

WISER: Waveform Instrument for Synchronized Environmental Recording

Sean McDaniel, Ph.D.

Peter Weed



Executive Summary

- **WISER: Research tool for (power) system analysis**
 - Low-cost, robust, easily-modified platform that will be easy to install, and will record high-bandwidth, full-waveform data
 - Suggested applications: identification and diagnosis of grid events, model verification of grid assets, etc.
 - Key technologies have been demonstrated in a lab environment
- **Addresses key challenges in distributed environmental monitoring**
 - *Flexibility*: Developing new platforms for different monitoring environments is high cost and high effort
 - *AC mains monitoring*: Modern, AC-mains (household) monitoring hardware is variously limited
 - *Time-domain analysis*: Low-bandwidth, phasor data restricts analysis methods
 - *Costs*: High costs limit density and deployment of conventional PMUs

Challenges

Challenges and solutions in distributed environmental monitoring

Challenge #1: Flexibility

- **PROBLEM**: Developing new platforms for different monitoring environments is high cost and high effort
 - Current method: different environment → different hardware → multiplied development times and costs
 - Unmonitored environments impede comprehensive generation-to-consumption insight
- **SOLUTION**: Create a single, easily-modified platform
 - Simple, compact, and robust hardware core will be common to all instantiations
 - External interface can be easily modified to suit instrumentation needs



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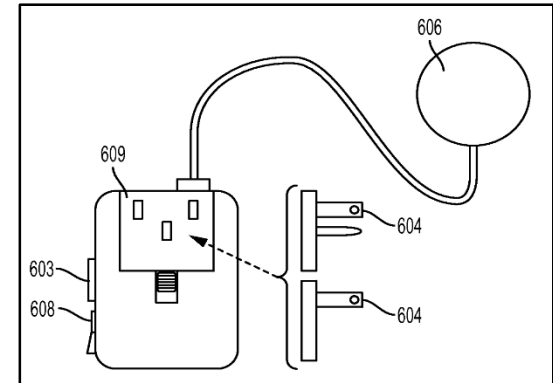
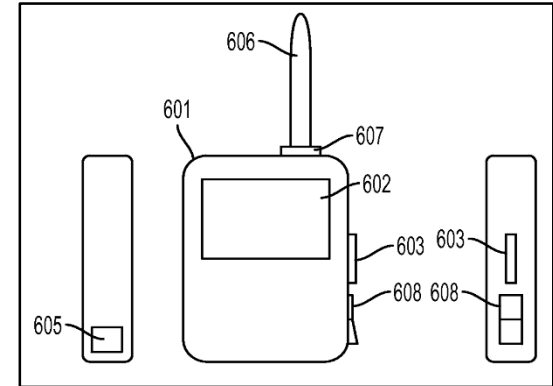
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Challenge #2: AC Mains Monitoring

- **PROBLEM**: Modern, AC-mains (household) monitoring hardware is variously limited
 - Current equipment can be bulky, difficult to install, or record heavily-filtered data
- **SOLUTION**: Create a compact, easy to install, simple to operate, waveform monitor
 - Plugs into standard NEMA receptacles
 - Interchangeable power plugs
 - Small, compact form (deck of cards)

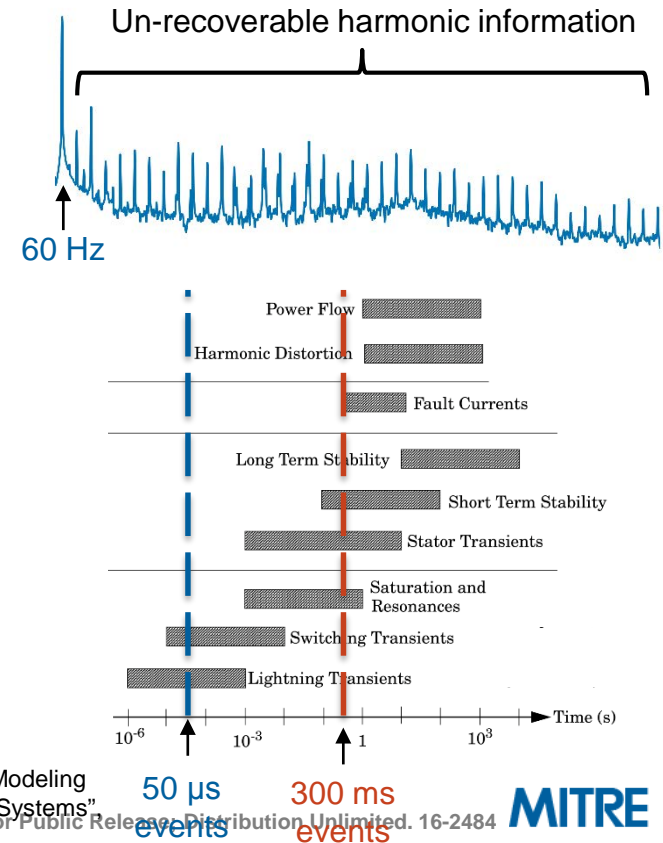
Left (top): Front view of a possible WISER prototype form. From patent submission application number 14621136 (McDaniel, Weed 2016)

Left (bottom): Back view of a possible WISER prototype form. Interchangeable plugs and alternative GPS antenna type are shown.



Challenge #3: Time-domain Analysis

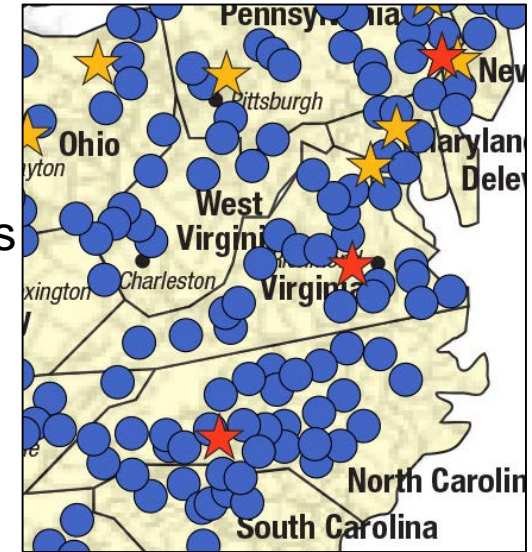
- **PROBLEM**: Low-bandwidth, phasor data restricts analysis methods
 - PMUs typically track phase, amplitude, angle of 60 Hz fundamental
 - Harmonic information cannot be recovered
 - Data reporting rates are too low to capture important transient events: 10 or 60 Hz limits detection from 300 to 50 ms
- **SOLUTION**: Capture the full-voltage waveform at a high-enough sampling rate to capture transient events of interest
 - At 64 ksps → capture 50 μs transient events



Lower Figure: Adapted from "Modeling and Analysis of Electric Power Systems" Göran Anderson 2008

Challenge #4: Costs

- **PROBLEM**: High costs limit density and deployment of conventional PMUs
 - Three drivers of high costs (\$40k – \$180k per unit)¹: hardware, installation, and communications
 - Present device density and dispersion in VA: 1 PMU per 2100 sq. mi. (22 total)
- **SOLUTION**: Reduce hardware, communications, and installation costs through intelligent design
 - *Hardware*: cost < \$400 per unit
 - *Communications*: Large local storage reduces communications burden
 - *Installation*: Intentionally simple operation—turn on and leave



1 – US DOE “Factors Affecting PMU Installation Costs” (2014)

Figure adapted from published image “March 2015 PMU Locations” by North American SyncroPhasor Institute, 2015

WISER

Hardware overview and applications

MITRE

WISER Overview

- **WISER is not a synchrophasor replacement, it's designed to be a research tool.**
 - GPS-synchronized, full waveform, voltage recorder with a micro-processor driven core
 - High sampling rate goal ($f_s \approx 64 \text{ ksps}$)
 - Large, local storage on micro-SD card
 - Low unit cost (per unit < \$400)
 - Low-power goal (< 1W)
 - Flexible hardware design that is easily adaptable to any environment
 - Easy installation for AC mains receptacles

WISER DAQ Overview

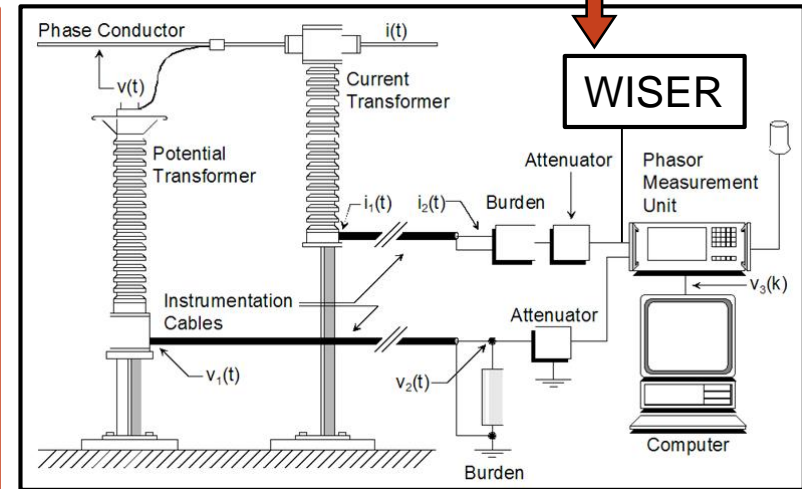
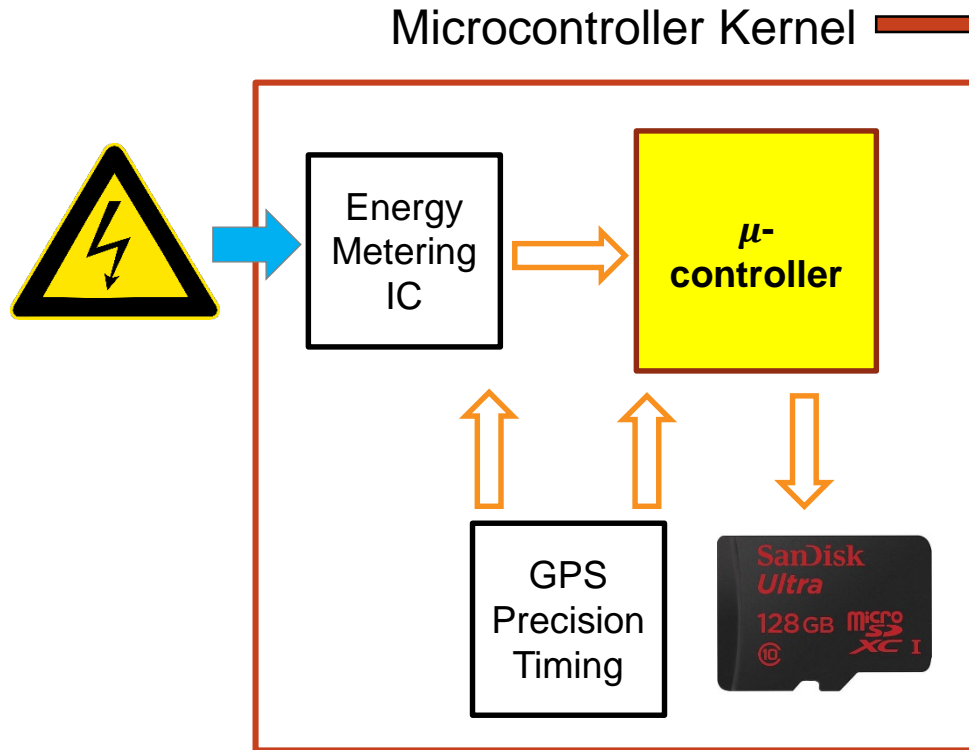


Figure (left): Simplified cartoon of internal WISER architecture

Figure (above): WISER implemented as a complementary data recorder at a substation

Power Industry Applications

Research tool for power system analysis

1. Identification and diagnosis of grid events

- Expand possible analysis techniques using waveform data
- Perform transient analysis using high-sampling-rate data

2. Model verification of grid assets

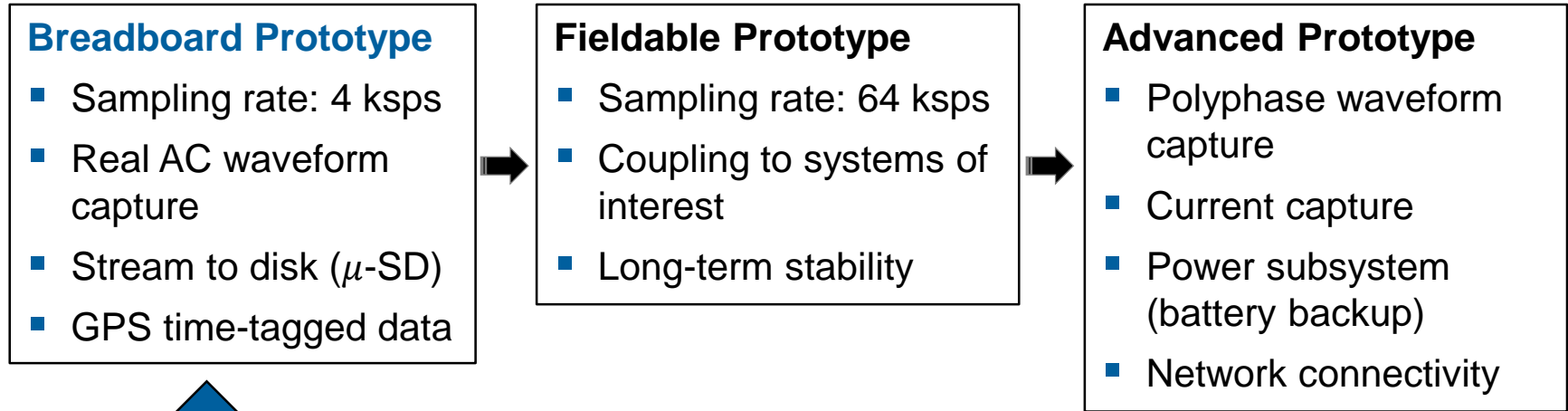
3. AC-mains receptacle monitor

4. Synchrophasor supplement

5. Increase sensor density and coverage

- At medium/high voltage nodes ($V_{\text{RMS}} > 2 \text{ kV}$)
- At low voltage nodes ($V_{\text{RMS}} \approx 120/240 \text{ kV}$)

Development Status and Roadmap



- **Current status:** breadboard prototype
- **Future development to be driven by government and industry concerns**

Summary

- **WISER is a GPS-synchronized, high-sampling-rate, voltage waveform recorder**
- **WISER was designed to solve four challenges**
 - *Flexibility*: Create a single, easily-modified platform for all measurement situations and voltage levels
 - *AC mains monitoring*: Create a compact, easy to install, trivial to operate, waveform monitor that can plug into any common AC receptacle
 - *Time-domain analysis*: Open up new, exciting time-domain analyses, particularly for transients
 - *Costs*: Reduce high hardware, communications, and installation costs
- **Key technologies have been proven in a lab environment**