NASPI Time Sync Task Force Report

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NASPI Work Group meeting
March 23, 2017
PNNL-SA-124707

NASPI North American SynchroPhasor Initiative

Why the NASPI Time Sync Task Force?

- PMUs and synchrophasor applications won't work if timing delivery doesn't work right or PMU measurements arrive too late to the application.
- Bad time signals cause bad phasor calculations that may go undetected and cause incorrect interpretations of grid conditions and inappropriate actions.
- Accurate timing delivery can fail for many reasons, including poor installation, space weather, interference, malicious actors, poor implementation of leap events, and poor interoperability.
- Synchrophasor technology can't be used for mission-critical and automated actions until we understand and resolve current time delivery problems.
- Synchrophasor technology is the leading edge of timing use for the power system, so NASPI might as well work with others now to figure this out and nudge vendors and standards-writers to get these problems identified and fixed.

Time Synchronization in the Electric Power Industry: A Primer

NASPI-2017-TR-001

Contents:

1) Introduction
2) Synchrophasor technology overview
3) Definitions – timing, timing characteristics, timing sources and systems
4) Power system uses of timing
5) Alternative timing sources and options
6) Timing problems, anomaly detection and mitigation
7) Improving synchrophasor system timing delivery and management
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Key definitions

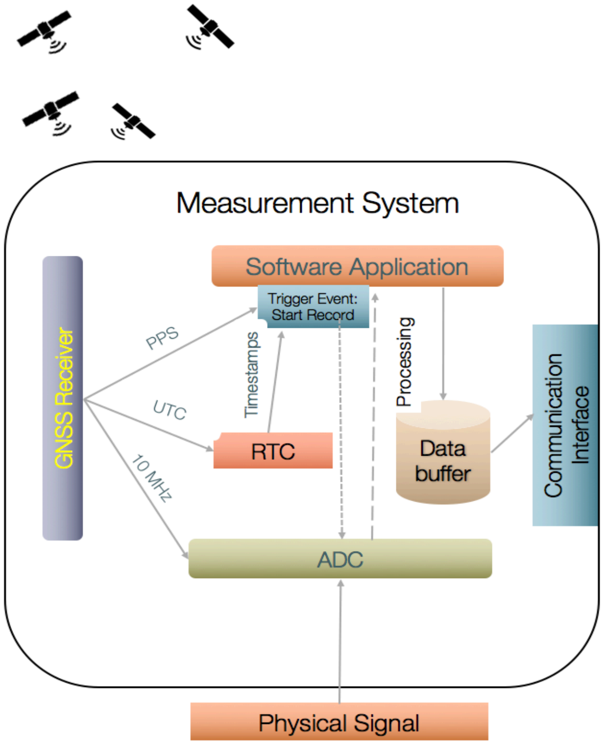
- Absolute time/synchronized time – events are recorded to absolute time when they are time-synchronized and time-stamped against a common time source such as GPS network-distributed time.
- Relative time -- counts time passed from an initiating event (such as from a lightning strike to a relay action); may not be synchronized.
- Time-synchronization – the coordination of disparate events according to a reference time in order to operate a system in unison, and track comparable data and events based on consistent time-based records.
- Accuracy – the closeness of agreement between the measurement (e.g., clock or GPS time) and the true value (e.g., UTC time).
- Precision -- A measurement is precise if repeated measurements under identical conditions produce the same result, i.e., it is repeatable and/or reproducible. A clock ensemble may yield precise yet inaccurate time signals.
- Resolution – The smallest change in a quantity being measured that causes a perceptible change in the corresponding indication (e.g., millisecond v. microsecond).

Timing acquisition and PMU message delivery

Timing message delivery time starts when the timing message is initiated, then passes to the PMU for time-stamp.

Measurement delivery time starts with the measurement and time-stamp, then the signal (measurement) passes from the PMU to the PDC through the networks to the end-use application.

GPS or GNSS



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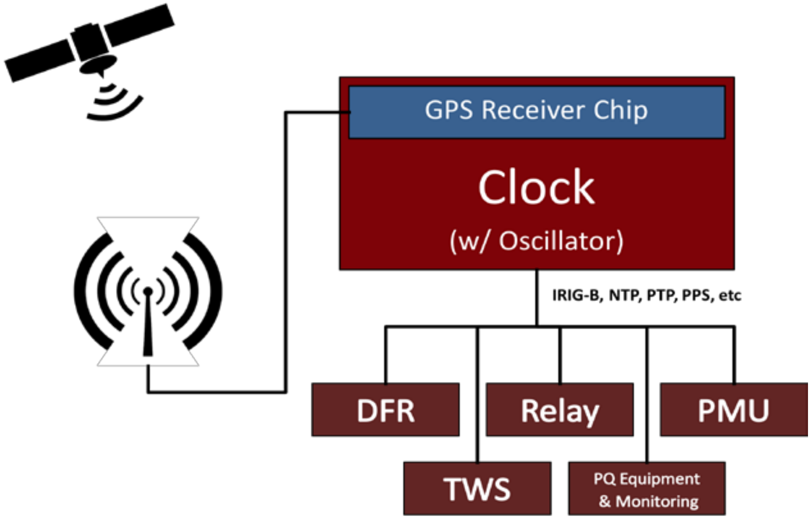

Power system uses of time-dependent data

Grid application	Timing requirements (minimum reporting resolution and accuracy relative to UTC)
Advanced time-of-use meters	15, 30, and 60 minute intervals are commonly specified (ANSI C12.1)
Non-TOU meters	On-going, with monthly reads or estimates
SCADA	Every 4-6 seconds reporting rate
Sequence of events recorder	50 ms to 2 ms
Digital fault recorder	50 ms to 1 ms
Protective relays	1 ms or better
Synchrophasor/phasor measurement unit (30 - 120 samples/second)	Better than 1 ms 30 to 120 Hz
Traveling wave fault location	100 ns
Micro-PMUs (sample at 512 samples/cycle)	Better than 1 ms

Primary timing sources today

- GNSS – Global Navigation Satellite System – worldwide (GPS, Galileo, Glonass, Beidou). Often primary timing source
- eLoran – Wireless, terrestrial towers. Can provide timing for 70-90 days independent of satellites, penetrate inside buildings and underground
- NIST WWVB – wireless, terrestrial radio. Good holdover source for loss of GNSS
- Optical transport network – wired, through public telecom network, SONET, Ethernet. Typical residential and commercial system.
- Oscillators – used inside a clock to provide frequency, with a counter to determine time, and a control loop to correct relative frequency error and drift. The best oscillators use rubidium or cesium atomic clocks.

Timing problems

Ways timing goes bad:

- From space (space weather, GPS signal anomalies, satellite constellation changes), unintentional interference, intentional jamming and spoofing
- On-site – poor quality GPS receiver, poor installation, no firmware updates, local interference, lost wires; poor PMU interoperability with GPS unit, no back-up time source, no detection of timing problems
- PDC & applications – inadequate detection of timing anomalies and gaps or errors resulting from timing problems

Improving synchrophasor system timing delivery & management

Improve synchrophasor system reliability for timing integrity and resilience with:

- Better design and installation practices for PMUs
- Better planning, installation and maintenance for GNSS equipment, starting with antennas and receivers
- Better detection of timing anomalies
- Better checking of timing signal integrity
- More use of GNSS-independent networks
- More use of local hold-over clocks
- Standards updates
- Conformance and interoperability testing for timing

For more information about the TSTF primer

NASPI TR-2017-001 TSTF Primer at _______

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