PHYS245 Lab: Introduction to function generator and oscilloscope

Purpose:

- Understand the basics of function generator and oscilloscope
- Obtain hands-on experience with function generator and oscilloscope
- Learn to do basic measurements on oscilloscope
- Get familiar with coaxial cables with BNC connectors

Equipment list: ELVIS II, coaxial cables with BNC connectors, cables with banana plugs, and jump wires

The oscilloscope is one of the most important diagnostic equipment used in science and engineering. It displays the electrical voltage as a function of time. Therefore it is used widely to obtain "voltage versus time" pictures of electrical signals. Function generator is a piece of equipment that generates electrical waveforms, a particular "voltage versus time" dependence of electrical signals. Therefore the function generator and oscilloscope can be combined to diagnose or characterize *a.c.* electrical circuits. In this Lab, you will generate signals using function generator and display the signals using oscilloscope. Both function generator and oscilloscope are integrated into the ELVIS II station. The FGEN is in analogy to the power supply of a *d.c.* circuit. The scope is in analogy to the DMM used in a *d.c.* circuit.

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Pre-Lab exercises

Thoroughly read through the brochure and answer the following questions

• The use of coaxial cables instead of regular cables will reduce the *a.c.* signal loss due to radiation, true or false?

• There is only one conductor in a coaxial cable, true or false?

• The Scope can be used to display the *a.c.* voltages as a function of time, true or false?

• The Scope can measure the amplitude, but not the frequency, of the *a.c.* signal, true or false?

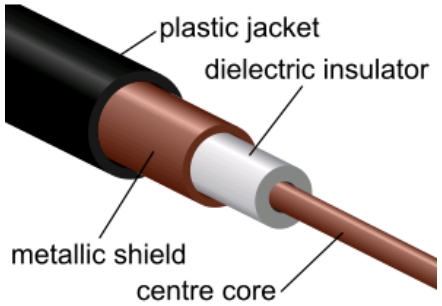
• The *a.c.* signal from the FGEN has to be obtained from the BNC connector on the left side of the ELVIS station, true or false?

• Outer shields of BNC connectors for FGEN, Scope Ch0 and Scope Ch1 are connected directly to electrical ground, true or false?

Experiment I: Direct observation of waveforms produced by function generator

Coaxial cable with BNC connectors

Coaxial cable cut away



In this Lab, you will use coaxial cable with BNC connectors to conduct *a.c.* electrical voltage signals. It is useful to understand why a coaxial cable, instead of ordinary wires, are used. In ordinary wire, there is only a central conductor in wire. In coaxial cable, there are two conductors: a central wire and a tubular shield. Therefore one cable is serving as two wires.

If two ordinary wires are used to supply the *a.c.* signals (especially high frequency signals), the two wire act as antenna. The high frequency currents radiates off the wire “radio waves”. This process will cause power loss in the transmission of signals. In a coaxial cable, however, one conductor is formed into a tube and encloses the other conductor. Therefore the radio waves from the central conductor is confined to the space in the tubular shield. The shield is usually connected to electrical ground so that it does not radiate radio waves. In this manner, the power loss in the *a.c.* signal due to radiation is greatly reduced.

The coaxial cable is terminated with BNC connectors. The center pin of the connector is connected to the centre conductor in the coaxial cable, and the outer shield of the connector is connected to the tubular shield inside the coaxial cable.

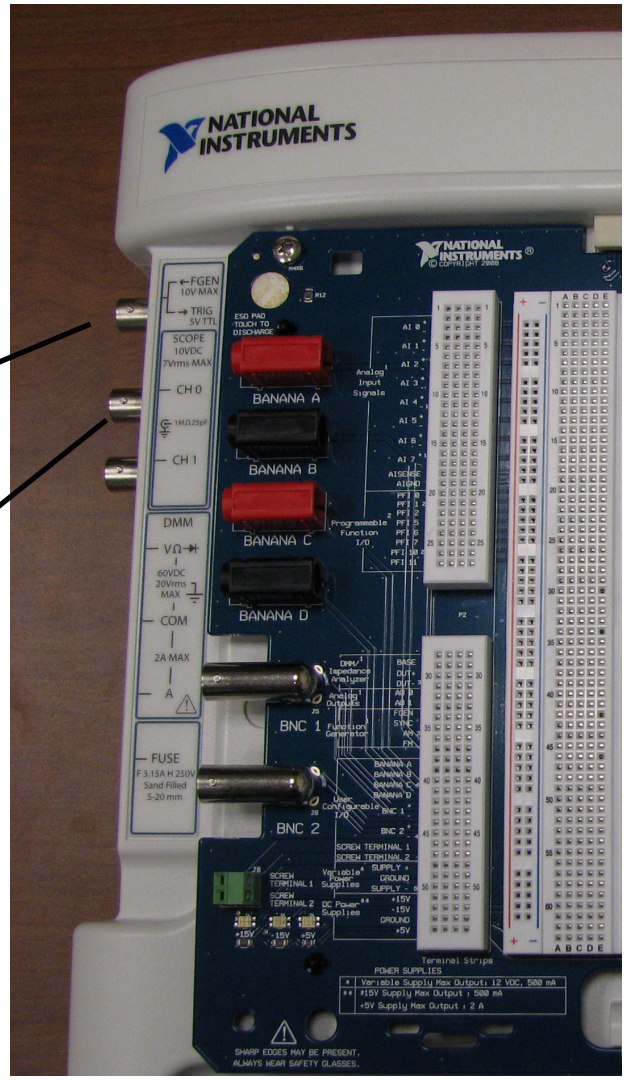
Hardware connections from FGEN to SCOPE

Use a coaxial cable with BNC connectors to connect the function generator (FGEN) and Channel 0 (Scope Ch0) of the oscilloscope. These connectors are located on the left side of the ELVIS II.

Only one coaxial cable is needed.

Align the notch on the BNC connector on the cable with the little protruding stud on the matching connector on ELVIS II, insert the connector, and then gently twist clockwise.

Note that the outer metal shield of the BNC connectors for the FGEN and Scope (Ch0 and Ch1) are connected to ground. Use the DMM with banana-plug-cables to verify that the outer shields of BNC connectors on FGEN, Scope Ch0 and Scope Ch1 are all connected internally.



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Software setup for FGEN

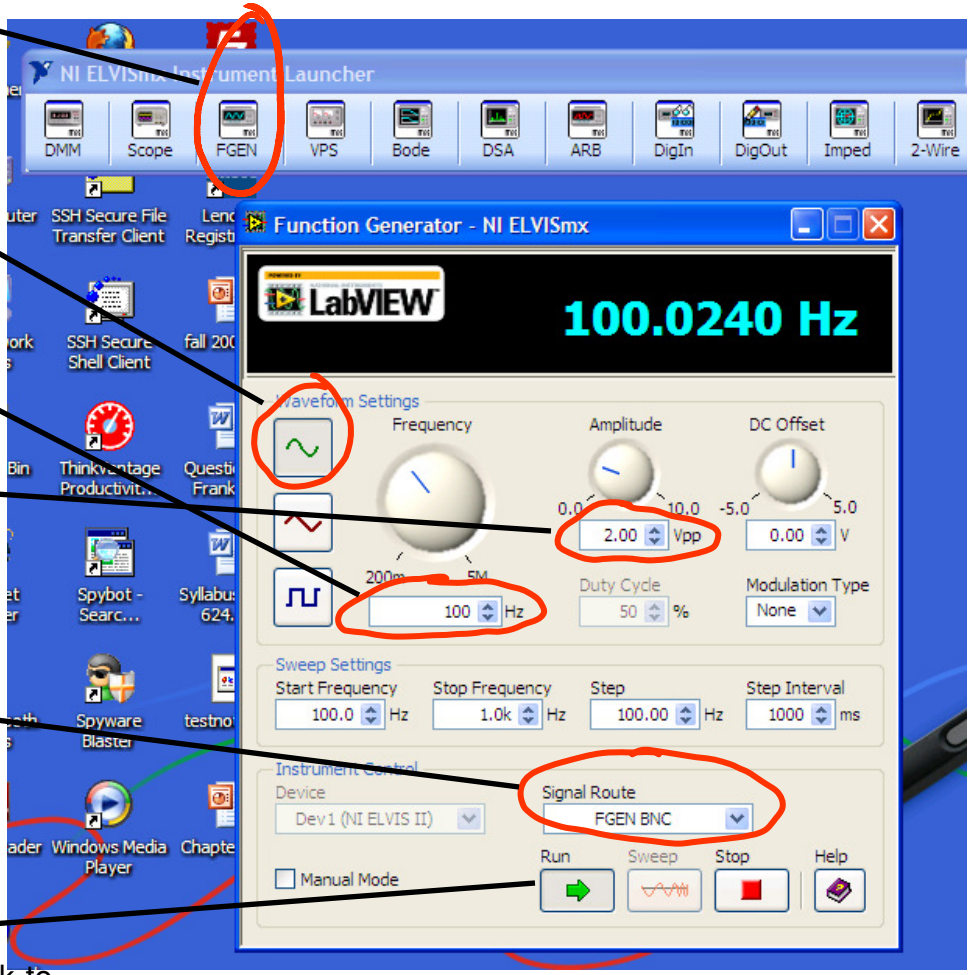
Select the FGEN on the ELVIS II instrument launcher.

Select the waveform. Choose sine wave for now.

Select frequency. Use 100 Hz for now.

Select the amplitude. Use 2.0 V_{pp}. V_{pp} stands for peak-to-peak voltage

Select the signal route. There are two signal routes: Prototyping board or the FGEN BNC. Select FGEN BNC.



Click “Run”. Now a 100 Hz sine wave voltage signal with a peak-to-peak voltage of 2.0 V is generated, and delivered to the Scope through the coaxial cable.

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Software setup for Scope

Now you need the set up the Scope correctly in order to display the signals.

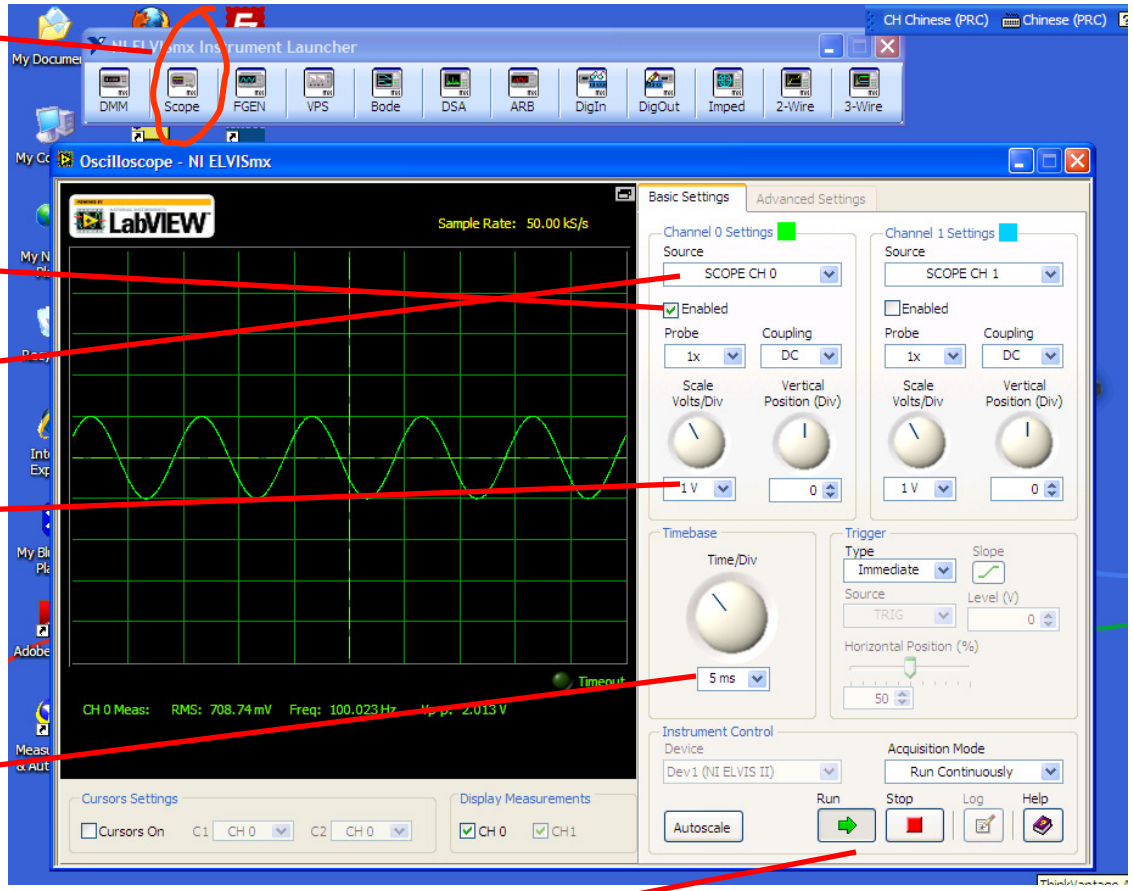
Select “Scope” on the Instrument Launcher.

There are two channels in the Scope. So you could display two different waveforms at the same time. But we only need one channel in this Lab. Check “Enable” for Channel 0 to activate this channel.

Select “Scope CH 0” as the Source.

Select “1V/Div” as the vertical scale. This means that each division on the vertical scale is equivalent to 1 volt of voltage.

Select “5 ms/Div” as the horizontal scale. This means that each division on the horizontal scale is equivalent to 5 milliseconds.



Hit “Run”, and a sine wave should be displayed on the screen.

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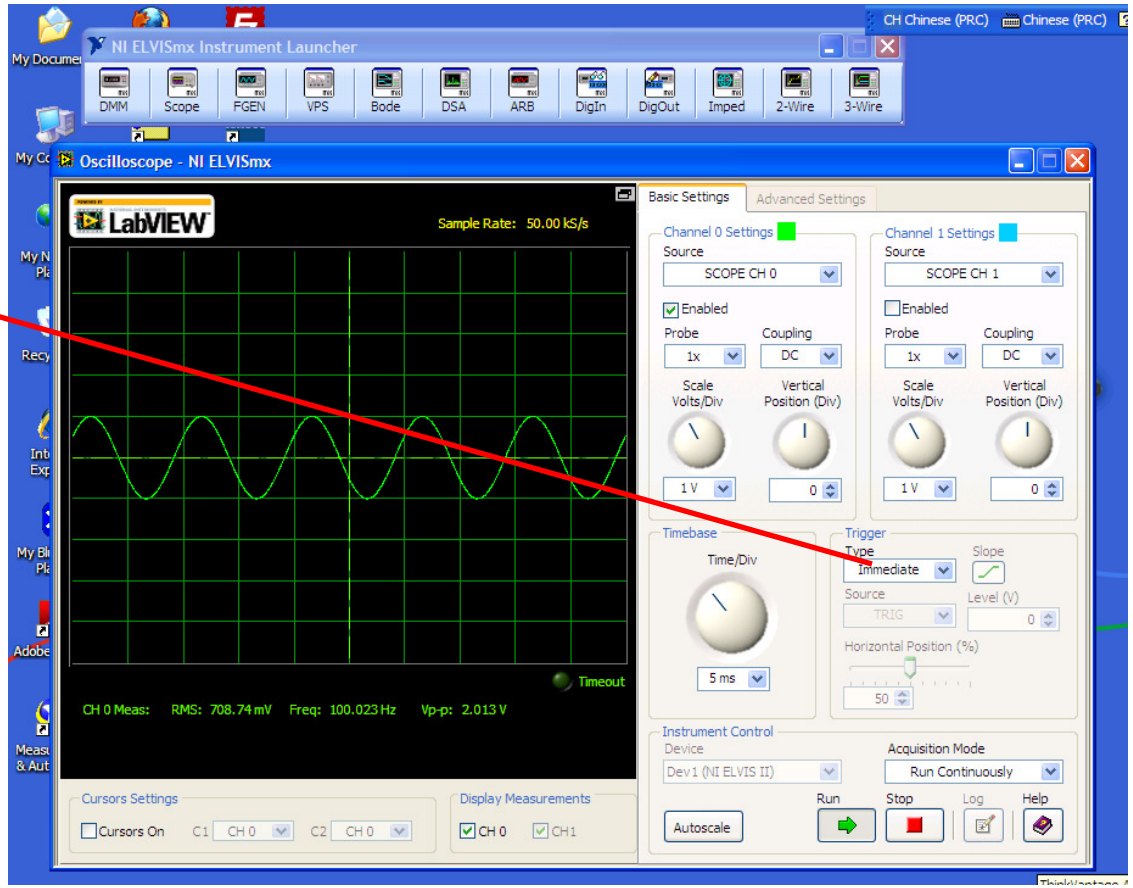
Triggering: Triggered sweeps in the Scope allows for a “snapshot” of a waveform. The display of a triggered sweep is a stable waveform, and allows for detailed measurements on the waveform.

Start with “Immediate” in the trigger type. This means that no triggering mechanism is in place. You may notice that the waveform is moving constantly across the screen.

Now switch to “Edge” trigger. A stable waveform will show on the screen.



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With a stable waveform, you can easily measure the frequency and the amplitude of the waveform.

Amplitude measurement:
Estimate the number of divisions on the vertical scale from the peak to the valley of the sine wave. The number of divisions multiplied by The sensitivity (the value of Volts/Div) gives the peak-to-peak voltage of the sine wave. You can adjust a couple things to make the measurement easier. The sensitivity can be adjusted so that the waveform amplitude occupies a good portion of the vertical scale, but does not go beyond the limit of the vertical scale. To the right of the sensitivity knob, there is a "vertical position" knob. This allows you to put a vertical offset on the waveform. Try playing with it for a while. If you set the peak (or valley) of the waveform at the beginning of a division, the measurement for the amplitude is more straightforward.

Frequency measurement:
Estimate the number of divisions on the horizontal scale for one complete period of the sine wave. The number of divisions multiplied by the timebase (Time/Div) is the period of the sine wave. The frequency is the reciprocal of the period.

Measure the amplitude and the frequency of the waveform displayed on the Scope. Verify that it is indeed 2 V in amplitude and 100 Hz in frequency as set by the function generator. This digital Scope actually automatically measures the amplitude and the frequency. At the bottom of the display, you will find the calculated frequency and the V_{pp} values. Compare these values to the values you measured manually.

Now one person in the team vary the amplitude between 1 to 10 V, and vary the frequency from 100 Hz to 100 k Hz by adjusting the function generator. The other person try to display the waveform properly on the scope and measure the amplitude and frequency. Please display and measure 5 – 10 different sine waves, as time permits. Then switch roles and repeat.

Generate square waves and then triangular waves with various frequencies in function generator, and display on the Scope.

Experiment II: Obtain function generator signals from the Prototyping board

It is important to deliver the *a.c.* signal from the function generator to the circuits on the prototyping board. You will need to feed *a.c.* signals to components on the board in the next a few Labs. Today, you will extract the *a.c.* signal from the board, and deliver it to the Scope.

Use a jump wire to connect between “FGEN” on the distribution stripe and the “BNC 1 +”, as indicated by the red line. Connect a coaxial cable between “BNC 1” and CH0 of the Scope, as indicated by the Magenta line.

In principle, you should also connect between “Ground” and the “BNC 1 –” on the prototyping board to complete the circuit, as indicated by the blue dashed line. However, the outer shield of the BNC connector for Ch0 of the Scope is already grounded internally in ELVIS II. By connecting between Ch0 and BNC 1 using coaxial cables. The “BNC 1 –” is therefore also grounded. So the blue dashed line is not really necessary. Remember this trick and this will simplify the wirings in future Labs.

Make sure select the “prototyping board” as the signal route on the FGEN software window.

Everything else works the same way as in experiment I. Verify that you can get the waveform of a sine wave on the Scope.