Adriaan Rijllart

Odd Andreassen

LabVIEW FPGA @ CERN 2021

- Unofficial
- For fun
- Share knowledge

LabVIEW FPGA @ CERN 2021

About the workshop

- 2 sessions
  - 14.06 at 16:00 2 hours
  - 17.06 at 16:00 2 hours

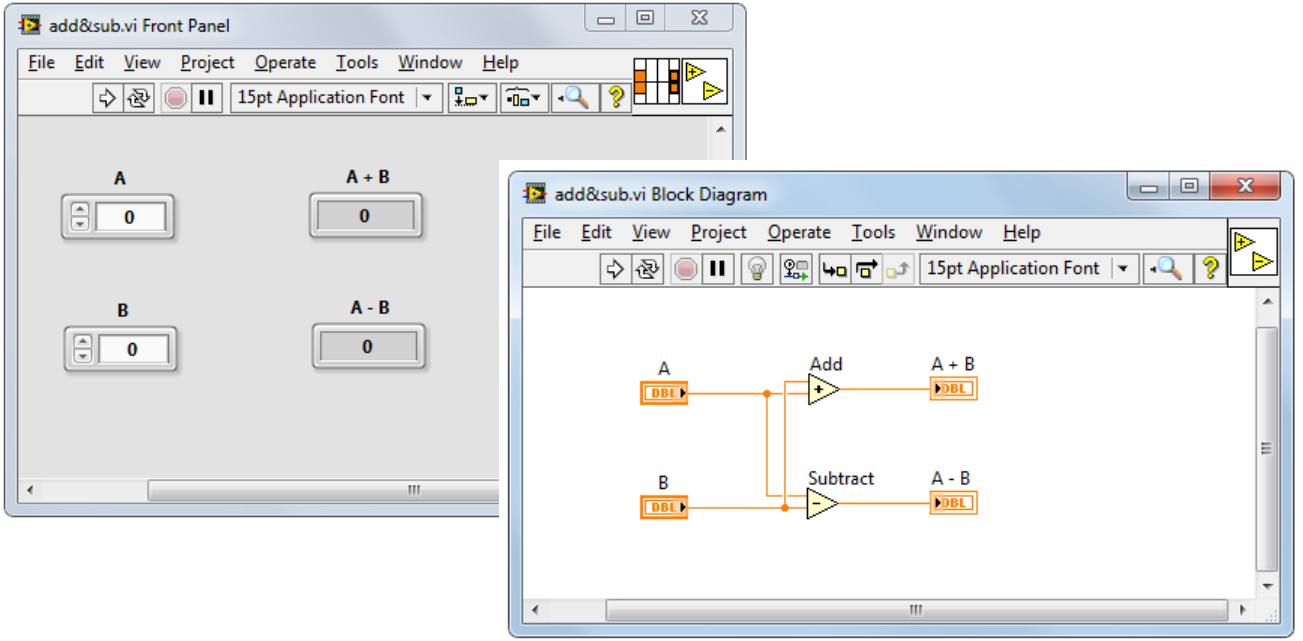
  Repeat
  - 11.10 at 16:00 2 hours
  - 14.10 at 16:00 2 hours

About the workshops

- Minimize theory
- Maximize practice
- Some fun examples

LabVIEW

- Intuitive
- Data driven
- Hardware integration



National Instruments

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

Eric Starkloff CEO

- 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

FORTUNE® 100 BEST COMPANIES TO WORK FOR

Diversity of applications

SEMICONDUCTOR

AUTOMOTIVE

AEROSPACE, DEFENSE, & GOVERNMENT

ELECTRONICS

ENERGY

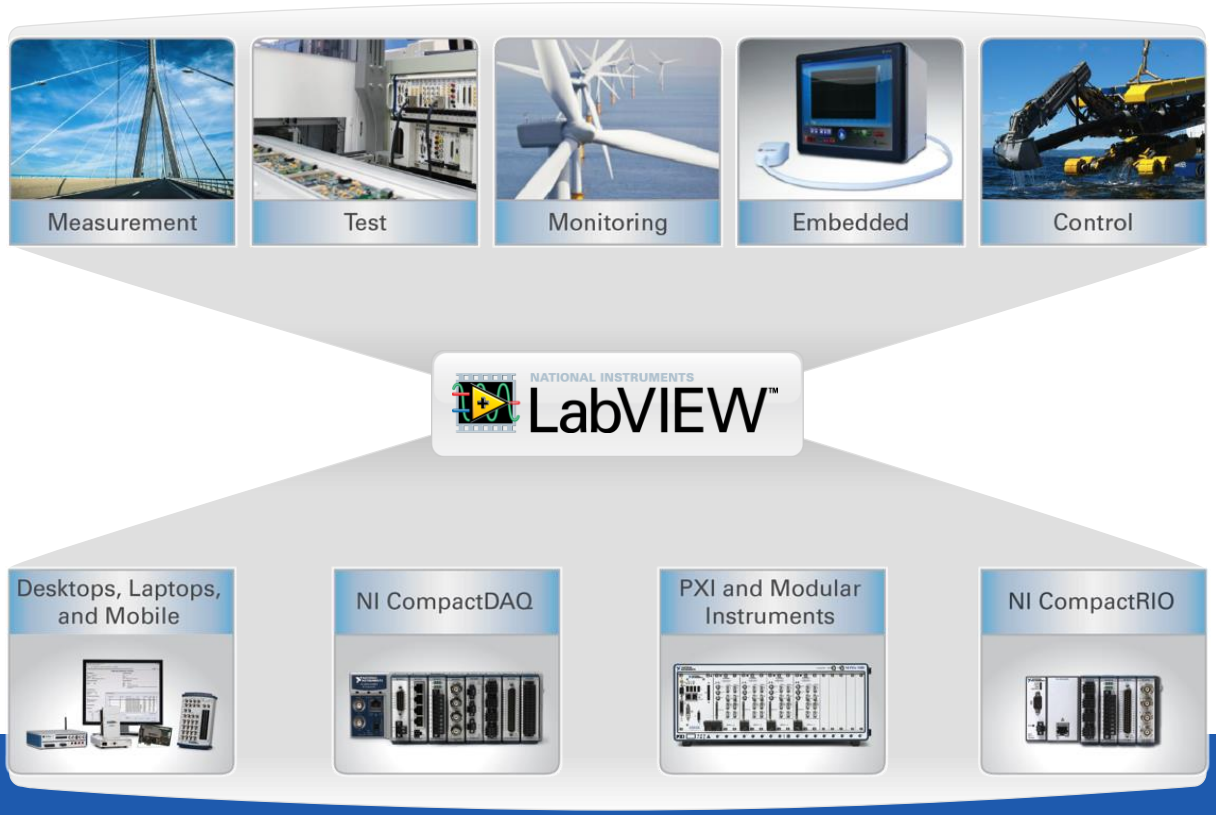
ACADEMIC & RESEARCH

Diversity of applications

SpaceX

Falcon rocket launch pad software

LabVIEW on different hardware

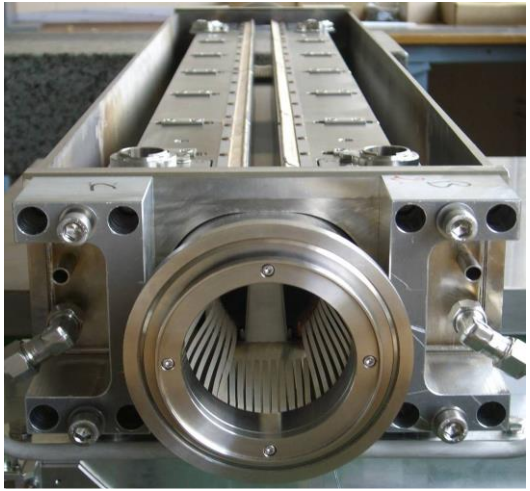


Applications

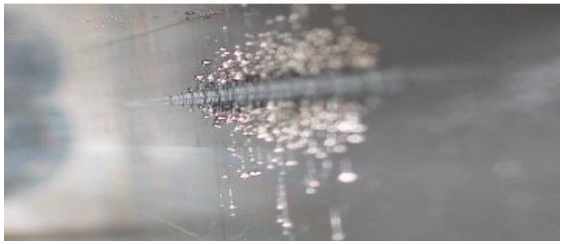
Hardware

Projects based on NI @ CERN

- LHC collimators real-time control system

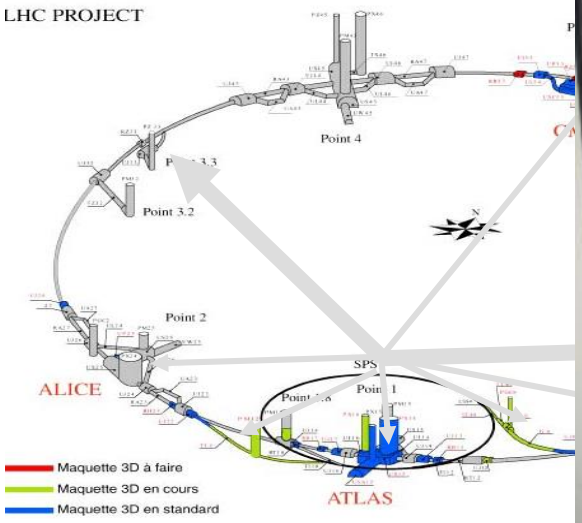


Control system requirements	
Axes positioning accuracy	few µm
Axes motion synchronization	below 1 ms
Response delay to a digital start trigger	100 µs
Position sensors RT survey frequency	100 Hz
Reliability	Very high



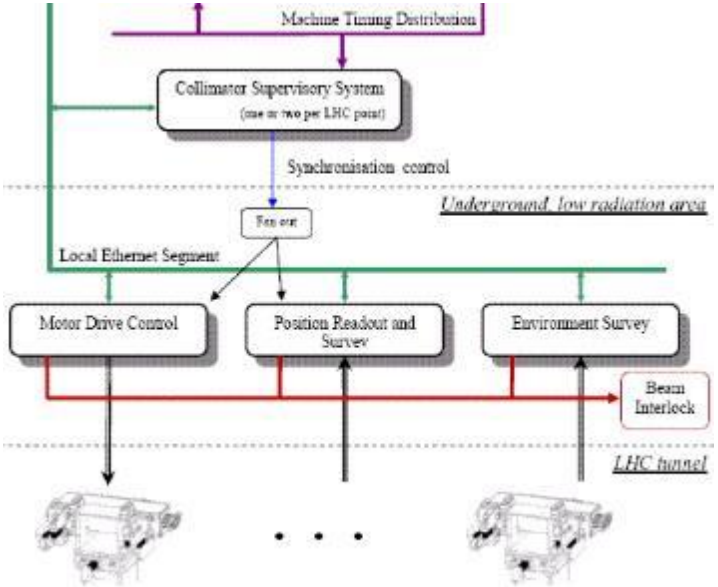
• LHC collimators real-time control system

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

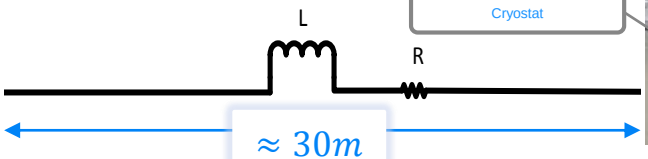
PXI system components:
- 7 x DMM 4081
- DAQ M-series 6251
- GPIB
- Ethernet

HV power supply – 3kV max

Discharge circuit

Capacitor bank 13,3 mF, 1500V

Measurement rack



LHC by-pass diodes

Mu-metal shield (against magnetic field)

Feedthrough 18kA

Cryostat

Measurement setup assembly and closed cryostat

CERN LabVIEW support

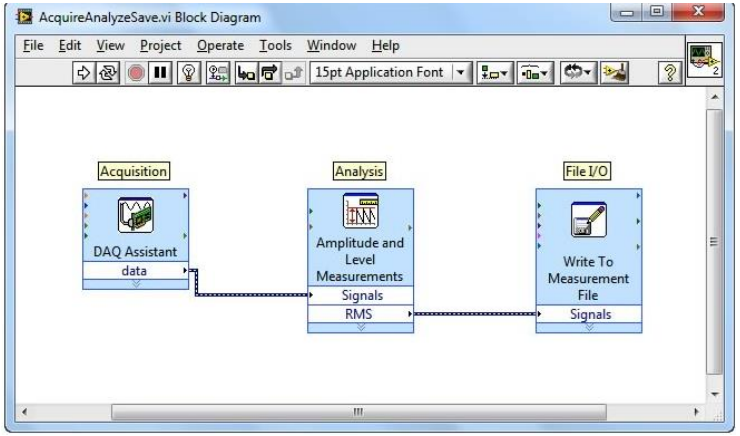
- Website: cern.ch/labview
- E-mail: labview.support@cern.ch

Getting the most out of this course

- Ask questions!
- Use the ”raise hand” function in Zoom for direct questions
- Use the chat for indirect questions
- Experiment with hands-on exercises to understand the methods used
- Explore – there are always several solutions possible

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)
- Intuitive
- Easy to debug
- Automatic parallelism
- Combines with other languages
- Hardware integration



B. Project Explorer

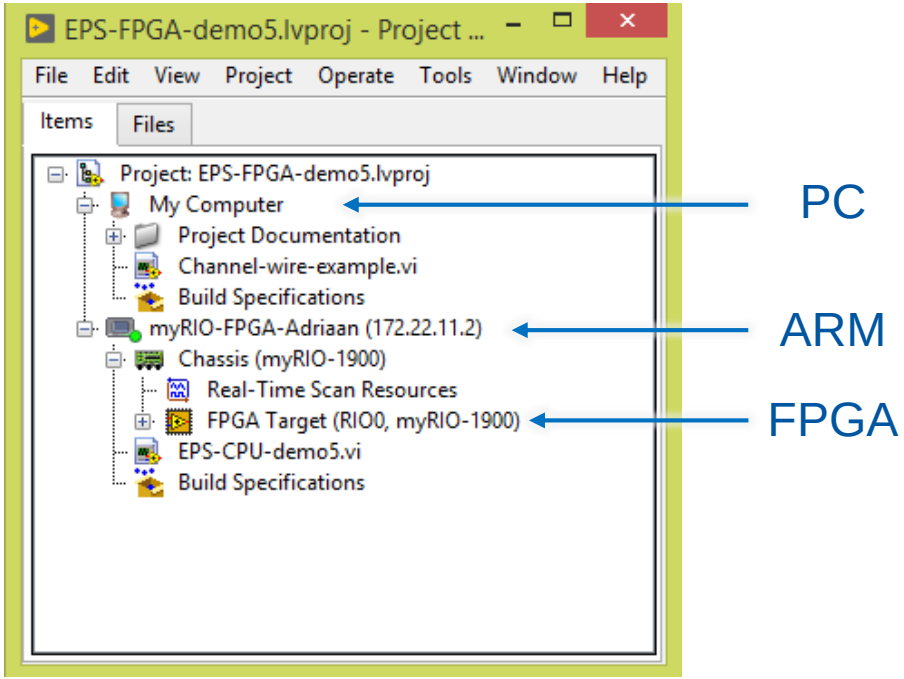
Project Explorer Window

Files Types

Project Folders

Project Explorer

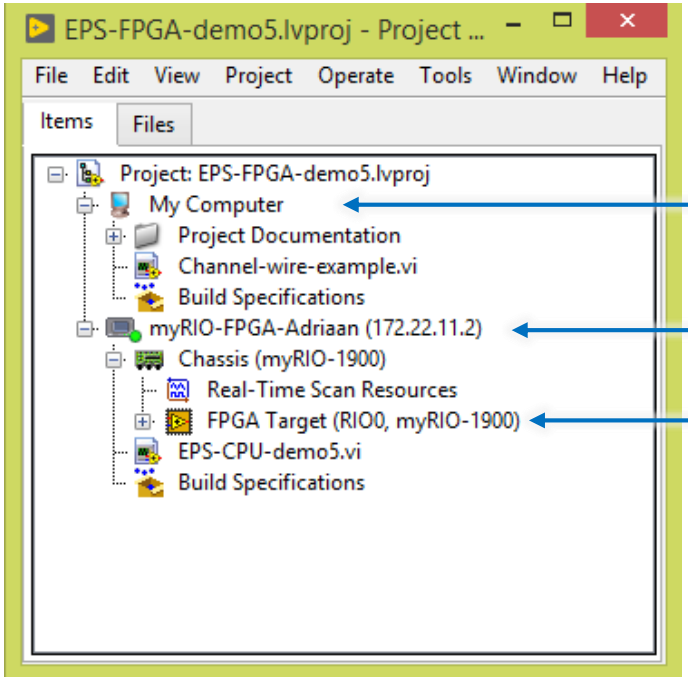
- See the hierarchy
- Organise project files
- Deploy files to targets
- Manage code for build options
  - Executables, installers, and zip files
- Integrate with source code control providers



Project Explorer

PC

Xilinx Zynq 7010



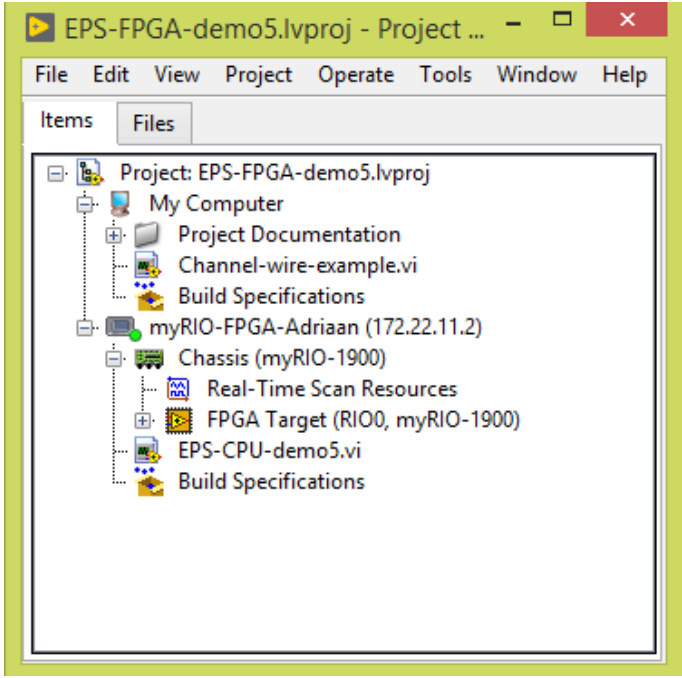
LabVIEW Files

- Common LabVIEW file extensions:

LabVIEW project —.lvproj

Virtual instrument (VI) — .vi

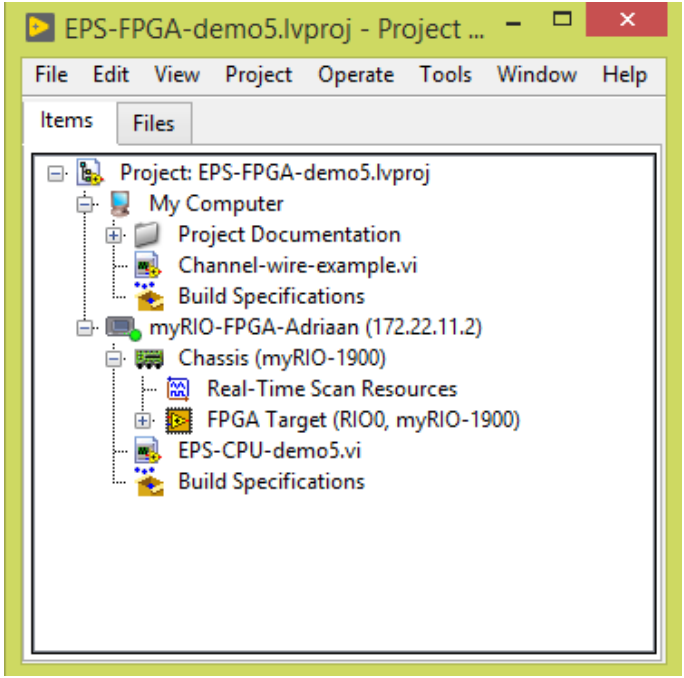
Custom control — .ctl



Adding Folders to a Project

- Virtual folder
  - Organizes project items and does not represent files on disk

- Auto-populating folder
  - Adds a directory on disk to the project
  - LabVIEW continuously monitors and updates the folder according to changes made in the project and on disk



Show-off(1)
Project Explorer

C. Parts of a VI

Front Panel

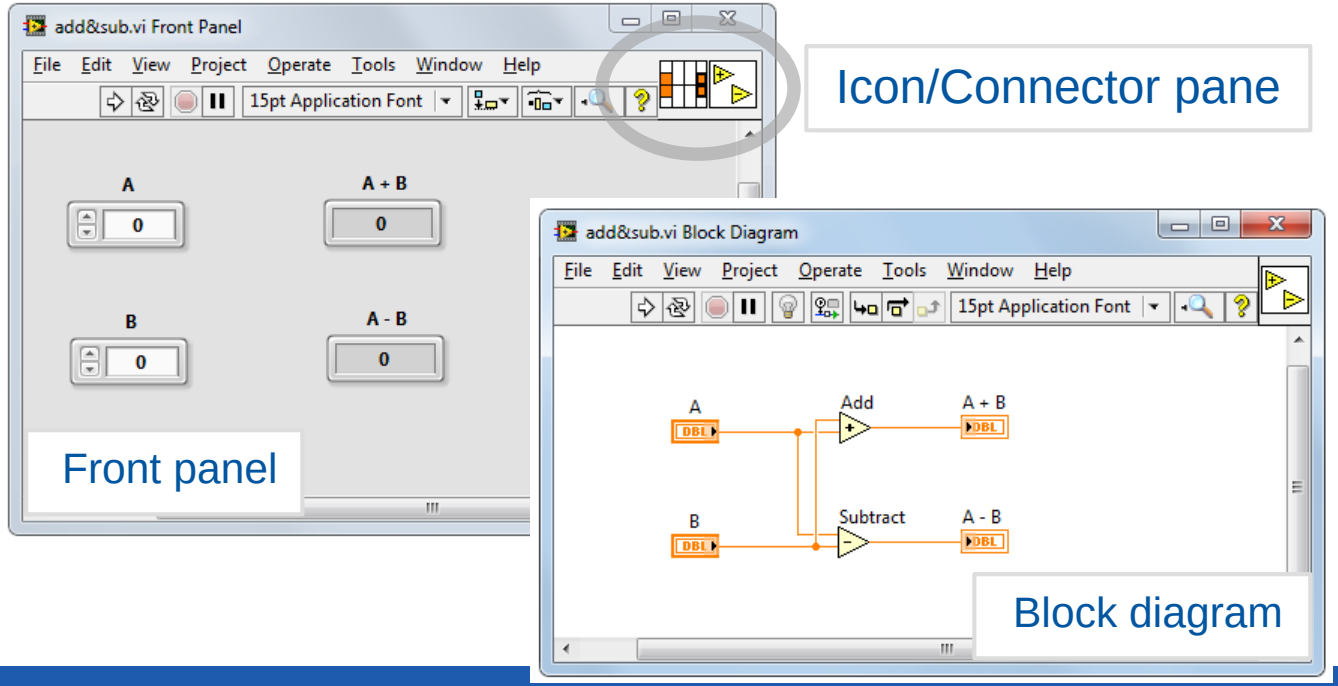
Block Diagram

Icon

Connector Pane

Parts of a VI

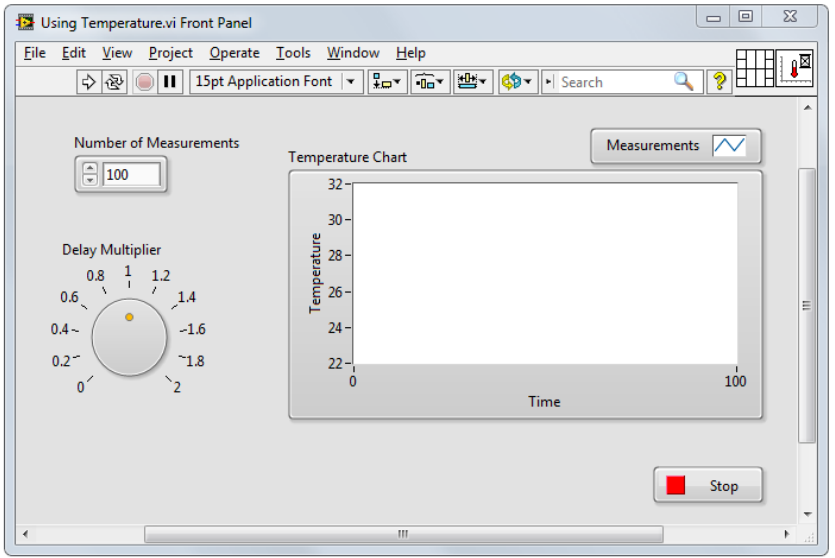
VIs have 3 main components:



Parts of a VI – Front Panel

Front Panel – User interface for the VI

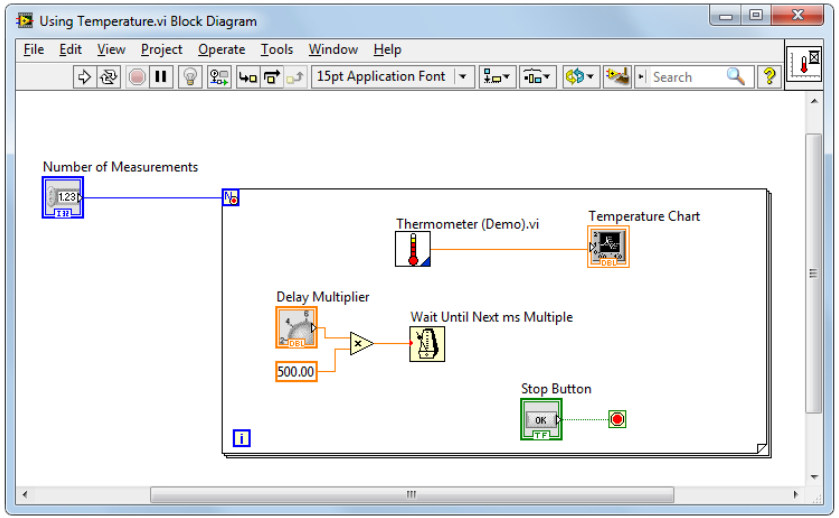
You build the front panel with controls (inputs) and indicators (outputs).



Parts of a VI – Block Diagram

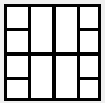
Block Diagram – Contains the graphical source code

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

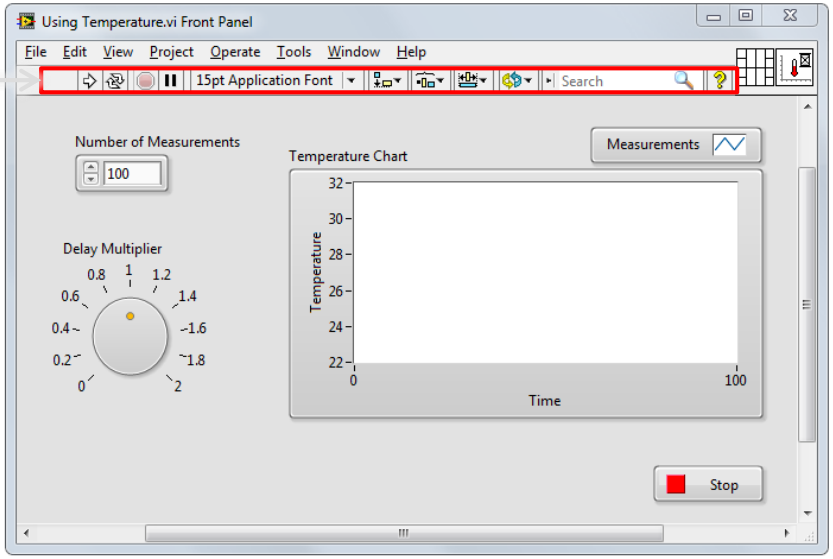
Object Styles

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

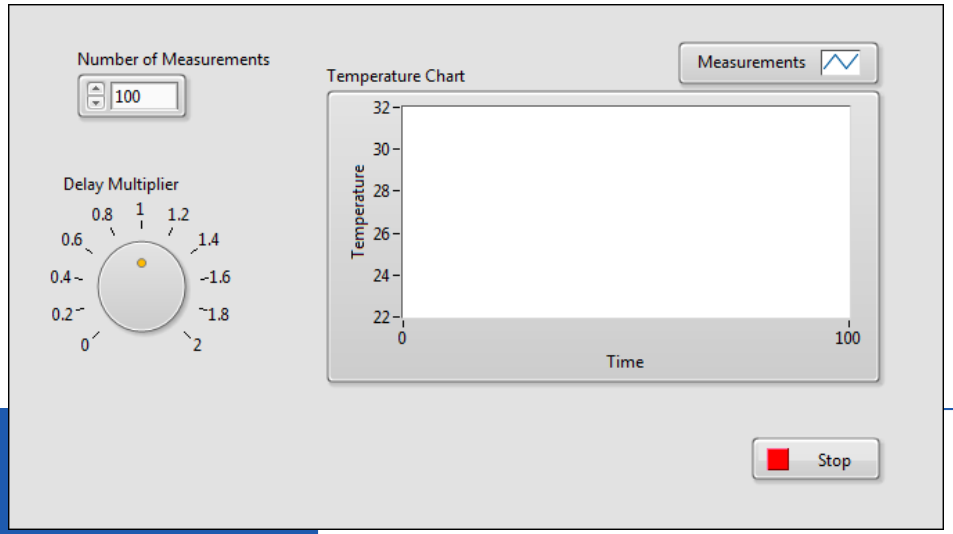
Controls and Indicators

Controls

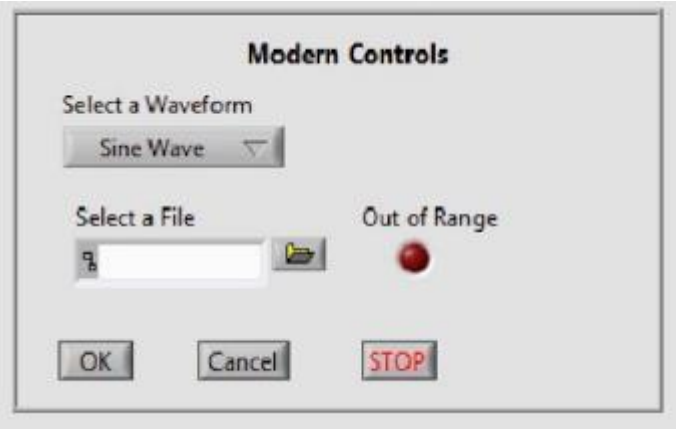
- Input devices
- Knobs, buttons, slides
- Supply data to the block diagram

Indicators

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

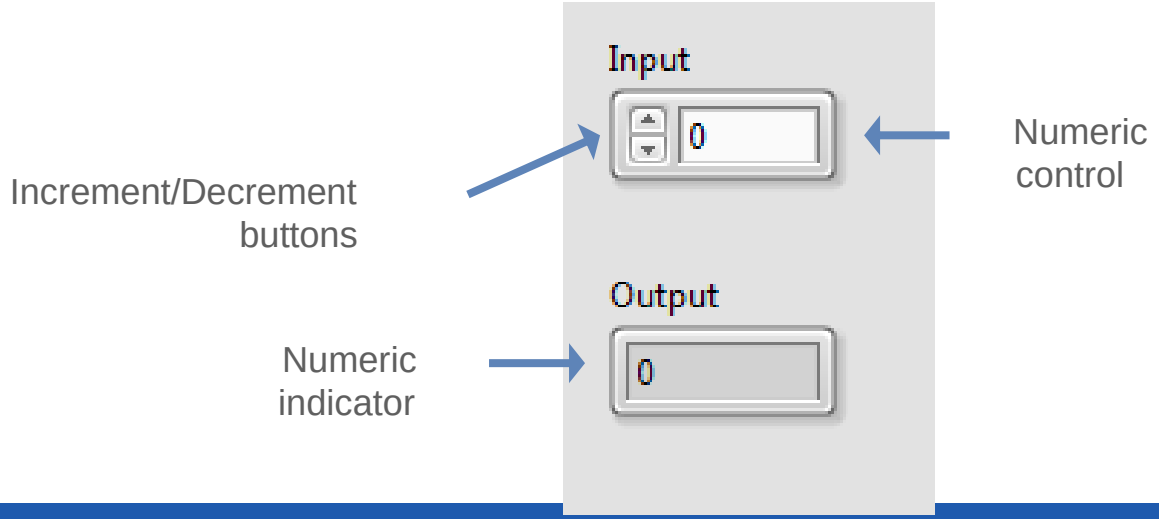


Front Panel Object Styles



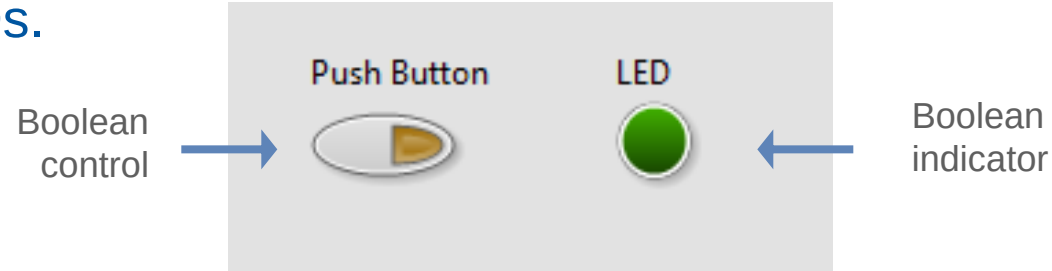
Numeric Controls and Indicators

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



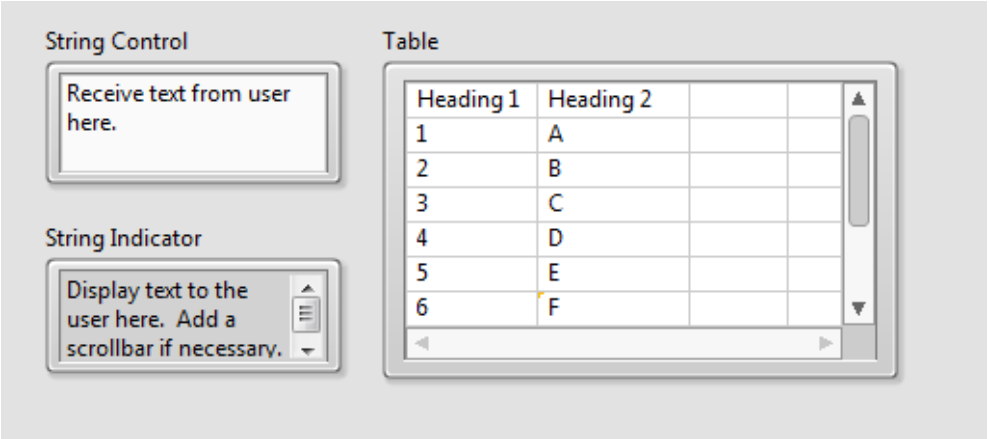
Boolean Controls and Indicators

- 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

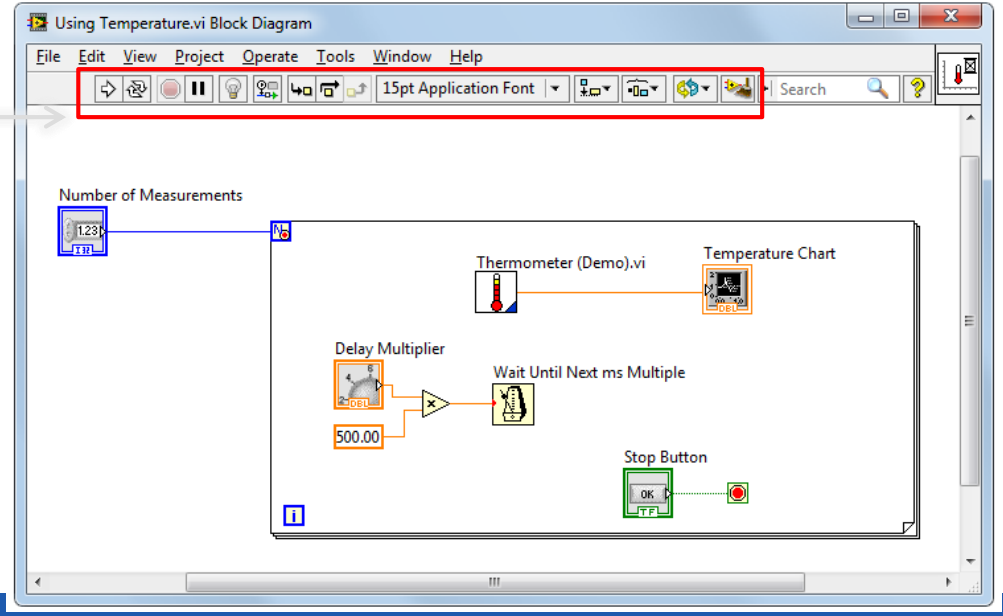
Terminals

Nodes

Wires

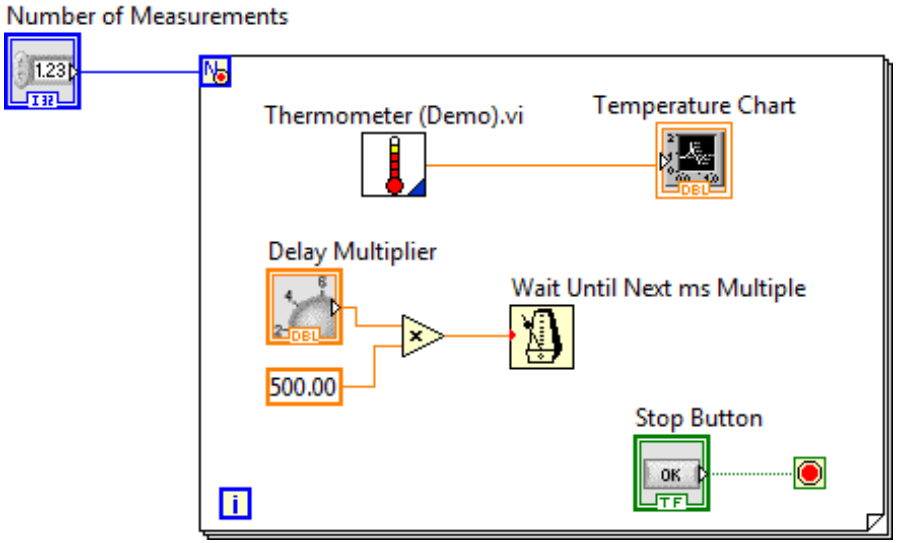
Help

Block Diagram

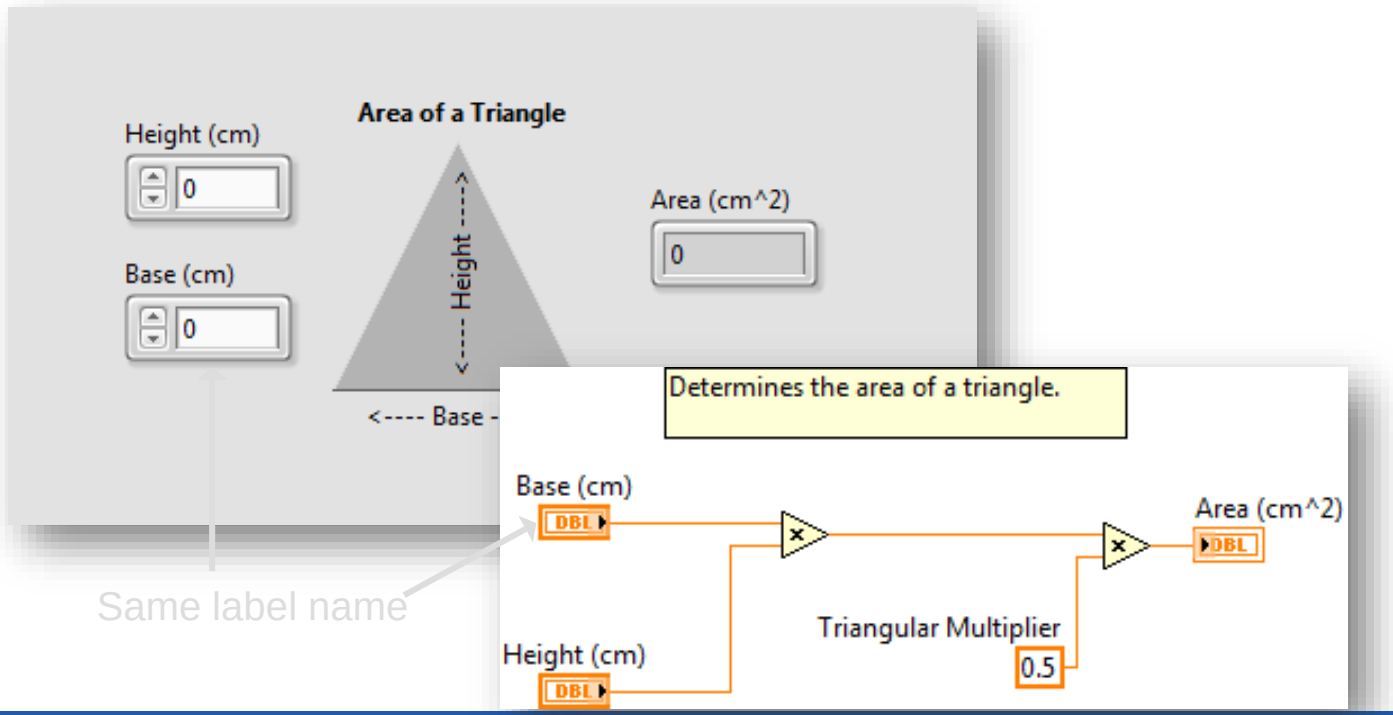


Block Diagram

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

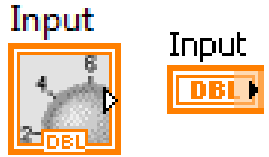


Terminals


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

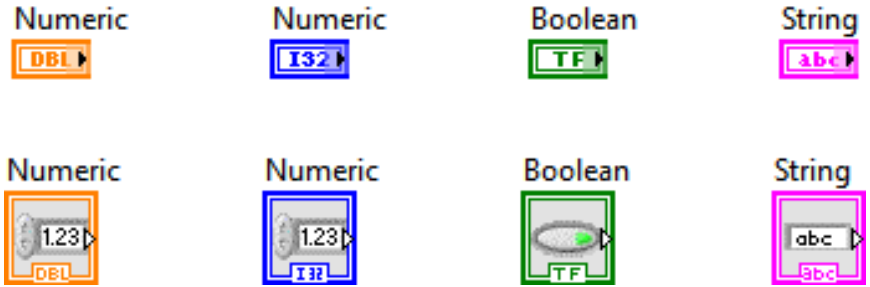
Terminals for Front Panel Objects

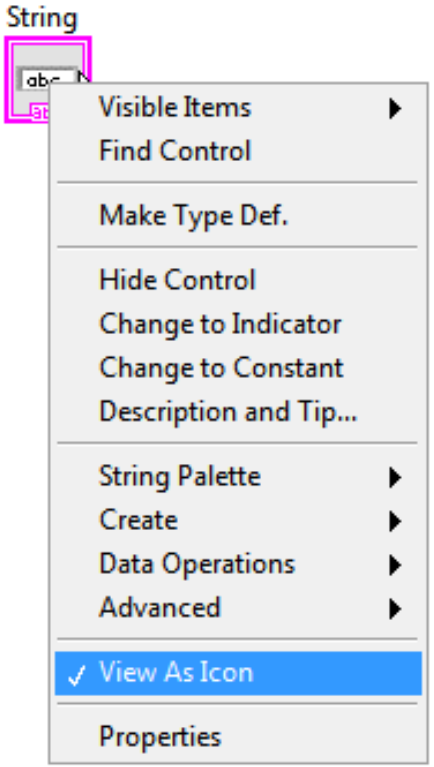
- Terminals are:
  - Entry and exit ports that exchange information between the front panel and block diagram.
  - Analogous to parameters in text-based programming languages.
- Double-click a terminal to locate the corresponding front panel object.



View Terminals as Icons

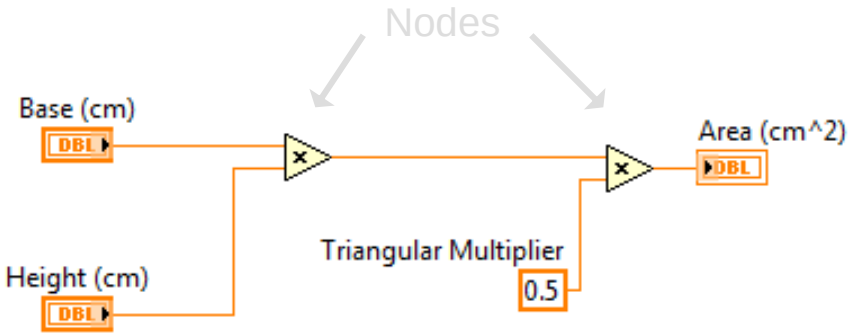
- By default, View as Icon option enabled.
- Deselect View as Icon for a more compact view.



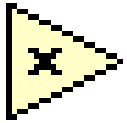


Nodes

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

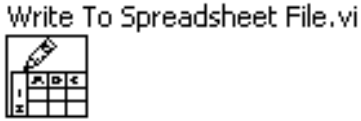


Function Nodes



- 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



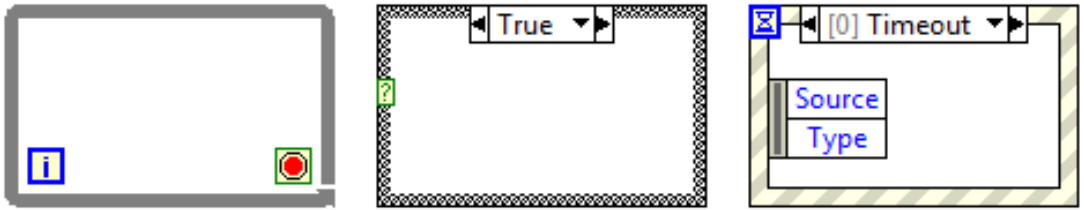
- SubVIs :
  - Are VIs that you use on the block diagram of another VI.
  - Have front panels and block diagrams.
  - Use the icon from the upper-right corner of the front panel as the icon that appears when you place the subVI on a block diagram.
- When you double-click a subVI, the front panel and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

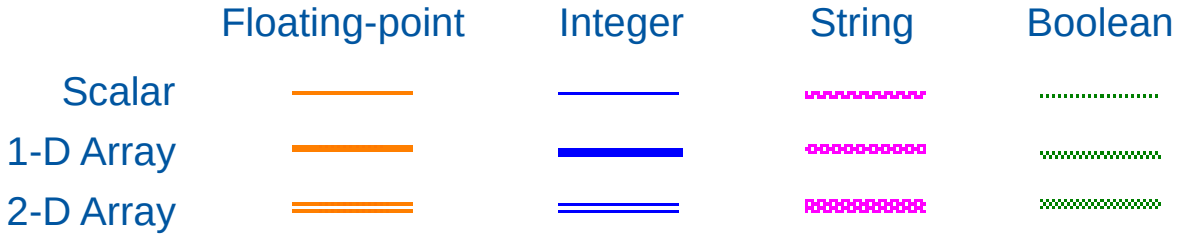
- Structures in LabVIEW have the form of frames.



- 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.

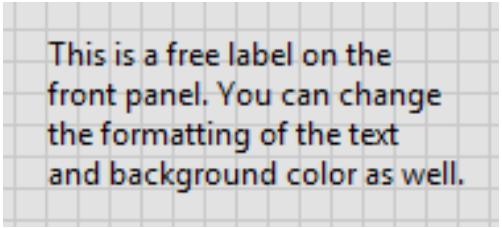
Constants

- 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

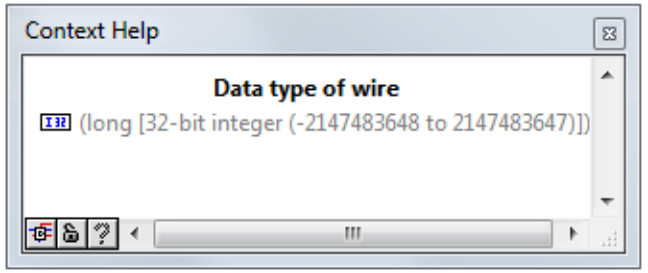
- A free label is a label (a text box) not attached to any object.
- Free labels can be put on the front panel or block diagram. They are created by double-clicking on empty space in the window.
- They can serve as comments or instructions to the user of the application.

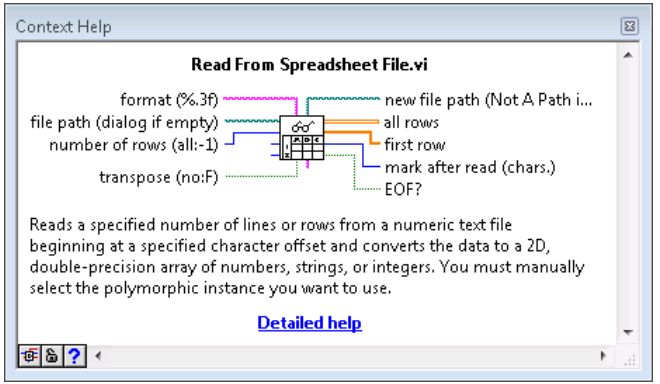


This is the default formatting
of a block diagram free label.

Context Help

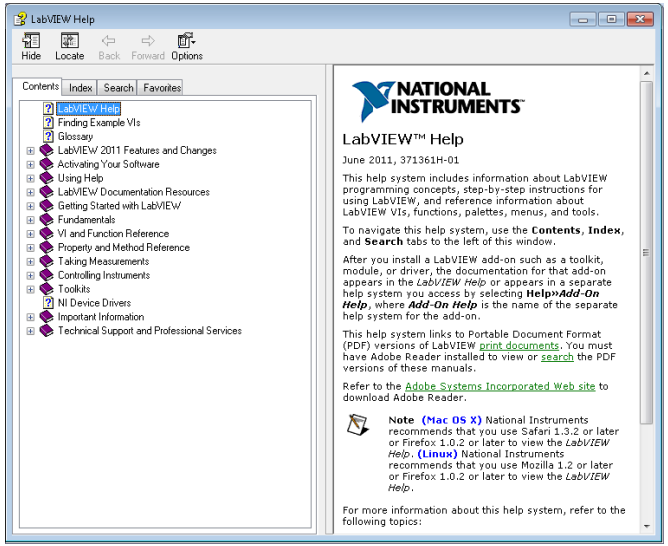
- Displays basic information about wires and nodes when you move the cursor over an object.
- Can be shown or hidden in the following ways:
  - Select **Help»Show Context Help** from the LabVIEW menu.
  - Press <Ctrl-H>.
  - Click the following button on the toolbar:





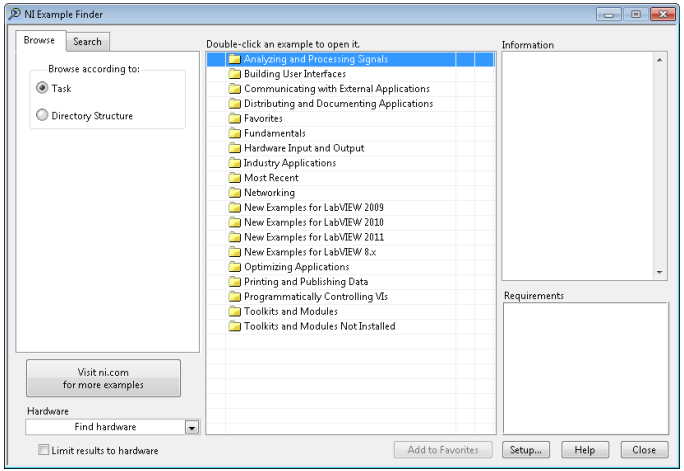
LabVIEW Help

- 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.

Group Exercise
Concept: Exploring a VI

Identify the parts of an existing VI.

F. Searching for Controls, VIs and Functions

Palettes

Quick Drop

NI Global Search

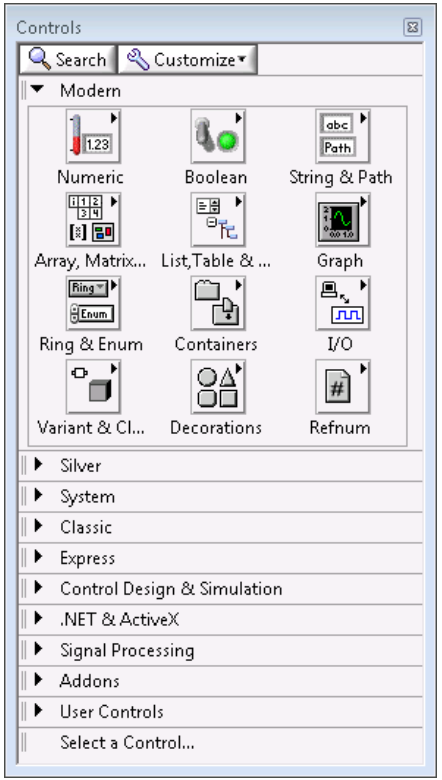
Searching for Controls, VIs and Functions

Ways to find controls, VIs, and functions:

- Search or navigate the palettes.
  - Controls palette
  - Functions palette
- Search by name of object.
  - Quick Drop dialog box
- Search palettes, *LabVIEW Help*, and `ni.com`.
  - Search text box in toolbar

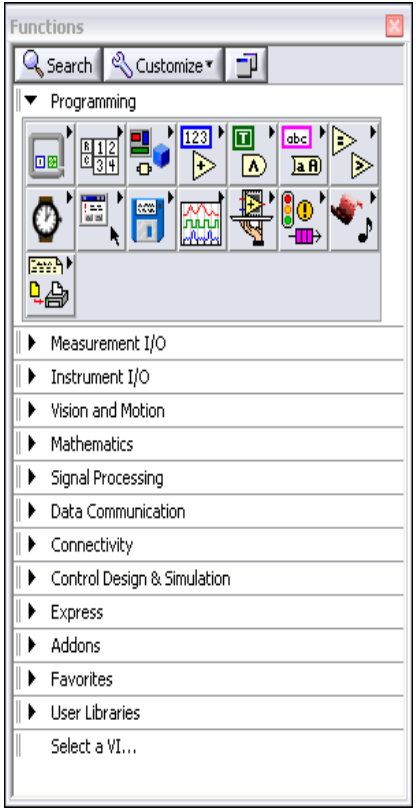
Controls Palette

- 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.



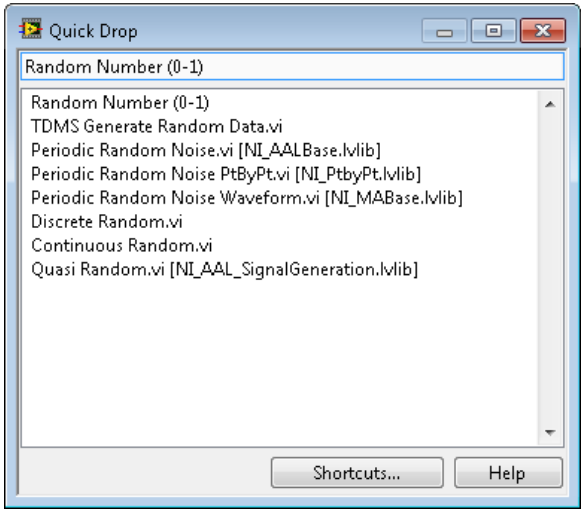
Functions Palette

- 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.



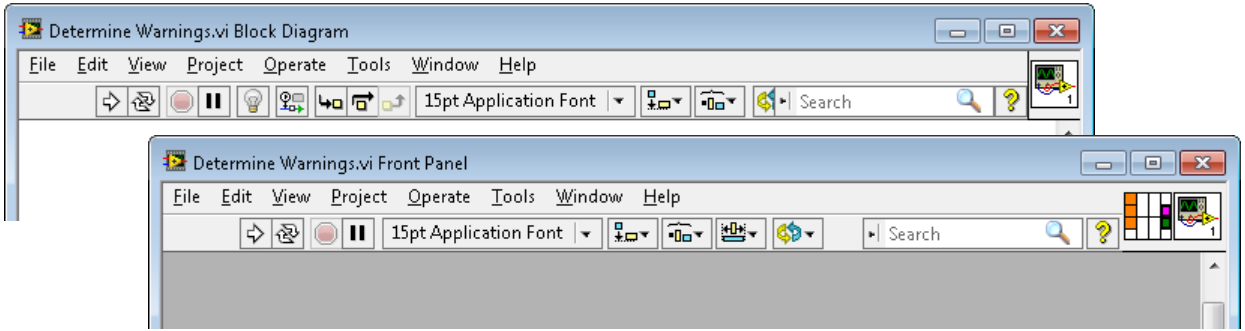
Searching with Quick Drop

- 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`.



Search for Controls, VIs and Functions

- Configure palettes to customize visible palettes.
- Search and navigate the palettes.
- Search for help using global search.
- Use Quick Drop to search by name.

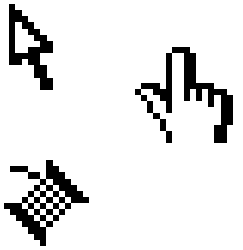
G. Selecting a Tool

Selecting a Tool

Block Diagram Clean-Up

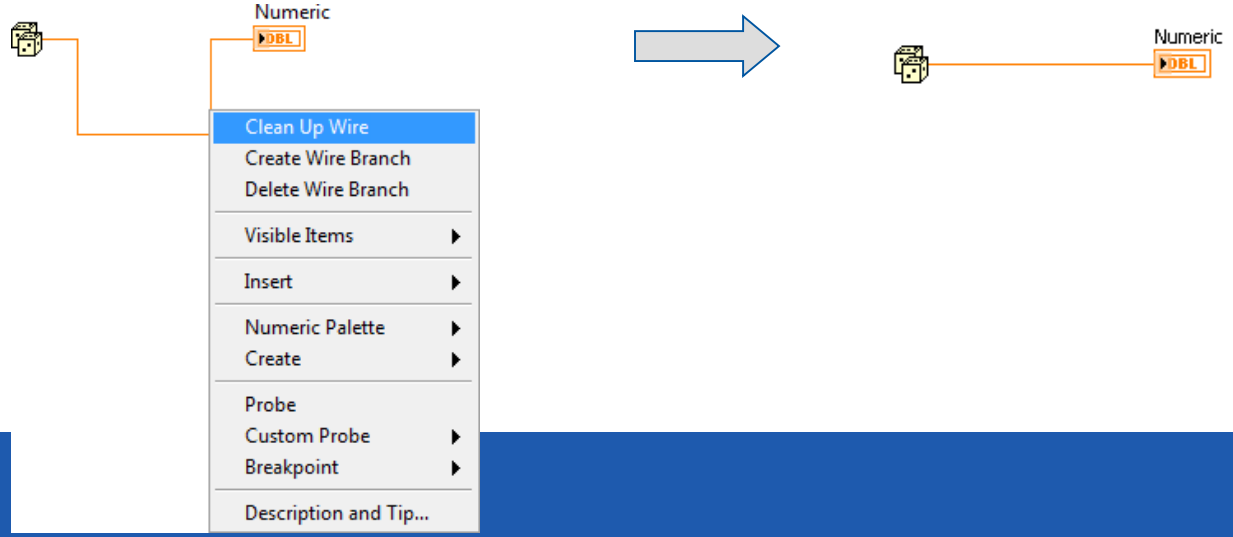
Selecting a Tool

- 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

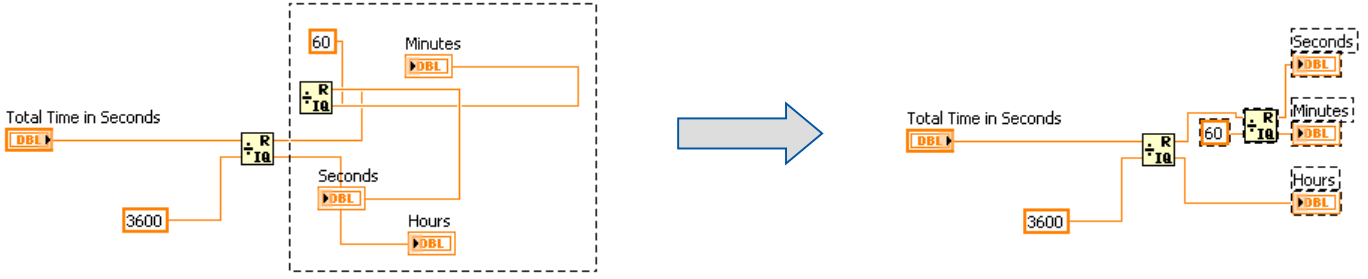
- Press <Ctrl-B> to delete broken wires.
- Right-click and select **Clean Up Wire** to reroute the wire.



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 and Moving Items

- Move an object using the following steps:

1. Select the Positioning tool.
2. Click and drag the object to new location.

- Clone an object 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.

Selecting, Editing, Resizing and Wiring

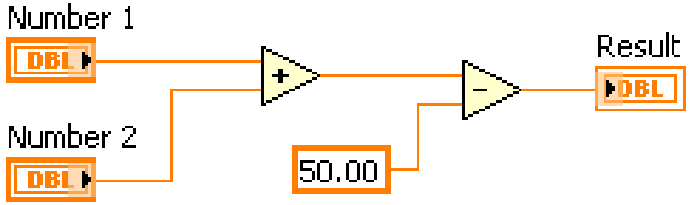
- Select item to move, copy, or delete
- Edit text
- Resize an object
- Wire terminals and nodes
- Automatic and manual tool selection

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



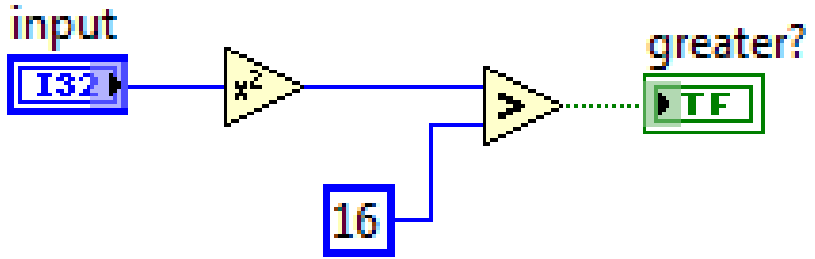
LabVIEW follows a dataflow model for running VIs.

- 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?

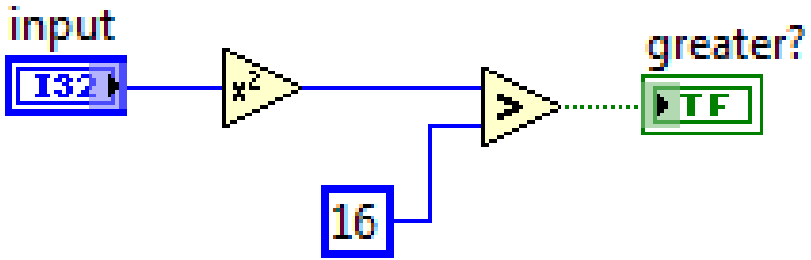
Which node executes first?



Dataflow – Quiz Answer

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

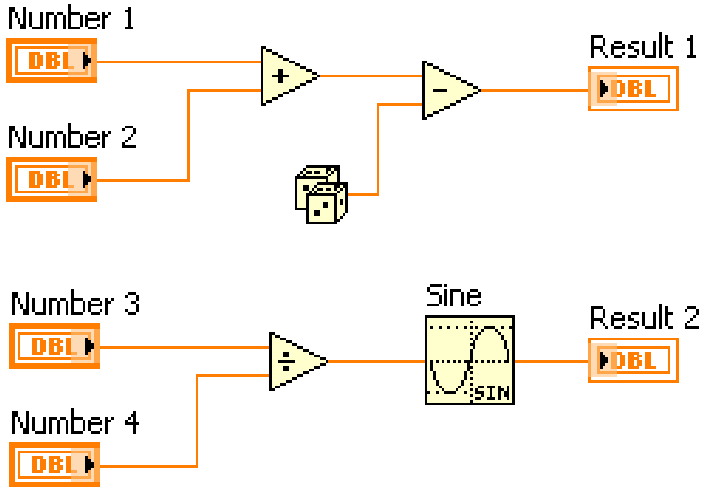
Square executes first.



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?

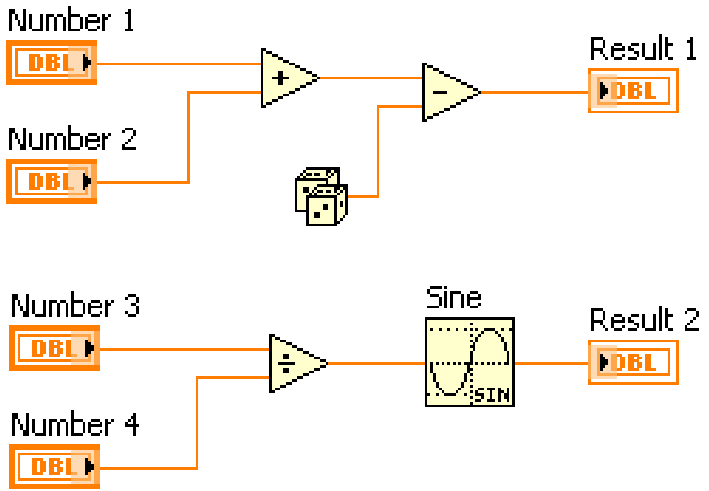
a) Add – **Possibly**

b) Subtract – **Definitely not**

c) Random Number – **Possibly**

d) Divide – **Possibly**

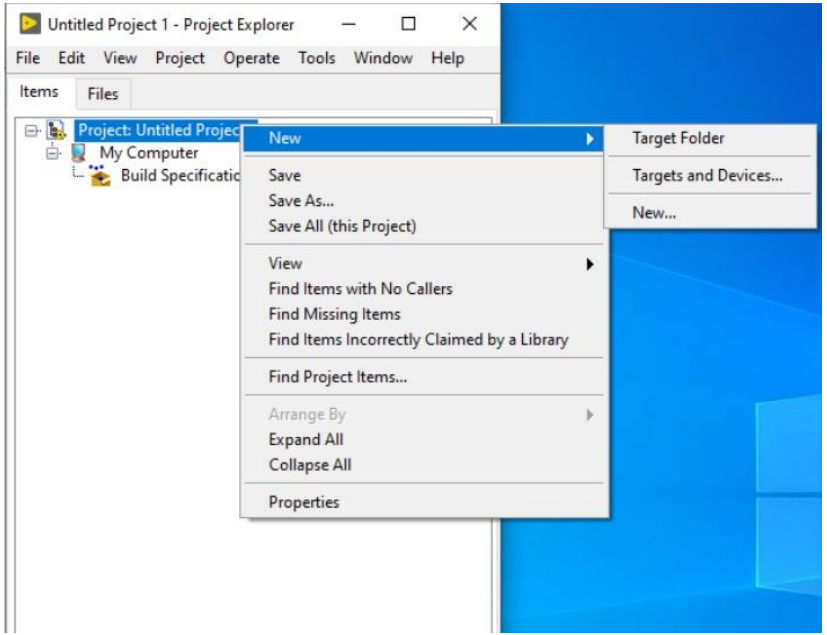
e) Sine – **Definitely not**



Connecting to the myRIO

Connecting to the myRIO

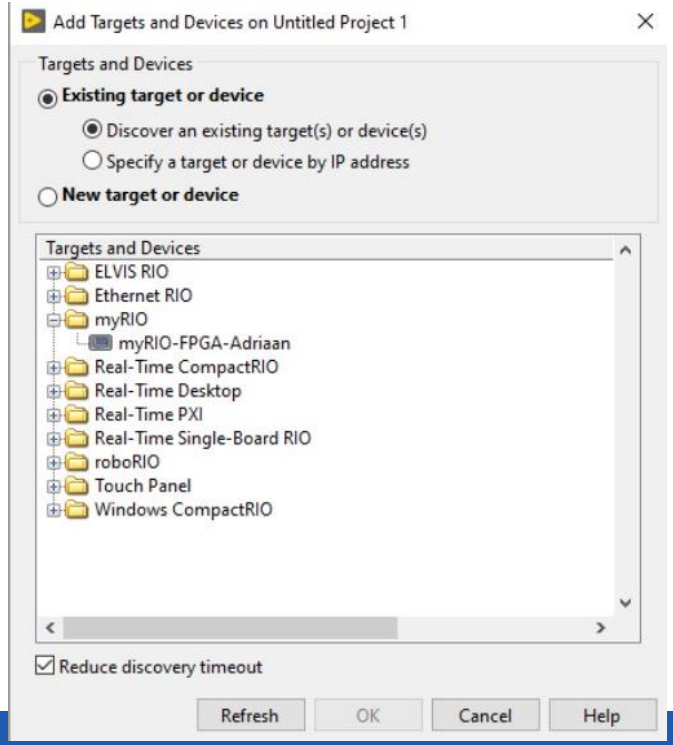
Create a blank project
Right click on Project:
→ Select New
→ Target and Devices



Connecting to the myRIO

Open the myRIO

→ select the myRIO-FPGA-nn



I. Building a Simple VI

Hello FPGA world