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Multi-Function Grid Edge Sensors and Computing Platform for Advanced Distribution Grids

Shikhar Pandey & Farnoosh Rahmatian

Outline

- About ComEd

- Varying needs

- Technologies and solutions for an evolving grid

- Advance sensors and grid edge computing

  - Serving multiple applications

- Example – Enhanced Power Quality Monitoring

- Example – Transients and travelling-wave event detection

- Data and Analytics Platform

ComEd, An Exelon Company

Our Company:
- One of six utilities owned by Exelon
- 6,400 employees
- Service territory: 11,428 square miles

Our Customers:
- More than 4.1 million customers in northern Illinois including the city of Chicago

Our Grid:
- Peak Load: 23,753 MW (Summer)
- 553,800 distribution transformers
- 66,200 circuit miles of primary distribution
- 52% overhead, 48% underground in distribution
- 5,800 circuit miles of transmission
- 93% overhead, 7% underground in transmission
- Interconnected DER: 640 MW

One System with Varying Needs

Every circuit has unique customer needs and evolving load profiles

Rural **Suburban** **Urban**

Diverse Load Profiles

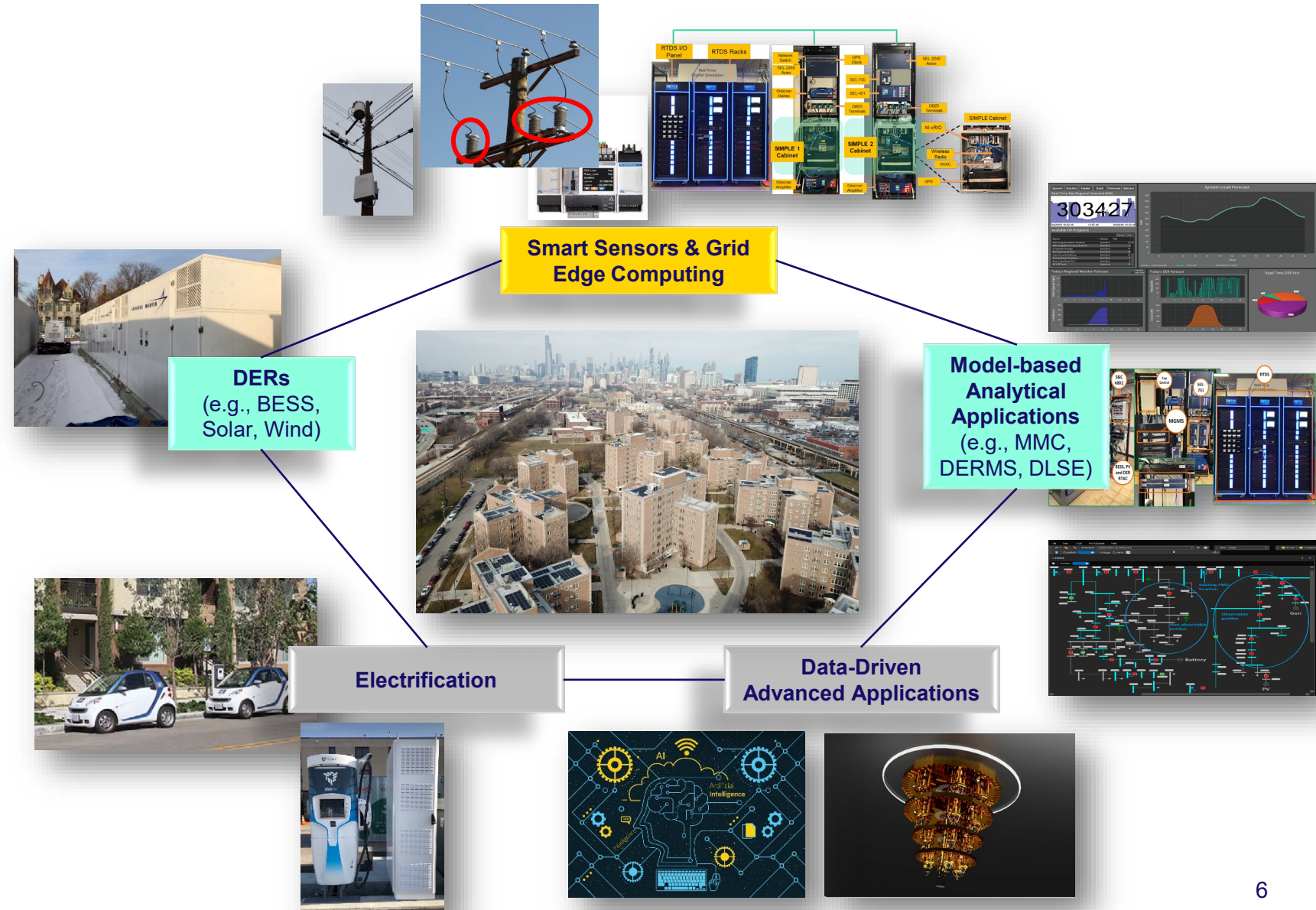# Technologies for Future Resilient Grid

- Sensors
  - Phasor Measurement Units
  - PQ Meters
  - Optical Sensors
  - SIMPLE
  - LiDar Sensors
  - Weather Station

- Distributed Energy Resources
  - Battery
  - PV
  - Electric Vehicle

- Advanced Applications and Platforms
  - Distribution Linear State Estimator
  - DER Management Systems
  - Microgrid Management Systems
  - ADMS
  - Managed Charging
  - Demand Response Management System

Solutions for an Evolving Grid

DERs introduce significant complexity to grid planning and operation.

Sustaining the level of reliability and performance that customers expect requires advanced:

- Monitoring
- Protection
- Automation
- Controls
- Communications
- Software applications & analytics

Smart Sensors & Grid Edge Computing

DERs (e.g., BESS, Solar, Wind)

Model-based Analytical Applications (e.g., MMC, DERMS, DLSE)

Electrification

Data-Driven Advanced Applications

Emerging Technology Demonstration for Future Grid

ComEd is preparing for the future by working with 50+ external collaborators including national labs, universities and vendors on 20+ DOE/NSF/DOD projects to demonstrate cutting-edge technologies for:
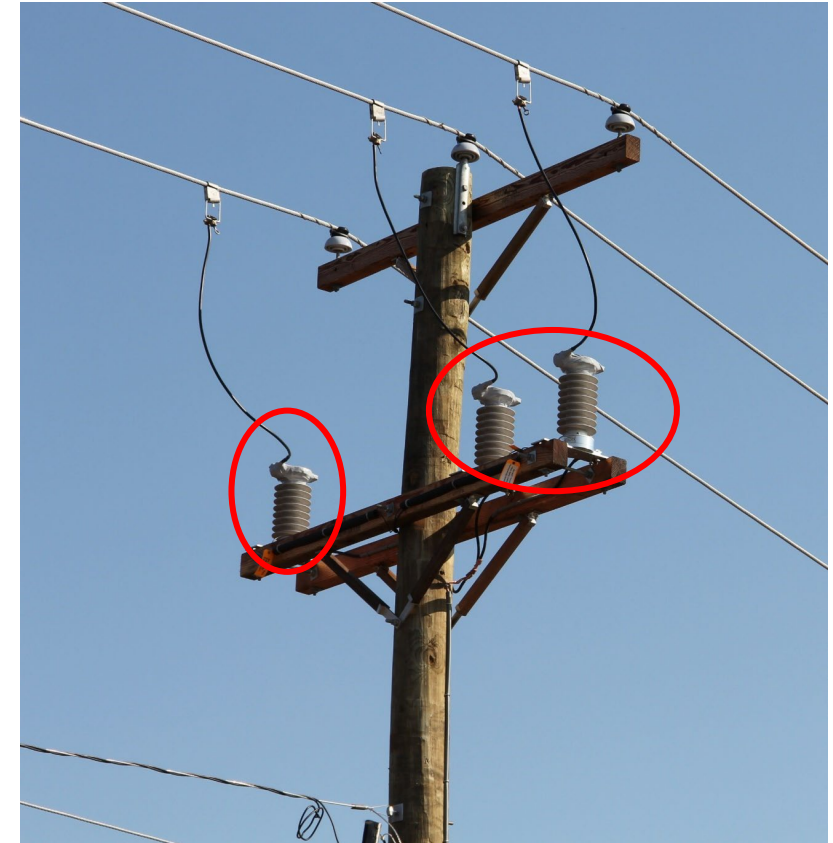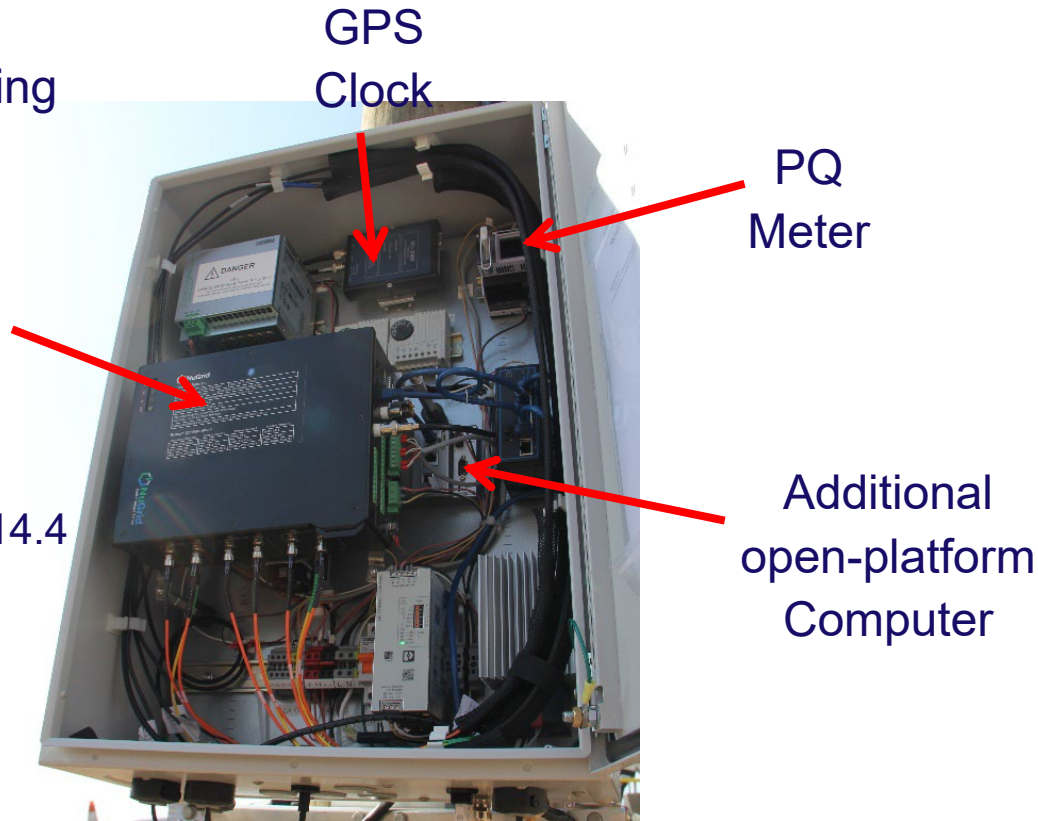
– Smart Sensors

– Synchrophasor applications

– DER coordination within community microgrids

– Behind-the-meter DER analysis

– Preventive maintenance

– Advanced state estimation
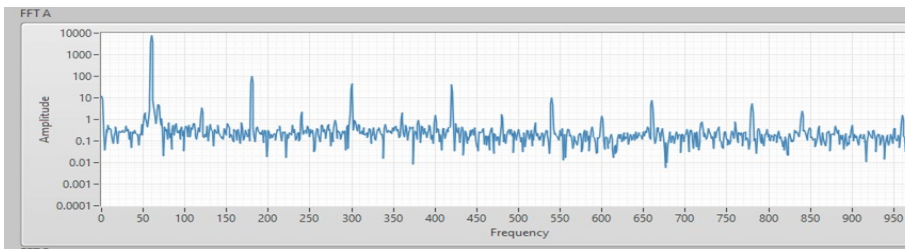
– AI-enabled Grid Control

– Cyber-security
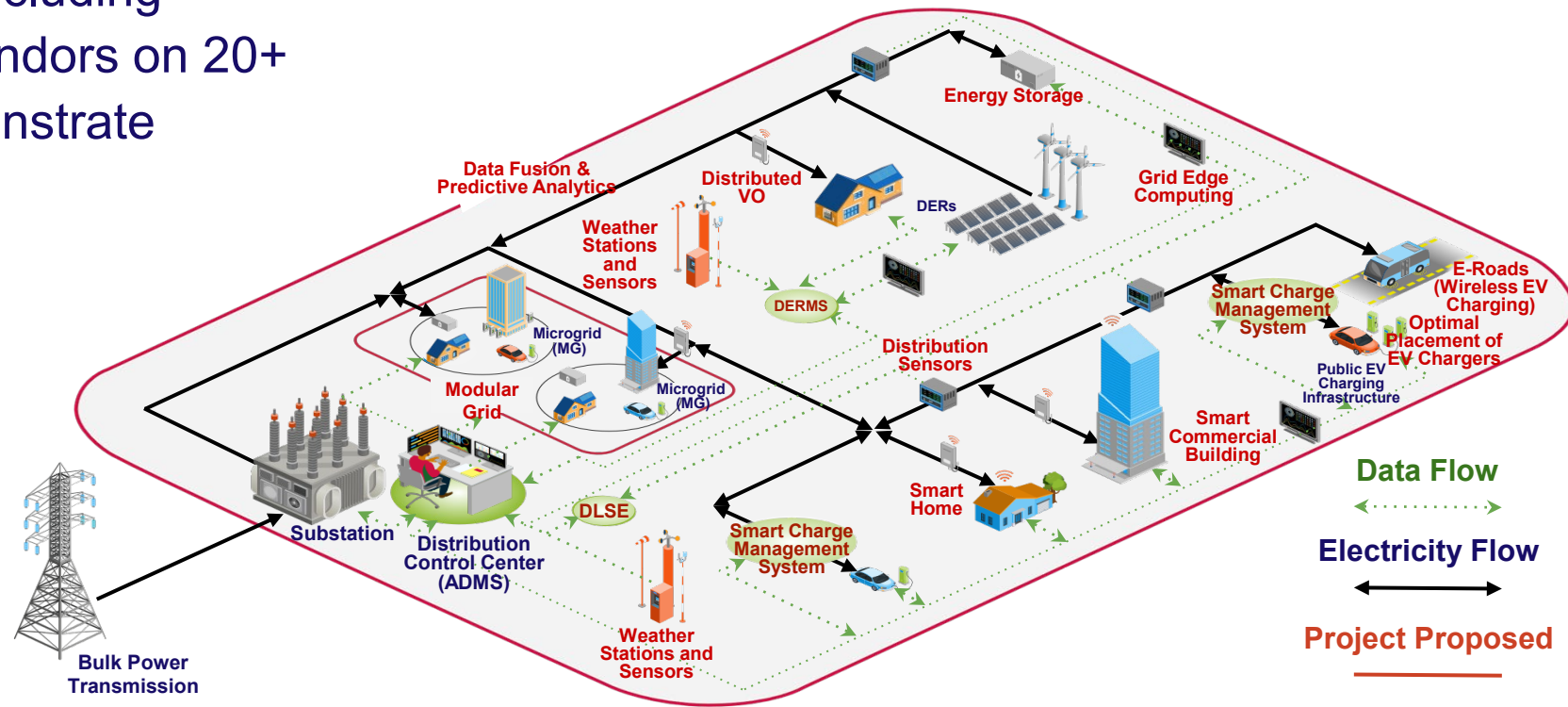
Example: Multi-function Grid Edge Sensors

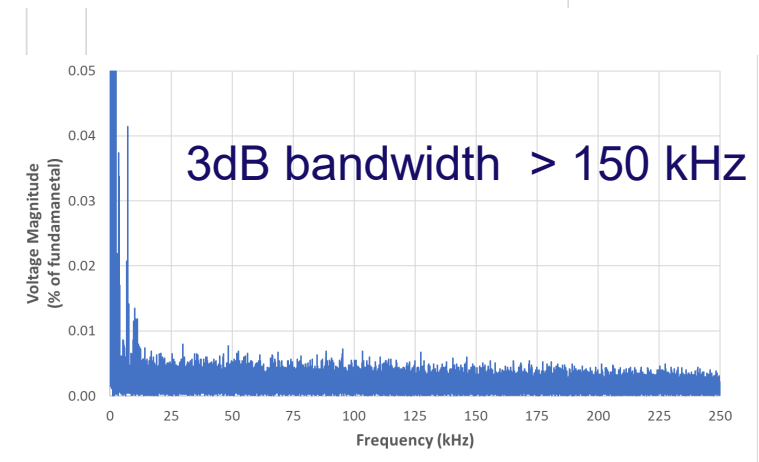Sensor signal processing and grid edge computation module, includes:
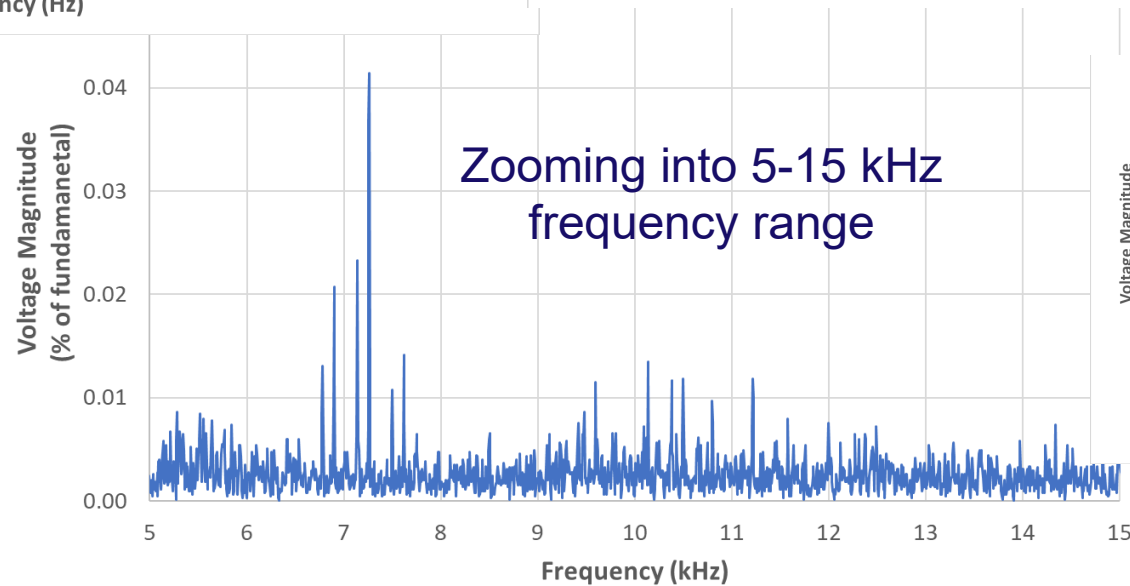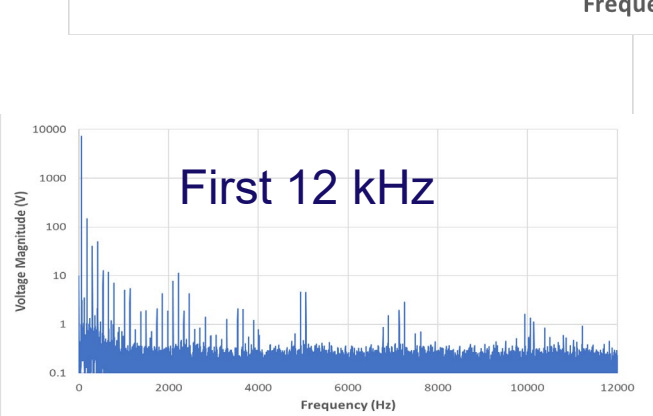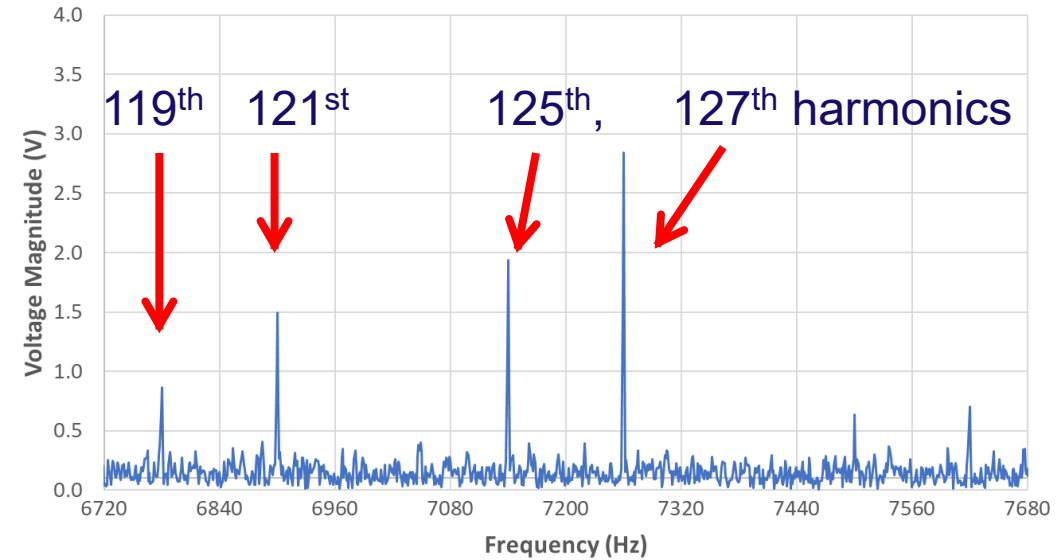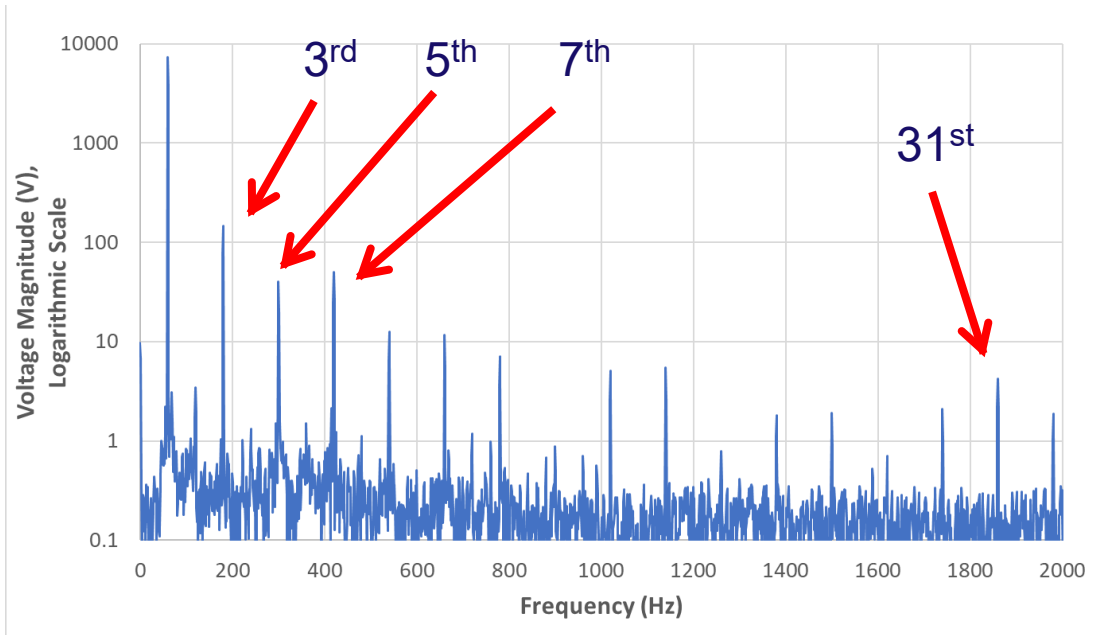
- MHz sampling
- PMU output
- IEC 61850 sampled-valued output (4.8 or 14.4 kHz)
- TW event detection function
- Low-voltage analog output

GPS Clock
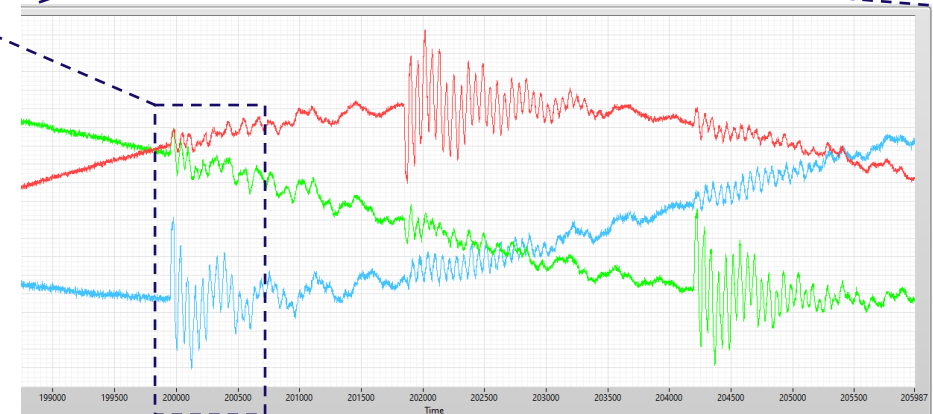
PQ Meter

Additional open-platform Computer

Wideband Optical Primary Sensors

Sample Results – Beyond Harmonics

3rd 5th 7th

31st

119th 121st 125th, 127th harmonics

First 12 kHz

Zooming into 5-15 kHz frequency range

3dB bandwidth > 150 kHz
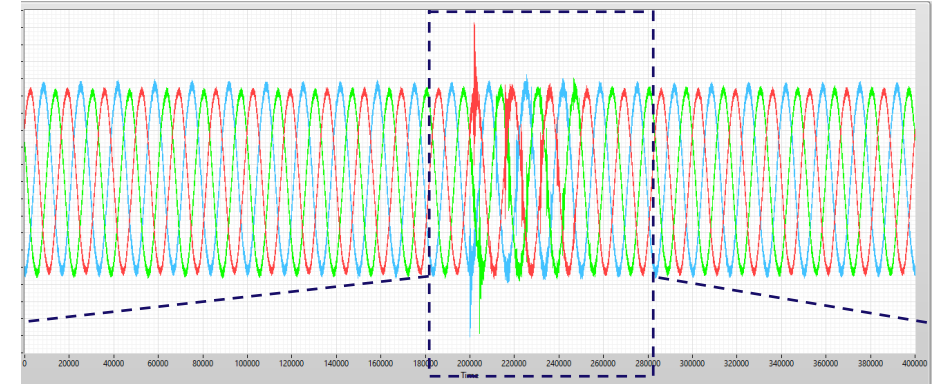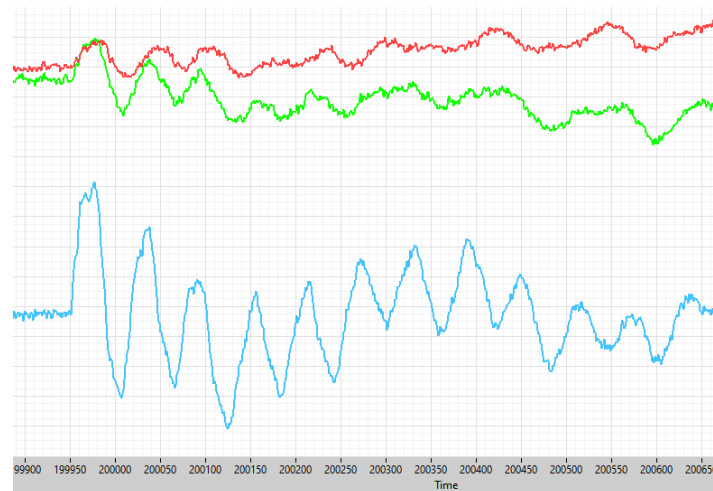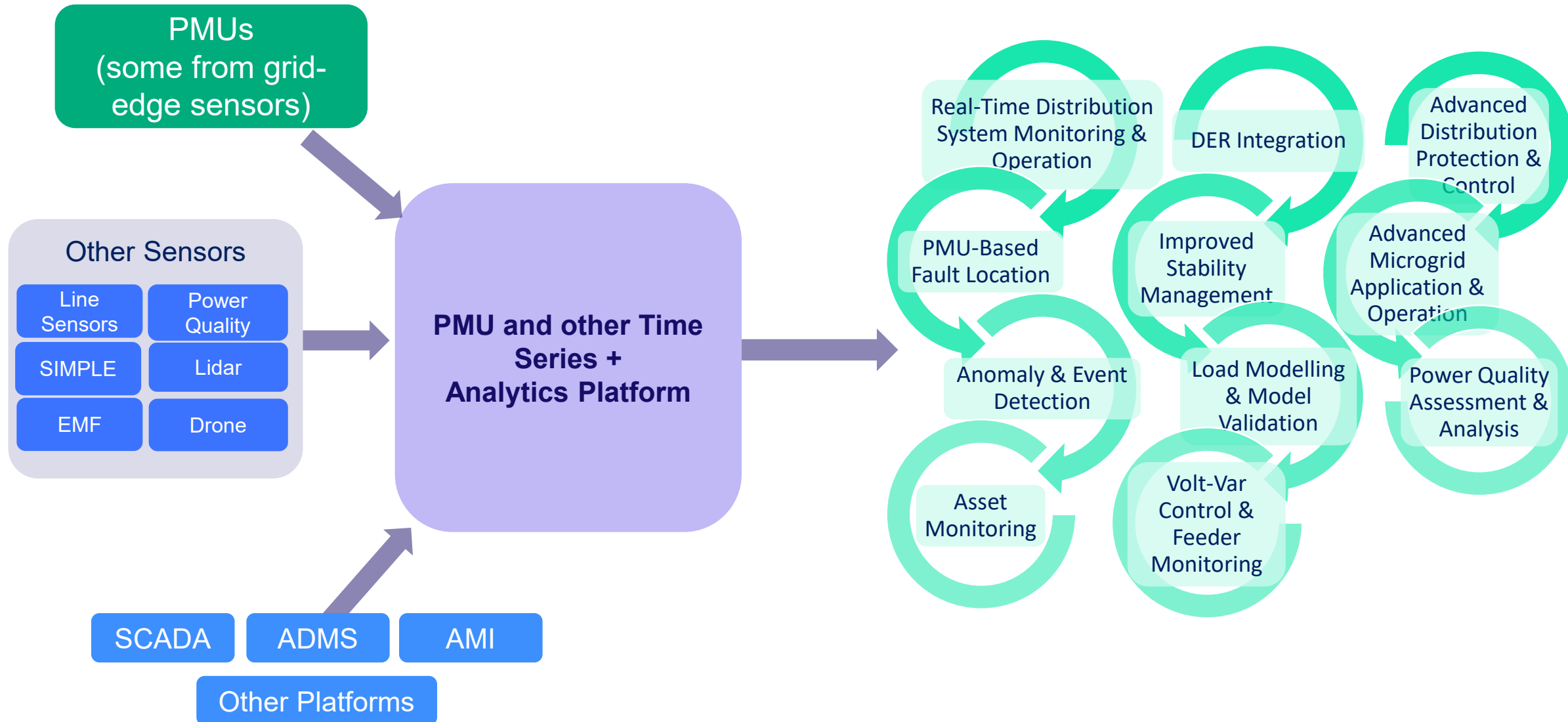
Sample Results – Transients and Travelling-Wave Reflections

Waveform visibility down to 1 µs resolution
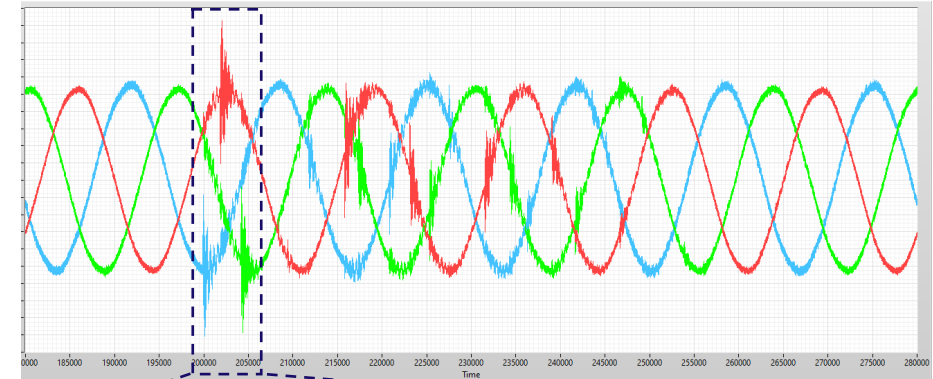
PMU Analytics and Application

PMUs
(some from grid-edge sensors)

Other Sensors
- Line Sensors
- Power Quality
- SIMPLE
- Lidar
- EMF
- Drone

PMU and other Time Series +
Analytics Platform

SCADA   ADMS   AMI
Other Platforms

Real-Time Distribution System Monitoring & Operation

DER Integration

Advanced Distribution Protection & Control

PMU-Based Fault Location

Improved Stability Management

Advanced Microgrid Application & Operation

Anomaly & Event Detection

Load Modelling & Model Validation

Power Quality Assessment & Analysis

Asset Monitoring

Volt-Var Control & Feeder Monitoring

Key Take-Aways

- Local (grid edge) high-resolution measurement and processing
  - Supporting multiple local high-speed or high-resolution applications

- Communicate compressed data (e.g., PMU, PQ, and triggered PoW data) to remote locations
  - Support wide area or slower applications

- All measurements are time-synchronized to 1 micro-second
  - Point on wave and transients at MHz and SV at 4.8 kHz, as well as PMU at 60 Hz, all are time sync-ed to 1 µs

- Serving multiple applications requires the sensor to be:
  - Non-intrusive – the presence of the sensor doesn't affect the circuit/signal being measured
  - Safe – use in high and medium voltage system (e.g., optical isolation)
  - Light and portable – economical and easy to use
  - Linear – accuracy over wide signal ranges (voltage or current)
  - Wide Bandwidth – useable over wide frequency range

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Thank you