AOE 3054

Data Acquisition with LabView

Connect NI USB-6211

- The USB DAQ connects like any other USB device.
- You can connect the white cable to the extension cable provided on the workbench or connect directly to the computer.

If this is the first time the DAQ has been plugged into the computer, you will need to follow the driver install procedure which is similar to any other USB device.

Next, Open a Blank VI.



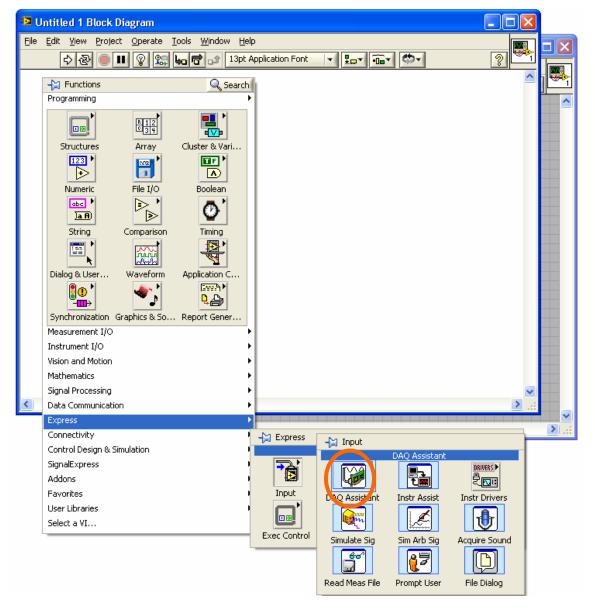
Open a New Blank VI

To begin a new program (or VI) click
 Blank VI.

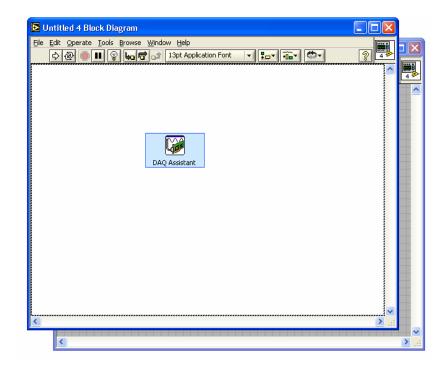
Getting Started	
<u>File Operate Tools H</u> elp	
LabVIEW 8.2	Licensed for Professional Version
Files	Resources
New	New To LabVIEW?
Blank VI	Getting Started with LabVIEW
🐌 Empty Project	LabVIEW Fundamentals
😼 VI from Template	Guide to LabVIEW Documentation
De More	LabVIEW Help
	Upgrading LabYIEW?
Open and a second se	MathScript
s ctofconverter.vi	3D Picture Control
Instrumentation 1.vi Instrumentation 1.vi Image: Dynamic Flex.vi	LabVIEW Object-Oriented Programming
	List of All New Features
spectralDemo.vi	Web Resources
🔜 Likelyhood.vi	Discussion Forums
🔜 spectralAliasing.vi	
🛃 CtoFconvert2.vi	Training Courses
🛃 CtoFconvert.vi	LabVIEW Zone
C Browse	Examples
	Find Examples

Select DAQ Assisant

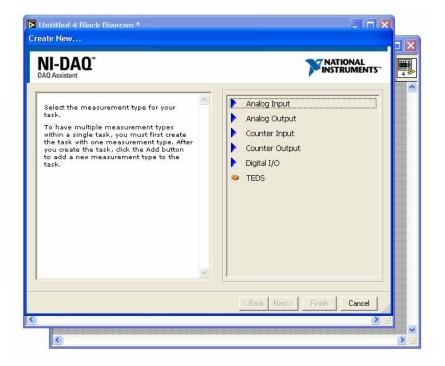
From the Block Diagram, Right click and select <u>Input</u>, <u>DAQ Assistant</u>.



Place VI on the Diagram

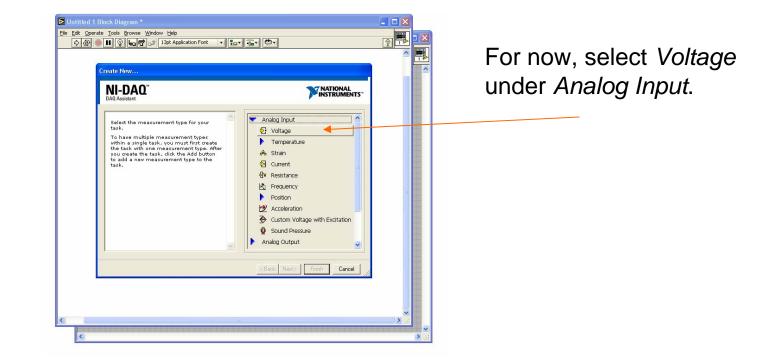


Configure the DAQ Assistant...



DAQ Assistant is a special type of sub VI which will automatically open a configuration window. The sub VI allows several operations to be configured. To read data into the computer, select Analog Input.

Configure the DAQ Assistant



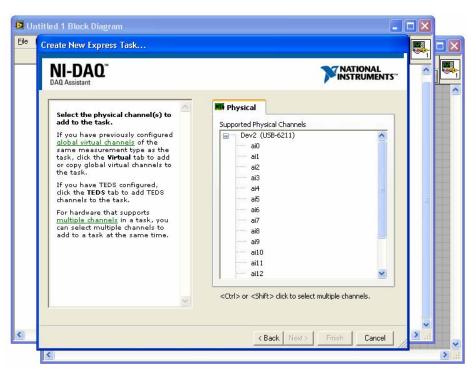
Analog input channel configuration allows conversion of inputs to some standard values. Use these when possible.

Physical Channels

Elle Create New Express Task	
Relet the physical channel(s) to add to the task. If you have previously configured alobal virtual channels of the same measurement type as the task, dick the Wirtual tab to add to the task. If you have TEDS configured, channels to the task. For hardware that supports multiple channels to add to a task at the same time. (Chrl> or <shift< th=""><th></th></shift<>	

You should then see this screen with the device and channels listed of the DAQ you are using. If you get "No supported devices found", then check the installation of the DAQ device in NI MAX (Measurement and Automation Explorer).

Physical Channels



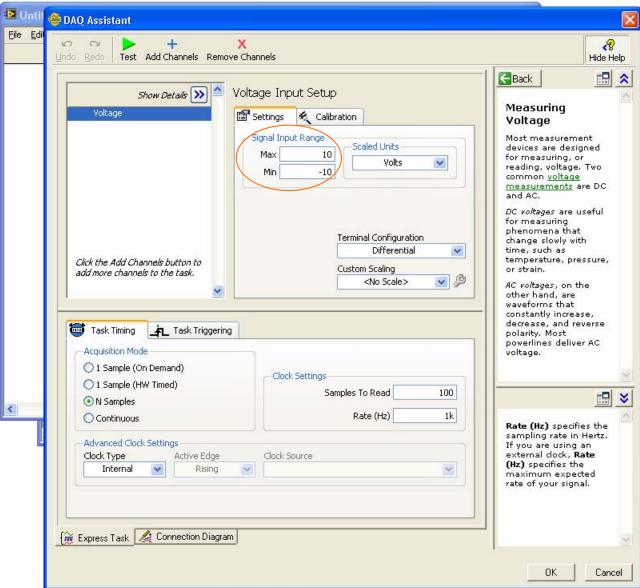
Select ai0 and click **Finish**.

You can select **one** channel or **multiple** channels here. This device allows for up to 16 single ended channels of input.

Here we setup the amplifier of the DAQ. Voltages enter through the wire connected to the DAQ, that will be connect later, and are translated into computer numbers that we can manipulate and record.

Undo Redo Test Add Channels Remove Channels	Hi
Show Details Voltage Input Setup Voltage Signal Input Range Signal Input Range Scaled Units Max 10 Voltage Wolts Min -10 Voltage Terminal Configuration Differential Custom Scaling Image: Task Triggering Acquisition Mode	Measuring Voltage Most measurement devices are designed for measuring, or reading, voltage. Tw common <u>voltage</u> measurements are D and AC. <i>DC voltages</i> are useful for measuring phenomena that change slowly with time, such as temperature, pressu or strain. <i>AC voltages</i> , on the other hand, are waveforms that constantly increase, decrease, and revers polarity. Most powerlines deliver AC voltage.
O 1 Sample (On Demand) O 1 Sample (HW Timed) O N Samples O Continuous Advanced Clock Settings Clock Type Active Edge Clock Source	Rate (Hz) specifies the sampling rate in Herr If you are using an external clock, Rate (Hz) specifies the maximum expected rate of your signal.

Input Range defines the span of voltage the DAQ will measure. Narrowing the range will concentrate the Analog to Digital Converter allowing better resolution of measurements. This translates to amplifier gain of the input of the DAQ.



Terminal connections can be made using **Differential** or **Single Ended**. Differential gives better common mode rejection and cleaner signals if the connections are properly wired.

Undo Redo Test Add Channels Remove Chan	nels	Ride H
Voltage Sig	ge Input Setup attings ▲ Calibration max 10 Scaled Units Max 10 Volts ♥ Terminal Configuration Differential Custom Scaling No Scale> ♥ ♪	gned , Two are DC useful t th esssure, he ase, everse
O 1 Sample (HW Timed) O 1 Samples O Continuous Advanced Clock Settings Clock Type Active Edge Internal ▼ Rising ▼ for Express Task Connection Diagram	Clock Settings Samples To Read 100 Rate (Hz) 1k Clock Source	Hertz. an t ate e cted

Scaling converts a somewhat arbitrary voltage into a meaningful unit of measure. For instance, 1 Volt equals 2 PSI. There are different ways to achieve scaling

🖻 Untit	le DAQ Assistant	
<u>Eile E</u> di		<mark>∢</mark> 8 Hide Help
	Show Details Voltage Input Setup Voltage Image Signal Input Range Scaled Units Max 10 Volts Image Min -10 Differential Image Custom Scaling No Scale> Voltage Task Triggering	Back Image Measuring Voltage Most measurement Image devices are designed for measuring, or reading, voltage. Two common voltage measurements measurements are DC and AC. DC voltages are useful for measuring phenomena that change slowly with time, such as temperature, pressure, or strain. AC voltages, on the other hand, are waveforms that constantly increase, decrease, and reverse polarity. Most powerlines deliver AC State
<	Acquisition Mode 1 Sample (On Demand) 1 Sample (HW Timed) N Samples Samples To Read 100 Continuous Rate (Hz) 1k Advanced Clock Settings Clock Source Internal Clock Type Active Edge Clock Source Internal Rising Image: Clock Source Internal Clock Source Image: Clock Source Internal Connection Diagram	voltage. Rate (Hz) specifies the sampling rate in Hertz. If you are using an external clock, Rate (Hz) specifies the maximum expected rate of your signal.
		OK Cancel

For our first measurement, we can use the default settings.

Open Column Image: Column Column Undo Redo Test Add Channels Remove Channels	Hide Help
Show Details Voltage Input Setup Voltage Settings Calibration Signal Input Range Scaled Units Signal Input Range Signal Input Range Scaled Units Image Click the Add Channels button to add more channels to the task. Terminal Configuration Differential Click the Add Channels button to add more channels to the task. Image Custom Scaling Image Task Tringering Custom Scaling Acquisition Mode Image Clock Settings Image Samples Clock Settings Continuous Clock Settings Samples To Read 100 Rate (Hz) Ik Advanced Clock Settings Clock Source Image	Weasuring Voltage Image: Constant State Measuring, voltage Measurement devices are designed for measuring, or reading, voltage. Two common voltage measurements are DC and AC. DC voltages are useful for measuring phenomena that change slowly with time, such as temperature, pressure, or strain. AC voltages, on the other hand, are waveforms that constantly increase, decrease, and reverse polarity. Most powerlines deliver AC voltage. Rate (Hz) specifies the sampling rate in Hertz. If you are using an external clock, Rate (Hz) specifies the maximum expected rate of your signal.
{ĵĝir Express Task	OK Cancel

🎯 DAQ Assistant	<u> </u>
😕 🖘 🕨 🕂 X Undo Redo Test Add Channels Remove Cha	nnels Show Help
Voltage	age Input Setup Settings Calibration Scaled Units Max 10 Scaled Units Min -10 Volts Calibration Differential Configuration Differential Custom Scaling Custom Scaling
Task Timing Task Triggering Acquisition Mode 1 Sample (On Demand) 1 Sample (HW Timed) N Samples Continuous Advanced Clock Settings	<no scale=""> Clock Settings Samples To Read 100 Rate (Hz) 1k</no>
Advanced Clock Settings Clock Type Active Edge Internal Express Task Connection Diagram	Clock Source

We can configure the operation of data acquisition timing for the program. Multiple point data acquisition can be thought of as gathering several individual data points and putting them together like a moving picture show.

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Eile Edil	X Channels	Show Help		
	/oltage Input Setup Signal Input Range Max 10 Min -10 Volts			Several options e acquisition mode <i>point</i> to <i>continuo</i>
Click the Add Channels button to add more channels to the task.	Terminal Configuration Differential Custom Scaling <no scale=""></no>	× •		at the default sele Samples.
Task Timing Task Triggering Acquisition Mode 1 Sample (On Demand) 1 Sample (HW Timed) N Samples Continuous	Clock Settings Samples To Read Rate (Hz)	100 1k	~	
Advanced Clock Settings Clock Type Active Edge Internal Rising	Clock Source		>	
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Intit	🐵 DAQ Assistant 🛛 🛛 🛛		
Edil	Indo Redo Test Add Channels Remove Channels Show Help	2	
	Indo Redo Test Add Channels Remove Channels Show Help Show Details Image Calibration Image Calibration Voltage Image Scaled Units Image Image Voltage Image Scaled Units Image Image Click the Add Channels button to add more channels to the task. Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image Image <th></th> <th></th>		
	 ○ 1 Sample (On Demand) ○ 1 Sample (HW Timed) ○ N Samples ○ Continuous Continuous Clock Settings 		>
	(m) Express Task Connection Diagram OK Cancel		

Samples to read defines how many data points the DAQ will return when this VI is called.

🗕 Until	🐵 DAQ Assistant	
<u>File E</u> dil	Image: Second	
	Show Details Voltage Input Setup Voltage Issettings Calibration Signal Input Range Scaled Units Image Click the Add Channels button to ad more channels to the task. Image Image Image Task Timing Image Image Image Task Triggering Clock Settings Image Image Image Clock Settings Image Image Clock Settings Image Image Image Image Clock Settings Image Image Image Image Image Rising Image Image Image Image Image Image Rising Image Image Image Image I	
	OK Cancel	

Rate tells the DAQ how fast to acquire the data.

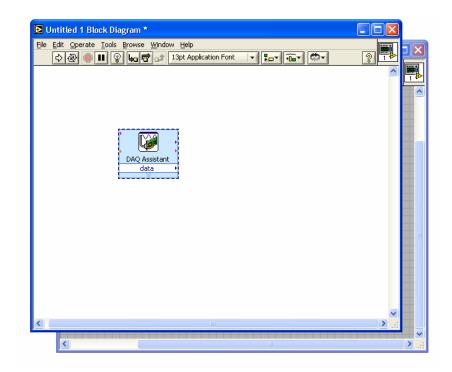
🔁 Until	🐵 DAQ Assistant 🛛 🛛 🔀		
<u>File E</u> di	Image: Second Redo Image: Head of the second redo Image: Head of th		
	Show Details >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	C)	
	Click the Add Channels button to add more channels to the task.		
<	 N Samples Continuous Advanced Clock Settings Clock Type Active Edge Clock Source Internal Rising Clock Source 		
	(m Express Task Connection Diagram)		

Divide the sample rate by the number of samples to determine the sample time. If we use 1000 samples at 1000Hz, that will be 1 second of data.

Until 🎯 DAQ Assistant					
undo Redo Test	+ X Add Channels Remove C			Show Help	
Voltage	Show Details >>> VC	Settings Calibration	icaled Units		
Clock Type Internal	Active Edge	Clock Source			
1mm Express Task			OK	Cancel	

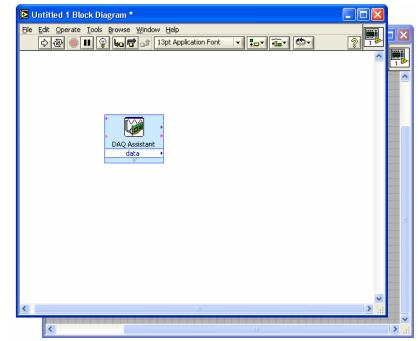
Click OK and the DAQ Assistant will build the code for the operations you selected. These can be changed later by double clicking the DAQ Assistant Icon.

Getting Data out of the VI



Click in the White space...

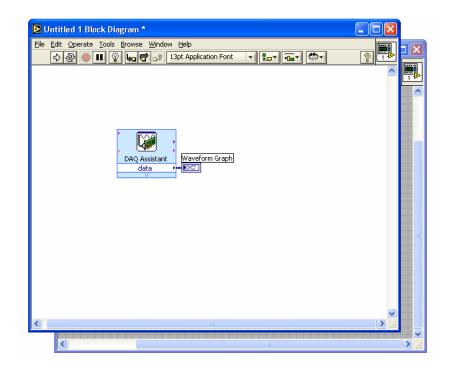
Create Graph Indicator



Hover over the right arrow of the terminal *Data...*

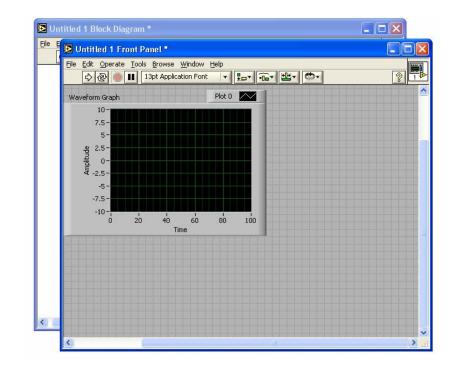
until the wiring tool appears and then right click and Select <u>Create >, Graph</u> <u>Indicator</u>.

Create Graph Indicator



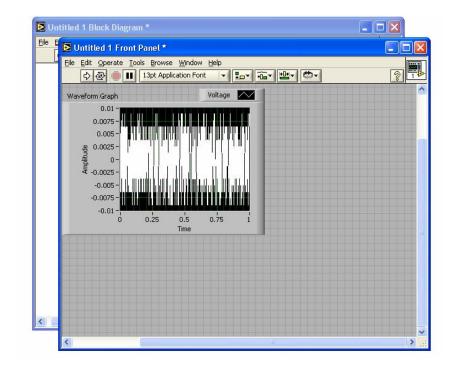
Now take a look at the Front Panel...

Ready to Test!



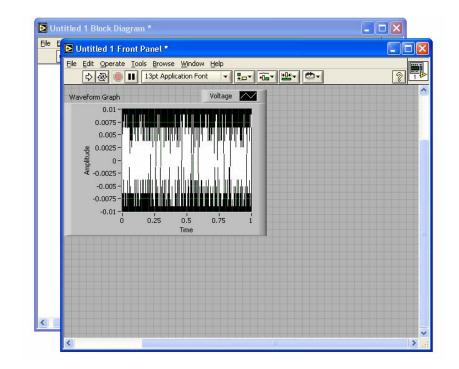
Click Run, wait for the second of data to be collected and...

Data!



But What is it? Shouldn't it be zero?

Data!



Since the DAQ is not connected to anything, we don't know what will result from the measurement. But we can see it is picking up some noise. If it were a flat line or just one point, that would indicate some other problem.

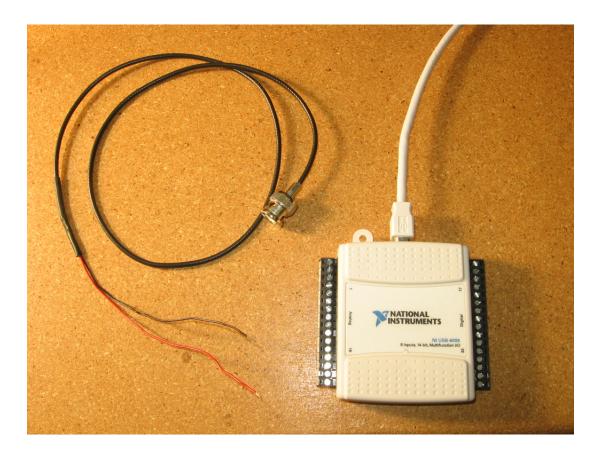
Saving the vi

- File, Save to save the vi.
- Make current values default to save front panel settings.

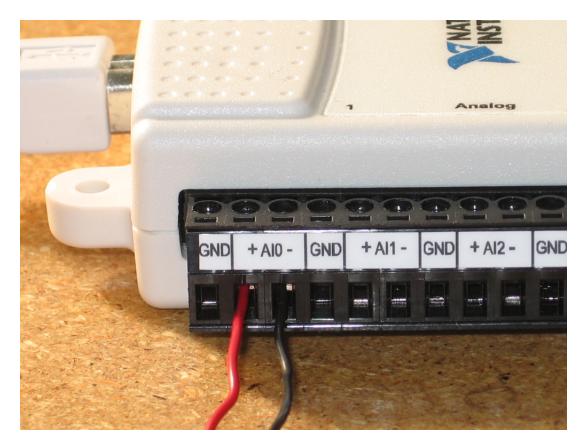
Wiring

• Making the device useful.

Use a cable with a BNC connector on one end and bare wire on the other end to connect the DAQ to the function Generator.

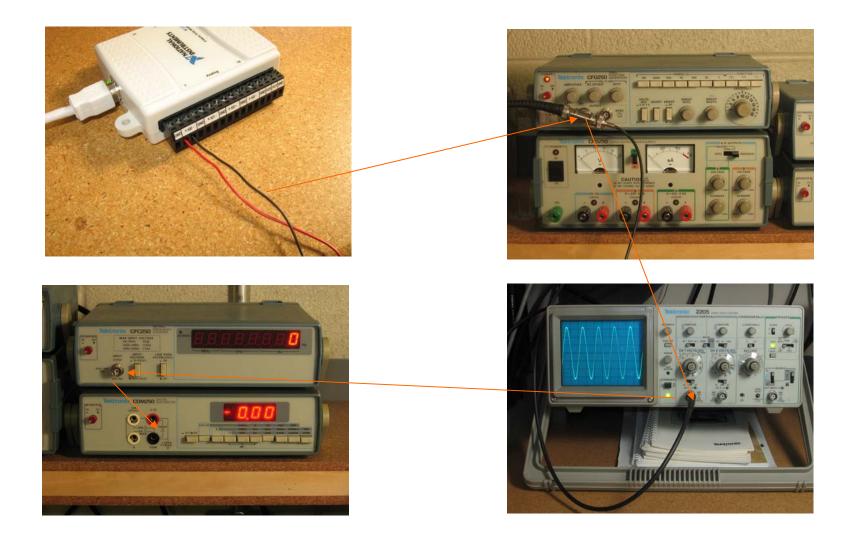


Analog In Terminals



Connect the bare wires to the AI0 + and - terminals on the DAQ

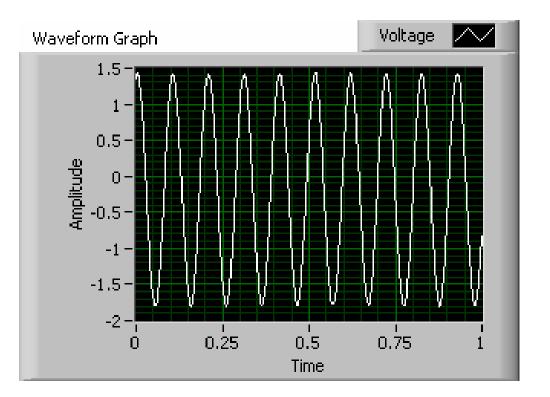
Complete Circuit



Run the program

- Now set the function generator on 10Hz
- Run the VI

Depending on the settings of the function generator, the amplitude scale could be different from the picture.



Task Timing Settings

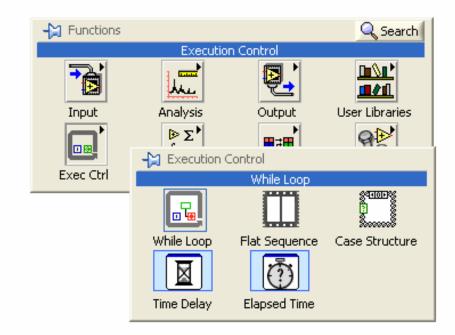
- To explore the operation of the equipment, A few changes need to be made to the settings.
 - DAQ Assistant
 - Under Clock Settings, Change Sample Rate to 10000Hz.
 - Change Samples to 500.
 - Function Generator
 - Set Frequency to **100Hz** Sine Wave.

Task Timing Settings

- Run the VI again and the output should be very similar to the previous test with the exception of the time scale which should be 0 to 0.05 seconds.
- Now modify the vi to have a **while loop** around the section of code on the block diagram.

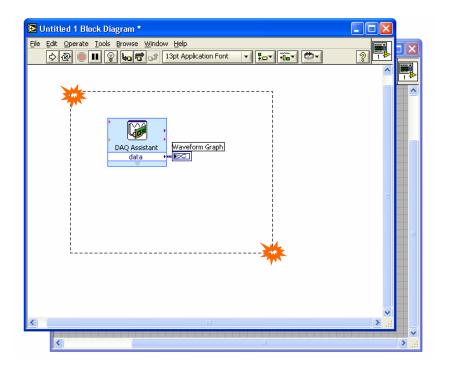
Add While Loop

• On the Block diagram, right click and select while loop from the Execution Control Pallet.



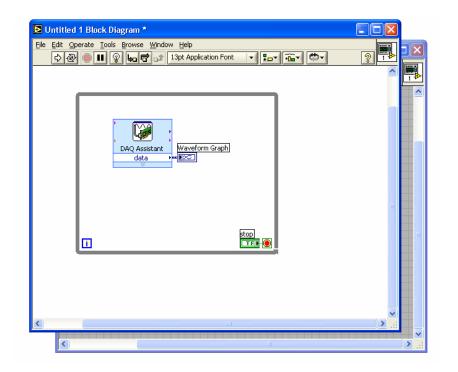
Add While Loop

Click in the upper Left corner...



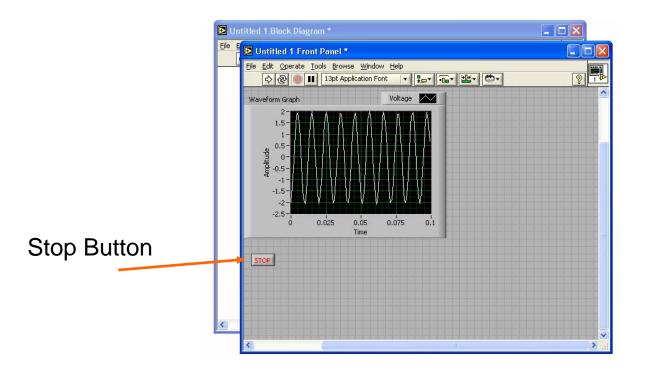
And enclose the code with the selection box and click in the lower right corner.

Add While Loop



The While loop causes the code inside the loop to be executed until the stop condition is met. In the default situation, a stop button is connected to the while loop that will halt execution of the vi.

Add While Loop



•If a stop button has been programmed in the vi, it should always be used instead of the Abort Button on the toolbar.

•Run the program and observe the output.

Looped Execution

- Adjust the Amplitude on the function generator to produce a 4 V peak-peak signal.
- Notice:
 - The voltage scale will auto adjust to the signal being measured.
 - The scale can be changed with settings on the graph. Just right click the graph in specific places and explore.

Range

- Compare this setting using the Oscilloscope.
- What is the RMS Reading on the Volt Meter? 1.41 VAC

Continuous Acquisition

- The configuration we have appears to be taking data continuously, however if the data is plotted, a small discontinuity will be noticed between each 500 samples (or "samples to read" setting).
- True continuous acquisition can be performed by setting the *Task Timing* to continuous.
- When using continuous timing, connect the stop button to the DAQ Assistant so it will know when to halt taking data. This is an example of when it is not appropriate to stop the VI using the abort button. The stop button will cleanly shutdown all the components in the program.

NI USB 6211 Specs

- Max sample rate 250kS/s.
- Max voltage +/- 10 VDC.
- Resolution 16-Bits.
- Analog Input: 8 Diff, 16 Single Ended.
- 2 12-Bit Analog Outputs (0-5 Volts, 150 Updates/sec max).
- 12 Digital I/O lines.

Rate

- Max 250kS/s (250,000 Samples/sec) for NI USB 6211.
- The maximum rate the DAQ can function.
- Divided among channels (Multiplexed).
- Some slight Inter-channel delay.

 1 Sample (On Demand) 1 Sample (HW Timed) N Samples Continuous 	Clock Settings Samples To Read 1000 Rate (Hz) 1000
Advanced Clock Settings Clock Type Active Edge Internal V Rising	Clock Source

Range

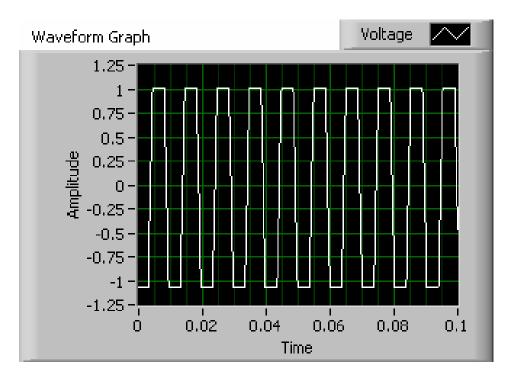
- The NI USB 6009 DAQ can be set to ±20, ±10, ±5, ±4, ±2.5, ±2, ±1.25, ±1 V input range.
- The Digital to Analog Converter changes the *analog voltage* into a *number* the computer can work with.
- 16 bits allow 2¹⁶ or 65,336 **integer** numbers to be used.
- These numbers are spread over the **range** of the input voltage.

show Details 🔊 🔷 Voltage Input Setup							
Voltage	🖀 Settings 🛛 🍕 Calibration						
	Signal Input Range Max 10 Min -10 Volts						
Click the Add Channels button to add more channels to the task.	Terminal Configuration Differential 💌 Custom Scaling <no scale=""> 💌 🔑</no>						

Range Example

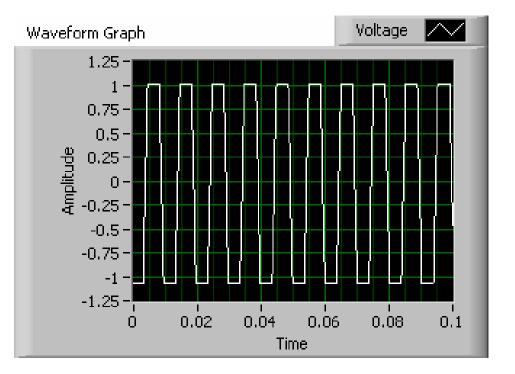
- Now change the voltage range to -1, +1 in DAQ Assistant Input Range.
- Observe the difference in the output.

Notice the flat top and bottom of the waveform at 1 and -1 volt. No matter how high the input voltage, the result will not exceed the set range.



Range Example

- Now change the voltage range to -1, +1 in DAQ Assistant Input Range.
- Observe the difference in the output.



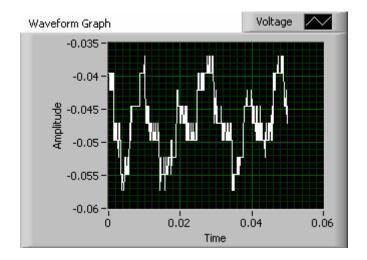
Absolutely do not exceed the maximum input rating of the board!!! (NI USB 6211 Overvoltage protection: +/-10V)

Resolution

- **Resolution** is the voltage range one number can represent.
- Example: +20 –(-20)=40, 40/16383=.00244V or 2.44mV resolution.
- Set the Range back to +/-20V
- Adjust the amplitude of the function generator to the minimum value. (Use the 0-2 Vp-p Range button)

Resolution Example

- This is typical of a DAQ input that is not using very much of it's range.
- You can see the step like pattern that should be an indication of this.



Aliasing-Varying Sample Rate

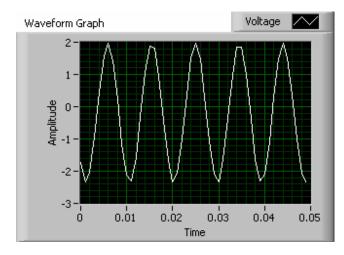
- Aliasing is when the DAQ is giving a result that is not what is really happing.
- Filters at the Nyquist frequency are the only way to prevent aliasing.
- Now set the function generator to
 - 2 Vр-р
 - 100 Hz
 - Sine Wave
- Set the DAQ to
 - 1000Hz sample rate
 - 50 Samples
- What is the sample time? 50mSec. Samples/rate
- How many wave cycles should we see? 5. Sample time/ (1/rate)

Aliasing-Varying Sample Rate

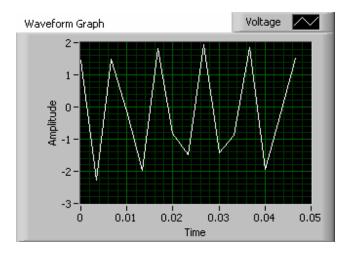
• Now try

- 1000Hz and 50 samples
- 500Hz and 25 samples
- 300Hz and 15 samples
- -210Hz and 10 samples
- Need Frequencies below Nyquist here:

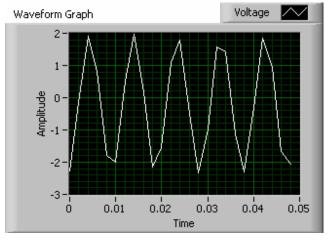
105 Hz signal at different sample rates above Nyquist Frequency



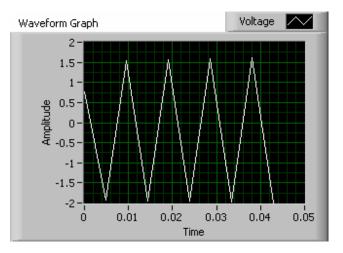
1000Hz sample rate, 50 samples



300Hz sample rate, 15 samples

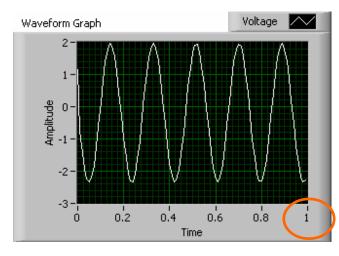


500Hz sample rate, 25 samples

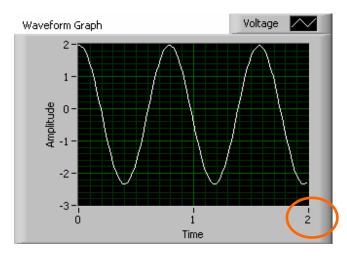


210Hz sample rate, 10 samples

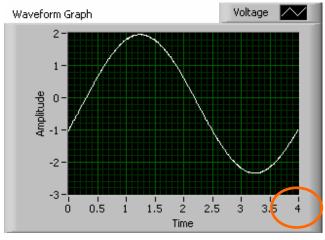
105 Hz signal at different sample rates below Nyquist Frequency



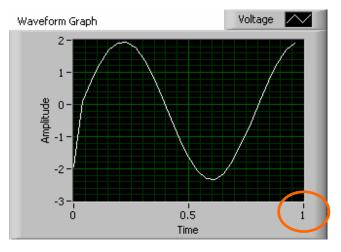
100Hz sample rate, 100 samples



52Hz sample rate, 100 samples



105 Hz sample rate, 420 samples

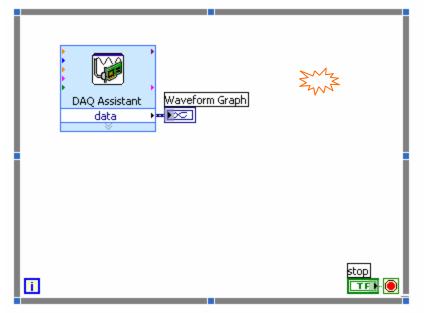


26Hz sample rate, 26 samples

Sampling Below Nyquist

- When the sample rate is less than half the frequency under measurement, aliasing or misinformation will result.
- The apparent frequency will not be the actual frequency.
- A perfect waveform can be observed that is likely some multiple of the actual frequency.
- Hardware filtering is the only way to avoid aliasing when the sample rate cannot be set high enough to include all frequency content being measured.

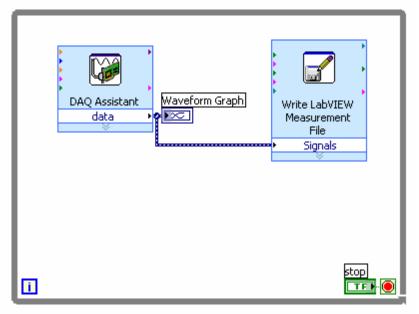
- Data can be saved with the Write LabView Measurement File express VI.
- Add the Write Meas File Express VI inside the while loop.
- The Write Meas File VI is located in the *Output* Express Pallet.
- Observe all the options in the express dialog.
- The default options will get the data saved.
- Other settings can optimize the program, for instance it may be better to not have the save VI overwrite data that has already been taken!



Drop the "Write to Measurement File.vi" to the diagram to the right of the DAQ assistant.

The Write to Measurement File.vi can be found under Output on the Express vi pallet.

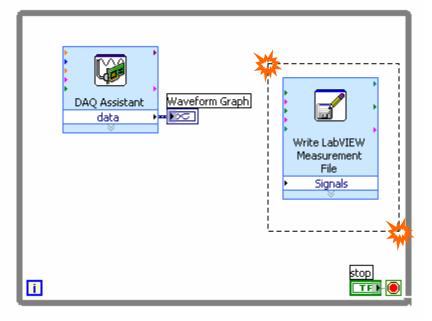
Configure Write To Measurement File [Write To M	easurement File]
File Name	 File Format Text (LVM) Binary (TDMS) Binary with XML Header (TDM) Lock file for faster access
Action	Segment Headers
 Save to one file Ask user to choose file Ask only once Ask each iteration If a file already exists Rename existing file Use next available file name Append to file Overwrite file Save to series of files (multiple files) Settings 	 One header per segment One header only No headers X Value Columns One column per channel One column only Empty time column Delimiter Tab Comma
File Description	



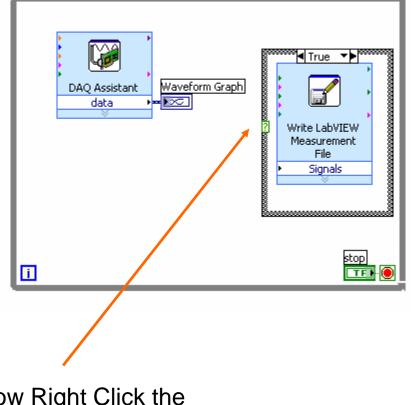
Connect the Signals Terminal on the Write to Measurement File to the wire the comes out of the DAQ Assistant.

Save Data Button

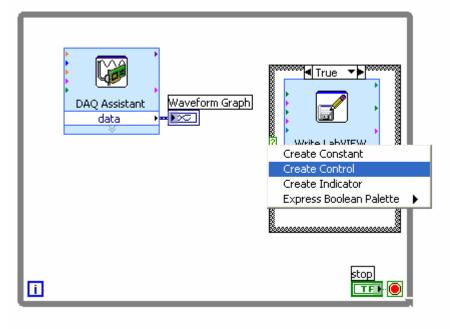
- In order to keep the program from saving data every cycle of the while loop, we should add a button to the front panel.
- The button will control a case structure that will decide if the save routine should run.
- Located on the *Exec Ctrl* express pallet, select the **Case Structure**.



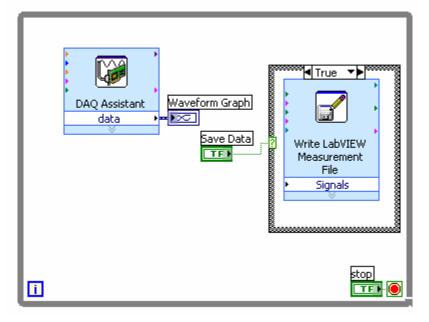
Click to surround the functions that should be included in the case structure. Include just the Write to Measurement file VI.



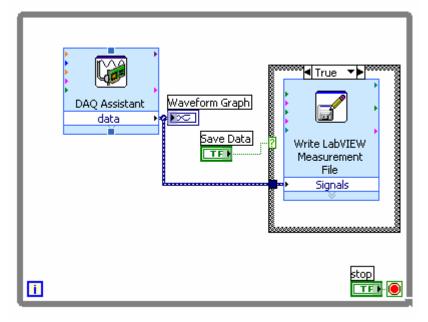
Now Right Click the left side of the decision terminal and select create control.



Create control will make a button to save data.



And rename it to "Save Data". Just start typing after selecting Create Control since the label is highlighted once it is created.



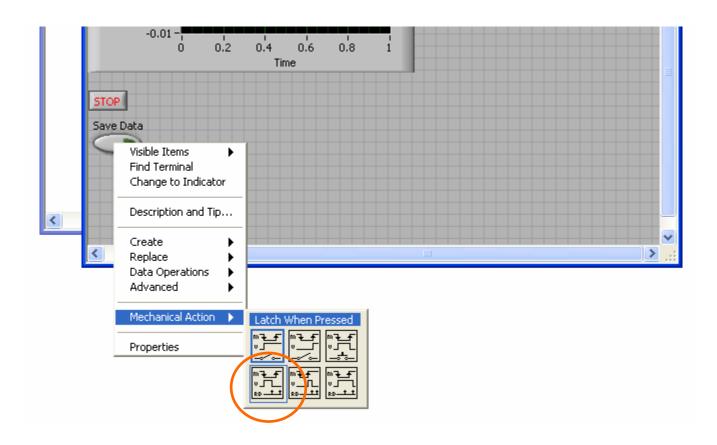
Connect the signals terminal to the DAQ output line.

Boolean Button

- A button is normally a click on, and click off type.
- For this program, it is best if the button is turned off after it has been selected for an operation.
- From the front panel, right click the newly created button and select Mechanical Action

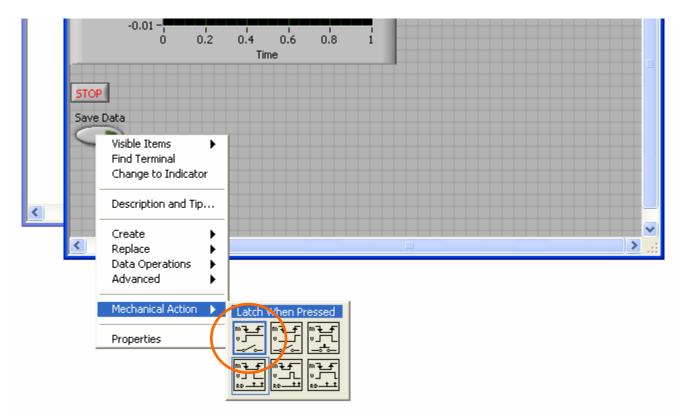
Setting the action of a Button

Set the action of the button to "Latch When Pressed". This will allow the program to turn off the button once the desired action has been performed once. This is a kind of one-shot.



Setting the action of a Button

If you want the program to save data as long as the button is pressed, leave it set to "switch when pressed". If this is done, remember to turn it off or an extremely large file could result. The file save settings will need to be adjusted for desired results.



Examining Data File

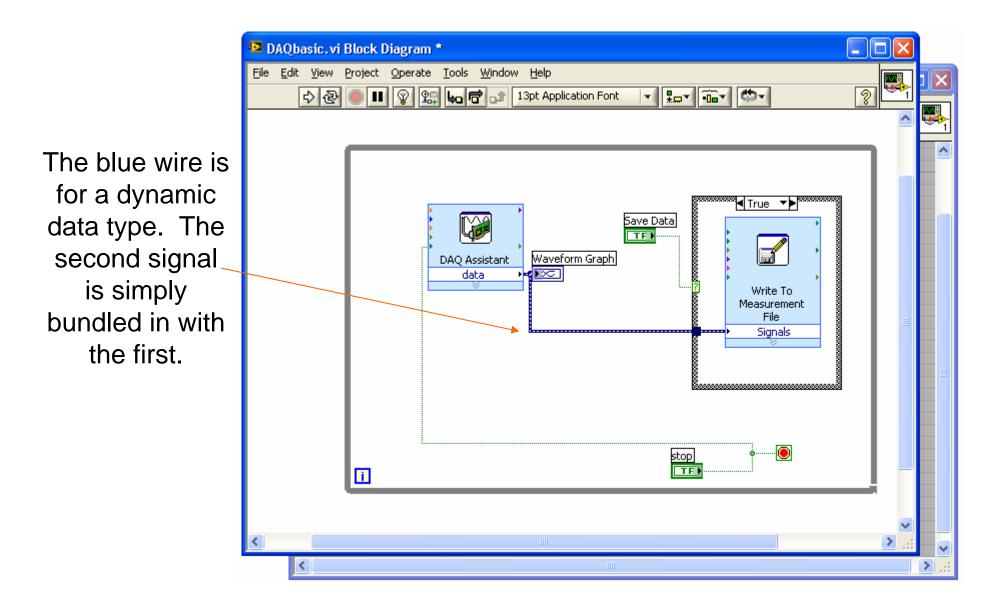
	A1	▼ fs	Lab∨lEW Measurement					
		A		В	С			
1	LabVIEW N	/leasuremen	t					
2	Writer_Ver:	sion	0.92					
3	Reader_Version			1				
4	Separator			Tab				
5	Multi_Headings		Yes					
6	X_Columns			Multi				
7	Time_Pref			Absolute				
8	Operator			LabUser				
9	Date			3/6/2006				
10	Time			27:55.1				
11	***End_of_l	Header***						
12								
13	Channels			1				
14	Samples			1000				
15	Date			3/6/2006				
16	Time			27:56.2				
17	Y_Unit_Lab			Volts				
18	X_Dimensio	on		Time				
19	XO			0.00E+00				
20				0.001				
21	***End_of_l	Header***						
22	X_Value			Voltage	Comment			
23			0	-0.002691				
24		0.00						
25		0.00						
26		0.00						
27		0.00						
28		0.00						
29		0.00						
30		0.00	7	0.004948				
H ← → H <u>test</u> /								

- Run the program and save some data.
- Open the file with Excel and look at the data it recorded.

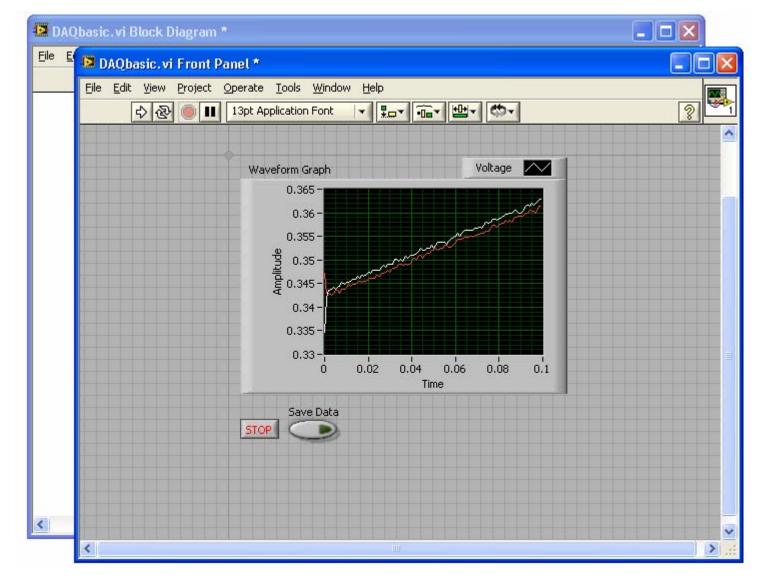
Multiple Analog Input Signals

- Add a second channel to the DAQ express vi.
 - Double Click the vi
 - Push Add Channels
 - Select Voltage
 - Select the channel(s) to be added.
- The channels can be renamed in the express vi dialog. (right click on them.)

Where is our second channel

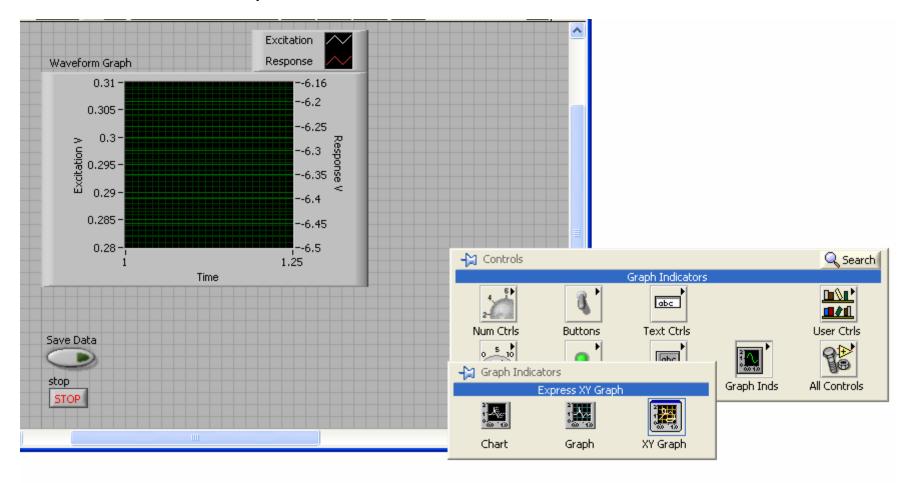


Check the signal from both channels



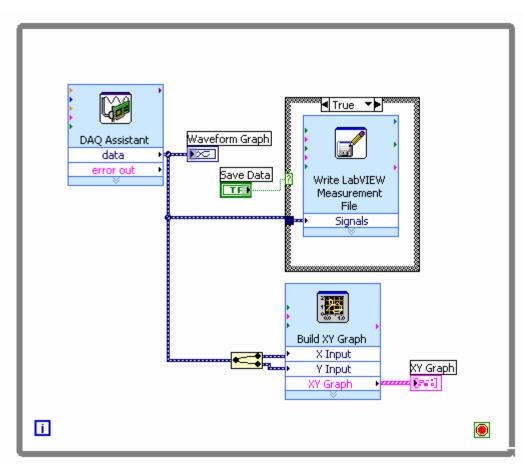
X-Y Graphs

• Add the X-Y Graph to the display with CH0 on one axis and CH1 on the other to the front panel.



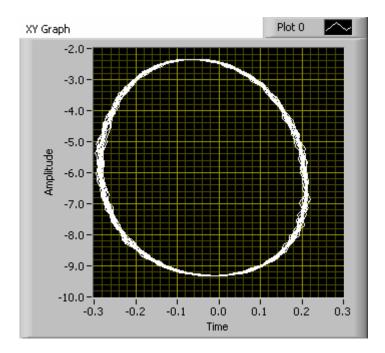
X-Y Graphs

- LabView adds the express vi to create the X and Y values and it adds the graph indicator.
- Under signal manipulation, add a "Split Signals" and connect the output from the DAQ Assistant vi.



X-Y Graphs

• Using this with the dynamic Beam can give the representation like the scope X-Y Mode.



Applications to Dynamic Beam

- Two inputs allow force and displacement voltages to be measured.
- Voltages converted to force and distance.
- Dynamic flexibility and spring constants measured at low frequencies and the result displayed.
- Data file saved and analyzed.