

## Lab #1 – DC Circuits

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The purposes of this lab are

- to familiarize yourself with equipment for generating and measuring DC voltages and currents, with resistors and potentiometers, and with the breadboard
  - to get a feel for the behavior of some basic circuits such as voltage and current dividers
  - to remind you that no equipment is ever ideal.
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Equipment at each station:

2 multimeters  
 2 power supplies  
 breadboard with power connections  
 potentiometer

Centrally available:

wire and wire cutters/stripper  
 red and black banana plug cables  
 alligator clips  
 assorted resistors

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### 1. Digital Voltmeter

- Instructor introduces the multimeter
- Use the voltmeter option to measure the DC voltage that the instructor puts around the room. Note that the voltage is relative, switch your leads and you get -V.

### 2. DC Power Supplies

- Examine your power supply. Note that the two outputs are ‘floating’: either can be grounded. If you ground the – terminal you have a positive source and if you ground the + terminal you have a negative source. If you ground neither there is simply  $X$  volts between the + and – terminals. The meter can read either volts or amperes. Use the volts setting first.
- Make a +5V power supply. Measure the output using a voltmeter. Note that you get an approximate value from the power supply meter and a more accurate value from the multimeter.
- Switch to the ampere setting on your +5V supply and **MOMENTARILY** short the outputs. What happens to the meter? By monitoring the amperes of your power supplies you can often detect unintentional shorts in your circuits and prevent serious damage.
- Make a –5V power supply and measure it with the voltmeter. You should now have a +5V and –5V power supply.

### 3. Resistors, Ohmage, and Potentiometer

- Instructor discusses some aspects of resistors: color coding and wattage rating. Instructor explains the ohmmeter option on the multimeter. Instructor explains the use of the potentiometer and the 62.5 mA fuse!
- Measure the resistances of several different resistors from the cabinet and verify your results by reading the color codings.
- Measure a few resistors of the same value and notice the variation.
- Satisfy yourself with the workings of the potentiometer using your ohmmeter.

#### 4. Breadboard and Voltage Divider

- Instructor describes the features of the breadboard (power terminals, internal conductors), the types of wires to use, and a tidy way to configure the board. Verify the connections of your breadboard with your ohmmeter.
- Connect your +5V and -5V power supplies to your boards to give them power. This will be a useful configuration for the upcoming labs.
- Using your breadboard verify with the ohmmeter that resistances add in series and conductances add in parallel.
- Design, construct, and measure a **voltage divider** on your breadboard.
  - Use unequal resistances. You may use the potentiometer for one or more of the resistances, but take care in limiting your currents!
  - Calculate the expected voltage at the node of the divider and the current in the circuit.
  - Measure the voltage using your voltmeter and switch to the ampere setting on the power supply to estimate the current. Verify that the voltage is divided as expected and the current is as expected. (Note that for some values of resistors the current may be too small to measure on the meter. Use this information when designing your voltage divider. But remember not too draw too much current:  $I^2R$  is the power dissipated in the resistor!)

#### 5. Ammeter and Current Divider

- Instructor explains the use of the ammeter. The ammeter must be in series with the component through which you wish to measure the current, i.e., you must break the circuit.
- Design, construct, and measure a **current divider** on your breadboard.
  - Use unequal resistances. You may use the potentiometer for one or more of the resistances, but again take care in limiting your currents!
- Calculate the expected currents in each leg of the divider and the total current.
- Measure the total current through your circuit and the current in each leg. The latter you can do simultaneously. Verify that the currents are divided as expected and that the currents sum to zero at a node.

#### 6. Internal Resistance Measurements

- Use one multimeter to find the input characteristics of the other when it is being used as (a) a voltmeter and (b) an ammeter. Make sure you see if the result changes for the different range settings of the meter.
- What are some situations where these values could be significant? Note these values for future reference.

#### 7. Thevenin's Theorem

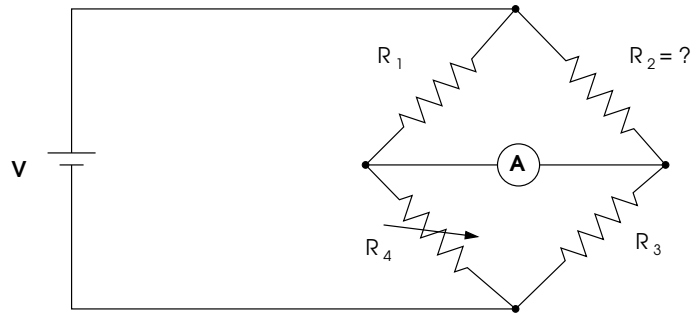
- Make an arbitrary network of resistors on your breadboard and measure the resistance  $R_{TH}$  between the two nodes. The network should have at least 6 components and at least 4 nodes. Aim at a resistance between 50 and 200 $\Omega$ . The network should be sufficiently complicated that you can not easily analyze it, but make a stab at guessing it **before** you measure it.
- Put  $R_{TH}$  in series with a power supply, an ammeter, and a load resistor  $R_L$ . The 1k potentiometer works well for this purpose. For a fixed supply voltage  $V_0 \sim 0.5V$ , measure the current  $I$  and the voltage  $V$  across  $R_L$  and make a plot of  $I$  vs.  $V$ . Don't forget to measure and include  $V_0$  in your plot.
- How accurately is Thevenin's Theorem obeyed?

## 8. Norton's Theorem

- Approximate a constant current source by putting a 4.7k resistor in series with your supply and turning up the voltage to its maximum value ( $\sim 30\text{V}$ ). Insert the same resistor network ( $R_{\text{TH}}$ ) into the appropriate position (in parallel with  $I_{\text{SC}}$  and repeat your I-V measurements and plot.
- How accurately is Norton's Theorem obeyed? Can you explain any differences?

## 9. Wheatstone Bridge

- Build a Wheatstone Bridge circuit (shown below) to determine an unknown resistance ( $R_2$ ) supplied by the instructor.



- To determine the values for the resistors, write down the relationship between  $R_1$ – $R_4$  and consider that  $R_4$  ranges from 0 to  $1\text{k}\Omega$ . As an additional hint,  $20 < R_2 < 50 \text{ k}\Omega$ .
- By using appropriate values of  $R_1$  and  $R_4$ , and adjusting the 0– $1\text{k}\Omega$  potentiometer ( $R_4$ ) to “balance” the bridge, determine the value of  $R_2$ .
- Why is this method better than using an ohmmeter?

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- If time permits feel free to try any other experiments you can think of doing.
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