**University of Rochester**

**Department of Electrical & Computer Engineering**

**ECE111 Laboratory #6 Signals and Oscilloscopes**

**Week of November 6 and 7, 2014**

## Time-Dependent Sources and Signals and Oscilloscopes

We are going to learn how to produce various time-dependent voltages as a function of time, and how do "see" them on an oscilloscope. No report will be required, but you should show some of your results to a TA, and they will ask you questions about what you are showing them.

## Pre-Lab Activities

Read through Chapter 5 of the text, reviewing the Step, Pulse, Square, and Sinusoidal Waveform descriptions in particular. Be sure you know the definitions of Amplitude and Frequency.

## Lab Activities

We can visualize, or "see", a voltage as a function of time using the "Cathode Ray Oscilloscope", or just "Oscilloscope", or just "'Scope". By sweeping a spot across a screen at a fixed rate of speed, and letting the vertical deflection be proportional to the voltage being measured at that time, we can produce a "trace" or graph that shows the voltage as a function of time. The 'scopes we have in the lab actually record the voltage and produce the graph later, but the principal is the same.

Turn on the 'scope and the signal generator at your station. While they are warming up, get one "BNC to Alligator Clip" wire from your workbench drawer. These have a round, "twisty" connector at one end and two alligator clips at the other end, one red and one black.

VITAL NOTE: The BLACK clips are grounded, and the RED hooks are to be hooked to the signal. If you hook these up backwards you will not just get an inverted signal, you will see nothing at all!

Find the lead connected to the Channel 1 input of the scope, and connect the BNC to Alligator Clip Lead to the "Function" output of the Stanford Research Systems Signal Generator. Connect the red clip to the large center hook of the scope lead, then connect the black clip to the (black) alligator clip on the scope lead.

Set the Oscilloscope to the following conditions:

1. Trace 1 displayed (Yellow on, Blue off)

2. Vertical Scale: 2 V/div

3. Horizontal Scale: 10 µs/div

4. Trigger on positive slope, level approximately 1/2 of maximum. (This is the input value that will be at the CENTER of the screen. You can move that point by turning the Horizontal Position knob.)

(DO NOT use the Auto Setup button or function, even if you find it. In this situation it MAY lock on to the correct signal, but under any circumstances the Auto function WILL find a signal, real or not, and show it on the screen. It may or may not be the correct one. It is always better to set it for what you expect than to use an Auto-Seek function that may fool you.)

Set the Generator to produce the following:

1. Square wave

2. Frequency 100 kHz.

3. Amplitude of 5 Volts peak to peak.

4. Offset 0 V.

Now observe the trace on the oscilloscope. Be sure that Channel 1 is turned on (Yellow trace) and you should turn off Channel 2 (Blue trace) for now. The solid vertical lines on the 'scope face are at fixed time intervals, set by the Horizontal knob and displayed on the bottom left of the screen. The horizontal lines are a fixed voltage apart, as determined by the Vertical knob and also displayed at the bottom left of the screen. What peak to peak amplitude do you measure for the voltage?

NOTE: The signal generators have a 50Ω output resistance, and assume you are going to connect them for maximum power transfer, or to a 50Ω load, and the amplitude shown on the signal generator front panel is the voltage that would be across the LOAD resistor. Since you are actually connecting to a 1MΩ 'scope input, you will be measuring the OPEN CIRCUIT voltage of the Signal Generator, which is exactly twice the 50Ω load voltage.

Get a breadboard and as close to a 50Ω resistor as you can (maybe 2 100Ω’s in parallel?) and insert it into the breadboard. Attach the red alligator clip to the lead at one end of the resistor and the black clip to the lead on the other end. Connect the scope probe to the red end and the alligator clip to the black end. Now what voltage do you measure across the resistor?

Measure the period of the square wave using the time base of the scope. Is it better to expand the time base to fill the screen with one cycle, or to measure time over N cycles and divide by N? The frequency in Hz is the reciprocal of the period, so what is the frequency of your signal?

Try changing the frequency and amplitude of the signal generator and see how the display changes, then go back to the original settings. Try changing the Offset setting to see how the display changes. Then go back to the original settings.

Now change the waveform to be a sine wave instead of a square wave, and note the amplitude and period of the signal. Remember that the amplitude is one-sided, while the peak-to-peak voltage is two-sided. Again, try changing frequency and amplitude to see how the display changes. You should feel free to change the time base or vertical scale settings if you need to to see the waveform best. Try changing the Offset settings to see how things change, then go back to the original settings.

Now change the waveform to Triangle and Ramp to see how the display changes.

Disconnect the scope probe from the resistor and attach it to a length of wire lying on the bench. Leave the alligator clip connected to the resistor, or let it “float” by not connecting it to anything. Adjust to a very sensitive vertical setting (millivolts per division) and see if you can find periodic waveforms in the signals you now see. Can you measure the period (and therefore the frequency) of these signals?

Demo of Oscilloscope Skills

1. The TA will ask each partner to set the signal generator to a different amplitude and frequency of a sinusoidal wave and ask you how to determine the amplitude and frequency of the signal from the oscilloscope.

Partners:

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Able to set generator and determine amplitude and frequency from ‘scope?

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Able to set generator and determine amplitude and frequency from ‘scope?