



## SynchroPhasor Technology Reference List

This collection identifies many useful recent synchrophasor resources from NASPI, industry, and academia. Here you will find a list of standards, current working groups, synchrophasor webinars, synchrophasor technology information and best practices, testing and certification of PMUs and much more. For the electronic version of this file visit the NASPI web site ([www.naspi.org/documents](http://www.naspi.org/documents)).

### DOE SGIG and Synchrophasors

- PMUs and Synchrophasor Data Flows in North America as of October 2014 ([PDF 219KB](#)).
- [Factors Affecting PMU Installation Costs, September 2014](#).
- [Recovery Act Smart Grid Investments Synchrophasor Project Status, June 30, 2014](#)
- [Synchrophasor Technologies and their Deployment in the Recovery Act Smart Grid Programs](#)
- [Model Validation Using Synchrophasors – NASPI Technical Workshop, October 2013](#)
- [Phasor Tool Visualization – NASPI Technical Workshop, February 28, 2012](#)
- [Synchrophasor Technology and Renewables Integration – NASPI Technical Workshop, June 7, 2012](#)
- [Synchrophasor Applications in Transmission Systems](#)

### Useful Synchrophasor Technology Information and Best Practices

- NASPI Synchrophasor Technology Fact Sheet, October 2014 ([PDF 417KB](#)).
- White A., & S. Jacobs, August 2014. "Use of Synchrophasors at Oklahoma Gas and Electric Company," ([PDF 1.3MB](#)).
- Galvan F. & P. Overholt, July 28, 2014. "[The Intelligent Grid Enters a New Dimension](#)." *Transmission and Distribution World*.
- Martin, K., July 21-25, 2013. [Synchrophasor Standards and Guides for the Smart Grid](#), from Power and Energy Society General Meeting (PES), 2013 IEEE.
- Martin, K., March 7, 2014, "Synchrophasor Characteristics & Terminology," ([PDF 754KB](#)) and Phasor System Design & PDC Characteristics ([PDF 782KB](#)), presented to ERCOT Synchrophasor Work Group.
- Data conditioning and validation reports prepared by the Electric Power Group
  - August 11, 2014 - Synchro-Phasor Data Validation and Conditioning Project Phase 2 Report on Demonstration of the Prototype for Data Validation and Conditioning ([PDF 1026KB](#))
  - May 10, 2014 - Real-Time Phasor Data Validation and Conditioning (PDVC) Phase 1, Task 3.3 ([PDF 884KB](#)).
  - April 26, 2014 - Synchro-Phasor Data Conditioning and Validation Project Phase 2, Task 1 Develop Error Simulation Utility ([PDF 1096KB](#)).
  - April 17, 2014 - Synchro-Phasor Data Conditioning and Validation Project Phase 1, Task 4 Review Meetings with Project Participants ([PDF 3182KB](#)).
  - March 21, 2014 - Synchro-Phasor Data Conditioning and Validation Project Phase 1, Task 3 Algorithms and Methods for Data Validation and Conditioning ([PDF 422KB](#)).
  - December 4, 2013 - Synchro-Phasor Data Conditioning and Validation Project Phase 1, Task 1 Report ([PDF 424KB](#))
  - August 14, 2013 - Synchro-Phasor Data Conditioning and Validation Project Phase 1, Task 2 Report ([PDF 542KB](#)).
- December 2013, "Synchrophasor Initiative in India" ([PDF 15.22MB](#)).
- DOE, "Synchrophasor Technologies and their Deployment in the Recovery Act Smart Grid Programs," August 2013 ([PDF 874KB](#)).
- Chow J., L. Beard, M. Patel, et al., June 2011, "Guidelines for Siting Phasor Measurement Units," ([PDF 680KB](#)).
- Boston T., M. Heyeck, and A. Mansoor, January 6, 2011, "[Phasor Measurements Go the Last Mile](#)," *Transmission and Distribution World*.



- Patel M., S. Aivaliotis, E. Allen, et al., October 2010. [NERC Real-Time Application of Synchrophasors for Improving Reliability](#).
- Becker D., May 2010, "[Harmonizing the International Electrotechnical Commission Common Information Model \(CIM\) and 61850 Key to Achieve Smart Grid Interoperability Objectives](#)," EPRI.
- Novosel D., V. Madani, B. Bhargava, V. Khoi & J. Cole, January-February 2008, "[Dawn of the Grid Synchronization](#)," *Power and Energy Magazine*, IEEE, vol.6, no.1, pp.49-60.
- Synchrophasor Technology Glossary of Terms ([PDF 325KB](#)).
- Phadke, A.G. & R.M. de Moraes, September-October 2008. "[The Wide World of Wide-area Measurement](#)," *Power and Energy Magazine*, IEEE, vol. 6, no. 5, pp. 52-65.
- [The IEEE Conformity Assessment Program \(ICAP\)](#).
- October 17, 2013, "North American Synchrophasor Initiative Report of Task Force on Testing and Certification Final Report," ([PDF 309KB](#)).

### NASPI Presentations

- Silverstein, A., March 2014, "Synchrophasor Technology and Human Performance in the Control Room," presented to NERC Human Performance Conference Workshop on Improving Human Performance and Increasing Bulk Power System Reliability ([PDF 873KB](#)).
- Silverstein, A., December 2013, "NASPI and Synchrophasor Technology Progress," presented to the NERC OC-PC Meeting ([PDF 3.31MB](#)).
- Silverstein, A., December 2011, "NASPI Update and Technology Roadmap," presented to the NERC Planning and Operating Committees ([PDF 1,509KB](#)).
- White, A. & S. Chisholm, June 2011, "SynchroPhasor Use at OG&E," presented to the NERC Operating Committee ([PDF 1,529KB](#)).
- Silverstein, A., J. Dagle & A. Johnson, June 2011, "NASPI Synchrophasors and Security," presented to the NERC Critical Infrastructure Protection Committee ([PDF 1,444KB](#)).
- Kosterev, D. & J. Undrill, June 2011, "Oscillations in Power Systems," presented to the NERC Operating Committee ([PDF 1,493KB](#)).
- Patel, M., June 2011, "Eastern Interconnection Wide Area SynchroPhasor Angles Baseline Study," presented to the NERC Planning Committee ([PDF 1,181KB](#)).
- Bilke T., March 2011, "SynchroPhasor Value to Operations," presented to the NERC Operating Committee ([PDF 4MB](#)).
- Kosterev D., March 2011, "Using Synchro-Phasors to Improve Dynamic Models of Electrical Loads," presented to the NERC Planning Committee ([PDF 741KB](#)).
- Johnson A., R. Bravo, & S. Robles, December 2010, "Operating the Grid Better with Phasor Data -- Understanding FIDVR," presented to the NERC Operating Committee ([PDF 619KB](#)).



### **NASPI Technical Workshops** (see also final technical reports listed in the SGIG section above)

- March 10, 2014, [NASPI PDC Configuration Workshop, Knoxville, TN](#)
- October 22, 2013, [NASPI Technical Workshop Model Validation Using Synchrophasor Data, Rosemont,](#)
- October 16, 2012, [NASPI 61850-90-5 Technical Report and Tutorial Workshop in Atlanta, GA](#)
- June 7, 2012 [NASPI-NREL Synchrophasor Technology and Renewables Integration Technical Report and Workshop – Denver, CO](#)
- Visualization, February 28, 2012, [NASPI Phasor Tools Visualization Technical Report and Workshop, Orlando, FL](#)
- IEEE-PES Tutorial - Synchrophasor Fundamentals, July 21-25, 2013, [Synchrophasor Fundamentals: from Computation to Implementation, IEEE PES General Meeting, Prof. Mario Paolone](#)

### **NASPInet**

- January 2010, "Use Case Report for NASPInet Data Bus and Phasor Gateway Specifications," v0.10 ([PDF 526KB](#)).
- May 2009 "Data Bus Technical Specifications for North American SynchroPhasor Initiative Network (NASPInet)," ([PDF 1,863KB](#)).
- May 2009, "Phasor Gateway Technical Specifications for North American SynchroPhasor Initiative Network (NASPInet)," ([PDF 2,000KB](#)).
- Chassin, D., R. Carroll & D. Bakken, July 2008, "NASPI Phasor Gateways and Their Relationship to Phasor Data Concentrators," ([Word 31KB](#)).
- Hu, Y. & M. Donnelly, June 2009, "Report on Final NASPInet Architecture Specifications," ([PDF 563KB](#)).
- Bobba, R., E. Heine, H. Khurana, & T. Yardley, "Exploring a Tiered Architecture for NASPInet," ([PDF 287KB](#)).

### **Synchrophasor-Related Webinars**

- Srivastava, A., May 6, 2014. Washington State University, PSERC Public Webinar: [Testing and Validation of Synchrophasor Devices and Applications](#).
- Myrda P. & S. Sternfeld, December 2013. Smart Grid Information Sharing Webcast: Synchrophasor Communications Infrastructure ([PDF 520KB](#)).
- Giri, J., October 11, 2012. [Enhanced Power Grid Operations with Synchrophasors](#).
- Biswas, S., Fundamentals of Synchrophasor Technology and Its Applications; [Lecture Module-1](#) -- Motivation for Synchrophasor Technology, [Lecture Module-2](#) -- Synchrophasor Fundamentals, [Lecture Module-3](#) - Synchrophasor Technology Applications, [Lecture Module-3a](#) -- An Example of a Real Time Voltage Stability Application – RT-VSM Tool, [Lecture Module-4](#) -- Synchrophasor Device (PMU) Testing.
- Elsayed, A., February 1, 2014, [Implementing IEEE C37.118 Synchrophasor Standard for Power Data Concentrators \(PDCs\) with Multiple Power Monitoring Units \(PMUs\)](#).
- Faris, T., [Synchrophasor Applications Using MATLAB](#).



<b>STANDARD AND GUIDES</b>	
These documents are accessible for a fee from the standards development bodies.	
IEEE C37.111-2013	<a href="#">IEEE/IEC Measuring relays and protection equipment – Part 24: Common format for transient data exchange (COMTRADE) for power systems</a>
IEC 61850-90-5	<a href="#">Communication networks and systems for power utility automation – Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118</a>
IEEE 1344-1995 (R2001)	<a href="#">IEEE Standard for Synchrophasors for Power Systems</a>
IEEE C37.118.1-2011	<a href="#">IEEE Standard for Synchrophasors for Power Systems</a>
IEEE C37.118.1a-2014	<a href="#">IEEE Standard for Synchrophasor Measurements for Power Systems -- Amendment 1: Modification of Selected Performance Requirements</a>
IEEE C37.118.2-2011	<a href="#">IEEE Standard for Synchrophasor Data Transfer for Power Systems</a>
IEEE C37.118-2005	<a href="#">IEEE Standard for Synchrophasors for Power Systems</a>
IEEE C37.238-2011	<a href="#">IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications</a>
IEEE C37.242-2013	<a href="#">Guide for PMU Synchronization, Calibration, Testing, &amp; Installation for Phasor Measurement Units (PMUs) for Power System Protection and Control</a>
IEEE C37.244-2013	<a href="#">IEEE Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring</a>
IEEE PC37.240	<a href="#">IEEE Draft Standard for Cyber Security Requirements for Substation Automation, Protection and Control Systems</a>
BS EN 60255-118-1	<a href="#">Measuring Relays and Protection Equipment – Part 195: Functional Requirements for Synchrophasor Measurements</a>

<b>PSRC Working Group</b>	
C4	<a href="#">Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring</a>
C5	<a href="#">Guide for Synchronization, Calibration, Testing, and Installation of Phasor Measurement Units (PMU) applied in Power System Protection and Control</a>
C19	<a href="#">Standard for Phasor Data Concentrators (PDC) for Power Systems</a>
C23	<a href="#">Coordination of Synchrophasor Related Activities</a>
H11	<a href="#">Revision of C37.118 Synchrophasor Standard Joint with IEC</a>
H21	<a href="#">Development of Standard Mapping between C37.118 and IEC61850-90-5</a>

### Related organizations

- [U.S. Department of Energy and Office of Electricity Delivery & Energy Reliability \(DOE-OE\)](#)
- [Consortium for Electric Reliability Technology Solutions \(CERTS\)](#)
- [Recovery Act Smart Grid Investment](#)
- [IEEE Power System Relaying Committee \(PSRC\)](#)
- [IEEE Cascading Failures Work Group](#)
- [Power Systems Engineering Research Center \(PSERC\)](#)