A NEW microPMU Technology for Distribution and MicroGrids

Bucharest 2018  (Andreas Eberhard, PSL)
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What is this NEW microPMU Measuring Technology?

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**Objective:** Implementing a synchro phasor technology for Distribution and MicroGrids

**Problem:** Traditional Transmission PMU units do not meet all the necessary requirements.
ARPA-E micro-synchrophasor Project

Synchrophasors -- for Distribution!

http://www.powersensorsltd.com/ARPA-E.php

2015-2017 Field deployment and installation at Lawrence Berkeley National Labs and partner utility companies of several hundreds of microPMUs in the US

2017-2018 Research Institutes and utilities around The world joining microPMU implementation
Synchrophasors compare voltage phase angle at different locations.

Phasor Measurement Units (PMUs)

Useful real-time information for system operators.

Power Flow and Oscillation.
Now also for **distribution**

- Integrate distributed generation (DG) into grid
Distribution Synchrophasor network concept:
Create observability and transparency for high-voltage circuits to support integration of distributed resources

Synchrophasors (PMUs) already increasingly being deployed on transmission systems

Micro-synchrophasor (μPMU) network for distribution
Challenges of measuring phase angle differences in distribution (vs. transmission)

Transmission
• Long distances, widely-spaced conductors = \textit{big L, big angles}

Distribution
• Short distances, bundled conductors = \textit{small L, tiny angles}
Challenges of measuring phase angle differences in distribution (vs. transmission)

**Transmission**
- Homogenous

**Distribution**
- Heterogenous, unbalanced
Challenges of measuring phase angle differences in distribution (vs. transmission)

**Transmission**
- ±1° adequate
- ± 1% TVE

**Distribution**
- ±0.001° adequate
- Does TVE apply? 0.01%? (Calibration challenges...)
- Error budget measured in millidegrees; at 60 Hz, 1 millidegree is 46 nanoseconds
Challenges of measuring millidegree phase angles (46 nsec per millidegree)

GPS signals

- ±1 microsecond – typical GPS receiver
  *(disciplined 150 MHz clock)*

- Cable transit time – ~7 nsec per meter
  *(autocalibrate using time-of-round-trip)*
ARPA-E micro-synchrophasor based on commercial PQube 3® instrument

- 32 GB of on-board storage
- TCP-IP (ethernet) coms
- Certifications: UL, TUV, CE, etc.
- Five ±1000V, 0.01% voltage channels
- Eight 0.01% current channels
- “Class A” Power Quality recorder
- “Class 0.2” Energy Revenue Meter
- Snap-on module expandability
The new micro-PMU
μPMU data results (example)
Field installations at substations, end-points completed
Patents filed
Several months/years of data
±0.002° accuracy confirmed (roughly 500 times better than standard PMU)
Research Software available
Installations in progress for Non-ARPA projects around the world
We hope MORE research teams to join the microPMU research project!!!!
ARPA-E Micro-synchrophasors for Distribution: Initial Research Facilities and Universities

- BC Hydro Research Division
- SDEE Transilvania Sud Romania
- Technical University Vienna/AIT, Polytechnic of Porto
- NTU Singapore
- University of British Columbia, Northwestern University
- Osaka and Kyoto Prefecture Universities
- NIST (US National Lab)
- Southern Company, TVA, Southern Cal Edison
- BAE System

Also here in beautiful Romania! Project SDEE Transilvania Sud
70 microPMUs and 20 PQube 3s deployed
Conclusions going in 2018

• Distribution synchrophasor idea is resonating well throughout research community and industry (microPMU name!!)

• Scary data volume (terabytes) can be handled effectively

• It’s NEW data for everyone!!!

• Starting to make basic sense of the measurements

• Many advanced application opportunities seem worth exploring

Photo: Alex McEachern
microPMU –
electron microscope for grid stability

A “microPMU” is a PSL PQube® 3 instrument with 3 additions:

1. a specially calibrated GPS receiver (that’s not an antenna – it is an antenna, plus a GPS receiver, plus some clever digital circuits – and the cable you see is entirely digital, not RF co-ax),

2. special firmware in the PQube 3 that converts it into the most precise synchrophasor instrument ever deployed, and

3. a special calibration process.

Any micro-PMU can be instantly converted, in the field, to a standard power-quality-and-energy PQube 3...
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THANK YOU (Email: aeberhard@powerstandards.com)