

# OSCILLOSCOPE

(two weeks)

**PURPOSE** The purpose of this experiment is to provide students with an introduction to the oscilloscope. In addition, the students will have an introduction to the function generator and the DMM.

**Introduction** The oscilloscope is the most versatile measurement instrument used in the electrical engineering laboratory. It allows the user to, not only view waveforms, but also show the relative shape and positions of several waveforms. There are four main groups of controls on the oscilloscope front panel. First is the input (vertical) control section found on the bottom left of the control section. Second is the time base (horizontal) that controls the time displayed on the horizontal axis. This control is found in the middle left of the control panel. Third is the trigger section that synchronizes the horizontal sweep time with the input signals. This section is found on the upper right of the control panel. The final section is the measurement section that provides voltage and time measurements. The measurement controls are located on the upper left of the control panel.

**Part I Vertical Controls** From the vertical control section select Channel 2. (If no trace is observed change the triggering mode to "AUTO" by selecting "MODE" from the trigger controls, and selecting "AUTO" from the on-screen menu.) From the on-screen menu labeled "COUPLING" select ground. There should be a trace on the screen with a caret on the right vertical axis. This caret shows where 0 volt is located. Observe the trace and caret as the vertical position knob (in the vertical control section) for channel #2 is rotated. Adjust the vertical position so that ground is in the center of the screen.

Change the channel setting from ground to "DC". Use a X10 probe to connect the calibrator voltage (the little medal loop just below the screen) to the Channel #2 input. (If the square wave from the calibrator and the horizontal sweep of the oscilloscope are not synchronized try turning the "trigger level control" in the triggering control section.) Adjust the "time base" control so that there are about 4 cycles of the calibrator voltage seen on the screen. Measure the peak to peak calibrator voltage with the on-screen probe control in the X1, X10 and X100 positions. Which do you think is the correct reading?

With Channel #1 on "DC", and the probe control set to X10, use the X10 probe to connect the function generator to channel #1 of the oscilloscope. Set the trigger source to Channel #1. Set the function generator for a 1KHz sinusoid with a 1 volt p-p amplitude and 0 volts DC offset. Adjust the oscilloscope time base control for about 4 cycles of the sine wave. Add a DC offset of 1 volt on the function generator. What happened on the oscilloscope? Change the channel coupling (from the on-screen menu) from DC to AC. Now what happened to the trace? Provide explanations for your observations.

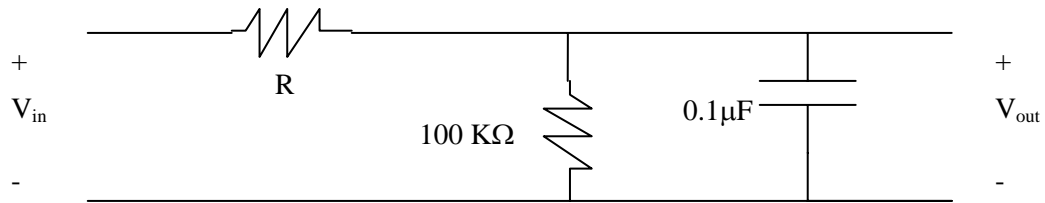


Figure 1. RC Circuit

Connect the circuit shown in Figure 1 above. Choose (or construct) a value of  $R$  from your lab kit so that there is about a  $45^\circ$  phase shift from  $V_{in}$  to  $V_{out}$  for a 1KHz sine wave. Connect  $V_{in}$  to the function generator (set for 1 volt p-p @ 1KHz and 0 volts DC offset). Connect Channel #1 of the oscilloscope to  $V_{in}$  and Channel #2 to  $V_{out}$ . You should now observe the relative time position of the circuit input and the circuit output on the oscilloscope. Sketch these waveforms.

Adjust the vertical position of Channel #2 until the signal is totally off of the screen. Observe that there is a small arrow (with a "2") pointing up to indicate that the Channel #2 signal is off of the top of the screen. Repeat the process for Channel #2 off of the bottom of the screen. This provision allows the user to "find" a waveform when it is off of the screen.

Suggestion: the data sheet for this section should contain sufficient space to record comments on the observations made in this section. There should be space for the three voltage measurements made on the calibrator voltage.

**Part II Triggering Controls** This part uses the same 1 Vp-p sine wave that was used in part I. From the triggering control section select "SOURCE" and from the on-screen menu select "CHANNEL #1". Next, from the triggering control section select "MODE" and from the on-screen menu select "NORM". If no trace is seen on the oscilloscope, turn the level control in the triggering control section. You should see a straight line across the screen. The oscilloscope will trigger at the point where this line intersects the signal voltage. Continue to turn the level control until a trace is observed. The trigger level signal should intersect the signal level signal at either the left side of the screen or the middle of the screen. (It depends on where the time reference is set. The time reference may be changed by selecting "MAIN/DELAYED" in the horizontal control section and "TIME REFERENCE" from the on-screen menu. Note that a caret at the top center of the screen indicates which point is the time reference.) Observe how the triggering point changes as the trigger level changes.

From the triggering control section select "SLOPE/COUPLING" and from the on-screen menu select "+/-" (arrow up or down). Observe what happens to the triggering point as the slope is toggled from + to -.

Observe what happened when the triggering mode is toggled from "AUTO" to "NORM". This observation should be made for triggering levels within the signal voltage and with triggering levels outside of the signal voltage range.

Suggestion: the data sheet for this section should contain sufficient space to record comments on the observations made in this section.

**Part III Measurements** This part considers the measurement section of the oscilloscope. It also helps to explain the voltage settings on the function generator.

First set the function generator for a 1 Vp-p 1KHz sine wave with 0 volts offset. Connect the function generator to the DMM and to Channel #2 of the oscilloscope. (USE a X10 probe for the oscilloscope.) From the measurement section of the oscilloscope select "VOLTAGE". From the on-screen menu select Channel #2 and measure Vp-p and Vrms for the waveform. Use the DMM to measure the AC (RMS) value of the waveform. Are all of these readings consistent? Now connect a  $51\Omega$  resistor across the function generator and repeat the readings. (The internal resistance of the function generator is about  $51\Omega$ .) Explain the results. When is the function generator set to the proper voltage?

Now connect the R-C circuit of Figure 1 as was done in Part I. Measure the RMS voltages of both waveforms. Clear the voltage measurements and use "FREQUENCY" to measure the frequency of the waveform. Clear the frequency measurement and select "TIME". Use the cursors to measure the period of the waveform and to measure the time delay between the two waveforms. Verify that the frequency and the period measurements are consistent. Use sinusoidal steady state techniques to calculate the relationship (magnitude and phase) between the input and output voltages. Do the measured and calculated values agree? The measured phase shift may be found from the period and the time delay between the two waveforms as follows:

$$phaseshift = 360 * timedelay / period$$

Suggestion: the data sheet for this section should have spaces to record all of the required voltage, frequency and time measurements.

## DISCUSSION TOPICS

1. What happened when the coupling was changed from DC to AC in part 1? Explain the difference between DC coupling and AC coupling on the vertical channel.
2. Sketch the input/output waveforms found in part I. Are they about  $45^\circ$  apart?
3. Explain the X1, X10, and X100 control.
4. What happened when the triggering level was changed from + to -?
5. Explain the difference between "AUTO" and "NORM" when the triggering level is outside the signal range.
6. Explain the significance of the  $51\Omega$  output resistance of the function generator.
7. Compare the measured and calculated magnitudes and phase shift of the R-C circuit.

**PRE-LAB** 20 points Prior to the laboratory meeting make a data sheet that can be used to record all of the data that will be taken during the experiment. In addition, the value of R required for a  $45^\circ$  phase shift should be calculated and the R-C circuit should be wired on a proto-board.

**COMMENT:** You will be using the oscilloscope extensively during your career as an electrical engineer. It is important that you become very familiar with its operation. Therefore, the purpose of this experiment is **NOT** to see how fast you can complete the work, but rather to take your time and study the oscilloscope operation as carefully as possible. The topics outlined for this experiment in the laboratory manual are suggestions of the minimum things that should be considered. It is expected that as students work through this experiment they will discover many other lines of investigation. Take time to satisfy your curiosity and ask the instructor for help as often as required.