

# Hardware and Software Technologies for Green Engineering



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District Sales Manager  
National Instruments Denmark

# Measure It

**Acquire**



**Analyze**

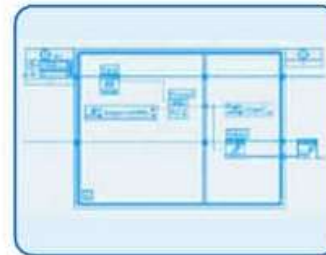


**Present**

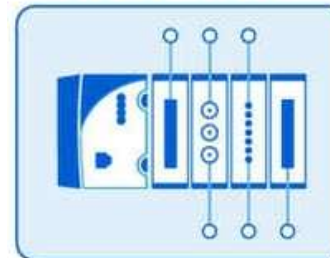


# Fix It!

**DESIGN**



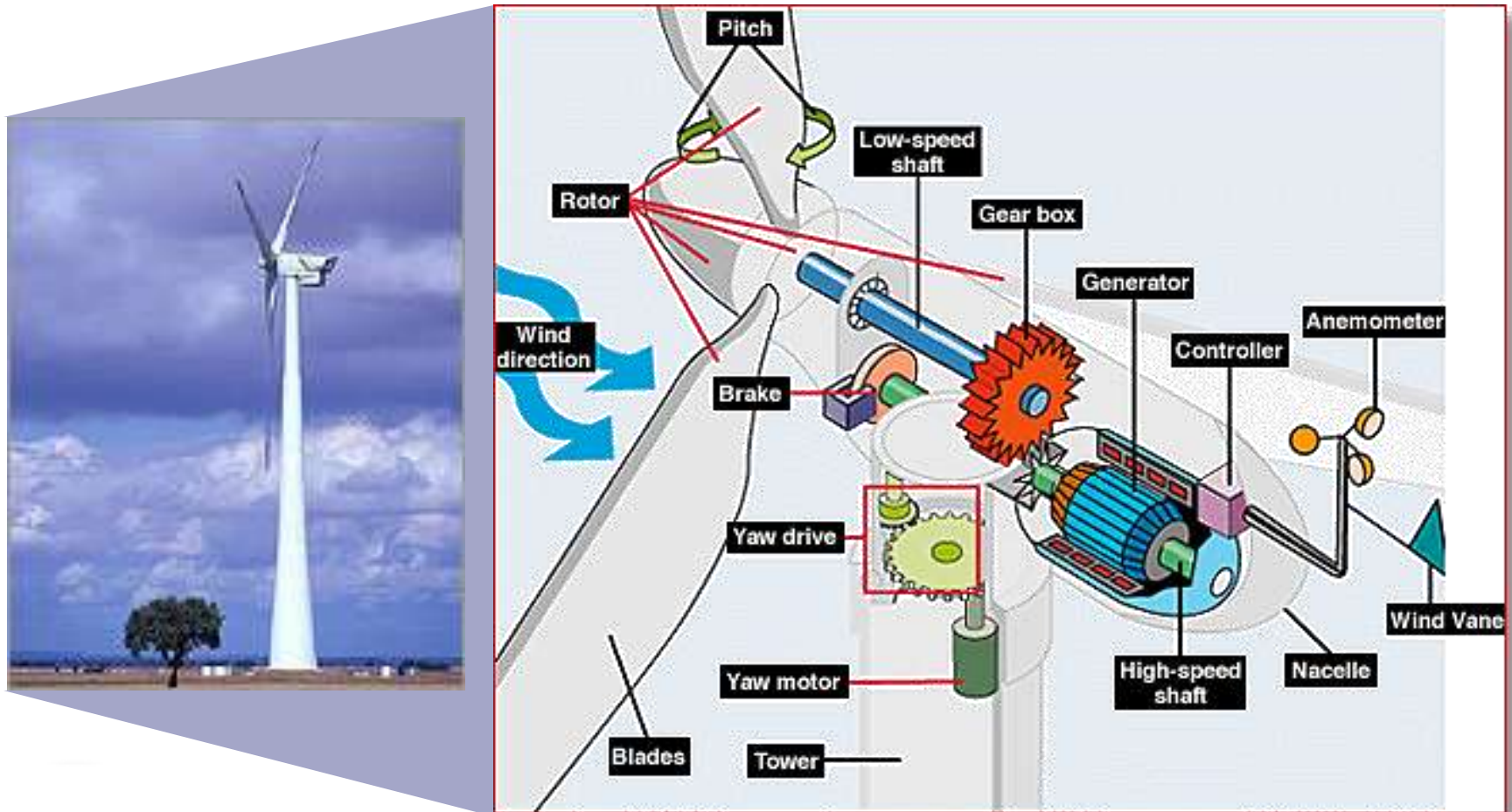
**PROTOTYPE**



**DEPLOY**



# Application Example - Wind Turbine





**Motor and Hydraulic  
Actuator Testing**



**Blade Testing**



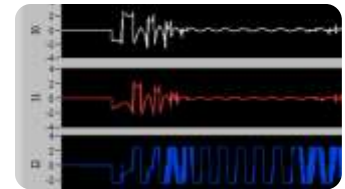
**Generator Testing**



**Gearbox Testing**



**Power Converter  
Testing**



**Grid Integration  
Testing**



**Control System  
Testing**



**Component  
Certification**



**Acoustic  
Emissions**





**Noise, Vibration, and Harshness (NVH)**



**Machine Condition Monitoring (MCM)**



**Electrical Power Grid Compliance**



**Power Quality and Transmission**

# Monitoring



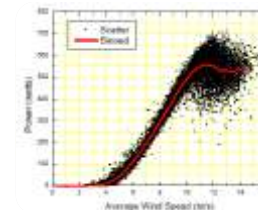
**Structural Health Monitoring**



**Fault Detection and Event Recording**



**Acoustic Emissions**



**Environmental and Weather Monitoring**

# NI Measurement Framework

Application Development Software

## NI LabVIEW

Graphical Development

Measurement and Control Services



GPIB/Serial  
and VXI



Data Acquisition and  
Signal Conditioning



Modular  
Instrumentation



PXI/CompactPCI



Motion



Vision



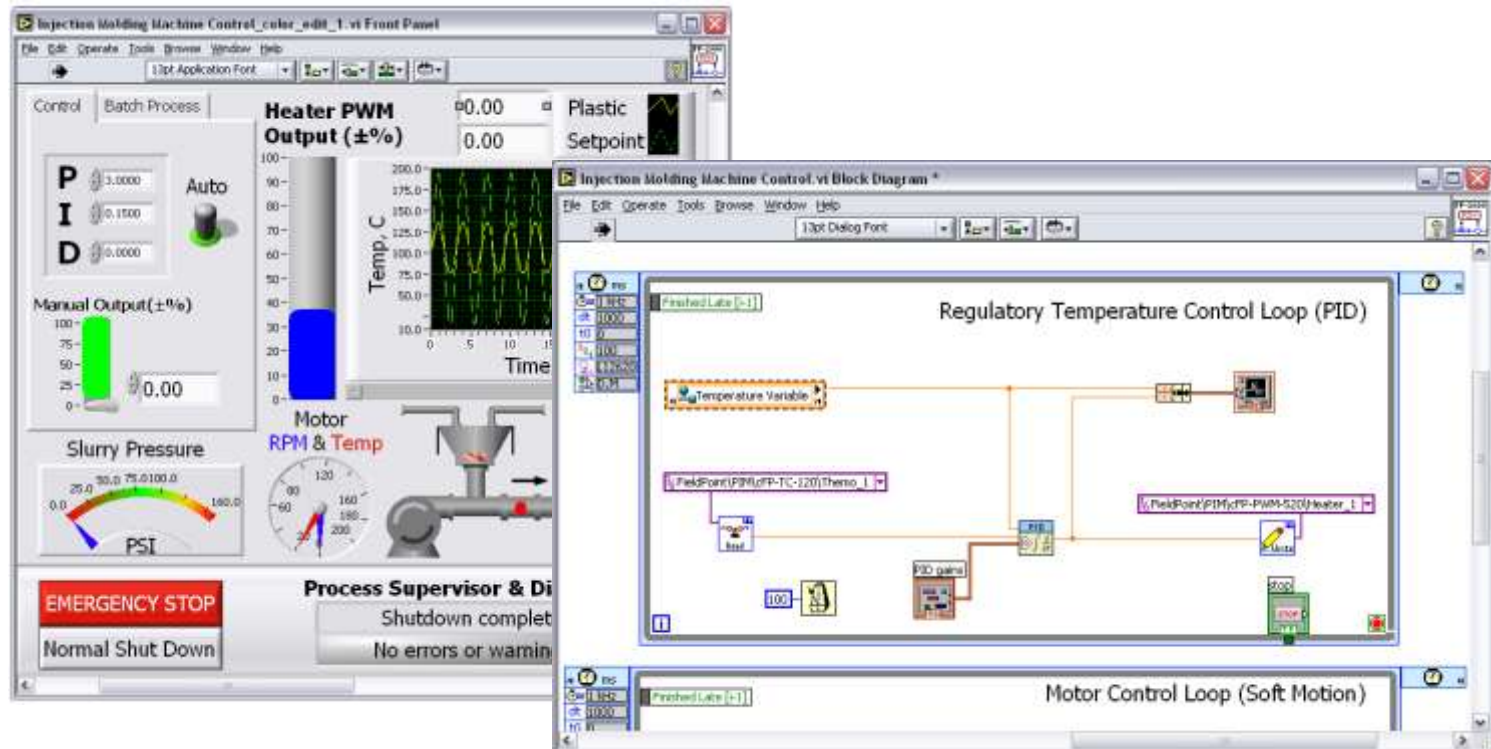
Distributed I/O



PLCs

# Measurement & Control Software

# LabVIEW Graphical Development Environment

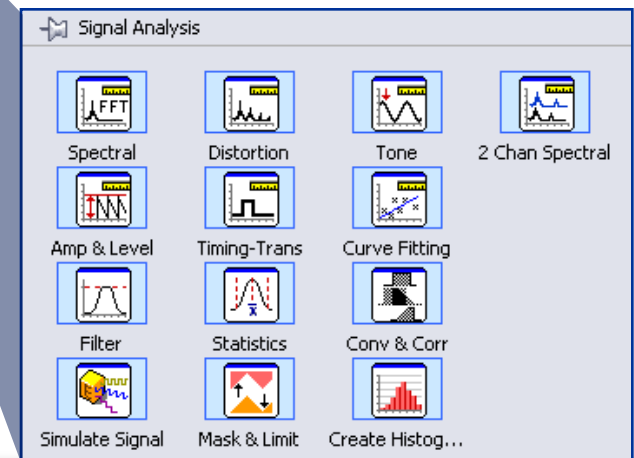
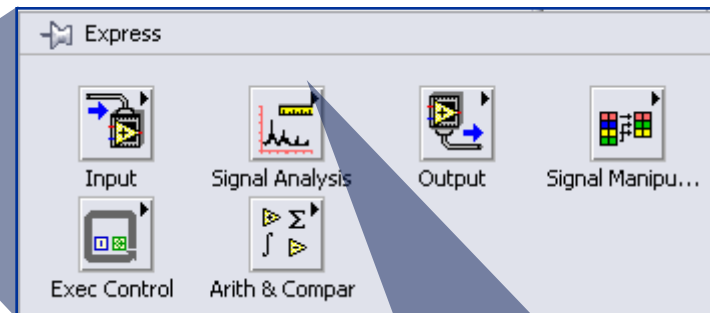
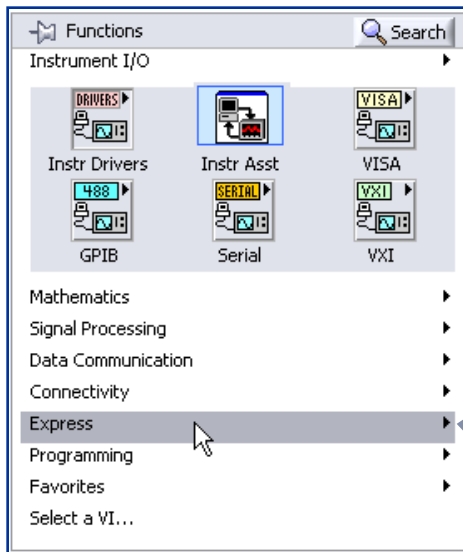


- Intuitive graphical programming language
- Deployment to desktop, mobile, industrial, and embedded targets



# LabVIEW Function Libraries

Easy, intuitive browsing through expandable function palettes



Hundreds of built-in functions for I/O, control, analysis, and data presentation

# Acquiring Measurements

*LabVIEW provides connectivity with a variety of measurement devices:*

- Connectivity to 5,000 instruments from more than 250 vendors with instrument drivers
- Modular data acquisition from DC to 2.7 GHz
- 140 motion control stages
- More than 150 cameras from 18 vendors
- Hundreds of PLCs
- Support for PXI, PCI, PCI Express, PCMCIA, USB, Ethernet, serial, GPIB, CompactFlash, and CAN



GPIB/Serial



Ethernet



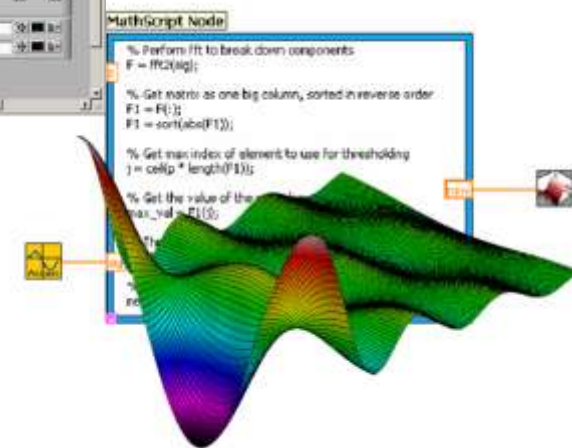
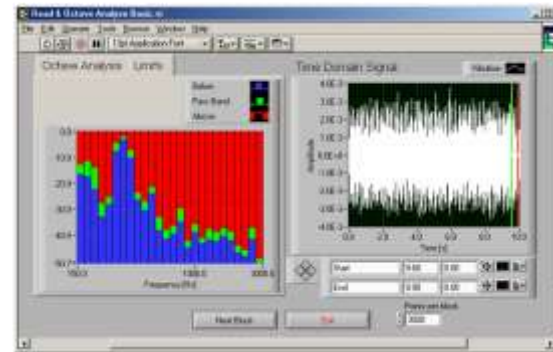
PXI



VXI

# Analysis of Measurement Data

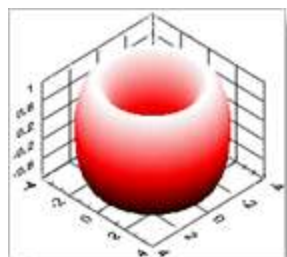
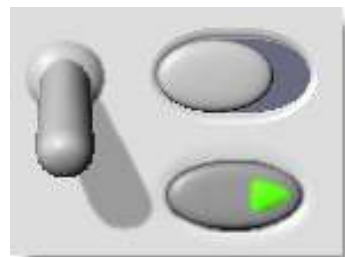
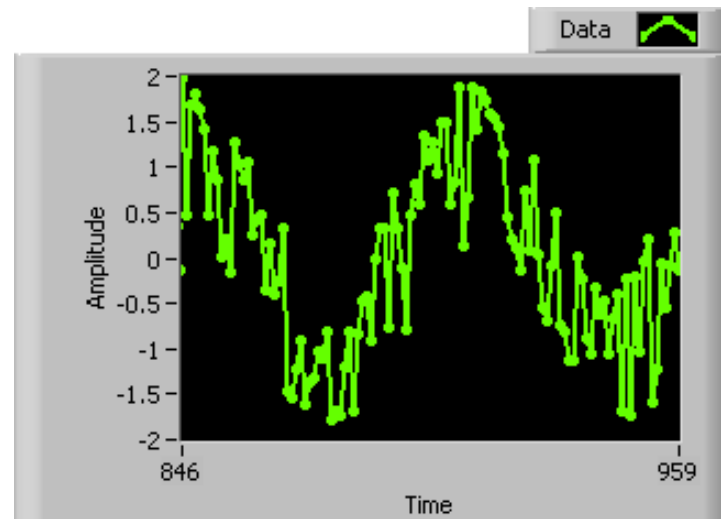
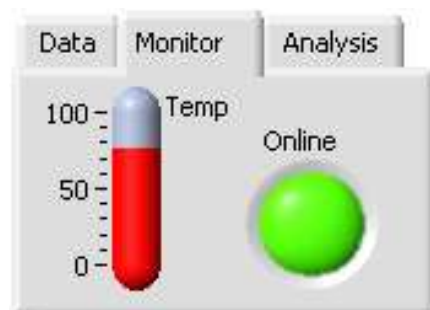
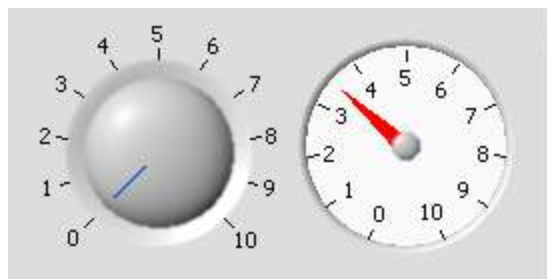
- Mathematics
- Signal generation
- Filtering
- Digital signal processing
- Probability and statistics
- Curve fitting and interpolation
- Time- and frequency-domain analysis
- Specific functions for image processing, sound & vibration analysis, and others
- More than 600 analysis functions



# Report & Present on Measurements

## Visualization

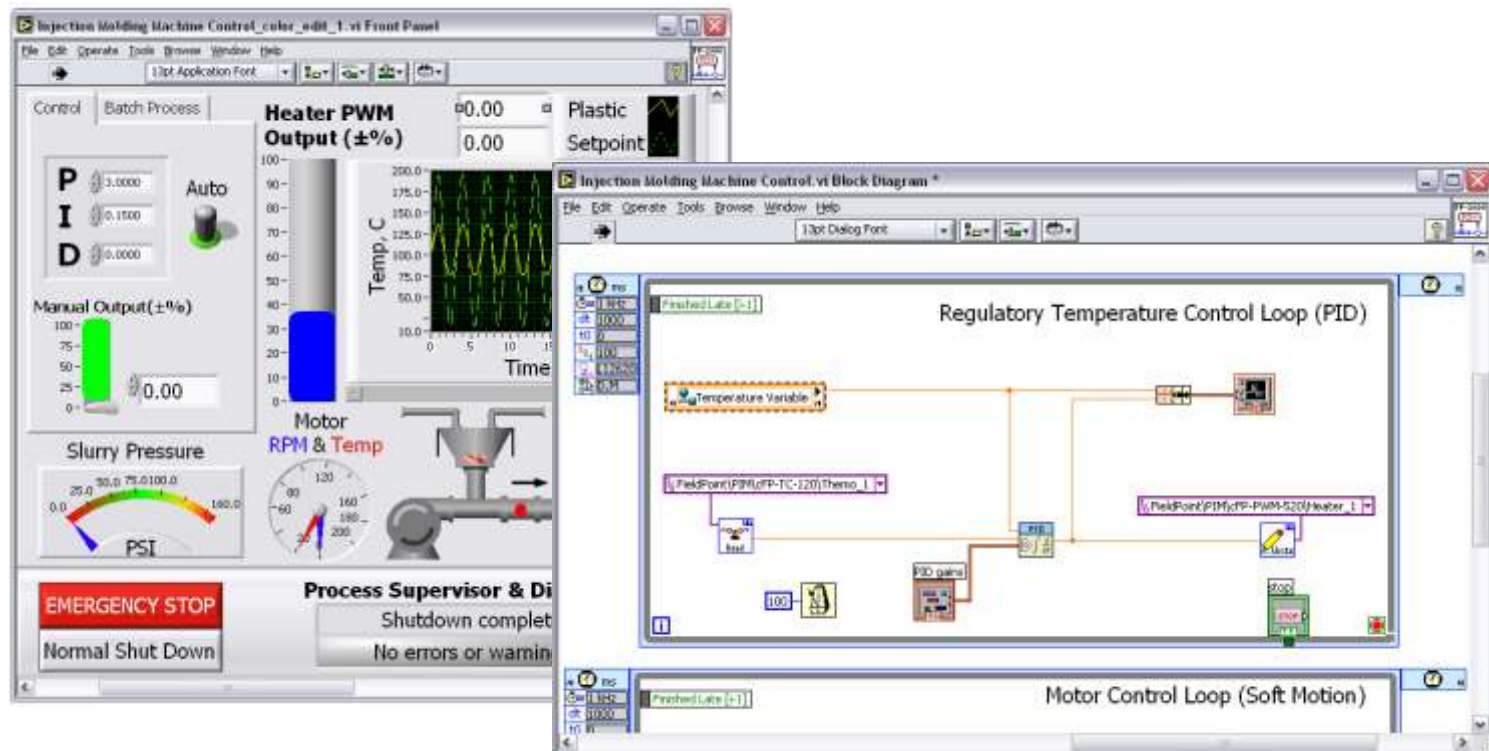
- Built-in user interface design objects
- Charting and graphing utilities
- Remote application viewing and control



## Report Generation

- File I/O functions
- HTML reports for the web
- Microsoft Word and Excel reports

# LabVIEW Demo

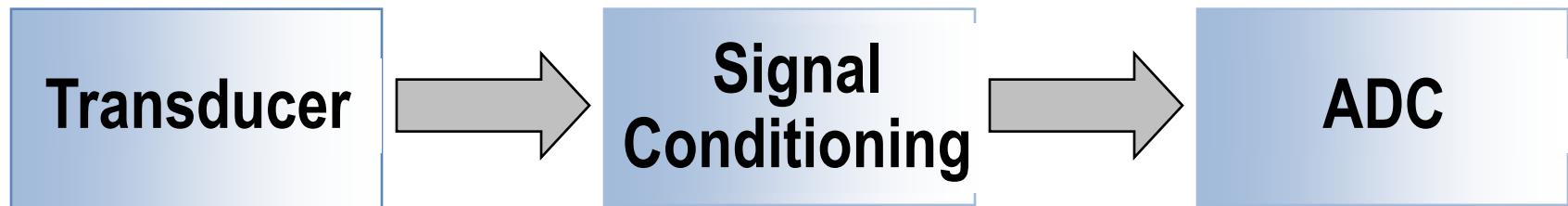




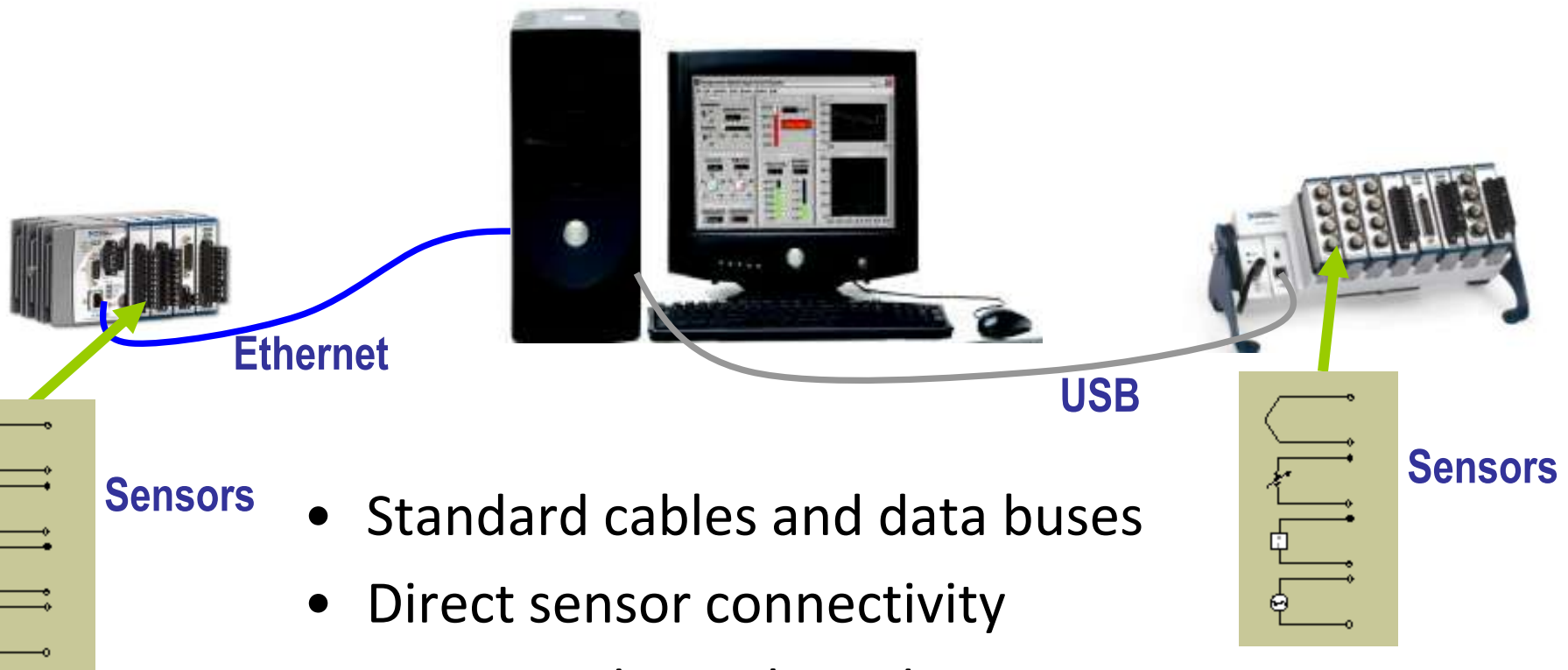
# Measurement Hardware

# Measurement System Components

*All monitoring systems have these components in common:*



# Measurement System Implementation

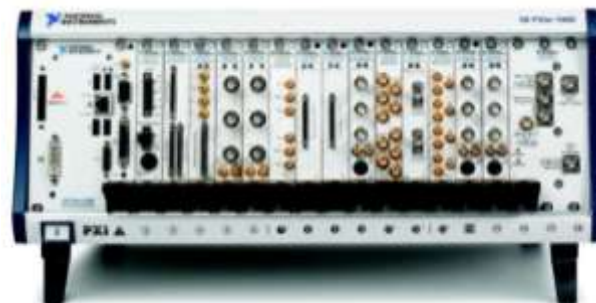


# Measurement System Architectures

Ethernet or  
wireless



Distributed



PXI



USB



SCXI

# Putting it all Together: Inside a Modern Measurement Module

## Direct Connectivity

Screw terminals, BNC, D-Sub connectors for industrial sensors and actuators

## Built-in Signal Conditioning

Amplification, anti-aliasing filters, bridge completion, CJC, sensor power, IEPE, TEDS

## Isolation Barrier

Safety, noise immunity, common-mode rejection

## Advanced ADCs

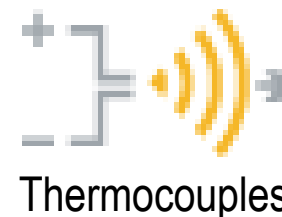
24-bit, delta-sigma, simultaneous sampling, up to 800 kS/s, NIST-traceable calibration



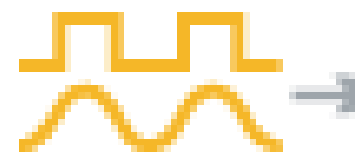


# Mixed Sensor and Signal Inputs

Phenomena	Transducer
Temperature	Thermocouples Resistive Temperature Devices (RTDs) Thermistors
Proximity	Limit Switches Proximity Switches
Vibration	Accelerometers Proximity Probes
Force and Pressure	Strain gages Load Cells
Position and Displacement	Potentiometers Linear voltage differential transformer (LVDTs) Tachometers
Fluid Flow	Rotational Flowmeters



Structural – strain, vibration



Voltage/Current

# Data Acquisition Demo



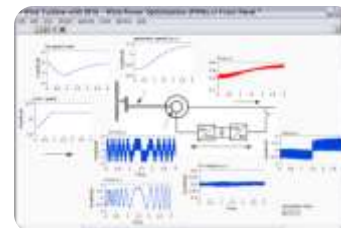
# System Automation&Control



**Blade  
Manufacturing**



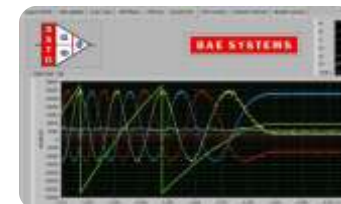
**Rapid Control  
Prototyping**



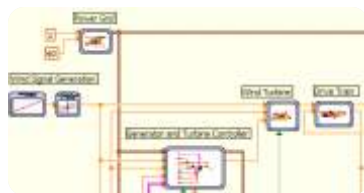
**HIL Real-Time  
Simulation**



**Component  
Manufacturing**



**“Field Oriented”  
Motor Control (FOC)**



**Control Algorithm  
Design**



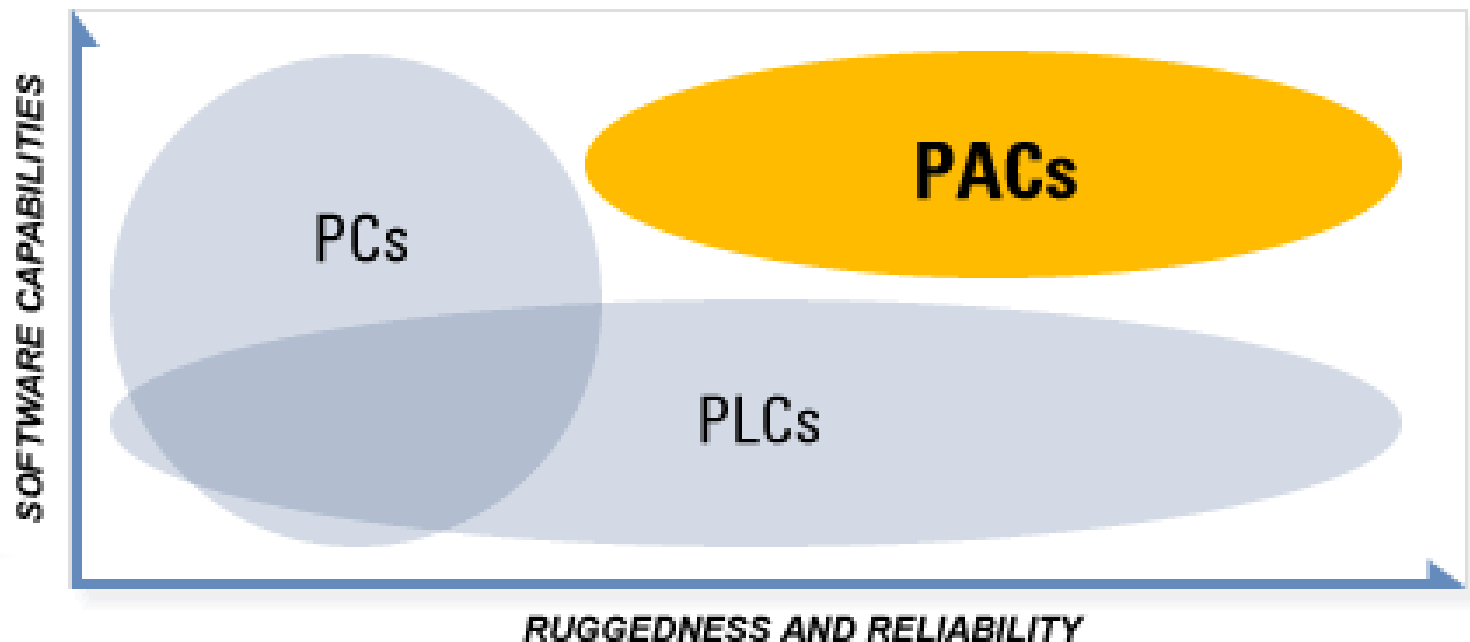
**Mechatronics**



**Power Electronics  
Control**

# Programmable Automation Controllers (PACs)

- PLC ruggedness and reliability
- PC openness and performance
- Synchronized measurement and motion control





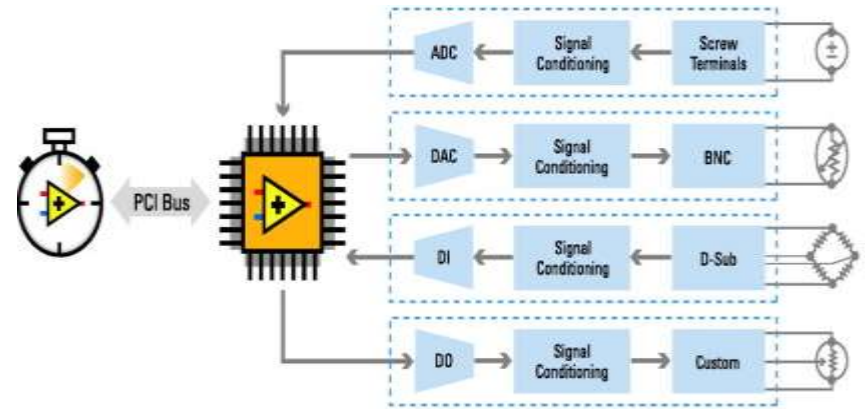
# NI CompactRIO PAC Architecture

Real-Time Processor

Reconfigurable FPGA



I/O Modules



## Extreme Ruggedness

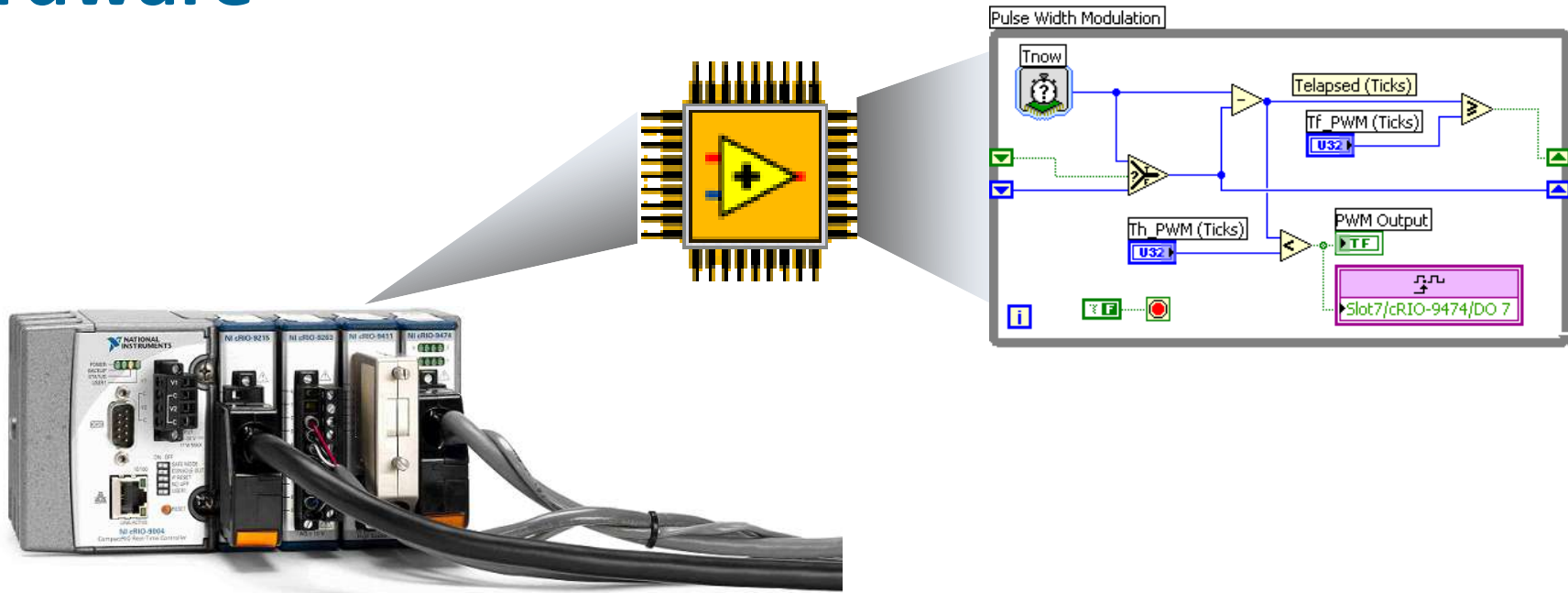
- -40 to 70 °C temperature range
- 50g shock, 5g vibration

## Low Power Consumption

- 9 to 35 VDC power, 7-10 W typical

- **I/O Modules** with built-in signal conditioning for connection to sensors/actuators
- **Reconfigurable FPGA** for high-speed and custom I/O timing, triggering, control
- **Real-Time Processor** for deterministic, stand-alone operation, logging and analysis

# FPGA Technology: Using Software to Design Hardware



Replace custom hardware with software-programmable FPGA logic

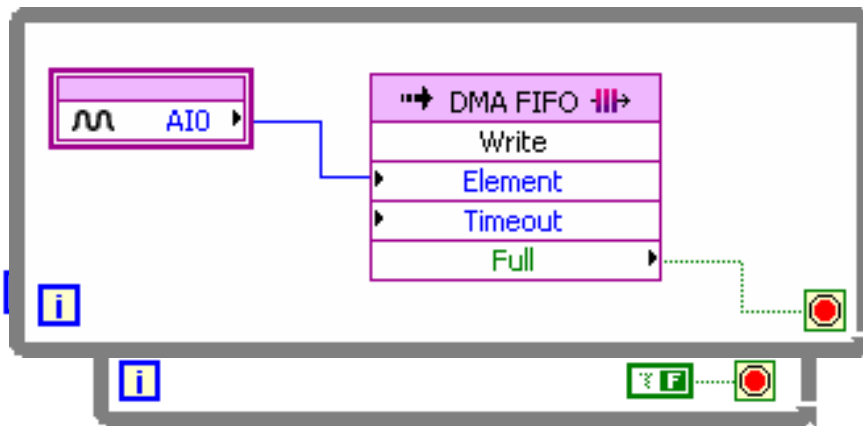
- High speed control (1 MHz digital / counter-timer, 200 kHz motion control / analog PID)
- Dedicated logic in silicon for highest reliability
- Signal processing (decoding industrial sensor signals)

# LabVIEW FPGA Code Abstraction

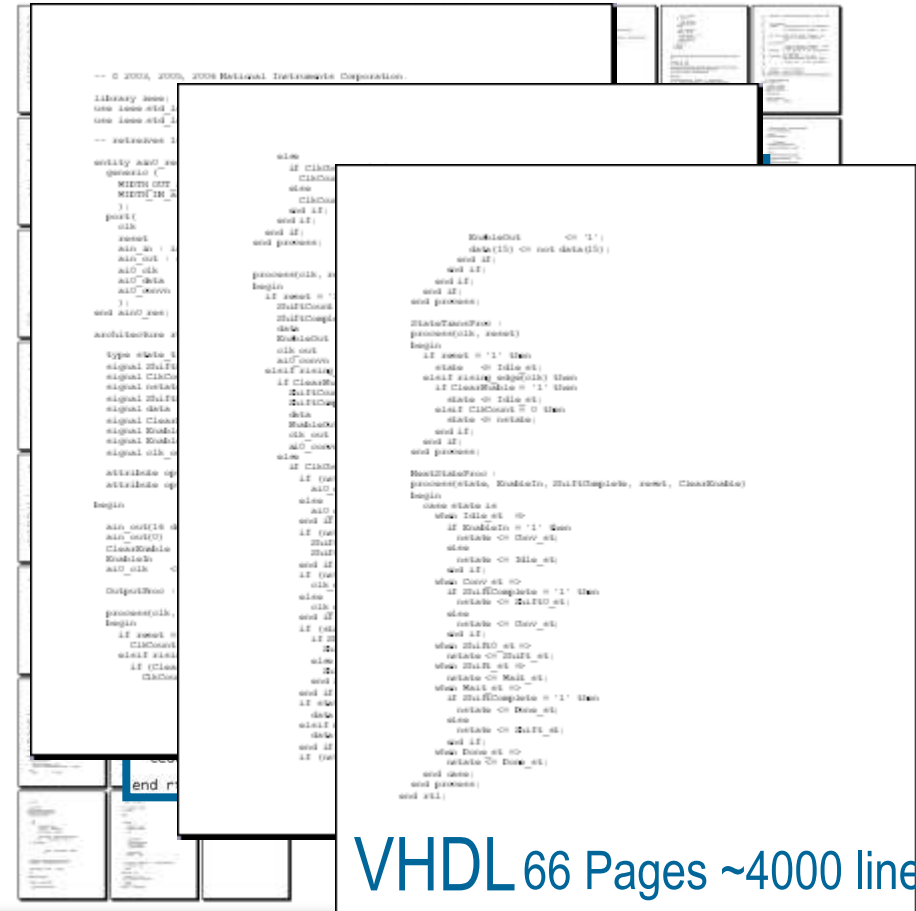
Counter

Analog I/O

I/O with DMA



LabVIEW  
FPGA



VHDL 66 Pages ~4000 lines

# Measurements with PACs

- Voltage, current, temperature, pressure, stress/strain, ...
- Digital, counter/timers, pulse width modulation, ...
- Encoders, resolvers, LVDTs, ...
- Acquisition speeds beyond 800,000 Samples/second



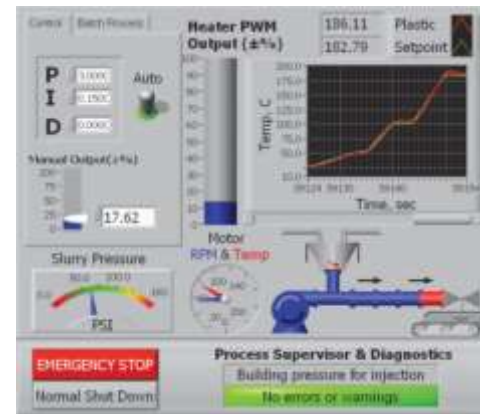
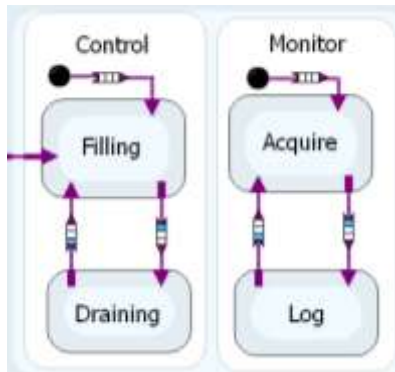
# Networking with PACs

- Standard communication to PLCs, touch panels, handhelds
- Support for industrial networks such as Ethernet, Modbus, CAN
- OPC Servers
- Local or networked data logging

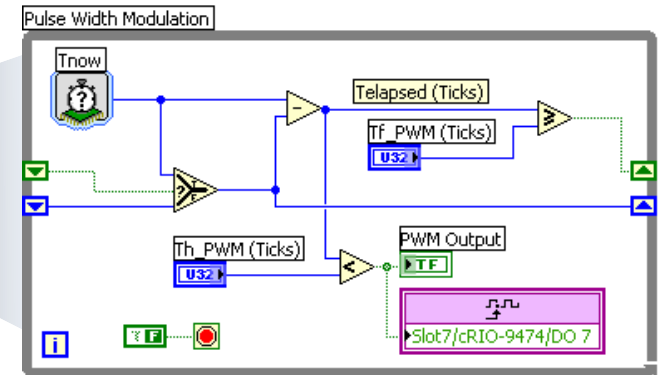
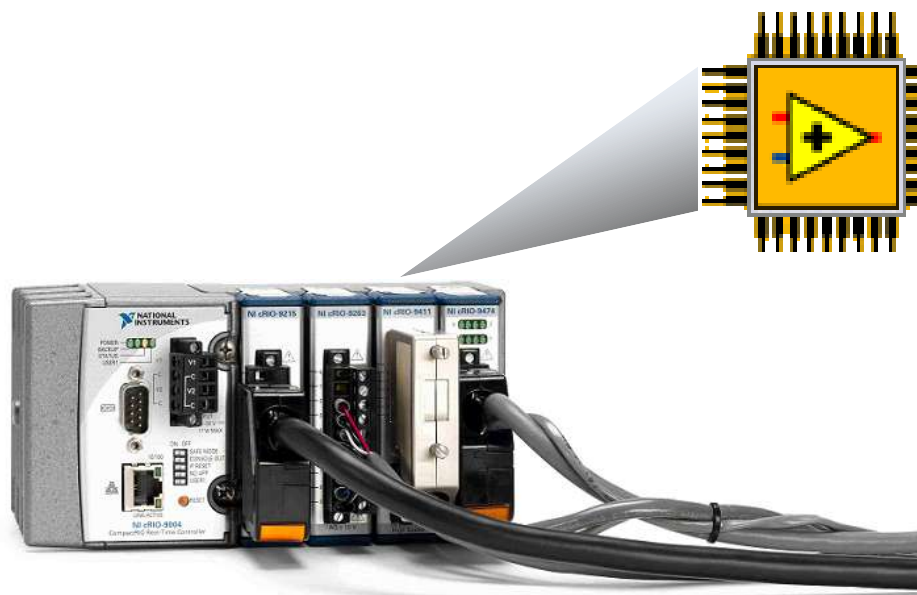


# Control with PACs

- Digital true/false logic
- State charts
- FPGA-based protection interlocks
- High speed PID control
- Advanced and custom control algorithms (gain scheduling, model predictive control, ...)

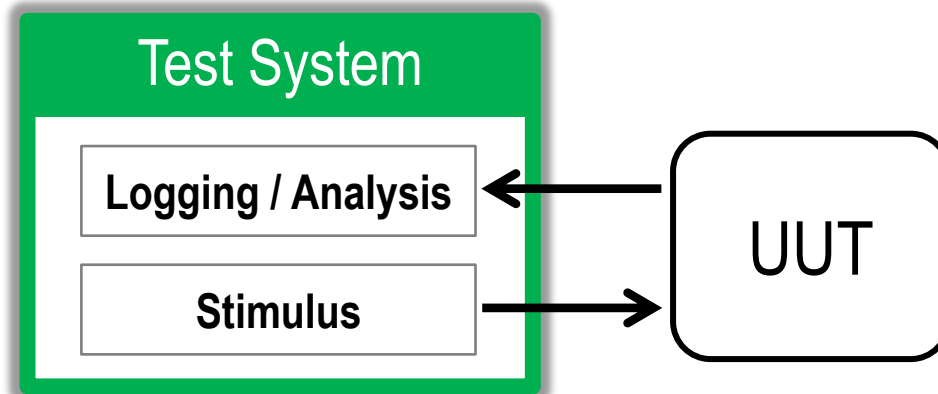


# CompactRIO Demo





# What is Real-Time Testing



The use of a real-time environment as part of a test system to increase performance or reliability.

# NI VeriStand™

## Real-Time Testing and Simulation Software

- Real-Time Stimulus
- Data Logging
- Run-time Editable User Interface
- I/O Configuration
- Calculated Channels
- Closed-Loop Control
- Deterministic Model Execution
- Alarming
- User Management
- Multi-Chassis Synchronization

