Distribution PMU's
Hardware and Firmware Lessons Learned

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Distribution “micro PMU’s”: lessons learned after 3 years

- ARPA-E, CEDS, DARPA
- Utilities: U.S., Canada, Europe, Asia, Pacific
- Basic technical targets
  - 2 orders of magnitude more precision than traditional PMU’s
  - Research-friendly data
  - Reliability: across all projects, 1 hardware failure
  - Ease-of-use: support engineers

Micro PMU lessons learned (1)

- Installation challenges
  - It's just a meter! But an unfamiliar meter…
  - PT's and CT's are in the critical accuracy path
    - Not very accurate – 0.2% at best
    - Highly stable, though, so resolution unaffected
    - Build algorithms that rely on *changes* in values
  - New algorithm (patent issued) substitutes in-use distribution power transformers for PT's
  - Calibrating distribution PT's and CT's
  - UL, CSA, TUV, S-mark, CCC mark, CE mark, …

Micro PMU lessons learned (2)

- Grid events make interesting data; grid steady-state does not.
  - "Dropped wrench" at LBNL
  - "Rat event" at Riverside Public Power
  - Oscillations between control algorithms, in general

Micro PMU lessons learned (3)

- Communication channels vanish.
  - On the distribution grid, they vanish whenever something interesting happens: big disturbances kill routers/switches/cell-telecoms
  - Distribution grids lack transmission grid communication infrastructure.
  - Data communications also stop when the receiving server goes through upgrade…
  - You must have at least a month of storage at the microPMU.

Micro PMU lessons learned (4)

- Data security is important.
  - SSL (but Certificates are a hassle)
  - Military-grade security – plug in modules, no comms, other approaches
  - Honey pots

Micro PMU lessons learned (5)

- Time-domain measurements (or frequency-domain measurements) *sometimes* are more useful than phasor-domain measurements
  - Micro-PMU's can be switched back and forth, remotely, between PMU-mode and PQube3-mode
  - Some big research projects use dual sensors, with the micro-PMU operating as an NTP time server for the PQube 3

Micro PMU lessons learned (6)

- Standards like C37 discourage innovation, especially for less-informed users.
  - Gate-keeping item: does microPMU conform the IEEE C37?
    - Well, yes. It has that mode. If you want to degrade its measurement performance…
    - And its communication performance…
    - BUT that's not what microPMU's are for.

Micro PMU lessons learned (7)

- Big data is a new shiny toy for utilities.
- Even a short, small microPMU project will generate terabytes of measurements.
- The challenge: how do you get useful information out of so much data?
  - Depends on the intended audience: researchers, control rooms, in-the-loop microgrid algorithms, etc.
  - Requires new skills, and new attitudes.

Micro PMU lessons learned (8)

- Latency has different meanings, and different importance, depending on application.
- In general, it's important for control applications, and unimportant for research applications.
- It has to be carefully defined: measurement latency (function of filters), transmission latency, channel latency, receiver latency, algorithm latency…

Micro PMU lessons learned (9)

- Never, ever connect a GPS antenna cable to an ultra-high-resolution microPMU!
  - Do the ballpark calculations about earth currents on the shield of the coax antenna cable.
  - Instead, put the receiver at the antenna, and optically couple the digital signal uplink and downlink.
  - Calibrate the cable.

Micro PMU lessons learned (10)

- Always something new…
  - What happens at a high-altitude Andes mine in Peru? (6,000+ meters)
  - What can you learn from micro-PMU measurements *inside* semiconductor manufacturing equipment?
  - What happens when a microPMU is installed upside down on the roof of a substation hut?
  - How are microPMU measurements affected by geomagnetic storms?

We're still learning!

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