Expand Synchrophasor Capabilities With the Substation Phasor Data Concentrator

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INTRODUCTION

A minimal synchrophasor system consists of phasor measurement units (PMUs) and integrates the collected data into centralized operator displays. This approach, while providing an immediate benefit over existing supervisory control and data acquisition (SCADA) systems, misses many opportunities for additional power system improvements.

A more capable system includes a substation phasor data concentrator (PDC) with archiving capability or a distributed control processor such as a synchrophasor vector processor (SVP). These solutions greatly expand synchrophasor system capabilities.

SUBSTATION PDCS

Capture Wide-Area Disturbance Information

The time stamps associated with synchrophasor data enable precise comparison of data collected at multiple locations. Use the archived PDC data to understand the cause of events, verify models, and analyze oscillations. The North American Electric Reliability Corporation (NERC) Standard PRC-002-2 establishes requirements to facilitate the analysis of power system disturbances. A substation PDC helps to fulfill these requirements.

Avoid Losing Data to Communications Interruptions

When the communications network between the substation and the central office has an outage, you can retrieve the lost data from the substation archive to rebuild the original phasor data.

Improve Total System Security

The substation PDC provides an additional layer of security. Using a layered security approach makes an attack more difficult. Because PMU functionality is often included with relays, the PDC is an important extra layer of security. Also, the substation PDC simplifies security management because the firewall rules are for a single device.

Increase the Diversity of Captured Synchrophasor Data

Not all PMU data are typically required at the operations center. Use the PDC to select only the data you need at the main office or control center. Meanwhile, archive all PMU data at the substation. The archived data are available for offline analysis.

Never Change a PMU Setting

Many relays include PMU functionality. Changing relay settings is something that should be avoided. Now, with the substation PDC, if you want to change the phasor data sent to the operations center, simply select the data at the PDC. By setting the PMU to send all of its phasor data to the PDC, you never need to reconfigure the relay settings for phasor data. This gives a "set it and forget it" approach when setting up relays for synchrophasors.

Minimize Communications Data Rate

Often, data at the operations center are only needed at low rates, such as 30 messages per second or even 1 message per second. However, the maximum PMU data rate is 60 messages per second. You can use the substation PDC as a high-resolution archive. Archive at the maximum rate, and use the PDC to select data for communicating out of the substation at a lower rate. When PMU data rates increase in the future, the archiving PDC captures these data without communications network changes.

Control the Data You Share

The substation PDC is a convenient means of distributing data to multiple sites. Use the PDC to determine what data are shared. Only send the data you want to share to transmission authorities or a nearby utility. This allows sending more detailed information to your company and less detailed data to others.

Add New Protocols at One Location

Synchrophasor technology continues to advance. For example, a new protocol is in development by the North American Synchrophasor Initiative (NASPI). The substation PDC isolates protocol changes from the PMU. When a protocol changes, only the substation PDC needs to change. The PMU can continue to use existing protocols because it is only communicating to the local PDC.

Coordinate Substation Visualization

A PDC distributes data for substation-level visualization. Using local visualization, it is easy to commission a synchrophasor system. For example, by using synchrophasor measurements, you quickly see the phase relationships between conductors. You can easily discover transposed phases after an equipment or line repair.

Upgrade to Wide-Area Control Without Changing Hardware

An SVP is a PDC that includes control. You can use the SVP to build real-time distributed system integrity protection schemes. Applications include phase angle difference-based control, distributed generation control, islanding control, system control based on modal analysis, and direct state measurement.

When initially building a synchrophasor system, consider getting the appropriate hardware in place now, so that new applications can be easily added in the future. For example, once an SEL hardware PDC is installed, it is possible to convert the PDC into an SVP with a software upgrade. This feature will be available later in 2010 and produces a system that scales for the future.

ARCHITECTURE

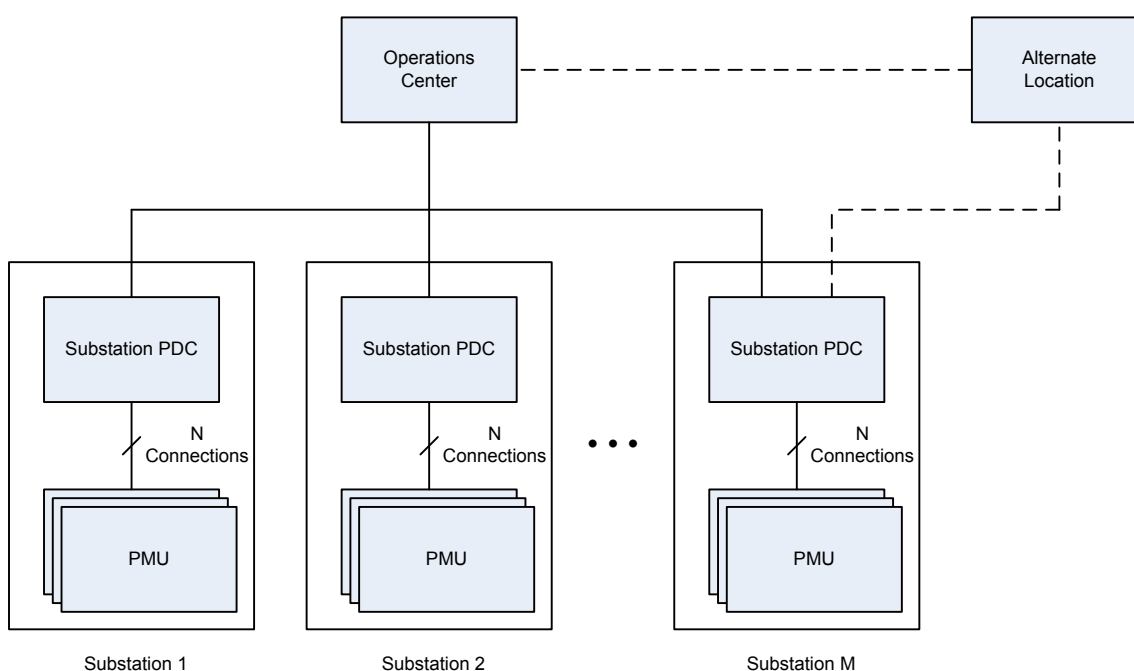Figure 1 shows the typical architecture of a system equipped with PDCs.

Figure 1   Typical System Architecture—Each Substation PDC Connects to N PMUs

SEL offers several options for the substation PDC shown in Figure 1. The new SEL-3373 Station Phasor Data Concentrator is a ruggedized hardware PDC that includes built-in archiving. The SEL-3378 Synchrophasor Vector Processor is a ruggedized hardware PDC that also includes control. Both the SEL-3373 and SEL-3378 operate at high speeds and with minimal data latency.

The new SEL-5073 SYNCHROWAVE® PDC System Software runs on the Microsoft® Windows® operating system. The number of PMUs supported by the SYNCHROWAVE PDC System scales with the hardware that it is run on. The SEL-5077 SYNCHROWAVE Server Software and SEL-5076 SYNCHROWAVE Archiver Software are separate PDC and archiving software applications that run on the Microsoft Windows operating system.

HARDWARE PDC DETAILS

Hardware PDCs are perfect for harsh substation environments. SEL hardware PDCs are designed and tested for the substation environment using the same engineering practices applied to SEL relays. Furthermore, guaranteed real-time performance is achieved by integrating the PDC and hardware design together. Because they do not use the Microsoft Windows operating system, hardware PDCs avoid the need for periodic changes due to operating system updates. The features of the SEL hardware PDCs are as follows:

- SEL-3373 Station Phasor Data Concentrator
  - The newest SEL hardware PDC—available soon
  - High performance: greater than 40 PMU inputs and greater than 10 server outputs
  - Database archiving with secure open database connectivity (ODBC) connection
  - Reliable solid-state hard drive, up to 120 GB
  - Authentication, logs, and port control for security
  - Simple configuration and status software
- SEL-3378 Synchrophasor Vector Processor
  - Built-in hardware phasor data concentration
  - Predefined algorithms: modal analysis, angle difference, substation topology, and power calculations
  - Fast Operate and IEEE C37.118 control commands
  - IEC 61131-3 programming logic language
  - Simple configuration and status software
- SEL-3306 Synchrophasor Processor
  - The original SEL phasor data concentrator
  - Successful track record of service since 2006
  - Up to 40 PMU inputs and 6 server outputs

SOFTWARE PDC DETAILS

Software PDCs are appropriate for use in operations centers and substations where the SEL-3354 Embedded Automation Computing Platform has already been installed. SEL offers several SYNCHROWAVE software solutions:

- SYNCHROWAVE PDC System
  - The newest SEL software PDC—available soon
  - Software performance scalable with selected hardware
  - Database archiving with secure ODBC connection
  - Authentication, logs, and port control for security
  - Simple configuration and status software
  - Microsoft Windows operating system compatible

- SYNCHROWAVE Archiver/SYNCHROWAVE Server
  - The original SEL software PDC and archiver
  - Successful track records of service since 2006
  - Separate archiving and data concentration, up to eight PMUs
  - Common Format for Transient Data Exchange (COMTRADE) and comma-separated value (CSV) file formats
  - Software upgradable to SYNCHROWAVE PDC System when installed on an SEL-3354

SEL SYNCHROPHASOR SUPPORT

All SEL products include a ten-year warranty. SEL supports its solutions with industry-leading customer service. If you have questions or need synchrophasor product support, please contact us directly:

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BIOGRAPHY

Greg Zweigle received his master of science in electrical engineering and master of science in chemistry degrees from Washington State University. He also received a bachelor of science in physics from Northwest Nazarene University. He is presently a research and engineering manager at Schweitzer Engineering Laboratories, Inc. (SEL). He previously worked as a principal research engineer in the research group and as a senior software developer at SEL. He has been responsible for phasor measurement unit signal processing algorithms, embedded system architectures, and synchrophasor-based power system solution designs. Mr. Zweigle holds seven patents and is presently pursuing a Ph.D. focusing on energy systems. He is a member of the IEEE and the American Chemical Society.

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