Synchrophasor FAQs

SEL®

Frequently Asked Questions

Synchrophasor-based systems provide wide-area measurements that significantly improve overall system operation. Learn more about how you can implement a system that meets your particular needs.

SEL Synchrophasors®

Should I use standalone PMUs or relays with built-in PMU functionality?

SEL has included phasor measurement unit (PMU) functionality in its relays as a standard feature since 2002—you likely have relays with PMU capability already installed in your substations. Thus, installing relays with PMU capability is an economical approach to using phasor measurements in your system.

- Relays are the most reliable instruments in the substation.
- Activating the PMU functionality in SEL relays minimizes the need for additional instruments and wiring.
- Relays have access to more information that can be included in the synchrophasor message streams, such as breaker status, relay alarms, etc.

If your company requires the use of standalone PMUs in your substation, SEL has standalone PMUs as well.

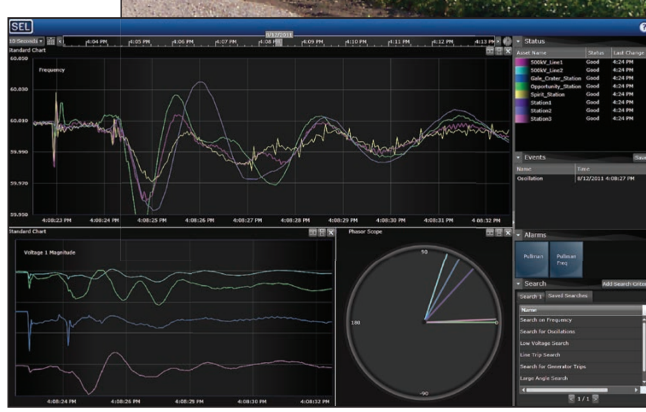
Will an integrated PMU degrade relay performance?

No. SEL designs all of its relays for reliable operation. There is no performance degradation when PMU or any other capability (e.g., Ethernet, DNP3 communications, and event generation) is enabled in the relay.

Where should I locate phasor data concentrators in my system?

For the best results, install phasor data concentrators (PDCs) at each substation and at each control center. Locating a PDC at each substation yields the following benefits:

- Minimizes the communications bandwidth needed outside the substation. (All PMU data are concentrated before they are sent on to the control center.)
- Improves security by providing a single point where synchrophasor communications streams can be managed before leaving the substation.



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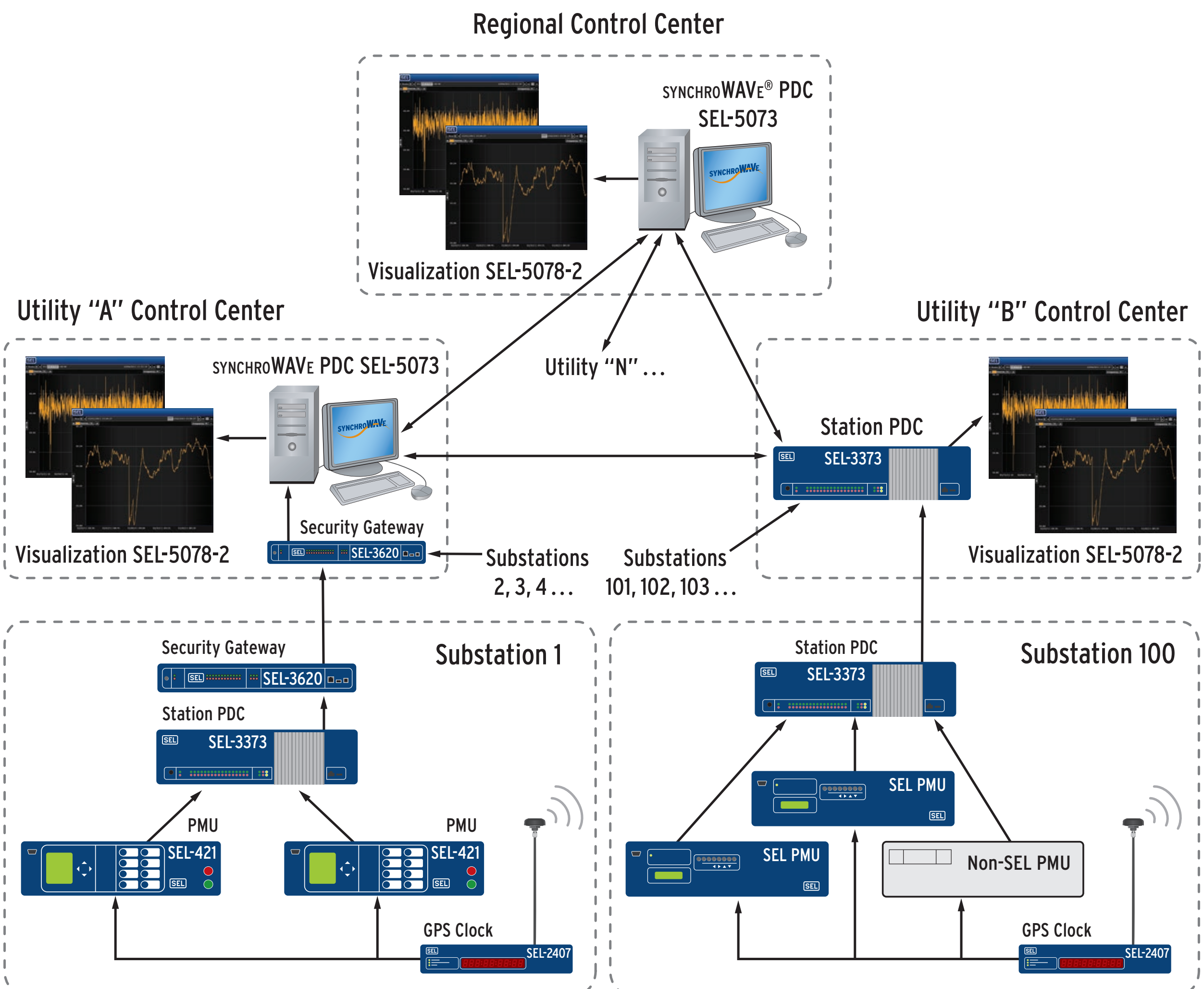
What is the recommended system architecture for synchrophasors?

PDCs in a hierarchical structure are shown below. At each PDC, you can choose a subset of the data and the rate at which to send that data to each location, e.g., engineering office, neighbor utility, RTO, or ISO. For control applications, the PDCs can directly communicate with each other. The system below shows a secure Ethernet gateway that provides the functions of a firewall and uses IPsec VPN to encrypt the synchrophasor messages.



What are the storage requirements for archiving synchrophasor data?

The following table shows typical storage space requirements for synchrophasor data.

Synchrophasor Data	Storage Requirement
4 PMUs, each with: • 8 phasors (32 total) • 6 analogs (24 total) • 2 digital words (8 total)	**30-Day Archive:** 60 GB **60-Day Archive:** 120 GB

- Archiving at 60 messages/second
- Archiving floating point data
- 2 digital words = 32 discrete status bits

What is the best archiving approach?

Archiving data in the substation provides several system benefits:

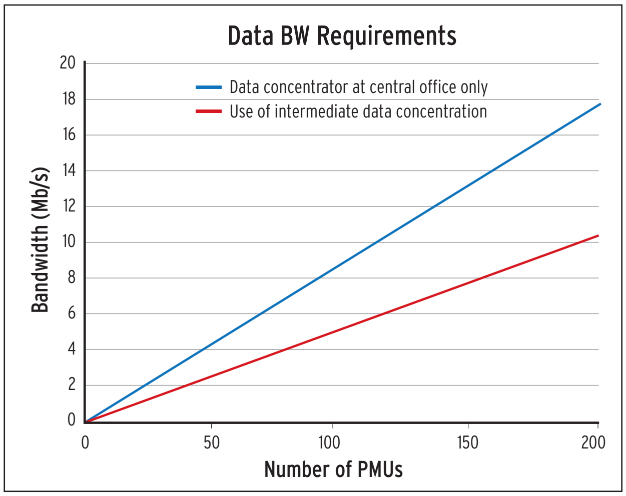
- An archive of synchrophasor data can be recovered if communications are ever lost.
- You can set the PMUs once at the maximum data rate, archive at that rate, and then downsample for downstream applications.
- You can build a system that meets NERC PRC-002-2 disturbance data recording and archiving requirements.
- Using the PDC's archive collection service, all data can be pulled to a central location for long-term storage.

How much communications bandwidth is needed for synchrophasor message streams?

Serial Connection

Synchrophasor Data (1 PMU)		
Message Rate (messages per second)	• 1 phasor • 0 analogs • 0 digital words	• 8 phasors • 6 analogs • 2 digital words
1	340 bits/sec	1.2 kbits/sec
10	3.4 kbits/sec	11.8 kbits/sec
30	10.2 kbits/sec	36 kbits/sec
60	20.4 kbits/sec	71 kbits/sec

A serial connection can be used to stream synchrophasor data.



How can I secure synchrophasor communications?

SEL can help you secure your communications paths through system design and by using secure communications devices. By using a PDC in your substation, all PMU communications go through the PDC, providing a layer between the PMU and the outgoing communications. Using the UDP_S protocol out of the PDC further secures the communications out of the substation because all inbound communications are ignored by UDP_S. Finally, SEL offers serial encryption devices, secure Ethernet gateways, etc., to secure communications into and out of your substation.

Can I use a synchrophasor system to meet NERC PRC-002-2 requirements?

Yes. The combination of the SEL-3373 Station PDC (or the SEL-5073 SYNCHROWAVE® PDC Software), ACSELERATOR TEAM® SEL-5045 Software, and SEL relays provides a system that meets draft PRC-002-2 requirements. The SEL Application Guide *SEL Disturbance Recording System Meets NERC PRC-002-2 (AG2010-12)* shows how and can be found online at **www.selinc.com/literature**.

Is there a way to get synchrophasor data into my SCADA system?

Yes. If your SCADA system supports the IEEE C37.118-2005 synchrophasor standard, you can send data directly from the PDC to your SCADA system. Otherwise, use the SEL-3530 Real-Time Automation Controller (RTAC) to translate from IEEE C37.118 to popular SCADA protocols.

When should I use a hardware PDC versus a software PDC?

A hardware-based PDC, like the SEL-3373, has a deterministic latency through the PDC. Software-based PDCs, like the SEL-5073, tend to scale with the computing hardware on which they run. In general, use a hardware-based PDC in substation environments and/or where you want to implement real-time control schemes. Software PDCs are used where there are a large number of PMUs or PDC inputs to concentrate and when more powerful computing platforms are required. Software-based PDCs are often used in control centers or regional centers.

Does a hierarchy of PDCs add extra latency to the synchrophasor data?

No. When aligning data according to their time stamps, each PDC is set to wait a certain length of time until all expected data for each time interval have been received. The waiting time is typically user-configurable and set according to the expected worst-case network communications delay. When building hierarchies of PDCs, each PDC can wait up to its maximum set waiting time before forwarding data. This time-alignment process does not add any additional latency to the data because even with a flat hierarchy, the time alignment must still wait for the last of the data to be received.

In saying that, a software PDC can add significant latency at each hierarchical level. When latency is a concern, the hardware PDC, with its fast and guaranteed performance, is the best choice.

Does PDC time alignment limit the maximum message rate?

No. Time alignment has no impact on the message rate, because message rates and time alignment of data are independent.

How does the streaming IEEE C37.118-2005 protocol compare to an event-based protocol?

For real-time applications, streaming protocols allow system design according to maximum data rate conditions. This is an advantage of the IEEE C37.118-2005 protocol. Unlike event-based protocols, streaming data are ideally suited for mission-critical, real-time applications. Therefore, system performance is guaranteed.

Can you provide examples of synchrophasor systems in service today?

SEL has been implementing real-world synchrophasor systems globally for over a decade. We have numerous technical papers that address a broad spectrum of applications using synchrophasors. The *SEL Synchrophasor Fact Sheet* summarizes SEL's history with synchrophasors and is available at **www.selinc.com/synchrophasors**.

Synchrophasor FAQs

Some SEL relays include a function called RTC. What is that?

RTC stands for real-time control. An RTC-enabled PMU can send and receive synchrophasor data. Relays with RTC can concentrate up to two additional PMU inputs. Users can build relay-to-relay control schemes by implementing control logic within the relay.

What happens if I lose the satellite clock signal to my synchrophasor system?

The IEEE C37.118 standard includes a time quality indicator as part of the phasor data message. This provides the user an indication that the phasor data received meet the required timing accuracy. Additionally, SEL satellite clocks (SEL-2401 and SEL-2407®) have "holdover stability," which means these GPS clocks will continue to provide an accurate time signal for up to 18 seconds. Lastly, the SEL ICON™ has the ability to distribute time over a wide-area network with better than 1 microsecond accuracy, so in the event of GPS failure, relative time is maintained in the communications network.

Can my existing communications system be used for synchrophasors?

Synchrophasor systems require data to be streamed from the substation back to the control center. Because of this, many customers are upgrading their communications systems. However, even with dial-up communications bandwidth, you can configure a system that benefits from the use of synchrophasor measurements.

What do I need to upgrade the communications system to each of my substations?

SEL offers the SEL ICON, a versatile product that can operate as a SONET multiplexer and an Ethernet switch. With the SEL ICON, you can build an intersubstation wide-area communications network or an intrasubstation communications network. Enhanced SONET security can be provided by using the optional cryptomodule with AES-256 encryption.

What solutions does SEL have today for synchrophasors?

SEL has everything you need for a complete synchrophasor system. SEL offers many different PMUs, hardware- and software-based PDCs, synchrophasor vector processors, satellite clocks, secure communications solutions (serial, Ethernet, and SONET), integrated communications systems, synchrophasor real-time visualization software, and more. Additionally, SEL's expert Engineering Services team can help you design, install, and commission your system.

SEL Relays With PMU Capability

SEL-311C, SEL-351, SEL-351A, and SEL-351S Protection Systems

SEL-351RS Kestrel® Single-Phase Recloser Control

SEL-411L, SEL-421, and SEL-451 Protection, Automation, and Control Systems

SEL-487E Transformer Protection Relay

SEL-487V Capacitor Protection and Control System

SEL-651R-2 Advanced Recloser Control

SEL-700G Generator Protection Relay

SEL-751 and SEL-751A Feeder Protection Relays

SEL-787 Transformer Protection Relay

SEL-2431 Voltage Regulator Control

Standalone PMUs

SEL-351A Phasor Measurement Unit

SEL-487E Station Phasor Measurement Unit

Visualization Software

SEL-5078-2 SYNCHROWAVE Central Software

Archiving Data Concentrators

SEL-3373 Station Phasor Data Concentrator (PDC)

SEL-5073 SYNCHROWAVE Phasor Data Concentrator (PDC) Software

Data Concentrators With Control Capabilities

SEL-3378 Synchrophasor Vector Processor

SEL-3530 Real-Time Automation Controller

Satellite Clocks

SEL-2407, SEL-2401, and SEL-2404 Satellite-Synchronized Clocks

Secure Communications

SEL-3025 Serial Shield™

SEL-3620 Ethernet Security Gateway

SEL ICON Integrated Communications Optical Network

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