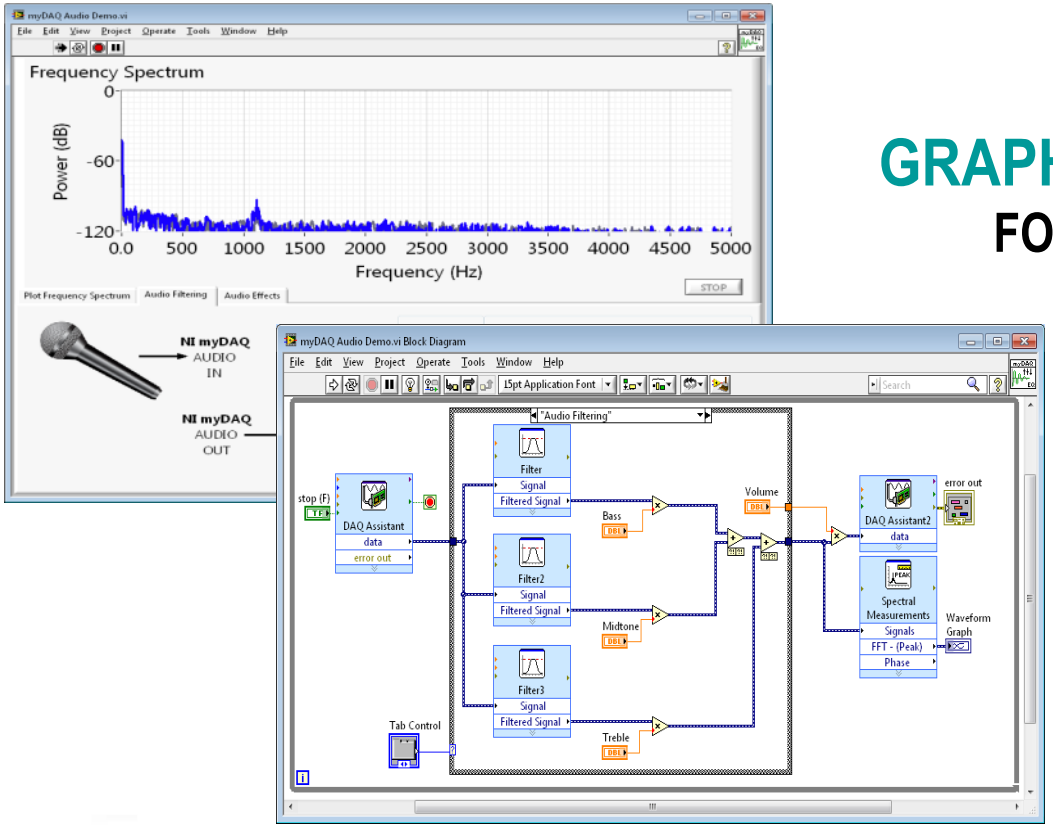
Hands-On with LabVIEW



GRAPHICAL PROGRAMMING

FOR ENGINEERS AND SCIENTISTS

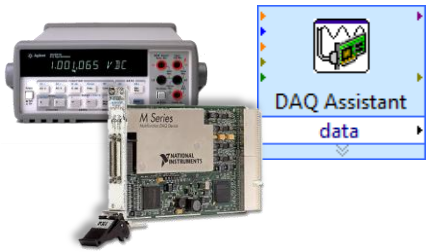
LabVIEW™

*Last revised for LabVIEW 2010

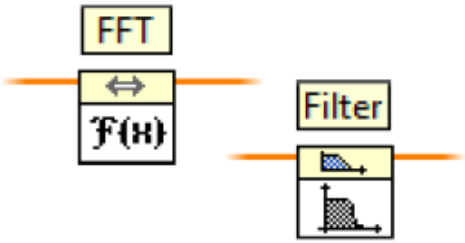
NATIONAL INSTRUMENTS

LabVIEW™

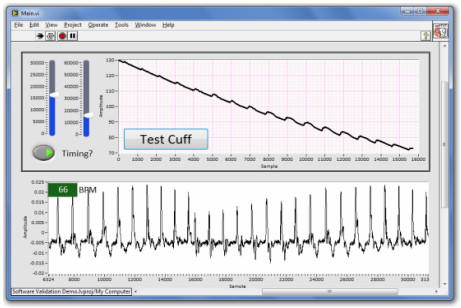
A Highly Productive Graphical Development Environment for Engineers and Scientists



Hardware APIs

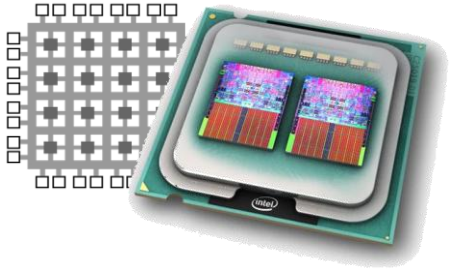


Built-in Libraries

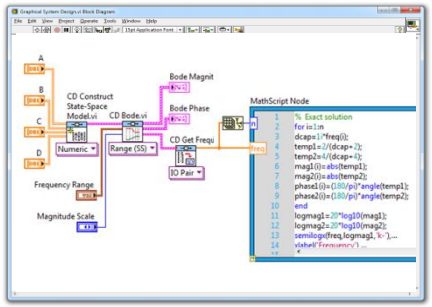


Custom User Interfaces

Deployment Targets



Technology Abstractions



Approaches

Section I – LabVIEW Environment

A. Set up Your Hardware
B. Take Your First Measurement
   - Open and Explore Final Project: Audio Equalizer
C. Demonstration: Creating our First VI
D. LabVIEW Environment
E. Hands-On Exercise: Acquiring Data
   - Write a program that reads in a signal from a microphone

A. Setting Up Your Hardware

- Data Acquisition Device (DAQ)
  - NI myDAQ
  - Configured in Measurement and Automation Explorer (MAX)

Track A

- Sound Card
  - Available in most PCs
  - No additional configurations required

Track B

NI myDAQ

Analog Input:

2 channels, 200kS/s/ch, 16-bit

Analog Output:

2 channels, 200kS/s/ch, 16-bit

DIO: 8 lines

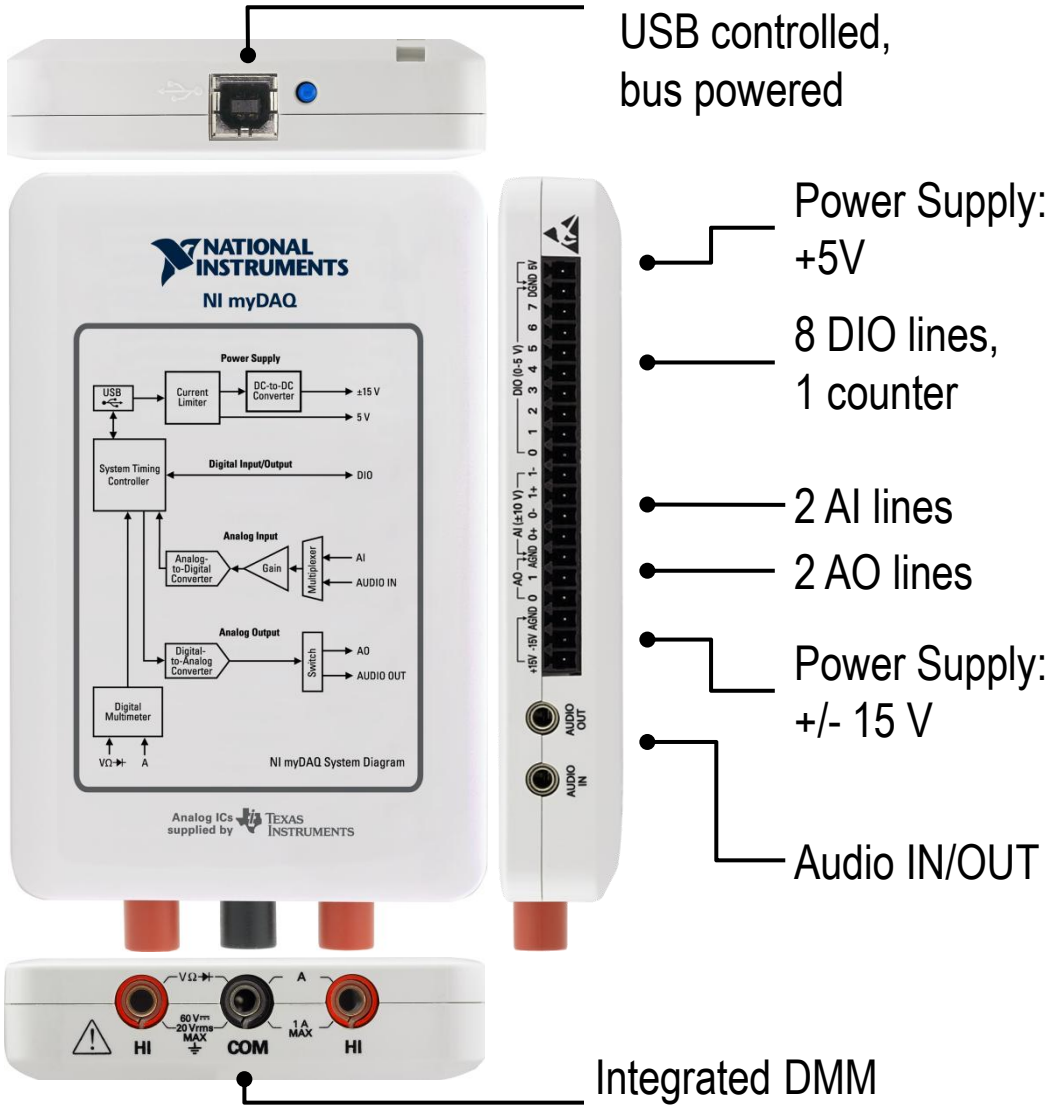
CTR: 1 counter

Integrated DMM: V, A, Ohm

Power Supply: +5V, +/-15V

3.5mm stereo audio jacks

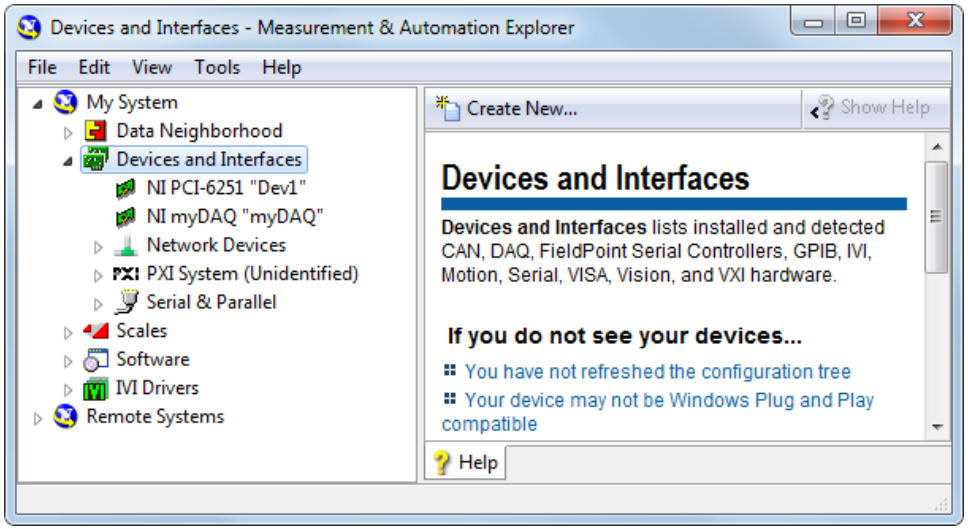
ELVISmx Software Instruments

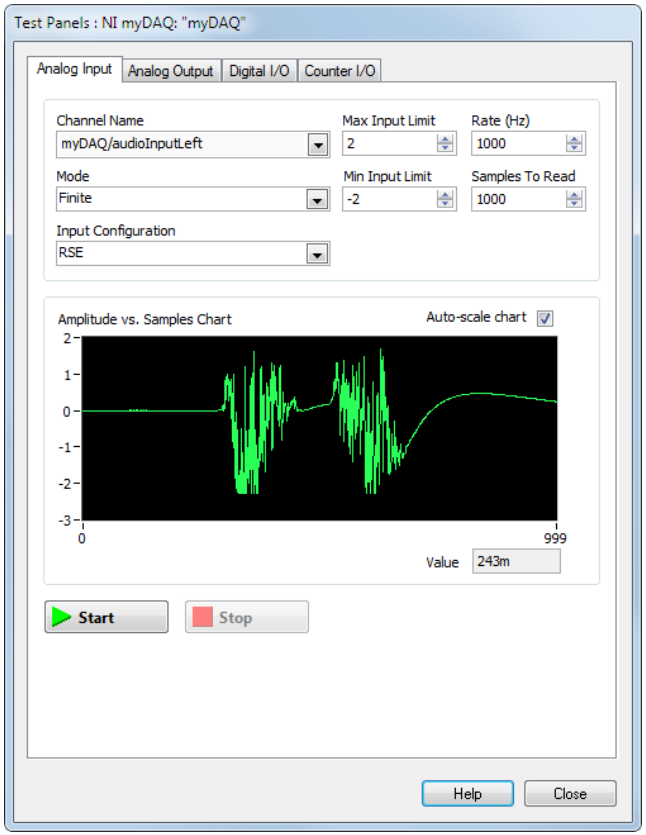


Demonstration: What is MAX?

Measurement & Automation

- Stands for Measurement & Automation Explorer
- Organizes all your National Instruments hardware and software
- Configure your hardware in MAX
- Tests your device in MAX

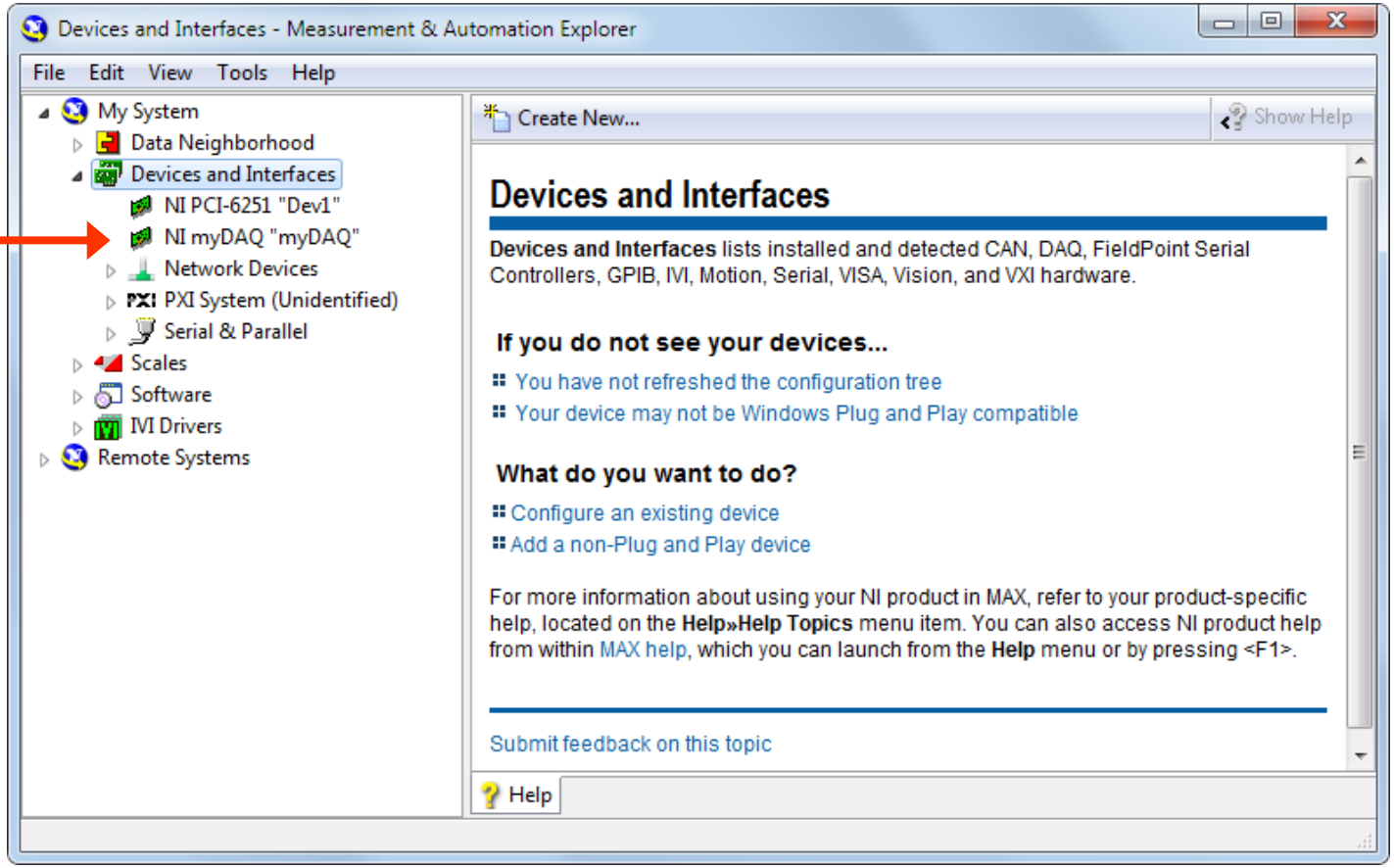




Exercise 1 – Setting Up Your Hardware Device

- Use Measurement and Automation Explorer (MAX) to:
  - Configure and test your myDAQ

Track A

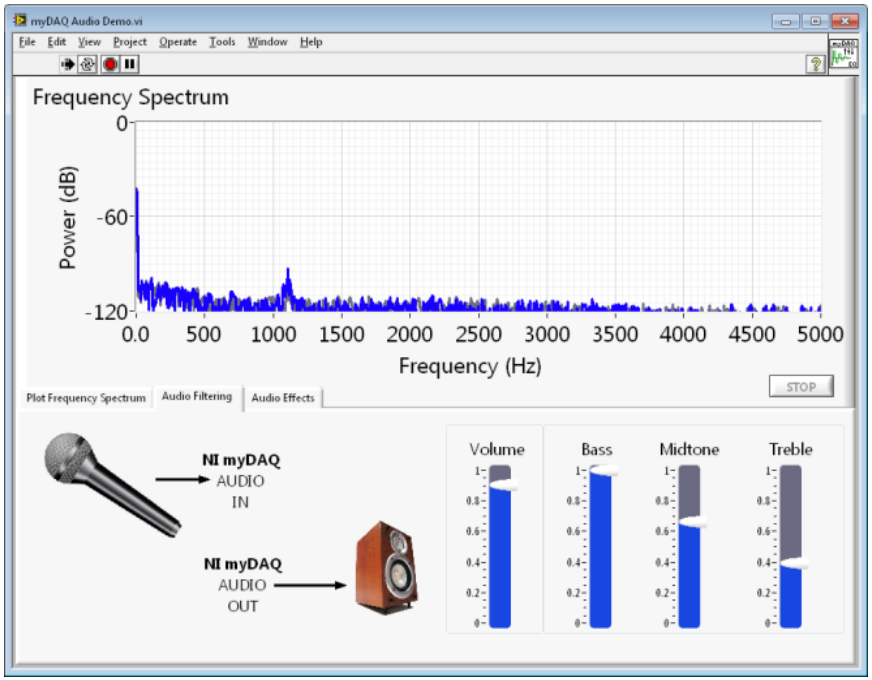


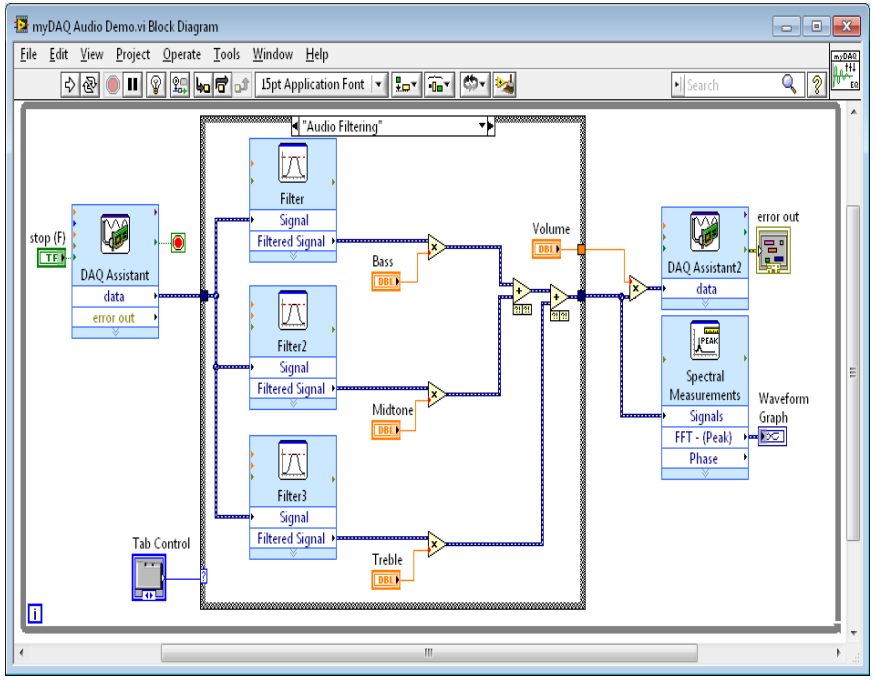
What is an Audio Equalizer?

- It's a car stereo!
- Audio Equalizers adjust the volume of a certain frequency within a signal.
- We are going to build a 3-band Audio Equalizer using filters that affects these frequency ranges
  - Bass
  - Midtones
  - Treble

Let's Explore the Final Project

Open up the myDAQ Audio Demo.vi and play around with it. Be sure you have your microphone (or MP3 player) plugged in along with the speakers!



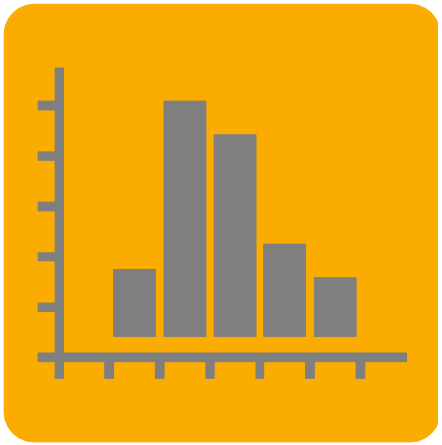


Time to Break it Down

Acquire

Gather data from your myDAQ or another data acquisition device.

Analyze



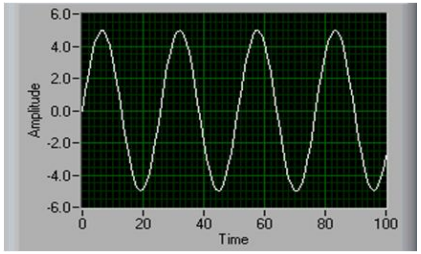
Extract useful information from your data with interactive wizards and more than 600 built-in LabVIEW measurement analysis and signal processing functions.

Present

Visualize results in graphs and charts. Create custom user interfaces and reports in text files, HTML, Microsoft Word, Microsoft Excel, and more.

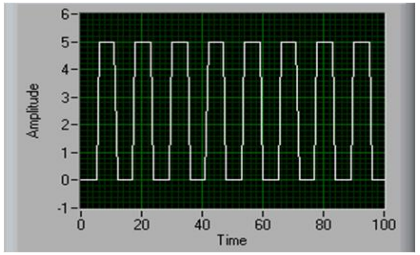
Types of Signals to Acquire

Analog



- Signal that varies continuously
- Most commonly a voltage or current
- In our case sound going into the microphone is converted to a voltage

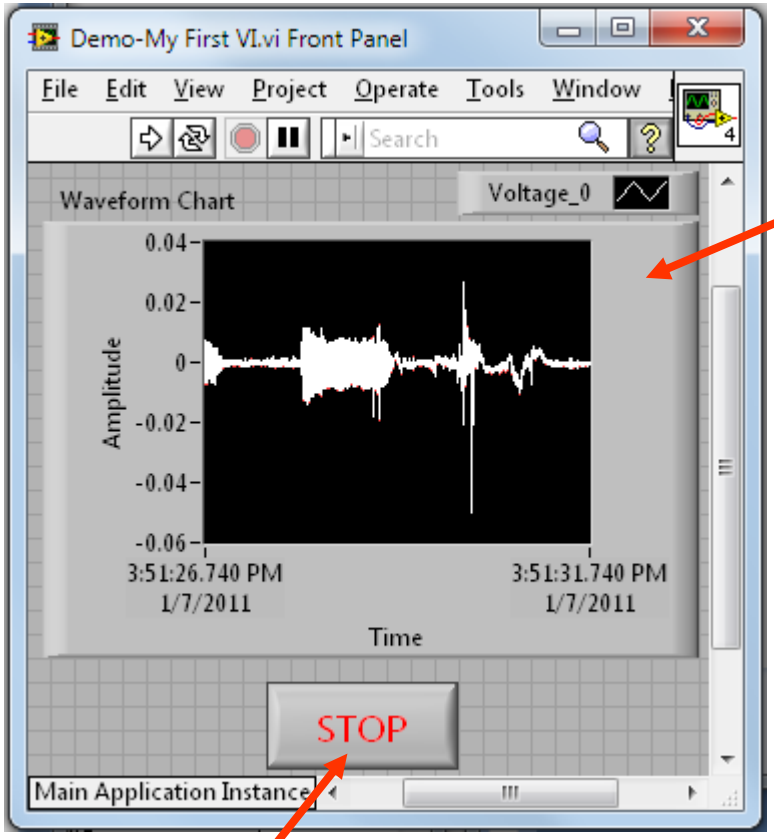
Digital



- Electrical signals that transfer digital data
- Usually represented by on/off, high/low, 0/1

Demonstration : Creating our First VI

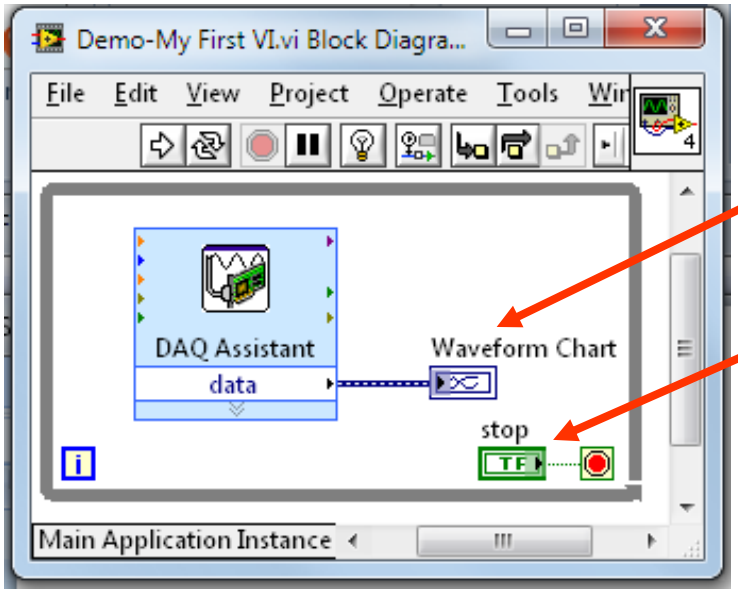
Front Panel Window



Graph Indicator

Boolean Control

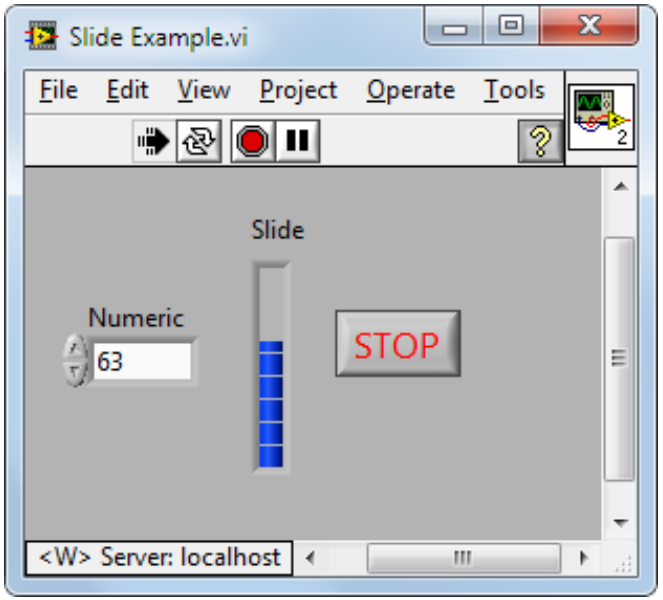
Block Diagram Window



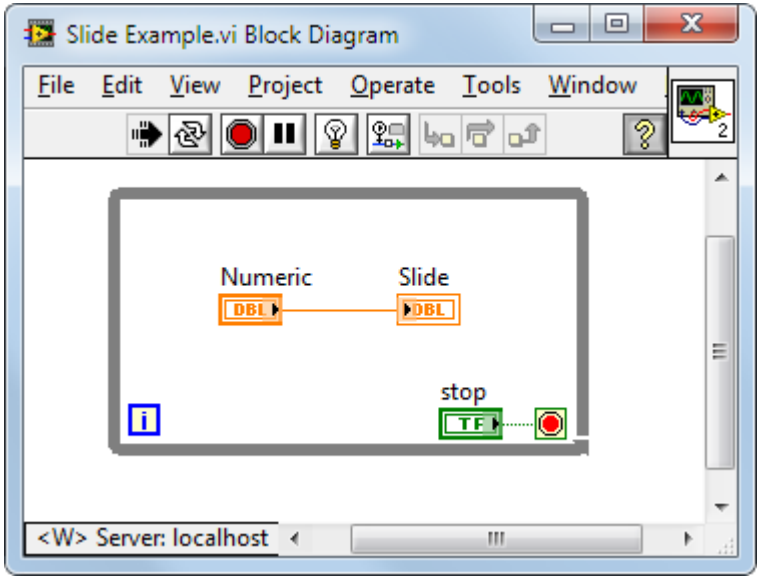
Output Terminal

Input Terminals

LabVIEW Environment



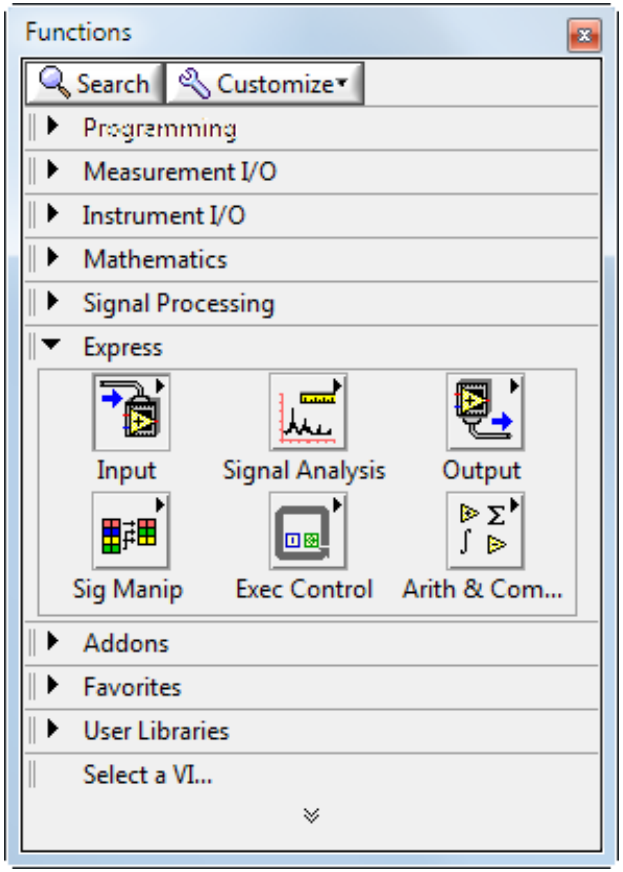
What is the front panel used for?
What are the inputs and outputs called?

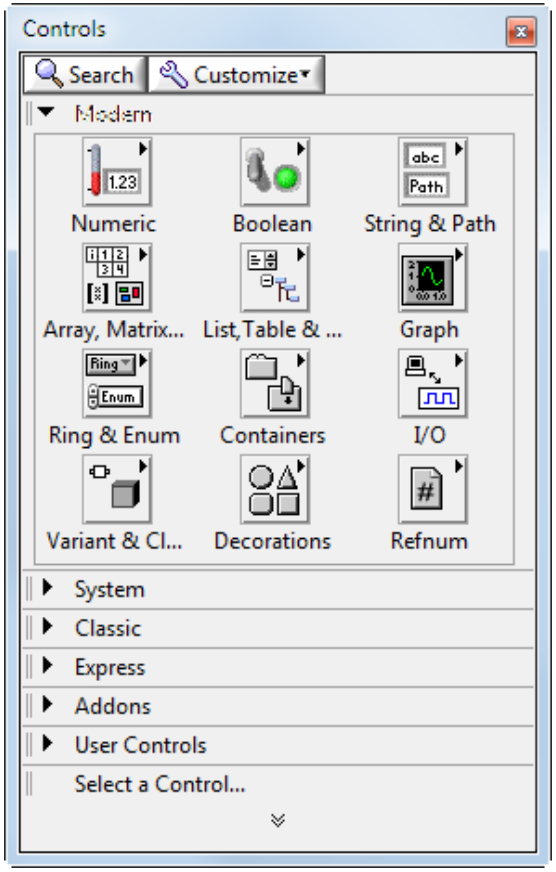


What is the block diagram used for?
How does data travel on the block diagram?

Palettes

Where can you find the following Palettes?

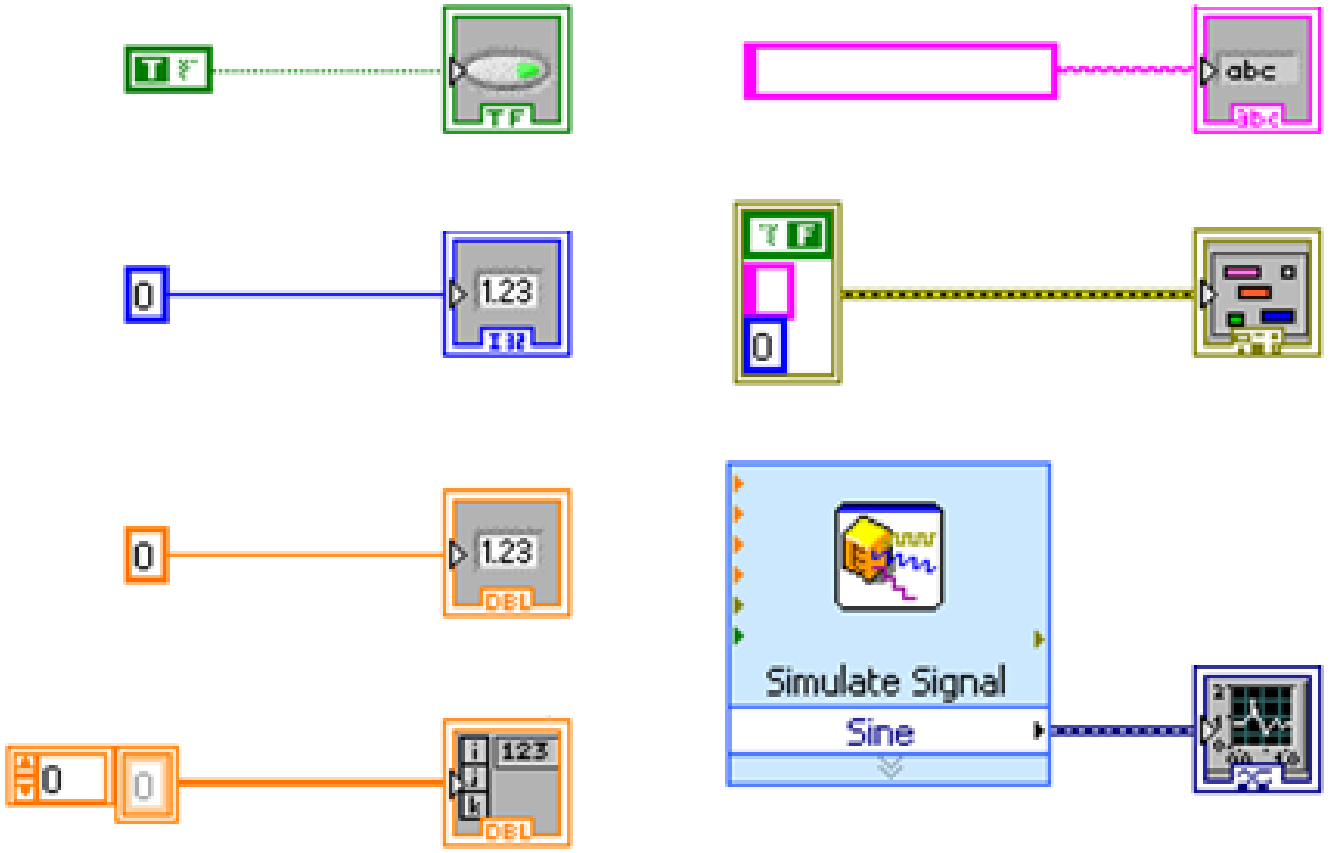




Bonus: How many of the tools can you name?

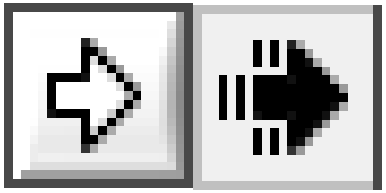
Data Types

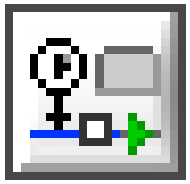
What are the following data types?

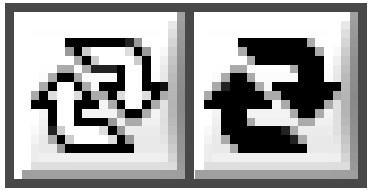


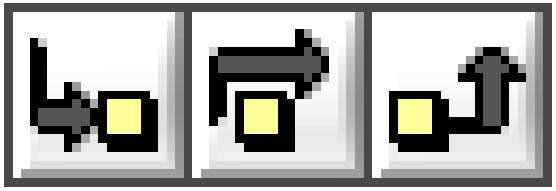
Toolbar

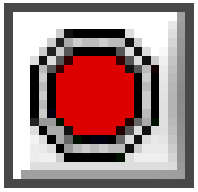
What do the following buttons do?

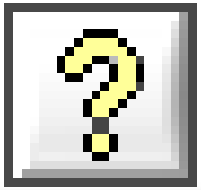












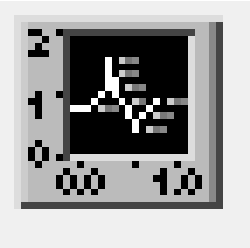
Using the Search Functions

Feel free to reference LabVIEW to find the answers

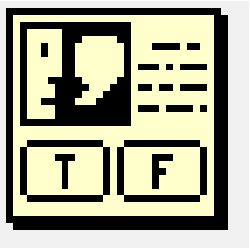
Can you name three ways you can search for a function in LabVIEW?

Where are the following items located?

DAQ Assistant



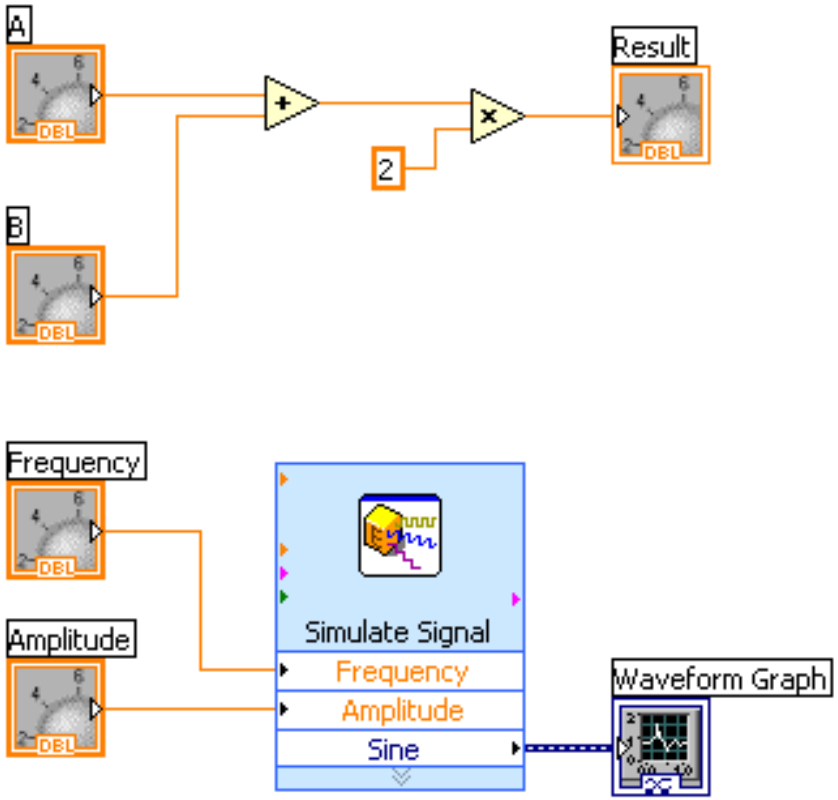
Waveform Chart



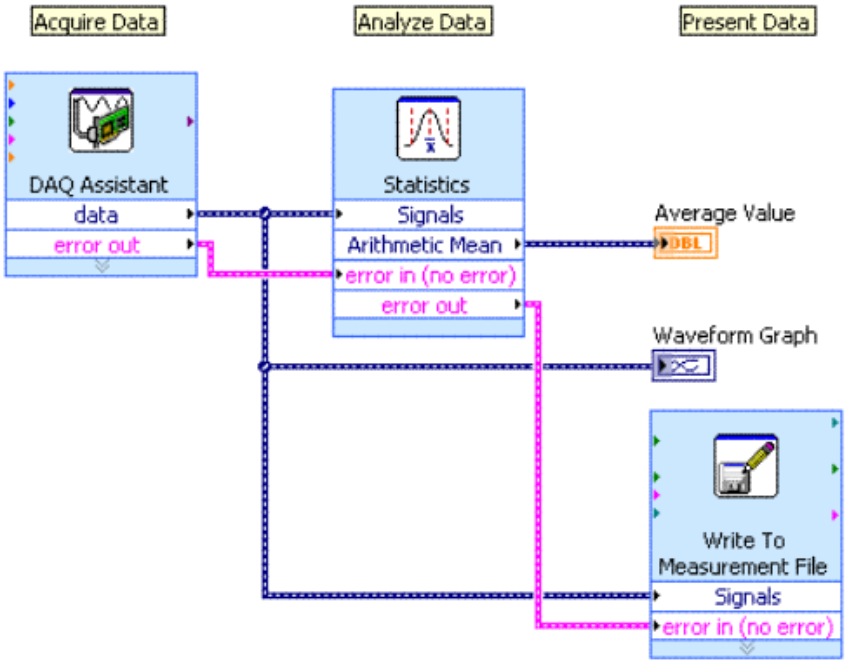
Two Button Dialog

Dataflow

Which VI(s) will execute first?



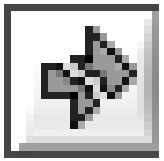
Which VI will execute last?



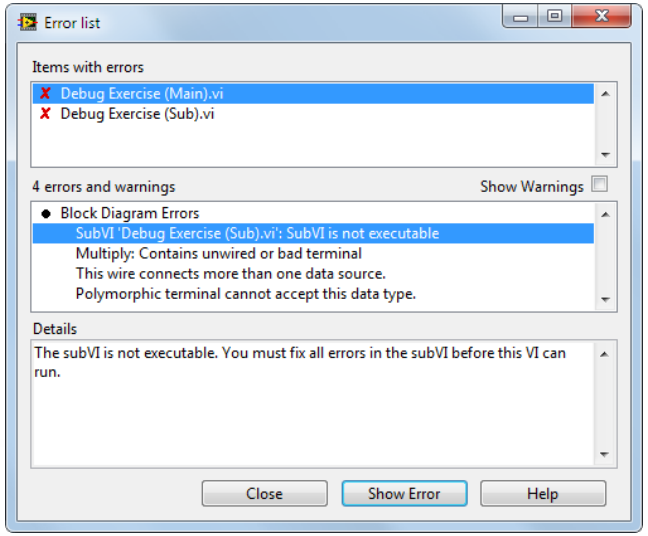
Debugging Techniques

How do you use the following debugging tools?

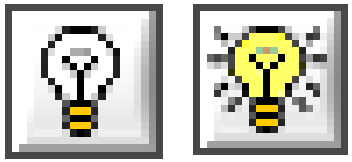
- **Broken Run Arrow**



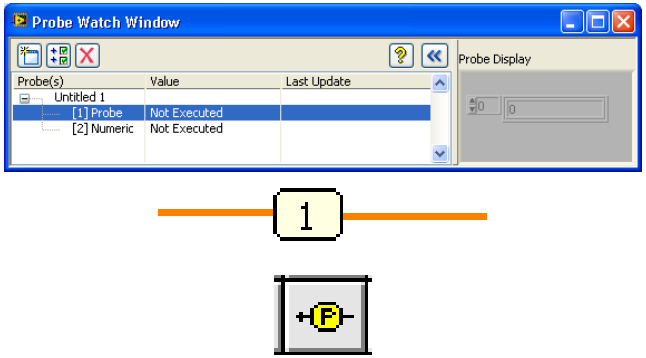
- **Error List**



- **Execution Highlighting**



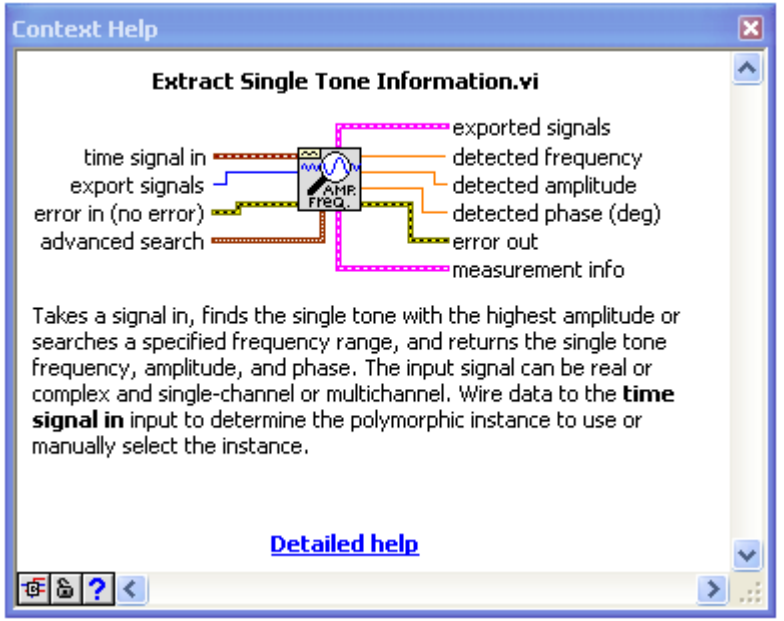
- **Probes**



Are there other debugging tools you can think of?

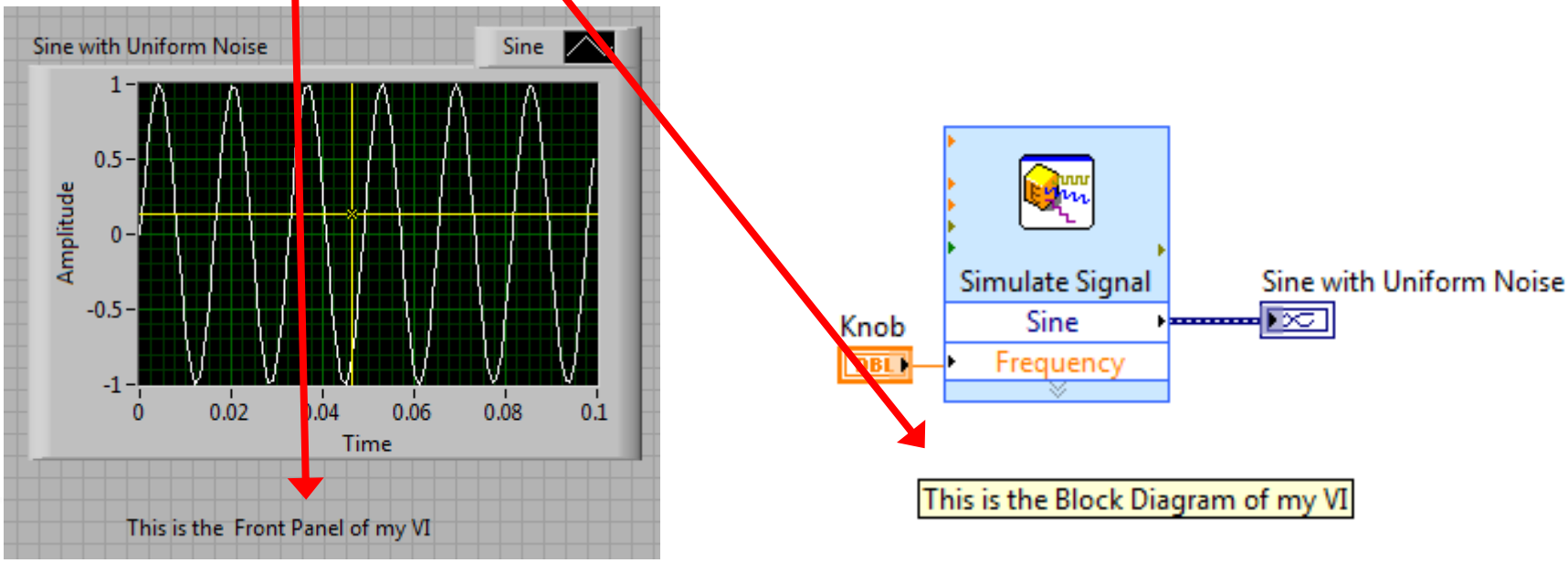
Context Help Window

How many ways to display the context help window can you list?



Commenting Your Code

Double-click anywhere on your front panel or block diagram to insert a **comment**

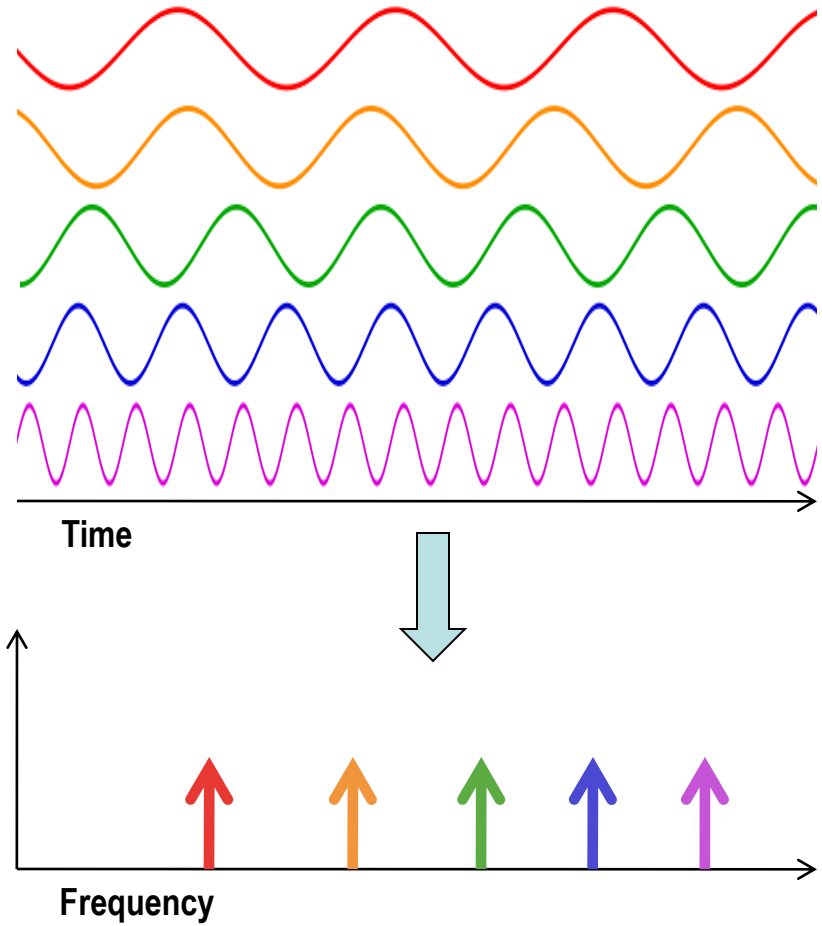


Tips for Working in LabVIEW

- **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)
  - <Ctrl+T> -- Tile Front Panel and Block Diagram
- **Tools»Options…** – Set Preferences in LabVIEW
- **File»VI Properties** – Configure VI Appearance, Documentation, etc.
- **Create»Control/Constant/Indicator** – Right-click on terminal to create

Peak Detection

- Convert Time-domain signals to Frequency-domain signals
- Analyze all frequency components to find the dominant frequency
- In this exercise
  - We take in the sound signal
  - Perform spectral analysis to detect peak frequency
  - Display on graph

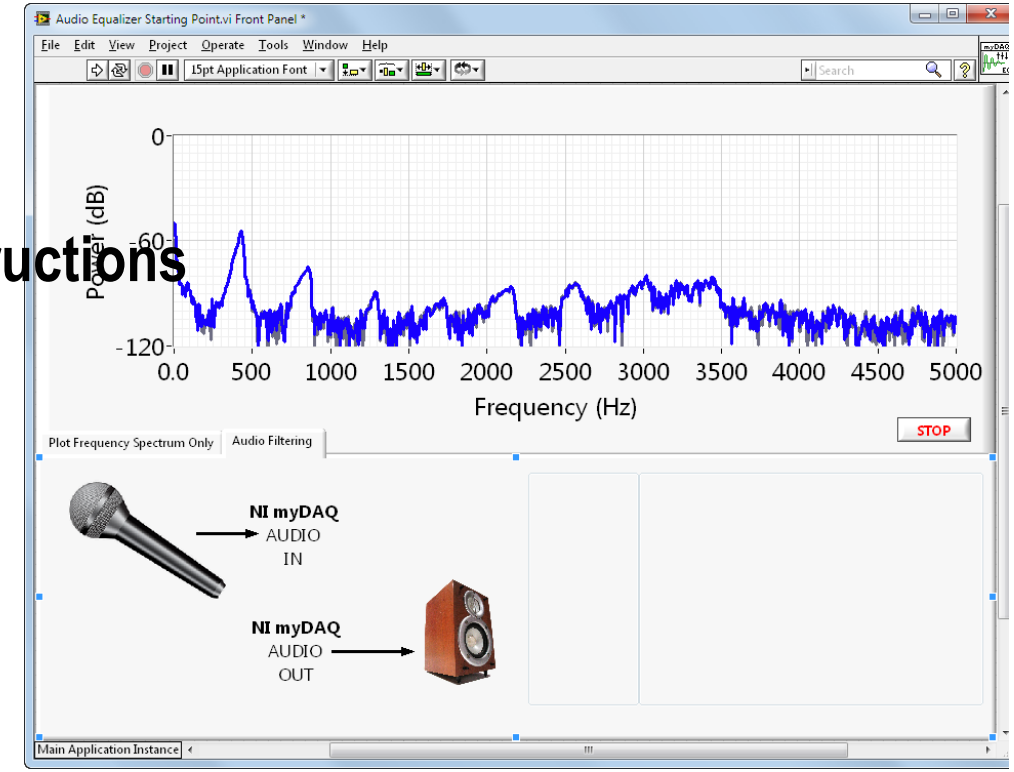


Exercise 2 – Acquiring a Signal with DAQ

- Use the exercise template to:
  - Acquire a signal from your myDAQ device
  - Take a Spectral Measurement

This exercise should take ~15 minutes.

Do Not Delete
Exercise 2 Instructions



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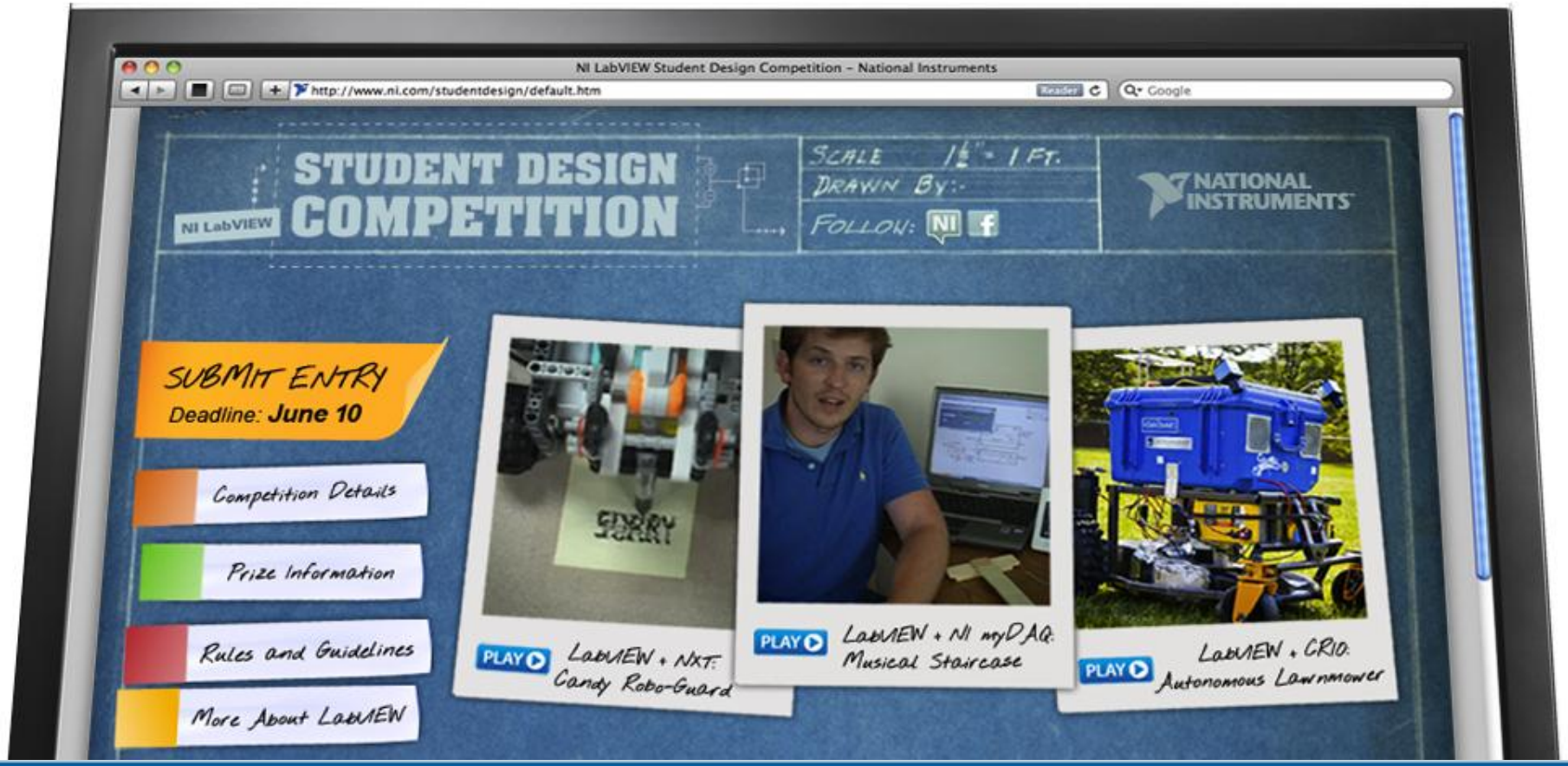


Video: Blind Driver Challenge

YouTube Link Part 1
YouTube Link Part 2

Don't forget to submit your project to ni.com/studentdesign for a chance to win prizes and a trip to Austin, TX

Section II – Elements of Typical Programs

A. Demonstration: While Loops and SubVI

B. Loops
   - While Loop
   - For Loop

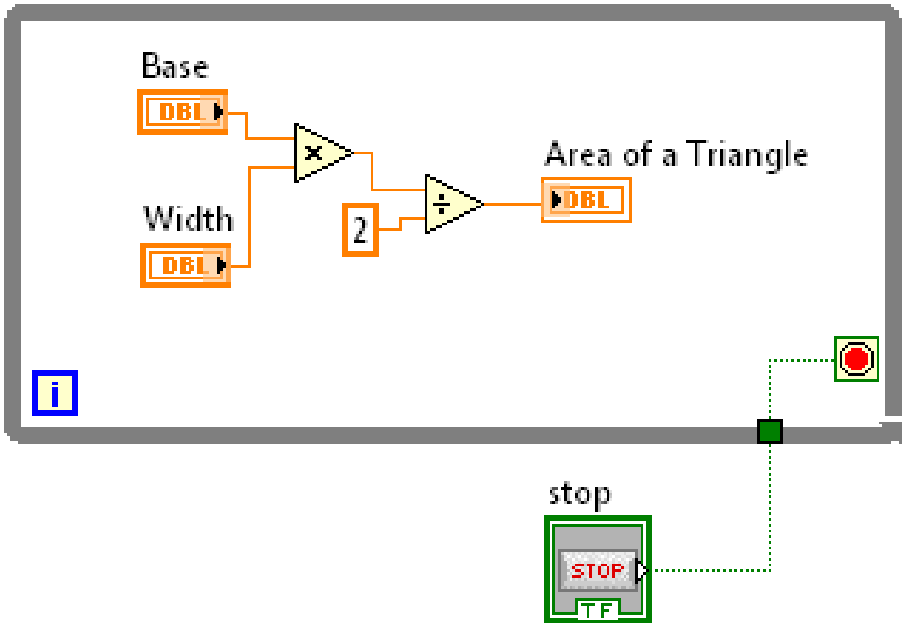
B. Functions and SubVIs
   - Types of Functions
   - Creating Custom Functions (subVI)

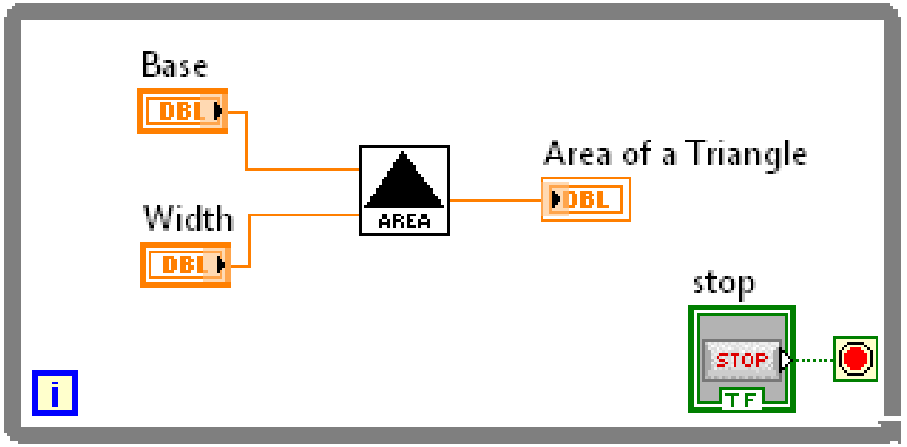
C. Hands-On Exercise: Filtering and Outputting Sound

Demonstration: While Loop and SubVIs

Dataflow and Loops

SubVIs





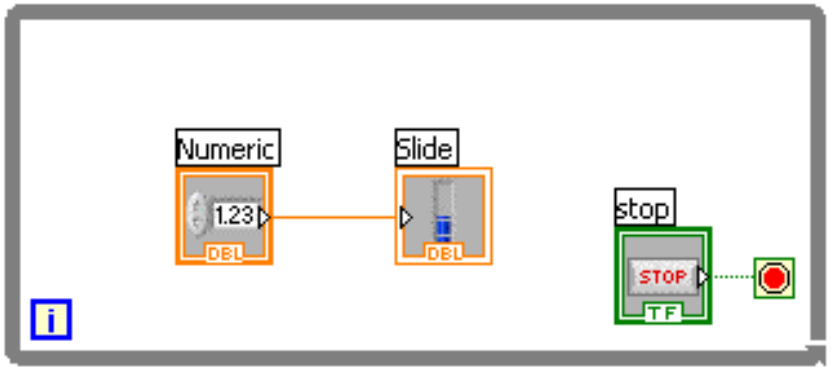
Bad Example

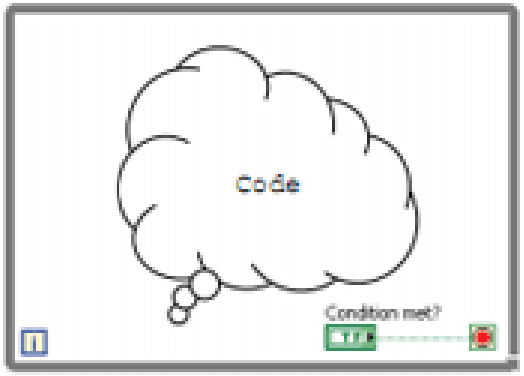
Good Example

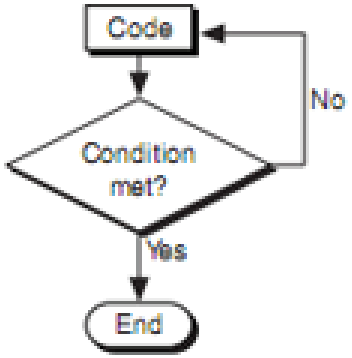
While Loop

- What do the following terminals do?

- How many times must a while loop run?



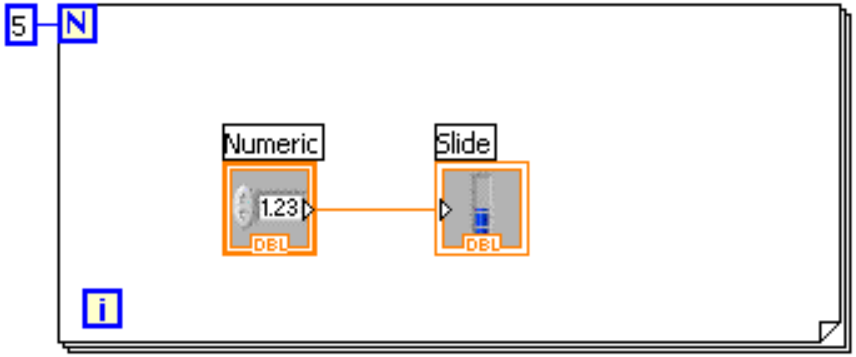


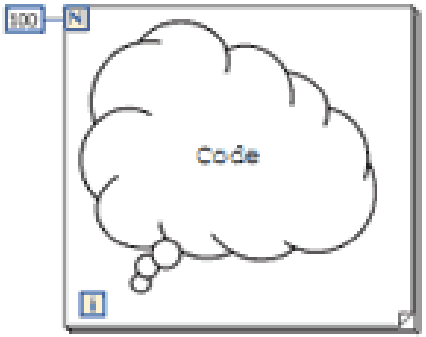


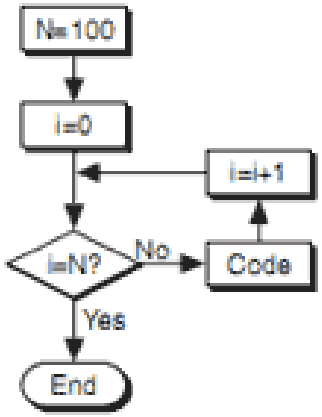

```
Repeat (code);
Until Condition met;
End;
```

For Loop

- What does the iteration terminal start counting from?
- How many times will a for loop execute?



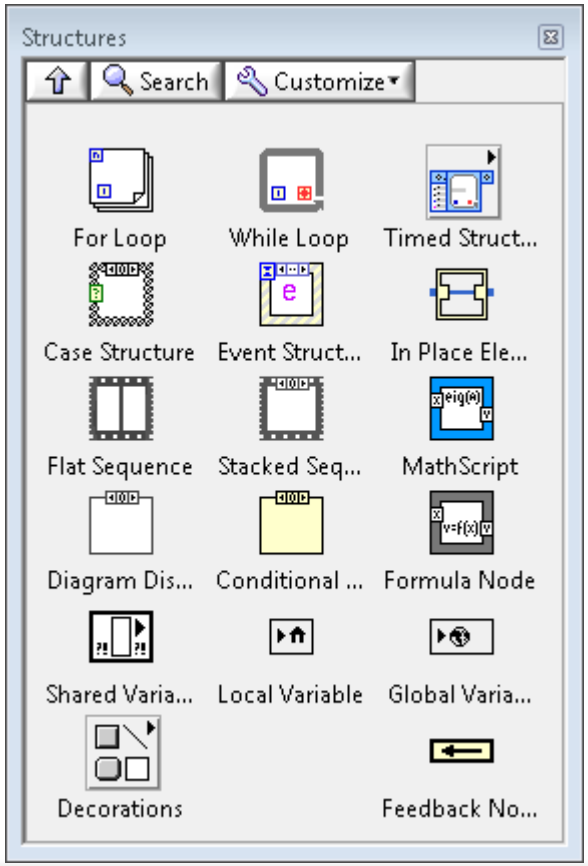




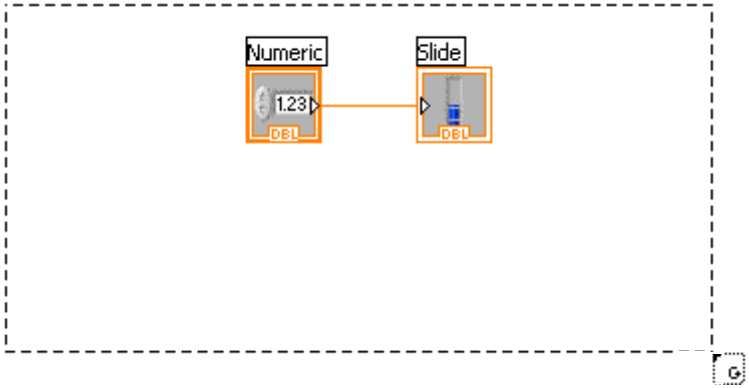

```
N=100;
i=0;
Until i=N:
    Repeat (code; i=i+1);
End;
```

Drawing a Loop

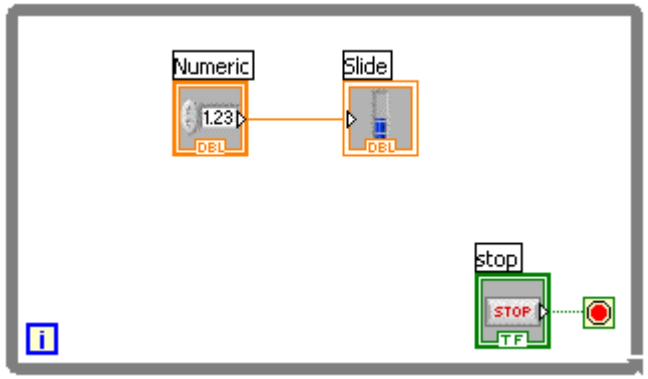
1. Select the structure (Programming»Structures)



2. Enclose code to be repeated

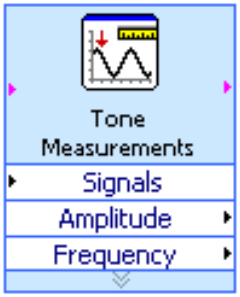


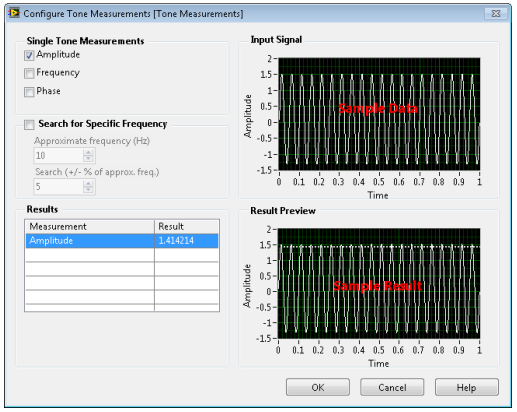
3. Wire up the Stop Condition and add any additional code.



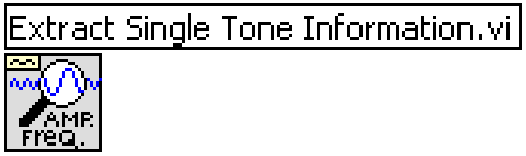
3 Types of Functions

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

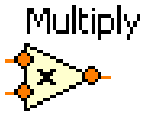




Standard VIs: modularized VIs customized by wiring (**customizable**)



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



LabVIEW Functions and SubVIs Operate Like Functions in Other Languages

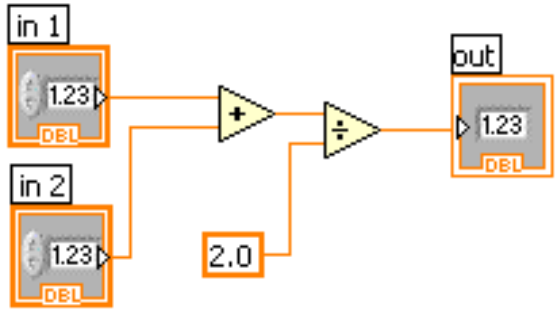
Function Pseudo Code

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

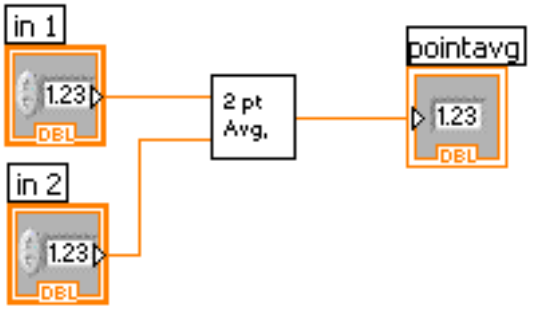
Calling Program Pseudo Code

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

SubVI Block Diagram

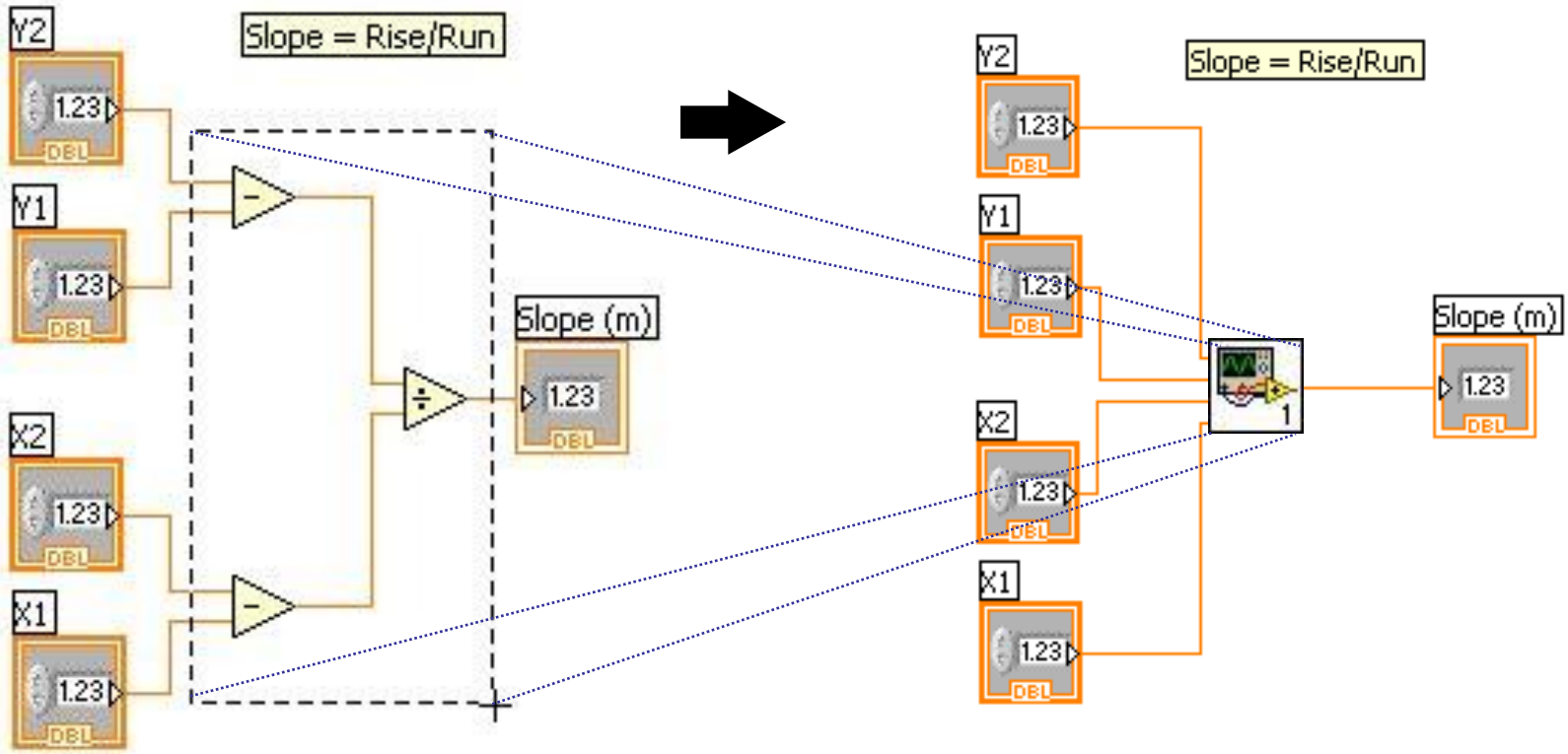


Calling VI Block Diagram



Create SubVI

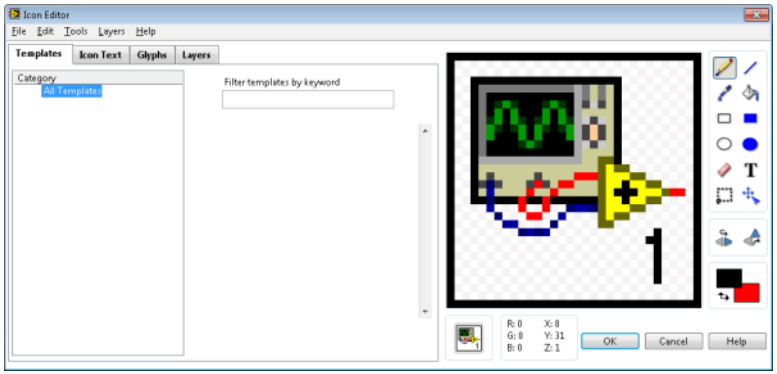
What are some ways that you can create subVIs?



Icon Editor and Connector Pane

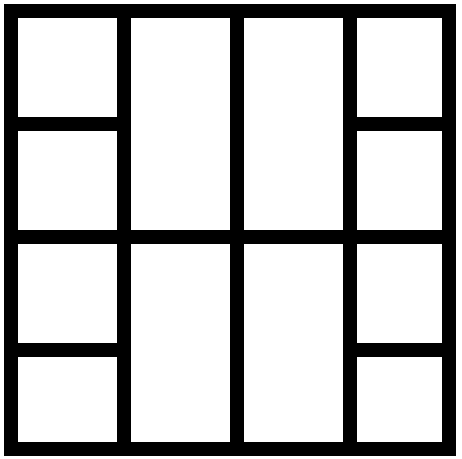
Icon Editor

- Why is having a good icon important?
- How can you edit the icon of your subVI?



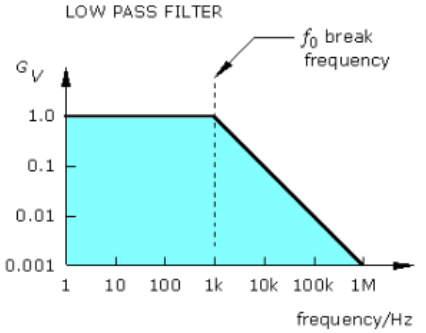
Connector Pane

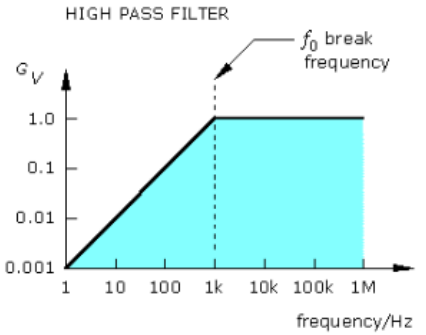
- Where do you find the connector pane?
- How do you add inputs or outputs to the connector pane?

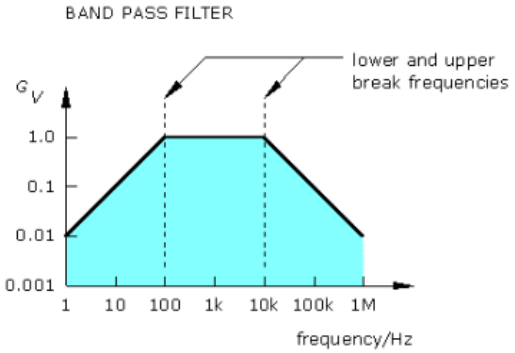


Analysis: Filters

- Allows some frequencies of a signal to pass more easily than others
- We will be using three types of filters in our project
  - Lowpass (Bass Filter)
  - Bandpass (Midtone Filter)
  - Highpass (Treble Filter)





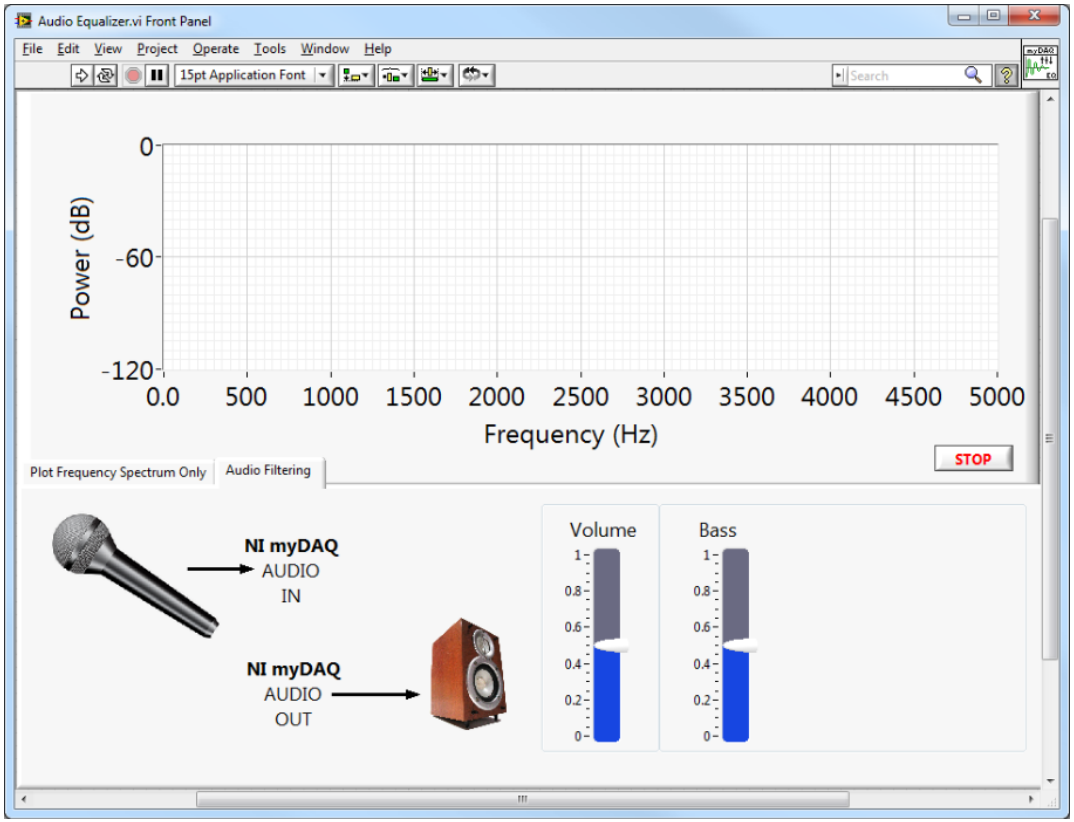


Outputting signal to DAQ

- Send a signal from the computer to your data acquisition device or sound card
- In our case we are modifying the audio input and sending the signal to our speakers.

Exercise 3 – Outputting Sound with myDAQ

- Use LabVIEW Express VIs to:
  - Acquire a signal
  - Apply a Filter
  - Output sound to your speakers



Video: myDAQ Piano Staircase

YouTube Video Link

Don’t forget to submit your project to ni.com/studentdesign for a chance to win prizes and a trip to Austin, TX

Section III-Analyzing and Presenting Your Results

A. Demonstration: Arrays and Auto-Indexing

B. Arrays

- Creating Arrays
- Auto-Indexing

B. Displaying Data on the Front Panel

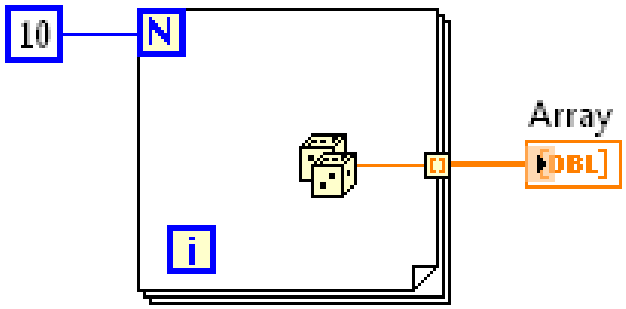
- Graphs and Charts

C. Demonstration: Case Structures

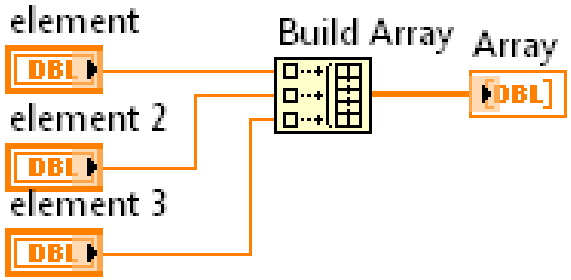
- Decision Making

D. Hands-On Exercise: Audio Equalizer

Demonstration: Arrays



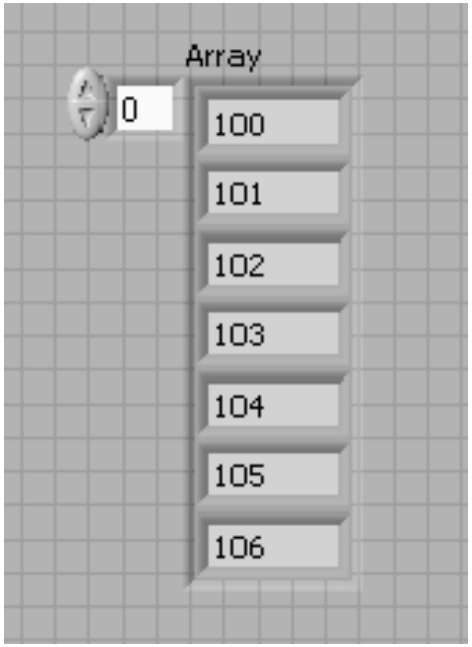
Creating Arrays and Auto-Indexing



Programatically Creating Arrays

Arrays

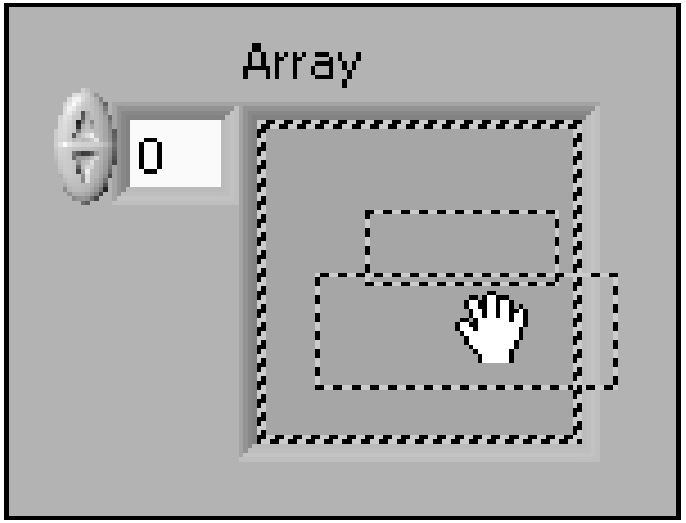
- An array consists of elements and dimension. What do those terms mean?
- When would you use an array?
- In LabVIEW, what is the index of the first element in an array?

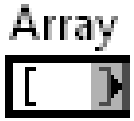


Creating an Array

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

1. Place an array shell on the front panel
2. Drag a data object or element into the array shell



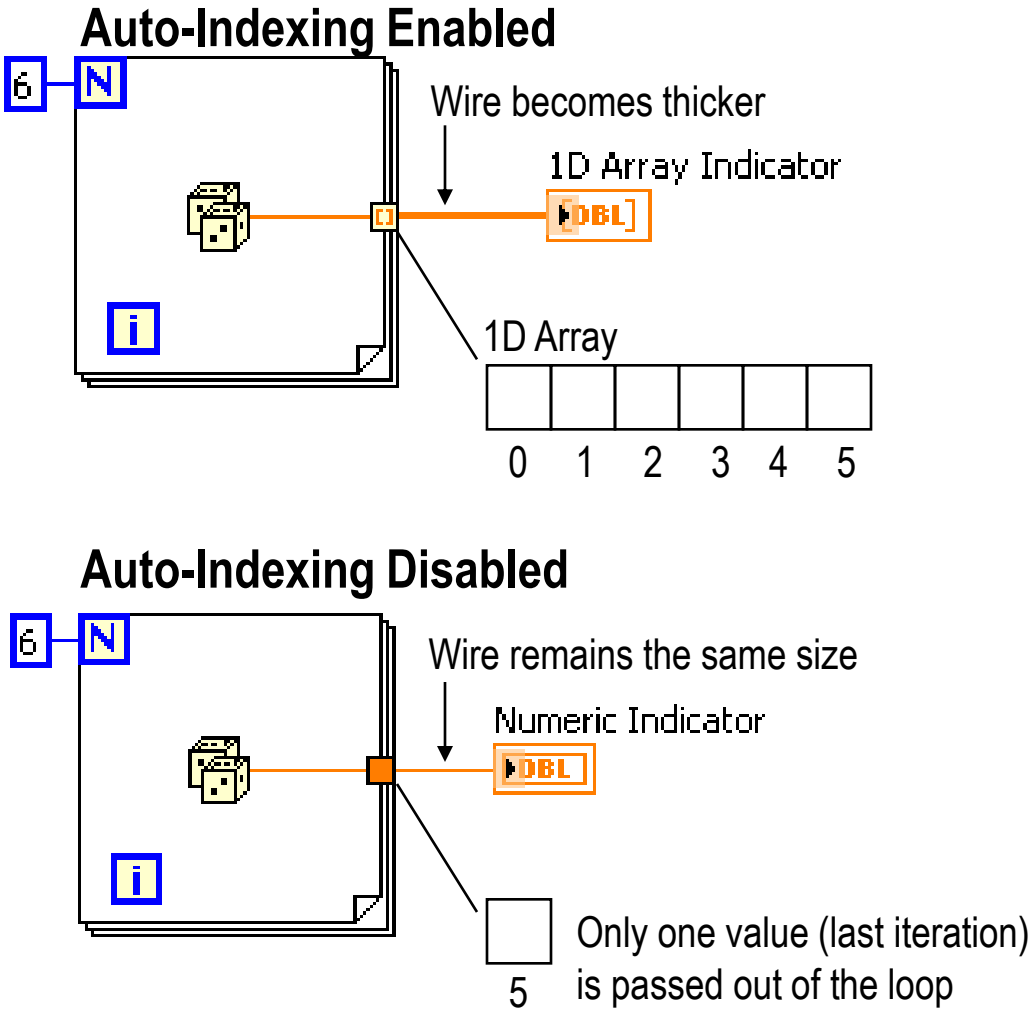


Empty array shell as seen on the block diagram.

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

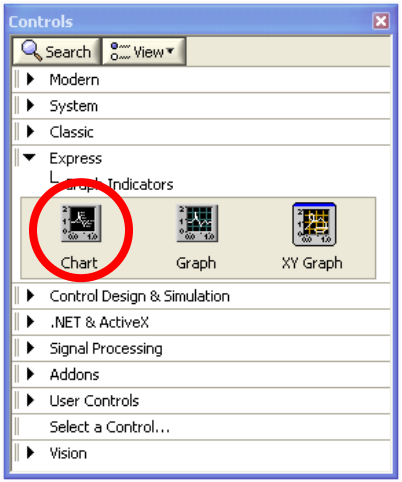
- How can you enable/disable auto-indexing?

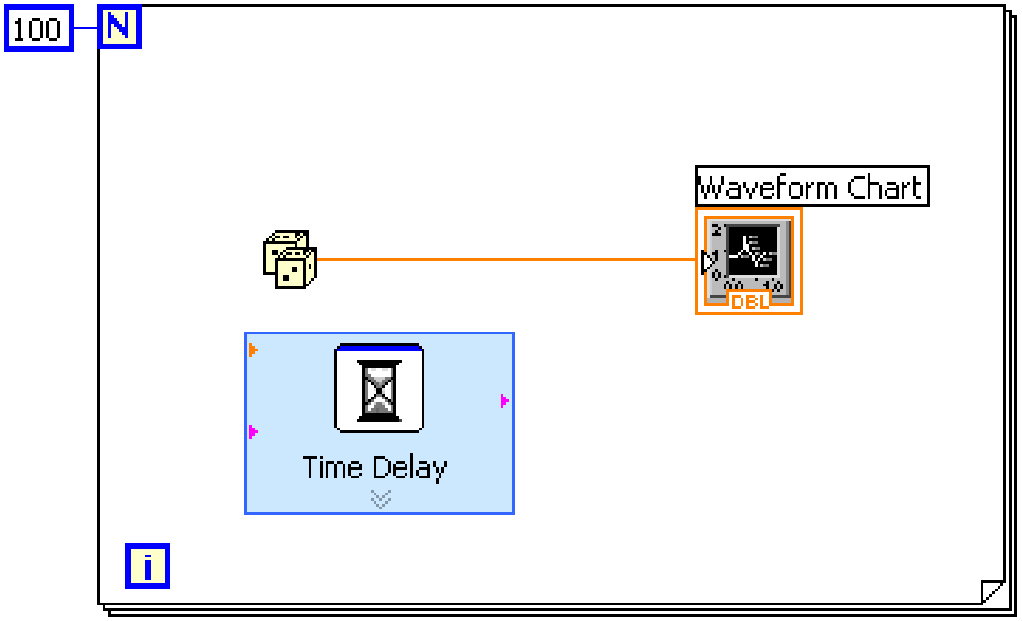


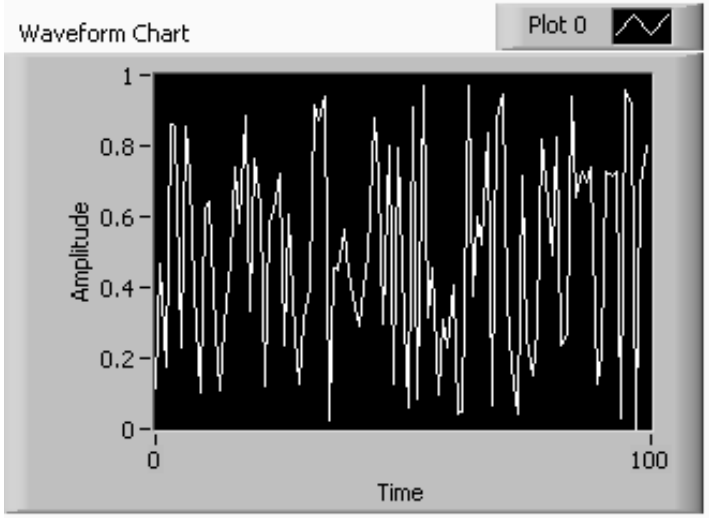
Waveform Charts

Waveform chart – special numeric indicator that can display a history of values. Charts add 1 data point at a time with history.

- Chart updates with each individual point it receives
- Controls»Express»Graph Indicators»Chart



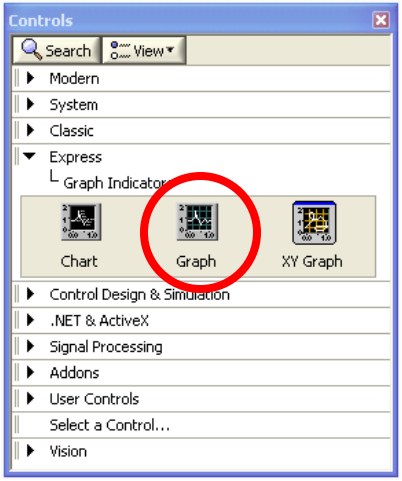


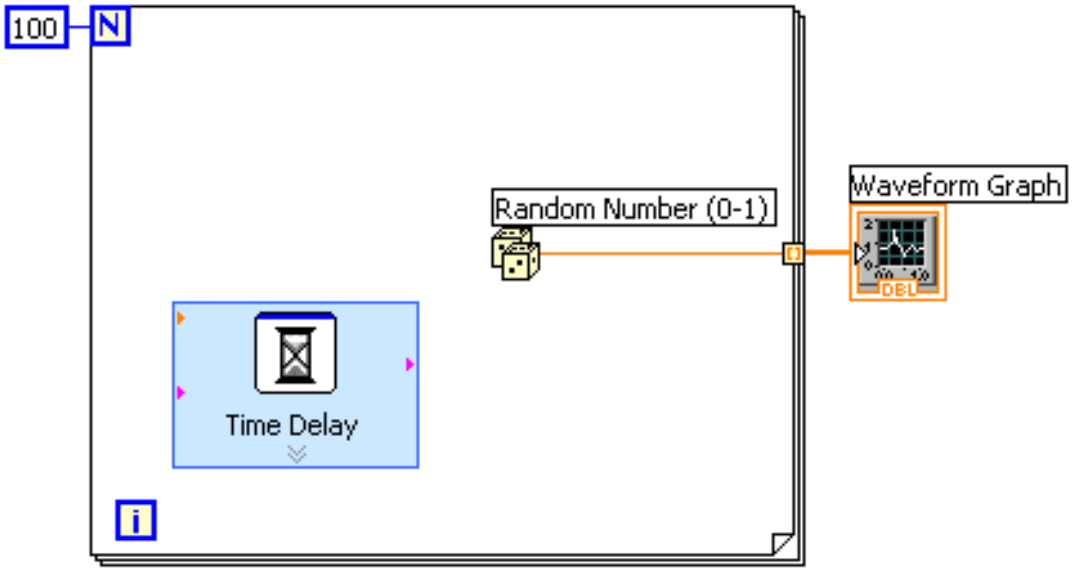


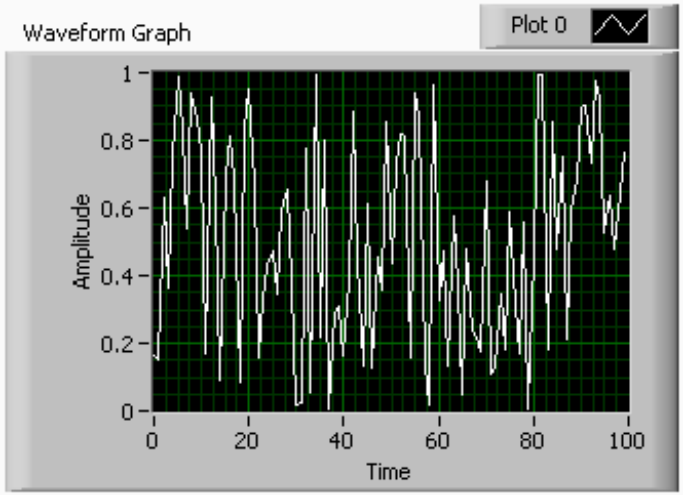
Waveform Graphs

Waveform graph – special numeric indicator that displays an array of data. A graph displays many data points at once

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

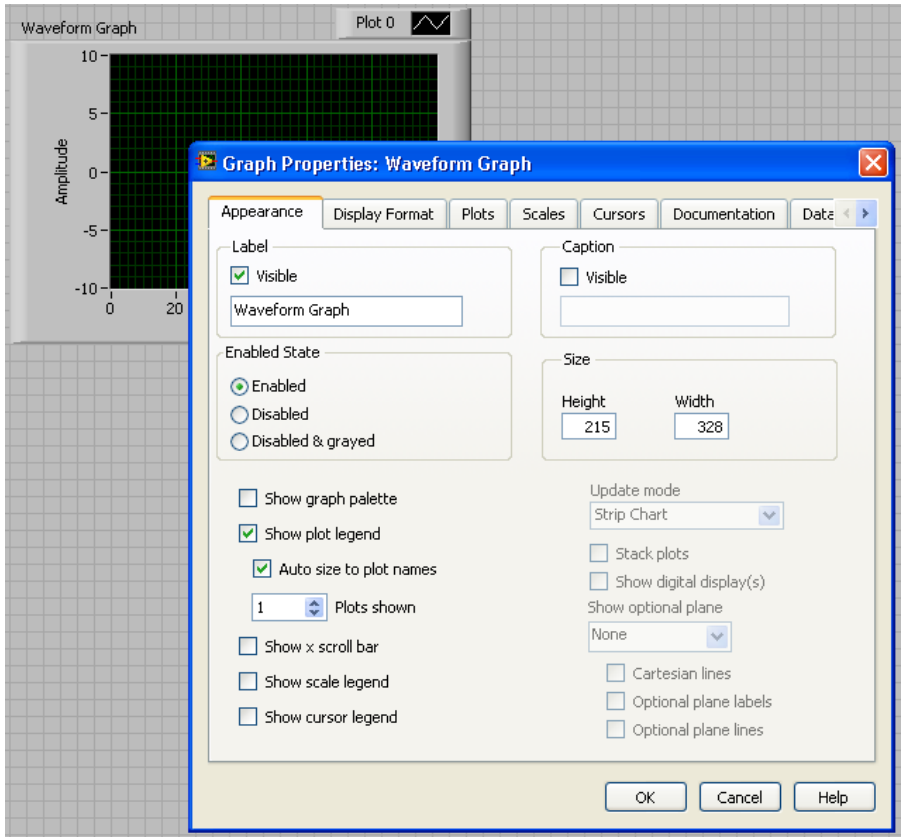




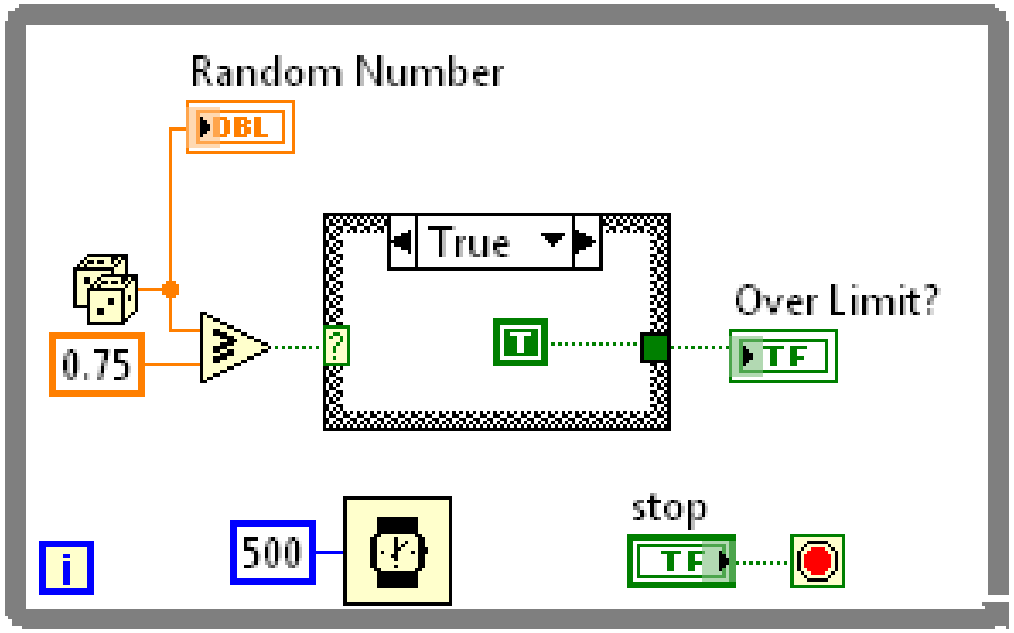


Control and Indicator Properties

- 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

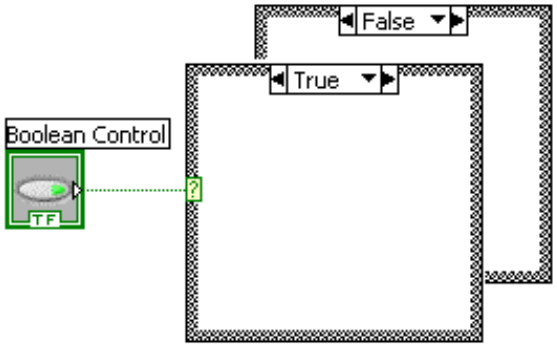


Demonstration: Case Structures

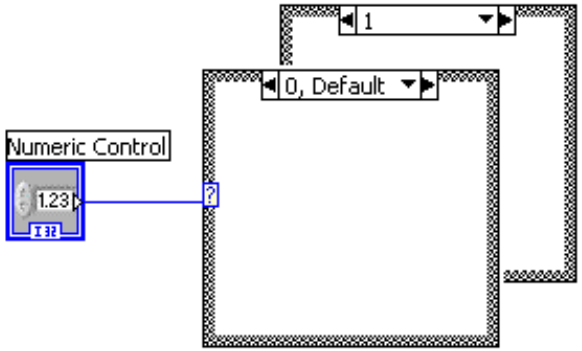


How Do I Make Decisions in LabVIEW?

1. Case Structures

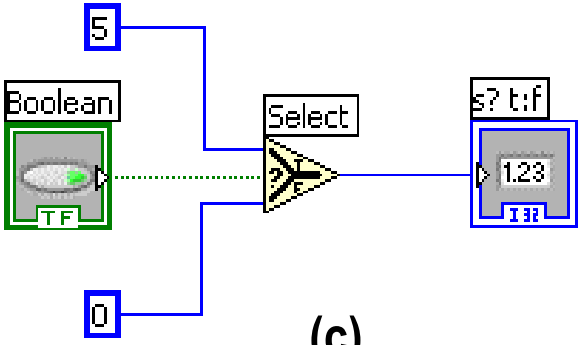


(a)



(b)

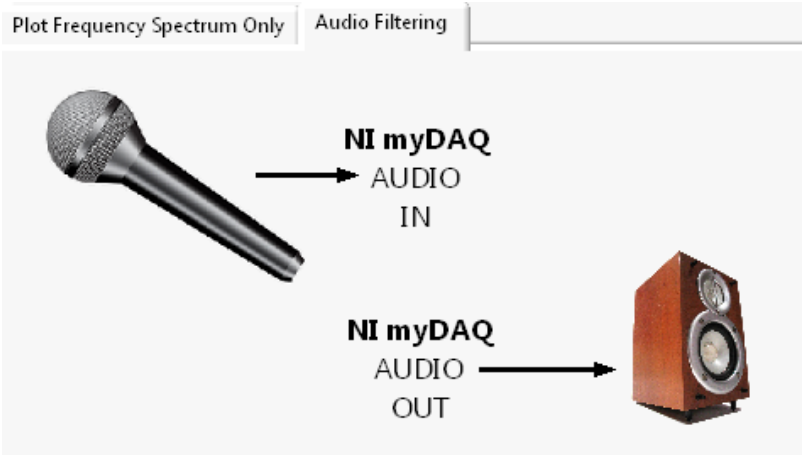
2. Select

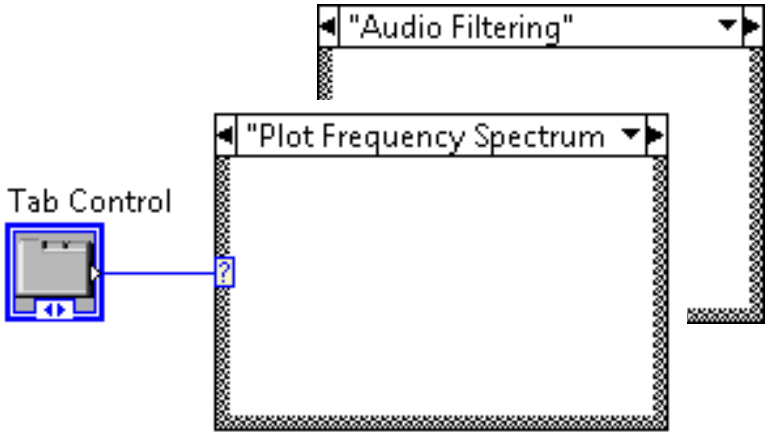


(c)

Tab Control

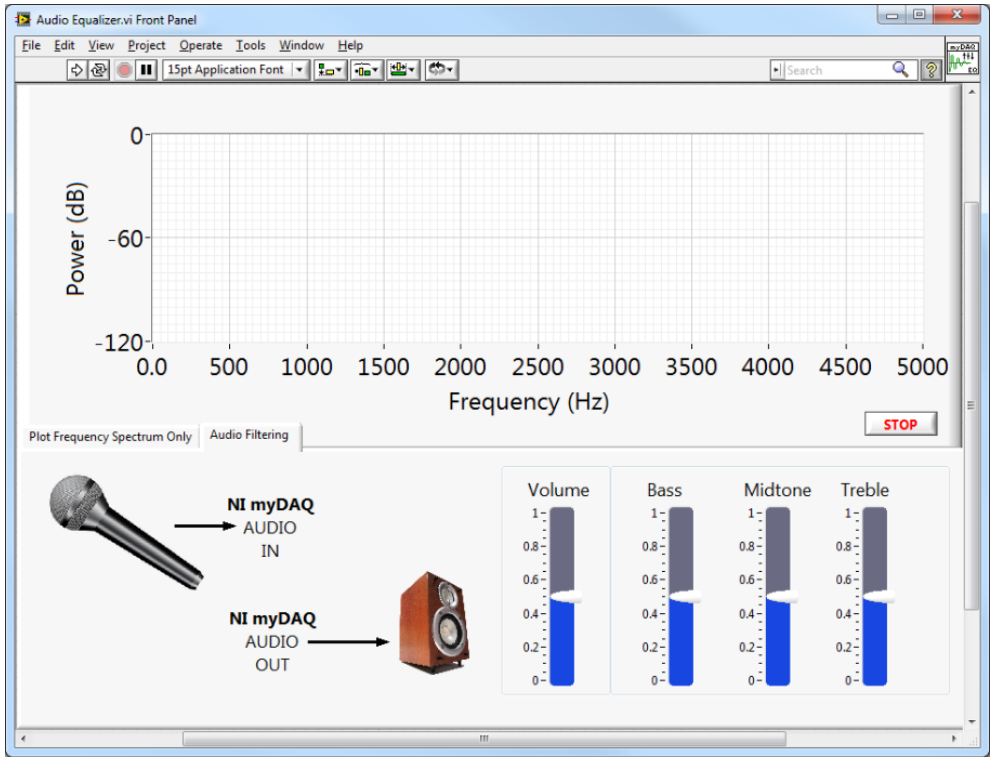
- Keep your front panel organized
- Add a new Tabs for new operations
- Use the Tab control to select operations and perform different analyses





Exercise 4- Building an Audio Equalizer

- Complete your 3 band equalizer
- Become familiar with Case Structures



Video: Mind Controlled Wheelchair

YouTube Link

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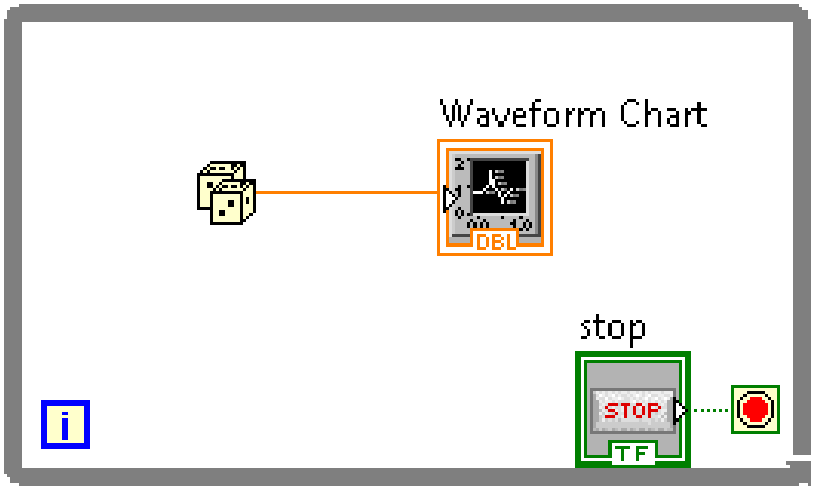
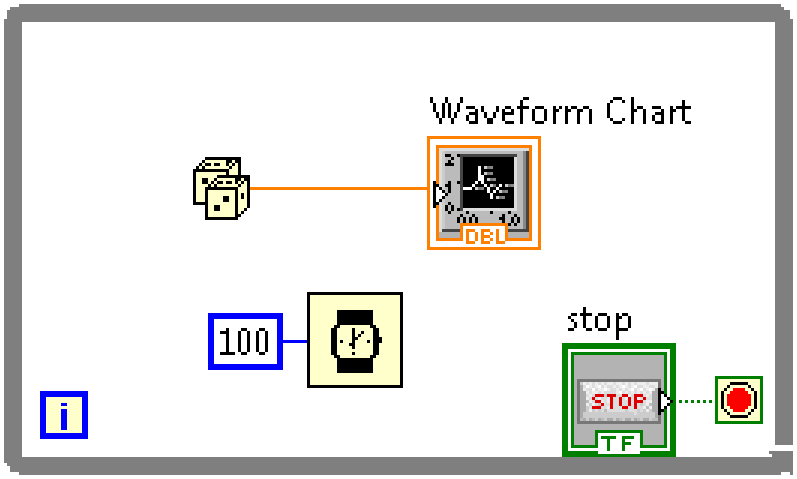
Section IV – Timing and File I/O

A. Demonstration: Timing a While Loop
B. Timing Loops
C. File I/O
D. Hands-On Exercise: Adding a Karaoke Machine

Demonstration: Timing a Loop

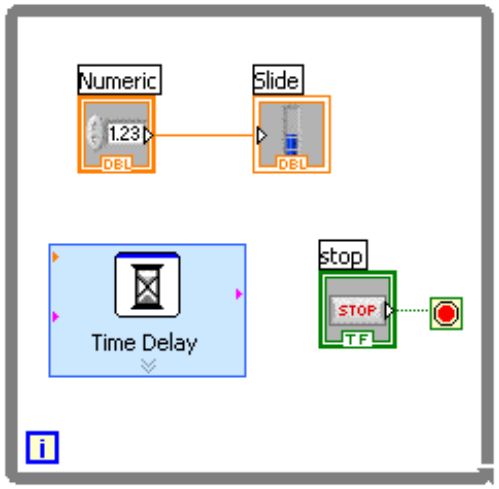


Vs.

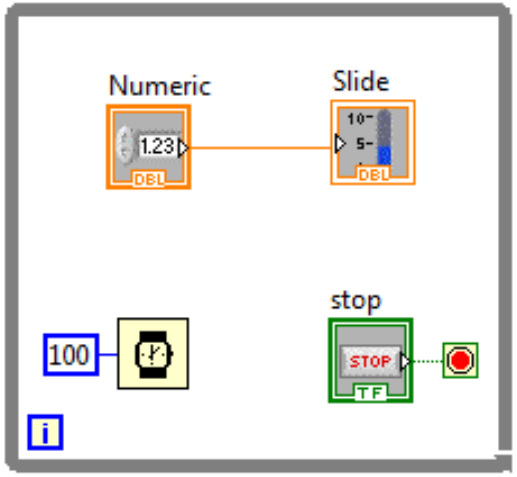


How Do I Time a Loop?

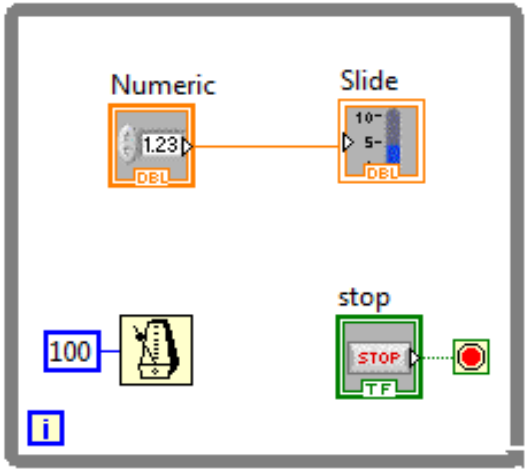
1. Configure the **Time Delay Express VI** for seconds to wait each iteration of the loop (works on for and while loops).
2. Configure the **Wait** and **Wait Next ms Multiple** for milliseconds to wait for each iteration of the loop



Time Delay



Wait

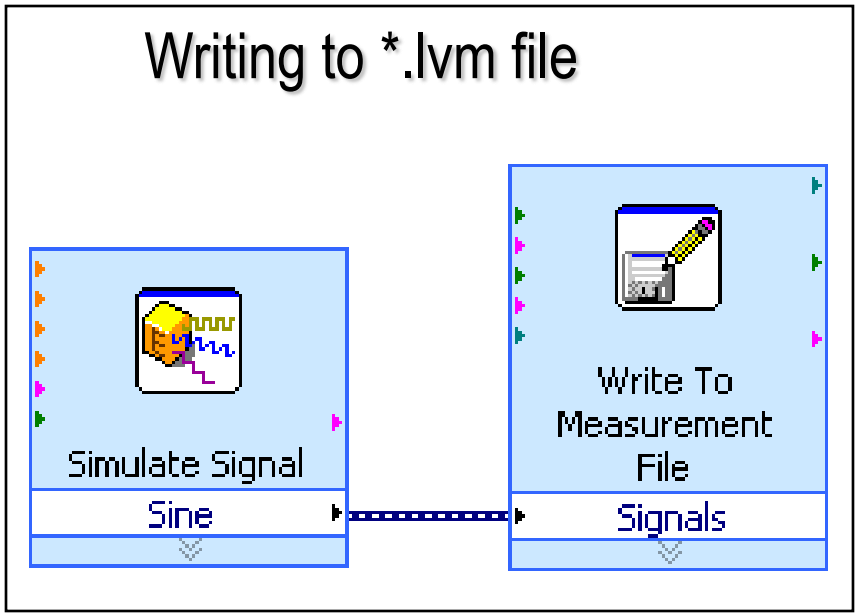


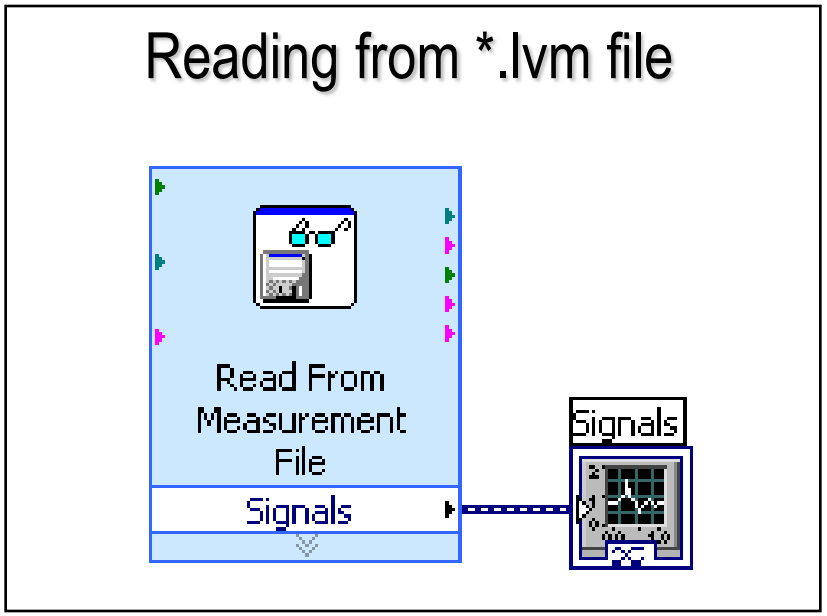
Wait Until Next ms Multiple

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)



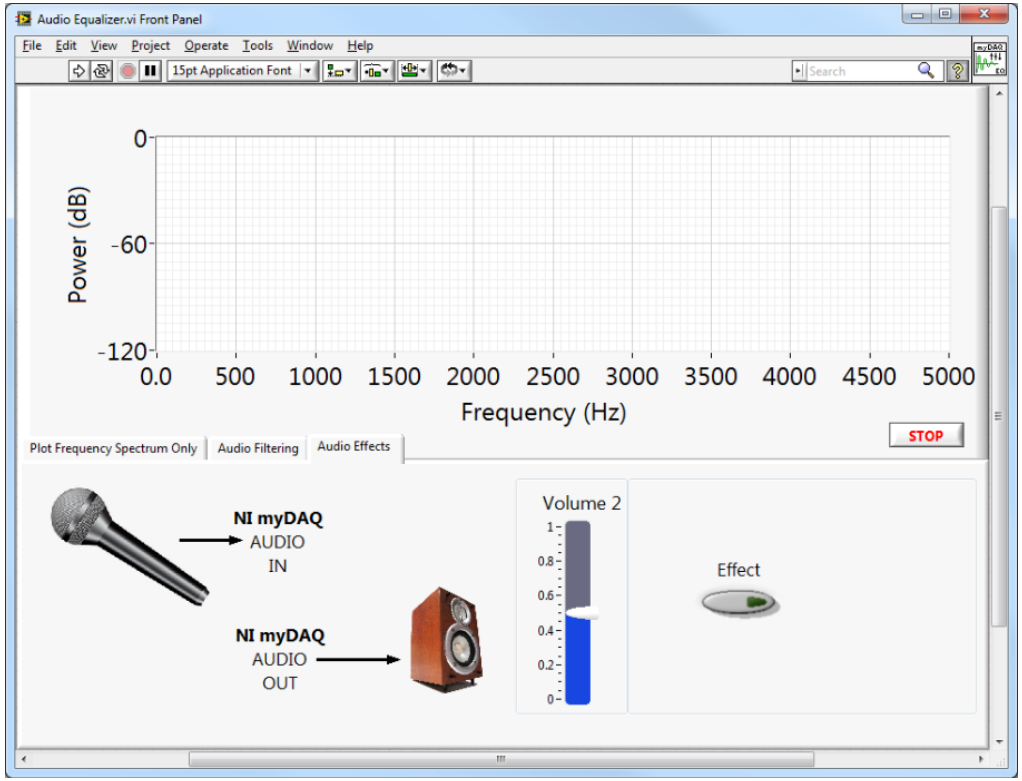


Karaoke!

- Stereo sound has two channels: left and right
- Sound is recorded using two strategically placed microphones
- Voice is present in both channels
- Subtract left channel from right channel to eliminate voice

Exercise 5 – Adding Karaoke Functionality

- Expand Audio Equalizer program to include Karaoke functionality



Do Not Delete

Exercise 5 Instructions

Video: myDAQ Optical Theramin

YouTube Link

Don’t forget to submit your project to ni.com/studentdesign for a chance to win prizes and a trip to Austin, TX

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

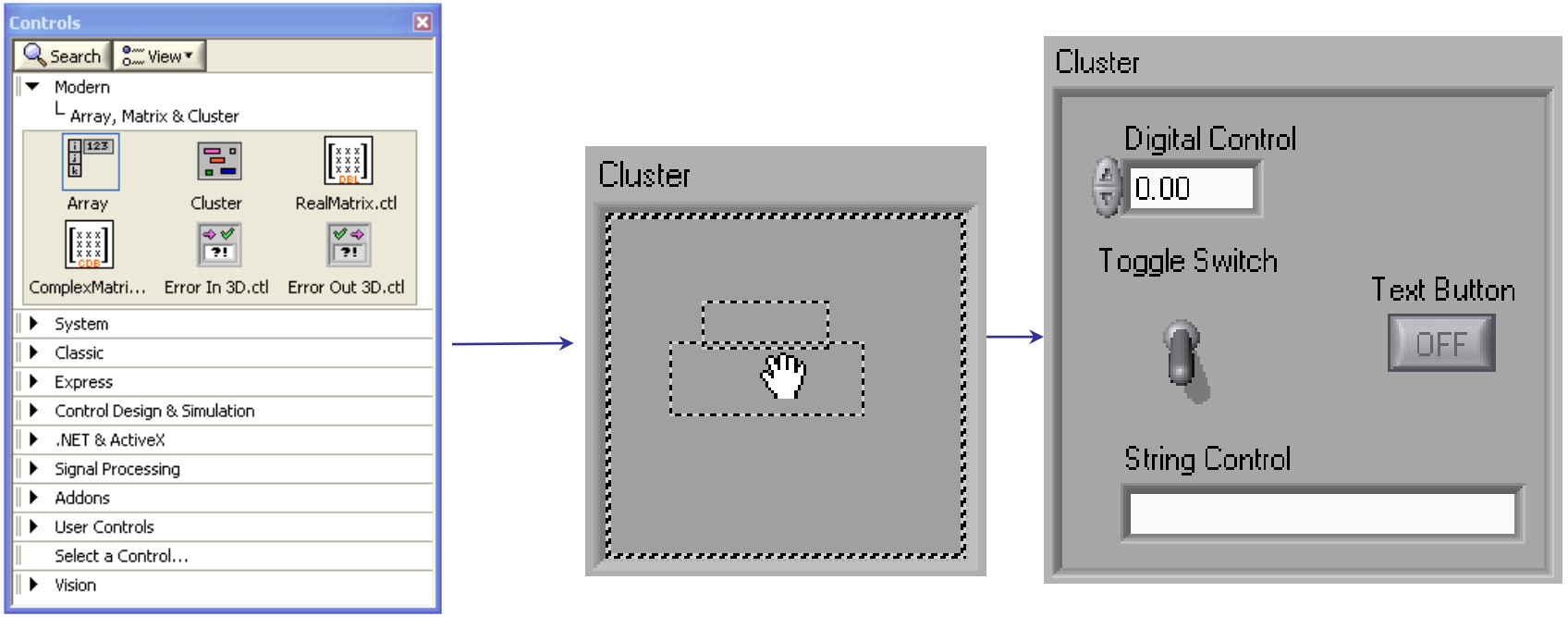
Introduction to Clusters

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

Creating a Cluster

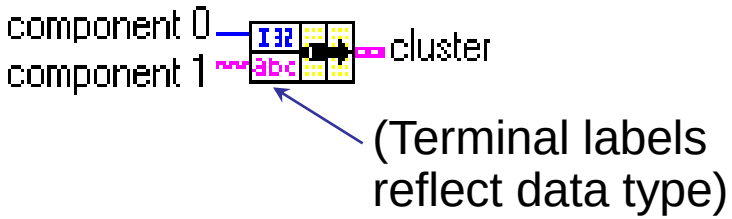
1. Select a **Cluster** shell.
2. Place objects inside the shell.

Controls»Modern»Array, Matrix & Cluster

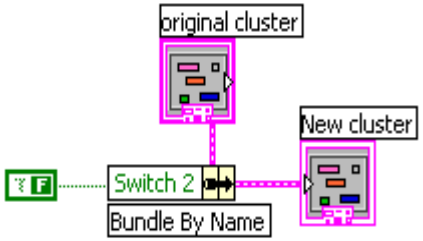


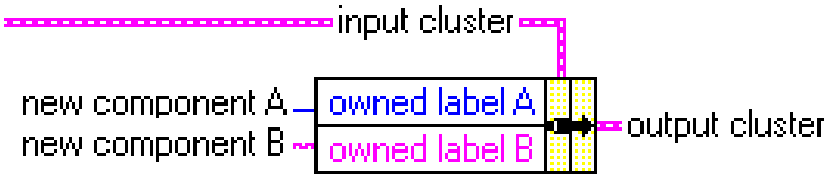
Cluster Functions

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



Bundle



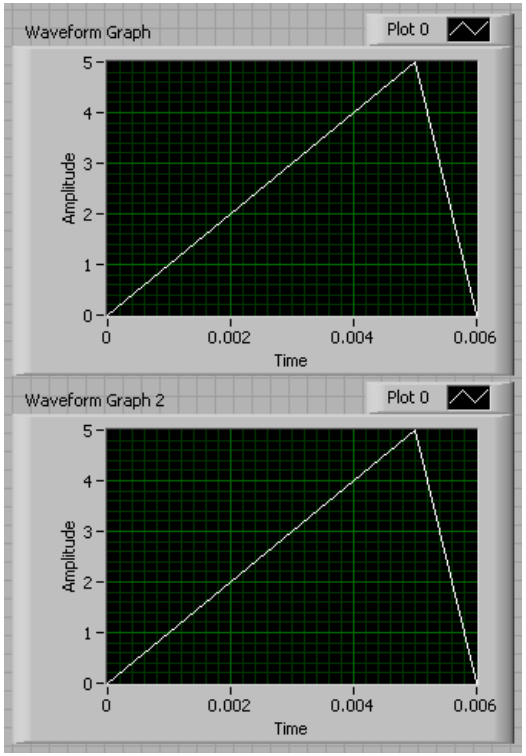


Bundle By Name

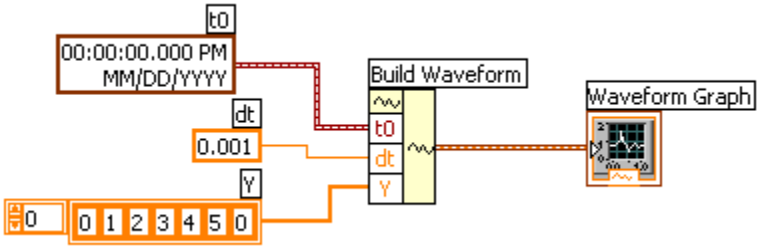
Using Arrays and Clusters with Graphs

The waveform data type contains 3 pieces of data:

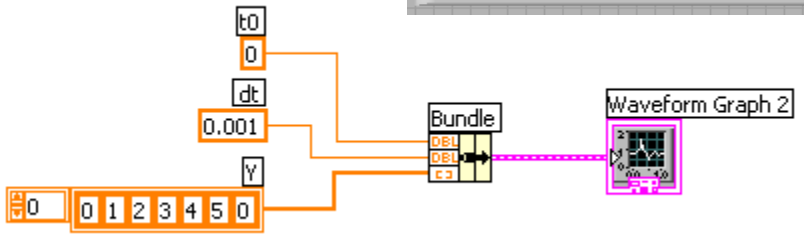
- t0 = Start time
- dt = Time between samples
- Y = Array of Y magnitudes



You can create a waveform cluster in two ways:



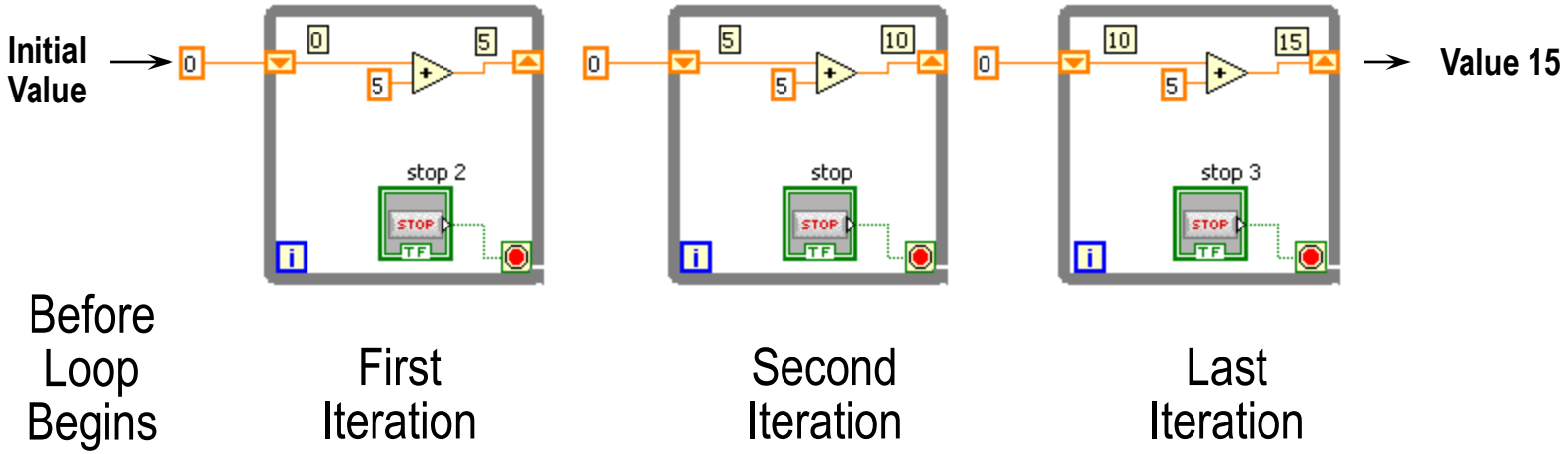
Build Waveform (absolute time)



Cluster (relative time)

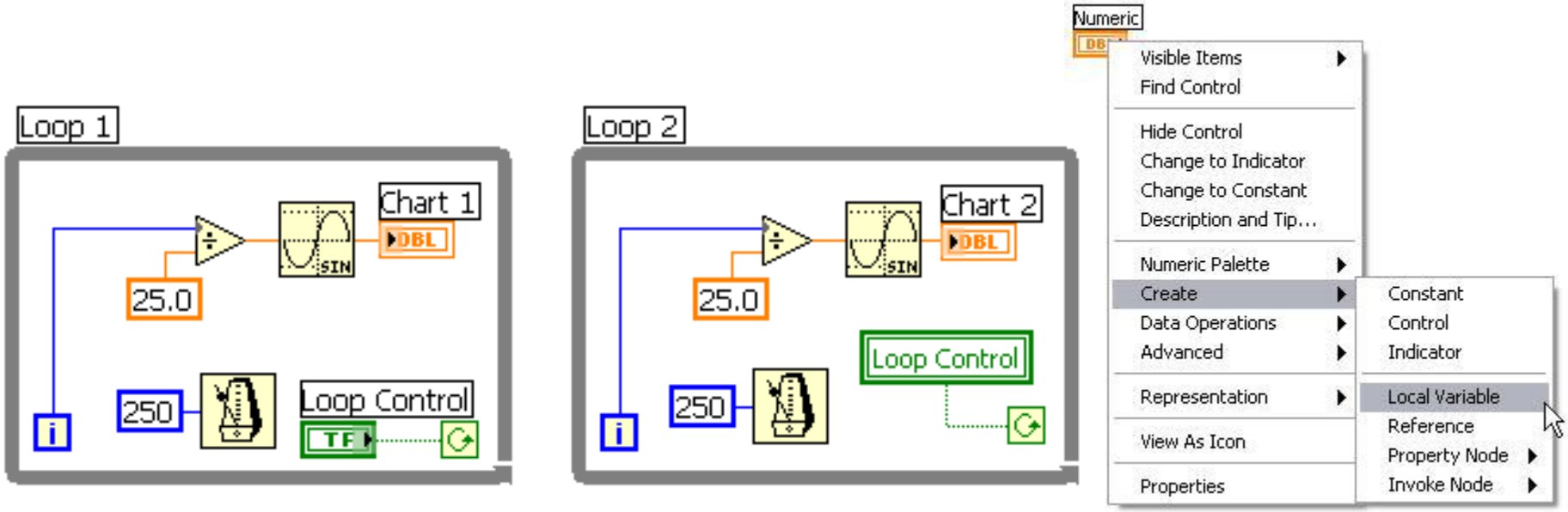
Shift Register – Access Previous Loop Data

- 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

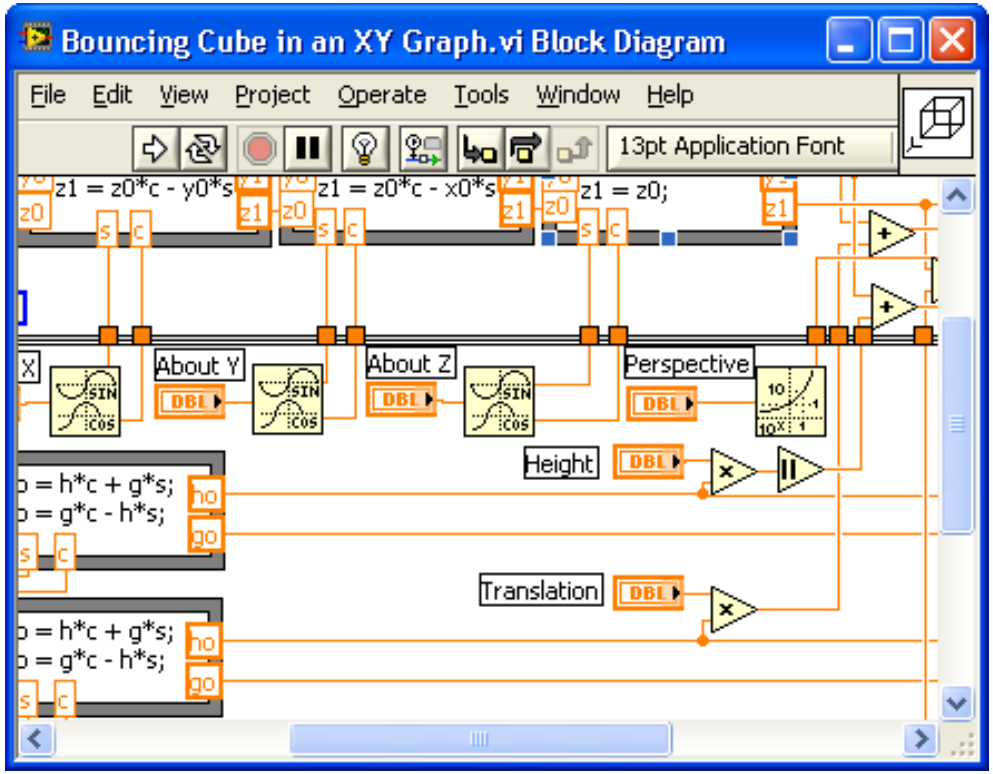


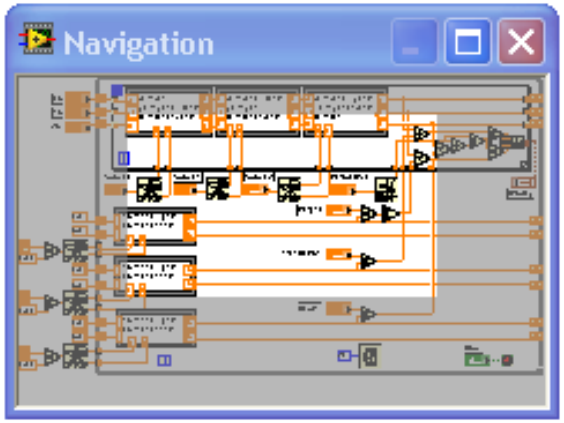
Local Variables

- Local variables allow data to be passed between parallel loops
- You can read or write a single control or indicator from more than one location in the program
  - Local variables break the dataflow paradigm and should be used sparingly



LabVIEW Navigation Window

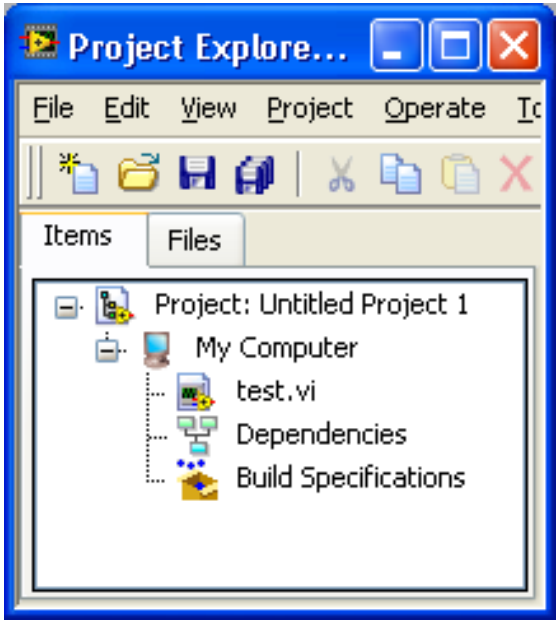




- Shows the current region of view compared to entire front panel or block diagram
- Great for large programs

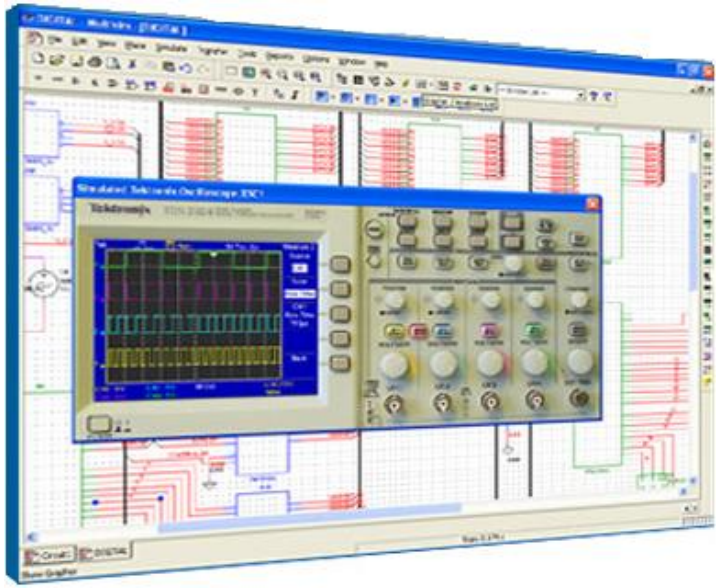
Organize and reduce program visual size with subVIs

LabVIEW Project



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

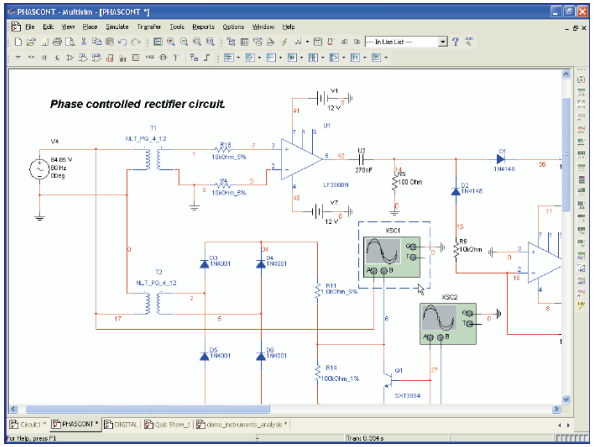
NI Multisim and Ultiboard



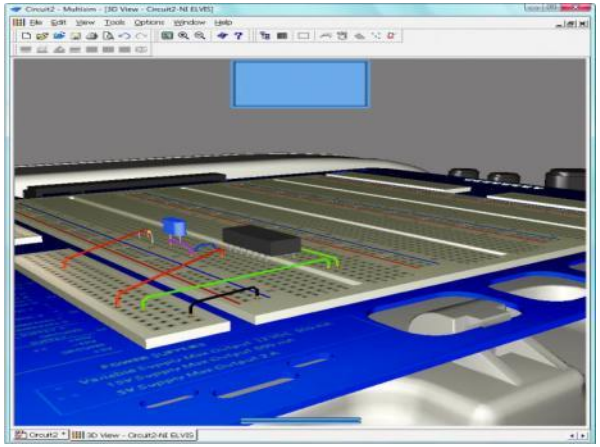
- World's most popular software for learning electronics
- 180,000 industrial and academic users
- Products include:
  - Multisim simulation and capture
  - Ultiboard PCB layout
  - Multisim MCU Module microcontroller simulation
- Low-cost student editions available
- ni.com/multisim

Multisim Integrated with LabVIEW

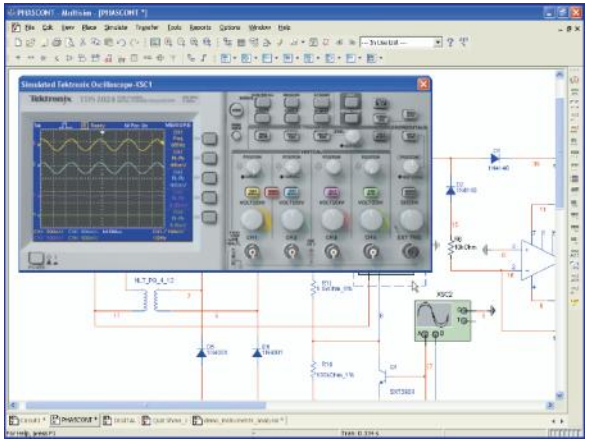
1. Create Schematic



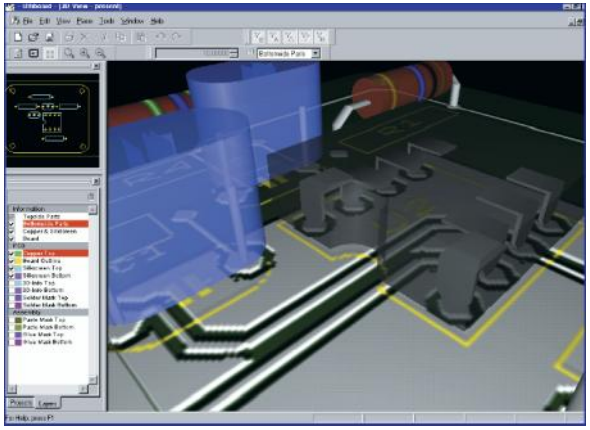
2. Virtual Breadboard



3. Simulate

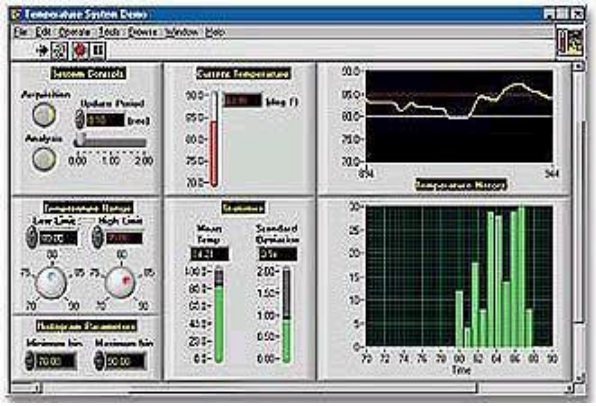


4. PCB Layout



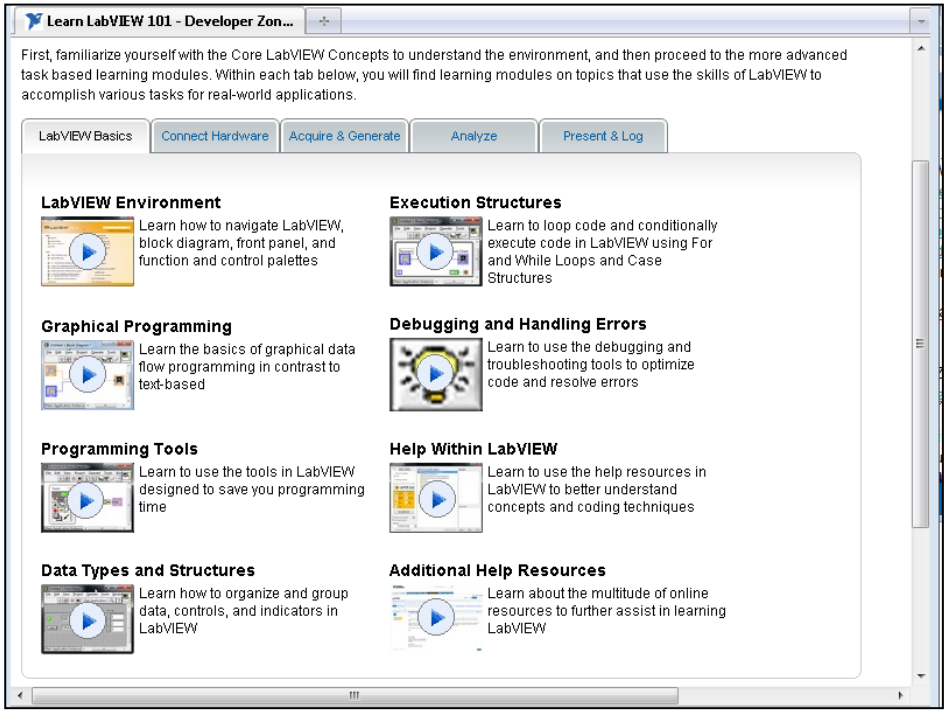
5. Test

6. Compare



Additional Resources

- NI Academic Web and Student Corner
  - ni.com/students
  - ni.com/lv101
  - ni.com/textbooks
  - Get your own copy of the LabVIEW Student Edition
- NI KnowledgeBase
  - ni.com/kb
- NI Developer Zone
  - ni.com/devzone
- LabVIEW Certification
  - LabVIEW Fundamentals Exam (free on ni.com/academic)
  - Certified LabVIEW Associate Developer Exam (industry-recognized certification)



ni.com/lv101

The LabVIEW Certification Program

Architect

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

Developer

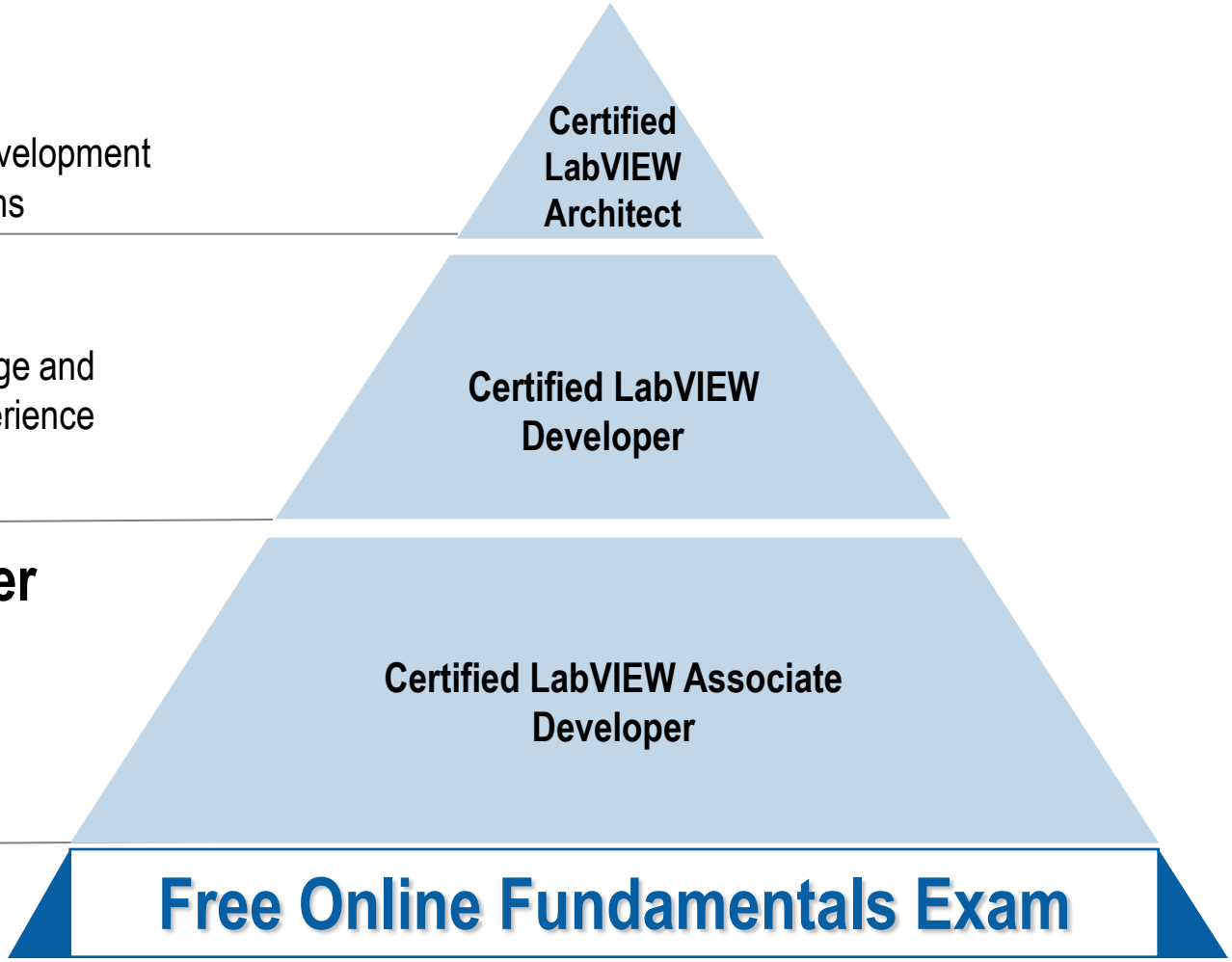
- Advanced LabVIEW knowledge and application development experience
- Project management skills

Associate Developer

- Proficiency in navigating the LabVIEW environment
- Some application development experience

Fundamentals Exam

- Pre-certification skills test



Your Next Step

LabVIEW Skills Evaluation Quiz:
https://lumen.ni.com/nicif/us/infolvcoursefinder/content.xhtml

CLAD Exam Practice:
https://lumen.ni.com/nicif/us/ekitcladexmprp/content.xhtml

CLAD Exam Prep Webcast:
http://zone.ni.com/wv/app/doc/p/id/wv-566

Your first step to LabVIEW certification!