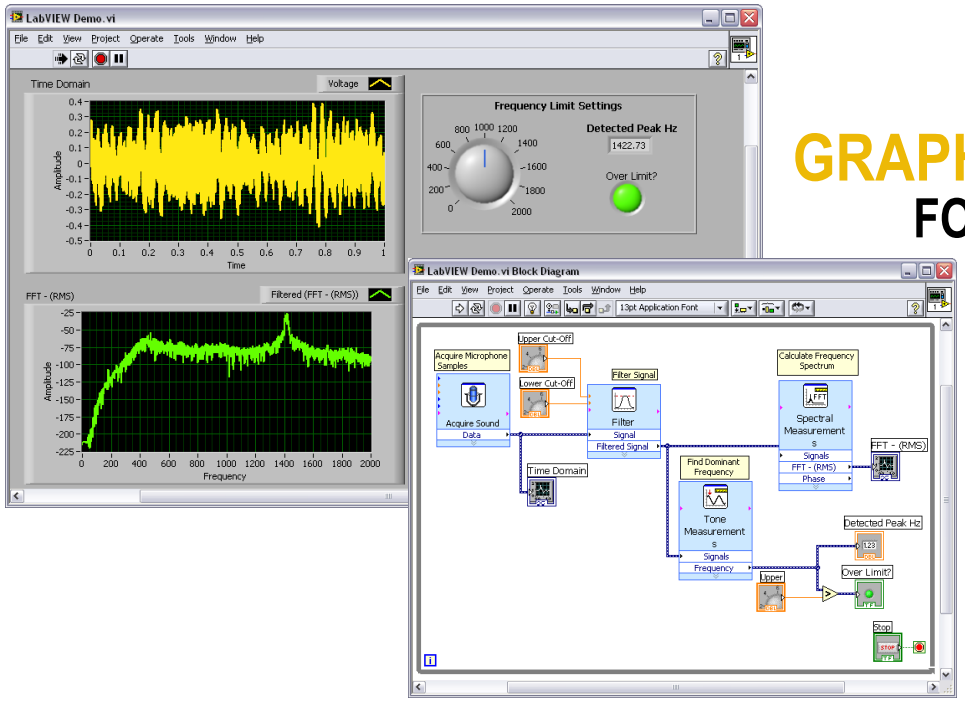
Introduction to LabVIEW



GRAPHICAL PROGRAMMING
FOR ENGINEERS AND SCIENTISTS

LabVIEW™ 8

Robert Berger

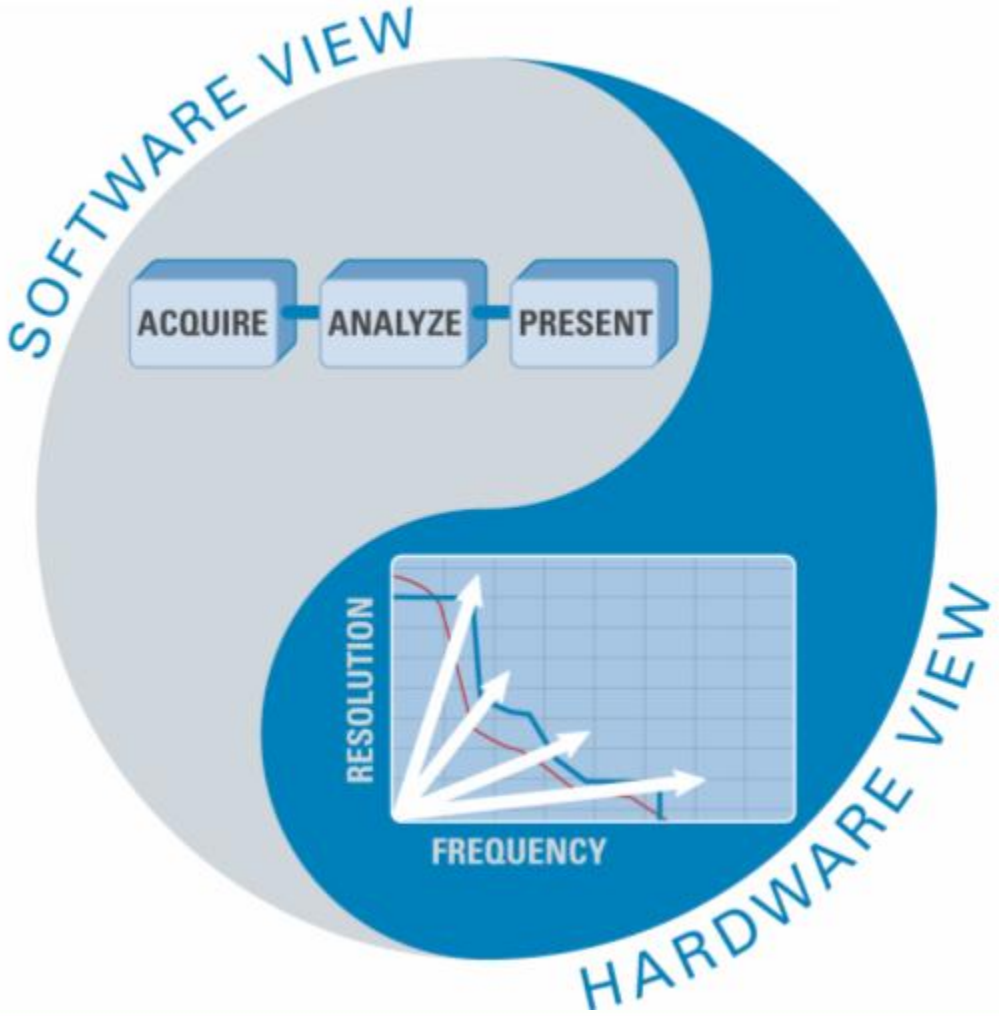
ni.com

NATIONAL INSTRUMENTS

Course Goals

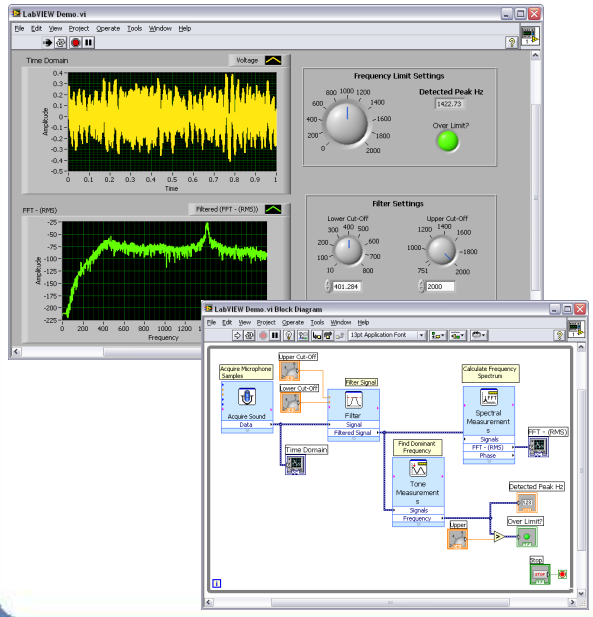
- Become comfortable with the LabVIEW environment and data flow execution
- Ability to use LabVIEW to solve problems
- LabVIEW Concepts
  - Acquiring, saving and loading data
  - Find and use math and complex analysis functions
  - Work with data types, such as arrays and clusters
  - Displaying and printing results

The Virtual Instrumentation Approach



LabVIEW Graphical Development System

- Graphical Programming Environment
- Compile code for multiple OS and devices
- Useful in a broad range of applications



LabVIEW Graphical Development Platform for Design, Control, and Test

Embedded Design and Prototyping	Industrial Monitoring and Control	Automated Test and Measurement

Filter Design/DSP	Advanced Control	HMI/SCADA	Data Logging and NVH	Communications Test
System Prototyping	Industrial Control (PID)	Machine Vision and Motion	ATE	

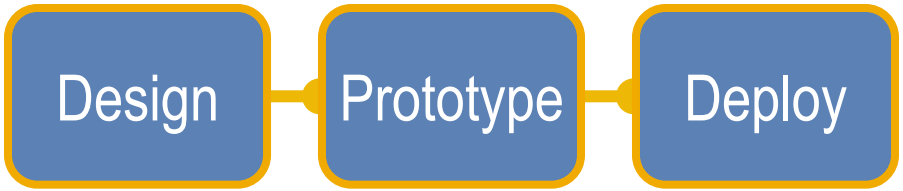
Computing Targets

Desktop | Industrial | Mobile | Embedded

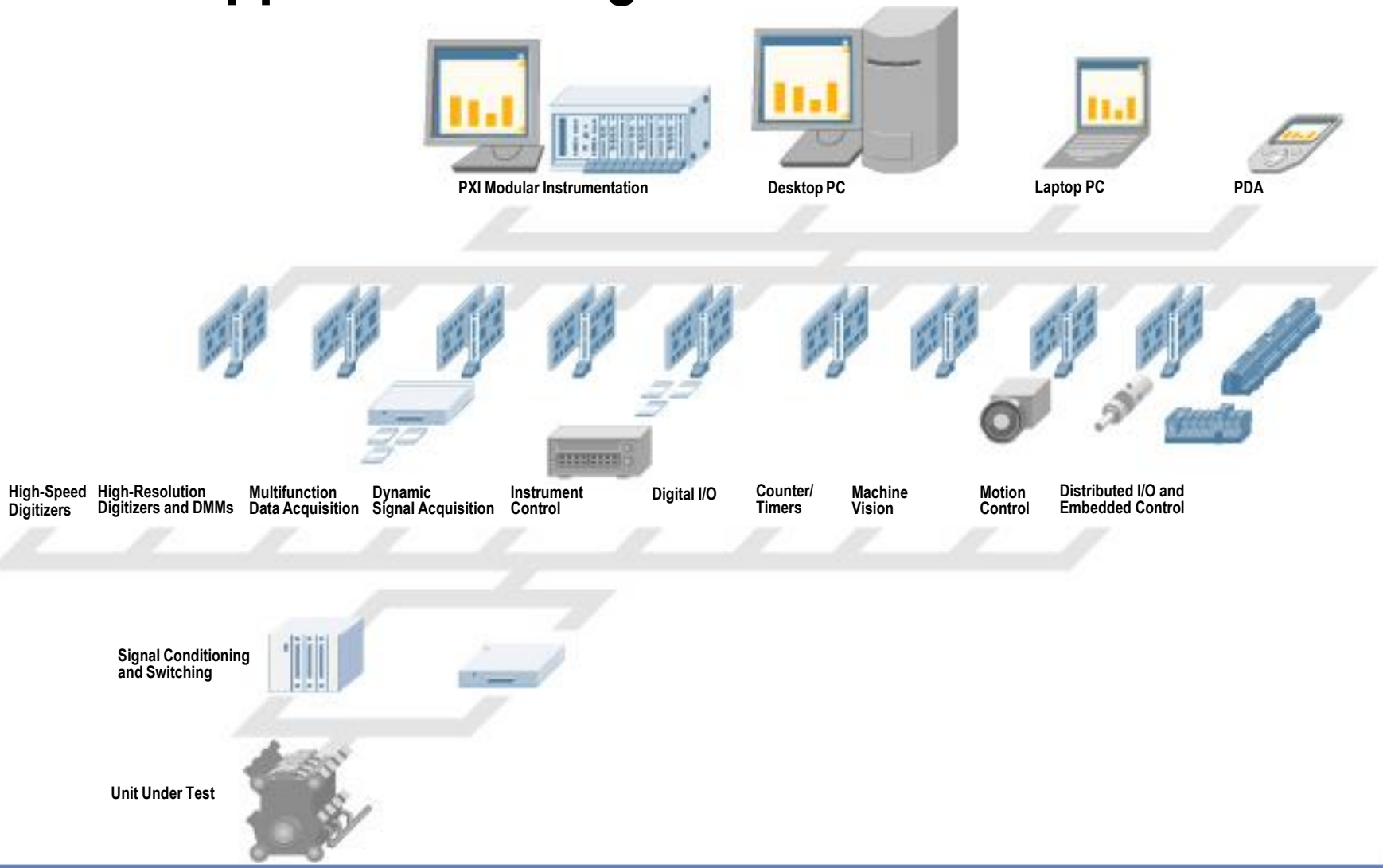
Virtual Instrumentation Applications

- **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



The NI Approach – Integrated Hardware Platforms



Section I – LabVIEW Environment

A. Getting Data into your Computer

- Data Acquisition Devices
  - NI-DAQ
  - Simulated Data Acquisition
  - Sound Card

B. LabVIEW Environment

- Front Panel / Block Diagram
- Toolbar /Tools Palette

C. Components of a LabVIEW Application

- Creating a VI
- Data Flow Execution

D. Additional Help

- Finding Functions
- Tips for Working in LabVIEW

A. Setting Up Your Hardware

- Data Acquisition Device (DAQ) Track A
  - Actual USB, PCI, or PXI Device
  - Configured in MAX

- Simulated Data Acquisition Device (DAQ) Track B
  - Software simulated at the driver level
  - Configured in MAX

- Sound Card Track C
  - Built into most computers

What type of device should I use?




	Sound Card*	NI USB DAQ	NI PCI DAQ	Instruments*
AI Bandwidth	8–44 KS/s	10–200 KS/s	250 K–1.2 Ms/s	20kS/s–2 GS/s
Accuracy	12–16 bit	12–16 bit	14–18 bit	12–24 bit
Portable	x	x	—	some
AI Channels	2	8–16	16–80	2
AO Channels	2	1–2	2–4	0
AC or DC	AC	AC/DC	AC/DC	AC/DC
Triggering	—	x	x	x
Calibrated	—	x	x	x

* The above table may not be representative of all device variations that exist in each category

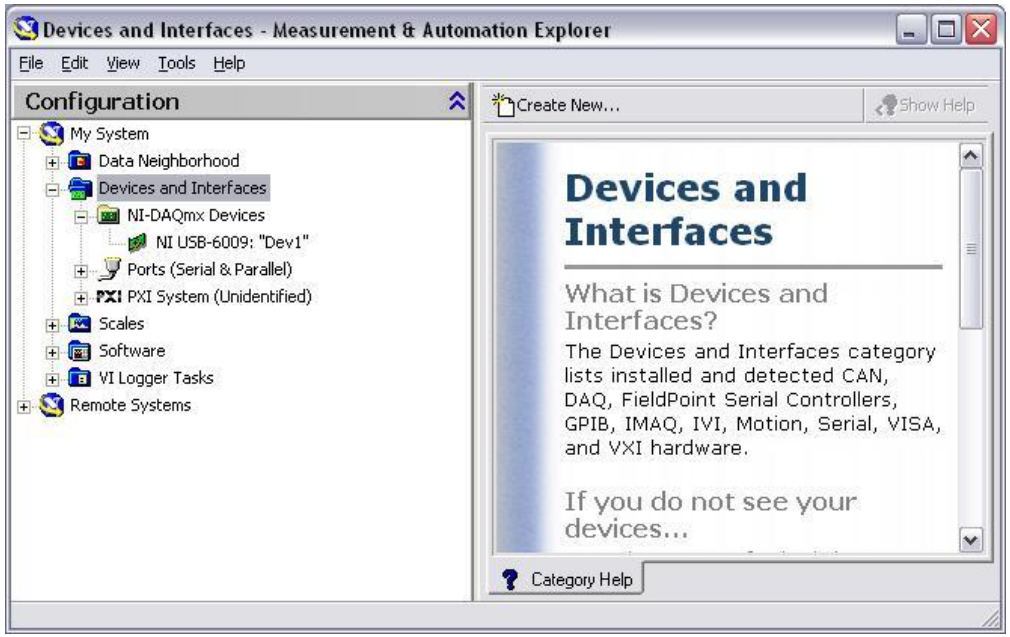
What is MAX?

- MAX stands for Measurement & Automation Explorer.
- MAX configures and organizes all your National Instruments DAQ, PCI/PXI instruments, GPIB, IMAQ, IVI, Motion, VISA, and VXI devices.
- Used for configuring and testing devices.

Icon Found on

Windows Desktop

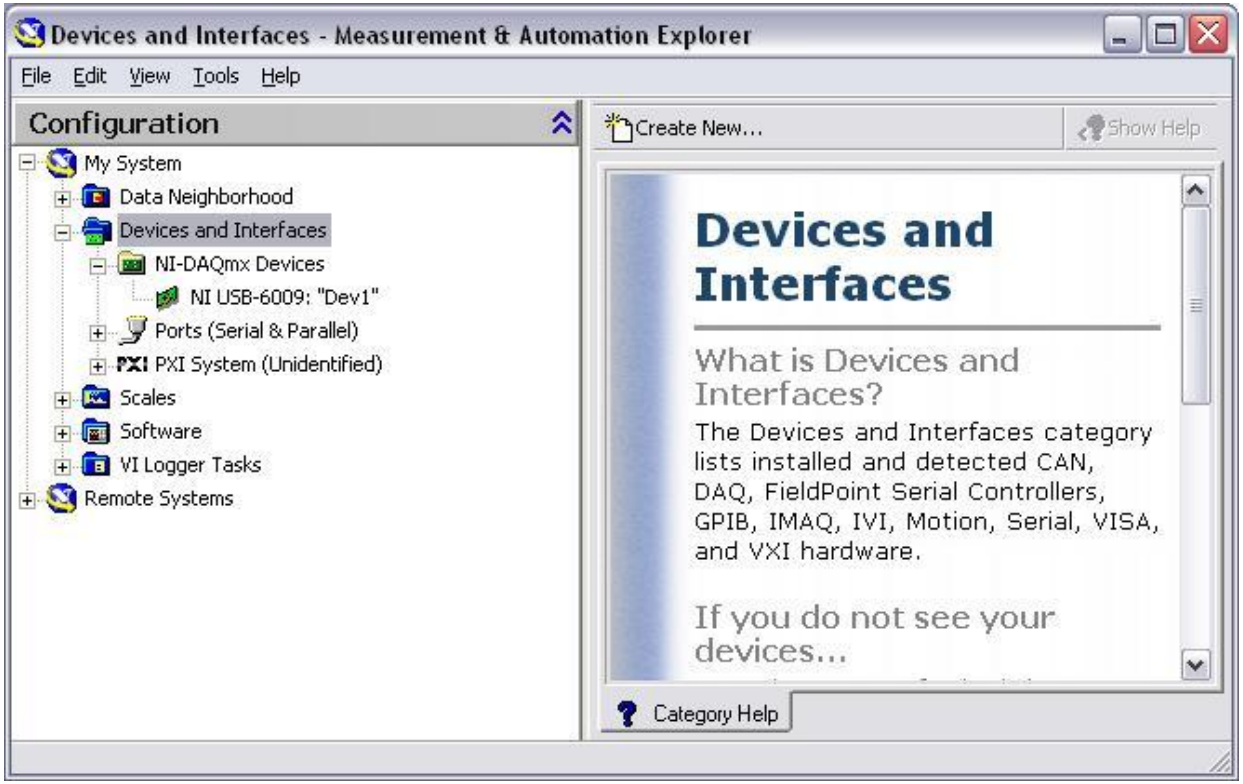
Measurement
& Automation



Track A

Exercise 1 – Setting Up Your Device

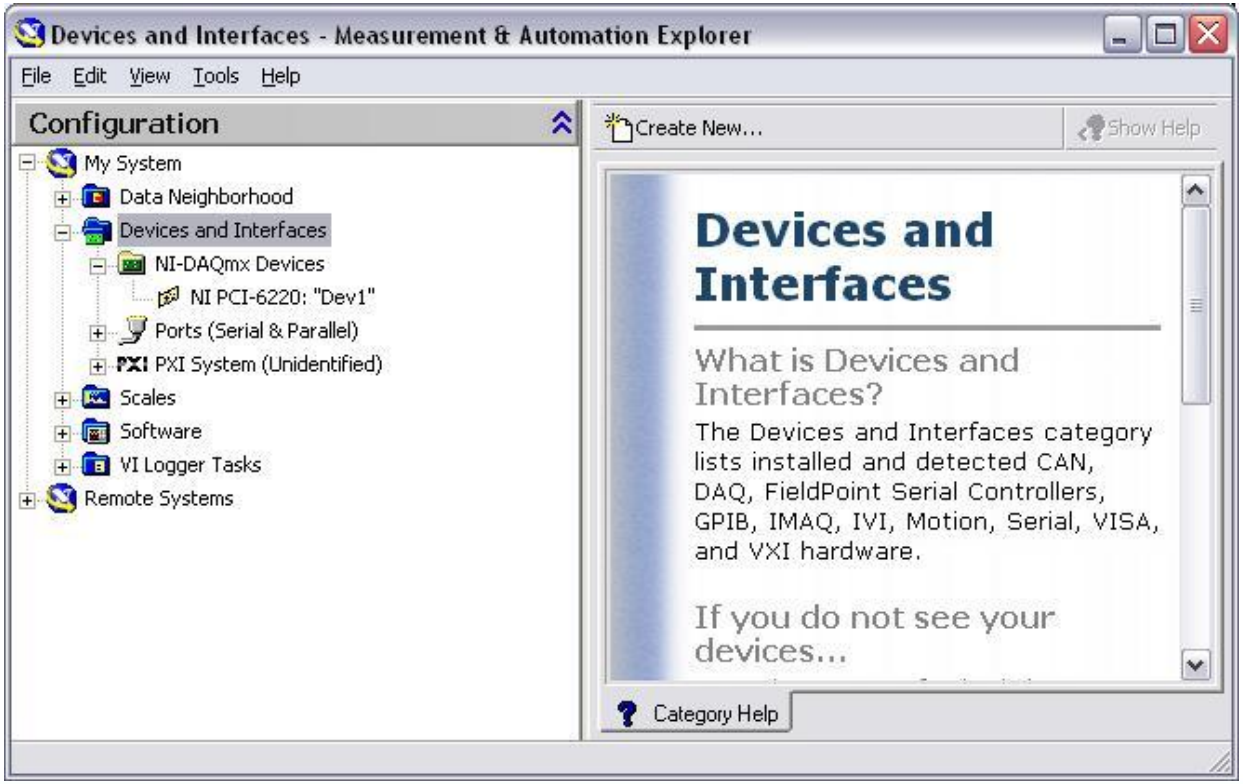
- Use Measurement and Automation Explorer (MAX) to:
  - Configure and test your Data Acquisition (DAQ) device



Track B

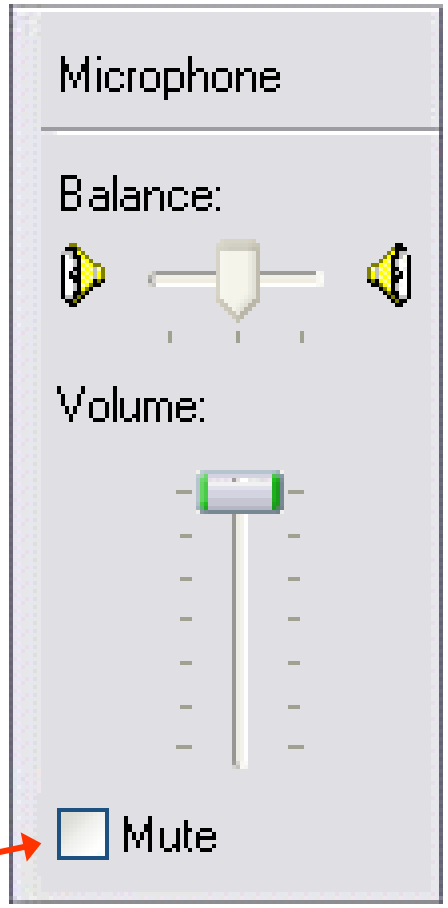
Exercise 1 – Setting Up Your Device

- Use Measurement and Automation Explorer (MAX) to:
  - Configure and test your Simulated Data Acquisition (DAQ) device



Exercise 1 – Setting Up Your Device

- Use Windows to:
  - Verify your Sound Card



Un-Mute Microphone

Open and Run LabVIEW

Start»All Programs»National Instruments LabVIEW 8.6

Startup Screen:

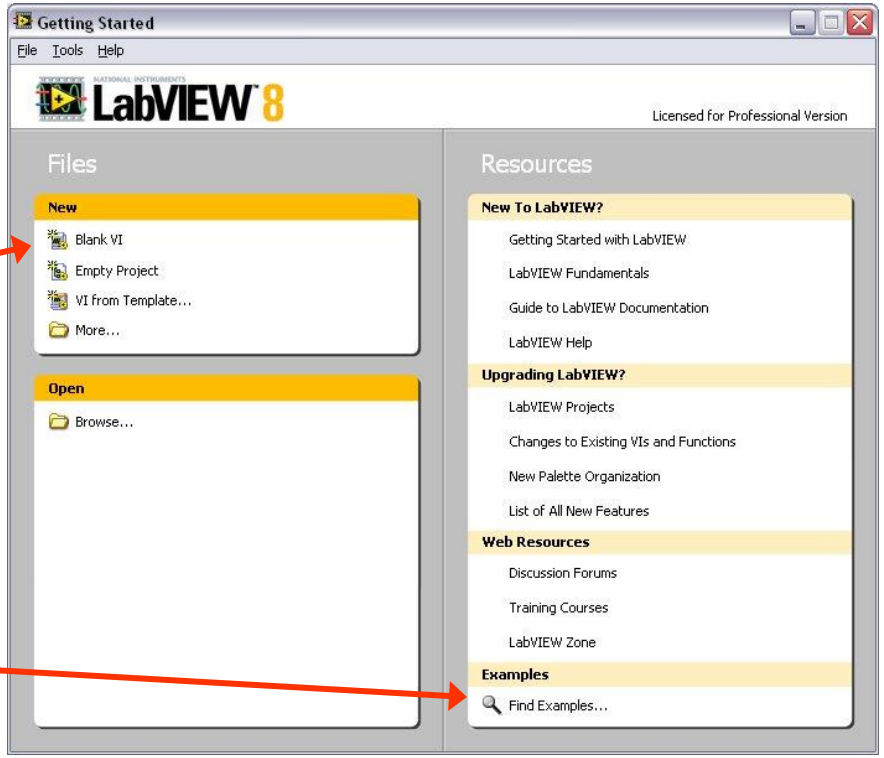
Start from a Blank VI:

New»Blank VI

or

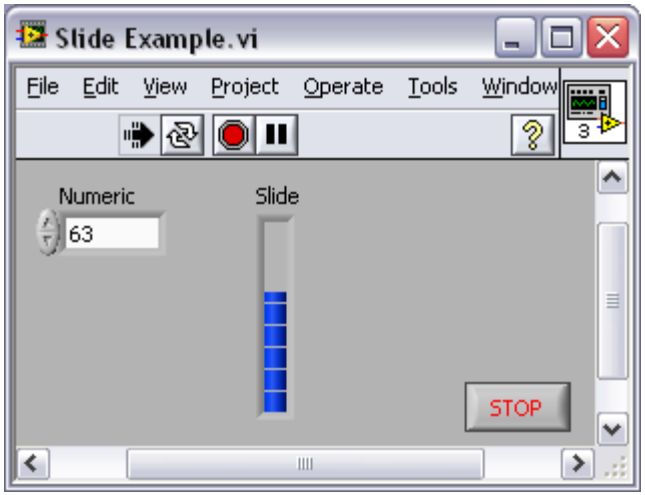
Start from an Example:

Examples»Find Examples…



LabVIEW Programs Are Called Virtual Instruments (VIs)

Each VI has 2 Windows

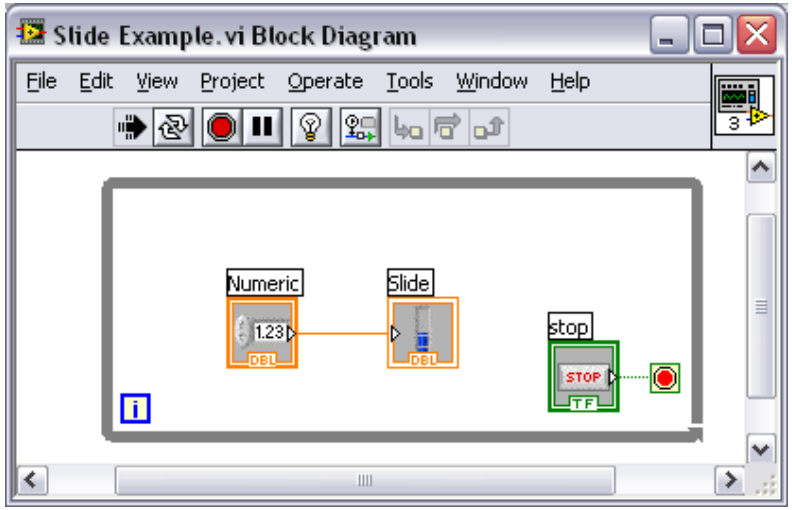


Front Panel

- User Interface (UI)
  - Controls = Inputs
  - Indicators = Outputs

Block Diagram

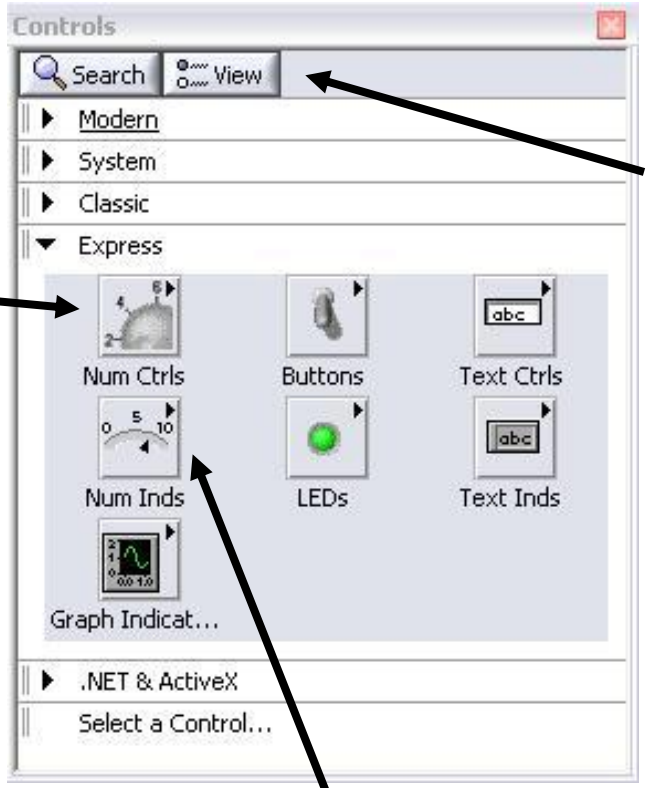
- Graphical Code
  - Data travels on wires from controls through functions to indicators
  - Blocks execute by Dataflow



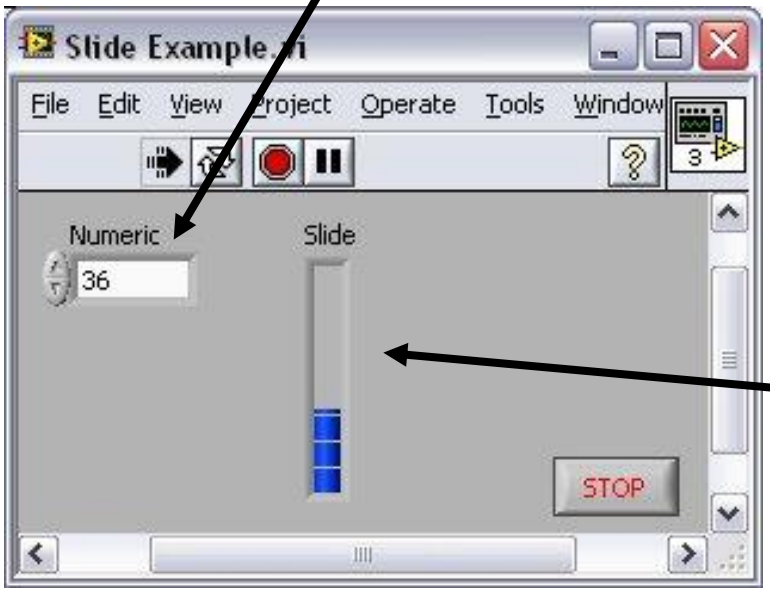
Controls Palette (Controls & Indicators)

(Place items on the Front Panel Window)

Control: Numeric

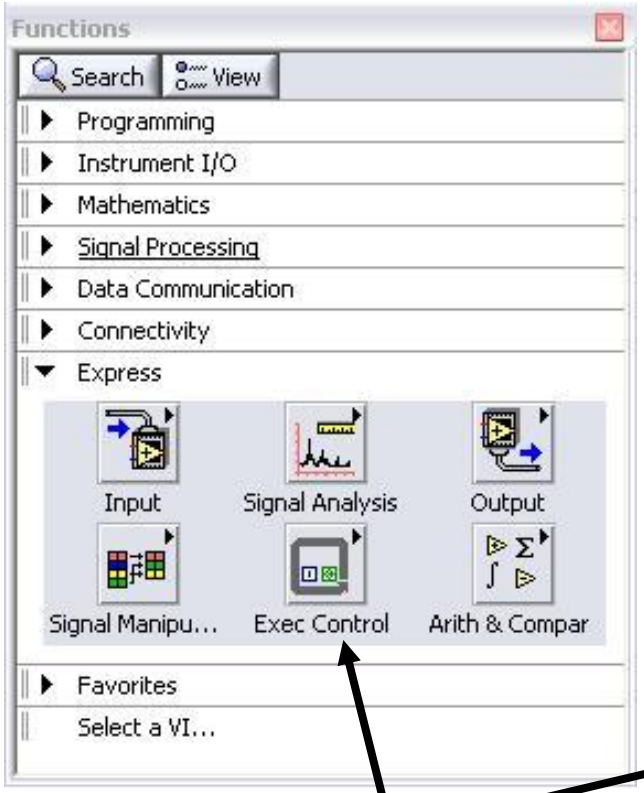


Customize Palette View

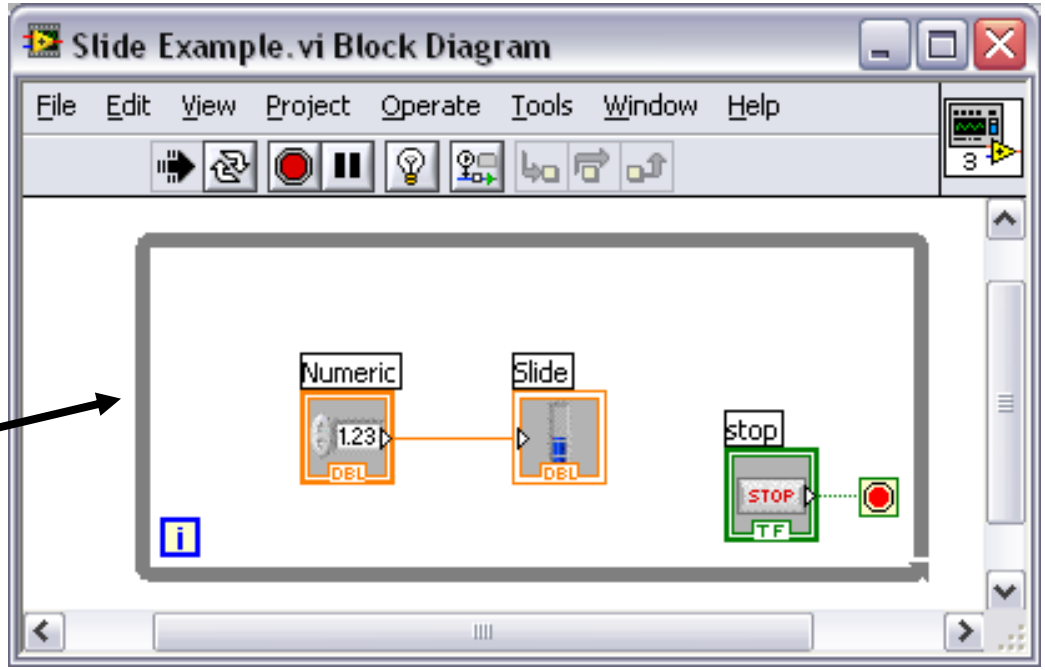


Indicator: Numeric Slide

Functions (and Structures) Palette

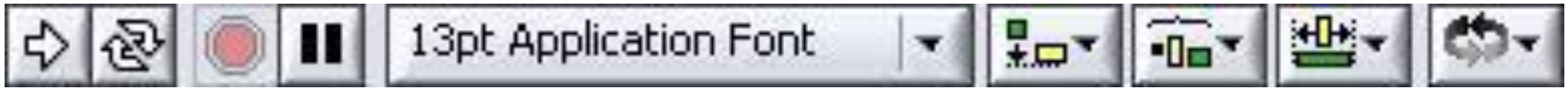


(Place items on the Block Diagram Window)



Structure: While Loop

Status Toolbar



Run Button

Continuous Run Button

Abort Execution

Additional Buttons on the Diagram Toolbar

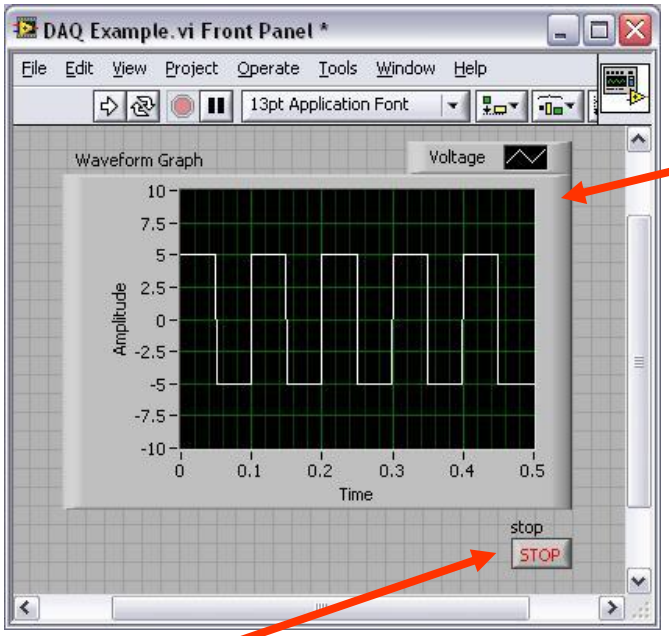
Execution Highlighting Button

Retain Wire Values Button

Step Function Buttons

Demonstration 1: Creating a VI

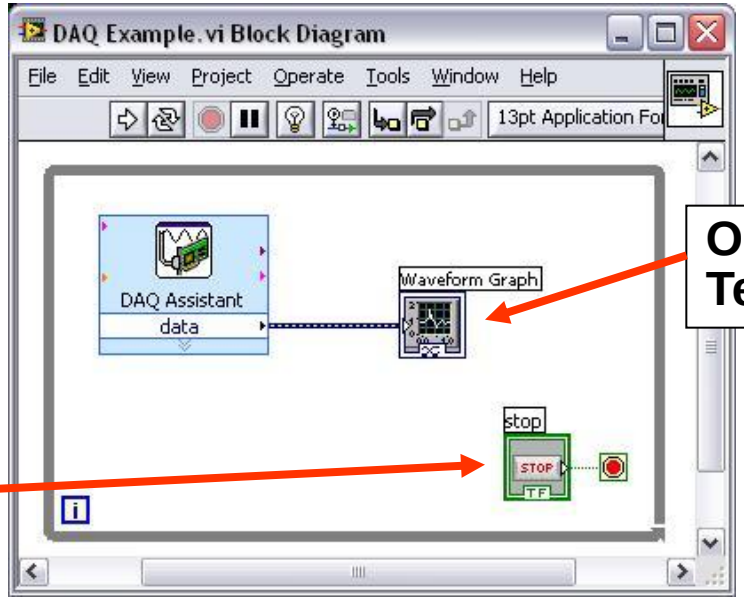
Front Panel Window



Graph Indicator

Boolean Control

Block Diagram Window

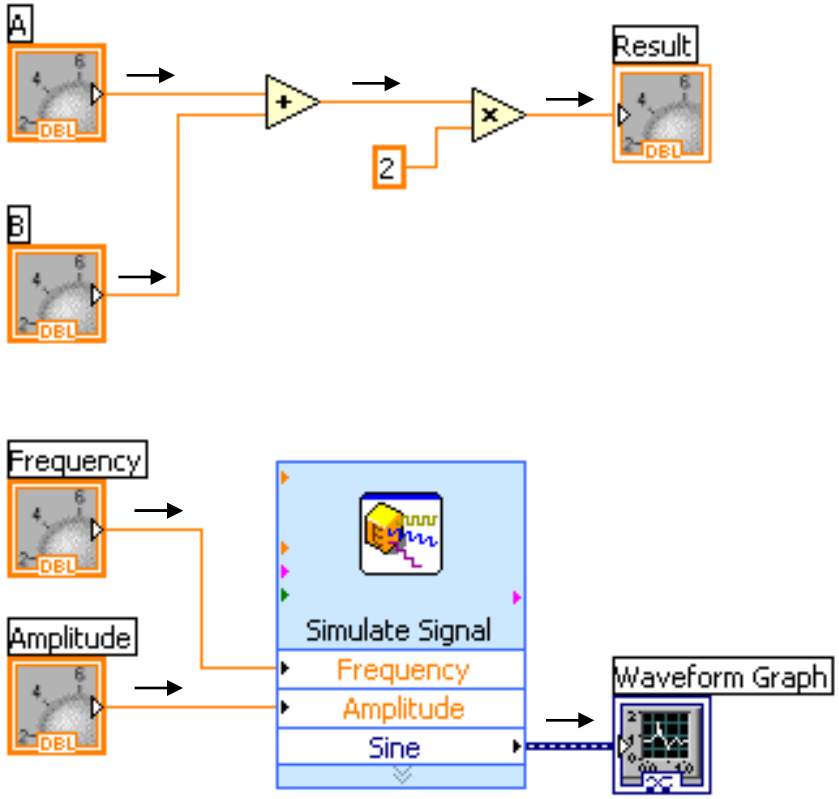


Output Terminal

Input Terminals

Dataflow Programming

- Block diagram execution
  - 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

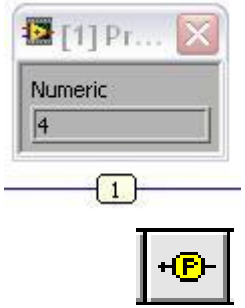
- **Finding Errors**

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.

- **Probes**



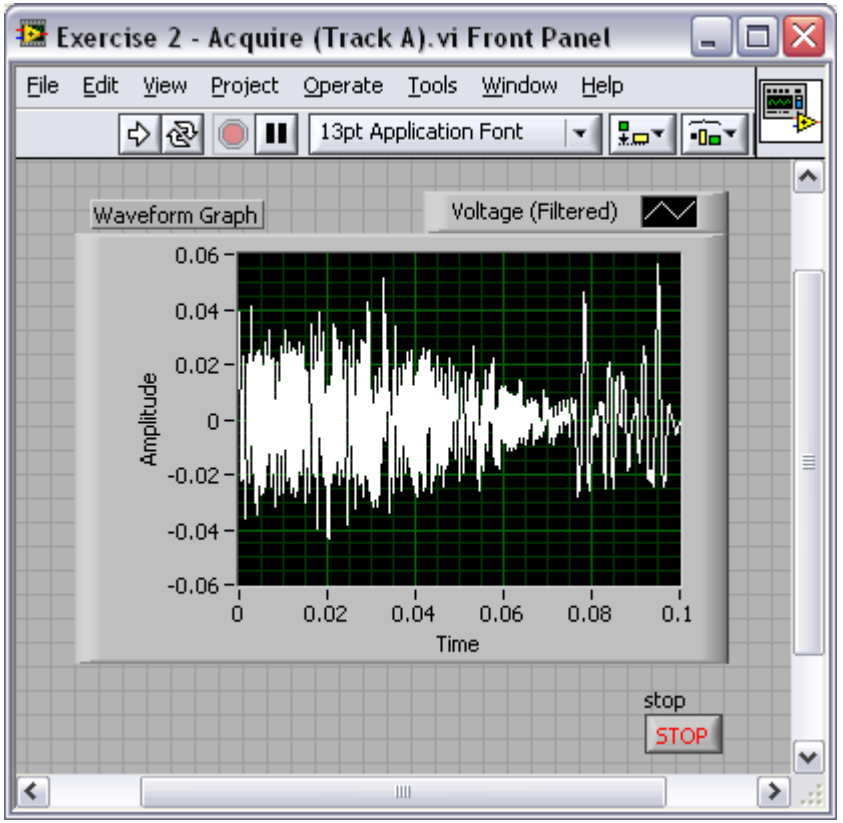
Right-click on wire to display probe and it shows data as it flows through wire segment.

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

Exercise 2 – Acquiring a Signal with DAQ

- Use a LabVIEW template to:
  - Acquire a signal from your DAQ device

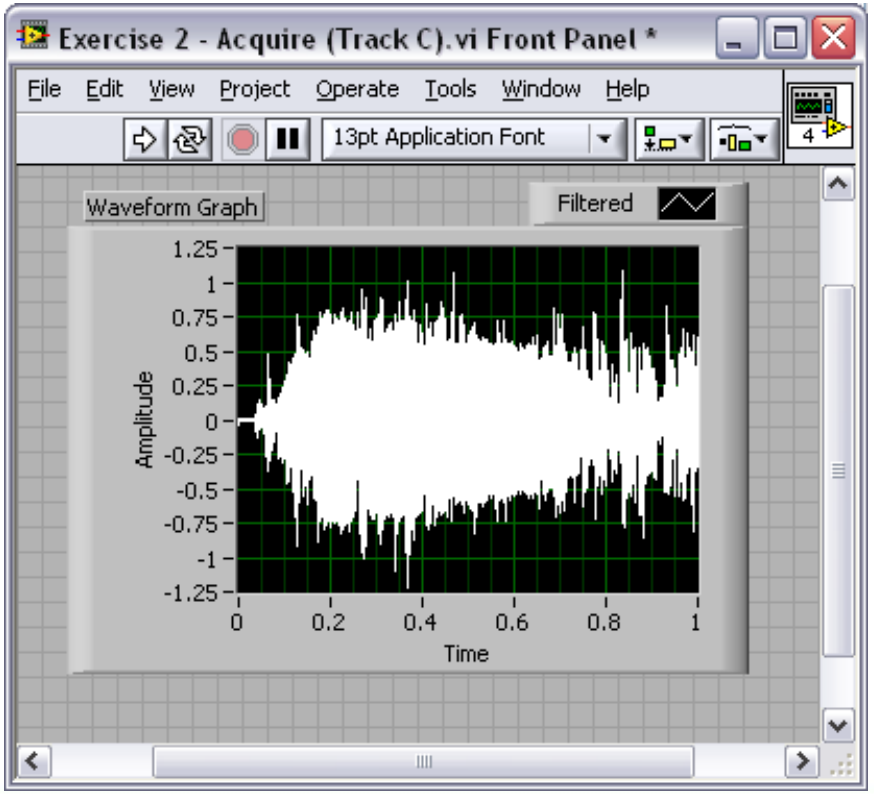
This exercise should take 15 minutes.



Exercise 2 – Acquiring a Signal with the Sound Card

- Use LabVIEW to:
  - Acquire a signal from your sound card

This exercise should take 15 minutes.

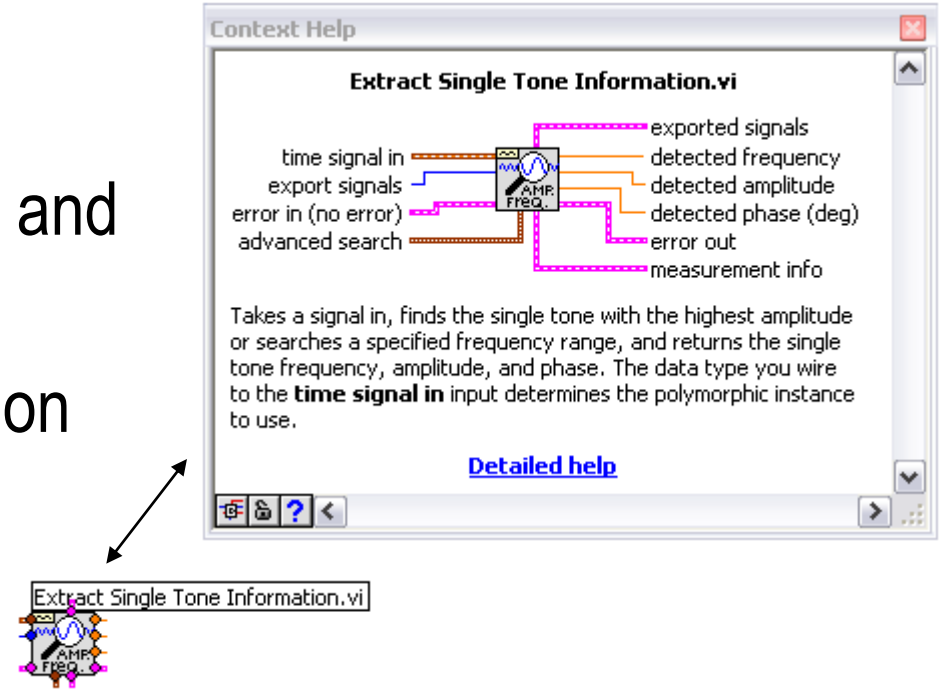


Context Help Window

- **Help»Show Context Help**, press the <Ctrl+H> keys
- Hover cursor over object to update window

Additional Help

- Right-Click on the VI icon and choose **Help**, or
- Choose "**Detailed Help**." on the context help window



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.

Section II – Elements of Typical Programs

A. Loops

- While Loop
- For Loop

B. Functions and SubVIs

- Types of Functions
- Creating Custom Functions (SubVI)
- Functions Palette & Searching

C. Decision Making and File IO

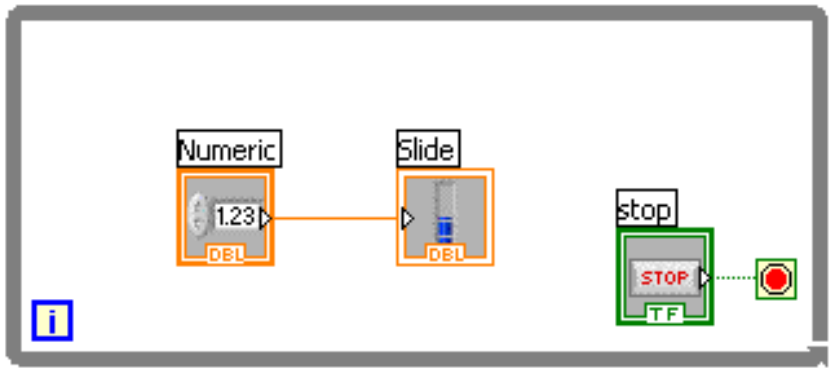
- Case Structure
- Select (simple If statement)
- File I/O

Loops

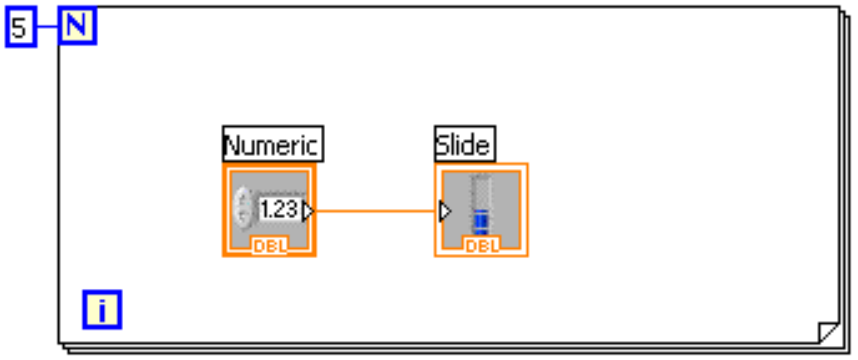
- While Loops
  - Terminal counts iteration
  - Always runs at least once
  - Runs until stop condition is met

- For Loops
  - Terminal counts iterations
  - Run according to input **N** of count terminal

While Loop

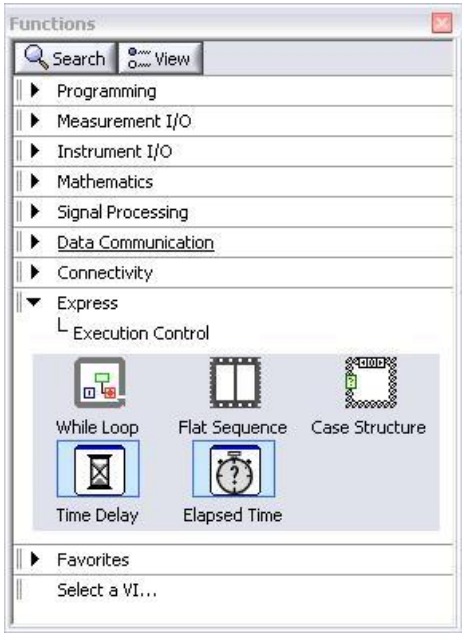


For Loop

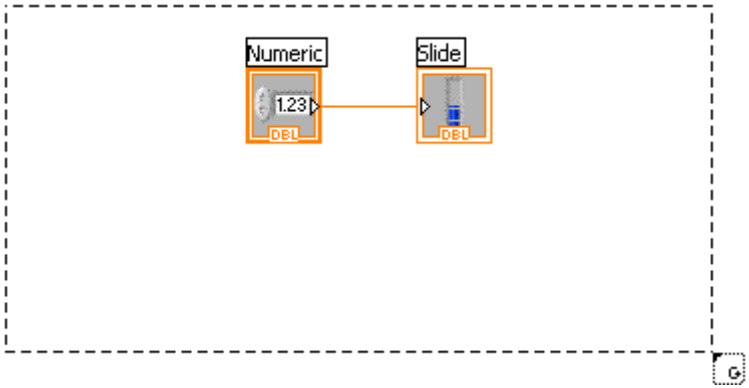


Drawing a Loop

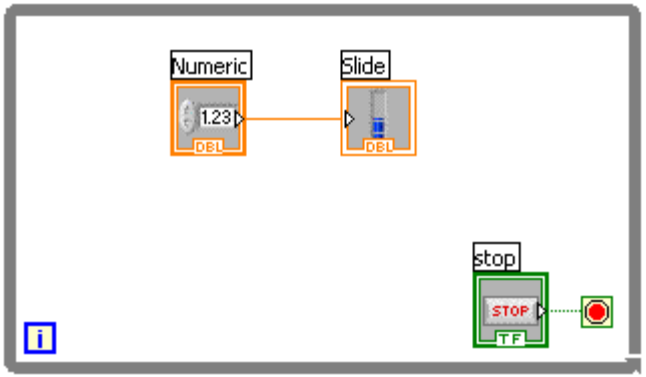
1. Select the structure



2. Enclose code to be repeated

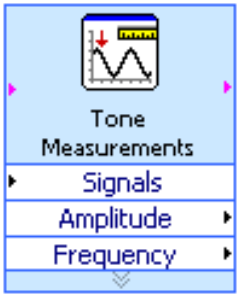


3. Drop or drag additional nodes and then wire

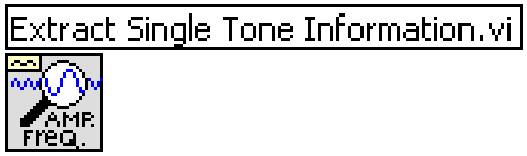


3 Types of Functions (from the Functions Palette)

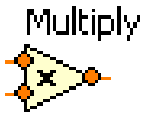
Express VIs: interactive VIs with configurable dialog page **(blue border)**



Standard VIs: modularized VIs customized by wiring **(customizable)**



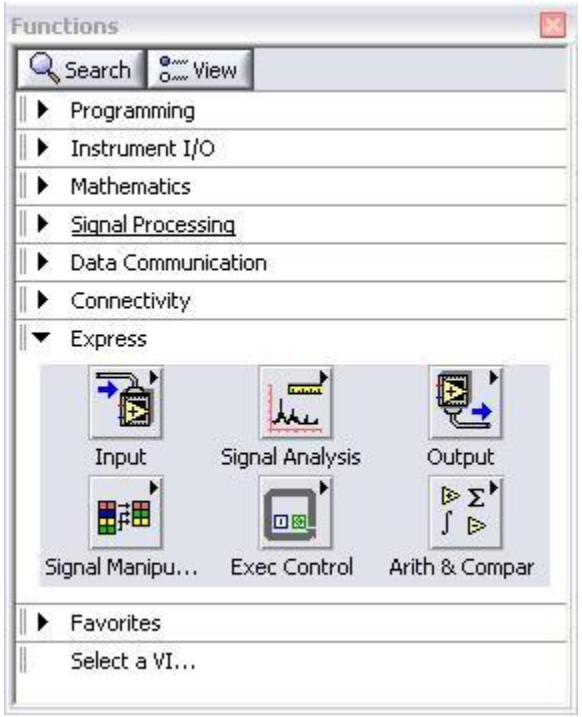
Functions: fundamental operating elements of LabVIEW; no front panel or block diagram **(yellow)**



What Types of Functions are Available?

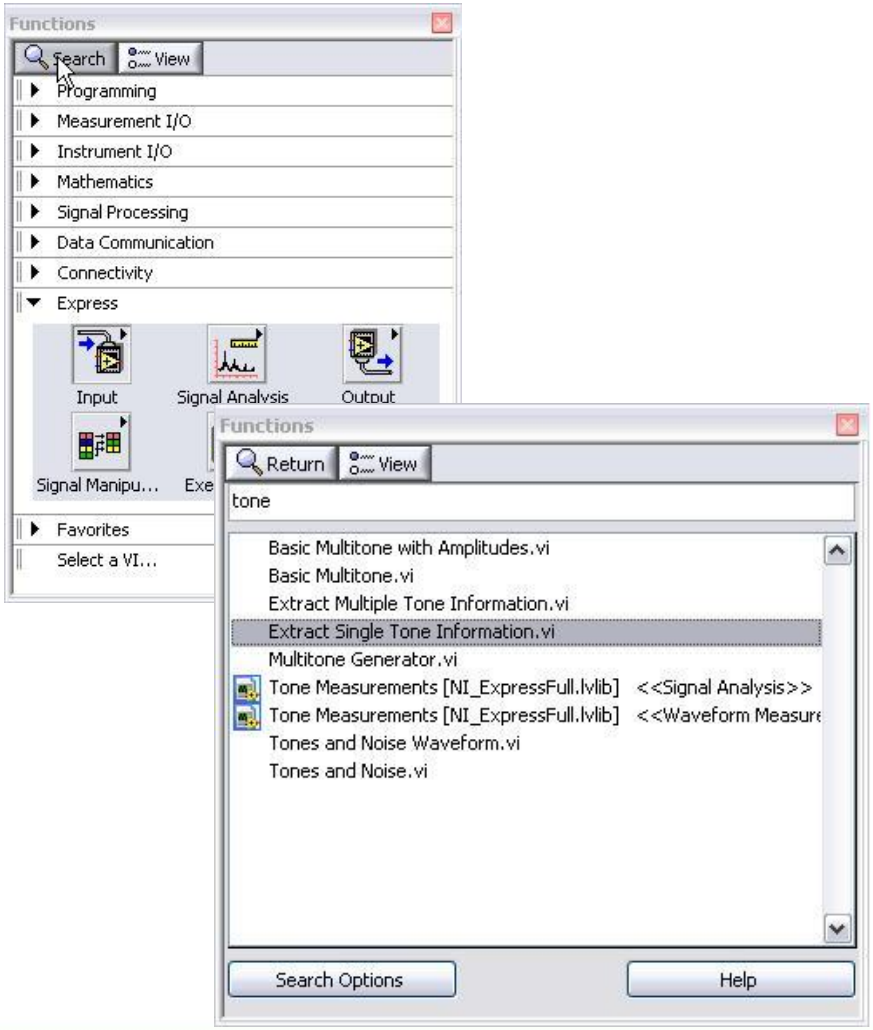
- **Input and Output**
  - Signal and Data Simulation
  - Acquire and Generate Real Signals with DAQ
  - Instrument I/O Assistant (Serial & GPIB)
  - ActiveX for communication with other programs
- **Analysis**
  - Signal Processing
  - Statistics
  - Advanced Math and Formulas
  - Continuous Time Solver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

Express Functions Palette



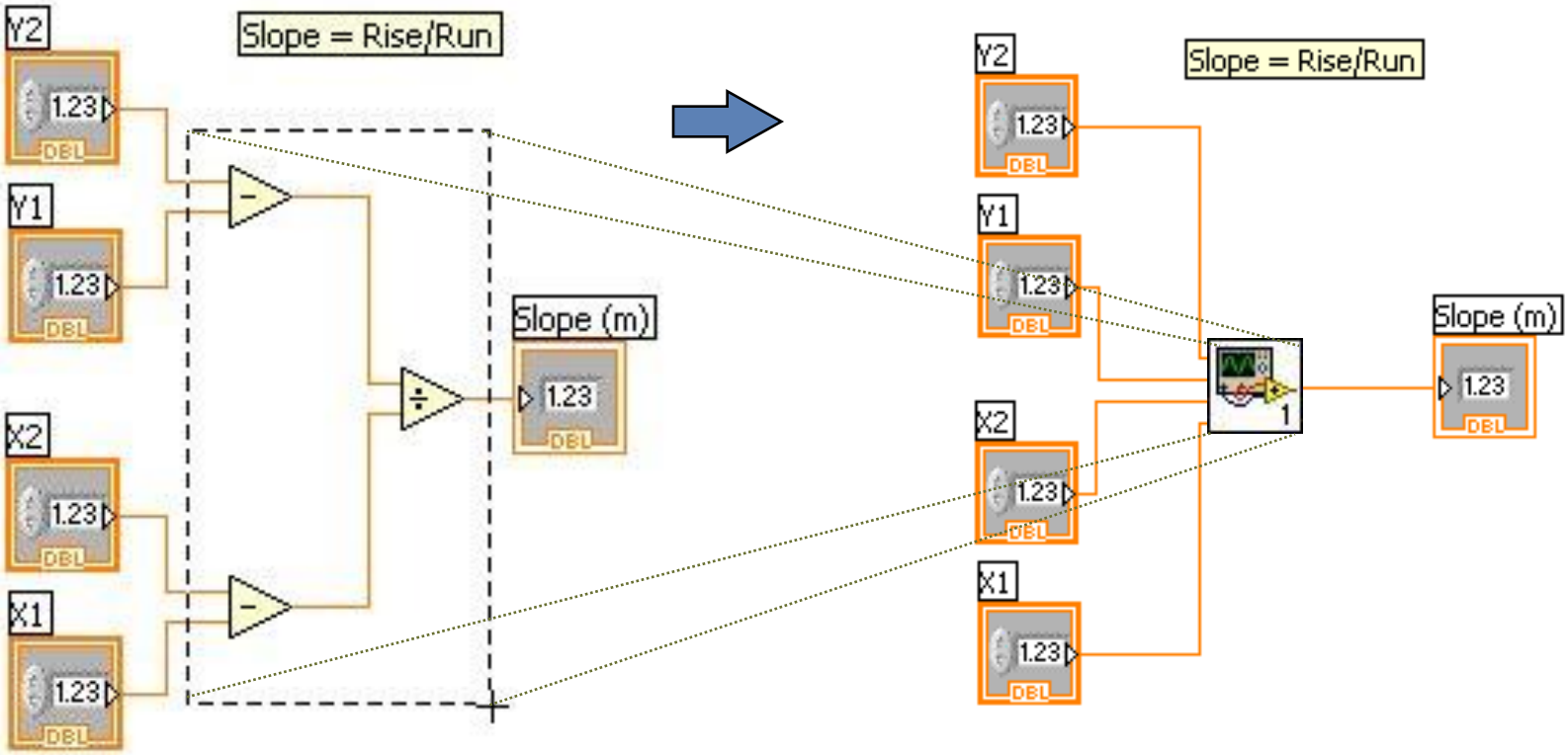
Searching for Controls, VIs, and Functions

- Palettes are filled with hundreds of VIs
- Press the search button to index the all VIs for text searching
- Click and drag an item from the search window to the block diagram
- Double-click an item to open the owning palette



Create SubVI

- Enclose area to be converted into a subVI.
- Select **Edit»Create SubVI** from the Edit Menu.



LabVIEW Functions and SubVIs operate like Functions in other languages

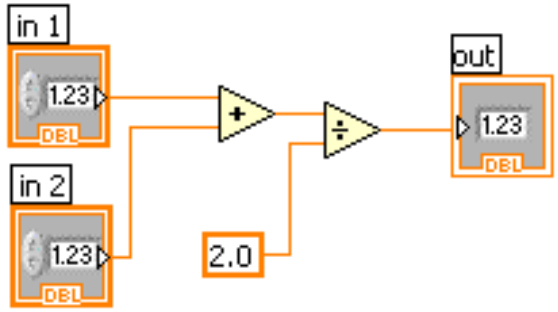
Function Pseudo Code

```
function average (in1, in2, out)
{
out = (in1 + in2)/2.0;
}
```

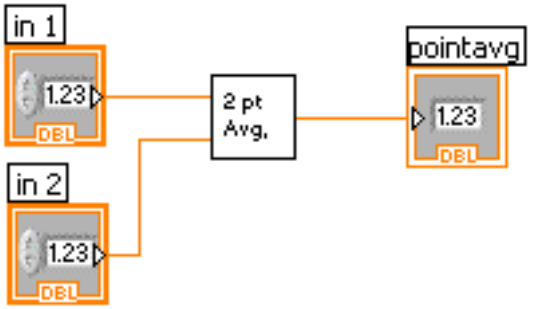
Calling Program Pseudo Code

```
main
{
average (in1, in2, pointavg)
}
```

SubVI Block Diagram



Calling VI Block Diagram

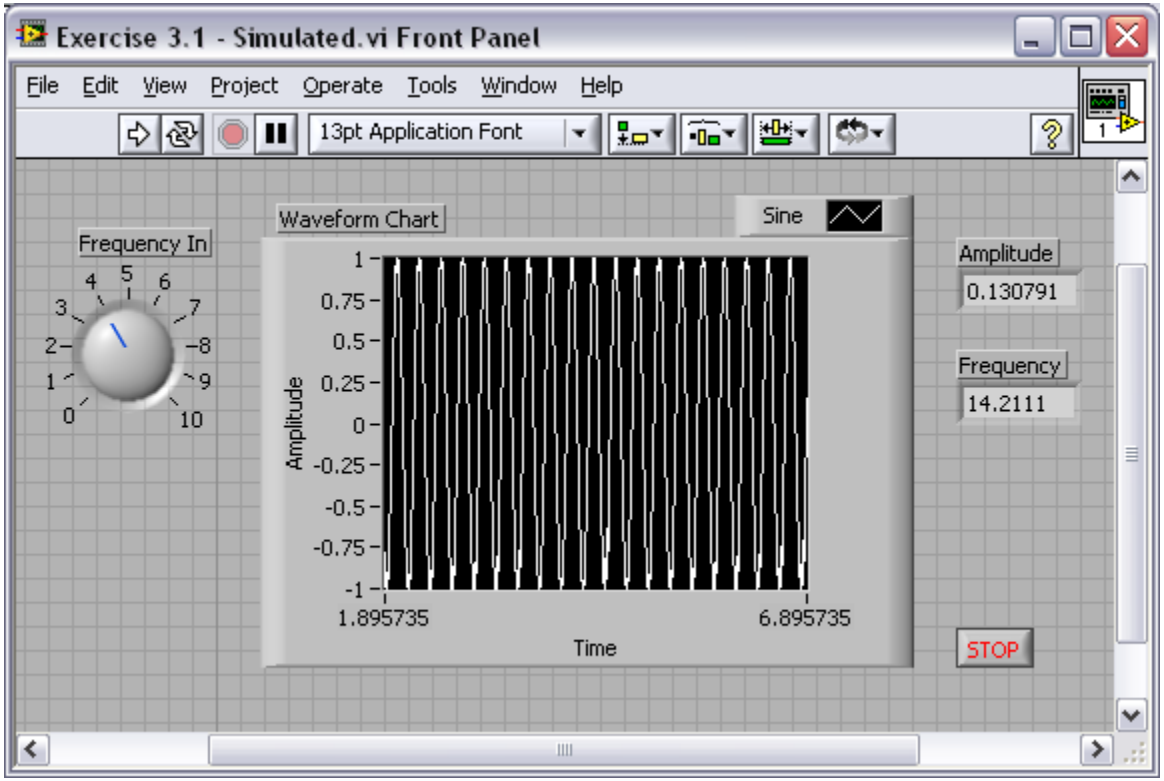


Track A,B,&C

Exercise 3.1 – Analysis

- Use LabVIEW Express VIs to:
  - Simulate a signal and display its amplitude and frequency

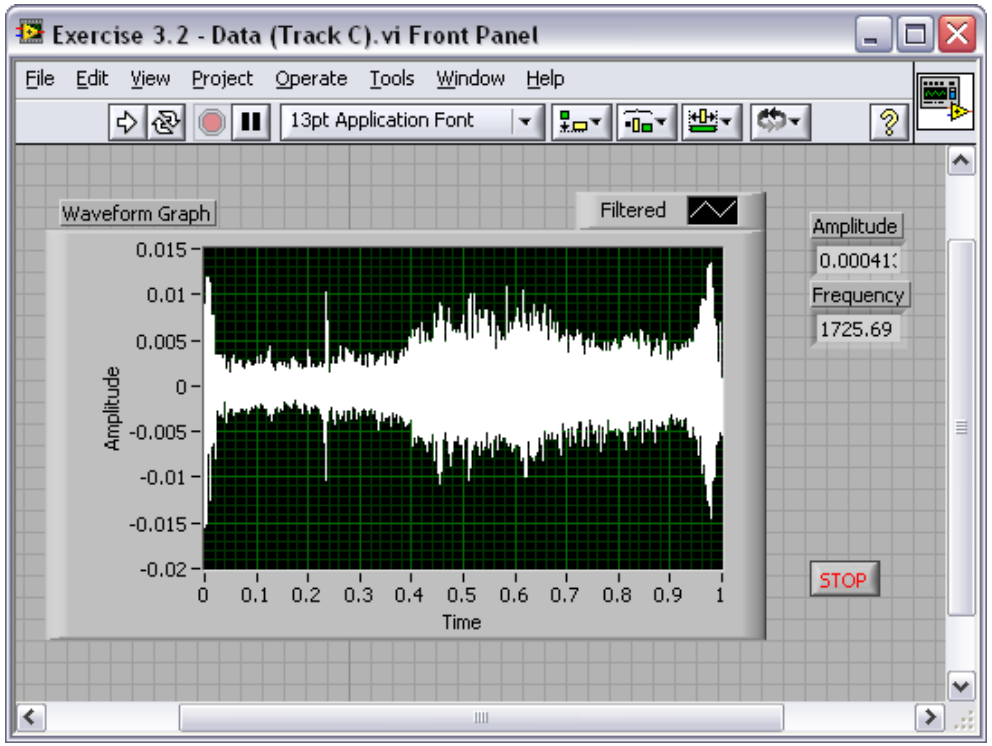
This exercise should take 15 minutes.



Exercise 3.2 – Analysis

- Use LabVIEW Express VIs to:
  - Acquire a signal and display its amplitude and frequency

This exercise should take 15 minutes.



Exercise 3.2 – Analysis

- Use LabVIEW Express VIs to:
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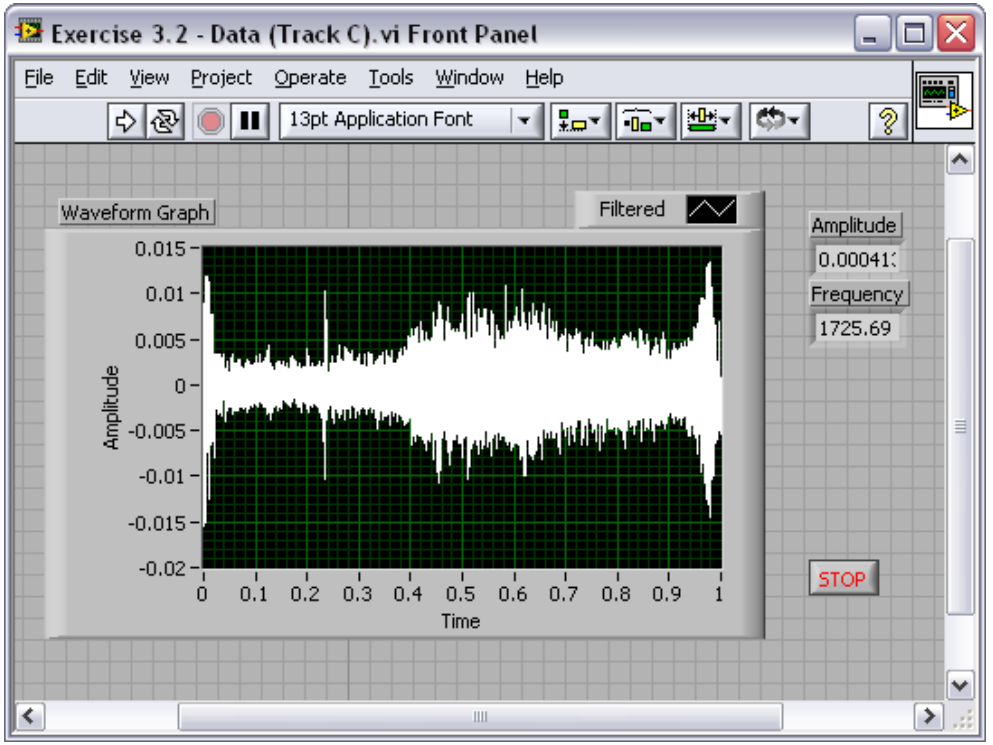
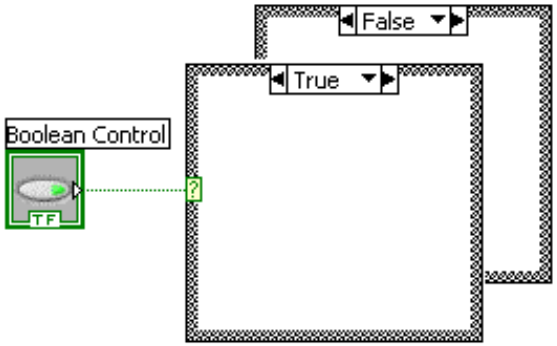
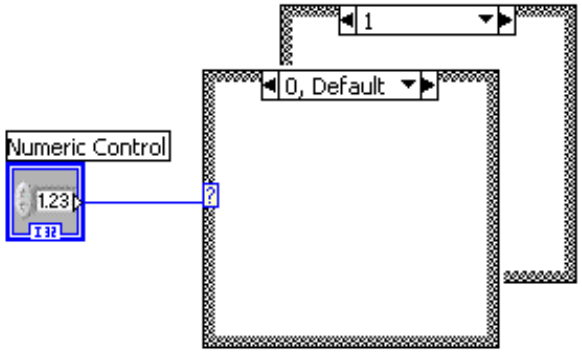


How Do I Make Decisions in LabVIEW?

1. Case Structures

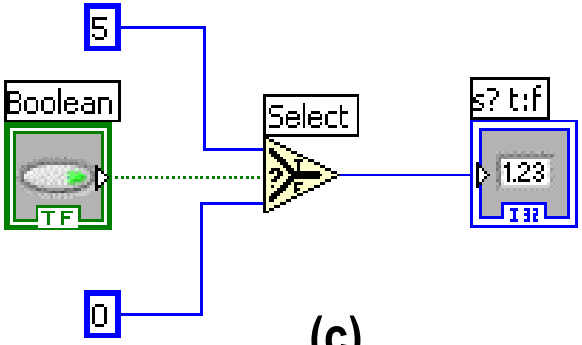


(a)



(b)

2. Select

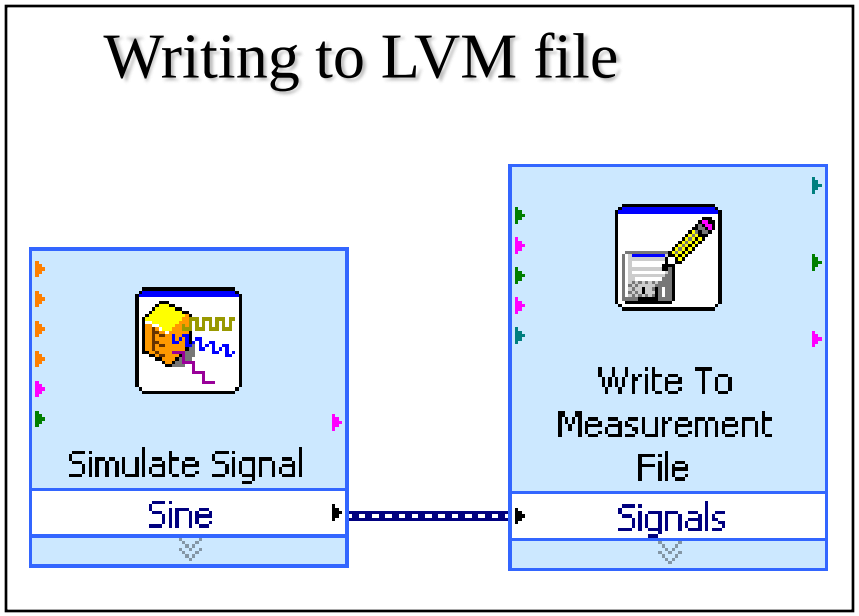


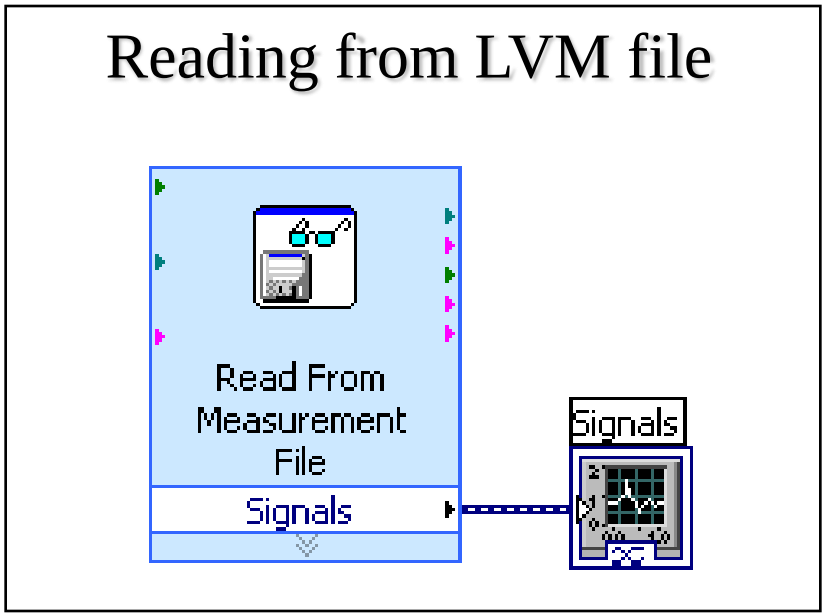
(c)

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)

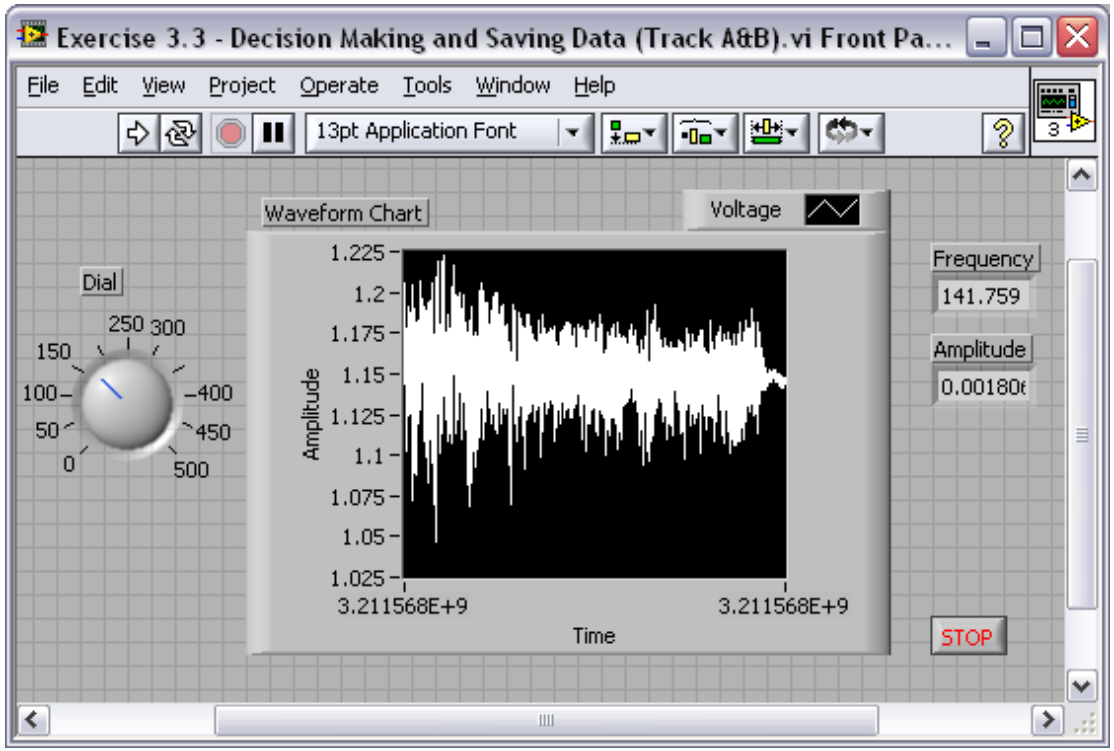




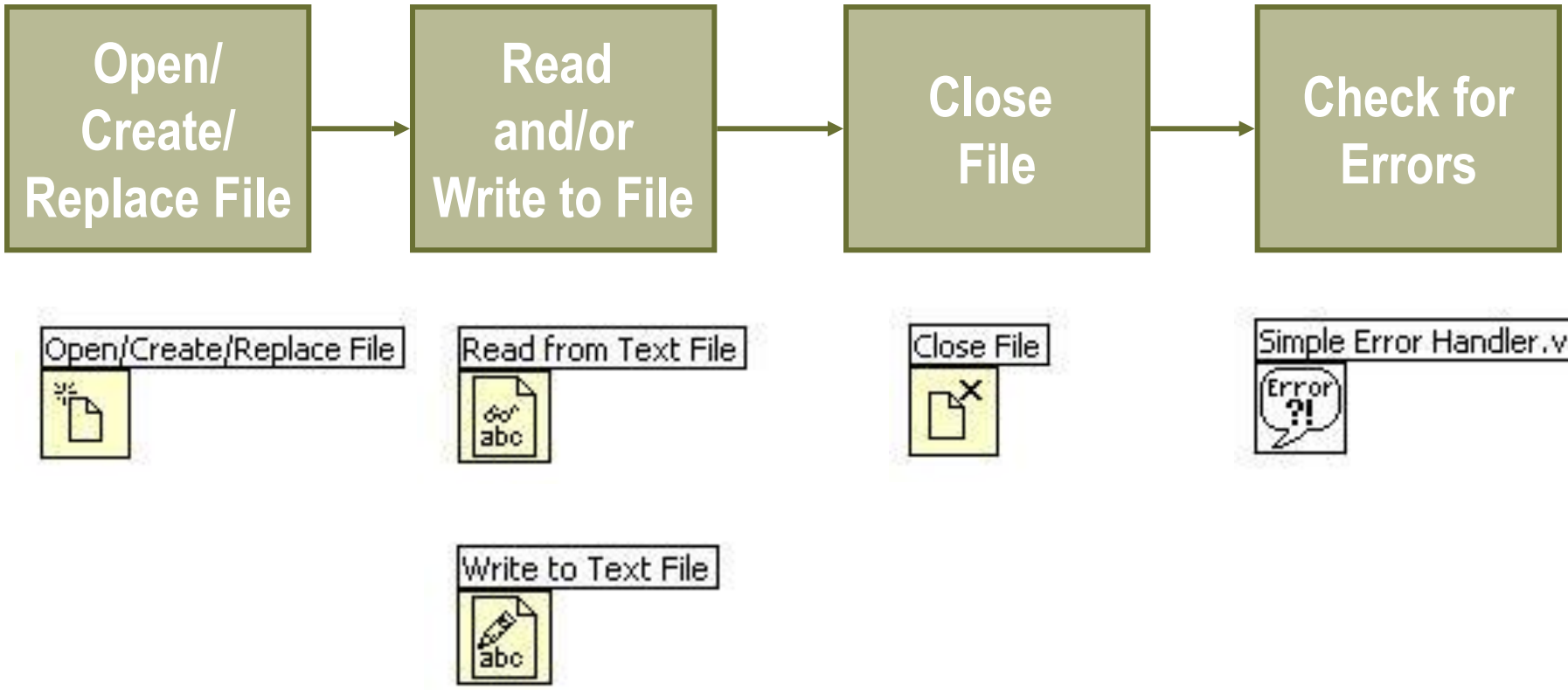
Exercise 3.3 – Decision Making and Saving Data

- Use a case structure to:
  - Make a VI that saves data when a condition is met

This exercise should take 15 minutes.



File I/O Programming Model – Under the hood



Section III – Presenting your Results

A. Displaying Data on the Front Panel

- Controls and Indicators
- Graphs and Charts
- Loop Timing

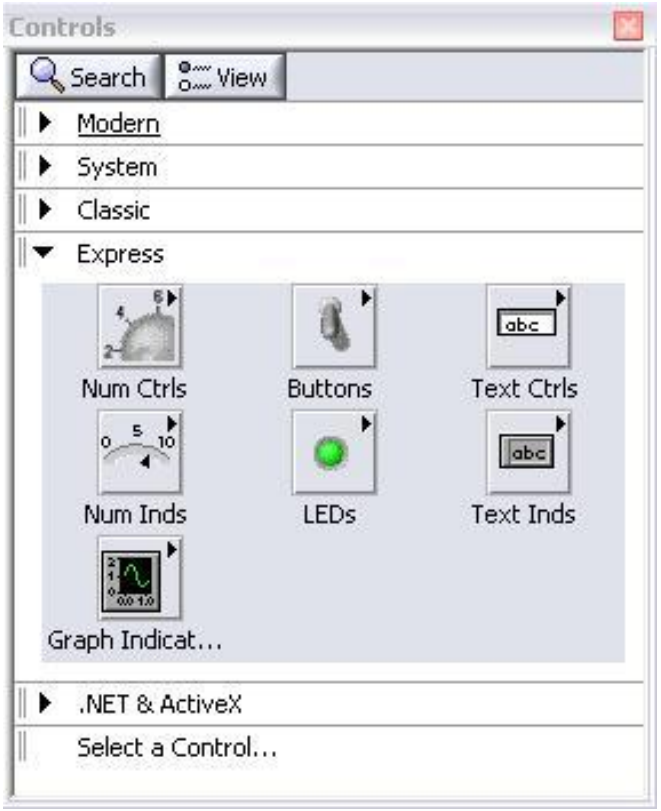
B. Signal Processing

- MathScript
- Arrays
- Clusters
- Waveforms

What Types of Controls and Indicators are Available?

- **Numeric Data**
  - Number input and display
  - Analog Sliders, Dials, and Gauges
- **Boolean Data**
  - Buttons and LEDs
- **Array & Matrix Data**
  - Numeric Display
  - Chart
  - Graph
  - XY Graph
  - Intensity Graph
  - 3D graph: point, surface, and model
- **Decorations**
  - Tab Control
  - Arrows
- **Other**
  - Strings and text boxes
  - Picture/Image Display
  - ActiveX Controls

Express Controls Palette

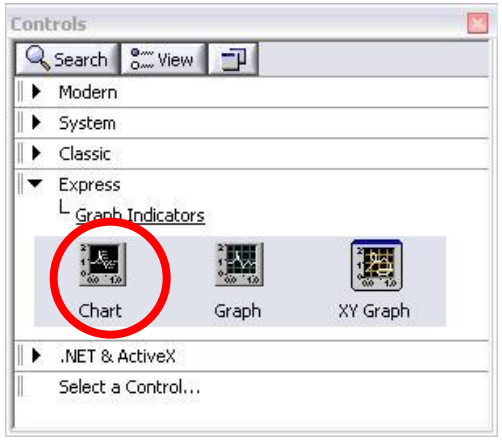


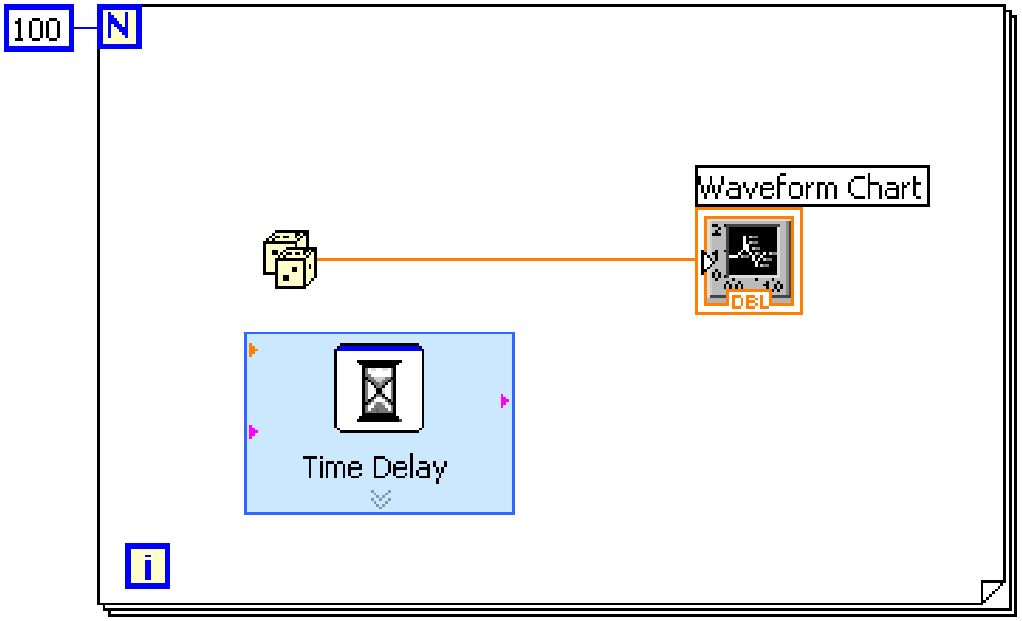
Charts – Add 1 data point at a time with history

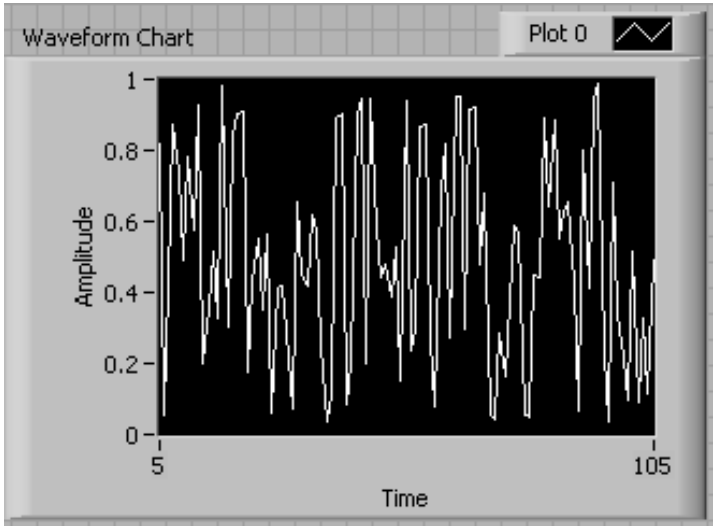
Waveform chart – special numeric indicator that can display a history of values

- Chart updates with each individual point it receives

Functions»Express»Graph Indicators»Chart



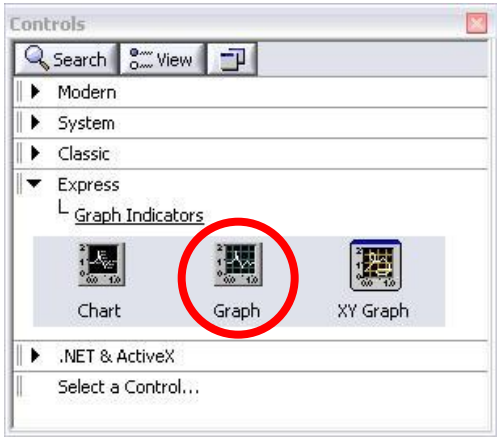




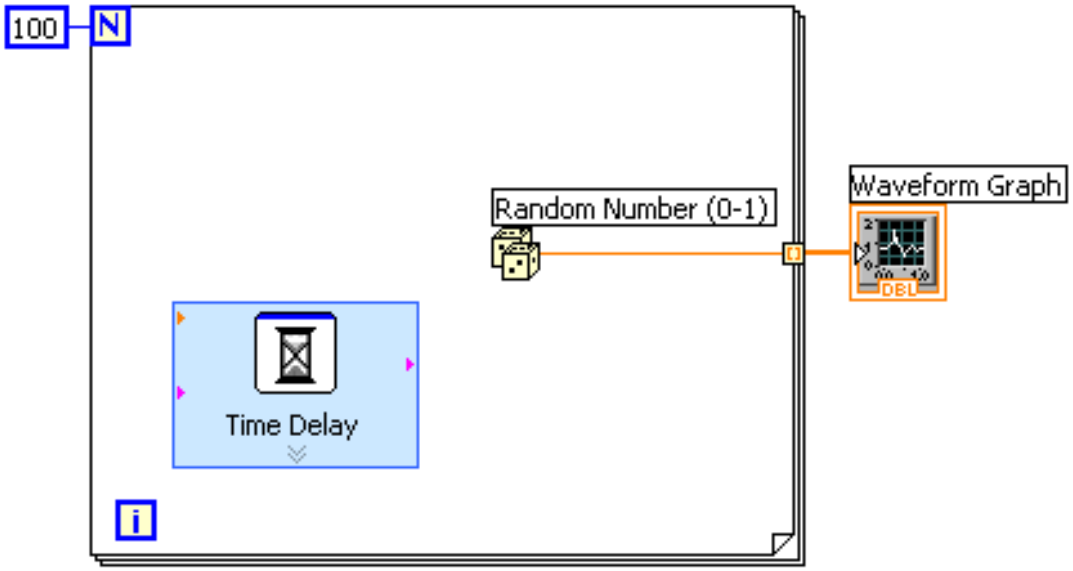
Graphs – Display many data points at once

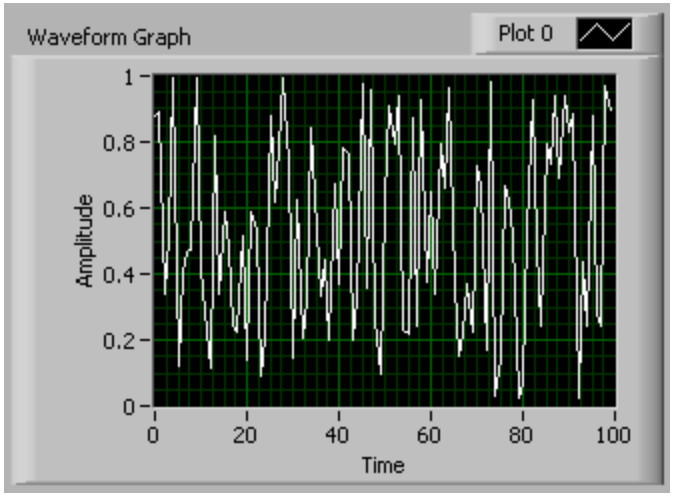
Waveform graph – special numeric indicator that displays an array of data

- Graph updates after all points have been collected
- May be used in a loop if VI collects buffers of data



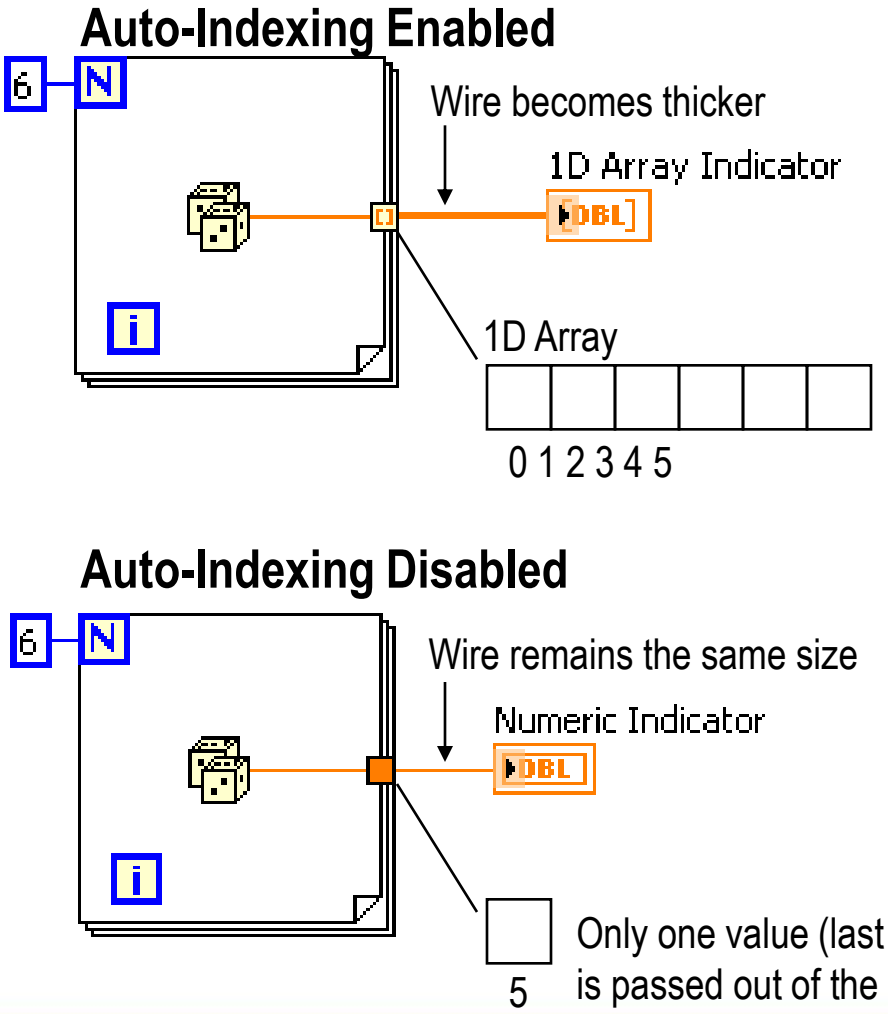
Functions»Express»Graph Indicators»Graph





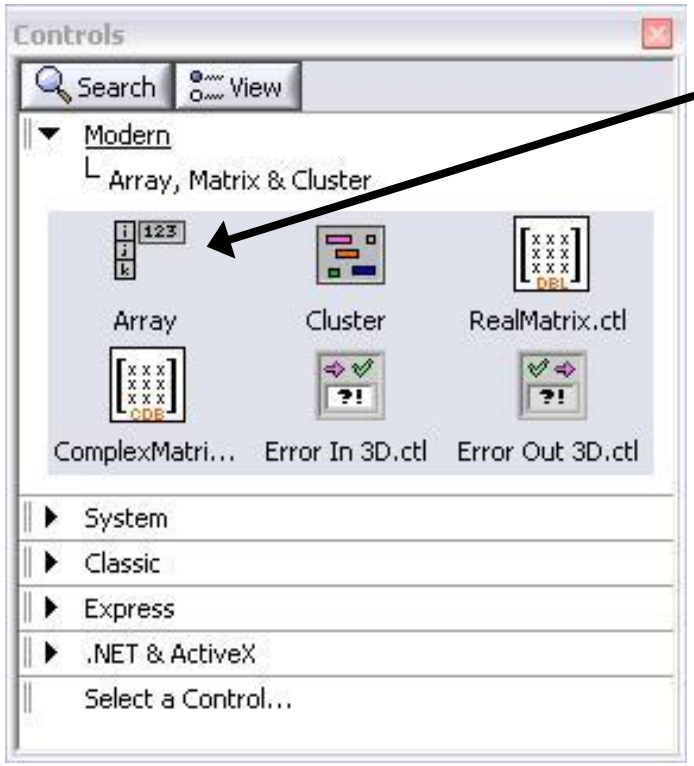
Building Arrays with Loops (Auto-Indexing)

- 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

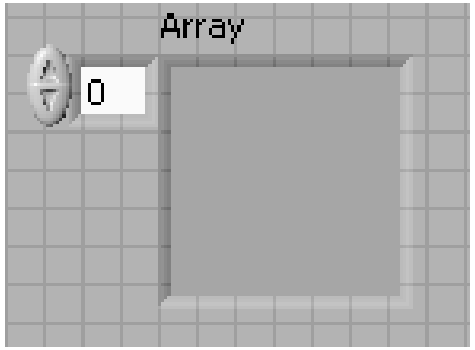


Creating an Array (Step 1 of 2)

From the **Controls»Modern»Array, Matrix, and Cluster** subpalette, select the **Array** icon.

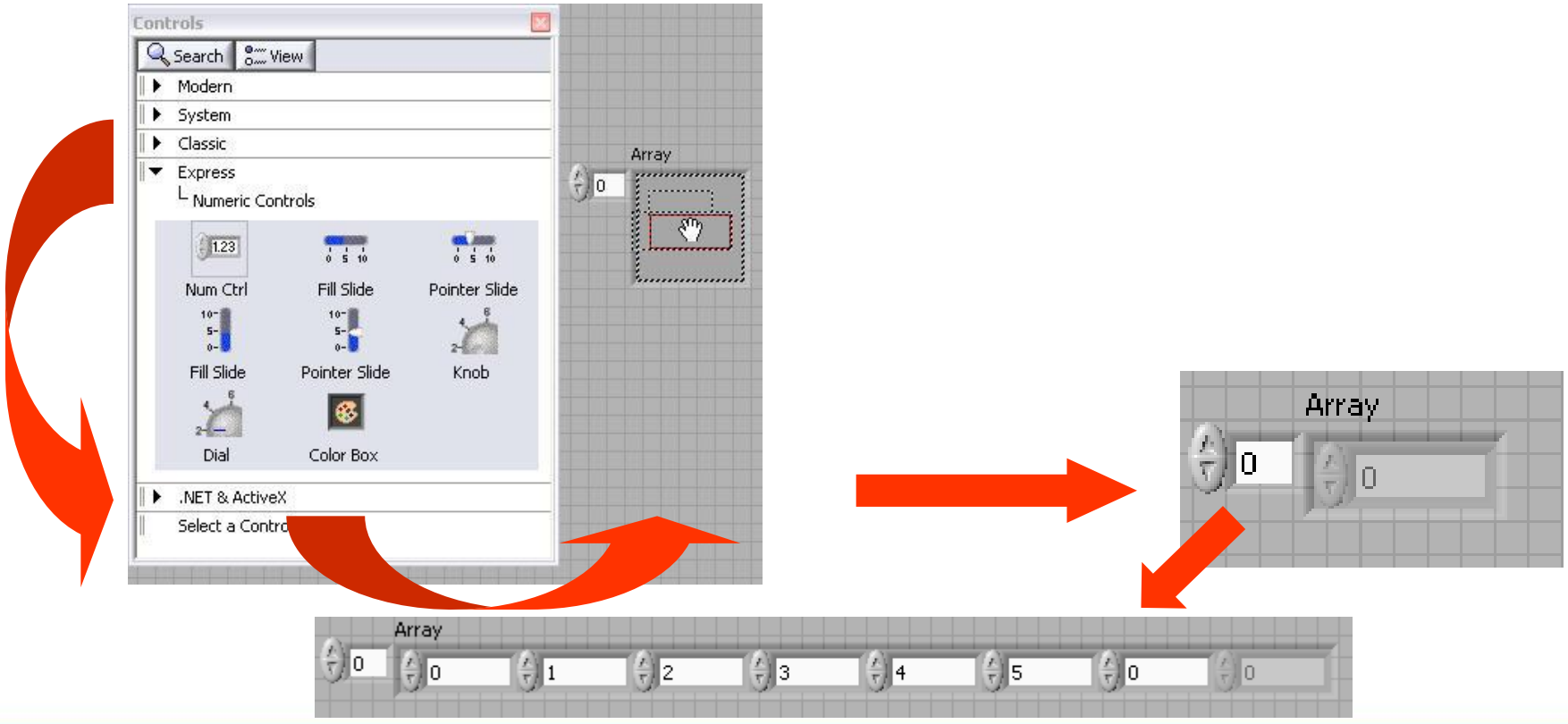


Drop it on the Front Panel.



Create an Array (Step 2 of 2)

1. Place an Array Shell.
2. Insert datatype into the shell (i.e. Numeric Control).



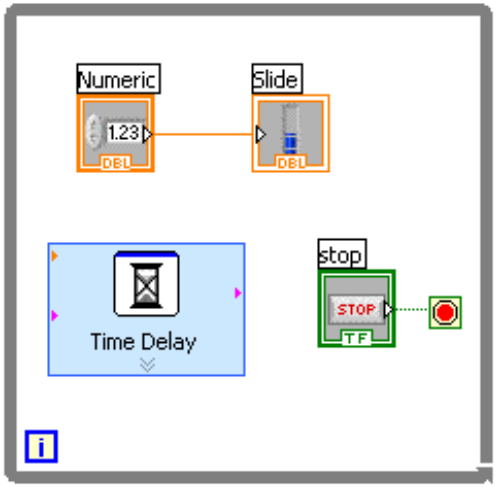
How Do I Time a Loop?

1. Loop Time Delay

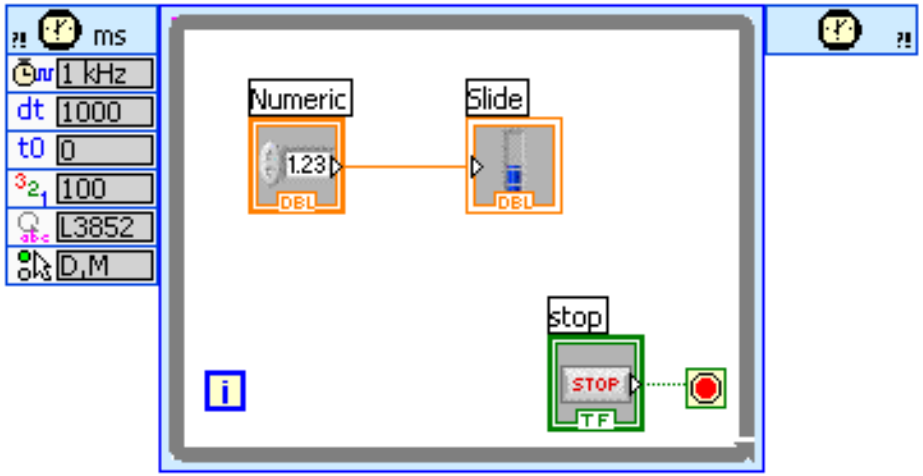
- Configure the Time Delay Express VI for seconds to wait each iteration of the loop (works on For and While loops).

2. Timed Loops

- Configure special timed While loop for desired *dt.*



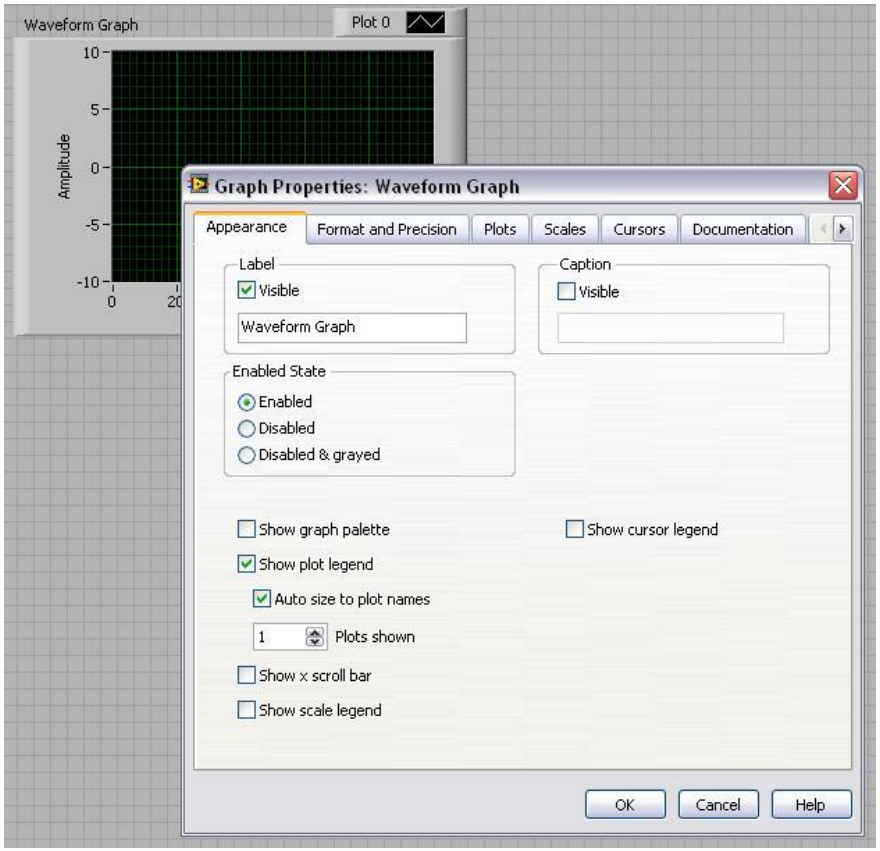
Time Delay



Timed Loop

Control & Indicator Properties

- Properties are characteristics or qualities about an object
- Properties can be found by right clicking on a Control or Indicator
  - Properties Include:
    - Size
    - Color
    - Plot Style
    - Plot color
  - Features include:
    - Cursors
    - Scaling

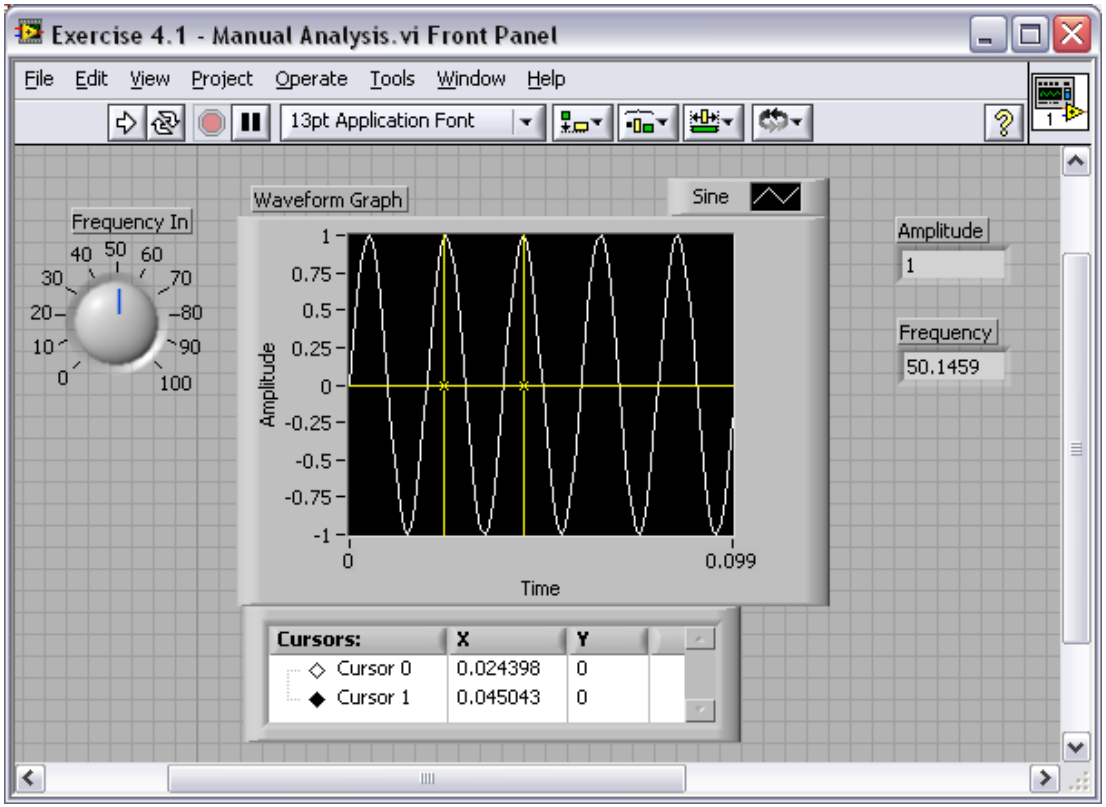


Exercise 4.1 – Manual Analysis

Track A,B,&C

- Use the cursor legend on a graph to:
  - Verify your frequency and amplitude measurements

This exercise should take 15 minutes.



Textual Math in LabVIEW

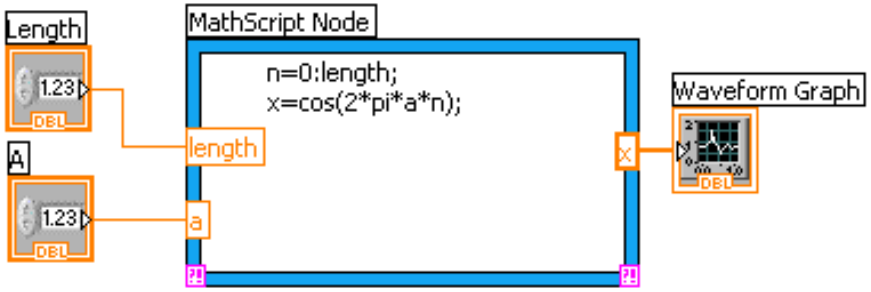
- Integrate existing scripts with LabVIEW for faster development
- Interactive, easy-to-use, hands-on learning environment
- Develop algorithms, explore mathematical concepts, and analyze results using a single environment
- Freedom to choose the most effective syntax, whether graphical or textual within one VI

Supported Math Tools:

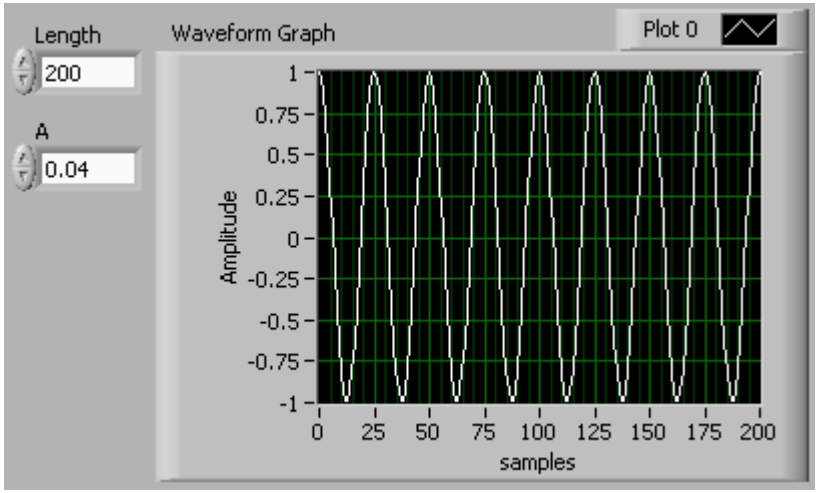
MathScript script node
Mathematica software
Maple software
MathSoft software
MATLAB® software
Xmath software

Math with the MathScript Node

- Implement equations and algorithms textually
- Input and Output variables created at the border
- Generally compatible with popular m-file script language
- Terminate statements with a semicolon to disable immediate output



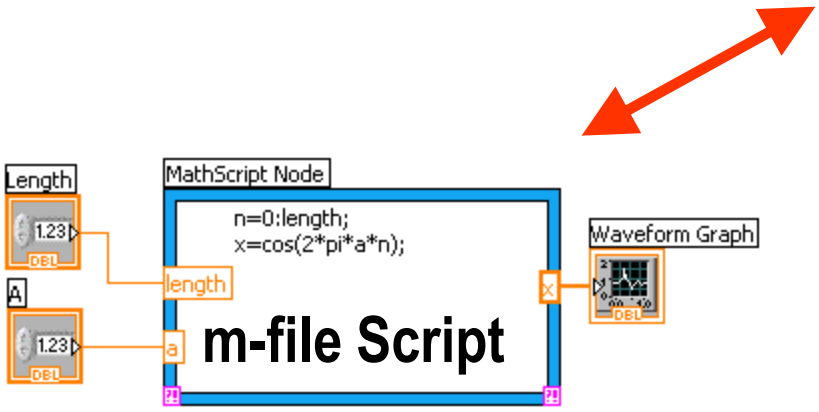
(Functions»Programming» Structures»MathScript)

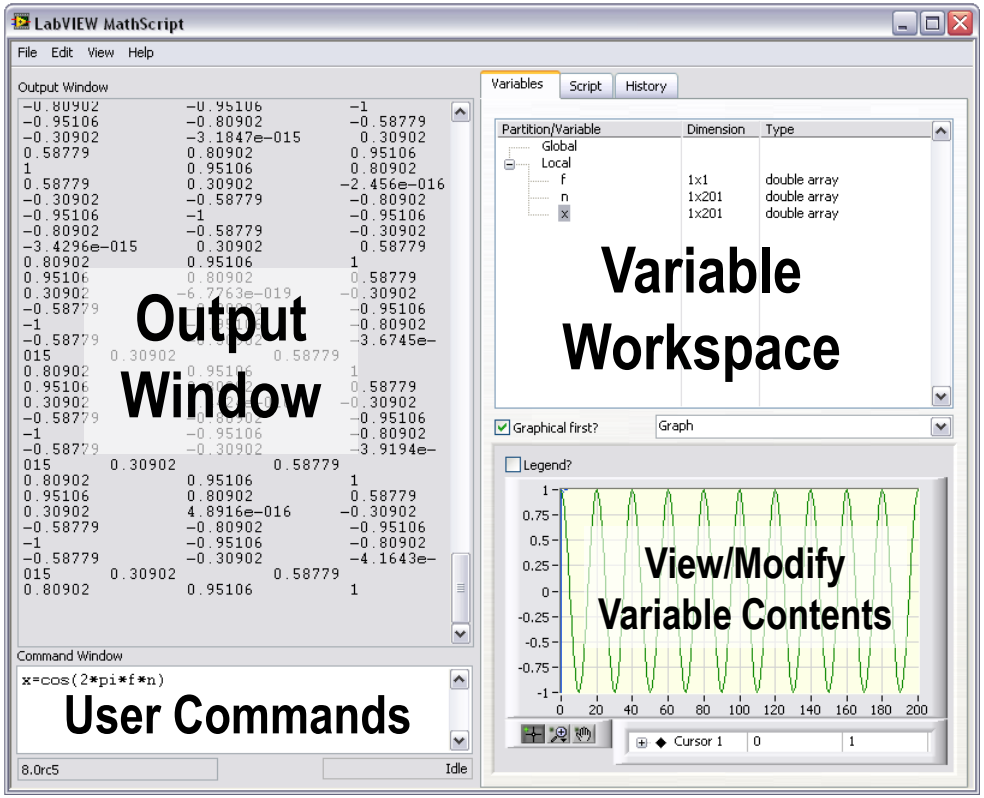


Prototype your equations in the interactive **MathScript Window**.

The Interactive MathScript Window

- Rapidly develop and test algorithms
- Share Scripts and Variables with the Node
- View /Modify Variable content in 1D, 2D, and 3D





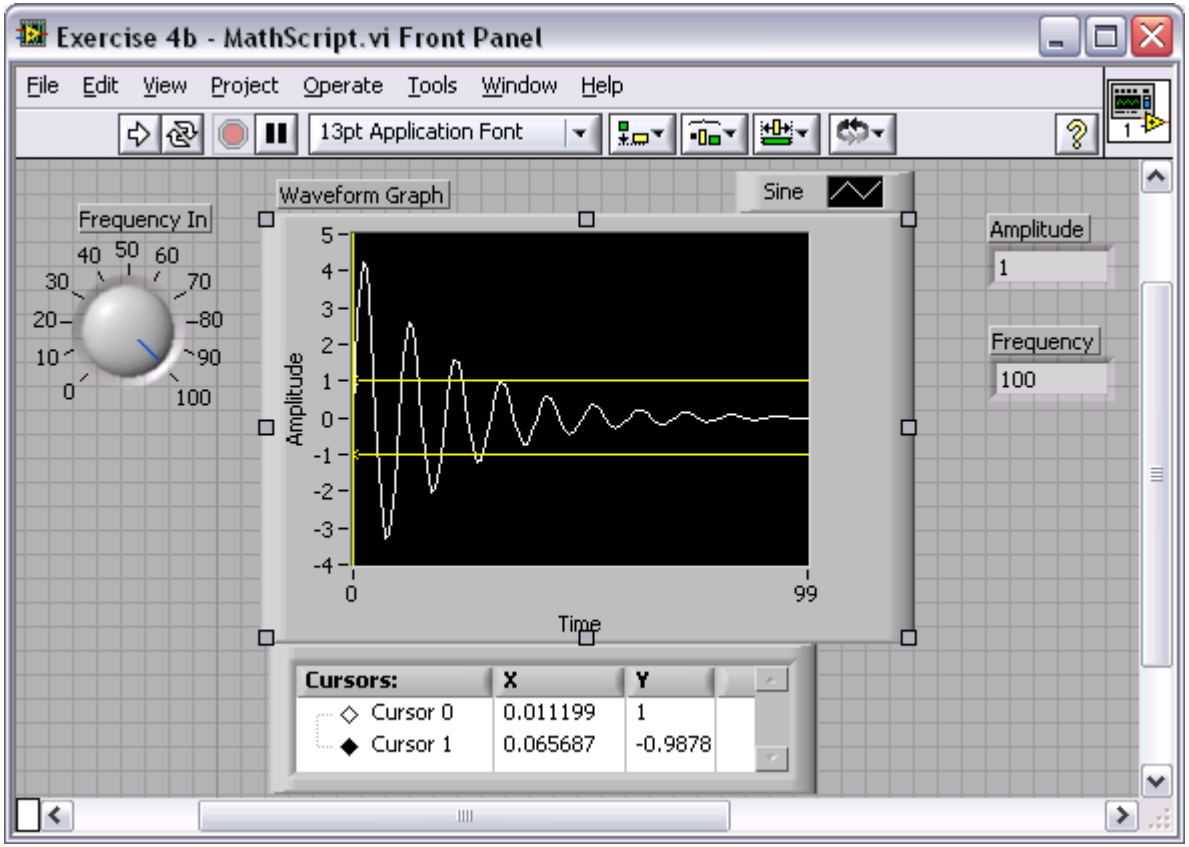
(LabVIEW»Tools»MathScript Window)

Exercise 4.2 – Using MathScript

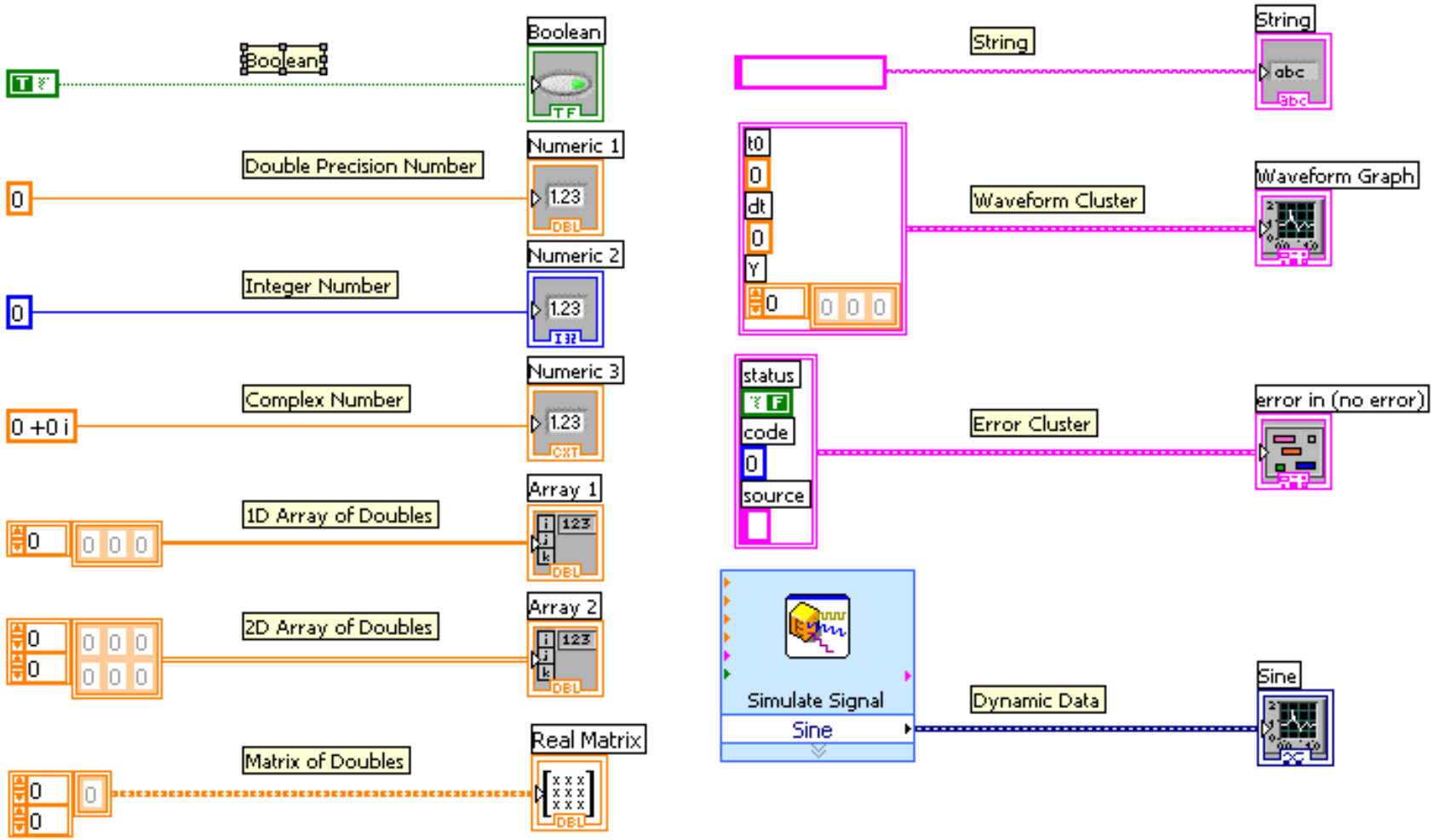
Track A,B,&C

Use the MathScript Node and Interactive Window to process the acquired signal (logarithmic decay) in the MathScript and save the script.

This exercise should take 25 minutes.



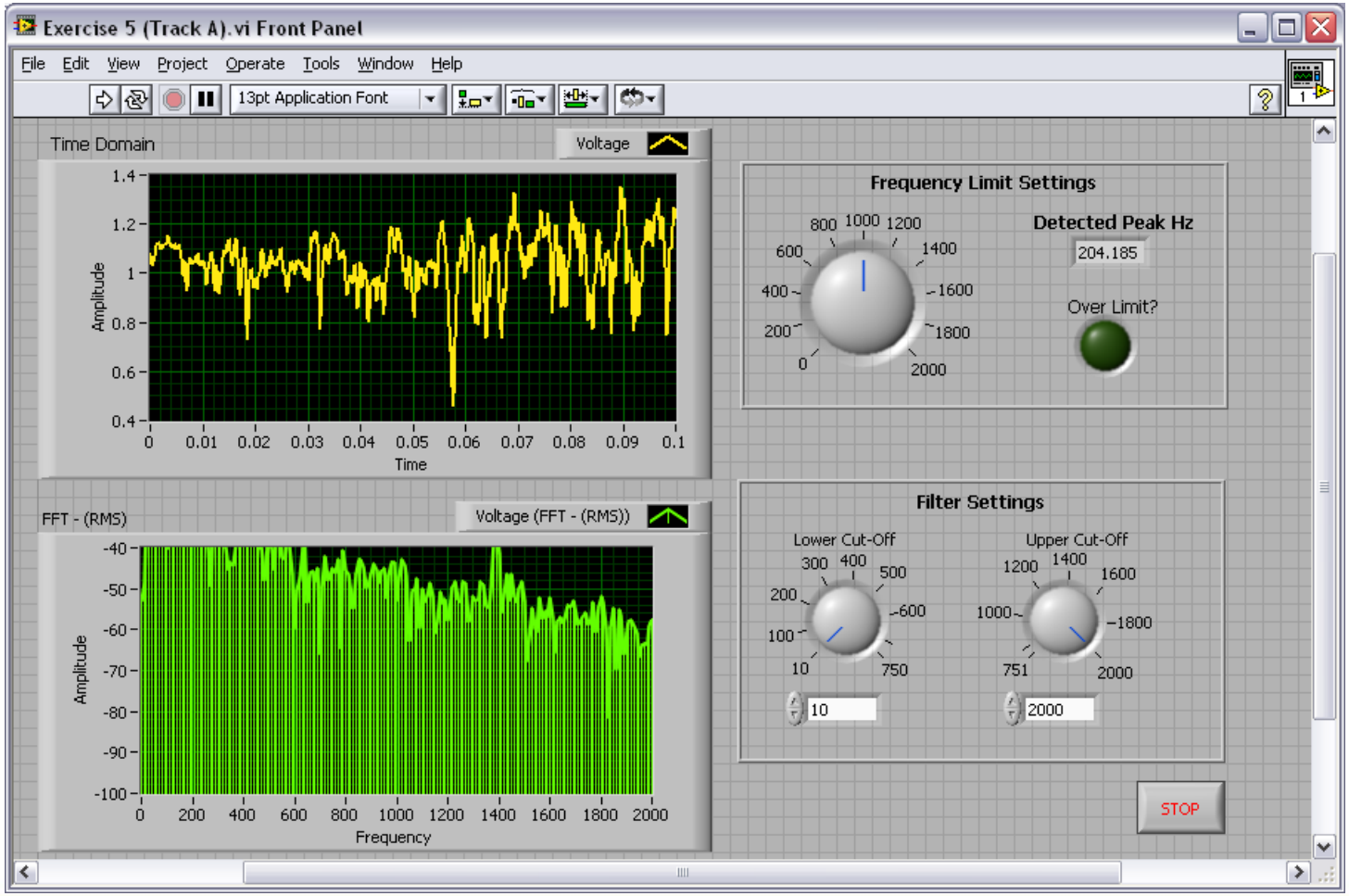
Review of Data Types Found in LabVIEW



Track A,B,&C

Exercise 5 – Apply What You Have Learned

This exercise should take 20 minutes.



Section IV – Advanced Data Flow Topics (optional)

A. Additional Data types

- Cluster

B. Data Flow Constructs

- Shift Register
- Local Variables

C. Large Application Development

- Navigator Window
- LabVIEW Projects

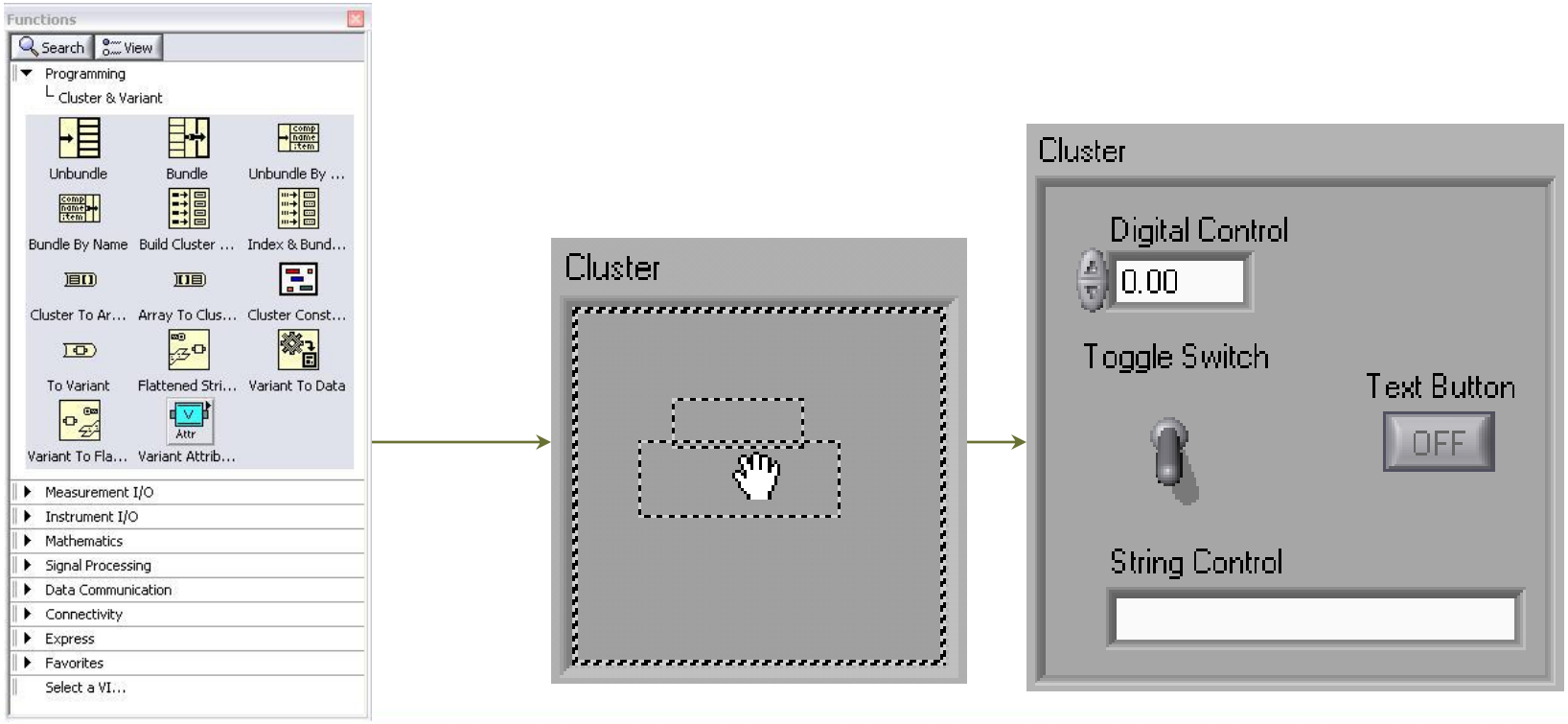
Introduction to Clusters

- 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
- **Order is important**

Creating a Cluster

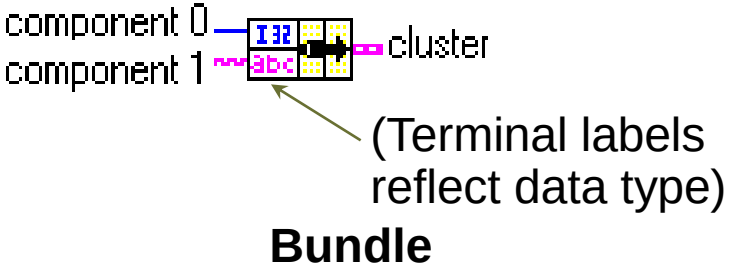
1. Select a **Cluster** shell.
2. Place objects inside the shell.

Controls»Modern»Array, Matrix & Cluster

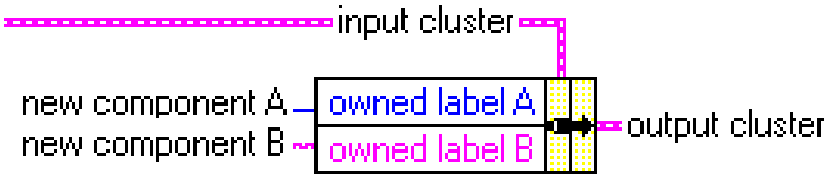


Cluster Functions

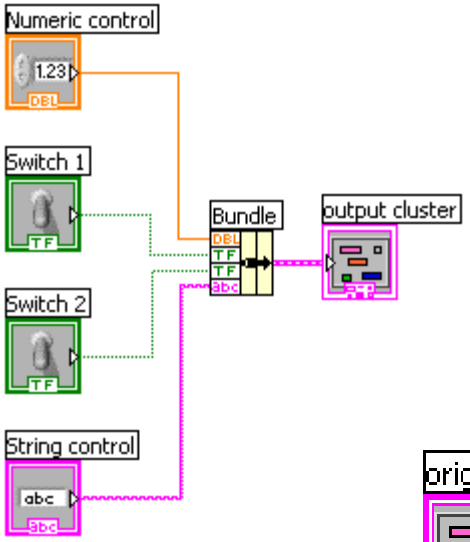
- In the **Cluster & Variant** subpalette of the **Programming** palette
- Can also be accessed by right-clicking the cluster terminal

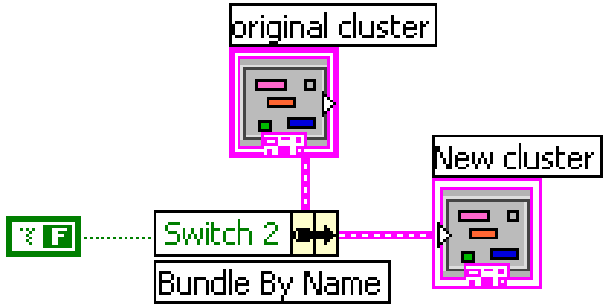


Bundle



Bundle By Name

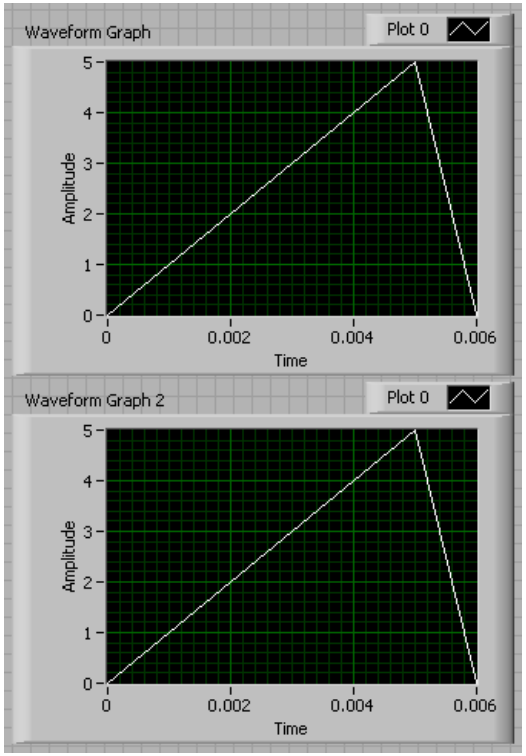




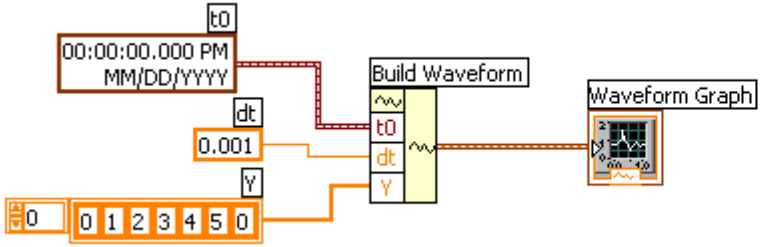
Using Arrays and Clusters with Graphs

The Waveform Datatype contains 3 pieces of data:

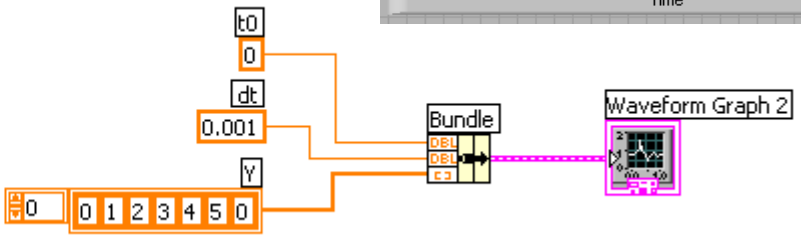
- t0 = Start Time
- dt = Time between Samples
- Y = Array of Y magnitudes



Two ways to create a Waveform Cluster:



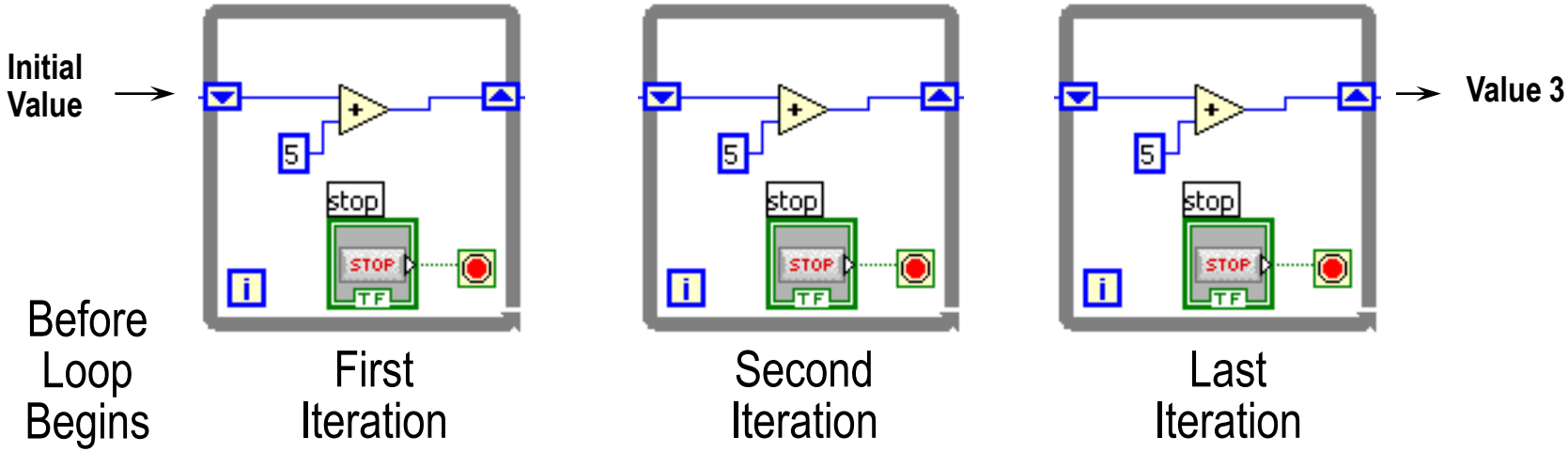
Build Waveform (absolute time)



Cluster (relative time)

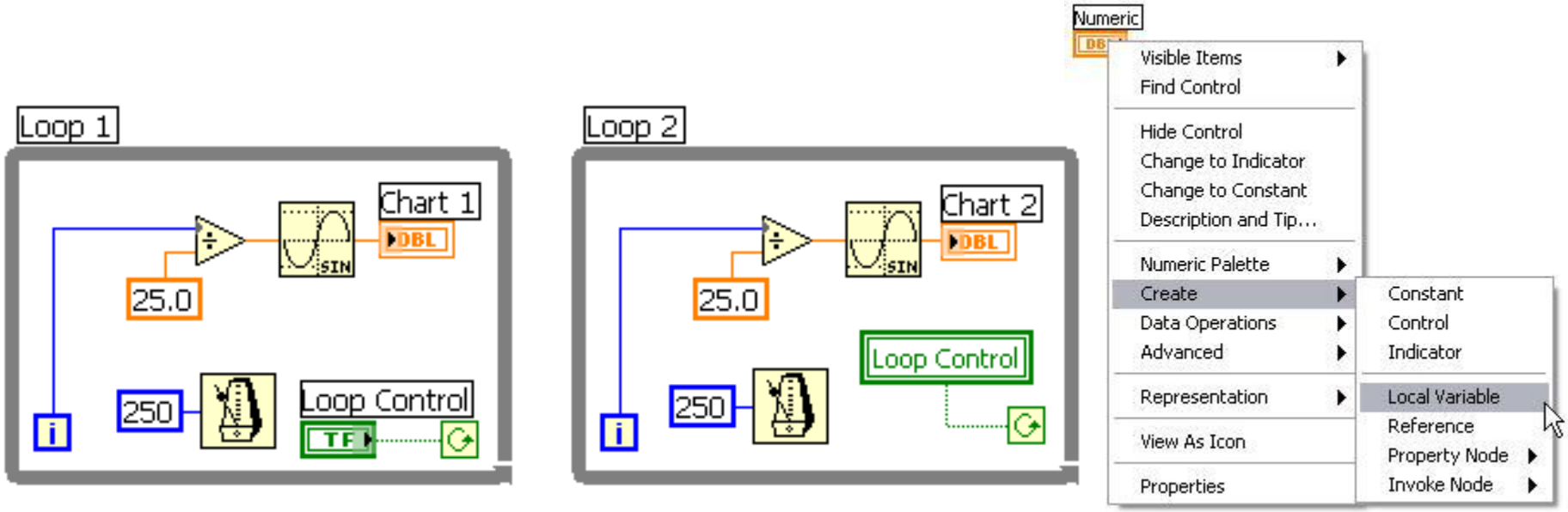
Shift Register – Access Previous Loop Data

- Available at left or right border of loop structures
- Right-click the border and select **Add Shift Register**
- Right terminal stores data on completion of iteration
- Left terminal provides stored data at beginning of next iteration

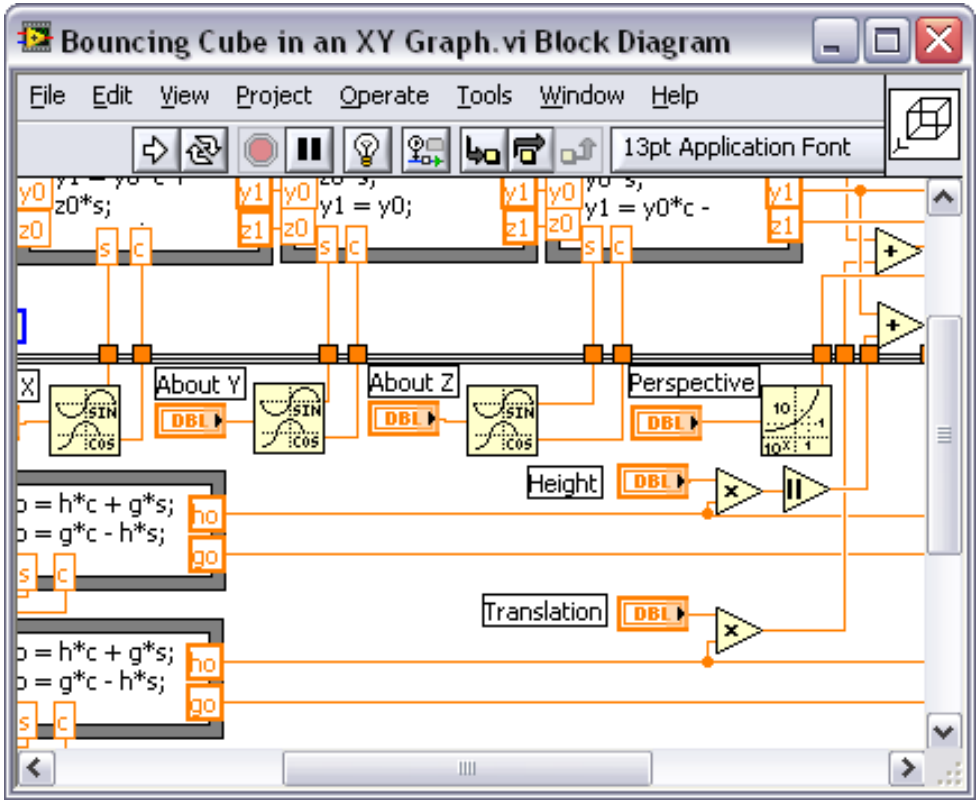


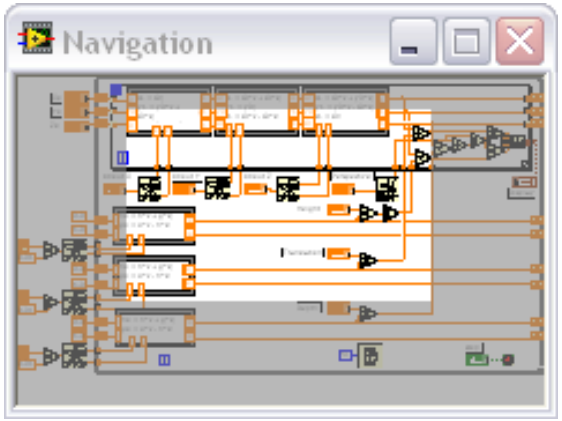
Local Variables

- Local Variables allow data to be passed between parallel loops.
- A single control or indicator can be read or written to from more than one location in the program
  - Local Variables break the dataflow paradigm and should be used sparingly



LabVIEW Navigation Window

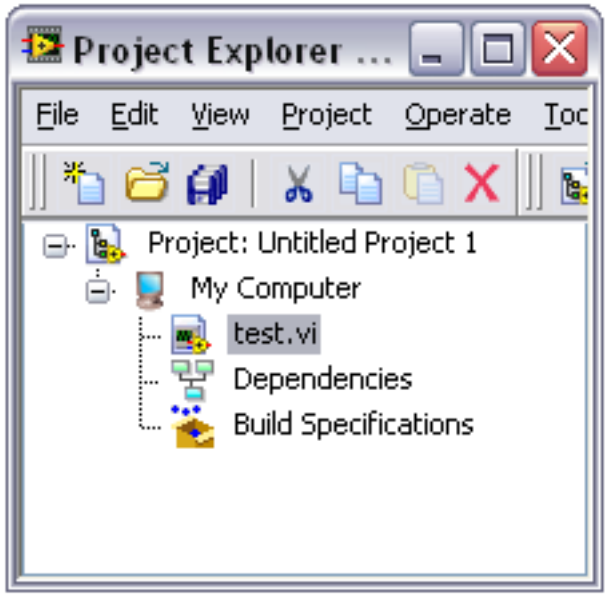




- Shows the current region of view compared to entire Front Panel or Block Diagram
- Great for large programs

* Organize and reduce program visual size with subVIs

LabVIEW Project



- Group and organize VIs
- Hardware and I/O management
- Manage VIs for multiple targets
- Build libraries and executables
- Manage large LabVIEW applications
- Enable version tracking and management

(**LabVIEW»Project»New**)

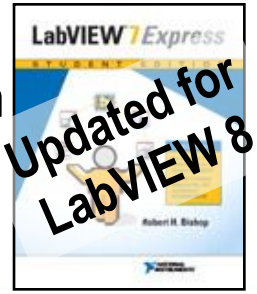
Additional Resources

- NI Academic Web & Student Corner
  - http://www.ni.com/academic

- Connexions: Full LabVIEW Training Course
  - www.cnx.rice.edu
  - Or search for "LabVIEW basics"

- LabVIEW Certification
  - LabVIEW Fundamentals Exam (free on www.ni.com/academic)
  - Certified LabVIEW Associate Developer Exam (industry recognized certification)

- Get your own copy of LabVIEW Student Edition
  - www.ni.com/academic



By Robert H Bishop.

Published by Prentice Hall.

The LabVIEW Certification Program

Architect

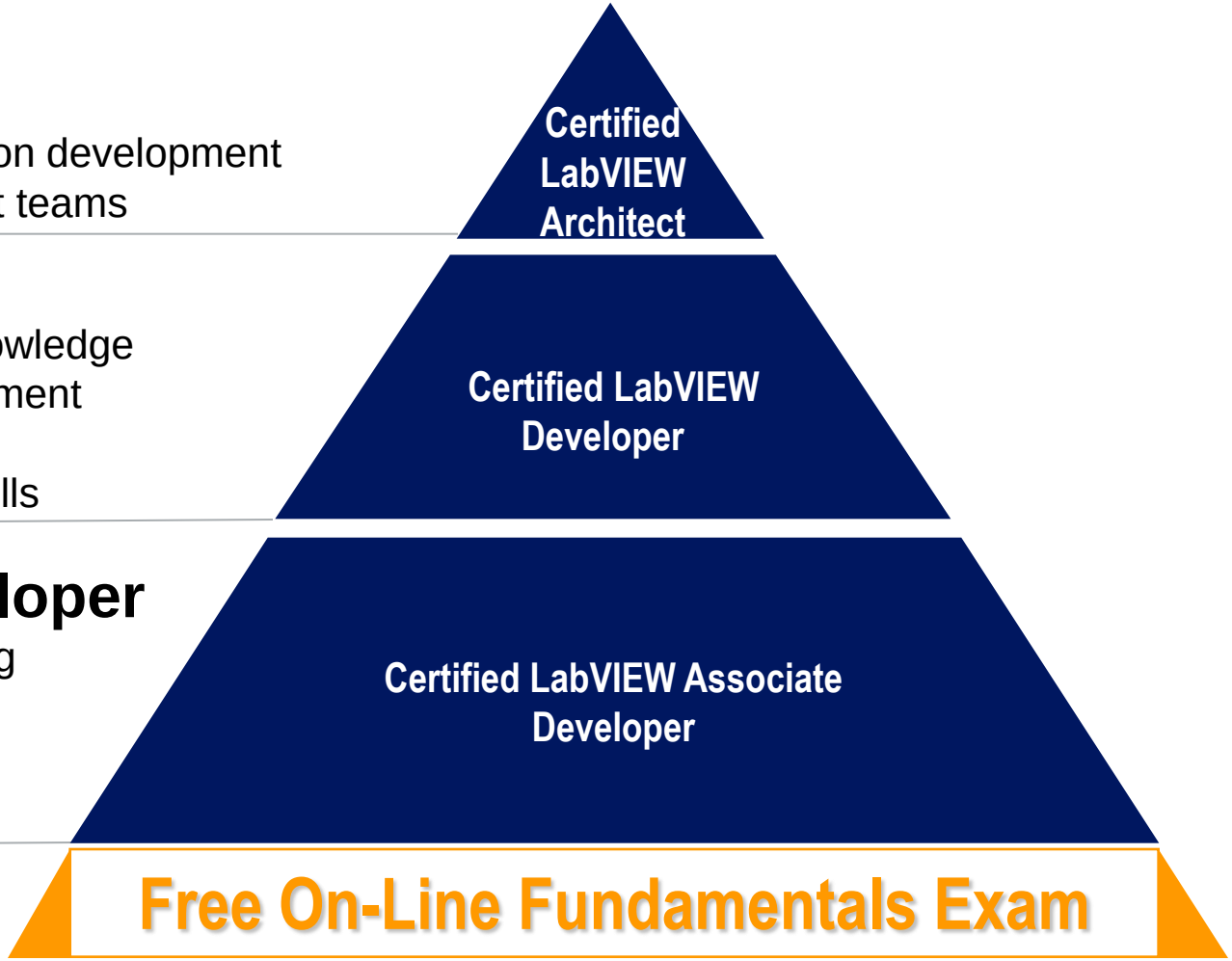
- Mastery of LabVIEW
- Expert in large application development
- Skilled in leading project teams

Developer

- Advanced LabVIEW knowledge and application development experience
- Project management skills

Associate Developer

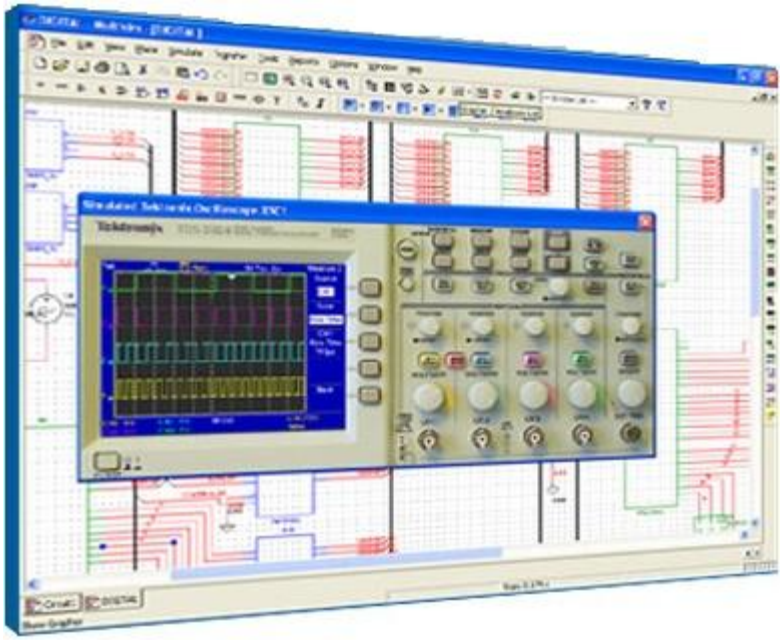
- Proficiency in navigating LabVIEW environment
- Some application development experience



Fundamentals Exam

- Pre-Certification Skills Test

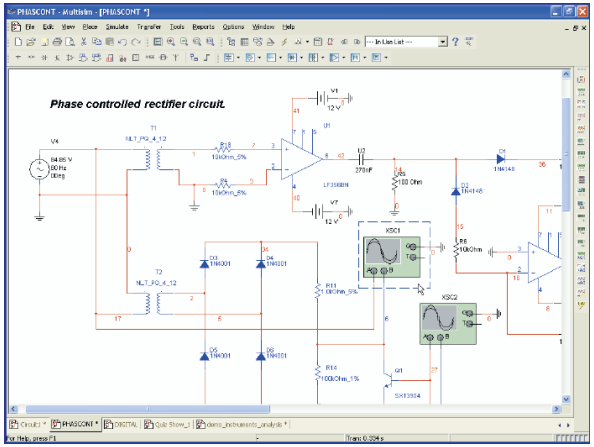
Electronics Workbench and Multisim



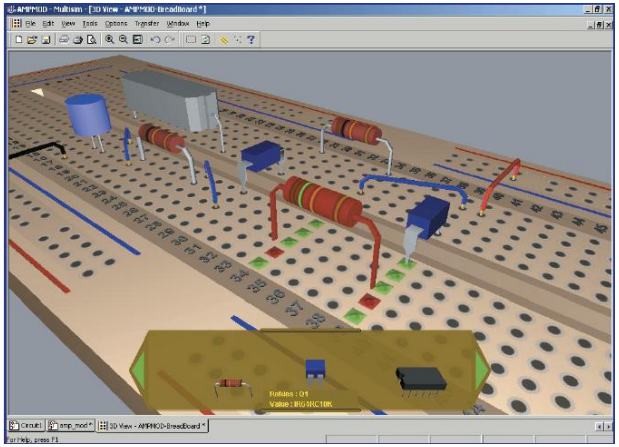
- World's most popular software for learning electronics
- 180,000 industrial and academic users
- Products include:
  - Multisim: Simulation and Capture
  - Multi-MCU: Microcontroller Simulation
  - MultiVHDL: VHDL Simulation
  - Ultiboard: PCB Layout
  - Electronics CBT: Computer-based training
- Low cost student editions available
- www.electronicsworkbench.com

Multisim Integrated with LabVIEW

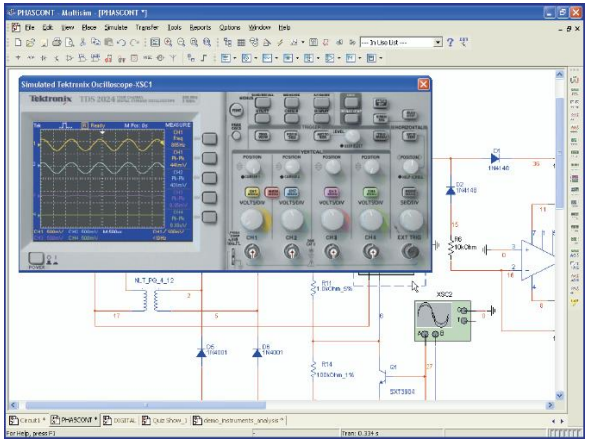
1. Create Schematic



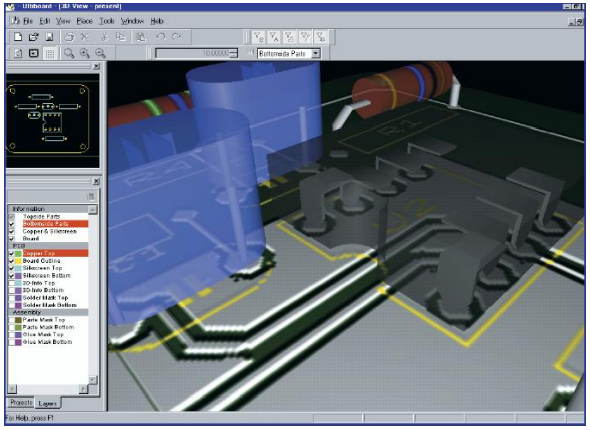
2. Virtual Breadboard



3. Simulate

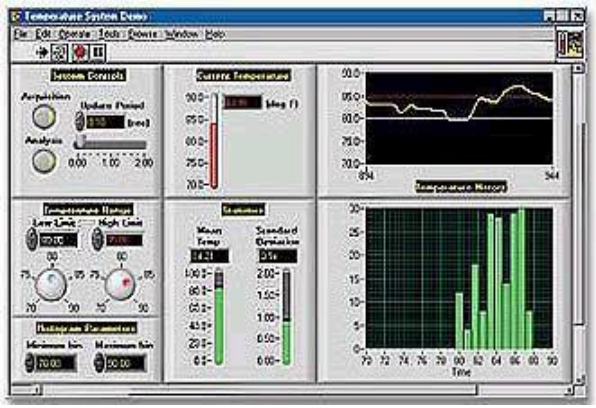


4. PCB Layout



5. Test

6. Compare



Your Next Step…

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