password
Tsp@2023

LabVIEW FPGA @ CERN 2023

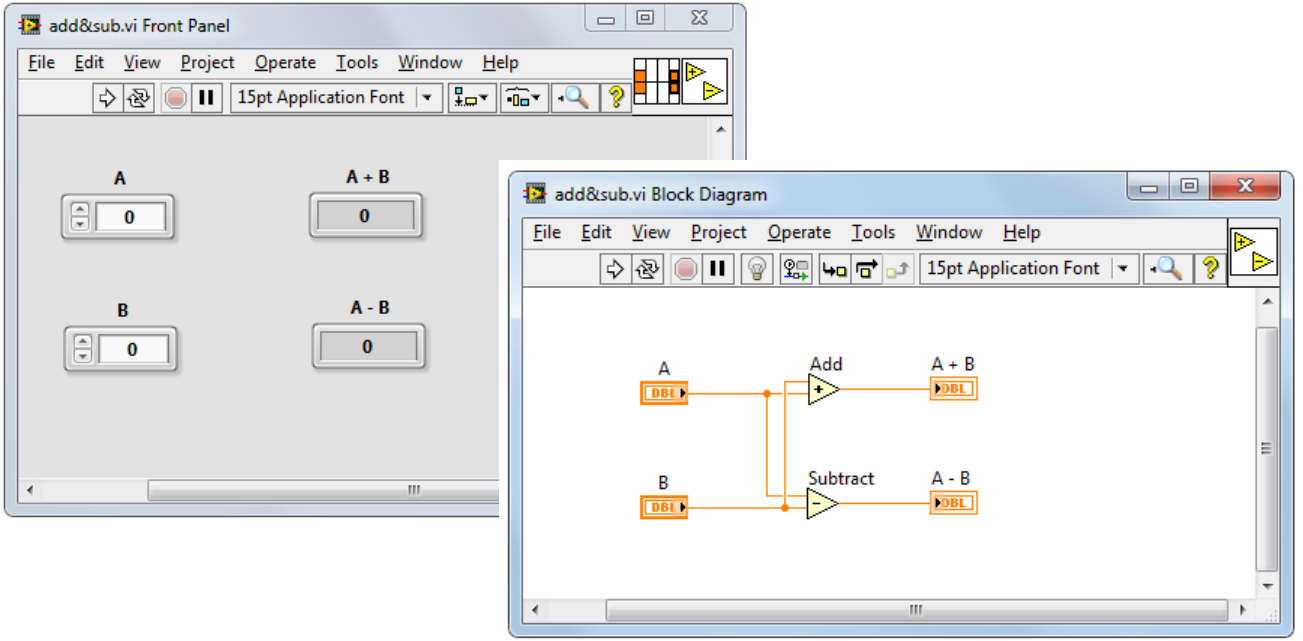
- Unofficial
- For fun
- Share knowledge

About the workshops

- Minimize theory
- Maximize practice
- Some fun examples

LabVIEW

- Intuitive
- Data driven
- Hardware integration



NI : part of Emerson

Leader in data acquisition technology with innovative modular instruments and LabVIEW graphical programming software

- Corporate headquarters in Austin, TX
- Offices in nearly 50 countries
- 35,000+ companies served annually
- More than 1,000 products
- Approx. 7,100 employees
- 600 Alliance Partners
- Part of Emerson Electric Co. this year

FORTUNE® 100 BEST COMPANIES TO WORK FOR

Ritu Favre / CEO

Diversity of applications

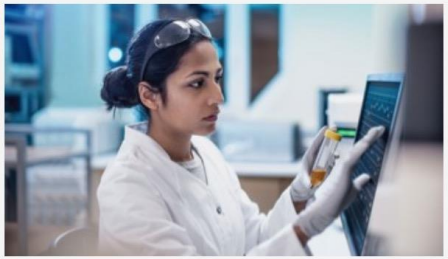
SEMICONDUCTOR

AUTOMOTIVE

AEROSPACE, DEFENSE, & GOVERNMENT

ELECTRONICS

ENERGY



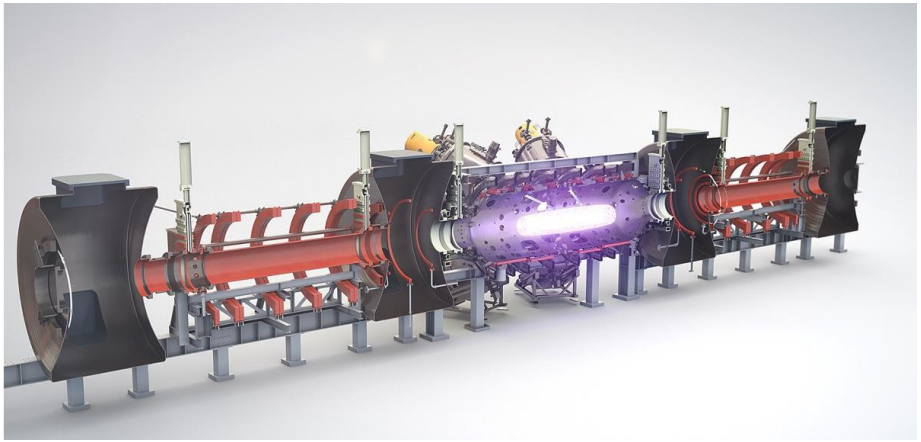
ACADEMIC & RESEARCH

SpaceX

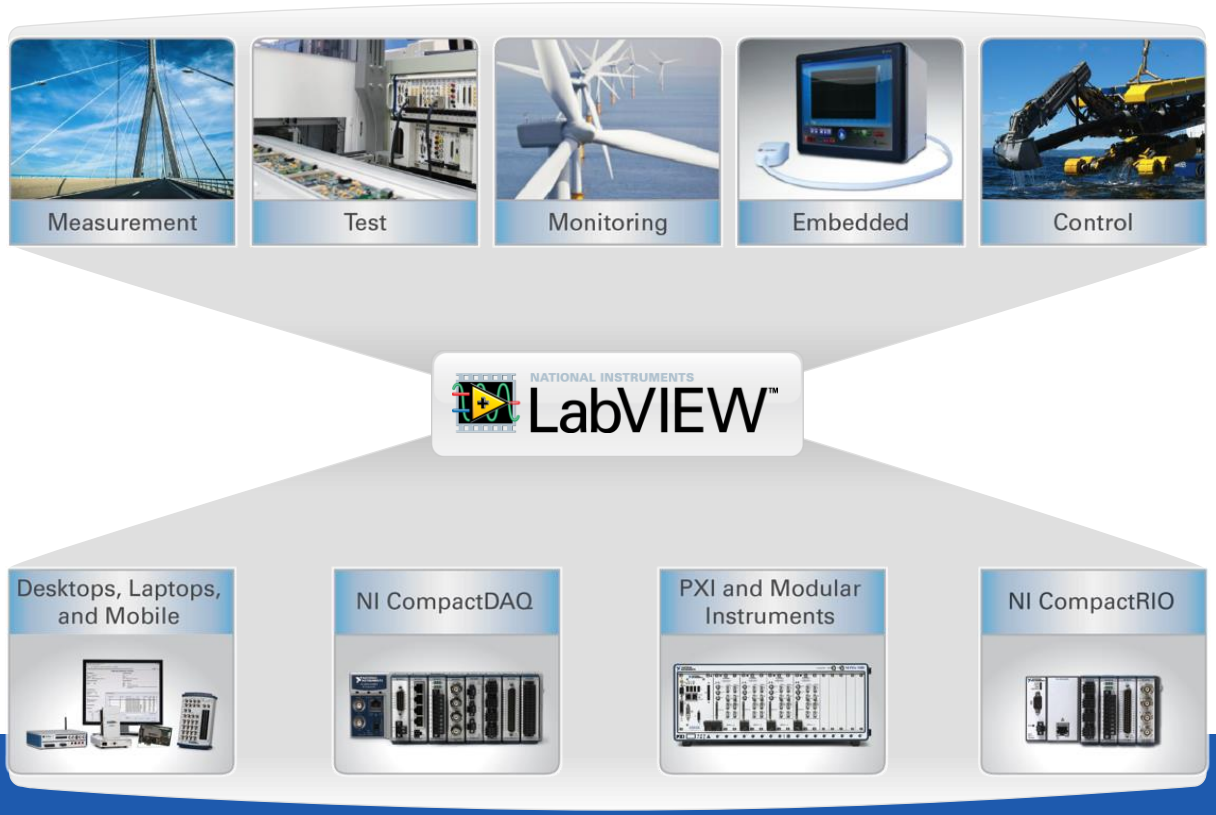
Falcon rocket launch pad software

TAE

Commercial nuclear fusion power



LabVIEW on different hardware

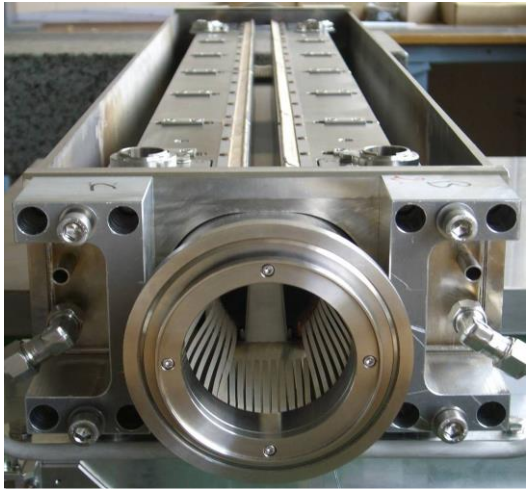


Applications

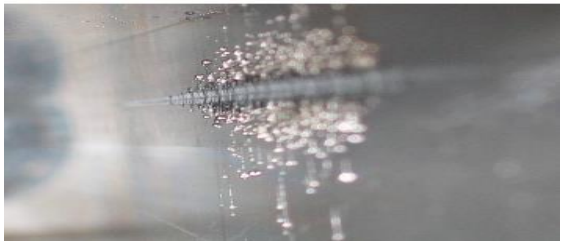
Hardware

Projects based on NI @ CERN

- LHC collimators real-time control system

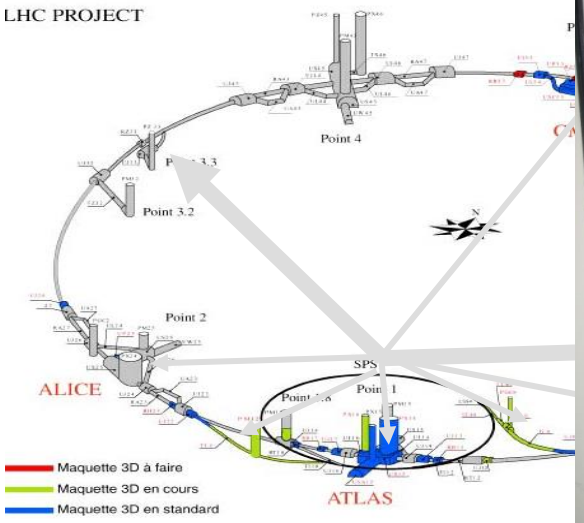


Control system requirements	
Axes positioning accuracy	few µm
Axes motion synchronization	below 1 ms
Response delay to a digital start trigger	100 µs
Position sensors RT survey frequency	100 Hz
Reliability	Very high

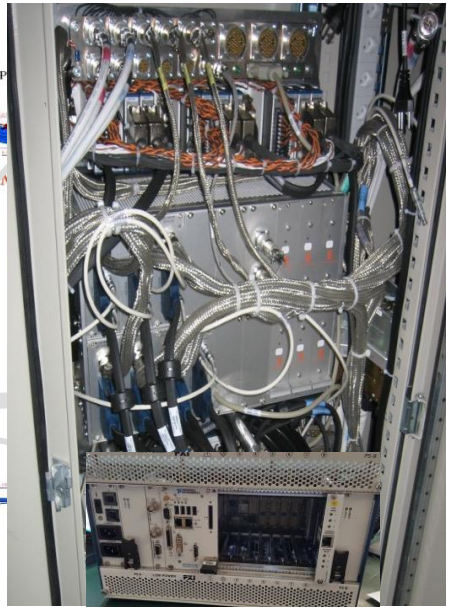


• LHC collimators real-time control system

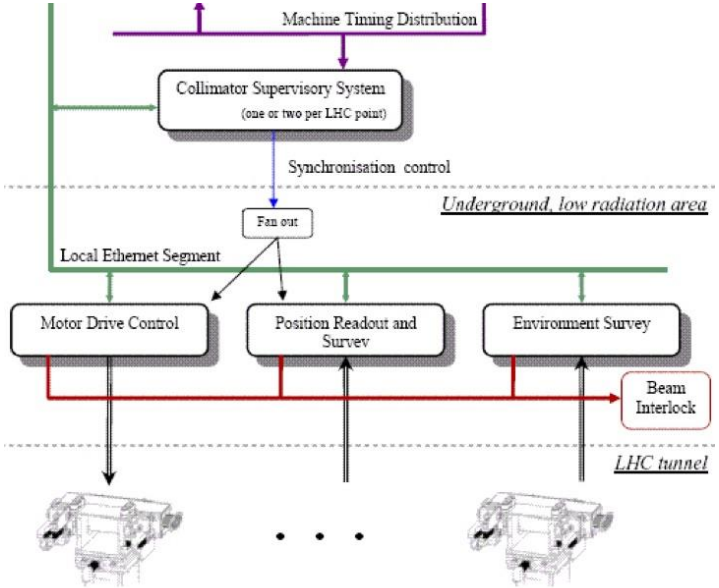
Layout



120 systems



Architecture



Projects based on NI @ CERN

- Measurement setup for characterization of the radiation hardness of cryogenic bypass diodes for the LHC-HL

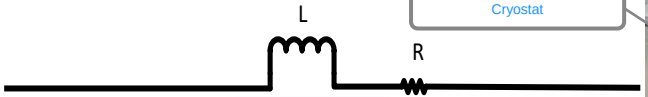
Power supplies for heaters

PXI system components:
- 7 x DMM 4081
- DAQ M-series 6251
- GPIB
- Ethernet

HV power supply – 3kV max

Discharge circuit

Capacitor bank 13,3 mF, 1500V



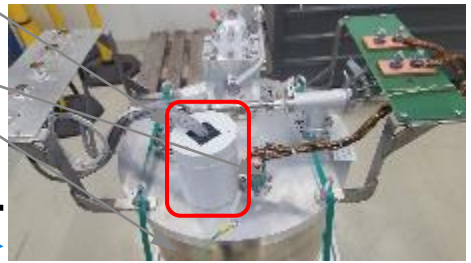
$\approx 30m$

LHC by-pass diodes

Mu-metal shield (against magnetic field)

Feedthrough 18kA

Cryostat



Measurement rack

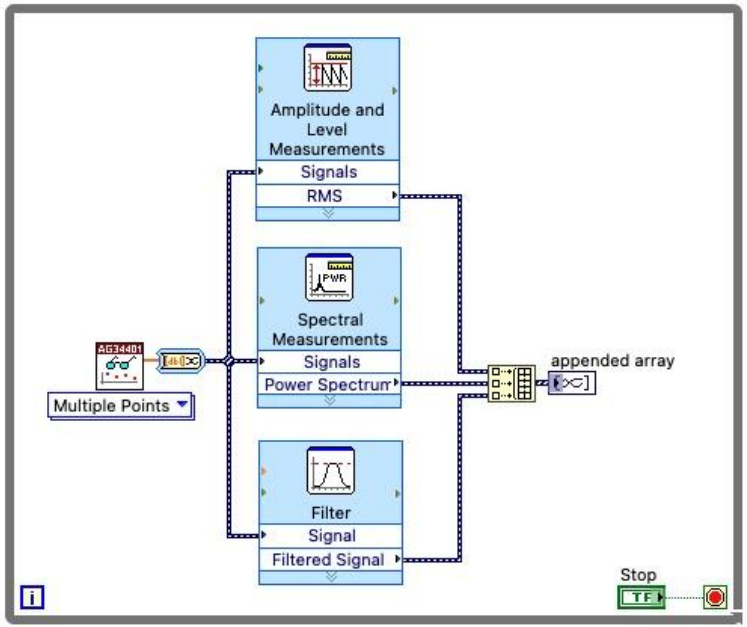
Measurement setup assembly and closed cryostat

CERN LabVIEW support

- Website: cern.ch/labview
- E-mail: labview.support@cern.ch

Why LabVIEW?

- Same concepts as in traditional languages (data types, loops, event handling, recursion and OOP)
- Data flow (execution is data-driven, not determined by sequential lines of text)
  - Automatic parallelism
  - Automatic data synchronisation
- Intuitive
- Easy to debug
- NI hardware integration
- Combines with other languages



B. Project Explorer

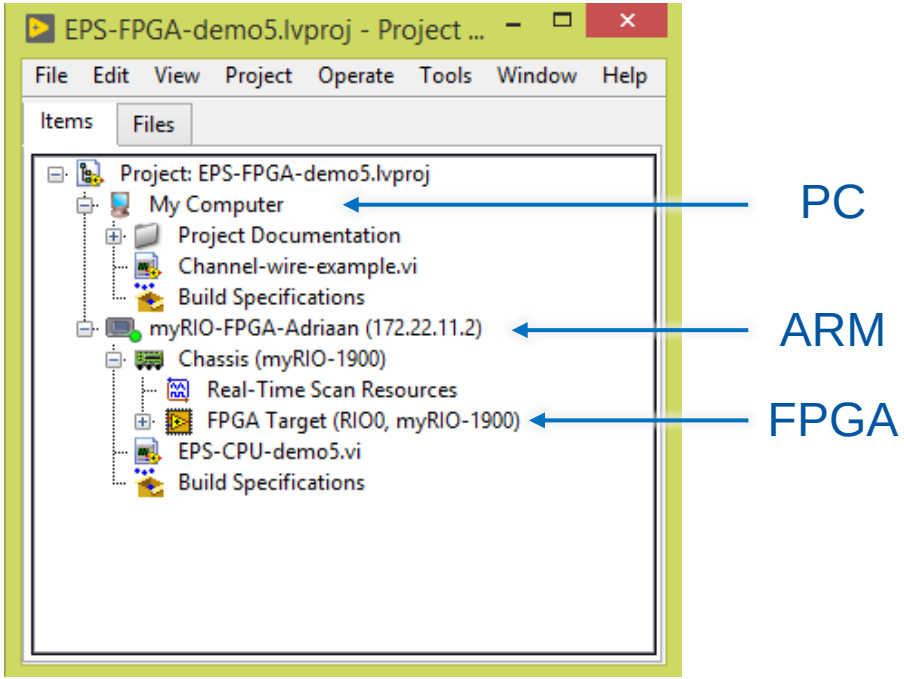
Project Explorer Window

Files Types

Project Folders

Project Explorer

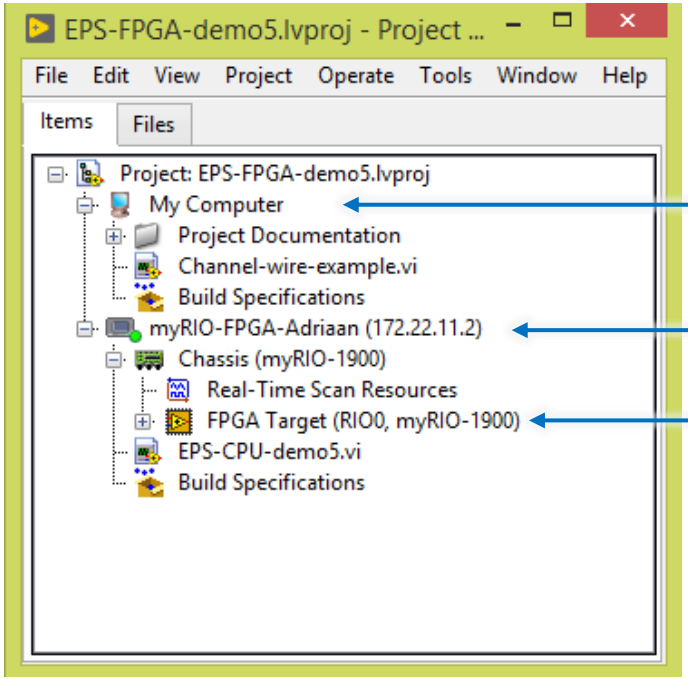
- See the hierarchy
- Organise project files
- Deploy files to targets
- Manage code for build options
  - Executables, installers, and zip files
- Integrate with source code control providers



Project Explorer

PC

Xilinx Zynq 7010



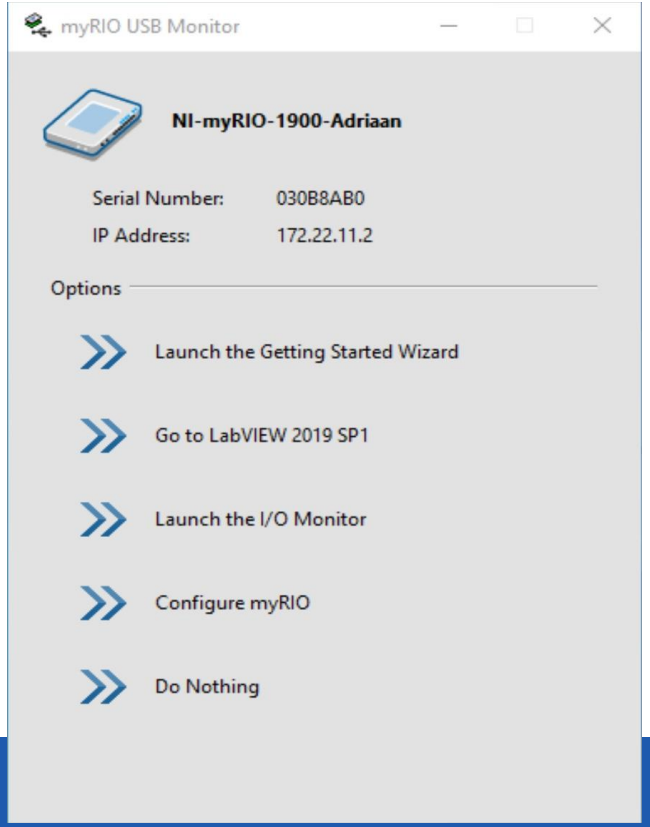
Connect to myRIO

1. Don’t have the myRIO connected yet
2. Power up the myRIO
3. Wait until the Status LED is off
4. Connect the myRIO to your PC

Start LabVIEW

PC

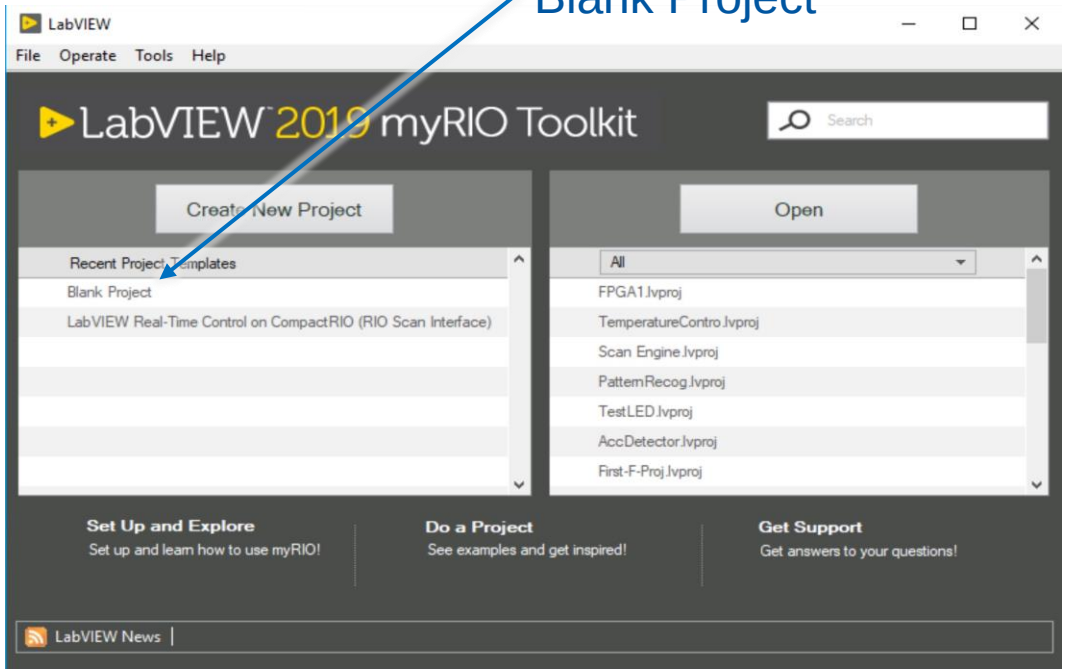
myRIO



Go to LabVIEW

Project

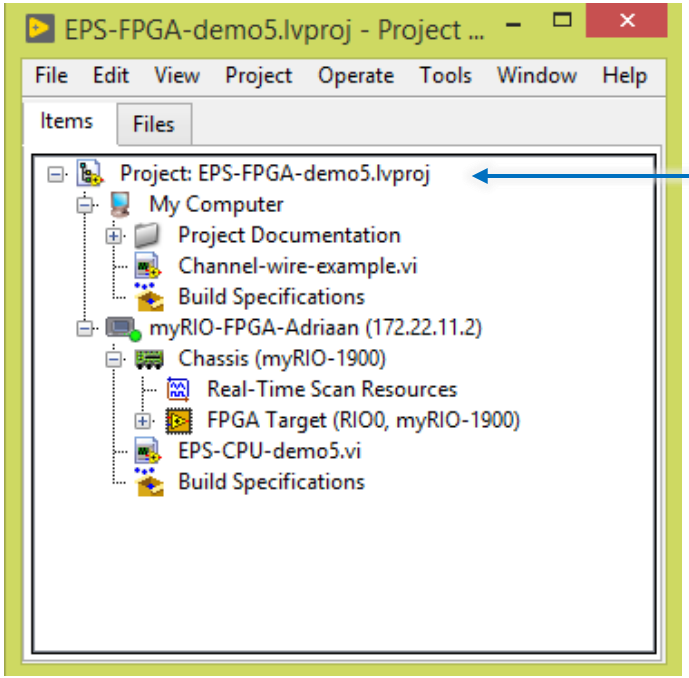

PC
myRIO


Blank Project
LabVIEW
File Operate Tools Help
LabVIEW 2019 myRIO Toolkit
Search
Create New Project
Open
Recent Project Templates
Blank Project
LabVIEW Real-Time Control on CompactRIO (RIO Scan Interface)
All
FPGA1.lvproj
TemperatureContro.lvproj
Scan Engine.lvproj
PatternRecog.lvproj
TestLED.lvproj
AccDetector.lvproj
First-F-Proj.lvproj
Set Up and Explore
Set up and learn how to use myRIO!
Do a Project
See examples and get inspired!
Get Support
Get answers to your questions!
LabVIEW News

New target

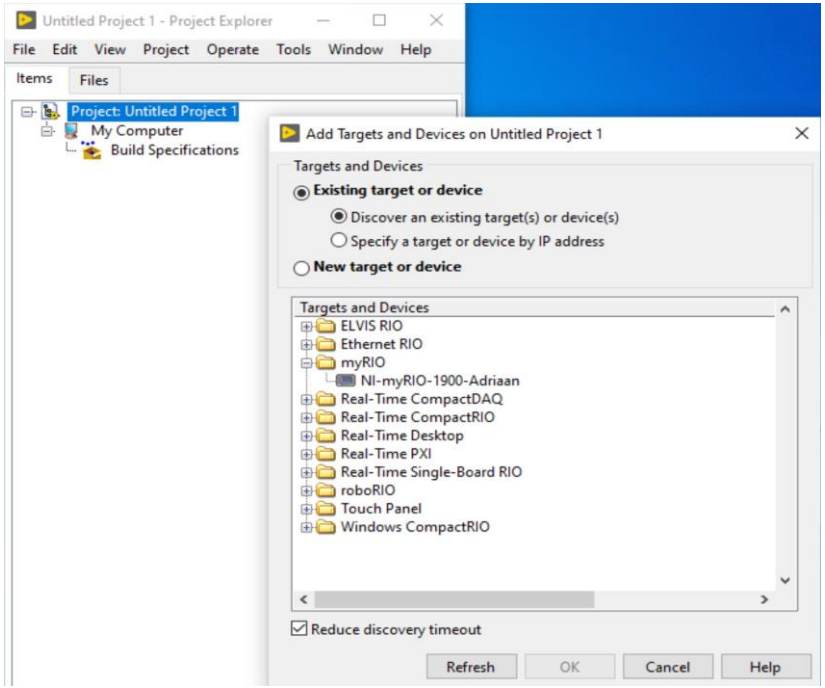
PC

myRIO



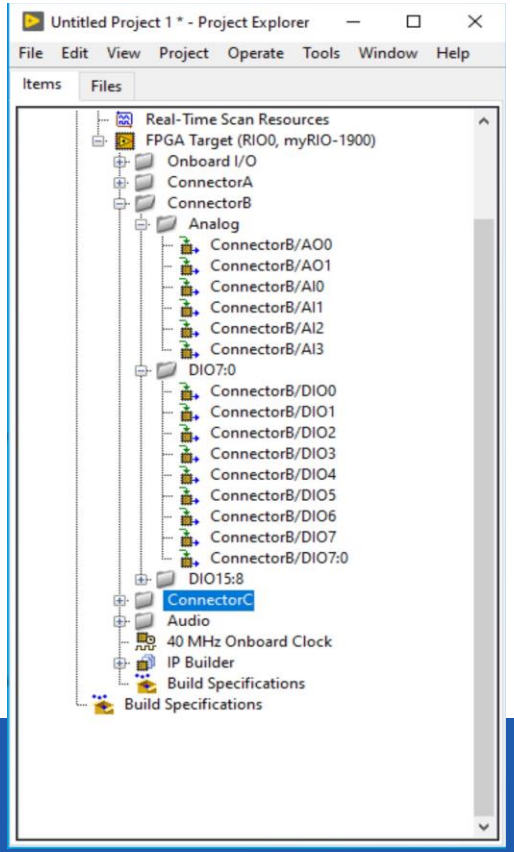
Right click Project
Choose: New ->
targets and devices

Select myRIO



Open myRIO with +
Select NI myRIO
OK

Prepare myRIO



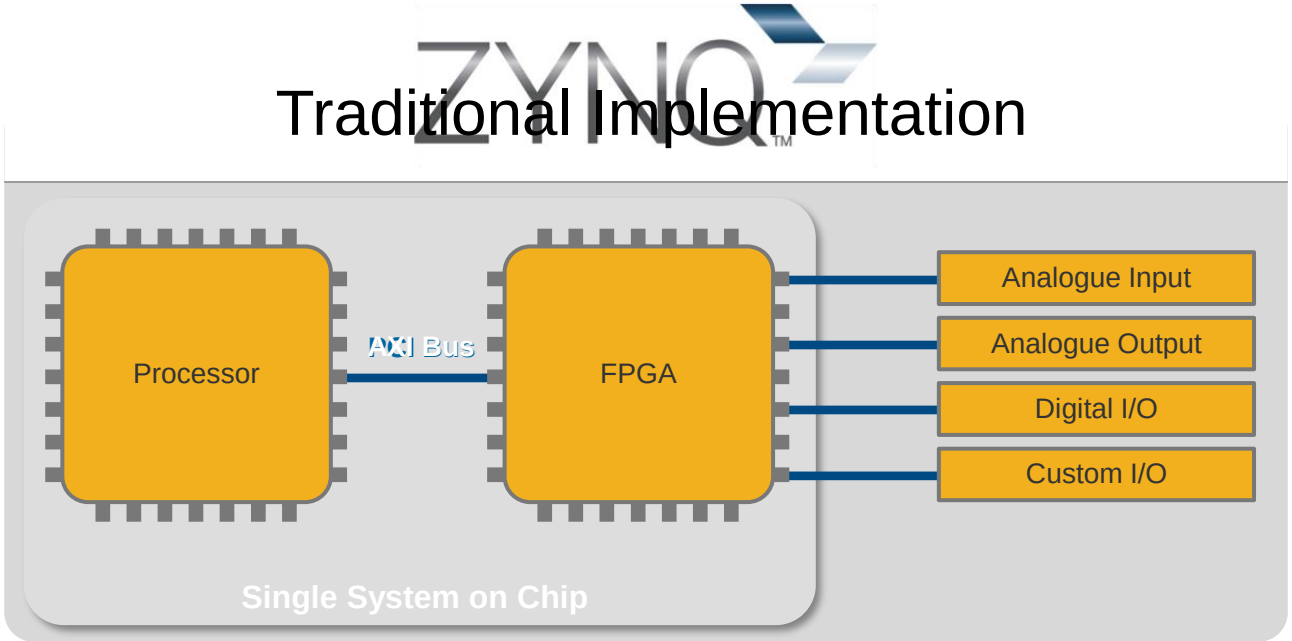
Close tabs:

- Onboard I/O
- Connector A
- Connector B DIO15:8
- Connector C
- Audio

NI myRIO Product Overview: Front View

XILINX Zynq SoC

What is Zynq?


ZYNQ
Traditional Implementation
Processor
AXI Bus
FPGA
Analogue Input
Analogue Output
Digital I/O
Custom I/O
Single System on Chip

Why Zynq Matters in Education

- Smaller Size, Lower Power
- 667 MHz Dual-Core ARM Cortex-A9 Processor
- Artix-7 FPGA, 28k logic cells
- 16 DMA Channels
- 92 Billion calculations per second

Why Zynq **Really** Matters in Education

Leading Industry Grade Technology

The same technology is used in the modular I/O Compact RIO systems

C. Parts of a VI

Front Panel

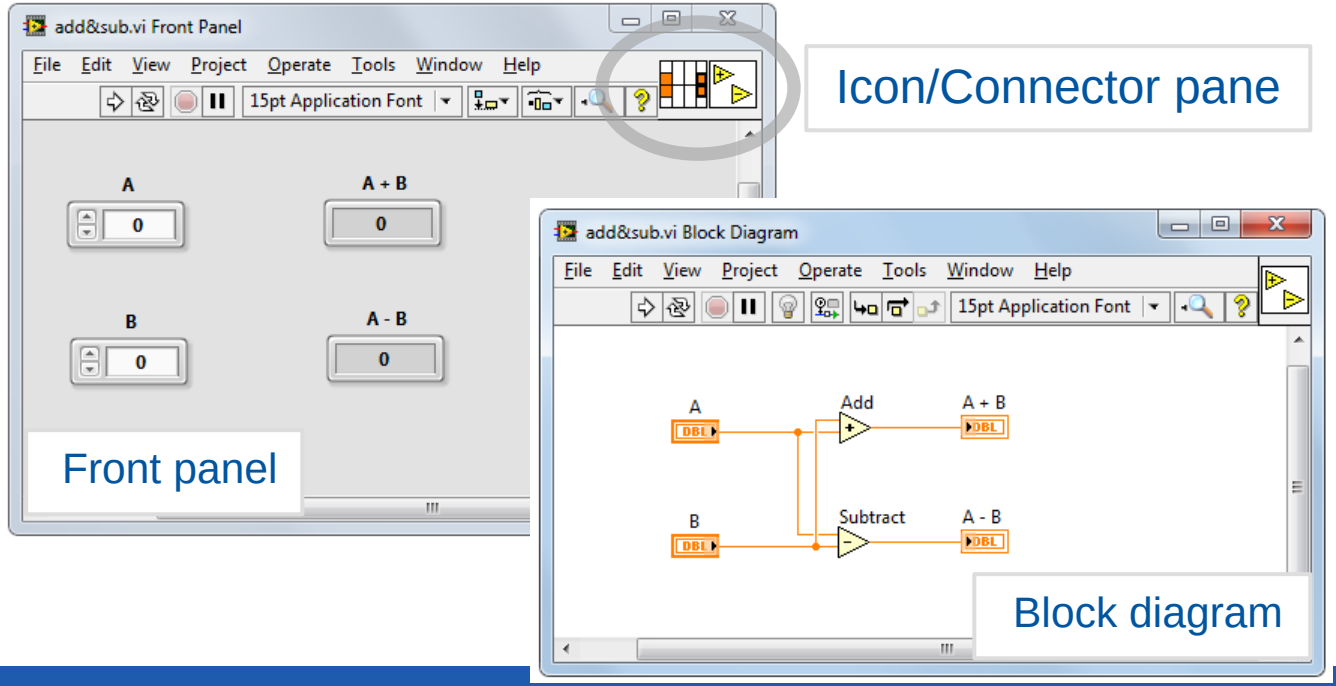
Block Diagram

Icon

Connector Pane

Parts of a VI

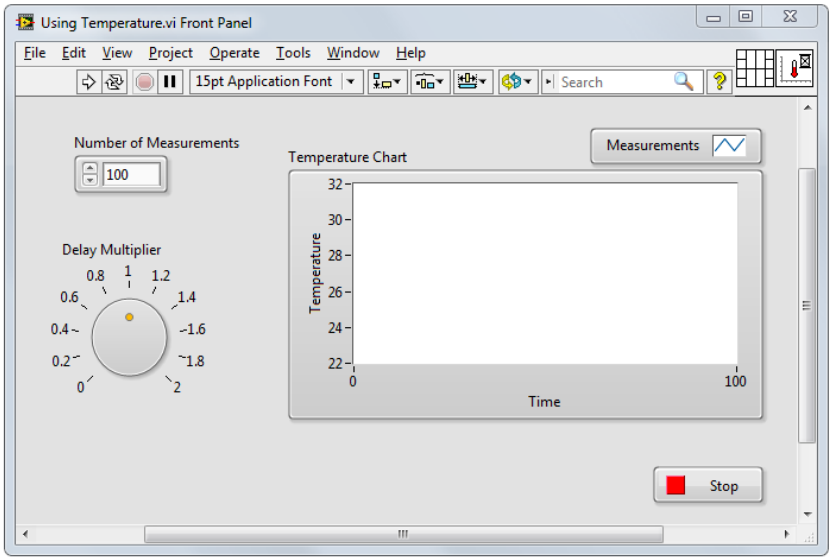
VIs have 3 main components:



Parts of a VI – Front Panel

Front Panel – User interface for the VI

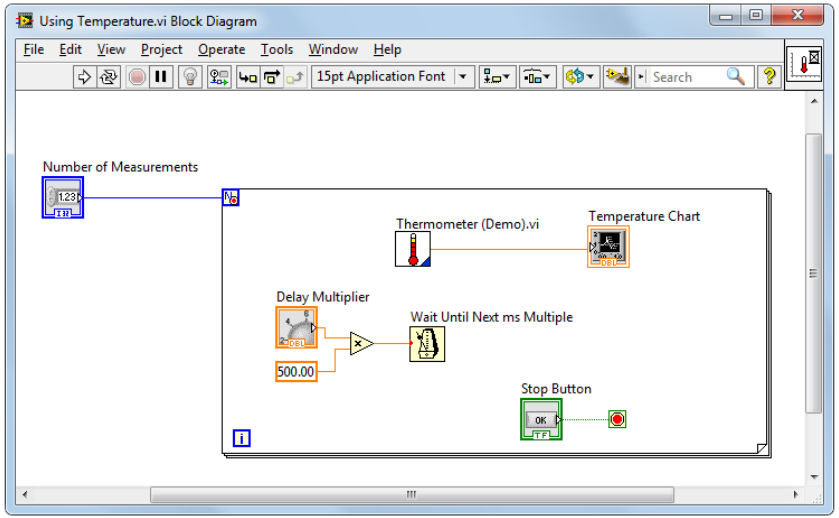
You build the front panel with controls (inputs) and indicators (outputs).



Parts of a VI – Block Diagram

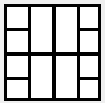
Block Diagram – Contains the graphical source code

Front panel objects appear as terminals on the block diagram.



Parts of a VI – Icon/Connector Pane

Icon – Graphical representation of a VI



Connector Pane – Map of the inputs and outputs of a VI

Icons and connector panes are necessary to use a VI as a subVI.

- A subVI is a VI that appears on the block diagram of another VI.
- A subVI is similar to a subroutine or function in a text-based programming language.

Show – off (2)

Figures

D. Front Panel

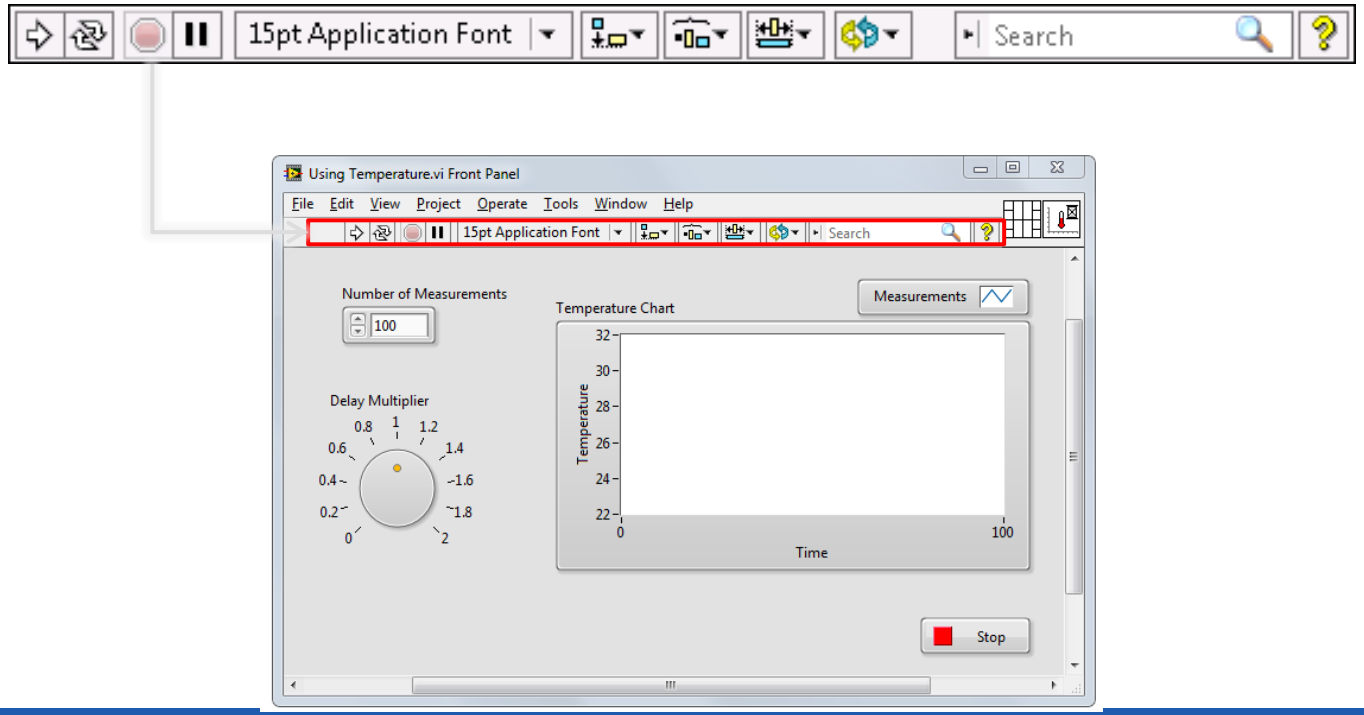
Controls and Indicators

Object Styles

Object Types

- Boolean
- Numeric
- String

Front Panel


15pt Application Font
Search
Using Temperature.vi Front Panel
File Edit View Project Operate Tools Window Help
15pt Application Font
Search
Number of Measurements
100
Delay Multiplier
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
Temperature Chart
Measurements
Temperature
32 30 28 26 24 22
0 100
Time
Stop

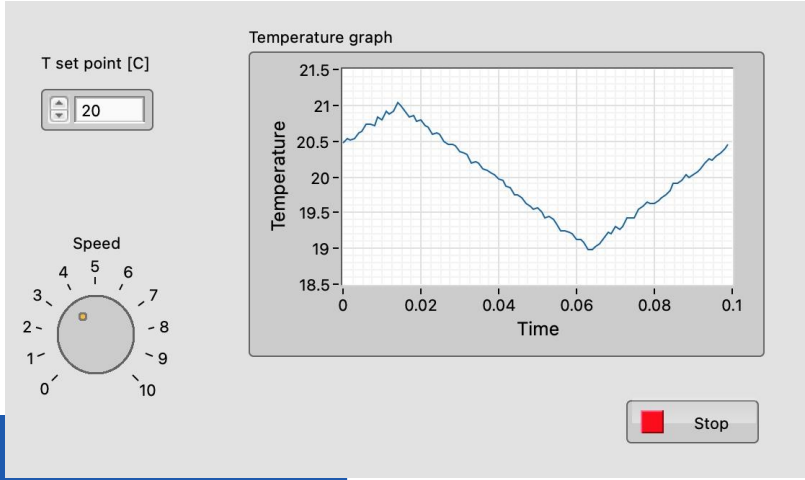
Controls and Indicators

Controls

- Input devices
- Knobs, buttons, slides
- Supply data to the block diagram

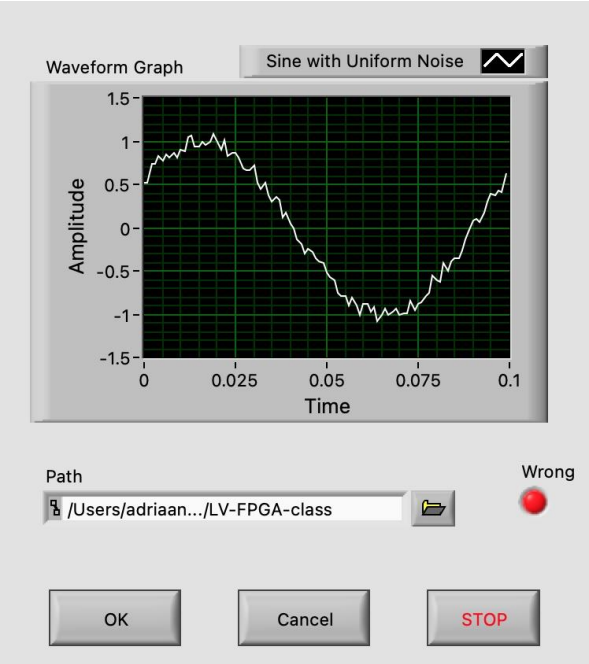
Indicators

- Output devices
- Graphs, LEDs
- Display data the block diagram acquires or generates

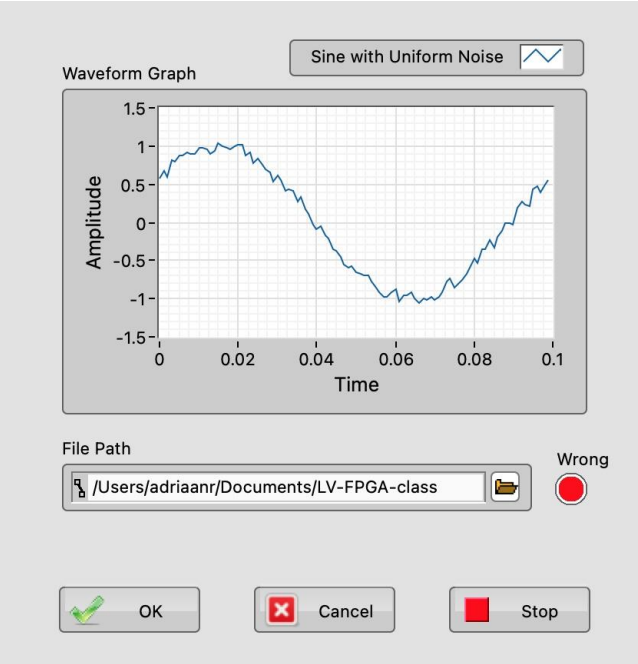


Front Panel Object Styles

Modern

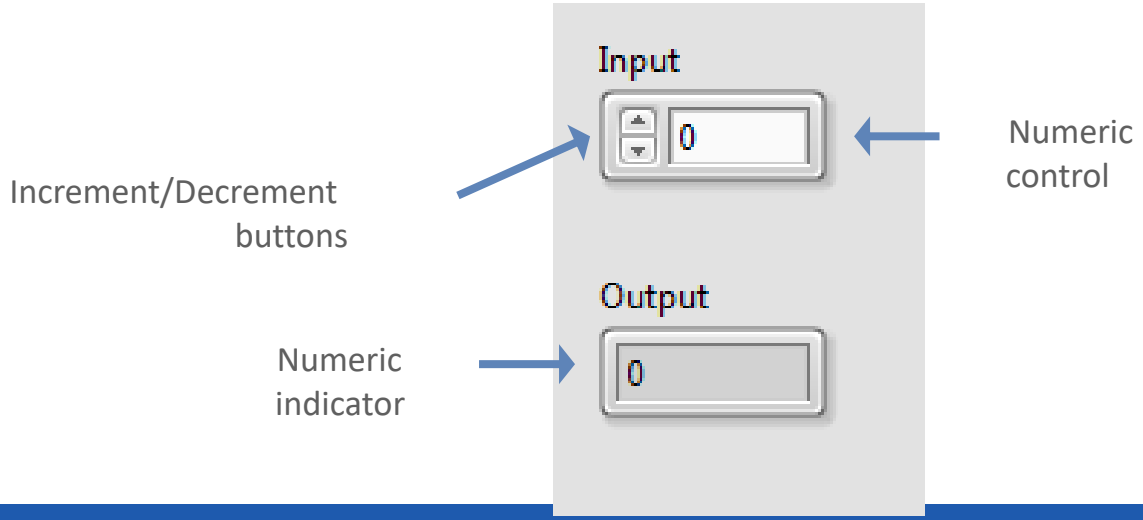


Silver



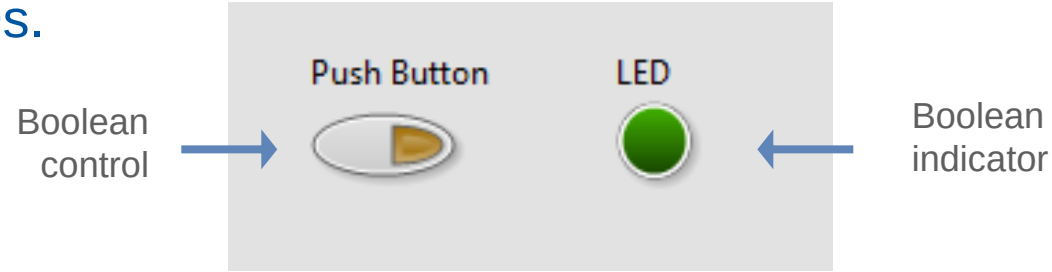
Numeric Controls and Indicators

The numeric data in a control or indicator can represent numbers of various types, such as integer or floating-point.



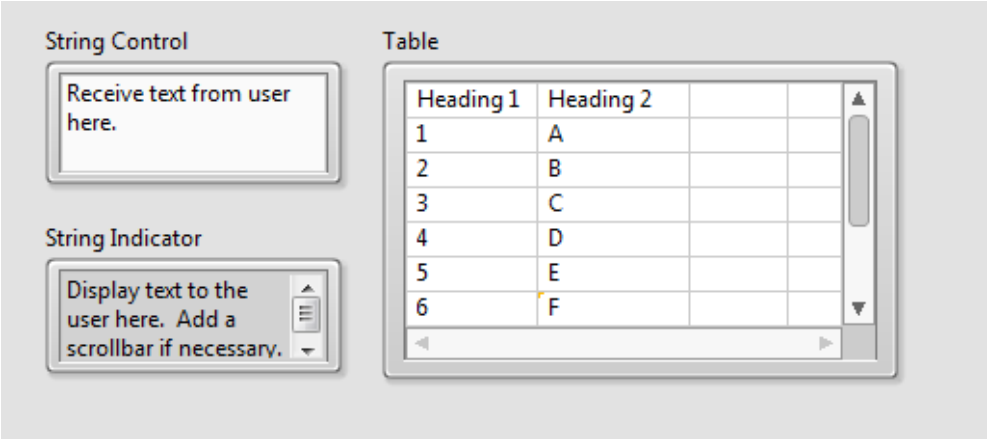
Boolean Controls and Indicators

- The Boolean data type represents data that has only two options, such as True/False or On/Off.
- Use Boolean controls and indicators to enter and display Boolean (TRUE/FALSE) values.
- Boolean objects simulate switches, push buttons and LEDs.



Strings

- The string data type is a sequence of ASCII characters.
- Use string controls to receive text from the user.
- Use string indicators to display text to the user.



E. Block Diagram

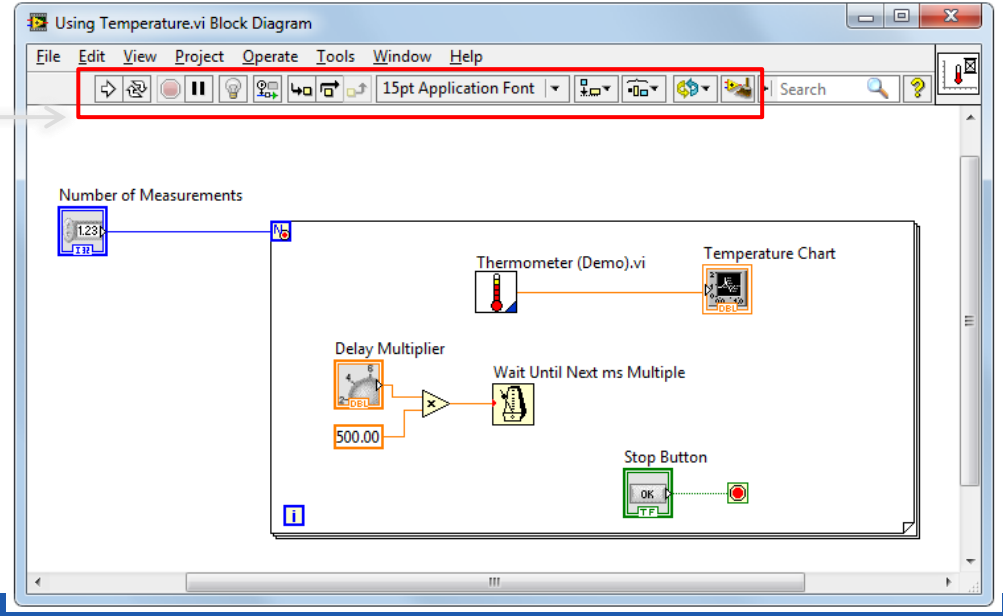
Terminals

Nodes

Wires

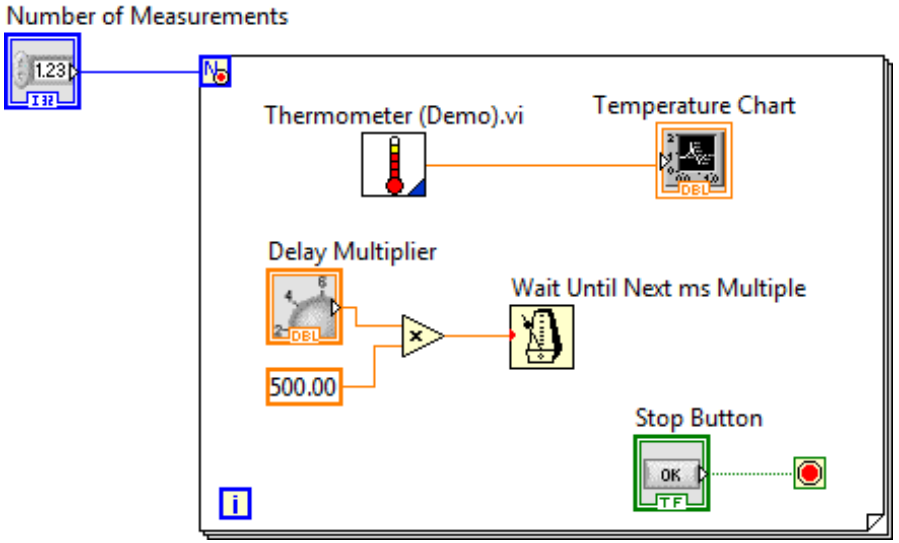
Help

Block Diagram

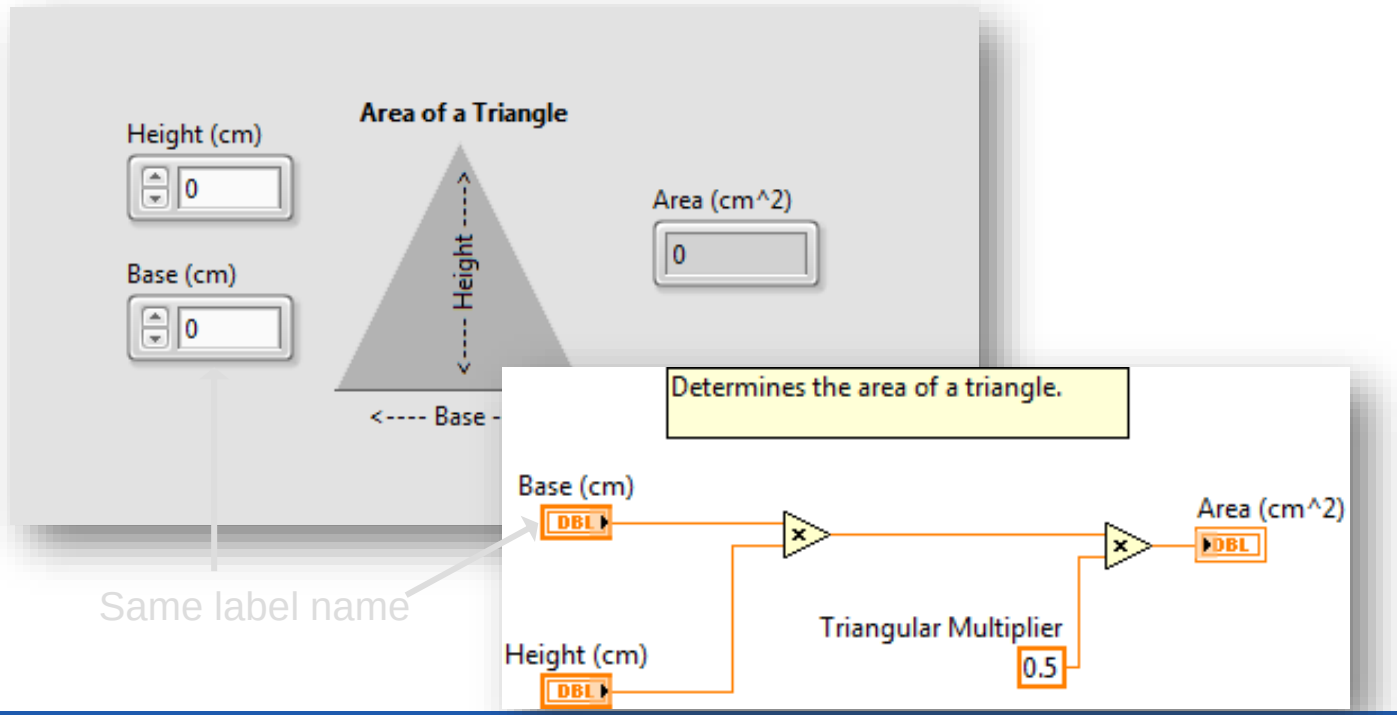


Block Diagram

- Block diagram items:
  - Terminals
  - Constants
  - Nodes
    - Functions
    - SubVIs
    - Structures
  - Wires
  - Free labels

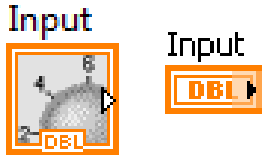


Terminals


Area of a Triangle
Height (cm)
0
Base (cm)
0
Height ---->
<---- Base ----
Area (cm^2)
0
Same label name
Determines the area of a triangle.
Base (cm)
DBL
Height (cm)
DBL
Triangular Multiplier
0.5
Area (cm^2)
DBL

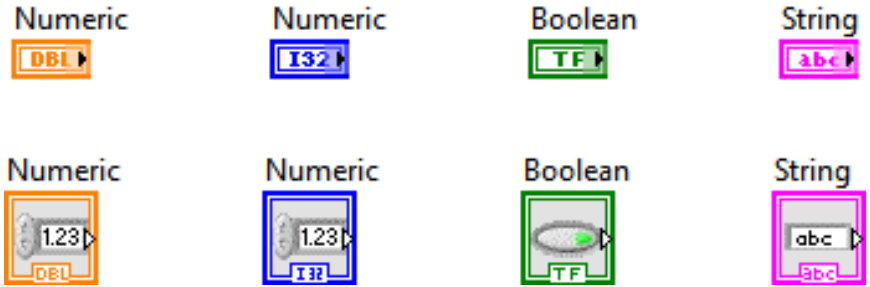
Terminals for Front Panel Objects

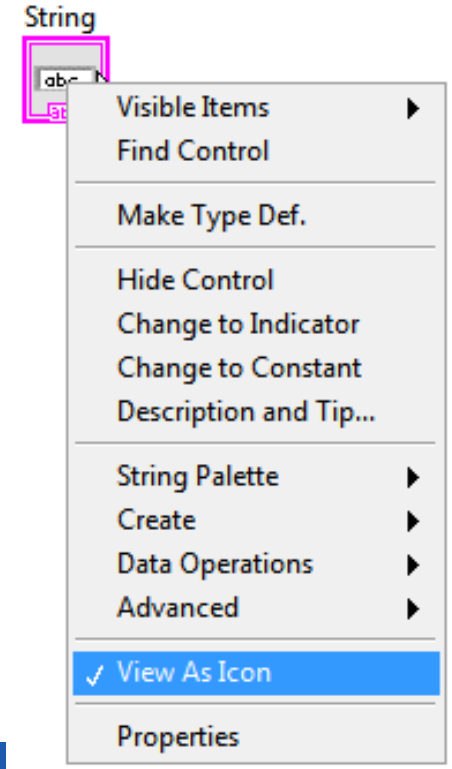
- Terminals are:
  - Entry and exit ports that exchange information between the front panel and block diagram
  - Analogous to parameters in text-based programming languages
- Double-click a terminal to locate the corresponding front panel object



View Terminals as Icons

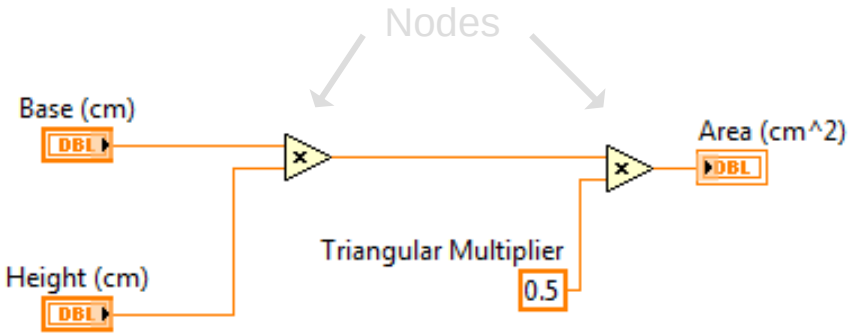
- By default, View as Icon option enabled.
- Deselect View as Icon for a more compact view.



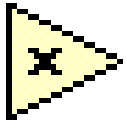


Nodes

Nodes are objects on the block diagram that have inputs and/or outputs and perform operations when a VI runs.

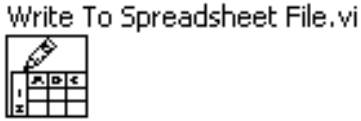


Function Nodes



- Functions are:
  - Fundamental operating elements of LabVIEW.
  - Do not have front panels or block diagrams, but do have connector panes.
  - Has a pale yellow background on its icon.
- Double-clicking a function only selects the function.
- Functions do not open like VIs and subVIs.

SubVI Nodes



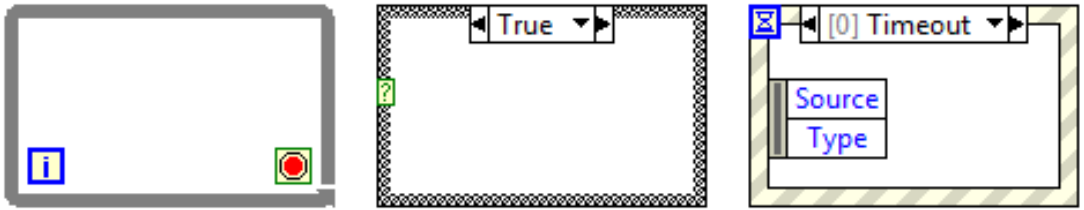
- SubVIs :
  - Are VIs that you use on the block diagram of another VI.
  - Have front panels and block diagrams.
  - Use the icon from the upper-right corner of the front panel as the icon that appears when you place the subVI on a block diagram.
- When you double-click a subVI, the front panel and block diagram open.
- Any VI has the potential to be used as a subVI.

Express VIs

- Express VIs:
  - Are a special type of subVI.
  - Require minimal wiring because you configure them with GUI dialog boxes.
  - Save each configuration as a subVI.
- Icons for Express VIs appear on the block diagram as icons surrounded by a blue field.

Structures

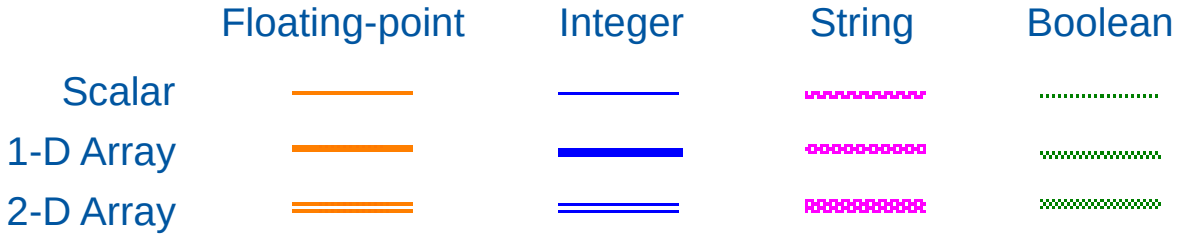
- Structures in LabVIEW have the form of frames.



- Other nodes (functions, subVIs, more structures) can be inserted into the frames.

Wires

- Wires transfer data between block diagram objects.
- Wires are different colors, styles, and thicknesses, depending on their data types.



- A broken wire appears as a dashed black line with a red X in the middle.

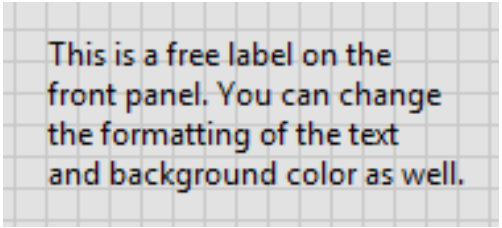
Constants

- Constants are the source of values just as control terminals, but their value is fixed in the code.

- You can create a constant of each data type.

Free labels

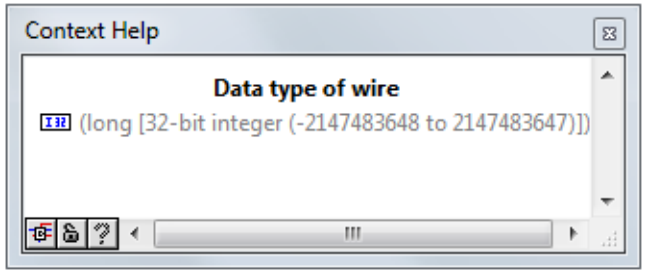
- A free label is a label (a text box) not attached to any object.
- Free labels can be put on the front panel or block diagram. They are created by double-clicking on empty space in the window.
- They can serve as comments or instructions to the user of the application.

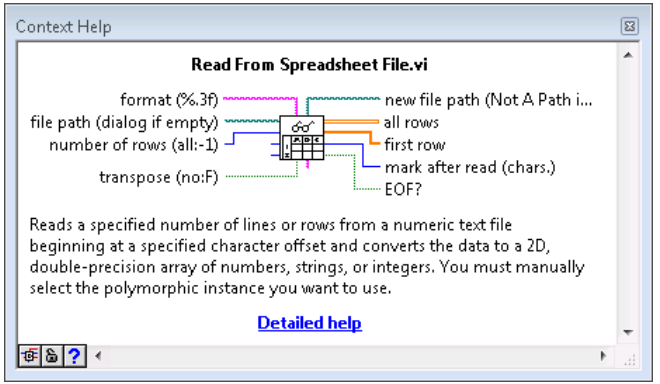


This is the default formatting
of a block diagram free label.

Context Help

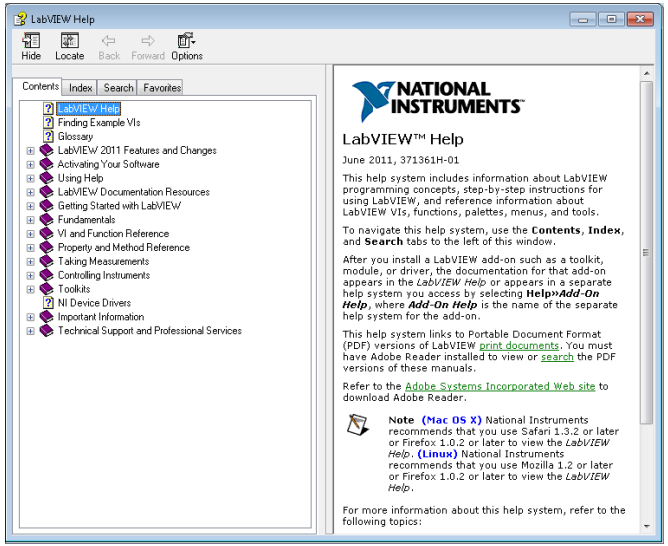
- Displays basic information about wires and nodes when you move the cursor over an object.
- Can be shown or hidden in the following ways:
  - Select **Help»Show Context Help** from the LabVIEW menu.
  - Press <Ctrl-H>.
  - Click the following button on the toolbar:





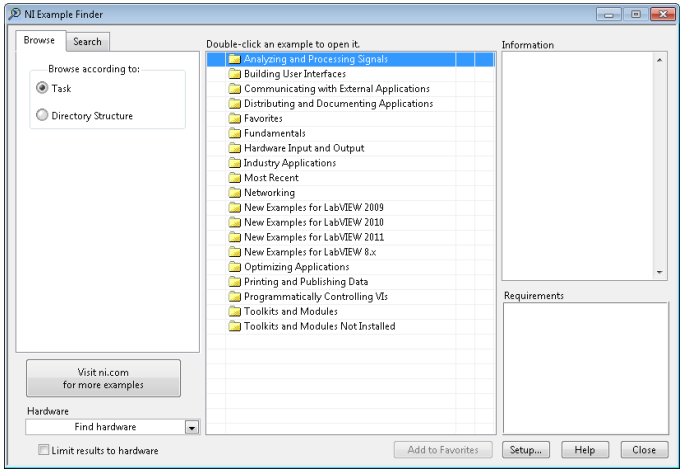
LabVIEW Help

- Contains detailed descriptions and instructions for most palettes, menus, tools, VIs, and functions.
- Can be accessed by:
  - Selecting Help» LabVIEW Help from the menu.
  - Clicking the Detailed help link in the Context Help window.
  - Right-clicking an object and selecting Help from the shortcut menu.



Examples

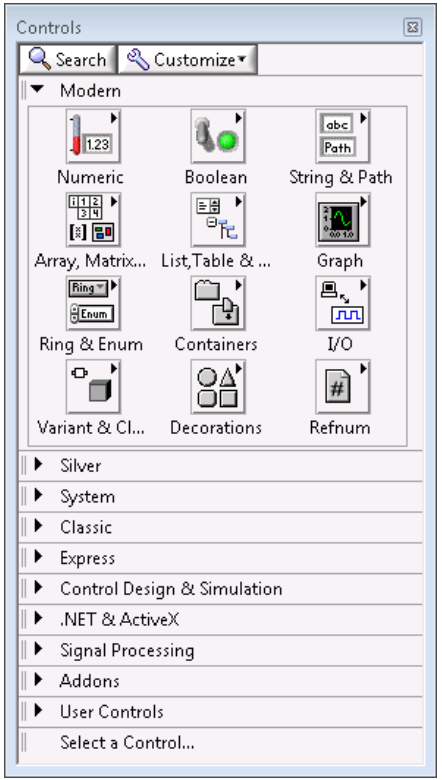
- LabVIEW includes hundreds of example VIs.
- Use NI Example Finder to browse and search installed examples.
  - Select **Help»Find Examples** in the menu.



- Click the example buttons in *LabVIEW Help* topics.

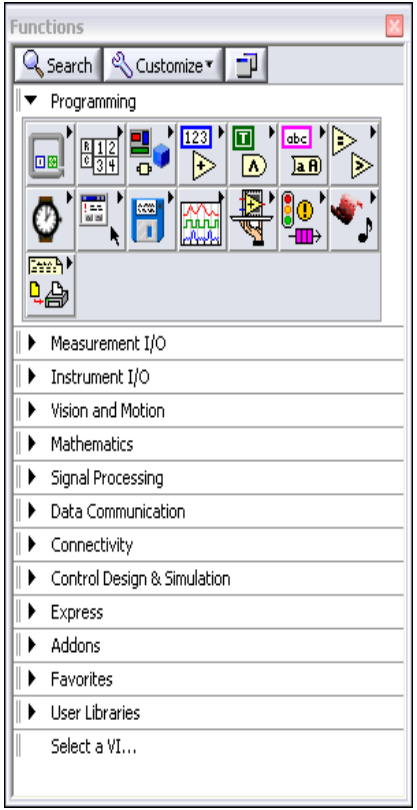
Controls Palette

- Contains the controls and indicators you use to create the front panel.
- Navigate the subpalettes or use the **Search** button to search the Controls palette.



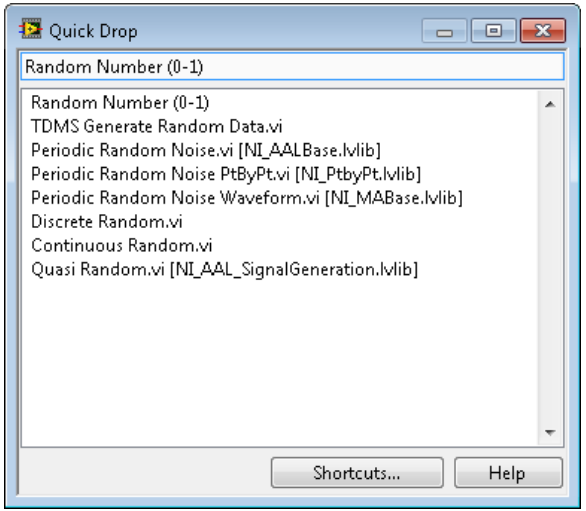
Functions Palette

- Contains the VIs, functions, and constants you use to create the block diagram.
- Navigate the subpalettes or use the **Search** button to search the Functions palette.



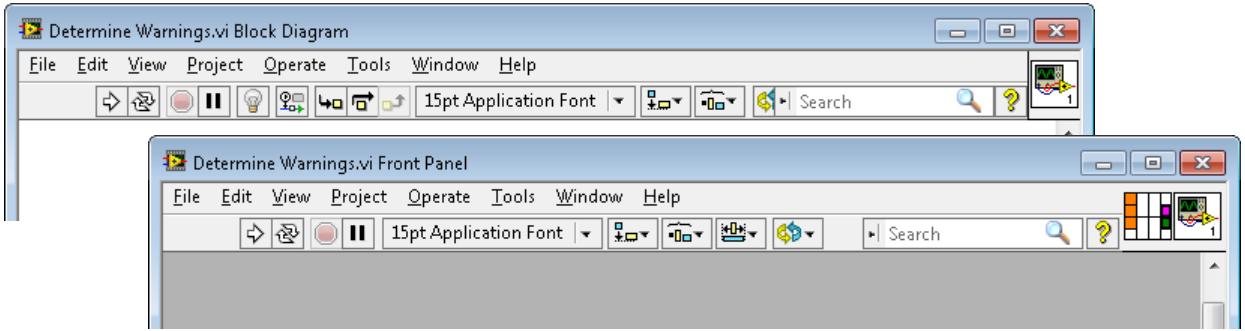
Searching with Quick Drop

- Lets you quickly find controls, functions, VIs, and other items by name.
- Press the <Ctrl-Space> keys to display the Quick Drop dialog box.



Global Search

Use the Search bar in the top right of the front panel and block diagram windows to search palettes, *LabVIEW Help*, and `ni.com`.



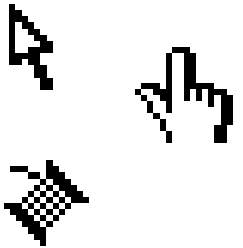
G. Selecting a Tool

Selecting a Tool

Block Diagram Clean-Up

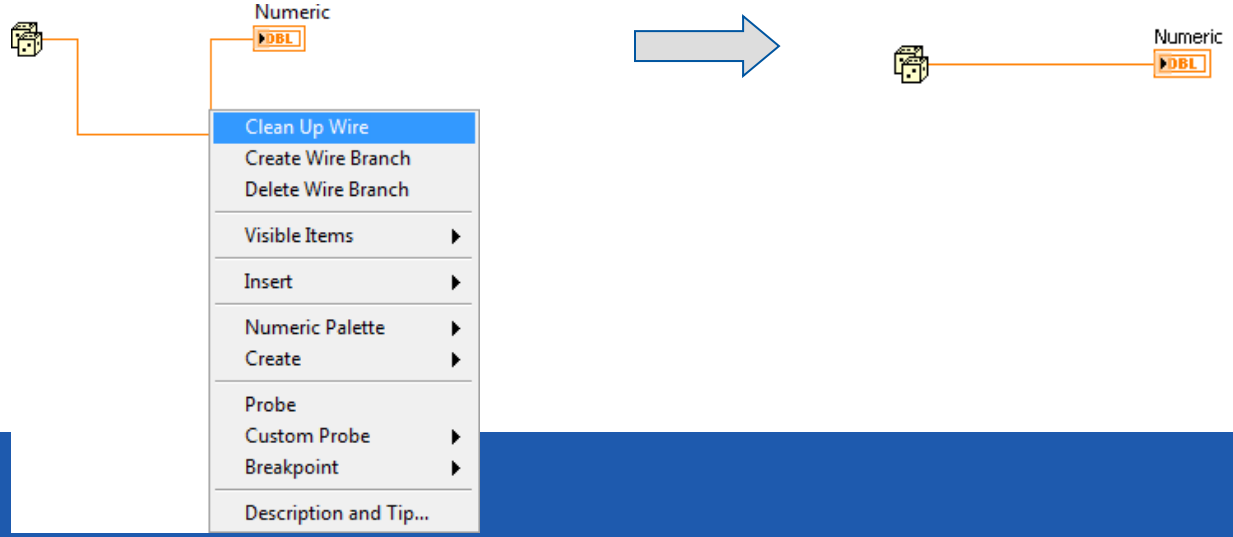
Selecting a Tool

- A tool is a special operating mode of the mouse cursor.
- Create, modify, and debug VIs using the tools provided by LabVIEW.
- By default, LabVIEW automatically selects tools based on the context of the cursor.
- If you need more control, use the **Tools** palette to select a specific tool.
  - Select **View»Tools Palette** to open the **Tools** palette.



Wiring Tips

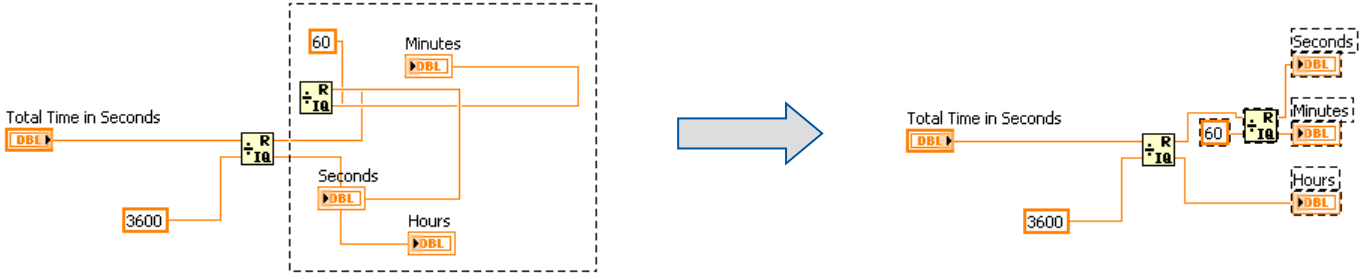
- Press <Ctrl-B> to delete broken wires.
- Right-click and select **Clean Up Wire** to reroute the wire.



Wiring Tips – Clean Up Diagram

Use the Clean Up Diagram tool to reroute multiple wires and objects and to improve readability.

1. Select a section of your block diagram.
2. Click the Clean Up Diagram button on the block diagram toolbar (or press <Ctrl-U>).



Cloning Items

- Clone an object in Windows using the following steps:

1. Select the Positioning tool.
2. Press the <Ctrl> key while clicking an object.
3. Drag the copy to new location.

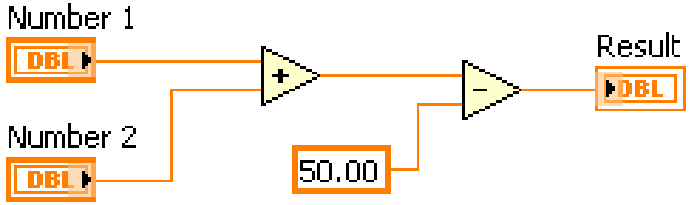
Note: Avoid cutting and pasting objects as this can impact related items. For example, cutting and pasting a block diagram terminal also moves the front panel object.

Setting options for the environment

- In **Tools»Options…** dialog box you can customize settings for the LabVIEW environment.
- Suggested changes:
  - Front Panel page
    - Set Control Style for New VIs to **Silver style**
  - Block Diagram page
    - Uncheck **Place front panel terminals as icons**
    - Configure **Block Diagram Cleanup** to customize your block diagram

H. Dataflow

Dataflow



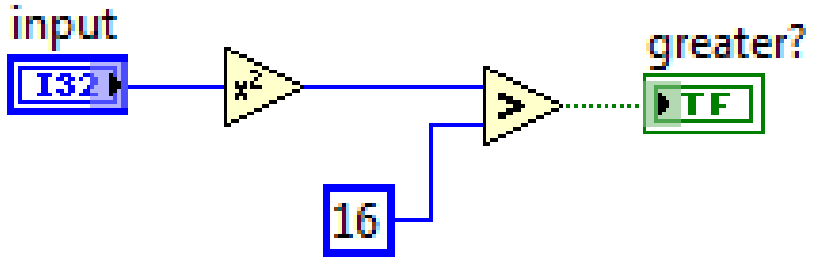
LabVIEW follows a dataflow model for running VIs.

- A node executes only when data are available at all of its required input terminals.
- A node supplies data to the output terminals only when the node finishes execution.

Dataflow – Quiz

What are the nodes in this fragment of code?

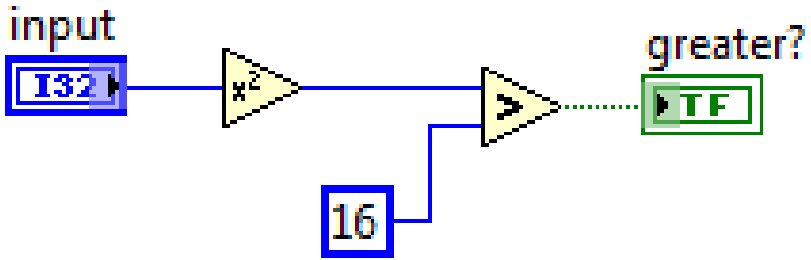
Which node executes first?



Dataflow – Quiz Answer

There are two nodes: „square” and „greater than?” functions.

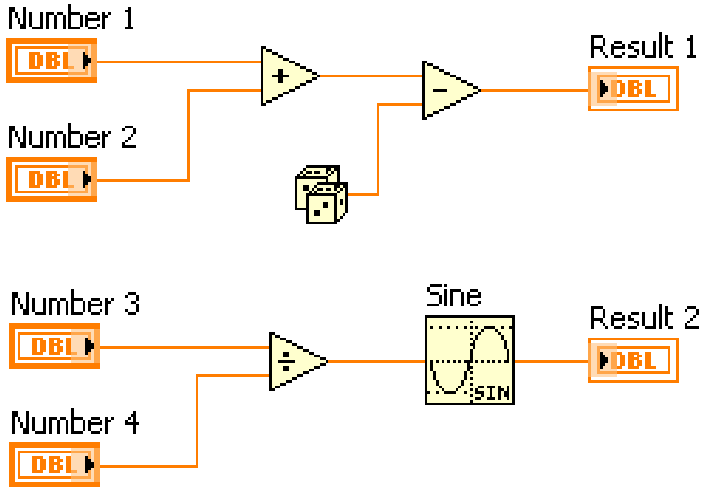
Square executes first.



Dataflow – Quiz

Which node executes first?

a) Add
b) Subtract
c) Random Number
d) Divide
e) Sine



Dataflow – Quiz Answer

No single correct answer.

Which node executes first?

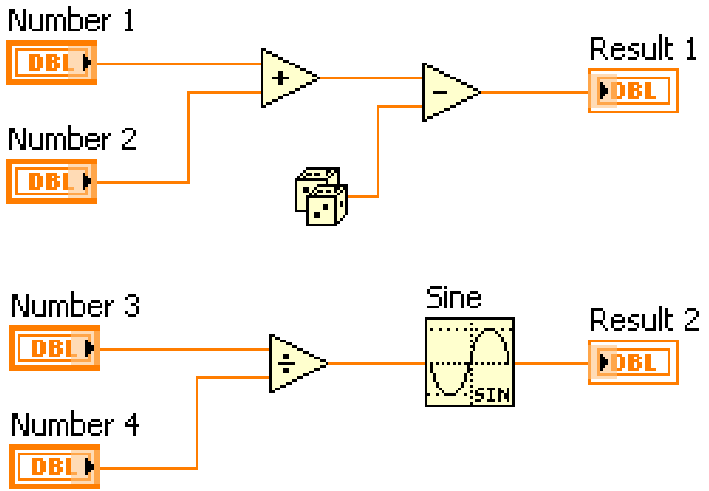
a) Add – **Possibly**

b) Subtract – **Definitely not**

c) Random Number – **Possibly**

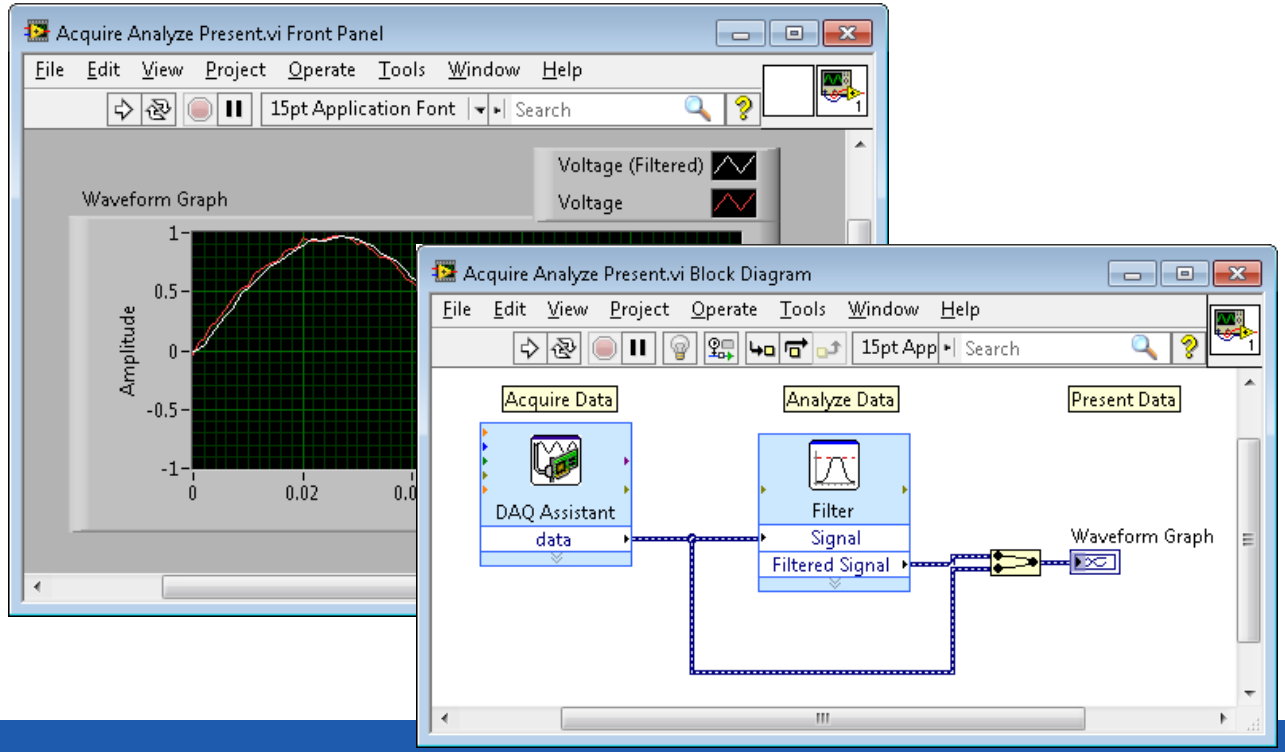
d) Divide – **Possibly**

e) Sine – **Definitely not**



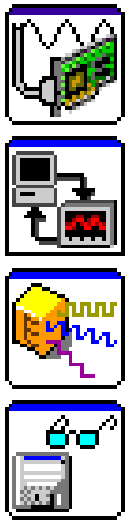
I. Building a Simple VI

Building a Simple VI



Acquire Express VIs

- DAQ Assistant Express VI
- Instrument I/O Assistant Express VI
- Simulate Signal Express VI
- Read from Measurement File Express VI

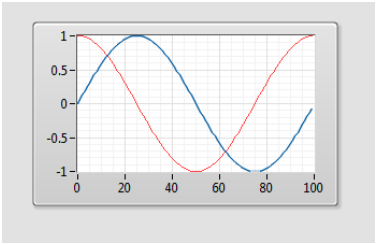


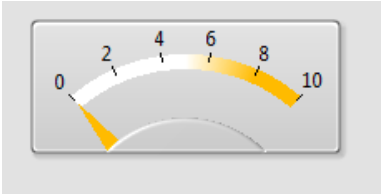
Analyze Express VIs

- Amplitude and Level Measurements Express VI
- Statistics Express VI
- Spectral Measurements Express VI
- Tone Measurements Express VI
- Filter Express VI

Present Express VIs and Indicators

- Display Message Express VI
- Play Waveform Express VI
- Report Express VI
- Write to Measurement File Express VI
- DIAdem Report Express VI





Building and Running a VI

1. Place Express VI on the block diagram.
2. Configure the dialog box that opens.
3. Wire Express VIs together.
4. Save and run the VI.

The **Run** button appears broken when the VI you are creating or editing contains errors.