

### 3.5 Laboratory Procedure / Summary Sheet

Group: \_\_\_\_\_ Names: \_\_\_\_\_  
 \_\_\_\_\_

- (1) In this step you will examine the effects of AC coupling of an oscilloscope.

Set the function generator to produce a  $5 V_{pp}$  1kHz sinusoidal output. To do this, press the  $V_{pp}$  button, enter 5, and press Enter. The "Not Entered" light should go off when you press Enter; otherwise, press it again more firmly and squarely.

Display the sinusoid on the oscilloscope with a sensitivity of 1 V/div. Make sure the triggering source is set to the proper "channel" (and not "line" triggering). **NOTE - If using the Philips PM5193 function generator, be sure to connect to the lower "OUTPUT" jack** (not the upper "TTL OUT" jack).

Adjust the triggering level and notice what effect it has.

Use the +/- trigger selector (press the slope button and toggle between positive and negative edge triggering) and notice what effect it has.

Refer back to Figure 3.2 for details on the impedances within the oscilloscope. We can simulate an AC coupled oscilloscope by adding an external coupling capacitor to a DC coupled oscilloscope. To do this, build the circuit shown in Figure 3.9. Using the function generator  $V_{dc}$  button, add a 5 Vdc offset to the  $5V_{pp}$  1kHz signal (by entering 5 and pressing Enter).

Be sure to select DC coupling on the oscilloscope. Use a  $0.022 \mu F$  coupling capacitor ( $C_{coupling}$ ) and note the resulting output. Then try a  $0.1 \mu F$  and a  $1 \mu F$  capacitor (refer back to Section 1.4 in Lab 1 for info on how to read capacitor values). **Note carefully what happens to the oscilloscope display when you first attach the scope 1X probe (or banana cable with alligator clip) to measure  $V_o$  for each case.** Make sure you discharge the coupling capacitor by shorting its leads before you attach the probe to measure the voltage. How do the results change with the capacitance value?

What is the effect of the function generator output impedance  $R_o$  on the measured voltage  $V_o$ ?

Now remove the coupling capacitor and toggle the oscilloscope between DC coupling and AC coupling and note what you observe in the measured voltage signal. Which of the three external coupling capacitors that you tried most closely approximates what you think the actual coupling capacitance of the oscilloscope is?

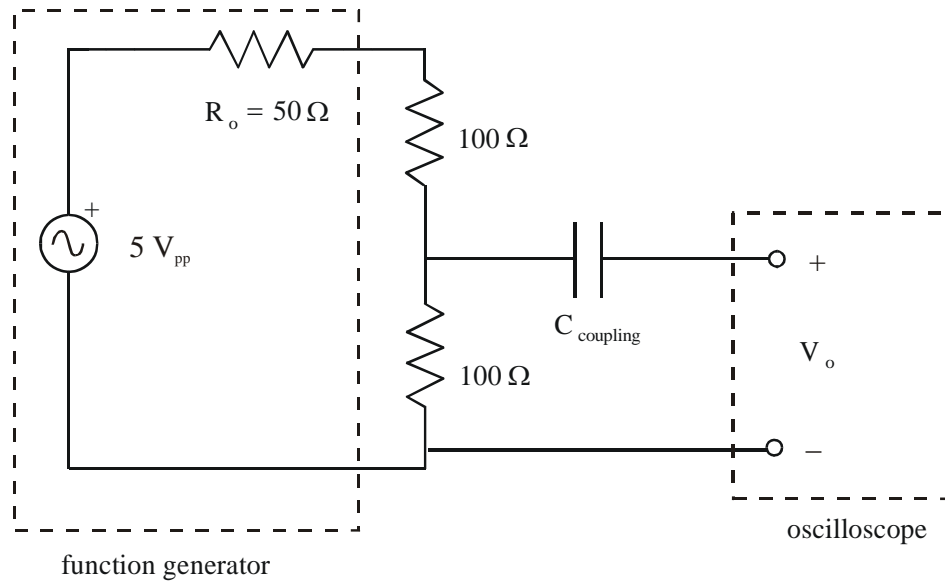


Figure 3.9 Coupling Capacitor Effects

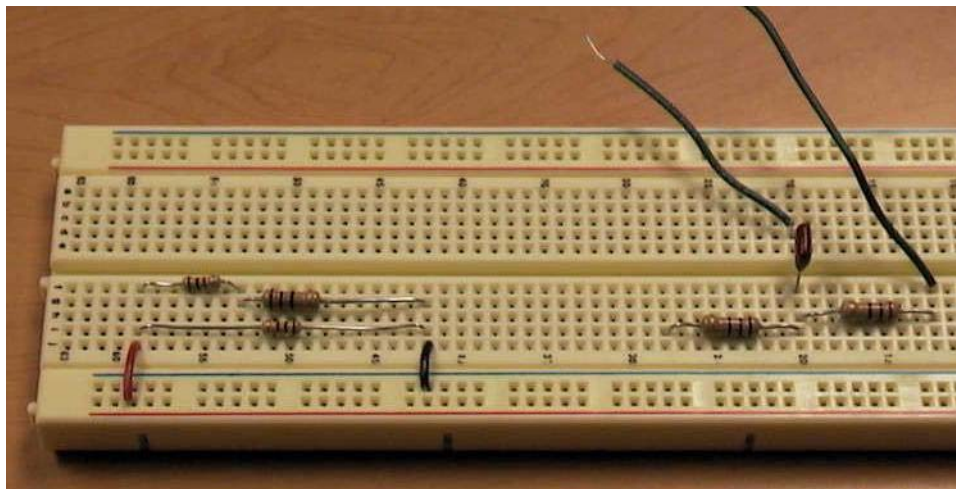


Figure 3.10 Circuits for Steps 1 (right) and 4 (left)

- (2) In this step and the next you will study the effects of oscilloscope input impedance. You will be using an oscilloscope 10X probe to increase the input impedance and note the consequences. **Before continuing, read through the probe calibration procedure described in Section 3.3.**

Connect a 10X attenuator probe to channel 1 and calibrate the probe. Use the probe adjust port on the oscilloscope.

Construct the circuit shown below with  $R_1 = R_2 = 1\text{ k}\Omega$  and set  $V_i$  to a  $6V_{pp}$ , 1kHz sine wave.

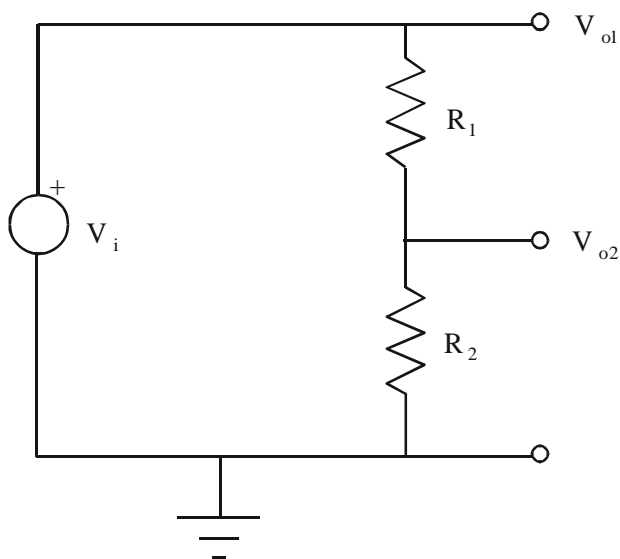


Figure 3.11 Probe Measurements

Using the attenuator probe, determine each of the voltages  $V_{o1}$  and  $V_{o2}$  for the circuit above and record the **peak-to-peak values** in the following table. Be sure that nothing is connected to Channel 2. Note that the voltages  $V_{o1}$  and  $V_{o2}$  labeled in the figure are node voltages defined relative to ground, and not “across” voltages, so the probe ground clip should be attached to the ground of your circuit.  $V_{o2}$  happens to also be the voltage across  $R_2$ , but  $V_{o1}$  is not the voltage across  $R_1$

$R_1 =$  \_\_\_\_\_

$R_2 =$  \_\_\_\_\_

	Calculated	Measured with 1X probe*	% Error	Measured with 10X probe	% Error
$V_{o1}$					
$V_{o2}$					

\*: Alternatively, you can use a plain banana plug wire with a BNC adapter.

- (3) Repeat Part 2 for  $R_1 = R_2 = 4.7 \text{ M}\Omega$  and record the values  $V_{o1}$  and  $V_{o2}$  in the following table.

$R_1 =$  \_\_\_\_\_

$R_2 =$  \_\_\_\_\_

	Calculated	Measured with 1X probe	% Error	Measured with 10X probe	% Error
$V_{o1}$					
$V_{o2}$					

- (4) Although the oscilloscope is primarily a voltage measuring instrument it can be used to indirectly measure current by inserting a small value resistor in the circuit branch of interest (unless there is a resistor in the branch already). In order to measure the current we use the oscilloscope to measure the voltage drop across this resistor and then the current through it can be calculated using Ohm's Law.

For the network shown below determine the current  $I$  by inserting resistor  $R$  of various values (see below) and measuring the voltage drop across it in each case.

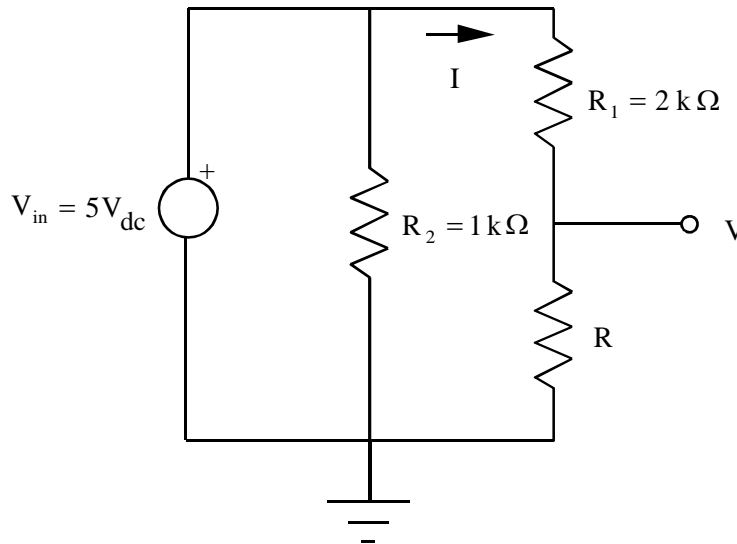


Figure 3.12 Measuring Current

Record the exact (measured) resistance values for  $R_1$  and  $R_2$ :

$$R_1 = \underline{\hspace{4cm}}$$

$$R_2 = \underline{\hspace{4cm}}$$

For each resistance value below, measure the voltage (V) across resistor R. **NOTE** - when measuring small voltages with the oscilloscope, you might need to adjust the voltage scale manually to get accurate readings.

R	Measured with 1X probe	Measured with 10X probe
10 $\Omega$		
100 $\Omega$		
1 K $\Omega$		

Record the exact (measured) resistance values for each of the three R resistors used:

$$R (10 \Omega) = \underline{\hspace{4cm}}$$

$$R (100 \Omega) = \underline{\hspace{4cm}}$$

$$R (1 \text{ k}\Omega) = \underline{\hspace{4cm}}$$

Calculate the expected current through R (for each value) using the actual values for  $R_1$  and R. Then calculate currents from the measured voltage values above (using Ohm's Law), and compare them to the expected current values:

R	expected (calculated) current	I via the 1X probe measurement	% Error	I via the 10X probe measurement	% Error
10 $\Omega$					
100 $\Omega$					
1 K $\Omega$					



- (5) You have a  $4 V_{pp}$ , 100 Hz sine wave, and I wish it to be displayed on the oscilloscope as shown below. Describe how to set the vertical amplifier, time base and trigger.

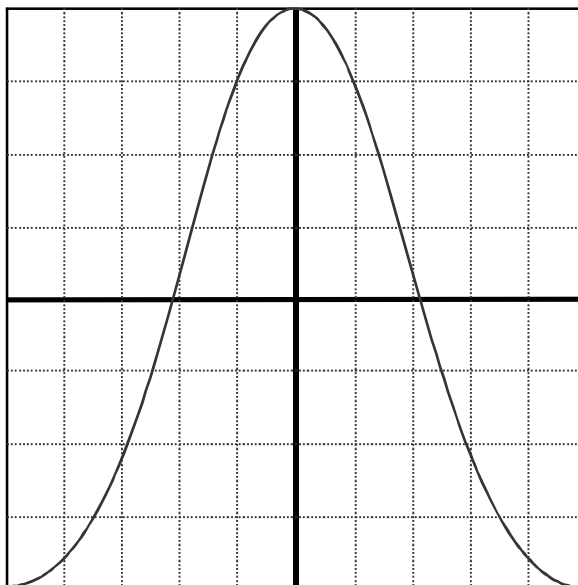


Figure 3.13 Oscilloscope Sine Wave Display

- (6) What is the effect of AC coupling when a signal with a DC offset is displayed on an oscilloscope?
- (7) In part 4, what effect does the inserted resistor have on the current measured?

