

Modernizing Power Grids with Distributed Intelligence and Smart Grid-Ready Instrumentation

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Our Challenges

- **Smart Grid is an umbrella term defining multiple efforts for modernizing power systems**
 - *Utilities are learning as they go, so flexibility is paramount*
- **Technology and standards are constantly evolving**
 - *Instruments are designed for functions and standards of an specific/fixed point in time (obsolescence risks)*
- **Computerized systems require enhanced/flexible security approaches**
 - *Special technology and costly components must be developed making existing instrumentation expensive and slow to adopt*
- **Economic pressure**
 - *Shrinking budget and resources and favors, high efficiency, multi-purpose/field-configurable instrumentation*

Grid: Measurement – Visualization – Automation

100's of Devices

Multiple Protocols

Multiple Buses

Fixed Functionality

Hundreds of Vendors

Poor Data Visualization Tools



Transformer Monitoring



Alarm Event Recorder



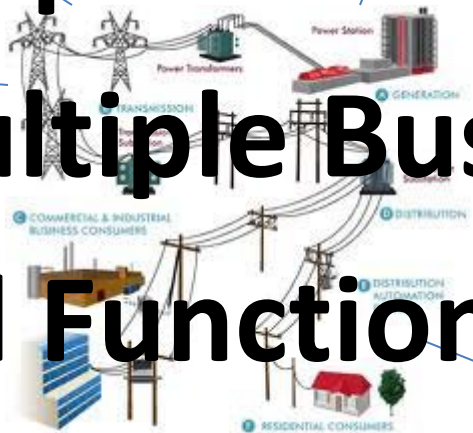
Recloser Control



Sectionalizer Control



Phasor Measurement Unit



Capacitor Control



Substation Automation



Demand Response



Metering



Power Quality Analyzer

Smart Grid Instrumentation Requirements

- **Distributed Intelligence**

- *Promotes optimum network response times and bandwidth utilization*
- *Allows unprecedented amounts of data and grid control operations to be seamlessly managed through the system*
- *Enhances reliability through decentralized coordination instead of through the imposition of hierarchical control.*

- **Flexible communication protocols**

- *Facilitates instrumentation interoperability*

- **Future-proof architecture**

- *Real-time platform that allows capture of fast moving data such as transients and line disturbances*
- *High Fidelity ADCs with 24-bits and Filtering Capabilities for Quality Measurements*
- *Common data file formats (Standards Based)*
- *I/O Expandable and Remote Upgrades*

- **Security**

- *NERC/CIP, SSL*

Smart Grid-Ready Instrumentation

Computers



- Processing Power
- Open Source
- I/O Expandable
- Programmable
- Software-Defined



- Measurement Quality
- Embedded Processing Power
- Reliable and Robust
- Open source and Programmable
- I/O Expandable and Standards-Based
- Software-defined

T&D Instrumentation



- Measurement Quality
- Embedded
- Reliable and Robust
- Standards-based
- Vendor-Defined

Closing the GAP: FPGA

Graphical Programming

Desktop Test Bench

Compilation

Synthesis

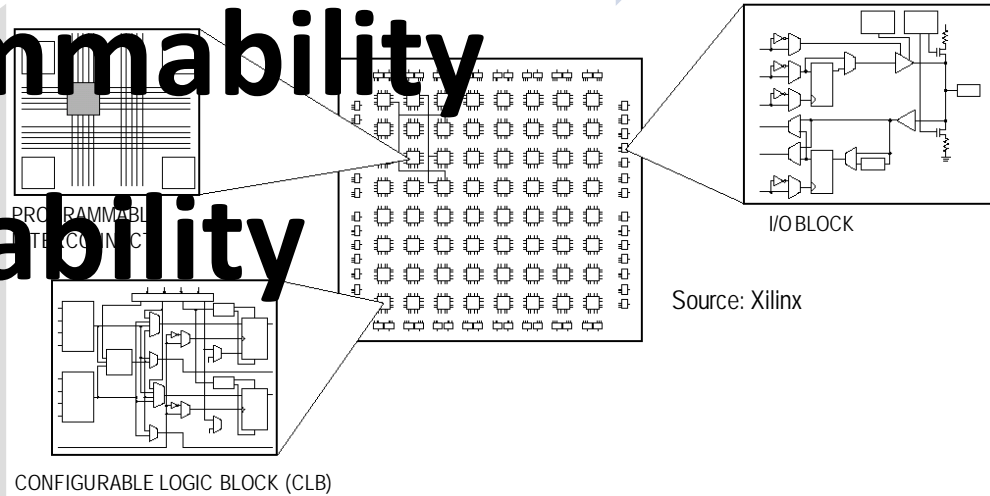
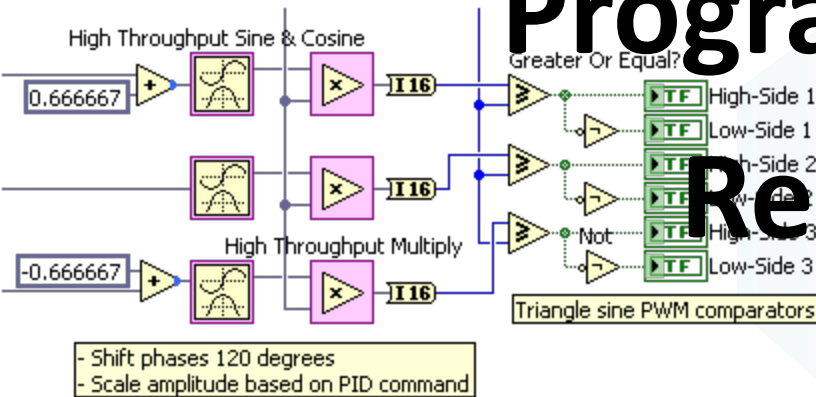
Place & Route

Deployment

Performance

Programmability

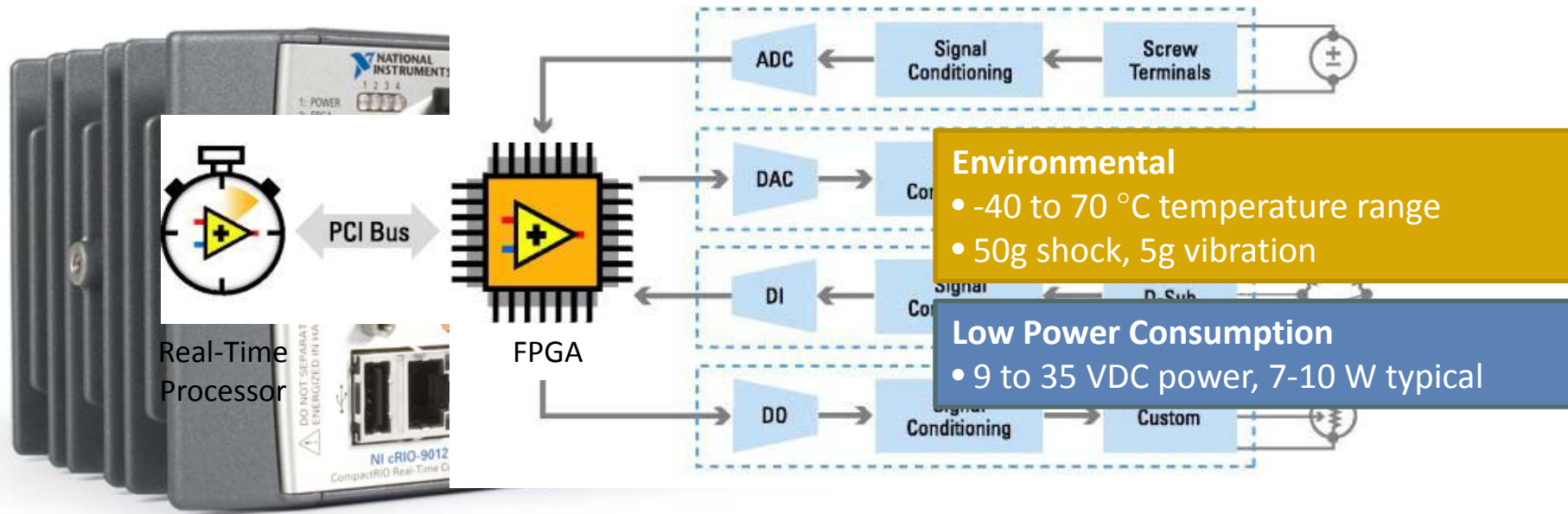
Reliability



LabVIEW FPGA

Reconfigurable Hardware

NI CompactRIO FPGA-based Platform



- **Reconfigurable FPGA** for high-speed and custom I/O timing, triggering, and control
- **I/O modules** with built-in signal conditioning for connection to sensors/actuators
- **Real-time processor** for reliable measurement, analysis, connectivity, and control

Over 100 C Series I/O Modules



- **Analog Input**

- Up to 1MS/s, simultaneous sampling
- 4, 8, 16, and 32-ch options
- Built-in signal condition for sensors
 - Strain gages, accelerometers, thermocouples, RTDs
- Up to ± 300 VRMS, ± 5 ARMS
- 12, 16 and 24-bit resolution
- Available ch-to-ch isolation

- **Analog Output**

- Up to 100 kS/s simultaneous updating
- Up to 16-ch per module
- 10 V, ± 20 mA
- Isolation

- **Digital I/O**

- Up to 10 MHz timing
- Counter/timer, PWM
- 8 and 32-channel options
- 5V/TTL, 12/24/48/60 V logic levels

- **Specialty**

- 2-port CAN modules
- Brushed DC servo motor drive

- **Third Party Modules**

- LIN, Profibus, WLAN, MIL-1553, ARINC-429, GPS, and more

LabVIEW Power Quality & PMU Toolkit Functionality

Voltage and Current	Power and Energy	Power Quality
Three Phase RMS (V and I)	Power per Phase	Voltage Sag (dip)
THD	Three Phase or Total	Voltage Swell
Harmonic (up to 64 th)	Power Factor	Impulsive Transient (V + I)
Interharmonics (0.5 to 63.5 th)	Active Power Total	Oscillatory Transient (V + I)
Voltage Unbalance	Active Power Harmonic	Overvoltage and undervoltage
Frequency Oscillation	Apparent Power Total	Overcurrent
Flicker	Apparent Power Harmonic	Phasor Imbalance
DC Portion	Reactive Power	Three Phase Voltage Harmonic
	Reactive Power Harmonic	Four Current Harmonic
	Energy Active Total	Harmonic per sec and per cycle
	Energy Apparent Total and +/-	Synchrophasor IEEE-C37.118
	Energy Reactive Total and L/C	

Communications Protocols

- Released: UDP, TCP/IP, Modbus RTU/ASCII/TCP, Ethernet/IP, DNP3.0, IEC 60870-5
- Expected in 2012/2013: IEC 61850 MMS & GOOSE



Houston, TX - USA

ADVANCED SMART SWITCH

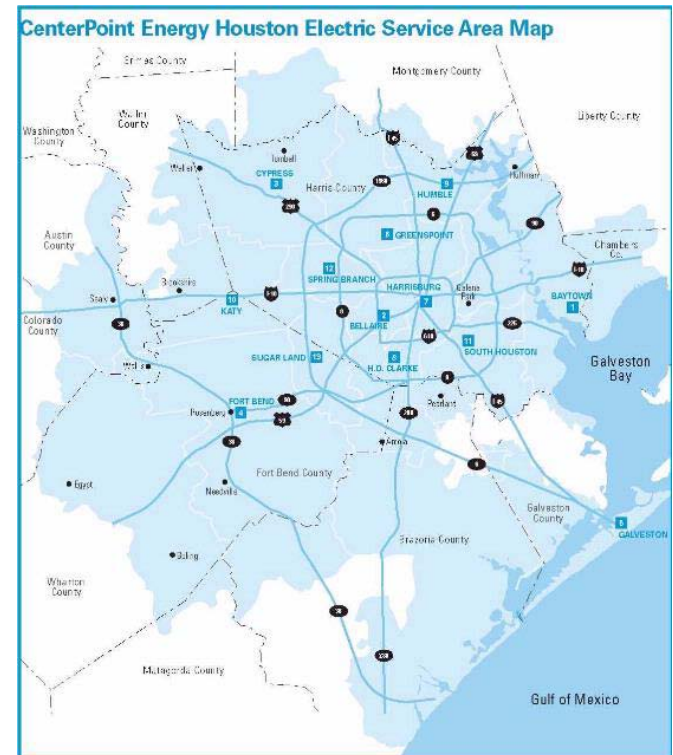
CenterPoint's Vision and Project Goal

- **Vision**

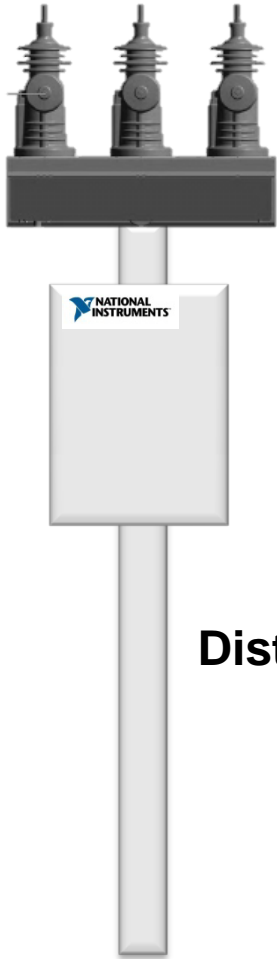
- *To be recognized as America's leading energy delivery company*

- **Project Goal**

- *To modernize and install smart/intelligent reclosers and sectionalizer on distribution grid*
 - *Faster fault identification*
 - *Automatic fault isolation*
 - *Real-time grid health monitoring*



Advanced Smart Distribution Switch



- Advanced analytics for distribution automation
- Development and introduction of advanced switching features
- Embedded electrical power measurements and monitoring
- Wireless communication for configuration and file transfer
- Remote updates, configuration and firmware upgrades

Distribution Switch

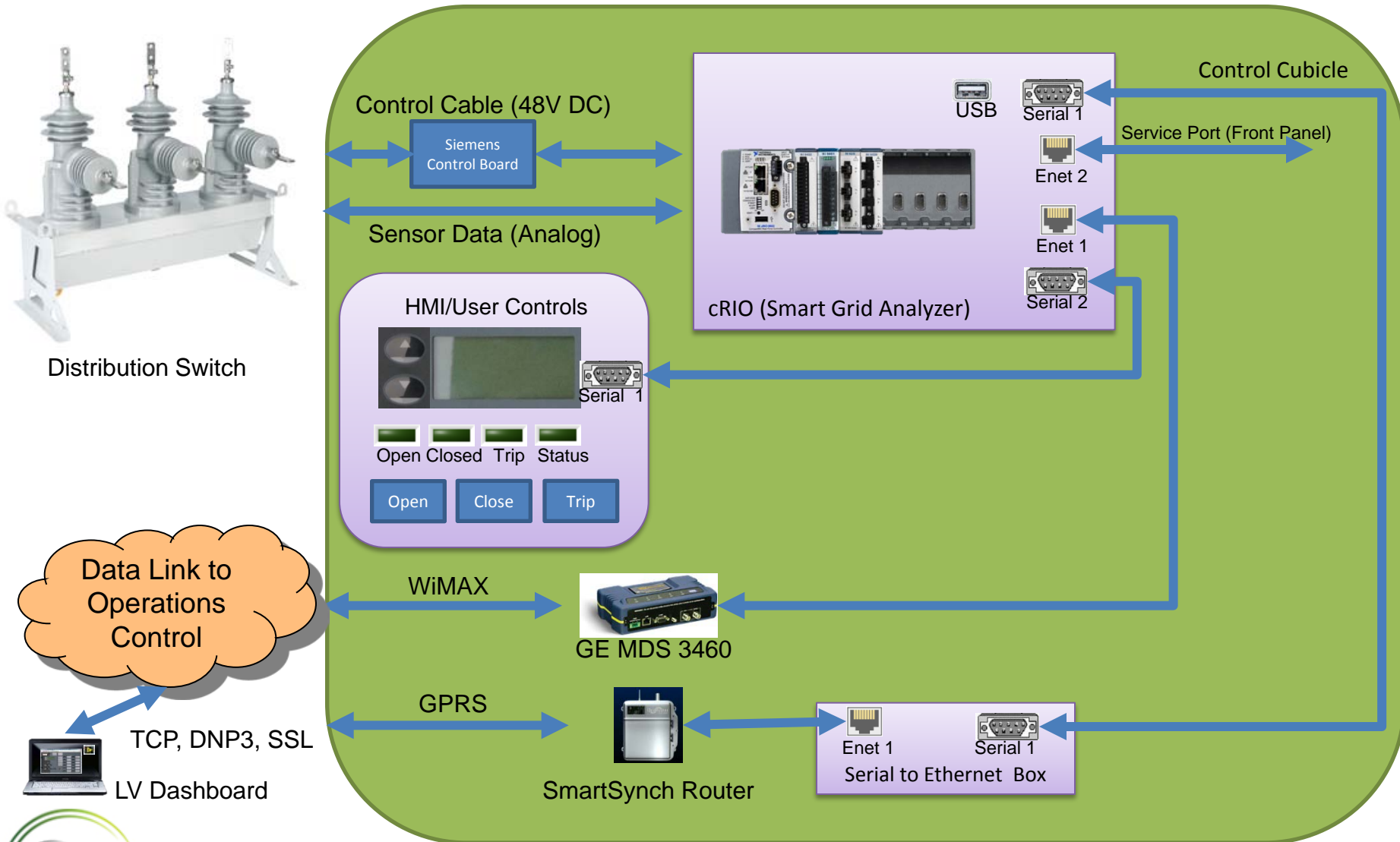
- *Rated Through 38kV*
- *Vacuum Interruption Technology*
- *Integrated CTs & Voltage Sensors*
- *Optional future upgrades*
 - *ANSI / IEEE C37.60*
 - *3-phase protection*



Analytics (NI Smart Grid Analyzer)

- *833 Samples/Cycle, 24-bit Resolution*
- *Advanced Embedded Analytics*
- *Data Storage, 1000+ event captures*
- *Remote upgrade*
- *Multi Protocol Communications*

Advanced Switch High Level Diagram







Questions

“When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.”

- Lord Kelvin, 1894

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