Synchrophasor Systems versus SCADA Systems for Electrical Utilities

SCADA systems have been around since the 1960s. They have evolved over the intervening decades from small control networks to wide area interconnected systems as Ethernet technology developed. They are used for monitoring and controlling remote devices. Consisting of remote terminal units (RTUs), which transmit data to centralized servers, SCADA systems were originally developed for manufacturing use. They are still used throughout industry, including wide use by electrical utilities. “Traditionally, Supervisory Control and Data Acquisition (SCADA) systems have been adopted for high-level monitoring of the grids.”[i]

However, with the increased complexity of the electrical grid, including the integration into the grid of renewable energy sources, SCADA systems present an important shortcoming. Renewable energy sources tend to introduce rapid transients into the grid. SCADA systems do not operate quickly enough to monitor these: “With the massive integration of renewables, SCADA systems are considered to be inadequate to capture fast system transients.”[ii]

Synchrophasor applications for electrical utilities have developed over the past thirty years. The North American SynchroPhasor Initiative (NASPI), a collaboration between the electric industry, the North American Electric Reliability Corporation (NERC) and the U.S. Department of Energy (DOE), was developed to advance the use of synchrophasor technology. This newer technology makes use of phasor measurement units (PMUs) that take time-synchronized phasor and related readings (voltage, phase angles, frequency, rate of change of frequency, etc.) from a specific point on the electrical grid and transmit them to a phasor data concentrator (PDC). The PDC collects and transmits the PMU data to the substation or control center’s supervisory application.

As stated on smartgrid.gov, “PMU measurements record grid conditions with great accuracy and offer insight into grid stability or stress. Synchrophasor technology is used for real-time operations and off-line engineering analyses to improve grid reliability and efficiency and lower operating costs...Recovery Act Smart Grid Investments have supported the installation of over 1,000 PMUs across North America, supported with high speed communications networks, and advanced analytical applications to use the data.”[iii]

The speed at which synchrophasors can sample data is many times that of a SCADA RTU. This quick processing speed means that PMUs can capture real time high speed transients and transmit that data. In this way, synchrophasor systems capture events that SCADA systems miss. This is a distinct advantage both for real time monitoring of grid conditions and for post-event analysis. Refer to the following table for a comparison of the measurements from SCADA devices and PMUs.[iv]

ATTRIBUTE	SCADA	PMU
Resolution	1 sample every 2-4 seconds	10-60 samples/second
Observability	Steady state	Dynamic
Measurements	$\|V\|$, I, MW, MVAR	$\|V\|$, I, δ, MW, MVAR, I, Frequency, ROCOF
Synchronization	No	Yes
Phase Angle	No	Yes
Focus	Local Monitoring and Control	Wide Area Monitoring and Control

The fact that PMUs are located across an electrical grid and are transmitting time-synchronized data gives grid operators wide area situational awareness of grid conditions, allowing quick response to changing conditions. Among the many advantages Synchrophasor systems have for electric utilities are the following:

- For transmission and sub-transmission, they support voltage stability assessment, improve grid resiliency and reliability, and help to determine dynamic line impedance.
- For power generation, both traditional and alternative, they provide real time frequency, detection of oscillation and low damping conditions; they facilitate post event analysis through correlating status and analogs; and they provide data for power system modeling and validation studies.
- For distribution system applications, they provide distribution state measurement, enable proactive island detection to prevent outages and ensure reliable power to customers; perform apparatus monitoring; smart inverter control; Volt-VAR optimization; and broken wire detection.
- For distributed energy resource (DER) monitoring, they provide DER system angular difference to facilitate long distance check sync, and rapid islanding detection for remedial actions.

It is clear to see why electric utilities have been increasing their use of synchrophasor systems. And the use will continue to grow as the electric grid continues to expand and more renewable energy sources are added to it.

As mentioned, the PMU is the backbone of a Synchrophasor system. EIG's Nexus® 1500+ high accuracy, advanced power quality meter supports synchrophasor systems by acting as a PMU, allowing it to fit seamlessly into a utility's Synchrophasor system. The meter's PMU features include:

- Supports both P (Fast Response) and M (Precise Measurement) classes.
- Data frame rates for 50 Hz: 10/25/50 frames per second; for 60 Hz: 10/12/15/20/30/60 frames per second.
- Data format: Configurable float or integer, polar or rectangular.
- Time sync standard: IRIG-B or IEEE 1588 PTPv2.
- Number of sessions: up to 2 simultaneous clients.

- Supports Ethernet or Fiber over Ethernet: TCP communication for header, configuration, and command; UDP communication for data, including unicast, broadcast, and multicast.

The Nexus® 1500+ meter as PMU provides the following synchronized measurements:

- Individual voltage/current phasors (VA, VB, VC, IA, IB, IC).
- Symmetrical components phasors (V0, V1, V2, I0, I1, I2).
- Frequency and Rate of Change of Frequency (ROCOF).
- Built-in digital inputs.
- Analog –
    - Fundamental power: (watt total and per phase, VA total and per phase, VAR total and per phase).
    - Displacement power factor: (total and per phase).

To learn more about the Nexus® 1500+ meter and its PMU capabilities, visit: https://www.electroind.com/products/nexus-1500-power-quality-meter-with-phasor-measurement-unit/

Notes

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[i] "Encyclopedia of Electrical and Electronic Power Engineering," Editor in Chief, Jorge Garcia, accessed 12/13/2023 from https://www.sciencedirect.com/topics/engineering/phasor-measurement-unit#:~:text=Phasor%20measurement%20units%20(PMUs)%20are,existing%20SCADA%20technologies%20%5B16%5D.
[ii] ibid.
[iii] "Recovery Act: Synchrophasor Applications in Transmission Systems," accessed 12/13/2023 from https://www.smartgrid.gov/archive/recovery_act/program_impacts/applications_synchrophasor_technology.
[iv] Reference for Table: "Applications of Synchrophasor Technologies in Power Systems," Muhammad Usama Usman, M. Omar Faruque, accessed 12/14/2023 from /https://www.osti.gov/servlets/purl/1592334.