TCNJ THE COLLEGE OF NEW JERSEY

Department of Electrical/
Computer Engineering

ENG 214 – Electrical Circuits Laboratory

Basic Electrical Measurements and Modeling

Laboratory Number 1

(Instructor Dr. Raziq Yaqub)

Objectives:

1. To familiarize students with the use of a digital multi-meter for the measurement of voltage, current and resistance

2. To make students aware of the importance of accuracy and precision in electrical measurement, and show their relation to overall measurement error.

3. To give students experience in designing a simple electrical circuit

4. To introduce the concept of a model, and show that a simple model can be used to predict the performance of a real device, and reinforce the relationship between voltage, power and energy.

Procedure:

1. Prior to lab determine the accuracy and precision of your group's multi-meter from the manufacturer's data. What is the overall measurement error when measuring voltage, current and resistance? Is the error affected by the meter range?

2. A voltage regulator (UA7800) will be used to simulate a voltage standard cell. Voltage regulator assemblies are available in the stock room for your use. Their reference voltage is marked on their housing. Prior to lab review the specifications of this regulator on the Internet. Connect the input of the regulator assembly to a variable voltage power supply set to at least 2 volts greater than the reference voltage. Be careful to use the correct polarity. Measure the output voltage with your multi-meter. Use this measurement to determine if your voltmeter is operating within its expected ***measurement error range*** (based on the meter's specifications determined prior to lab). Assume the output voltage of the regulator has the accuracy of a standard cell. Is the difference between measured voltage and the regulator's reference voltage with the ***expected*** *measurement error range*?

3. Set a variable voltage supply as close as possible to 8 volts as measured on your group's volt meter. (Do not assume that the meters in the power supplies are of high accuracy). What is the possible error of this voltage?

   Prior to lab, design a voltage divider to reduce the power supply voltage to 2 volts with in +/- 10%. Clearly draw the schematic of your design in your lab notebook. Use standard resistor values available from the laboratory stock room. There are many solutions to this design. Make sure the resistor values chosen do not exceed their power rating. The small resistors can dissipate 1/4 watt of power and have a ±5% tolerance (gold band). Calculate the expected error (+/- range from 2 volts) in the output voltage of the divider based on the tolerance of the resistors to justify your design.

4. Construct the voltage divider. **Measure** the **resistance** of the components used to fabricate the divider. Calculate the expected error in the output voltage of the divider based on the measured resistance values.

Connect the voltage divider to the 8 volt supply. Test the voltage divider by **measuring** both the **voltage** produced by the divider and the **current** drawn by the divider from the power supply. How does the voltage measured compare with the calculated voltage based on the nominal resistor values and the measured resistor values?

5. How does the multi-meter affect (*load*) the circuit when used as a voltmeter? What would be the affect of a load resistance on your voltage divider's performance? Over what load resistance range could your voltage divider's design specification (+/- 10%) be maintained?

6. Discuss the measurement of current. How does the multi-meter affect the circuit when used as a current meter?

7. Model your circuit using the SPICE program. Compare the output of the model to the measured results.

8. A simple model of the battery can be created by connecting a voltage source (ideal battery) of voltage Voc in series with a resistor of value Ri (internal resistance of the battery). Prior to lab research batteries on the Internet. Think about the proposed battery model. Draw a schematic diagram of the model in your lab notebook, and try to figure out how to measure Voc and Ri.

9. Obtain two fresh 1.5 Volt AA size batteries in a special holder that is available in the stock room. Measure the open circuit voltage produced by the two batteries in series with your voltmeter. This voltage is Voc.

10. Connect the two batteries in series with a one ohm resistor mounted on the batter holder assembly. Quickly measure the resulting voltage, and record the values of this voltage and the measured value of the one ohm load resistance. To avoid discharging the battery, do not keep the load resistor connected to the batteries any longer than necessary to accomplish the measurement.

11. Calculate the (Ri) of the battery from the loaded voltage (voltage of step 10) and the Voc (step 9).

12. Test the simple battery model by loading the real battery (two batteries in series) with a number of (5 or more) different load resistances and noting the resulting voltage. (Keep the load resistors connected for a minimum period of time to avoid discharging the battery). Compare the measured voltage with the voltage predicted by the model. Graph your results. Put both measured and predicted voltage values on the same graph. How much do the voltages (and currents) predicted by the model and those measured differ?

13. Test your model over time by loading the battery with a one half ohm resistor on the battery holder assembly. Measure and record Voc before starting the test. Measure and record the voltage across the load resistor at the start of the test and every minute for 15 minutes. Measure and record Voc at the end of the test. Graph the voltage and power as a function of time.

14. Calculate the energy supplied by the battery to the load resistor during the test. Compare this energy with the energy predicted by the model.

15. Does the simple model of the battery apply when the battery is heavily loaded over an extended period of time? Does the internal resistance (Ri) of the battery change with time? Can you come up with a more complex, but better model to represent the battery under load?

16. How does the real battery's observed performance compare with its expected performance? (Information on the specifications and discharge characteristics of Zinc Carbon batteries can be found on the Internet).

Reference on internal resistance of battery.

http://www.youtube.com/watch?v=IftDnfr5ow0&feature=colike