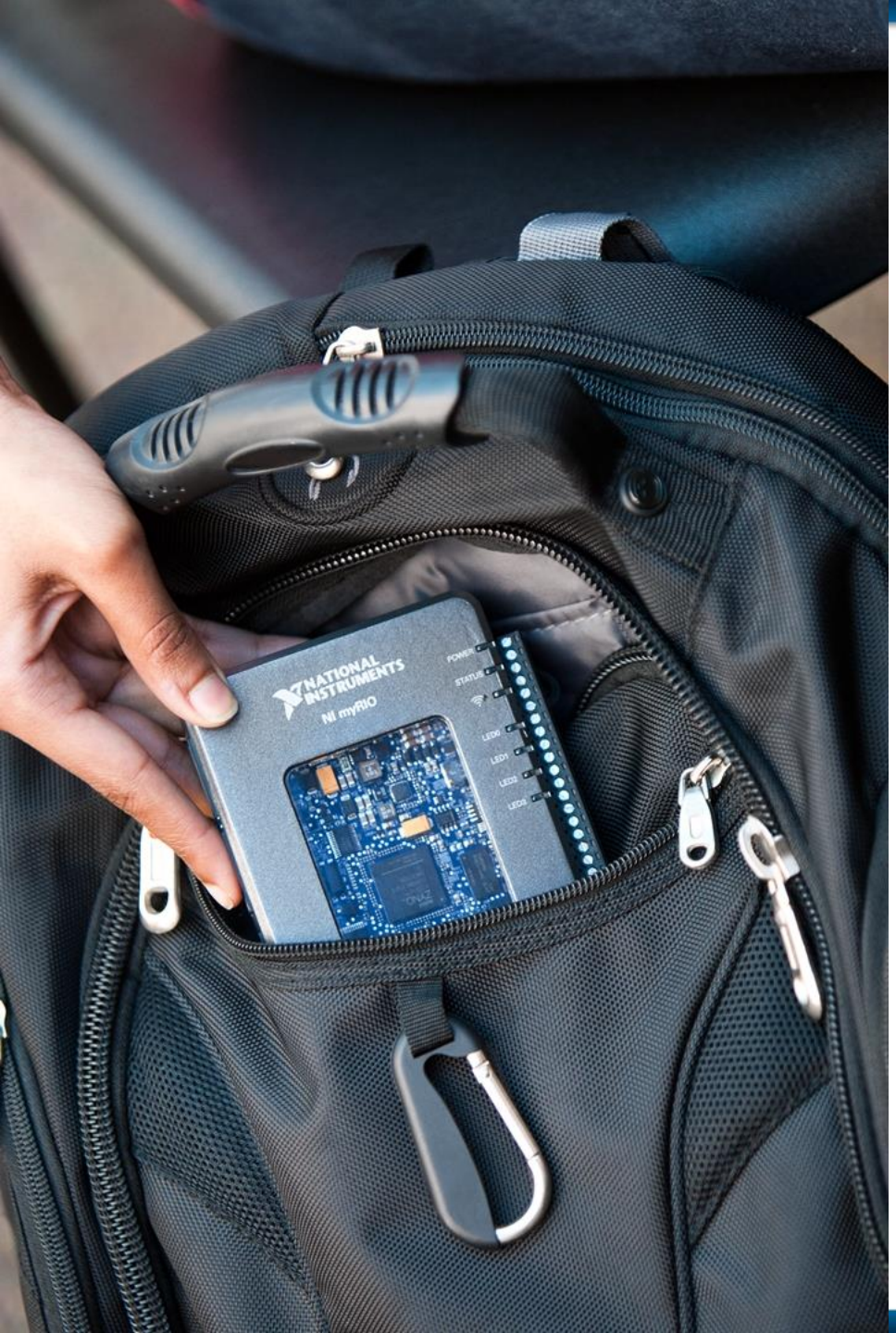

NATIONAL
INSTRUMENTS™



Sviluppa Sistemi embedded con LabVIEW

Design Real Systems, Fast

Luca Gallo

Academic Sales Engineer,

National Instruments Italy

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Agenda

- Introduction to NI
- Introduction to LabVIEW
- Introduction to NI myRIO
- Introduction to LabVIEW Real-Time
- A simple control system with LabVIEW and myRIO

- BONUS: getting started with LV and Raspberry PI

NI Example Applications

Controlling a Robotic Manipulator for Nuclear Decommissioning

Tuning Aston Martin Engines for Endurance Races

Plasma control in the world's first bench top Tokamak

NI Example Applications

Controlling 70-Ton Robotic Gripper Arms for Offshore Wind Turbine Construction

Measuring Biomechanical Stresses in Rugby Scrummaging

Control and Monitor Community Generation Sources in Canada's Smart Grid

More than 30,000 companies

…including 90% of Fortune 500 manufacturing companies

The Origin of Automated Measurements

- Traditional pen-and-paper approach
- Redundant circuitry between instruments (e.g., displays)
- Manual data recording and analysis
- Error-prone processes
- Difficult to reproduce or redo

Thermoelectric Voltage in mV											
°C	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.050	0.101	0.151	0.202	0.253	0.303	0.354	0.405	0.456	0.507
10	0.507	0.558	0.609	0.660	0.711	0.762	0.814	0.865	0.916	0.968	1.019
20	1.019	1.071	1.122	1.174	1.226	1.277	1.329	1.381	1.433	1.485	1.537
30	1.537	1.589	1.641	1.693	1.745	1.797	1.849	1.902	1.954	2.006	2.059
40	2.059	2.111	2.164	2.216	2.269	2.322	2.374	2.427	2.480	2.532	2.585
50	2.585	2.638	2.691	2.744	2.797	2.850	2.903	2.956	3.009	3.062	3.116
60	3.116	3.169	3.222	3.275	3.329	3.382	3.436	3.489	3.543	3.596	3.650
	.650	3.703	3.757	3.810	3.864	3.918	3.971	4.025	4.079	4.133	4.187
		4.240	4.294	4.348	4.402	4.456	4.510	4.564	4.618	4.672	4.726
			4.835	4.889	4.943	4.997	5.052	5.106	5.160	5.215	5.269

Measurement Challenges Are Compounded By:

- Compressed Timelines
- Fixed Software and Hardware
- Conflicting Programming Approaches
- Inadequate Hardware Performance
- Disparate Driver APIs
- Varying Sensors and Connectivity
- Custom Signal Conditioning
- Advanced Visualization
- Changing Application Requirements
- Complex Analysis Algorithms
- Evolving Technology Trends
- Confusing Data Storage
- Differing Sampling Rates

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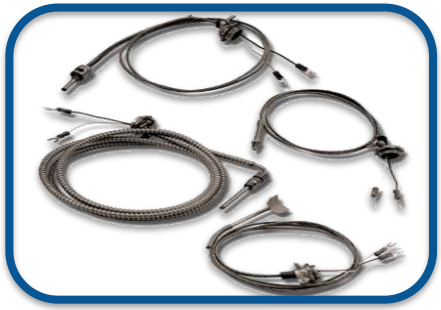
Mixed-Measurement Applications Are Diverse

Vibration

Torque

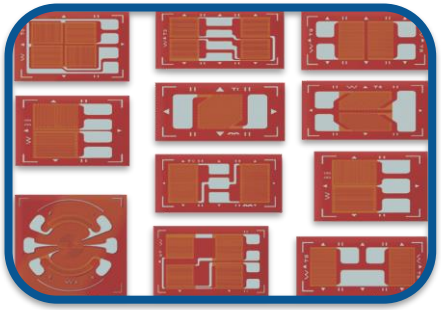
Displacement

Pressure



Temperature

Force



Strain

Example Application: Air Quality Measurements

- Potential Sensors Needed:
  - Context
    - GPS
      - Timestamp
      - Position
    - Attitude
    - Altitude
    - Range Finder
  - Environmental
    - Temperature
    - Oxygen
    - Carbon Dioxide
    - Ozone
    - Nitrogen

Sensors, Interfaces, and Signal Conditioning

Sensor		Interface	Conditioning?
GPS		RS232	No
Attitude, Altitude		RS232	No
LiDAR		Ethernet	No
Temperature		Analog Voltage	Required
O_2, CO_2, O_3, NH_3		Analog Voltage	Required

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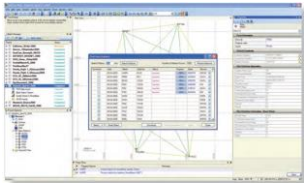
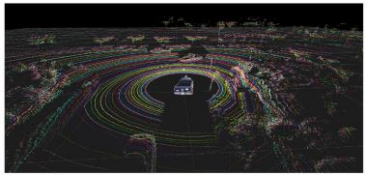
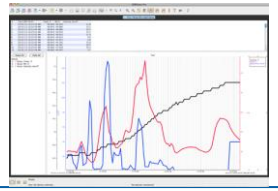
Software Provided With Sensors

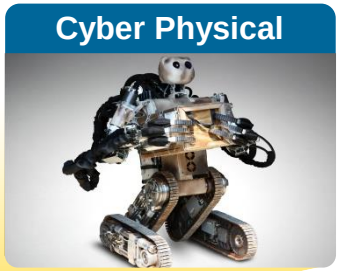
Sensor		Software
GPS		
Attitude, Altitude		
LiDAR		
Temperature		
O_2, CO_2, O_3, NH_3		<No Software Provided>

With a System Like This, How Do You Accommodate…

- …changes in requirements?
- …mixed measurements in a single system?
- …varying connectivity?
- …signal conditioning for sensors?
- …adding or replacing measurements or sensors?
- …incorporating timing, triggering, or synchronization?
- …leveraging emerging technology trends?
- …multiple disparate software environments and APIs?

National Instruments' Strategy: Graphical System Design

Your Investment in a Platform-Based Approach to Measurements Scales Across…

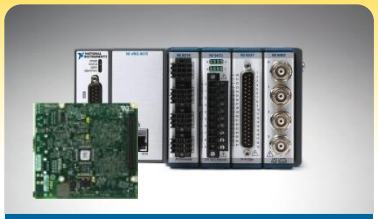


Industries and Applications

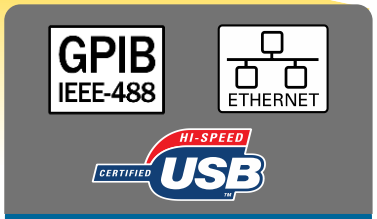
NATIONAL INSTRUMENTS LabVIEW™

Desktops and PC-Based DAQ

PXI and Modular Instruments



NI CompactRIO



Open Connectivity With Third-Party I/O

Introduction to LabVIEW

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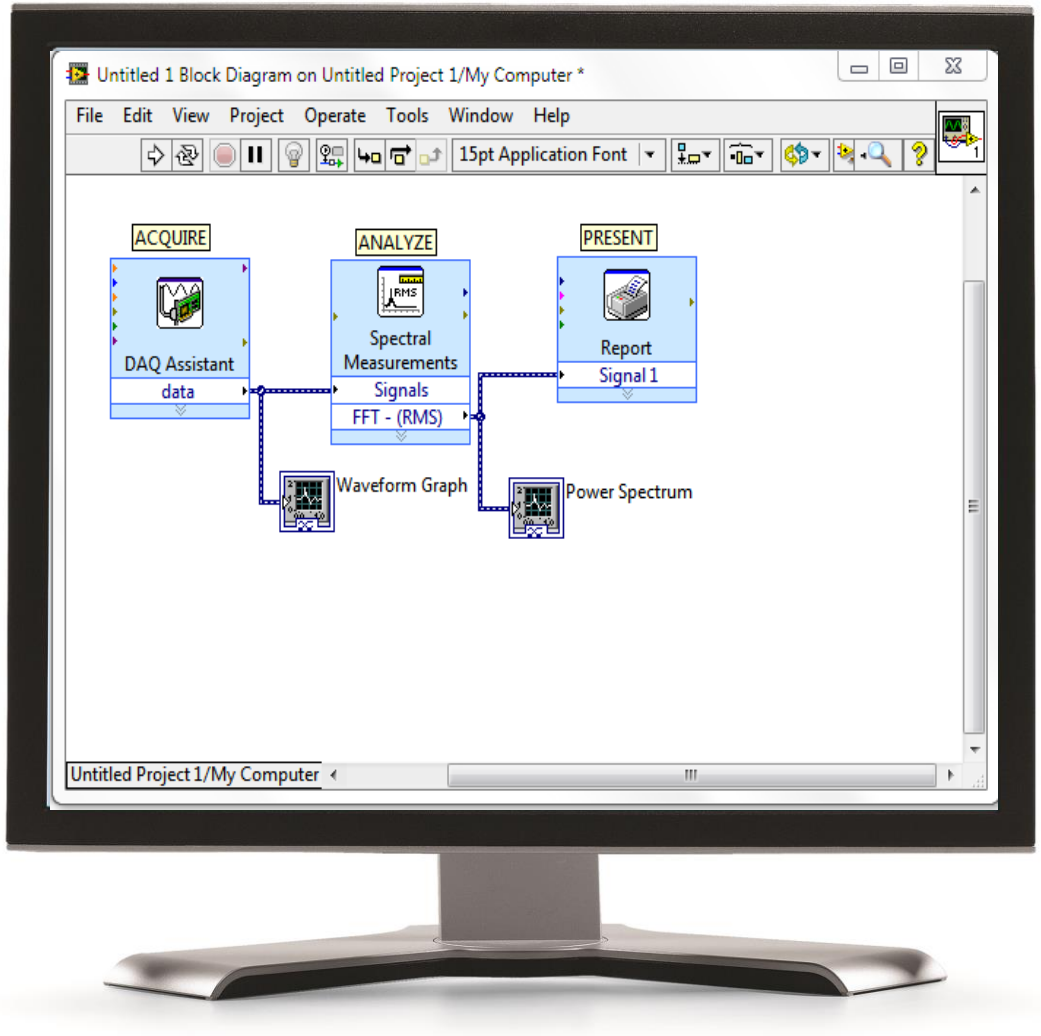
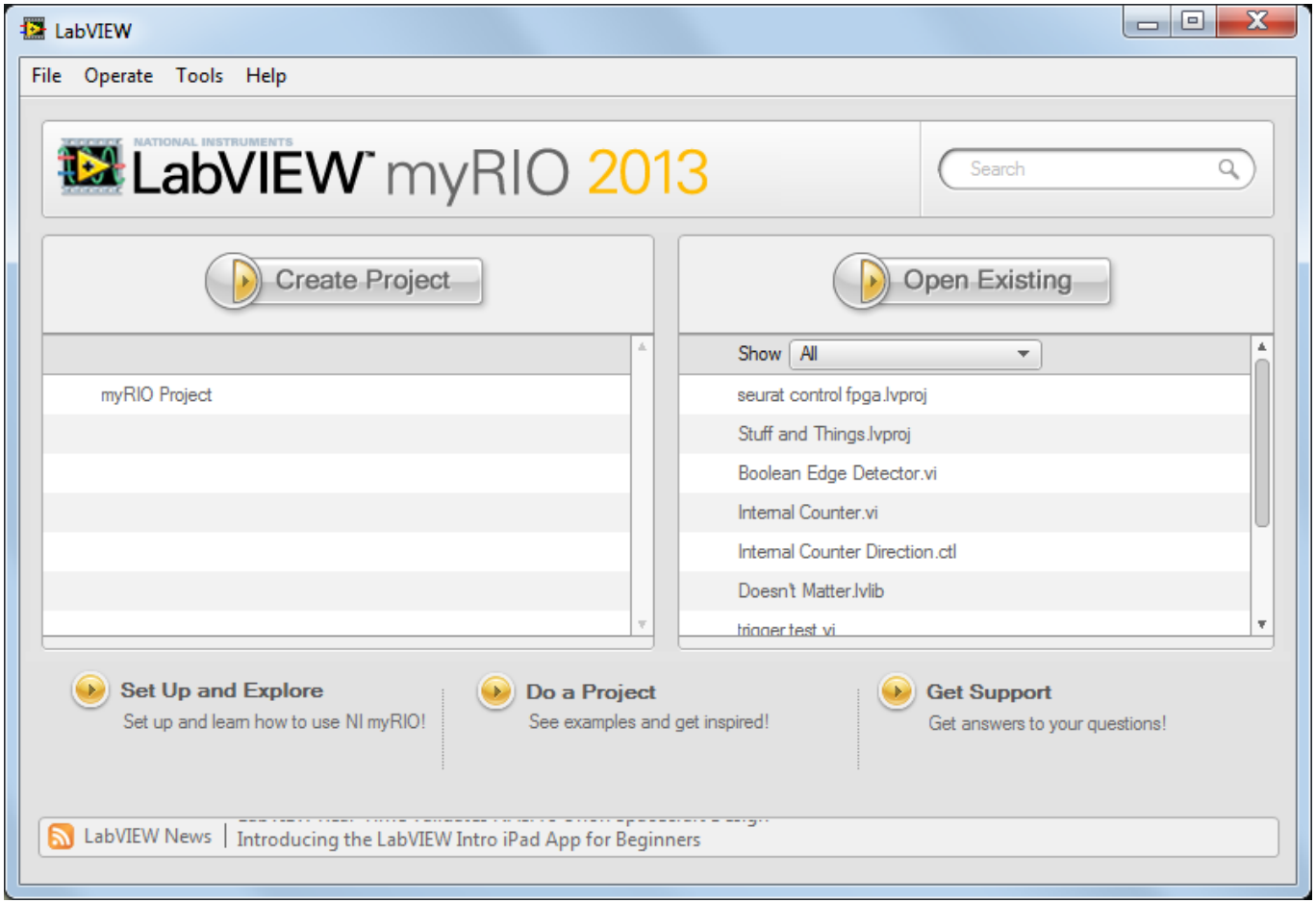
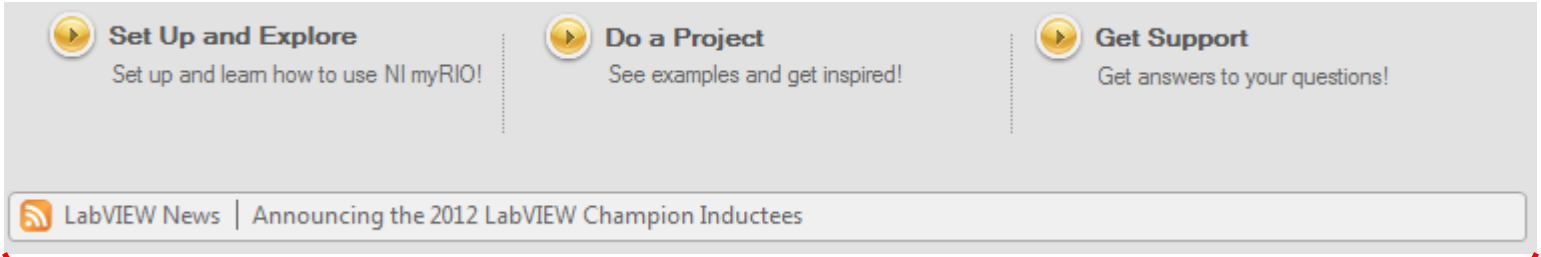
Data Flow


Untitled 1 Block Diagram on Untitled Project 1/My Computer *
File Edit View Project Operate Tools Window Help
15pt Application Font
ACQUIRE
DAQ Assistant
data
ANALYZE
Spectral Measurements
Signals
FFT - (RMS)
PRESENT
Report
Signal 1
Waveform Graph
Power Spectrum
Untitled Project 1/My Computer

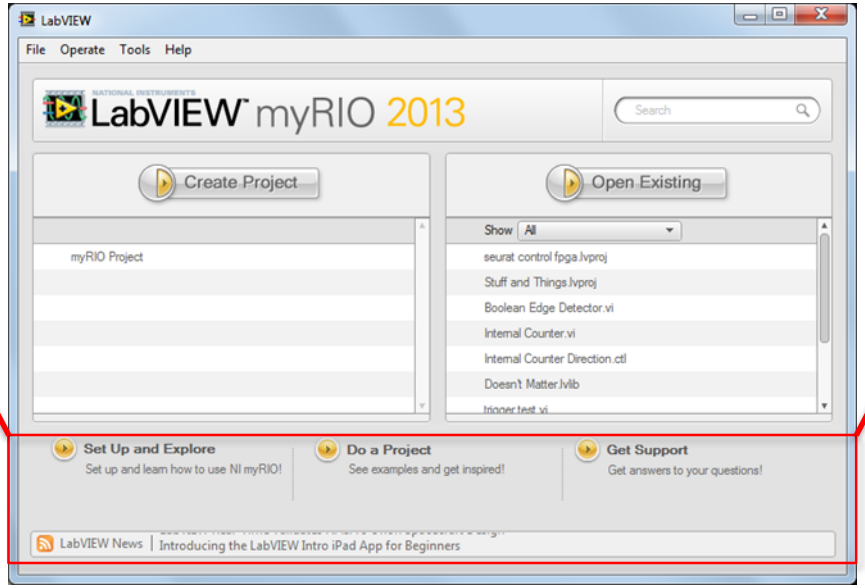
LabVIEW Getting Started Window



LabVIEW Getting Started Window



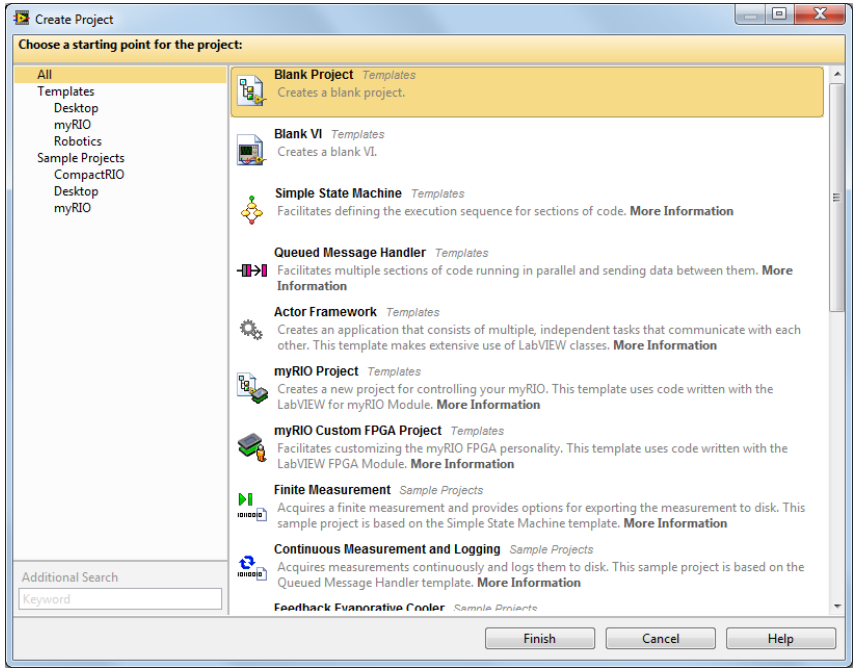
Additional support, tutorials, and explanations can all be found using the links here. These are specifically tailored to NI myRIO users.



Create a Project

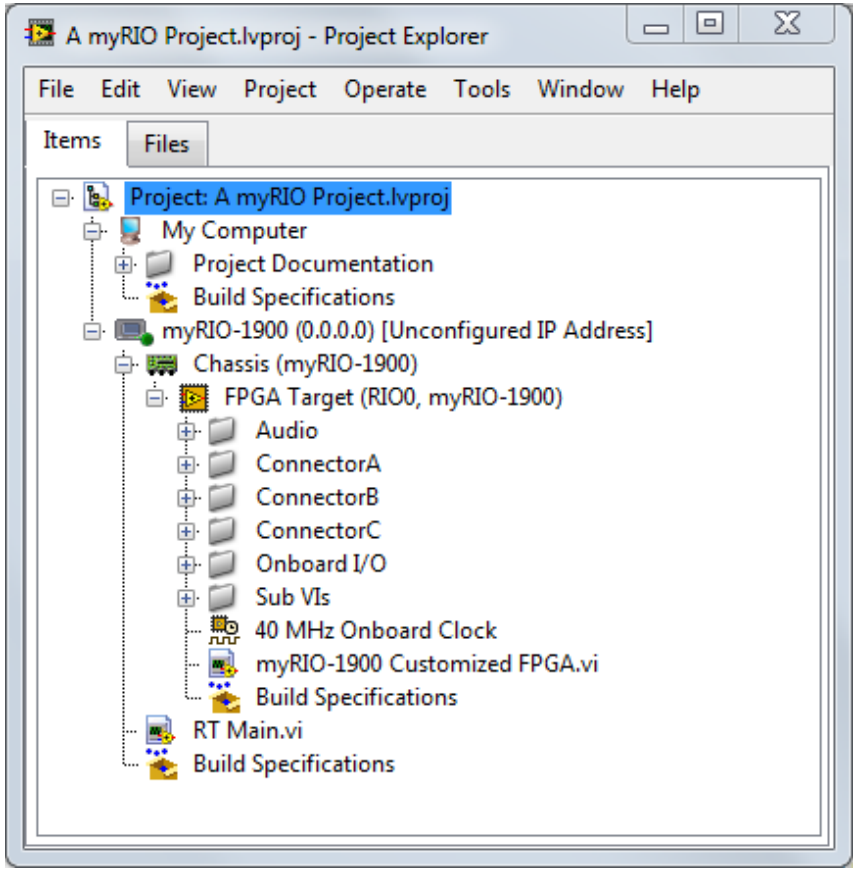
- Click the **Create Project** button
- Select **Blank Project**.
- Click **Finish.**

- To save the project:
  - **File >> Save**
  - Select the desired directory and choose a meaningful name.
  - Remember, two LabVIEW projects cannot share the same directory.



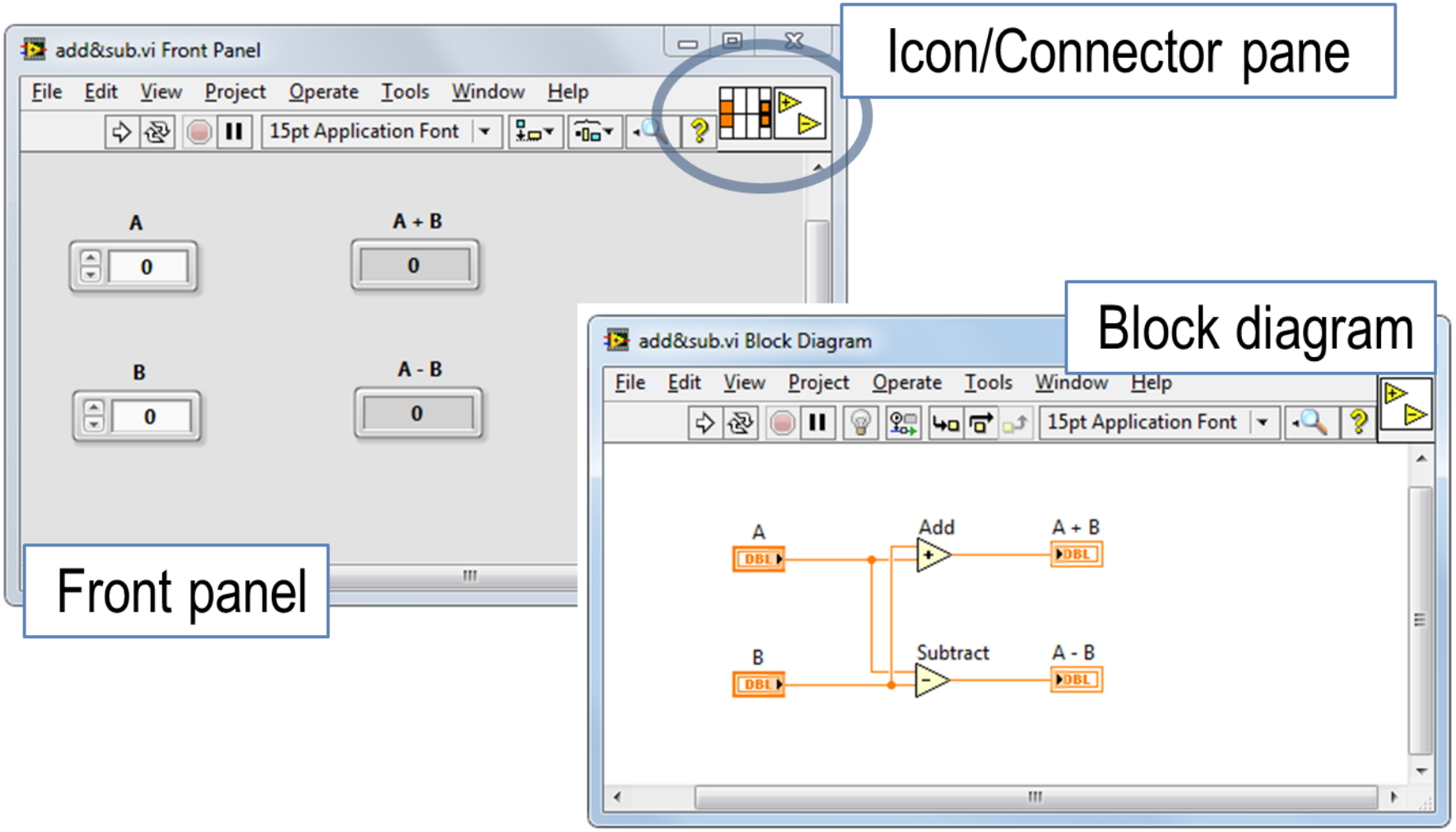
Project Explorer

- Find, access, and organize project files
- Deploy or download files to targets
- Manage code for build options
  - Executables, installers, and zip files



Parts of a VI

VIs have three main components:



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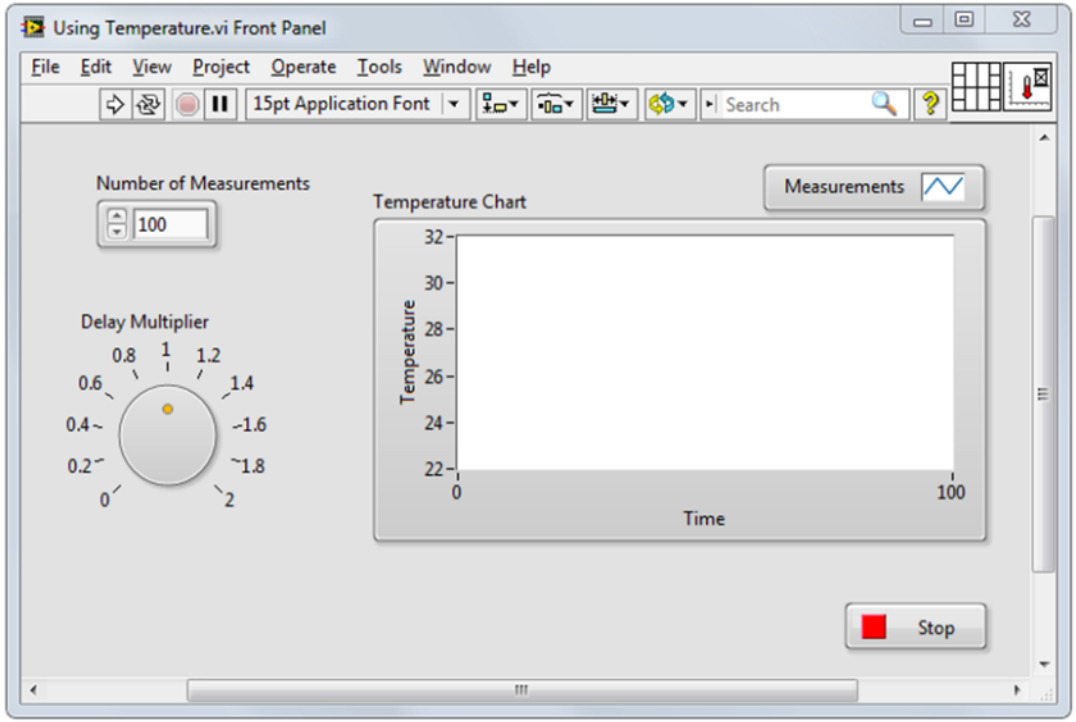
Parts of a VI – Front Panel

Front Panel – User interface for the VI

The front panel is constructed using controls (inputs) and indicators (outputs).

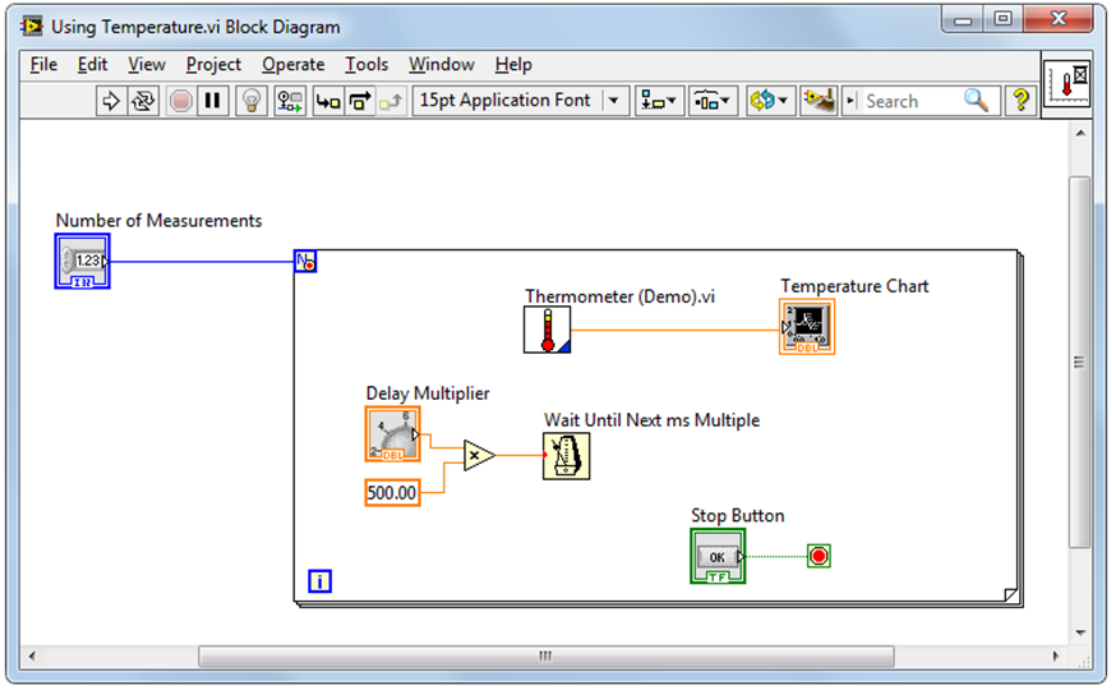


Parts of a VI – Block Diagram

Block Diagram – Contains the graphical source code

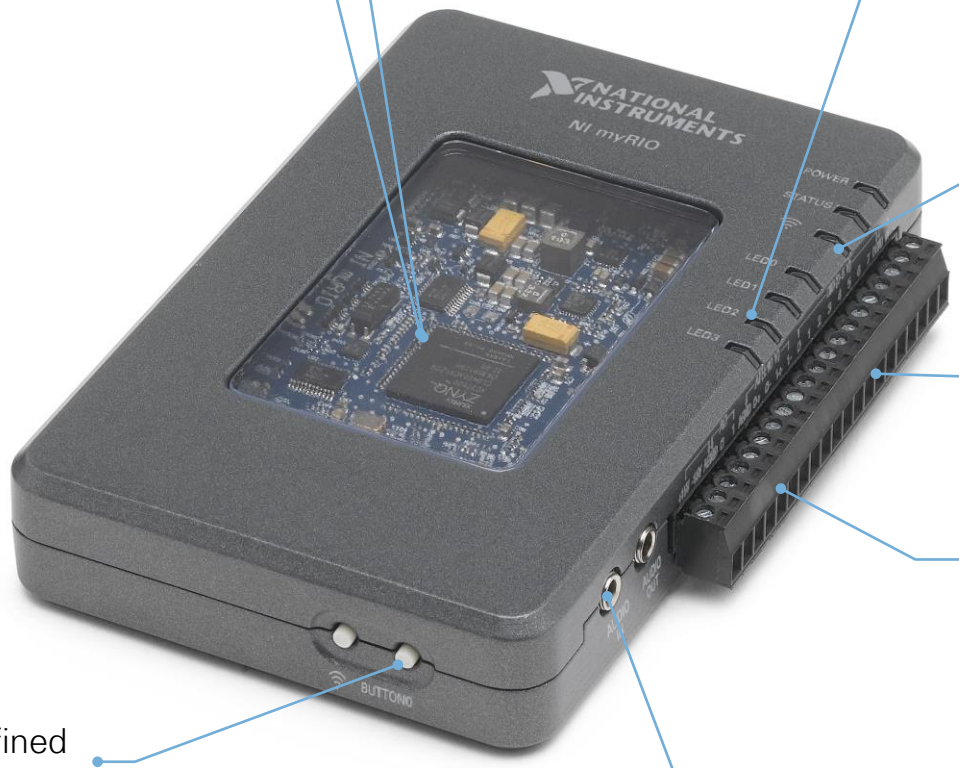
Front panel object appear as terminals on the block diagram.

This is where "programming" is done in LabVIEW.



Overview of NI myRIO

NI myRIO



Xilinx Zynq FPGA and dual-core ARM Cortex-A9

Onboard 3-axis accelerometer

User defined LEDs

Integrated WiFI

40 channels digital I/O (SPI, I2C, UART, PWM, Encoder input)

10 channels analog input
6 channels analog output

User defined button

Stereo audio I/O

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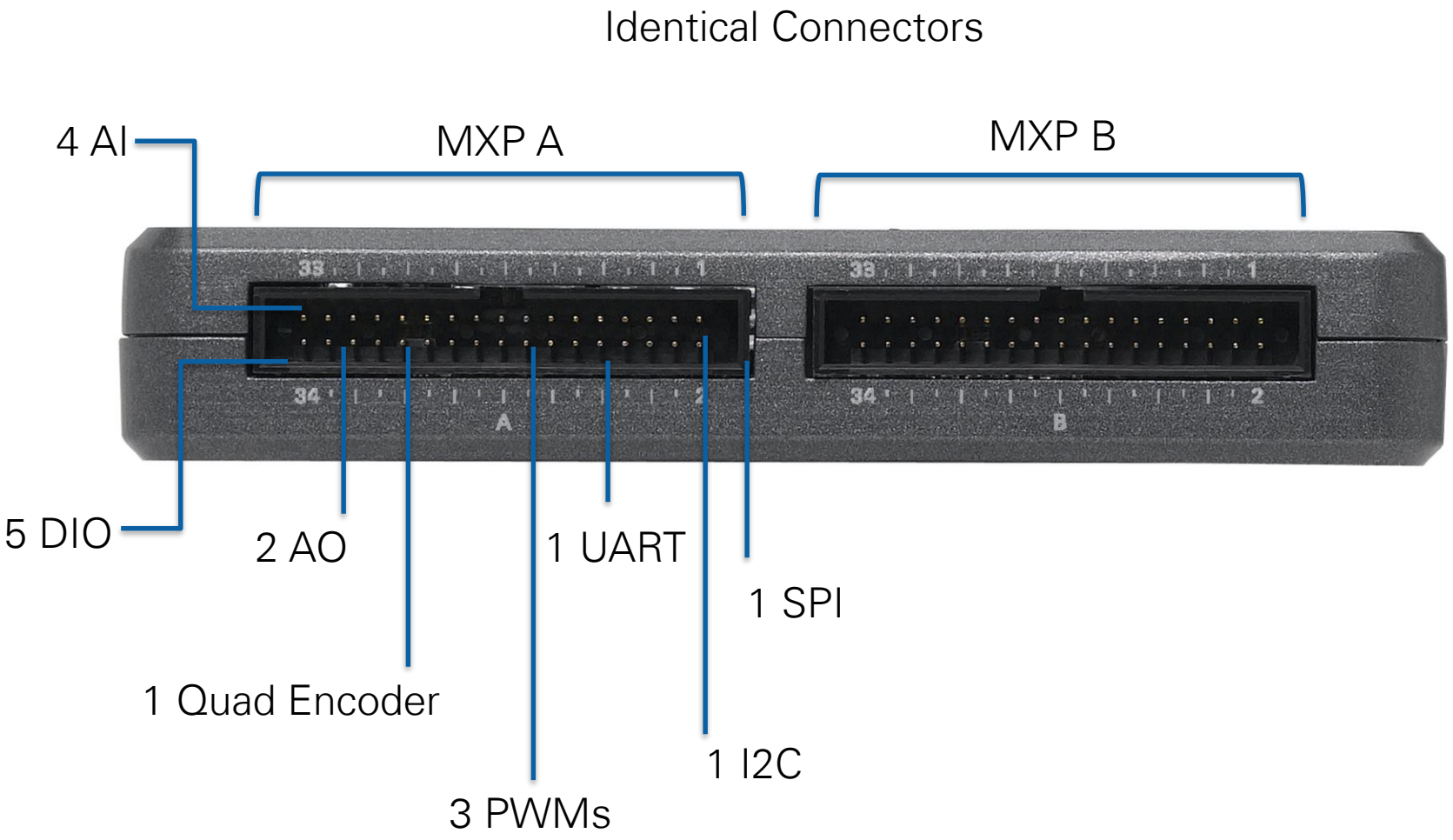
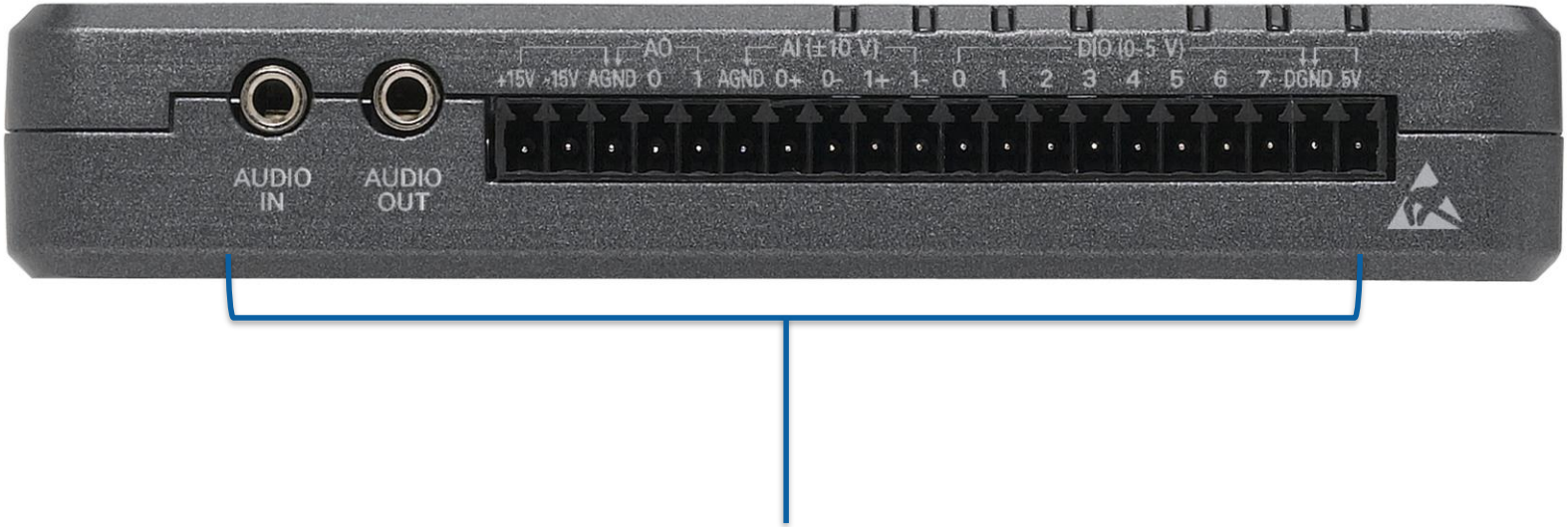
Additional Features

- Fully programmable FPGA through LabVIEW FPGA
- Dual-Core ARM Cortex-A9 processor
- Expandable ecosystem of sensors and actuators
- Ready to use projects and courseware
- Deploy code to real-time processor and FPGA via USB or WiFi
- Minutes to first measurement
- Processor programmable in C/C++

NI myRIO Expansion Port (MXP)



miniSystems Port (MSP)



Identical to NI myDAQ

Why myRIO **Really** Matters in Education

Leading Industry Grade Technology

The same technology is used in our latest industry and research ready Compact RIO systems

Introduction to LabVIEW Real-Time

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What is Real-Time?

- Real-time **does not** always mean real fast
- Real-time means **absolute reliability**
- Real-time systems have timing constraints that must be met to avoid failure
- Determinism is the timing reliability of the system

Critical Applications to Consider

Event Response

Closed-Loop Control

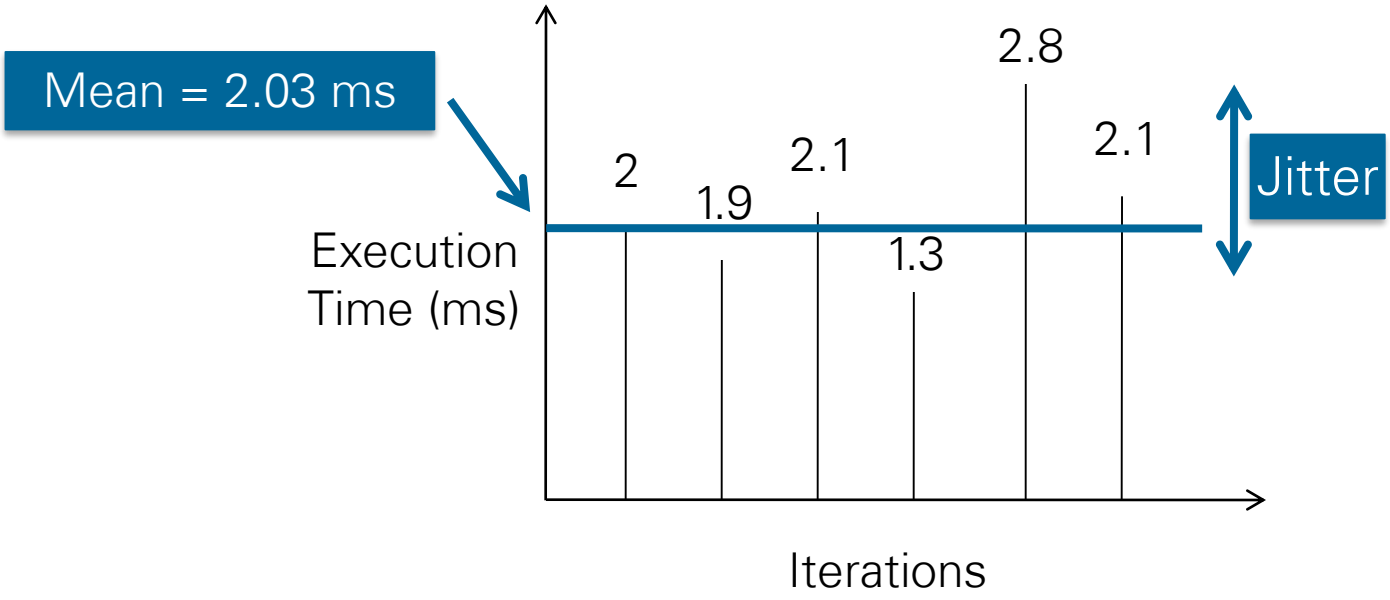
Critical Tests

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

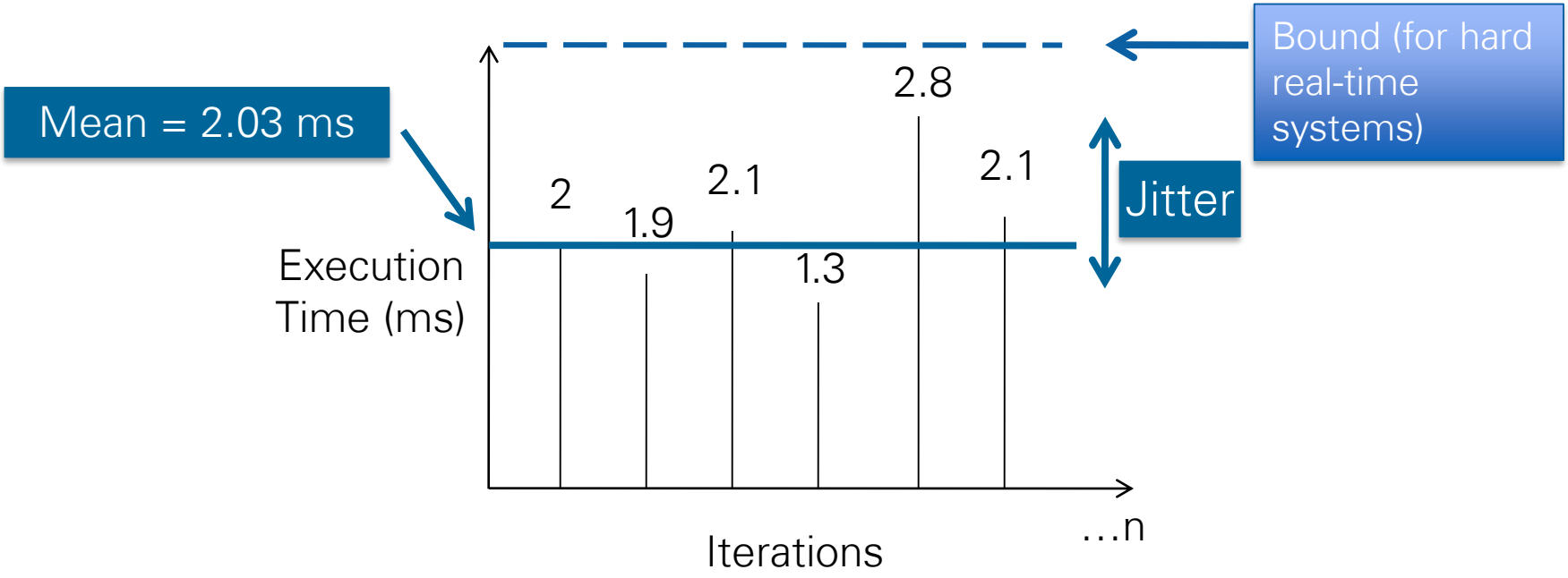
Key Careabouts for Critical Applications

- **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

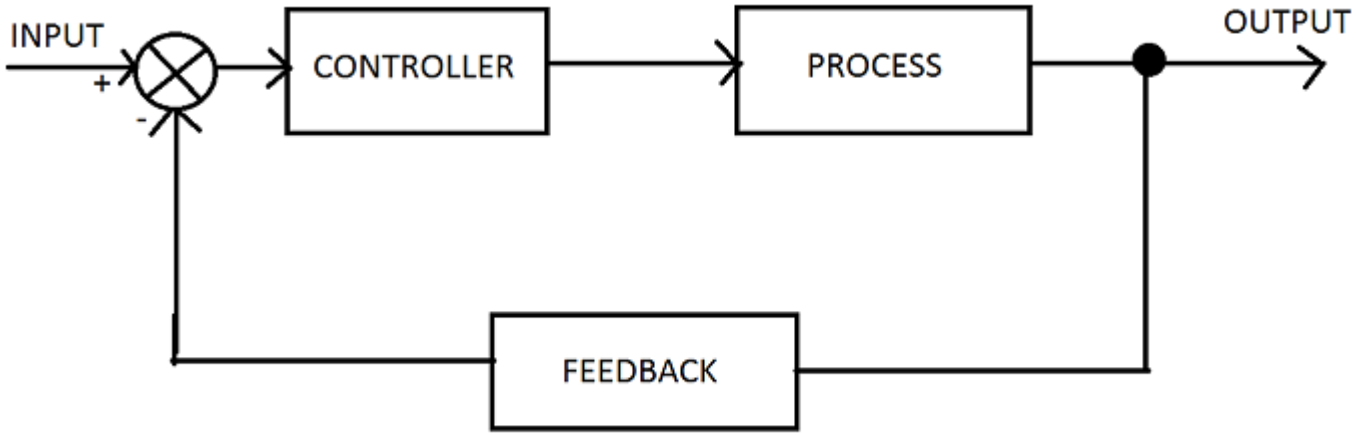


NI Linux Real-Time

- Unlock the vast Linux ecosystem

Database	Security	Code Reuse	Connectivity
Raima	OpenVPN	C/C++	Isshd
MySQL	IP Tables	Shell Scripting	IPv6
SQLite	System Logging	Python	SNMP
MongoDB	fail2ban	Ruby	NTP
CouchDB	denyhost	Perl	netstat

Control System with myRIO and LabVIEW Real-Time



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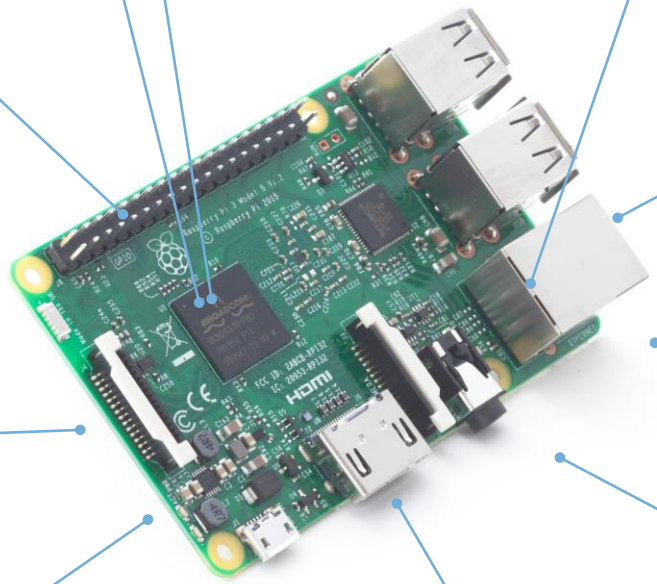
Raspberry PI 3



A 1.2GHz 64-bit quad-core ARMv8 CPU

1GB RAM

4 USB Ports

40 GPIO pins

Ethernet Port

Combined 3.5mm audio jack and composite video

Display interface (DSI)

Integrated WiFi

VideoCore IV 3D graphics core

Camera interface (CSI)

LabVIEW MakerHub

LabVIEW LINX Library

LINX provides easy to use LabVIEW VIs for interacting with common embedded platforms like **Arduino, Raspberry PI, chipKIT and myRIO**. Use the built in sensor VIs to start getting data to your PC in seconds or use the peripheral VIs to access your devices digital I/O, analog I/O, SPI, I2C, UART, PWM and more.

www.labviewmakerhub.com

NI myRIO Kits | ni.com/myrio

Starter

LEDs & switches
7-segment display
Potentiometer
Thermistor
Photo resistor
Hall effect
Microphone/Speaker
Battery holder
DC motor

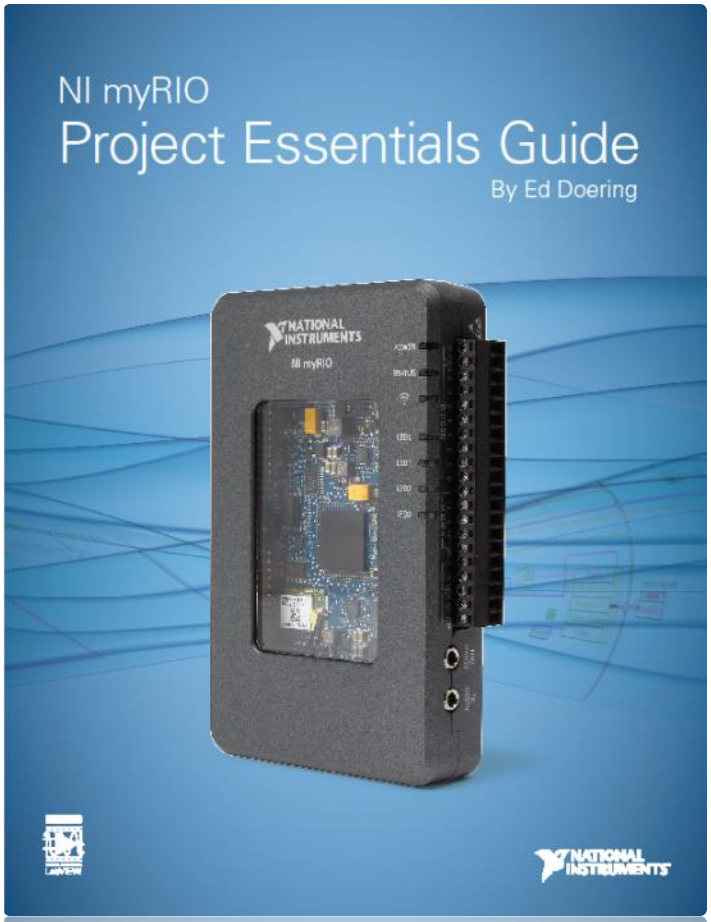
Mechatronics

DC gear motors/encoders
H-bridge driver
Accelerometer
Triple-axis gyro
Infrared proximity sensor
Ambient light sensor
Ultrasonic range finder
Compass
Hobby servo motors

Embedded

RFID reader kit
Numeric keypad
LED matrix
Digital potentiometer
Character LCD
Digital temp sensor
EEPROM

NI myRIO | Courseware



2 Discrete LED

LEDs, or light-emitting diodes, provide simple yet essential visual indicators for system status and error conditions. Figure 2.1 shows the four types of LEDs included in the SparkFun "LED Mixed Bag (5mm)" kit `http://www.sparkfun.com/products/9881`.

Learning Objectives: In this module you will create a standard interface circuit to verify correct operation of the LED, learn interface circuit design principles and related LabVIEW programming techniques, make some basic modifications to extend your understanding of the interface, and then challenge yourself to design a system that integrates the discrete LED with additional components or devices.

2.1 Component Verification

Follow these steps to verify correct operation of the discrete LED component.

Select these parts:

- Resistor, 220 ohm
- "Basic Red" LED from Sparkfun 9881
- Breadboard
- Connecting wires [need details]

ownload the LabVIEW project: Download the roject `Discrete LED demo.lvproj` from eed details].

2.3. BASIC MODIFICATIONS

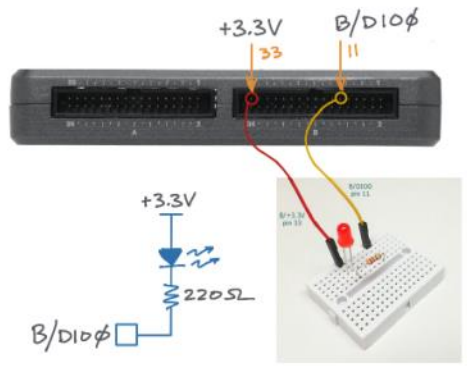


Figure 2.2: Discrete LED verification circuit: schematic diagram, recommended breadboard layout, and connection to NI myRIO MXP Connector B.

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Learn More About Programming NI myRIO

ni.com/learn-myrio

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