ENGINEERING SERVICES OVERVIEW

PROTECTION SERVICES
Protection design, settings, testing, commissioning, and more.

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

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.

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.

AUTOMATION SERVICES
SCADA and HMI systems, remote terminal unit (RTU) replacement, DNA® (Distribution Network Automation), event monitoring and collection, intelligent electronic device (IED) integration, condition monitoring, and NERC PRC-005 solutions.

CYBERSECURITY SOLUTIONS
Assessment, support, and development of control system security infrastructure to support NERC CIP standards as well as other security standards and regulations.

DESIGN AND DRAFTING SERVICES
Full substation design packages, site retrofits for existing electrical gear, or detailed design drawings related to power system protection, automation, metering, and control.

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

GOVERNMENT ENGINEERING SOLUTIONS
Innovative, technologically advanced power management solutions for municipalities and government organizations, including branches of the military, national laboratories, and governmental agencies.
MICROGRID SOLUTIONS
Comprehensive microgrid control, protection, and metering systems and tactical microgrid systems for mobile forward operating bases.

POWERMAX® POWER MANAGEMENT AND CONTROL SYSTEMS
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.

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

MOTORMAX® LOW-VOLTAGE MOTOR MANAGEMENT AND PROTECTION SYSTEM
A centralized motor management system that provides comprehensive control, protection, analysis, and monitoring for your motor control center (MCC).

SYNCHRONIZING SYSTEMS
Conventional and advanced generator and microgrid synchronizing systems with automatic and manual synchronizing capabilities.

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.

CUSTOM PANEL AND ENCLOSURE SOLUTIONS
Custom protection, control, and metering panels; control cabinets; and retrofit doors to match your specifications.
PROTECTION SERVICES

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.

selinc.com/solutions/protection-services

PROJECT SCOPE AND SPECIFICATION
SEL experts assist you from the conceptual phase of a project through execution and commissioning. Front-end 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, test, 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 for your personnel.

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

NERC COMPLIANCE
Whether you need to meet NERC reliability requirements or want to improve your protection system reliability through automated verification, we can help. Our engineers know industry best practices, and we can audit your NERC compliance program to recommend additional efficiencies. 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 intelligent electronic devices (IEDs) already installed in your system to perform real-time validation and status reporting.
AUTOMATION SERVICES

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 intelligent electronic device (IED) integration. Many standard SEL designs are scalable with various interfaces. We can also engineer individual solutions to meet specific requirements.

selinc.com/solutions/automation-services

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 available 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 voltage and VAR regulating devices to achieve goals such as power factor correction and demand reduction.

CONDITION-BASED MONITORING (CBM)

SEL engineers use proven methods to integrate CBM 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 available 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.
ENGINEERING STUDIES AND SIMULATION SERVICES

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.

selinc.com/solutions/system-modeling

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 testing. Our engineers build a model of your 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
CYBERSECURITY SERVICES

Now more than ever, cybersecurity is vital for the protection of critical infrastructure. Preventing attacks takes knowledge, technology, and skill. The SEL Cybersecurity Services team has an extensive understanding of power system protection, automation, integration, control, information security, and compliance. We provide security assessments, including the following:

- Scanning
- Vulnerability assessments
- Security controls testing
- Intrusion detection system (IDS) and networking services

We are experts in NERC compliance and can help you with the following:

- Audit preparation
- Self-certifications
- Security policy review and creation
- Electronic security perimeter (ESP) and asset review or design
- Paper vulnerability assessments
- Other NERC requirements

In addition, we can conduct an intensive, real-time assessment of power system behavior under a simulated attack. We have over 30 years of experience securing power systems and electrical substations.

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

SECURITY ASSESSMENTS

We offer general and custom two-day security assessments that provide an analysis of existing security measures and a review of security plans, policies, processes, and procedures.

A general cybersecurity assessment provides a snapshot of your cybersecurity posture using ten of the most important security factors, including assets, controls, and risk management.

A custom security assessment offers more details within a specific focus area of your choice. It can include any of the following:

- Cyber and physical security audit that focuses on people, property, policies, procedures, risk awareness, and NERC CIP/O&P compliance.
- Cyber and physical vulnerability assessment, including patch management, configuration management, incident management, best practices, physical gates, security guards, and surveillance.
- Network security, such as firewalls, IDSs, intrusion prevention systems (IPSs), perimeters, and entry points.
- Information technology (IT), operational technology (OT), and network considerations, including design, efficiency, resilience, and components.

SEL SOLUTIONS AND SERVICES

Today’s power systems face a growing number of risks varying in scope and complexity. We constantly seek ways to ensure SEL products and solutions stay ahead of the threat environment. Our scalable solutions portfolio includes:

- Automated password management with SEL and other control system devices.
- Central and multifactor user authentication.
- Deny-by-default firewall configuration.
- Internet Protocol Security (IPsec) VPNs for site-to-site security.
- Risk and vulnerability assessments.
- Co-op- and municipality-focused security and compliance services.
- NERC CIP and FERC Order No. 693 (O&P) compliance services.
- Connection directory for 10,000 intelligent electronic devices (IEDs) in acSELErator TEAM® SEL-5045 Software.
- Secure serial and Ethernet designs.
- Proxied command line interface to IEDs.
- Serial security solutions for SCADA and real-time protection.
- Network-edge security appliances, including an IDS, an IPS, a firewall, application whitelisting, and SEL software-defined networking.

SCALABLE SYSTEMS

Whether you need to secure and control one substation or hundreds, we create manageable, scalable defense-in-depth solutions that make your system secure and easy to control.

AUTOMATED ACCOUNTABILITY AND COMPLIANCE

Our team can help you implement offsite log storage, which eases compliance with NERC CIP critical infrastructure event logging rules and regulations. SEL-3620 Ethernet Security Gateway proxy services generate user command reports and trace all actions performed on IEDs back to individual users. With syslog, you can integrate these messages into existing log management systems.
ENGINEERING SERVICES AND SOLUTIONS

ARC-FLASH RISK ASSESSMENT SERVICES

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-2015, NESC-2012, and CSA Z462-2015). We apply proven methods to create site-specific arc-flash protection and personal protective equipment (PPE) requirements. We can provide a complete, cost-effective arc-flash solution for your facility.

selinc.com/solutions/arc-flash-studies

POWER SYSTEM MODELING

SEL engineers create a three-phase computer model of your power system in an electrical one-line format, including facility-specific equipment and electrical data for all portions of the system.

SHORT-CIRCUIT STUDIES

Computerized short-circuit studies determine fault current levels at all electrical buses to as low as 208 V for multiple operating configurations.

PROTECTIVE-DEVICE COORDINATION STUDIES

SEL engineers enter existing fuse, relay, and circuit breaker protective device settings into a power system model to determine short-circuit clearing times. They create graphical coordination curves to prove selectivity with other protective devices.

ARC-FLASH ANALYSIS STUDIES

SEL engineers calculate arcing fault currents, determine protective device trip times, and report incident energy, flash boundaries, and PPE categories. Arc-flash software computes incident energy levels based on 100 and 85 percent of calculated arcing currents and reports the worst case. We provide arc-flash analysis studies for both ac 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.

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 data.

ARC-FLASH ENGINEERING REPORTS

We compile the results of each study into an engineering report, which includes the power system model for your facility.

FIELD SURVEYS

We also do the following 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.

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.
DESIGN AND DRAFTING SERVICES

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

Our experts 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.

Versatility

SEL Engineering Services supports multiple software tools to accommodate your preferred software, including Autodesk® AutoCAD®, AutoCAD Electrical, and AutoCAD Raster Design®; Bentley® Descartes, MicroStation®, and Substation; and SCADA Systems Elecdes. Over the years, 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.

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

selinc.com/solutions/design-and-drafting-services
TRANSMISSION PLANNING SERVICES

The purpose of transmission planning is to maintain reliability, security, and stability while meeting system needs and additions. 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 each region, over a wide range of study scenarios from 69 kV to 525 kV.

selinc.com/solutions/transmission-planning

STUDIES FOR EVERY SITUATION

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

- Path-rating studies
- FERC generator interconnection studies
- Wires-to-wires interconnection studies
- NERC MOD-026, MOD-027, PRC-019, and PRC-006 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

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
- Electrocon International’s Computer-Aided Protection Engineering (CAPE)
- Mathworks® Simulink®
- AspenTech’s Aspen short-circuit programs
- User-written routines

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.
SUBSTATION ENGINEERING SERVICES

SEL Engineering Services provides comprehensive solutions for substation design projects. Our professional 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 budgeting, design, construction, and testing process. We have engineers with expertise in civil, mechanical, and electrical engineering; protection; automation; controls; networking; and cybersecurity.

 selinc.com/solutions/substation-engineering-services

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 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, and steel structures.
• Electrical engineering, including grounding, equipment (buses, CTs, PTs, etc.), cable and conduit sizing, lightning protection, wiring, and SCADA designs with analyses and studies (coordination, temporary overvoltage, harmonics, arc-flash hazards, etc.).
• Complete engineering substation services.

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 and can serve as your advocate during the construction phase of a project by performing the following:

• Contractor prequalification
• Contractor evaluation and selection
• Construction oversight and inspection
• Construction management
• Construction record documentation
METERING SERVICES

SEL Engineering Services provides solutions that ensure the accurate, precise, and reliable operation of meters and support devices. Metering systems are critical to infrastructure as consumers become more energy-conscious. 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.

selinc.com/solutions/metering-solutions

SYSTEM DESIGN AND CONFIGURATION
At SEL, we can design metering systems for new or existing facilities. We provide the following solutions to both producers and consumers of energy:

• Meter programming
• Metering system design
• 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

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.
GOVERNMENT ENGINEERING 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.

selinc.com/solutions/government-services

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.

GSA-APPROVED PRODUCTS AND SERVICES
The SEL General Services Administration (GSA) contract provides federal agencies with access to many SEL products and services. A GSA purchase from SEL is simple. Government customers can order directly from SEL by including contract number GS-07F-0123N on their purchase order or through GSA Advantage!, GSA’s online shopping and ordering system.
MICROGRID SOLUTIONS

SEL 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. SEL systems allow you to operate independently, ensuring a constant supply of energy after the loss of the utility point of common coupling (PCC). SEL microgrid control systems also let you manage energy storage to maximize renewable generation and reduce peak charges.

selinc.com/solutions/microgrids

MICROGRID CONTROLLER

The SEL solution centers on a powerful microgrid controller that can respond to external data, such as real-time pricing signals, weather forecasts, and fast-changing system dynamics. This strategy enables the microgrid controller to optimize the system configuration based on your priorities and real-time data. You can assign priorities to various user-defined scenarios, such as economic dispatch, carbon footprint minimization, renewable integration, and system resiliency. The fast, deterministic controller operates in as little as 8 ms to reliably balance load with available generation.

Each microgrid system is unique and depends on variables such as the type of distributed energy resources, system owner operation priorities, project drivers, and utility interconnection requirements. The SEL microgrid controller is both flexible and customizable to ensure interoperability with all system components and resources.

SEL microgrid control systems offer the following benefits:

- A powerful microgrid controller provides stable, reliable, and fast deterministic control for all systems (generation, load, system separation, synchronization, etc.).
- The economic dispatch functionality reduces emissions and uses real-time pricing inputs to minimize energy costs.
- A relay-speed controller quickly detects grid disturbances and disconnects all interties with the utility grid, eliminating system blackouts.
- Grid-connected optimization controls bidirectional power flow management, demand response (sourcing or sinking), peak shaving, etc.
- High-resolution metering and fast control maintain high power quality throughout the system.
- Frequency-based, inertial-compensated load tracking trips the right load every time.
- Advanced protective relays provide safe operation using adaptive protection settings that protect equipment and systems across all scenarios.
- A scalable control system minimizes configuration and development costs.
- Having no single point of failure maximizes uptime.
- Distribution automation functionality provides fault-finding and isolation along with service restoration.
- All SEL microgrid control systems include factory acceptance testing (FAT), SCADA/distributed control system (DCS) integration, and onsite performance testing, reducing commissioning times at the site.
POWERMAX® POWER MANAGEMENT AND CONTROL SYSTEMS

If you have onsite generation and/or significant import/export power, the SEL POWERMAX Power Management and Control System from SEL Engineering Services is the ideal solution for protection and control of islanded power systems. POWERMAX contains advanced, innovative automated control functions specifically designed to help prevent, detect, and mitigate system blackouts while preserving critical assets. POWERMAX components work together seamlessly to deliver exceptional control system performance and power system reliability.

selinc.com/solutions/powermax-controls

ECONOMICAL OPERATION
POWERMAX automation functions let you control major power system assets for optimal economical operation. With POWERMAX, you can collect, manipulate, and present power system data as usable information to enable operators, maintenance personnel, and engineering staff to diagnose system events, predict equipment failures, minimize unnecessary maintenance, and provide high-speed solutions with subcycle round-trip times.

POWER MANAGEMENT AND CONTROL SYSTEM SOLUTIONS
The SEL POWERMAX team can provide the following solutions and services:
- Load-shedding systems
- Steam controls
- Inverter controls
- Generator shedding and runback systems
- Island autosynchronization systems (25A)
- Fast decoupling solutions using 81RF, dv/dt, df/dt, and synchrophasors
- Generation control systems
- Security and risk analysis

ARCHITECTURE AND SYSTEM CAPABILITIES
The SEL POWERMAX System includes substation-hardened computers, protective relays, power quality monitoring, revenue metering, serial and Ethernet communications processing platforms, an IEC 61131-3 programming environment, and a fully redundant server-based data acquisition and monitoring system.

Robust, easy-to-use software, available without a license or support fees, substantially reduces system acquisition and maintenance expenses. You can control every aspect of your power system with software that includes:
- Control and monitoring of intelligent electronic devices (IEDs)
- Digital fault-recording (oscillography) features
- Fault data analysis capabilities
- Time synchronization of all IEDs
- Sequential Events Recorder (SER) analysis tools
- Interfacing with and outputting data to other systems
- Protective relay settings management
- Communications system management
REMEDIAL ACTION SCHEMES

SEL remedial action schemes (RASs) maintain system stability by detecting abnormal conditions in power systems and taking automatic corrective actions that include flexible generation and load shedding, reactive compensation, and custom actions. SEL engineers have the knowledge and experience to integrate these schemes into your current system.

selinc.com/solutions/PowerMAX-RAS-utils

REMEDIAL ACTION CONTROL SYSTEM SOLUTIONS

SEL RASs control and automatically respond to multiple, consecutive system contingencies with high-speed Mirrored Bits® communications or IEC 61850 GOOSE messaging and synchrophasors. Solutions include the following:

- Load and generation shedding and runback to satisfy various system contingencies
- Interarea oscillation detection and control
- Reactive compensation
- Wide-area protection and control
- Generation control systems
- Volt/VAR compensation
- Fast decoupling
- Autosynchronizing of power system islands
- Flexible communications channels, device options, and protocols, including synchrophasors

PROACTIVE CONTROL

An SEL RAS proactively controls your equipment to prevent system collapse and controls dc ties, static and synchronous condensers, generator field exciters and governors, and flexible ac transmission systems. With an SEL RAS, you can set system operating conditions at an optimal operating point to withstand major system disturbances.

EFFICIENT EVENT ANALYSIS

The system provides a detailed history of alarms, errors, and failovers, and the software displays oscillograms and vector diagrams to accelerate event report analysis. HMI and SCADA alarms provide online monitoring of pertinent control system conditions.

COMPLETE TESTING AND SIMULATION

SEL experts thoroughly simulate and evaluate all RASs under real-world conditions using high-speed closed-loop testing. This eliminates many unforeseen complications before bringing the system online. All systems are reviewed and tested during system design, manufacture, and final validation.

Example system architecture overview.
**MOTORMAX® LOW-VOLTAGE MOTOR MANAGEMENT AND PROTECTION SYSTEM**

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.

- [selinc.com/solutions/motormax](http://selinc.com/solutions/motormax)

**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.

**System Diagram**

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.
SYNCHRONIZING SYSTEMS

SEL Engineering Services provides both custom and pre-engineered synchronization systems. These systems automatically reduce slip, phase angles, and voltage differences before automatically closing a circuit breaker. The systems send control set points to any number of generators or inverters. An SEL relay at each point of coupling automatically closes the circuit breaker once it detects acceptable slip, phase angles, and voltage differences.

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 high-speed communications.

SCALABLE SOLUTIONS

SEL autosynchronization 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. 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, pre-engineered SEL-451 autosynchronizer, or we can provide a customized solution that fits the exact needs of your project, operational procedures, and specifications.

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

Digital secondary systems improve safety and reduce costs by moving high-energy signals out of the control house, significantly reducing the quantity of copper wire. You can modernize your substation by choosing from two SEL digital secondary system solutions that advance how you protect and control the primary equipment in your substation:

- SEL Time-Domain Link (TiDL®) technology uses a secure point-to-point fiber connection to eliminate complex Ethernet network design.
- An SEL Sampled Values (SV) solution combines protection in the merging unit with the flexibility of IEC 61850-9-2.

[Digital secondary systems image]

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

SEL TIDL TECHNOLOGY—A SIMPLE, FAST, AND SECURE DIGITAL SECONDARY SYSTEM

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

Simple Architecture

SEL-2240 Axion® TiDL nodes are placed in the yard close to the primary equipment. They act as field modules to 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. In this simple point-to-point architecture, each Axion TiDL node is paired with one TiDL-enabled SEL-400 series relay. The Axion’s 24 kHz sampling rate improves the accuracy of the signals used for protection, and its modular architecture allows you to select the number of analog and digital input modules to match any application. Relay settings remain the same as those in the present SEL-400 series models, providing consistency and simplicity.

Because TiDL is a point-to-point architecture, implementation is simple and requires zero network engineering. The isolated network and the absence of switches and routers reduce the electronic security perimeter and limit attack points.

No External Time Reference

TiDL maintains relative time; therefore, it does not rely on an external time reference for protection. All remote Axion TiDL nodes sample synchronously with each other regardless of the number of Axion nodes connected to the network or the length of the fiber used.

A Scalable and Flexible Solution

By combining the proven protection of SEL-400 series relays with the modularity and flexibility of the Axion, TiDL provides a scalable and flexible solution. Implement TiDL for a simple, fast, and secure digital secondary system.

SEL SV—AN IEC 61850-9-2 INTEROPERABLE SOLUTION USING THE ONLY MERGING UNIT WITH PROTECTION

SEL SV is the only digital secondary system in the world that combines protection in the merging unit with the flexibility of IEC 61850-9-2 to increase the reliability of your power system. The merging unit digitizes analog signals from primary equipment and then transmits them to the control house via an Ethernet network. SEL SV devices are fully compliant with IEC 61850-9-2 and UCA 61850-9-2LE guidelines.

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 that is unmatched by any other merging unit.
CUSTOM PANEL AND ENCRYLURE SOLUTIONS

At SEL, we design, manufacture, test, and deliver custom protection, control, and metering panels as well as control cabinets and retrofit doors to match your specifications and needs. We support our panels with an unmatched warranty and extraordinary customer service.

selinc.com/solutions/custom-panel-solutions

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 manufactured system before it ships, reducing your overall project costs and engineering time. This testing contributes to easier and faster commissioning.

COMPLETE PANEL SOLUTIONS

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

• Consulting and engineering design
• Panel manufacturing and testing
• Protection, automation, and control equipment manufacturing
• Field service
• Standard cabinet design
• Indoor and outdoor design
• Submersible cabinets for underground distribution and automation
CUSTOM ENCLOSURE SOLUTIONS
We integrate multiple pieces of equipment and hardware (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. Every solution is designed, assembled, wired, and tested to meet your specifications and exceed your expectations. To simplify repeat ordering and approvals, we create a single part number for your custom enclosure solution design.

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SOLUTION CAPABILITIES
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
- Build-only capacity for your pre-existing designs
- Stainless steel, mild steel, aluminum, fiberglass, and polycarbonates
- UL508A and CSA-C22.2 No. 14 certification

SEL ENCLOSURE ADVANTAGES
We build all custom enclosure solutions to stringent SEL quality standards. A single part number for each custom assembly simplifies ordering and approvals. In addition, a parent serial number encompasses all SEL equipment serial numbers, configurations, and accessories for full traceability.