

ECE214: Electrical Circuits Laboratory
Lab #1 — Test Equipment Loading
Week of 20 January 2015

1 Introduction

In this lab you are to determine the voltage ratio, V_{OUT}/V_{IN} , produced by the voltage divider with resistors R_a and R_b shown in Figure 1, and with capacitors C_a and C_b shown in Figure 2.

This lab illustrates that the impedance of test equipment and cables must always be considered when determining the true value of the voltage being measured across a circuit element.

A voltage generator or battery has a source impedance. Measurement equipment such as an oscilloscope has an input impedance (that presents a load to the circuit). Each cable that connects the circuit to the test equipment introduces an additional impedance to the circuit.

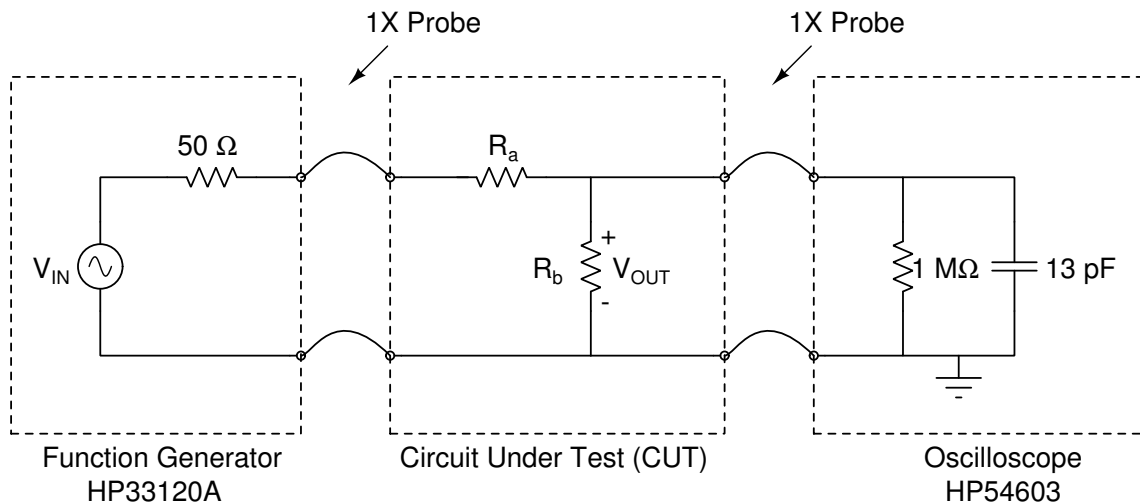


Figure 1: Test set-up and resistor divider circuit for Lab #1.

2 Pre-lab

There is no pre-lab for this lab.

3 Lab Procedure

Part A

1. Configure the HP33120A Function Generator (FG) to generate a 1kHz sinusoidal signal with $V_{IN} = 1\text{V}$ peak. Make sure you understand the relationship between the voltage displayed on the FG and the value of V_{IN} .
2. Connect the output of the FG directly to the input of the HP54603 Oscilloscope (scope) and measure the FG output voltage and frequency. Verify that the FG is producing a 1V peak signal with a frequency of 1kHz.

Part B

- Use the Tenma 72-1025 LCR Meter to measure the capacitance of your 1X probes at a frequency of 1kHz. Also measure the Dissipation Factor (D) of the probes at a frequency of 1kHz.
- Obtain one resistor with each of the following values: 10Ω , 20Ω , $10k\Omega$, $20k\Omega$, $1M\Omega$ and $2M\Omega$. Measure the resistance of each resistor using your digital volt meter (DVM).
- Place resistors R_a and R_b , with the values given below on the white breadboard in a series circuit.
 - $R_a = 10\Omega$, $R_b = 20\Omega$
 - $R_a = 10k\Omega$, $R_b = 20k\Omega$
 - $R_a = 1M\Omega$, $R_b = 2M\Omega$
- Set the FG to generate a 1kHz sinusoidal signal with peak voltage $V_{IN} = 1V$. Verify both the frequency and peak voltage using the scope, then connect the FG and scope to the resistors R_a and R_b as shown in Figure 1.
- Use the scope to measure the peak value of the output voltage (V_{OUT}) across resistor R_b for the three resistor combinations. Record all results in your engineering notebook.
- In an ideal world, where the FG has no source resistance, the probes are perfect connectors, the scope has no input resistance, the scope had no input capacitance, and the values of the resistors are exact, what would be the ratio of V_{OUT}/V_{IN} ?
- Using the measured values of the resistors, the measured capacitance of the 1X probe, the output resistance of the FG and the input impedance of the scope, calculate the expected ratio of V_{OUT}/V_{IN} for the three cases. Show all calculations in your notebook. Complete the following table and record the results in your notebook:

R_a	R_b	V_{out}/V_{in}			
		Ideal	Calculated	Measured	% Error
10Ω	20Ω				
$10k\Omega$	$20k\Omega$				
$1M\Omega$	$2M\Omega$				

Note: The % Error is determined by:

$$\%Error = 100 \times \frac{|Calculated - Measured|}{Calculated}$$

- Explain in your notebook any discrepancy between the measured and calculated values. Indicate possible sources of the error.

Part C

- Change the FG output to a square wave with a 1V peak amplitude. Keep the frequency at 1kHz.
- Record in your notebook the shape of the rising edge of the signal, as observed on the oscilloscope, for each of the three resistor combinations from Part B. Expand the sweep time to see the details of the signal (it is not just a vertical line).
- Measure and record both the rise time and the time constant of the signals at V_{OUT} . The signal should appear similar to the response of a first order RC system.

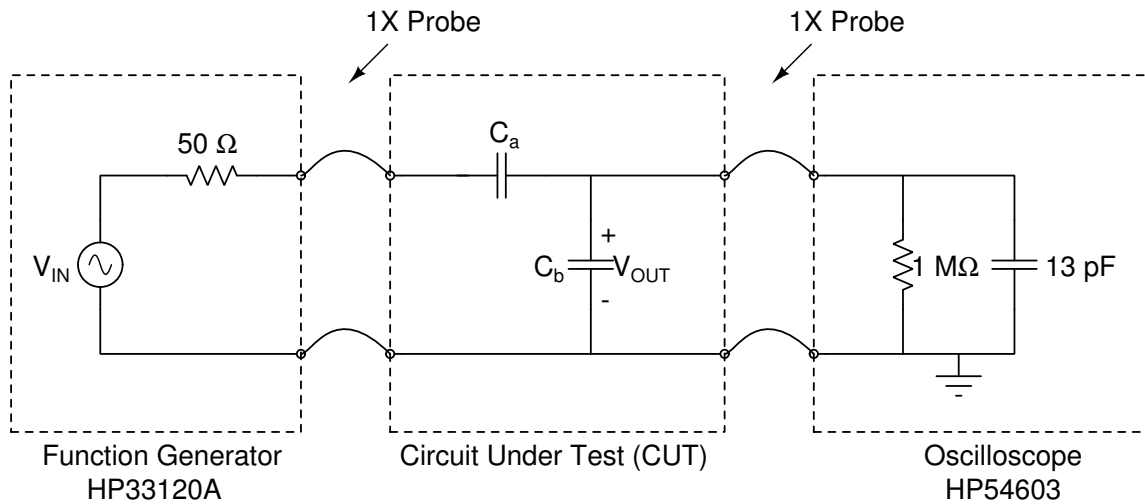


Figure 2: Test set-up and capacitor divider circuit for Lab #1.

Part D

- Obtain one capacitor with each of the following values: 100pF, 220pF, 1nF and 2.2nF. Measure the capacitance of each capacitor using the Tenma 72-1025 LCR meter.
- Place capacitors, C_a and C_b , with the values given below on the white breadboard in a series circuit.
 - $C_a = 100\text{pF}$, $C_b = 220\text{pF}$
 - $C_a = 1\text{nF}$, $C_b = 2.2\text{nF}$
- Set the FG to generate a 1kHz sinusoidal signal with peak voltage $V_{IN} = 1\text{V}$ and connect the FG and scope as shown in Figure 2.
- Use the scope to measure the peak value of the output voltage (V_{OUT}) across capacitor C_b for the two cases above. Record all results in your engineering notebook.
- In an ideal world, where the FG has no source resistance, the probes are perfect connectors, the scope has no input resistance, and the values of the resistors are exact, what would be the ratio of V_{OUT}/V_{IN} ?
- Using the measured values of the resistors, the measured capacitance of the 1X probe, the output resistance of the FG and the input impedance of the scope, calculate the expected ratio of V_{OUT}/V_{IN} for the three cases. Show all calculations in your notebook. Complete the following table and record the results in your notebook:

C_a	C_b	V_{out}/V_{in}			
		Ideal	Calculated	Measured	% Error
100pF	220pF				
1nF	2.2nF				

- Explain in your notebook any discrepancy between the measured and calculated values. Indicate possible source of the error.

4 Post-Lab

What is the most important piece of information you learned in this laboratory? Provide a short summary of your major results and conclusions. Note the location of the summary in the Table of Contents of your notebook.