The Synchrophasor Report

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Synchrophasors and Communications Bandwidth

Communications Needs for Synchrophasors

Many customers are in the process of obtaining synchrophasor measurements from their power systems by installing phasor measurement units (PMUs). One concern with installing this new technology is how to get real-time synchrophasor information to a central location. This is of special concern for substations that are located at remote sites and typically have limited communications bandwidth. This article will review the communications standard defined for sending synchrophasor information and discuss different approaches for getting the right communications architecture for your needs.

IEEE C37.118-2005

IEEE C37.118-2005 is the IEEE standard for using synchrophasors in power systems. The standard defines synchronized phasor measurements used in electric power systems and provides a method to quantify measurements and test to be sure that the measurements conform to the definition. It also defines the Total Vector Error (TVE) limits for measurement accuracy as well as a data communications protocol, including message formats for communicating this data in a real-time system. The IEEE C37.118 standard replaces the previous standard IEEE 1344-1995, which was the original standard developed for synchronized phasor data. IEEE C37.118 provides a fairly minimal and efficient communications protocol for sending synchronized phasor measurement data. Equipment that conforms to the IEEE C37.118 standard will interoperate, thus allowing users to use different PMUs and different PDCs (phasor data concentrators) from different manufacturers. IEEE C37.118 is structured so that various communications methods may be used for data transmission. Some of the most used methods include serial-, UDP/IP- and TCP/IP-based communications schemes. Information in the IEEE C37.118 messaging includes data, configuration, and header and command data. Messages include information about the quality of the data received from the PMU. This ensures that the user knows if he is getting valid synchronized measurement data or not.

Different Communications Methods Using SEL PMUs and PDCs

Communications into and out of substations typically include an Internet connection via fiber or cable, or a serial connection via a dial-up telephone line or radio link. Synchrophasor data can be sent using either Internet or serial connections. If an Internet connection is used, the user can select between User Datagram Protocol (UDP) and

Transmission Control Protocol (TCP).

UDP provides the best real-time performance and requires less bandwidth because it uses a simple transmission model without handshaking. If you decide to use UDP, SEL recommends using the UDP send-only protocol (UDP_S) because this protocol provides a more secure communications path. A PMU using UDP_S only sends data and does not listen to incoming commands.

TCP is a connection-oriented protocol. This means that it requires handshaking to setup and maintain an end-to-end connection. The handshaking performed using TCP ensures a more robust communications channel, but requires additional bandwidth.

Finally, serial communications use handshaking and control the lines that are used to setup and take down a communications circuit. Sending data via serial communications is also fairly efficient in terms of minimizing the additional bandwidth needed to send the phasor data. The biggest drawback with serial communications is the limited maximum data throughput.

The table below shows the various data bandwidths required for UDP, TCP, and serial protocols to communicate IEEE C37.118 message data.

IEEE C37.118 Message Size (payload only)	**104**	bytes
Serial Bandwidth Needed	**49.9**	Kbps
TCP Bandwidth Needed	**90**	Kbps
UDP Bandwidth Needed	**82.5**	Kbps

Impacts of Synchrophasor System Architectures on Bandwidth

There are generally two different system architectures that can be used for synchrophasors, central concentration and local concentration. With central concentration architecture, each PMU in the substation sends its phasor data to the control center where the data are concentrated. In local concentration architecture, PDCs concentrate PMU inputs at the substation and then only send a single output from the PDC to the control center.

While both central and local concentration are possible architectures, using PDCs in each substation (local concentration) significantly reduces the communications bandwidth needed for the phasor data from the substation to the control center. Through the data concentration process, data from each PMU is integrated, time-aligned, and packaged up in the PDC. This more efficient data stream is then output to the central office. The figure below shows the required communications bandwidth for both the central and local architectures.

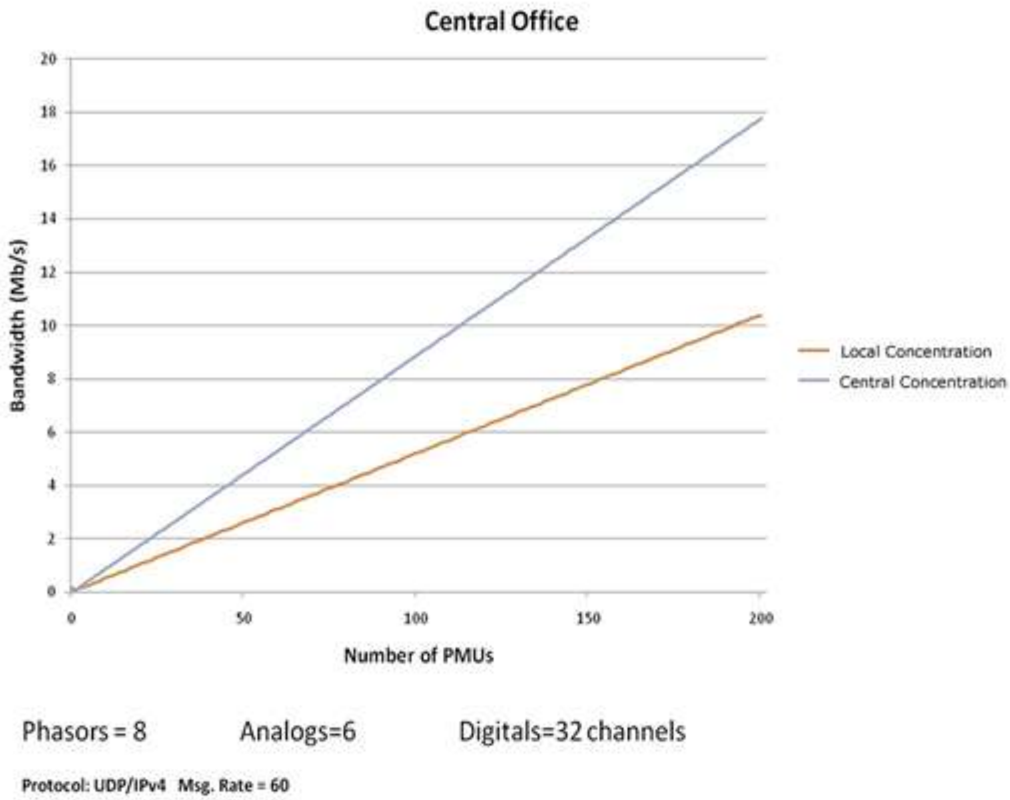

Figure 1. Communications bandwidth required with local concentration or with central concentration.

An additional benefit of using local concentration is that it improves overall system security because all PMUs are concentrated into a single communications stream out of the substation. This provides a layered security approach by keeping all communication with the relays within the substation. By providing a single communications path for synchrophasor message data, it becomes easier to add encryption or use other means to further secure outgoing data.

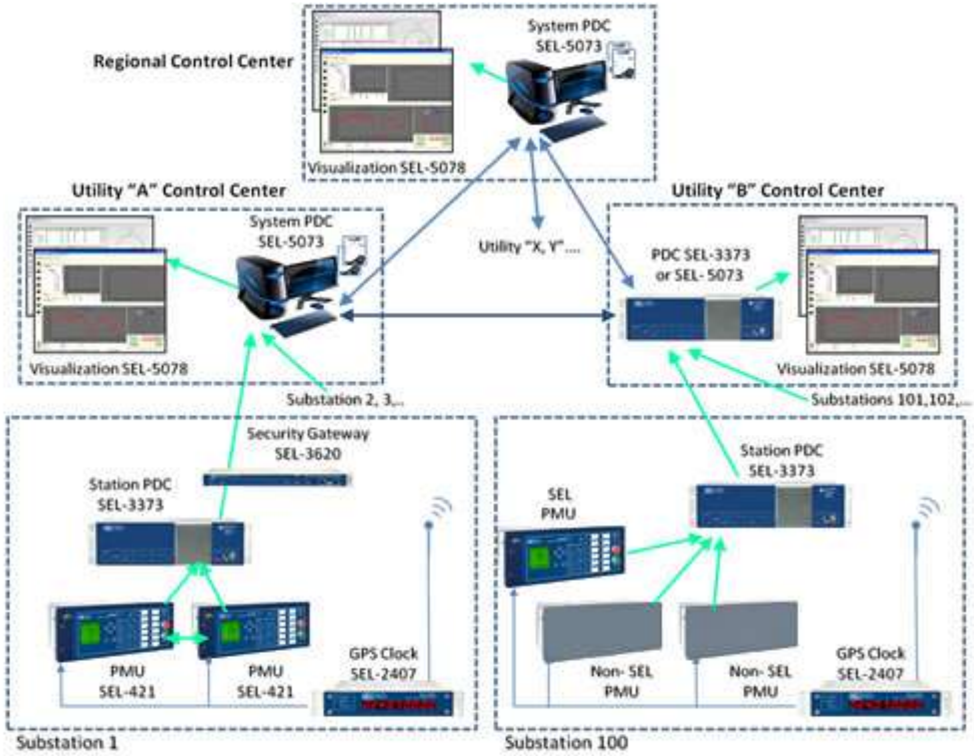

Figure 2. Typical system architecture.

Vector Processors Further Reduce Communications Bandwidth Needed

Using a PDC, like the SEL-3378 Synchrophasor Vector Processor, a user can further reduce the communications bandwidth needed for synchrophasor data. The SEL-3378 offers flexible programmable logic for wide-area protection and control applications. This programmable logic controller can be used to obtain all the phasor measurements from your system and send only the required data. For example, your substation may have several PMUs that obtain measurements from various transmission lines and buses. Voltages from each of these points can be concentrated, and the user can choose to send only the required voltages (that are representative of the various inputs) instead of voltages from each line. Additionally, if there is an outlier voltage, the vector processor logic can be used to send this outlying voltage back to the control center to alert an operator of a possible problem.

Summary

Synchrophasor systems provide real-time phasor data that can be used for improving system models, improving reliability and power quality, integrating distributed generation and even wide-area control systems that improve system stability. Communication plays a critical role in these real-time data intensive systems. With the proper system design and architecture, the required communications bandwidth between substations and the central office can be minimized. Using the SEL-3373 Station PDC, SEL-5073 System PDC, or the SEL-3378 Synchrophasor Vector Processor will significantly reduce the communications bandwidth needed and will provide additional capabilities. If you have questions on the communications bandwidth needed to implement a system in your network, please contact SEL. We have experts that can help you design and implement a system that meets your requirements. All SEL products include a ten-year warranty. SEL supports our solutions with industry-leading customer service.

Contact us directly at tsr@selinc.com for product support and questions.

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