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

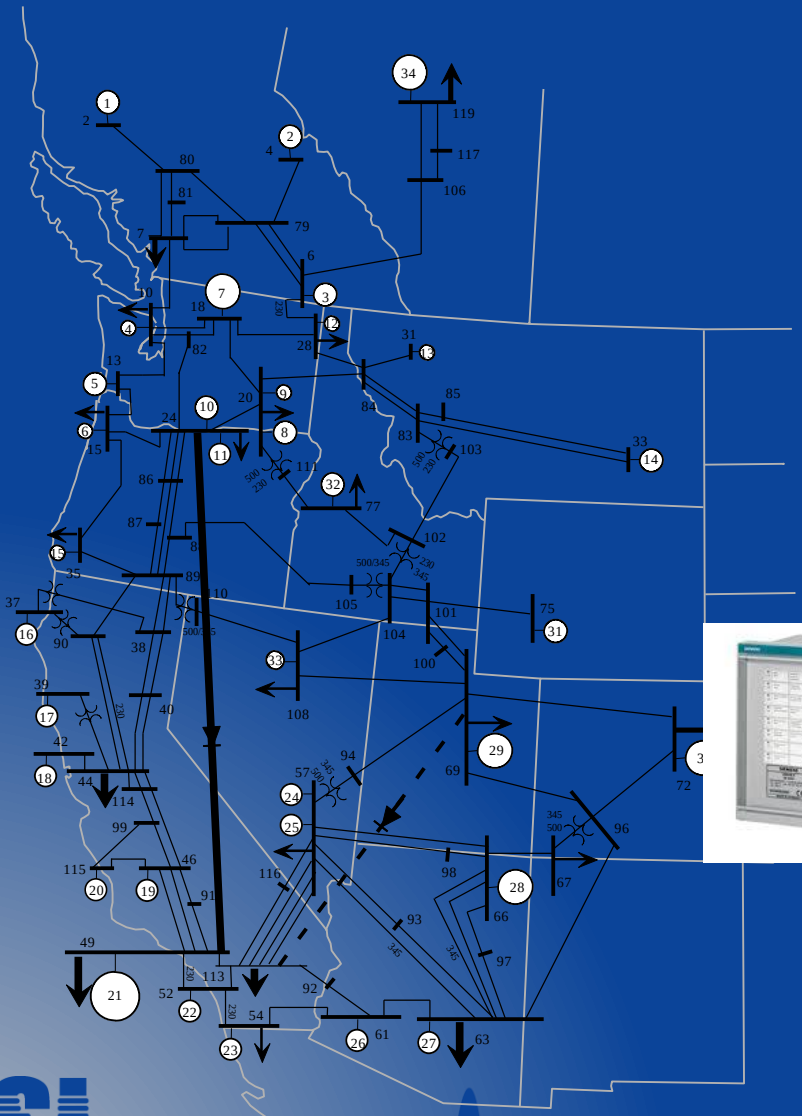
Synchrophasors -- for Distribution!

2014-2015 Start with ARPA-E Funded Project (Advanced Research Projects Agency - Energy). http://www.powersensorsltd.com/ARPA-E.php

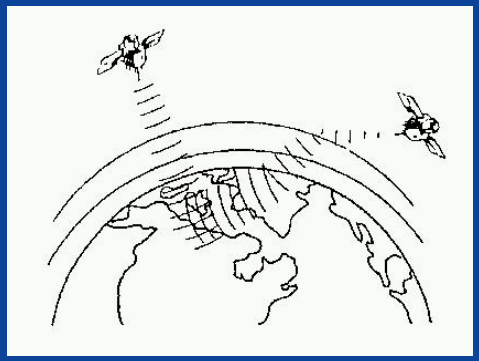
2015-2017 Field deployment and installation at Lawrence Berkeley National Labs and partner utility companies of several hundreds of microPMUs in the US

2017-2018 Research Institutes and utilities around The world joining microPMU implementation

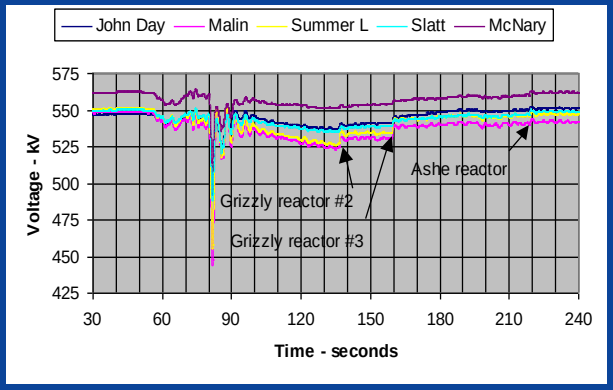
Synchrophasors compare voltage phase angle at different locations



synchronous data



Phasor Measurement Units (PMUs)



useful real-time information for system operators

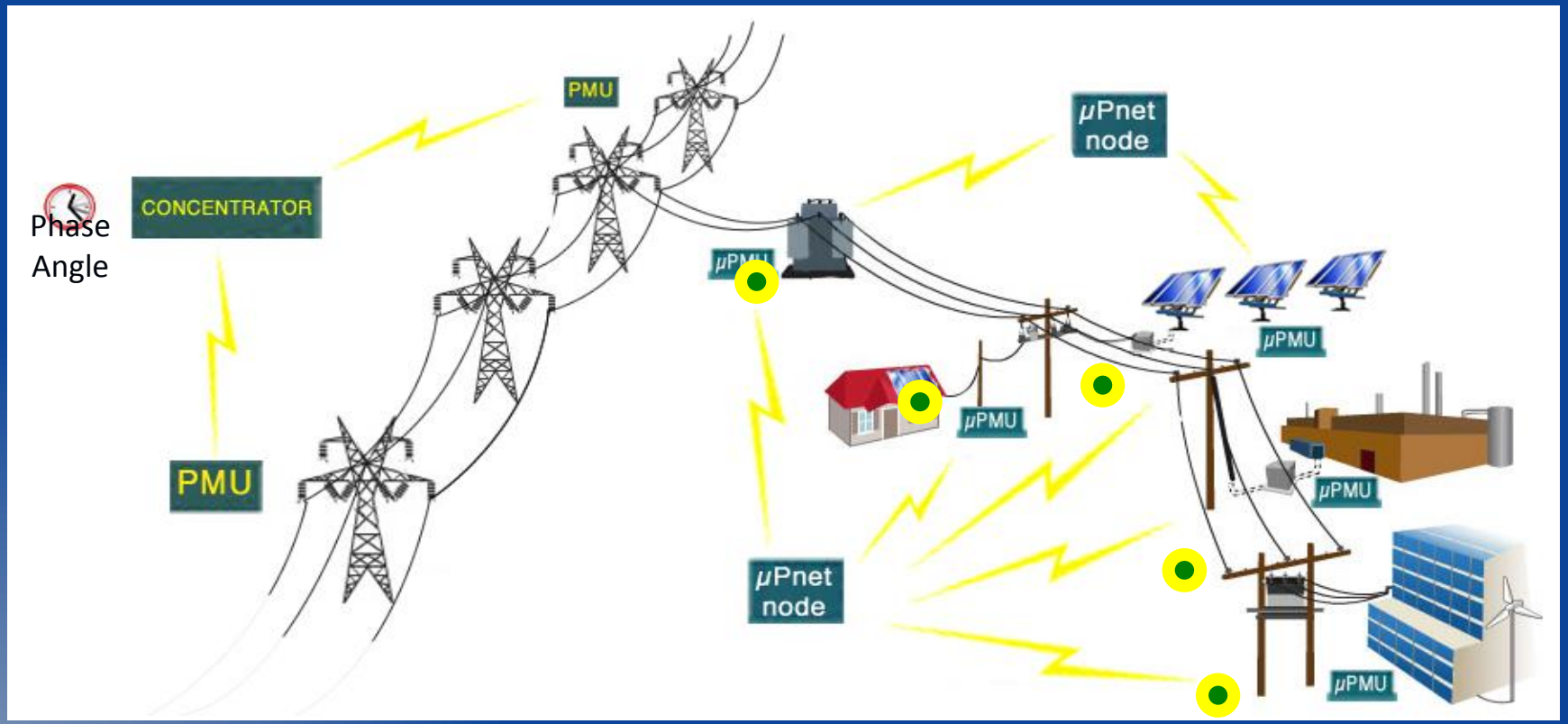
Power Flow and Oscillation

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

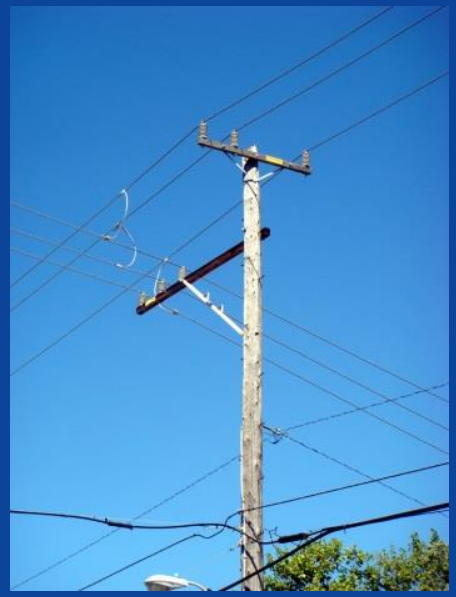
- Long distances, widely-spaced conductors =

  big L, big angles

Distribution

- Short distances, bundled conductors =

  small L, tiny angles



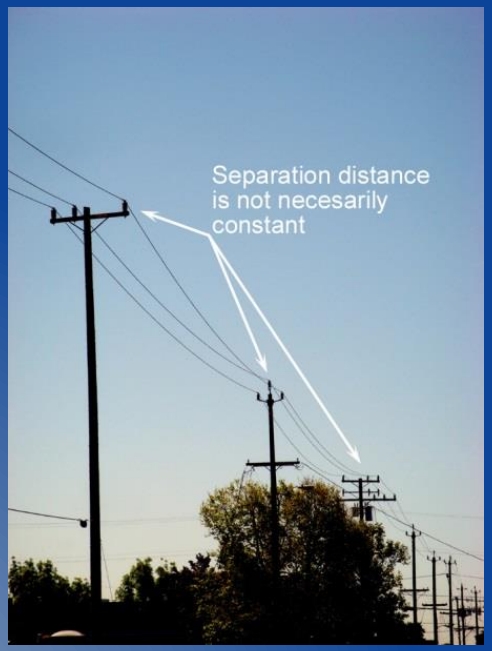
Challenges of measuring phase angle differences in distribution (vs. transmission)

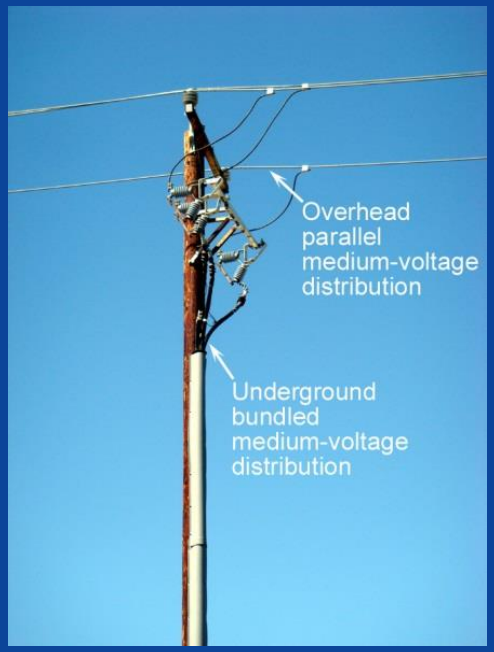
Transmission

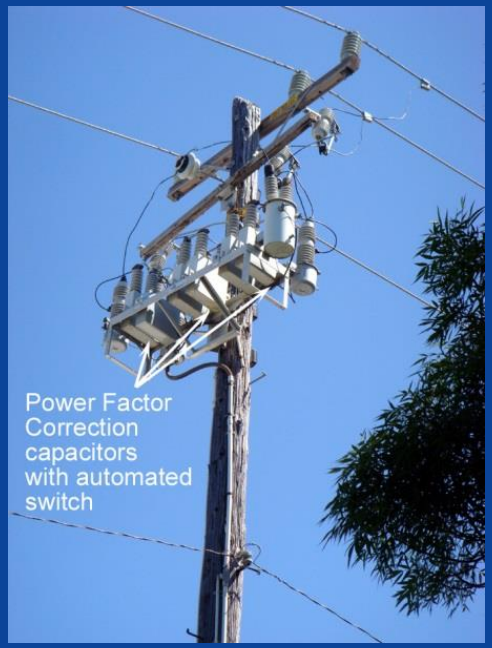
- Homogenous

Distribution

- Heterogenous, unbalanced



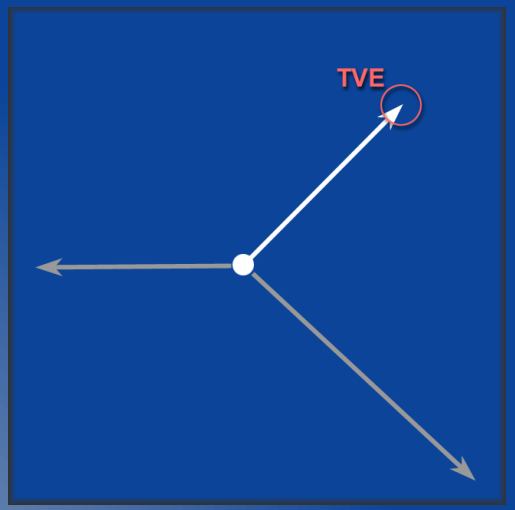




Challenges of measuring phase angle differences in distribution (vs. transmission)

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

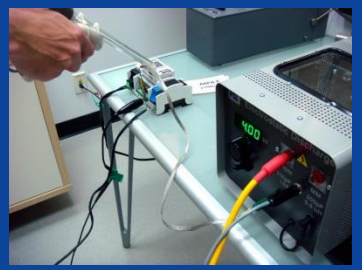
(disciplined 150 MHz clock)

- Cable transit time – ~7 nsec per meter

(autocalibrate using time-of-round-trip)

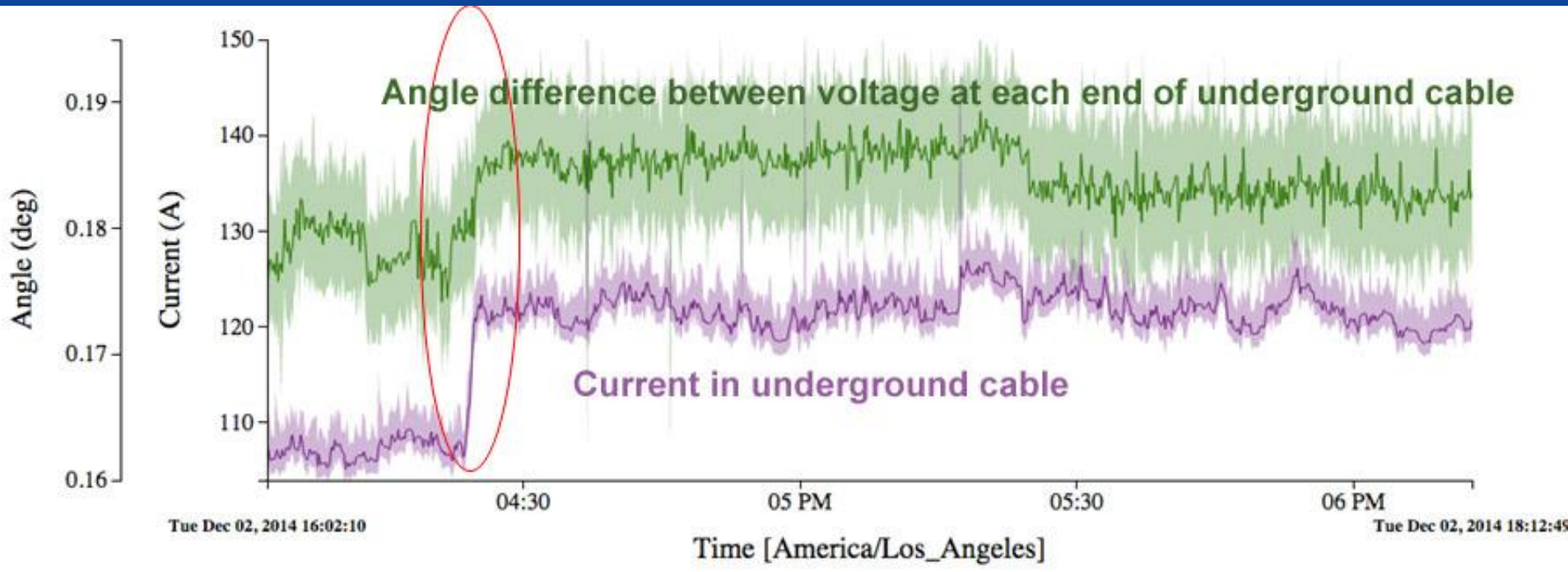
ARPA-E micro-synchrophasor based on commercial PQube 3® instrument

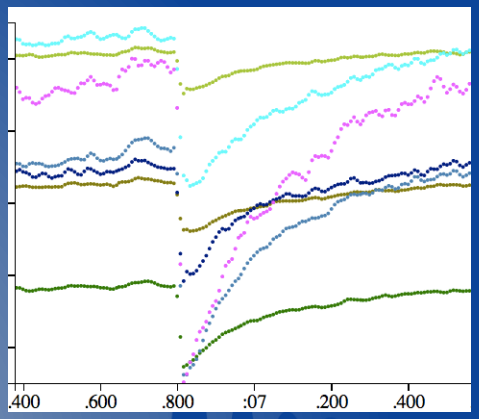
- 32 GB of on-board storage
- TCP-IP (ethernet) coms
- Certifications: UL, TUV, CE, etc.
- Five ±1000V, 0.01% voltage channels
- Eight 0.01% current channels
- “Class A” Power Quality recorder
- “Class 0.2” Energy Revenue Meter
- Snap-on module expandability

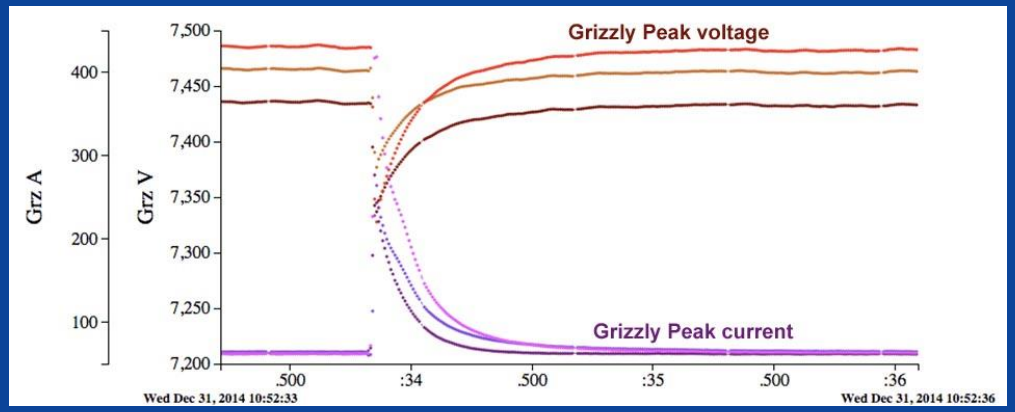


The new micro-PMU

µPMU data results (example)







ARPA-E Micro-synchrophasors for Distribution: Project Status 2017/2018/2019

- 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 (https://spectrum.ieee.org/energy/the-smarter-grid/sniffing-out-grid-attacks)

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

Cristina Stanescu, SDEE Transilvania Sud

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)