TCIPG

Synchrophasor Data Quality

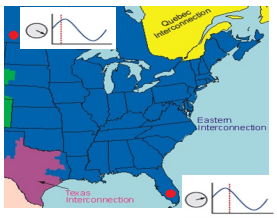
Open-Box Phasor Measurement Unit (PMU)

Bogdan Pinte, Andy Yoon, Michael Quinlan, and Karl Reinhard

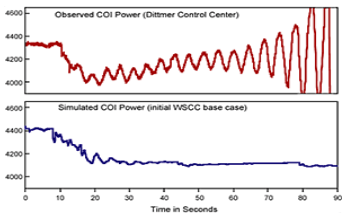
GOALS

- Build & test an open-box PMU to understand the challenges of measuring, processing, synchronizing, and integrating synchrophasor data.
- Investigate synchrophasor data quality issues and identify remedies.

FUNDAMENTAL QUESTIONS/CHALLENGES

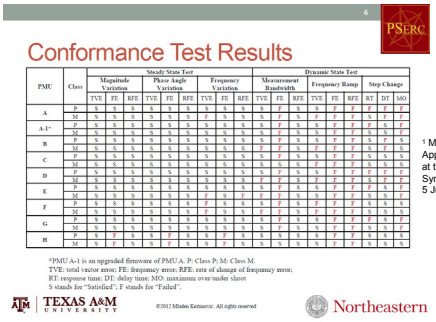


Accurately compare synchronized measurements at distant points



Refining system models – observed vs. simulated conditions

- Substantially reduce PMU costs (which now are well over $1,000 per device).
- Improve PMU performance to meet next-generation synchrophasor measurement requirements.
- No PMU fully complies with established IEEE standards[1].



[1] Mladen Kezunovic, "Verifying Interoperability and Application Performance of PMUs and PMU-enabled IEDs at the Device and System Level," North American Synchrophasor Phasor Initiative Working Group Meeting, 5 Jun 12, Denver, CO.

RESEARCH PLAN

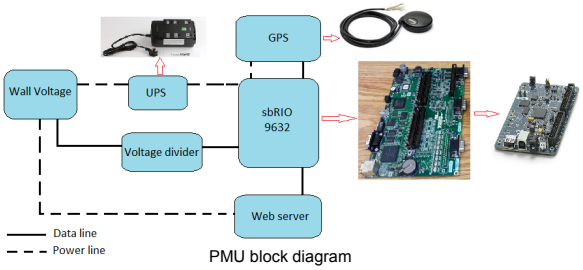
- Complete PMU integration with an uninterruptible power supply (UPS), enabling synchrophasor data collection during power interruptions.
- Explore next-generation PMU device requirements.
- Develop and implement new algorithms for next-generation PMUs.

BROADER IMPACT

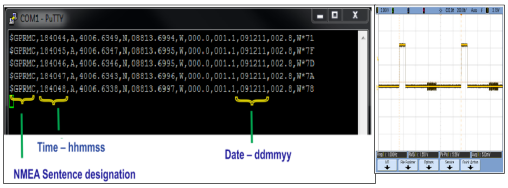
- Gain detailed understanding of PMU measurement challenges, supporting overall synchrophasor data quality activity research.
- Substantially reduce PMU per-unit cost to ~$250.
- Install low-cost PMUs supporting distribution system research.

RESEARCH RESULTS

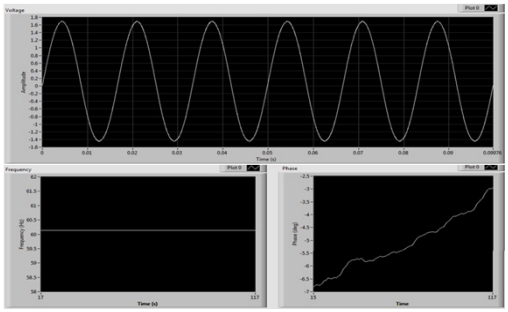
- Wall voltage sampled at 10 kHz; computes 10 phasor data sets/sec.
- Synchrophasor timestamp is derived from GPS timing signal/data.
- Data are buffered and transferred each hour to a remote Linux web server via FTP connection.
- Standalone PMU implemented on NI's sbRIO-9632.



PMU block diagram



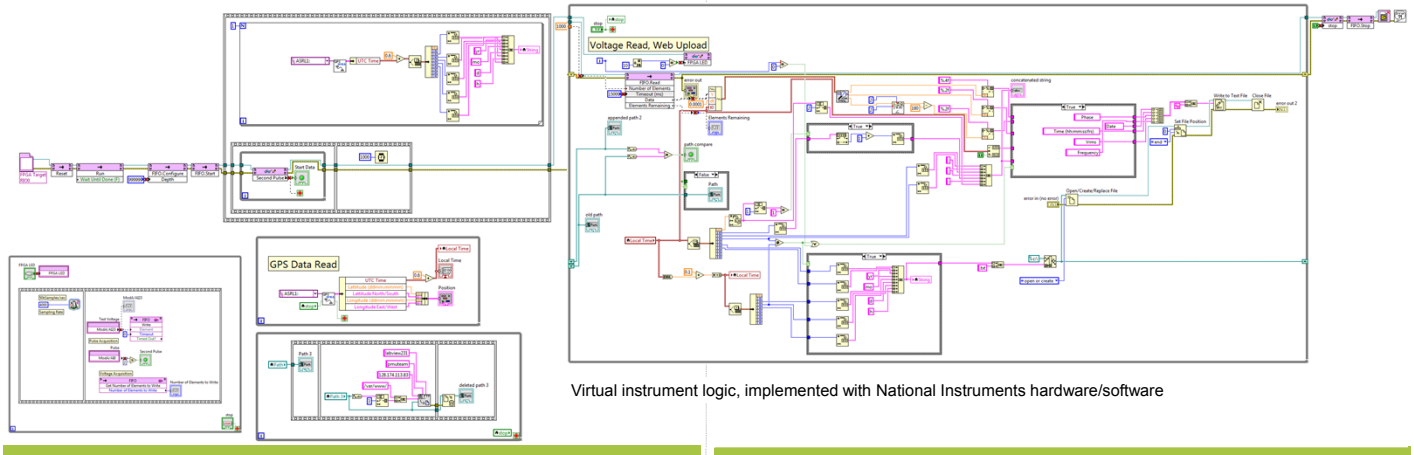
GPS time data (left) and second pulse (right)



Voltage, frequency, and phase data

Date	Time	Phase	Vrms	Frequency
08/09/13	7:0:1:900000	62.14	125.15	59.9910
08/09/13	7:0:2:000000	61.79	125.15	59.9922
08/09/13	7:0:2:099999	61.51	125.15	59.9927
08/09/13	7:0:2:199999	61.24	125.14	59.9908
08/09/13	7:0:2:299999	60.91	125.15	59.9930
08/09/13	7:0:2:399999	60.69	125.15	59.9924
08/09/13	7:0:2:499999	60.41	125.08	59.9904
08/09/13	7:0:2:600000	60.09	125.08	59.9935
08/09/13	7:0:2:700000	59.81	125.08	59.9917
08/09/13	7:0:2:800000	59.53	125.09	59.9902
08/09/13	7:0:2:900000	59.17	125.12	59.9919
08/09/13	7:0:3:000000	58.86	125.16	59.9905
08/09/13	7:0:3:099999	58.53	125.16	59.9916

Sample synchrophasor data stream for upload to a web server



Virtual instrument logic, implemented with National Instruments hardware/software

INTERACTION WITH OTHER PROJECTS

- Apply the experience and insights gained to investigate synchrophasor data quality in real-world power systems.
- Provide our PMU to the TCIPG testbed to assess vulnerabilities to GPS signal spoofing.

FUTURE EFFORTS

- Improve our PMU's performance to fully comply with IEEE standards.
- Implement security measures to safeguard data (e.g., encryption).
- Apply knowledge gained to improve synchrophasor data quality.

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