D	3, 4	13				
414	19E	3, 4	13	0	4294967295		Port 3 Settings CRC
415	19F	3, 4	13				
416	1A0	3, 4	13	0	4294967295		Port 1 Settings CRC
417	1A1	3, 4	13				
418	1A2	3, 4	13	0	4294967295		Global Settings CRC
419	1A3	3, 4	13				
420	1A4	3, 4	13	0	4294967295		Device Settings CRC
421	1A5	3, 4	13				
422	1A6	3, 4	13	0	4294967295		Logic Settings CRC
423	1A7	3, 4	13				
424	1A8	3, 4	13	0	4294967295		Report Settings CRC
425	1A9	3, 4	13				
426	1AA	3, 4	13	0	4294967295		DNP 1 Settings CRC
427	1AB	3, 4	13				
428	1AC	3, 4	13	0	4294967295		DNP 2 Settings CRC
429	1AD	3, 4	13				
430	1AE	3, 4	13	0	4294967295		DNP 3 Settings CRC
431	1AF	3, 4	13				
432–499	1B0–1F3	3, 4	5	8000	8000	8000	Reserved = 8000 Hex
Device Word Status							
500	1F4	03h, 04h	11	0	65281		Row 0
501–620	1F5–26C	03h, 04h	11	0	65281		Row 1–Row 120
624–699	26D–2BB	03h, 04h	5	8000	8000	8000	Reserved = 8000h
Modbus Communications Counters							
700	2BC	03h, 04h	11	0	65535		Messages Received
701	2BD	03h, 04h	11	0	65535		Messages Transmitted
702	2BE	03h, 04h	11	0	65535		Invalid Address
703	2BF	03h, 04h	1	0	65535		Bad CRC
704	2C0	03h, 04h	1	0	65535		UART Error
705	2C1	03h, 04h	1	0	65535		Illegal Function
706	2C2	03h, 04h	1	0	65535		Illegal Register
707	2C3	03h, 04h	1	0	65535		Illegal Write
708	2C4	03h, 04h	1	0	65535		Bad Packet Format

Table E.17 Modbus Register Map (Sheet 3 of 5)

Address in Decimal	Address in Hex	Function Code	Conversion	Min	Max	Default	Name/Enums
709	2C5	03h, 04h	1	0	65535		Bad Packet Length
710–799	2C6–31F	03h, 04h	5	8000	8000	8000	Reserved = 8000h
Remote Analogs							
800–863	320–35F	03h, 04h, 06h, 10h	15	–9999999	+9999999	0	RA001 [0: UW], [1: LW] to RA032 [0: UW], [1: LW]
864–927	360–39F	03h, 04h, 06h, 10h	15	–9999999	+9999999	0	RA033 [0: UW], [1: LW] to RA064 [0: UW], [1: LW]
928–991	3A0–3DF	03h, 04h, 06h, 10h	15	–9999999	+9999999	0	RA065 [0: UW], [1: LW] to RA096 [0: UW], [1: LW]
992–1055	3E0–41F	03h, 04h, 06h, 10h	15	–9999999	+9999999	0	RA097 [0: UW], [1: LW] to RA128 [0: UW], [1: LW]
1056–1099	420–44B	03h, 04h	5	8000	8000	8000	Reserved = 8000h
Command Region							
1100	44C	03h, 04h, 06h[a], 10h	11				Parameter 2[b]
1101	44D	03h, 04h, 06h[a], 10h	11				Parameter 1[b]
1102	44E	03h, 04h, 06h[a] 10h	11				Command Code[b]
Device Counters							
1200	4B0	3, 4	1	0	16777215	0	SC01 - Upper Word
1201	4B1					0	SC01 - Lower Word
1202	4B2	3, 4	1	0	16777215	0	SC02 - Upper Word
1203	4B3					0	SC02 - Lower Word
1204	4B4	3, 4	1	0	16777215	0	SC03 - Upper Word
1205	4B5					0	SC03 - Lower Word
1206	4B6	3. 4	1	0	16777215	0	SC04 - Upper Word
1207	4B7					0	SC04 - Lower Word
1208	4B8	3, 4	1	0	16777215	0	SC05 - Upper Word
1209	4B9					0	SC05 - Lower Word
1210	4BA	3, 4	1	0	16777215	0	SC06 - Upper Word
1211	4BB					0	SC06 - Lower Word
1212	4BC	3, 4	1	0	16777215	0	SC07 - Upper Word
1213	4BD					0	SC07 - Lower Word
1214	4BE	3, 4	1	0	16777215	0	SC08 - Upper Word
1215	4BF					0	SC08 - Lower Word
1216	4C0	3, 4	1	0	16777215	0	SC09 - Upper Word
1217	4C1					0	SC09 - Lower Word
1218	4C2	3, 4	1	0	16777215	0	SC10 - Upper Word
1219	4C3					0	SC10 - Lower Word
1220	4C4	3, 4	1	0	16777215	0	SC11 - Upper Word
1221	4C5					0	SC11 - Lower Word

Table E.17 Modbus Register Map (Sheet 4 of 5)

Address in Decimal	Address in Hex	Function Code	Conversion	Min	Max	Default	Name/Enums
1222	4C6	3, 4	1	0	16777215	0	SC12 - Upper Word
1223	4C7					0	SC12 - Lower Word
1224	4C8	3, 4	1	0	16777215	0	SC13 - Upper Word
1225	4C9					0	SC13 - Lower Word
1226	4CA	3, 4	1	0	16777215	0	SC14 - Upper Word
1227	4CB					0	SC14 - Lower Word
1228	4CC	3, 4	1	0	16777215	0	SC15 - Upper Word
1229	4CD					0	SC15 - Lower Word
1230	4CE	3, 4	1	0	16777215	0	SC16 - Upper Word
1231	4CF					0	SC16 - Lower Word
1232	4D0	3, 4	1	0	16777215	0	SC17 - Upper Word
1233	4D1					0	SC17 - Lower Word
1234	4D2	3, 4	1	0	16777215	0	SC18 - Upper Word
1235	4D3					0	SC18 - Lower Word
1236	4D4	3, 4	1	0	16777215	0	SC19 - Upper Word
1237	4D5					0	SC19 - Lower Word
1238	4D6	3, 4	1	0	16777215	0	SC20 - Upper Word
1239	4D7					0	SC20 - Lower Word
1240	4D8	3, 4	1	0	16777215	0	SC21 - Upper Word
1241	4D9					0	SC21 - Lower Word
1242	4DA	3, 4	1	0	16777215	0	SC22 - Upper Word
1243	4DB					0	SC22 - Lower Word
1244	4DC	3, 4	1	0	16777215	0	SC23 - Upper Word
1245	4DD					0	SC23 - Lower Word
1246	4DE	3, 4	1	0	16777215	0	SC24 - Upper Word
1247	4DF					0	SC24 - Lower Word
1248	4E0	3, 4	1	0	16777215	0	SC25 - Upper Word
1249	4E1					0	SC25 - Lower Word
1250	4E2	3, 4	1	0	16777215	0	SC26 - Upper Word
1251	4E3					0	SC26 - Lower Word
1252	4E4	3, 4	1	0	16777215	0	SC27 - Upper Word
1253	4E5					0	SC27 - Lower Word
1254	4E6	3, 4	1	0	16777215	0	SC28 - Upper Word
1255	4E7					0	SC28 - Lower Word
1256	4E8	3, 4	1	0	16777215	0	SC29 - Upper Word
1257	4E9					0	SC29 - Lower Word
1258	4EA	3, 4	1	0	16777215	0	SC30 - Upper Word
1259	4EB					0	SC30 - Lower Word
1260	4EC	3, 4	1	0	16777215	0	SC31 - Upper Word
1261	4ED					0	SC32 - Lower Word

Table E.17 Modbus Register Map (Sheet 5 of 5)

Address in Decimal	Address in Hex	Function Code	Conversion	Min	Max	Default	Name/Enums
1262	4EE	3, 4	1	0	16777215	0	SC32 - Upper Word
1263	4EF					0	SC32 - Lower Word
1264–3999	4F0–F9F	3, 4	5	8000	8000	8000	Reserved = 8000 Hex
4000–65535	FA0–FFFF	3, 4	5	8000	8000	8000	Reserved = 8000 Hex

[a] If function code 6 is used to write to a command code region that has parameters, the parameters must be written first.
[b] Once the command code is written, parameters 1 and 2 are cleared and must be rewritten prior to the next command.

Table E.18 Device Word Bit Locations

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
B7	B6	B5	B4	B3	B2	B1	B0	0	0	0	0	0	0	0	[a]

[a] This bit will be asserted if any of bits 8–15 are asserted.

Conversion Table

Use the information in *Table E.19* to convert the units of the received data into the appropriate scale for further processing or display.

Table E.19 Conversion Table

Index[a]	Type	Multiply	Divide	Offset	Base
0	Boolean	1	1	0	1
1	Unsigned Integer	1	1	0	1
2	Unsigned Integer	1	10	0	1
3	Unsigned Integer	1	100	0	1
4	Unsigned Integer	1	1000	0	1
5	HEX	1	1	0	1
6	Integer	1	1	0	1
7	Integer	1	10	0	1
8	Integer	1	100	0	1
9	Integer	1	1000	0	1
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1
12	Two 8 bit ASCII characters	1	1	0	1
13	Long Integer	1	1	0	1
14	Long Integer	1	10	0	1
15	Long Integer	1	100	0	1
16	Long Integer	1	1000	0	1

[a] Refers to the conversion column in *Table E.17*.

Appendix F
IEC 61850 Communications

Features

NOTE: The SEL-2440 supports one CID file, which should be transferred only if a change in the device configuration is required. If an invalid CID file is transferred, the device 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 device.

The SEL-2440 device supports the following features through use of Ethernet and IEC 61850:

SCADA. Connect as many as 7 simultaneous IEC 61850 Manufacturing Message Specification (MMS) client sessions. The device supports as many as 12 buffered and 7 unbuffered report control blocks. See *Table F.27* for details on the logical nodes associated with these bits. This information is useful for issuing controls with an MMS browser. Controls support the Normal and Enhanced Security control models for Direct and Select Before Operate operations.

Real-Time Status and Control. Use GOOSE with as many as 16 incoming (receive) and as many as 8 outgoing (transmit) messages. Controls only support the direct-with-normal-security control model. Remote Bits (RB01–RB32), Virtual Bits (VB001–VB128) and remote analogs (RA001–RA128) can also be mapped from GOOSE receive messages using ACSELERATOR Architect® SEL-5032 Software.

Configuration. Use FTP client software or Architect to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) files to the device.

Commissioning and Troubleshooting. Use software such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc., to browse the device logical nodes and verify functionality.

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 F.1*. The original parts were first published between 2001 and 2004 and are often referred to as IEC 61850 Edition 1 (Ed1). Selected parts of the standard were updated again between 2018 and 2020. The revised versions are collectively known as Edition 2 Amendment 1 (Ed2.1), published in 2020, and include modifications to the following core parts:

- IEC 61850-6
- IEC 61850-7-1
- IEC 61850-7-2, 7-3, 7-4
- IEC 61850-8-1
- IEC 61850-9-2, IEC 61869-9
- IEC 61850-10

It is possible and even likely, that an installation can have a mixture of devices that conform to different editions. The standard generally supports backward compatibility, i.e., Ed2 devices can send and receive messages to and from Ed1 devices. However, there are important considerations to be made when adding Ed2 or Ed2.1 devices to an existing Ed1 system. Refer to *Potential Client and Automation Application Issues With Ed2 and 2.1 Upgrades on page F.51* for more information.

Table F.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 (CDC)
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

IEC 61850 and Ethernet networking model options are available when ordering a new device and may also be available as field upgrades to devices equipped with the Ethernet card. In addition to IEC 61850, the Ethernet card provides support protocols and data exchange, including FTP and Telnet, to SEL devices. Access the device Port 5 settings to configure all of the Ethernet settings, including the IEC 61850 network settings.

The device supports IEC 61850 services, including transport of logical node objects, over TCP/IP. The device can coordinate a maximum of seven concurrent IEC 61850 MMS 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 ser vices that exist independently of any underlying protocols. These objects are in conformance with the 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) and description (DC). Functional constraints, CDCs, and CDC attributes are used as building blocks for defining logical nodes. *Table F.2* shows the CDCs supported in the SEL-2440.

Table F.2 Device Common Data Classes (Sheet 1 of 2)

CDC Name	Description
Status Information	
SPS	Single point status
INS	Integer status
ENS	Enumerated status
BCR	Binary counter reading
VSS	Visible string status
Measurand Information	
MV	Measured value
Status Settings	
SPG	Single point setting
ING	Integer status setting
ENG	Enumerated status setting
ORG	Object reference setting

Table F.2 Device Common Data Classes (Sheet 2 of 2)

CDC Name	Description
TSG	Time setting group
VSG	Visible string setting
Description Information	
DPL	Device name plate
LPL	Logical node name plate
Controls	
SPC	Controllable single point
ENC	Controllable enumerated status

The standard describes elements of the power system that use semantic representations. A physical device contains one or more logical devices that contain many logical nodes. A 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 nonrevenue grade measurement data and other points associated with three-phase metering. 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. Clients can request and display a list and description of the data available in an IEC 61850 server. Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also shows 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 query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other 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 F.3* shows how the A-Phase current magnitude expressed as MMXUAphsA$cVal.mag.f is broken down into its component parts.

Table F.3 Example IEC 61850 Descriptor Components

Component		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
PhsA	Subdata Object	A-Phase
cVal	Data Attribute	Complex value
mag	Sub-data attribute	Magnitude
f	Data type	Float32

Functional Naming

Substation design typically starts with a one-line diagram and progresses down to the assignment of functions to IEDs. In this top-down approach, the functions are identified and named independently from the IEDs to which they are assigned. Because a logical device is a grouping of logical nodes that perform a certain

NOTE: Functional naming is not supported by all MMS clients and GOOSE subscribers. Verify support for this feature before configuring functional names in a publishing IED. Earlier SEL-2440 firmware that do not support functional naming can subscribe to GOOSE publications from IEDs that use functional naming.

high-level function at a substation, the associated name often indicates the assigned function. The functional naming feature allows users to name a logical device based on the function it provides independent of the name of the IED to which the function is assigned. The alternative is product naming, which prepends the IED name to the logical device instance to create the logical device name. The functional name is used on the communications interface for all references to data in the logical device.

The SEL-2440 supports functional naming of logical devices. You can add functional names in Architect for supported Ed2 relays. To enable it in Architect, navigate to **Edit > Project Settings** and select the **Enable functional name editing on Server Model tab of supporting IEDs** check box, as shown in *Figure F.1*.

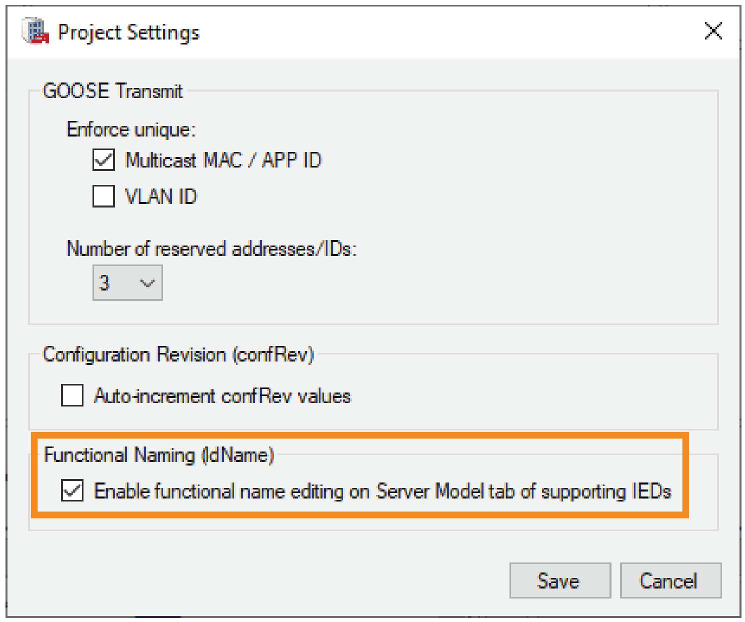


Figure F.1 Enabling Functional Naming in Architect

To provide functional names to the logical devices, navigate to the Server Model tab for the IED. Because data sets and control blocks are in the CFG logical device, any functional name given to the CFG logical device instance is used in data set references, control block references, and published GOOSE messages, as shown in *Figure F.2*. The IED Server Model also allows the user to change the default logical node prefix and instance values.

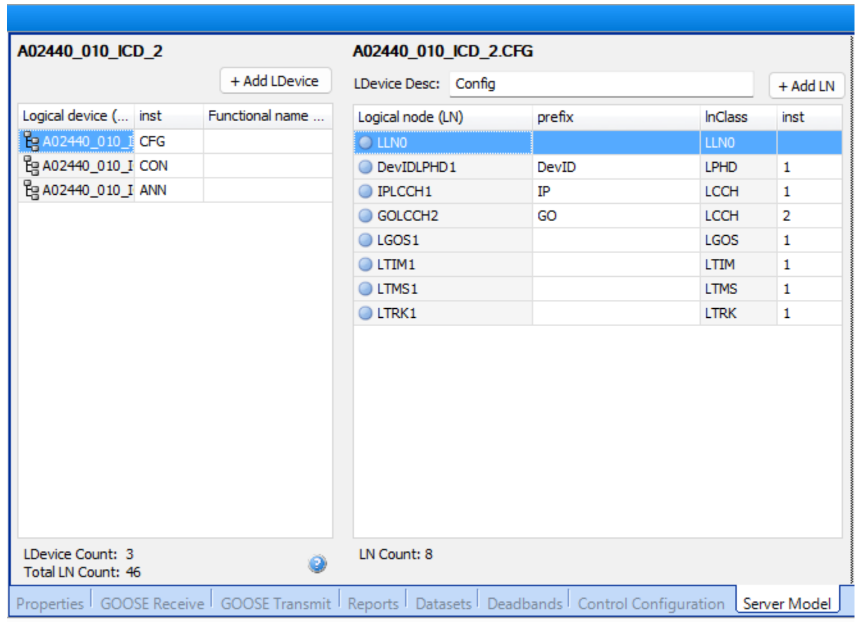


Figure F.2 Server Model View in Architect

Data Mapping

Device data are mapped to IEC 61850 LN according to rules defined by SEL. Refer to IEC 61850-5:2013(E) and IEC 61850-7-4:2010(E) for the mandatory content and usage of these LNs. The device logical nodes are grouped under Log cal Devices for organization based on function. See *Table F.4* for descriptions of the logical devices in a relay. See *Logical Nodes on page F.35* for a description of the LNs that make up these logical devices.

Table F.4 Relay Logical Devices

Logical Device	Description
CFG	Configuration elements—data sets and report control blocks
PRO	Protection elements—protection functions and breaker control
MET	Metering or Measurement elements— currents, voltages, power, etc.
CON	Control elements—remote bits
ANN	Annunciator elements—alarms, status values

MMS

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. MMS associations are discussed within IEC61850-8-1, Clause 10 of the Ed1 standard.

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 device.

- ➤ If the correct password authentication parameter value is not received, the device will return a not authenticated error code. If a user attempts to log in to the device with three consecutive invalid login attempts within a 1-minute period, the device will disable login requests for 30 seconds and pulse the SALARM Device Word bit.
- ➤ If the correct password authentication parameter value is received, the device will provide a successful association response. The device will allow access to all supported MMS services for that association.

Control

IEC 61850 Controls

An IEC 61850 server may allow a client to manipulate data related to its outputs, external devices, or internal functions. This is accomplished by the IEC 61850 control model, which provides services to execute control commands. The control models are defined in IEC 61850-7-2 and the mapping to the MMS application protocol is defined in IEC 61850-8-1. The former describes control functionality while the latter maps the IEC 61850 control primitives to MMS.

The SEL-2440 supports four different control models:

- ➤ Status only
- ➤ Direct with normal security
- ➤ Direct with enhanced security
- ➤ SBO with normal security
- ➤ SBO with enhanced security

One control model must be selected during initial IED configuration in Architect and be applied throughout the CID file. This control model applies to all controls in the IED. For CID files created from an ICD file with ClassFileVersion 010 or later, Architect allows modifying the control model on a per-control basis if a different control model is required other than the one selected during initial IED configuration.

Firmware that supports Ed2.1 and ClassFileVersion 010 or later supports pulsing the SPC and DPC control models as defined in IEC 61850-7-3 by configuring pulseConfig attributes cmdQual, onDur, offDur, and numPls.

Direct Control Models

The direct control models provide the simplest means to initiate actions on the server. In these models, the client issues a control request via MMS and the server validates the request. Once validated, the server attempts to act upon the request. Note that if multiple clients try to perform control actions, the server does nothing to prevent the simultaneous control actions.

SBO Control Model

The SBO control model supports the SelectWithValue Service and can be used to prevent multiple clients from performing simultaneous control actions. In this mode, a client has to “reserve” the control object by sending a “select” control command. Once an object is selected, only the client that made the selection is allowed to perform control actions on it. If that client does not send a valid operate request for the object by the time the select time-out runs out, the object becomes available for selection again. The device supports as many as ten pending control object selections at any time.

NOTE: When an IED is configured with the SBO with enhanced security control model, the sboTimeout attribute of the controllable CDCs in the CID file is set to ten seconds. This time-out is not configurable via Architect.

The attribute stSeld (selected status) of the controllable CDC is set to TRUE when a client successfully selects the control object. The attribute is reset to FALSE when either the control (operate) command is successfully executed, an error occurs, or no operate command is received within the select time-out period. The stSeld attribute may trigger a report just like any data attribute with trigger option.

Security in Control Models

"Security" in the control model context refers to additional supervision of the status value by the control object. The enhanced security models report additional error information on failed operations to the requesting client unlike the models with "normal security." Enhanced security control models provide a command termination report indicating if the control actually reached the new state as commanded within a configurable time-out period.

NOTE: The maximum time required for a control operation to be completed should be less than the configured time-out period to avoid erroneous command termination reports indicating failure.

The time-out period between the execution of a control and the generation of a command termination report indicating failure has a default value of 1 s and is configurable via the CID file. This time out is not configurable via Architect.

Optional Control Configurations

The SEL-2440 devices that have Ed2.1 and ClassFileVersion 010 or later support pulse configuration option specified in Clause 6.7 of IEC 61850-7-3. For devices that do not support Ed2.1, some control logical nodes are available that pulse the control for one processing interval.

Controls that can be configured for pulse operations, such as the SPCSO data objects in the RBGGIO logical nodes, contain a pulseConfig constructed data attribute type.

The cmdQual data attribute of an SPC or DPC control defines whether the control will be persistent or pulsed.

- cmdQual defines whether the control is persistent or pulsed. If cCmdQual = 0 (pulse), the control object pulses when the command is written to, according to the onDur, offDur and numPls attributes. If cmdQual = 1 (persistent), the control object asserts if ctlVal is true or deassert if ctlVal is false.

  Figure F.3 shows an example of how onDur, offDur, and numPls are used when the control is pulsed.

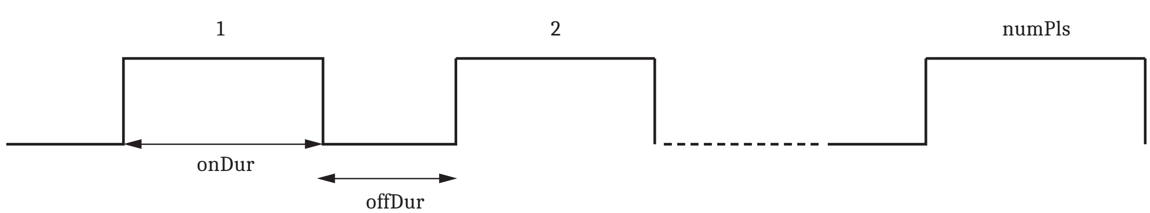


Figure F.3 Pulse Behavior in Control Operations

- If cmdQual = 0 (pulse), onDur = 0, and offDur = 0, the control object pulses for one processing interval.

Use Architect to configure a control to pulse by selecting a controllable data object (such as a remote bit), selecting the Control Configuration tab, and setting the pulseConfig.cmdQual to pulse (see *Figure F.4*). Setting pulseConfig.cmdQual allows changes to the onDur, offDur, and numPls attributes.

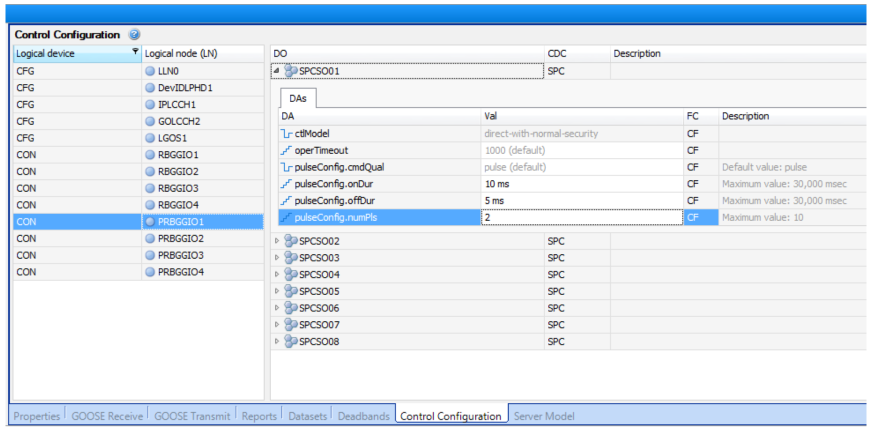


Figure F.4 Configuration of Pulse Control Operation

Local/Remote Control Authority

Control commands at a substation originate from one of three levels: remote (network control center), station, or bay. Under certain operational conditions (e.g., during maintenance), you may need to block control commands from one or more of these levels. The local/remote control feature allows you to enable or disable control authority at any of the three levels. The level at which a control command originates is determined by the value of the origin.orCat (originator category) attribute in the command. *Table F.5* describes the different orCat values defined in IEC 61850-7-2.

Table F.5 Originator Categories

Originator Category	Value
Not-supported	0
Bay-control	1
Station-control	2
Remote-control	3
Automatic-bay	4
Automatic-station	5
Automatic-remote	6
Maintenance	7
Process	8

SEL-2411 devices support the local/remote control feature defined in IEC 61850-7-4. The feature is supported at the IED level and logical node level with identical and configurable attributes in the LLN0 logical node in each logical device and in CSWI logical nodes. *Table F.6* describes the attributes and their data sources in various logical nodes.

Table F.6 Control Authority Attributes

Logical Node	Attribute	Data Source	Description
LLN0	Loc.stVal	LOCAL	Control authority of the IED at local (bay) level
	LocSta.stVal	LOCSTA	Control authority of the IED at station level
	MltLev.setVal	MLTLEV	Multi-level control authority

You can control the Relay Word bits LOCAL, LOCSTA, and MLTLEV through SELOGIC control equations. LOCSTA is set to True when the SELOGIC control equation SC850LS asserts and is set to False when SC850LS deasserts. LOCSTA can also be controlled through MMS, but if LOCSTA is set to True through SELOGIC control equations, it cannot be set to False through MMS. By default, all three attributes are set to False, so only remote commands are allowed.

The IED-level local/remote behavior can be changed by changing the value of the LOCAL Relay Word Bit through a SELOGIC control equation.

Using the Loc, LocSta, and MltLev LLNO stVal attributes, you can enable or disable control authority at any of the three switching levels, as shown in *Table F.7*.

Table F.7 Control Authority Settings

LLNO			orCat Value		
Loc.stVal	**LocSta.stVal**	**MltLev.setVal**	**Bay (1 or 4)**	**Station (2 or 5)**	**Remote (3 or 6)**
F	F	F	NA	NA	AA
F	F	T	AA	AA	AA
F	T	F	NA	AA	NA
T	X	X	AA	NA	NA
F	T	T	AA	AA	NA

Control Requests

IEC 61850 control services are implemented by reading and writing to pseudo-variables in the device in response to MMS requests. Similar to how client requests are generated and mapped to MMS read or write service requests, server actions are also mapped to internal commands, read and write actions, and MMS information report messages. In the case of an unsuccessful control request, the device sends the appropriate response PDU indicating that there was a problem and an MMS information report that contains more detailed information about the problem that occurred.

When writing controls, the client must select and write the entire Oper, SBOw or Cancel structure to the device. See *Figure F.5* for the attributes of the CON logical device and the ST and CO functional constraints (FC) of LN RBGGIO1 used for controls of RB01 through RB08.

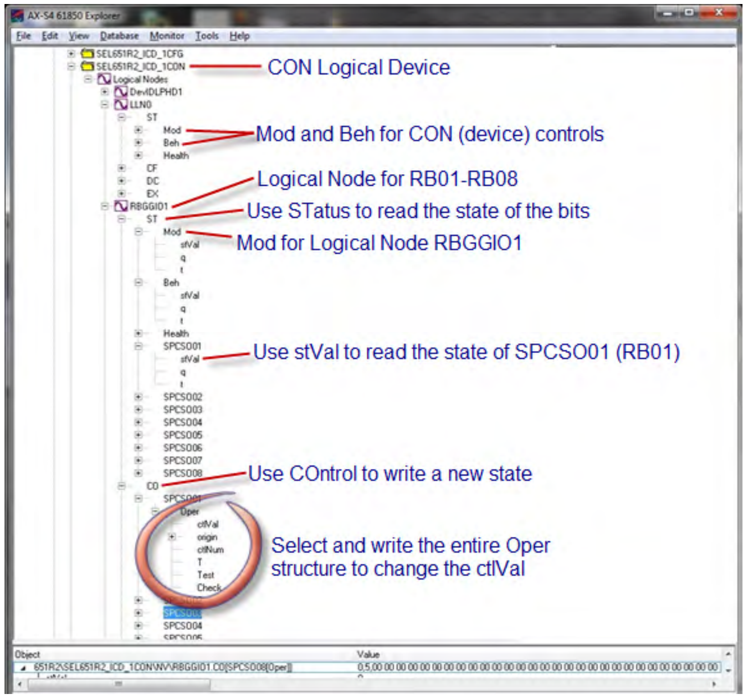


Figure F.5 MMS Client View of the CON Logical Device

Control Error Messages

If a control request results in an error condition, the device responds with an AddCause value in an MMS information report. See Clause 20.5.2.9 of IEC 61850-7-2 for additional information on the AddCause values.

The SEL-2440 supports the AddCause values in *Table F.8* as part of the LastApplError information report.

Table F.8 AddCause Descriptions (Sheet 1 of 2)

AddCause Enumeration	AddCause Description	Error Condition
0	Unknown	No other AddCause value defined within this section applies
2	Blocked-by-switching-hierarchy	Logical node is set to local mode, i.e., Loc.stVal = true
3	Select-failed	Originator category not allowed to issue control commands or SelectWithValue operation fails
4	Invalid-position	For controls with enhanced security, an AddCause of “Invalid-position” (4) will be sent if the control status changes to an unexpected value. If no control status change is detected after the operate time-out period, an AddCause of “Time-limit-over” (16) will be sent.
5	Position-reached	Control status is already at the desired state
6	Parameter-change-in-execution	Control object is already selected by the client, and 1. Logical node is set to local mode i.e., Loc.stVal = true, or 2. Originator category not allowed to issue control commands
8	Blocked-by-mode	Mode of logical device or node is not ON
10	Block-by-interlocking	Selection of switch device failed due to interlock check
12	Command-already-in-execution	Execution of a previous control is not completed
13	Blocked-by-health	Health of logical device or node is not OK

Table F.8 AddCause Descriptions (Sheet 2 of 2)

AddCause Enumeration	AddCause Description	Error Condition
16	Time-limit-over	CommandTermination gives a negative response. (The control failed to reach its intended state prior to time-out.)
18	Object-not-selected	Cancel operation fails

Any AddCause value not specified above is not supported. Control CDC data attributes that are associated with unsupported AddCause values and are not part of a control structure will be accepted but ignored. For example, the attribute CmdBlk.stVal, which is associated with the AddCause value "blocked-by-command" and is not part of a SBOw, Oper, or Cancel structure, will be ignored.

Service Tracking

The IEC 61850 standard defines many services to be provided by an IED (server). These services include control services, reporting services, logging services, and group switch control services. IEC 61850 Ed2 defines the service tracking feature to allow these services to be reported or logged, whether they succeed or fail.

The SEL-2440 supports the service tracking feature for control commands, report control block edits, and group switch selection. You can report these services.

Tracking of these services is enabled by data objects in the service tracking logical node LTRK. *Table F.9* lists the service tracking data objects. Their data attributes mirror those in the service request or in the control block that was the target of the service request.

Table F.9 Service Tracking Data Objects

Data Object	CDC	Description
SpcTrk	CTS	Tracks control service requests targeted at a controllable single-point object
EncTrk	CTS	Tracks control service requests targeted at a controllable enumerated status object
UrcbTrk	UTS	Tracks unbuffered report control block edits
BrcbTrk	BTS	Tracks buffered report control block edits

Refer to *Table F.25* for information regarding the available attributes in each tracking data object.

Each tracking data object includes the data attributes objRef, serviceType, and errorCode. The attribute objRef provides the reference to the control object or control block instance that was the target of the service request. The attribute serviceType provides an enumerated value for the specific service requested or executed. *Table F.10* defines the service type enumerations.

Table F.10 IEC 61850 Service Type Enumeration (Sheet 1 of 2)

Service Type	Service Name	Description
16	SelectActiveSG	Active settings group switch request
24	SetBRCBValues	Write request on one or more of the following buffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, PurgeBuf, EntryID, or GI
26	SetURCBValues	Write request on one or more of the following unbuffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, Resv, or GI
44	SelectWithValue	Select control request
45	Cancel	Cancel control request

Table F.10 IEC 61850 Service Type Enumeration (Sheet 2 of 2)

Service Type	Service Name	Description
46	Operate	Operate control request
47	CommandTermination	Control processing completed on a control object configured with enhanced security control model
54	InternalChange	Report control block has been automatically disabled, i.e., RptEna is set to False after a loss of association with the client

The attribute errorCode provides the error code that indicates whether the service was successful or unsuccessful. The codes are listed in *Table F.11* together with the corresponding ACSI errors.

Table F.11 IEC 61850 ACSI Service Error

Error Code	ACSI Error
0	no-error
1	instance-not-available
3	access-violation
5	parameter-value-inappropriate
6	parameter-value-inconsistent
7	class-not-supported
8	instance-locked-by-other-client
10	type-conflict
11	failed-due-to-communications-constraint
12	failed-due-to-server-constraint

When creating data sets to track the services through information reporting, it is important to include the tracking data objects as a whole object (FCD—functionally constrained data), and not as individual data attributes (FCDA—functional constrained data attribute). Only the objRef attribute has a trigger option (dupd—data update) and can trigger a report. The dupd trigger option must also be enabled in the report control block that is reporting changes in the tracking data objects.

File Services

The Ethernet file system allows reading or writing data as files. 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.

NOTE: The SEL-2440 supports SER and analog signal profile report retrieval.

The device supports MMS file transfer with or without authentication. Note that the MMS File Transfer service will still be supported even if the device contains an invalid CID file. The service is intended to support:

- Settings file download and upload

  CID file download and upload

  Event report retrieval

MMS File Services are enabled or disabled via the Port 1 settings, EMMSFS. Permissions for the Access Level 2 apply to MMS File Services requests. All files and directories that are available at the Access Level 2 via any supported file transfer mechanism (FTP, file read/write, etc.) are also available for transfer via MMS File Services. See *Virtual File Interface on page 6.30* for details on the files available for MMS 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:

- IED Capability Description (.ICD) file
- System Specification Description (.SSD) file
- Substation Configuration Description (.SCD) file
- Configured IED Description (.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.

Reports

IEC 61850 provides two classes of reporting services, unbuffered and buffered, that a client can use to receive event data from a server. The unbuffered report service provides event data on a best-effort basis only while the client is connected. In contrast, the buffered report service keeps an internal buffer of events, which ensures clients can receive a sequence of events even after reconnecting following a lost connection. The relay supports unbuffered and buffered report control blocks in the report model as defined in IEC 61850-8-1:2020.

IEC 61850 servers can deliver the same event data to multiple clients. IEC 61850 Ed1 proposed two different approaches that a server could use to accomplish this: association-based (non-indexed) reports and indexed reports. As of Ed2.1, SEL-2440 devices support both methods. The device supports as many as 24 report control blocks (12 each of buffered and unbuffered reports). Reports can either be configured as association-based reports or indexed reports. Configuring a mix of association-based reports and indexed reports is not allowed, and such a configuration will be rejected by the IED. SEL devices with ClassFileVersion 009 or earlier support only association-based reports. Devices that are ClassFileVersion 010 or later support association-based reports as well as indexed reports.

ICD files with ClassFileVersion 009 and earlier only support dynamic report reservations. Writing to ResvTms of the buffered report control block (BRCB) or Resv of the unbuffered report control block (URCB) causes the client to dynamically obtain a reservation. ICD files with ClassFileVersion 009 and later support both preconfigured report reservations and dynamic reservations. SEL-2411 does not support report reservations; however, other SEL relays with Ed2.1 do support report reservations.

Reports are serviced at a 2 Hz rate. The client can set the IntgPd to any value with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The report service rate of 2 Hz results in a report being sent within 500 ms of expiration of the IntgPd. The new IntgPd begins at the time that the current report is serviced.

When you are configuring unbuffered and buffered reports that contain only analog values, a data change report only is triggered when there is a change in the magnitude value in excess of the deadband setting. When you are configuring unbuffered and buffered reports that contain a combination of digital and analog values, any digital value change triggers a data change report, which contains the current value of the analogs contained in the report at the time of the trigger.

Unbuffered Reports

By using Architect, you can define if the URCB should be association-based or indexed. You can allocate data within each report data set to present different data attributes for each report. For unbuffered reports, connected clients may edit the report parameters shown in *Table F.12*.

Table F.12 Unbuffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)[a]	User Changeable (Report Enabled)	Default Values
RptID	YES		URep01–URep07
RptEna	YES	YES	FALSE
Resv	YES		Rsev = FALSE if no URCB instances are preconfigured for a client Resv = TRUE for all URCB instances if one or more preconfigured clients are specified by the SCL
OptFlds	YES		seqNum
			timeStamp
			dataSet
			reasonCode
BufTm	YES		250
TrgOps	YES		dchg
			qchg
			period
IntgPd	YES		0
GI		YES[b]	FALSE
Owner			If the ReportControl has a single preconfigured client and its IP address can be found in the SCL, the IP address of the client is used as the default value for Owner; otherwise, the default value is NULL.

[a] The report must be actively reserved by setting Resv to 1 before the attribute values can be changed.
[b] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.

Association-Based (Non-Indexed) URCBs

In association-based URCBs, the relay provides a unique URCB instance for each client association. Each client sees a different instance, although all instances have the same URCB name. This results in multiple client associations for that URCB. Once enabled, each client has independent access to an instance of that URCB. The server automatically ensures that a URCB instance is available to each client. SEL first offered association-based URCB support in the IEC 61850 Ed1 release of the relay.

The relay supports seven association-based URCBs and 7 simultaneous clients, resulting in a total of 49 URCB instances because each client views a different instance.

For example, if an association-based URCB is named UrcbA, seven clients can get independent access to UrcbA.

Indexed URCBs

In indexed URCBs, the server provides multiple URCB instances with all instances visible to all clients. Because all clients can see all instances, each instance must have a unique name. So, the report name is appended with a two-digit number *nn*, where *nn* ranges from 01 to the maximum number of instances supported for that control block. This allows a client to view all instances of a report control block, unlike association-based reports, where each client can only view the instance to which it is connected. Clients can reserve an instance by using the URCB Resv attribute. To prevent conflicts between clients, Ed2 introduced the concept of preconfigured reservations.

The relay added support for as many as 49 indexed URCB instances as part of the IEC 61850 Ed2.1 release of the relay.

Each report control block has seven instances available to connect to when a URCB is configured as indexed. For example, if UrcbA is configured as indexed, a client can connect to any one of the instances named UrcbA*xx*, where *xx* = 01–07.

Buffered Reports

By using Architect, you can define if the BRCB should be association-based or indexed. You can allocate data within each report data set to present different data attributes for each report. For buffered reports, connected clients can edit the report parameters shown in *Table F.13*.

Table F.13 Buffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)[a]	User Changeable (Report Enabled)	Default Values
RptID	YES		BRep01–BRep07
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum
			timeStamp
			dataSet
			reasonCode
			entryID
BufTm	YES		500
TrgOps	YES		dchg
			qchg
			period
IntgPd	YES		0
GI	YES[b,c]	YES[b]	0
PurgeBuf	YES[b]		FALSE
EntryId	YES		0
RsevTms	YES		–1 if the BRCB instance is preconfigured for a specific client in the SCL 0 if the BRCB instance is not reserved 60 if the report has been reserved with a write value of 0
Owner			NULL if the BRCB instance is not preconfigured or the IP address of the client in the SCL if it is preconfigured or dynamically assigned

[a] The report must be actively reserved by setting Resv to 1 before the attribute values can be changed.
[b] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.
[c] When disabled, a GI will be processed and the report buffered if a buffer has been previously established. Buffered reports begin buffering at startup.

ResvTms is an indication of the report reservation time for buffered reports. Clients must actively reserve the BRCB by setting ResvTms to a value greater than 0 before the report can be enabled. This is applicable to preconfigured SCL clients as well. A successful write to ResvTms results in the Owner attribute being updated to the IP address of the client that performed the write operation. When the MMS client disables the BRCB by setting RptEna to False and actively unreserves it by setting ResvTms to 0, the report is immediately available for write operations. After the ResvTms duration elapses, ResvTms reverts to 0 for dynamic associations, indicating the control block is available to other clients.

Association-Based (Non-Indexed) BRCBs

When a BRCB is configured as association-based or non-indexed, only one client can enable the BRCB at a time, which results in a client association for that BRCB. Once enabled, the associated client has exclusive access to the BRCB until the connection is closed or the BRCB is unreserved. Once enabled by a client, all unassociated clients have read-only access to the BRCB. SEL first offered association-based BRCB support in the IEC 61850 Ed1 release of the relay. For example, if an association-based BRCB is named BrcbA, a client can connect to the report with name BrcbA.

Indexed BRCBs

In indexed BRCBs, the server provides multiple BRCB instances with all instances visible to all clients. The report name is appended with a two-digit number *nn*, where *nn* ranges from 01 to the maximum number of instances supported for that control block. This allows a client to view all instances of a report control block. Clients can reserve an instance by using the BRCB ResvTms attribute.

The relay supports seven indexed BRCB instances as part of IEC 61850 Ed2.1 release of the relay.

Only one instance of the report control block is available to connect to when a BRCB is configured as indexed. For example, if BrcbA is configured as indexed in Architect, a client connects to the report with name BrcbA01.

Data Sets

IEC 61850 data sets are lists of references to DataObject attributes for the purpose of efficient observation and transmission of data. Architect ICD files come with predefined data sets that can be used to transfer data via GOOSE messages, SV messages, or MMS reports.

- GOOSE: You can use predefined or edited data sets, or create new data sets for outgoing GOOSE transmission.
- SV: Four predefined data sets are provided. Each data set includes three phase currents and the neutral current as well as three phase voltages and the neutral voltage.
- Reports: Fourteen predefined data sets (BRDSet01–BRDSet07 and URDSet01–URDSet07) correspond to the default seven buffered and seven unbuffered reports, respectively. Note that you cannot change the number (14) of each type of report (buffered or unbuffered) within Architect. However, you can alter the data attributes that a data set contains or even create new data sets, and so define what data an IEC 61850 client receives with a report.

Deadband Configuration and Functionality

Analog values of the MV, CMV, APC, and BAC CDCs defined in IEC 61850-7-3 have associated deadbands that determine when the analog values should be updated. The MV and CMV analog objects contain attributes that reflect the instantaneous value of the magnitude (instMag) and the value of the magnitude (mag), which is updated based on the deadband calculation.

Deadband calculations in Ed1 and Ed2 use a percent multiplier and the maximum range. The percent multiplier, a number between 0 and 100,000, is multiplied by 0.001 percent to determine the percentage of the maximum range to use as a deadband. Architect handles these calculations in the background, enabling users to configure the deadbands using nominal values. *Figure F.6* displays the view from the Deadband tab in Architect for both Ed1 and Ed2 implementations.

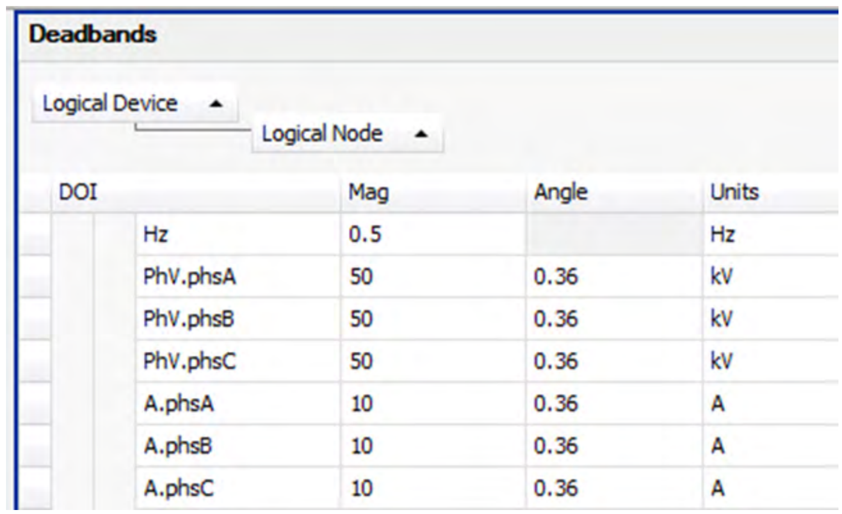


Figure F.6 Deadband Configuration View for Ed1 and Ed2

Ed2.1 introduced deadband-related attributes, dbRef, dbAngRef, zeroDb, and zeroDbRef, to explicitly expose the deadband behavior. The attribute dbRef may have a value of 0, which means the value db is used as the percentage of the last transmitted value in units of 0.001 percent. This is appropriate for currents and voltages. If the dbRef value is less than 0, it means the db represents the percentage of the dbRef in units of 0.001 percent and is appropriate for values with constant or small-changing values, for example frequency. The zeroDb attribute is the configuration parameter used to calculate the range around zero where the deadbanded value mag is forced to zero. The value of zeroDb represents the percentage of zeroDdRef in units of 0.001 percent.

For ICD files with ClassFileVersion 010 or higher, use Architect to view and configure the deadbands for analog values. The configuration values for the parameters shown in *Figure F.7* are editable, and Architect displays the resulting deadband value.

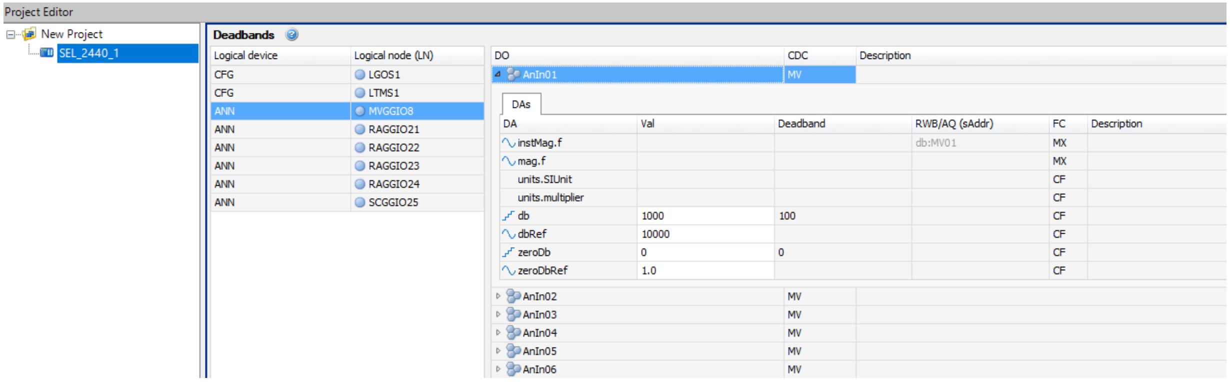


Figure F.7 Deadband Configuration View for Ed2.1

Supplemental Software Support

Examine the data structure and values of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 61850 from Sisco, Inc.

The settings needed to browse the device with an MMS browser are shown below.

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The time stamp is determined when data or quality change is detected. A change in the quality attribute can also be used to issue an internal event.

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. However, there is a difference in how the change is detected between the different attribute types. For points in a data set that are also listed in the SER, the change is detected by the SER process. For all other Booleans or Bstrings, the change is detected via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the deadband configured for the point to indicate a change and apply the time stamp. In all cases, these time stamps are used for the reporting model.

LN data attributes listed in the SER will have SER time stamps of 1 ms accuracy for data change events. All other LN data attributes are scanned on a 1/2-second interval for data change and have 1/2-second time-stamp accuracy.

The device 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. *Figure F.8* shows the GOOSE quality attributes available to devices that subscribe to GOOSE messages from device data sets that contain them. Internal status indicators provide the information necessary for the device to set these attributes. For example, if the device becomes disabled, as shown via status indications (e.g., an internal self-test failure), the device will set the Validity attribute to INVALID and the Failure attribute to TRUE. Note that the device does not set any of the other quality attributes. These attributes will always indicate FALSE (0). See the Architect online help for additional information on GOOSE quality attributes.

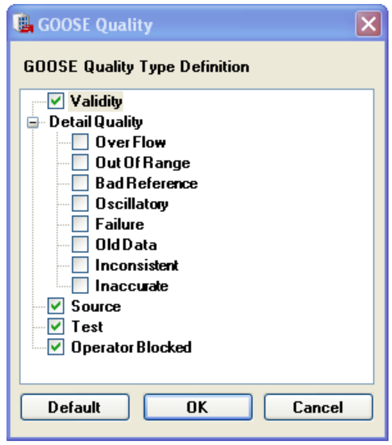


Figure F.8 GOOSE Quality Attributes

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.

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 Architect. Also, configure outgoing GOOSE messages for SEL devices in Architect. See the Architect online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference) in each outgoing message and an Ethernet multicast group address. Devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages.

Virtual bits (VB001–VB128) are control inputs that you can map to values from incoming GOOSE messages by using the Architect software. See the VB*nnn* bits in *Table F.26* for details on which logical nodes and names are used for these bits. This information can be useful when searching through device data with MMS browsers. If you intend to use any device Virtual bits for controls, you must create SELOGIC control equations to define these operations. The device is capable of receiving and sending analog values via peer-to-peer GOOSE messages. Remote analogs (RA001–RA128) are analog inputs that you can map to values from incoming GOOSE messages. Remote analog outputs (RA01–RA128) can be used to transmit analog values via GOOSE messages. You must create SELOGIC control equations to assign internal device values to RA points to transmit them via GOOSE.

GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2011(E), IEC 61850-7-2:2010(E), and IEC 61850-8-1:2011(E) via the installed Ethernet port.

Outgoing GOOSE messages are processed in accordance with the following constraints.

- The user can define as many as eight data sets for 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 data sets, or one or more times within the same outgoing GOOSE data set. A user can also map a single GOOSE data set to multiple GOOSE control blocks. The number of unique Boolean variables is limited to a combined total of 512 digital bits across all eight outgoing messages.

- High-speed GOOSE messaging (as defined under GOOSE Performance) is available for GOOSE messages that contain either all Boolean data or a combination of Boolean data and remote analog output (RA01–RA128) data.
- The device will transmit all configured GOOSE immediately upon successful initialization. If a GOOSE message is not retriggered, then following the initial transmission, the device shall retransmit that GOOSE based on the Min. Time and Max. Time configured for that GOOSE message. The first transmission shall occur immediately upon triggering of an element within the GOOSE data set. The second transmission shall occur Min. Time later. The third shall occur Min. Time after the second. The fourth shall occur twice Min. Time after the third. All subsequent transmissions shall occur at the Max. Time interval. For example, a message with a Min. Time of 4 ms and Max. Time of 1000 ms, will be transmitted upon triggering, then retransmitted at intervals of 4 ms, 4 ms, 8 ms, and then at 1000 ms indefinitely or until another change triggers a new GOOSE message (see IEC 61850-8-1, Sec. 18.1).
- Each outgoing GOOSE includes communications parameters (VLAN, priority, and multicast address) and is transmitted entirely in a single network frame.
- The device maintains the configuration of outgoing GOOSE messages through a power cycle and device reset.

Incoming GOOSE messages are processed in accordance with the following constraints.

- The user can configure the device to subscribe to as many as 16 incoming GOOSE messages.
- Control bits in the device get data from incoming GOOSE messages which are mapped to virtual bits (VB*nnn*). Virtual bits are volatile and are reset to zero when a new CID file is loaded, the device is restarted, or they are overwritten by data from a subscribed GOOSE message.
- The device recognizes incoming GOOSE messages as valid based on the following content:
  - Source Broadcast MAC Address
  - Data Set Reference*
  - Application ID*
  - GOOSE Control Reference*
  - Configuration Revision*
  - Needs Commissioning*
  - Quality Test*

NOTE: Options marked with * are configurable via tools such as Architect. The device, by default, checks against this parameter.

Any GOOSE message that fails these checks shall be rejected. You can find the default quality check in the quality mask in Architect. See *Figure F.10* for an example.

- Every received and validated GOOSE message that indicates a data change, by an incremented status number, is evaluated as follows:
  - Data within the received GOOSE data set that are mapped to host data bits are identified.
  - Mapped bits are compared against a local version of the available host data bits.
  - If the state of the received bits is different than the local version:
    - Update the local version with the new state for that bit.
    - Pass the new state for the bit to the device.
- Rejection of all DA contained in an incoming GOOSE message, based on the presence of the following error indications created by inspection of the received GOOSE message:
  - Configuration Mismatch: The configuration number of the incoming GOOSE message changes.
  - Needs Commissioning: This Boolean parameter of the incoming GOOSE message is true.
  - Decode Error: The format of the incoming GOOSE message is not as configured.
- Reject DAs with quality indicating test if the subscriber is in On or On-blocked mode.
- Upon transition of a device or logical node from On to Test, previously processed incoming GOOSE messages will be re-evaluated for test data and processed.
- Upon a transition of Mod/Beh, the received GOOSE messages are evaluated to determine if the messages will be processed according to IEC 61850-7-4 Appendix A.
- The device will discard incoming GOOSE under the following conditions:
  - After a permanent (latching) self-test failure
  - When EGSE is set to No

Link-layer priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2011.

GOOSE Performance

For outgoing high-speed data (as identified under GOOSE Processing), transmission of GOOSE begins within 2 ms of transition of digital data within the device. Note that you can include RAO points in outgoing GOOSE for high-speed transmission. Only the transition of a digital point will trigger the transmission within 2 ms. For all other data contained in outgoing GOOSE, transmission of GOOSE begins within 500 ms of transition of data within the device. For incoming GOOSE data with an included change of state, the corresponding mapped virtual bit states update within two processing intervals.

IEC 61850 Simulation Mode

The SEL-2440 devices can be configured to operate in simulation mode. In this mode, the SEL-2440 continues to process normal GOOSE messages until a simulated GOOSE message is received for a subscription. Once a simulated GOOSE message is received, only simulated GOOSE messages are processed for that subscription. Simulated mode only terminates when the Device Word bit LPHDSIM is returned to FALSE. When the device is not in simulation mode, only normal GOOSE messages are processed for all subscriptions.

A user can place the SEL-2440 in IEC 61850 simulation mode by setting CFG.DevIDLPHD1.Sim.stVal to TRUE via MMS messaging.

Alternatively, you can use SELOGIC variable SC850SM to set LPHDSIM. The rising edge of SC850SM sets LPHDSIM, and the falling edge of SC850SM clears LPHDSIM. When you use SC850SM to enter simulation mode, the relay rejects MMS attempts to enter or exit simulation mode until SC850SM deasserts.

IEC 61850 Mode/Behavior

NOTE: IEC 61850 Mode/Behavior is only available in IEDs with IEC 61850 Ed2 support.

The IEC 61850-7-4:2010 standard defines behaviors of different modes to facilitate testing. The SEL-2440 supports the following modes:

- On
- Blocked
- Test
- Test/Blocked
- Off

IEC 61850 Behavior is jointly determined by the logical device mode and its logical node mode according to the IEC 61850 standard. For the SEL-2440, the selected IEC 61850 Mode/Behavior applies to the entire IED, including all its logical devices and all logical nodes. The behavior of the IED is always the same as the selected mode.

Table F.14 describes the available services based on the mode/behavior of the IED.

NOTE: The device, when disabled due to a diagnostic failure, sets I850MOD to 5, "Off".

Table F.14 IEC 61850 Services Available Based on Mode/Behavior

Mode	MMS	GOOSE Publication and Subscription
On	Available	Available
Blocked	Available	Available
Test	Available	Available
Test/Blocked	Available	Available
Off	No services[a]	Publication[b]

[a] All MMS control requests to change the mode with Test = false will be processed.
[b] GOOSE and SV publication in mode Off are disabled if EOFFMTX = N.

The analog quantity I850MOD is an enumerated number that corresponds to mode and behavior as shown in *Table F.15*.

Table F.15 Analog Quantity I850MOD Status Based on the Selected IEC 61850 Mode/Behavior

I850MOD	IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	Not Supported

Mode/Behavior Control

Enable Mode/Behavior Control

IEC 61850 Mode/Behavior, by default, is disabled on SEL-2440 devices. To enable IEC 61850 Mode/Behavior, you must set Port 1 setting E61850 to **Y**. To enable IEC 61850 Mode/Behavior control, you must set port setting E850MBC to **Y** and the CID file setting controllableModeSupported to **True**. You can set the controllableModeSupported setting by selecting **Enable control of IEC 61850 Mode/Behavior** when adding an IED into an Architect project, as shown in *Figure F.9*.

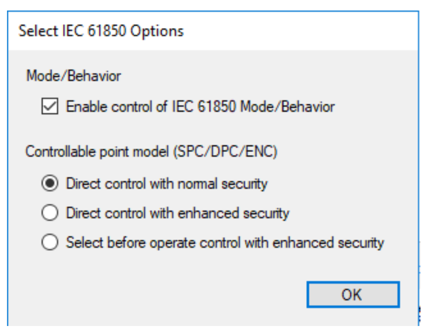


Figure F.9 Set controllableModeSupported = True

Enhanced Secure Mode Control

Device setting E850MBC and CID file setting controllableModeSupported provide security to prevent accidental switching into an unplanned IEC 61850 Mode/Behavior during normal operations. For example, following IED testing, a technician can disable unplanned switching of IEC 61850 Mode/Behavior by setting E850MBC to N after switching the device back to On mode.

Change Mode Via MMS or SELogic

If IEC 61850 Mode/Behavior is set as controllable, you can control the IEC 61850 Mode/Behavior via MMS writes to the LLN0 logical node mode data object (Mod.ctlVal) in logical device CFG. Note that Mod.ctVal in other logical devices does not accept MMS writes.

Write Values to Mod.ctVal in Logical Device CFG	Selected IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off

You can also control IEC 61850 Mode/Behavior through the use of SET G global settings SC850TM and SC850BM SELOGIC variables. These variables control Test Mode and Blocked Mode, respectively.

NOTE: The variables SC850TM and SC850BM are not protection settings.

SC850TM	SC850BM	Selected IEC 61850 Mode/Behavior
0	0	See Note[a]
1	0	Test
0	1	Blocked
1	1	Test/Blocked
See Note[b]	See Note[b]	Off

[a] Note: The SELOGIC controls have higher priority than MMS clients in controlling the Test mode and Blocked mode. When SC850TM and SC850BM both evaluate to 0 (false), IEC 61850 Mode/Behavior control is available to MMS clients. If either SC850TM or SC850BM evaluates to 1 (true), SELOGIC determines the IEC 61850 Mode/Behavior of the IED regardless of MMS control values.

[b] Note: You cannot control Off mode by using SC850TM and SC850BM. When an MMS client causes the IED to be in Off mode, the SELOGIC controls are disabled and SC850TM and SC850BM are not evaluated.

EXAMPLE F.1 Change Mode Via SELOGIC

In this example, remote bits RB1 and RB2 control SC850TM. Remote bits RB3 and RB4 control SC850BM. If you assert RB1, the device enters Test mode. If you assert RB3, the device transitions from Test mode into Test/Blocked mode. Assert RB2 and RB3 to reset Test mode and Blocked mode, respectively.

NOTE: Extraneous settings omitted in SHO L and SHO G.

```
=>>SHO G <Enter>

Global

IEC 61850 Mode/Behavior Configuration
SC850BM  := LT01
SC850TM  := LT02

=>>
=>>SHO L <Enter>

Logic

Latch Bit Set/Reset SELogic Equations
SET01    := RB01
RST01    := RB02
SET02    := RB03
RST02    := RB04

=>>
```

You can read the current IEC 61850 Mode/Behavior through an MMS client or by using the **STA** commands.

Mode Indications on HMI

If the Mode/Behavior is Test, Blocked, or Test/Blocked, the device toggles the **ENABLED** LED on the front panel approximately every half a second to alarm users that the device is not in On mode. When the device is placed in Off mode, the device is disabled and the device **ENABLED** LED is solid red.

Incoming Messages Processing

IEC 61850 incoming data processing is jointly determined by quality validity, test, and operatorBlocked. SEL-2440, by default, checks if the quality operatorBlocked = False; if not, the devices treat the messages as invalid. You can disable the default check by changing the quality mask of GOOSE subscriptions. *Figure F.10* illustrates the default quality check for GOOSE subscription on the SEL-2440.

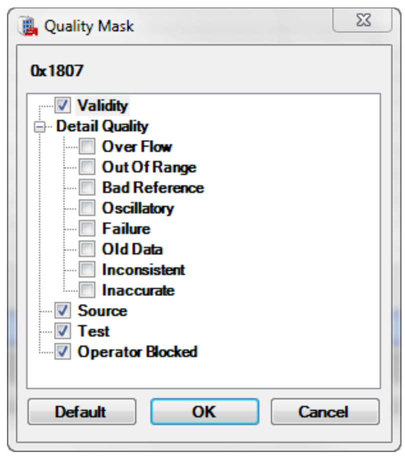


Figure F.10 Default Quality Check on GOOSE Subscription if Quality Is Present

Device Operation for Different IEC 61850 Modes/Behaviors

Mode: On

In On mode, the device operates as normal; it reports IEC 61850 Mode/Behavior status as On and processes all inputs and outputs as normal. If the quality of the subscribed GOOSE messages satisfies the GOOSE processing, the device processes the received GOOSE messages as valid.

NOTE: An IEC 61850 IED determines the processing of GOOSE messages based on the received quality of the GOOSE data and its current mode. If a GOOSE message does not contain quality information, the device always processes it as valid. To use the IEC 61850 Mode/Behavior, SEL recommends including quality attributes in GOOSE messages.

Table F.16 IEC 61850 Incoming Message Handling in On Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Processed	Processed as invalid
GOOSE	Processed	Processed as invalid

Table F.17 IEC 61850 Outgoing Message Handling in On Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	False
GOOSE	False

Figure F.11 illustrates the mode/behavior.

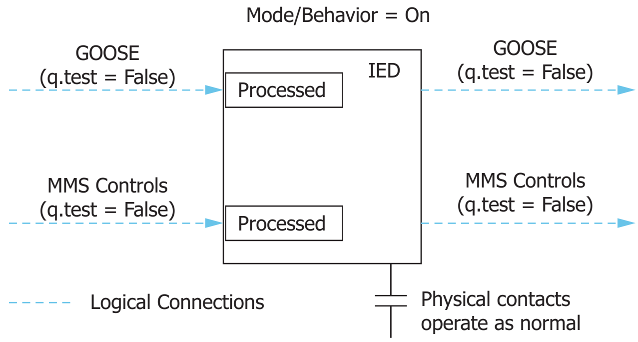


Figure F.11 Relay Operations in On Mode

Mode: Blocked

The device operates in Blocked mode similarly to how it operates in On mode, except that it does not operate any physical contact outputs in this mode. It does continue to operate control bits such as remote bits and output contact bits.

NOTE: In Blocked mode, the physical output contacts are frozen in the state they were in prior to entering Blocked mode.

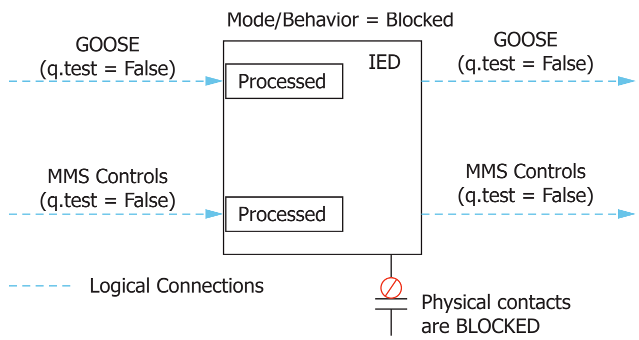


Figure F.12 Relay Operations in Blocked Mode

Mode: Test

In Test mode, the device processes valid incoming test signals or normal messages and operates physical contact outputs if triggered. In this mode/behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False), the device processes the received GOOSE messages as valid.

NOTE: An IEC 61850 IED determines the processing of GOOSE messages based on the received quality of the GOOSE data and its current mode. If a GOOSE message does not contain quality information, the device always processes it as valid. To use the IEC 61850 Mode/Behavior, SEL recommends including quality attributes in GOOSE messages.

Table F.18 IEC 61850 Incoming Message Handling in Test Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Not Processed	Processed
GOOSE	Processed	Processed

Table F.19 IEC 61850 Outgoing Message Handling in Test Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	True
GOOSE	True

Figure F.13 illustrates the mode/behavior.

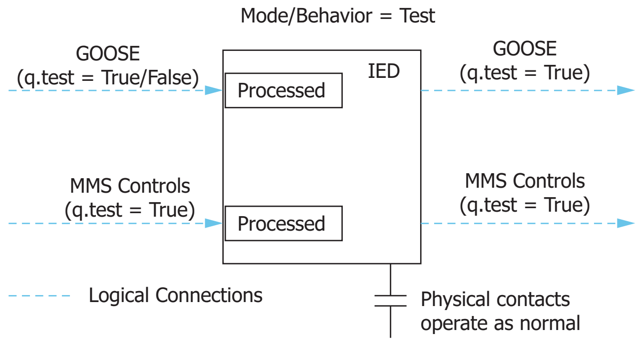


Figure F.13 Relay Operations in Test Mode

Mode: Test/Blocked

In Test/Blocked mode the device processes valid incoming test signals or normal messages but blocks any physical contact outputs from operating. In this mode/behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False), the device processes the received GOOSE messages as valid.

NOTE: An IEC 61850 IED determines the processing of GOOSE messages based on the received quality of the GOOSE data and its current mode. If a GOOSE message does not contain quality information, the device always processes it as valid. To use the IEC 61850 Mode/Behavior, SEL recommends including quality attributes in GOOSE messages.

Figure F.14 illustrates the mode/behavior.

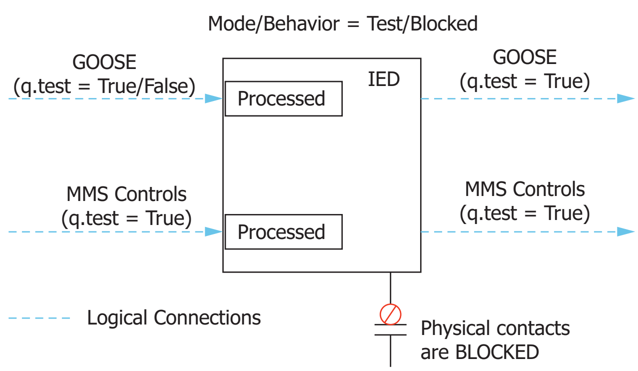


Figure F.14 Relay Operations in Test/Blocked Mode

Mode: Off

In Off mode, the device no longer processes incoming GOOSE messages. The device processes MMS control requests to change the IEC 61850 Mode/Behavior if the quality Test bit is set to False. The device is in a disabled state, and it no longer trips any physical contact outputs.

In this mode, the device is in a disabled state. Device Word bit EN is set to False. The device processes MMS control requests to change the active mode of IEC 61850 Mode/Behavior if the quality Test bit of the control is set to False.

If EOFFMTX is set to True, the device continues to transmit GOOSE messages with the quality test bit set to False (0) and the validity set to Invalid (01) if the quality is present in the messages. If EOFFMTX is set to False, the device does not transmit GOOSE messages in this mode. The device also does not process any incoming GOOSE messages.

Table F.20 IEC 61850 Incoming Message Handling in Off Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Relay Only Processes Messages to Control the Mode	Not Processed
GOOSE	Not Processed	Not Processed

Table F.21 IEC 61850 Outgoing Message Handling in Off Mode

IEC 61850 Messages	Outgoing Message Quality Validity Bit
MMS	Invalid
GOOSE	Invalid

Figure F.15 illustrates the IEC 61850 Mode/Behavior.

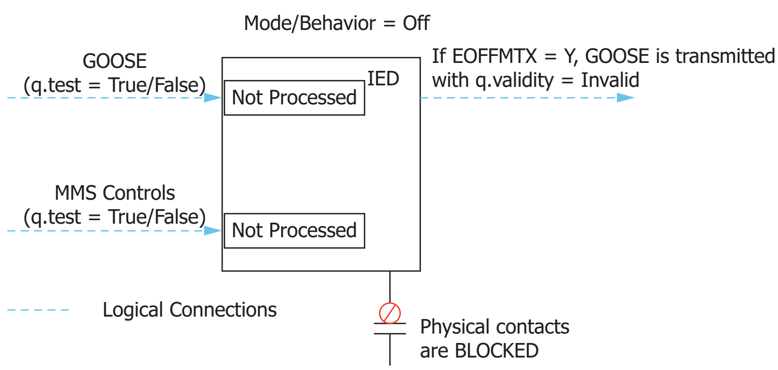


Figure F.15 Relay Operations in Off Mode

IEC 61850 Configuration

Settings

Table F.22 lists IEC 61850 settings. These settings are only available if your device includes the optional IEC 61850 protocol.

Table F.22 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE	Outgoing IEC 61850 generic substation event (GSE) message enable	Y, N	N
EMMSFS	Enable MMS File Services	Y, N	N
E850MBC	Enable IEC 61850 Mode/Behavior control	Y, N	N
EOFFMTX	Enable GOOSE in Off mode	Y, N	N

Architect

The Architect software enables protection and integration engineers to design and commission IEC 61850 substations containing SEL IEDs.

Engineers can use Architect to perform the following configuration tasks:

- Organize and configure all SEL IEDs in a substation project
- Configure incoming and outgoing GOOSE messages

- ➤ Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options
- ➤ Load device settings and IEC 61850 CID files into SEL IEDs
- ➤ Generate ICD files that will provide SEL IED descriptions to other manufacturer's tools so they can use SEL GOOSE messages and reporting features
- ➤ Configure protection, logic, control, and communication settings of all SEL IEDs in the substation

Architect provides a GUI for engineers to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes.

Common Logical Nodes

Each logical device (LD) has a set of common data objects at the top-level LN0. These represent the current state of the device, as well as some informational data. These data objects are Mod (Mode), Beh (Behavior), Health, and NamPlt. See the following brief descriptions of each object.

Mode/Behavior

In the SEL-2440, the top-level LN0 within each LD includes the following enumerations for **Mod.stVal** and **Beh.stVal**.

Table F.23 Mod.stVal and Beh.stVal Enumerations

Mod.stVal Enumeration	Beh.stVal Enumeration	Description
1	1	On
2	2	Blocked
3	3	Test
4	4	Test/Blocked
5	5	Off
0	0	IEC 61850 Mode/Behavior disabled

The top-level logical node of each LD also includes the following Mod and Beh attributes:

- ➤ **Mod.q** and **Beh.q** represents quality
- ➤ **Mod.t** and **Beh.t** represents time stamps

See *Change Mode Via MMS or SELOGIC on page F.24* for instructions on changing the Mode/Behavior.

Health

In the SEL-2440, the top-level LN0 within each LD includes the following enumerations for **Health.stVal**.

Table F.24 Health.stVal Enumerations

Health.stVal Enumeration	Health.stVal Enumeration	Description
1	Ok	ENABLED Device Word bit = 1
3	Alarm	ENABLED Device Word bit = 0

The logical nodes also include the following Health attributes:

- **Health.q** represents quality
- **Health.t** represents time stamps

NamPlt

The top-level LN0 of each LD includes the following NamPlt attributes:

- **NamPlt.vendor** has a string value set to SEL
- **NamPlt.swRev** contains the device FID string value
- **NamPlt.d** contains the LD description

LPHD

The LPHD logical node in the CFG logical device contains information about the physical device, such as the physical device nameplate information. SEL extended this logical node to include an object that provides an identifier for the version of the IEC 61850 component firmware in the device. This object, LPHD.SelLibID, contains a checksum derived from the IEC 61850 library version and is the same value across different devices with the same underlying code. This value is also available in the 61850ID field of the ID command.

```
==>>ID
"FID=SEL-2440-R301-V0-Z009004-D20250228","08DB"
"BFID=SLBT2440-R600-V0-Z000000-D20220621","0930"
"CID=B01E","0265"
"DEVID=SEL-2440","03F4"
"DEVCODE=64","0311"
"PARTNO=24402H11A1A11640","05D6"
"SERIALNO=123456789101112","060D"
"CONFIG=000000","0383"
"iedName=A02440_010_R301_ICD_1","088F"
"type=SEL_2440","047C"
"configVersion=ICD-2440-R112-V0-Z301010-D20250228","0D48"
"61850ID=2B6EB876","0414"
```

Standard Logical Nodes

Table F.25 lists the logical nodes that the SEL-2440 supports in the CFG, logical device, and the data attributes within.

Table F.25 Logical Device: CFG (Configuration) (Sheet 1 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
DevIDLPHD1	Sim.Oper.ctlVal	LPHDSIM	IEC 61850 logical node for physical device simulation
GOLCCH2	RsStat.Oper.ctlVal	GORST[a]	Reset statistics for GOOSE traffic
IPLCCH1	RsStat.Oper.ctlVal	IPRST[a]	Reset statistics for general IP traffic (excluding GOOSE, SV, and 87L traffic)
LLN0	Mod.Oper.ctlVal[b]	I60MOD[c]	IEC 61850 mode/behavior control
LLN0	LocSta.Oper.ctlVAl	LOCSTA	Control authority at station level
LGOS*n*[d]	RsStat.Oper.ctlVal	GRST*n*[e]	Reset GOOSE statistics for Message *n*
Functional Constraint = DC			
DevIDLPHD1	PhyNam.hwRev	HWREV[f]	Hardware version of the relay mainboard
DevIDLPHD1	PhyNam.model	PARNUM	Relay part number string
DevIDLPHD1	PhyNam.serNum	SERNUM	Relay serial number string
DevIDLPHD1	SelLibId.val	61850ID	IEC 61850 Library Version Checksum contained in **ID** command
LLN0	NamPlt.swRev	FID	Relay FID string
Functional Constraint = ST			
DevIDLPHD1	Sim.stVal	LPHDSIM	IEC 61850 logical node for physical device simulation
DevIDLPHD1	PhyHealth.stVal	EN?3:1[g]	Relay enabled

Table F.25 Logical Device: CFG (Configuration) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
GOLCCH2	ChLiv.stVal	GOCH[a]	Status of primary GOOSE channel
GOLCCH2	RedChLiv.stVal	GORCH[a]	Status of redundant GOOSE channel
GOLCCH2	RxCnt.actVal	GORX[a]	Number of frames received over the primary GOOSE channel
GOLCCH2	RedRxCnt.actVal	GORRX[a]	Number of frames received over the redundant GOOSE channel
GOLCCH2	TxCnt.actVal	GOTX[a]	Number of frames transmitted on both primary and redundant GOOSE channels
GOLCCH2	FerCh.stVal[h]	GOFER[a]	Frame error rate on the primary GOOSE channel
GOLCCH2	RedFerCh.stVal[h]	GORFER[a]	Frame error rate on the redundant GOOSE channel
GOLCCH2	RsStat.stVal	GORST[a]	Status of statistics reset for GOOSE traffic
IPLCCH1	ChLiv.stVal	IPCH[a]	Status of primary IP channel
IPLCCH1	RedChLiv.stVal	IPRCH[a]	Status of redundant IP channel
IPLCCH1	RxCnt.actVal	IPRX[a]	Number of frames received over the primary IP channel
IPLCCH1	RedRxCnt.actVal	IPRRX[a]	Number of frames received over the redundant IP channel
IPLCCH1	TxCnt.actVal	IPTX[a]	Number of frames transmitted on both primary and redundant IP channels
IPLCCH1	FerCh.stVal[h]	IPFER[a]	Frame error rate on the primary IP channel
IPLCCH1	RedFerCh.stVal[h]	IPRFER[a]	Frame error rate on the redundant IP channel
IPLCCH1	RsStat.stVal	IPRST[a]	Status of statistics reset for general IP traffic (excludes GOOSE, SV, and 87L traffic)
LLN0	Mod.stVal	I60MOD[c]	IEC 61850 mode/behavior status
LLN0	Health.stVal	EN?3:1[g]	Relay enabled
LLN0	Loc.stVal	LOCAL	Control authority at local (bay) level
LGOS*n*[d]	NdsCom.stVal	GNCM*n*[e]	Subscription needs commissioning for GOOSE Message *n*. True if ConfRevNum does not match RxConfRevNum
LGOS*n*[d]	St.stVal	GST*n*[e]	Status of the subscription (True = active, False = not active) for GOOSE Message *n*
LGOS*n*[d]	SimSt.stVal	GSIM*n*[e]	Status showing that simulation messages are received and accepted for GOOSE Message *n*
LGOS*n*[d]	LastStNum.stVal	GLST*n*[e]	Last state number received (StNum) for GOOSE Message *n*
LGOS*n*[d]	LastSqNum.stVal	GLSQ*n*[e]	Last sequence number received (SqNum) for GOOSE Message *n*
LGOS*n*[d]	LastTal.stVal	GTAL*n*[e]	Last time-allowed-to-live received (TTL) for GOOSE Message *n*
LGOS*n*[d]	ConfRevNum.stVal	–[i]	Expected configuration revision number for GOOSE Message *n*
LGOS*n*[d]	RxConfRevNum.stVal	GCNF*n*[e]	Received configuration revision number for GOOSE Message *n*
LGOS*n*[d]	ErrSt.stVal[j]	GERR*n*[e]	Error status of the subscription for GOOSE Message *n*
LGOS*n*[d]	OosCnt.stVal	GOOS*n*[e]	Number of out-of-sequence (OOS) errors for GOOSE Message *n*
LGOS*n*[d]	TalCnt.stVal	GTLC*n*[e]	Number of time-allowed-to-live violations for GOOSE Message *n*
LGOS*n*[d]	DecErrCnt.stVal	GDER*n*[e]	Number of messages that failed decoding for GOOSE Message *n*
LGOS*n*[d]	BufOvflCnt.stVal	GBFO*n*[e]	Number of messages lost because of buffer overflow for GOOSE Message *n*
LGOS*n*[d]	MsgLosCnt.stVal	GMSL*n*[e]	Number of messages lost due to OOS errors (estimated) for GOOSE Message *n*
LGOS*n*[d]	MaxMsgLos.stVal	GMXM*n*[e]	Maximum number of sequential messages lost because of OOS error (estimated) for GOOSE Message *n*
LGOS*n*[d]	RsStat.stVal	GRST*n*[e]	Status of statistics reset for GOOSE messages
LTIM	TmDT.stVal	TMDT[a]	Indicates daylight-saving time is currently in effect at the IED location

Table F.25 Logical Device: CFG (Configuration) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
LTMS	TmAcc.stVal	TSACC[a]	Number of significant bits in the FractionOfSecond (an attribute of TimeStamp) 18: 4 µs accuracy (2–18) 10: 1 ms accuracy (2–10) 7: 10 ms accuracy (2–7) 31: Unknown accuracy
LTMS	TmSrc.stVal	TSSRC[a]	Time-source identity. If TmSrcTyp is PTP, TmSrc indicates the timeSource value received in Announce messages from the Grandmaster Clock If TmSrcTyp is SNTP, TmSrc indicates the IP address of the SNTP server For all other values of TmSrcTyp, TmSrc is set to "NA"
LTMS	TmSrcTyp.stVal	TSTYPE[a]	Type of the clock source as defined by Device Word bits TSNTP and TIRIG 1: Unknown 2: SNTP 3: PTP 4: IRIG-B
LTMS	TmSyn.stVal	TSSYN[a]	Traceability of the reference time to which the IED is synchronized 2: GlobalAreaClock—TmSrcTyp is IRIG-B with IRIGC = C37.118[k] or TmSrcTyp is SNTP or TmSrcTyp is PTP with grandmaster clock class = 6 1: LocalAreaClock—TmSrcTyp is IRIG-B with IRIGC ≠ C37.118 or TmSrcTyp is PTP with grandmaster clock class (not equal to) 6 0: InternalClock—TmSrcTyp is unknown
LTMS	TmSynLkd.stVal	TSSYNLK[a]	Status of clock synchronization: 1: Locked 2: Unlocked for 0–10 seconds 3: Unlocked for 10–100 seconds 4: Unlocked for 100–1000 seconds 5: Unlocked for more than 1000 seconds
Functional Constraint = MX			
LGOS*n*[d]	TotDwnTm.instMag.f	GDWT*n*[e]	Total downtime in seconds for GOOSE Message *n*
LGOS*n*[d]	MaxDwnTm.instMag.f	GMXD*n*[e]	Maximum continuous downtime in seconds for GOOSE Message *n*
LSVS*n*[l]	NetwDly.instMag.f	SNET*n*[e]	Network delay in milliseconds for SV Stream *n*
LSVS*n*[l]	TotDwnTm.instMag.f	SDWT*n*[e]	Total downtime in seconds for SV Stream *n*
LSVS*n*[l]	MaxDwnTm.instMag.f	SMXD*n*[e]	Maximum continuous downtime in seconds for SV Stream *n*
LTMS	TmTosPer.instMag.f	TSPER[a]	Duration, in milliseconds, between two consecutive top-of-second points on the synchronized time; TmTosPer is set to 0 for time sources other than high-accuracy IRIG-B or PTP
Functional Constraint = SP			
GOLCCH2	NetMod.setVal	NETMODE	Port 1 network operating mode setting (1: Fixed, 2: Failover, 3: Switched, 4: PRP)[m]
IPLCCH1	NetMod.setVal	NETMODE	Port 1 network operating mode setting (1: Fixed, 2: Failover, 3: Switched, 4: PRP)[m]
LGOS*n*[d]	GoCBRef.setSrcRef	–[i]	Configured GOOSE control block reference for GOOSE Message *n*
LGOS*n*[d]	DatSet.setSrcRef	–[i]	Configured data set reference for GOOSE Message *n*
LGOS*n*[d]	GoID.setVal	–[i]	Configured ID for GOOSE Message *n*
LGOS*n*[d]	Addr.setVal	–[i]	Configured multicast MAC address for GOOSE Message *n*
LGOS*n*[d]	VlanID.setVal	–[i]	Configured VLAN ID for GOOSE Message *n*
LGOS*n*[d]	VlanPri.setVal	–[i]	Configured VLAN priority for GOOSE Message *n*

Table F.25 Logical Device: CFG (Configuration) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
LGOS*n*[d]	AppID.setVal	–[i]	Configured APPID for GOOSE Message *n*
LTIM	TmOfsTmm.setVal	TMOFFS[a]	Offset of local time from UTC in minutes
LTIM	TmUseDT.setVal	TMUSEDT[a]	Set to True if daylight-saving time is enabled
LTIM	TmChgDT.setTm	TMCHGDT[a]	Local time of next change to daylight-saving time
LTIM	TmChgST.setTm	TMCHGST[a]	Local time of next change to standard time
Functional Constraint = SR			
LTRK1	SpcTrk.objRef	–[n]	ACSI reference to the SPC object targeted in the request
LTRK1	SpcTrk.serviceType	–[n, o]	Type of service requested or executed
LTRK1	SpcTrk.errorCode	–[n, p]	ACSI service error status
LTRK1	SpcTrk.ctlVal	–[n]	Control value in the request
LTRK1	SpcTrk.ctlNum	–[n]	Control number in the request
LTRK1	SpcTrk.origin.orCat	–[n]	Originator category value in the request
LTRK1	SpcTrk.origin.orIdent	–[n]	Originator identity value in the request
LTRK1	SpcTrk.T	–[n]	Time-stamp value in the request
LTRK1	SpcTrk.Test	–[n]	Test value in the request
LTRK1	SpcTrk.Check	–[n]	Check condition value in the request
LTRK1	SpcTrk.respAddCause	–[n]	AddCause value returned in the response
LTRK1	EncTrk.objRef	–[n]	ACSI reference of the ENC object targeted in the request
LTRK1	EncTrk.serviceType	–[n, o]	Type of service requested or executed
LTRK1	EncTrk.errorCode	–[n, p]	ACSI service error status
LTRK1	EncTrk.ctlVal	–[n]	Control value in the request
LTRK1	EncTrk.ctlNum	–[n]	Control number in the request
LTRK1	EncTrk.origin.orCat	–[n]	Originator category value in the request
LTRK1	EncTrk.origin.orIdent	–[n]	Originator identity value in the request
LTRK1	EncTrk.T	–[n]	Time-stamp value in the request
LTRK1	EncTrk.Test	–[n]	Test value in the request
LTRK1	EncTrk.Check	–[n]	Check condition value in the request
LTRK1	EncTrk.respAddCause	–[n]	AddCause value returned in the response
LTRK1	BrcbTrk.objRef	–[n]	ACSI reference of the BRCB object targeted in the request
LTRK1	BrcbTrk.serviceType	–[n, o]	Type of service requested or executed
LTRK1	BrcbTrk.errorCode	–[n, p]	ACSI service error status
LTRK1	BrcbTrk.rptID	–[n]	RptID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.rptEna	–[n]	RptEna attribute value in the request or target BRCB object
LTRK1	BrcbTrk.datSet	–[n]	DatSet attribute value in the target BRCB object
LTRK1	BrcbTrk.confRev	–[n]	ConfRev attribute value in the target BRCB object
LTRK1	BrcbTrk.optFlds	–[n]	OptFlds attribute value in the request or target BRCB object
LTRK1	BrcbTrk.bufTm	–[n]	BufTm attribute value in the request or target BRCB object
LTRK1	BrcbTrk.sqNum	–[n]	SqNum attribute value in the target BRCB object
LTRK1	BrcbTrk.trgOps	–[n]	TrgOps attribute value in the request or target BRCB object
LTRK1	BrcbTrk.intgPd	–[n]	IntgPd attribute value in the request or target BRCB object
LTRK1	BrcbTrk.gi	–[n]	GI attribute value in the request or target BRCB object

Table F.25 Logical Device: CFG (Configuration) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
LTRK1	BrcbTrk.purgeBuf	–[n]	PurgeBuf attribute value in the request or target BRCB object
LTRK1	BrcbTrk.entryID	–[n]	EntryID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.timeOfEntry	–[n]	TimeOfEntry attribute value in the target BRCB object
LTRK1	UrcbTrk.objRef	–[n]	ACSI reference of the URCB object targeted in the request
LTRK1	UrcbTrk.serviceType	–[n, o]	Type of service requested or executed
LTRK1	UrcbTrk.errorCode	–[n, p]	ACSI service error status
LTRK1	UrcbTrk.rptID	–[n]	RptID attribute value in the request or target URCB object
LTRK1	UrcbTrk.rptEna	–[n]	RptEna attribute value in the request or target URCB object
LTRK1	UrcbTrk.resv	–[n]	Resv attribute value in the request or target URCB object
LTRK1	UrcbTrk.datSet	–[n]	DatSet attribute value in the target URCB object
LTRK1	UrcbTrk.confRev	–[n]	ConfRev attribute value in the target URCB object
LTRK1	UrcbTrk.optFlds	–[n]	OptFlds attribute value in the request or target URCB object
LTRK1	UrcbTrk.bufTm	–[n]	BufTm attribute value in the request or target URCB object
LTRK1	UrcbTrk.sqNum	–[n]	SqNum attribute value in the target URCB object
LTRK1	UrcbTrk.trgOps	–[n]	TrgOps attribute value in the request or target URCB object
LTRK1	UrcbTrk.intgPd	–[n]	IntgPd attribute value in the request or target URCB object
LTRK1	UrcbTrk.gi	–[n]	GI attribute value in the request or target URCB object

[a] Internal data source and not available to the user.
[b] MMS controls to Mod.Oper are only accepted if IEC 61850 Mode/Behavior is enabled on the device. Refer to *IEC 61850 Mode/Behavior on page F.23* for more details.
[c] I60MOD is an internal data source derived from the I850MOD analog quantity and is not available to the user.
[d] Where *n* = 1–64, corresponding to the first 64 GOOSE message subscriptions.
[e] Internal data source not available to the user.
[f] HWREV is an internal data source and is not available to the user.
[g] If enabled, value = 1. If disabled, value = 3.
[h] When NETMODE = PRP the value indicates the number of duplicate frames not received for every 1000 PRP tagged frames received.
[i] Data source defined in the IEC 61850 Configured IED Description (CID) file.
[j] Error status of the GOOSE subscription. Matches CODE field in the GOOS command response.
[k] This device does not support IRIG-B with IRIGC = C37.118.
[l] Where *n* = 1–7, corresponding to each of the seven possible SV subscriptions.
[m] This device does not support isolatedIP network operating mode.
[n] The value depends on the ACSI service type requested, the target object, and the error status.
[o] Refer to *Table F.10*.
[p] Refer to *Table F.11*.

Logical Nodes

Table F.26 through *Table F.27* show the LNs supported in the SEL-2440 and the associated Device Word bits or Measured Values mapped to those LNs. Any differences between ICD file versions are also indicated in the tables.

For additional details of implemented LNs, see the Model Implementation Conformance Statement (MICS) for this device. The MICS lists implemented LNs, newly created LNs and SEL-extended local nodes (with their data objects). The MICS also lists new and/or extended enumeration types.

The MICS for this device can be found at selinc.com.

Table F.26 shows the LNs associated with annunciation element defined as Logical Device ANN.

Table F.26 Logical Device: ANN (Annunciation)

Logical Nodes	Status or Measurand	Device Word Bits or Analog Quantities
Analog Quantities		
MVGGIO8	AnIn01.mag to AnIn32.mag	Math Variables (MV01 to MV32)
RAGGIO21	Ra001.instMag to Ra032.instMag	Remote Analogs (RA001 to RA032)
RAGGIO22	Ra033.instMag to Ra064.instMag	Remote Analogs (RA033 to RA064)
RAGGIO23	Ra065.instMag to Ra096.instMag	Remote Analogs (RA065 to RA096)
RAGGIO24	Ra097.instMag to Ra128.instMag	Remote Analogs (RA097 to RA128)
SCGGIO25	AnIn01.instMag to AnIn32.instMag	SELOGIC Counters (SC01 to SC32)
Device Word Bits		
SVGGIO1	Ind01.stVal to Ind64.stVal	SELOGIC Variables (SV01 to SV64)
SVTGGIO2	Ind01.stVal to Ind64.stVal	SELOGIC Variable Timers (SV01T to SV64T)
LTGGIO3	Ind01.stVal to Ind32.stVal	Latch Bits (LT01 to LT32)
RMBAGGIO4	Ind01.stVal to Ind08.stVal	Receive MIRRORED BITS (RMBA1 to RMBA8)
TMBAGGIO5	Ind01.stVal to Ind08.stVal	Transmit MIRRORED BITS (TMBA1 to TMBA8)
RMBBGGIO6	Ind01.stVal to Ind08.stVal	Receive MIRRORED BITS (RMBB1 to RMBB8)
TMBBGGIO7	Ind01.stVal to Ind08.stVal	Transmit MIRRORED BITS (TMBB1 to TMBB8)
IN1GGIO9	Ind01.stVal to Ind16.stVal	Digital Inputs (IN101 to IN116)—Group 1
IN1EGGIO10	Ind01.stVal to Ind16.stVal	Edge Trigger Operator (IN101E to IN116E)—Group 1
IN1RGGIO11	Ind01.stVal to Ind16.stVal	Raw Digital Inputs (IN101R to IN116R) — Group 1
IN2GGIO12	Ind01.stVal to Ind16.stVal	Digital Inputs (IN201 to IN216)—Group 2
IN2EGGIO13	Ind01.stVal to Ind16.stVal	Edge Trigger Operator (IN201E to IN216E)—Group 2
IN2RGGIO14	Ind01.stVal to Ind16.stVal	Raw Digital Inputs (IN201R to IN216R) — Group 2
IN3GGIO15	Ind01.stVal to Ind16.stVal	Digital Inputs (IN301 to IN316)—Group 3
IN3EGGIO16	Ind01.stVal to Ind16.stVal	Edge Trigger Operator (IN301E to IN316E)—Group 3
IN3RGGIO17	Ind01.stVal to Ind16.stVal	Raw Digital Inputs (IN301R to IN316R) — Group 3
OUT1GGIO18	Ind01.stVal to Ind16.stVal	Digital Outputs (OUT101 to OUT116) — Group 1
OUT3GGIO19	Ind01.stVal to Ind16.stVal	Digital Outputs (OUT301 to OUT316)—Group 3
VBGGIO20	Ind001.stVal to Ind128.stVal	Virtual Bits (VB001 to VB128)
MBOKGGIO26	ROKA.stVal to LBOKB.stVal	MIRRORED BITS Status Bits
MISCGGIO27	MATHERR.stVal to PTPB.stVal	Device and Time Source Status Bits
ETHGGIO28	LINKA.stVal to LINKFAIL.stVAl	Port 1 (Ethernet) Link A and Link B status

Table F.27 shows the LNs associated with control elements defined as Logical Device CON.

Table F.27 Logical Device: CON (Control)

Logical Nodes	Status and Control	Device Word Bits
RBGGIO1	**Status** SPCSO01.stVal to SPCSO08.stVal **Control** SPCSO01.Oper.ctlVal to SPCSO08.Oper.ctlVal	Remote Bits (RB01 to RB08)
RBGGIO2	**Status** SPCSO09.stVal to SPCSO16.stVal **Control** SPCSO09.Oper.ctlVal to SPCSO16.Oper.ctlVal	Remote Bits (RB09 to RB16)
RBGGIO3	**Status** SPCSO17.stVal to SPCSO24.stVal **Control** SPCSO17.Oper.ctlVal to SPCSO24.Oper.ctlVal	Remote Bits (RB17 to RB24)
RBGGIO4	**Status** SPCSO25.stVal to SPCSO32.stVal **Control** SPCSO25.Oper.ctlVal to SPCSO32.Oper.ctlVal	Remote Bits (RB25 to RB32)
PRBGGIO1[a]	**Status** SPCSO01.stVal to SPCSO08.stVal **Control** SPCSO01.Oper.ctlVal to SPCSO08.Oper.ctlVal	Pulse Remote Bits (RB01:RB01 to RB08:RB08)[a]
PRBGGIO2[a]	**Status** SPCSO09.stVal to SPCSO16.stVal **Control** SPCSO09.Oper.ctlVal to SPCSO16.Oper.ctlVal	Pulse Remote Bits (RB09:RB09 to RB16:RB16)[a]
PRBGGIO3[a]	**Status** SPCSO17.stVal to SPCSO24.stVal **Control** SPCSO17.Oper.ctlVal to SPCSO24.Oper.ctlVal	Pulse Remote Bits (RB17:RB17 to RB24:RB24)[a]
PRBGGIO4[a]	**Status** SPCSO25.stVal to SPCSO32.stVal **Control** SPCSO25.Oper.ctlVal to SPCSO32.Oper.ctlVal	Pulse Remote Bits (RB25:RB25 to RB32:RB32)[a]

[a] The first remote bit in the pulse remote bit pair will assert for one processing cycle when a 1 is written to the ctlVal and the second remote bit will assert for one processing cycle when a 0 is written to the ctlVal. Additionally, the first or second bit can be assigned the value of NOOP if no operation is desired. For example, if the pair is defined as RB01:NOOP, RB01 will assert for one processing cycle when a 1 is written to the ctlVal and no operation will be executed when a 0 is written to the ctlVal.

SEL Nameplate Data

The CID file contains information that describes the physical device attributes according to IEC 61850 standards. The LN0 logical node of each logical device contains the Nameplate DOI (instantiated data object) with the following data.

Table F.28 SEL Nameplate Data

Data Attribute	Value
vendor	"SEL"
swRev	Contents of FID string from **ID** command
d	Description of LD
configRev	Always 0
1dNs	IEC 61850-7-4:2007B

Architect Flexible Server Model (FSM)

Architect provides an interface to build custom ICD files for Ed2.1 devices that have ICD files ClassFileVersion 010 or later. SEL devices have a default ICD file available in Architect, but you may need to add IEC 61850 optional objects to the default logical nodes or add additional logical nodes based on your application.

You may need to customize the SCL server model of a device to model functions configured in SELOGIC control equations, and make them available through MMS or GOOSE. Various functions, such as automatic tap changer control, gas alarm for GIS, etc., can be configured in SELOGIC programming but require specific customization to implement in IEC 61850.

For example, the SIML logical node models insulation medium supervision (liquid). Transformers or tap changers use oil as an insulator, and sensors or measuring devices may be wired into relay contact inputs. Because the connection of these sensors into a device are application-specific, they are not included in the default ICD file. The FSM provides an interface to add and customize the SIML logical node.

Begin by adding a device to the Project Editor in Architect and selecting an existing ICD file, (ClassFileVersion 010 or later). Select the **Server Model** tab to view the logical devices, logical nodes, and data objects that exist in the default ICD file. Although logical nodes can be added to an existing logical device, SEL recommends adding a new logical device for customized logical nodes. If SEL releases new logical nodes or features in the future, the merge operation between default and customized files is less prone to inadvertent removal of the customized logical nodes.

The default ICD file in this example contains five logical devices: CFG, CON, and ANN. To add a logical device, select the **+ Add LDevice** button in the logical device pane. Provide an instance name for the new logical device. The new logical device is named XFMR, as shown in *Figure F.16*.

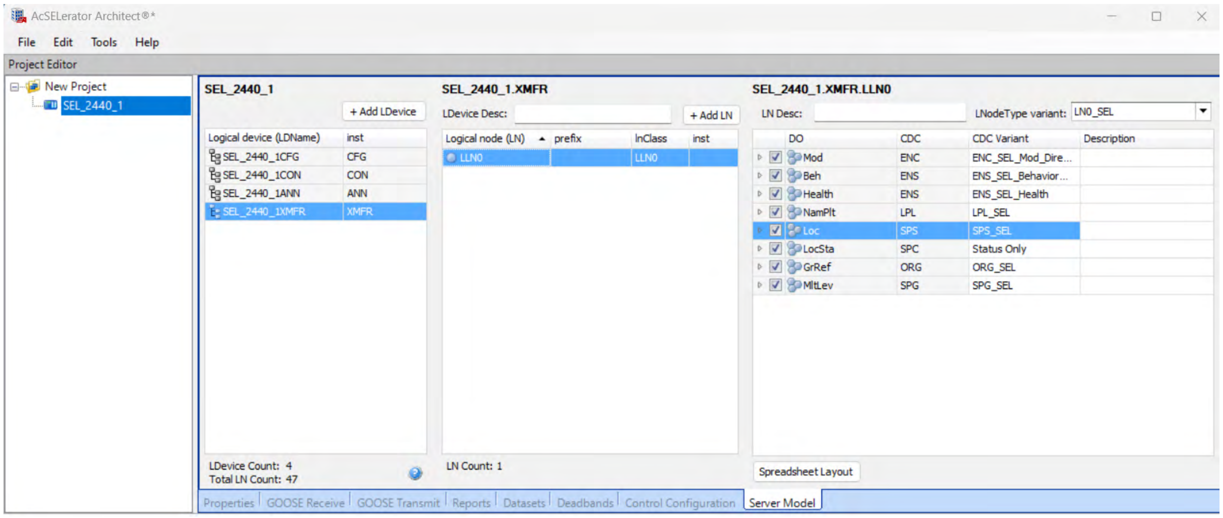


Figure F.16 Server Model View in Architect

Every logical device contains an LLN0 or common logical node that provides common information. To add another logical node, either right-click in the logical node pane or select the **+ Add LN** button. This opens a pop-up window that contains a list of logical nodes that are present in the Architect Library. There may be more than one variant of each logical node, where each variant may have different data objects included. In this case, only one SIML logical node is added to this file (see *Figure F.17*).

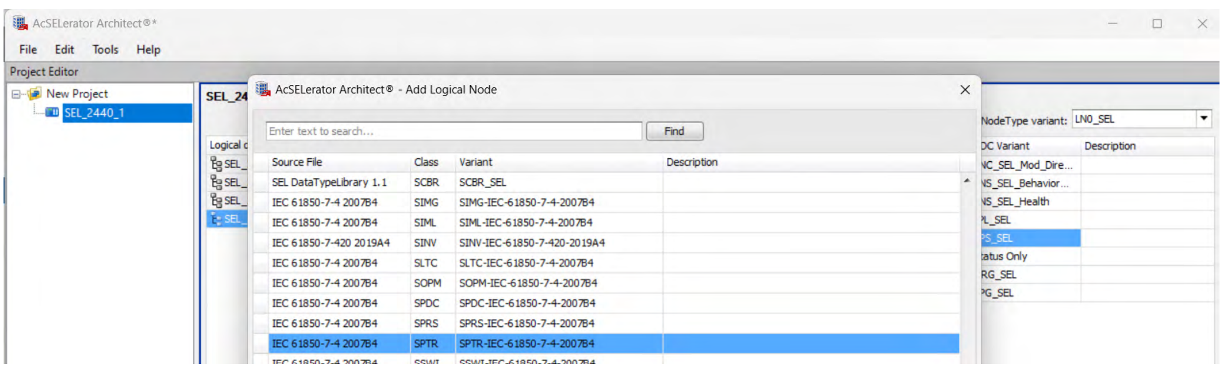


Figure F.17 Add a Logical Node From the Architect Library

Once the logical node is added to the logical device, select the logical node, which will display the data objects available in the data object pane (see *Figure F.18*). Add the TmpAlm and GasInsAlm objects by selecting the box to the left of the attribute name. Each object conforms to a particular CDC defined for that object in the IEC 61850 standard. In this example, both TmpAlm and GasInsAlm are single point status (SPS) data objects. *Table F.2* lists the CDCs supported by the SEL-2440.

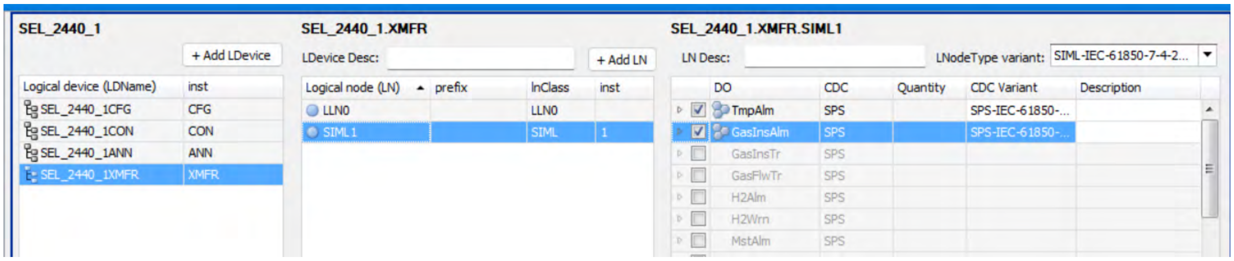


Figure F.18 Add Data Objects to a Logical Node

Each object contains a list of attributes. TmpAlm, when expanded, lists the associated attributes. In this example, the temperature alarm is wired to Input 6 on I/O Card 2, which is represented by Relay Word bit IN206. The association between TmpAlm.stVal (status value) and IN206 must be made by entering the Relay Word bit name following the db prompt in the RWB/AQ column, as shown in *Figure F.19*.

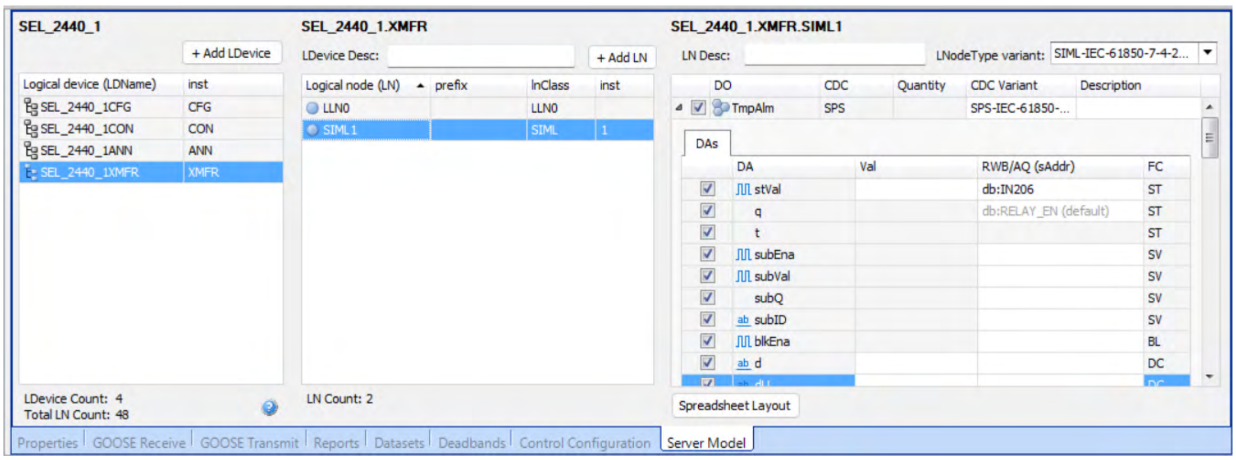
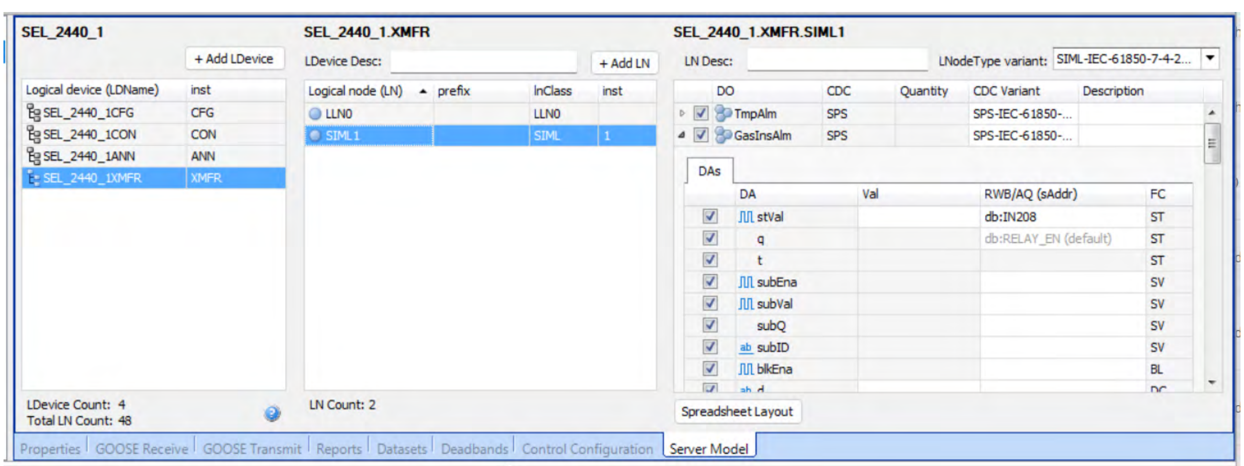


Figure F.19 Associate a Data Attribute's Value to a Relay Variable

Follow the same procedure to configure the Gas Insulation Alarm (GasInsAlm.stVal), which in this example is wired to Input 7 on I/O Card 2 and is represented by Relay Word bit IN207.



If desired, other logical nodes can be added to the new XFMR logical device. Save the configuration of the project and device. The new logical node objects and attributes are available for adding to data sets that may be sent in a GOOSE message or added to a report.

Protocol Implementation Conformance Statement

Table F.29 and *Table F.30* are as shown in the IEC 61850 standard, Part 8-1, Section 24. Because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table F.29 PICS for A-Profile Support

Profile	Client	Server	Value/Comment
A1 Client/Server	N	Y	
A2 GOOSE/GSE management	Y	Y	Only GOOSE, not GSSE Management
A3 GSSE	N	N	
A4 Time Sync	N	N	

Table F.30 PICS for T-Profile Support

Profile	Client	Server	Value/Comment
T1 TCP/IP	N	Y	
T2 OSI	N	N	
T3 GOOSE/GSE	Y	Y	Only GOOSE, Not GSSE
T4 GSSE	N	N	
T5 Time Sync	N	N	

Refer to the ACSI Conformance statements in the Reference Manual for information on the supported services.

MMS Conformance

The MMS stack provides the basis for many IEC 61850 Protocol services. *Table F.31* defines the service support requirement and restrictions of the MMS services in the SEL-2440 series products supporting IEC 61850. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table F.31 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		

Table F.31 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		

Table F.31 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		
fileRead		
fileClose		
fileRename		
fileDelete		
fileDirectory		
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table F.32 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table F.32 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		Y
VALT		Y
TPY		Y
VLIS		Y
CEI		

The following variable access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table F.33 Alternate Access Selection Conformance Statement

Alternate Access Selection	Client-CR Supported	Server-CR Supported
accessSelection		Y
component		Y
index		
indexRange		
allElements		
alternateAccess		Y
selectAccess		Y
component		Y
index		
indexRange		
allElements		

Table F.34 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table F.35 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table F.36 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table F.37 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		
address		
typeSpecification		

Table F.38 DefineNamedVariableList Conformance Statement

DefineNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table F.39 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table F.40 DeleteNamedVariableList Statement

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table F.41 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	Y	Y	
SendGOOSEMessage		Y	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		Y	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		Y	

ACSI Conformance Statements

Table F.42 ACSI Basic Conformance Statement

		Client/Subscriber	Server/Publisher	SEL-2440 Support
Client-Server Roles				
B11	Server side (of Two-Party Application-Association)	-	c1[a]	YES
B12	Client side (of Two-Party Application-Association)	c1[a]	-	
SCMS Supported				
B21	SCSM: IEC 61850-8-1 used			YES
B22	SCSM: IEC 61850-9-1 used			
B23	SCSM: IEC 61850-9-2 used			
B24	SCSM: other			
Generic Substation Event Model (GSE)				
B31	Publisher side	-	O[b]	YES
B32	Subscriber side	O[b]	-	YES
Transmission of Sampled Value Model (SVC)				
B41	Published side	-	O[b]	
B42	Subscriber side	O[b]	-	

[a] c1 shall be mandatory if support for LOGICAL-DEVICE model has been declared.
[b] O = Optional.

Table F.43 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-2440 Support
If Server Side (B11) Supported				
M1	Logical device	c2[a]	c2[a]	YES
M2	Logical node	c3[b]	c3[b]	YES
M3	Data	c4[c]	c4[c]	YES
M4	Data set	c5[d]	c5[d]	YES
M5	Substation	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	
Reporting				
M7	Buffered report control	O[e]	O[e]	YES
M7-1	sequence-number			YES
M7-2	report-time-stamp			YES
M7-3	reason-for-inclusion			YES
M7-4	data-set-name			YES
M7-5	data-reference			YES
M7-6	buffer-overflow			YES
M7-7	entryID			YES
M7-8	BufTm			YES
M7-9	IntgPd			YES
M7-10	G1			YES
M8	Unbuffered report control	O[e]	O[e]	YES
M8-1	sequence-number			YES
M8-2	report-time-stamp			YES
M8-3	reason-for-inclusion			YES
M8-4	data-set-name			YES
M8-5	data-reference			YES
M8-6	BufTm			YES
M8-7	IntgPd			YES
M-8-8	GI			YES
Logging		O[e]	O[e]	
M9	Log control	O[e]	O[e]	
M9-1	IntgPd			
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[f]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataReflnc			YES
M13	GSSE	O[e]	O[e]	
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	

Table F.43 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-2440 Support
M16	Time	M[f]	M[f]	
M17	File Transfer	O[e]	O[e]	

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = Optional.
[f] M = Mandatory.

Table F.44 ACSI Services Conformance Statement (Sheet 1 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-2440 Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES
Data (Clause 10)					
S8	GetDataValues	TP	M[a]	M[a]	YES
S9	SetDataValues	TP	O[b]	O[b]	YES
S10	GetDataDirectory	TP	O[b]	M[a]	YES
S11	GetDataDefinition	TP	O[b]	M[a]	YES
Data Set (Clause 11)					
S12	GetDataSetValues	TP	O[b]	M[a]	YES
S13	SetDataSetValues	TP	O[b]	O[b]	YES
S14	CreateDataSet	TP	O[b]	O[b]	
S15	DeleteDataSet	TP	O[b]	O[b]	
S16	GetDataSetDirectory	TP	O[b]	O[b]	YES
Substitution (Clause12)					
S17	SetDataValues	TP	M[a]	M[a]	
Setting Group Control (Clause 13)					
S18	SelectActiveSG	TP	O[b]	O[b]	
S19	SelectEditSG	TP	O[b]	O[b]	
S20	SetSGvalues	TP	O[b]	O[b]	
S21	ConfirmEditSGVal	TP	O[b]	O[b]	
S22	GetSGValues	TP	O[b]	O[b]	
S23	GetSGCBValues	TP	O[b]	O[b]	

Table F.44 ACSI Services Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-2440 Support
S24	Report	TP	c6[c]	c6[c]	YES
S24-1	data-change (dchg)				YES
S24-2	qchg-change (qchg)				YES
S24-3	data-update (dupd)				
S25	GetBRCBValues	TP	c6[c]	c6[c]	YES
S26	SetBRCBValues	TP	c6[c]	c6[c]	YES
Unbuffered Report Control Block (URCB)					
S27	Report	TP	c6[c]	c6[c]	YES
S27-1	data-change (dchg)				YES
S27-2	qchg-change (qchg)				YES
S27-3	data-update (dupd)				
S28	GetURCBValues	TP	c6[c]	c6[c]	YES
S29	SetURCBValues	TP	c6[c]	c6[c]	YES
Logging (Clause 14)					
Log Control Block					
S30	GetLCBValues	TP	M[a]	M[a]	
S31	SetLCBValues	TP	O[b]	M[a]	
LOG					
S32	QueryLogByTime	TP	c7[d]	M[a]	
S33	QueryLogByEntry	TP	c7[d]	M[a]	
S34	GetLogStatusValues	TP	M[a]	M[a]	
Generic Substation Event Model (GSE) (Clause 14.3.5.3.4)					
GOOSE-Control-Block					
S35	SendGOOSEMessage	MC	c8[e]	c8[e]	YES
S36	GetReference	TP	O[b]	c9[f]	
S37	GetGOOSEElement				
Number	TP	O[b]	c9[f]		
S38	GetGoCBValues	TP	O[b]	O[b]	YES
S39	SetGoCBValues	TP	O[b]	O[b]	Client/Sub
ONLY					
GSSE-Control-Block					
S40	SendGSSEMessage	MC	c8[e]	c8[e]	
S41	GetReference	TP	O[b]	c9[f]	
S42	GetGSSEElement				
Number	TP	Ob	c9[f]		
S43	GetGsCBValues	TP	O[b]	O[b]	
S44	GetGsCBValues	TP	O[b]	O[b]	

Table F.44 ACSI Services Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-2440 Support
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[g]	c10[g]	
S46	GetMSVCBValues	TP	O[b]	O[b]	
S47	SetMSVCBValues	TP	O[b]	O[b]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[g]	c10[g]	
S49	GetUSVCBValues	TP	O[b]	O[b]	
S50	SetUSVCBValues	TP	O[b]	O[b]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	YES
S52	SelectWithValue	TP	Ma	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in secs)			2–10 (1 ms)	T1
T2	Time accuracy of internal clock				10/9
	T1				YES
	T2				YES
	T3				YES
	T4				YES
T3	Supported TimeStamp resolution (nearest negative power of 2 in secs)			2–10 (1 ms)	10

[a] M = Mandatory.
[b] O = Optional.
[c] c6 shall declare support for at least one (BRCB or URCB).
[d] c7 shall declare support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 shall declare support if TP association is available.
[g] c10 shall declare support for at least one (SendMSVMessage or SendUSVMessage).

Potential Client and Automation Application Issues With Ed2 and 2.1 Upgrades

The following are issues that IEC 61850 Ed1-based client or automation applications may experience with IEC 61850 Ed2 ICD and firmware changes. However, such issues may be resolved by reconfiguring the client or automation application or worked around by restoring the Ed1 configuration (CID file). None of these should prevent a client application from dynamically discovering the data in the IED as long as the application adheres to the specification of the standard. Note that upgrading to Ed2 firmware will not break existing Ed1 configurations (CID files) in the field nor require loading an Ed2 version of the CID file.

In some cases, updating Ed1 client applications or server devices in an existing IEC 61850 system may not be feasible. While Ed2 or Ed2.1 devices are generally backward-compatible, it might be preferable to use an Ed1 ICD file in a device that supports Ed2 or 2.1. Architect provides a selection option to allow an Ed2.1 device to communicate with an Ed1 client.

Ed2 introduced the concept of simulated information for testing. Ed1 subscribers cannot interpret the Simulation bit in a GOOSE or Sampled Values APDU, which could lead to a misoperation. Therefore, caution and thorough testing are essential in mixed edition systems.

Unexpected Error Messages

Some MMS and control errors have been changed in Ed2. Hence, the firmware now issues only the Ed2-compliant errors. Clients or automation applications that rely on the Ed1-compliant errors will not function correctly. You can resolve this by reconfiguring the client or automation application to accept Ed2-compliant error messages.

Missing or Unknown Data Objects and Attributes

Ed2 has changed some data object and attribute names, as well as the data types of some attributes. Ed2 also prohibits the use of proprietary CDCs. See *Common Logical Nodes on page F.30* to determine the Ed2 names. This may cause the failure of clients or automation applications that rely on the Ed1 names. A workaround is to use the Ed1 version of the CID file, if available, to configure the IED. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 names.

Unable to Find Operate Time-Out

A proprietary method was used to specify the operate time-out of control objects in the CID files. A client or automation application that relies on this proprietary method will fail to find the operate time-out in the CID file. A workaround is to use the Ed1 CID file to configure the IED. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 control object operate time-outs.

Unexpected Control Block Data Attribute Type

The string type data attributes in control blocks (RptID, DatSet, etc.) have been changed from a maximum length of 65 to 129 characters, i.e., VisString65 to VisString 129. Some clients and automation applications might see this as an error when the type is reported in the MMS GetVariableAccessAttributes response. You can resolve this by reconfiguring the client or automation application.

Unexpected Reports

Ed2 requires report buffering to start when the device is turned on, unlike in the Ed1 implementation where report buffering started after the first report enable. If a client or automation application relies on the Ed1 behavior, it might fail or indicate an error if the IED sends buffered reports immediately after the first enable. You can resolve this by reconfiguring the client or automation application.

Failure to Reselect a Control Object Before the Time-Out

In Ed1, if a client reselected a control object before the select-before-operate time-out expired, the reselection would succeed and cause the selected time-out to restart. According to Ed2, this reselection is supposed to fail. Ed1-based clients or automation applications that rely on successful reselection might operate incorrectly. You can resolve this by reconfiguring the client or automation application.

Test Control Commands Fail Immediately

In Ed1, if the test attribute was set in a control command structure, the relay would accept the command but perform no action on the target control object. With enhanced control models, the IED eventually reported an operate timeout error after the operate time-out expired. However, in Ed2, any such test commands fail immediately with an error indicating that the command is blocked because the IED is not in the appropriate mode. Clients or automation applications that depend on the Ed1 behavior might fail. You can resolve this by reconfiguring the client or automation application.

No Reports

Ed2 specifies that no reports are to be generated for a deadbanded attribute if the deadband is set to 0. Previously in Ed1, a deadband of 0 caused the relay to generate reports for any change in the instantaneous value. Ed1-based clients or automation applications might not operate correctly because of the lack of reports. You can resolve this by reconfiguring the client or automation application.

Known Interoperability Issues Between Ed2.1 and Ed2

For unbuffered and buffered reporting, the client reserves the RCB first before changing the configuration and enabling it. Otherwise, if not reserved, the server refuses the configuration and enable request. SEL recommends that the you update each client system to Ed2.1 when an Ed2.1 server device is used.

Changes to Data Modeling in Ed2.1

Some logical nodes and data objects have been extended and updated in Ed2.1. The logical nodes and objects present in the default ICD files for SEL devices may have changed for Ed2.1. Table F.x lists the objects included in the default ICD files. Optional objects and attributes not included in the default ICD files may not be listed.

The name space for data modeling in Ed2.1 has been changed from IEC 61850-7-4:2007A to IEC 61850-7-4:2007B.

Changes Related to Communication Services in Ed2.1

The changes for communication services in Ed2.1 include:

- Unbuffered Reporting
  - Clients must always set Resv = TRUE, even when the URCB is preassigned, before the report can be enabled.
  - When a URCB instance is pre-assigned to a specific client, Resv = TRUE.
  - Server will refuse configuration and RptEna=T if the client did not reserve a report.
- GOOSE Publish
  - Definition of maxTime has been updated.
- Time Sync
  - IEC 618580-9-3 PTP is optional (SNTP stays mandatory).

Appendix G
MIRRORED BITS Communications

Overview

IMPORTANT: Be sure to configure the port before connecting to a MIRRORED BITS device. If you connect an unconfigured port to a MIRRORED BITS device, the device will appear to be locked up.

MIRRORED BITS® communications is a direct device-to-device communications protocol that allows IEDs to exchange information quickly, securely, and with minimal expense.

Because of different applications, the SEL product range supports several variations of the MIRRORED BITS communications protocol, which are configured with port settings.

Operation

Message Transmission

NOTE: Millisecond MIRRORED BITS (115,200 bps) on EIA-232 cables are limited to a cable length of 7.62 m (25 ft).

In the DPAC, the MIRRORED BITS transmission rate is a function of the baud rate. At baud rates below 9600 bps, the SEL-2440 transmits MIRRORED BITS as fast as possible. At 9600 bps the DPAC transmits MIRRORED BITS at 4 ms per packet. At 19200 and 38400 bps, the DPAC transmits MIRRORED BITS at a configurable rate, 2 ms per packet if TXMODE:=N or, for slower devices such as SEL-300 series relays, 4 ms per packet if TXMODE:=P. At 57600 and 115200 bps, the DPAC transmits MIRRORED BITS at 2 ms per packet and 1 ms per packet respectively; these baud rates are available for Millisecond MIRRORED BITS applications. *Table G.1* shows the MIRRORED BITS transmission rate associated with the baud rates.

Table G.1 MIRRORED BITS Message Rates for Different Baud

Baud Rate	Transmission Rate of Mirrored Bits Packets (ms/packet)
2400	15
4800	7.5
9600	4
19200	2 if TXMODE:=N or 4 if TXMODE:=P
38400	2 if TXMODE:=N or 4 if TXMODE:=P
57600	2
115200	1

Message Reception Overview

During synchronized MIRRORED BITS communications with the communications channel in the normal state, the device decodes and checks each received message. If the message is valid, the device sends each received logic bit (RMB*n*, where *n* = 1–8) to the corresponding pickup and dropout security counters, which in turn set or clear the RMB*n*A and RMB*n*B device element bits.

Message Decoding and Integrity Checks

Set the RX_ID of the local DPAC to match the TX_ID of the remote DPAC. The DPAC provides the status of each MIRRORED BITS communications channel with Device Word bits ROKA and ROKB. Upon detecting conditions, the device clears the ROK*c* bit.

The device asserts ROK*c* after successful synchronization and two consecutive messages pass the data checks described above. After ROK*c* is reasserted, received data may be delayed while passing through the security counters.

While ROK*c* is deasserted, the device does not transfer new RMB data to the pickup-dropout security counters. Instead, the device sends one of the user-definable default values to the security counter inputs. For each of the RX setting, the setting is a mask of 1s, 0s, and/or Xs, where X represents the most recently received valid value. The positions of the 1s and 0s correspond to the respective positions of the MIRRORED BITS in the Device Word bits. *Table G.2* shows an example of the values of the MIRRORED BITS for an RXDFLT setting of 10100111.

Table G.2 MIRRORED BITS Values for an RXDFLT Setting of 10100111

Bit	7	6	5	4	3	2	1	0
	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
	1	0	1	0	0	1	1	1

Individual pickup and dropout security counters supervise the movement of each received data bit into the corresponding RMB*n* element. You can set each pickup/dropout security counter from 1 to 8. A setting of 1 causes a security counter to pass every occurrence, while a setting of 8 causes a counter to wait for eight consecutive occurrences in the received data before updating the data bits. The pickup and dropout security count settings are separate. Control the security count settings with the settings RMB*n*PU and RMB*n*DO.

Channel Synchronization

When the DPAC detects a communications error, it deasserts ROKA or ROKB. If the DPAC detects two consecutive communications errors, it transmits an attention message, which includes the TXID setting until it receives an attention message that includes a match to the TXID setting value. If the attention message is successful, the device has properly synchronized and data transmission resumes. Otherwise, the device repeats the attention message until it is successful.

Loopback Testing

Use the **LOO** command to enable loopback testing. While in loopback mode, ROK*c* is deasserted, and another user accessible Device Word bit, LBOK*c* (Loop Back OK) asserts and deasserts based on the received data checks (see *Section 6: Communications* for the ASCII commands).

Channel Monitoring

Based on the results of data checks (described above), the device collects information regarding the 255 most recent communications errors. Each record contains at least the following fields: DATE, TIME, RECOVERY_DATE, RECOVERY_TIME, DURATION, and CAUSE (see *Message Decoding and Integrity Checks on page G.2*).

NOTE: Combine error conditions including RBADA, RBADB, CBADA, and CBADB with other alarm conditions by using SELOGIC control equations. You can use these alarm conditions to program the device to take appropriate action when it detects a communications channel failure.

When the duration of an outage on Channel A or B exceeds a user-definable threshold RBADPU, the device asserts Device Word bit RBADA or RBADB. When channel unavailability exceeds the threshold CBADPU for Channel A or B, the device asserts a user-accessible Device Word bit CBADA or CBADB. See *COMMUNICATIONS Command on page 6.13* for more information.

Appendix H

Device Word Bits

Overview

The protection and control element results are represented by Device Word bits in the SEL-2440. Each Device Word bit has a label name and can be in either of the following states:

- 1 (logical 1)
- 0 (logical 0)

Logical 1 represents an element being picked up or otherwise asserted. Logical 0 represents an element being dropped out or otherwise deasserted. *Table H.1* and *Table H.2* show a list of Device Word bits and corresponding descriptions. The Device Word bit row numbers correspond to the row numbers used in the **TAR** command (see *TARGET Command (Display Device Word Bit Status) on page 6.25*).

Use any Device Word bit (except Row 0) in SELOGIC® control equations (see *Section 4: Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 7: Analyzing Events*).

Table H.1 SEL-2440 Device Word Bits (Sheet 1 of 4)

Bit/ Row	Device Word Bits							
	7	6	5	4	3	2	1	0
0	ENABLED	*	*	*	*	*	*	*
1	*	*	*	MODE	*	SALARM	*	HALARM
2	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
3	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
4	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
5	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
6	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
7	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
8	SV09	SV10	SV11	SV12	SV13	SV14	SV15	SV16
9	SV09T	SV10T	SV11T	SV12T	SV13T	SV14T	SV15T	SV16T
10	SV17	SV18	SV19	SV20	SV21	SV22	SV23	SV24
11	SV17T	SV18T	SV19T	SV20T	SV21T	SV22T	SV23T	SV24T
12	SV25	SV26	SV27	SV28	SV29	SV30	SV31	SV32
13	SV25T	SV26T	SV27T	SV28T	SV29T	SV30T	SV31T	SV32T
14	SV33	SV34	SV35	SV36	SV37	SV38	SV39	SV40
15	SV33T	SV34T	SV35T	SV36T	SV37T	SV38T	SV39T	SV40T

Table H.1 SEL-2440 Device Word Bits (Sheet 2 of 4)

Bit/ Row	Device Word Bits							
	7	6	5	4	3	2	1	0
16	SV41	SV42	SV43	SV44	SV45	SV46	SV47	SV48
17	SV41T	SV42T	SV43T	SV44T	SV45T	SV46T	SV47T	SV48T
18	SV49	SV50	SV51	SV52	SV53	SV54	SV55	SV56
19	SV49T	SV50T	SV51T	SV52T	SV53T	SV54T	SV55T	SV56T
20	SV57	SV58	SV59	SV60	SV61	SV62	SV63	SV64
21	SV57T	SV58T	SV59T	SV60T	SV61T	SV62T	SV63T	SV64T
22	SET01	SET02	SET03	SET04	SET05	SET06	SET07	SET08
23	RST01	RST02	RST03	RST04	RST05	RST06	RST07	RST08
24	SET09	SET10	SET11	SET12	SET13	SET14	SET15	SET16
25	RST09	RST10	RST11	RST12	RST13	RST14	RST15	RST16
26	SET17	SET18	SET19	SET20	SET21	SET22	SET23	SET24
27	RST17	RST18	RST19	RST20	RST21	RST22	RST23	RST24
28	SET25	SET26	SET27	SET28	SET29	SET30	SET31	SET32
29	RST25	RST26	RST27	RST28	RST29	RST30	RST31	RST32
30	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
31	LT09	LT10	LT11	LT12	LT13	LT14	LT15	LT16
32	LT17	LT18	LT19	LT20	LT21	LT22	LT23	LT24
33	LT25	LT26	LT27	LT28	LT29	LT30	LT31	LT32
34	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
35	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD
36	SC09QU	SC10QU	SC11QU	SC12QU	SC13QU	SC14QU	SC15QU	SC16QU
37	SC09QD	SC10QD	SC11QD	SC12QD	SC13QD	SC14QD	SC15QD	SC16QD
38	SC17QU	SC18QU	SC19QU	SC20QU	SC21QU	SC22QU	SC23QU	SC24QU
39	SC17QD	SC18QD	SC19QD	SC20QD	SC21QD	SC22QD	SC23QD	SC24QD
40	SC25QU	SC26QU	SC27QU	SC28QU	SC29QU	SC30QU	SC31QU	SC32QU
41	SC25QD	SC26QD	SC27QD	SC28QD	SC29QD	SC30QD	SC31QD	SC32QD
42	*	*	*	*	TRGTR	SPEN	MATHSTRT	MATHTSK
43	RELAY_EN	*	*	*	MATHERR	*	*	*
44	EACC	E2AC	*	*	*	*	*	*
45	IN101	IN102	IN103	IN104	IN105	IN106	IN107	IN108
46	IN109	IN110	IN111	IN112	IN113	IN114	IN115	IN116
47	*	*	*	*	*	*	*	*
48	*	*	*	*	*	*	*	*
49	IN201	IN202	IN203	IN204	IN205	IN206	IN207	IN208
50	IN209	IN210	IN211	IN212	IN213	IN214	IN215	IN216
51	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308
52	IN309	IN310	IN311	IN312	IN313	IN314	IN315	IN316
53	*	*	*	*	*	*	*	*
54	OUT101	OUT102	OUT103	OUT104	OUT105	OUT106	OUT107	OUT108
55	OUT109	OUT110	OUT111	OUT112	OUT113	OUT114	OUT115	OUT116

Table H.1 SEL-2440 Device Word Bits (Sheet 3 of 4)

Bit/ Row	Device Word Bits							
	7	6	5	4	3	2	1	0
56	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308
57	OUT309	OUT310	OUT311	OUT312	OUT313	OUT314	OUT315	OUT316
58	LINKA	LINKB	LINKFAIL	PASEL	PBSEL	*	*	*
59	IRIGOK	TSOK	TSYNC	TOS	*	*	*	*
60	TDNP3	*		*	TESTDB	SC850TM	SC850BM	*
61	IN101E	IN102E	IN103E	IN104E	IN105E	IN106E	IN107E	IN108E
62	IN109E	IN110E	IN111E	IN112E	IN113E	IN114E	IN115E	IN116E
63	*	*	*	*	*	*	*	*
64	*	*	*	*	*	*	*	*
65	IN201E	IN202E	IN203E	IN204E	IN205E	IN206E	IN207E	IN208E
66	IN209E	IN210E	IN211E	IN212E	IN213E	IN214E	IN215E	IN216E
67	IN301E	IN302E	IN303E	IN304E	IN305E	IN306E	IN307E	IN308E
68	IN309E	IN310E	IN311E	IN312E	IN313E	IN314E	IN315E	IN316E
69	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
70	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
71	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
72	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
73	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
74	*	v	*	*	*	*	*	*
75	*	*	*	*	*	*	*	*
76	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
77	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
78	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
79	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
80	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
81	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
82	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
83	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
84	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
85	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
86	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
87	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
88	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
89	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
90	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
91	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
92	*	*	*	*	*	*	*	*
93	IN101R	IN102R	IN103R	IN104R	IN105R	IN106R	IN107R	IN108R
94	IN109R	IN110R	IN111R	IN112R	IN113R	IN114R	IN115R	IN116R
95	*	*	*	*	*	*	*	*

Table H.1 SEL-2440 Device Word Bits (Sheet 4 of 4)

Bit/ Row	Device Word Bits							
	7	6	5	4	3	2	1	0
96	*	*	*	*	*	*	*	*
97	IN201R	IN202R	IN203R	IN204R	IN205R	IN206R	IN207R	IN208R
98	IN209R	IN210R	IN211R	IN212R	IN213R	IN214R	IN215R	IN216R
99	IN301R	IN302R	IN303R	IN304R	IN305R	IN306R	IN307R	IN308R
100	IN309R	IN310R	IN311R	IN312R	IN313R	IN314R	IN315R	IN316R
101	CB001	CB002	CB003	CB004	CB005	CB006	CB007	CB008
102	CB009	CB010	CB011	CB012	CB013	CB014	CB015	CB016
103	CB017	CB018	CB019	CB020	CB021	CB022	CB023	CB024
104	CB025	CB026	CB027	CB028	CB029	CB030	CB031	CB032
105	CB033	CB034	CB035	CB036	CB037	CB038	CB039	CB040
106	CB041	CB042	CB043	CB044	CB045	CB046	CB047	CB048
107	CB049	CB050	CB051	CB052	CB053	CB054	CB055	CB056
108	CB057	CB058	CB059	CB060	CB061	CB062	CB063	CB064
109	CB065	CB066	CB067	CB068	CB069	CB070	CB071	CB072
110	CB073	CB074	CB075	CB076	CB077	CB078	CB079	CB080
111	CB081	CB082	CB083	CB084	CB085	CB086	CB087	CB088
112	CB089	CB090	CB091	CB092	CB093	CB094	CB095	CB096
113	CB097	CB098	CB099	CB100	CB101	CB102	CB103	CB104
114	CB105	CB106	CB107	CB108	CB109	CB110	CB111	CB112
115	CB113	CB114	CB115	CB116	CB117	CB118	CB119	CB120
116	CB121	CB122	CB123	CB124	CB125	CB126	CB127	CB128
117	TQUAL1	TQUAL2	TQUAL4	TQUAL8	{DST}	DSTP	LPSEC	LPSECP
118	TSNTPB	TSNTPP	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
119	DNP1_TO	DNP2_TO	DNP3_TO	DNP4_TO	DNP5_TO	P2_TO	P3_TO	*
120	MOD1_TO	MOD2_TO	*	*	SC850SM	LPHDSIM	*	*
121	PTP_TIM	PTP_OK	PTPSYNC	PTPA	PTPB	*	*	*
122	EN_LRC	LOCAL	SC850LS	LOCSTA	MLTLEV	*	*	*
123	*	SPD1	SPD1B	SPD1A	DUP1	DUP1B	DUP1A	*
124	*	*	*	*	*	*	*	*
125	*	*	*	*	*	*	*	*
126	*	*	*	*	*	*	*	*
127	*	*	*	*	*	*	*	*
128	*	*	*	*	*	*	*	*

Definitions

Table H.2 Device Word Bit Definitions (Sheet 1 of 6)

Row	Bit	Definition
0	ENABLED	Relay Enabled
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
1	*	Reserved
	*	Reserved
	*	Reserved
	MODE	Mode of Device (0 = EASY Mode, 1 = Flexible Mode)
	*	Reserved
	SALARM	Software Alarms: invalid password, changing access levels, settings changes
	*	Reserved
	HALARM	Diagnostics Failure
2	RB01–RB08	Remote Bits RB01–RB08
3	RB09–RB16	Remote Bits RB09–RB16
4	RB17–RB24	Remote Bits RB17–RB24
5	RB25–RB32	Remote Bits RB25–RB32
6	SV01–SV08	SELOGIC variables SV01–SV08
7	SV01T–SV08T	SELOGIC variables SV01T–SV08T with settable pickup and dropout time delay
8	SV09–SV16	SELOGIC variables SV09–SV16
9	SV09T–SV16T	SELOGIC variables SV09T–SV16T with settable pickup and dropout time delay
10	SV17–SV24	SELOGIC variables SV17–SV24
11	SV17T–SV24T	SELOGIC variables SV17T–SV24T with settable pickup and dropout time delay
12	SV25–SV32	SELOGIC variables SV25–SV32
13	SV25T–SV32T	SELOGIC variables SV25T–SV32T with settable pickup and dropout time delay
14	SV33–SV40	SELOGIC variables SV33–SV40
15	SV33T–SV40T	SELOGIC variables SV33T–SV40T with settable pickup and dropout time delay
16	SV41–SV48	SELOGIC variables SV41–SV48
17	SV41T–SV48T	SELOGIC variables SV41T–SV48T with settable pickup and dropout time delay
18	SV49–SV56	SELOGIC variables SV49–SV56
19	SV49T–SV56T	SELOGIC variables SV49T–SV56T with settable pickup and dropout time delay
20	SV57–SV64	SELOGIC variables SV57–SV64
21	SV57T–SV64T	SELOGIC variables SV57T–SV64T with settable pickup and dropout time delay
22	SET01–SET08	SELOGIC Set latch bit variables SET01–SET08
23	RST01–RST08	SELOGIC Reset latch bit variables RST01–RST08

Table H.2 Device Word Bit Definitions (Sheet 2 of 6)

Row	Bit	Definition
24	SET09–SET16	SELOGIC Set latch bit variables SET09–SET16
25	RST09–RST16	SELOGIC Reset latch bit variables RST09–RST16
26	SET17–SET24	SELOGIC Set latch bit variables SET17–SET24
27	RST17–RST24	SELOGIC Reset latch bit variables RST17–RST24
28	SET25–SET32	SELOGIC Set latch bit variables SET25–SET32
29	RST25–RST32	SELOGIC Reset latch bit variables RST25–RST32
30	LT01–LT08	Latch bit variables LT01–LT08
31	LT09–LT16	Latch bit variables LT09–LT16
32	LT17–LT25	Latch bit variables LT17–LT24
33	LT25–LT32	Latch bit variables LT25–LT32
34	SC01QU–SC08QU	SELOGIC Counters 01–08 asserted when counter = preset value
35	SC01QD–SC08QD	SELOGIC Counters 01–08 asserted when counter = 0
36	SC09QU–SC16QU	SELOGIC Counters 09–16 asserted when counter = preset value
37	SC09QD–SC16QD	SELOGIC Counters 09–16 asserted when counter = 0
38	SC17QU–SC24QU	SELOGIC Counters 17–24 asserted when counter = preset value
39	SC17QD–SC24QD	SELOGIC Counters 17–24 asserted when counter = preset value
40	SC25QU–SC32QU	SELOGIC Counters 25–32 asserted when counter = preset value
41	SC25QD–SC32QD	SELOGIC Counters 25–32 asserted when counter = 0
42	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	TRGTR	Target Reset. Asserts for one quarter cycle if front panel or serial port target reset is executed.
	SPEN	SELOGIC Equation SPEN. (Enables Signal Profiling when set).
	MATHSTRT	One processing interval pulse when SELMath starts.
	MATHTSK	Asserts when SELMath is running.
43	RELAY_EN	61850 Data Quality Bit
	*	Reserved
	*	Reserved
	*	Reserved
	MATHERR	SELOGIC control equation math error: asserts when there is an overflow, NAN or divide by zero condition.
	*	Reserved
	*	Reserved
	*	Reserved
44	EACC	Enable ACC Port Access Control
	E2AC	Enable 2AC Port Access Control
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved

Table H.2 Device Word Bit Definitions (Sheet 3 of 6)

Row	Bit	Definition
	*	Reserved
45	IN101–IN108	Digital inputs group 1 (101–108)
46	IN109–IN116	Digital inputs group 1 (109–116)
47	*	Reserved
48	*	Reserved
49	IN201–IN208	Digital inputs group 2 (201–208)
50	IN209–IN216	Digital inputs group 2 (209–216)
51	IN301–IN308	Digital inputs group 3 (301–308)
52	IN309–IN316	Digital inputs group 3 (309–316)
53	*	Reserved
54	OUT101–OUT108	Digital outputs group 1 (101–108)
55	OUT109–OUT116	Digital outputs group 1 (109–116)
56	OUT301–OUT308	Digital outputs group 3 (301–308)
57	OUT309–OUT316	Digital outputs group 3 (309–316)
58	LINKA	Dual Ethernet link status for Port A.
	LINKB	Dual Ethernet link status for Port B.
	LINKFAIL	Dual Ethernet active port link status failure indicator.
	PASEL	Dual Ethernet active Port A indicator.
	PBSEL	Dual Ethernet active Port B indicator.
	*	Reserved
	*	Reserved
	*	Reserved
59	IRIGOK	IRIG-B Time Synchronism-Check Input Data is valid.
	TSOK	IRIG meets “high accuracy” requirements, or device timekeeping is in holdover if IRIGOK := 0.
	TSYNC	Time Synchronization. The device is synchronized to the time source reference.
	TOS	Top-of-second. Asserts for 4 ms at the top-of-second.
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
60	TDNP3	Time Source in DNP3 Master
	*	Reserved
	*	Reserved
	TESTDB	TEST DB override is active
	SC850TM	SELOGIC Control for IEC 61850 Test Mode
	SC850BM	SELOGIC Control for IEC 61850 Blocked Mode
	*	Reserved
	*	Reserved
61	IN101E–IN108E	Edge detect digital inputs group 1 (101–108)
62	IN109E–IN116E	Edge detect digital inputs group 1 (109–116)
63	*	Reserved

Table H.2 Device Word Bit Definitions (Sheet 4 of 6)

Row	Bit	Definition
64	*	Reserved
65	IN201E–IN208E	Edge detect digital inputs group 2 (201–208)
66	IN209E–IN216E	Edge detect digital inputs group 2 (209–216)
67	IN301E–IN308E	Edge detect digital inputs group 3 (301–308)
68	IN309E–IN316E	Edge detect digital inputs group 3 (309–316)
69	RMB8A–RMB1A	Channel A receive MIRRORED BITS® RMB1A–RMB8A
70	TMB8A–TMB1A	Channel A transmit MIRRORED BITS TMB1A–TMB8A
71	RMB8B–RMB1B	Channel B receive MIRRORED BITS RMB1B–RMB8B
72	TMB8B–TMB1B	Channel B transmit MIRRORED BITS TMB1B–TMB8B
73	LBOKB	Channel B, looped back ok
	CBADB	Channel B, channel unavailability over threshold
	RBADB	Channel B, outage duration over threshold
	ROKB	Channel B, received data ok
	LBOKA	Channel A, looped back ok
	CBADA	Channel A, channel unavailability over threshold
	RBADA	Channel A, outage duration over threshold
	ROKA	Channel A, received data ok
74	*	Reserved
75	*	Reserved
76–91	VB001–VB128	Virtual Bits used for Incoming GOOSE messages.
92	*	Reserved
93	IN101R–IN108R	Raw digital inputs group 1 (101–108)
94	IN109R–IN116R	Raw digital inputs group 1 (109–116)
95	*	Reserved
96	*	Reserved
97	IN201R–IN208R	Raw digital inputs group 2 (201–208)
98	IN209R–IN216R	Raw digital inputs group 2 (209–216)
99	IN301R–IN308R	Raw digital inputs group 3 (301–308)
100	IN309R–IN316R	Raw digital inputs group 3 (309–316)
101–116	CB001–CB128	Control bits
117	TQUAL1	Time Quality Bit, add 1 when asserted.
	TQUAL2	Time Quality Bit, add 2 when asserted.
	TQUAL4	Time Quality Bit, add 4 when asserted.
	TQUAL8	Time Quality Bit, add 8 when asserted.
	DST	Daylight Savings Time.
	DSTP	Daylight Savings Time pending.
	LPSEC	Direction of the upcoming leap second. 1 := delete, 0 := insert, as indicated by the SNTP Server.
	LPSECP	Leap second pending, as indicated by the SNTP Server.
118	TSNTPB	SNTP Secondary Server is active.
	TSNTPP	SNTP Primary Server is active.
	TUTCS	Offset hours sign from UTC time.

Table H.2 Device Word Bit Definitions (Sheet 5 of 6)

Row	Bit	Definition
	TUTC1	Offset hours from UTC time, binary, add 1 if asserted.
	TUTC2	Offset hours from UTC time, binary, add 2 if asserted.
	TUTC4	Offset hours from UTC time, binary, add 4 if asserted.
	TUTC8	Offset hours from UTC time, binary, add 8 if asserted.
	TUTCH	Offset half-hour from UTC time, binary, add 0,5 if asserted.
119	DNP1_TO	Port 1 DNP session 1 time out
	DNP2_TO	Port 1 DNP session 2 time out
	DNP3_TO	Port 1 DNP session 3 time out
	DNP4_TO	Port 1 DNP session 4 time out
	DNP5_TO	Port 1 DNP session 5 time out
	P2_TO	Indication of Port 2 time out for DNP or MODBUS
	P3_TO	Indication of Port 3 time out for DNP or MODBUS
	*	Reserved
120	MOD1_TO	Port 1 Modbus session 1 time out
	MOD2_TO	Port 1 Modbus session 2 time out
	*	Reserved
	*	Reserved
	SC850SM	SELOGIC Control for processing simulated GOOSE messages
	LPHDSIM	Indication of whether the device is in Simulation Mode
	*	Reserved
	*	Reserved
121	PTP_TIM	Valid PTP time source is detected
	PTP_OK	PTP time is within the 4 ms local offset
	PTPSYNC	The device is using PTP time to do time sync
	PTPA	PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1A
	PTPB	PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1B
	*	Reserved
	*	Reserved
	*	Reserved
122	EN_LRC	Enable Local/Remote Mode
	LOCAL	SELOGIC Control for local level authority
	SC850LS	SELOGIC Control for station level authority
	LOCSTA	Indication of set control authority at station level
	MLTLEV	SELOGIC Control for multi-level authority
	*	Reserved
	*	Reserved
	*	Reserved
123	SPD1	Port1 Speed. Asserts for 100 Mbps and deasserts for 10Mbps
	SPD1B	Port1B Speed. Asserts for 100 Mbps and deasserts for 10Mbps
	SPD1A	Port1A Speed. Asserts for 100 Mbps and deasserts for 10Mbps
	DUP1	Port1 Duplex Mode. Asserts for full duplex and deasserts for half duplex

Table H.2 Device Word Bit Definitions (Sheet 6 of 6)

Row	Bit	Definition
	DUP1B	Port1B Duplex Mode. Asserts for full duplex and deasserts for half duplex
	DUP1A	Port1A Duplex Mode. Asserts for full duplex and deasserts for half duplex
124–128	*	Reserved

Appendix I
Cybersecurity Features

The SEL-2440 provides a number of features to help meet cybersecurity design requirements.

Access Control

The SEL-2440 has a number of mechanisms for managing electronic access. These include ways to limit access, provide 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 of the ports are enabled. It is good security practice to disable unused ports.

IP Ports

When using Ethernet, there are a number of IP ports available within the SEL-2440. Many of these IP port numbers are user-configurable. All IP ports can be disabled. *Table I.1* describes each of these.

Table I.1 IP Port Numbers

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
21	--	TCP	Enabled	EFTP	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
319/320	--	UDP	Disabled	EPTP[a]	PTP time synchronization
502	MODNUM1/ MODNUM2	TCP	Disabled	EMOD	MODBUS for SCADA functionality
20000	DNPNUM	TCP/UDP	Disabled	EDNP	DNP for SCADA functionality

[a] When PTPPRO = DEFAULT and PTPTR = UDP.

See *Network Settings (PORT 1) on page 3.7* and *Ethernet Port on page 6.3* for more information on these settings.

Authentication and Authorization

The device supports four levels of access, as described in *Access Levels on page 6.11*. 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.

The device supports strong passwords with as many as 12 characters, using any printable character, allowing users to select complex passwords if they so choose. SEL recommends that passwords have a minimum of 8 characters and include at least one of each of the following: lowercase letter, uppercase letter, number, and special character.

Ethernet protocols Telnet and FTP require 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 6: Communications* for more information on access restrictions for the Ethernet protocols.

Monitoring and Logging

The device provides Deice Word bits that are useful for monitoring relay access:

- SALARM—Pulses for approximately one second whenever a user gains access to Level 2, when an incorrect password is entered, or when a setting is changed.
- PASEL, PBSEL—Assert while the Ethernet port(s) is active.
- LINK1, LINKA, LINKB—Assert while the link is active on the Ethernet port(s). Loss of a link can be an indication that an Ethernet cable has been disconnected.
- LINKFAIL—Asserts if link is lost on the active IP port (Ports 1A or 1B).

NOTE: Refer to Access Commands (ACCESS and 2ACCESS) for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

These bits can be mapped for SCADA monitoring via DNP3, IEC 61850, Modbus, or SEL Fast Message. They also may be added to the SER for later analysis or assigned to output contacts for alarm purposes.

The device SER is a useful tool for capturing a variety of device 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 7.1* for more information about SER.

Configuration Management

Many users are concerned about managing the configuration of their relays. The device provides mechanisms to help users manage device 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 relay configuration by pulsing for approximately one second when any of the following occur:

- Settings are changed or saved
- A password changes

See *Self-Test on page 8.2* for more information regarding the Device Word bit SALARM.

Malware Protection

The SEL-2440 has inherent and contiguous monitoring for malware. For a full description of this, see selinc.com/mitigating_malware/.

Firmware Hash Verification

This device supports digitally signed firmware upgrades. SEL uses the SHA-256 secure hash algorithm to compress and digitally sign firmware upgrade files. The signature ensures that the file has been provided by SEL and that its contents have not been altered. When the file is uploaded to the relay, the signature is verified using a public key stored on the relay. If the relay cannot verify the signature, it rejects the file. See *Appendix B: Firmware Upgrade Instructions* for more information on firmware upgrades.

Operating System/ Firmware

SEL-2440 devices are embedded devices that do not allow additional software to be installed. The devices include a self-test that continually checks running code against the known good baseline version of code in nonvolatile memory. This process is outlined in more detail in the document titled The SEL Process for Mitigating Malware Risk to Embedded Devices located at selinc.com/mitigating_malware/. The devices run in an embedded environment for which there is no commercial anti-virus software available.

Software/Firmware Verification

The devices have the ability to install firmware updates in the field. Authenticity and integrity of firmware updates can be verified by using the *Firmware Hash* page at selinc.com/products/firmware/.

Physical Access Security

Physical security of cybersecurity assets is a common concern. Typically, relays are installed within a control enclosure that provides physical security. Other times, they are installed in boxes within the switchyard. The relay provides some tools that may be useful for managing physical security, especially when the unit is installed in the switchyard.

You can monitor physical ingress by wiring a door sensor to one of the relay contact inputs. This input can then be mapped for SCADA monitoring or added to the SER log so that you can detect when physical access to the relay occurs.

It is also possible to wire an electronic latch to a relay contact output. You could then map this input for SCADA control.

Vulnerability Notification Process

Security Vulnerability Process

SEL provides security disclosure alerts to customers, and SEL instruction manuals document all releases. SEL security vulnerability disclosures are described in The SEL Process for Disclosing Security Vulnerabilities at selinc.com.

Emailed Security Notification

You can sign up to receive email notifications when SEL releases security vulnerability notices and service bulletins at selinc.com/support/securitynotifications/.

Settings Erasure

NOTE: Do not erase the settings when sending the device to the factory for service. SEL needs to be able to see how the relay was configured to properly diagnose many

It is often desirable to erase the settings from the relay when it is removed from service. You can completely erase all the configuration settings from the device using this procedure:

Step 1. Go to Access Level C. See *Access Levels on page 6.11*.

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

Once this procedure is complete, all internal instances of user settings and passwords will be erased. Do not do this when sending in the relay for service at the factory. SEL needs to see how the relay was configured to properly diagnose many problems.

Index

Page numbers appearing in bold mark the location of the topic's primary discussion.

SEL-2440 DPAC Command Summary

The table below lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but they can also be entered using lowercase letters.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Go to Access Level 1.
QUI	Go to Access Level 0.
Access Level 1 Commands	
2AC	Go to Access Level 2.
COM A	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS® communications Channel A.
COM B	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels. Append an A for Channel A or a B for Channel B.
COM L	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer. Append an A for Channel A or a B for Channel B.
COM S	Return a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Display the values of the SELOGIC® counters *n* times.
DAT	View the date.
DAT *x*	Enter date *x* in the format specified by the DATE_F settings (dd/mm/yyy, mm/dd/yyy, or yyy/mm/dd).
ETH	View Ethernet status and settings.
FIL DIR	Return a list of files.
FIL READ *filename*	Transfer settings file *filename* from the device to the PC.
FIL SHOW *filename*	Displays contents of the file *filename*.
GOO *k*	Display transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
HEL	Display a short description of selected commands.
IRIG	Force synchronization of internal control clock to IRIG-B time-code input.
MAC	Display the MAC address of the Ethernet port (PORT 1).
MAP *x y*	Display DNP map for port *x*, session *y*.
MET MATH	Display Math Variable metering data.
MET RA	Display remote analog metering data.
PRO	Display analog signal profile data. Append a C to clear profile data.
SER	Display all Sequential Events Recorder (SER) data. Append a C to clear SER data.
SER *date1*	Display all SER records made on *date1*.

Serial Port Command	Command Description
SER ***date1 date2***	Display all SER records made from dates *date2* to *date1*, inclusive, starting with *date2*.
SER ***row1***	Display a chronological progression of the first *row1* rows.
SER ***row1 row2***	Display all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*.
SER C	Clear all SER data.
SHO	Show device settings. Append a DN for DNP settings, G for Global settings, L for Logic settings, P *n* for Port *n* settings, or R for Report settings.
STA	Display device self-test status.
STA S	Display SELOGIC usage status report.
TAR	Display Device Word Row 0 (front-panel target LEDs).
TAR ***n k***	Display Device Word Row *n* (*n* = 0–140). Repeat *k* times (1–32767).
TAR ***name k***	Display Device Word Row containing Device Word *name*. Repeat *k* times.
TAR R	Reset front-panel trip/target LEDs.
TAR … ROW	Adding ROW to the command displays the Device Word Row number at the start of each line.
TIM	View time.
TIM ***hh:mm:ss***	Set time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
Access Level 2 Commands	
CAL	Go to Access Level C.
CON ***n***	Set, clear, or pulse an internal remote bit (*n* is the remote bit number from 1–32).
FIL WRITE ***filename***	Transfer settings file *filename* from the PC to the device.
L_D	Load new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enable loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enable loopback on MIRRORED BITS Channel B for the next 5 minutes.
PAS	Show existing Access Level 1 and Level 2 passwords.
PAS 1 ***password***	Change Access Level 1 password to *password*.
PAS 2 ***password***	Change Access Level 2 password to *password*.
PUL ***n***	Pulse output contact *n* for 1 second.
SET	Enter/change device settings. Append a DN for DNP settings, G for Global settings, L for Logic settings, P *n* for Port *n* settings, or R for Report settings.
SET ***name***	For all **SET** commands, jump ahead to a specific setting by entering the setting name.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA R or C	Clear self-test status and restart device.

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