Phy 415/515 Lab #1 2009 Voltage dividers

The purpose of this lab is to familiarize you with the equipment you will be using in the rest of the class. **You will turn in only the results sheet, page 6 for this lab.**

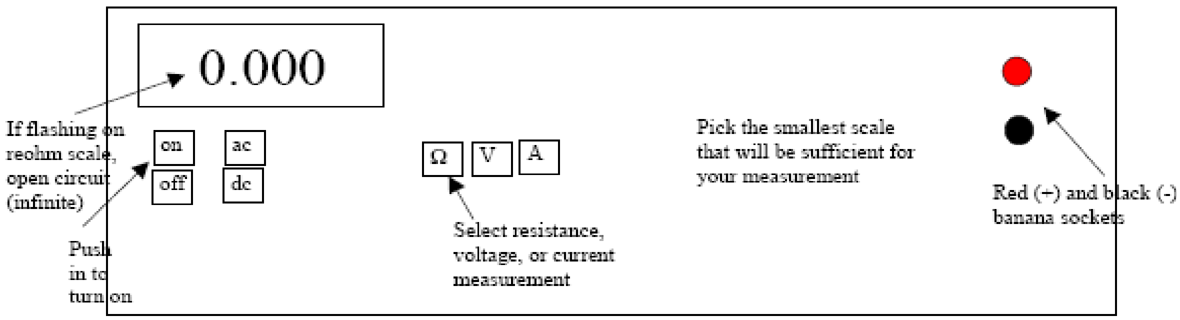

Figure 1. Keithley DVM

1. The Keithly multimeter (we will call this the DVM, for digital voltmeter)

1.1. Measure open or closed circuits

The DVM is shown in Figure 1. Plug in the DVM and turn it on.
Select the resistance (Ω) scale. Plug a red banana-to-alligator cable into the red socket on the DVM (a banana-to-banana cable is shown in Figure 2 and an alligator-to-alligator in Figure 3).
Plug a black banana-to-alligator cable into the black socket.
Touch the two alligator clips together to change the readout from flashing to constant zero. (Flashing means not connected or "open circuit", R=∞, and constant zero means connected, or "short circuit", with R=0.)

Figure 2. Banana (-to-banana) cable from muellerelectric.com.

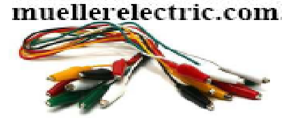

Figure 3. Alligator-to-alligator cable from muellerelectric.com.

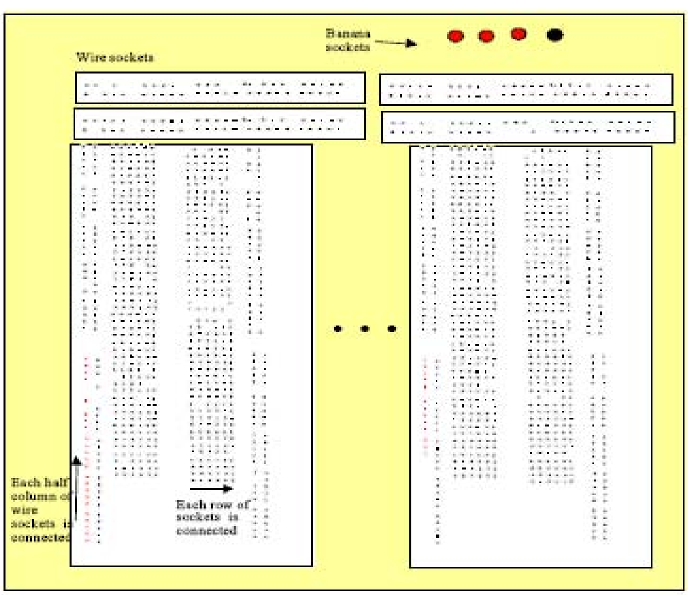

Figure 5. The Breadboard.

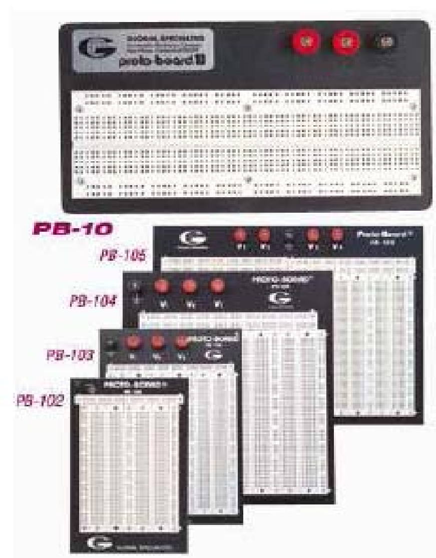

Figure 4. Picture of breadboard from globalspecialities.com.

2. The Breadboard

2.1. Wiring Area

The breadboard is shown in Figure 4 and Figure 5.

Connect the red alligator clip on the DVM to an orange or yellow wire, and the black clip to a blue or green wire. Stick the blue wire into a hole somewhere on the wiring area of the breadboard. Observing the diagram below, verify that the rows of wire connections are shorted and the columns of wire connections are shorted along the edges by moving the orange and blue wires to different locations. The column connection stops at a break halfway down the column.

2.2. Setting up the power strips

Connect a red wire to the leftmost red socket on the breadboard, as shown in Figure 6.

Stick the other end of the wire into the topmost row on the breadboard. Use red wires to jumper to the leftmost column of one of the six wiring boards (the column is labeled "W") and jumper across the break halfway down the column (near number 35). ALWAYS and ONLY use RED wires for the + side of the voltage supply in this class. Connect a black wire between the black banana socket and the bottom (fourth) row on the breadboard. Use black wires to jumper to the rightmost row (labeled Z) on the same wiring block and to jumper across the break halfway down

.

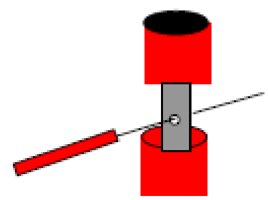

Figure 6. Close-up of banana socket on breadboard. Unscrewing the top partway up the post reveals a hole through which a wire can be threaded. Screw the top back down to clamp the wire.

2.3. Voltage Measurements

Select V on the DVM, and select the 20 V scale.

3. Kepco Power Supply

3.1. Powering the Breadboard

Plug in the Kepco power supply, shown in Figure 7. Move the white center knob to the right, so that the meters read the right set of outputs. Connect a black banana cable from either of the black left sockets of the power supply to the black socket on the breadboard. Connect either red 6 V output to the red banana socket. Plug the wires attached to the DVM into the bottommost holes of the Z and W columns. Turn on the power supply and adjust the voltage to 6 volts using the lower right knob and reading the lower voltage scale.

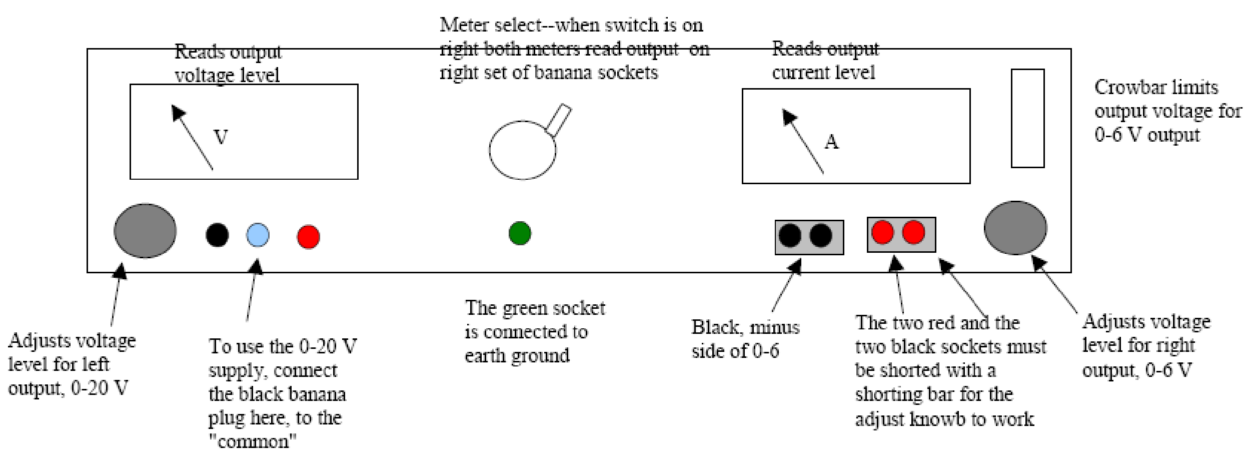

Figure 7. Kepco Power supply

Verify that the voltage between the columns is 6 volts using the DVM. ALWAYS USE THIS POWER CONFIGURATION FOR THE BREADBOARD.

3.3. The 0-20 V supply.

Click the white knob to the +0-20V setting. Adjust the voltage to 10 V using the left voltage adjust knob, reading the upper voltage scale. Move the banana cables attached to the breadboard to the 0-20 V side of the power supply. (The black cable is connected to blue socket, not the ground socket.) Measure the voltage with the wires on the DVM and adjust if necessary. Turn power supply off while adjusting wiring.

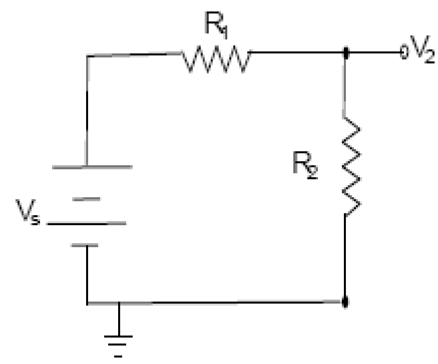

Figure 8. Voltage divider. V_S is 10 Volts, R_1 and R_2 are equal.

4. Voltage divider

4.1. Resistors

Select two 10kΩ resistors. The resistors are color coded. The first two colors are the number, the third is the exponent, and any more refer to precision (10%, 5%, 1%, etc.). The colors refer to numbers in the order of the rainbow, or using some mnemonic (for example, "better be right or your great big venture goes west" for black, brown, red, orange, yellow, green, blue, violet, grey, white, standing for 0,1,2,…9. So you are looking for a brown black orange, for $10\times10^3\,\Omega$.

4.2. Low Impedance divider

Wire a voltage divider as shown in Figure 8: Plug one end of one resistor into the Z column, and the other end into 50E. Plug the other resistor between 50A and the W column. Measure the voltage across the second resistor using the DVM: Plug the negative wire from the DVM into the Z column, and plug the positive wire into the 50 row between A and E. **Record your value on your results sheet**. You should get 5 Volts:

$$V_s = I R_1 + I R_2 = I(R_1 + R_2) \quad \Rightarrow I = \frac{V_s}{R_1 + R_2}$$

$$\Rightarrow V_2 = I R_2 = \frac{R_2}{R_1 + R_2} V_s = \frac{V_s}{2}$$

Measure the voltage across the first resistor using the DVM (move both DVM wires). **Record your value on your results sheet**. These are 10% resistors. Are the two voltages equal to within 10%? Leave the 10K voltage divider in place.

4.3. Neater Voltage Measuring

Rather than having alligator clips and wires hanging out, coming loose, shorting and generally creating confusion, it is better to use the banana sockets and create another strip for voltage probes. Change the black banana-to-alligator cable to a blue or black banana-to-banana cable, and plug it in on top of the black banana socket. (Note this restricts us to measurements relative to the black socket, which we will call ground).

Connect a yellow or orange wire from a second red banana socket to create a third, "probe" strip on the top of the breadboard. Jumper this strip to an unused column on the wiring block. Change the red banana-to-alligator cable to a yellow banana-to-banana cable, and plug it into the second, "probe" red banana socket. Plug a long yellow or orange wire into the "probe" column on the wiring block, and test the voltage V_2 on the meter.

4.4. High Impedance divider—Meter impedance

Select two 10MΩ resistors and wire a second voltage divider. **What is the voltage across the second resistor?** Now the voltage is not evenly divided. It reads less than 5 V. The circuit is really that shown in Figure 9. **Using**

$$V_2 = \frac{R_{||}}{R_1 + R_{||}} V_s \quad \Rightarrow R_{||} = \frac{V_2}{V_S - V_2} R_1$$

What is the parallel resistance? Using

$$\frac{1}{R_{||}} = \frac{1}{R_2} + \frac{1}{R_M}$$

What is the internal resistance of the meter, R_M? Record your values on your results sheet.

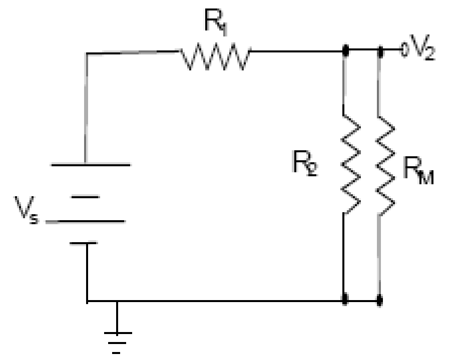

Figure 9. Voltage divider. V_S is 10 Volts, R_1 and R_2 are equal. The internal resistance of the meter is shown as R_M.

5. Using the Oscilloscope as a Voltmeter.

5.1. Finding the trace:

Plug in and turn on the T932 or TDS 1001B oscilloscope (it takes a couple of seconds to warm up).

For T932:

a) Within the appearance controls:

The area with impedance controls is shown in Figure 10. Set the focus and intensity near the middle. Once a green line appears you can adjust these. You may not see the line until you have completed the following adjustments.

b) Within the timebase controls:

Set the hold-off fully counterclockwise. Set the trigger to line, and trigger mode to auto.

Set the time base to 5 µs/div. It is important that the interior red knob be clicked fully left or the scale is meaningless. Put the time base position knob near the middle.

c) Within the vertical controls:

Pick channel one (from dual or channel 2)--that selects which of the inputs the scope is looking at. Ground the channel input by selecting ground with the switch below the Y input on the left. Set the scale to 5 V/div, reading the light scale next to the words (1X probe). The interior red knob must be clicked right.

Adjust the vertical position knob until the green line appears. Line it up on the center horizontal line of the scope display. Switch the input from ground to dc (direct current).

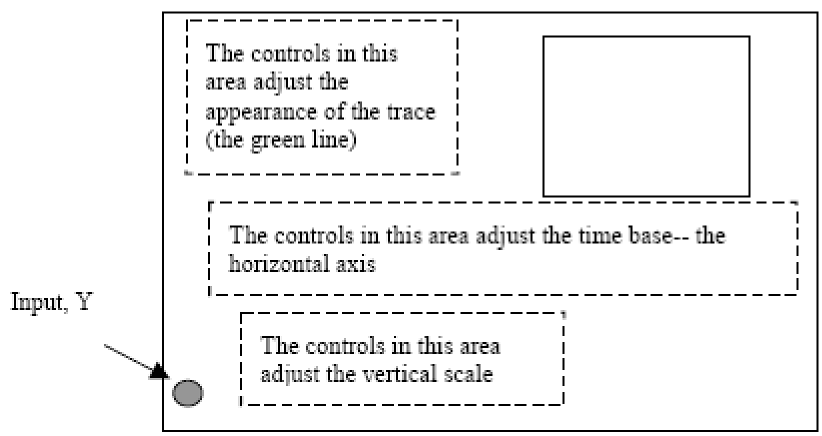

Figure 10. Oscilloscope

d) Adjust: now that you can see a trace, adjust the intensity and focus.

For TDS 1001B:
a) Screen should automatically come up once turned on.
b) Press HORIZ MENU button. Select Set Trigger Holdoff to the minimum value (500.0ns). Press TRIG MENU button. Set Source to CH1, Type to Edge, Mode to Auto and time base to 5.ooμs (using SEC/DIV knob).
c) Set the scale to 5V/div. Adjust the vertical position knob to overlap center horizontal line (CH1 vertical position 0.00 divs (0.00V))

5.2. Connecting to the breadboard
Connect the bnc to banana connector (as shown in Figure 11) to the input of oscilloscope. Move the banana cables from the DVM to the scope. Move the yellow or orange probe wire to +10 and verify that the scope displays 10V. Move the probe wire to the output of the 10 kΩ voltage divider. **Record your voltage on the results page.**

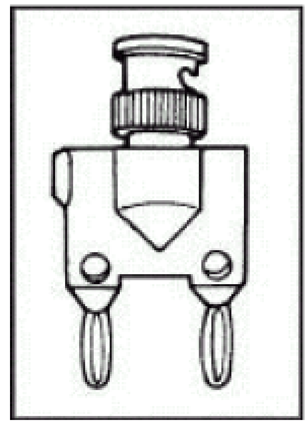

Figure 11. BNC-to-banana connector. The side with the tab (left above) is connected to the outer (ground) side of the cable.

5.3. Scope Impedance
Repeat using 10 MΩ resistors. **Record your voltage** (it should be small.) If the voltage is hard to read, change the number of volts/div. **What is the parallel resistance (see 4.4)? What is the resistance of the oscilloscope?** Verify the order of magnitude of your results by measuring the output of a divider with 1 M Ω resistors and with 100 kΩ resistors—if the resistance is much less than the scope resistance, you should get about 5 Volts. Do you get 5 Volts for either? **Find (by trial and error) the maximum resistor amount that results in 5V measurement (note: keep $R_1 = R_2$).**

5.4. 10X Probe
Replace the connector to the oscilloscope with the 10X probe. (Clip the alligator clip to the ground socket). Set the Voltage scale to 5 V/Div on the 10X scale (0.5 V/div on the 1X scale for T932. Press CH1 MENU, select Probe Voltage and change Attenuation to 10X for TDS1001B), and touch the probe to the side of a resistor wire stuck into +10 V. Do you read 10V? Test ground and the divided voltages with the 10kΩ and 10MΩ resistors. **Record the voltage for the 10M voltage divider. What is the parallel resistance? What is the resistance of the 10X probe? (note: probe is connected in series with oscilloscope)**

6. Variable Voltage Divider
Plug a 10K potentiometer into the board, so for example the center wire is on row 30, and the other two on rows 29 and 31. Jumper +10V to row 29 and ground to row 31.
Measure the voltage (using the DVM) at pin 30 as you rotate the knob with a small screwdriver.
What range of voltages do you find using the potentiometer?

Results Sheet Name:____
Partner’s Name:____

Part 4.2: Measured Voltage across second resistor for 10 k Ω voltage divider__________
Measured Voltage across first resistor for 10 k Ω voltage divider__________

Part 4.4: Measured Voltage for 10 M Ω voltage divider using DVM. _________________
Parallel Resistance______________
Internal Resistance of Meter_______________

Part 5.2: Voltage across second resistor for 10 k Ω voltage divider using scope__________

Part 5.3: Measured Voltage for 10 M Ω voltage divider using Scope. _________________
Parallel Resistance______________
Internal Resistance of Scope_______________
Max resistor that gives 5 V__________________

Part 5.4: Voltage with 10X probe_______________
Parallel Resistance______________
Internal Resistance of 10X probe_______________

Part 6: Range of voltages with potentiometer._________________