ECET 102/CPET101

Lab 3
Ohm's Law Simulation and Circuit Lab
By
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Required Devices & Equipment:
    Resistors: 1kΩ x 2
    Bread board x 1
    Variable Power Supply x 1
    Digital Multimeter (DMM) x 1

Objectives:
1. Learn to use the variable power supply.
2. Learn to measure DC Voltage using DMM
3. Learn to measure DC mA Current using DMM
4. Verify Ohm's Law using Multisim simulation program
5. Verify Ohm's Law using measurement method

Procedure:
Part 1. Power Supply Voltage Measurement
   a) Connect the two leads of the DMM to the outputs of the DC power supply (Black-to-Black leads, Red-to-Red leads).
   b) Set the power supply to 2 volts, 5 volts, 10 volts, 15 volts, and 20 volts using the reading displayed on meter of the power supply and measure the actual voltage at each set point using your DMM. Place these results in the Table 1 below.
   c) Assume that the DMM reading is a secondary measurement standard. Measurement accuracy can be calculated as: % error = $[(V_{DMM} - V_{powerSupply})/V_{DMM}]$ x 100. Calculate the measurement error for each reading. Place these results in the %error column.
   d) Comment on the accuracy on the display readings from of the power supply

Table 1. Voltage measurement and measurement errors

Power Supply Output voltage (using displayed reading on power supply)	DC Voltage Value measured using DMM (DCV)	% error
2		
5		
10		
15		
20		
24		

Part 2. Ohm's Law Verification using Multisim
Ohm's law states that the voltage (V) across a resistor is the product of the current (I) through the resistor times the value of the resistance (R). Ohm's law can be written as:

$$V = I * R$$

The unit of voltage is in Volts, the current is in Amperes and the resistance is in Ohms (Ω).

Consider a simple circuit, as shown in Figure 1a. To verify the Ohm's law through measurements, we will setup a circuit similar to Figure 1b as the following:
- Measure Rx using a DMM: 1 kΩ
- Place the Rx on a bread board.
- For measuring I_{RX}
  - Connect the red lead of a DMM (DC mA) to the + output of the variable power supply (E)
  - Connect the black lead of the DMM (DC mA) to the resistor Rx
- For measuring V_{RX}
- Connect another DMM (DC Voltmeter) across the Rx for measuring the voltage V
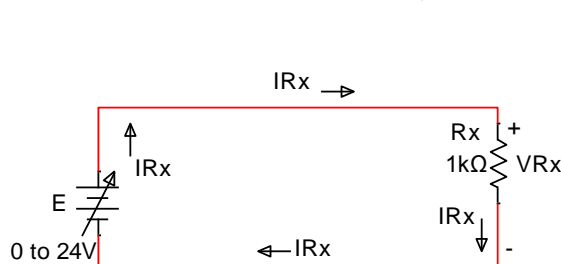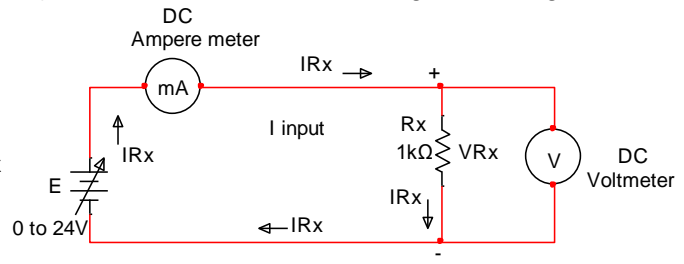

Figure 1a. A simple circuit   Figure 1b. Setup for measuring V_{RX} and I_{RX}

Procedure:
Follow the steps as shown below for the Ohm's Law Verification through Multisim Simulation.
   a) To start Multisim circuit simulation program:
      - Click on Microsoft Window's Start (Globe) => National Instruments => Circuit Design Suites 14.0 => Multisim 14.0
   b) To place the power supply on the simulation screen
      - Click on Place => Components => (Group) Basic => Source => DC Power
      - Then Place the DC Power source on the simulation screen
      - Double click on the DC supply now on the simulation screen
        - Click on "Label" to change the name of the DC source from "V" to "E"
        - Click on "Value" to change the voltage value to 2
   c) To place the 1 kΩ on the simulation screen:
      - Click on Place => Component => Basic => Resistor => 1 k
      - Place this resistor on the simulation screen
      - Right click the 1k resistor, then chose "Rotate 90^0 Clockwise" to place the resistor in the desired orientation.
   d) To place a DMM (mA ammeter), in between the power supply (E) and resistor Rx, on the simulation screen:
      - Locate the Agilent DMM located on the very right edge of the Multisim application screen, Click it and bring it to the simulation screen.
      - Double click on the XMM1, you will see the simulated Agilent 34401A DMM as shown below. To make it as a DC I meter, you will Click on the Shift button, and then Click on the DC V button. It is as shown in Figure 2 below.

Figure 2. Simulated Agilent DMM

e) To place another DMM (DC Voltmeter) on the right side of the resistor Rx, on the simulation screen:
- Locate the Agilent DMM located on the very right edge of the Multisim application screen, Click it and bring it to the simulation screen. It is now called XMM2.
- Double click on the XMM2, you will see the simulated Agilent 34401A DMM, similar to Figure 2 as shown above. To make it as a DC V meter, you will Click on the DC V button.
- Right click on the XMM, then select "Flip horizontally" to set it in the orientation that make wiring easier.

f) To wire the circuit as shown in Figure 3:
- Double click the XMM1 for terminal labels
- Place the mouse on the top of the E, then move your mouse to Input (V Ω) terminal of the XMM1.
- Place your mouse on LO terminal (Black), then move your mouse to the upper side of the Rx.
- Place your mouse on the lower side of the Rx, then move your mouse to the negative side of the power supply E.
- Connect XMM2 to Rx using your mouse
- Click Place => Text => to add additional notation to your simulation
  - I Input, Ammeter, Voltmeter
  - IRx
  - VRx
  - + and – symbols
- Click Place => Graphics => Line to draw a short line, then change it to an arrow line for showing current flowing direction
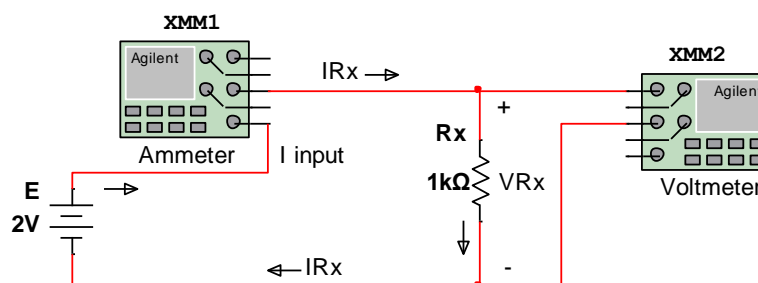

Figure 3. The simple circuit with DMM (DCV) and DMM (DC mA) meters

g) To run this simulation, you click on "Simulate" => Run; or just click on the green Triangle symbol on the menu bar.
h) Double click on XMM1 to view the DC mA reading (IRx), as shown in Figure 4.
i) Double click on XMM2 to view the DC V reading (VRx), as shown in Figure 4
j) Write down the current and voltage readings from the two DMM on the Table 2, below.
k) Stop the simulation by clicking on red square button on the menu bar.
l) Click on the power supply E, then change its output value to 5V
m) Click on "Simulate" => Run or click on the green Triangle symbol on the menu bar to run the simulation again with 5V power supply; write down its readings from XMM1 and XMM2
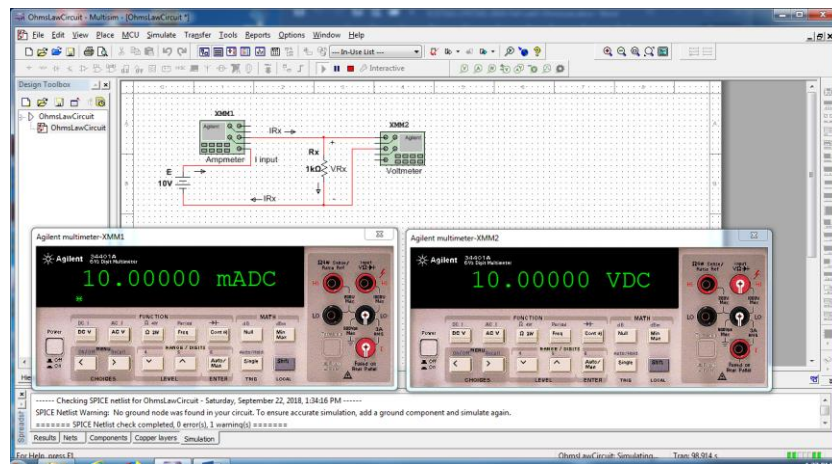n) Repeat from STEP k to finish all power supply input voltage required value

Figure 4. Multisim simulation screen

o) Using the VRX and IRX values from Table 2 to plot a X-Y chart: X axis (V_{RX}), Y axis (I_{RX})

Table 2. V_{RX} and I_{RX} obtained from the simulation

Power Supply Output (E)	V_{RX} Voltage Value measured using XMM2 - DMM (DC V)	I_{RX} Current Value measured using XMM1 - DMM (DC mA)	Calculated Rx (Ohms)
2			
5			
10			
15			
20			
24			

Part 3. Ohm's Law Verification through Measurement Method
To conduct the measurement using the circuit as shown in Figure 1b, we will need to use two DMMs one setup as voltmeter and another one as ammeter. Or alternatively, we can use just one DMM as DC mA meter, as shown in Figure 5, the voltage measurement can be provided through the voltage display available from the power supply.
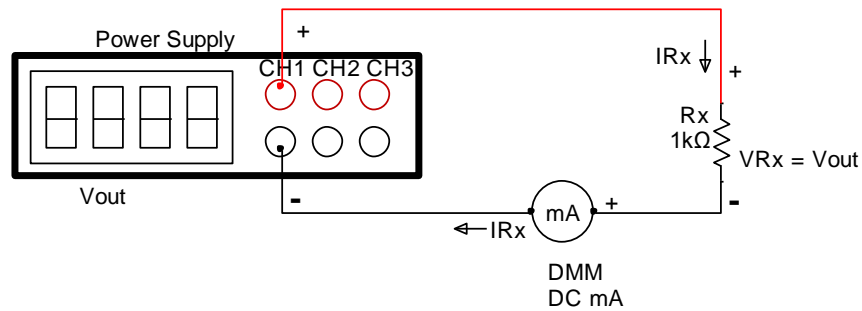
Figure 5. Measurement Setup

Procedure

Following the following steps to complete the Part III lab:

a) Connect the circuit as shown in Figure 5.
b) Adjust power supply output E = 2V, push the "Output" button to deliver the desired DC 2V output to the circuit.
c) Measure I_{RX} current, then write down both Vout and I_{RX} values on the Table 3.
d) Change power supply output E = 5V, then measure I_{RX} current, then write down both Vout and I_{RX} values on the Table 3.
e) Repeat Step (d) for E = 10, 15, 20, and 24V outputs
f) Make a XY-plot that shows V-I relationship.

Table 3. V_{RX} and I_{RX} obtained from the simulation

Desired Supply Output (E)	Power Supply Voltage V_{RX} (Vout Display)- three digit precision (DC V)	I_{RX} Current Value measured using DMM (DC mA)	Calculated Rx (Ohms)
2			
5			
10			
15			
20			
24			