SEL-2100 Logic Processor

The SEL-2100 Logic Processor interconnects as many as 15 MIRRORED BITS® devices. Combine the resulting 120 inputs and outputs using SELOGIC® control equations to implement fast, flexible bus protection, bus sectionalizing, and breaker failure protection. Apply the SEL-2100 to any protection, control, or automation application that requires collection and processing of local and remote protective elements, contact status, or logic points at protection speeds. Use Advanced Application Logic modules that are optimized to perform specific logic functions.

Features

- 15 MIRRORED BITS communications ports
- Advanced monitoring and recording of the performance of each MIRRORED BITS channel
- DNP3 Level 2 Slave
- Sequential Events Recorder (SER) with 144 programmable SER triggers and more than 32,000 time-stamped records
- Unsolicited SER Protocol
- Advanced SELOGIC control equations
- Advanced Application Logic standard and custom modules
- Optional I/O—16 control inputs, 4 contact outputs
- External IRIG-B time synchronization
- IRIG-B time-code output available on all 16 rear ports
- LEDs on all ports for transmitting and receiving
- Simple ASCII interface
- Compact 2-rack unit package

Applications

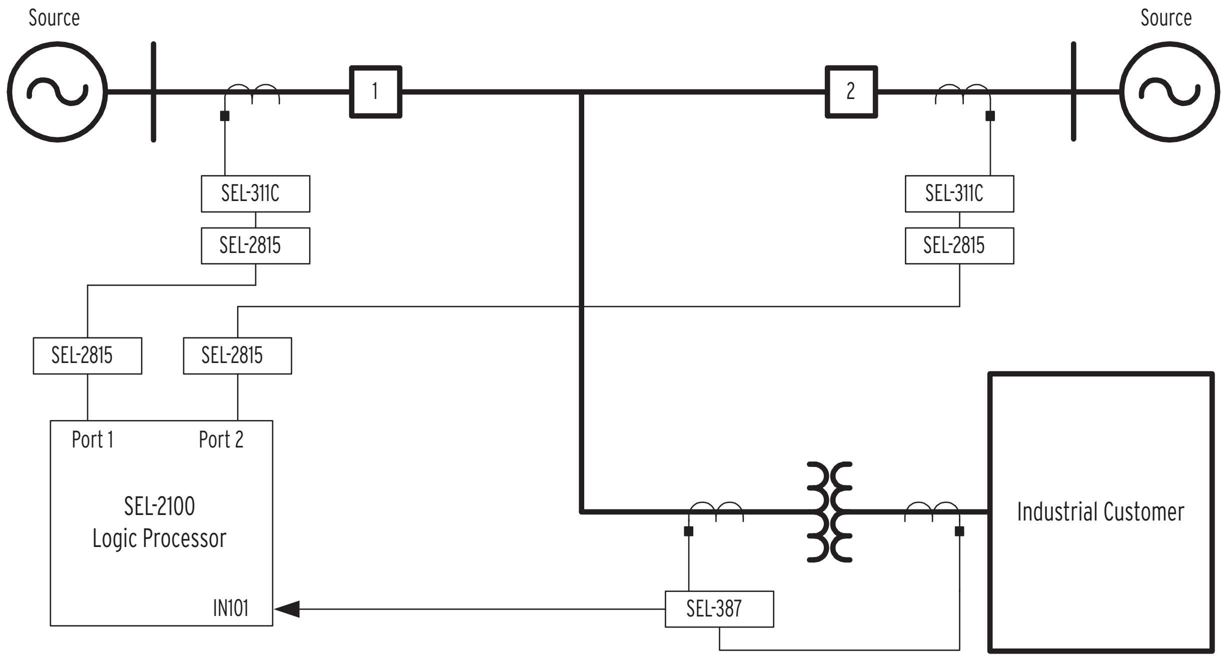


Figure 1 SEL-2100 Protects a Tapped Transmission Line

Using the SEL-2100 on a tapped transmission line provides these benefits:

- ➤ Maintain line availability.
- ➤ Improve customers' service.
- ➤ Eliminate circuit breaker costs.

The SEL-2100 in *Figure 1* transfers the SEL-387 Relay trip signal to each line relay, and routes pilot protection signals between line relays using MIRRORED BITS communications over direct fiber.

Distribution Bus Protection

Radial Feeders

The SEL-2100 shown in *Figure 2* provides fast bus protection, breaker failure protection, and centralized breaker control using SEL-2505 Remote I/O Modules and existing feeder relays.

This scheme clears bus faults nearly as fast as dedicated bus differential protection, but costs a fraction as much. During a bus fault, the transformer low side relay at Breaker 1 detects a fault, but the feeder relays do not. During a feeder fault, the transformer low-side relay and one of the feeder relays detects a fault.

When a feeder relay detects a fault, it closes a contact output, that energizes a control input on the SEL-2505. The SEL-2505 transfers the control input assertion to the SEL-2100 via MIRRORED BITS over inexpensive multimode fiber.

The SEL-2100 creates the logical OR of all the feeder relays fault detections, and transmits the result to the SEL-2505 at Breaker 1. The SEL-2505 translates the combined fault detection into a contact closure that energizes a control input on the SEL-251C Distribution Bus Relay. If the SEL-251C detects a fault, and its contact input does not assert, the fault must be on the bus, and the SEL-251C trips Breaker 1.

The SEL-2100 also provides breaker failure protection for all the breakers shown. If the transformer low-side breaker fails, the SEL-2100 sends a direct trip signal to the high side breaker, or to the other end of the transmission line if there is no high side breaker.

This combination of breaker failure protection and fast bus protection eliminates delays associated with time dial or definite time coordination between the SEL-251C and the feeder relays.

In addition, the SEL-2100 provides a central location to control and monitor all connected breakers. A single DNP3 link to the SEL-2100 can trip, close, and retrieve the status of every breaker shown in *Figure 2*.

All communications in this scheme use the SEL-2800 Fiber-Optic Transceiver and inexpensive multimode fiber for distances of as much as 500 meters. Traditionally, this installation would use control wiring from the feeder relays to the low-side transformer relay. However, fiber optics are not susceptible to dc grounds, and MIRRORED BITS continuously monitors the health of the fiber and the SEL-2505. The SEL-2100 alarms if the data link degrades or fails for any reason.

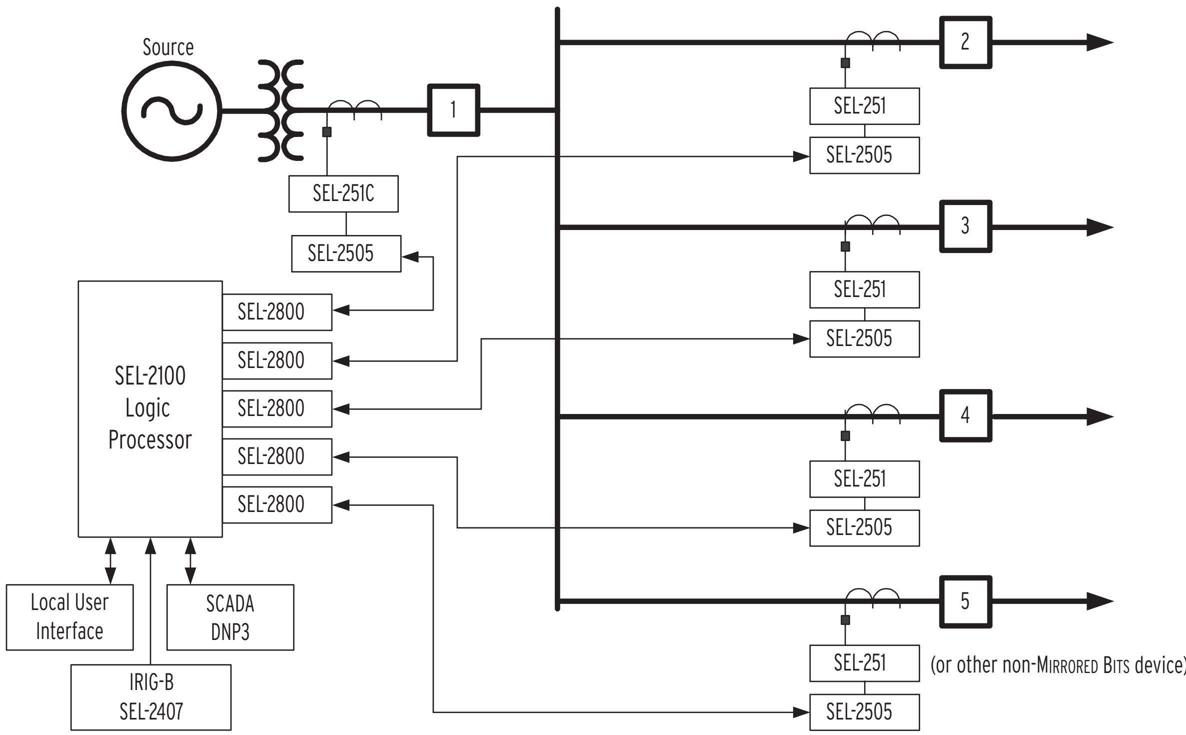


Figure 2 Fast Bus Trip Using the SEL-2100

Looped Feeders

The SEL-2100 in *Figure 3* provides bus protection and sectionalization, breaker failure protection, and remote and local breaker control and status indication for a non-radial system. Each feeder shown may be looped or have a remote source.

The relays associated with each breaker have directional elements that operate in both forward and reverse directions. In addition to protecting the associated line, each relay transmits the status of its directional overcurrent elements to the SEL-2100 via MIRRORED BITS communications. The SEL-2100 combines directional decisions and trips the appropriate breakers in the event of a bus fault or a failed breaker.

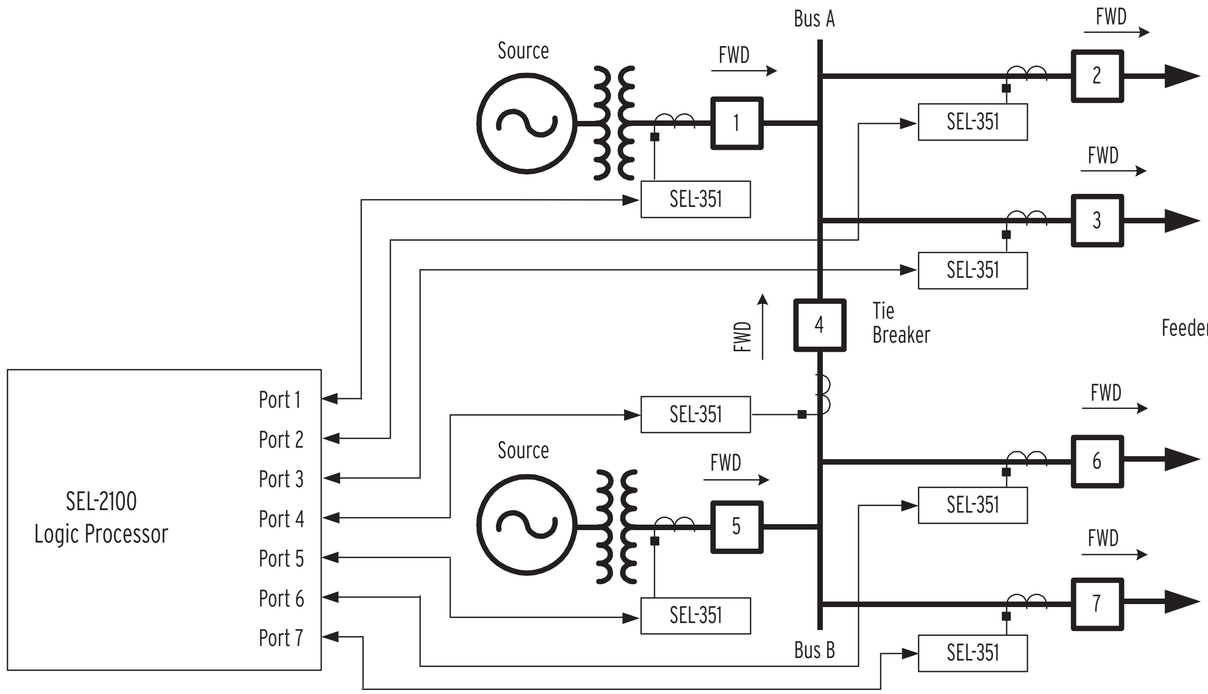


Figure 3 SEL-2100 Protects Sectionalized Bus With Looped Feeders

The SEL-2100 declares a bus fault if any relay detects a fault in the direction of a bus section, and no relay connected to that section detects a fault in the direction away from the bus. This logic recognizes that a remote breaker might be open, or a line might be radial, eliminating any directional decision from the line relay. When the SEL-2100 detects a bus fault, it issues trip commands via MIRRORED BITS to each relay on the faulted bus section.

The SEL-2100 Logic Processor allows any relay to be taken out of service with the associated breaker open without impacting bus protection. Should any relay fail without being taken out of service, or in the event a relay loses a VT connection, the SEL-2100 disables bus protection, and sends a signal to all relays on the affected bus section. The relays then revert to coordinated time overcurrent protection to protect the bus and breakers.

Three-Terminal Transmission Line Protection

The SEL-2100 Logic Processor in *Figure 4* coordinates permissive tripping between all terminals on a multiterminal line. The SEL-2100 connects to each line relay via a MIRRORED BITS link. This link can be as simple as a direct fiber connection as shown in the figure, or as flexible as a channel on a SONET ring or on a digital microwave network.

The SEL-2100 transmits permissive trip to a relay if it receives permissive trip from each of the other relays. The SEL-2100 combines permissive trip signals, enabling the SEL-311C Transmission Protection System Relay in *Figure 4* to use built-in POTT and weak-infeed logic without modification. For example, if the SEL-2100 receives a permissive trip from the relay at Terminal 2 AND the relay at Terminal 3, it transmits a permissive trip to the relay at Terminal 1. The relay at Terminal 1 uses the received permissive trip signal exactly as if it were in a two-terminal POTT scheme.

The scheme also provides direct transfer tripping at no additional cost. If any relay trips, it sends a direct trip signal to the SEL-2100 which distributes the direct trip to the other relays.

The SEL-2100 provides a convenient location to monitor all communications channels. The SEL-2100 monitors and records the health of each MIRRORED BITS link, and can instantly determine which channel has the problem. The SEL-2100 also sends a signal to a relay if either of the communications links to the other relays fails.

The SEL-2815 Fiber-Optic Transceivers shown in *Figure 4* connect two devices as much as 15 km apart. The SEL-2815 takes power directly from the serial port, and requires no settings.

Dynamic Load Shedding with the Advanced Application Logic Crosspoint Switch

The Crosspoint Switch Advanced Application Logic Module is a powerful addition to the SEL-2100 that uses instructions transferred into the SEL-2100 from another IED to route dynamically transmit MIRRORED BITS and logic point values. The Crosspoint Switch is ideal for load-shedding applications.

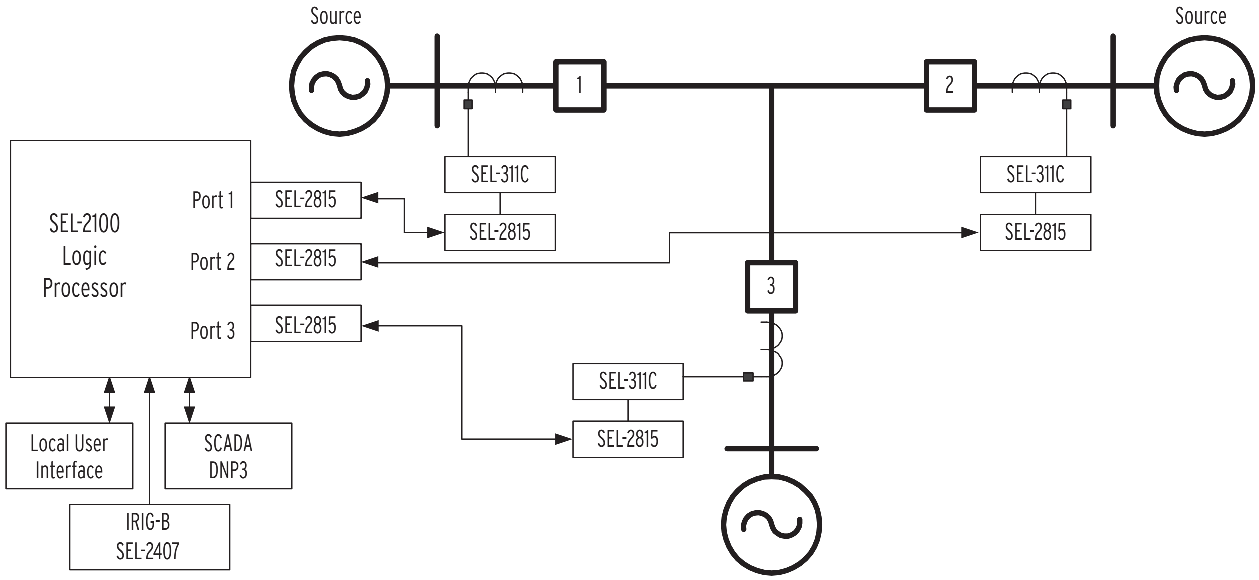


Figure 4 SEL-2100 Three-Terminal Line Configuration Diagram

Load Shedding Requires Complex Control

Many industrial power systems require intentional tripping (shedding) of loads for maintenance, high-load conditions, or contractual arrangement. Several variables, including the previous state of the system and the specific outage detected, determine the decision about which load or loads to trip. Pre-programming the load-shedding response into IEDs for anything more than a few contingencies is very cumbersome and often impossible. A substation computer, using information from numerous locations in the power system, can determine load-shedding actions for a given system configuration.

Upon losing a power source, the predetermined load-shedding instructions require an action that must be performed quickly, typically in less than 100 milliseconds. This performance goal is difficult to achieve with a centralized computer alone. Moving the high-speed decisions closer to the circuit breakers and motor contactors achieves the performance goal.

Crosspoint Switch Advanced Application Logic Solution

The SEL-2100 Crosspoint Switch Advanced Application Logic module implements the high-speed decisions for this type of application. *Figure 5* shows a simplified substation bus with SEL-2505 Remote I/O Modules at each circuit breaker connected via SEL-2815 Fiber-Optic Transceivers to an SEL-2100 Logic Processor. The SEL-2100 runs the Crosspoint Switch module, with the SEL-3351 System Computing Platform sending the load-shedding instructions to the SEL-2100 every two seconds.

The SEL-2100 uses the load-shedding instructions received from the computing platform to populate a Crosspoint Switch matrix. Once loaded, the logic processor uses this matrix to issue trip commands via MIRRORED BITS communications every 4 to 6 ms.

The end-to-end performance of a load-shedding system with three tiers of SEL-2100 logic processors is less than 70 ms (timed between the initiating event and the issuing of the circuit breaker trip signal).

Expansion and Additional Features

Expansion to larger systems is possible because the SEL-3351 can control more than one SEL-2100. Additionally, the Ethernet connection can include links to other SEL-3351 computers running similar schemes, and the HMI terminal allows remote or local access to any portion of the scheme.

Other features available in this scheme include SEL Fast Meter commands that transmit circuit breaker status information from the SEL-2100 to the SEL-3351 over the same serial-port connection used for sending the load-shed instructions. Additional control actions can be sent from the SEL-3351 via SEL Fast Operate commands that control remote bits within the SEL-2100.

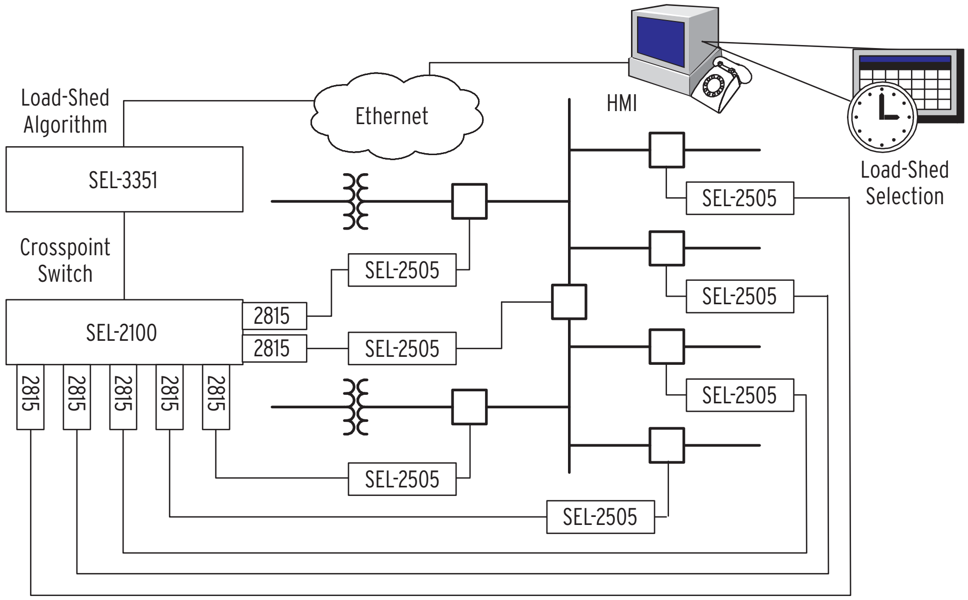


Figure 5 High-Speed Crosspoint Switch Controls Load Shedding Application

SELOGIC Control Equation Capacity is Reduced

Advanced Application Logic modules consume a portion of available SELOGIC control equation elements and edges. To preserve the maximum amount of programming capability, SEL recommends ordering or specifying an Advanced Application Logic module only when the function is required for a specific application, not for general-purpose use.

Additional Applications

Substation Sequential Events Record

Trigger a nonvolatile record in the Sequential Events Recorder (SER) when any of as much as 144 user-selected elements change state. The SEL-2100 is a low-cost solution to standalone SERs.

Control Reclose Scheme

The SEL-2100 can determine the local substation topology and remote breaker status from the data sent to it by the connected relays. Use this information to control reclosing.

Use Events to Switch Relay Setting Groups

Program the SEL-2100 to modify relay setting group selection to accommodate source changes. The command to switch setting groups can come from bus topology changes, local control switches, or from SCADA.

Monitor Relay Alarm Contacts

Program the SEL-2100 to monitor relay Alarm contacts using 16 optional inputs. These individual alarms can be combined in SELOGIC control equations to generate major or minor alarm conditions.

Redundant Pilot Communications Paths

Communications channel availability is critical for pilot schemes. Use the SEL-2100 to send the same permissive, blocking, or other trip message to the remote terminal(s) via multiple paths, as shown in *Figure 6*. For example, use Port 1 of the SEL-2100 to communicate directly with the remote relay on one of its serial ports using MIRRORED BITS communications via one path, and use Port 2 of the SEL-2100 to communicate to another port on the remote relay using a totally separate path. Using this redundant communications channel increases the availability of the tripping scheme, because the likelihood of both paths failing simultaneously is remote.

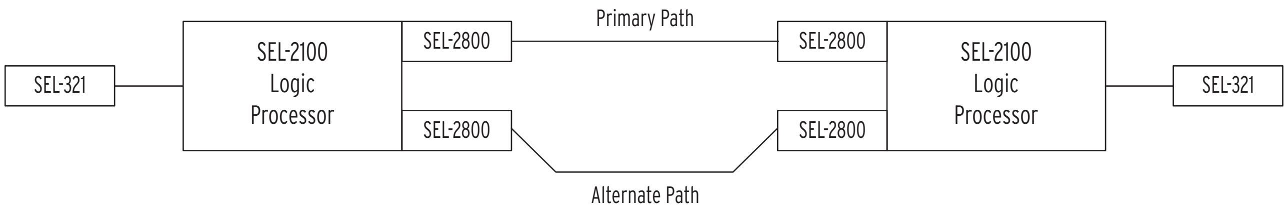


Figure 6 SEL-2100 Provides Redundant Communications Paths for Pilot Schemes

Functional Description

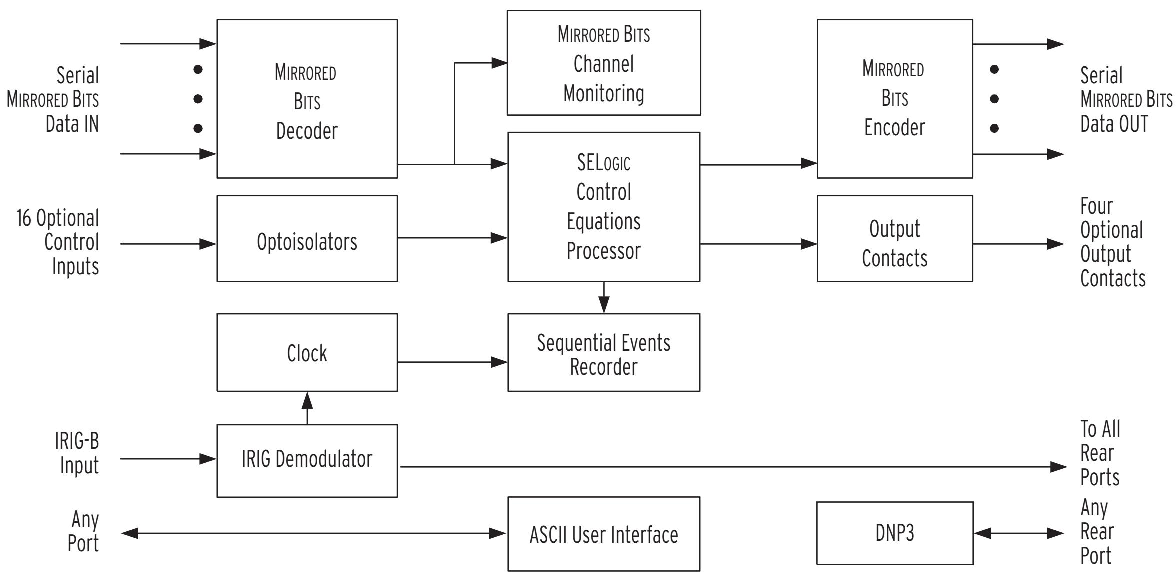


Figure 7 SEL-2100 Functional Block Diagram

The SEL-2100 receives and transmits MIRRORED BITS data on as much as 15 of the 16 rear-panel EIA-232 ports. MIRRORED BITS communications exchanges eight bits of information between devices at minimal expense and provides speed and security suitable for power system protection.

MIRRORED BITS Decoder and SELOGIC Control Equation Processor

The SEL-2100 decodes MIRRORED BITS data and checks for errors in the received data. The decoded data are passed to the SELOGIC control equations processor, which combines data with optional optoisolated contact inputs using user-defined Boolean equations. The outputs of the Boolean equations set the value of Transmit MIRRORED BITS and control optional contact outputs.

MIRRORED BITS Encoder

The MIRRORED BITS encoder creates an information packet from eight Transmit MIRRORED BITS per port, and transmits the encoded data out the MIRRORED BITS ports.

Channel Monitoring

The SEL-2100 Logic Processor monitors each MIRRORED BITS channel. Each time the MIRRORED BITS decoder detects an error the channel monitor generates a new record. The channel monitor summarizes all disturbances in a report, and creates instantaneous and filtered alarm points for short-term and long-term channel problems. Use the channel monitor to detect when a fiber or cable is cut, disconnected, or degraded, or even when a remote device is unreliable.

Sequential events Recorder (SER)

A Sequential Events Recorder (SER) tracks changes in as much as 144 user-selected elements inside the SEL-2100. The SER records every time a breaker or switch opens or closes via a contact input or via MIRRORED BITS. It also records each time the SEL-2100 issues a trip command via a contact output or Transmit MIRRORED BITS, or every time a relay is taken out of service, etc.

Unsolicited SER

SEL Unsolicited Sequential Events Recorder (SER) Protocol provides SER events to an automated data collection system. SEL Unsolicited SER Protocol is available on any serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from the SEL-2100.

IRIG-B Time Code

The SEL-2100 receives an IRIG-B time code that synchronizes the time stamps in SER reports. It distributes the received time code to any device connected to a rear-panel serial port.

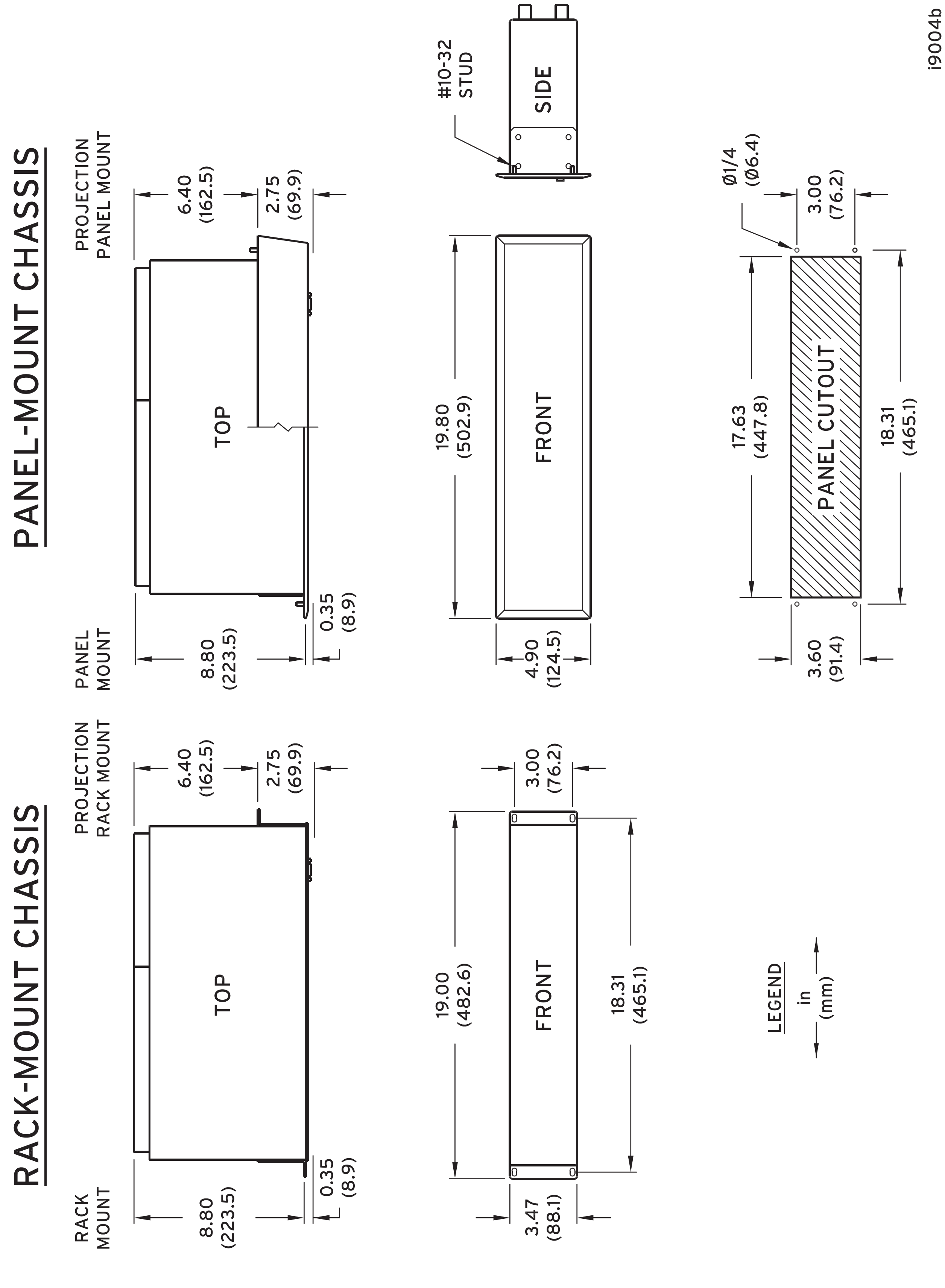
Table 1 Protocol Settings

	SEL ASCII	DNP3	MIRRORED BITS
Front Port	≤ 9600 baud	No	No
Rear Port 16	Yes	Yes	No
Rear Ports 1-15	Yes	Yes	Yes

The front-panel EIA-232 serial port provides communications access to change settings, view the SER report or MIRRORED BITS channel monitor report, and view any Relay Word bit. *Table 1* summarizes the capabilities of each of the 17 EIA-232 ports.

Connect the SEL-2100 to your existing SCADA system using DNP3. The SEL-2100 supports DNP3 on any rear-panel serial port. Use DNP3 to select any of the six settings groups, get change-of-state information via the SER, read any Relay Word bit, or control the 64 remote control bits.

Mechanical Diagram



SEL-2100 Front- and Rear-Panel Features

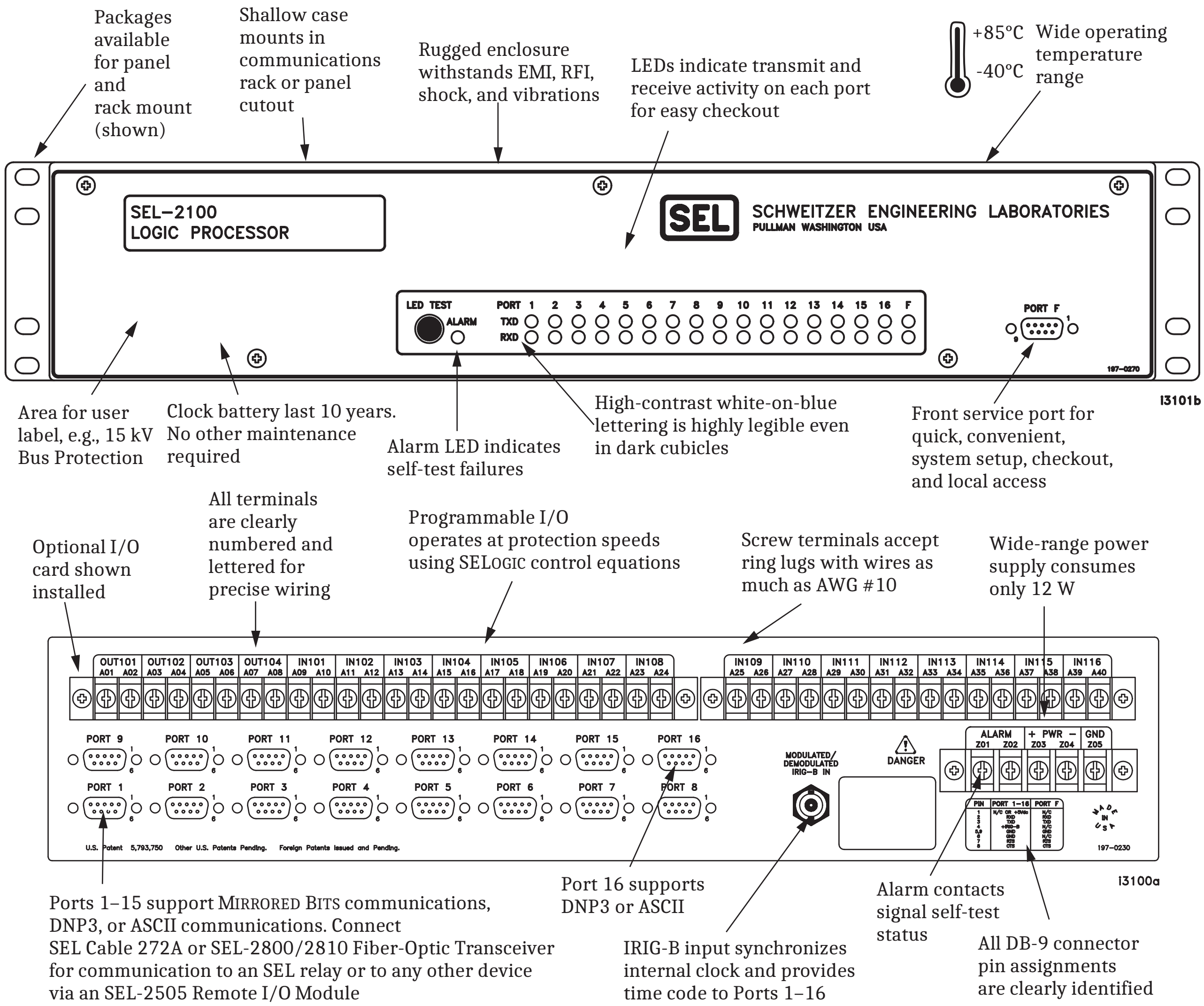


Figure 8 Front- and Rear-Panel Features

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards (File E202915; NRAQ, NRAQ7)

General

Tightening Torque

Terminal Block

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

Terminal Connections

Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105°C

Power Supply

125/250 Vdc or Vac

Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W

48/125 Vdc or 125 Vac

Range:	36–200 Vdc or 85–140 Vac
Burden:	<25 W

24/48 Vdc

Range:	18–60 Vdc polarity dependent
Burden:	<25 W

Jumper Selectable +5 Vdc out on Pin 1, Ports 1–16: 0.5 A total

Output Contacts

Per IEC 255-0-20:1974, using the simplified method of assessment.

Make:	30 A
Carry:	6 A
MOV protected:	270 Vac rms 330 Vdc continuous

Note: Make per IEEE C37.90 Tripping Output Performance Requirements.

Optoisolated Input Ratings

DC Range

250 Vdc:	Pickup 200–300 Vdc; Dropout 150 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout 75 Vdc
110 Vdc:	Pickup 88–132 Vdc; Dropout 66 Vdc
48 Vdc:	Pickup 38.4–60 Vdc; Dropout 28.8 Vdc
24 Vdc:	Pickup 15.0–30 Vdc

AC Range

250 Vdc:	Pickup 172.9–300 Vdc; Dropout 106.0 Vdc
125 Vdc:	Pickup 90.7–150 Vdc; Dropout 53 Vdc
110 Vdc:	Pickup 76.1–132 Vdc; Dropout 46.6 Vdc
48 Vdc:	Pickup 33.2–60 Vdc; Dropout 20.3 Vdc
24 Vdc:	Pickup 13.0–30 Vdc

Note: 24, 48, 125, and 250 Vdc optoisolated inputs draw approx. 5 mA of current; 110 Vdc inputs draw approx. 8 mA of current. All current ratings are at nominal input voltage.

Communications Ports

EIA-232:	1 Front and 16 Rear
Data Rate:	300–38400 bps

Time-Code Input

Connector:	Female BNC
Time Code:	Modulated IRIG-B, 1000 Vdc isolation Demodulated IRIG-B, TTL-compatible

Automatically sets real-time clock/calendar.

Time-Code Output on Rear Serial Ports

Pinout:	Pin 4 TTL-level signal Pin 6 reference
Connectors:	All 16 rear DB-9 port connectors

Outputs are generated from IRIG-B input (when present).

MIRRORED BITS Communications Time

1 ms at 38400 baud

SELOGIC Control Equation Update Time

4–5 ms

Real-Time Clock/Calendar

Battery Type:	IEC No. BR2335 Lithium
Battery Life:	10 years
Clock Accuracy:	±20 min/yr @ 25°C (without power applied). ±1 min/yr @ 25°C (with power applied) ±5 ms with IRIG-B time-code input

Operating Temperature

–40° to +85°C (–40° to +185°F)

Unit Weight

3.50 kg (7 lb, 12 oz)

Type Tests and Standards

Radiated and Conducted Emissions

Product Specific:	IEC 60255-25:2000
Conducted RF Immunity:	IEC 61000-4-6:1996 Severity Level: 10 Vrms
Digital Radio Telephone RF Immunity:	ENV 50204:1995 Severity Level: 10 V/m at 900MHz and 1.89 GHz
Electrostatic Discharge:	IEC 60255-22-2:1996 Severity Level: Equipment is tested at both polarities at levels 1, 2, 3, 4 IEC 61000-4-2:1995 Severity Level: Equipment is tested at both polarities at levels 1, 2, 3, 4
Fast Transient/Burst:	IEC 61000-4-4:1995 Severity Level: 4 kV at 2.5 kHz IEC 60255-22-4:1992 Severity Level: 4 kV at 2.5 kHz
Generic Standards:	EN 50082-2:1995
Magnetic Field:	IEC 61000-4-8:1993 Severity Level: 1000 A/m for 3 s, 100 A/m for 1 min IEC 61000-4-9:1993 Severity Level: 1000 A/m

Radiated Radio Frequency:	IEC 60255-22-3:1989 Severity Level: 10 V/m (Exceptions: 4.3.2.2 Frequency sweep approx. with 200 frequency steps per octave) IEC 61000-4-3:1998 Severity Level: 10 V/m IEEE C37.90.2:1995 Severity Level: 35 V/m
Surge Withstand Capability:	IEC 60255-22-1:1988 Severity Level: 2.5 kV peak common mode, 2.5 kV peak differential mode IEEE C37.90.1:1989 Severity Level: 3.0 kV oscillatory, 5.0 kV fast transient

Environmental

Cold:	IEC 60068-2-1:1990 Severity Level: 16 hours at –40°C
Dry Heat:	IEC 60068-2-2:1974 Severity Level: 16 hours at +85°C
Damp Heat, Cyclic:	IEC 60068-2-30:1980 Severity Level: 25°C to 55°C, 6 cycles, Relative Humidity: 95%
Vibration:	IEC 60255-21-1:1988 Severity Level: Class 1 IEC 60255-21-2:1988 Severity Level: Class 1 IEC 60255-21-3:1993 Severity Level: Class 2 (Quake Response)

Safety

Dielectric Strength:	IEC 60255-5:2000 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type tested for 1 min. IEEE C37.90:1989 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type tested for 1 min.
Impulse:	IIEC 60255-5:2000 Severity Level: 0.5 Joule, 5 kV

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