Introduction to LabVIEW
Lawrence Berkeley National Lab – LabTech Day 2014

Chris Grabski
National Instruments – Field Engineer
Today’s Agenda

- 9:00 – 9:50 AM – Introduction to LabVIEW
- 10:00 – 10:50 AM – The LabVIEW RIO Architecture
- 11:00 – 11:45 AM - NI Big Physics Applications
National Instruments: Our Mission

We equip engineers and scientists with tools that accelerate productivity, innovation, and discovery.
National Instruments at a Glance

**Annual Revenue:** $1.14 billion

**Global Operations:** Approximately 7,100 employees; operations in more than 40 countries

**Broad Customer Base:** More than 35,000 companies served annually

**Diversity:** No industry >15% of revenue

**Culture:** Ranked among the top 25 companies to work worldwide by the Great Place to Work Institute

**Strong Cash Position:** Cash and short-term investments of $327 million at March 31, 2013
Software

CONNECTIVITY
- 9000+ instrument drivers
- 8000+ example programs
- 1000+ motion drives
- 1000+ smart sensors
- 1000+ third-party PAC devices

COMMUNITY
- 200,000+ online members
- 450+ registered user groups
- 3,000+ job postings online
- 8,000 classrooms using NI tools
- 74 peer-driven support forums

COLLABORATION
- 100+ third-party add-ons
- 700+ alliance partners
- 1,000+ value-added resellers
- 35+ training courses

Hardware

Computing Technology
- Intel, Microsoft, Freescale, Wind River
- Multi-core and real-time technology

FPGA
- Xilinx Virtex & Spartan
- Reconfigurable hardware

IP
- Control & signal processing IP & I/O drivers
- Built-in graphical IP, integrate user IP

I/O
- Analog Devices, Texas Instruments
- Connect to any sensor & actuator

BUS
- PCI/PCIe, Enet, USB, wireless, deterministic Enet, Open architecture

World Class Technology Ecosystem

ni.com
Graphical System Design

A platform-based approach for measurement and control
Graphical System Design

A platform-based approach for measurement and control

- Measurement
- Test
- Monitor
- Embedded
- Control

LabVIEW

- Deployable Targets
- Commercial Technology
- Models of Computation

- Desktops and PC-Based DAQ
- PXI and Modular Instruments
- CompactRIO and Custom Designs
- NI Single Board RIO
LabVIEW System Design Software

- **Project Explorer**: Manage and organize all system resources, including I/O and deployment targets.
- **Deployment Targets**: Deploy LabVIEW code to the leading desktop, real-time, and FPGA hardware targets.
- **Front Panel**: Create event-driven user interfaces to control systems and display measurements.
- **Instant Compilation**: See the state of your application at all times, instantly.
- **Hardware Connectivity**: Bring real-world signals into LabVIEW from any I/O on any instrument.
- **Parallel Programming**: Create independent loops that automatically execute in parallel.
- **Block Diagram**: Define and customize the behavior of your system using graphical programming.
- **Analysis Libraries**: Use high-performance analysis libraries designed for engineering and science.
- **Models of Computation**: Combine and reuse .m files, C code, and HDL with graphical code.
- **Timing**: Define explicit execution order and timing with sequential data flow.

---

**Accelerates Your Success**

By abstracting low-level complexity and integrating all of the tools you need to build any measurement or control system.

ni.com
Integration of Modular I/O Hardware

Box Instruments

Modular Instruments
Complete NI PXI Instrumentation Portfolio

DAQ and Control
- Multifunction I/O
- FPGA / Reconfigurable I/O
- Digital I/O
- Analog Input / Output
- Vision and Motion
- Counter / Timer / Clock

Instruments
- Oscilloscopes
- High-Speed Digital I/O
- Digital Multimeters
- Signal Generators
- Switching
- RF Analyzers & Generators

Interfaces
- GPIB, USB, LAN
- RS232 / RS485
- CAN, LIN, DeviceNet
- SCSI, Ethernet
- VXI - VME
- Boundary Scan / JTAG

ni.com
NI CompactRIO

- FPGA
- Processor
- Modular I/O
Introduction to LabVIEW

System Design Software for Any Measurement Application
Because It Has Been Proven Over Nearly 30 Years…

Withstanding the test of time across operating systems, buses, technologies, and more
…LabVIEW Is the Standard for Making Measurements

Software Used for Data Acquisition and Instrument Control

0%  5%  10%  15%  20%  25%  30%  35%  40%

- NI LabVIEW
- Microsoft Visual C/C++
- Microsoft Visual Basic
- Microsoft Visual Basic 6.0
- NI - LabWindows™/CVI
- Microsoft C#
- The MathWorks, Inc. - MATLAB®
- NI Measurement Studio
- Agilent VEE
- NI TestStand
- Agilent IO Libraries Suite
- Python
- GeoTest ATEasy
- Other
- Don't use
Unrivaled Hardware Integration in a Single Environment

- NI hardware
  - 200+ data acquisition devices
  - 450+ modular instruments
  - Cameras
  - Motion control

- Third-party hardware
  - Instrument Driver Network
    - 10,000+ instrument drivers
    - 350+ instrument vendors
    - 100+ instrument types
  - Communicate over any bus
The Foundation of LabVIEW: Virtual Instrumentation

By leveraging COTS PC components, the software becomes the instrument.

LabVIEW unlocks the power of instrument and data acquisition hardware by capitalizing on the PC industry and abstracting redundant circuitry.
Therefore, LabVIEW Building Blocks Are Called Virtual Instruments (*.VI)

- **LabVIEW Front Panel**: The user interface of a VI
- **LabVIEW Block Diagram**: The source code of a VI
- **Icon / Connector Pane**: Maps inputs and outputs

*Note: A *.vi file encapsulates all three elements*
Front Panel Objects

Decorations
- Decorative elements and imagery
  - Text
  - Arrows
  - Callouts
  - Lines
  - Images
  - ...and more

Customizable Indicators
- Used to convey outputs to a user
  - Graphs and Charts
  - Progress Bars
  - Gauges and Meters
  - LEDs
  - Numerics
  - Strings and Paths
  - ...and more

Customizable Controls
- Used to receive input from a user
  - Knobs and Dials
  - Sliders
  - Buttons
  - Numerics
  - Strings and Paths
  - ...and more
LabVIEW Front Panels in Action

All of the front panels above were contributed for sharing and reuse by members of the global LabVIEW community.

Dozens of LabVIEW front panels at SpaceX Mission Control during successful launch of Dragon

Photo Credit: Elon Musk
With LabVIEW, You Can Program the Way You Think
With LabVIEW, You Can Program the Way You Think

The graphical, dataflow-based G programming language is ideal for programming parallel data acquisition hardware.
Exploring a LabVIEW Block Diagram

Any block diagram entity that can contain code within it is called a **structure**.

**UI Thread**
This thread handles events from the front panel (user interface).

**Two Asynchronous Threads**
Because no data is passed between entities, they execute in parallel.

**DAQ Thread**
This thread interacts with data acquisition hardware.
Exploring a LabVIEW Block Diagram

**While Loops**
Iterate continuously until a true value is passed to the stop terminal

**Case Structure**
Executes different subdiagrams based on the value of its selector terminal

**Event Structure**
Executes different subdiagrams based on events and interrupts
Demonstration
Never Start a LabVIEW Project From Scratch

Abundant sample projects and templates provide a scalable starting point

• Recommended starting points for common LabVIEW applications
• Clearly indicate where to add or change functionality
• Shows best practices for code design, documentation, and organization
• Add custom templates and sample projects
Extending LabVIEW Beyond Data Acquisition

Advanced Analysis

External Code Integration

Complex Visualization

Automated Reporting

Spectral Measurements
Distortion Measurements
Amplitude and Level Measurements
Timing and Transition Measurements
Curve Fitting
Filters
Convolution and Correlation
Signal Simulation
Mask and Limit Testing
Histogram

Digital Filters and Banks
Frequency and Time Domain
Time Measurements
IPOA
Sampling, Re-Sampling
Transforms
Wavelet and Windowing
Signal and Waveform Generation
Pulse and Pattern Generation
Basic Numeric Functions
Curve Fitting and Data Modeling
Differential Equations and Linear Algebra
Interpolation and Optimization
Random Systems
Root Finding
Statistics and Random Processes

Amplitude
Distortion
Frequency Domain (Spectral)
Noise
Phase Noise/Interf.Alt. Analysis
Power (AC) Measurements
Pulse and Transition
Sampling (Discrete Time) Concerns
Tone Domain Analysis
Tone Detection
Transmit Signal Analysis

,.NET Assembly, C DLL, .m File

ni.com
Leveraging the LabVIEW Ecosystem

LabVIEW Tools Network
1,000,000+ Add-Ons Downloaded
26+ Certified Add-Ons
100+ Available Add-Ons

User Community
9,000+ Certified Users
700+ Alliance Partners
60+ Registered User Groups

Modules and Toolkits
40+ Toolkits and Modules Including:

- LabVIEW Real-Time Module
- LabVIEW FPGA Module
- LabVIEW Embedded Module for ARM
- LabVIEW Touch Panel Module
- LabVIEW Wireless Sensor Network Module
- LabVIEW C Code Generator
- NI Real-Time Hypervisor
- Vision Development Module for LabVIEW
- Sound and Vibration Measurement Suite
- Sound and Vibration Toolkit
- LabVIEW Advanced Signal Processing Toolkit
- LabVIEW Adaptive Filter Toolkit
- LabVIEW Digital Filter Design Toolkit
- LabVIEW MathScript RT Module
- Spectral Measurements Toolkit
- Modulation Toolkit for LabVIEW
- LabVIEW Robotics Module
- LabVIEW Biomedical Toolkit
- ECU Measurement and Calibration Toolkit
- GPS Simulation Toolkit for LabVIEW
- Measurement Suite for Fixed WiMAX
- WLAN Measurement Suite
- Automotive Diagnostic Command Set
- LabVIEW GPU Analysis Toolkit
- Multicore Analysis and Sparse Matrix Toolkit
- LabVIEW PID and Fuzzy Logic Toolkit
- LabVIEW Control Design and Simulation Module
- LabVIEW System Identification Toolkit
- LabVIEW Simulation Interface Toolkit
- LabVIEW SoftMotion Module
- LabVIEW Datalogging and Supervisory Control Module
- LabVIEW Report Generation Toolkit for Microsoft Office
- LabVIEW Database Connectivity Toolkit
- LabVIEW DataFinder Toolkit
- LabVIEW SignalExpress
- LabVIEW VI Analyzer Toolkit
- LabVIEW Statechart Module
- LabVIEW Desktop Execution Trace Toolkit
- NI Requirements Gateway
- NI Real-Time Execution Trace Toolkit
- LabVIEW Unit Test Framework Toolkit
- LabVIEW Application Builder for Windows
Questions