White Paper

The New Role of Precise Timing in the Smart Grid

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Electricity travels at the speed of light. This is precisely why microsecond accuracy is critical for today's regional grid authorities. Every second of every day, thousands of interdependent events occur between generators, transmission lines, circuit breakers, power substations, and transformers scattered across thousands of miles. In full operation, a typical transmission substation will generate and process 100,000 data samples per second at the process bus level[1]. Add to that the estimated 50 TB of smart metering data generated and transmitted per day in North America, and it becomes obvious that without the benefit of time, a utility just has data and the ensuing chaos of how to process it.

Timing has always had a role in the smart grid. Consider for a moment the protection, metering, and control substation functions; the byproduct of protection is time-stamped data and the direct output of control and metering is time-stamped data.

Timing has become increasingly accurate in the Smart Grid and as a consequence, it is now a leading contributor to grid security. In addition, bay-level clocks do not fit naturally into the smart substation architecture and the centralized substation clock must meet many new objectives.

- The clock must support the legacy equipment in the substation

- It must deliver NTP for local consumption

- Utilities will deploy IEEE 1588 compliant IEDs at different speeds, but the clock installed today should be futureproof and have a natural path to C37.238

- Able to monitor the integrity of the GPS reference, and switch to an alternate source if compromised

- The reliability and manageability of the clock is critical; particularly as the process bus becomes a reality

- No one can ignore the importance of the NERC CIP requirements and the clock cannot compromise the integrity of the cyber security system that has been or will be established

Energy accounting applications are the least demanding in terms of precision, and metering instruments are normally synchronized from within 1 second of an accepted time reference. Forensics applications are slightly more demanding, and protection relays and disturbance recorders are typically synchronized within 1 ms of a grid-wide standard. In the operational realm, SCADA applications are also met with data time-stamped within 1 ms of the same reference.

The need for synchronization is understood but until recently, timing was considered optional by many, and this is reflected in the deployment practice evident at many utilities. GPS clocks are often installed autonomously for an application or project. GPS certainly meets the accuracy needs, but it is not uncommon to see multiple project-based GPS systems in a single substation, with the resulting antenna array on the control room roof. More importantly, these GPS devices are rarely managed beyond the catastrophic failure of the clock.

As utilities strive to deliver more from their existing grid infrastructure, the control and protection functions have become more dependent on data that is synchronized with greater precision. Applications such as wide area measurement systems[2], traveling wave fault locators, and sample values require microsecond accuracy. Synchronous sampling and time stamping of sampled values is critical, as failure to do so across the substation can result in incorrect tripping by protection relays. Timing is therefore no longer optional—it is now an operational necessity, and an ad-hoc approach to timing cannot be sustained.

With the need for more precision established, the challenge is how to distribute a 1 µs reference reliably and cost-effectively. Engineering a parallel timing bus to every IED is not sustainable, and 1 µs is beyond the reach of the Network Time Protocol (selected by current release IEC 61850). An IEEE Power System Relaying Committee task group defined a profile of the IEEE 1588 protocol to deliver 1 µs in the substation and this profile is defined in the IEEE C37.238 standard. This solution overcomes the limitations of previous technologies—high precision, in-band distribution over the LAN, and management of the clock quality. When published, the power profile will also be referenced in the IEC 61850-9-2 standard to address the higher accuracy needs of sampled values.

To help with grid security, Microsemi designs and manufactures centralized substation clocks that meet the legacy timing needs as well as those of the Smart Grid.

Learn more at www.microsemi.com/applications/industrial/power-utilities.

[1]60 Hz system, 20 bays with 5000 sample values per second.
[2]Scheme of phasor measurement units sampling phase data at synchronous moments and reporting of the synchrophasor data to a central location.

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