Basic Circuit Measurements and Ohm's Law

ECE 2100 Circuit Analysis Laboratory
version 22 September 2021

Equipment and Supplies

DC Voltage Source, 0 to 15V
AC Voltage Source, 0 to 120V(RMS)
(2) Digital Multimeters (DMMs)
(1) Light Bulb Base
Banana-to-Banana Plug Cables
(1) Low Wattage (15W) Incandescent Light Bulb
(1) High Wattage (100W) Incandescent Light Bulb
(1) 1kΩ ¼W resistor
(6) ¼W resistors
SAFETY GLASSES

Pre-Laboratory Assignment

1. Re-read and study the ECE 2100 Laboratory: Safety and Rules document and the ECE 2100 Laboratory: Notebook Requirements document (available on-line).

2. Read this laboratory.

3. Consider the circuit of Figure 1.
   Use LTspice® to plot the power of RL as the source voltage is varied from 0 to 12V (use a DC sweep simuation).
   Note that Vammeter has no effect on the circuit and is used to measure current I.
   Also note that the current through the DC VOLTMETER is ideally zero.
   Thus you only need to include Vs and RL in your schematic.
   Your plot will have the same shape as Figure 2
   (**Figure 2 is for RL=500Ω; your value of RL is 1kΩ**).

4. If RL=1kΩ is a 1/4 W resistor, use your LTspice® simulation plot to find the maximum voltage that can be applied to RL assuming a 50% safety factor (that is, the power of RL cannot exceed 1/8W).

5. Verify your value of RL from pre-lab step 4 using a hand calculation.

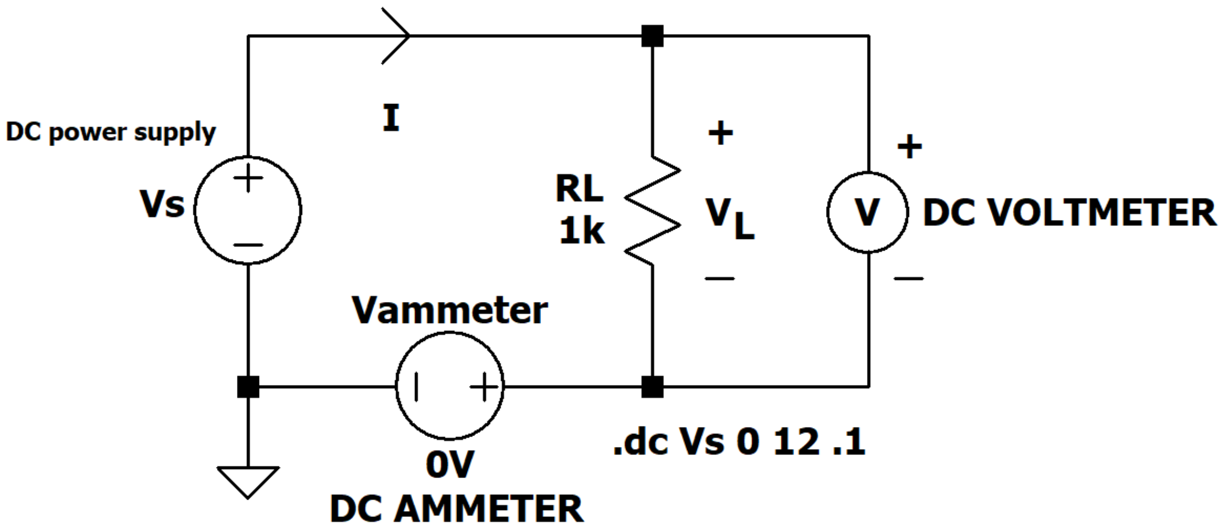

Figure 1. Simple DC resistive circuit

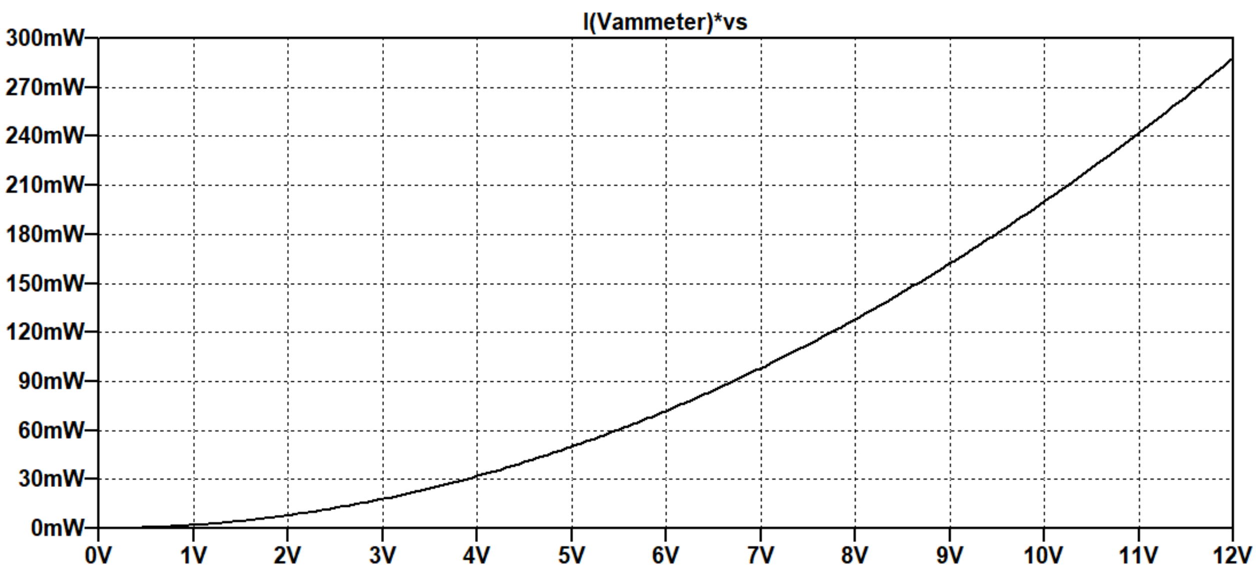

Figure 2. Power of RL=500Ω as a function of Vs in the circuit of Figure 1

Procedures

RESISTANCE MEASUREMENT

1. Select six random resistors from the "grab bag" in front of the lab. Determine the *nominal*, *maximum* and *minimum* resistance values of each resistor using the color band code.

   Using a digital multimeter (DMM), measure and record the resistance of each resistor. Complete the following table. Do not touch the DMM probe tips as this can affect the measurement.

number	nominal	maximum	minimum	measured
1				
2				
3				
4				
5				
6				

Notes:

a. After measuring resistance, never leave a multimeter function switch in the OHMs position. **Always return the multimeter to a voltage measurement mode**.

b. Be sure to have your instructor review your results and initial your lab notebook before continuing.

2. **Be sure the DC power supply is OFF and set to 0V.** Use a 1.0 kΩ, ¼ W resistor, along with two DMMs, to construct the circuit of Figure 1. Note that voltage Vs is ACROSS the resistor and current I is THROUGH the resistor. There is no connection due to the reference ground.

DC VOLTAGE AND CURRENT MEASUREMENT AND POWER

3. Being careful to **never exceed the maximum allowable voltage (with a 50% safety factor) found in the prelab, turn on the DC power supply**, and measure and record voltage and current values for Vs ranging from 0 to 10V in steps of 1V as illustrated in the table below. Be sure to record the units associated with every measurement. **Turn off the DC power supply and set to 0V when done.**

V_S (units)	V_L (units)	I (units)	'measured' power (units)	simulated power (units)
0V 1V 2V . . . 10V				

Table 1. Experimental data and computed power of RL

4. Use your measured Vs and I values to compute and fill in the 'measured' power column for each value of Vs in Table 1 (note the power was not directly 'measured').

5. Use your LTspice® plot to fill out the simulated power column in Table 1.
   Do not proceed unless the 'measured' and simulated columns are in close agreement.

AC VOLTAGE AND CURRENT MEASUREMENT AND POWER

6. Calculate the current (in mA) for a 120 VAC, _______ W low-wattage incandescent light bulb. Also, measure and record the "cold" resistance of the bulb.

7. **Be sure that the VARIAC (VARIable AC power supply) source is OFF and set to 0 before proceeding. Be extra careful when using the VARIAC; do not work on or reach across a powered circuit. Be SURE all watches, rings, and other conductive items have been removed.**

   Note: The VARIAC is an AC power supply that can provide a variable 60 Hz ≈120V sinusoidal voltage up to 2.5 A. We will not often use this supply this semester, but it is important for future ECE work since the US electrical grid is based on a 60 Hz frequency.

   DO NOT APPLY POWER UNTIL YOUR INSTRUCTOR HAS INSPECTED YOUR CIRCUIT.

   Note that the VARIAC dial scale is a percentage and NOT volts. Construct circuit of Figure 3 using the low-wattage incandescent bulb of laboratory procedures step 6 as instructed by your laboratory instructor. Use the VARIAC as the voltage source and the light bulb as the resistive load (note correspondence between this circuit and the circuit of Figure 1).

   As before, set up one DMM to measure the voltage *across* the bulb and another to measure the current *through* the bulb **before turning on the VARIAC**. Note the change from DC to AC measurements in the DMM!

   Double check that the DMM used to measure the voltage is set to measure voltage and NOT CURRENT. This will short the VARIAC!

   Once your instructor has inspected the circuit, you will be given a set of voltage values to use for the source. Tabulate as in laboratory procedure step 3 (the last two columns are not used here).

   **Note that the source voltage and lamp current are sinusoidal (AC) waveforms.
   We will learn more about what these measured values mean later in the semester.**

8. Repeat laboratory procedures steps 6 and 7 using a high-wattage incandescent light bulb rated at 120 VAC, ______ W provided by your instructor.

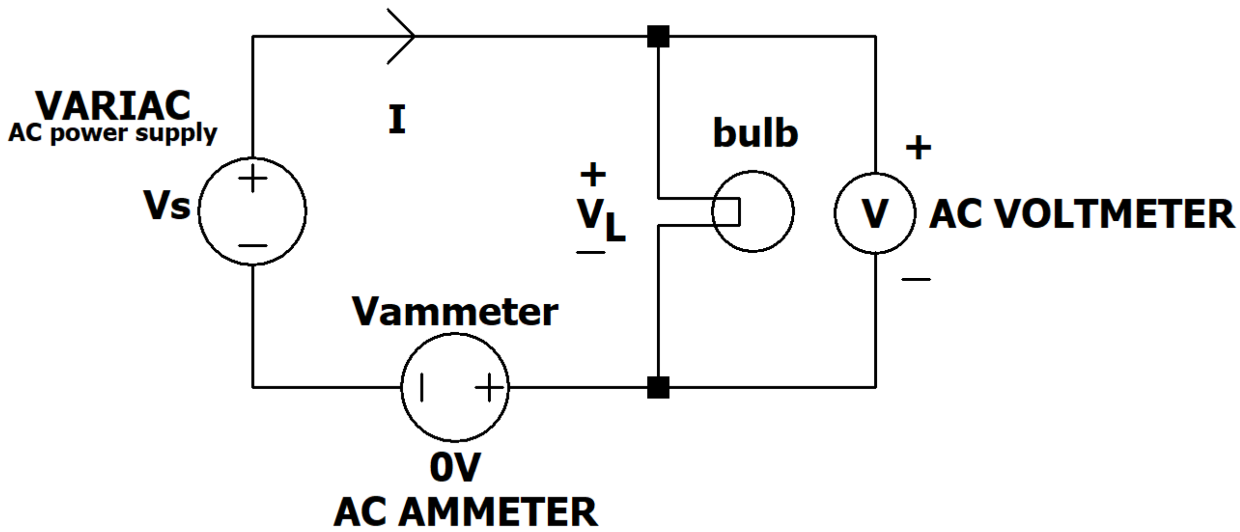

Figure 3. Simple AC light bulb circuit

Analysis

Perform this analysis work in your lab notebook.

1. Which of the resistors of laboratory procedures step 1 (if any) are out of tolerance?

2. Graph the current vs. voltage (I-V) data from laboratory procedures steps 3, 7, and 8 for the resistor and the two light bulbs (the vertical axis is the current axis). Plot all three curves on the same set of axes, perhaps using different scales for each curve. Compare the shapes of the three plots. Are they different? Why or why not?

3. Find the average error between the 'measured' and simulated powers of laboratory procedure step 3. Consider the simulated power as the ideal value.

4. Use the graph from analysis step 2 to determine the resistance and conductance at 50%, 75%, and 100% of the maximum applied voltage for the resistor. Briefly comment on the results.

5. Use the graph from analysis step 2 to determine the resistance at 50%, 75%, and 100% of the rated voltage for each light bulb. Briefly comment on the results.

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Adapted from material developed by current and former ECE faculty, including Professors Joseph Kelemen and Frank Severance, and input from ECE laboratory instructors.