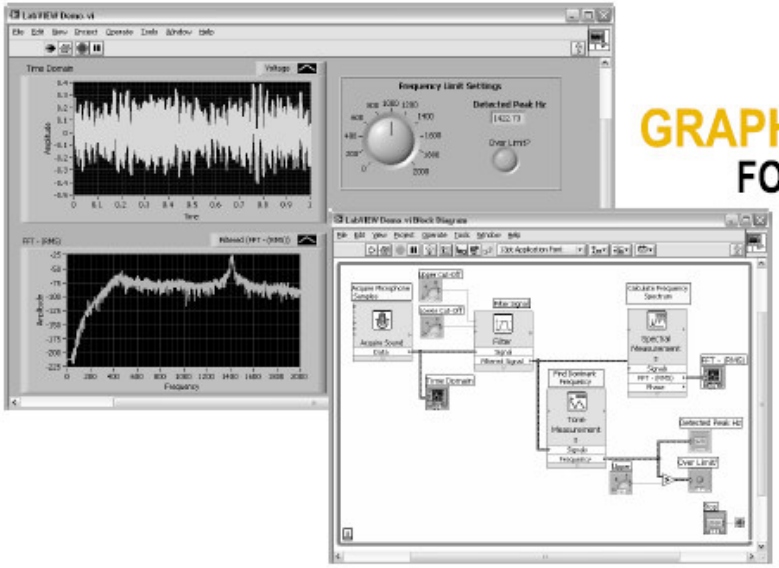
Introduction to LabVIEW



GRAPHICAL PROGRAMMING
FOR ENGINEERS AND SCIENTISTS

LabVIEW™

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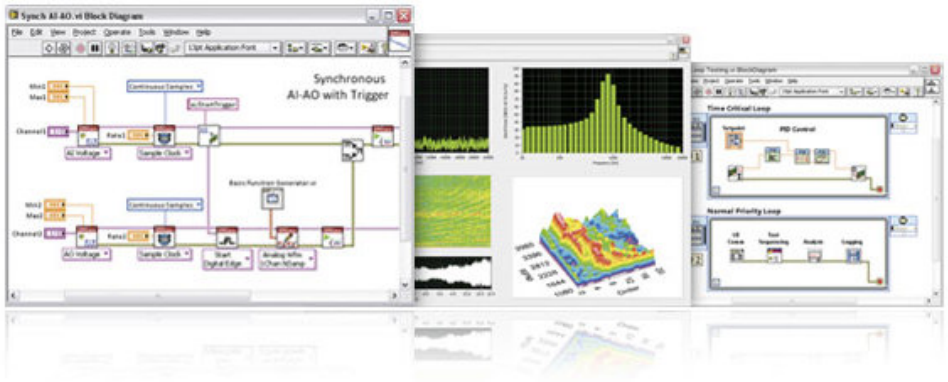
NATIONAL INSTRUMENTS

National Instruments: LabVIEW

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution order.

You can purchase several add-on software toolkits for developing specialized applications. All the toolkits integrate seamlessly in LabVIEW.

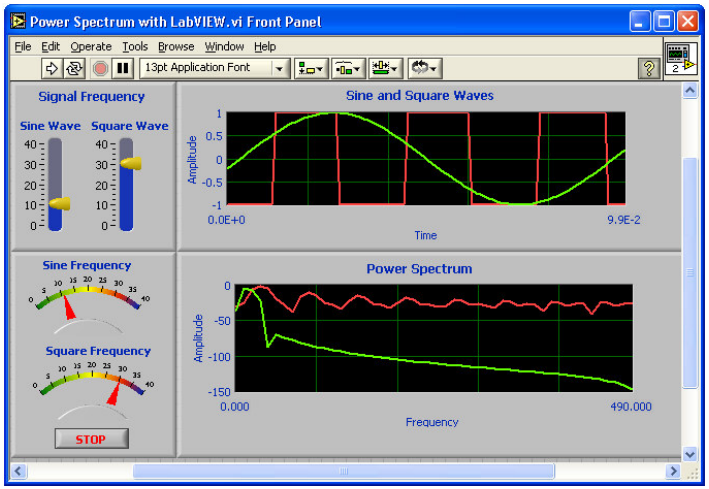
http://www.ni.com



LabVIEW Programs: Virtual Instruments (VIs)

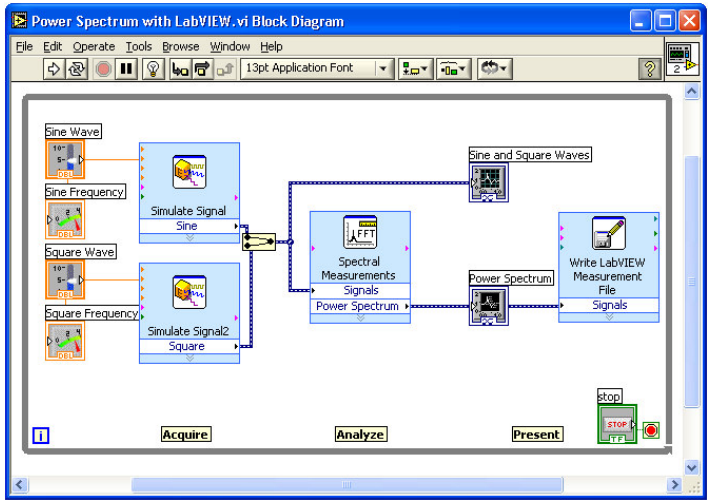
Front Panel

- Controls = Inputs
- Indicators = Outputs



Block Diagram

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

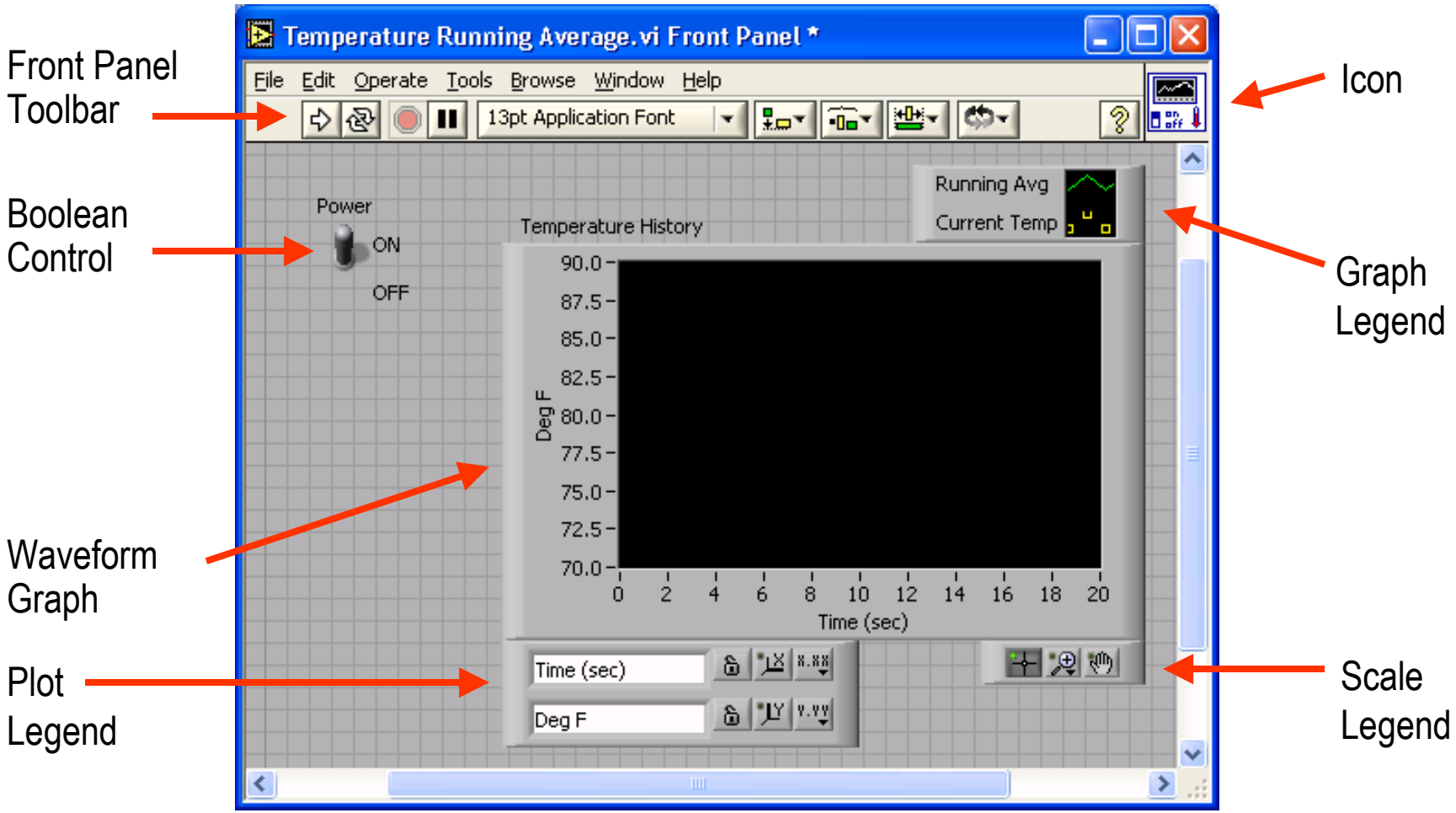


LabVIEW programming style

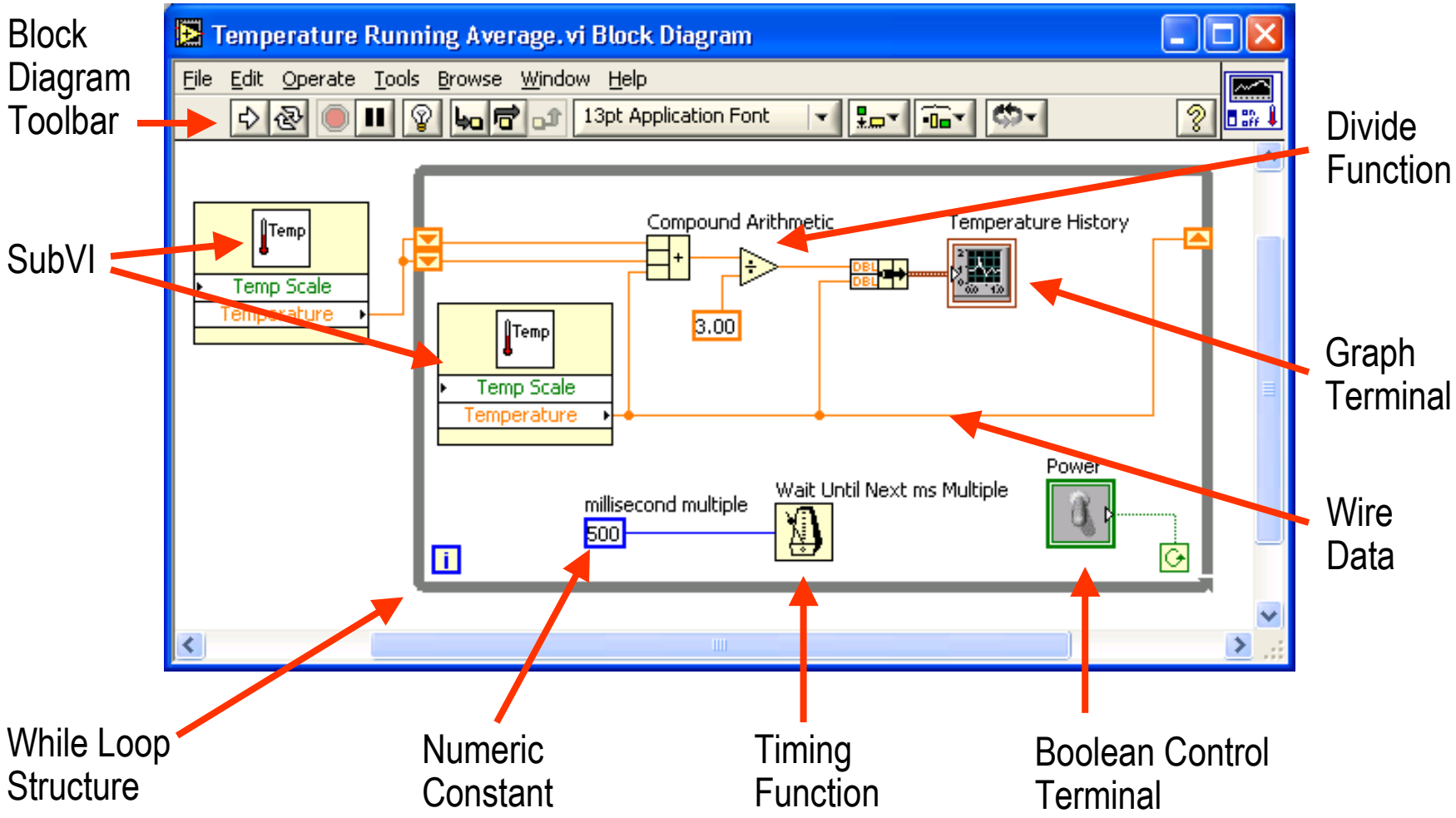
Users interact with the **Front Panel** when the program is running. Users can control the program, change inputs, and see data updated in real time. **Controls** are used for inputs such as, adjusting a slide control to set an alarm value, turning a switch on or off, or to stop a program. **Indicators** are used as outputs. Thermometers, lights, and other indicators display output values from the program. These may include data, program states, and other information.

Every front panel control or indicator has a corresponding terminal on the **block diagram**. When a VI is run, values from controls flow through the block diagram, where they are used in the **functions** on the diagram, and the results are passed into other functions or indicators through **wires**.

VI Front Panel

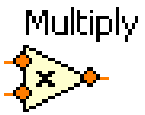


VI Block Diagram

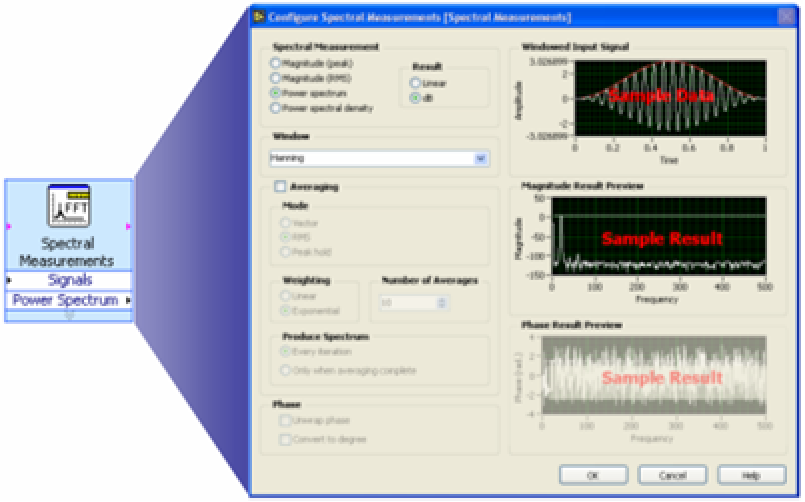


Express VIs, VIs and Functions

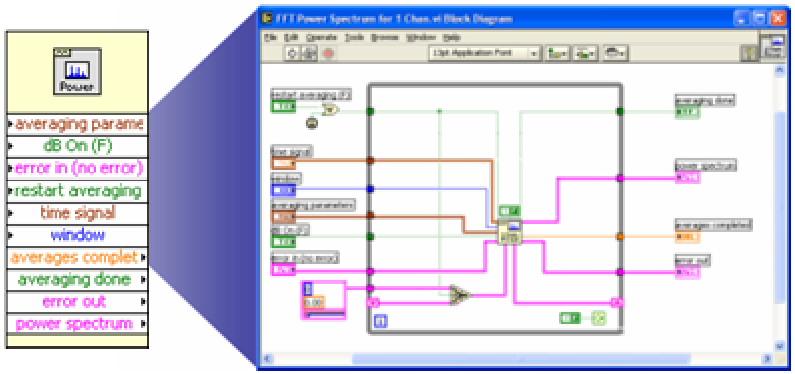
- Express VIs: interactive VIs with configurable dialog page
- Standard VIs: modularized VIs customized by wiring
- Functions: fundamental operating elements of LabVIEW; no front panel or block diagram



Function



Express VI



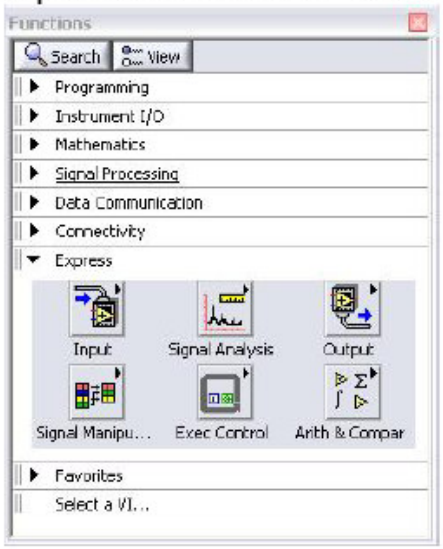
Standard VI

Labview Functions

What Types of Functions are Available?

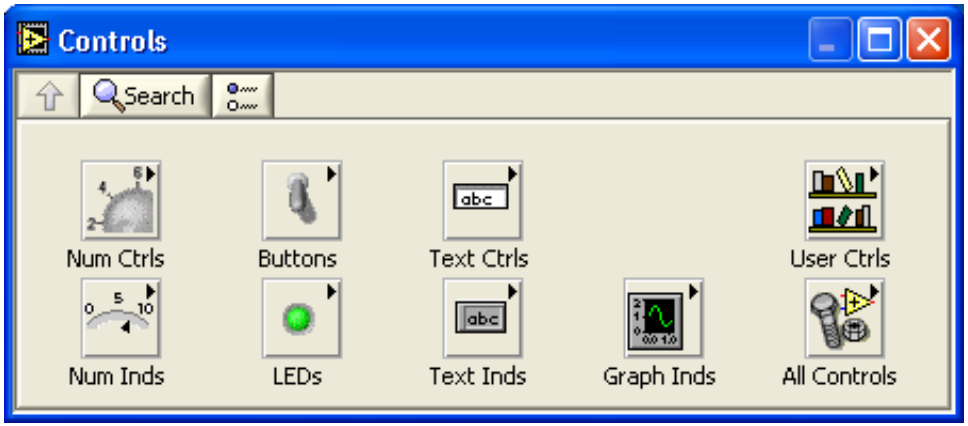
- **Input and Output**
  - Signal and Data Simulation
  - Acquire and Generate Real Signals with DAQ
  - Instrument I/O Assistant (Serial & GPIB)
  - ActiveX for communication with other programs
- **Analysis**
  - Signal Processing
  - Statistics
  - Advanced Math and Formulas
  - Continuous Time Solver
- **Storage**
  - File I/O

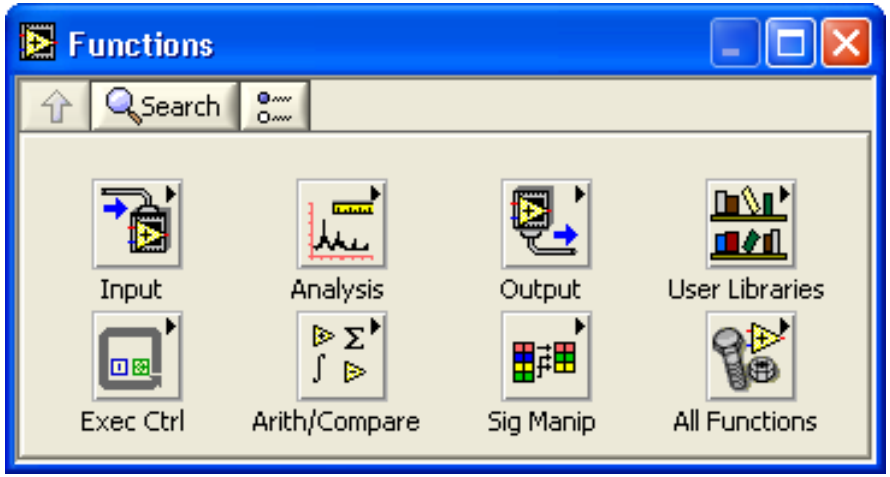
Express Functions Palette



Controls and Functions Palettes

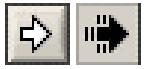
Controls Palette
(Front Panel Window)





Functions Palette
(Block Diagram Window)

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

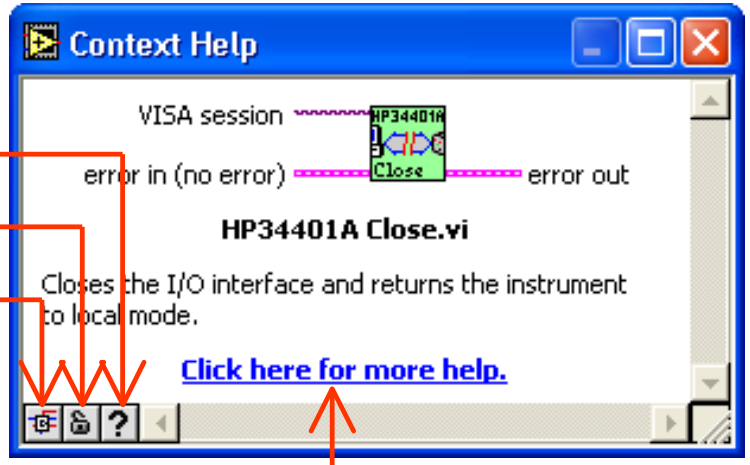
Step Over Button

Step Out Button

Help Options

Context Help

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



Online reference

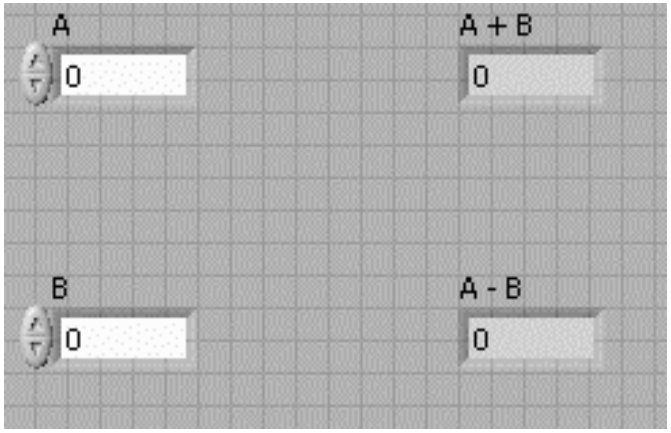
- All menus online
- Pop up on functions in diagram to access online info directly

Tips for Working in LabVIEW

- Keystroke Shortcuts
  - <Ctrl-H> – Activate/Deactivate Context Help Window
  - <Ctrl-B> – Remove Broken Wires From Block Diagram
  - <Ctrl-E> – Toggle Between Front Panel and Block Diagram
  - <Ctrl-Z> – Undo (Also in Edit Menu)
- Tools » Options… – Set Preferences in LabVIEW
- VI Properties – Configure VI Appearance, Documentation, etc.

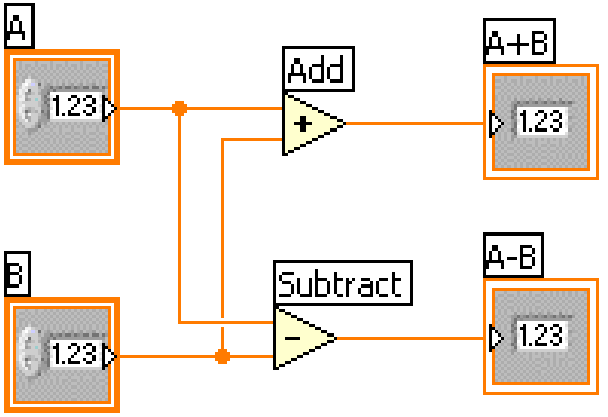
Creating a VI

Front Panel Window



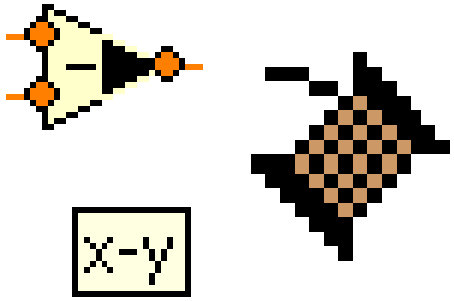
Block Diagram Window

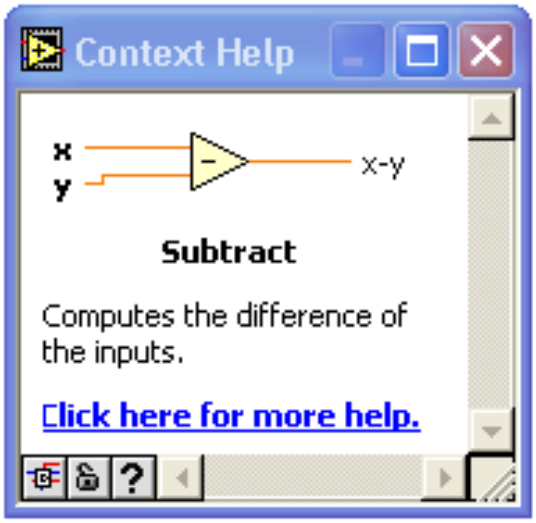
Control Terminals

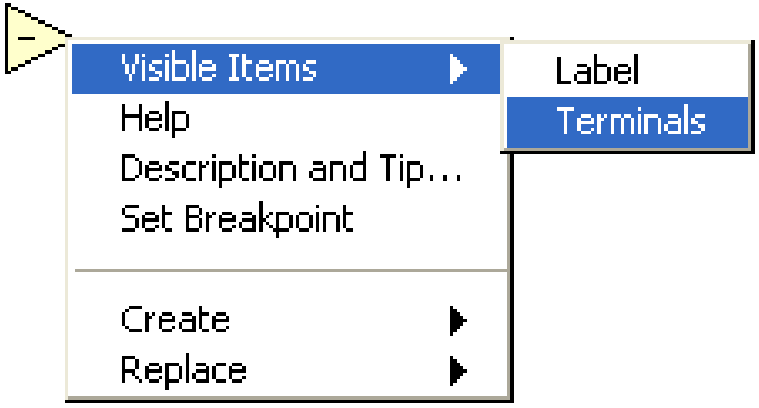


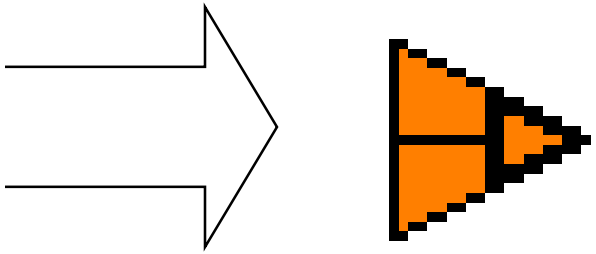
Indicator Terminals

Creating a VI – Block Diagram



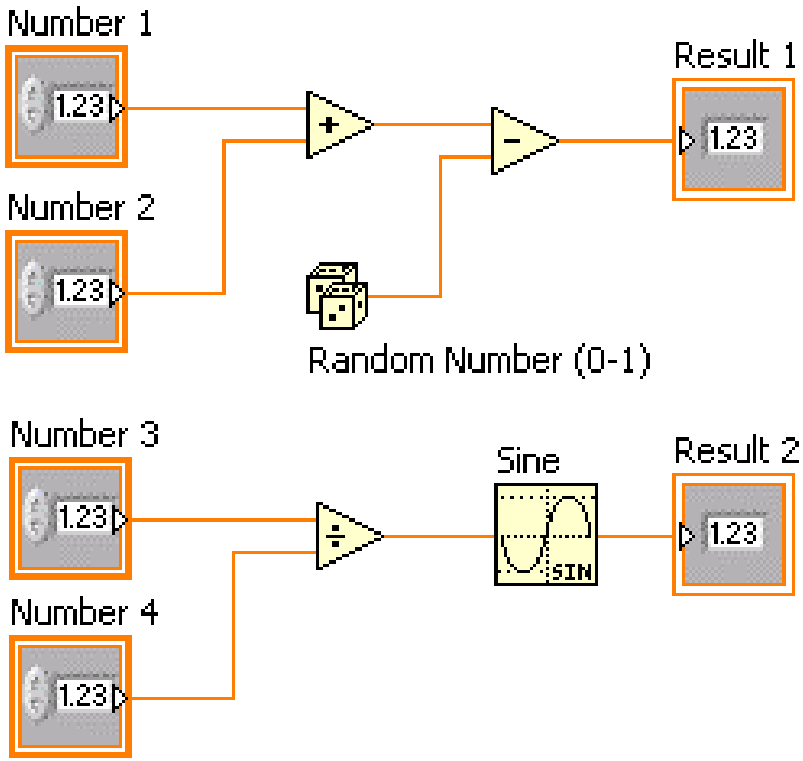






Dataflow Programming

- 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



Debugging Techniques

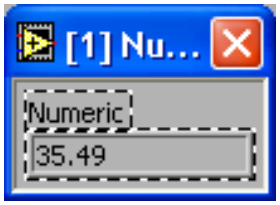
- **Finding Errors**

Click on broken Run button
Window showing error appears

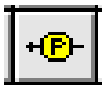
- **Execution Highlighting**

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

- **Probe**

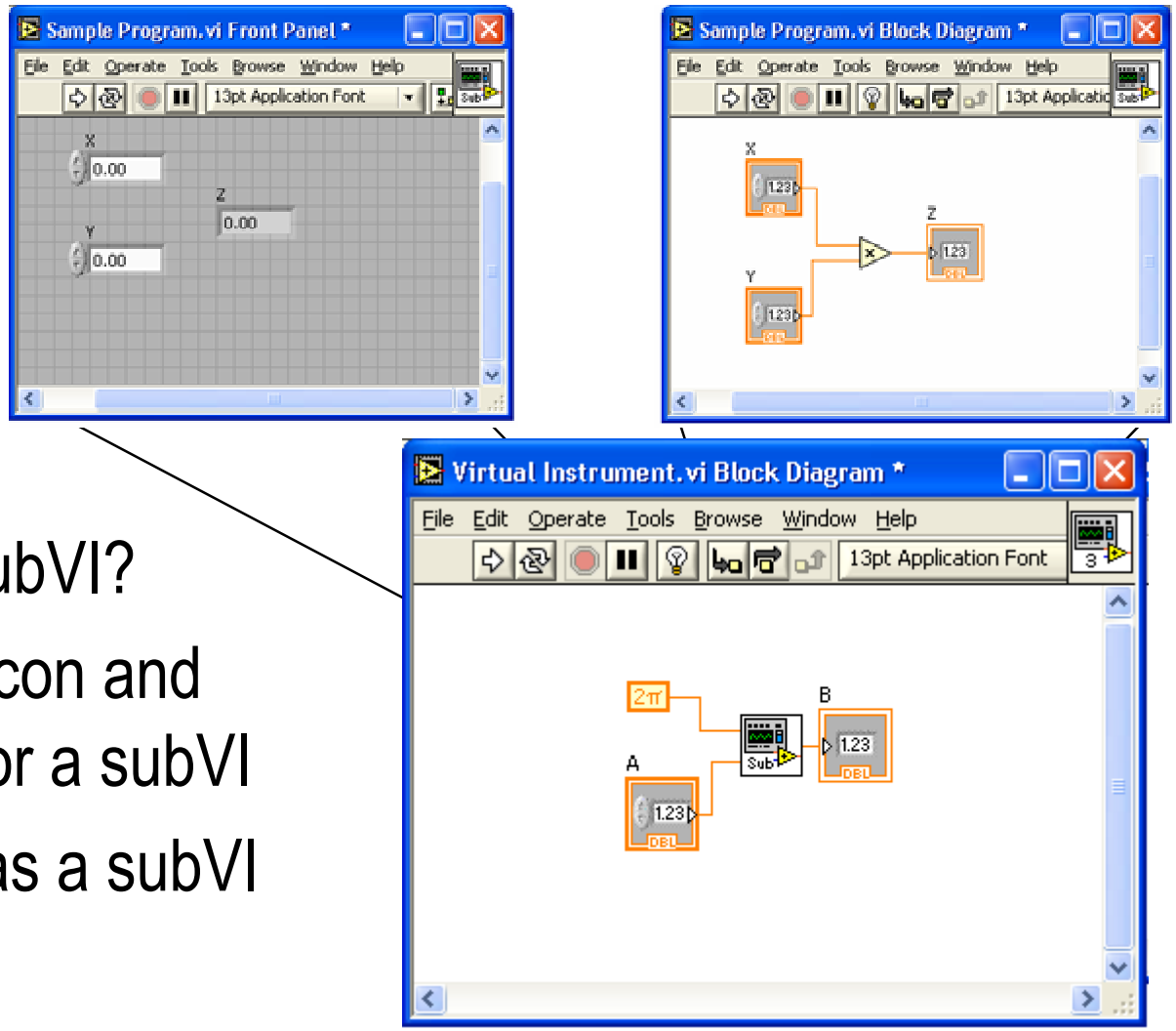


Right-click on wire to display probe and it shows data as it flows through wire segment



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

SubVIs

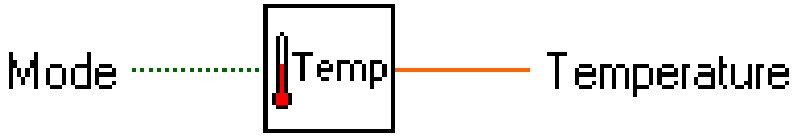


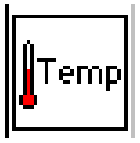
- What is a subVI?
- Making an icon and connector for a subVI
- Using a VI as a subVI

SubVIs

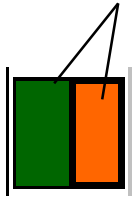
- A SubVI is a VI that can be used within another VI
- Similar to a subroutine
- Advantages
  - Modular
  - Easier to debug
  - Don’t have to recreate code
  - Require less memory

Icon and Connector





- An icon represents a VI in other block diagrams



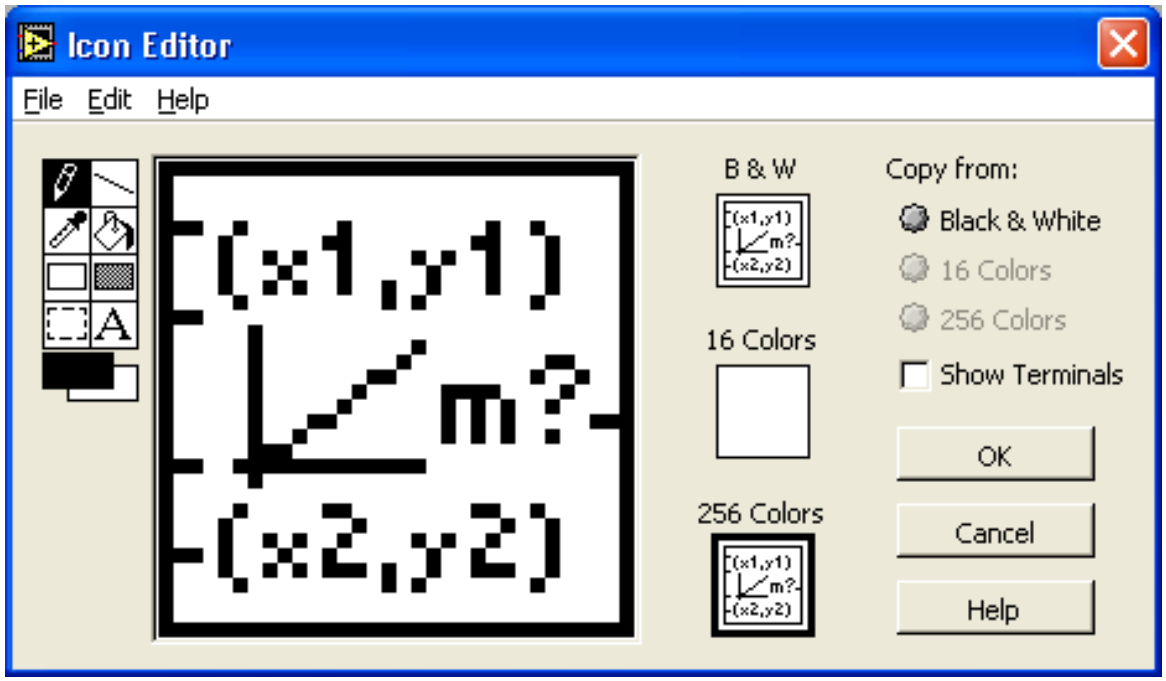
- A connector shows available terminals for data transfer

Steps to Create a SubVI

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

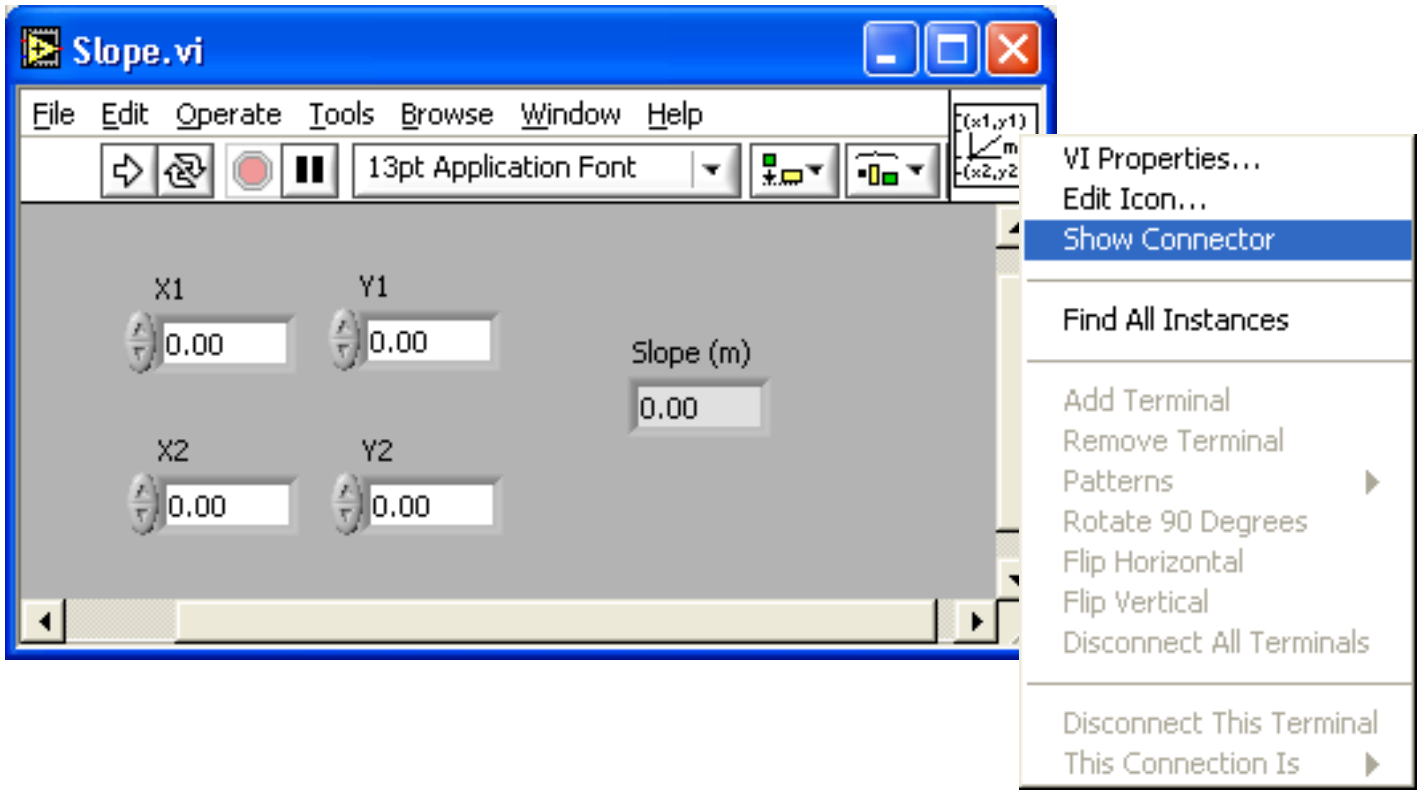
Create the Icon

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

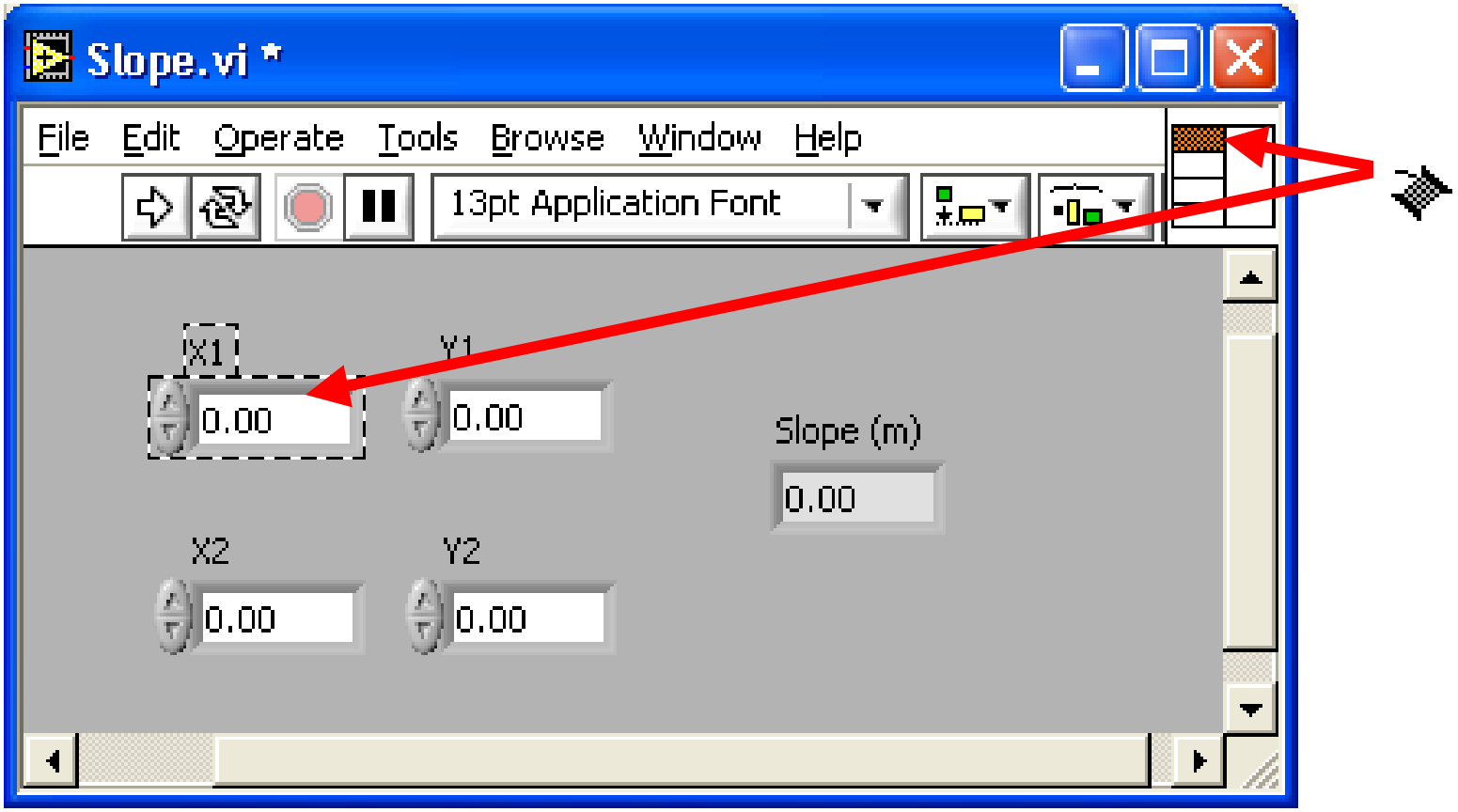


Create the Connector

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

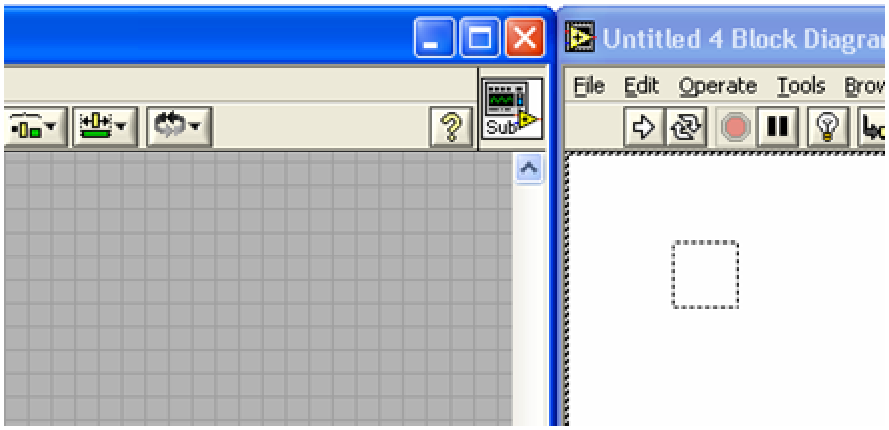
Insert the SubVI into a Top Level VI

Accessing user-made subVIs

Functions >>All Functions >> Select a VI

Or

Drag icon onto target diagram

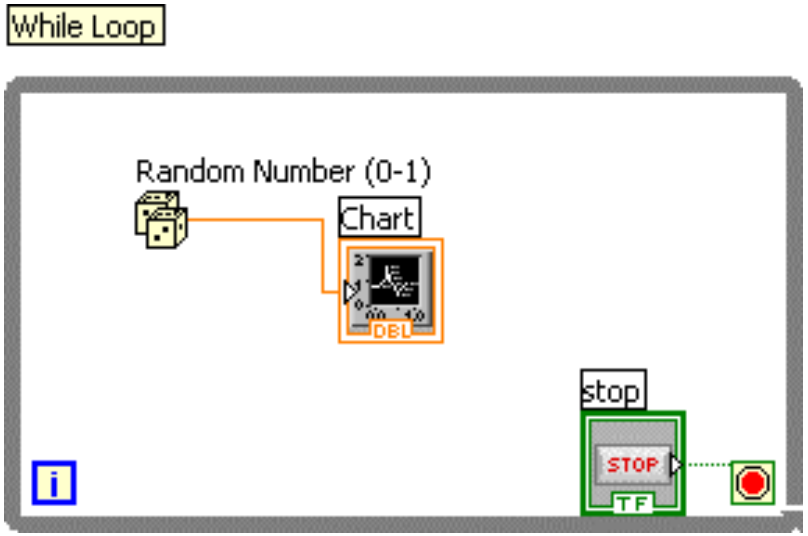


Loops and Charts

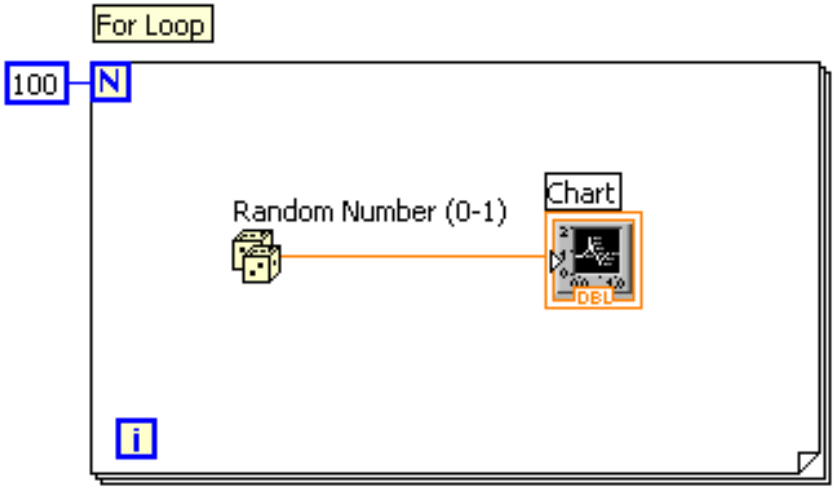
- For Loop
- While Loop
- Charts
- Multiplots

Loops

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

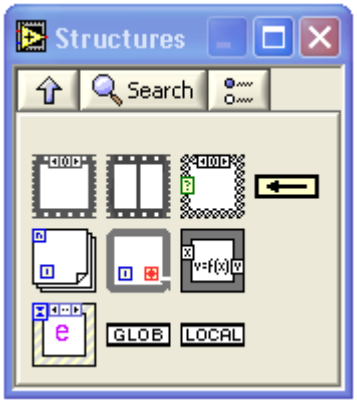


- For Loops
  - Have Iteration Terminal
  - Run According to input **N** of Count Terminal

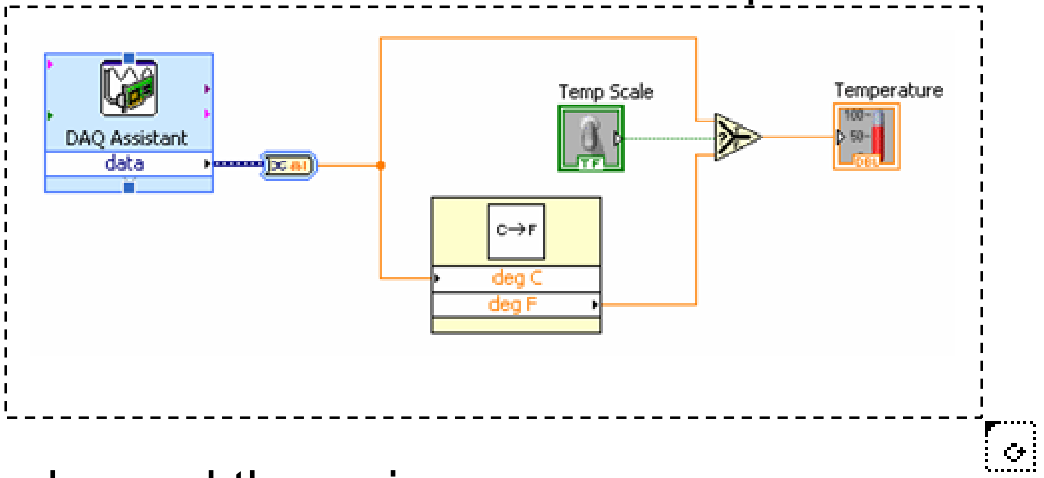


Loops

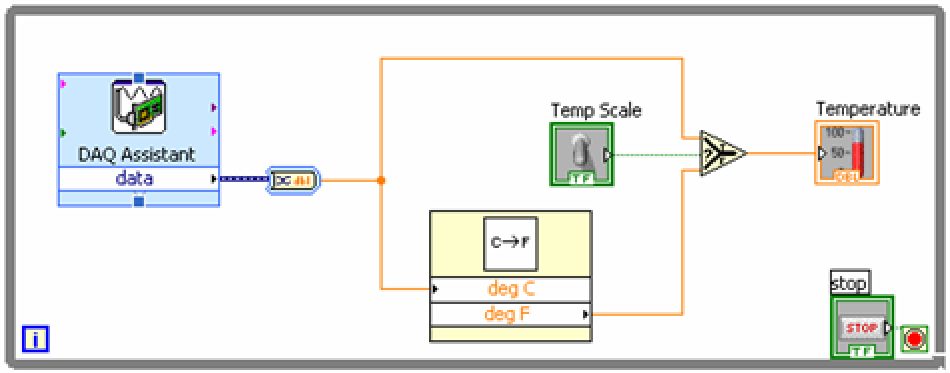
1. Select the loop



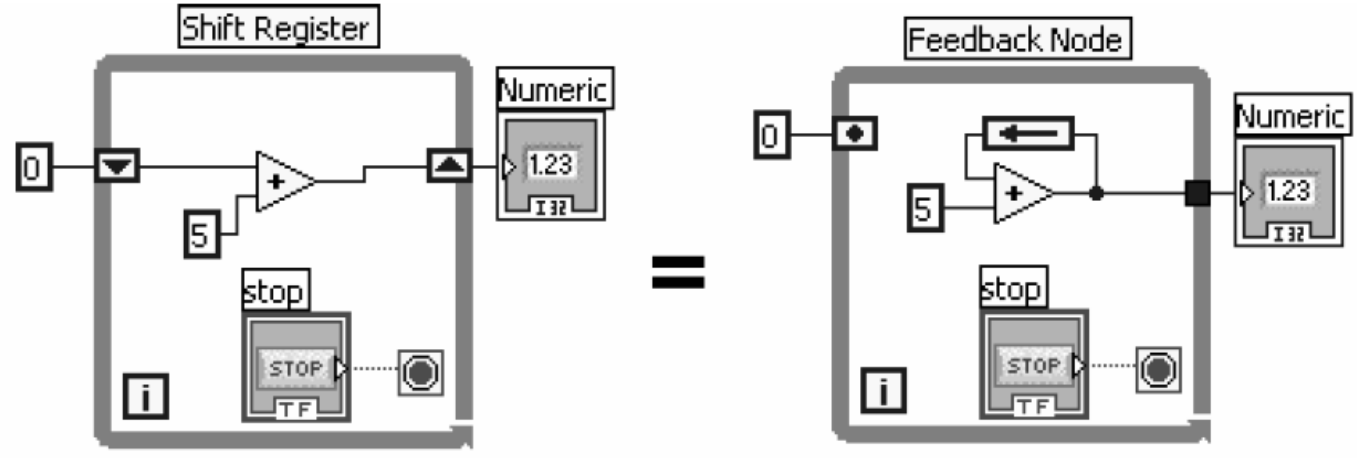
2. Enclose code to be repeated



3. Drop or drag additional nodes and then wire



Shift register

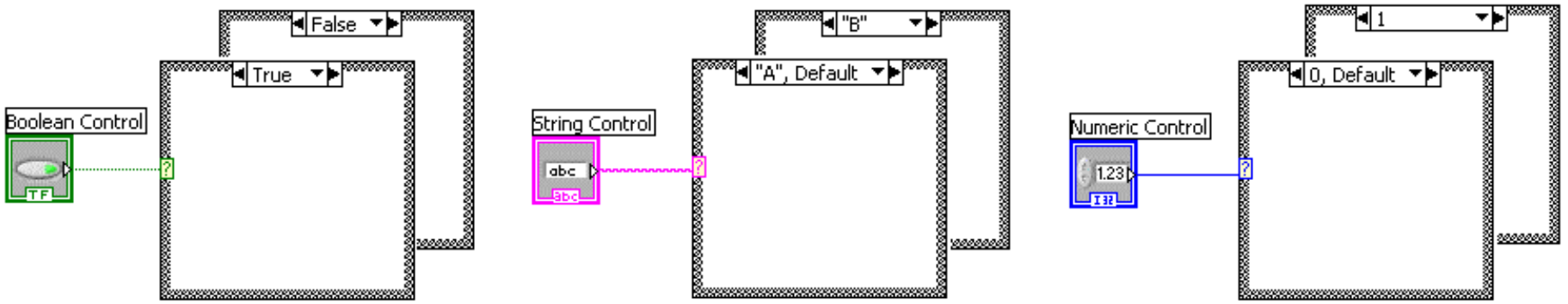


An input of 0 would result in an output of 5 the first iteration, 10 the second iteration and 15 the third iteration. Said another way, shift registers are used to retain values from one iteration to the next. They are valuable for many applications that have memory or feedback between states.

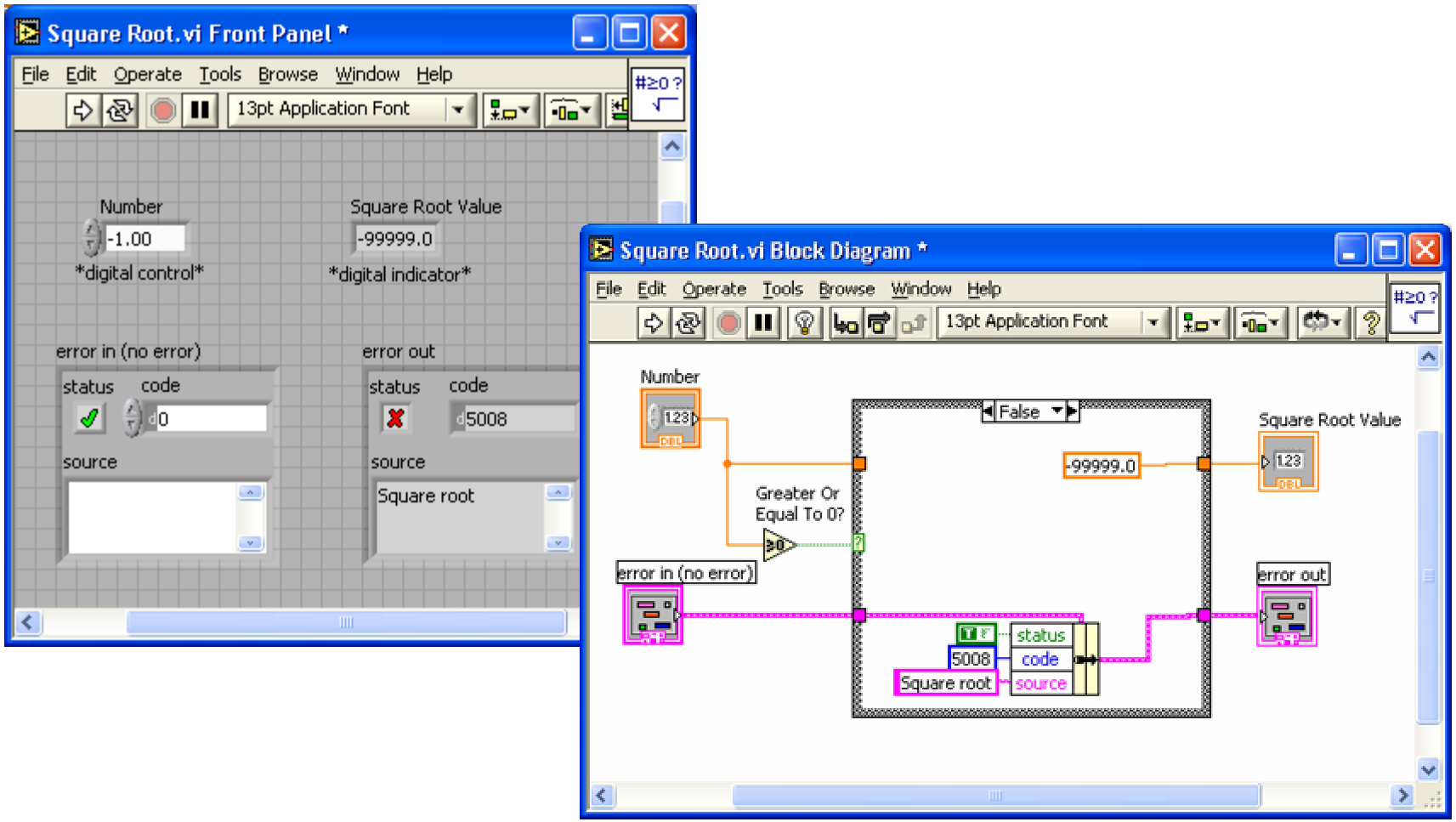
Case Structures

- 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



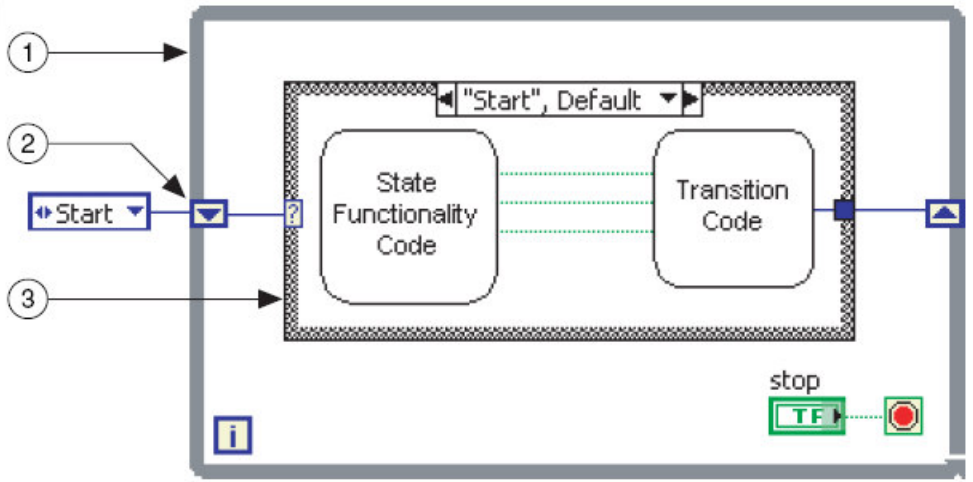
Case Structures



State machine with Labview

State Machines

- While Loop
- Case Structure
- Shift Register



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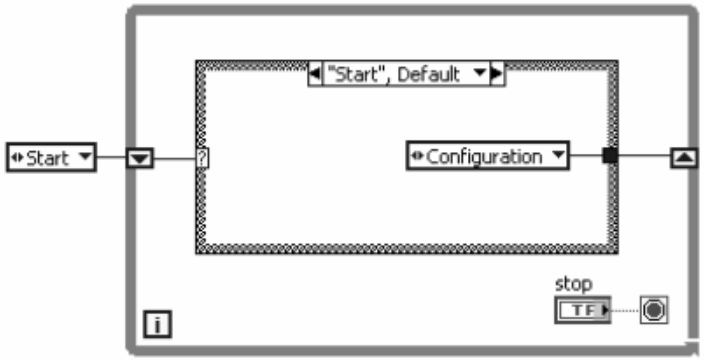
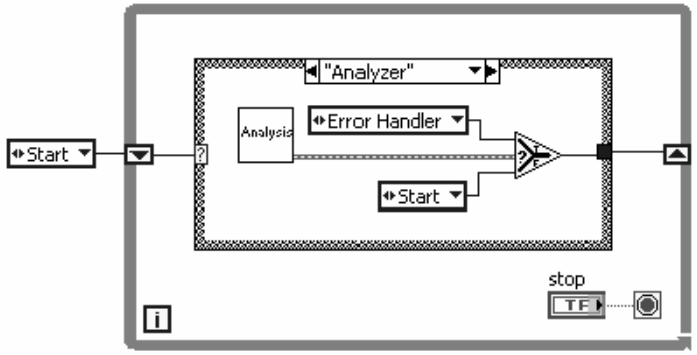
State machine with Labview

State Machines Transitions

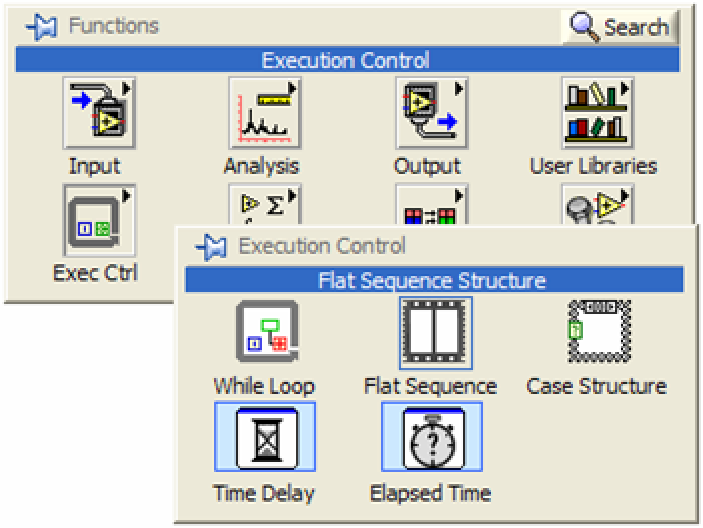
- Several programming techniques exist for transitioning from state to state in LabVIEW using State Machines
- Default transition implies that after one state, another state always follows
- Transitions between two potential states can be handled by a Select Function

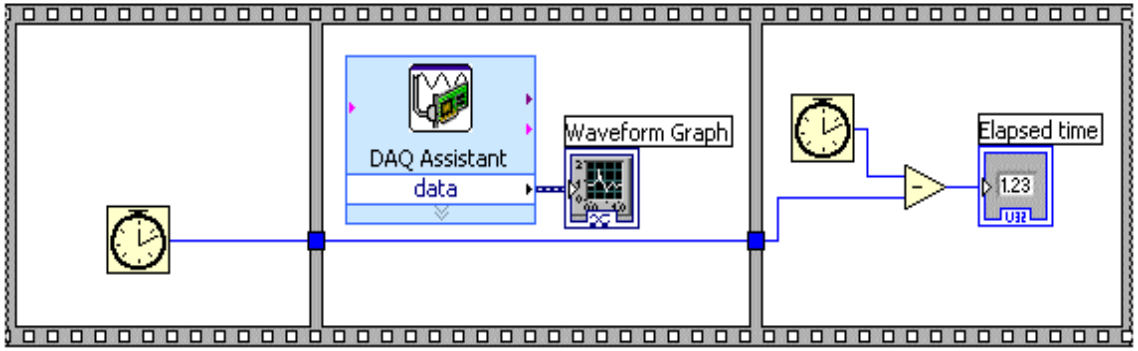




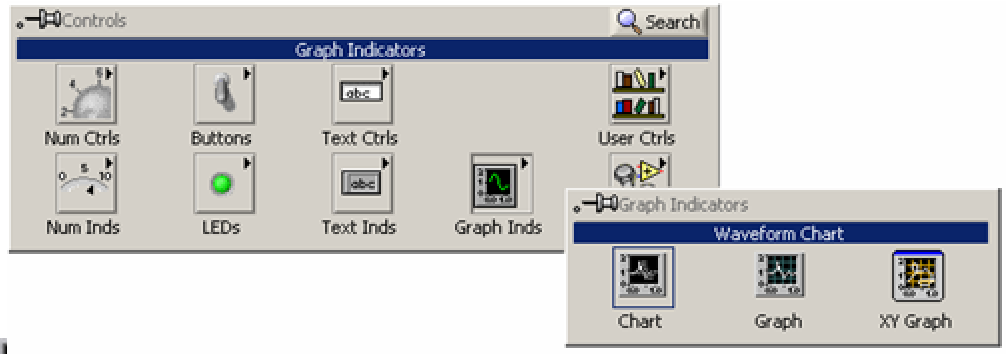
Sequence Structures

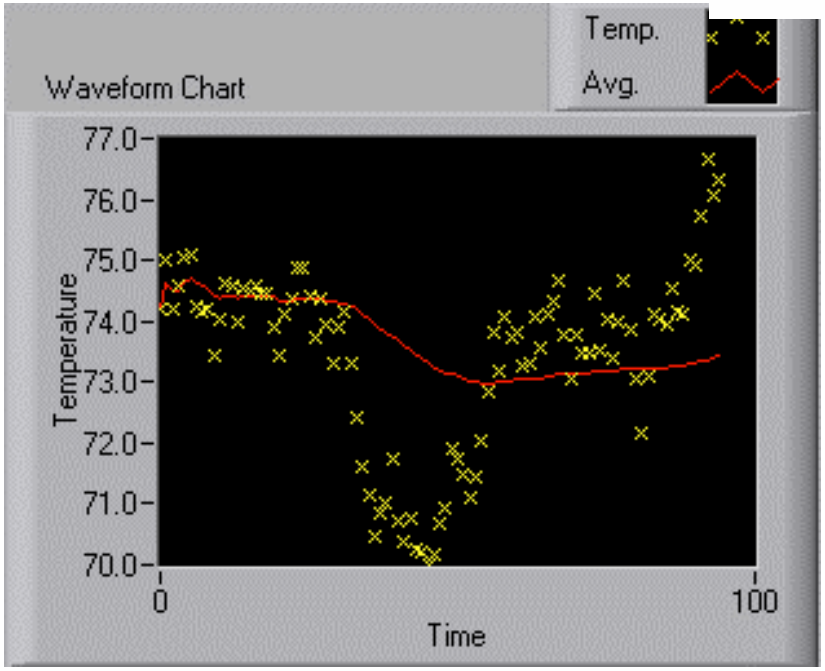
- In the **Execution Control** subpalette of Functions palette
- Executes diagrams sequentially
- Right-click to add new frame





Charts



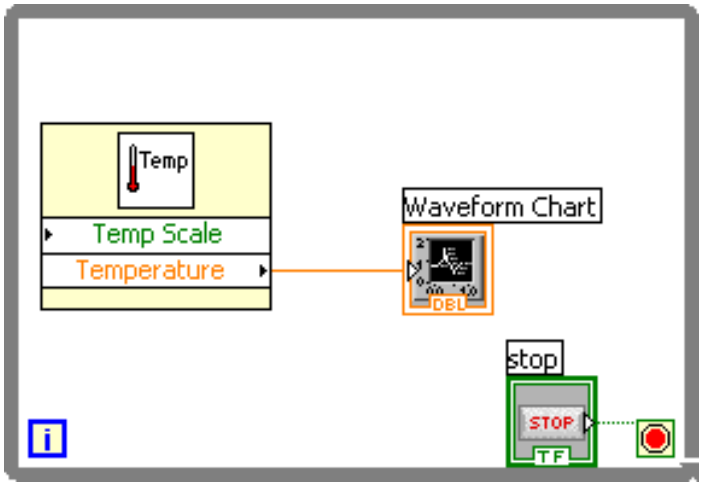


Waveform chart – special numeric indicator that can display a history of values

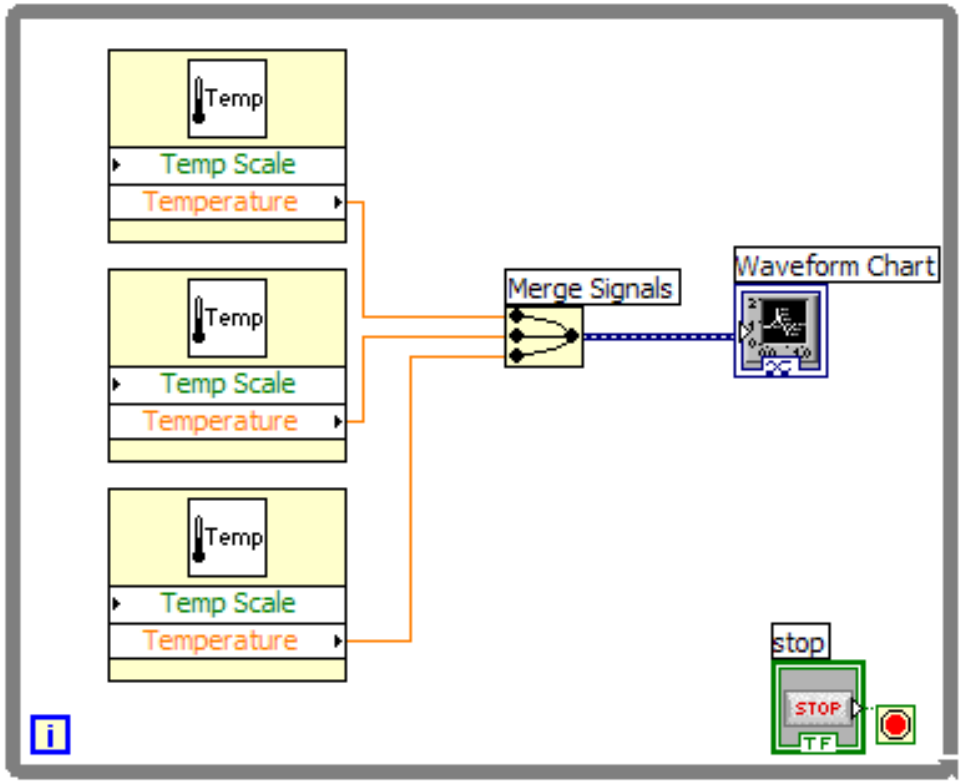
Controls >> Graph Indicators >> Waveform Chart

Wiring Data into Charts

Single Plot Charts



Multiplot Charts



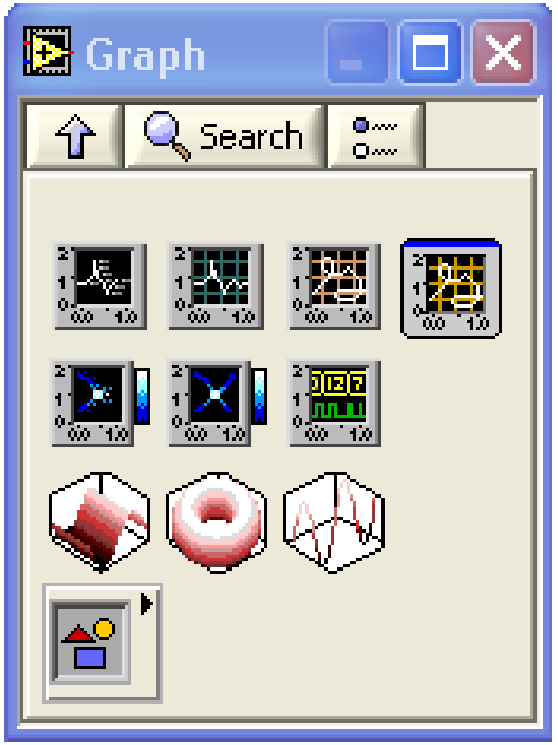
Graphs

- Selected from the Graph palette of Controls menu **Controls>>All Controls>>Graphs**

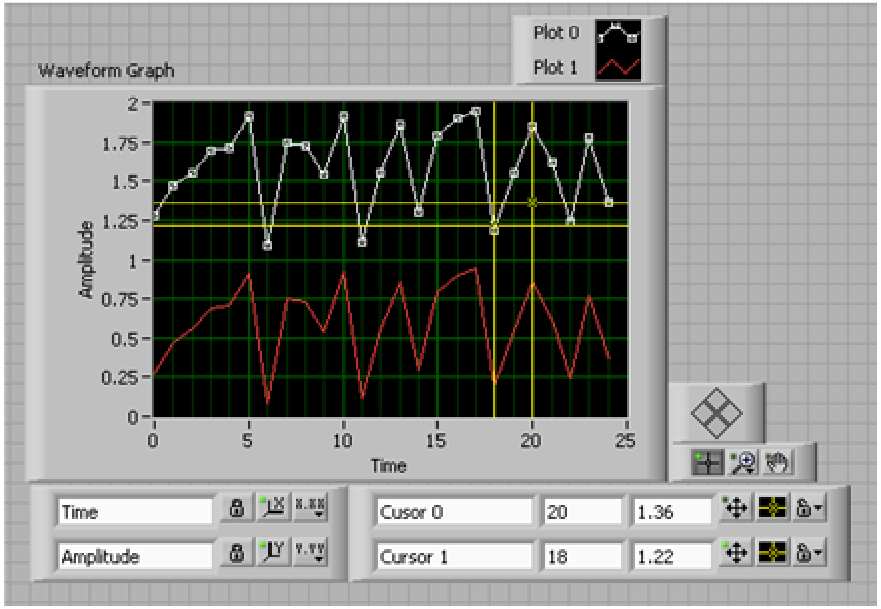
Waveform Graph – Plot an array of numbers against their indices

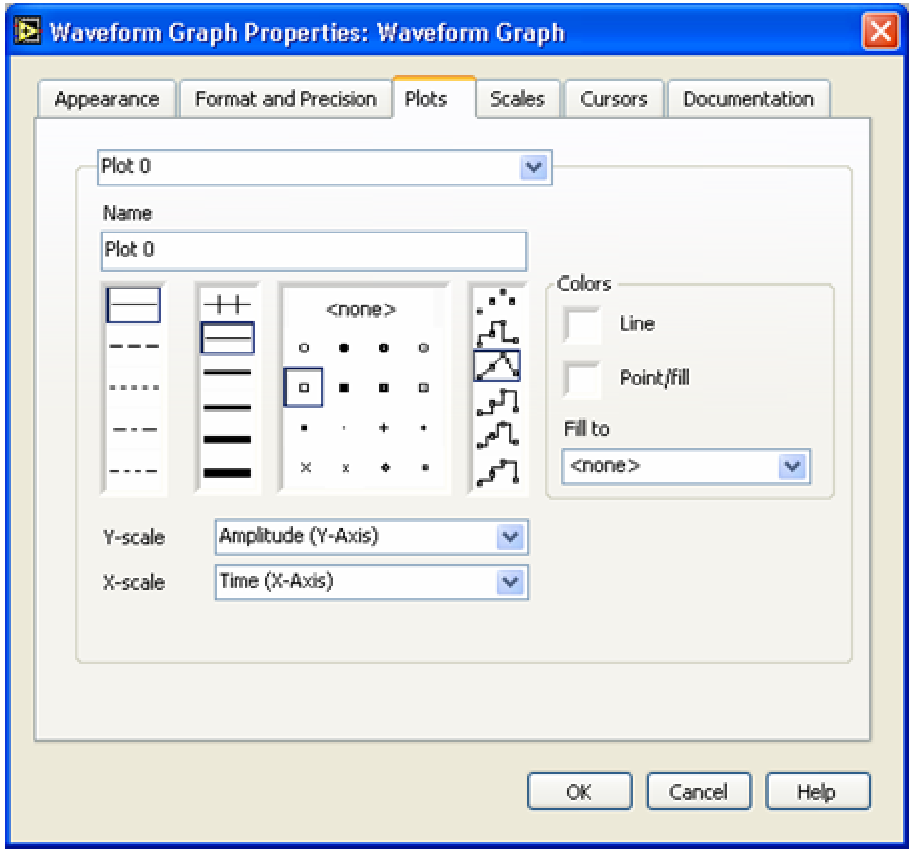
Express XY Graph – Plot one array against another

Digital Waveform Graph – Plot bits from binary data



Graphs





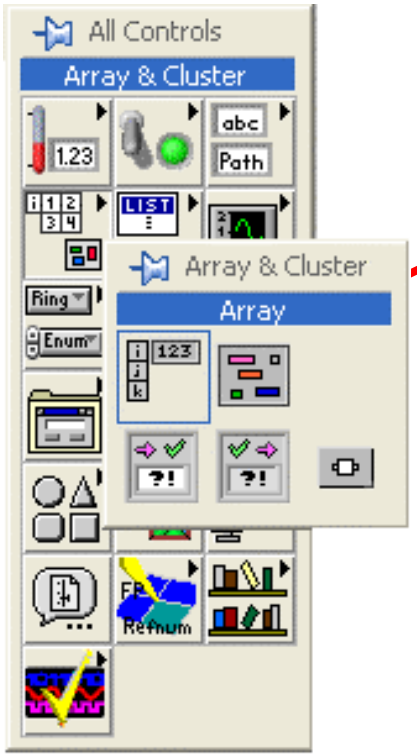
Right-Click on the Graph and choose Properties to Interactively Customize

Arrays & File I/O

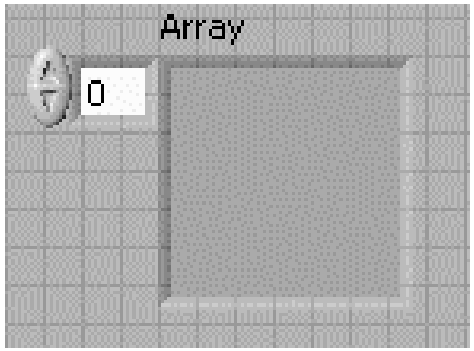
- Build arrays manually
- Have LabVIEW build arrays automatically
- Write to a spreadsheet file
- Read from a spreadsheet file

Adding an Array to the Front Panel

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

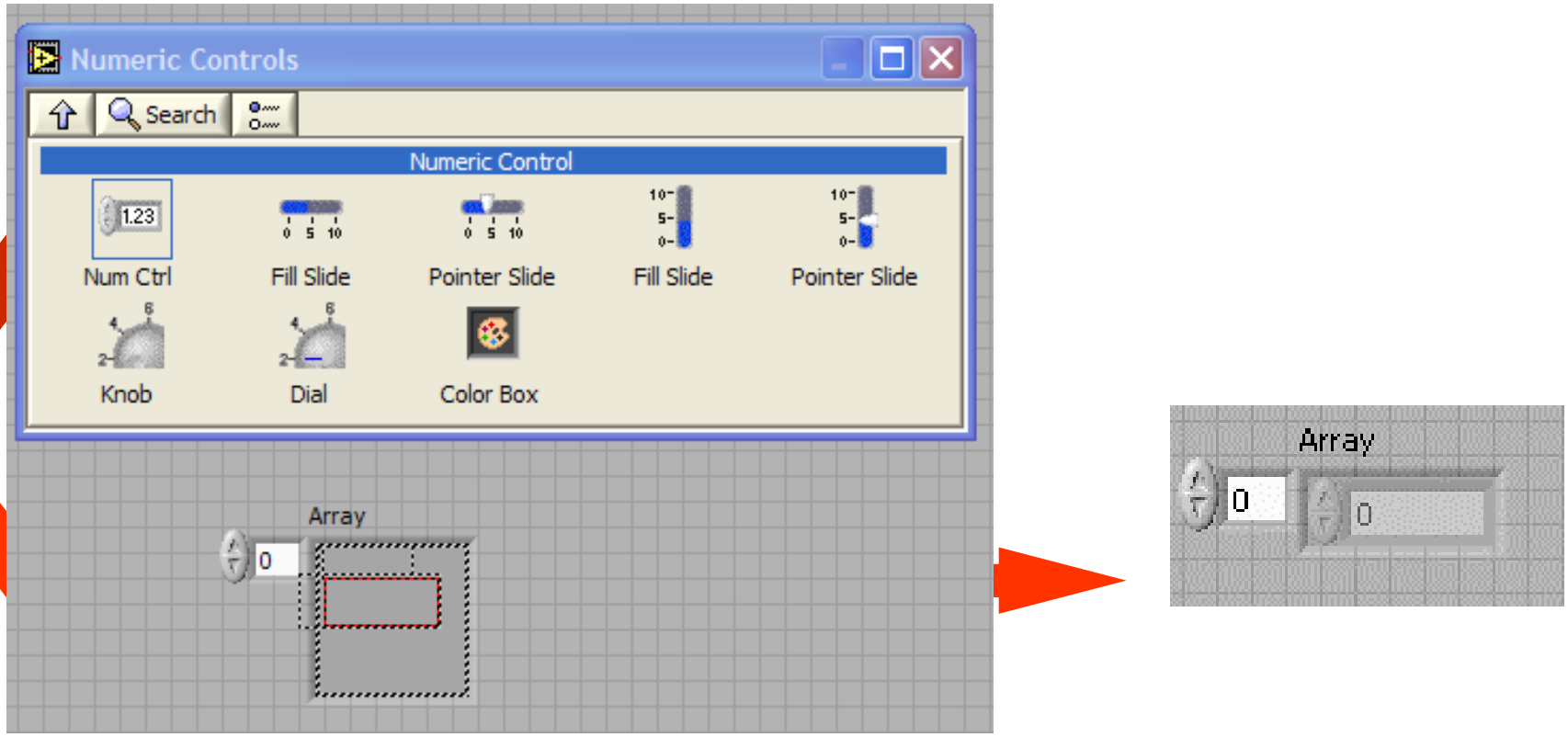


Drop it on the screen.



Adding an Array

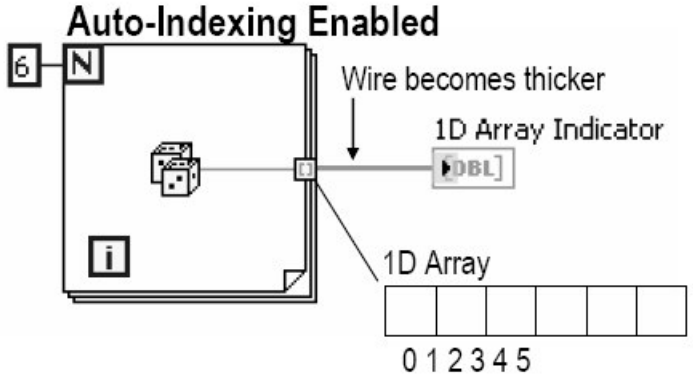
Place data object into shell (i.e. Numeric Control)

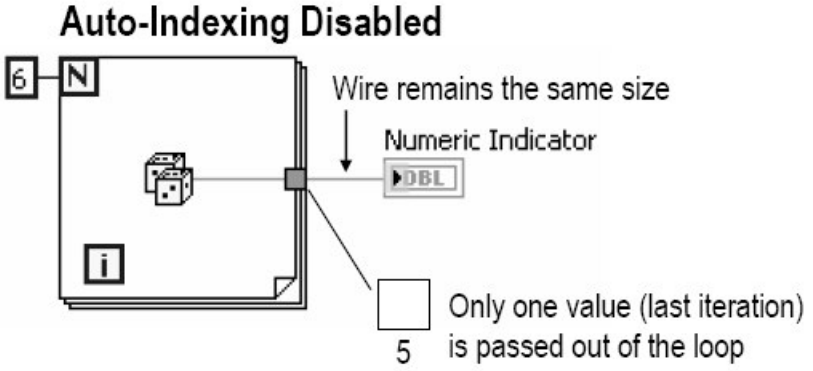


Building an Array

Building Arrays with Loops (Auto-Indexing)

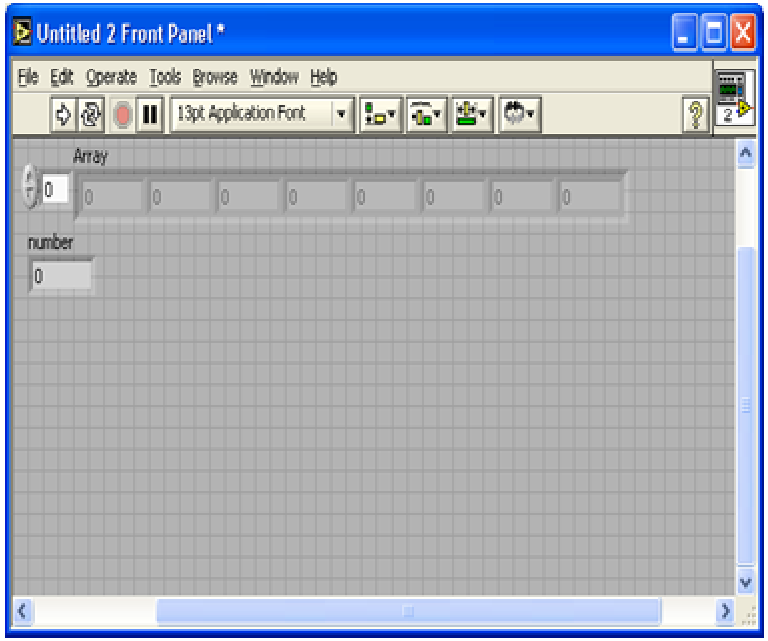
- Loops can accumulate arrays at their boundaries with auto-indexing
- For Loops auto-index by default
- While Loops output only the final value by default
- Right-click tunnel and enable/disable auto-indexing

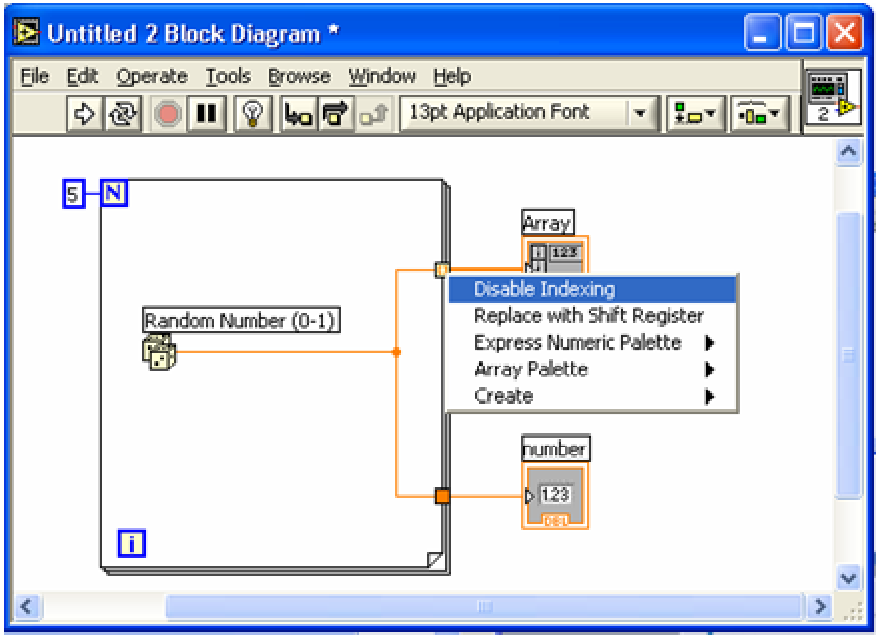




Creating an Array with a Loop

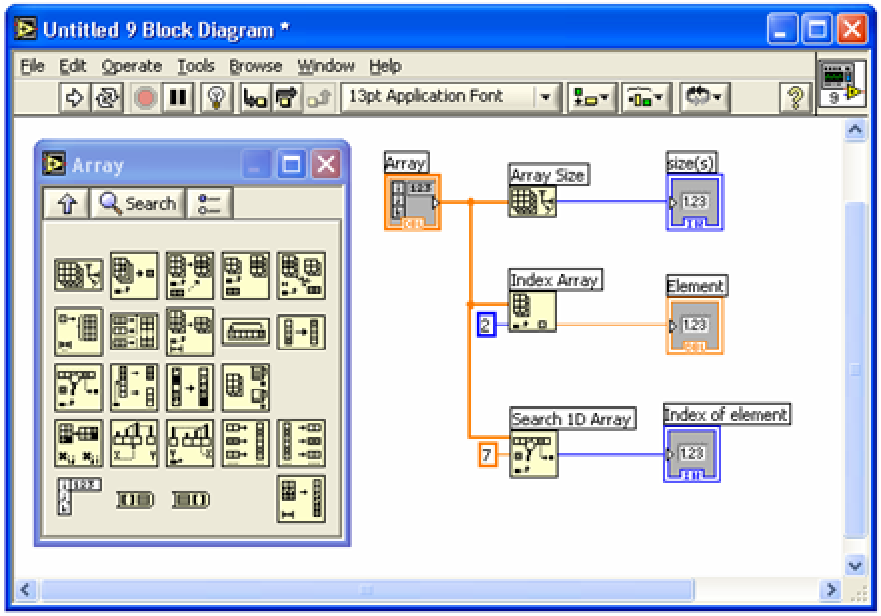
- Loops accumulate arrays at their boundaries

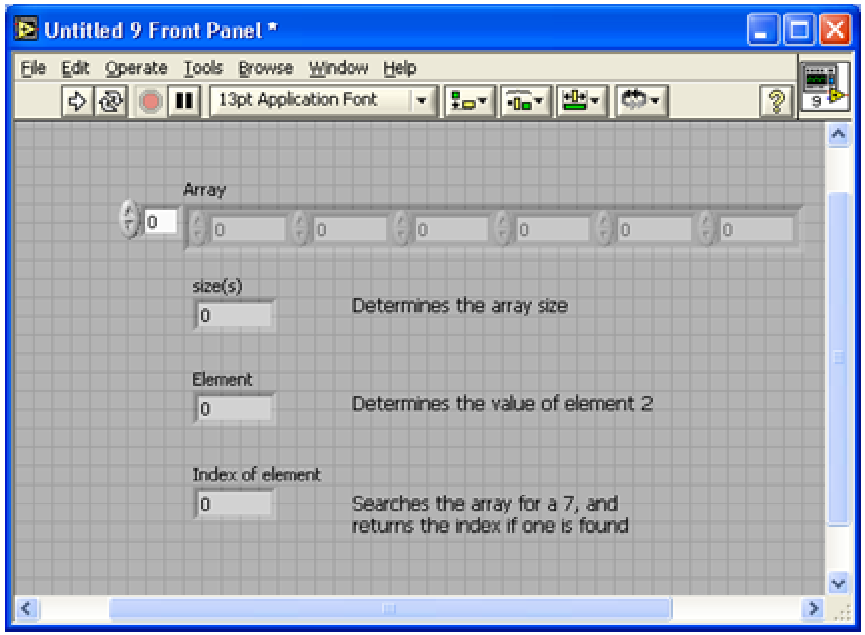




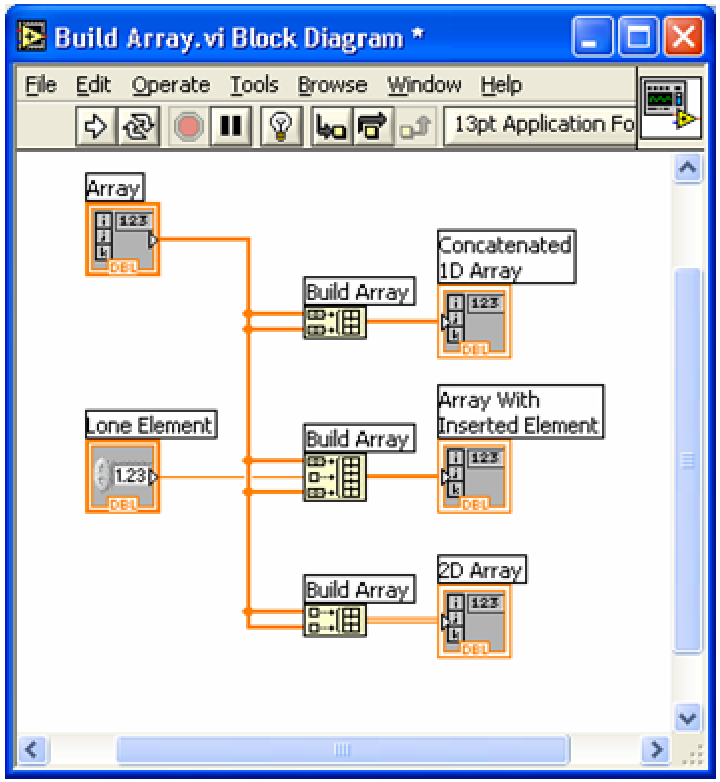
Array Functions – Basics

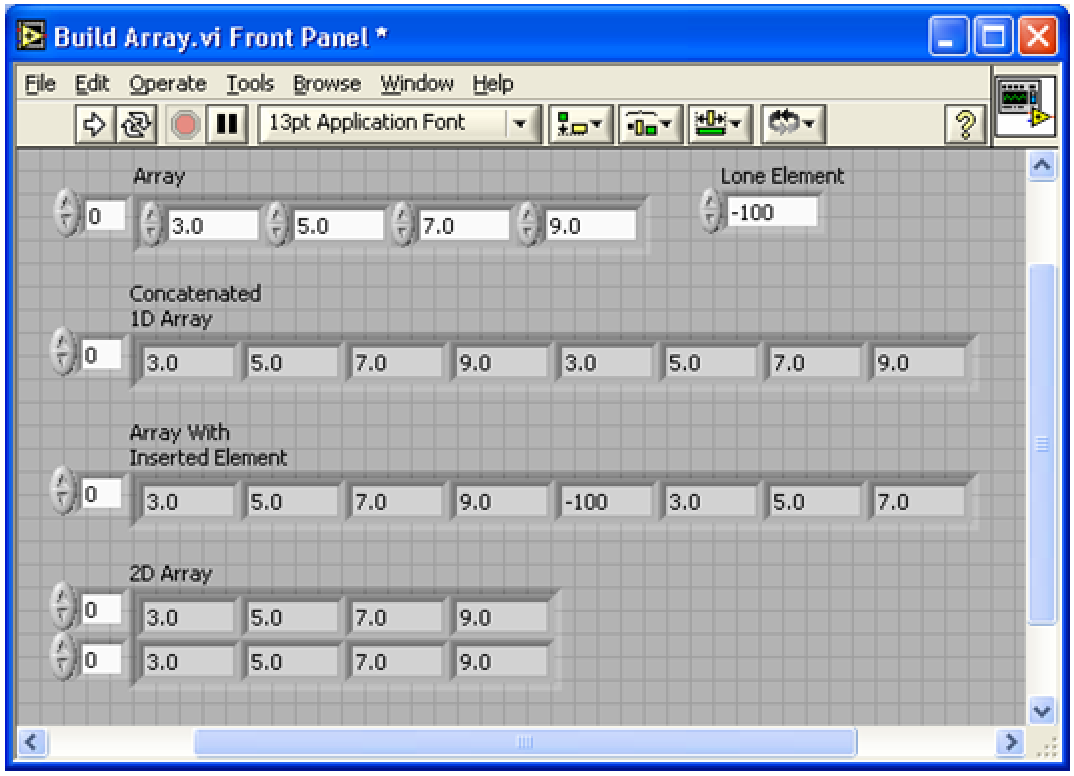
Functions >> All functions>> Array





Array Functions – Build Array



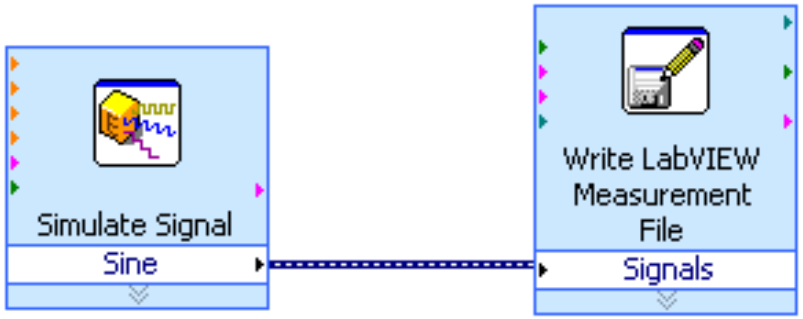


File I/O

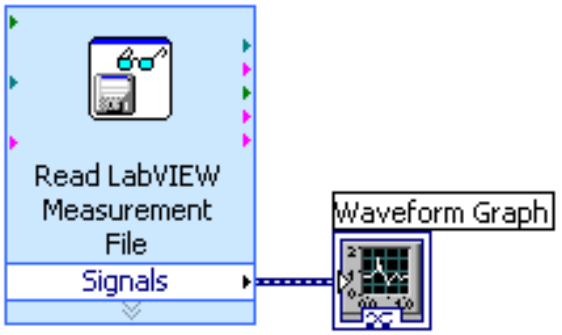
File I/O – passing data to and from files

- Files can be binary, text, or spreadsheet
- Write/Read LabVIEW Measurements file (*.lvm)

Writing to LVM file

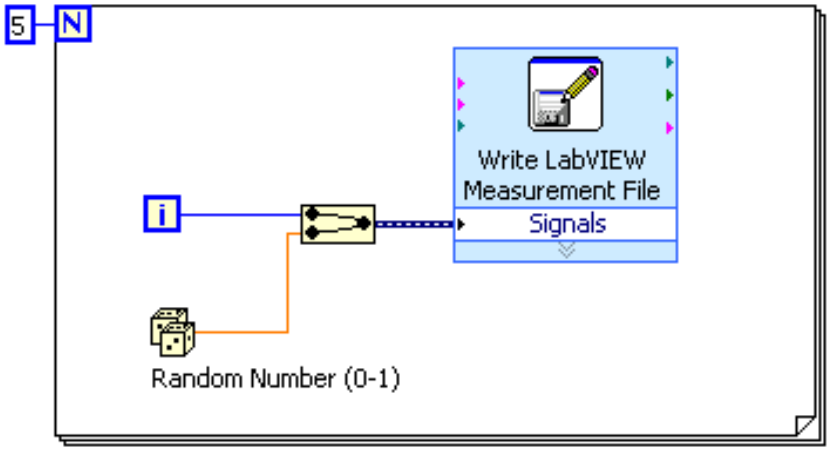


Reading from LVM file



Write LabVIEW Measurement File

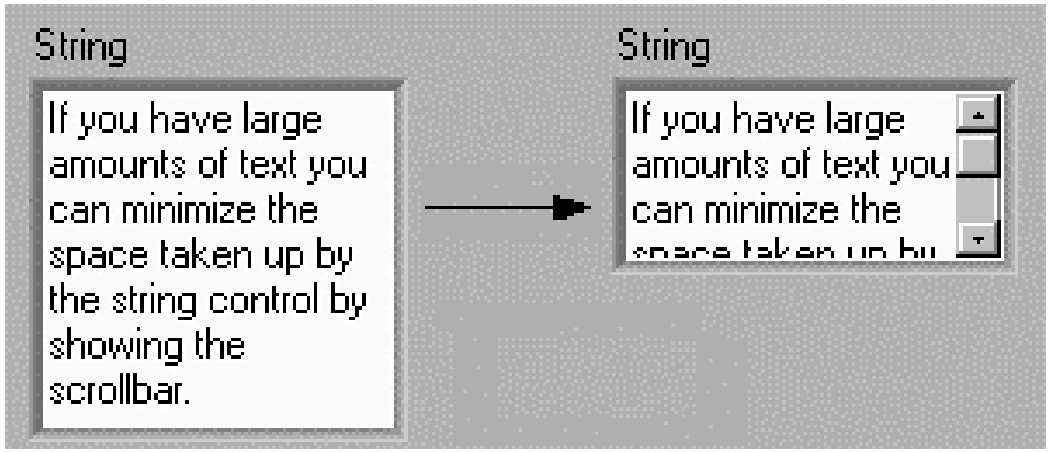
- Includes the open, write, close and error handling functions
- Handles formatting the string with either a tab or comma delimiter
- Merge Signals function is used to combine data into the dynamic data type



	A	B	C	D
1		0	0.385055	
2		1	0.23516	
3		2	0.985184	
4		3	0.177893	
5		4	0.935915	
6				
7				

Strings

- A string is a sequence of displayable or nondisplayable characters (ASCII)
- Many uses – displaying messages, instrument control, file I/O
- String control/indicator is in the **Controls »Text Control** or **Text Indicator**



Clusters

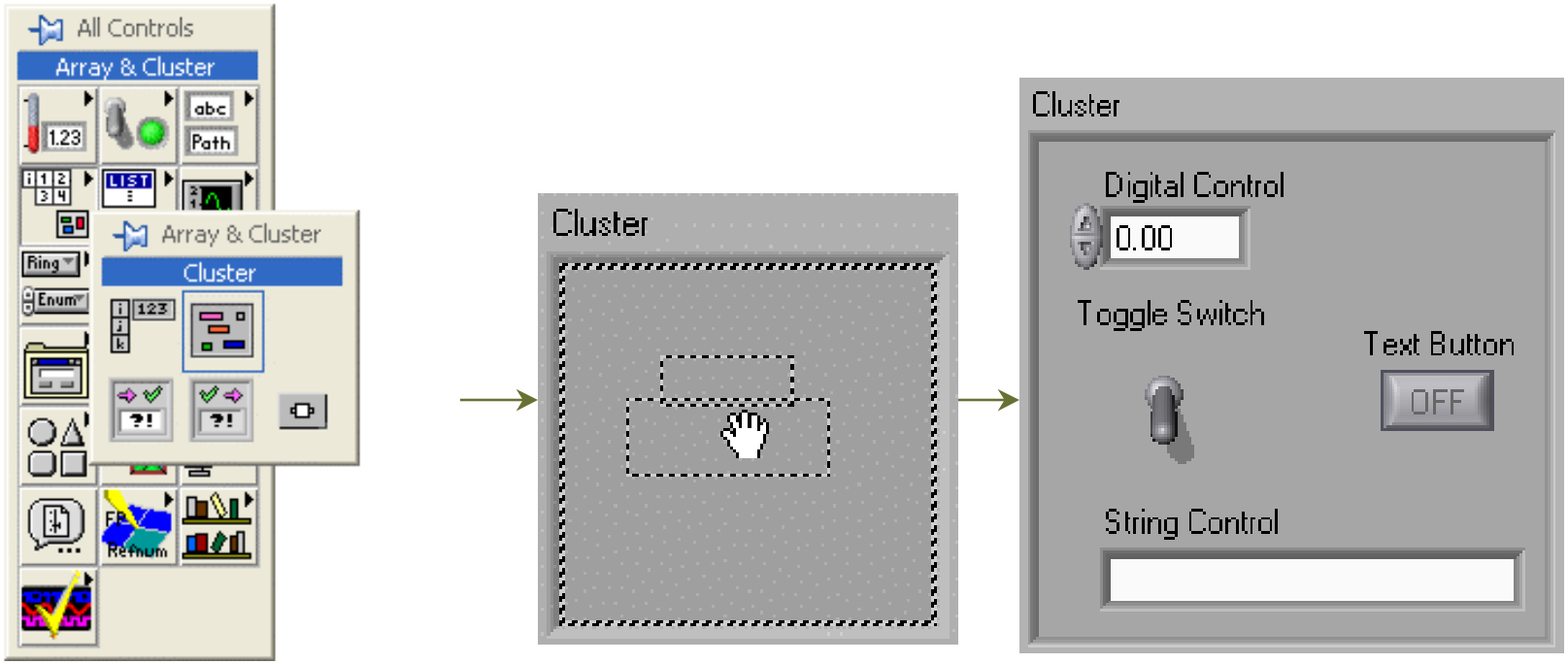
- Data structure that groups data together
- Data may be of different types
- Analogous to *struct* in C
- Elements must be either all controls or all indicators
- Thought of as wires bundled into a cable

Creating a Cluster

1. Select a **Cluster** shell

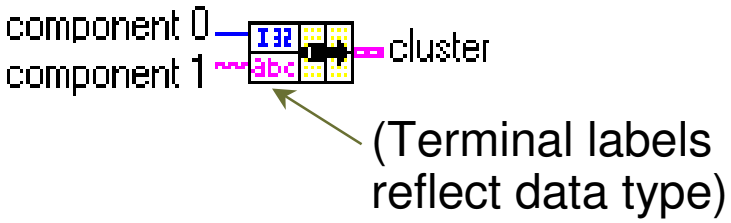
2. Place objects inside the shell

Controls >> All Controls >> Array & Cluster



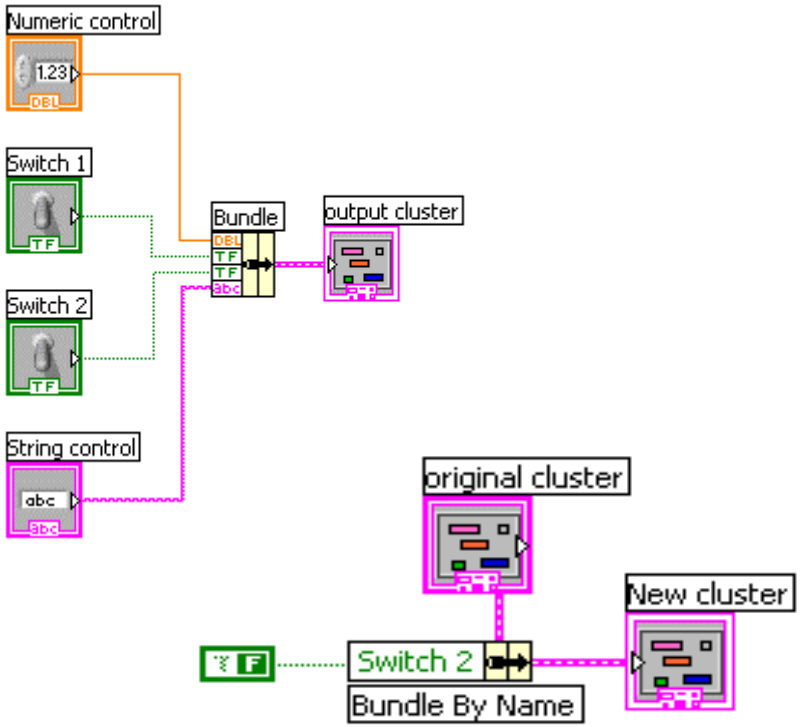
Cluster Functions

- In the **Cluster** subpalette of the **Functions>>All functions** palette
- Can also be accessed by right-clicking on the cluster terminal

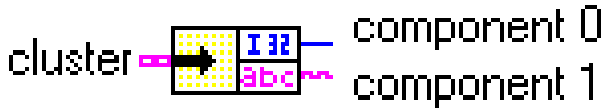


Bundle

Bundle By Name

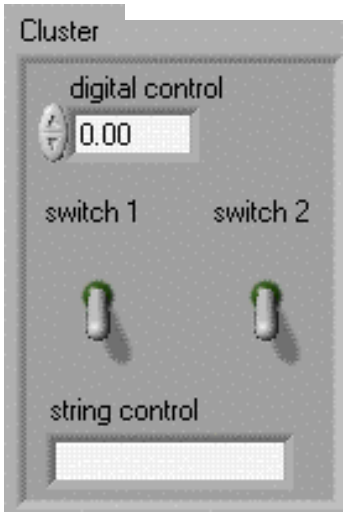


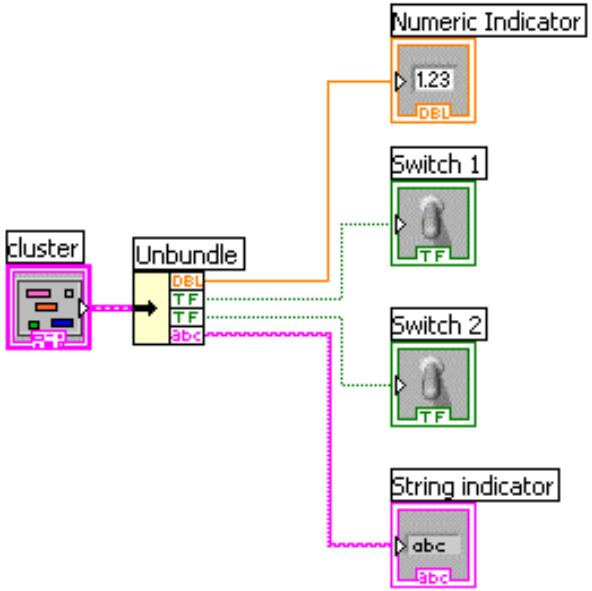
Cluster Functions

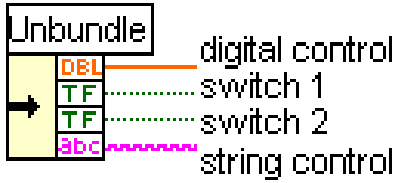


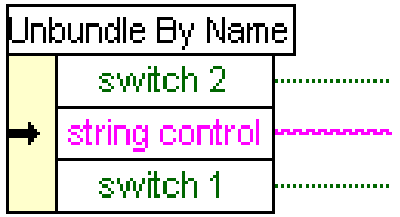
Unbundle

Unbundle By Name





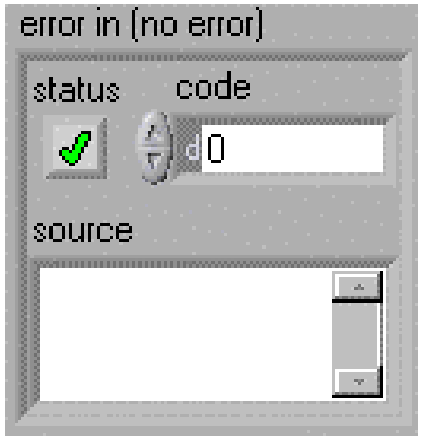


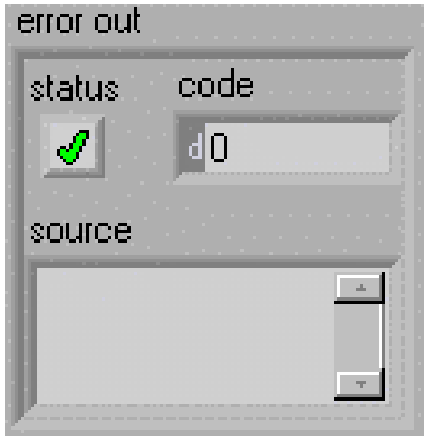


Unbundled cluster in the diagram

Error Clusters

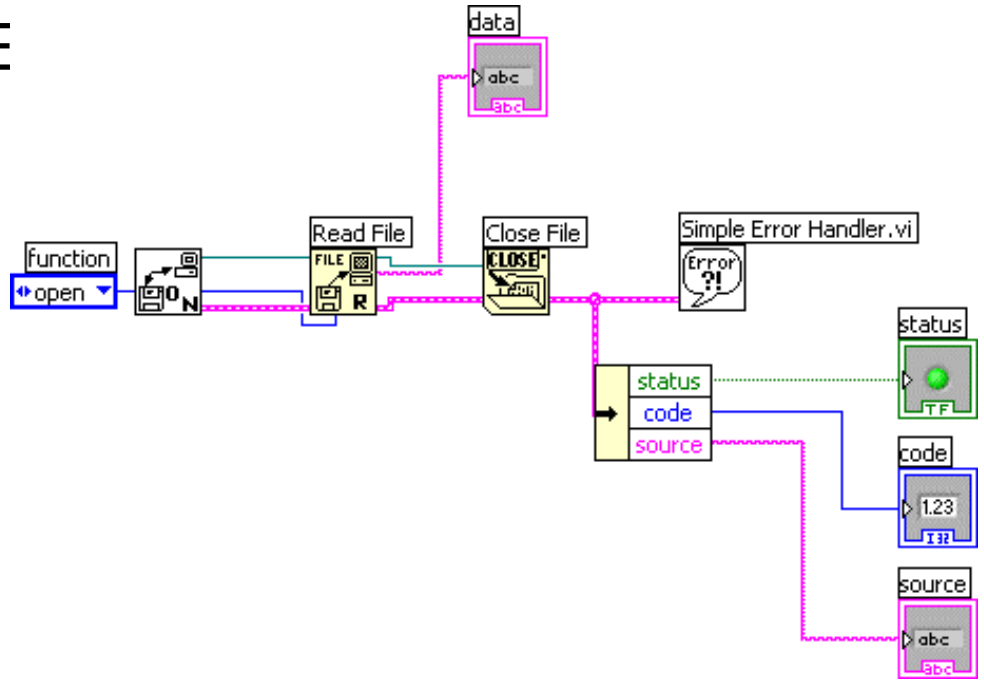
- Error cluster contains the following information:
  - –Boolean to report whether error occurred
  - –Integer to report a specific error code
  - –String to give information about the error





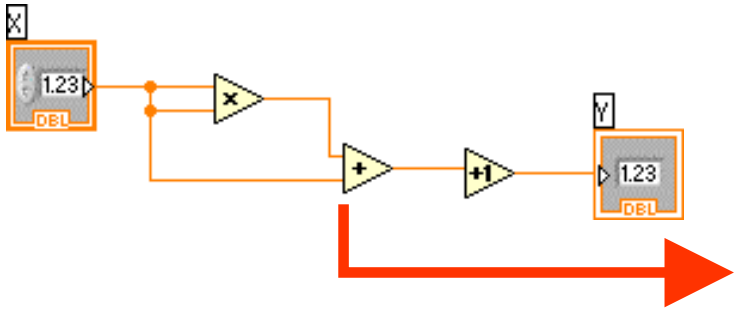
Error Handling Techniques

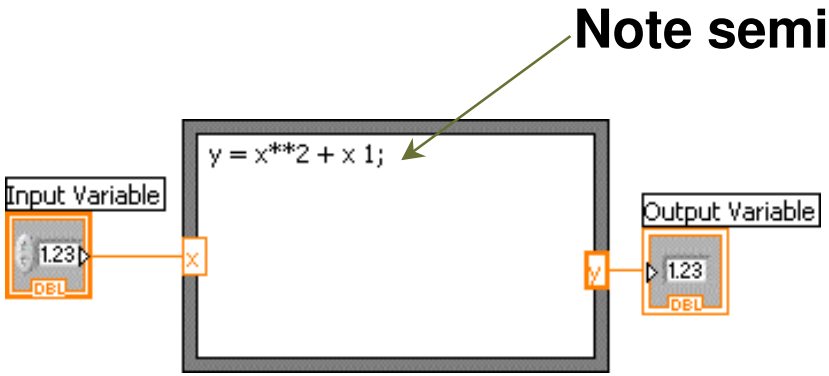
- Error information is passed from one subVI to the next
- If an error occurs in one subVI, all subsequent subVIs are not executed in the usual manner
- Error Clusters contain all error conditions
- Automatic E



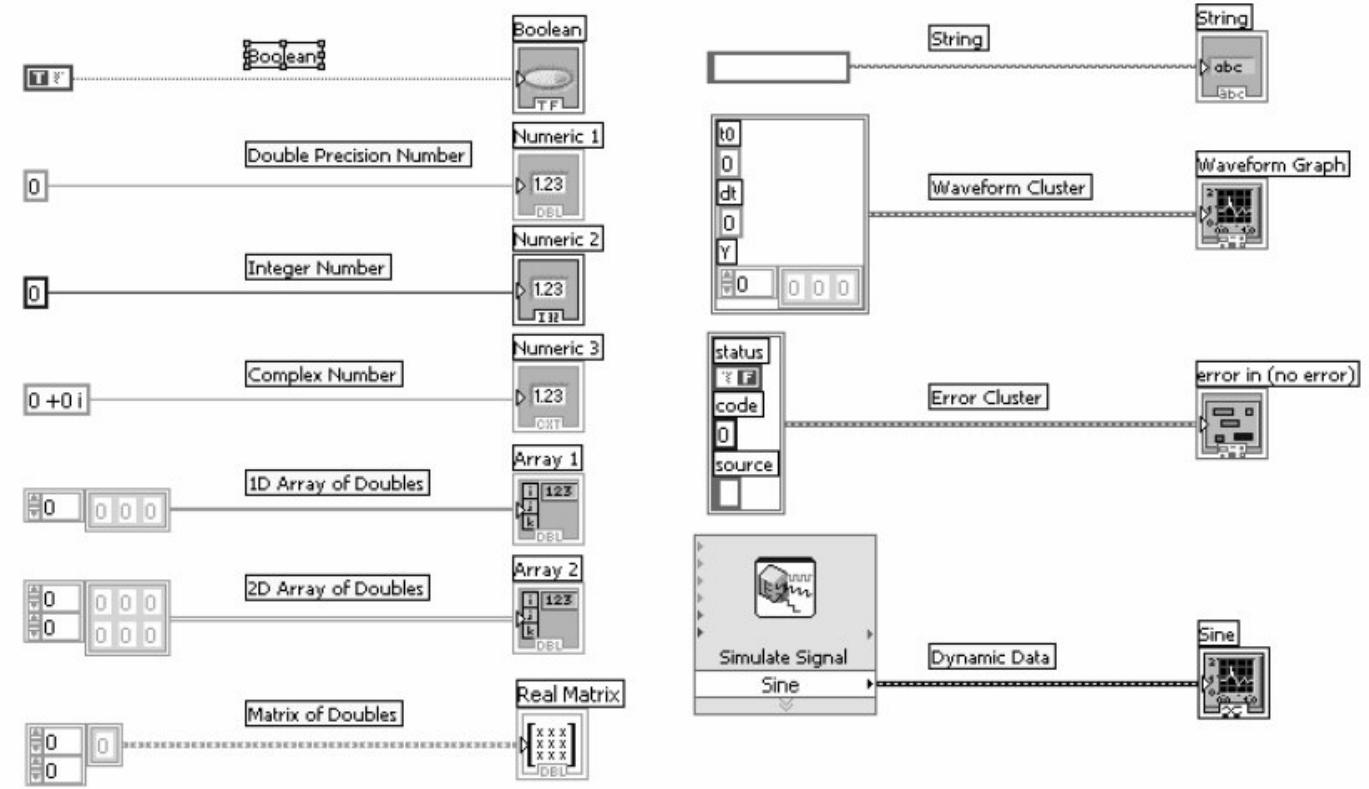
Formula Nodes

- 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





Review of Data Types Found in LabVIEW

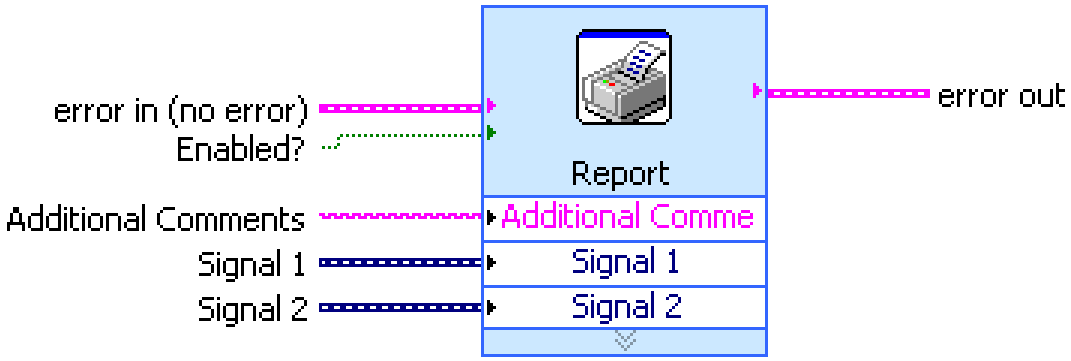


Printing & Documentation

- Print From File Menu to Printer, HTML, Rich Text File
- Programmatically Print Graphs or Front Panel Images
- Document VIs in VI Properties » Documentation Dialog
- Add Comments Using Free Labels on Front Panel & Block Diagram

Printing

- **File » Print**… Gives Many Printing Options
  - Choose to Print Icon, Front Panel, Block Diagram, VI Hierarchy, Included SubVIs, VI History
- Print Panel.vi (Programmatically Prints a Front Panel)
  - **Functions » All Functions » Application Control**
- Generate & Print Reports (**Functions » Output » Report**)

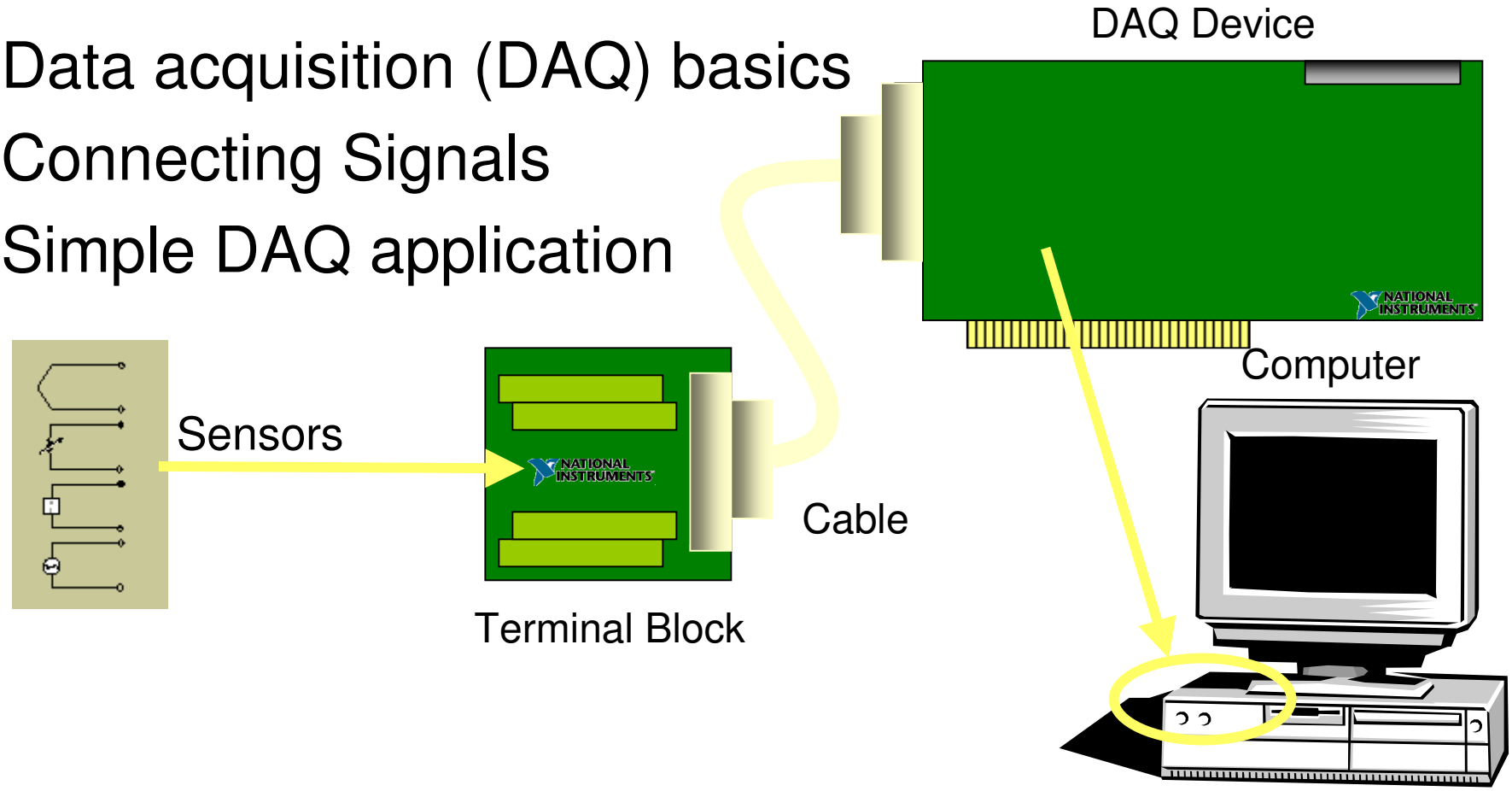


Documenting VIs

- VI Properties » Documentation
  - Provide a Description and Help Information for a VI
- VI Properties » Revision History
  - Track Changes Between Versions of a VI
- Individual Controls » Description and Tip…
  - Right Click to Provide Description and Tip Strip
- Use Labeling Tool to Document Front Panels & Block Diagrams

Data Acquisition

- Data acquisition (DAQ) basics
- Connecting Signals
- Simple DAQ application

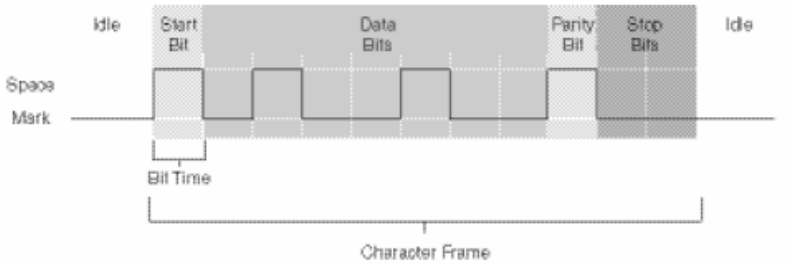


What Types of Instruments Can Be Controlled?

- GPIB
- Serial
- Modular Instruments
- PXI Modular Instruments
- Image Acquisition
- Motion Control
- USB
- Ethernet
- Parallel Port
- CAN

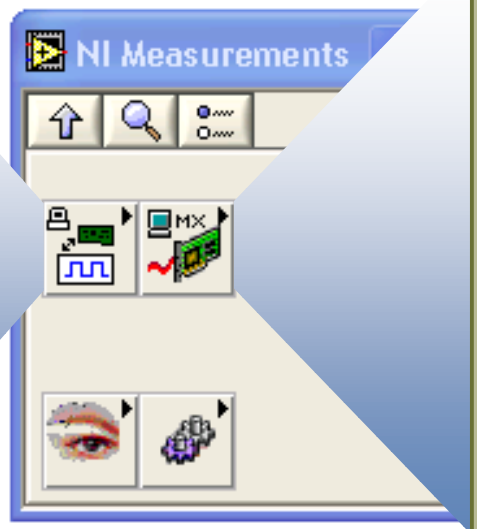
Serial

- Serial communication transmits one bit at a time over a transmission line
- Usually does not require external hardware
- Four parameters: baud rate, data bits, parity bit, stop bits



Data Acquisition in Labview

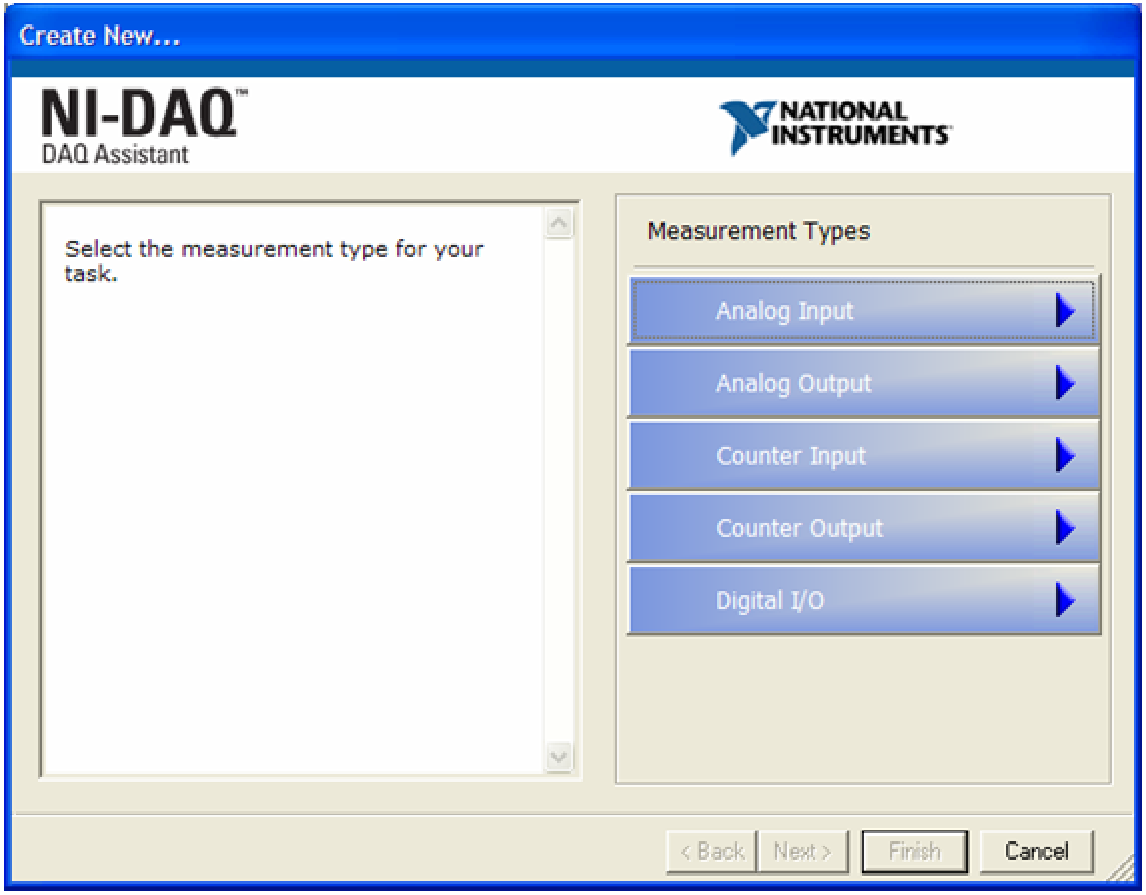
Traditional NI-DAQ
Specific VIs for performing:
- Analog Input
- Analog Output
- Digital I/O
- Counter operations



NI-DAQmx
Next generation driver:
- VIs for performing a task
- One set of VIs for all measurement types

Data Acquisition

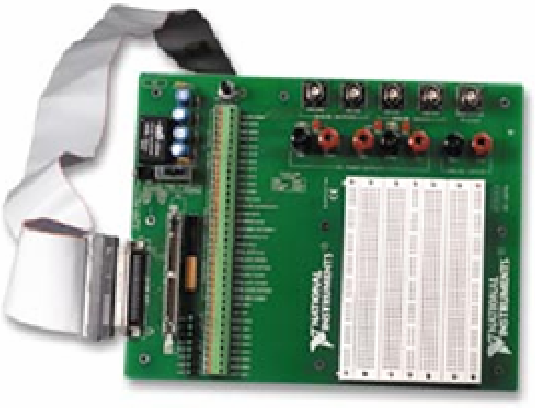
Temperature Acquisition using the DAQ Assistant



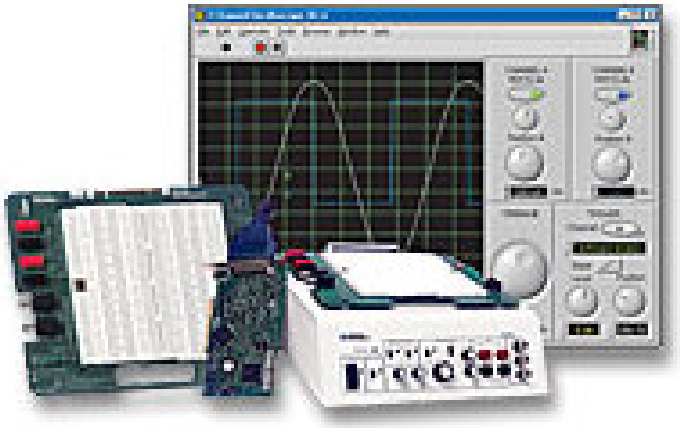
Hardware Connections

BNC-2120

SC-2075



NI-ELVIS



SCB-68

Virtual Instrumentation Applications

- **Design**
  - Signal and Image Processing
  - Embedded System Programming
    - (PC, DSP, FPGA, Microcontroller)
  - Simulation and Prototyping
  - And more…
- **Control**
  - Automatic Controls and Dynamic Systems
  - Mechatronics and Robotics
  - And more…
- **Measurements**
  - Circuits and Electronics
  - Measurements and Instrumentation
  - And more…

A single graphical development platform

Next step:

LABVIEW FPGA