Symmetricom®

1µs and the Smart Grid Need or Myth?

Why do we need to increase precision 1000 fold in

Deliver a 1ms time source to every substation, referenced to one time standard, and for use by all time-sensitive applications. That has always been the goal. Why then do we keep hearing about 1µs, and do we really need the clock time to be 1000 times more accurate?

In short, the answer is yes and to understand why we need to examine the time-critical applications.

The early time-dependent applications were focused on energy accounting as time of use tariffs were implemented between utilities, internal groups and at large customers. Time accuracies in the order of seconds met those needs and remains relevant today.

Later, as digital event and waveform recorders became available, events time-stamped with an accuracy of 1ms was needed to support post-event analysis. This functionality and time accuracy has prevailed, and 1ms referenced to the UTC time standard still meets the needs of modern IED's that record event data.

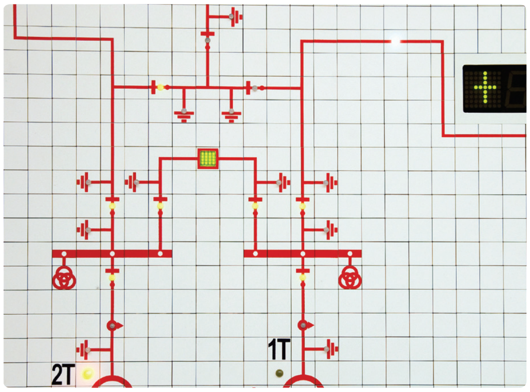
With the need to operate the grid more efficiently, new applications have been developed, and while the functions may be diverse, these applications all have one thing in common... they require time with a precision of 1µs across the substation, and throughout the grid.

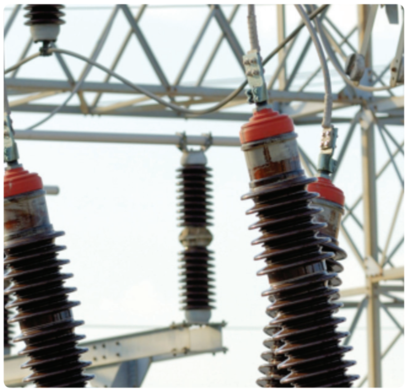
The first, and most prominent application is the Synchrophasor. To set the context, Phasor Measurement Units (PMU) measure the phase and magnitude of electrical quantities in the grid. The resultant measurement is called the Synchrophasor, and is a data object containing the magnitude and phase of the electrical quantity, the time of the sample, and the quality (accuracy) of the time. The Synchrophasor is not really an application but is a wide area measurement system that supports new grid-wide applications, some of which operate in real-time. Wide area control and protection schemes are examples of these real time applications.

Time is important to the Synchrophasor because the phase angles are compared to a UTC reference for relevance across

Time and frequency sensitive applications in the Power Grid include:

- Analogue trace recorders
- Energy Management Systems
- Lightning strike correlation
- Merging unit and sample value (IEC 61850-9-2) measurement
- Power quality measurement
- SCADA
- Sequence of event recording
- Substation automation
- Synchrophasor measurements
- System frequency management (AGC)
- TDM network synchronization
- Time of use tariff metering
- Wide area control and protection





the new Smart Grid?

the grid. The precision of the clock varies as a function of the error in the magnitude measurement (called the Time Vector Error), but in general 5µs satisfies the application and 1µs defines the clock source accuracy. Understanding and reporting the quality and accuracy of the clock is equally important, because it prevents inadvertent control and protection when the time component of the Synchrophasor is compromised.

The IEEE specification C37.118 defines the Synchrophasor measurement and exchange, with the clock accuracy and quality described in section 4.4 and annexes E and F.

The second significant time dependent application is the digital "sample values" of the electrical quantities as defined in the IEC standards 60044-8:2002 and 61850. These standards outline the exchange of volt and current quantities in the switch yard and transporting those measurements over the Ethernet process bus to IED's.

"Without Time There is Chaos."

When measurements are distributed in Ethernet packets, protection IED's need three things... frequent samples (4600 per second at 60 hertz), the exact time when the measurements were made, and knowledge of the clock integrity. If the clock quality is overtly compromised, the IED could in the extreme trip inadvertently, or the more likely outcome will be to default to a safe state and operate the circuit breaker. In either event the result is the same. An undesired trip function...

B.2

Operation principle of the digital output.

To use efficiently the advantages for electrical current and voltage transformers, the signals must be treated in a uniform way. Instantaneous values of current and voltage, taken from the same instance with a time uncertainty of less than a few microseconds, must be transmitted to the measuring and protection equipment.

Applications that depend on the integrity of sample values assume that the source has been synchronized with an accuracy of 1µs, with the sampling process being in the outside plant where the measurements are performed. The switch yard is clearly not GPS or IRIG-B friendly, and the methods used to provide 1µs accuracy outdoors are a 1 pulse-per-second light source over a fiber-optic cable, or the more widely described IEEE 1588 precision time protocol embedded in the data Ethernet.

Development of new applications that support the operation of the grid closer to it's limit will continue, and while there may be diversity in implementation, precise timing will continue to be an integral part of the result. The new time transfer standards such as the IEEE C37.238 and IEEE 1588 will support existing and new applications without the need for a dedicated timing infrastructure for every application.

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