



The logo for NIDays Engineer Next is centered on a blue background with diagonal stripes. It features the text "NIDays" in white inside a white rectangular box, followed by the words "ENGINEER" and "NEXT" in large, bold, white capital letters. A yellow graphic element, resembling a stylized arrow or a series of parallel lines, is positioned between "ENGINEER" and "NEXT".

NIDays
ENGINEER
NEXT



Komplexní systém pro monitoring fázorů a kvality
elektriny v přenosové soustavě Slovenské republiky

Phasors and Power Quality Monitoring in Czech
and Slovakia Grid

ELCOM, a.s.

Dr. Daniel Kaminský, Dr. Jiří Hula

ELCOM Corporate Overview

- **Founded in 1990 in the Czech Republic**
 - Core Business: Electrical Engineering and Instrumentation
- **Five divisions with total 170 employees**
 - Applied Electronics
 - Drives and Motors
 - Design and Deployments
 - Virtual Instrumentation
 - Manufacturing
- **Annual revenue 350mil CZK**
- **Company rating by D&B is 1A2**
- **Target industries**
 - Power Generation, Distribution and Transmission
 - Test and Measurement, Automotive,
 - Electronic Components Manufacturing
 - Chemical and Pharmaceutical
 - Water Supply



Virtual Instrumentation Division Focus

- **Division started in October 1997**
 - Spin-off from Technical University of Ostrava
 - 90 employees
 - Annual Revenue 8mil USD
- **Core business: Test and Measurement Engineering**



- **Ready-to-run solutions**
 - Production testers for electrical and optical tests
 - Laboratory testers
 - Assembly lines
- **Products**
 - Portable power quality analyzers
 - Power quality analyzers for permanent installations
 - PMUs, WAM systems
 - Distributed systems for power quality monitoring
 - Vision components
- **Design and development services**
 - Instrument drivers and firmware applications
 - End user software for test and measurement automation
 - SCADA
 - Customs mechanical components



Challenge

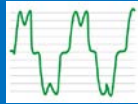
- Design and develop platform that is flexible in terms of SW deployment to different product models and that is open for adding new personalities
- Deploy the platform in large distributed monitoring systems at distribution and transmission companies

Energy Monitoring – Layers of Complexity



Global Measurements systems for Phasors monitoring(WAMS)

International Level, Transmission Grid



Large Distributed PQ Monitoring

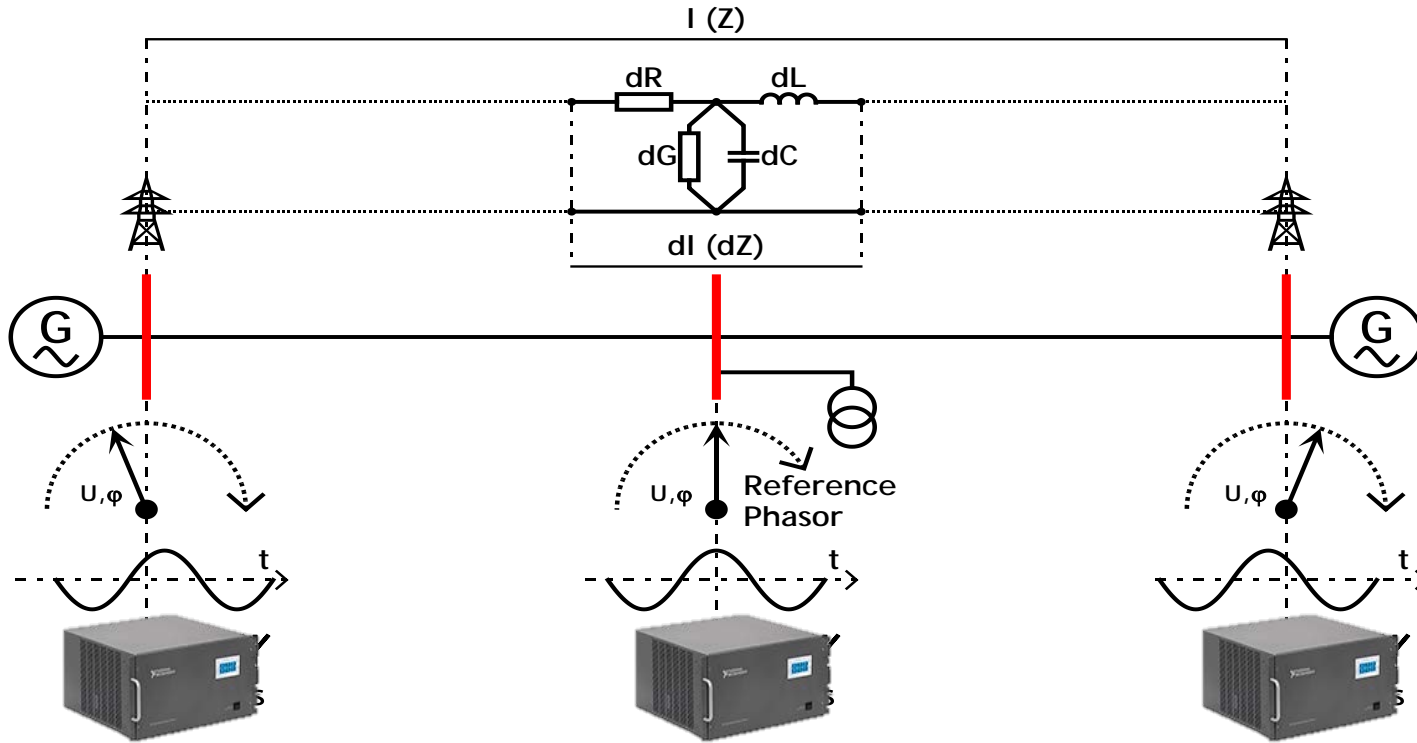
National Level, Points between Distribution and Transmission Grids



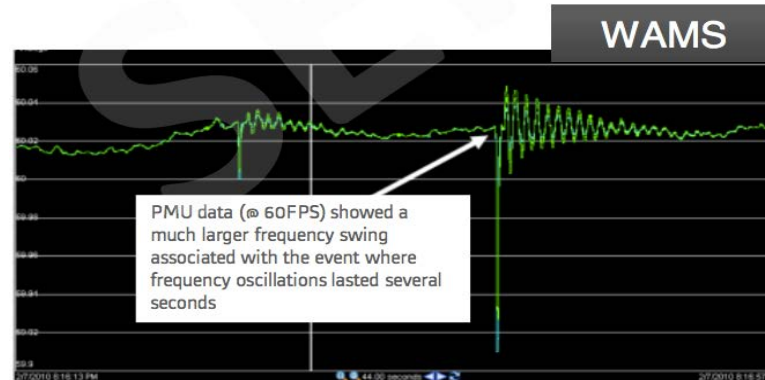
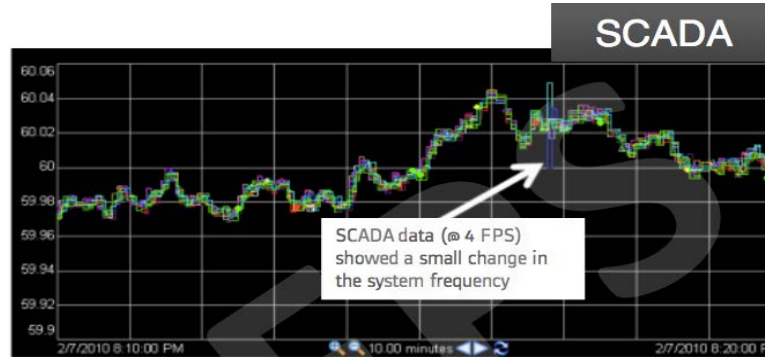
Detailed Energy Monitoring on Manufacturing Plants

Local Distribution Grids

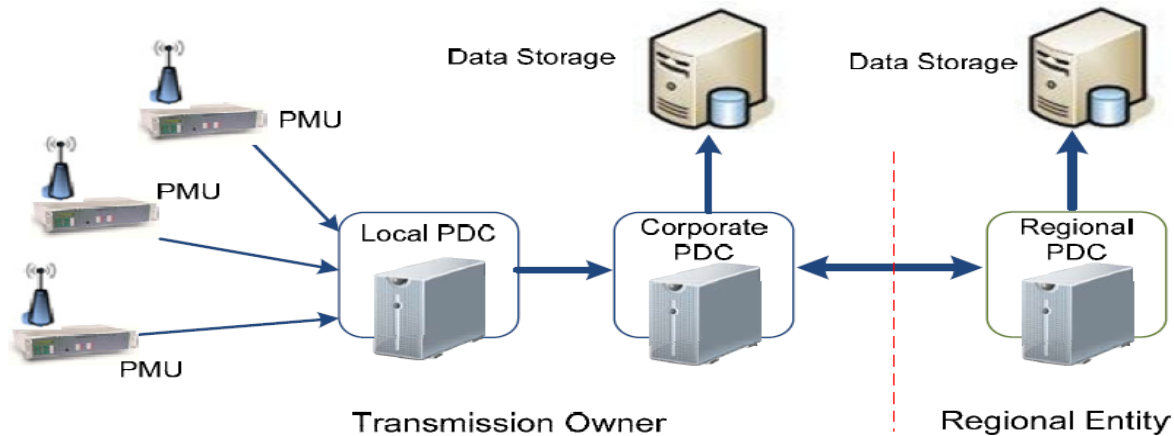
Synchronous Phase Measurements



SCADA versus WAMS



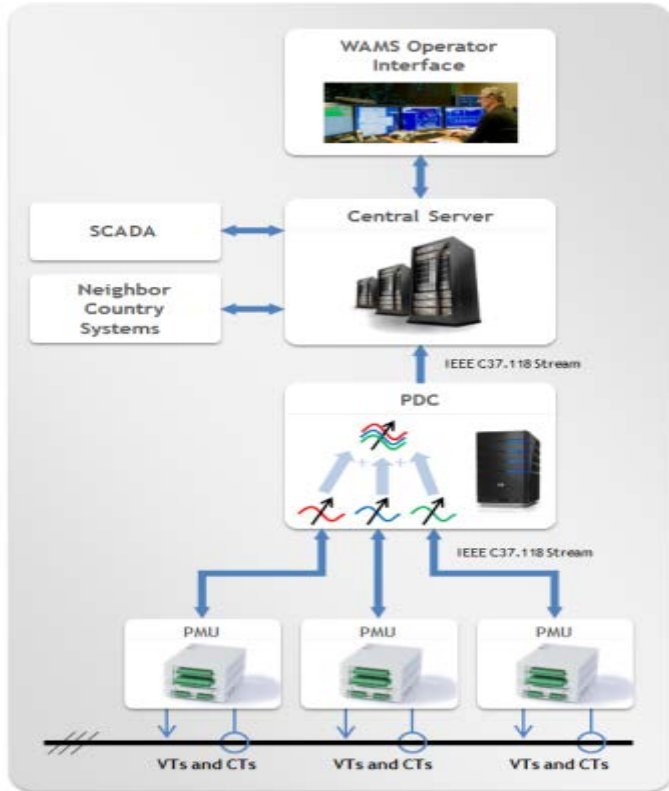
Typical PMU System Architecture



- **Defined by IEEE standards**
 - Measurement: C37.118.1
 - Communication: C37.118.2 and IEC 61850-90-5
 - Installation and Calibration: C37.242

Source: IEEE C37.118/2011 standard

Wide Area Monitoring System



WAMS Operator Interface

WAMS Central Server

Phasor Data Concentrators (PDCs)

Phasor Measurement Units (PMUs)

WAMS for SEPS Project Overview

- **Slovak TSO**

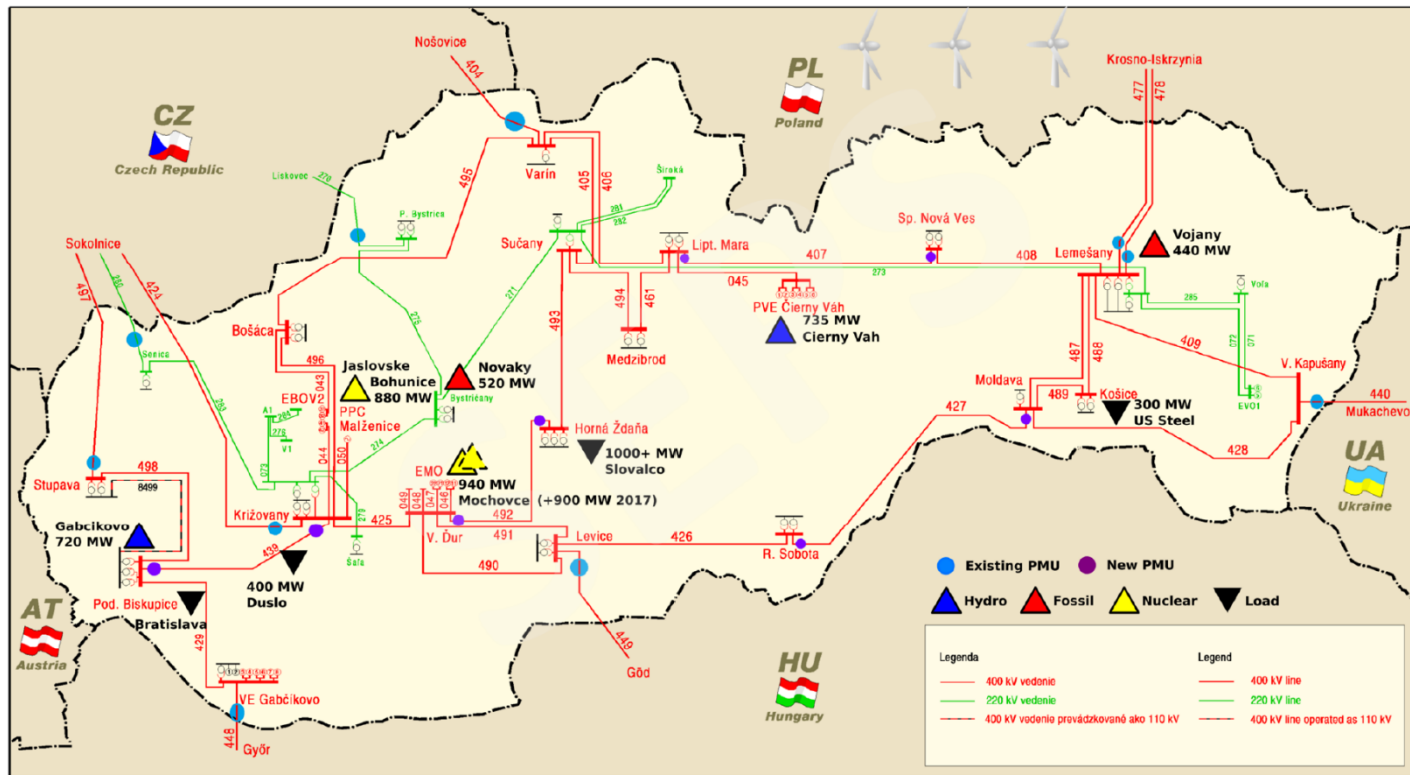
- 400 kV 1 951km
- 220 kV 832km
- 110 kV 79,8 km
- Transmitted Electricity 28,3 GW



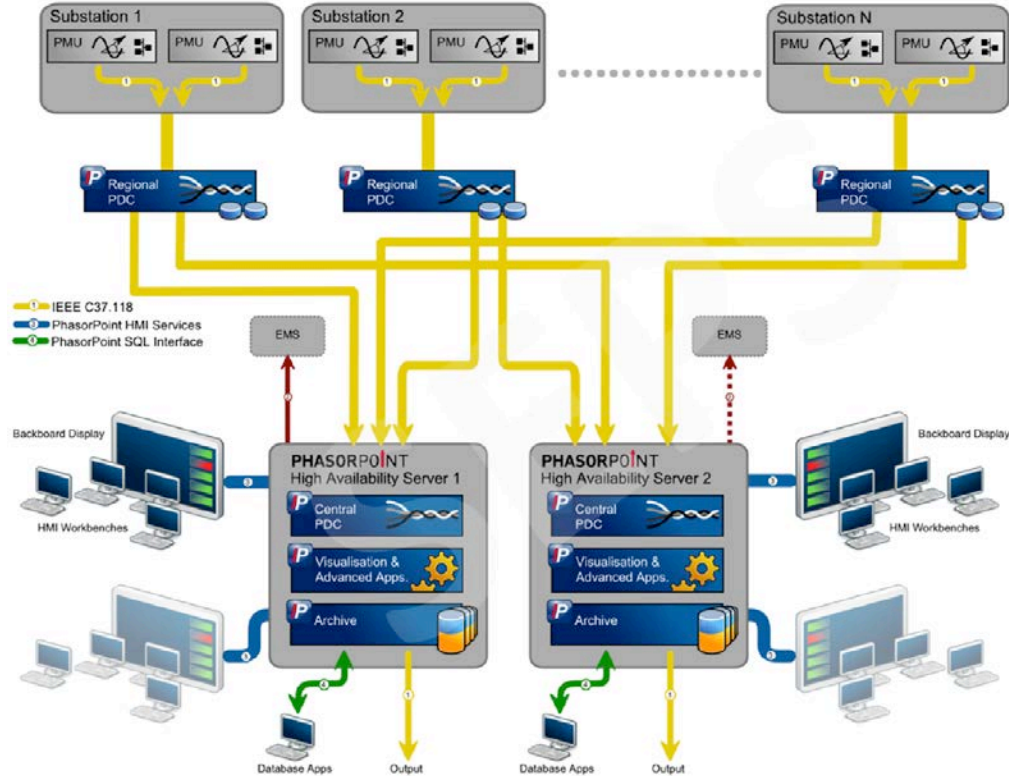
- **Project Scope**

- Wide Area Monitoring System installation and commissioning
- Number of PMUs: 20 at 10 substations
- Reporting Rate: 50 Hz
- Only part of the grid is covered

Slovak Power Grid



SEPS WAMS Architecture

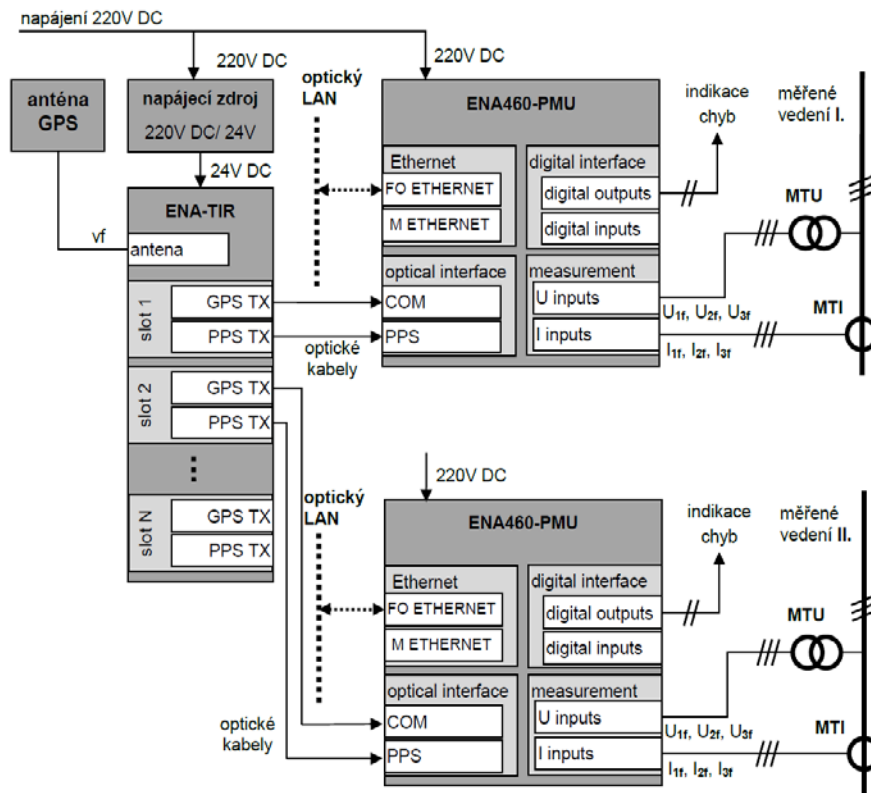


ELCOM PMU ENA460



- Compact aluminum case, DIN rail mountable
- 4 voltage inputs up to 600 V RMS; 4 current inputs 5A RMS; 4,2kV isolation; 0.1% precision
- 8 digital inputs
- sbRIO based (NI sbRIO-9612)
- Works either as PQ meter or PMU

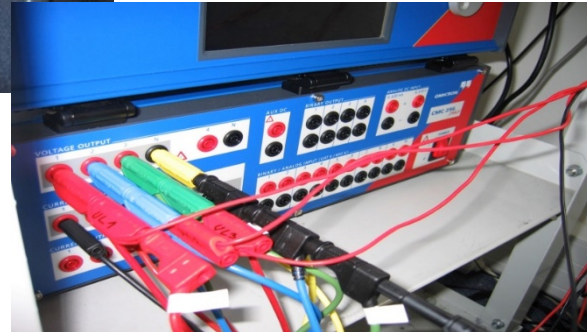
PMU Architecture



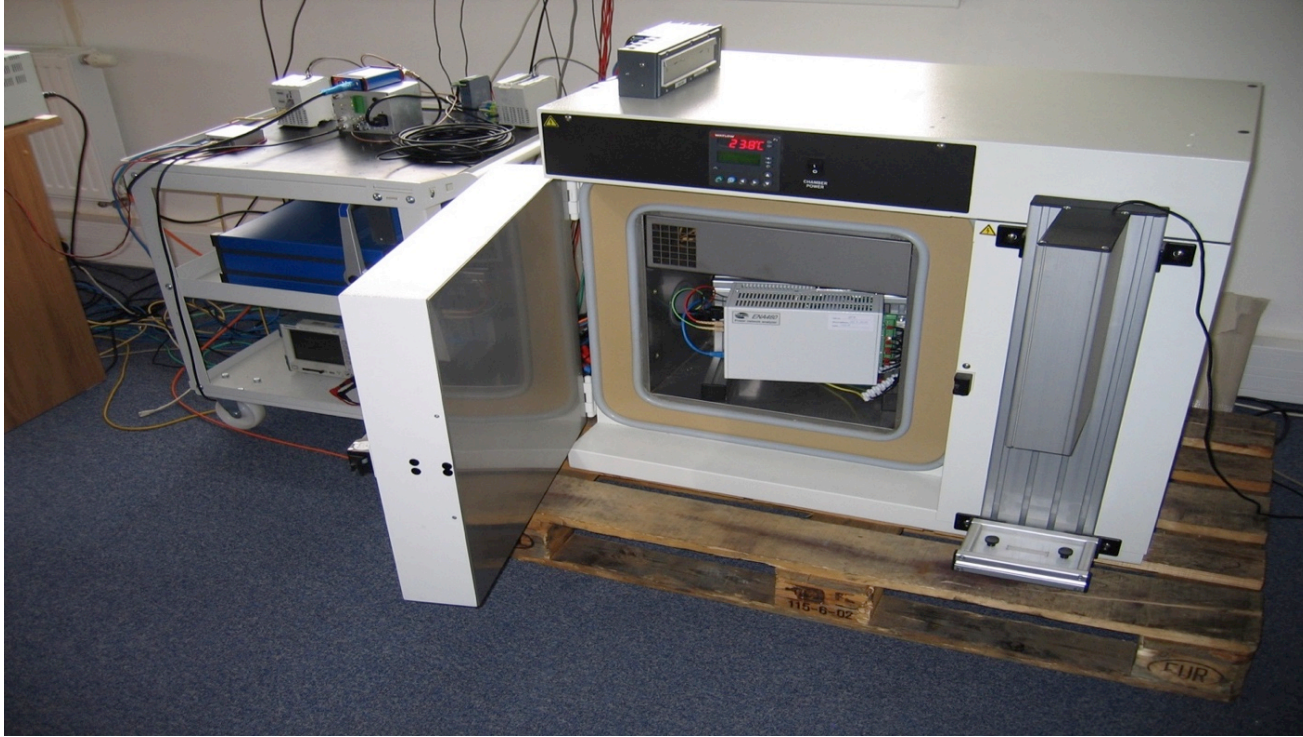
Precision Verification



- ELCOM's Test Lab
 - HP Calibrator
 - Omicron Tester
 - Temperature Test Chamber



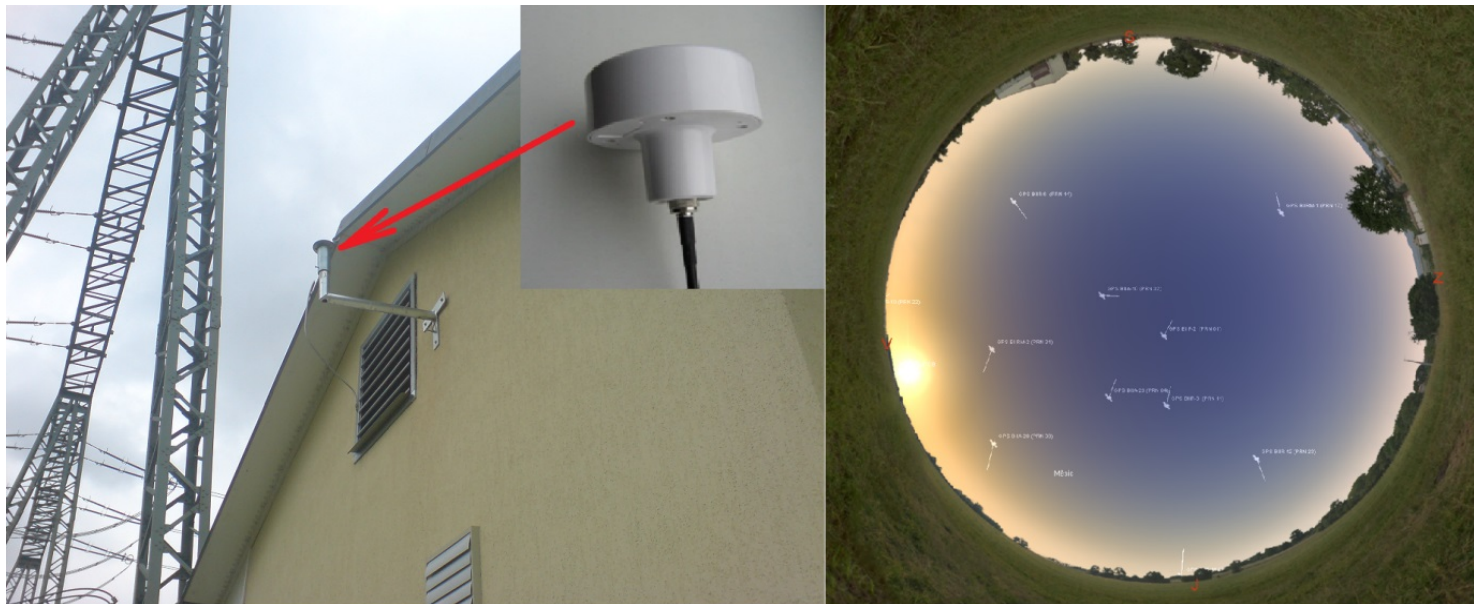
Precision Verification during WAMS Delivery



GPS Receiver ENA-TIR

- Core of the solution is based on TELIT chip supporting GPS and GLONASS standards
- ENA TIR is connected with ENA-PMU via fiber optic cables
- The precision of rising edge of PPS signal is better than $1 \mu s = 0.018^\circ$.

Installation of GPS Receivers



PDC (Phasor Data Concentrator)

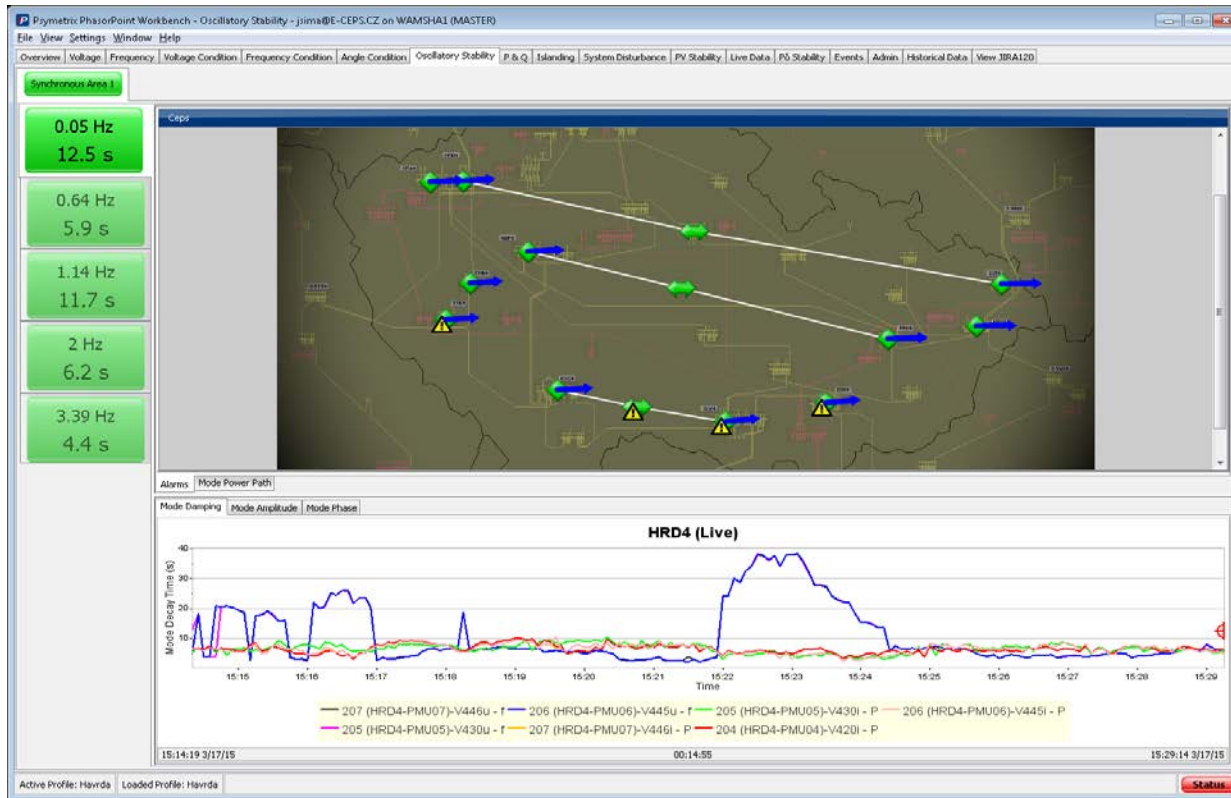
- Receives C37.118 data streams from the PMUs
- Transmits one C37.118 aggregated stream to each central server (2 pcs).
- Acts as temporary data buffer solving the situation of data connection faults between power distribution station and central servers control room
- Collects and provides diagnostic information about WAMS using EIC ...104
- Based on embedded PC from iEi manufacturer with OS Debian Linux

Server Application for WAMS – PhasorPoint™

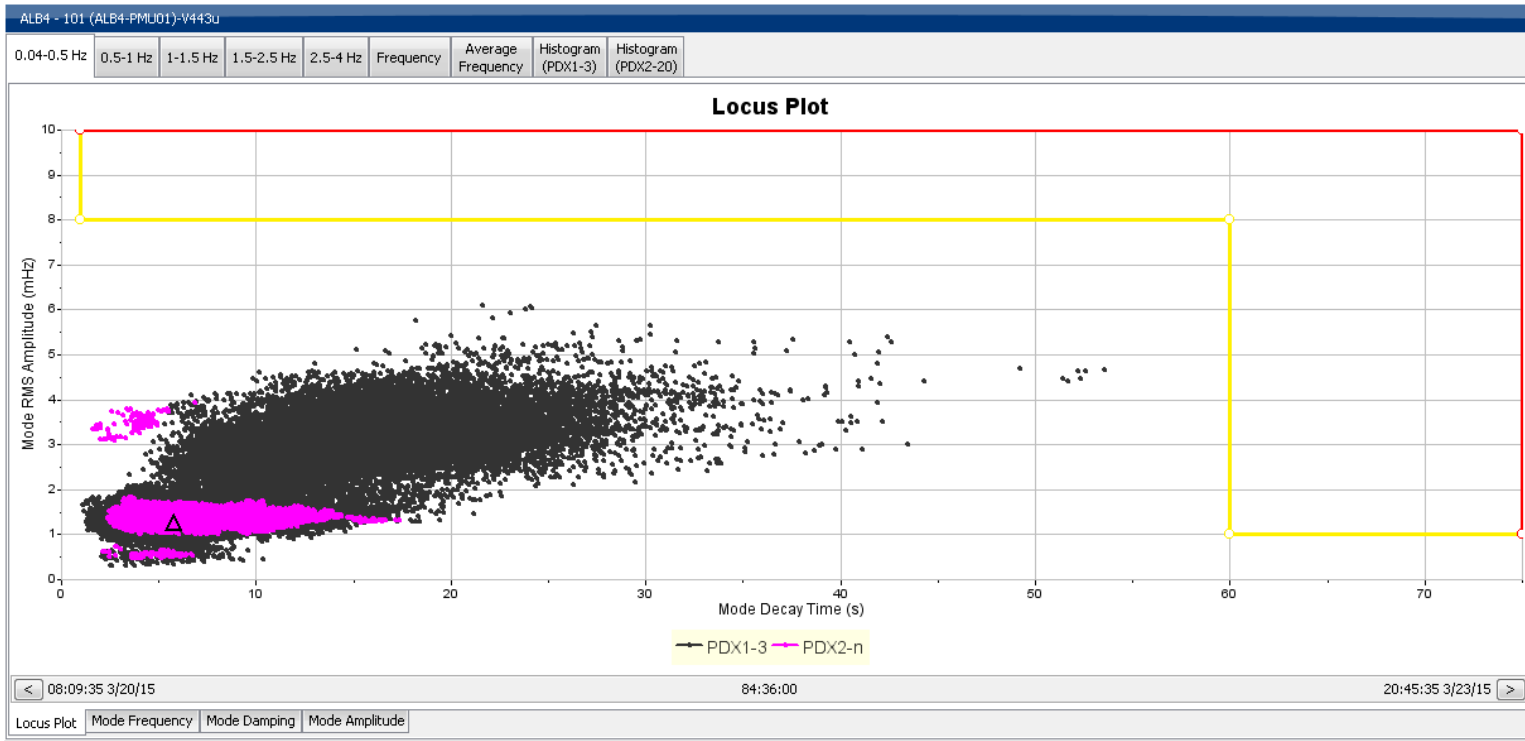
The central server is running the SW application PhasorPoint from Psymetrix Ltd. (member of GE). The main functionality covers the following features:

- **Phasors monitoring and monitoring and visualization**
 - The limit values for angles differences are monitored and in a case the limit values are exceeded the warning is issued.
- **Islanding, resynchronization and black start detection and monitoring**
 - PhasorPoint application provides a real time tool for identifying islanding and providing information valuable in successful resynchronization .
- **Oscillations detection**
 - This part includes advance application that provides foremost analysis and visualization tools form monitoring the dynamics of the power system through a study of its oscillatory modes.
- **Static stability monitoring**
 - On the base of measured phasors the PhasorPoint calculates the immediate reserve of static stability of the given transmission corridor and displays it in the form of the graph $P=f(\delta)$
- **Monitoring of voltage stability**
 - PhasorPoint calculates and displays the Power – Voltage and Power Angle curves

Oscillations Detection and Analysis

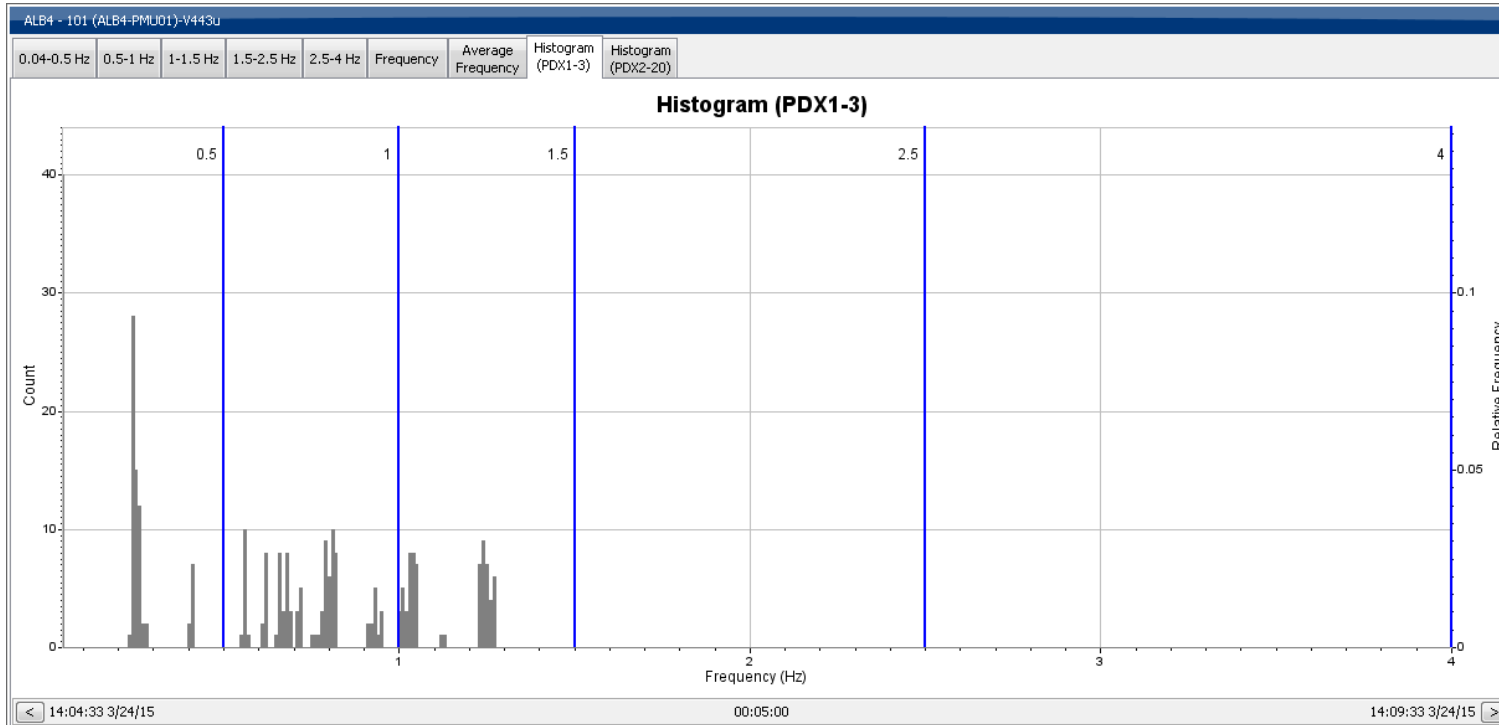


Oscillations Detection and Analysis

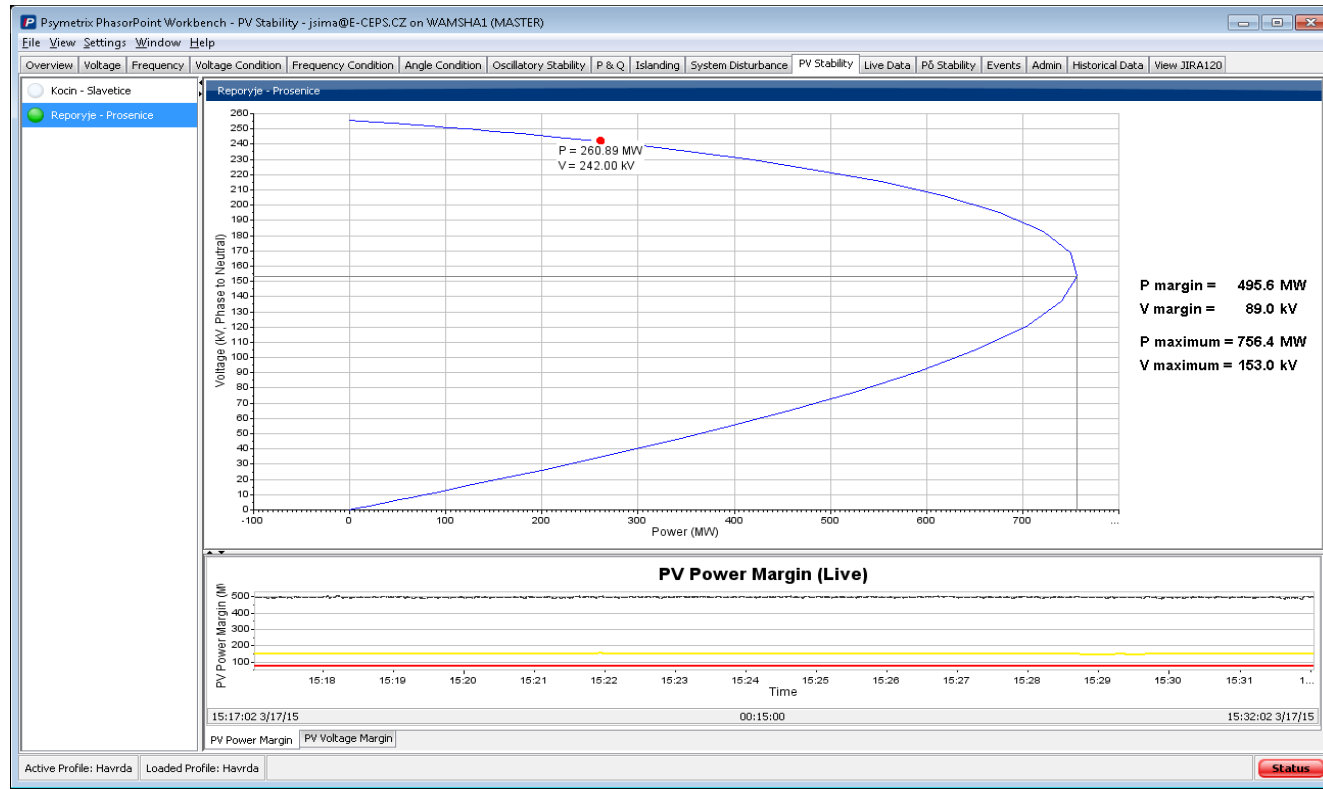


Oscillations Detection and Analysis

Oscillations Histogram



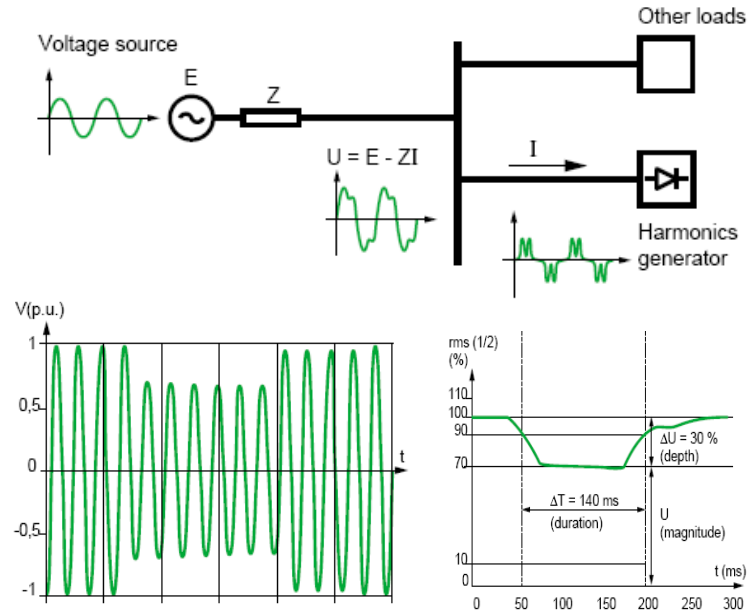
P-V Application, P-delta



Power Quality Measurements

Electricity can be seen as a product, so it has to meet certain qualitative parameters. These are defined by a series of international standards (EN50160, 61000-4-30, 61000-4-15, 61000-4-7). Measured quantities are as follows:

- Line frequency
- Voltage level
- Flicker
- Short voltage events
- Voltage interruption
- Phase Voltage Non-Symetry
- Harmonics and Interharmonics
- Signaling Voltages
- Rapid Voltage Changes



Power Quality Measurements

Power Quality Instruments similarly as the PMUs measure voltages and currents either directly, typically via measuring transformers. The measurement method is defined by standards, all ELCOM analyzers meet the requirements of ČSN EN 61000-4-30 Class A

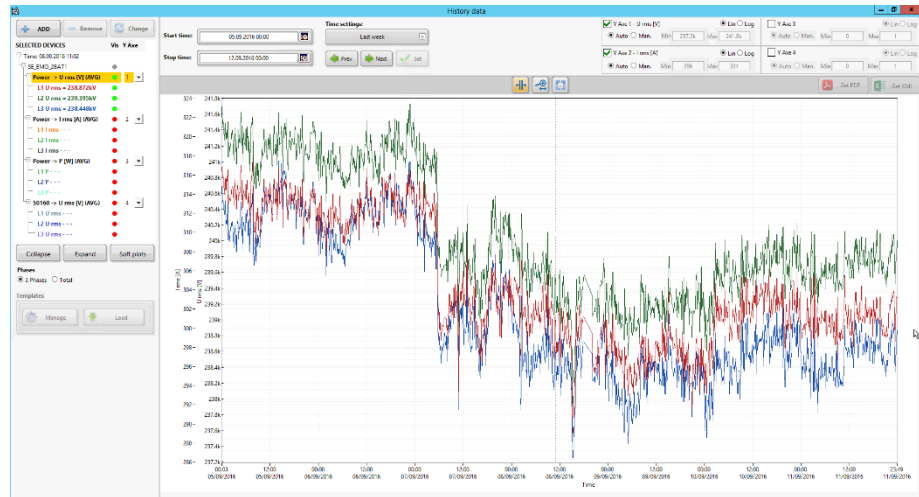
Functionality of ENA PQ Analyzers Are the Following:

- FFT analyzer
- Energy and Power Monitor
- Voltage Monitor according to EN50160
- Symmetrical Components
- Telegrams (Signaling)
- Transient Recorder – can store time window with signal sampled by 57600 S/s (raw voltage and current waveforms) in the length of 60 s with pre-trigger 1.2 s
- Disturbance Monitor – Stores data with the sampling rate 1 sample per half period (half period RMS values). The length of data file is up to 10 minutes with pre-trigger 30 sec
- Impedance
- Digital Inputs

Power Quality Measurements

ENA-SCADA is a distributed system for collecting and delivering immediate and historical values from power quality analyzers. It typically monitors hundreds of real-time systems, stores data in SQL databases, provides various instant value displays, and analyzes and displays historical data, sends automated reports and exports, includes a supervision system,

It is currently used by transmission and distribution operators and by large industrial plants too.



Power Quality Measurements

ENA Instruments:



ENA NGX – New Generation of ENA PQA and PMU based on NI-SOM

Available Configurations:

- Power Quality Analyzer (PQA)
- Phasor Measurement Unit (PMU)
- Multichannel Power Monitor (for Transformer Stations)
- **Combinations of Above**

Available Modules:

- **CPU:** Control Unit, Optionally with GPS or Fibre Optic Input (CPU)
- **HVI:** 3f Voltage Input Module (HVI)
- **HCI:** 3f Current Input Module, 1A or 5A (HCI)
- **LVI:** 16 Inputs Module for current measurements with CTS XX A/330mV or XX A/200mA, with the additional 2 input channels for temperature measurements by NI1000
- **LVI:** 16 Inputs Low Voltage Input module - 1V Inputs
- **DI:** Digital Input Module with 16DI



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