Engineering Services Overview



Protection

Protection Services

Protection solutions and related services for electric power systems, including scheme designs, relay settings, and more.

Substation Engineering Services

Comprehensive solutions for power and substation design projects, from initial cost estimates to a completed substation.

Arc-Flash Risk-Assessment Services

Flexible, customized arc-flash risk assessment services to improve employee safety and address regulations.

Transmission Planning Services

Transmission planning analysis and design services over a wide range of study scenarios, from 69 kV to 525 kV.

Synchronizing Systems

Conventional and advanced generator and microgrid synchronizing systems with automatic and manual synchronizing.

Phase-Shifting Transformer (PST) Protection and Control Systems

Pre-engineered PST protection systems based on the SEL-487E Transformer Protection Relay.

Digital Secondary System Solutions

SEL Time-Domain Link (TiDL®) and SEL Sampled Values (SV) solutions that advance how you protect and control the primary equipment in your substation.



Automation

Automation Services

Proven automation and integration services using SEL technology, including solutions for SCADA, distribution network automation, and renewable energy control.

MOTOR MAX[®] Low-Voltage Motor Management and Protection System

Centralized motor management system for comprehensive control, protection, analysis, and monitoring in motor control centers (MCCs).

Metering Services

Metering solutions for both producers and consumers of energy, including custom solutions for electric power, steam, water, or gas applications in new or existing facilities.



POWERMAX[®] Power Management

POWERMAX Power Management Solutions

Integrated control systems composed of scalable relay and control hardware, software, and logic processing and designed by SEL experts.

POWERMAX for Industrial Power Management

Power management and control systems specifically engineered for industries with critical processes that need to stay online, improving power system reliability, personnel safety, and process uptime.

POWERMAX for Utilities

Custom solutions that maintain power system stability by detecting abnormal conditions and taking automatic corrective actions, including generation and load shedding and reactive compensation.

POWERMAX for Mobile Microgrids

Solutions that meet the needs of applications requiring mobility or rapid deployment, such as a military forward operating base (FOB) or a disaster relief effort.

POWERMAX for Garrison Microgrids

Dependable computing and communications, adaptive relaying, cybersecurity, and a TMS-MIL-STD-compliant microgrid controller that is interoperable with all makes and models of generators, inverters, and loads.

POWERMAX for Commercial Microgrids

Comprehensive control, protection, and metering systems to keep your power system operating when separated from the bulk electric grid.



Cybersecurity

Cybersecurity Solutions

Solutions to improve cyber defense, streamline ongoing management, and respond to incidents.



General Engineering

Design and Drafting Services

Full substation design packages, site retrofits for existing electrical gear, and detailed design drawings for power system protection, automation, metering, and control.

Government Engineering Services

Innovative, technologically advanced power management services and solutions for municipalities and government organizations, including branches of the military, national laboratories, and governmental agencies.

Engineering Studies and Simulation Services

Hardware-in-the-loop (HIL) testing services, feasibility studies, coordination reports, system stability assessments, and more.

Custom Panel and Enclosure Solutions

Custom protection, control, and metering panels; control cabinets; and retrofit doors to match your specifications.

Protection Services

selinc.com/solutions/protection-services \Box

SEL Engineering Services specifies, designs, implements, tests, and commissions protection systems. Our engineers are experts at multifunction microprocessor-based relay technology, and we design protection schemes for generation, transmission, distribution, and low-voltage systems worldwide. We can provide all the design documentation, testing procedures, and setting reports for protection, control, automation, and communications systems.



SEL experts assist you from the conceptual phase of a project through execution and commissioning. Frontend engineering design services range from preliminary designs to complete project estimates.

Scheme design

Schematics and diagrams prepared by SEL engineers help you take full advantage of SEL multifunctional technology for protection and automation schemes.

Protection and control retrofit design services

We help you reduce operating costs and improve the reliability of your aging systems by replacing outdated or unreliable equipment with SEL solutions. We have expert teams ready to meet your retrofit requirements.

Relay settings

We program and configure protection and control equipment for a wide variety of applications.

Panels and assemblies

SEL experts design, build, assemble, wire, package, and ship panels worldwide and also provide factory and onsite testing.

Field testing and commissioning

Industry-trained SEL technical staff support field testing and commissioning onsite and provide hands-on training.



Training

Application-specific training and SEL University courses for protection and automation technology increase the effectiveness of your operations and engineering staff.

NERC compliance

SEL Engineering Services offers extensive services to support setting up NERC PRC standards compliance programs and completing NERC PRC compliance studies.

Our in-depth knowledge of NERC PRC standards and protection systems allows us to perform compliance verification studies and recommend innovative correctiveaction plans for noncompliant protection systems. We have developed reports to clearly demonstrate NERC PRC compliance to auditors.

We have been building continuous monitoring for protection and control systems using microprocessor-based protective relays and real-time automation controllers since before NERC defined the term. Our engineers know industry best practices. Whether or not you need to comply with regulatory standards, we can audit your maintenance programs to determine areas for improvement. Our team of experienced engineers will demonstrate how to leverage the benefits of the IEDs already installed in your system to perform real-time validation and status reporting.

Substation Engineering Services

selinc.com/solutions/substation-engineering-services \Box

SEL Engineering Services provides comprehensive solutions for substation design projects. Our team has experience providing everything from initial cost estimates to a completed substation. Our experienced project management team provides permitting, scheduling, reporting, and procurement services. SEL licensed professional engineers walk your team through the conceptualization, estimation, budgeting, design, construction, and testing process. We have engineers with expertise in civil, mechanical, and electrical engineering; protection; system modeling, load flow, and short-circuit studies; automation; microgrid controls; networking; and cybersecurity.

Conceptual design and evaluation

To help establish all of the necessary site conditions, we offer:

- Project basis-of-design information.
- Field surveys, geotechnical investigations, and evaluation of existing utility and elevation layouts.
- Substation, distribution, and transmission planning, initial electrical studies, and analyses.
- Conceptual layout drawings and one-line diagrams.
- Desktop study reports, site surveys (digital and hard copy), and soil resistivity reports.

Substation design

Our team provides a clear path to completing your substation project, including permitting strategies, timelines, and technical support. The design phase includes detailed engineering calculations, bills of materials (BOMs), studies, analyses, plans, specifications, schedules, and cost estimates. We can provide:

- Civil engineering, including site layout, demolition and removal, erosion and sedimentation controls, site work, utility layout, foundations, steel structures, geotechnical investigations, equipment loading, yard stoning, and fencing.
- Electrical engineering, including grounding, major equipment (transformers, breakers, capacitors, reactors, underground cables, etc.) specification and design, duct bank design, cable and conduit sizing, lightning and surge protection, yard lighting, relay panel and control house design, control and protection design, wiring, and SCADA designs with analyses and studies (relay coordination, temporary overvoltage, harmonics, arcflash hazards, etc.).



Request for proposal (RFP) services

The SEL Engineering Services team provides the vital RFP services needed to prepare construction documentation for bidding. We can prepare RFP packages, submit them for bids, select bidders, and perform other activities to support the proposal process.

Construction support

We provide many of the services necessary for a project's construction. We can serve as your advocate by performing contractor prequalification, evaluation, and selection and providing construction oversight, inspection, management, and record documentation.



• Complete engineering substation services.

Arc-Flash Risk Assessment Services

selinc.com/solutions/arc-flash-studies \Box

SEL custom arc-flash risk assessments help mitigate arc-flash hazards, improve employee safety, and address a variety of regulations (OSHA 29 CFR 1910.269, IEEE 1584b-2011, NFPA-70E-2018, NESC-2012, and CSA Z462-2015). SEL Engineering Services applies proven methods to create site-specific arc-flash mitigation and personal protective equipment (PPE) requirements. We can provide a complete, cost-effective arc-flash solution for your facility.

Power system modeling

SEL Engineering Services will create a computer model of your power system in the modeling software of your choice. The model includes facility equipment electrical data for all parts of the system. We can help with compiling data for modeling the system.

We can perform the following services to assist in surveying your facility:

- Obtain and verify electrical equipment nameplate data.
- Record equipment nominal and short-circuit ratings.
- Record the cable types, sizes, lengths, and insulation.
- Document the electrical system topography.
- Record circuit breaker and relay settings.
- Determine the location of arc-flash fiber-optic sensors.

Short-circuit studies

Computerized short-circuit studies determine fault current levels at all locations in the system for different operating configurations. The values are used to evaluate bus, fuse interrupting capacity, CT saturation, and circuit breaker interrupting ratings.

Protective-device coordination studies

SEL engineers enter existing protective-device settings in the power system model to determine short-circuit clearing times. They create graphical time current coordination curves to prove adequate sensitivity and speed of operation to protect equipment and personnel and to prove selectivity with protective equipment to isolate as little of the system as possible and prevent disruption. The criteria priority will be based on your specific system.



Arc-flash analysis studies

SEL engineers calculate arcing fault currents, determine protective-device trip times, and report incident energy, arc-flash boundaries, and PPE categories. Our software computes arcing currents and reports worst-case incident energy. We offer arc-flash analysis studies for both ac (single- and multiphase) and dc systems.

Arc-flash mitigation studies

We investigate methods to reduce unacceptably high incident energy levels by modeling current-limiting solutions, reducing protective-device clearing times, implementing differential relaying schemes, and applying other economical solutions based on your system topology and available equipment capabilities.

Arc-flash hazard warning plans

SEL engineers provide customized arc-flash and shock hazard warning and danger labels that detail boundary distances, arc-flash energy levels, PPE classification levels, and other relevant data, as mandated by the appropriate standard. We also provide installation services.

Arc-flash engineering reports

We compile the results of each study into an easy-to-read and easy-to-understand engineering report. Additionally, we will release the power system model developed for the study to your facility for use and maintenance.

Detailed engineering studies

If the ratings of existing equipment are inadequate, we can help evaluate alternatives. These studies typically examine ways to redesign the existing electrical system to fix problems, keep personnel safe, and save money.

Transmission Planning Services

selinc.com/solutions/transmission-planning \Box

The purpose of transmission planning is to maintain reliability, security, and stability while meeting current and future system needs. Transmission planning requirements and processes vary by region. The experienced team at SEL creates transmission plans and analyses that are uniquely suited to meet the requirements for your region over a wide range of study scenarios, from 69 kV to 525 kV.

Studies for every situation

Using the GE Positive Sequence Load Flow (PSLF) software package and custom tools, we perform the following services:

- Path-rating studies
- FERC generator interconnection studies
- Wires-to-wires interconnection studies
- NERC MOD-026, MOD-027, PRC-006, PRC-019, PRC-024, PRC-025, and PRC-026 compliance studies
- Import/export studies
- Load-serving studies
- Underfrequency load-shedding (UFLS)/undervoltage load-shedding (UVLS) studies
- Wind turbine studies
- Microgrid studies
- Transformer emergency loading above nameplate rating calculations
- Overhead conductor steady-state thermal rating studies
- Protective-relay coordination studies

Even if you are not required to perform these specific types of analyses, you can benefit from transmission planning best practices. We provide hard and electronic copies of all reports and models for future use. It is easy to update system models for future planning needs, saving time and money versus creating new models.



Powerful software tools

Our team can analyze and provide recommendations for a variety of planning and operating power system scenarios. Software tools we use include the following:

- GE PSLF and ProvisoHD
- Siemens PSS®CAPE (previously Electrocon's CAPE)
- MathWorks Simulink & Simscape
- AspenTech Aspen software
- SKM Power*Tools for Windows (PTW)
- CYME Power Engineering software

With these tools, SEL engineers can perform transient stability, post-transient, and voltage/thermal analyses as well as relay coordination.

Applications

The results of transmission planning studies can help you:

- Determine facility equipment and operating practices to reliably meet existing and future load needs.
- Identify the facilities needed for new generators while meeting generator interconnection requirements.
- Fulfill compliance requirements for national and regional modeling and planning standards.
- Perform transmission regulatory studies to meet regional resource planning statutes.
- Provide recommendations to mitigate local and wide-area power system disturbances.
- Alleviate system bottlenecks to eliminate or delay the need for new infrastructure.

Synchronizing Systems

selinc.com/solutions/synchronizing-systems \Box

SEL Engineering Services provides both custom and preengineered synchronizing systems. These systems adjust the frequency and voltage of the generator or microgrid to bring the frequency difference (slip) and voltage difference into the synchronizing acceptance band and energize the breaker close coil at the slip-compensated advanced angle. An SEL relay with advanced synchrocheck functionality at each point of coupling provides synchrocheck supervision and/or the close command when parameters are acceptable to close the breaker connecting two power systems together.

Advanced systems

SEL engineers can create custom solutions for applications such as resynchronizing islands, remote synchronization with fiber-optic communications, flexible systems with internal PT signal switching between as many as six PT inputs, systems requiring communications and integration with distributed control systems, systems requiring HMI visualization, and many others.

Autosynchronization systems

SEL autosynchronizers replace the synchronizing panel hardware and circuits required for manual breaker closing. Autosynchronizers are more precise than manual systems, and SEL solutions include advanced reporting, communications, protection-class equipment, and highspeed communications.



The SEL synchronizing system can include automatic and manual controls to locally close the breaker on achieving synchronism.



Scalable solutions

SEL synchronizing solutions are scalable to meet your needs, whether your system consists of small emergency generators or large utility generators. You can synchronize multiple machines across multiple locations and set different parameters to optimize each synchronizing scenario using multiple settings groups and flexible logic.

Pre-engineered and customized solutions

We can build a synchronizing system based on the autosynchronization functions in the SEL-700G Generator Protection Relay or SEL-651R Advanced Recloser Control. Alternatively, we can provide more advanced systems built around a pre-engineered autosynchronizer using the SEL-451 Protection, Automation, and Bay Control System (when purchased with a separate configuration and documentation CD). You can select a standard, preengineered SEL-451 autosynchronizer, or we can provide a customized solution that fits the exact needs of your project, operational procedures, and specifications.

Phase-Shifting Transformer (PST) Protection and Control Systems

selinc.com/solutions/protection-services

SEL Engineering Services provides PST—also known as a phase angle regulating (PAR) transformer—protection and control systems. We have extensive experience with modeling, designing, setting, and testing protection and control systems for the many different configurations of these unique transformers.

Comprehensive protection in a single relay

SEL provides a pre-engineered PST protection system based on a single SEL-487E Transformer Protection Relay. Traditional protection for conventional, two-core PSTs requires separate differential relays to cover the primary windings (87P) and the secondary windings (87S) of the series and excitation transformers. Typically, four relays are required to provide a redundant protection system. The SEL solution provides both sets of differential elements in a single SEL-487E relay so that only two relays are necessary to provide fully redundant electrical protection.

Traditional 87P and 87S elements are blind to turn-to-turn faults in the regulating windings of a PST, where partial winding faults are most likely to occur. SEL supplements the 87P and 87S elements with patented positive- and negative-sequence differential elements (87-1 and 87-2) that compensate for the variable phase shift introduced by the PST. These elements are sensitive to all in-zone fault types, including turn-to-turn faults in the regulating winding of the PST. This significant advancement in PST protection is included in IEEE C37.245-2018.

These patented elements only require CTs at the zone boundaries (source and load sides) and do not require CTs embedded inside the PST, as conventional protection does. This unique capability also makes the SEL PST protection



system suitable for modernizing the protection of PSTs without CTs in the correct locations to implement conventional protection.

Additionally, this comprehensive solution provides bypass-offneutral protection (60CC), system ground backup (51N), and secondary winding ground protection (64T). Primary winding restricted earth fault protection is inherently provided by the 87P elements.

Pre-engineered and custom on-load tap changer control systems

Traditionally, PSTs have been limited to manual control due to the complexities of automatically regulating real power flow on the grid. SEL has developed technology to automatically control the on-load tap changers that regulate the power flow through a PST. We adapt our extensive library of solutions to the unique needs of your power flow control applications. Our capability includes controls for automatically operating parallel PSTs as well as redundant master/hot-standby automatic control systems.



Digital Secondary System Solutions

selinc.com/solutions/p/digital-secondary-systems 🖵

Digital secondary system solutions advance how you protect and control the primary equipment in your substation. These solutions reduce substation construction and expansion costs, improve personnel safety, and increase flexibility by replacing copper with fiber. You can modernize your substation by choosing from two SEL digital secondary system solutions:

- SEL Time-Domain Link (TiDL[®]) technology—a protection-centered, point-to-point solution that eliminates complex Ethernet network design.
- SEL Sampled Values (SV) technology—a communications-centric, network-based solution that combines protection in the merging unit with the flexibility of IEC 61850-9-2.

SEL SV Technology

SEL SV combines protection in the merging unit with the flexibility of IEC 61850-9-2. The merging unit (publisher) digitizes analog signals from primary equipment and then transmits them to an SV-supported relay (subscriber) in the control house via an Ethernet network.

Merging units with built-in protection

In an SEL SV solution, the SEL-401 Protection, Automation, and Control Merging Unit provides overcurrent and breaker failure protection and the SEL-421 Protection, Automation, and Control Merging Unit provides complete line protection, including five zones of subcycle mho and quadrilateral distance elements. If IEC 61850 network communications are lost, the SEL merging units provide backup standalone protection.



Interoperability

SEL SV devices are fully compliant with IEC 61850-9-2 and the UCA 61850-9-2LE guideline. You can use them with primary equipment that generates SV streams or with other manufacturers' SV-compliant units.

Unique testing and troubleshooting tools

The COM SV command in SEL merging units provides you with information about your SV configuration, including warning and error codes that detail why a relay rejected an SV stream, which aids troubleshooting. The TEST SV command allows you to check the network connectivity and the CT and PT ratios between publisher and subscriber devices.

Flexible Ethernet network

SEL SV technology allows you to create a flexible Ethernetbased point-to-multipoint network using tools such as software-defined networks or VLANs to fit your application needs. You can use the SEL-2740S Software-Defined Network Switch to provide centralized traffic engineering and improve Ethernet performance. The switch acts as a transparent Precision Time Protocol clock that supports the IEEE C37.238 power system profile, ensuring submicrosecond time synchronization of the end devices.



A complete SEL SV solution.



SEL TiDL Technology

TiDL technology is an innovative digital secondary system solution engineered with simplicity in mind. This technology requires no external time source, has strong cybersecurity, and is easy to implement, with no network engineering required.

Simple architecture

SEL-TMU TiDL Merging Units are placed in the yard close to the primary equipment and digitize discrete I/O signals and analog data, such as voltages and currents. These data are then transported over fiber-optic cables to a TiDL-enabled relay in the control house. With this point-to-point architecture, implementation is simple and requires zero network engineering.

Data-sharing capabilities

Each SEL-TMU can be paired with up to four SEL-400 series TiDL-enabled relays. This new data-sharing capability gives you flexibility on how to best design protection for your system and makes installations more economical by reducing the device count. In addition, the point-to-point connections make expanding easy.



Each SEL-TMU can share data with up to four TiDL-enabled relays.



TiDL uses a simple point-to-point architecture.

No external time reference

TiDL maintains relative time; therefore, it does not rely on an external time reference for protection. All data from the SEL-TMU units are synchronized with each other regardless of the number of units connected to the relay or the length of the fiber.

Strong cybersecurity posture

The dedicated, deterministic TiDL system helps secure mission-critical systems. The isolated point-to-point connections and the absence of switches and routers reduce the electronic security perimeter and limit attack points. This security-minded architecture prevents remote access, and its simplicity eliminates the need for managing port access.

Minimal training required

TiDL-enabled relay settings are the same as those in the popular SEL-400 series models, providing consistency and simplicity. You can use the same protection schemes and applications for complete distance, feeder, bus, and transformer protection.

Automation Services

selinc.com/solutions/automation-services \square

SEL Engineering Services offers proven automation and integration solutions using SEL technology. These solutions support electrical power system substations, commercial buildings, industrial sites, generation plants, and manufacturing sites worldwide. This includes fully configured, tested, and documented settings for networking, control, communications, automation, and protection equipment. We also provide complete substation upgrades and replacement of legacy protection and remote terminal units (RTUs); event monitoring, collection, and analysis; and IED integration. Many standard SEL designs are scalable with various interfaces. We can also engineer individual solutions to meet specific requirements.

SCADA solutions

We design, develop, test, and deploy complete SCADA systems to monitor and control your systems or processes. We have experience providing systems of various sizes, ranging from simple standalone systems to complex networked systems. These SCADA systems include the following components:

- Master and local substation HMIs
- Station- and system-wide Sequential Events Recorder (SER)
- System-wide relay event retrieval
- Master SCADA server redundancy
- Remote access
- Enterprise and local power system report managers

DNA® (Distribution Network Automation)

SEL DNA systems increase system operational efficiency and reduce operating costs to provide affordable and reliable electric service. Our DNA systems combine fast protection with flexible automation control and communications for a distribution automation solution that makes your system safer, more reliable, and more economical. The SEL Distribution Automation Controller (DAC) System is an add-on feature for SEL Real-Time Automation Controllers (RTACs). The DAC provides automatic reconfiguration of distribution networks to restore power to as many customers as possible after system events, such as permanent faults and open-phase conditions. Optionally, the DAC can also provide dynamic feeder optimization, which automates control of voltageand VAR-regulating devices to achieve goals such as power factor correction and demand reduction.



Condition-based monitoring

SEL engineers use proven methods to integrate conditionbased monitoring systems from multiple vendors into a comprehensive system that monitors the health of your power system. We integrate third-party systems for monitoring transformers, motors, circuit breakers, adjustable-speed drives, generators, uninterruptible power supplies, dc chargers, partial discharge, busbar joints, vibration, the environment, and cables.

Renewable energy control

We offer a control system that enables renewable energy installations with dynamic VAR sources to meet utility interconnection and regulatory requirements. The SEL Grid Connection Control System is an add-on feature for SEL RTACs. It simplifies interconnection control and solves common interconnection issues, such as adapting for varying cloud cover, nonresponsive inverter controls, and unexpected voltage excursions. The control system contains pre-engineered function blocks for controlling the point of interconnection (POI) between the utility grid and a power generation source. Using the SEL pre-engineered control system library gets renewable projects online sooner than developing custom, project-specific controls.

MOTORMAX[®] Low-Voltage Motor Management and Protection System

selinc.com/solutions/motormax 🖵

MOTORMAX is a centralized motor management system that provides comprehensive control, protection, analysis, and monitoring for original equipment manufacturer (OEM) motor control centers (MCCs). It incorporates low-voltage motor control into an overall plant control system. MOTORMAX also works with the SEL POWERMAX® Power Management and Control System for a single-source, fully integrated solution.

Architecture

MOTORMAX is a combination of motor protection, network management, and real-time automation control. It uses the SEL-849 Motor Management Relay and features from other key devices, such as the communications abilities in SEL Real-Time Automation Controllers (RTACs) and managed Ethernet switches. Together, these devices deliver high-performance motor protection as well as high-speed reporting of motor status, alarms, and operating conditions at the HMI.

System delivery

We preconfigure and test all relay, network, and automation control settings to your specifications before shipment. Every system is delivered with a complete test report, a bill of materials, cabling, and labels to simplify onsite installation. A fully tested, preconfigured system reduces installation and commissioning time.



Benefits over a traditional MCC

- Seamless integration with POWERMAX allows operators to manage a facility's power system, including end devices, from a single HMI screen.
- The absence of programmable logic controllers (PLCs), associated wiring, pushbutton controls, and interposing relays minimizes interconnect cabling.
- Arc-flash detection (AFD) increases safety by reducing incident energy. All incoming breakers are signaled to trip in <16 ms after an arc event anywhere in the MCC.
- SEL-849 relays and SEL-751 Feeder Protection Relays provide more data than traditional MCC components, which gives a better insight of end device operation.
- By using SEL components, the system can achieve higher safety integrity level (SIL) ratings.
- Oscillography and Sequence of Events (SOE) recording enable online diagnostic analysis.
- Our delivery method reduces the time and cost of installation, startup, and maintenance.



MOTORMAX provides complete management, protection, and arc-flash remediation for small and large MCCs with any combination of direct online motors, variable-frequency drives, and feeders.

Cybersecurity Solutions

selinc.com/solutions/sfci/professional-security-services \Box

Now more than ever, cybersecurity is vital for the protection of critical infrastructure. With extensive operational technology (OT) and cybersecurity expertise, the SEL Secure Solutions team builds effective solutions that improve cyber defense and streamline ongoing management. SEL central asset management solutions maintain system health throughout their life cycle. We offer secure solutions across the five functional areas of the National Institute of Standards and Technology (NIST) cybersecurity framework.



IDENTIFY

PROTECT

DETECT

RECOVER

Identify

Identify vulnerabilities as the first step to improve cybersecurity. We offer:

- Assessment services conducted to a known cybersecurity framework or standard:
 - Stage 0 (1–2 days)—Overview of cybersecurity controls.
 - Stage 1 (3+ days)—Evaluating the presence of cybersecurity controls.
 - Stage 2 (5+ days)—Validating the application of cybersecurity controls.
 - Stage 3 (10+ days)—Testing the effectiveness of cybersecurity controls.
- Development of strategic cybersecurity roadmaps.
- Governance, risk, and compliance reviews and recommendations.
- Consultant services.

Protect

Provide ongoing protection of your OT system with SEL solutions, including:

- Centralized user access controls.
- Password management.
- Secure remote access.
- Integrated physical security with cybersecurity controls.
- Networking for substation LAN/WAN.
- Security hardening guides.
- Security Technical Implementation Guides (STIGs).
- Cybersecurity interconnection requirements.
- System backups.
- Turnkey program management and integration.
- Unified threat management firewall.

Detect

Reliably detect cybersecurity events on your system. We offer:

· Centralized asset management software.

RESPOND

- Centralized update management, including firmware, patches, antivirus signatures, and the Microsoft Windows Server Update Service.
- Baseline monitoring.
- System health monitoring.
- System cybersecurity compliance.
- Host-based and network-based intrusion detection systems (IDSs).
- Security information and event management (SIEM) systems for event logging and alerts.

Respond

Ensure that your organization responds effectively to cybersecurity events. SEL solutions include:

- System and cybersecurity training.
- Incident response and forensics.
- Alarms and alerts.

Recover

Promptly restore your system with SEL services, including:

- System recovery.
- Resource augmentation.
- Spare parts inventory.

Our specialized team of certified security professionals can help you establish the proactive and sustainable plans, policies, and procedures that you need to keep your systems secure. Our solutions can be tailored to fit your unique security needs and even make it easier to meet and address today's regulatory standards, including NERC CIP. With multidisciplinary experience in substation, control system, and information security design, our cybersecurity team is here to work with you to assess, support, and develop a sensible security approach to protect your assets. SEL cybersecurity services include:

- Security awareness and training
- · Compliance support for cybersecurity standards
- Cybersecurity assessments against known frameworks



POWERMAX[®] Power Management Solutions

selinc.com/solutions/powermax-controls \square

An SEL POWERMAX Power Management and Control System is an integrated system composed of scalable relay and control hardware, software, and logic processing and designed by our engineering services experts. Ultra-high power system reliability and availability make POWERMAX ideal for locations with onsite generation and/or multiple utility power feeds

Controlling the energy balance in the microgrid system is one of the most difficult challenges for reliable microgrid operation. By operating at relay speeds, the deterministic controller can reliably balance load with the available generation. This speed provides seamless islanding and resynchronizing, so processes stay online.

SEL has designed, tested, and commissioned POWERMAX systems for military, utility, and industrial customers across the globe. Our solutions are based on sound engineering principles, robust system architectures, and industry-leading protection, automation, computing, communications, and security products. POWERMAX systems provide relay-speed operation across wide areas. These solutions are scalable,



starting with the control of a simple, isolated microgrid up to a complex wide-area power system. Each solution is tailored in both complexity and cost for your needs.

For small-scale microgrid or distributed energy resource (DER) control, we also offer simple solutions using the standalone SEL relays and Real-Time Automation Controllers (RTACs).

POWERMAX Solutions

Solution	POWERMAX for Mobile Microgrids	POWERMAX for Garrison Microgrids	PowerMAX for Commercial Microgrids	PowerMAX for Industrial Power Management	POWERMAX for Utilities
Example Applications	Military, disaster relief agencies, mobile operations	Military bases, energy service companies (ESCOs)	Universities, communities	Heavy industries	Utility
Power Consumption	<1 MW	<10 MW	<10 MW	>10 MW	>1,000 MW

POWERMAX[®] for Industrial Power Management

selinc.com/solutions/powermax-industries 🖵

A POWERMAX system increases process uptime by protecting against blackouts with advanced high-speed protection and control technology. Any production facility with onsite generation will benefit from the stability and protection of a POWERMAX system. These solutions offer:

- Load-shedding systems.
- Steam controls.
- · Generation-shedding and runback systems.
- Autosynchronization systems.
- Fast decoupling solutions.
- Generation control systems.
- Factory acceptance tests.
- Control system simulations.
- Cybersecurity.
- Synchrophasor monitoring and control.
- мотокMAX[®] Low-Voltage Motor Management and Protection System.

POWERMAX improves personnel safety and reduces equipment damage with adaptive protection, advanced protection systems, and arc-flash mitigation. POWERMAX also improves total system awareness with time-synchronized



condition-monitoring systems, which keep track of equipment status, electrical metering, cyber attacks, network traffic, and more.

POWERMAX technology is proven to keep facilities running and is specifically engineered for industries with critical processes that need to stay online. These facilities include:

- · Oil and petrochemical refining operations.
- Pulp and paper manufacturing facilities.
- Mining and metals processing facilities.
- Water and wastewater treatment plants.
- Data centers.

POWERMAX for Utilities

selinc.com/solutions/powermax-ras-utilities 🖵

A POWERMAX system for utilities uses a remedial action scheme (RAS) in a control system for large geographic regions of interconnected transmission, generation, and loads. Distributed computing and communications provide smart transmission grid management for integrating renewable generation and distributed energy resources (DERs). This solution is commonly used for the wide-area monitoring, control, and integration of large wind power stations.

A POWERMAX RAS integrates with existing relays, meters, and communications systems to minimize the footprint and complexity.

With a POWERMAX RAS, utilities can function closer to stability limits, operating transmission corridors at a higher capacity than ever before. In some cases, utilities can transmit over 50 percent



more power across existing transmission lines. This increases daily revenues and can free up billions of dollars to enhance existing transmission lines instead of building new lines.

POWERMAX[®] for Mobile Microgrids

selinc.com/engineering-services/mobile

POWERMAX ensures reliable power for microgrids that require mobility or rapid deployment, such as a military forward operating base (FOB) or a disaster relief effort.

For FOB military applications, you can parallel diesel generators instead of using the traditional setup of a dedicated generator per B-Hut or tent. Instead of sizing a generator to the peak demand of the respective function (e.g., tactical operations center, mess hall, or medical facility) and running it inefficiently most of the time, FOBs can now have parallel generators. This allows you to run a few diesel generators at high efficiency while resting the remaining generators. As loads increase, you can bring more generators online to meet the demand. This process increases operational efficiency by reducing wet stacking (and maintenance) and saving fuel, which prolongs mission operations and increases resiliency.

Additionally, the POWERMAX control system eliminates single points of failure by sharing the load between generators and can be located anywhere within the base, allowing you to be more strategic with the base layout. If a generator



or communications are lost, the system reroutes power to keep the lights on. If the generation does not meet the load requirements, POWERMAX prioritizes loads and minimizes load shedding to maintain your critical loads.

What makes SEL's TMS-MIL-STD-compliant microgrid unique is that it works with all makes and models of generators, inverters, and loads. You can easily retrofit existing commercial off-the-shelf and tactical microgrid system (TMS) generators in the field with an SEL control system.

POWERMAX for Garrison Microgrids

selinc.com/engineering-services/garrison 🖵

POWERMAX uses dependable computing and communications, including adaptive relaying and cybersecurity, to provide high-performance control for garrison microgrids.

A microgrid has low inertia compared to the larger macrogrid, which is why the relay-speed POWERMAX system is ideal. Our control algorithms and demand response operate fast enough to preserve the load and generation energy balance, maintain system stability and, most importantly, make sure the base is operating at all times.

With POWERMAX, you can operate an independent power system that prevents blackouts, reduces distributed energy resource (DER) operating costs, and protects people from injury and equipment from damage during faults. Even if closely timed faults occur, subcycle inertial-compensated control algorithms prevent blackouts. And if you want to connect to the bulk electric system, our point of common coupling (PCC) control methods can seamlessly reconnect or island the microgrid. SEL software-defined networking (SDN) ensures that all system communications happen as planned and with complete security.

For military installations that use backup diesel generation, POWERMAX can parallel existing diesel generators. The benefits of paralleling include wet-stacking correction and fuel savings, which prolong mission operations and increase resiliency.

The SEL solution is unique because it uses a TMS-MIL-STDcompliant microgrid controller that works with all makes and models of generators, inverters, and loads. If your device communicates, we can connect, control, and parallel it. Additionally, you do not have to procure the entire control system up front but can purchase and build your system in blocks over time as funding permits.

POWERMAX[®] for Commercial Microgrids

selinc.com/engineering-services/commercial-campus 🖵

SEL POWERMAX commercial microgrids keep the lights on, seamlessly islanding and reconnecting with the bulk electric system. POWERMAX microgrid control systems are efficient, reliable, and secure solutions for guaranteeing uninterrupted energy delivery to your facility and customers. They control and protect both renewable and conventional generation.

In "grid connect" mode, the SEL system manages active and reactive power sharing, maximizes renewable generation, reduces peak charges, and controls the power factor or active-reactive power across the point of common coupling (PCC). SEL systems allow you to operate independently, ensuring a constant supply of energy after the loss of the utility PCC by maintaining island nominal voltage and frequency. These systems also perform PCC smoothing, load shifting, demand response, battery energy storage system (BESS) charge/discharge management, and other ancillary services.

In 2018, the SEL POWERMAX won the National Renewable Energy Lab microgrid shootout, a rigorous 21-week microgrid control and cybersecurity evaluation competition that pitted SEL microgrid controller technology against four competitors. SEL was also selected as the top microgrid provider by Navigant Research as part of their "Navigant Research Leaderboard: Microgrid Controls" report.



Every POWERMAX commercial microgrid control system includes a factory acceptance test (FAT) for you to attend that follows the IEEE 2030.8 testing standard. SEL owns and operates the largest controller hardware-in-the-loop (cHIL) testing facility in North America. This facility contains a large number of Real Time Digital Simulator (RTDS) racks used exclusively for cHIL testing of SEL protection and control systems under realistic conditions. During the FAT, you can observe and verify the full functionality of the system.

Metering Services

selinc.com/solutions/metering-solutions \Box

SEL Engineering Services provides solutions that ensure the accurate, precise, and reliable operation of meters and support devices. By using best practices, experienced engineers, industry-leading technology, and a gated quality control process, the SEL team can design the best metering solution for your electric power, steam, water, or gas application.

System design and configuration

Whether for new or existing facilities, we can design metering systems that fit your budget and needs. We provide the following solutions to both producers and consumers of energy:

- Meter programming
- Metering system design
- Power quality studies
- Energy consumption studies
- Onsite accuracy testing and verification
- Metering asset integration
- Demand response and leveling system design
- Campus submetering design
- Pulse input conversion from conventional meters to ACSELERATOR[®] Meter Reports SEL-5630 Software

Integration services

Our team provides three tiers of metering asset integration services to deliver custom systems with high reliability and low maintenance costs. We offer:

- Basic systems that include data integration from SEL and third-party devices combined with real-time data visualization.
- Intermediate systems that add database concentration and historical visualization to a basic system.

Water Air

Gas

Steam

 Advanced systems that add database exchange, customized reports, and third-party software integration to an intermediate system.



Powerful data

Accurate metering data improve an asset's or system's performance and help you make better decisions. Experienced SEL engineers can also help you analyze your metering data to better understand your assets and processes.

Time alignment

With large campus metering systems, it is important that the system be time-aligned. We design solutions that incorporate time-aligned Sequence of Events (SOE) reporting to help you better understand event causes and effects across your system. Oscillography is available to assist with troubleshooting without the need for additional test equipment.



SEL solutions simplify site-wide metering and system integration.

Design and Drafting Services

selinc.com/solutions/design-and-drafting-services \square

SEL Engineering Services provides local design and drafting services for power and control systems, including critical infrastructure projects, around the world. We create new design and drafting packages and revise existing drawings. The team's drafting processes ensure the final design package is accurate and delivered on time.

Complete design packages

SEL has experts in all areas of electrical and civil design. We offer full design packages that include ac and dc schematics, one-line diagrams, wiring diagrams, panel layout drawings, logic schematics, and communications and network drawings. We can also convert existing plastic sheet (Mylar), vellum, and paper drawings into electronic files for easier access and storage.

We provide protection and control, automation, and full substation designs. Typical complete design packages include multiple design drawing submittals for each stage of the design, including 30 percent, 60 percent, and 90 percent Issued for Review (IFR) submittals; an Issued for Construction (IFC) submittal; and final construction as-built documentation.

Versatility

SEL Engineering Services supports multiple software tools to accommodate your preferred software. For drawings, we support Autodesk AutoCAD, AutoCAD Electrical, and AutoCAD Raster Design; Bentley Descartes, MicroStation, and Substation; and SCADA Systems Elecdes. For substation models and site plans, we support Autodesk Inventor and Civil 3D, and we use BlueBeam for creating and editing PDFs. Our design team has developed large libraries of blocks, cells, tables, and other useful tools to aid in our designs. These tools help our designers and drafters produce high-quality drawings with greater efficiency.

We are also versed in utility drafting and design standards, specifications, and procedures. This allows us to readily execute each project with a focus on quality and deliverable timeliness.



Typical design and drafting drawings

Our extensive experience and drafting resources let us provide the following services to save you time and money and enable you to use your resources more productively:

- AC and dc schematics
- One-line diagrams
- Wiring diagrams
- Panel layout drawings
- Logic schematics
- Communications and network drawings
- Substation layouts and site plans
- Civil substation design drawings
- Demolition and removal design conversion
- Shop drawings
- Retrofit drawings
- Paper-to-electronic file conversion



Government Engineering Services

selinc.com/solutions/government-services

The SEL Government Engineering Solutions (GES) team understands the unique demands of government projects and offers the industry's best people, products, technology, and services. We offer engineering services and product solutions for government agencies, military installations, and navy ships to create a safer work environment and a more reliable and economical electric power system. Our engineers' many years of experience in the power industry allows them to easily translate your needs into workable solutions.

Protection services

SEL experts can perform fault, system protection and coordination, and arc-flash studies; recommend protection schemes to match your system and goals; and develop and program relay settings.

Automation services

GES automation services include communications architecture design, the design and programming of HMIs for small- to large-scale systems, and the development and programming of communications and logic processor settings.

Microgrid systems

SEL microgrid systems reduce energy costs and emissions through optimized resource management. Our microgrids ensure uninterrupted energy delivery with robust cybersecurity and physical security. Our systems control and manage microgrids from 1 MW to more than 1 GW by using a flexible and expandable architecture.



Application services

Our team reviews system designs and settings to reduce equipment and operational costs while increasing system performance and functionality. We can select the SEL products best suited to your power system protection and automation requirements.

Field services

The SEL GES team can:

- Upgrade aging infrastructure.
- Perform engineering work that requires a specialized workforce of cleared personnel.
- Provide onsite commissioning support from trained technical staff.
- Support or perform SEL product field testing.
- Analyze event reports to determine ways to improve system performance and increase reliability.
- Provide application-specific training for operations and engineering staff.
- Increase system performance and functionality.

Engineering Studies and Simulation Services

selinc.com/solutions/system-modeling 🖵

SEL Engineering Services conducts power system studies using simulation software. Our experienced team of engineers has the software and equipment necessary to model any power system and operating scenario. The results of these studies increase power system awareness or confirm reliable performance. With this insight and analysis, you can improve performance, ensure safe operation, and optimize device settings in your system.



Protection studies

Protection studies are important for identifying deficiencies and developing improvements to ensure a reliable electric power system. Our protection studies can improve relay coordination and reduce system outages. We review or build models to determine the system impacts during a faulted condition. To model the entire network, we use software applications, such as Electrocon International's Computer-Aided Protection Engineering (CAPE), AspenTech's software suite, and solutions from SKM Systems Analysis, EasyPower, and ETAP. We then compare model results and calculated values against equipment ratings to verify that the system is protected and operating safely.

Our protection study services include the following:

- Real and reactive (VAR) power flow and optimization
- Voltage drop and regulation analysis
- Short-circuit analysis
- Circuit breaker and bus rating evaluation
- Protection coordination, settings, and conversions
- Arc-flash hazard analysis
- Harmonic and power quality assessment
- Power factor improvement
- Transient stability analysis

Hardware-in-the-loop (HIL) testing

HIL testing improves power system reliability and reduces the costs associated with real-time transient power system and integrate it with physical protection and control devices to simulate real-time operation. Validated models confirm that the simulated response to a disturbance or event reasonably matches the measured response to a similar disturbance. Incorporating these models with HIL testing demonstrates the performance of the protection and control scheme as well as its effect on the power system. We test scenarios for short-term versus long-term capacity limits to ensure a more accurate representation of a system's operations. Thorough modeling and understanding result in better system performance.

We have the largest commercial simulator for performing HIL testing in the United States, allowing our team to test many complicated scenarios, including the following:

- Communications-assisted tripping schemes
- Autosynchronizing schemes
- Load-shedding schemes
- Generation shedding and runback schemes
- Control schemes
- Islanding detection and decoupling schemes
- Remedial action schemes
- Phase-shifting transformer protection and control schemes
- Open-phase detection schemes

Custom Panel and Enclosure Solutions

selinc.com/solutions/custom-panel-solutions selinc.com/solutions/custom-enclosure-solutions

We design, manufacture, test, and deliver custom protection, control, and metering panels, control cabinets, retrofit doors, and enclosures. We integrate multiple pieces of equipment (from SEL and other manufacturers) into a single assembly or kit, enabling one-stop shopping for parts and labor with a quick turnaround time. Our experts will work with you to understand your requirements and challenges and provide innovative, economical solutions built to stringent SEL quality standards.

Complete design, manufacturing, testing, and commissioning services

To exactly meet your needs, we offer complete panel and enclosure solutions, from design through commissioning. We test the final implementation of every product or system before it ships, reducing your overall project costs and engineering time. This testing makes commissioning easier and faster.

Complete panel solutions

SEL custom panel solutions come with the following options and services:

- Consulting and engineering design
- Testing and verification, including loading settings, functionality, point-to-point wire connectivity, ac/dc circuit operation, and Megger and HiPot testing
- Protection, automation, and control equipment manufacturing
- Field service
- Standard cabinet design
- Indoor and outdoor design
- Submersible cabinets for underground distribution
 and automation
- Delivery in 10–12 weeks
- Assigned project manager





Complete enclosure solutions

SEL custom enclosure solutions offer the following options and capabilities:

- Enclosures, racks, bezels, plates, portable enclosures, swing panels, and doors
- Custom adapters that integrate SEL equipment into your existing systems
- Prewired assemblies for easy installation and minimal field wiring
- Wiring conversion assemblies and terminals
- Fully assembled and wired test racks and simulator systems
- Easily extractable assemblies for SEL-700 and SEL-2400 series products
- Assembly for your pre-existing designs
- Stainless steel, mild steel, aluminum, fiberglass, and polycarbonates
- UL508A and CSA-C22.2 No. 14 certification



SEL-7200 Configure-to-Order (CTO) Panels and Retrofit Plates xxx

selinc.com/products/7200 🗔

SEL-7200 CTO panels and retrofit plates provide predesigned, advanced solutions for protection, control, automation, communications, and cybersecurity for substation applications. These panels offer a consistent, methodical design and manufacturing approach, resulting in higher quality, reliability, and performance than traditional custom panels. They are predesigned and come with prevalidated settings, speeding up deployment while guaranteeing functionality. Additionally, CTO panels ship within 4 weeks and achieve up to a 40 percent savings in total cost of ownership versus a comparable custom panel.

SEL CTO panels are available through our Engineering Services (ES) division and embody SEL best-known engineering methods and field-tested expertise in mechanical design, cable management, protection, precise time, automation, communications, and metering.

Application modules support common protection and automation practices while universal wiring to terminal blocks allows customization flexibility to adapt to any common primary equipment configuration and operation practice.

Design principles

SEL CTO panels provide the following:

- Fully redundant protection and breaker failure protection at all voltage levels.
- Preconfiguration for cybersecurity framework integration.
- Advanced SEL technology, such as arc-flash protection and zone interlocked bus protection logic, that is ready to deploy.
- Simple integration to SCADA and HMIs.
- Continuous monitoring to reduce the possibility of hidden failures and facilitate extended testing intervals.
- An industrial design for improved human performance.

Quality

We engineer, manufacture, and test our panels to ensure adequate operation before delivery. When a panel arrives at your site, it is already verified as fully functional. SEL panels are supported by an unmatched ten-year warranty and the industry's best customer service.

For a complete list of available options, visit selinc.com/products/7200.



Design validation that guarantees expected performance

We develop and test each application module design to ensure it meets functional specifications. This process allows our manufacturing facility to properly document processes and test procedures prior to production.

Available solutions include the following:



SEL-7201 Feeder Protection Panels Provide advanced protection and control for up to four feeders using either SEL-351 or SEL-751 Feeder Protection

Relays. These panels include protection functions, such as overcurrent, voltage, frequency, and breaker failure, and control functions, such as reclosing, sync-check, and hot-line tagging.



SEL-7207 Automation and Communications Panels

Provide high-accuracy time synchronization; centralized engineering access with user-based authentication and authorization; data collection for SCADA; and inherently cyber-secure, reliable, and high-performance Ethernet communications using SEL software-defined networking (SDN) technology.

SEL-7210 Retrofit Plates

Retrofit and modernize existing panels or switchgear, and get all the benefits of CTO panel solutions. Fifteen-foot pigtails provide connection to your existing terminal blocks.