Combine the power of synchrophasor message processing with flexible programmable logic for wide-area protection and control applications. The Synchrophasor Vector Processor (SVP) time aligns synchrophasor messages, processes them with a programmable logic engine, and sends control commands to external devices to perform user-defined actions. The SVP also sends calculated or derived data to devices such as other SVPs, phasor data concentrators (PDCs), and monitoring systems.

**Benefit From the Power of the SVP and Synchrophasors**

- Create real-time wide-area monitoring, protection, automation, and control (WAMPAC) schemes.
- Improve overall system reliability with simplified System Integrity Protection Schemes (SIPS).
- Identify and respond to interarea power oscillations that compromise power system stability.
- Collect data, perform mathematical operations, and output results.
- Monitor measurements to detect wiring, CT, and PT problems.
- Refine measurements to improve system state assessment.
- Eliminate redundant measurements to minimize communications channel requirements.
- Detect power swing oscillations and power system out-of-step conditions using phasor-angle measurements.
- Calculate impedances in real time to verify network parameters.
- Run custom IEC 61131-3 programmed applications.
SVP Major Features

➤ Supports serial or Ethernet® communications to collect synchrophasor data.
➤ Connects to as many as 20 PMUs, including SEL relays, using the IEEE C37.118-2005 protocol.
➤ Processes synchrophasor data at speeds as fast as 60 messages per second.
➤ Concentrates synchrophasor data and transmits time-aligned data to six external clients and one internal client in less than 8 ms.
➤ Issues control commands, based on synchrophasor measurements, to external devices in less than 8 ms.
➤ Combines SEL predefined function blocks with standard IEC 61131-3 logic to build a synchrophasor-based monitoring, protection, automation, and control system.
➤ Creates synchrophasor superpackets, using data from relays or PMUs connected to the SVP, for multitier applications.
➤ Generates user-defined synchrophasor messages to test synchrophasor systems or to provide data to upper-tier applications.
SVP Applications

Acquire and Concentrate Synchrophasors From Remote Locations

Use the SVP to gather synchrophasor data from as many as 20 PMUs located at different geographical areas, concentrate the data, and output the time-

Detect and Respond to Power Oscillations

Line tripping, loss of generation, and other system events cause power oscillations. Use the SVP to identify oscillations in the early stages and alert power system operators to potential unstable operating conditions.
Detect and Respond to Power Swings and Out-of-Step Conditions

Use the SVP to detect power swing oscillations and predict out-of-step (OOS) conditions in real time. In this example, the power swing detection algorithm uses angle difference, slip, and acceleration between two system buses without setting traditional impedance-based OOS characteristics.
Connect the SVP to gather substation topology information (breaker and disconnect switch statuses) and synchrophasor messages from relays to check measurement consistency. Configure the SVP to identify and flag bad measurements. For current measurements, the SVP uses Kirchhoff’s Current Law and the network topology to obtain better measurement estimates. In this example, the sum of the Bus 1 currents in all phases is less than the user-defined KCL imbalance threshold (KCL Okay), while the sum of the Bus 2 currents is greater than this imbalance threshold (KCL NOT Okay). Improperly connected CTs or misaligned disconnect auxiliary contacts can cause the KCL NOT Okay operating condition. For full system observability, program SVPs across the power system to send the system state to your company’s Energy Management System (EMS).
Not all applications require high message rates. For example, use a low bandwidth communications channel to provide synchronized voltage and current measurements once per second. This message rate is appropriate for continuously monitoring transmission line operation and estimating line parameters in long transmission line applications.
Simplify Your Automatic Generator Shedding Scheme Using Synchrophasors

In this System Integrity Protection Scheme (SIPS), relays at Area 1 and Area 2 send synchronized positive-sequence voltage angle information to the SVP. The SVP calculates the angle difference between the two areas to detect when Link 1 and Link 2 are open. This scheme does not require traditional and unreliable open line detectors. When both links are open, the SVP sends a trip command to all but one generator in Area 2 to avoid uncontrolled power flow over the subtransmission network. The generator that remains in service feeds the load in Area 2 and Area 3. The oscillogram shows that the angle difference grows beyond the angle difference threshold when the two links are open. The scheme detects this condition and sends generator trip commands. The system starts to recover after SIPS sheds the excess of generation in Area 2.

Increase Wide-Area Protection and Control Scheme Reliability

In this application, relays acquire and send synchrophasor measurements to the SVP. The SVP time aligns and processes these measurements, then generates trip and control commands that relays execute. SIPSs that use the SVP and relays have fewer components and are more reliable than traditional schemes.
Product Overview

The SVP system, shown in Product Overview diagram below, allows you to use synchrophasors for real-time power system monitoring, protection, automation, and control. The SVP system includes the following components:

➤ Communications Interface
➤ Time Alignment Client Server (TCS)
➤ Run-Time System (RTS)
➤ SVP Configurator Software
Communications Interface

The SVP uses serial or Ethernet communications to collect synchrophasor measurements from relays, meters, PMUs, and PDCs. The SVP communicates with any device that uses the IEEE C37.118-2005 protocol and works with as many as 20 PMUs. Incoming message processing occurs as fast as 60 messages per second.

Because the SVP receives synchrophasor data via serial or Ethernet communications, it interfaces easily with a variety of communication technologies including modems, leased lines, and fiber-optic networks.

The SVP supports serial connectivity with 15 DB-9 ports and one console port to provide network settings.

The SVP includes two independent Ethernet connections.

➤ Port 1—Jumper-selectable ST fiber-optic (100BASE-FX) or RJ-45 (10/100BASE-T) copper ports.

➤ Port 2—ST (100BASE-FX) fiber-optic port.

See Front- and Rear-Panel Diagrams on page 12 for rear-panel connection details.

Time Alignment Client Server

The Time Alignment Client Server (TCS) within the SVP time aligns incoming synchrophasor messages from external servers and transmits the time-aligned data to the RTS and as many as six external C37.118 clients.

Run-Time System

The RTS is a real-time processing engine within the SVP that runs applications using custom logic and SEL predefined function blocks. Program monitoring and control applications with the IEC 61131-3 programming language within the SVP Configurator Software. Program the SVP to issue SEL Fast Operate commands for control of external devices. For example, configure the SEL-3378 to send control commands that cause external devices (i.e., SEL-421, SEL-2515, SEL-2411) to perform remedial actions.

Predefined Function Blocks

The SVP includes the following predefined function blocks and function:

➤ Power Calculation Function Block (PWRC).
PWRC calculates the real and reactive power from a user-selected set of voltage and current phasors.

Fast Operate Commands (FO). Program the SVP to activate 32 remote-bit and 8 breaker-control Fast Operate commands per external device.

Phase Angle Difference Monitor Function Block (PADM). PADM calculates the angle difference between two user-selected phasors and provides two angle difference alarms based on user-defined thresholds.

Modal Analysis Function Block (MA). MA calculates the modes of a user-selected signal. The SVP performs Modal Analysis on as many as 6 signals and calculates 15 modes for each signal.

Substation State and Topology Processor (SSTP). The SSTP identifies measurement errors, calculates current unbalance and symmetrical components, and refines voltage and current measurements.
User-Defined Synchrophasor Message

The SVP includes one programmable synchrophasor server, referred to as the Local PMCU, that outputs user-configurable synchrophasor messages over Ethernet. The Local PMCU supports 480 phasors, 320 analogs, and 64 digital words. Program the Local PMCU with the outputs of the available function blocks or any available signal within the RTS. The Local PMCU can send messages to other SVPs for multitier synchrophasor applications. Program your SVP to generate synchrophasor messages for testing purposes. Use the SYNCHROWAVE® Central SEL-5078-2 Software to monitor your application internal variables.

SVP Configurator Software

Use the SVP Configurator software programming environment to develop your application and monitor it in real time.

1. Develop applications on your PC
2. Download applications to the SVP
3. Monitor real-time data and control signals

The SVP Configurator Supports All IEC 61131-3 Programming Languages

Structured Text (ST)

\[ C := A \text{ AND NOT } B \]

Function Block Diagram (FBD)

Ladder Diagram (LD)

Instruction List (IL)
Comprehensive Synchrophasor System

The SVP is part of a family of products for your wide-area monitoring, protection, and control applications.

Guideform Specification

The synchronized phasor measurement processing system shall operate as a programmable data concentrator with network access to provide a combination of functions including, but not limited to, simultaneous collection of data from serial- and Ethernet-connected phasor measurement units, correlation and concentration of collected data based on UTC time stamp, and simultaneous transmission of time-aligned IEEE C37.118-2005 synchrophasor messages for as many as six clients.

➤ Throughput Latency (time alignment client server). The synchrophasor message throughput latency shall be less than 8 ms for up to 16 inputs, and less than 20 ms for 17 to 20 inputs.

➤ Throughput Latency (local PMCU client). The synchrophasor message throughput latency for the server shall be less than 12 ms for up to 16 inputs, and less than 30 ms for 17 to 20 inputs.

➤ Processing Speed. The synchronized phasor measurement processing system shall process the synchrophasor data and send commands to external devices in less than 8 ms plus the synchrophasor message time interval.

➤ Preprogrammed Functions. The synchronized phasor measurement processing system shall include function blocks to perform power calculation, phase angle difference monitoring, and signal modal analysis.

➤ Measurement Error Detection. The synchronized phasor measurement processing system shall be able to assess the substation topology and state to identify voltage and current measurement errors and assert the corresponding alarms.

➤ Programmable Synchrophasor Message. The synchronized phasor measurement processing system shall allow the user to program a unique synchrophasor message to monitor user-defined internal logic.

➤ Health Monitor. The synchronized phasor measurement processing system shall include constant self-health monitoring.
➤ **Environment.** The synchronized phasor measurement processor shall be suitable for continuous operation over a temperature range of –40° to +75°C.

➤ **Warranty.** The synchronized phasor measurement processing system shall have a minimum 10-year, worldwide warranty.

### Front- and Rear-Panel Diagrams

**Front Panel, Rack Mount**

**Front Panel, Panel Mount**

**Rear Panel**
Specifications

General

Operating Temperature
–40° to +75°C (–40° to +167°F)

Storage Temperature
–40° to 85°C (–40° to +185°F)

Terminal Connections

Rear Screw-Terminal Tightening Torque
Minimum: 0.8 Nm (7 in-lb)
Maximum: 1.4 Nm (12 in-lb)

User terminals and stranded copper wire should have a minimum temperature rating of 105°C. Ring terminals are recommended.

Operating Environment

Pollution Degree: 2 as per IEC 60950
Overvoltage Category: II as per IEC 60950
Humidity: 5 to 95% without condensing
Altitude: 2000 m maximum
Atmospheric Pressure: 80 to 110 kPa
Unit Weight: 5 kg (11 lbs)

Communications Ports

Serial Ports: Sixteen serial ports
Console Port: EIA-232 with DB-9 connectors
Serial Data Speed: 9600 bps
Ports 1–15: EIA-232 with DB-9 connectors
Serial Data Speed: 9600, 19200, 38400, 57600, 115200 bps
Ethernet Ports: Two Ethernet ports
Ethernet Port 1: 10/100BASE-T copper or 100BASE-FX fiber-optic ports, jumper selectable.
Ethernet Port 2: 100BASE-FX fiber-optic port

IRIG-B Ports

Time-Code Input
Connector: Female BNC
Time-Code: Demodulated IRIG-B TTL compatible

Time-Code Output
Connector: 15 rear DB-9 port connectors
Time-Code: Demodulated IRIG-B TTL compatible
Pinout: DB-9 port connectors
Pin 4 TTL-level signal
Pin 6 chassis ground reference
Female BNC

Note: IRIG-B output available only when IRIG-B input is present.

Synchronphasor Data Format

Input Data Formats
IEEE C37.118-2005: Ethernet and serial

Output Data Formats
IEEE C37.118-2005: Ethernet

Synchronphasor Input/Output Message Rates

60 Hz Nominal Data Rate: 1, 2, 4, 5, 10, 12, 15, 20, 30, 60 messages per second
50 Hz Nominal Data Rate: 1, 2, 5, 10, 25, 50 messages per second

Synchronphasor Data

Servers (PMUs): 20
Clients: 7

Synchronphasor Processing Capacity

Processing Capacity: 20 PMCs
Processing Interval: 4 ms
Typical Message Size: 158 bytes
Maximum Data Rate: 60 messages per second

Data Through Latency

TCS
Average: 4 ms
Maximum: 8 ms (1–16 inputs)
20 ms (17–20 inputs)

PMCU
Average: 8 ms
Maximum: 12 ms (1–16 inputs)
30 ms (17–20 inputs)

Command Processing Latency: 8 ms (plus the synchronphasor message time interval)

Fast Operate Commands

Transmitted Remote Bits Per External Device: 32
Transmitted Breaker Control Bits per External Device: 8
Received Remote Bits: 32
Communications Output: Serial and Ethernet

IEC 61131-3 Programming Languages

Instruction List
Structured Text
Sequential Function Chart
Function Block Diagram
Ladder Diagram
Continuous Function Chart Editor

Power Supply

125/250 Vdc or 120/230 Vac; 50/60 Hz
DC Range: 85–300 Vdc
AC Range: 85–264 Vac
Frequency Range: 30–120 Hz
Burden: < 40 W

48/125 Vdc or 120 Vac; 50/60 Hz
DC Range: 38–140 Vdc
AC Range: 85–140 Vac
Frequency Range: 30–120 Hz
Burden: < 40 W
24/48 Vdc
DC Range: 20–60 Vdc polarity dependent
Burden: < 40 W
Main Supply Voltage
Fluctuations: as much as ±10% of nominal voltage

### Type Tests

#### Environmental

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard/Methodology</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosure</td>
<td>IEC 60529-IP20</td>
<td></td>
</tr>
<tr>
<td>Protection Class</td>
<td>UL 50: Enclosure Type 1</td>
<td></td>
</tr>
<tr>
<td>Damp Heat, Cyclic</td>
<td>IEC 60068-2-30:1980 + A1:1985 Test Db: (12 + 12-hour cycle), 95% r.h. 25°C to 55°C, 6 cycles</td>
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</tr>
<tr>
<td>Vibration Resistance</td>
<td>IEC 60255-21-1:1988, Endurance Class 1 Response Class 1</td>
<td></td>
</tr>
<tr>
<td>Object Penetration</td>
<td>IEC 60529-2001 + CRGD:2003, IP30 from front of unit</td>
<td></td>
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</tbody>
</table>

#### Electromagnetic Compatibility Immunity

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard/Methodology</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrostatic Discharge</td>
<td>IEC 60255-22-2:1996, IEEE 61000-4-2:2001 IEEE C37.90.3-2001</td>
<td>Severity Level: 2, 4, 6, 8 kV contact discharge; 2, 4, 8, 15 kV air discharge</td>
</tr>
<tr>
<td>Fast Transient Burst</td>
<td>IEC 61000-4-4:1995 + A1:2000 + A2:2001 IEC 60255-22-2:2002</td>
<td>Severity Level: Class A 4 kV, 2.5 kHz on power supply; 2 kV, 5 kHz on communication lines, digital inputs, and digital outputs</td>
</tr>
</tbody>
</table>

#### Surge Withstand

<table>
<thead>
<tr>
<th>Capability Immunity</th>
<th>Standard/Methodology</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply and outputs</td>
<td>IEC 60255-22-1:2005</td>
<td></td>
</tr>
<tr>
<td>2.5 kV peak common mode</td>
<td>IEC 60255-22-2:2002</td>
<td></td>
</tr>
<tr>
<td>1.0 kV peak differential mode</td>
<td>IEC 60255-22-3:2002</td>
<td></td>
</tr>
<tr>
<td>Communications ports</td>
<td>IEC 60255-22-4:2002</td>
<td></td>
</tr>
<tr>
<td>1.0 kV peak common mode</td>
<td>IEEE C37.90.1-2002</td>
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</tr>
<tr>
<td>Severity Level: 2.5 kV oscillatory</td>
<td>IEC 60255-22-5:2000</td>
<td></td>
</tr>
<tr>
<td>4 kV fast transient</td>
<td>IEC 60255-22-6:2000</td>
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#### Surge Immunity

<table>
<thead>
<tr>
<th>Standard/Methodology</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60255-22-5:2002</td>
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</tr>
<tr>
<td>Severity Level: 0.5, 1.0 kV Line-to-Line; 0.5, 1.0, 2.0 kV Line-to-Earth</td>
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</table>

#### Conducted Emissions

<table>
<thead>
<tr>
<th>Standard/Methodology</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>IEC 60255-25:2000</td>
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<tr>
<td>Level: Class A</td>
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#### Radiated Emissions

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<tr>
<th>Standard/Methodology</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>IEC 60255-25:2000</td>
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<tr>
<td>Level: Class A</td>
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#### Voltage Fluctuations and Flicker

<table>
<thead>
<tr>
<th>Standard/Methodology</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>IEC 61000-3-3:2002</td>
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#### Conducted Immunity

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<th>Standard/Methodology</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>IEC 61000-4-6:2004</td>
<td></td>
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<tr>
<td>IEC 60255-22-6:2001</td>
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<tr>
<td>Severity Level: 10 Vrms</td>
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#### Power Frequency

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<tr>
<th>Standard/Methodology</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>IEC 61000-4-8:2001</td>
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#### Magnetic Field

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<th>Standard/Methodology</th>
<th>Conditions</th>
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</thead>
<tbody>
<tr>
<td>1000 A/m for 3 s</td>
<td></td>
</tr>
<tr>
<td>100 A/m for 1 min., Level 5</td>
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</tbody>
</table>

#### Safety

<table>
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<tr>
<th>Test</th>
<th>Standard/Methodology</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>Dielectric Strength</td>
<td>IEC 60255-5:2000, IEEE C37.90-1989, 3100 Vdc for 1 min. on power supply</td>
<td></td>
</tr>
</tbody>
</table>

#### Certifications

ISO: This product was designed and manufactured under an ISO 9001 certified quality program.

CE: CE Mark
EN 61326: 1997—EMC Directive
EN 50263:1999—EMC Directive
EN 61010-1:2001—Low-Voltage Directive (Safety)
IEC 60255-6:1998—Low-Voltage Directive (Safety)