Lab #2: Non-Ideal Sources and Renewable Energy Sources

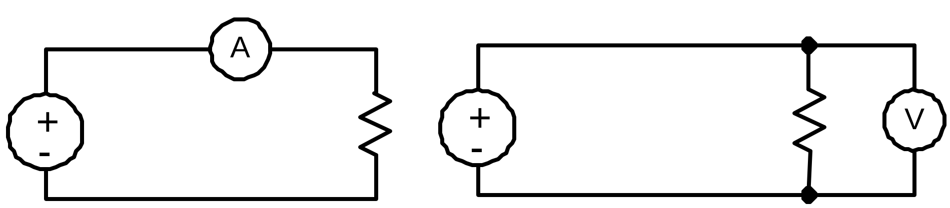
Theory & Introduction –

Goals for Lab #2 –
The goals for this lab are to introduce you to the limitations of real power sources and compare them to the ideal power sources available in a laboratory environment. Along with this, we will explore how solar panels work in the lab environment. It is our hope to have solar panels and wind turbines mounted on the roof of the Zachry building during the semester for use in the ELEN 214 labs and possibly for use by ELEN 405 students. Therefore, a brief introduction to renewable sources is presented at this time.

Theory –
Ideal and Non –Ideal Sources
In order to understand how battery differs from an ideal source, you will build a circuit first with an ideal source and then with a battery. The circuit will use an inverter. Do not worry about what happens within the inverter at this time, but know that the inverter will turn the DC power you supply to it into AC power for the fan. Part of the experiment will be to determine the internal resistance of the battery. Although there is internal resistance to a source in lab, we cannot measure it in this experiment. Why? (Think about how you use an ideal voltage source in lab. What value do you set?)

Unlike the ideal source, practical voltage sources have measurable internal resistance. By using Kirchhoff's Voltage Law and the voltage divider equation, the equivalent internal resistance of a non-deal source can be calculated. You will gain experience in measuring voltage and current of a circuit with the digital multimeters. For measuring voltage, you will use the HP DMM as used in Lab #1. For measuring current, we have an additional Fluke ammeter to use.

It is important to remember that although you can use the same digital mutlimeter to measure both current and voltage, you must measure current in series, as shown in Figure 2.1a, and voltage in parallel, as shown in Figure 2.1b.



(a) (b)
Fig. 2.1 Current and volt meter connections.

Renewable Energy Sources
If you paid attention to the news in the United States for August 2003, you are certainly aware how vulnerable our power systems can be in the United States and around the world. One way to insure uninterrupted power is to create a renewable energy power generating system at your home or business. You could also use a non-renewable power generating system. One recent

estimate said that to obtain a generator for the average family home would cost roughly $10,000. A similar amount could be spent in Texas to provide solar panels for the same home. If you have interest in renewable energy sources, especially solar power, there are several competitions for college students including the solar car and the solar house competitions. A little research on the web could provide much more information on these issues.

For now, we will focus on solar power systems. Solar power systems work by mounting silicon panels where they can receive maximum sunlight and collecting the DC current generated on the panels. This light generated current will create a voltage across the solar panel that can be used as DC power or can be converted to AC power with the use of an inverter. After the panels have been mounted on the roof of Zachry, we will use the power in the ELEN 214 lab by accessing the direct current generated from the solar panels.

It would be helpful to review information on the following websites:

http://www.treia.org/
http://www.seia.org/
http://www.nrel.gov/ncpv/

To see solar power generation at work, we will use small, encapsulated solar modules, shown below in Figure 2.2, in a circuit in lab and compare the current and voltage generated with ambient light in the lab to the current and voltage generated by shining a Lamp on the solar panel. Note how the solar panels can be modeled as a dependent source like you have discussed or will be discussing) in lecture.

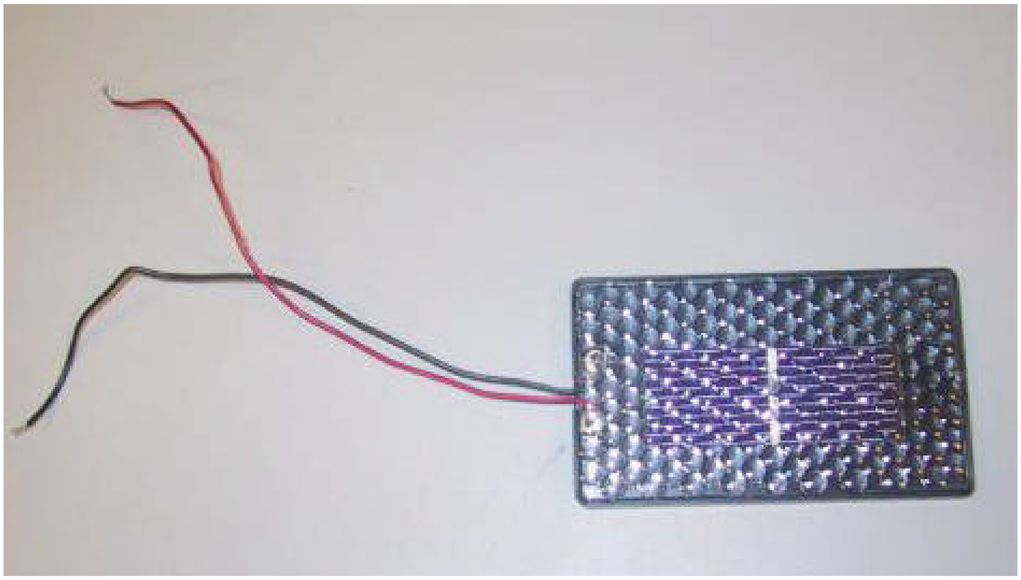


Figure 2.2

Prelab –

Be sure to read the entire lab #2. Be prepared to answer the questions suggested in the theory section of the lab.

For the circuit drawn in Figure 2.3, answer the following questions given Vs = 12V.

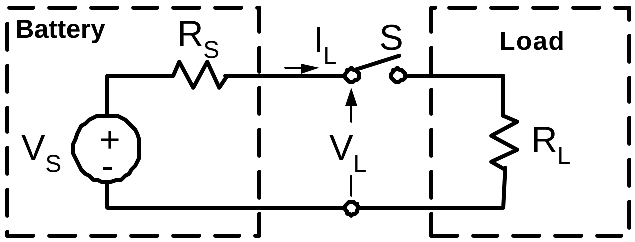


Figure 2.3

1. What is the value of V_L?
2. Can you determine the value of R_s or R_L? If so, what are their values? If not, why not?

For the circuit drawn in Figure 2.4, answer the following questions given V_S = 12V, I_L= 2.5A and V_L = 10V.

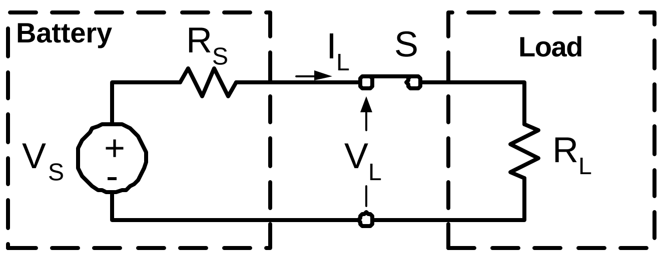


Figure 2.4

1. What is the value of R_S?
2. What is the value of R_L?
3. How much power is dissipated in R_L?
4. What value of R_L would give the maximum power dissipated in R_L? (Hint: This is given in your text book if you use your index.)

Model the circuit in Figure 2.4 in PSPICE using the value of R_S and R_L calculated above and the value given for V_S. Do your PSPICE results match your calculations? Print a copy of your PSPICE schematic with the values of current and voltage shown and hand it in as part of your pre-lab.

The solar module to be used in lab is rated for 0.5V and 300 mA. What is the maximum amount of power that this module can provide to a circuit? Show your calculations.

Procedure –

Equipment to be used:

Battery, 12V, 7.2Ah
DC/AC Inverter, 150W, 12VDC-to-110VAC
Fan with variable speed
1 – 1.0k Ω resistor, ¼ W
1 – 100 Ω resistor, ¼ W
1 –10 Ω resistor, ¼ W
0.5V, 300mA Enclosed Solar Module
Lamp
3 – banana to banana connectors
2 – banana to breadboard connectors

Task #1 – Measuring the current drawn by a fan from a non-ideal source and the internal resistance of a Battery

A. Use the HP DMM to measure the open circuit voltage (VL) of the battery as shown below in Figure 2.5. Record its value in Table 1. Do not connect the ampere meter. Record the open circuit current.

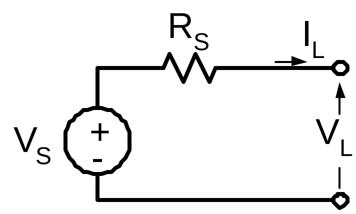


Figure 2.5: Open circuit voltage and current.

B. Construct the circuit shown in Figure 2.6 with the details given below the figure. CAUTION: DO NOT CONNECT THE BATTERY TO ANYTHING OR TURN ON THE INVERTER UNTIL YOUR TA HAS CHECKED YOUR CIRCUIT.

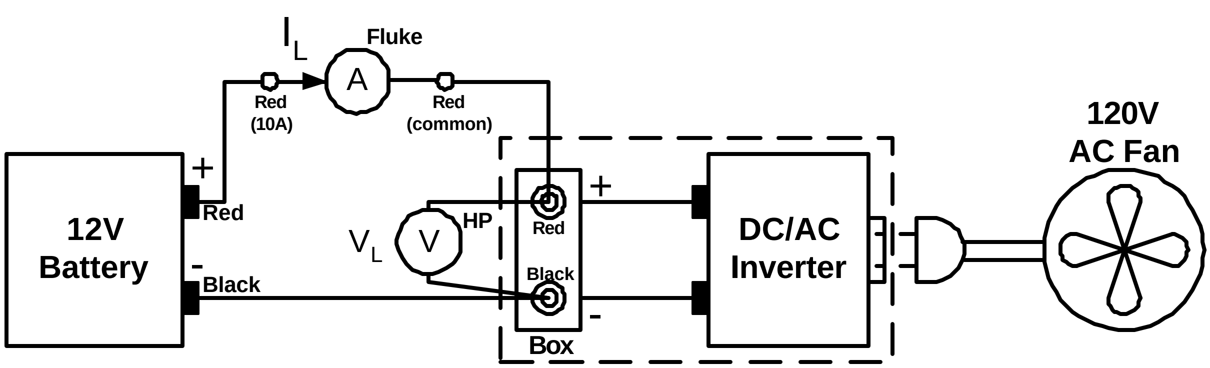


Figure 2.6

Put the inverter switch in OFF position before you start.

Connect the HP DMM on the lab bench to the DC/AC inverter box terminals (red to red, black to black).
Connect the battery negative terminal (black) to the negative terminal (black) of the DC/AC inverter block.
Connect the battery positive terminal (red) to the Fluke 8010A digital ampere meter (10A red terminal). Connect the common terminal of the ampere meter to the red terminal of the DC/AC inverter block.
Ask your TA to verify your connection

C. Make sure the fan is in the off position. Turn on the DC/AC inverter. Record the current and voltage displayed in Table 2.
D. Turn the fan on Low. Record the current and voltage displayed in Table 2.
E. Turn the fan on Medium. Record the current and voltage displayed in Table 2.
F. Turn the fan on High. Record the current and voltage displayed in Table 2.
G. Turn OFF the fan and turn off the inverter. Disconnect the battery from the circuit.

Task #2 – Measuring the current drawn by a fan from an ideal source

A. Before connecting to anything, turn on the Xantrex power supply, shown in Figure 2.7, and set the voltage to 12V. Turn off the Xantrex power supply.

Figure 2.7

B. Connect the Xantrex power source on the bench to the circuit in place of the battery as shown in Figure 2.6. Use banana to banana connectors to connect the red of the power supply to the red of the inverter. Connect the black of the power supply to the black of the inverter. HAVE YOUR TA CHECK YOUR CIRCUIT
C. Turn on the Xantrex power source
D. Repeat steps C through G from Task #1 and record the measurements in Table 3.

E. Turn off the inverter. Turn off the power supply. Disconnect the circuit.

Can we complete the table? Why or why not? What are the limitations of using ideal sources when attempting to calculate efficiency?

Task #3 – Measuring voltage and current through a solar panel at different levels of light.

A. The following connections are shown in Figure 2.8. Connect the red lead from the solar panel to a node on the breadboard. Connect the black lead from the solar panel to a different node on the breadboard.

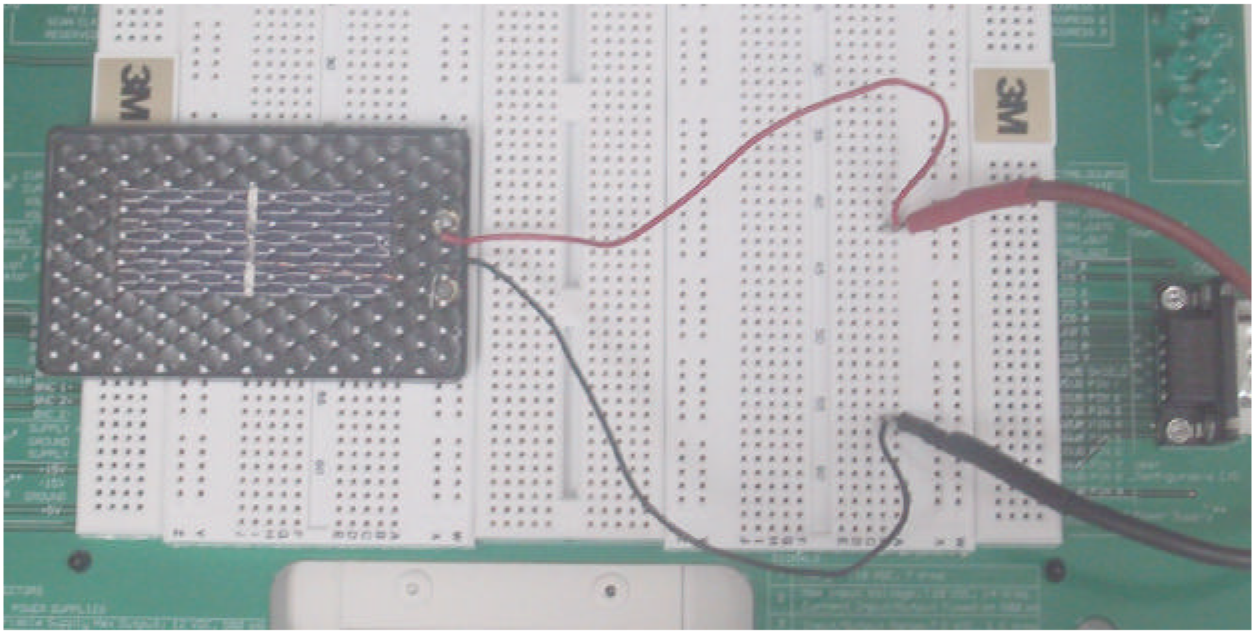


Figure 2.8

B. Connect the red lead to the red lead from the DMM. Connect the black lead from the DMM to the black lead on the breadboard as shown in Figure 2.8. Turn on the HP DMM. Observe the voltage across the solar panel. You do not need to record it at this time. This is a check to see that the solar panel is working. Disconnect the HP DMM for now.

C. Using the red Banana to Pin connector, connect the 10mA socket in the Fluke Ammeter used in Task 2 to the red lead from the solar panel. Using the black Banana to Pin connector, connect the ground socket from the Fluke Ammeter to a new node on the breadboard. For details, see Figure 2.9.

D. Connect the node on the breadboard to a 1 kΩ resistor. Connect the other end of the 1kΩ resistor to another node on the breadboard.

E. Connect the HP DMM voltmeter across the 1 kΩ resistor. Connect the 2nd node of the 1 kΩ resistor to the black connector of the solar panel. To double check the connection see figure 2.9 on the next page.

F. Turn on the Fluke ammeter HP DMM.

G. Turn off the lights in the lab for a moment. Record the voltage and current in Table 4.

H. Turn the lights in the lab back on. Record the voltage and current in Table 4.

I. Shine a lamp on the solar panel. In order to avoid hurting the solar panel, keep the bulb of the lamp at least 5 inches from the solar panel. Experiment with how close and where to hold the lamp to maximize the power in the resistor. Record these values and describe how the lamp is positioned. Figure 2.10 is an example of how to hold the lamp.

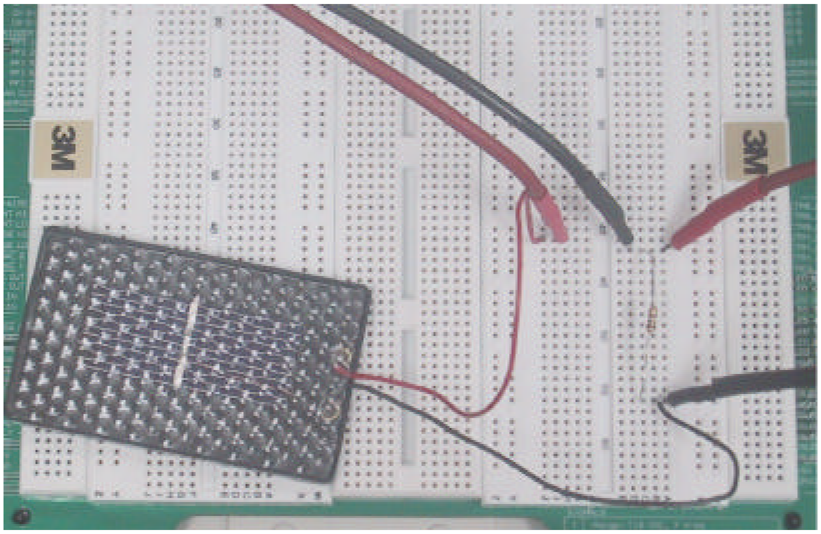


Figure 2.9

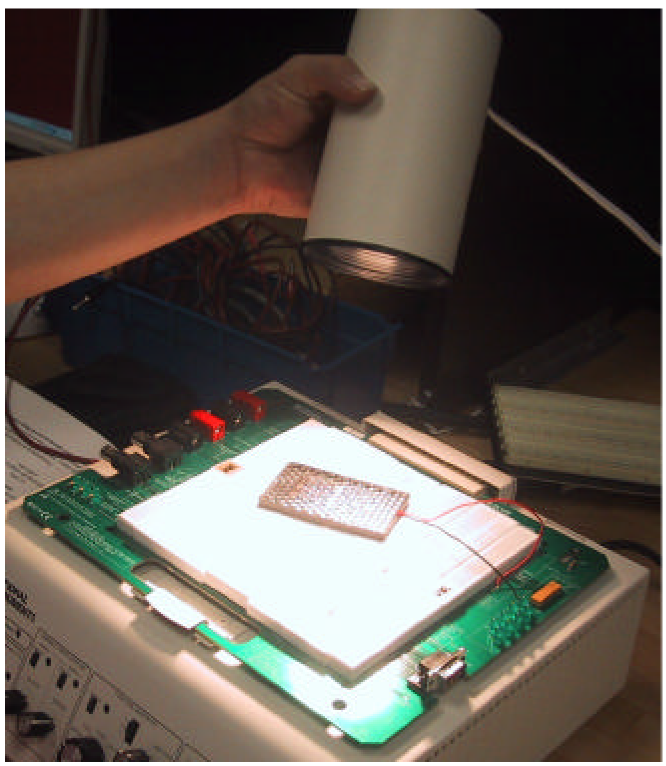


Figure 2.10

J. Replace the 1kΩ resistor with a 100Ω resistor. Repeat the experiment with the Lamp to find the maximum power in the resistor. Record these values and describe how the Lamp is positioned.

K. Replace the 100 Ω resistor with a 10Ω resistor. Repeat the experiment with the Lamp to find the maximum power in the resistor. Record these values and describe how the Lamp is positioned.

Which resistor dissipates the most power? Why?

L. Turn off the ammeter and voltmeter. Disconnect the circuit.

Report Requirements –

For the first task, reproduce Table 2 and complete the calculations required. Show example calculations for each column.

Plot V_L versus I_L from the data in Table 2

Plot V_L versus I_L from the data in Table 3.

Plot R_S versus I_L from the data in Table 2.

For the second task, reproduce Table 2 and complete the columns as you can. Why can you not complete all of the columns? What are the limitations of using an ideal source for the questions in this lab report?

For the third task, reproduce Table 3. Comment on how the maximum power is achieved. What determines the amount of current that will flow through the 1 kΩ resistor?

What value resistor should be used in Task #3 for maximum power? How is this determined?

Be prepared to answer similar questions to the following on the quiz at the next meeting session:

Tables and Results –

Table 1: Task #1

V_L	I_L

Table 2: Task #1:

Fan Speed	V_L Measured	I_L Measured	Calculated Power Delivered to Load ($P_{OUT}=V_L*I_L$)	Calculated R_L	Calculated R_S	Calculated Power Dissipated in R_S ($P_{LOSS}=I_L^2*R_S$)	Efficiency $h = \frac{P_{OUT}}{P_{OUT}+P_{LOSS}}$
Off							
Low							
Medium							
High							

Table 3: Task #2

Fan Speed	V_L Measured	I_L Measured	Calculated Power Delivered to Load ($P_{OUT}=V_L*I_L$)	Calculated R_L	Calculated R_S	Calculated Power Dissipated in R_S ($P_{LOSS}=I_L^2*R_S$)	Efficiency $h = \frac{P_{OUT}}{P_{OUT}+P_{LOSS}}$
Off							
Low							
Medium							
High							

Table #4: Task #3

Light Level	Voltage	Current
Lights Off – 1kΩ		
Lights On – 1kΩ		
Lamp – 1 kΩ resistor		
Lamp - 100Ω resistor		
Lamp - 10Ω resistor		

How is the Lamp positioned to obtain maximum power?