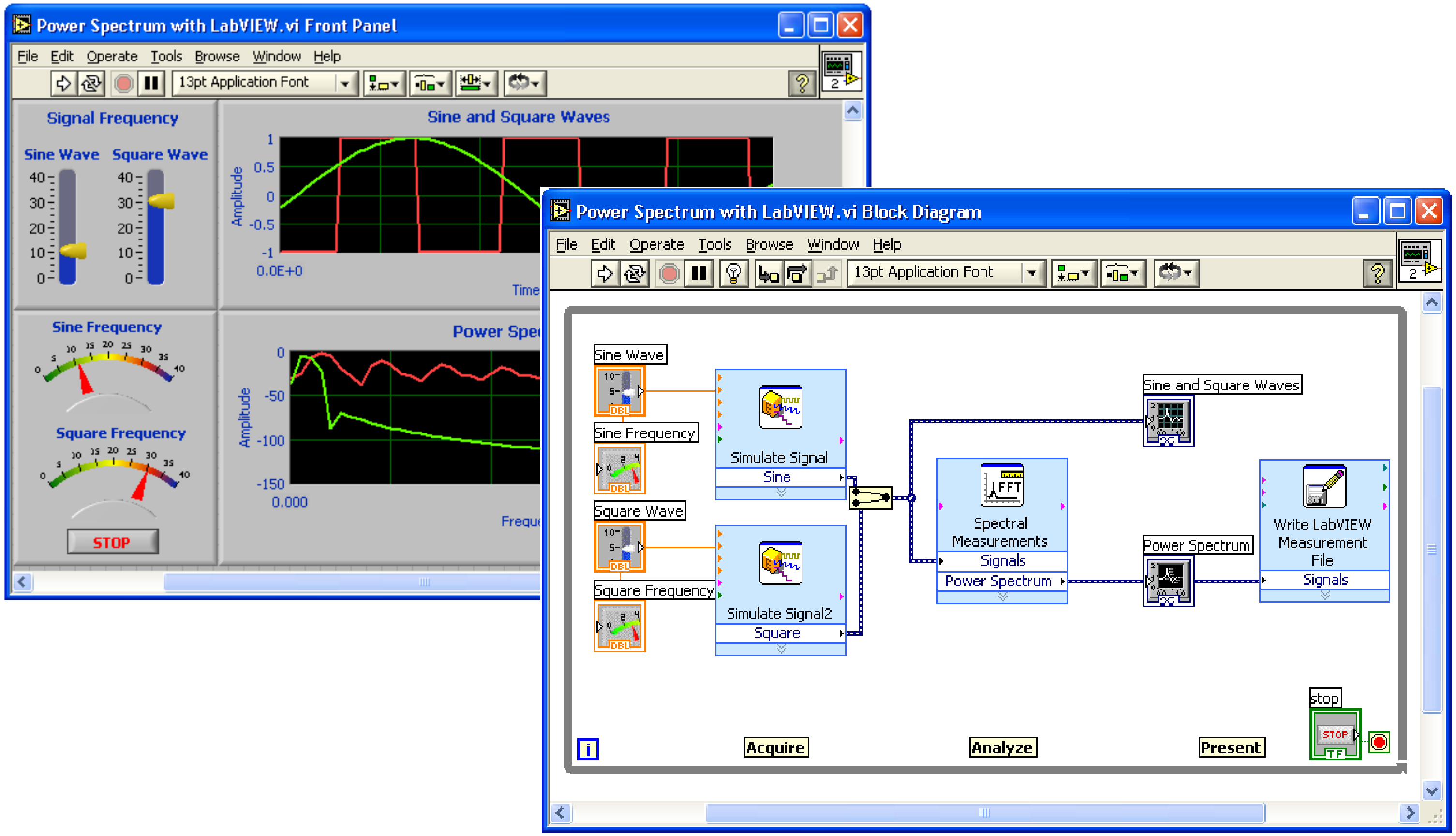
Virtual Instrumentation With LabVIEW



Course Goals

- Understand the components of a Virtual Instrument
- Introduce LabVIEW and common LabVIEW functions
- Create a subroutine in LabVIEW
- Work with Arrays, Clusters, and Structures
- Develop in Basic Programming Architectures

Section I

- LabVIEW terms
- Components of a LabVIEW application
- LabVIEW programming tools
- Creating an application in LabVIEW

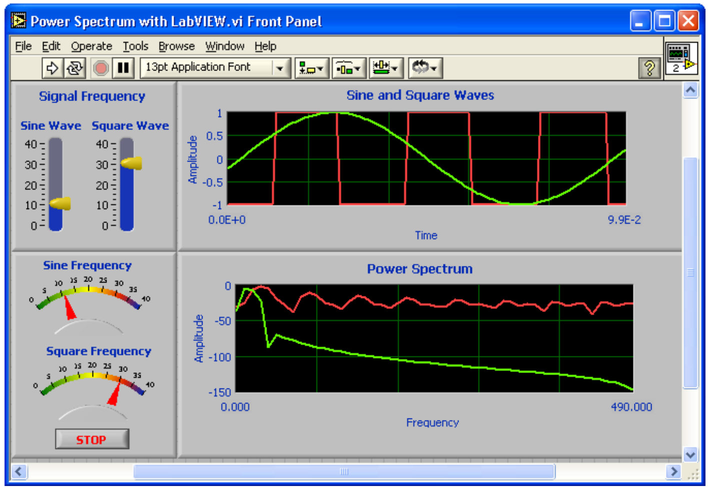
LabVIEW Programs Are Called Virtual Instruments (VIs)

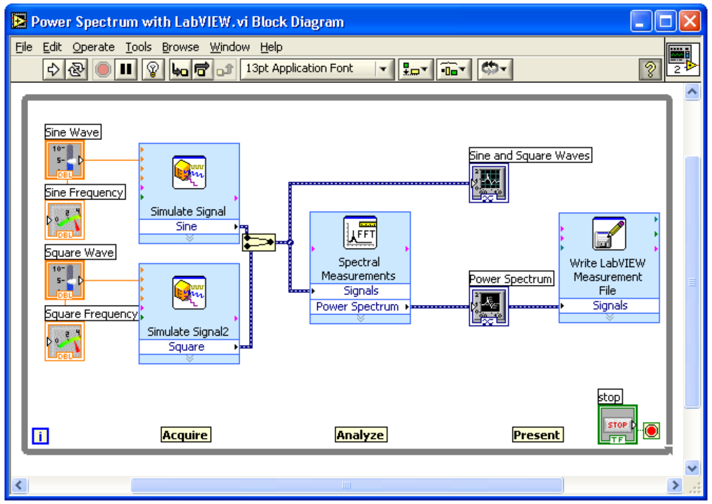
Front Panel

- Controls = Inputs
- Indicators = Outputs

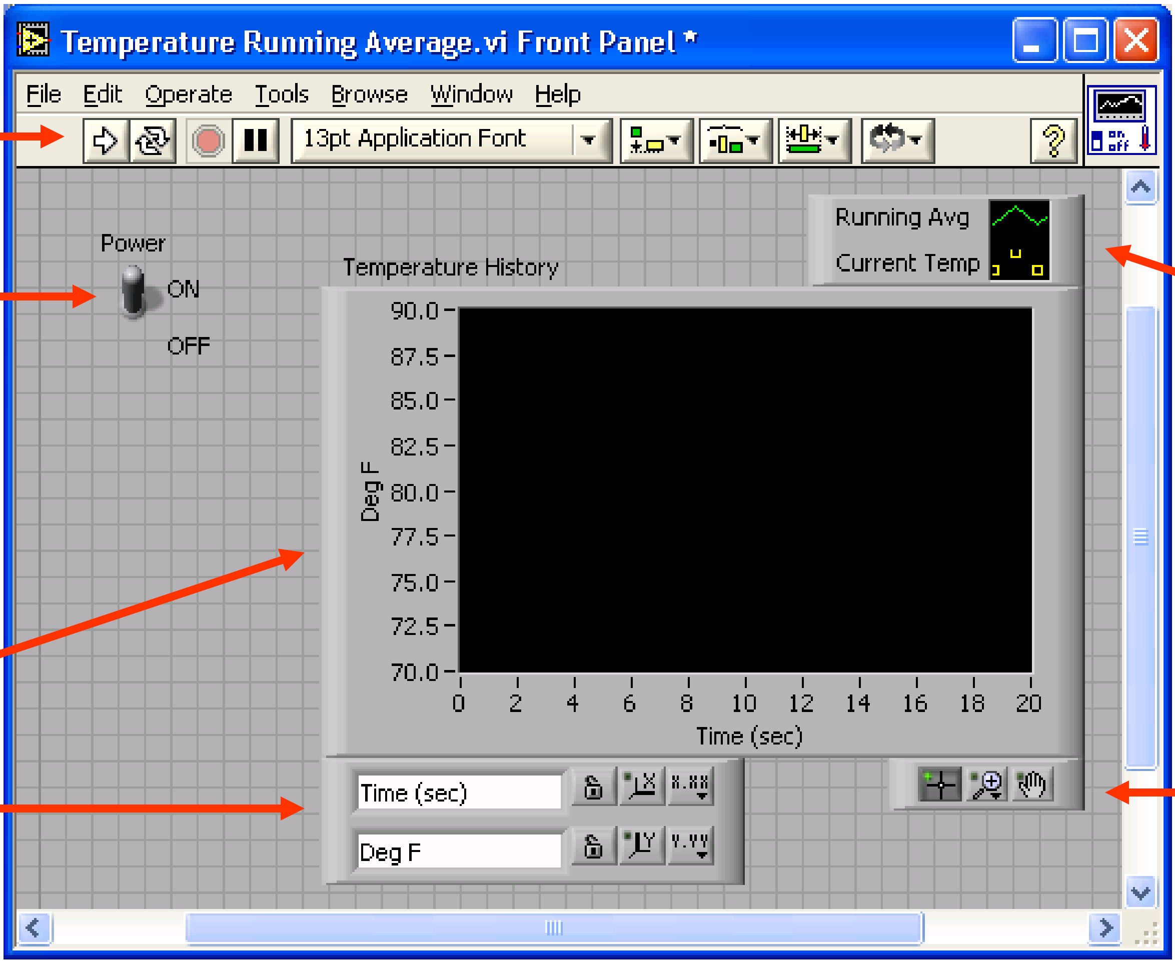
Block Diagram

- Accompanying "program" for front panel
- Components "wired" together





VI Front Panel



Front Panel Toolbar

Boolean Control

Waveform Graph

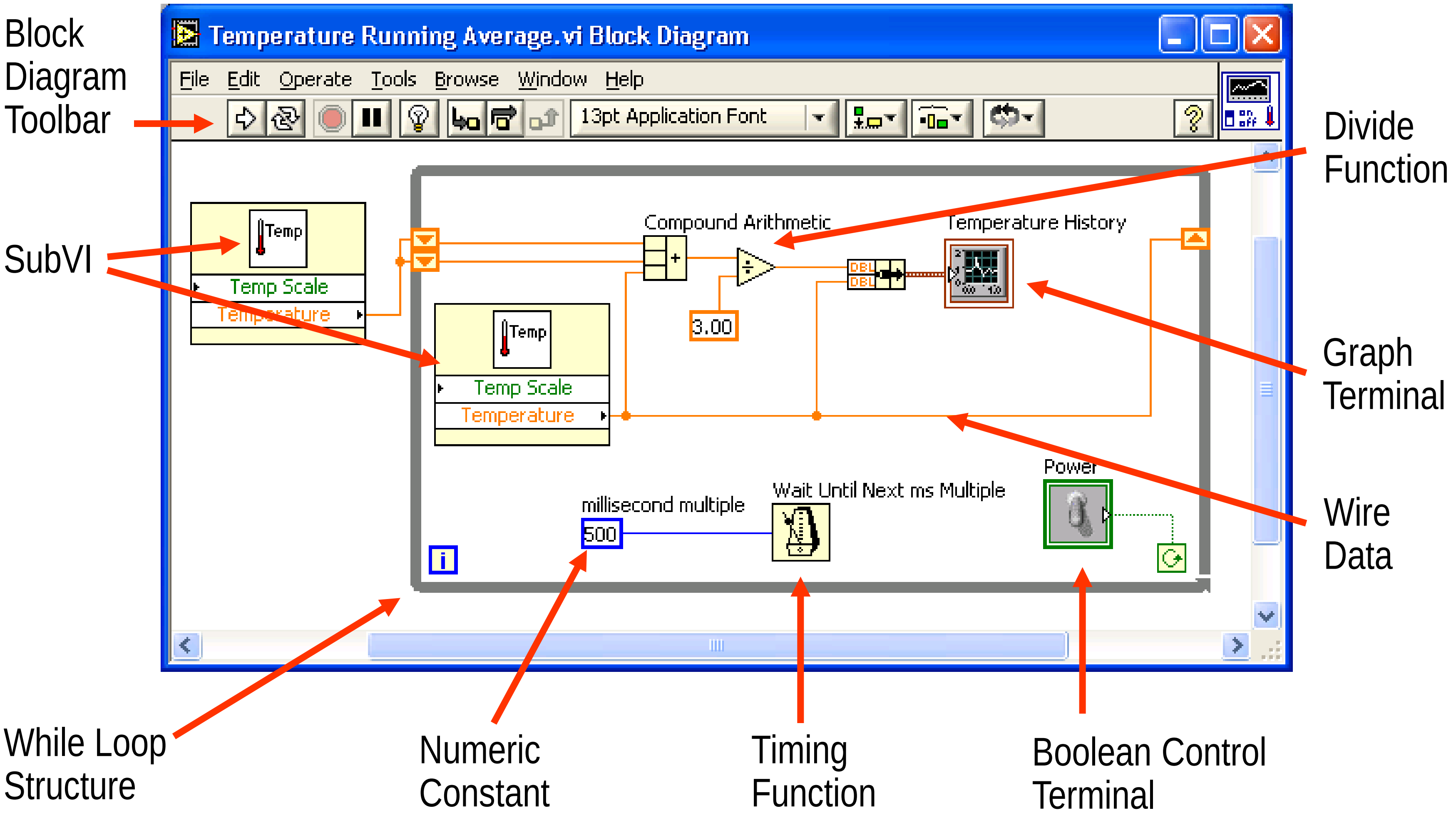
Plot Legend

Icon

Graph Legend

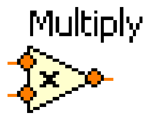
Scale Legend

VI Block Diagram

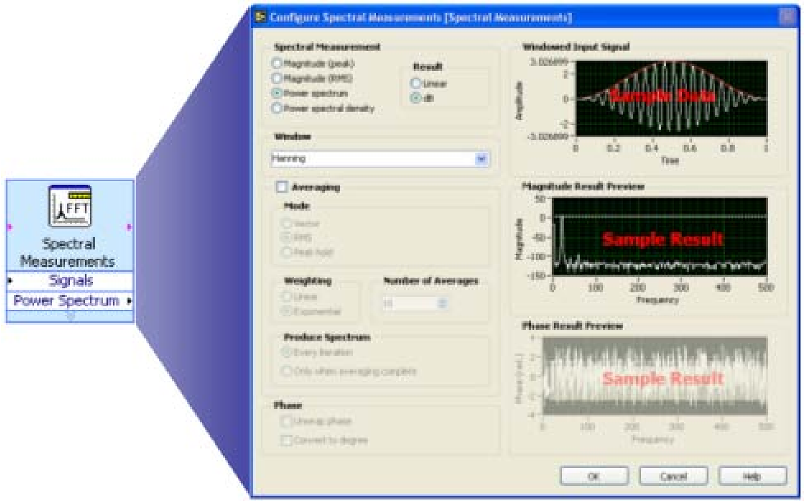


Express VIs, VIs and Functions

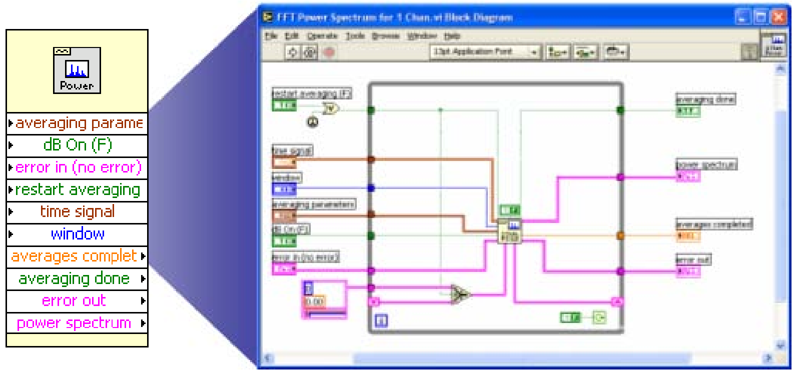
- Express VIs: interactive VIs with configurable dialog page
- Standard VIs: modularized VIs customized by wiring
- Functions: fundamental operating elements of LabVIEW; no front panel or block diagram



Function



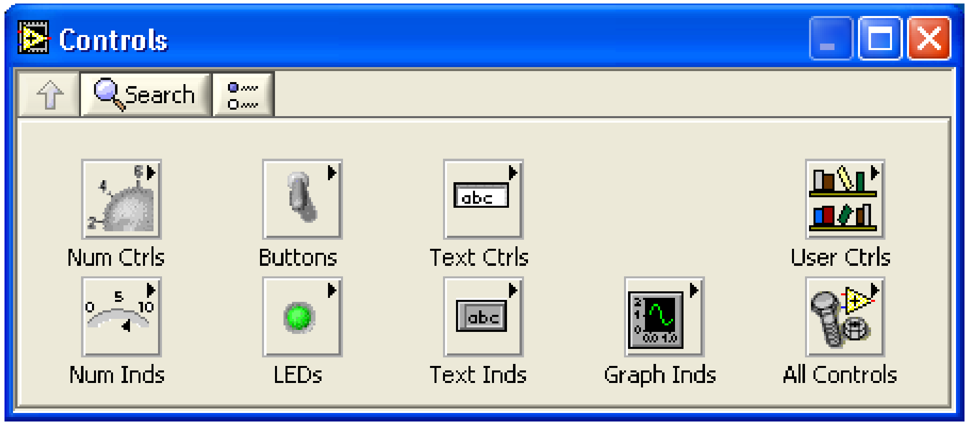
Express VI

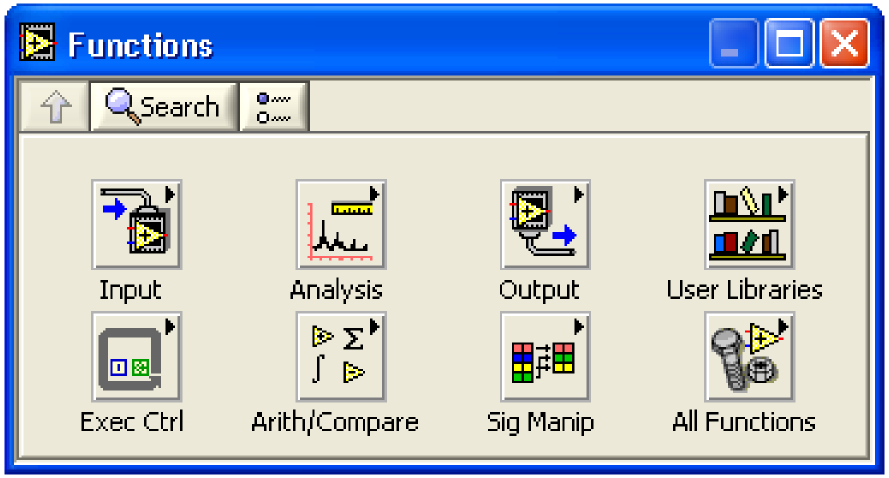


Standard VI

Controls and Functions Palettes

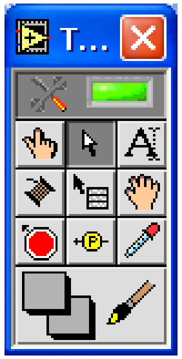
Controls Palette
(Front Panel Window)





Functions Palette
(Block Diagram Window)

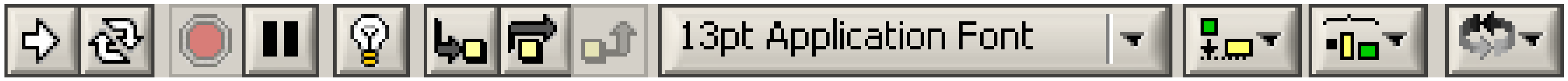
Tools Palette



- **Floating Palette**
- **Used to operate and modify front panel and block diagram objects.**

Automatic Selection Tool	
Operating Tool	**Scrolling Tool**
Positioning/Resizing Tool	**Breakpoint Tool**
Labeling Tool	**Probe Tool**
Wiring Tool	**Color Copy Tool**
Shortcut Menu Tool	**Coloring Tool**

Status Toolbar



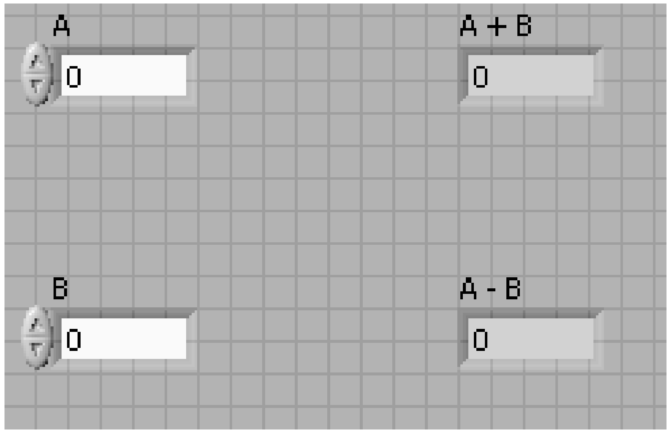
- Run Button
- Continuous Run Button
- Abort Execution
- Pause/Continue Button
- Text Settings
- Align Objects
- Distribute Objects
- Reorder
- Resize front panel objects

Additional Buttons on the Diagram Toolbar

- Execution Highlighting Button
- Step Into Button
- Step Over Button
- Step Out Button

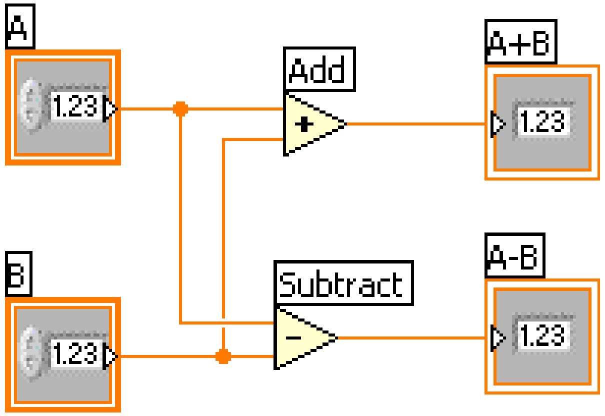
Creating a VI

Front Panel Window



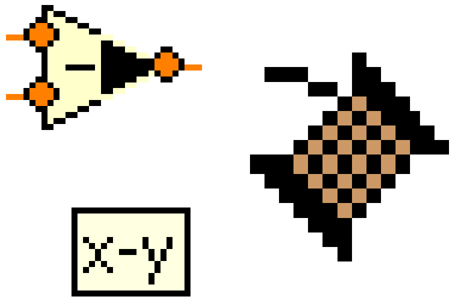
Block Diagram Window

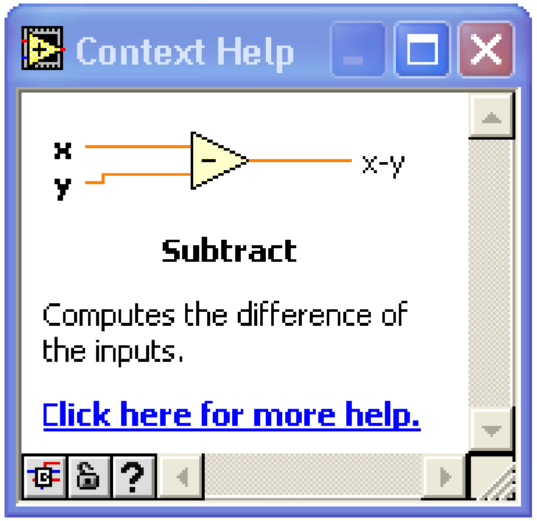
Control Terminals



Indicator Terminals

Creating a VI – Block Diagram

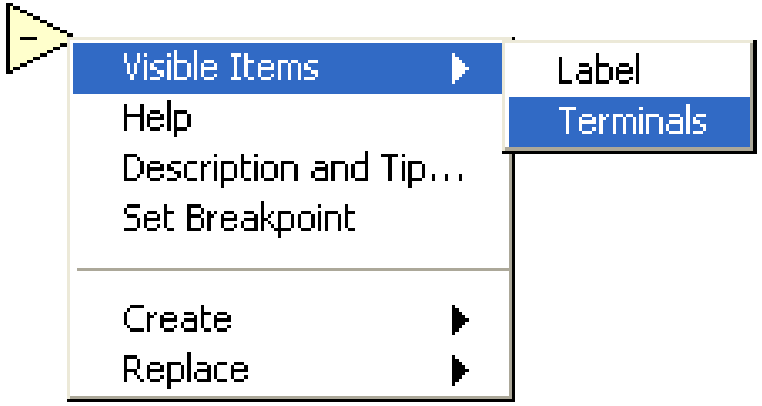


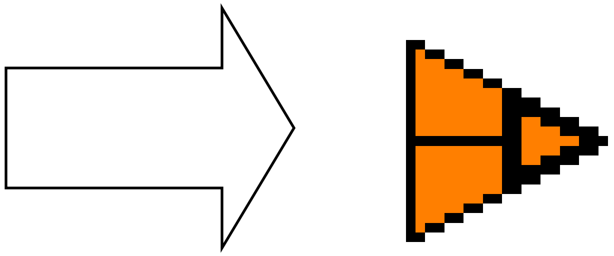


Subtract

Computes the difference of the inputs.

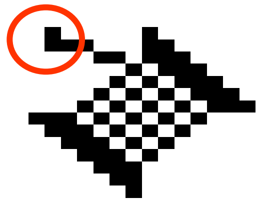
Click here for more help.



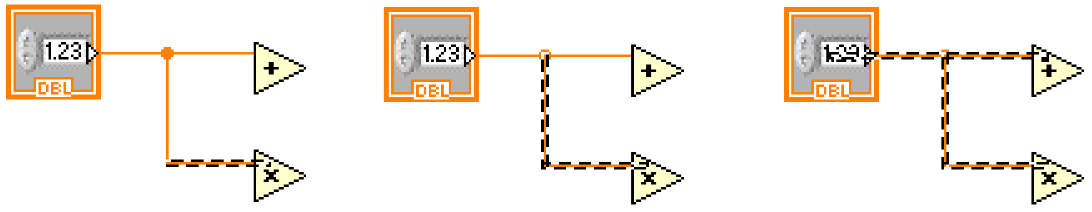


Wiring Tips – Block Diagram

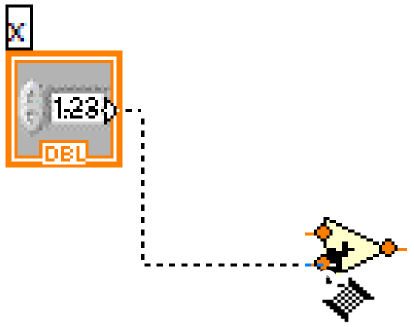
Wiring "Hot Spot"



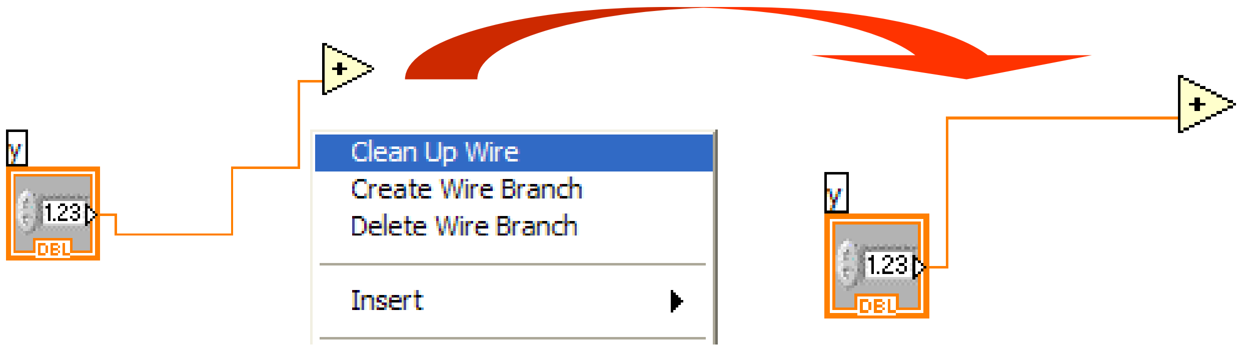
Click To Select Wires



Use Automatic Wire Routing

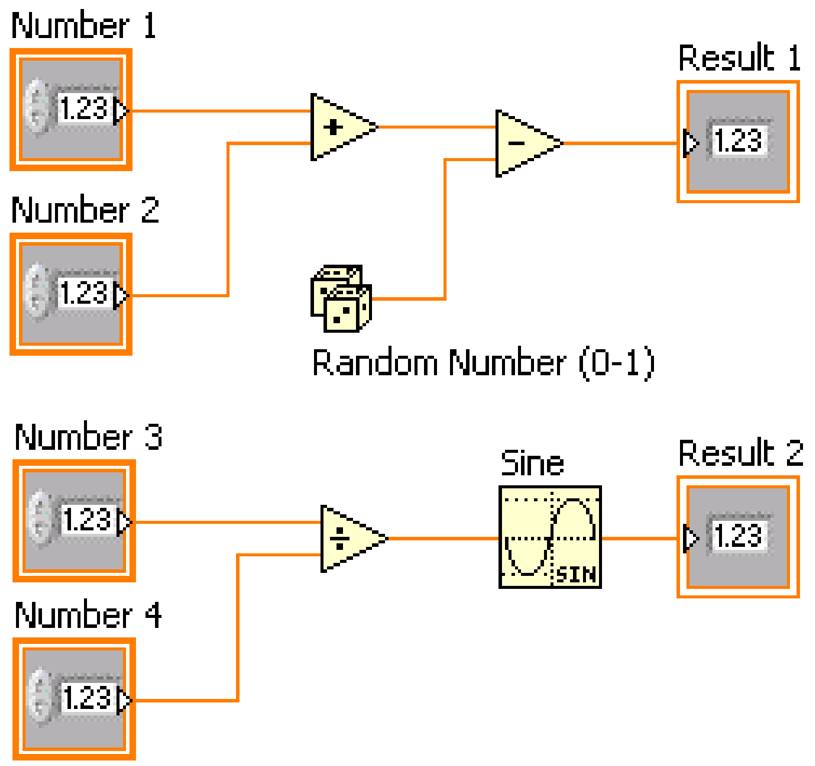


Clean Up Wiring



Dataflow Programming

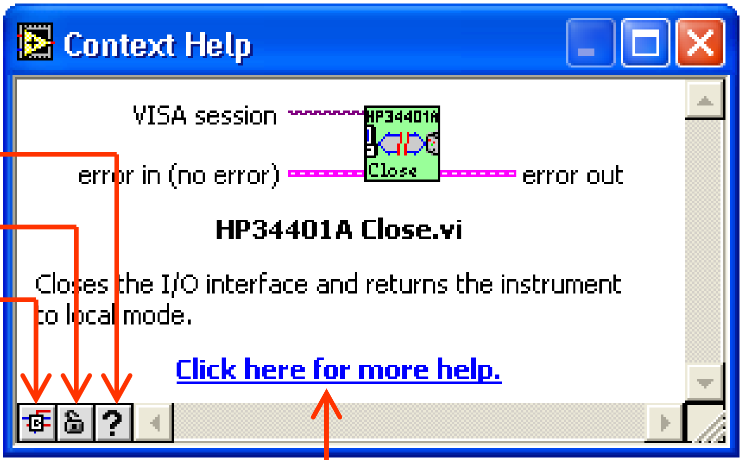
- Block diagram executes dependent on the flow of data; block diagram does NOT execute left to right
- Node executes when data is available to ALL input terminals
- Nodes supply data to all output terminals when done



Help Options

Context Help

- Online help
- Lock help
- Simple/Complex Diagram help
- Ctrl + H



HP34401A Close.vi

Closes the I/O interface and returns the instrument to local mode.

Click here for more help.

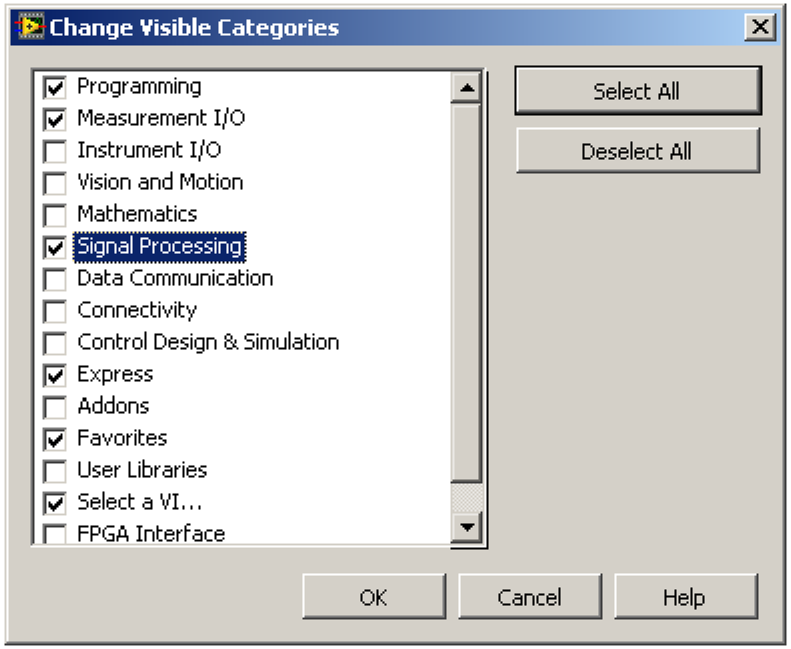
Online reference

- All menus online
- Pop up on functions in diagram to access online info directly

Customize LabVIEW

- Launch LabVIEW and create a Blank VI.
- Set Up Programming Pallette
  - Click on **Window -> Show Block Diagram**
  - Right Click on the blank white screen to bring up the functions pallette.
  - Click **Search** - this takes a minute the first time
  - Click **View -> Change Visable Categories**

Customize LabVIEW (cont.)



Change Visible Categories

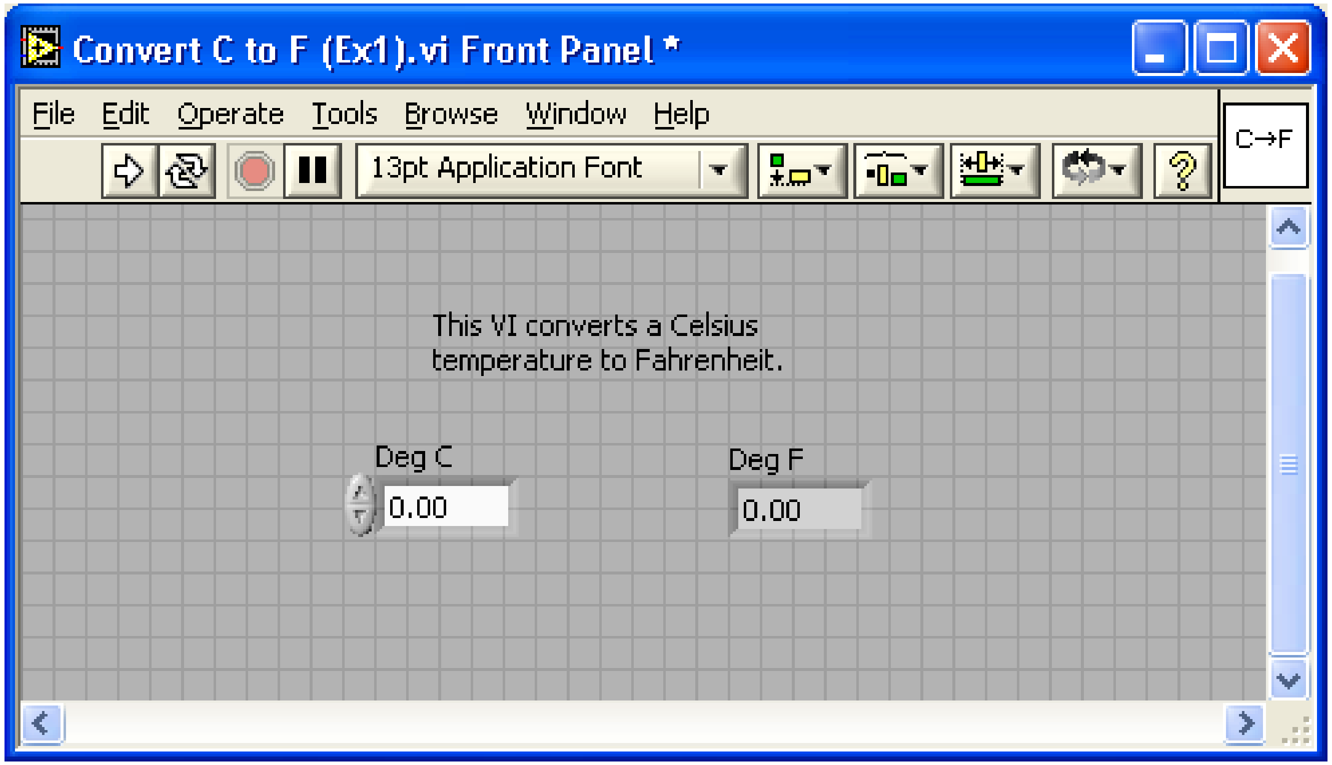
- [✓] Programming
- [✓] Measurement I/O
- [ ] Instrument I/O
- [ ] Vision and Motion
- [ ] Mathematics
- [✓] Signal Processing
- [ ] Data Communication
- [ ] Connectivity
- [ ] Control Design & Simulation
- [✓] Express
- [ ] Addons
- [✓] Favorites
- [ ] User Libraries
- [✓] Select a VI...
- [ ] FPGA Interface

– Check Programming, Measurement I/O, Express, and Select a VI…. Click OK

Customize LabVIEW (cont.)

- Set Options
  - Click on **Tools -> Options…**
    - Click on Block Diagram
      - Uncheck **Enable automatic wire routing**
      - Uncheck **Place front panel terminals as icons**
    - Click on Environment
      - Uncheck **Maximum undo steps per VI -> Use default**
      - Set **Maximum undo steps per VI** to 99
    - Click OK

Exercise 1 - Convert °C to °F


Convert C to F (Ex1).vi Front Panel *
File Edit Operate Tools Browse Window Help
13pt Application Font
C→F

This VI converts a Celsius temperature to Fahrenheit.

Deg C 0.00

Deg F 0.00

Debugging Techniques

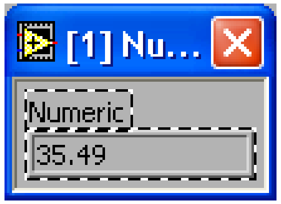
- **Finding Errors**

  Click on broken Run button
  Window showing error appears

- **Execution Highlighting**

  Click on Execution Highlighting button; data flow is animated using bubbles. Values are displayed on wires.

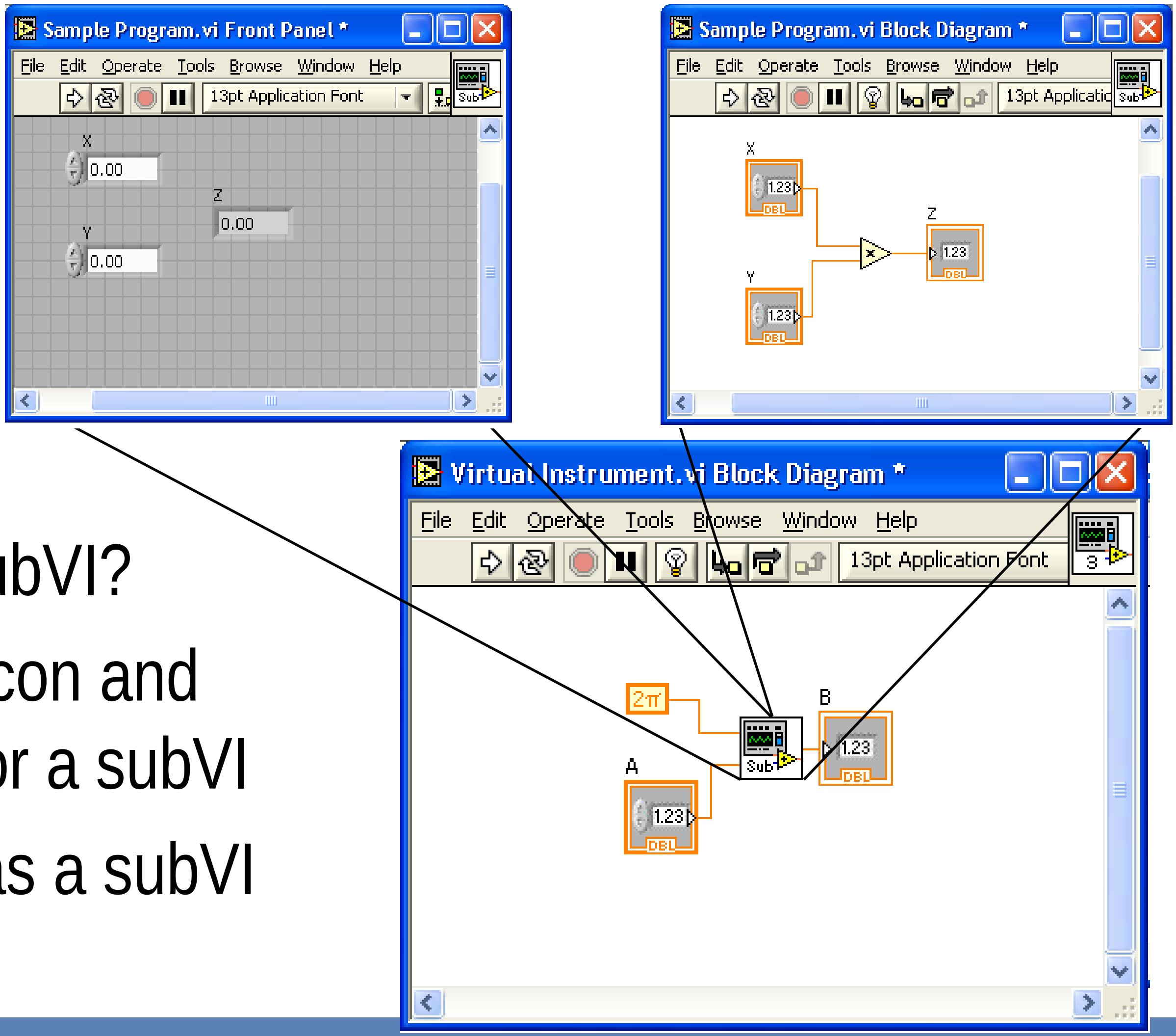
- **Probe**



  Right-click on wire to display probe and it shows data as it flows through wire segment

  You can also select Probe tool from Tools palette and click on wire

Section II – SubVIs

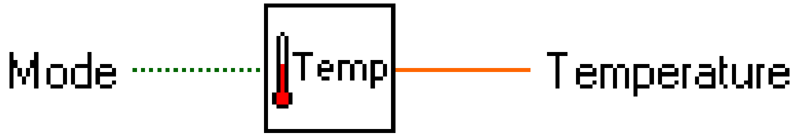

Sample Program.vi Front Panel *
File Edit Operate Tools Browse Window Help
13pt Application Font
X
0.00
Y
0.00
Z
0.00
Sample Program.vi Block Diagram *
File Edit Operate Tools Browse Window Help
13pt Applicatio
X
Y
Z
1.23
DBL
Virtual Instrument.vi Block Diagram *
File Edit Operate Tools Browse Window Help
13pt Application Font
2π
A
B
Sub
1.23
DBL

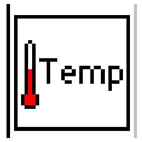
- What is a subVI?
- Making an icon and connector for a subVI
- Using a VI as a subVI

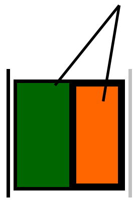
SubVIs

- A SubVI is a VI that can be used within another VI
- Similar to a subroutine
- Advantages
  - Modular
  - Easier to debug
  - Don’t have to recreate code
  - Require less memory

Icon and Connector

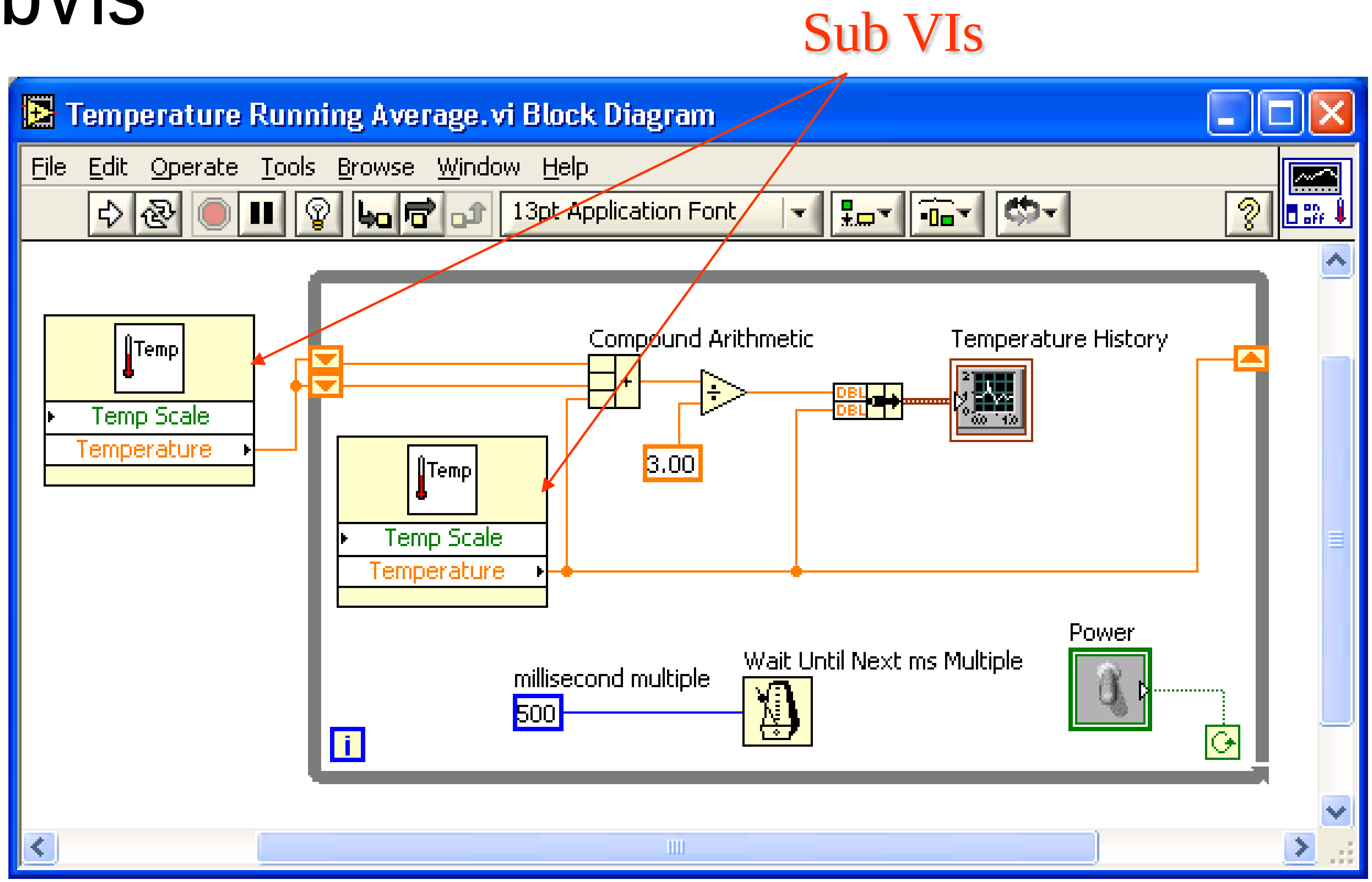






- An icon represents a VI in other block diagrams
- A connector shows available terminals for data transfer

SubVIs



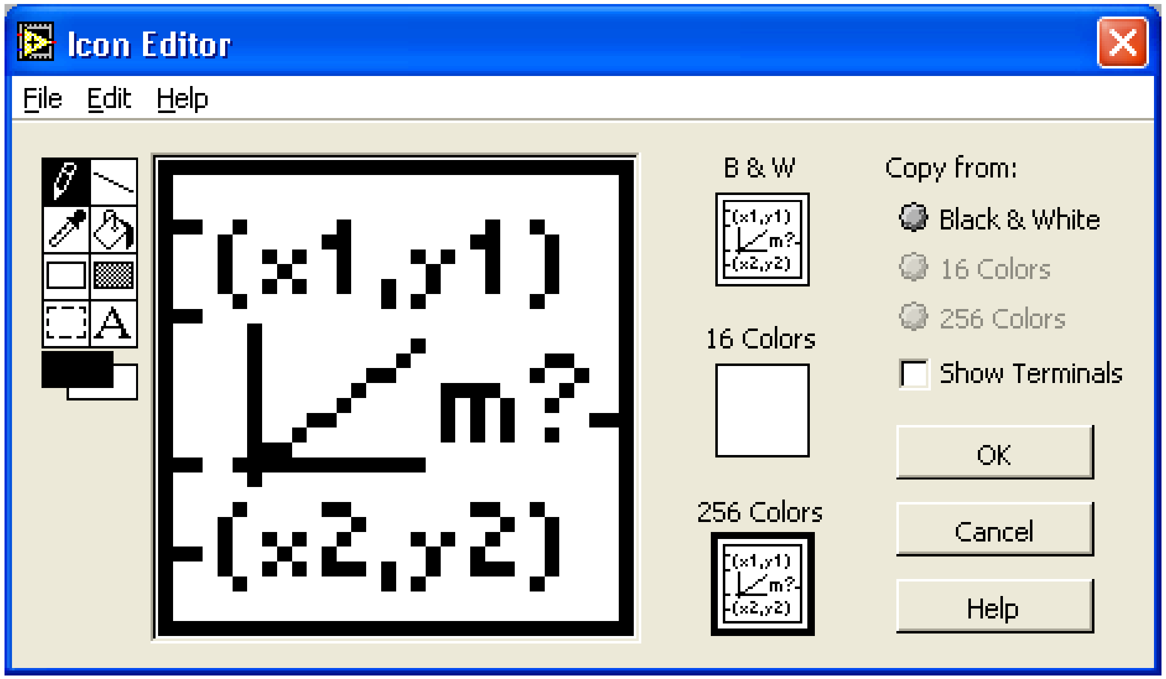
NATIONAL INSTRUMENTS

Steps to Create a SubVI

- Create the Icon
- Create the Connector
- Assign Terminals
- Save the VI
- Insert the VI into a Top Level VI

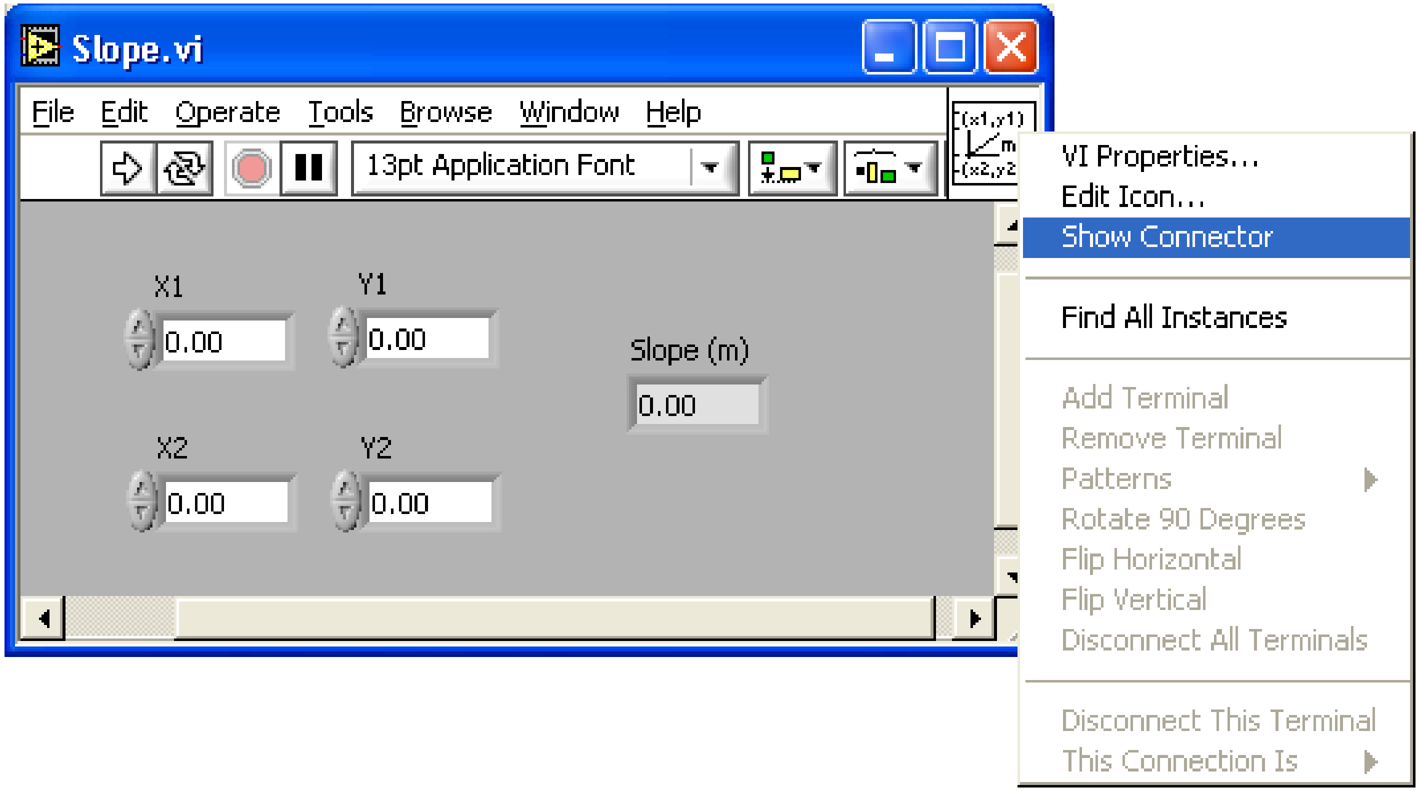
Create the Icon

- Right-click on the icon in the block diagram or front panel

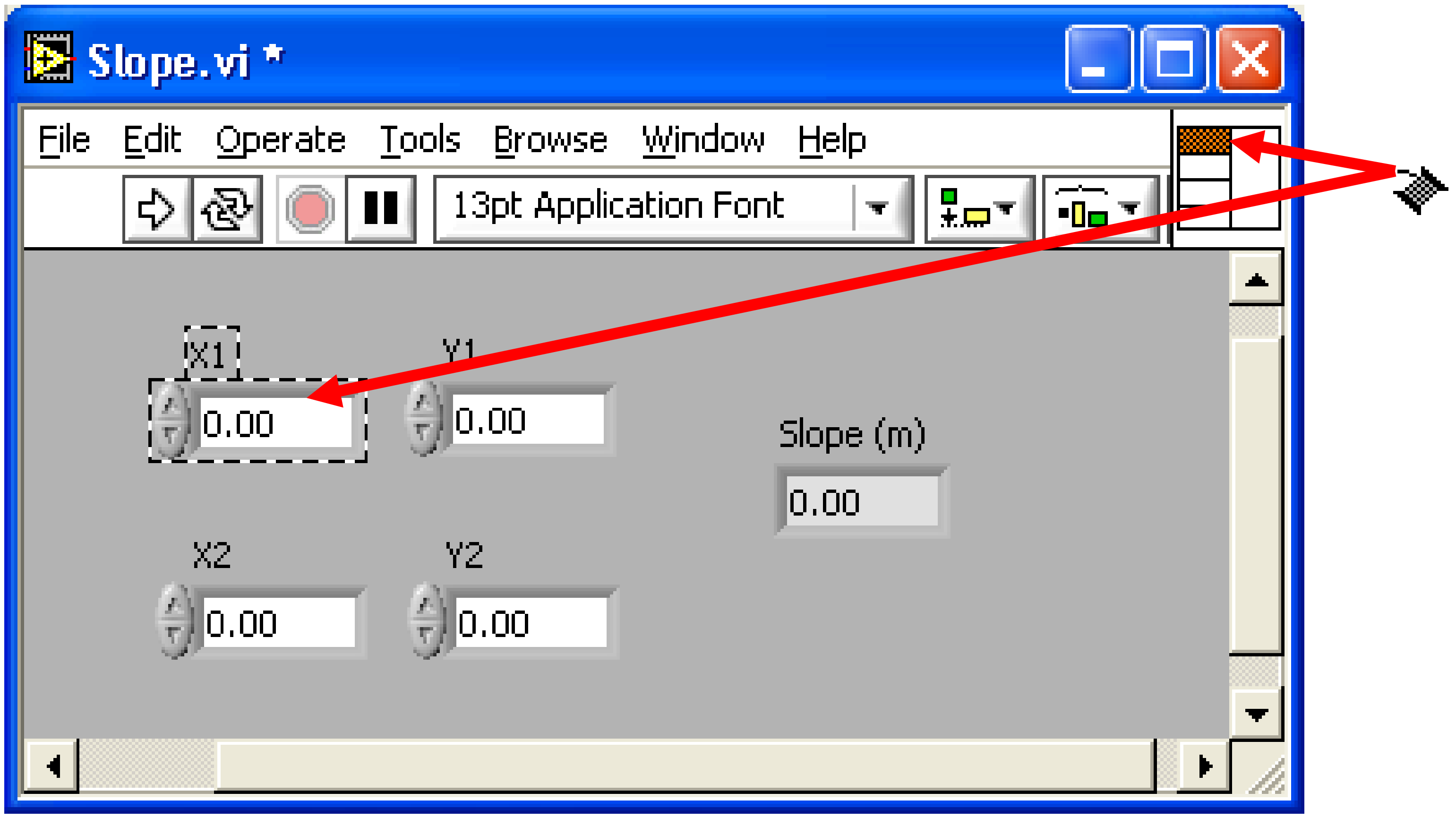


Create the Connector

Right click on the icon pane (front panel only)



Assign Terminals



Save The VI

- Choose an Easy to Remember Location
- Organize by Functionality
  - Save Similar VIs into one directory (e.g. Math Utilities)
- Organize by Application
  - Save all VIs Used for a Specific Application into one directory or library file (e.g. Lab 1 – Frequency Response)
    - Library Files (.llbs) combine many VI's into a single file, ideal for transferring entire applications across computers

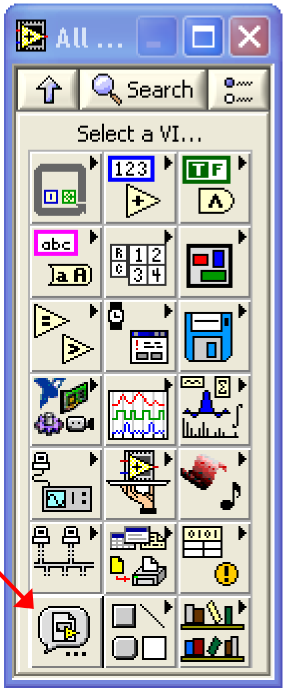
Insert the SubVI into a Top Level VI

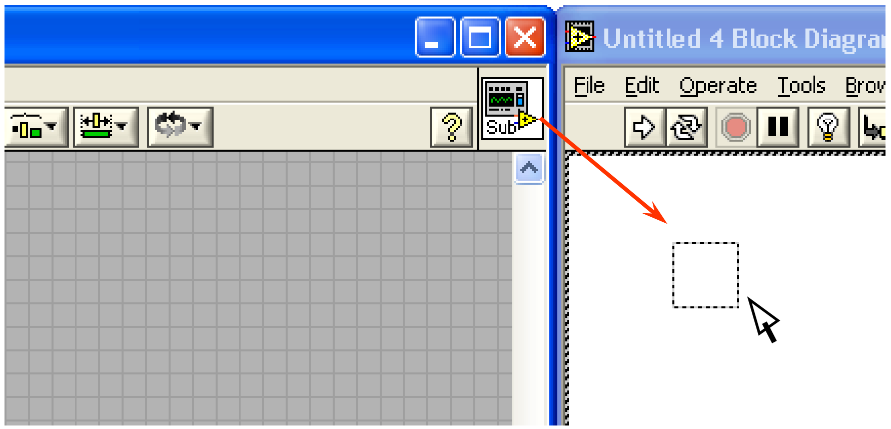
Accessing user-made subVIs

Functions >>All Functions >> Select a VI

Or

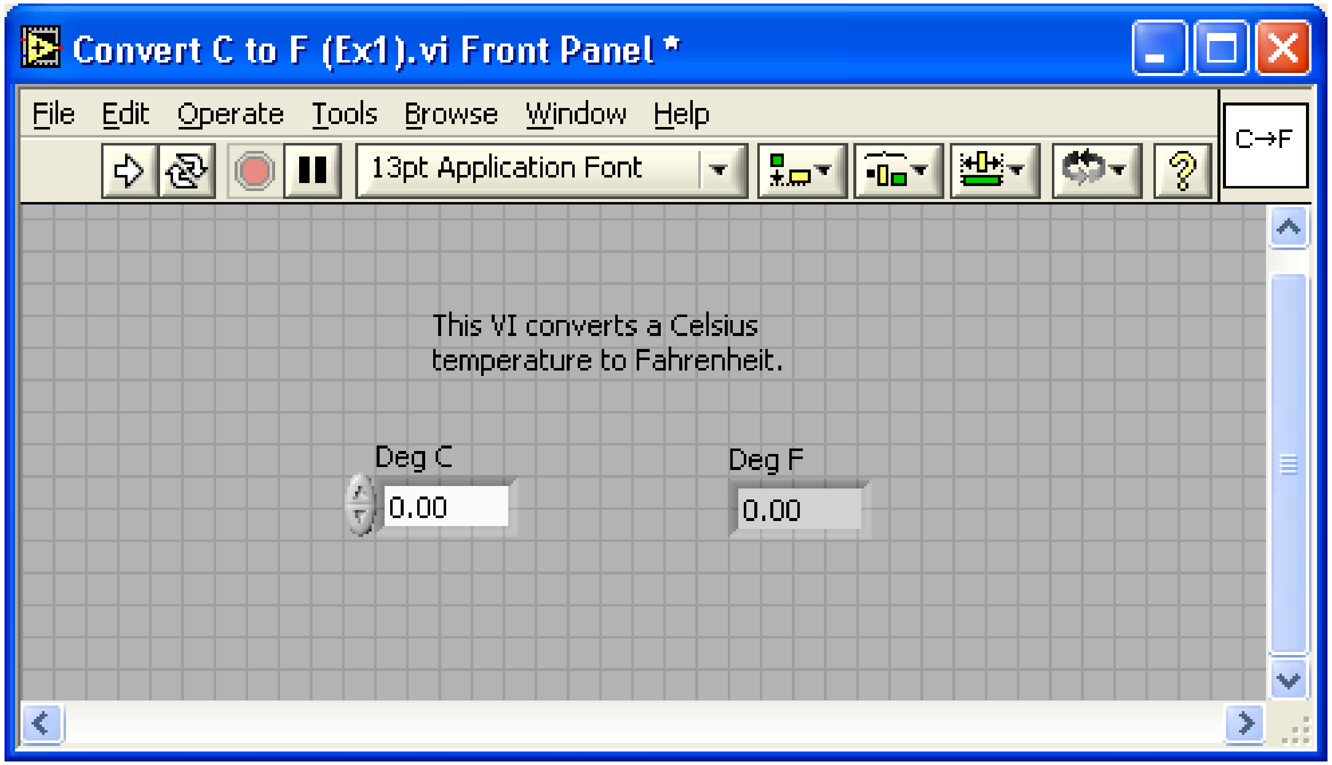
Drag icon onto target diagram





NATIONAL INSTRUMENTS

Exercise 2 – Make C2F.vi a SubVI


Convert C to F (Ex1).vi Front Panel *
File Edit Operate Tools Browse Window Help
13pt Application Font
C→F

This VI converts a Celsius temperature to Fahrenheit.

Deg C: 0.00

Deg F: 0.00

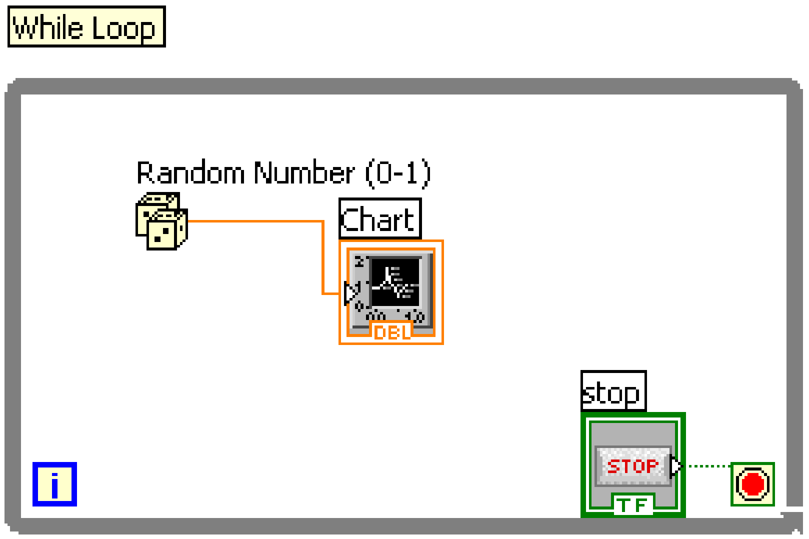
Section III – Loops and Charts

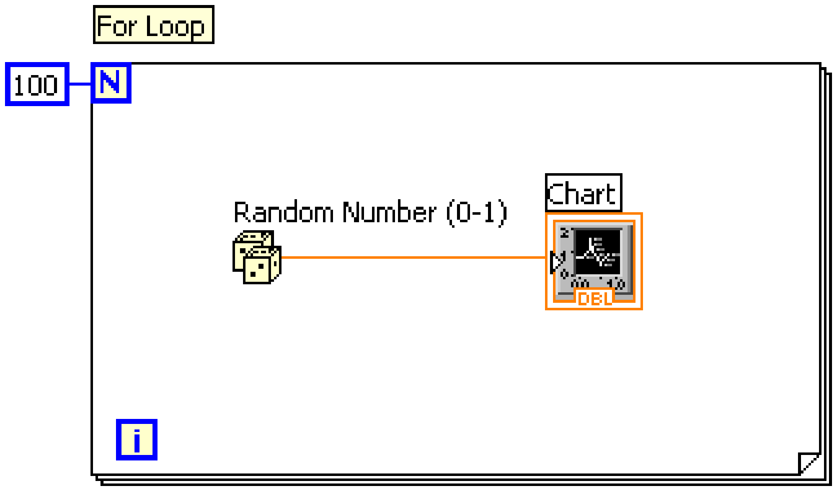
- For Loop
- While Loop
- Charts
- Multiplots

Loops

- While Loops
  - Have Iteration Terminal
  - Always Run at least Once
  - Run According to Conditional Terminal

- For Loops
  - Have Iteration Terminal
  - Run According to input **N** of Count Terminal

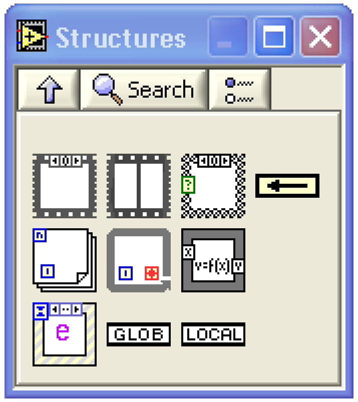




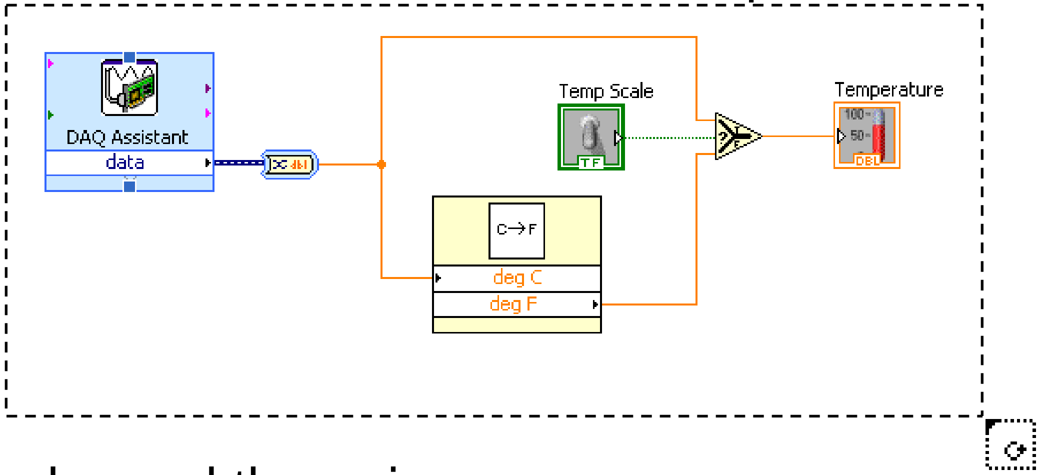
NATIONAL INSTRUMENTS

Loops (cont.)

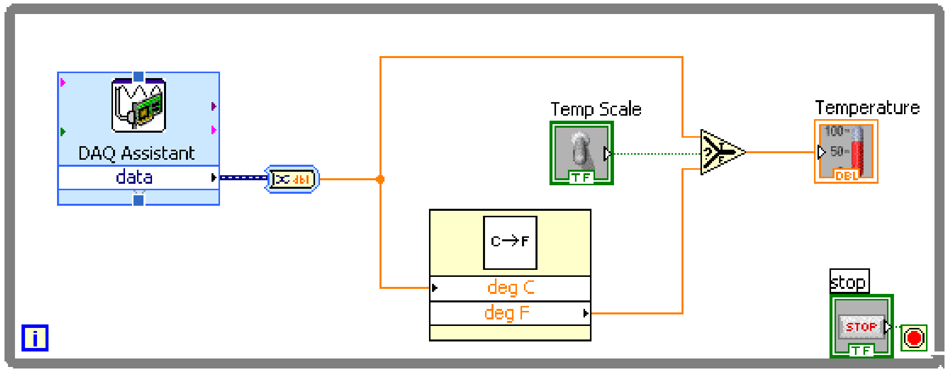
1. Select the loop



2. Enclose code to be repeated



3. Drop or drag additional nodes and then wire

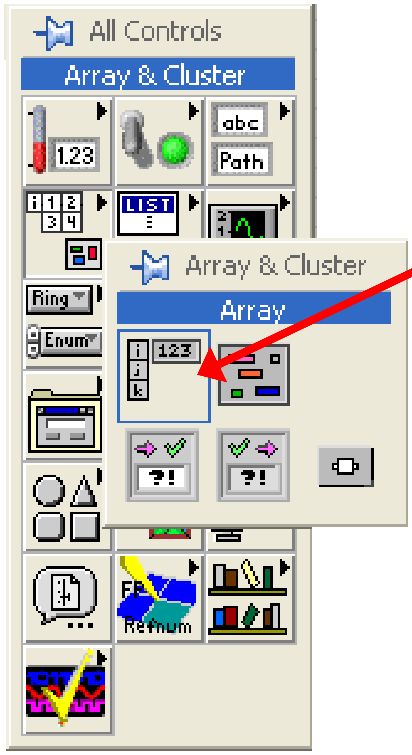


Section IV – Arrays

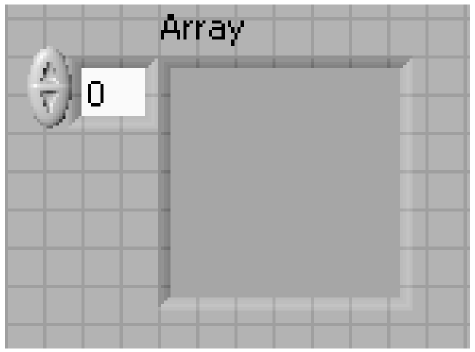
- Build arrays manually
- Have LabVIEW build arrays automatically

Adding an Array to the Front Panel

From the **Controls >> All Controls >> Array and Cluster** subpalette, select the **Array Shell**

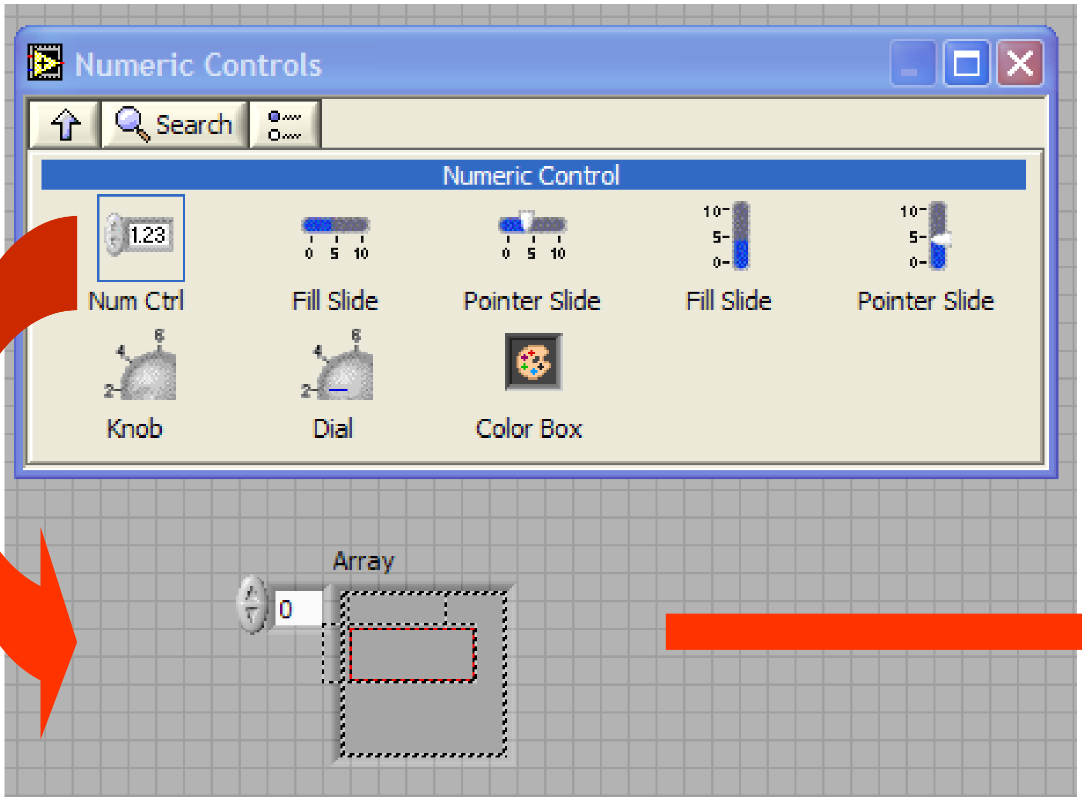


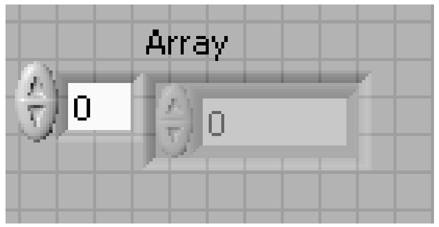
Drop it on the screen.



Adding an Array (cont.)

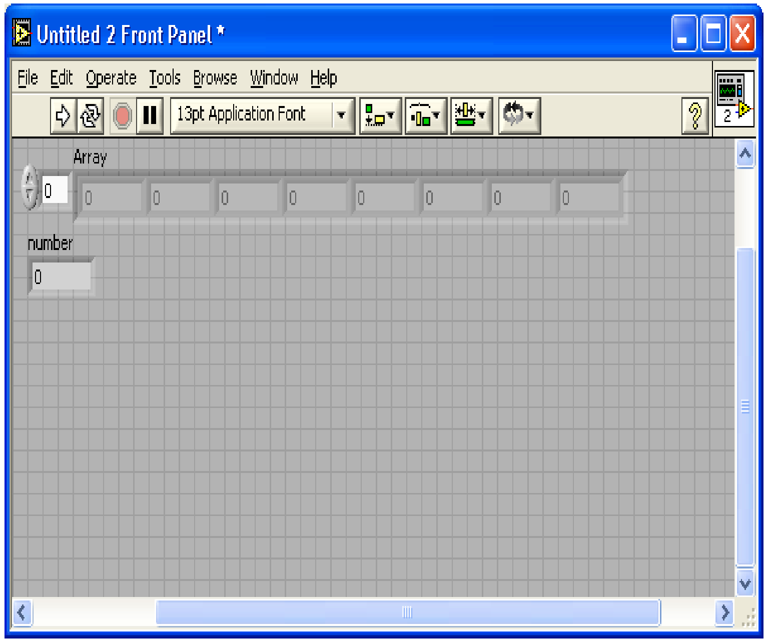
Place data object into shell (i.e. Numeric Control)

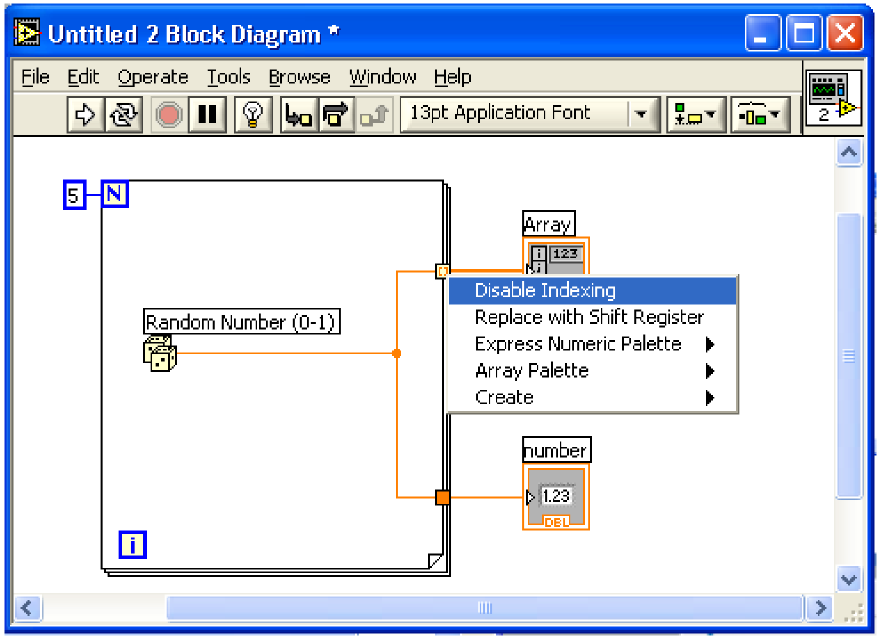




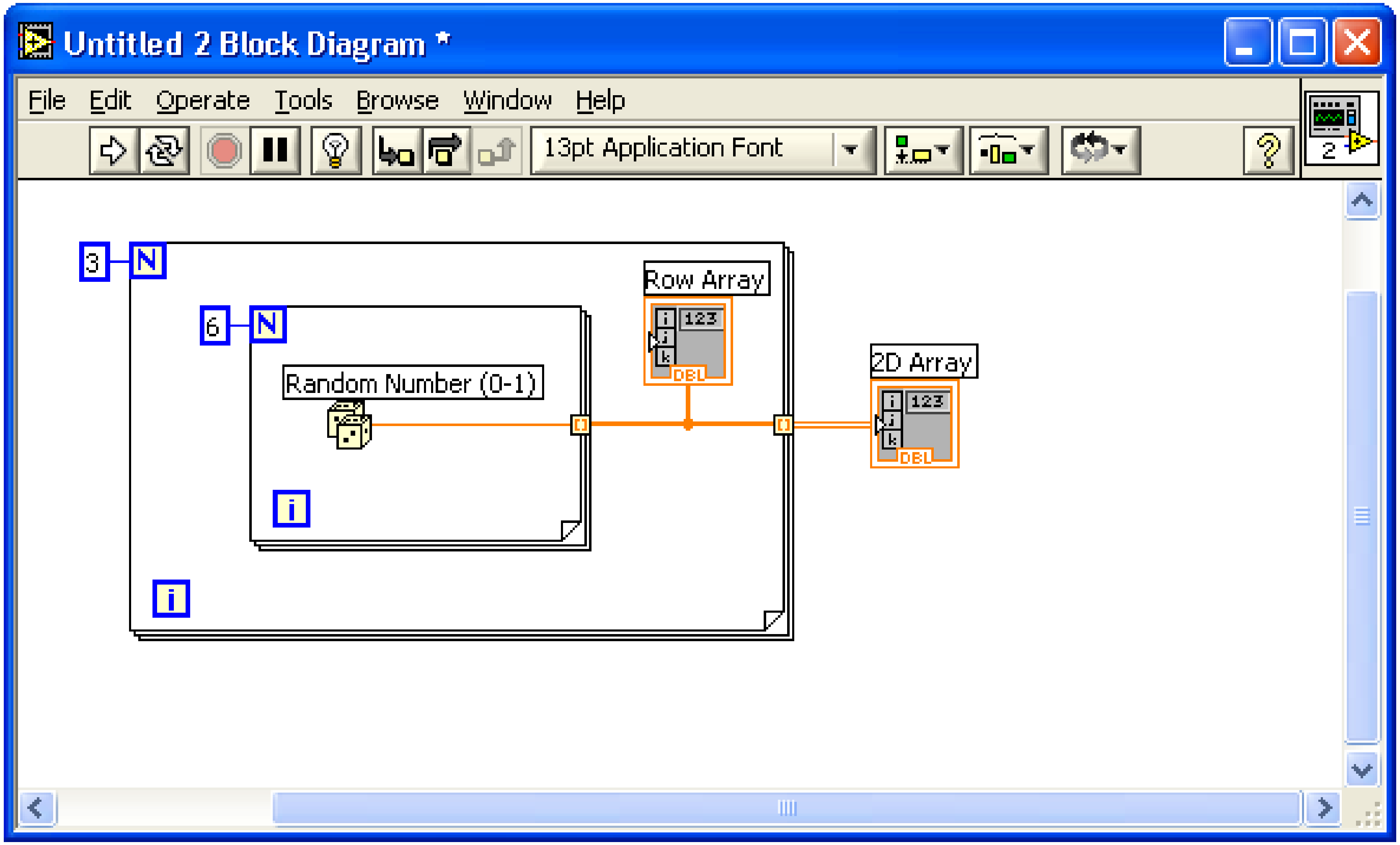
Creating an Array with a Loop

- Loops accumulate arrays at their boundaries





Creating 2D Arrays

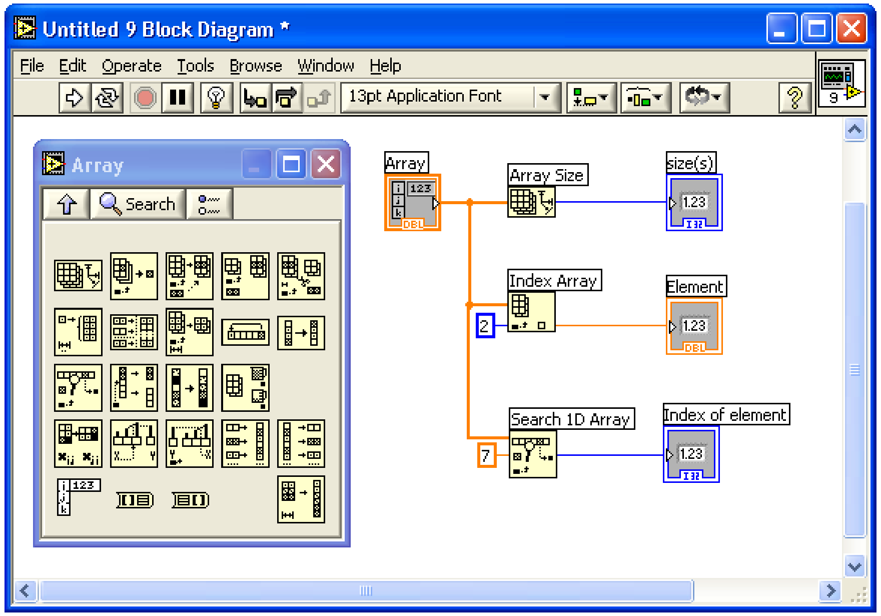


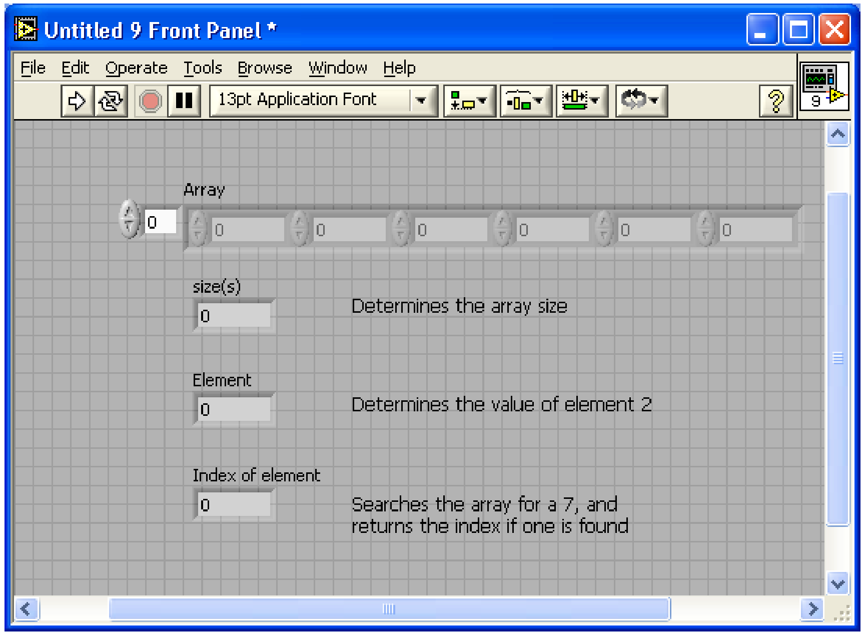
Section V – Array Functions & Graphs

- Basic Array Functions
- Use graphs
- Create multiplots with graphs

Array Functions – Basics

Functions >> All functions>> Array



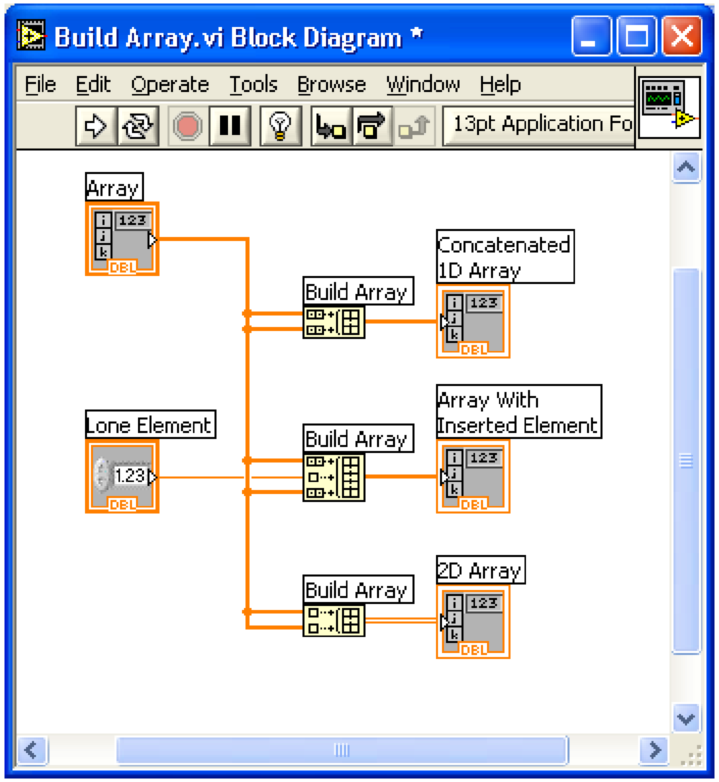


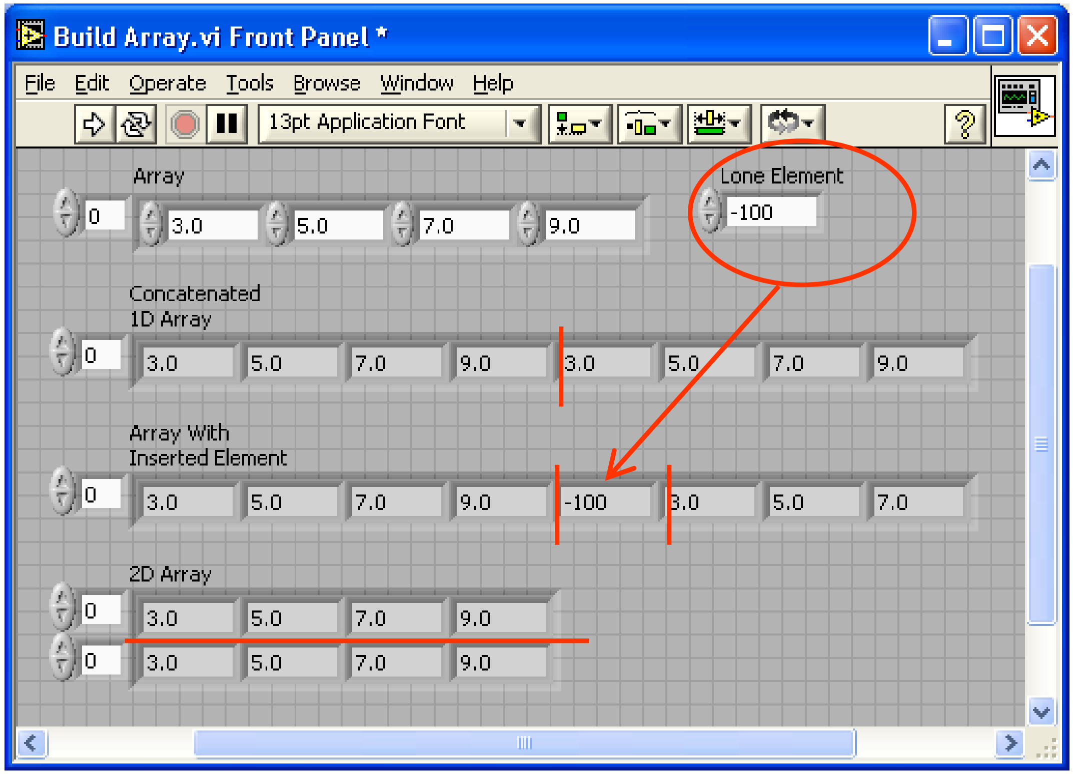
Determines the array size

Determines the value of element 2

Searches the array for a 7, and returns the index if one is found

Array Functions – Build Array




Build Array.vi Front Panel *
File Edit Operate Tools Browse Window Help
13pt Application Font
Lone Element
-100

Array

0	3.0	5.0	7.0	9.0

Concatenated 1D Array

0	3.0	5.0	7.0	9.0	3.0	5.0	7.0	9.0

Array With Inserted Element

0	3.0	5.0	7.0	9.0	-100	3.0	5.0	7.0

2D Array

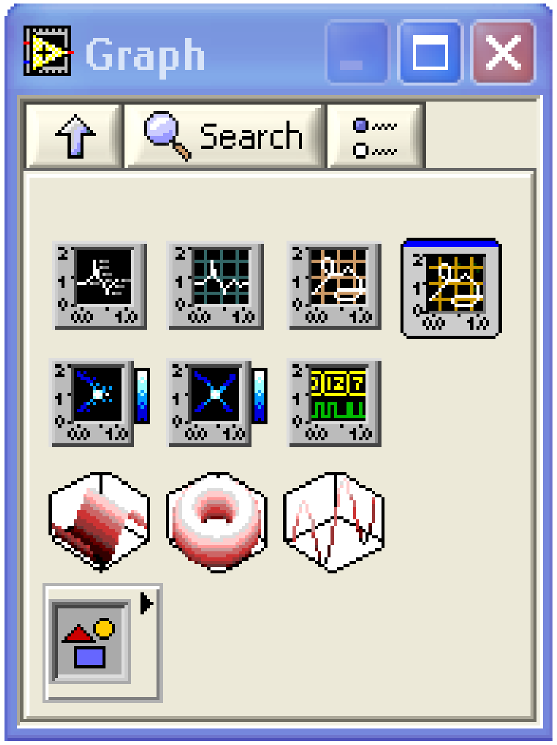
0	3.0	5.0	7.0	9.0
0	3.0	5.0	7.0	9.0

Graphs

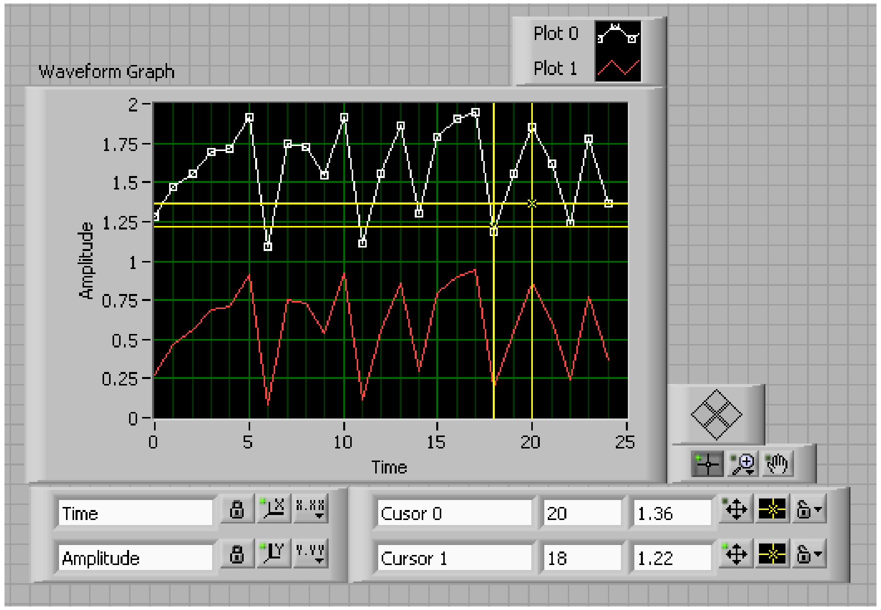
- Selected from the Graph palette of Controls menu

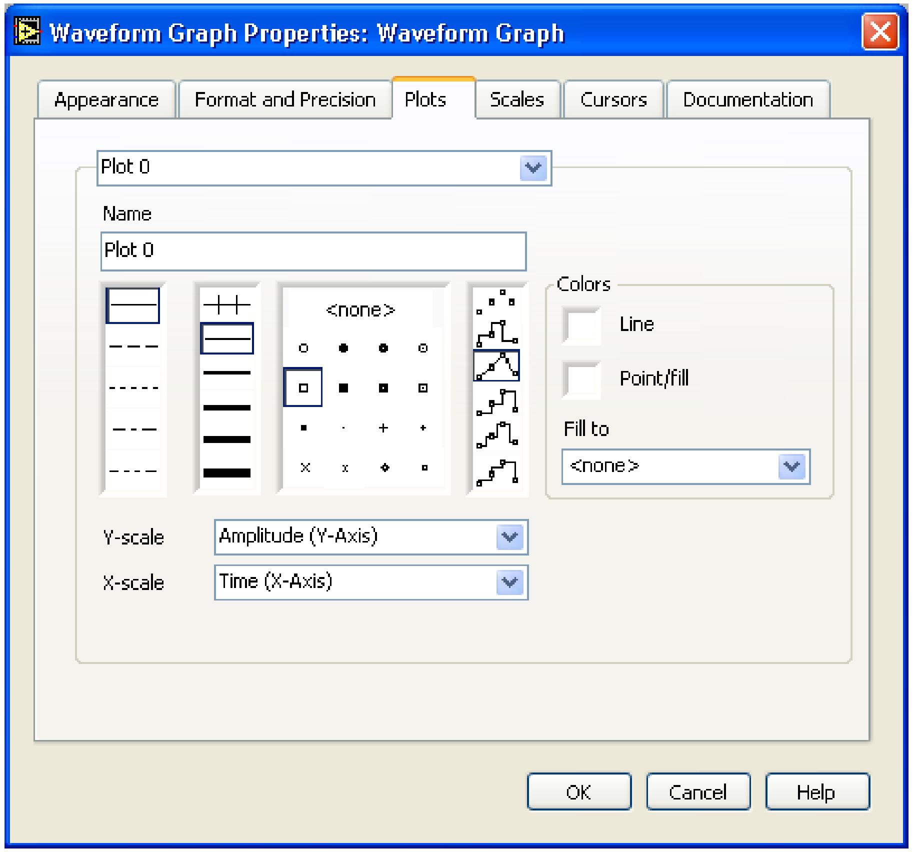
Controls>>All Controls>>Graphs

Waveform Graph – Plot an array of numbers against their indices
Express XY Graph – Plot one array against another
Digital Waveform Graph – Plot bits from binary data



Graphs




Waveform Graph Properties: Waveform Graph

Appearance | Format and Precision | Plots | Scales | Cursors | Documentation

Plot 0

Name: Plot 0

Colors: Line, Point/fill

Fill to: <none>

Y-scale: Amplitude (Y-Axis)

X-scale: Time (X-Axis)

OK Cancel Help

Right-Click on the Graph and choose Properties to Interactively Customize

Exercise 3 – Instantiate C2F.vi in a Top Level VI

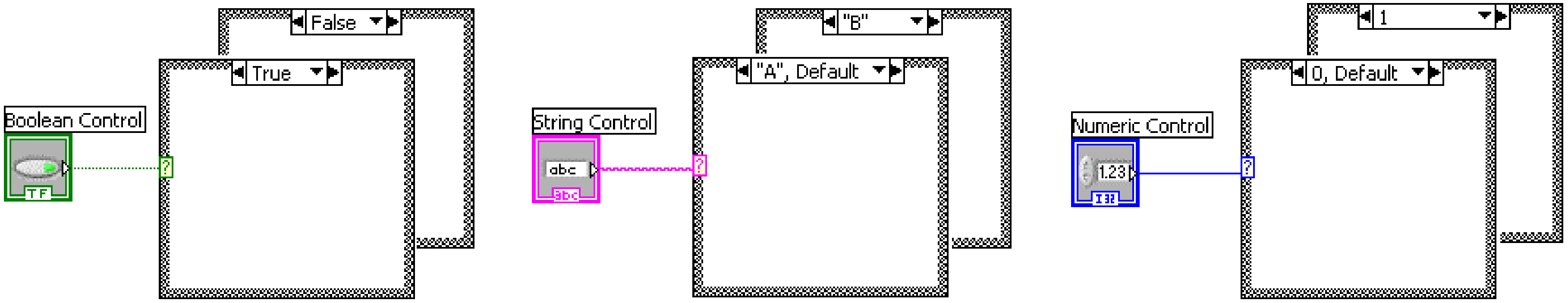
- Create a Top Level VI and insert C2F.vi
- Put C2F.vi in a For Loop and call it 100 times
  - Use the index i as the Celsius input to C2F.vi
  - Wire the output to the edge of the For Loop to create an array and plot the output

Section VI - Case & Sequence Structures, Formula Nodes

Case Structures

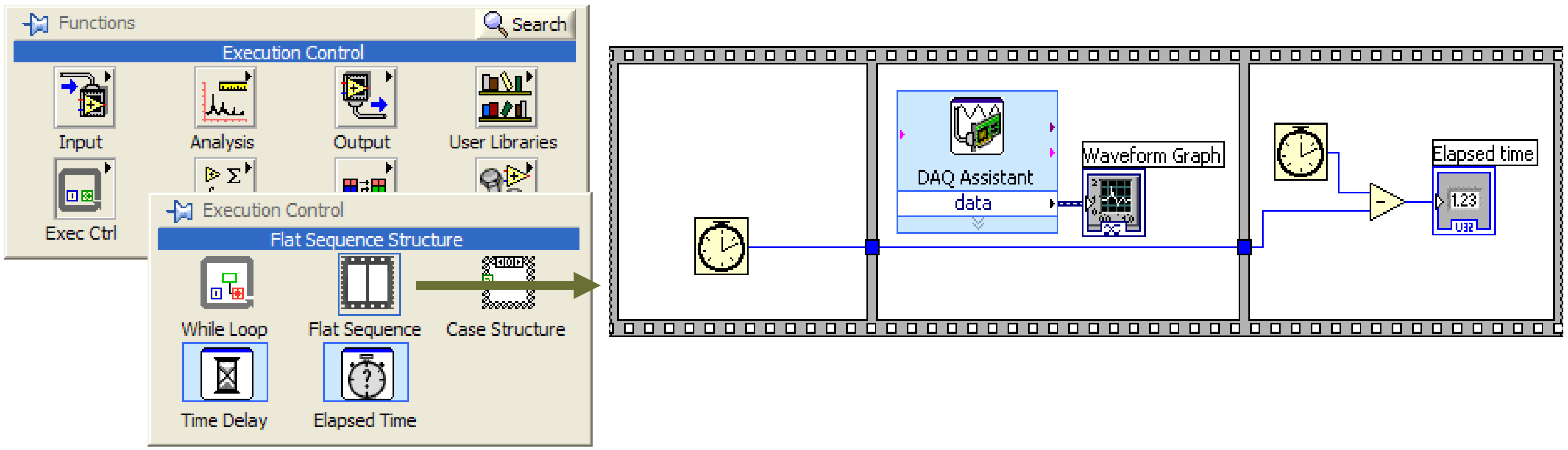
- In the Structures subpalette of Functions palette
- Enclose nodes or drag them inside the structure
- Stacked like a deck of cards, only one case visible

Functions >> Execution control



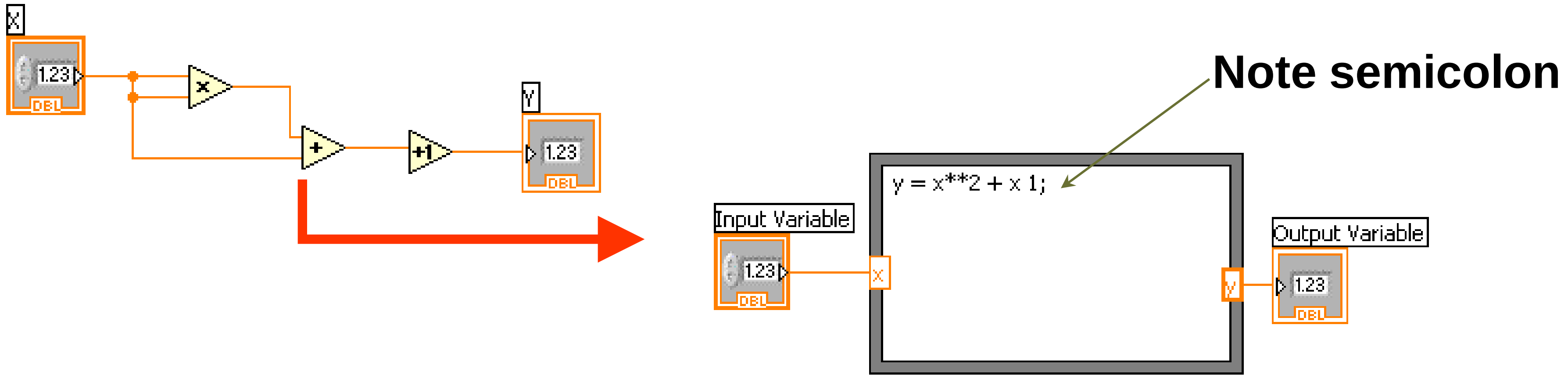
Sequence Structures

- In the **Execution Control** subpalette of Functions palette
- Executes diagrams sequentially
- Right-click to add new frame



Formula Nodes

- In the Structures subpalette
- Implement complicated equations
- Variables created at border
- Variable names are case sensitive
- Each statement must terminate with a semicolon (;)
- Context Help Window shows available functions


X
1.23
DBL
Y
1.23
DBL
Note semicolon
y = x**2 + x 1;
Input Variable
1.23
DBL
x
y
Output Variable
1.23
DBL