University of Rochester

Department of Electrical & Computer Engineering

ECE111 Laboratory #1 Simple DC circuits

Sept. 18 or 19, 2014

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Unless prior arrangements are made with the instructor, all laboratories are to be conducted during regularly scheduled lab. Write-ups must be prepared with word-processing software and should be organized as follows: 1) statement of laboratory objectives; 2) concise description of lab procedures with diagrams of all circuits; 3) detailed description of the results with error and precision; 4) discussion and conclusions; 5) on a separate sheet - stapled to the top of the report - prepare an Executive Summary as described. Report grades will be based upon conciseness, grammar, and spelling, as well as completeness and correctness of quantitative results. Poorly written reports will be returned for revision.

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0. Laboratory preparation

Prepare for this lab by reviewing voltage & current divider network relations as covered in lectures and in the text.

In this and subsequent lab assignments, you will be collecting resistors and other components from the marked drawers to build your circuits. Unless stated otherwise, you should simply select the components in your sessions in Gavett 306. Students are expected to work in teams of two. Data, circuit setups, component values, and relevant calculations must be recorded, either in a lab notebook or in an electronic document (Word, Excel, or other). Lab write-ups (one per team of two students) are due one week after the laboratory has been performed. **Late work will not be accepted.** Write-ups must be prepared with word-processing software.

*V*bat

10 k

+

-

*v*2

5 k

2 k

100 

*v*1

+

-

+

*i*

**A**

Fig. 1. Parallel resistive circuit for KCL test.

It will almost never be necessary to use better than standard ±10% components, so do not waste time looking for “perfect” resistor values.

In this lab, you will investigate KCL and KVL, i.e., Kirchhoff’s current and voltage laws for resistive circuits with a 9 Volt battery as the voltage source.

1. Current divider

Build the circuit shown in Fig. 1 and then use a voltmeter to measure the voltage drops necessary to calculate values of the currents flowing through all the resistors. Be sure to take into account the uncertainties of the resistors and errors of measurement. Use your results for these current values to check the condition enforced by KCL at node A, which is marked by an arrow in the figure. In your lab write-up, make sure to write down an expression for KCL in the form specific for this circuit.

As part of this exercise, you also should estimate measurement errors due to the meter and use this information as you compare the calculated and measured values. Do not use too many places of accuracy in your answer.

**II. Voltage divider**

Vbat

5 k

+

-

2 k

1 k

*i*

Fig. 2. Resistive voltage divider circuit for testing KVL.

Build the circuit shown in Fig. 2 and then use the voltmeter to measure the voltages across the three individual series resistors. After recording these voltage values, use them to check the validity of KVL for the circuit loop, taking into account the uncertainty of the resistor and battery voltage values.

In your lab write-up, make sure to write down KVL in the form specific for this circuit. As before, please make sure to estimate the uncertainties of all numerical values, both calculated and measured.

III. Current measurement

Next, build the circuit shown in Fig. 3, using some resistor *R*x in the range from 5 k to 20 k. Measure **only** the total battery voltage *V*bat and the voltage *v*c across the 100  resistor. Calculate the current *i* = *v*c/100 and use this current value to calculate the quotient: *V*bat/*i*. Compare your result to the nominal value of your resistor *R*x. These values should be rather close, but probably not identical.

After you have completed this exercise, ask the TA to give you another (unknown) resistor *R*x. Repeat the procedure to obtain a value for the unknown **and** its uncertainty in ±%. When you think you know what the value is, ask the TA for the true value. If you are in error, go back and try to find where you went wrong.

*V*bat

*R*X

+

-

*v*c

*R*C = 100 

+

*i*

Fig. 3. Current measuring circuit for measuring unknown resistors. Note the requirement that Rc << Rx.

This method of using a small current detection resistor is a very common and useful technique for measuring voltage and current in unknown components. Note that it is only accurate if *R*c << *R*x. In the write-up, explain why this is so.

IV. Wheatstone bridge

Build the Wheatstone bridge circuit shown in Fig. 4, using a 20 k potentiometer for one side of the bridge and two resistors, *R*1 = 5 k and *R*2 = 10 k on the other side.

Set up the voltmeter to measure the voltage difference *v*g. (In the classical Wheatstone bridge, *v*g was usually monitored by a galvanometer. Here, a voltmeter serves as a very sensitive and adequate substitute.)

*V*bat

*R*1

+

-

*v*g

+

*R*2

*R*a

*R*b

Fig. 4. DC Wheatstone bridge circuit using a potentiometer. The nulling voltage *v*g is measured using the voltmeter. At the desired null condition, *v*g = 0.

Once your circuit is working, you should see a DC voltage *v*g that may be positive or negative. By turning the potentiometer, this voltage will rise or fall. Adjust the “pot” until you get zero. This is the condition where the two resistive dividers are exactly balanced. When you have obtained this condition, carefully remove the pot from the circuit and measure the two resistances *R*a and *R*b. Compare the two resistive ratios: *R*a/*R*band *R*1/*R*2. Within the limits of precision, they should be equal.

NB: Unless otherwise stated, please assume that the tolerances for electronic components are ±10%. Thus, if a resistor in a circuit is specified to be 4.7 k (±10%), then you should be able to perform your laboratory successfully with any resistor value between ~4.2 k and ~5.2 k. By using an ohmmeter or bridge to measure and record the actual values of your components, you will be able to perform subsequent calculations with greater accuracy**.**

• It is a fool’s errand to search for "perfect" components! Designing circuits and other systems that work reliably with low-cost, low-tolerance components is an important skill to be mastered by all EE’s. The same can be said for any engineered systems – cost cannot be ignored in good design. In the particular case of electronics, precision components are always more expensive and best avoided when possible.

• Avoid the mistake of overstating or understating the precision of voltages, currents, resistances, power, etc.! Overstating component precision wastes money while understating it may result in a design that does not work. A brief guide to sensitivity analysis, sigdig.pdf, is on the course Blackboard site.