

A Power Grid Anomaly Detection Algorithm with Point on Wave Data Recording

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Design Objective for Anomaly Monitoring Units

- Phasor measurement units
 - ❖ Synchronized measurement but no POW record during the anomaly
- Online POW measurement units
 - ❖ Communication difficulty
- Our solution
 - ❖ Deploy anomaly detection algorithm in the device level
 - ❖ Stream POW if anomaly detected, otherwise stream synchrophasors

Anomaly detection Algorithm (1/2)

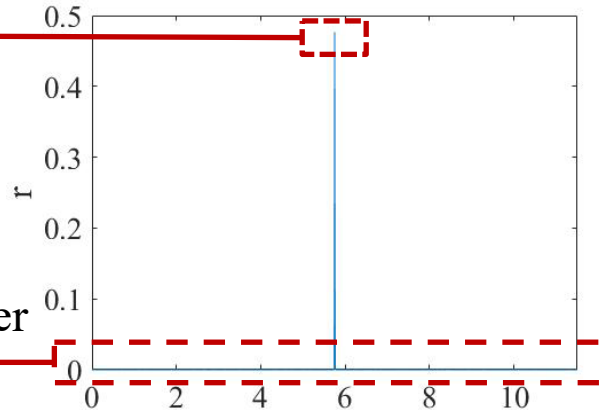
- Time domain waveform subtraction
 - ❖ Anomalies between adjacent cycles of waveform measurements
 - ❖ Use cases: real-time, ultra fast, sensitive to phase shift, high speed magnitude change



Minimum detectable Temporary Voltage drop (1.2% reduction)

Trigger value under anomaly case

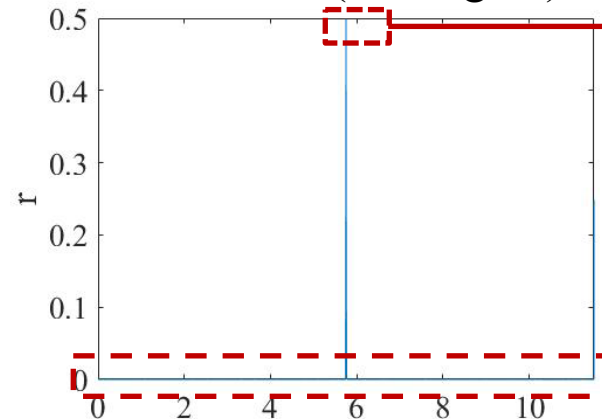
Trigger value under Normal cases



Minimum detectable Phase shift (0.6 degree)

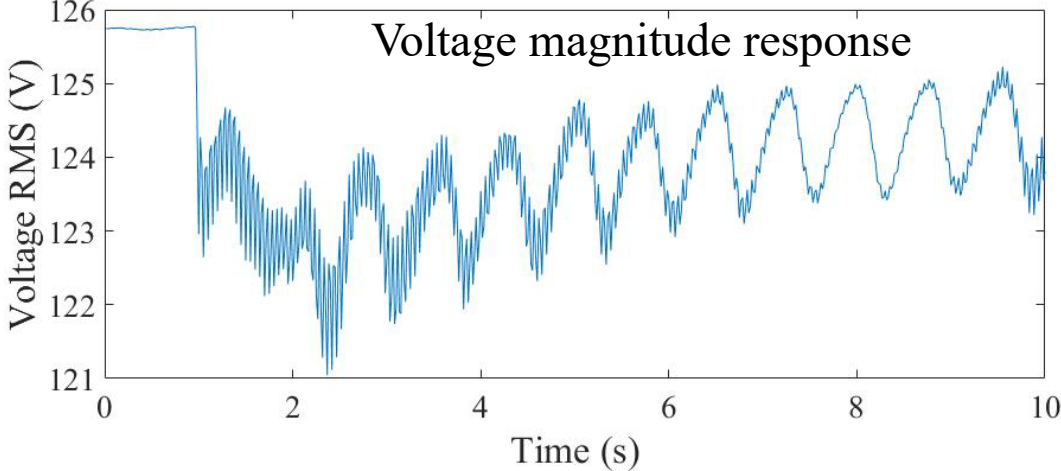
Trigger value under fault case

Trigger value under Normal cases

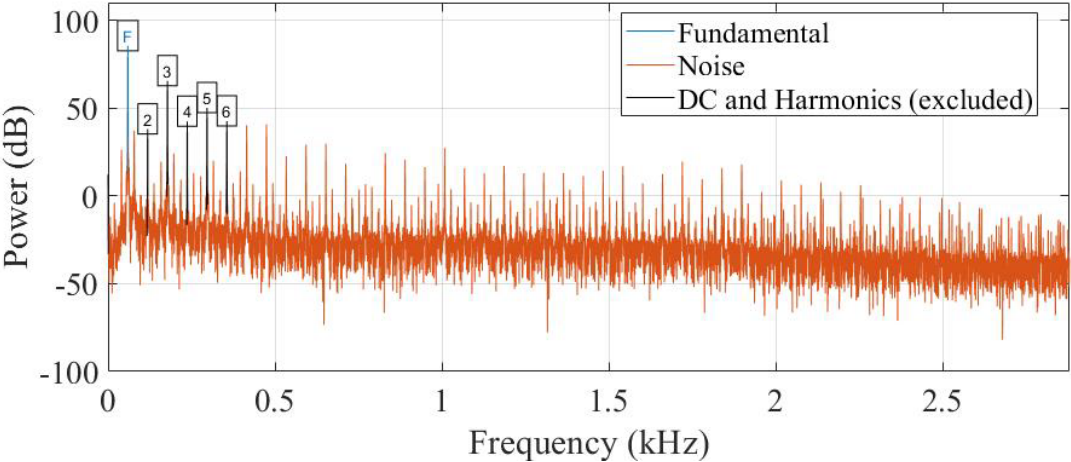


Anomaly detection Algorithm (2/2)

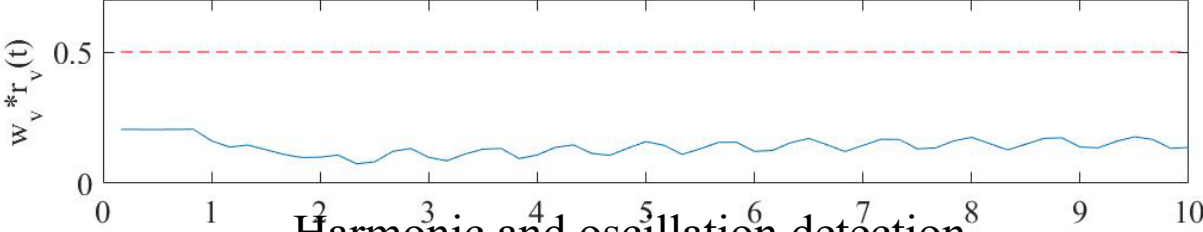
- Oscillation, harmonics, and voltage magnitude detection
 - ❖ Anomalies in time domain
 - Low speed Magnitude change
 - ❖ Anomalies in frequency domain
 - Harmonics, Oscillations



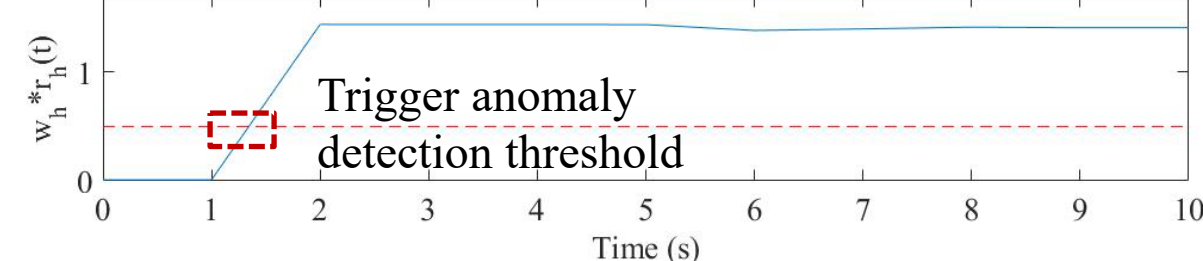
SNR: 39.57 dB



Low speed Magnitude change detection

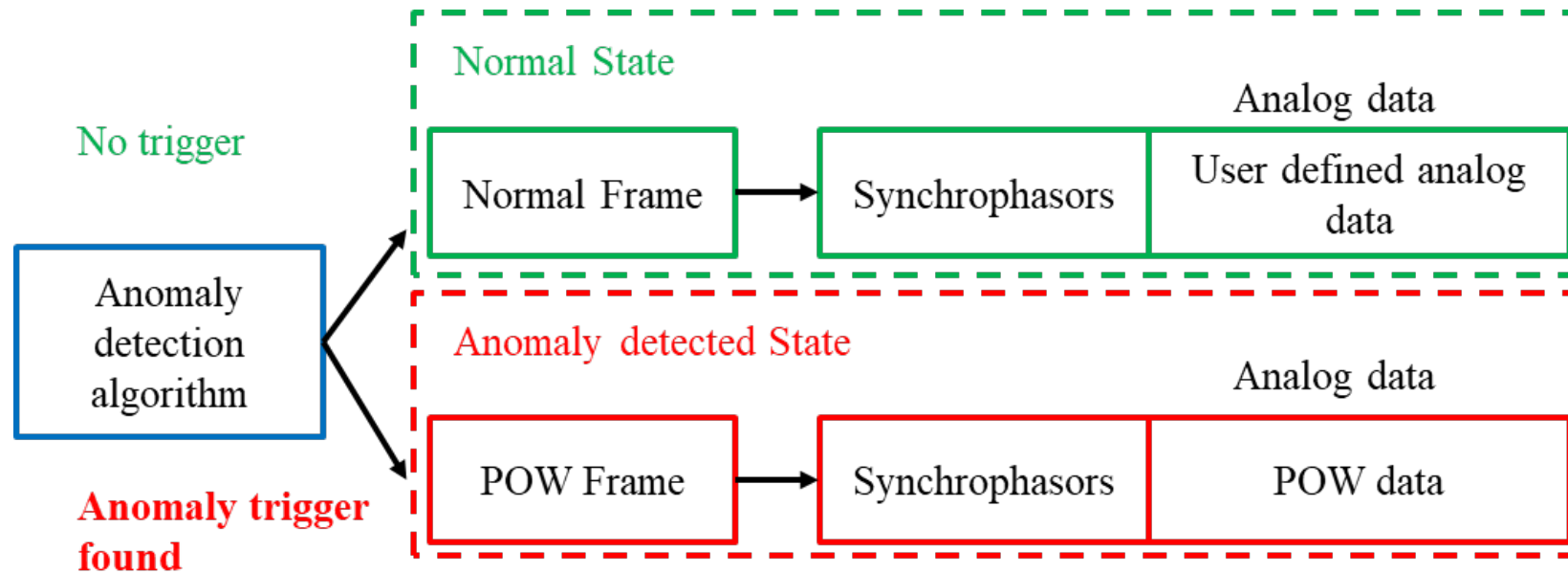


Harmonic and oscillation detection



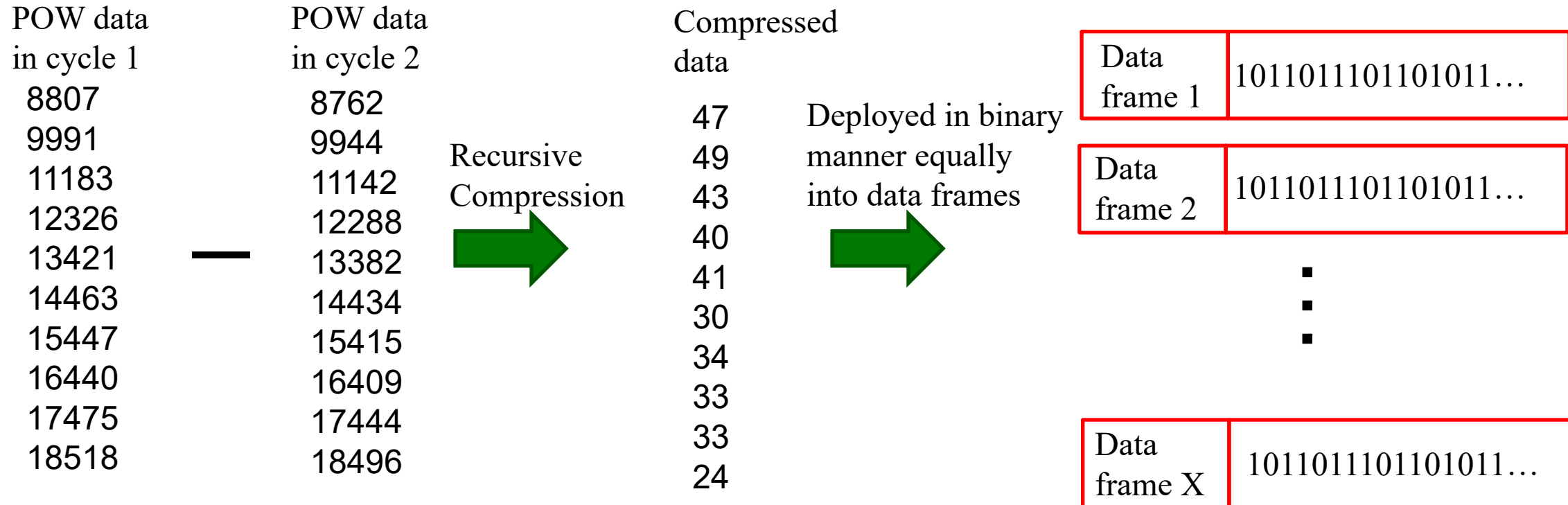
Anomaly measurement transmission

- Different data frame structure
 - ❖ Normal state: synchrophasor + user defined analog
 - ❖ Anomaly detected state: synchrophasor + Point On the Wave (POW) measurement



POW measurement data compression

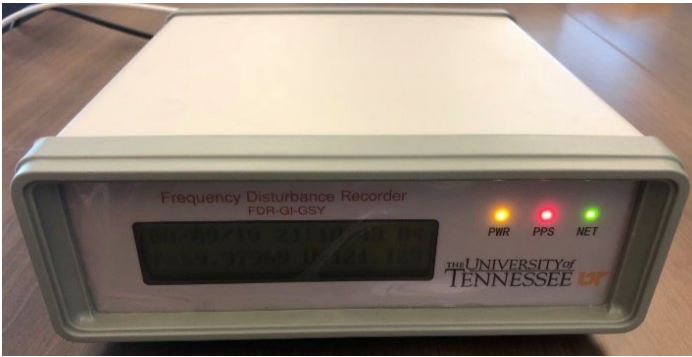
- High density waveform transmission
 - ❖ Data compression technology: Higher Order Periodic Recursive Compression Algorithm



Field Demonstration System

- Device level deployment: waveform detection algorithm
- Data center level deployment: harmonic, oscillation, and low speed voltage magnitude detection algorithms

UGA device

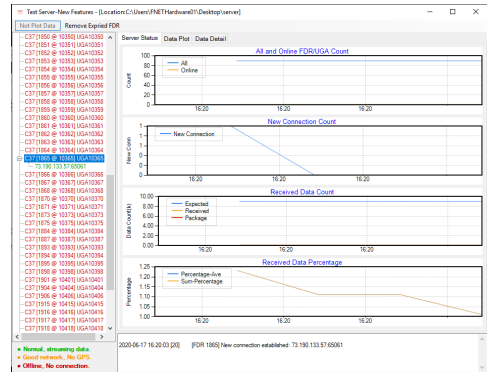


- Synchrophasor measurement
- POW data compression
- waveform detection



Island power grid

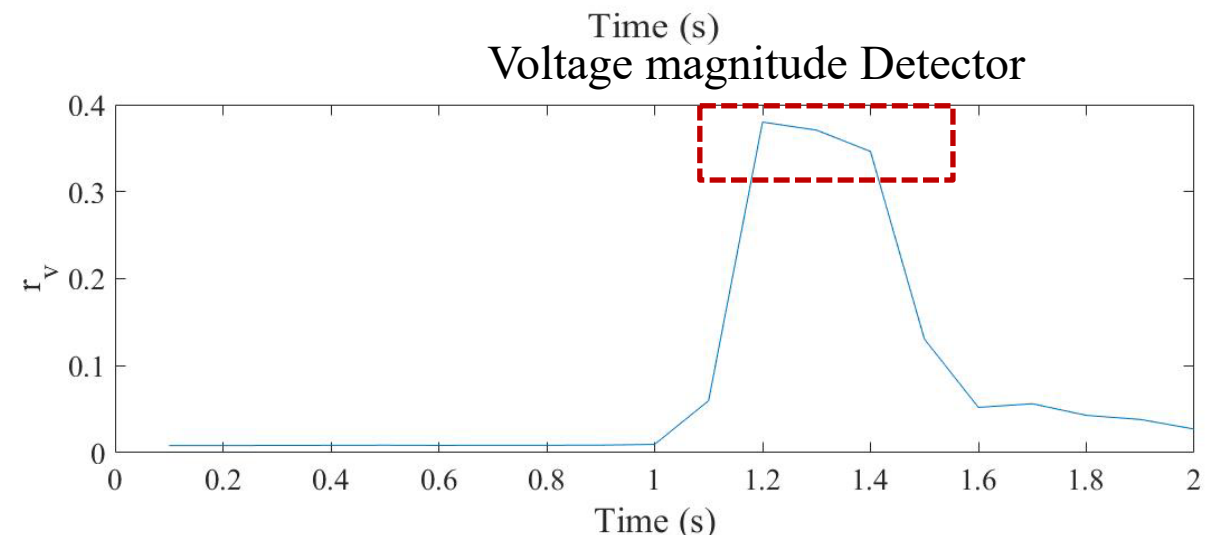
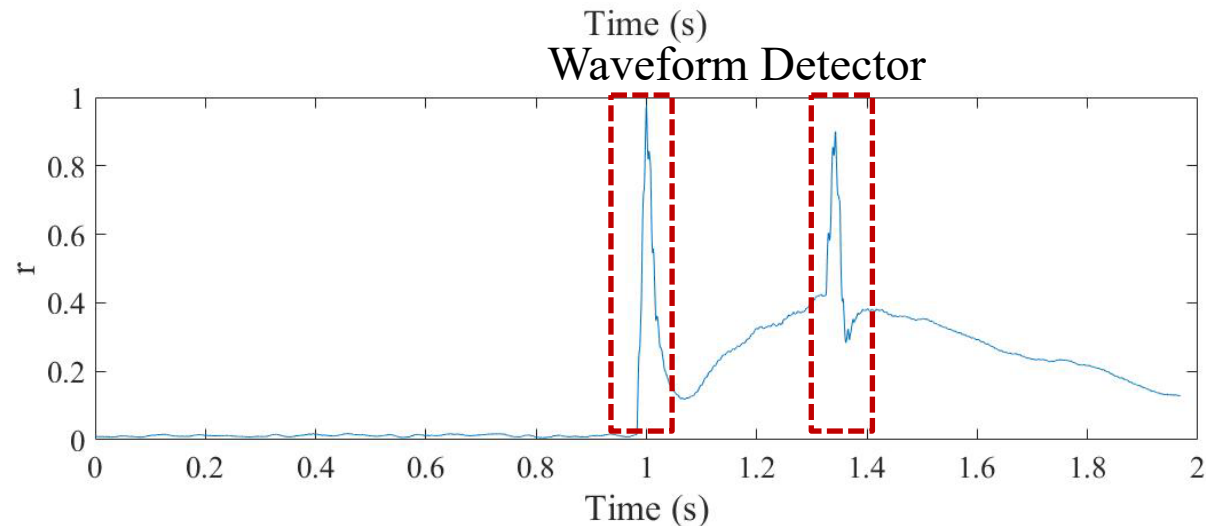
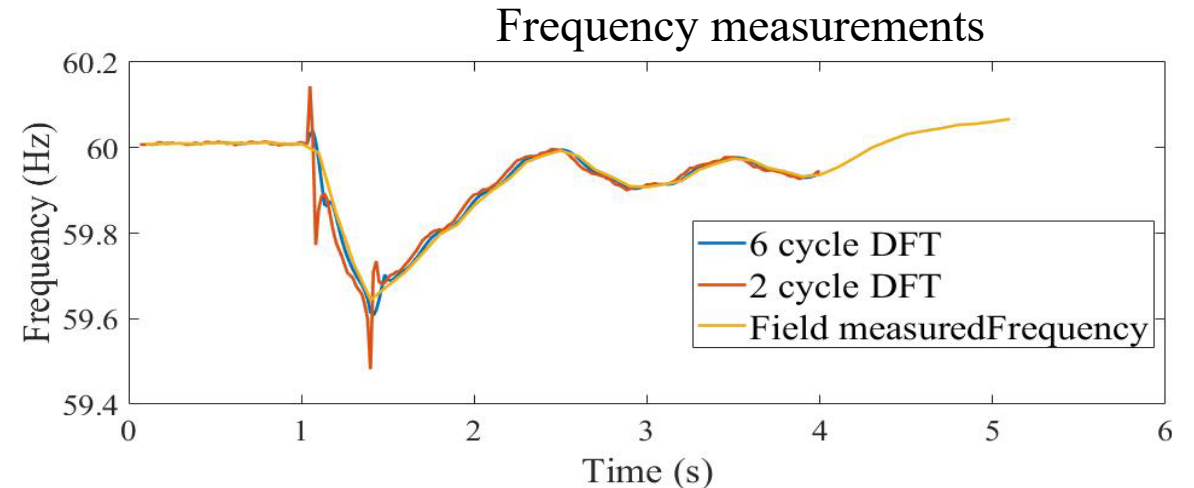
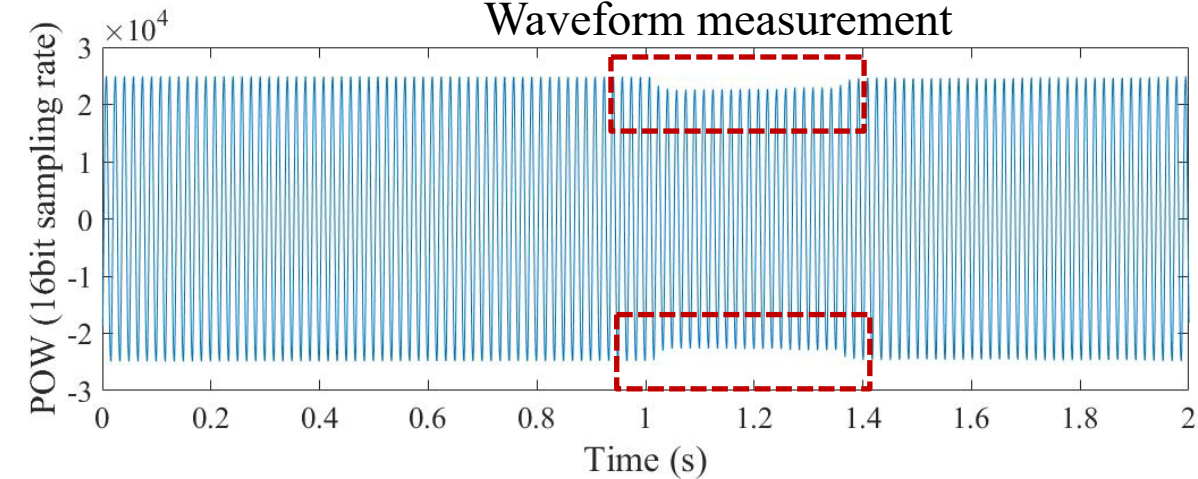
FNET data center



- Data acquisition
- POW data decompression
- Harmonic detection
- Oscillation detection
- Low speed voltage magnitude detection

Test Results in Island Grid (1/4)

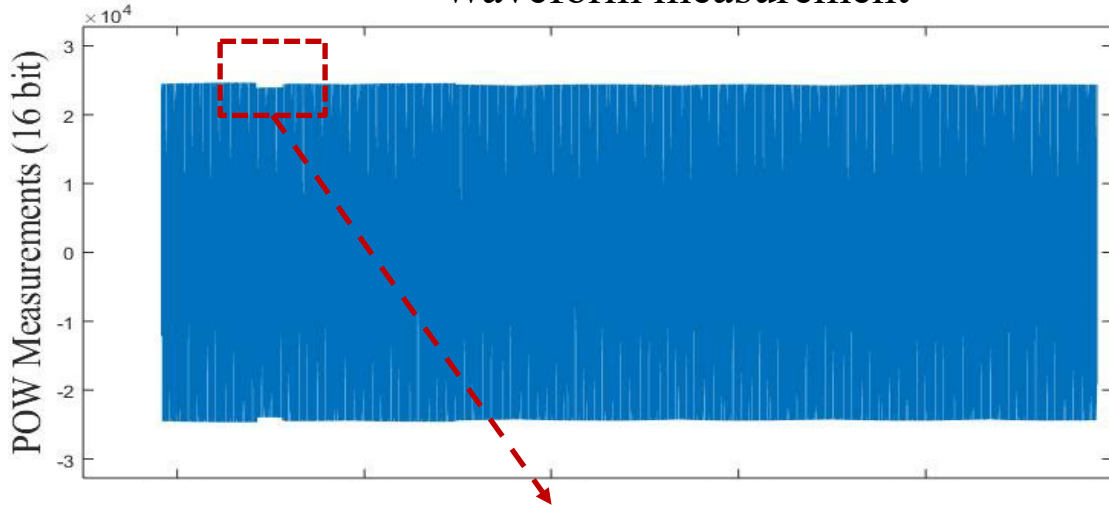
- Generator trip event from real-world island



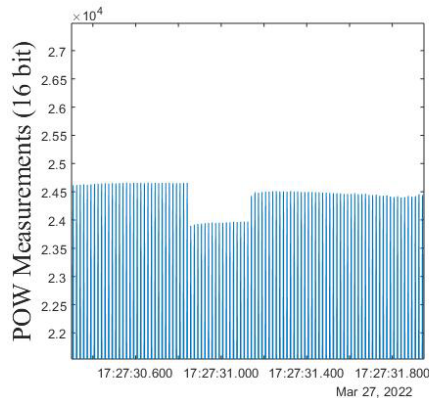
Test Results in Island Grid (2/4)

- Magnitude step change event from real-world island

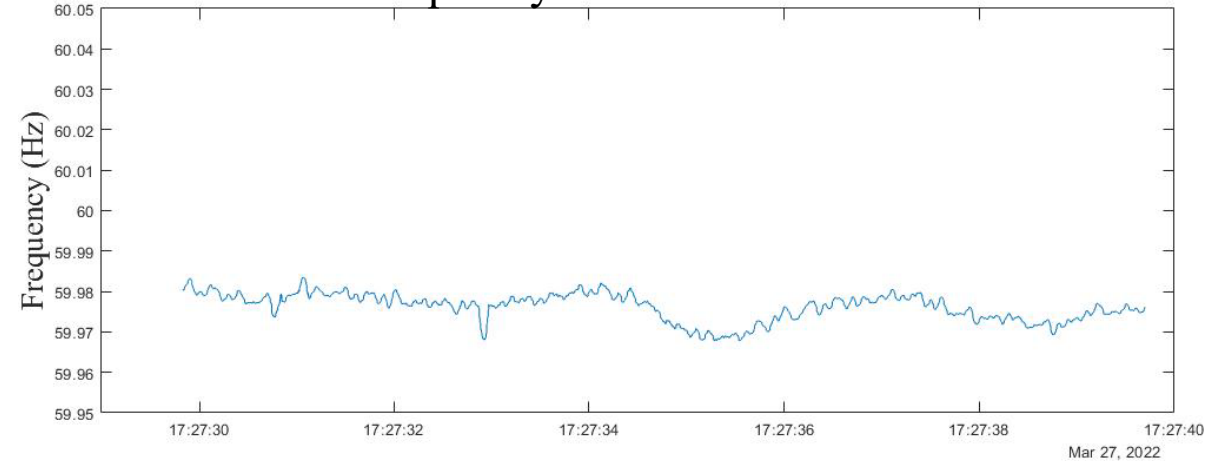
Waveform measurement



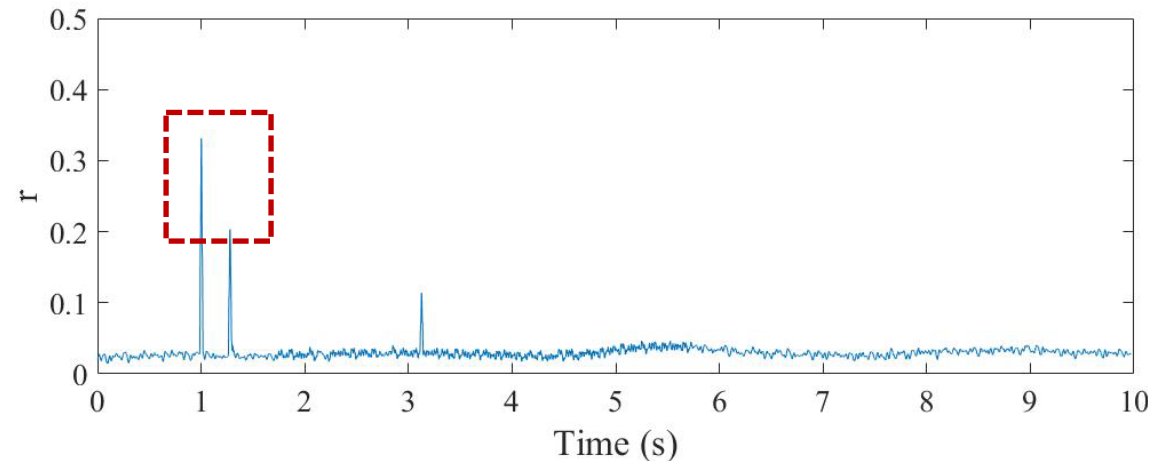
Zoomed in version



Frequency measurements



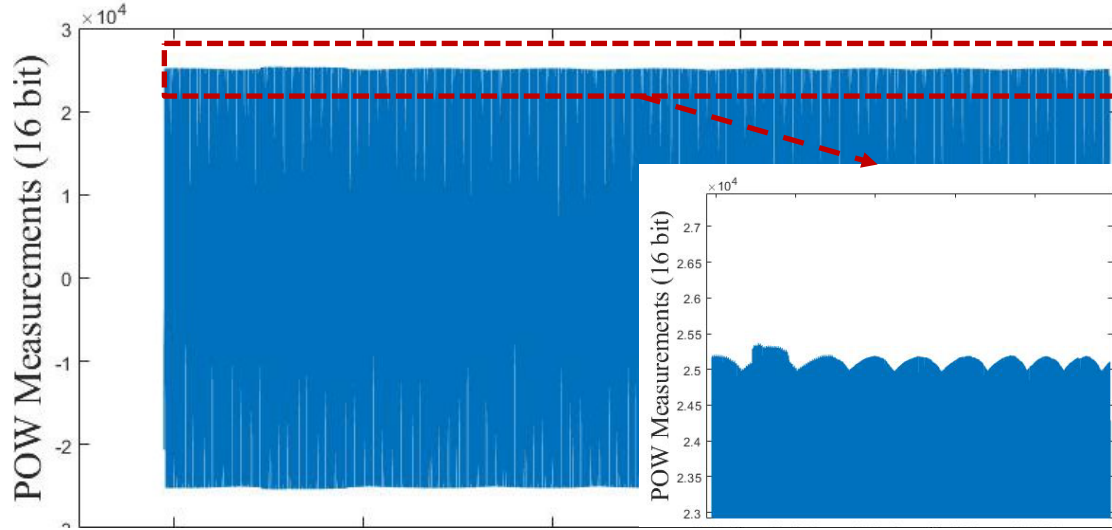
Waveform Detector



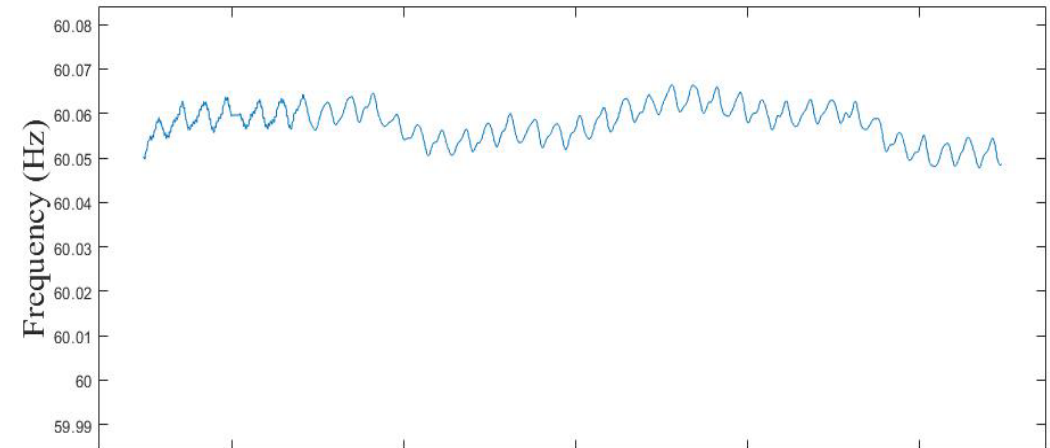
Test Results in Island Grid (3/4)

- Oscillation event from real-world island

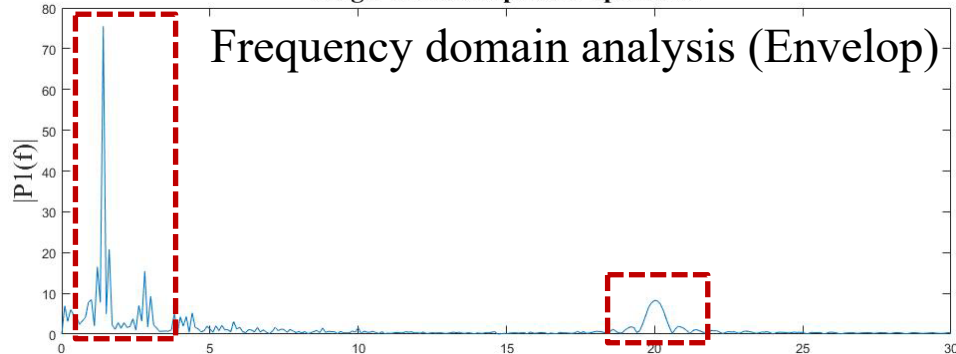
Waveform measurement



Frequency measurements

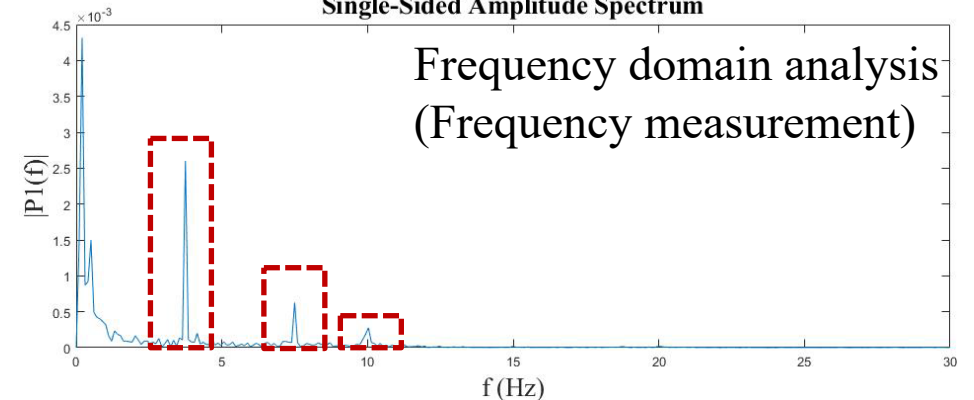


Single-Sided Amplitude Spectrum



Frequency domain analysis (Envelop)

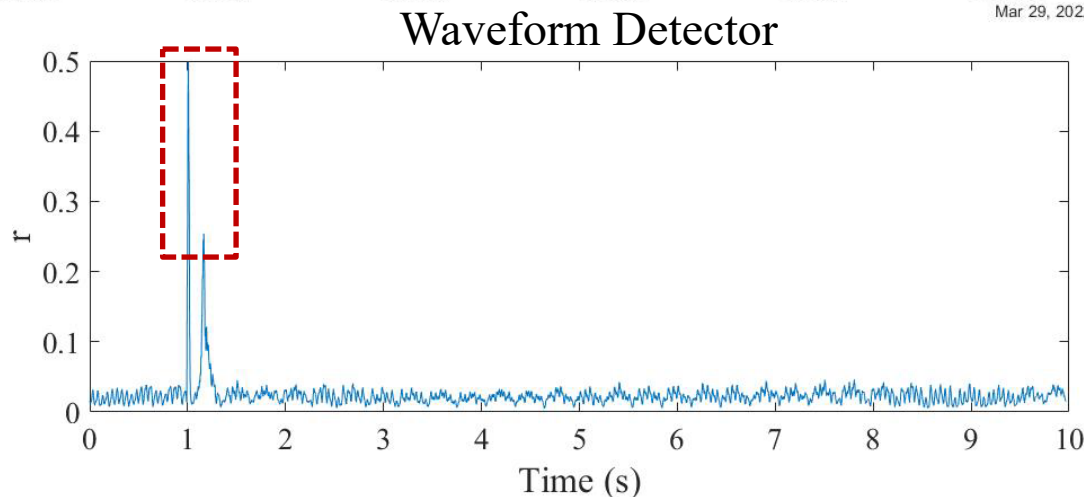
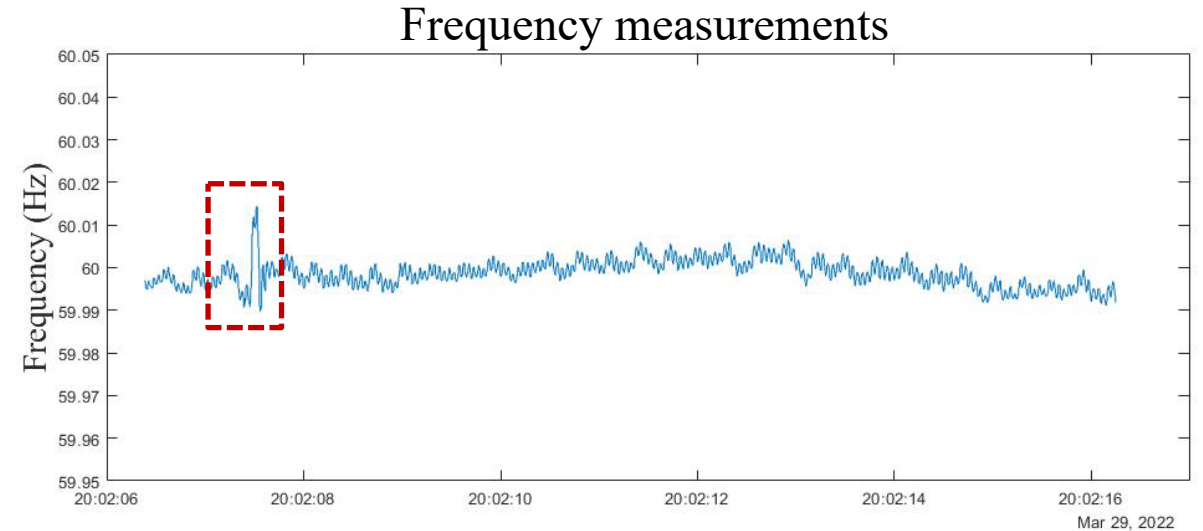
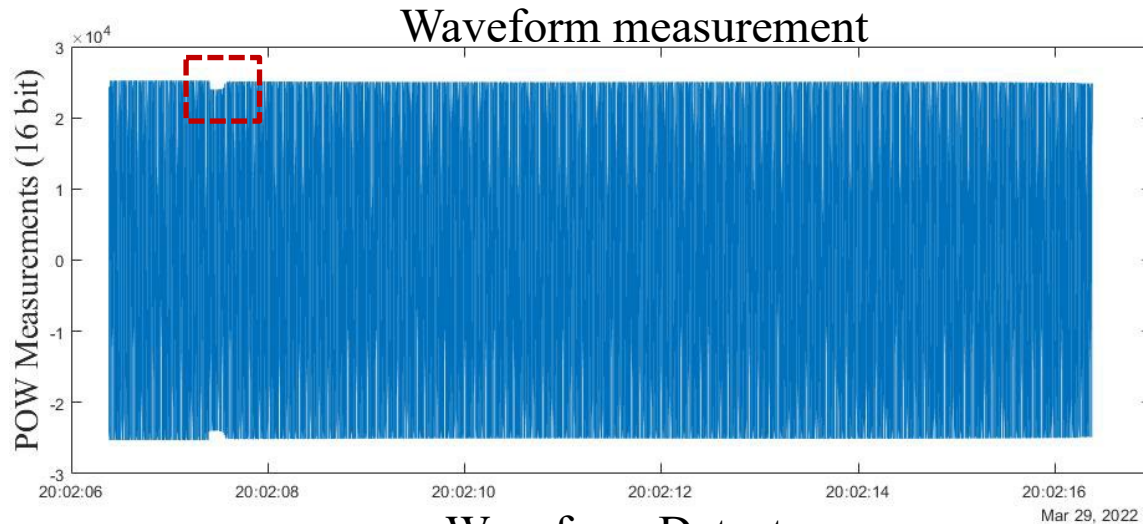
Single-Sided Amplitude Spectrum



Frequency domain analysis (Frequency measurement)

Test Results in Island Grid (4/4)

- Device operations from real-world islands



	Day 1	Day 2	Day 3	Day 4	Day 5
Event number	63	60	105	77	220

Most of them are the device operations and oscillation anomalies

Conclusion

- A multiple functional phasor measurement unit is proposed to provide detailed POW measurements during anomalies
- An anomaly detection algorithm is proposed to capture four types of anomalies
- The POW data during the anomalies will be transferred back to the server with data compression technology
- The anomaly system has been set up in Island Grid and anomaly cases are studied

Thank you!

Q & A

Acknowledgement

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