Advanced Sensors for Calibration & Testing

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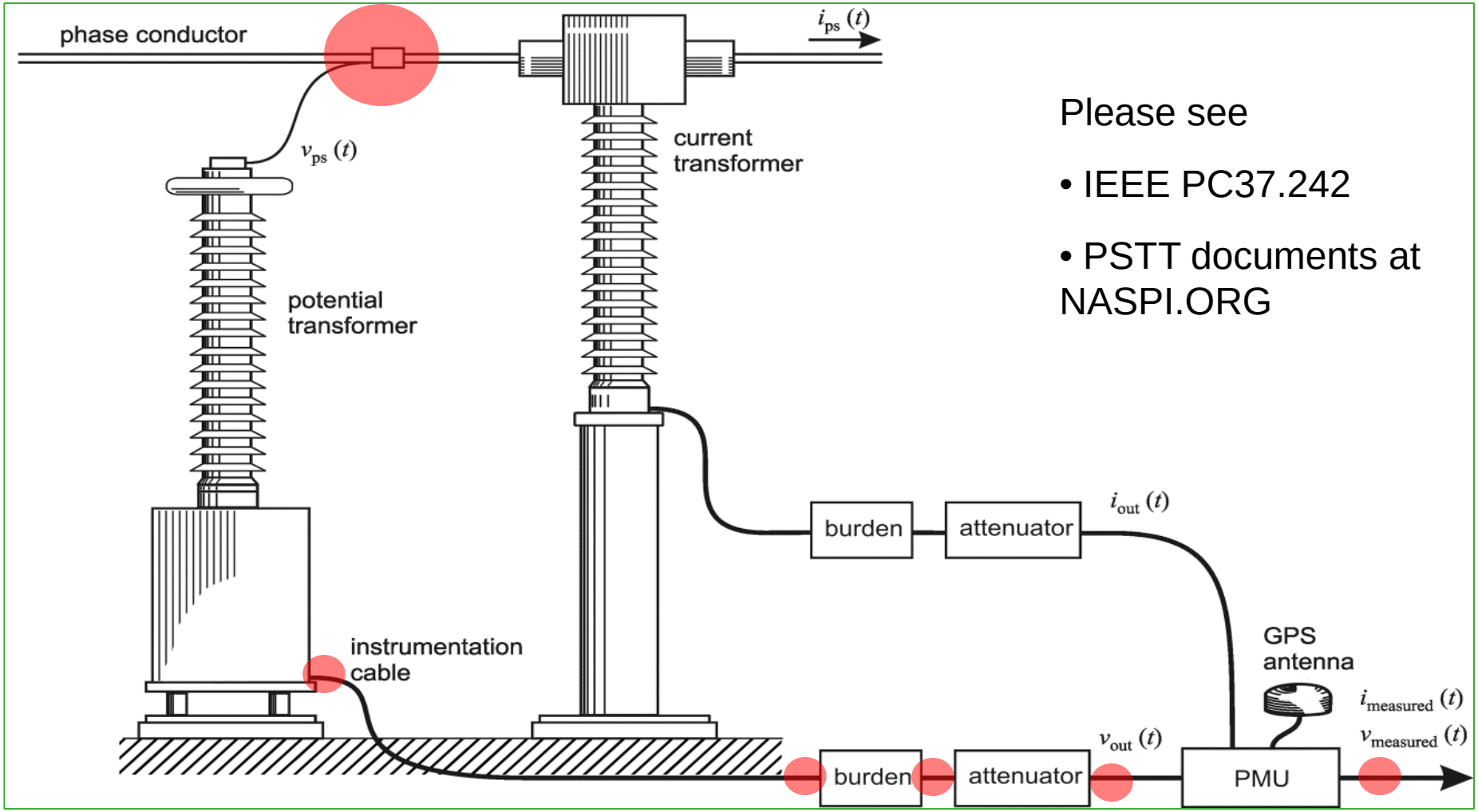
Outline:

- Live voltage measurement at transmission voltages
  - Voltage Transformer Calibration - including Cabling
    - EMS/phasor measurement systems
    - Revenue metering verification/re-classification
  - HV Harmonics and Power Quality Measurements
  - Health Diagnostics
- Field accuracy issues
  - Measurement traceability
  - System accuracy

QUANTA TECHNOLOGY

The Measurement Chain



Please see

- IEEE PC37.242
- PSTT documents at NASPI.ORG

The IED (e.g., PMU) is only part of the measurement chain

Why to do Online Verification of Accuracy

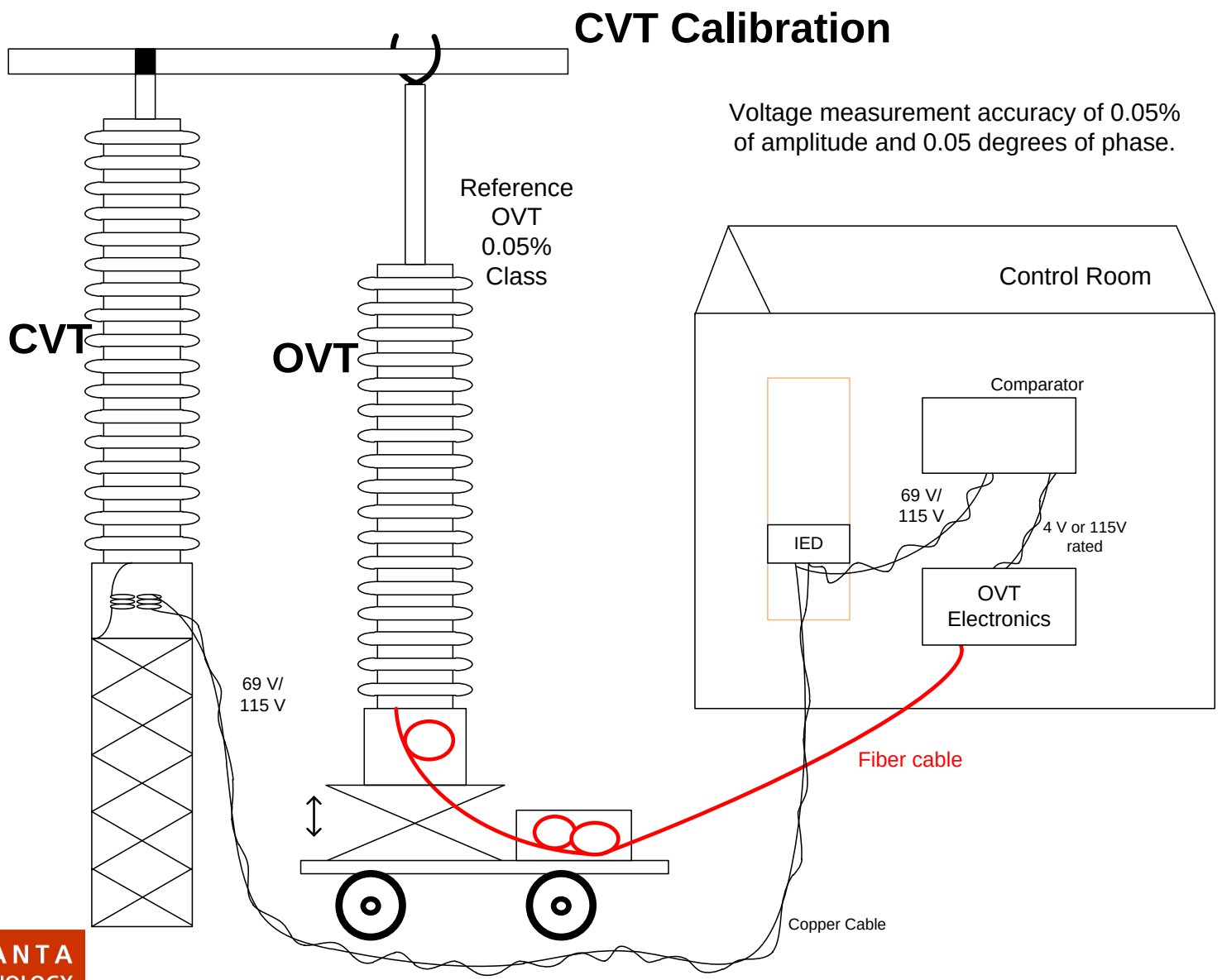
- By “Online” verification we mean no need for power outage.
- Various “applications” can benefit from accurate measurements
  - Revenue metering calibration and (re-) verification of instrument transformers
  - Synchrophasor applications requiring accurate measurement such as Congestion Management, Overload Monitoring with Dynamic Rating, State Estimation, System Model Validation and Fine-Tuning, Out of Step and SIPS (especially on shorter lines), operate better with more accurate data.
  - CVT health indication – significant safety benefit (CVT ratio drift is a prime indicator of CVTs aging and dielectric health)
  - Cost effective tool for system application validations
    - Substation State Estimator
    - Enhanced State Estimator
- Typical accuracy targets in the range of 0.2% to 5%
- Very low cost due to
  - **No power outage** required {Live connection to High Voltage}
  - Very quick and efficient – can verify all VTs in a substation in one day (2 technicians)

Example of Accuracy Requirements for Selected Wide Area Functions

- Phase accuracy requirements are divided into three general categories:
  L - Low: > 5 degrees, M - Medium: 1-5 degrees, and H - High: < 1 degree.
- Functions requiring high accuracy data would benefit significantly from calibration.

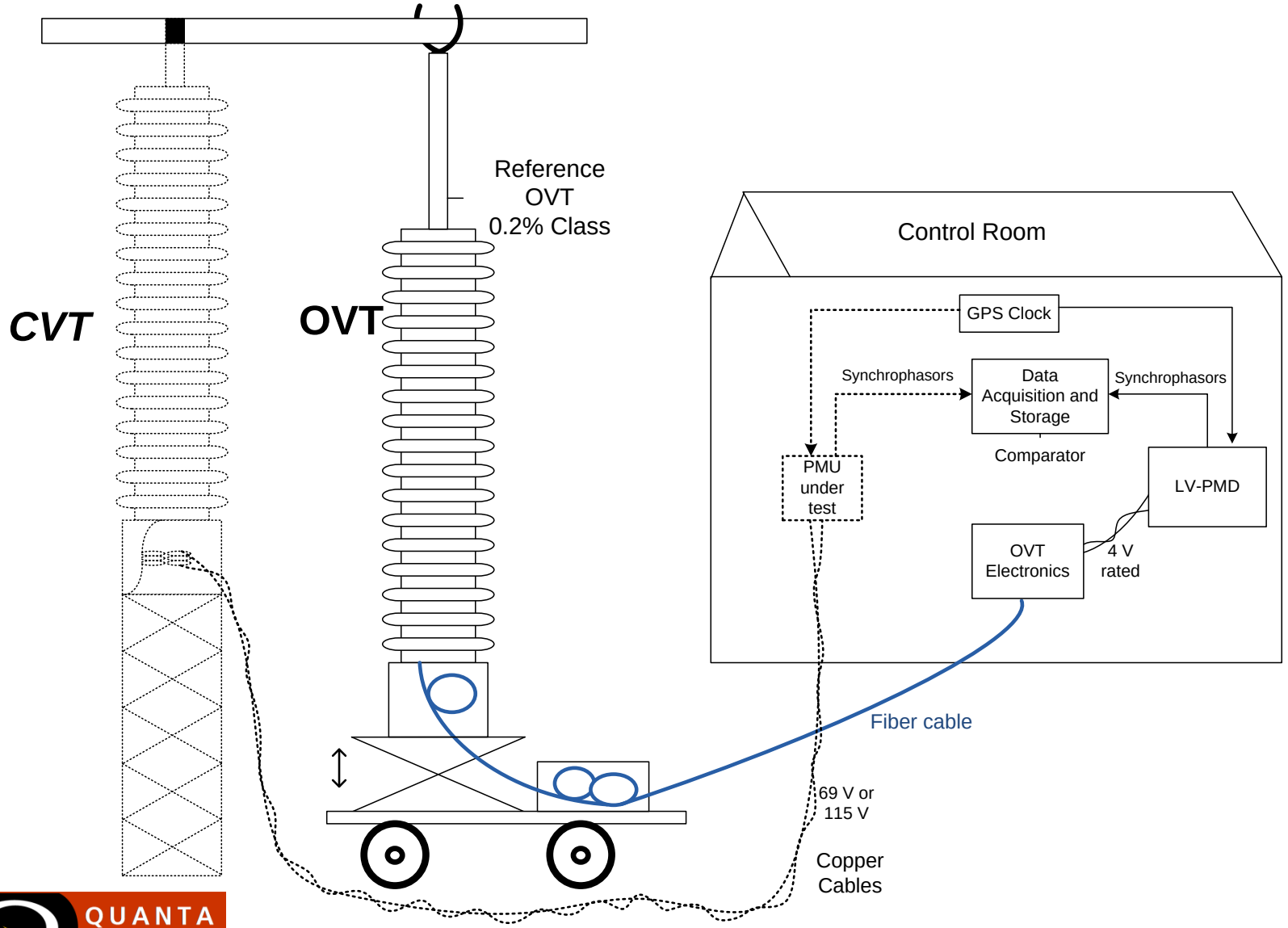
Function	Accuracy Requirements
Post-disturbance Analysis	H
System Model Validation and Fine-Tuning	H
Situational Awareness/Visualization	L
Power System Restoration	M
State Estimation (SE)	H
Angular Stability Monitoring and Control	H
Overload Monitoring and Dynamic Rating	H
Voltage Stability Monitoring and Control	L
Congestion Management	H
Distributed Generation Control	M
Real-Time Automated Control	M
Adaptive Protection	H
System Integrity Protection Scheme	H

CVT/VT Calibration – Analog Output



Voltage Phasor Calibration and Application Validation

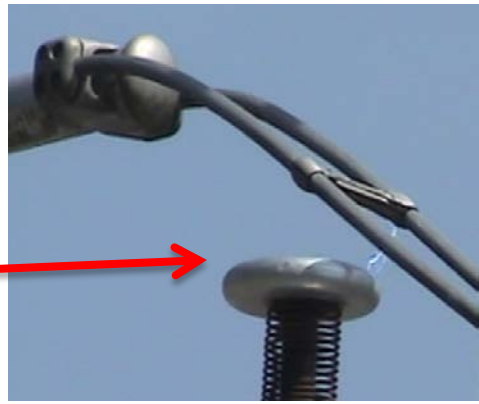
Syncrophasor / Application accuracy check



CVT or PT Calibration

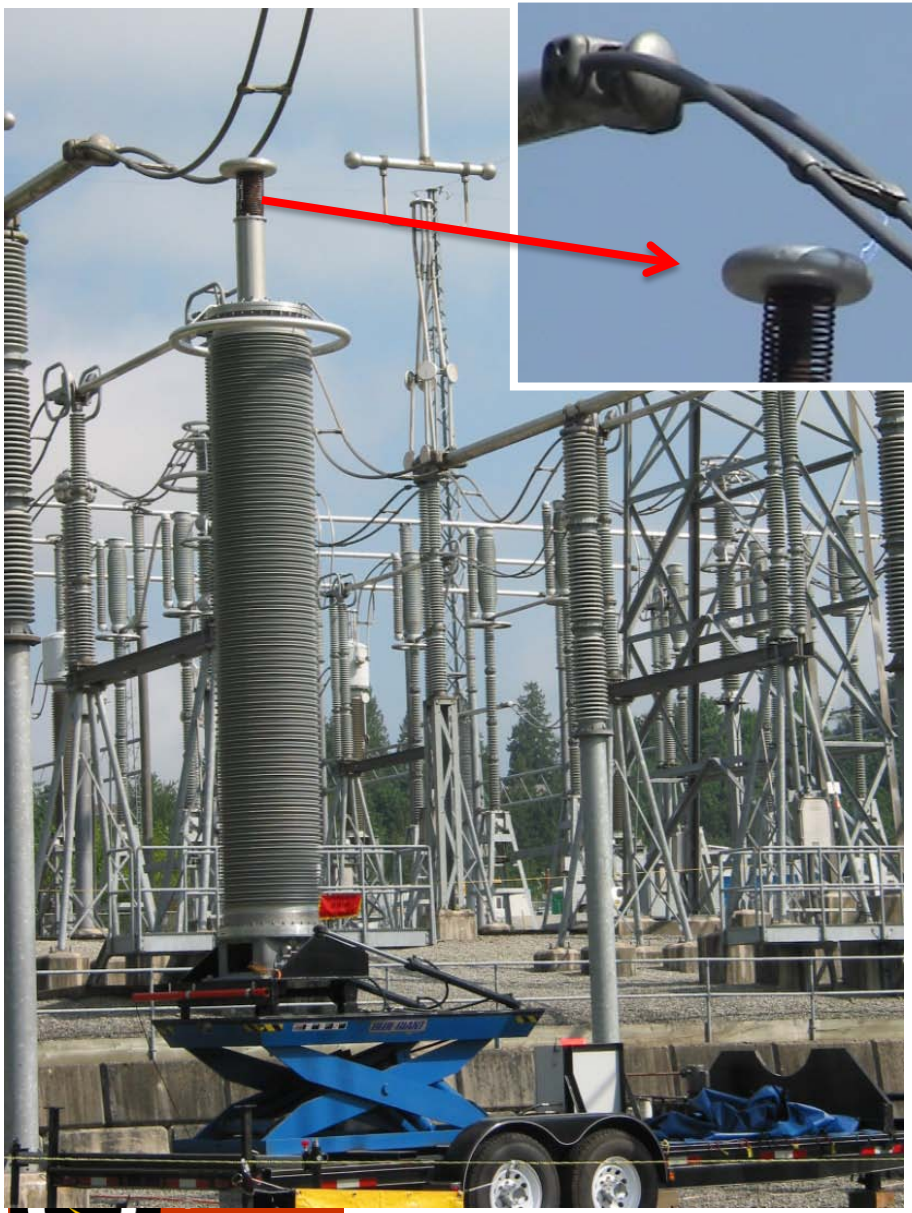
CVTs or PT under test

Ref. VTs connecting to HV line (live)



Electronic comparator (bridge)

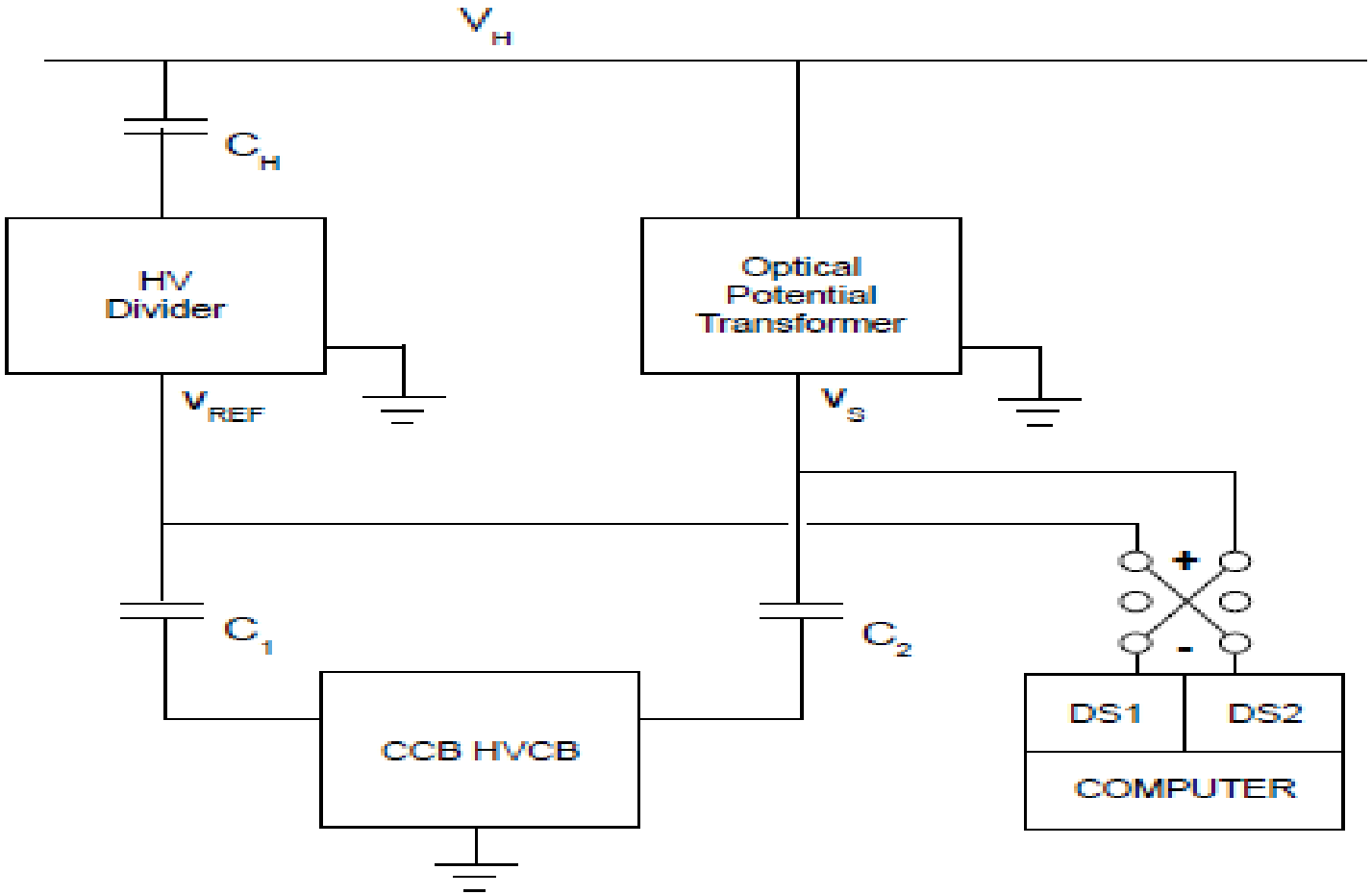
Live Connection of a Reference Optical VT



Live Voltage Measurement

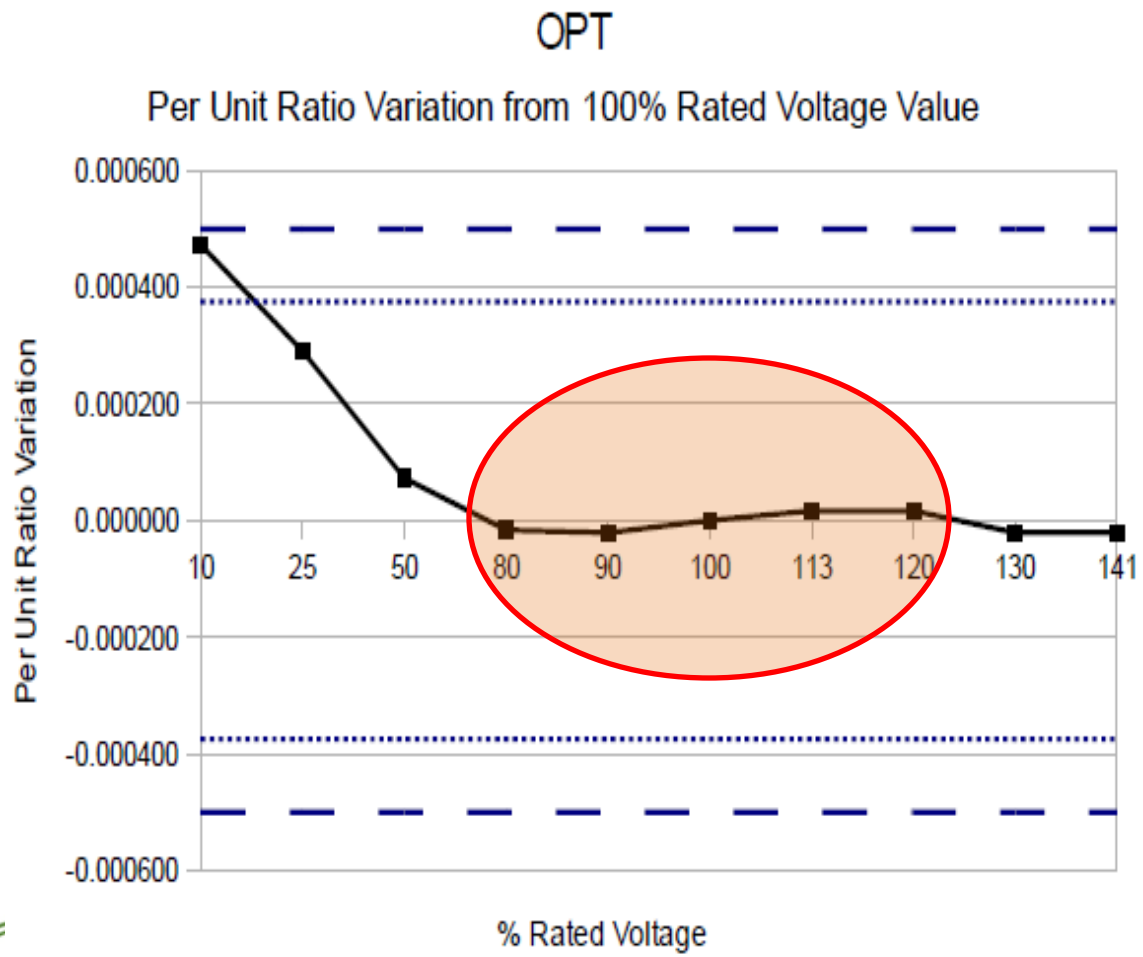
- Voltage Transformer Calibration
  - Revenue metering verification/re-classification
  - EMS and synchrophasor measurement systems
- CVT health diagnostics
- Transformer bushing / oil-filled CT insulation monitoring
- HV Harmonics and Power Quality Measurements

Qualifying the Test System: Calibration Circuit for OVT

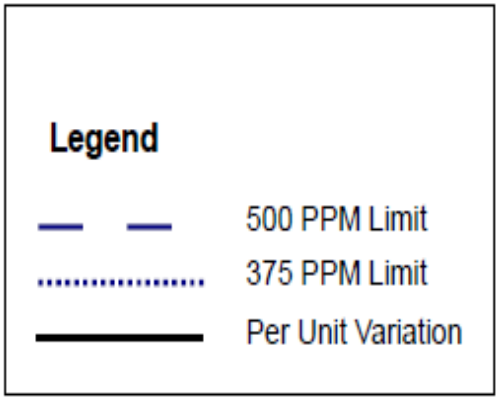


Calibration setup for OVT (OPT)

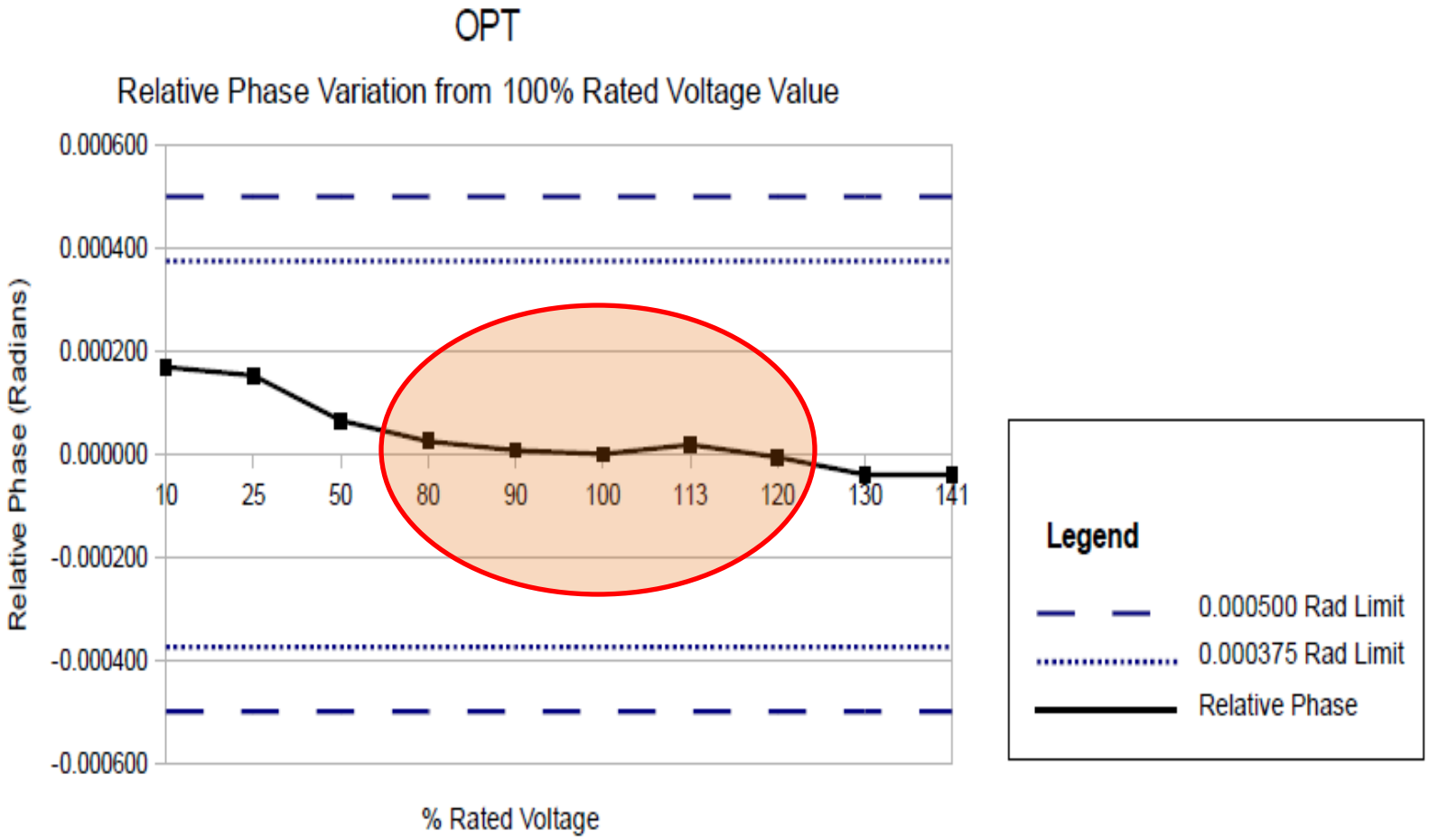
Calibration Results for OVT (OPT) Ratio Error



Better than **0.05% error** down to 10% of rated voltage.

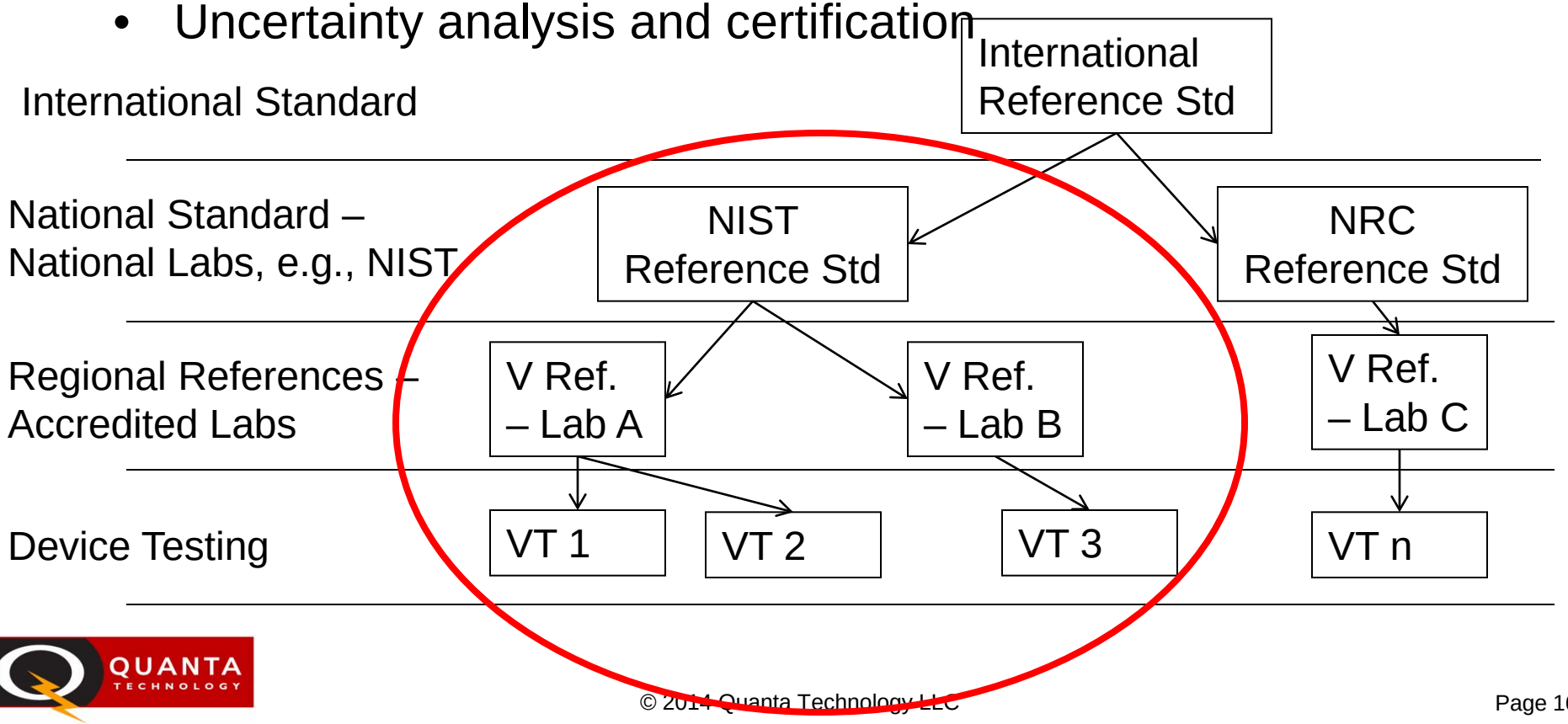


Calibration Results for OVT (or OPT) Phase Error



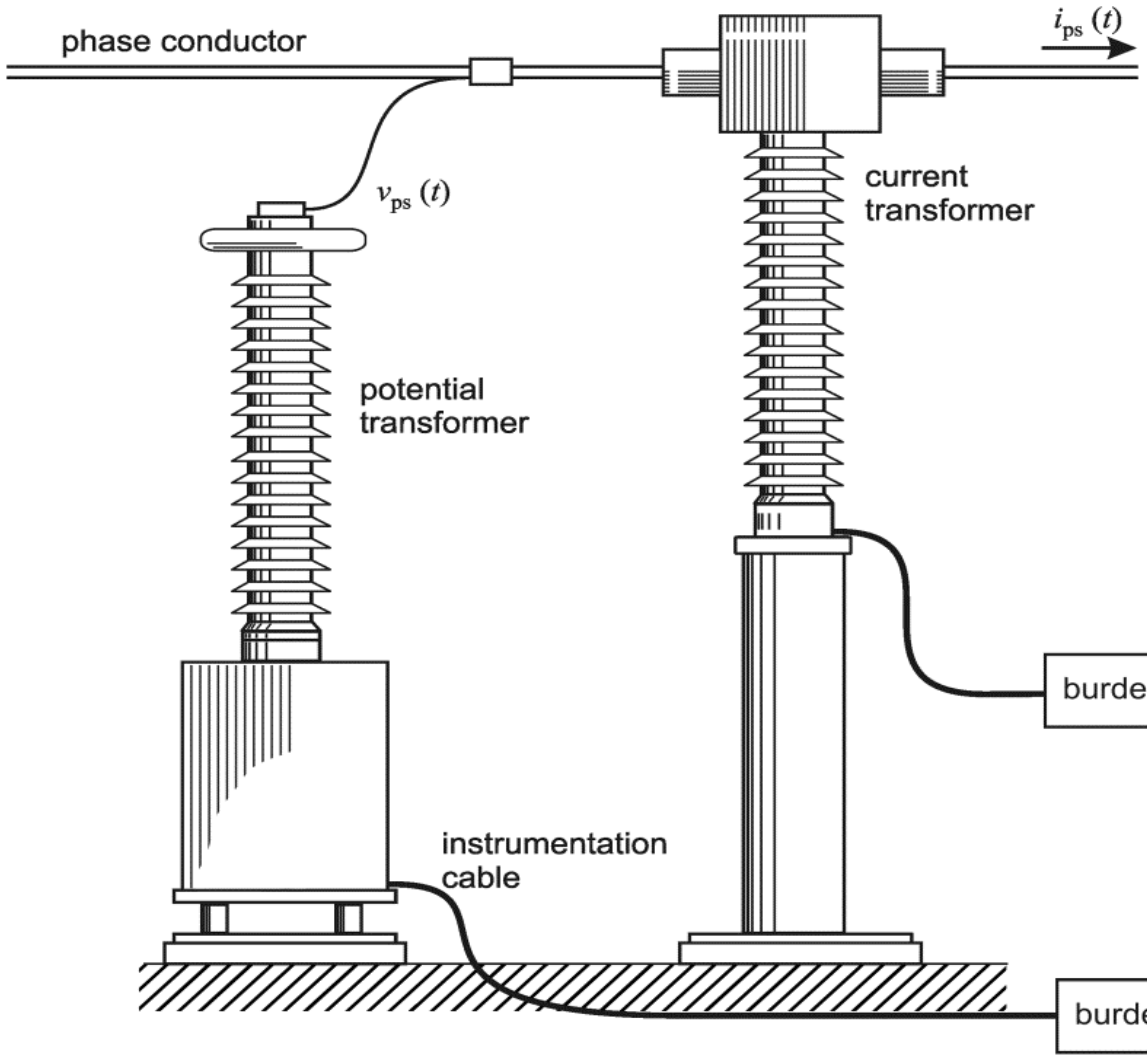
Calibration and Traceability

- Traceability is the basis for consistency
  - over time and geography
- Traceability
  - Unbroken Chain of Measurements Tracing Back to National and/or International Standards
  - Uncertainty analysis and certification



PMU Calibration vs. Synchrophasor Calibration

- The PMU is only part of the measurement chain
  - To achieve data accuracy need to calibrate the entire instrumentation chain



See

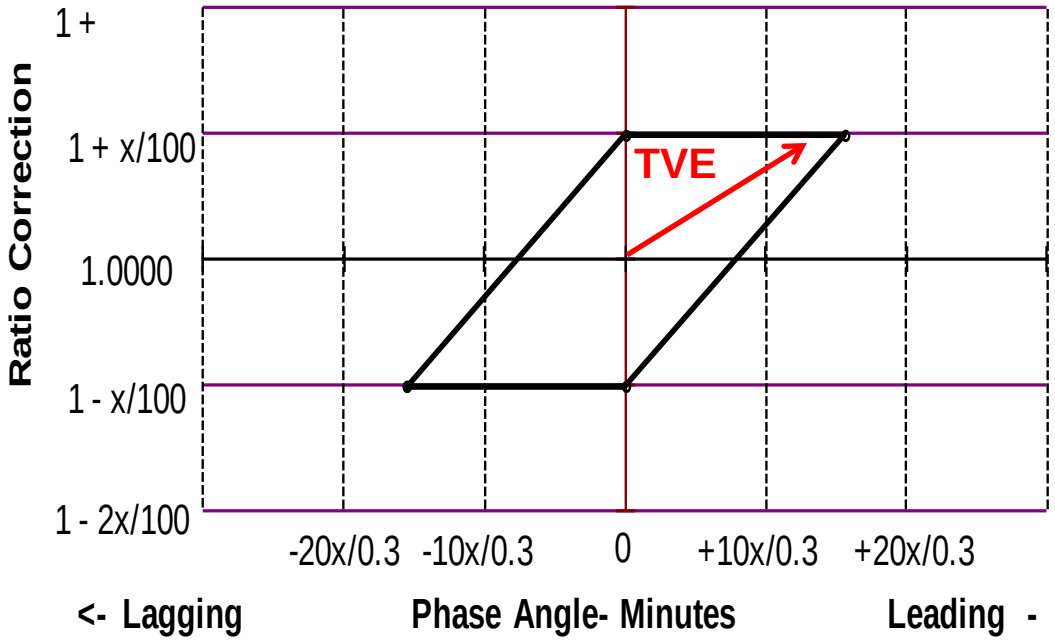
- PSTT documents at NASPI.ORG and
- IEEE PC37.242

Measurement Chain

- PMU Accuracy – 1% TVE
- Instrument Transformer accuracy classes
  - Accuracy at operating point versus accuracy class
- Cabling and burdens

CT Accuracy Class X

IEEE C57.13 or 1601



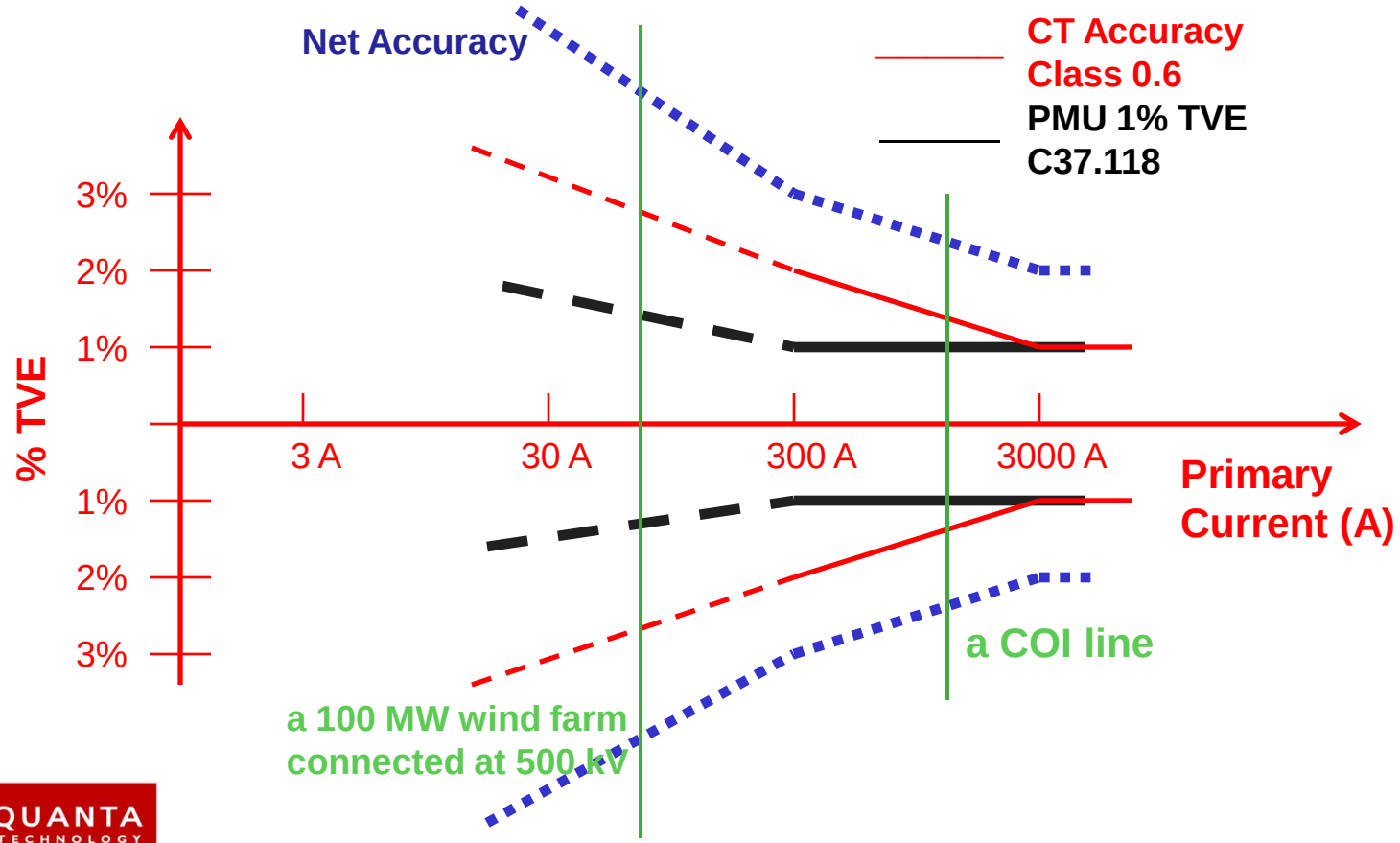
e.g.: Class 0.6 is equivalent to

- 1% TVE at rated current
- 2% TVE at 10% of rated current
- possibly more than 2% TVE below 10% of rated current (no requirements)

Measurement Chain Alignment

Example:

- PMU Accuracy – 1% TVE
- Instrument Transformer accuracy class 0.6, rated for protection application with rated primary current of 3000 A



Questions?

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