

DOE/OE Transmission Reliability Program

Synchrophasor Standards Development & Support

Kenneth Martin

 **E**lectric **P**ower **G**roup

martin@electricpowergroup.com

Allen Goldstein

allen.goldstein@nist.gov

June 3-4, 2014

Washington, DC



CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Introduction

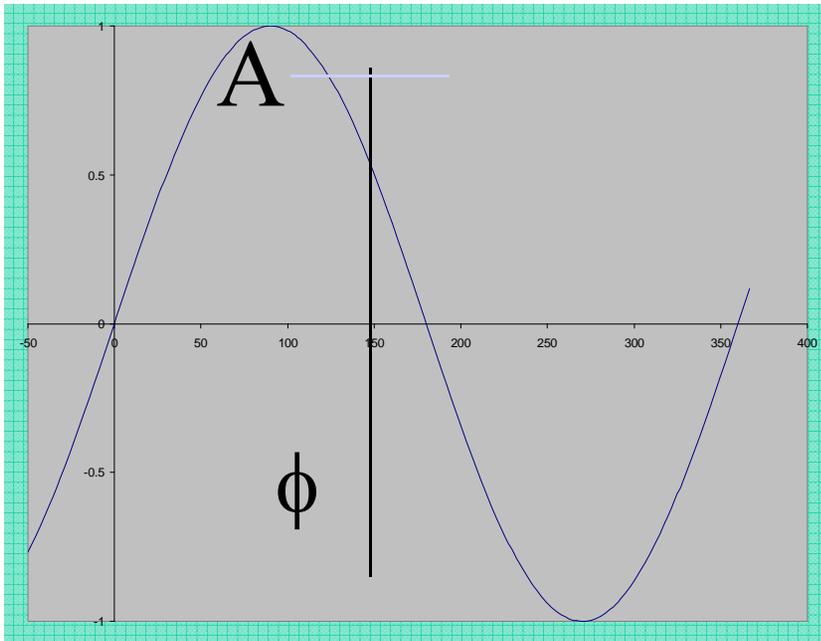
- Synchrophasor measurement systems widely deployed
- Enable a new generation of power system monitor & control capability
 - Improved power system analysis & system models
 - Wide area, high-resolution visibility
 - Basis for a new generation of controls
- Research challenge – standards to enable interoperability
 - Measurement performance
 - Standards compliance certification
 - Communications
 - Joint international standard revision
- Research focus – facilitate development, testing, and validation of standards to promote interoperability



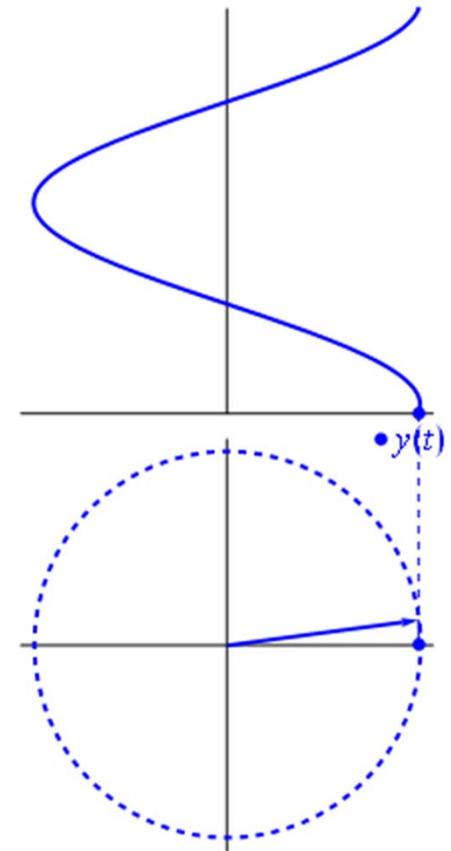
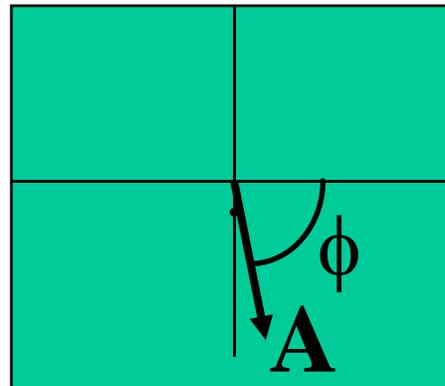
Basic phasor concept well known

A phasor is the complex form of the AC waveform

$$\sqrt{2} A \cos (2 \pi \omega_0 t + \phi)$$



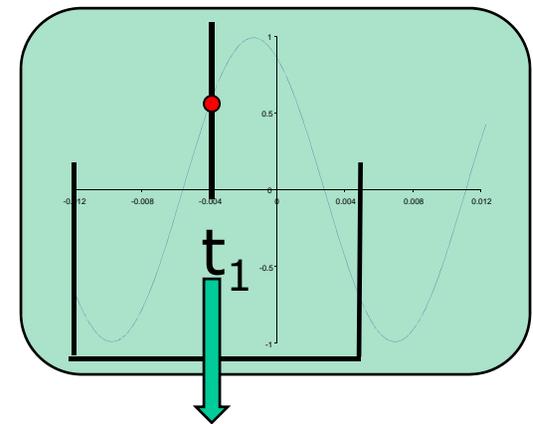
$$A e^{j\phi}$$



Synchrophasor value estimated from waveform depends on method

- Given waveform, what is the phasor?
 - There is no phasor in waveform
 - We cannot measure an instantaneous phasor
- Observe waveform over interval
 - The instantaneous phasor value at t_1 is estimated over an interval around t_1
- Estimate depends on sampling, window, algorithm, etc.
- **Standards assure measurement with bounded uncertainty**

Sample the given waveform:



Estimate the phasor over interval: $\mathbf{X}(t_1) = (X_m/\sqrt{2})e^{j\phi}$

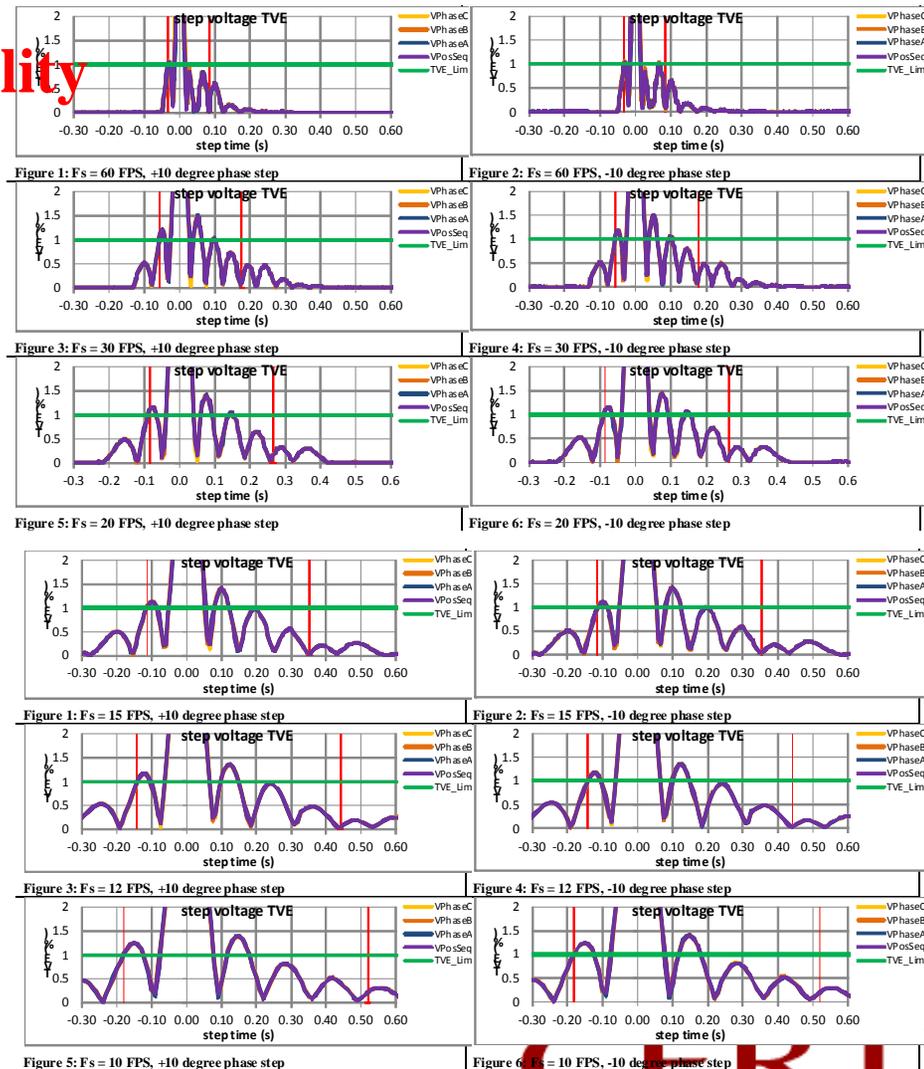


Need for standards

Standard analog transducers

Standards assure comparability

- Apparent response depends on:
 - Technology
 - Timetag options
 - Measurement window
 - Filtering

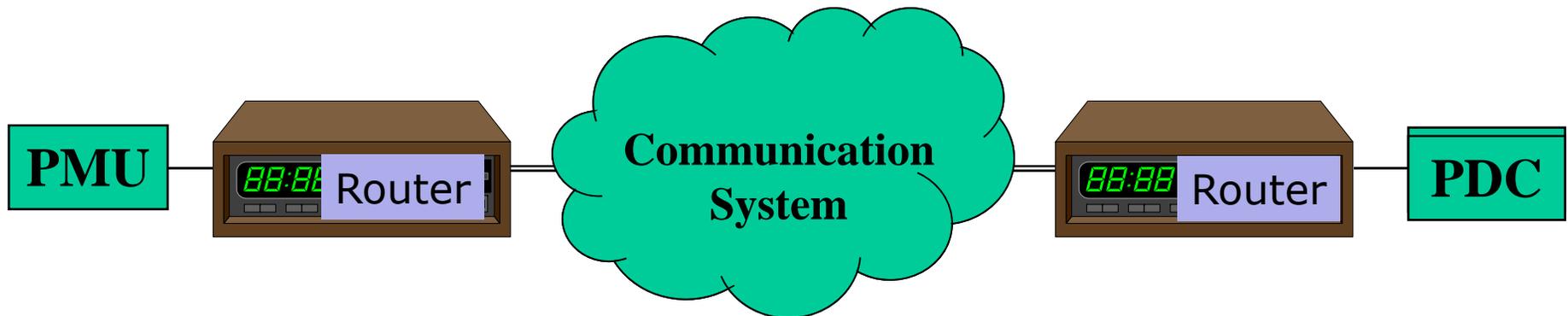


Time in samples (1/30 sec)

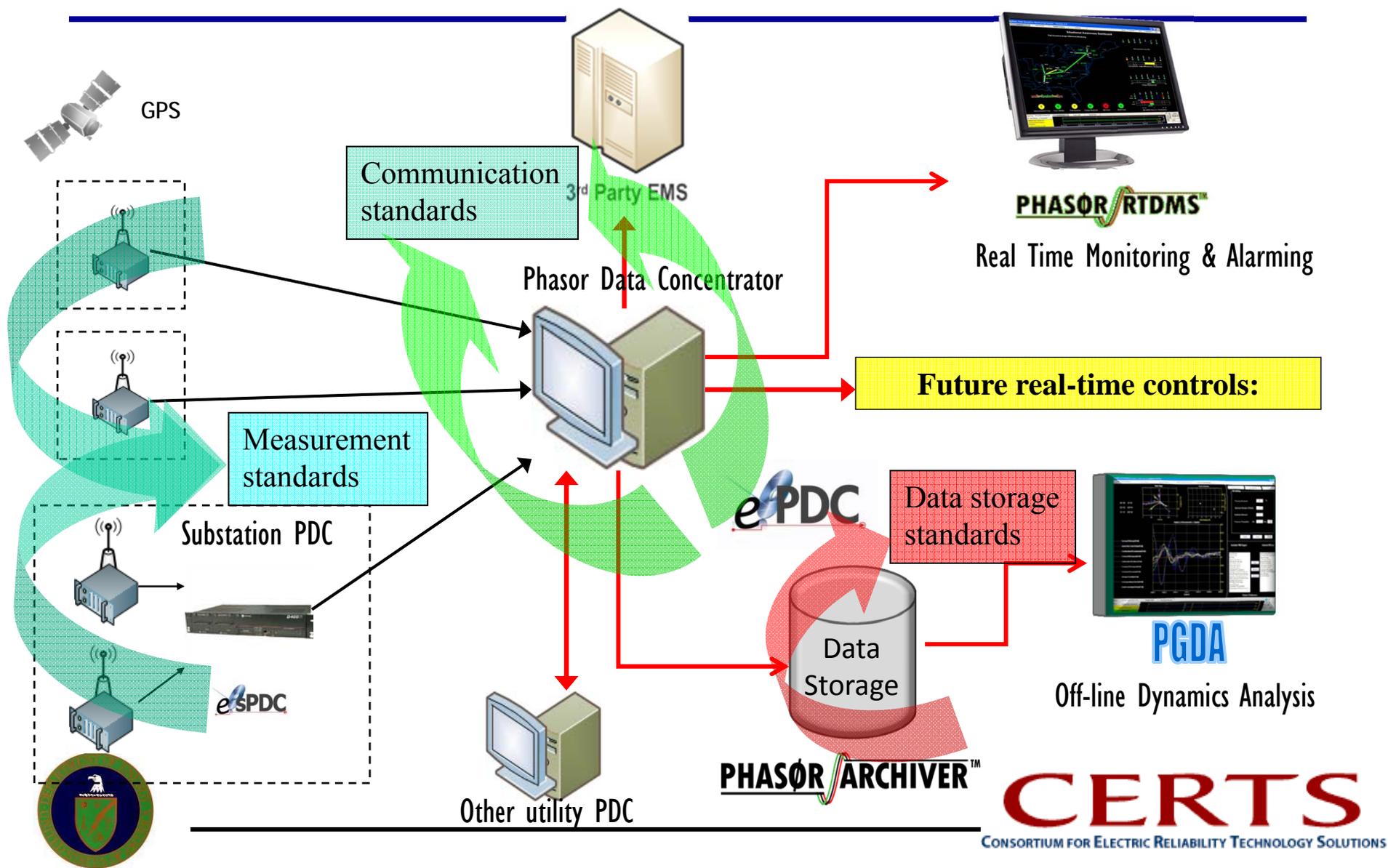
CLRTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Synchrophasor communications

- Interface connection & protocol
- Communication system (WAN)
- Messaging and contents
- End-to-end compatibility
- Standards assure common interfaces and protocols



Standards in Measurement Systems



Research need & project objective

- Extensive development of synchrophasor systems
 - Technology requires many systems for operation
 - Measurement technology new and developing
- Project objective
 - Develop & harmonize IEEE & IEC synchrophasor standards
 - Measurements, communications, & data storage
 - Support continuing technology development
 - Assess implementation issues for standards updates
 - Guides for synchrophasor applications
 - Provide standard & guide interpretations
 - Disseminate information about standards & guides



Synchrophasor Standards & Guides

- **C37.118.1-2011 – Measurement requirements**
 - Synchrophasor measurement including frequency and rate of change of frequency
- **C37.118.2-2011 – Synchrophasor communications**
 - Extension of the original synchrophasor standard (2005)
- **IEC 61850-90-5 – Phasor measurement communications**
 - Technical Report that adds wide-area capability for phasors
- **C37.242-2013 – Guide for PMU utilization**
 - Installation, testing, synchronization & measurement error issues
- **C37.244-2013 – Guide for PDC**
 - Definitions and functions used in PDC units



Current status

- Communication standards done
 - IEEE C37.118.2 widely used, no problems reported but some gaps exist
 - IEC 61850-90-5 some implementation, details under development
 - Standard bi-directional mapping between C37.118.2 and IEC 61850 90-5 under development
- Amendment IEEE C37.118.1a-2014 published
- IEEE Standard for PDC initiated in May 2013
 - Anticipate completion in 2016
- Joint IEEE-IEC standard development in progress
 - IEC TC 95 JWG1 / IEEE PES PSRC WG H11
 - New standard IEC/IEEE 60255-118-1 (estimated 2017/2018)



C37.118.1a-2014 amendment has been published

- Synchrophasor technology under development
 - Standard is defining the technology as it develops
 - C37.118.1 included the first formal definition for dynamic phasors and mathematical definitions for Frequency & rate-of-change of frequency (ROCOF) as related to synchrophasors
- Immediate issues have been resolved
 - Ramp test exclusion lengthened for M class filters
 - ROCOF limits relaxed or suspended
 - Filtering for M class improved for OOB & other tests
 - Modulation types separately tested for better evaluation
 - Reference frequency estimation method improved
- Publication date: April 30 2014



ICAP - SCASC

- IEEE Conformity Assessment Program (ICAP)
 - Follows the guidelines of the Smart Grid Interoperability Panel (SGIP) Interoperability Process Reference Manual (IPRM)
- ICAP Synchrophasor Conformity Assessment Steering Committee (SCASC)
 - Formed in 2012
 - Development of testing & certification program for PMUs
- Test labs may use different methods & get different results
 - Test Suite Specification assures that labs use identical test methodology
 - written in accordance with SGIP IPRM
- PMUs get certification to assure users of compliance



Other accomplishments for 2012-3

- New guides and standard updates previously described
- Each IEEE Working Groups completed an IEEE paper on the respective standards
- Presentations on synchrophasors & standards:
 - Tutorials at CBIP in Delhi, India , IEEE ISGT in DC, IEEE T&D in Chicago, and IEEE PES General Meeting at National Harbor, DC (July)
 - Synchrophasor assessment overview: NASPI in Oct 2013
 - Synchrophasor assessment lessons learned: NASPI in March 2014
 - Presentations at i-PCGrid
- Standards harmonization discussion with China synchrophasor group



Risk Factors

- Applications should dictate requirements
 - So far, requirements anticipate applications
 - Not enough applications with specific requirements
 - Joint IEC/IEEE Synchrophasor working group is seeking use cases and information about the requirements of the applications
- Development of divergent standards
 - C37.118 popular, 61850 widely used for other applications
- Proprietary methods outside of standards
 - Gives vendors marketing edge
 - Creates problems for users
 - But may be needed for “special applications” (e.g. distribution, forensics, DER, etc)



Follow-on for 2015

- Continue information exchange
 - Presentations at meetings, workshops, conferences, etc.
 - Solicit information from projects, technical development, other standards
- Continue standards development
 - Joint IEC/IEEE measurement standard
 - PDC standard
 - 61850 ↔ C37.118.2 mapping
- Develop guides for understanding standards
 - Propose a workshop for vendors on the measurement standard
- Develop PMU performance certification program



Questions?

