2016 Leap Second Experiences

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Leap second context

- We saw lots of timing-based PMU data problems with the 2015 leap second.
- Incorrect leap second processing creates a data quality problem, with missing or untrustworthy and inconsistent data.
- Timing-based PMU data errors may show up as data gaps or incorrect, fast-changing phase angles.
- Reminder – GPS and other timing sources put out the leap second signal; it's the device (clock, PMU, etc.) programming that does the leap second processing.
- The 2016 leap second occurred on the transition from 2016 to 2017.

Summary of 2016 leap second observations

- There were diverse causes for timing problems, but most of them have to do with either clock problems or clock-to-PMU interactions.
- Incorrect leaps occurred in PMUs with and without firmware updates.
- Incorrect leap second processing violates the PMU standard.
- Leap second processing is inconsistent and the types of errors manifested vary widely.

POSOCO India

- Across a varied fleet of PMU types, all PMUs added the leap second.
- Some PMUs processed the leap second from 2-3 days early; others processed it 2-3 seconds early.
- Many PMUs processed the leap second several seconds late.
- Leap second implementation varied by milliseconds across different PMUs.
- Restoration of the data stream with the updated clock was delayed for varying durations in different PMUs.
- Some of the late-processing PMUs began manifesting data latency after the leap second execution; this lasted up to 15 minutes. This system never produced any recorded data for the leap second.

Source: P.K. Agarwal

BPA

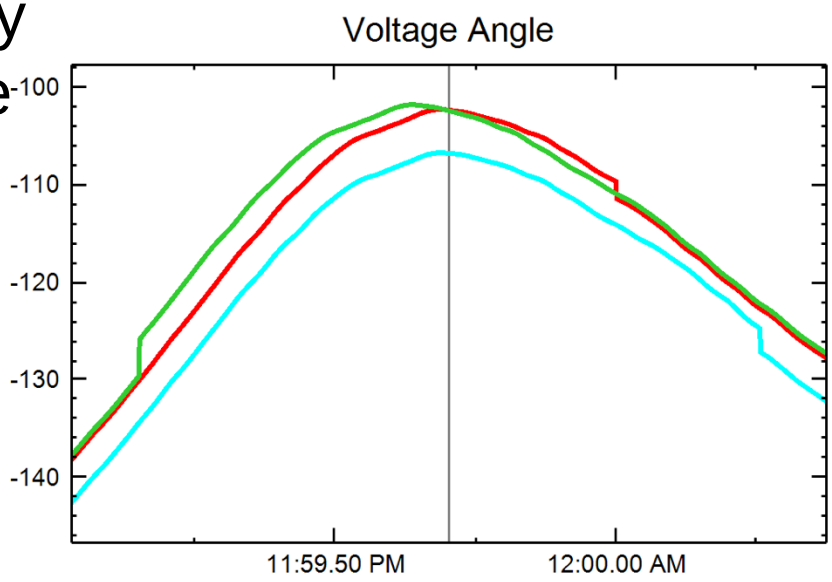
- During leap second insertion all PMUs experienced a 2-second bad data problem from 00:00:01.0 until 00:00:03.0 UTC.
- But six hours later (22:13:25.0 PST on 12/31), 57 PMUs began experiencing sustained timing problems – all started at the same time, but each recovered at different times. Most recovered soon after 11:00:00 am PST on 1/1/17, but three continued with problems until after 16:00 PST 1/1/17.
- The problems appear to stem from the GPS clocks that feed time signals to the PMUs. Per the PDC servers, the problematic PMUs were sending a time stamp that was exactly 1 second ahead of the data coming from the rest of the PMUs – i.e., they missed the leap second insertion.

Source: Jeff Anderson (BPA)

OG&E

- 82% of PMUs leapt correctly
- Discovered 8 GPS clocks with old firmware, that leapt 1 week early
- Discovered 2 PMU models that need firmware updates
  - 1 leapt 17 seconds early
  - 1 leapt 5-6 seconds late

Green = early leap
Red = correct leap
Blue = late leap



Source: Austin White (OG&E)

Closing thoughts

- If you didn't observe any PMU timing errors, maybe you weren't looking for them….
- Timing-based bad data problems may not be a problem today, but if we don't figure out how to fix them, they could create big problems for PMU-based mission-critical operations support and automated controls.
- We need clock and PMU vendors and standards writers and testers to pay attention to this and get it fixed.

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