PMU Installation and Placement

Kyle Thomas
ET Operations Engineering
Dominion Virginia Power

October 14, 2015
PMU Installation

Architecture Design

- Stand-alone PMUs
- Dual-use PMUs
  - DFRs
  - Relays
  - PQ Meters
- Clock synchronization
- Data resolution

- PDC Architecture
  - Include substation PDC?
    - Local storage
    - Down-sample
    - Reduce open ports from substation
  - Central PDC
- CIP versus non-CIP determination
PMU Installation

Inside the substation control house

- **Wiring to the PMUs**
  - Connecting measurements:
    - Voltages (single phase vs. 3-phase)
    - Currents (single phase vs. 3-phase)
    - Digital signals (e.g., circuit breaker status)
    - Analogs
  - Communications
    - Ethernet, fiber, serial, etc.
  - Time Synchronization
    - Satellite clock, direct antenna, PTP, etc.

- **PMU Settings**
  - Standard setting templates

- **Phasor naming conventions**
  - Owner conventions versus ISO/RTO conventions
PMU Installation

Commissioning

• Commissioning is a key step to ensuring field installation is complete and correct
  • Connect PMU stream with stream reader
  • Capture and store small set of data to check (1 minute to 5 minutes)

• Items to validate:
  • Timestamps
  • PMU Status word
  • Phasor magnitudes
  • Phasor angles
  • Frequency & dfdt
  • Any digitals and analogs
PMU Placement Strategies

PMU locations can enable the use of applications and tools

- Place PMUs at locations critical to your system
  - EHV substations, then work on lower voltage levels
  - Critical flow paths
  - Grid interconnections
  - Nuclear plant interfaces
  - Unique system locations (FACTs devices, Arc furnaces, etc.)

- Real-time Applications
  - State Estimation
  - Oscillation Monitoring & Analysis
  - Inter-Area Mode Monitoring & Analysis
  - Angle Difference Monitoring
  - Blackstart and System Restoration
  - Remedial Action Schemes
  - Major Interfaces – IROLs & SOLs
  - Renewable Energy Resource Integration
  - Voltage Stability and Control
PMU Placement Strategies

Offline Applications

- **Generator Model Validation**
- **System Model Validation**
  - Large power plants and generating units
  - Dynamic reactive power resources (ex: FACTs devices)
  - HVDC terminals
  - Automatic controls such as Under-Load Tap Changers (ULTC), phase-shifting transformers, and switched shunt devices
- **Load Model Validation**
  - Cohesive load zones – capture aggregate load response
  - Major system loads – large industrial or block loads
- **Disturbance Monitoring & Event Analysis**
  - PRC-002-2
- **Frequency Response Analysis**
- **Distribution System Monitoring**
PMU Installation and Placement

• Optimize PMU Placement by finding any applications that utilize the same system locations

• PMU Standardization – rapid deployment, locations dependent on project locations

• Two great resources:
  • “Guidelines for Siting Phasor Measurement Units”, NASPI RITT
  • “Reliability Guideline: PMU Placement”, NERC Synchronized Measurement Subcommittee (SMS)
    ▪ Currently in progress