Engr325 **Lab #1** **Winter, 2020**

DC and AC Measurements

Name ___________________________________

Partner (s)_______________________________ **Grade _______/10**

Introduction
The goal of this lab is to review basic circuit theory and operation of the test equipment that will be used this quarter including multi-meters, oscilloscopes, signal generators, power supplies, and bread boards.

Learning Objectives
By the end of this laboratory exercise, you should have accomplished the following:
- Refreshed knowledge of circuits;
- Reviewed operation and use of electronic test equipment;
- Observed and quantified loading effects;
- Observed variations in AC measurements.

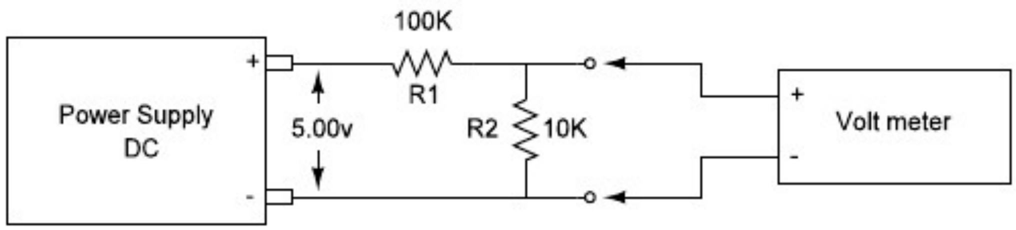
Equipment Provided
- HP 6236B DC Power supply;
- Fluke 8846A Benchtop Digital Multi-Meter (DMM);
- Wavetek 220 handheld DMM;
- Tektronix TBS2000 Series Oscilloscope;
- Agilent 33250A Function generator;
- Decade resistance box;
- Breadboard;
- Assorted resistors.

References
- Instrumentation text book;
- Course web page.

Procedure

Note 1: When recording electronic measurements, you must state the units and use the number of significant digits appropriate to the accuracy of the measurement (usually 4).

Note 2: A number is incomplete unless it has units. **Add units to all numerical answers**.



Part I – DC Measurements

Using the individual resistors provided, construct the voltage divider circuit shown above on a breadboard, but measure each resistor before placing them in the circuit. Use the Fluke 8846A meter to measure resistance and also to set the power supply to 5.00 volts DC. Record the resistor values in the table below.

1) Using the following formula, calculate and record the percentage error in the resistors.

$$Percentage\ Error = |(Nominal\ value - Measured\ value)|/(Nominal\ value) * 100\%$$

Resistor ID	Nominal Value (Ω)	Measured Value (Ω)	Percentage Error (%)
R_1	100KΩ		
R_2	10KΩ		

2) Use circuit theory and measured resistance values to calculate the expected voltage across R_2 (think voltage divider). **Add units to all your answers**.

$V_{2,calculated}$ ___________

3) Measure the voltage across R_2 with the Fluke 8846A meter.

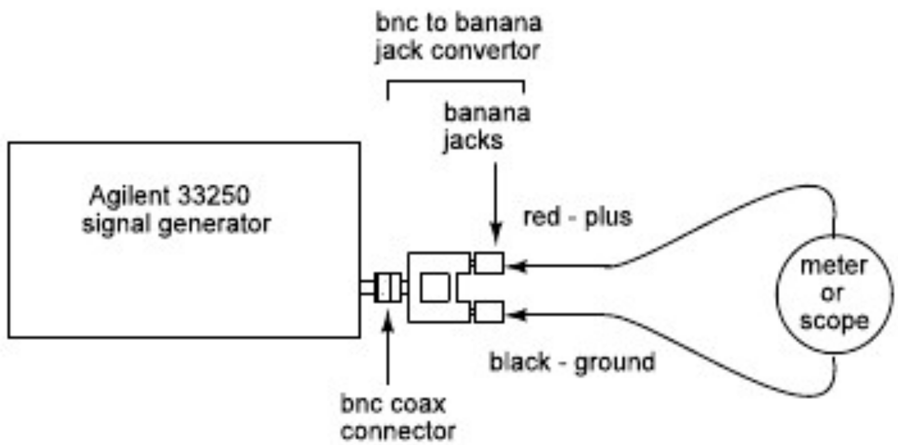
$V_{2,measured}$ ____________

4) Using the 8846A, measure the current flowing from the power supply through this circuit (recall that to measure current through an element the meter must be placed ***in series*** with that element).

I _________

Part 2 – AC Sinusoidal Voltage Measurement

Use a voltmeter or oscilloscope to measure the voltage produced by the Agilent function generator as shown below. Set the signal generator wave-type to a sine wave with 2.0 volts peak-to-peak amplitude as reported on the display of the signal generator. Set the offset voltage to zero and the frequency to 100Hz. Be sure to indicate units **and** the type of voltage being measured i.e. rms, peak, etc.



1) Record the AC voltage with the 8846A meter: ___________

2) Record the AC voltage with the Wavetek 220 handheld meter: ____________

3) Using your 1 data point, determine a calibration factor for the handheld meter. Multiplying the value measured using the 8846A meter by the calibration factor should give the value measured with the handheld meter. These should be relatively close: _____________

4) Measure the Pk-to-Pk voltage with the oscilloscope by reading the value visually from the displayed waveform and using the grid scale on the scope face (rather than the digital readout). _____________

5) Use the *Measure* function on the oscilloscope to display the following parameters and record them here:

   RMS Voltage ____________ Peak-to-Peak Voltage ____________

Part 3 – Non-Sinusoidal Voltage Measurement

Use the same setup as in Part 2 above but change the signal generator waveform to a *Square Wave*. Continue using 2.0 volt peak-to-peak voltage with zero offset and a frequency of 100Hz.

1) Calculate the RMS value of the waveform: _____________

$$\sqrt{\frac{1}{T}\int_0^t [f(t)]^2\,dt}$$

2) Record the AC voltage with the 8846A meter: ___________

3) Record the AC voltage with the handheld meter: ____________

4) Using your 1 data point, again determine a calibration factor for the handheld meter ___________

5) Are the calibration numbers the same for Parts 2.3 and 3.4? What are your thoughts on the methods used by both meters to measure AC voltage?

6) Add a 2.0v DC offset. Calculate the new, expected RMS voltage. Verify by measuring the voltage with both meters and the oscilloscope.

$V_{RMS,calculated}$ ____________ $V_{RMS, Fluke\ meter}$ __________

$V_{RMS, Wavetek\ meter}$ __________ $V_{RMS,scope}$ _____________

Part 4 – Waveform Measurements

Use the same equipment and hook-up as that in Part 3, but change the frequency to 10 KHz. Continue using 2.0 volt peak-to-peak voltage with zero offset.

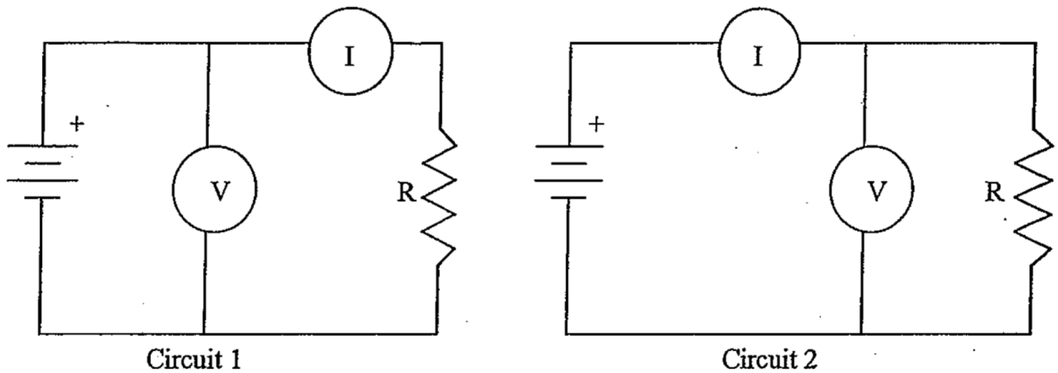
1) Visually measure the waveform period with the oscilloscope: _______________

2) Visually measure waveform rise time and fall time with the oscilloscope. Sketch the edge shapes and annotate with measured values. Ask the instructor or lab TA for help if needed.

Part 5 – Instrument Imperfections

Multimeters are used to make current, voltage, and resistance measurements in both AC and DC circuits. We would like to avoid if at all possible a situation where the instrument itself affects the circuit under measurement. In this part of the laboratory experiment, we will use two meters to make measurements in two different ways, and then compare the results.

Resistance can be determined by measuring voltage and current and then calculating R from Ohm's Law. There are two possible circuit arrangements for measuring V and I as shown below:



Of course, it is desired to measure the voltage across the resistor while simultaneously measuring the current through the resistor. However, a careful look at the circuits shows that there is a measurement flaw in each of the circuits. In circuit 1, the voltmeter measures the voltage across the ammeter and the resistor in series; while in circuit 2, the ammeter measures the sum of the currents passing through the resistor and the voltmeter.

1) Connect circuit l above. A breadboard is not necessary. Set the DC input voltage as close to l.00 volts as possible. Using the decade resistance box, measure and record V, I, and R for R ranging from 50Ω to 100Ω in 10Ω steps.
Note 1: Be absolutely sure that you do not put power to your circuit when the decade resistance box is set to 0 ohms.
Note 2: **Use the Fluke 8846A meter to measure current and the handheld meter to measure voltage**.

R_{dial}	50Ω	60Ω	70Ω	80Ω	90Ω	100Ω
V						
I						
R_{calc}						

2) Implement circuit 2 above and repeat the same measurements as in part l above.

R_{dial}	50Ω	60Ω	70Ω	80Ω	90Ω	100Ω
V						
I						
R_{calc}						

3) Using Matlab or Excel, on the same graph plot the calculated R_{calc} values on the y-axis versus R_{dial} on the x-axis for both circuits. Be sure to label which is circuit 1 and which is circuit 2. Draw a straight line fitting the data of step #1. Repeat for step #2. The second line should parallel the first line.

4) Discuss why the calculated values of R from circuit 2 are equal to the values of R set on the decade box dial, while the values of R calculated from circuit 1 are not. Note the constant difference between the two lines in the graph and relate this to the input resistance of the meter.

Summary

There are several methods of measuring an AC voltage and then displaying an RMS value:

- True RMS - most modern instruments, including the Fluke 8846A, calculate true RMS. This is done by using sophisticated signal processing techniques.
- Find an "average" value and then multiply by a scaling factor to get RMS (handheld meter).
- Find the peak value and then multiply by a scaling factor to get RMS (cheaper meters).