A Case for Multi-Function PMU

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PMU Definition

- **PMU is generally defined as:**
  - IEEE C37.118 compliant device
    - Time synchronized measurements
      - Voltages and currents
      - Frequency and rate of change of frequency
    - Real-time streaming of phasor values

IEEE C37.118 Requirements

- **Functional Requirements**
  - Measurements synchronized to UTC
  - Calculations of phasor values in real-time
  - Phasor value streaming at high rate
- **Measurement Accuracy and Response Requirements**
  - Accurate time stamp for measurements
  - 1% TVE (Total Vector Error) under specific conditions
  - Frequency accuracy 4 to 6 mHz over a specific range*
  - Steady state and dynamic response as defined in the standard*
- Members of IEEE PES PSRC H-11 WG are revising C37.118 to include these parameters for frequency accuracy and dynamic response testing for phasors.

PMU Requirements Not Recognized in C37.118

- Configurability
  - Selection of inputs, calculations and applications . . .
- Overall performance parameters
  - Filters, latency, application priorities . . .
- Data handling
  - Handling of data types with different attributes, time delays . . .
  - Access to and management of locally stored data
- Interoperability for Smart Grid infrastructure
  - PMU integration in a networked environment
  - Use of synchrophasors in substation applications

PMU Design Options

- Dedicated (stand-alone) device for phasor streaming
- Phasor streaming as an add-on function in a substation device such as a relay, recorder, meter, etc.
- Multifunction PMU as
  - A data acquisition device with generalized software that delivers synchronized measurements and various types of results (data) in real-time to serve the user-selected widest set of T&D automation applications

Multi-Function PMU Measurements

- Measurement Data Types in T&D Automation . . .
  - Time*
  - Point on the wave data
  - Phasors*
  - Calculated results*
    - Virtual channels such as V, I, P, Q, F, dF/dt
  - Events
  - Trigger markers

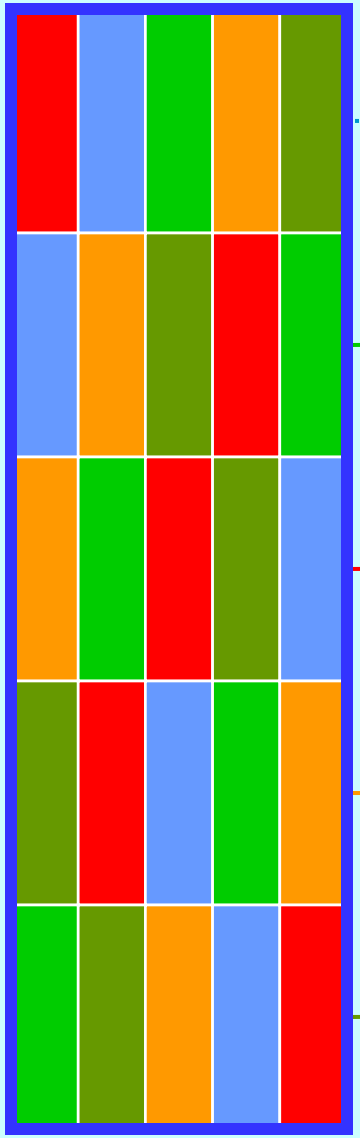
* IEEE C37.118 defines application of synchrophasor technology to one data stream consisting of these data types

Multi-Function PMU Data Streams and Applications

Multi-Function PMU

Data Types

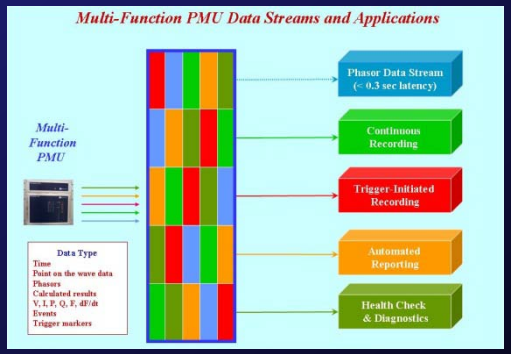
- Time
- Point on the wave data
- Phasors
- Calculated results
  - V, I, P, Q, F, dF/dt
- Events
- Trigger markers



- Phasor Data Stream (< 0.3 sec latency)
- Continuous Recording
- Trigger-Initiated Recording
- Automated Reporting
- Health Check & Diagnostics

Multi-Function PMU Data Acquisition

- Data streams are generated by measurements controlled by system firmware (collection rate, sequence, etc.)
- Data Streams
  - Logical grouping of data with common attributes
- Data Stream Sorting & Handling
  - Continuous (real-time pass through)
  - Trigger-initiated (initially recorded then transmitted)
  - Events (either or both of above)
- Data Output Options
  - As continuous stream
  - As file transfer of locally stored data
  - Data with selective delivery/retrieval



Mehta Tech's PMU Data Streams

- **Data stream management***
  - Multiple data streams
    - Multiple types, multiple streams of same type
  - Data stream configuration
    - Content and data rate
  - Storage of raw and processed data
    - Continuous and trigger initiated storage
  - Simultaneous communications
    - Streaming, file transfer, web interface

* Certain configuration rules apply

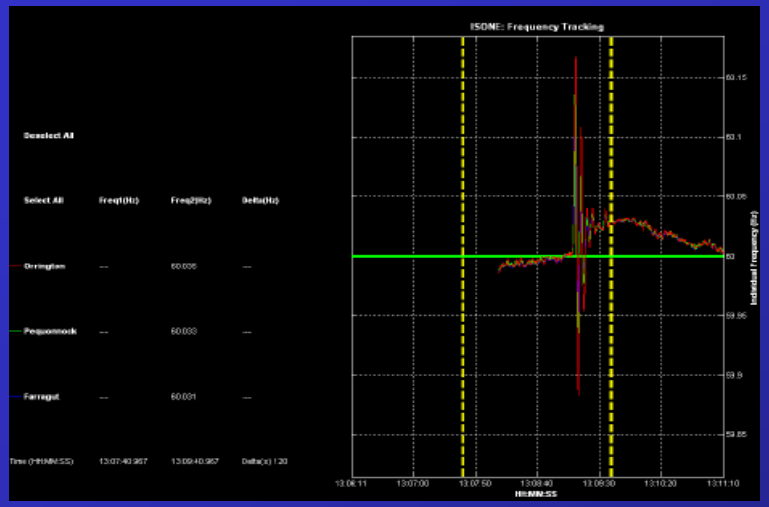
Mehta Tech's PMU
Resolves Issues Not Defined in C37.118

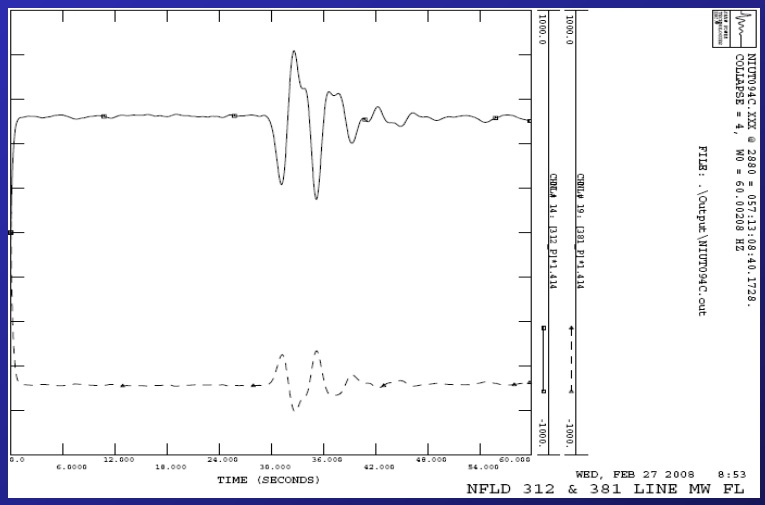
- **Architecture provides predictable response and versatile communication, enabling multiple independent applications**
  - Capability to extract the widest set of information
    - Application-driven successive phasor/data filters to differentiate between primary and secondary applications
    - Records of point on wave values for high resolution data
    - Sequence of events
  - Data streaming, file transfer as well as local storage of continuous and triggered records
  - Industry standard protocols and web interface

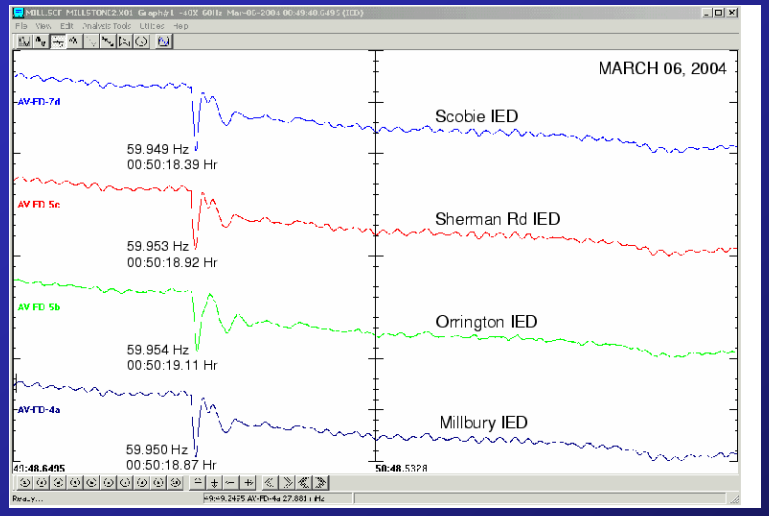
Mehta Tech's PMU Benefits

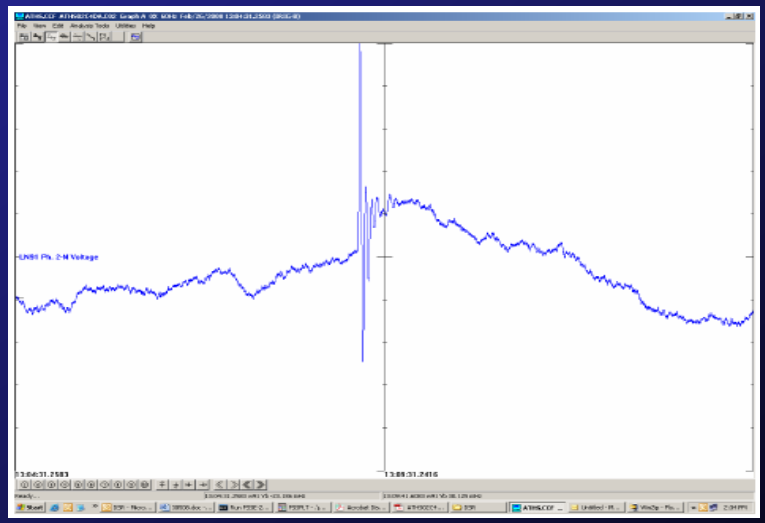
- **Comprehensive set of information from a single source**
- **Applications Served**
  - Comprehensive set of information for situational awareness and forensic analysis
    - Phasor measurement and streaming
    - Continuous Recording
    - Trigger-initiated fault, disturbance and sequence of events recording
  - NERC and Regional requirements satisfied
    - PRC-002 & PRC- 018 and other standards

PMU Measurement Examples



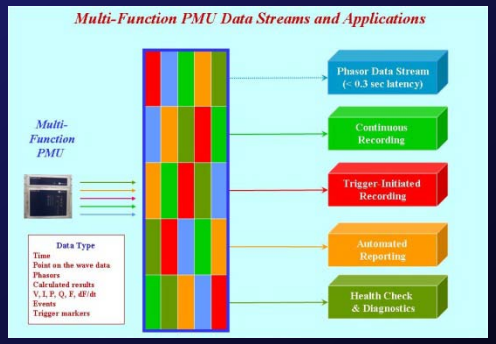






Summary

- Multi-Function PMU delivers the most comprehensive deployment of synchrophasor technology
- Mehta Tech's multi-function PMU
  - Meets C37.118 requirements while resolving many issues not addressed in C37.118
  - Offers interoperability for Smart Grid integration
  - Provides configurability, upgradability and responsiveness using patented product architecture for data stream management



Thank You!

Questions?