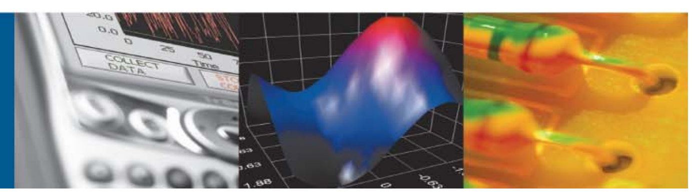
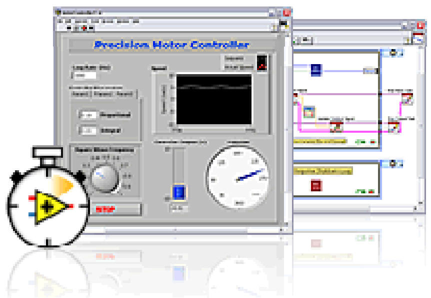
Introduction to LabVIEW Real-Time and FPGA

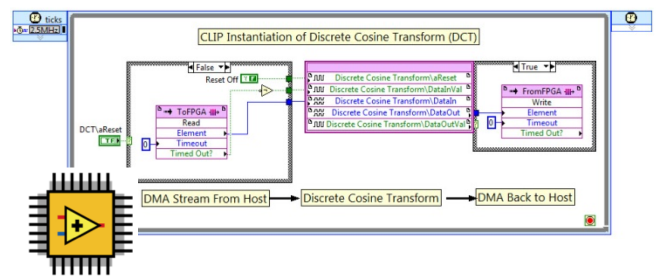


LabVIEW 2010 Real-Time Module



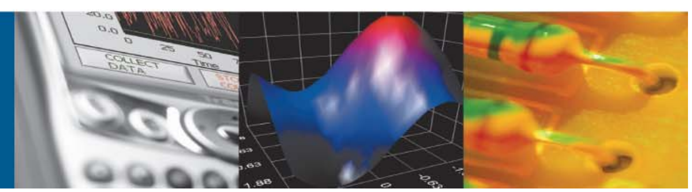
Add-on for creating deterministic, stand-alone systems

LabVIEW 2010 FPGA Module



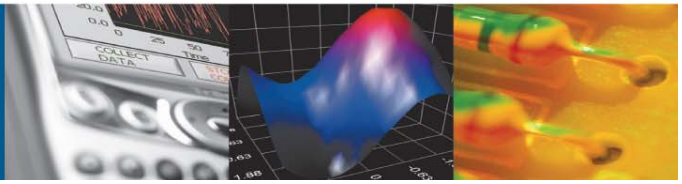
Add-on for programming reconfigurable FPGA hardware using graphical programming

Part 1: Understanding Real-Time Systems and LabVIEW Real-Time



Critical Applications to Consider

Event Response	Closed-Loop Control	Critical Tests
		

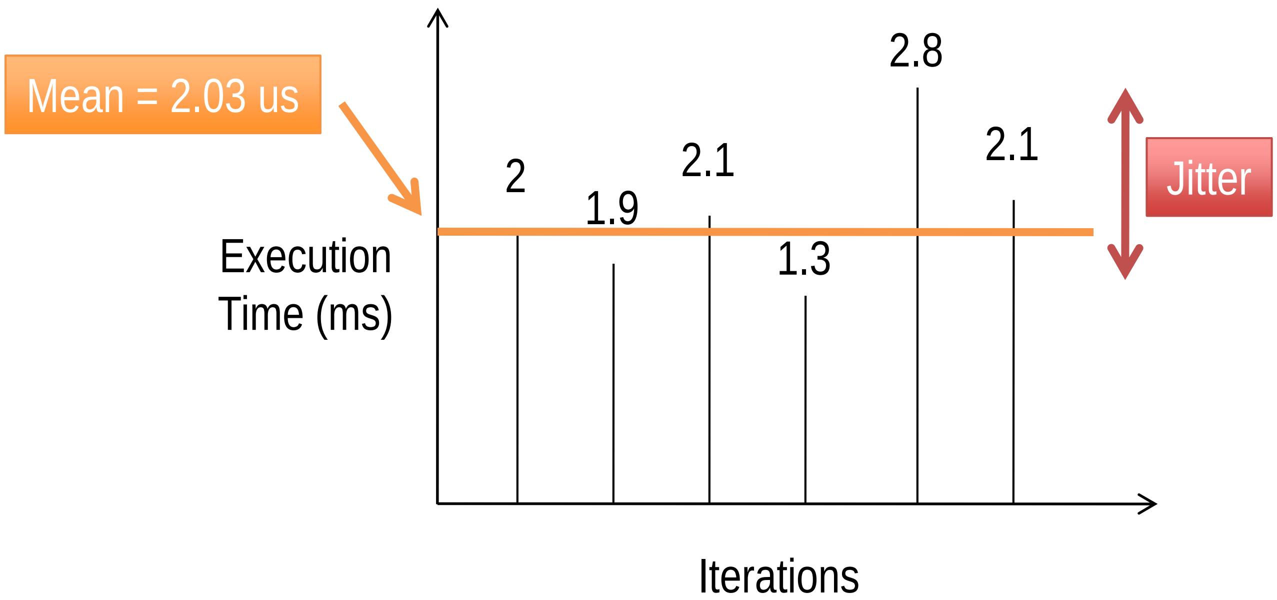


When General Purpose OSs Fall Short

- Design for fairness and user responsiveness vs. strictly prioritizing tasks
- Focus on multitasking instead of maximum reliability / uptime
- Not the result of bad products, only certain design goals

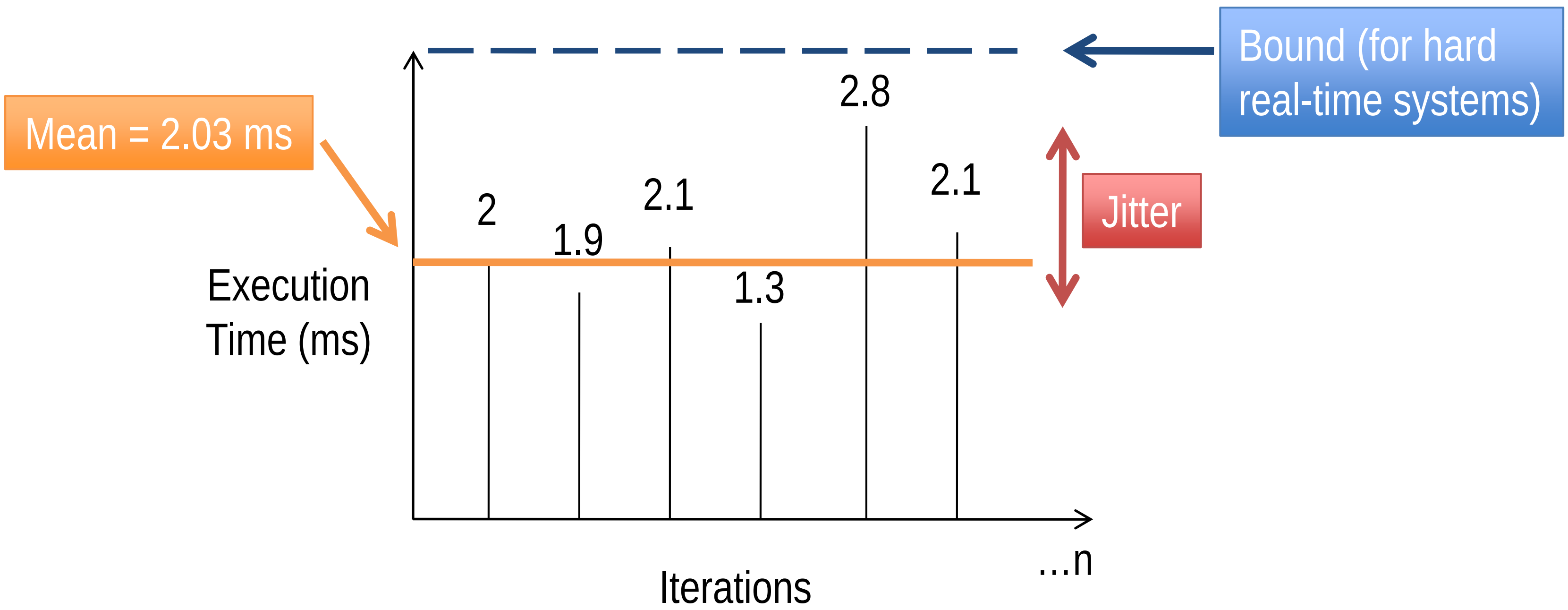
Key Careabouts for Critical Applications

- **Jitter:** execution time variability of a given operation or application



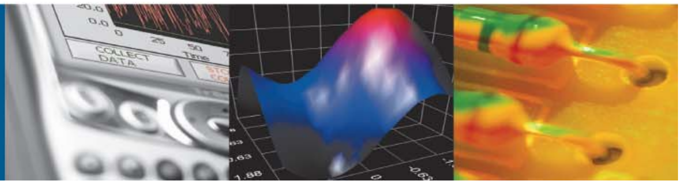
Key Careabouts for Critical Applications

- **Determinism:** a condition that is met if an operation or application has bounded jitter



Using a Real-Time Operating System (RTOS) for Reliability and Precise Timing

- Designed with critical, stand-alone applications in mind (minimal, bounded jitter)
- Use advanced schedulers to ensure that key pieces of code take precedence over others
- Minimize interrupt and thread switching latencies



Real-Time System Design

Development Tools

- Editor, Compiler, and Linker
- Debugging and Analysis Tools

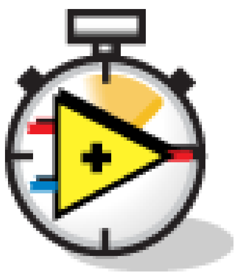
System Components

- Real-Time Operating System (RTOS)
- Board Support
- Additional I/O Drivers

LabVIEW Real-Time Module

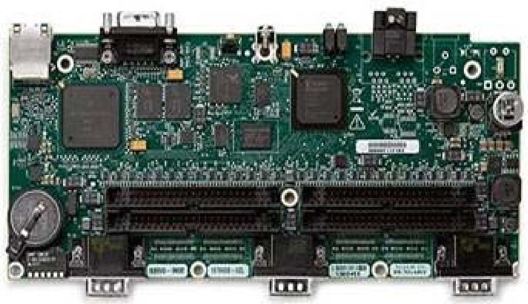
- Deterministic, hard real-time performance
  (with SMP support)

- Compiler, Linker, Debugging, RTOS, and board support included
  (requires LabVIEW Full or Pro)



- Hundreds of real-time drivers and analysis functions available

LabVIEW Real-Time Hardware Targets



A Different Model for Development, Deployment, and Debugging

Ethernet

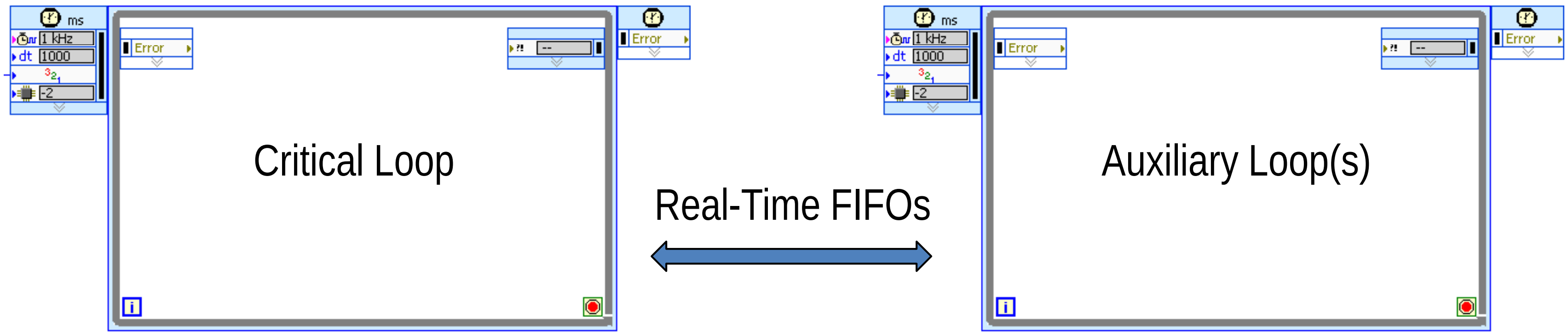
Development PC

Deployed Real-Time System

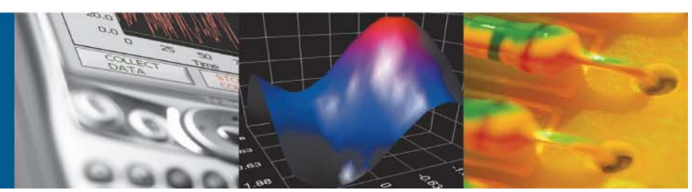
Demo: Configuring and Programming a LabVIEW Real-Time System

Demo: Comparing RTOS and GPOS Jitter

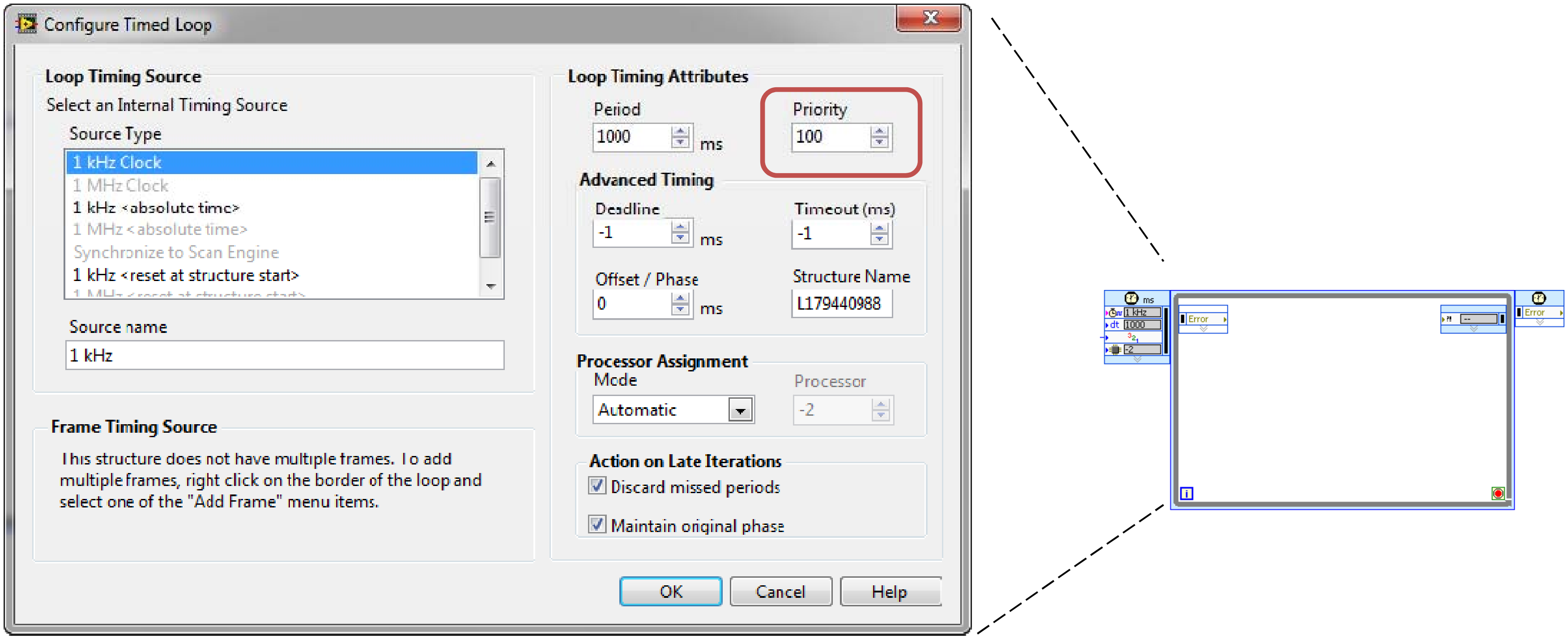
Separating Deterministic and Non-Deterministic Tasks

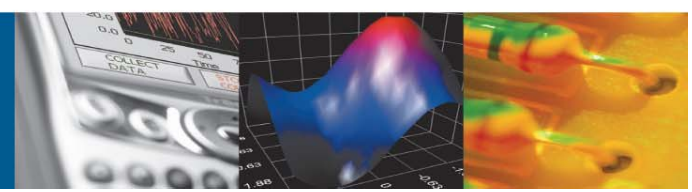


Deterministic Operations	Non-Deterministic Operations
• PID control • Motion control • Safety logic • Calls to deterministic drivers or libraries	• File I/O • Network or serial communication • Memory allocation • Calls to non-deterministic libraries or drivers



Setting Priorities

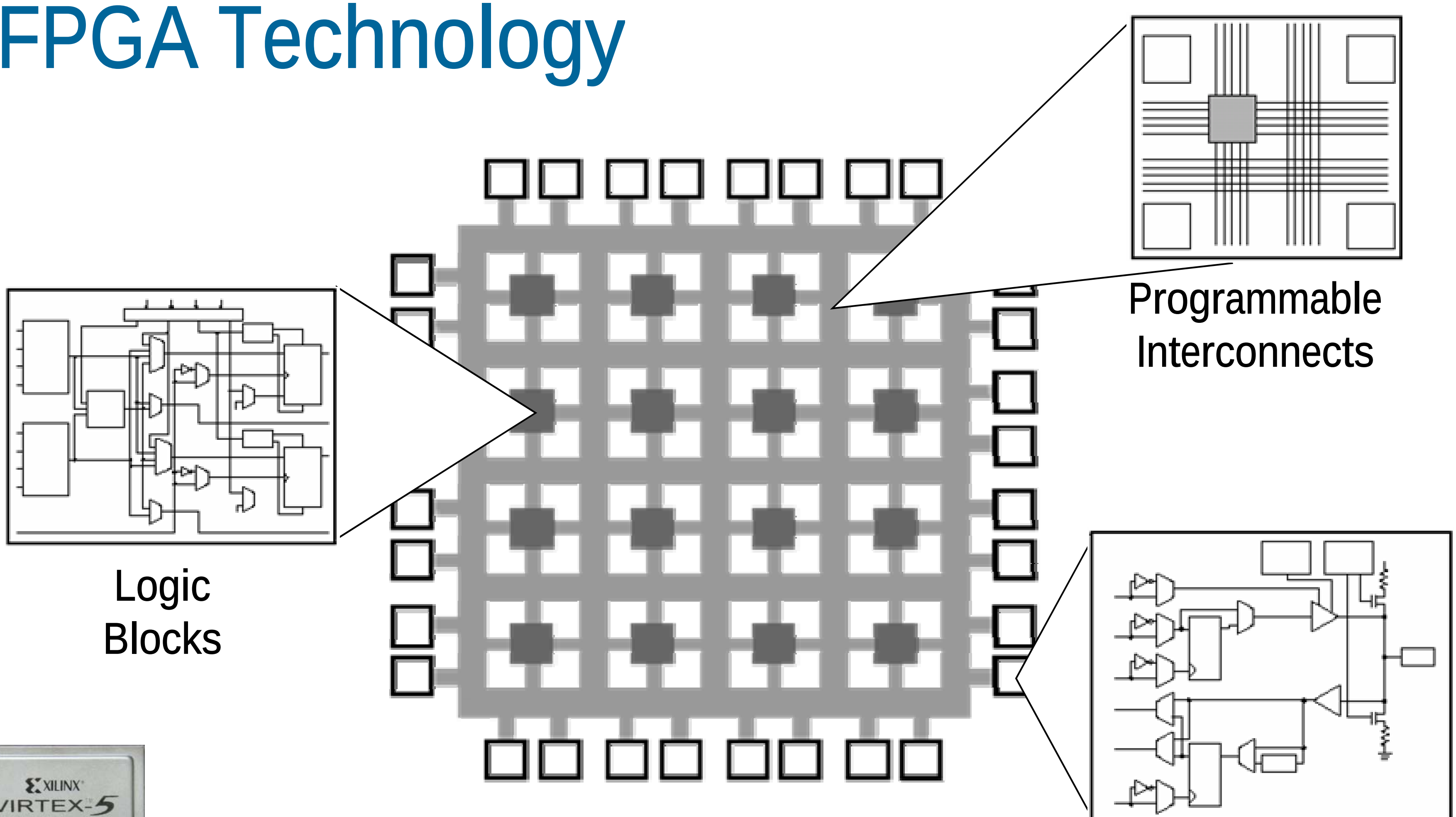




Demo: Simple PID Control System

Part 2: Programmable Logic and LabVIEW FPGA

FPGA Technology



Why Are FPGAs Useful?

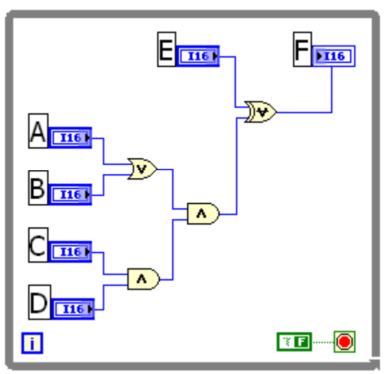
- *True Parallelism* – Provides parallel tasks and pipelining
- *High Reliability* – Designs become a custom circuit
- *High Determinism* – Runs algorithms at deterministic rates down to 25 ns (faster in many cases)
- *Reconfigurable* – Create new and alter existing task-specific personalities

From LabVIEW to Hardware

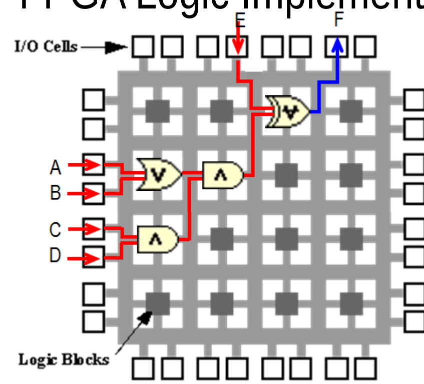
Translation → Optimization → Synthesis → Bit Stream

Translation	Optimization	Synthesis	Bit Stream
VHDL Generation	Analysis Logic Reduction	Place and Route Timing Verification	Generation Download/Run

LabVIEW FPGA Code



FPGA Logic Implementation



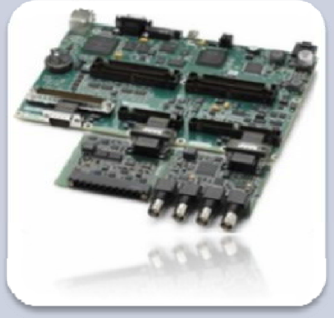
NI LabVIEW FPGA Hardware Targets

R Series Multifunction RIO

- General Purpose I/O for Measurement and Control

NI CompactRIO

- Industrial Control and Monitoring



NI SingleboardRIO

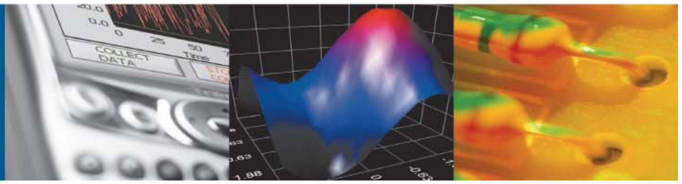
- Embedded Systems

NI FlexRIO

- Manufacturing Test and Design Validation

Other

- RIO IF Transceiver
- PCIe Framegrabbers
- Compact Vision System

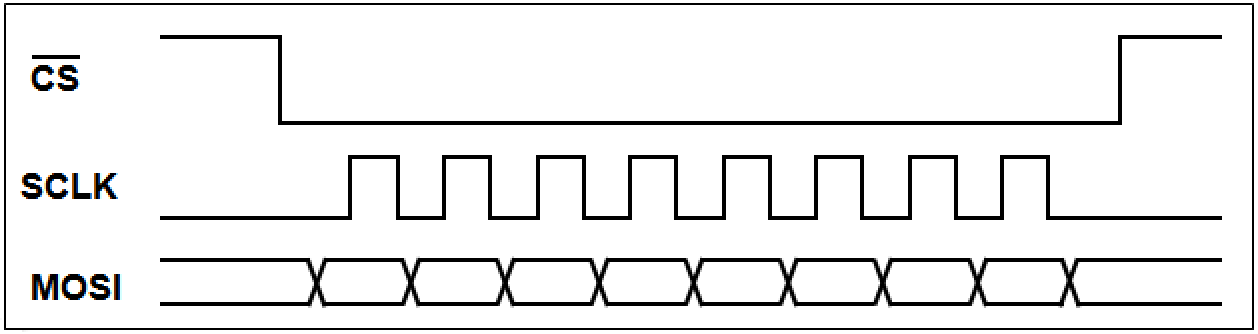


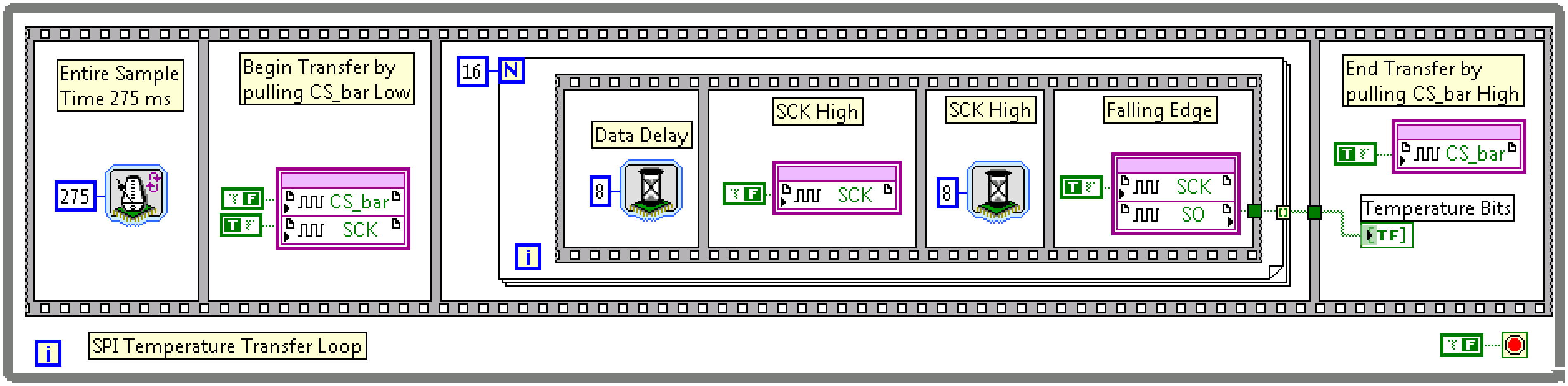
Common Applications

- High-speed control
- Custom DAQ
- Digital communication protocols
- Sensor simulation
- Onboard processing and data reduction

Digital Communication

Example – SPI





Built-In Intellectual Property (IP)

FFT

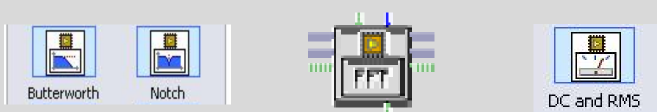
DC/RMS

Waveform Averaging

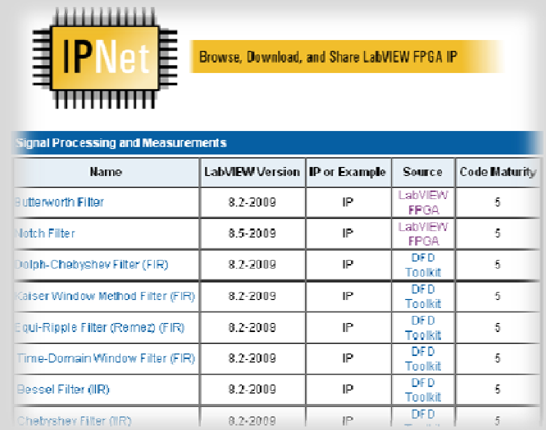
Digital filtering

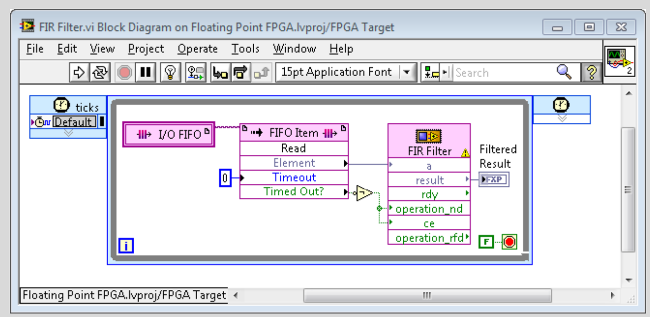
Windowing

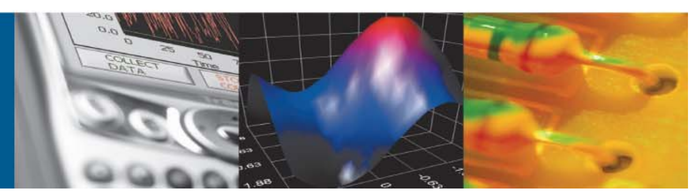
Resampling



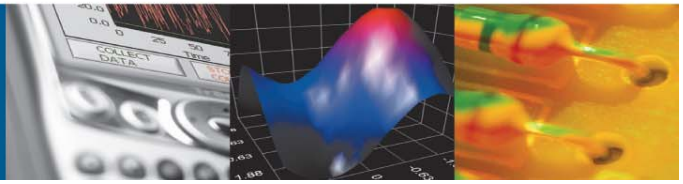
Importing and Reusing IP



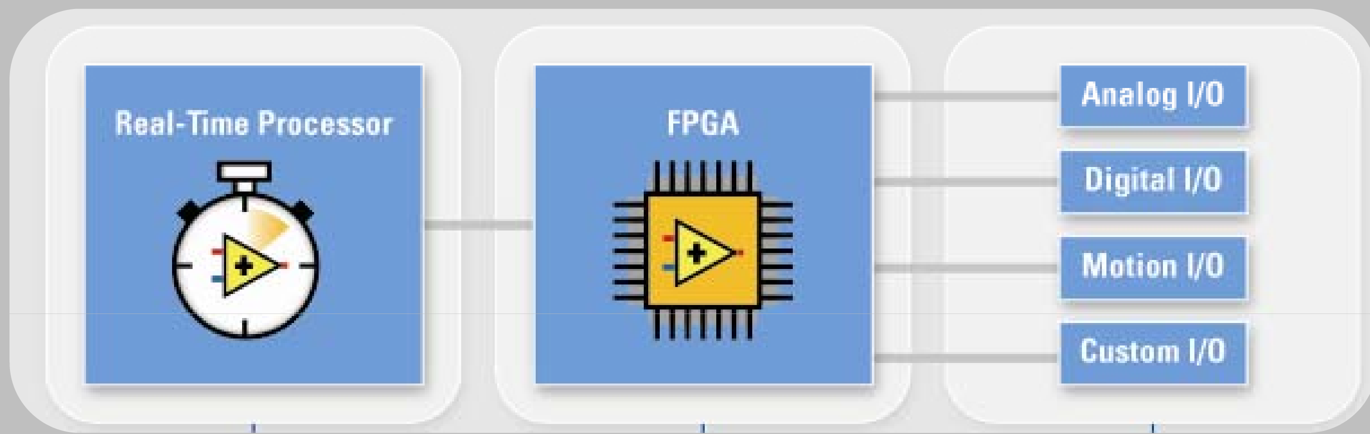




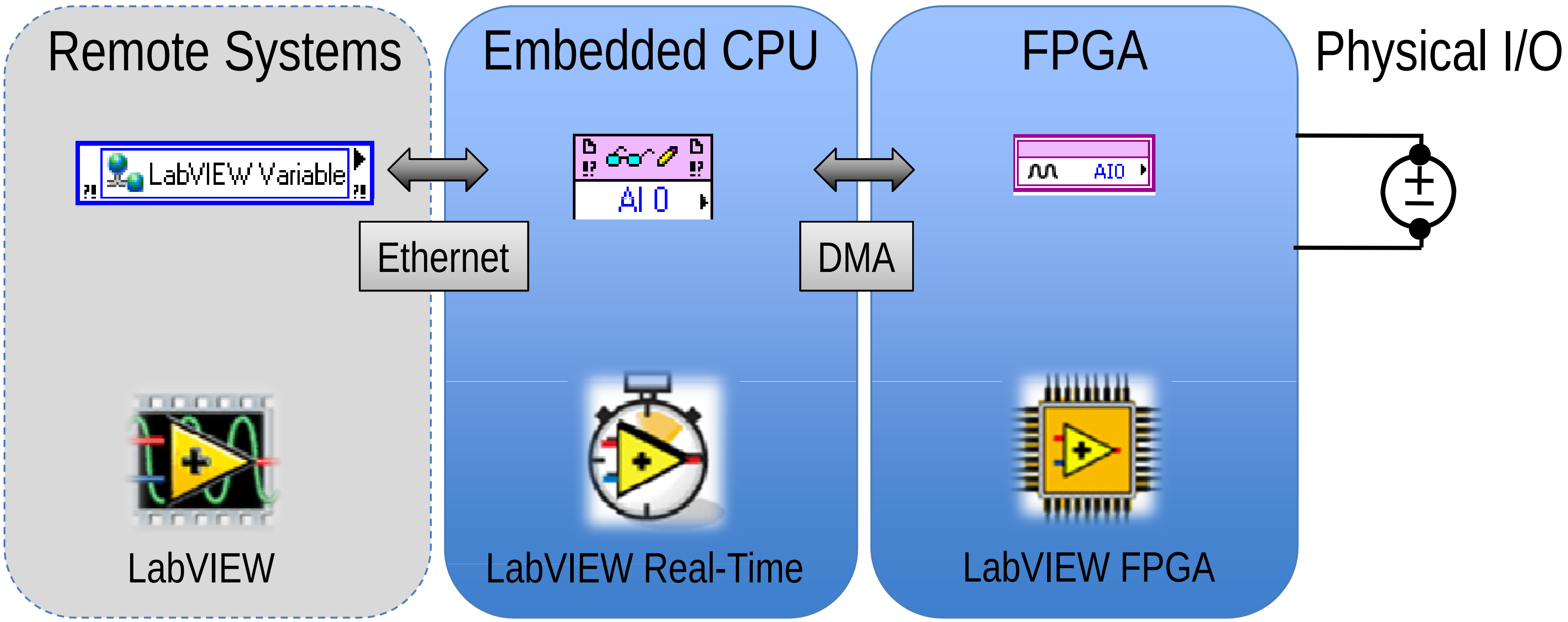
Part 3: Reconfigurable I/O (RIO) Architecture



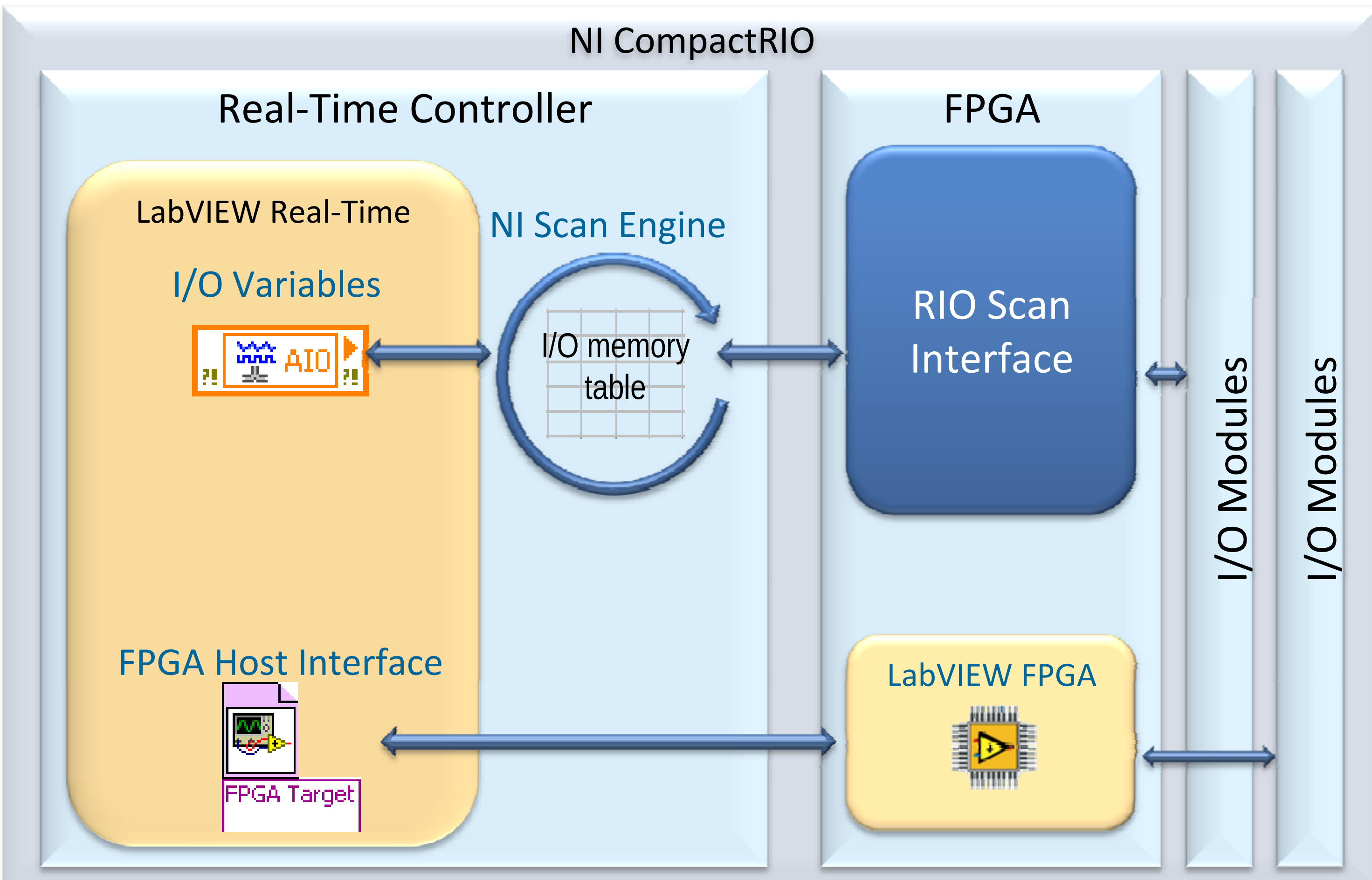
Reconfigurable I/O (RIO) Architecture



Communicating Between FPGA, CPU, and Other Systems



Default FPGA Personality: Scan Mode



Demo: CompactRIO…

FedEx Express Fire Suppression System with NI Single-Board RIO

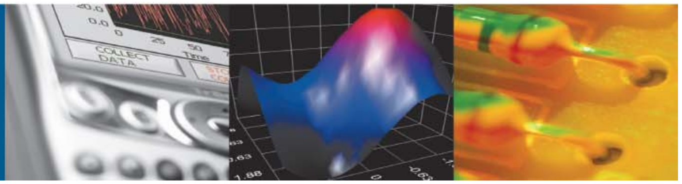
Application: Embedded temperature monitoring and control of a suppression system.

Challenge: Prototyping and deploying a cost-effective and reliable control solution for a fire suppression system for the main deck of a FedEx Express freighter aircraft while meeting a very aggressive deployment schedule.

Products: NI CompactRIO; LabVIEW; LabVIEW Real-Time, LabVIEW FPGA, and LabVIEW Touch Panel modules; and NI Single-Board RIO

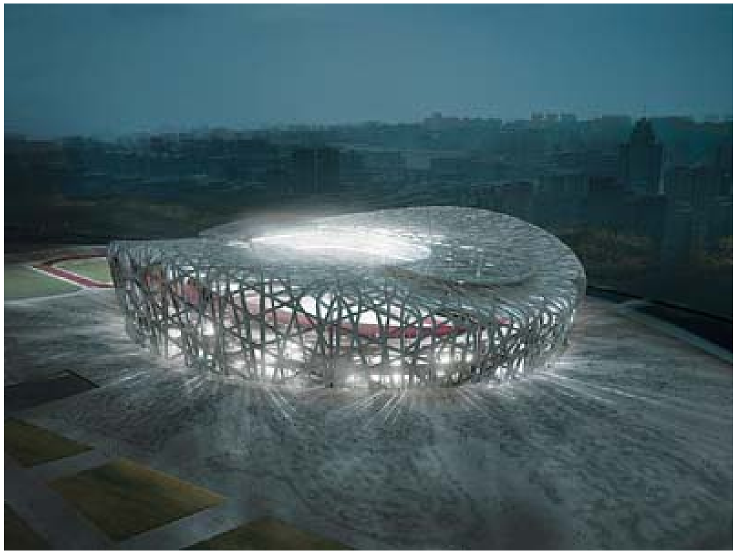
Key Benefit: Rapid embedded prototyping with CompactRIO and LabVIEW, and fast deployment with NI Single-Board RIO.

"We were able to start with LabVIEW and CompactRIO for prototyping and quickly migrate our code to the new NI Single-Board RIO for deployment – all in less than a year."
– Jeremy Snow, Ventura Aerospace



Performing Structural Health Monitoring of the 2008 Olympic Venues Using NI LabVIEW and CompactRIO

Application: Structural health monitoring (SHM) to determine stability, reliability, and livability of megastructures in China.



Challenge: Developing a reliable SHM system with continuous monitoring, rugged enclosure, GPS synchronization, and remote access.

Products: LabVIEW and CompactRIO

Key Benefit: Custom channel count per SHM system, GPS timing and synchronization, and off-the-shelf hardware to enable unmatched price/performance.

"Using National Instruments hardware and software, we designed, prototyped, and deployed a high-channel-count, SHM system with GPS synchronization in less than one year."

– Chris McDonald, CGM Engineering

Siemens Wind Power Develops a Hardware-in-the-Loop Simulator for Wind Turbine Control System Software Testing

Application: A new real-time test system for hardware-in-the-loop (HIL) testing of the embedded control software releases of Siemens wind turbine control systems.

Challenge: Improving the automated testing of frequent software releases of Siemens wind turbine control systems as well as testing and verifying the wind turbine control system components in the development phase.

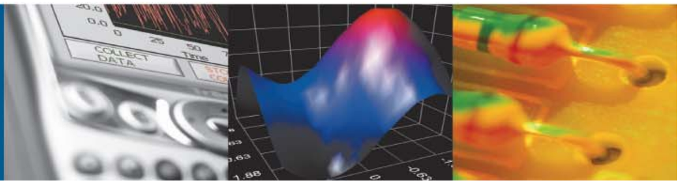
Products: LabVIEW, LabVIEW Real-Time Module, LabVIEW FPGA Module, LabVIEW Simulation Interface Toolkit, PXI-1042Q, PXI-8106, PXI-6704, PXI-6514, PXI-6515, PXI-6733, PXI-7813R, PXI-7833R, NI 9151, NI 9205, NI 9425, NI 9476, NI 9265, NI 9264

Key Benefit: The simulator provides an environment to effectively verify the new software releases and test special situations in our laboratory.

"The modular architecture allows us to scale-up the system to meet the growing requirements of rapidly evolving wind energy technology." – Samir Bico, Siemens Wind Power A/S

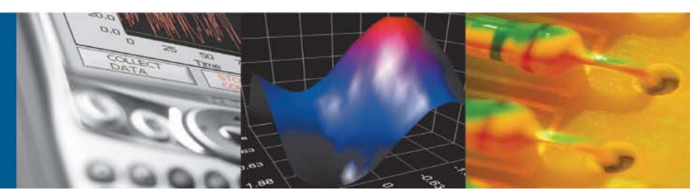
Next Steps

- Enroll in a hands-on LabVIEW Real-Time or FPGA training course (ni.com/training)
- Embedded Evaluation kit available at ni.com/embeddedeval
- Talk to your local NI representative or call to discuss your application

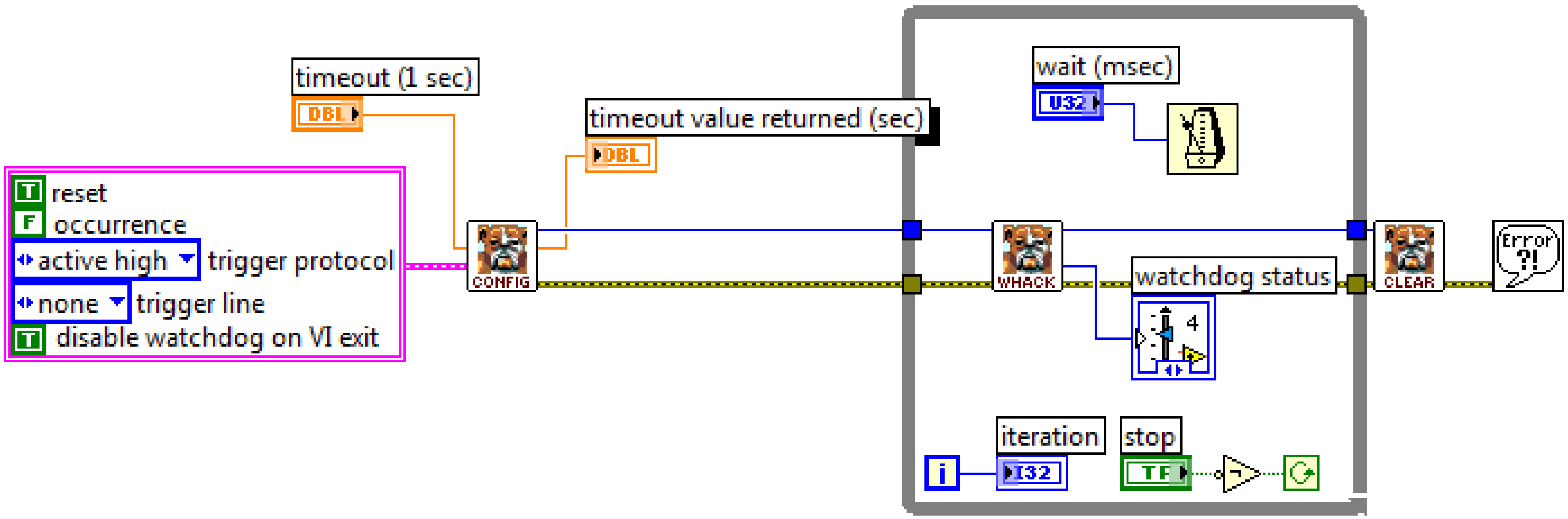


Auxiliary Slides (use if desired)

Additional LabVIEW Real-Time Information

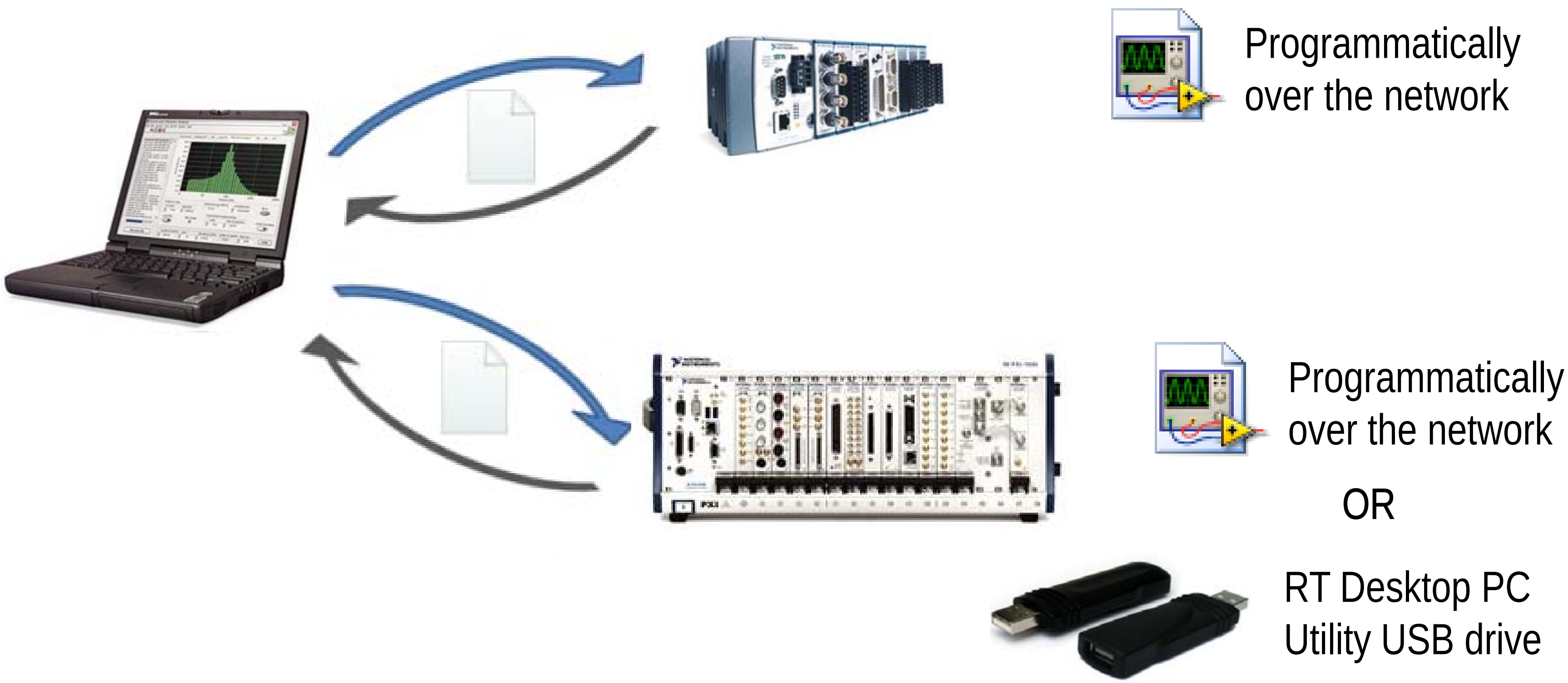


Designing for Reliability

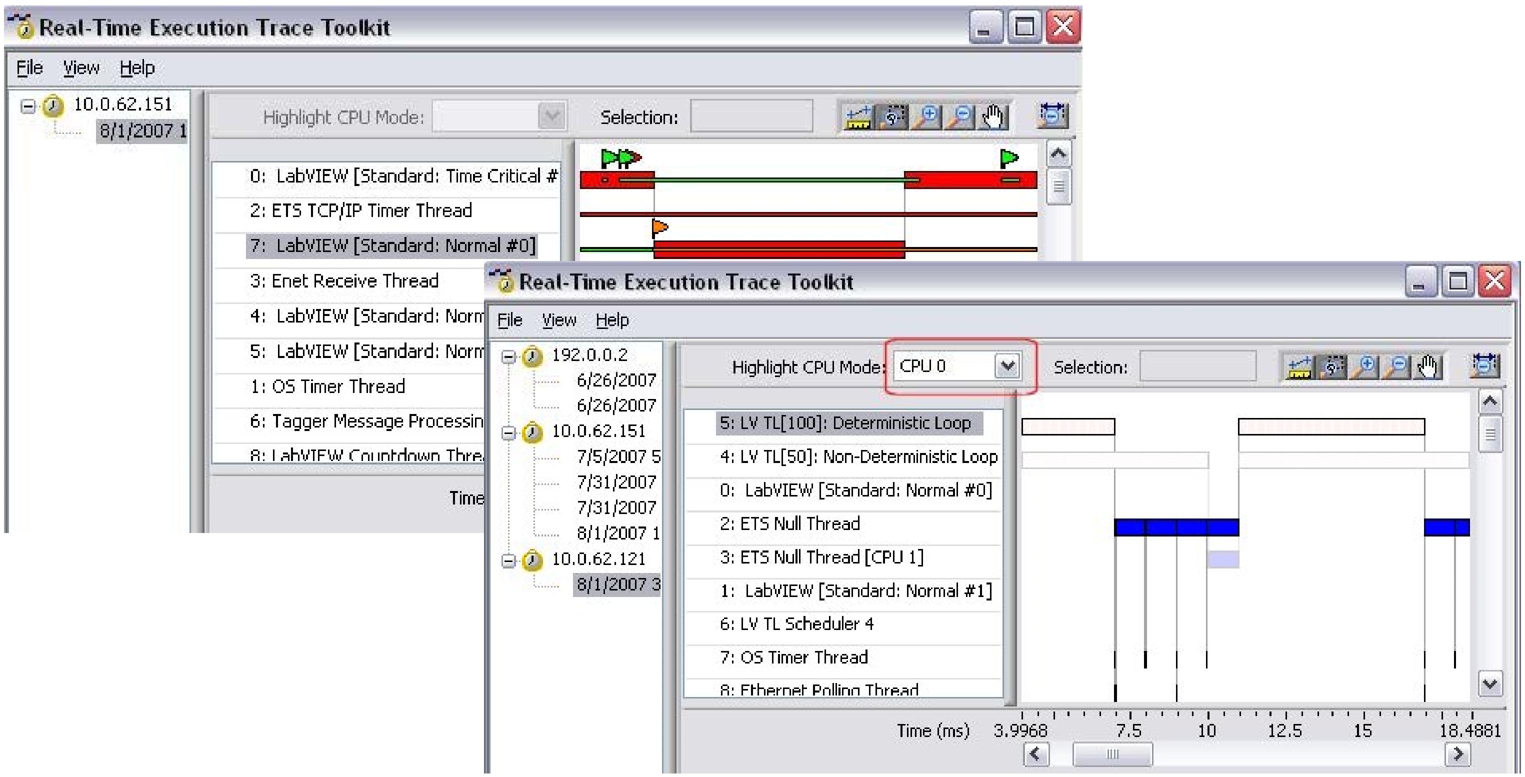


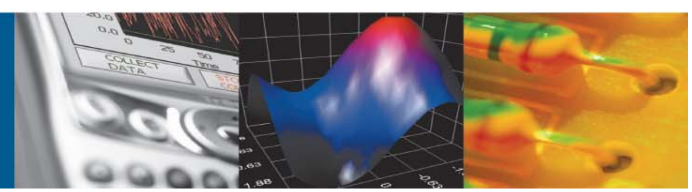
Use watchdog timers to automatically reset a system or send a hardware signal if a problem occurs.

Replicating Real-Time Systems

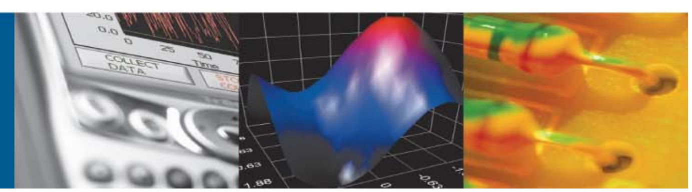


Thread-Level Debugging with the Real-Time Execution Trace Toolkit



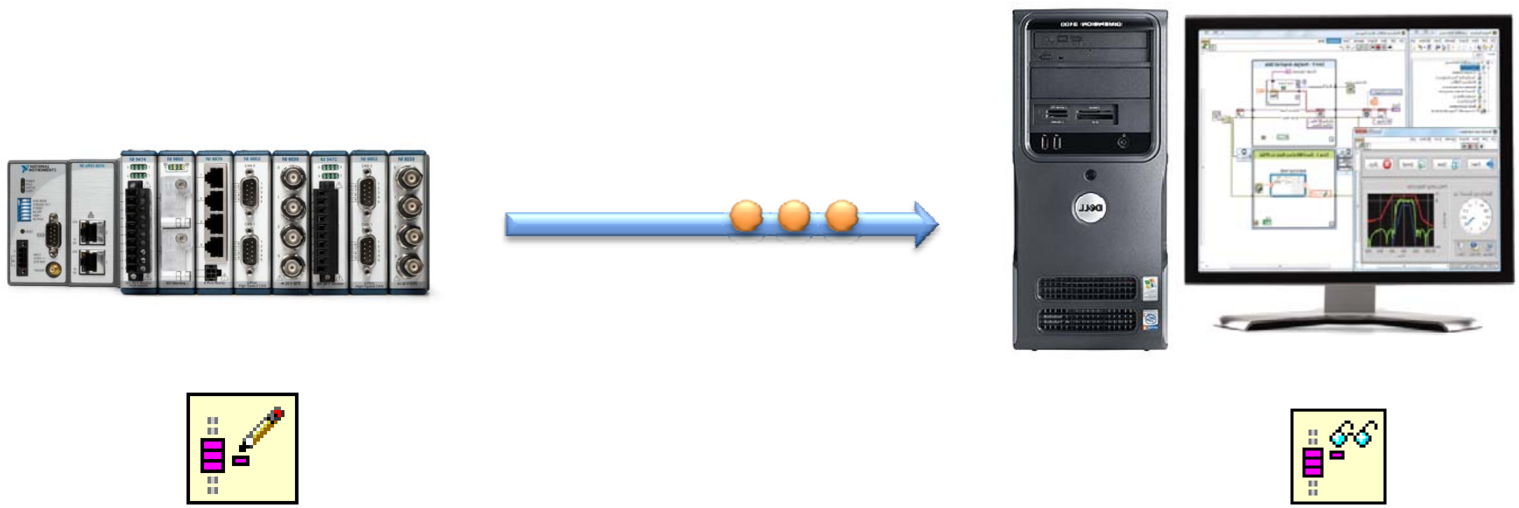


New Features in the LabVIEW 2010 Real-Time Module

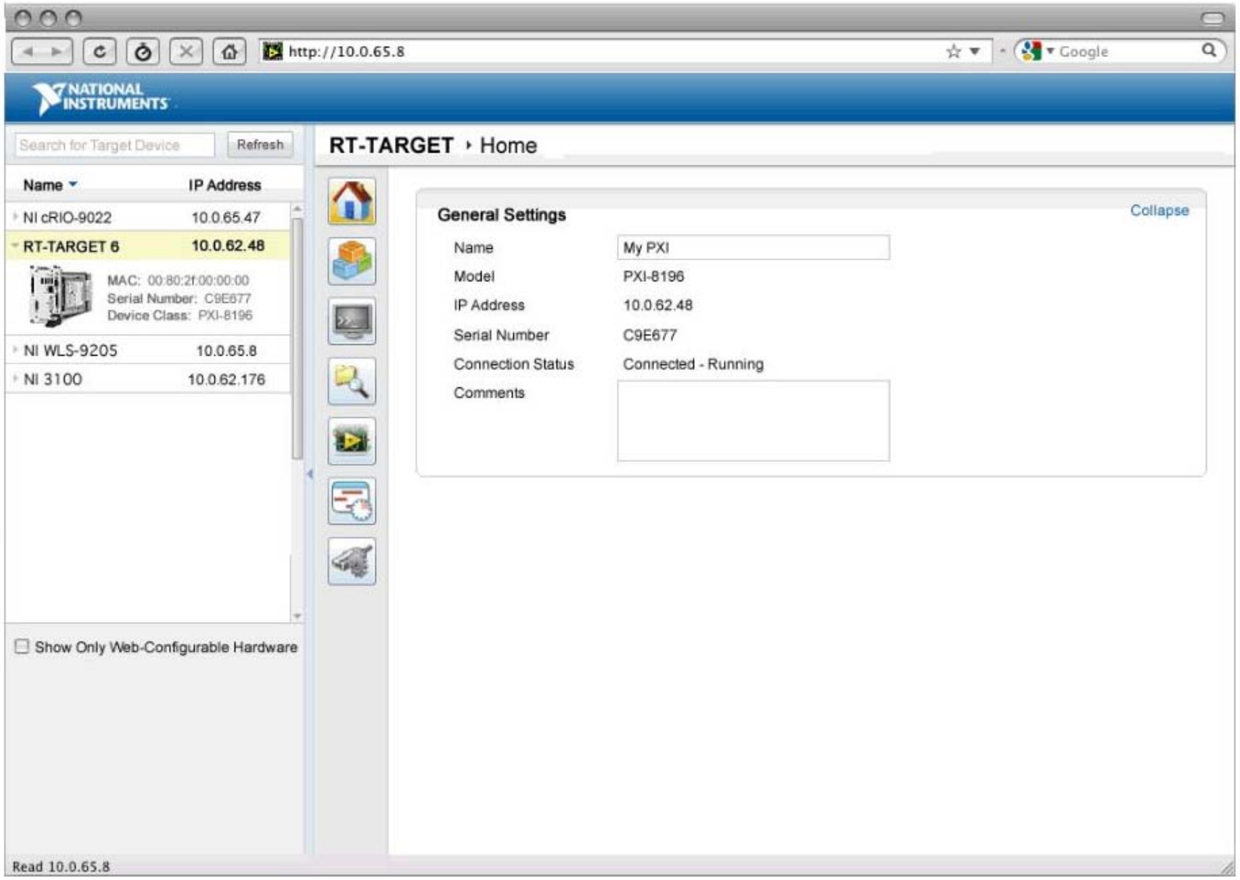


Network Streams

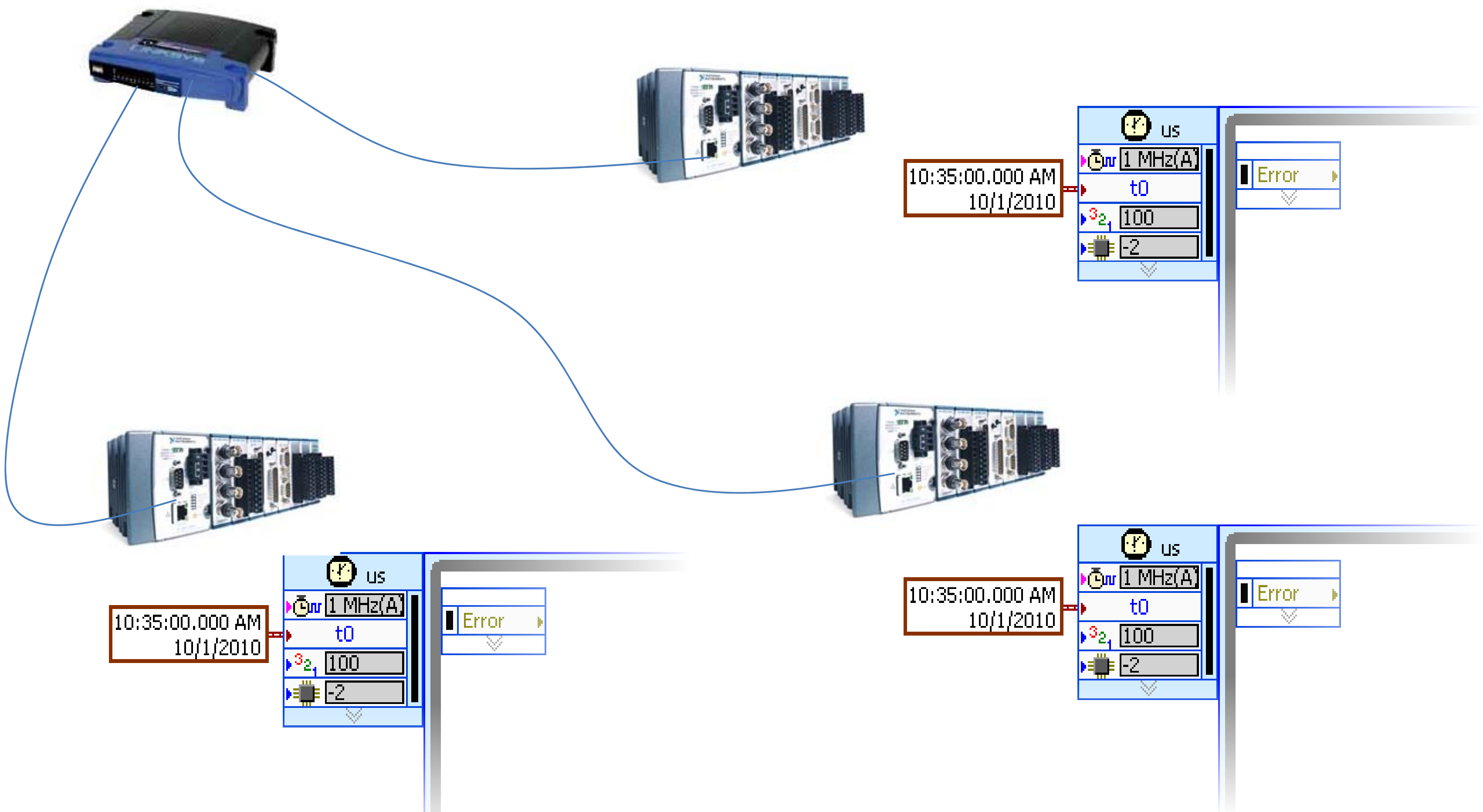
- Simplified lossless buffered data transfer between two points



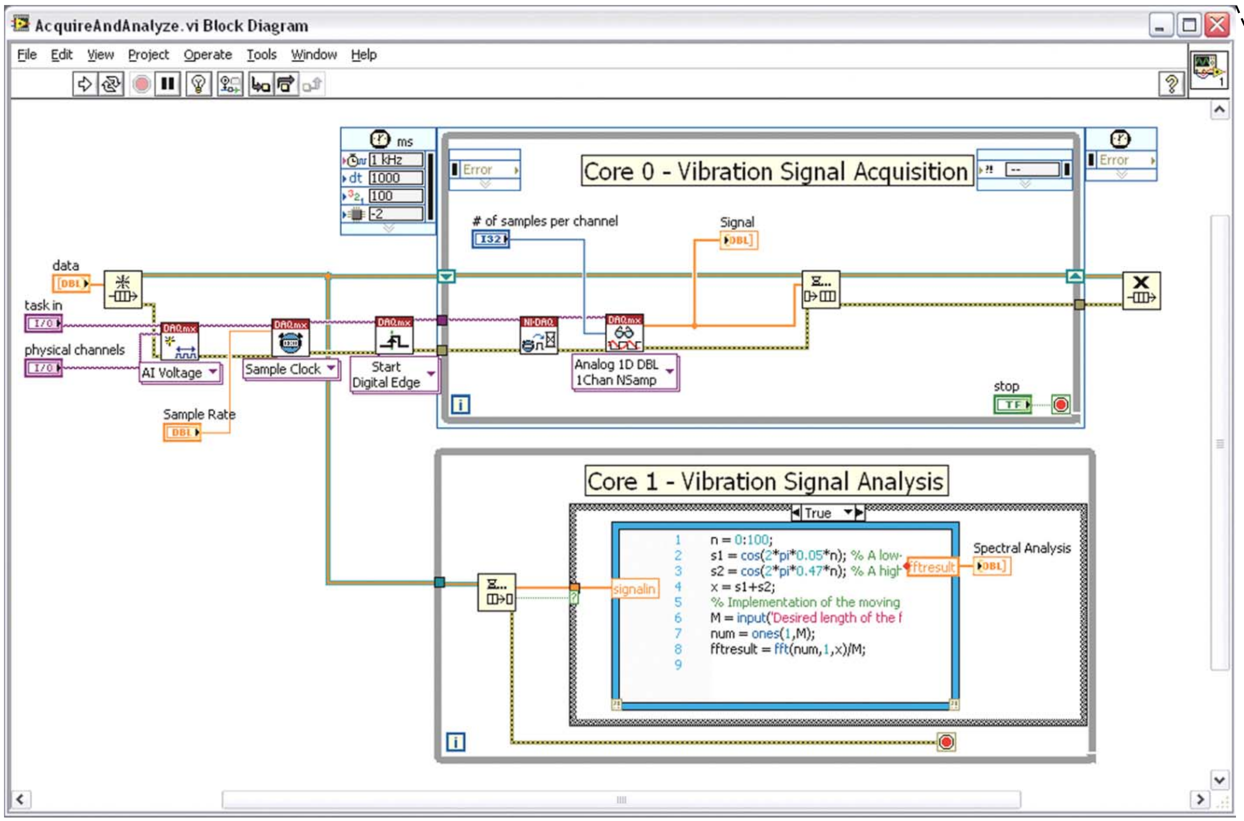
Web Monitoring and Configuration

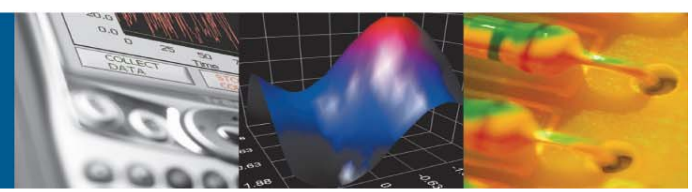


1588 Time Synchronization Across Targets



Running .m Files Deterministically with the Mathscript RT Module





Programmatic Target Configuration