PHYSICS 327

LAB 1 - DC VOLTAGE DIVIDER

Homework: Read Faissler Chapters 2-6, 15-16. Do Problems 4.10 – 4.12, 5.1, 6.6.

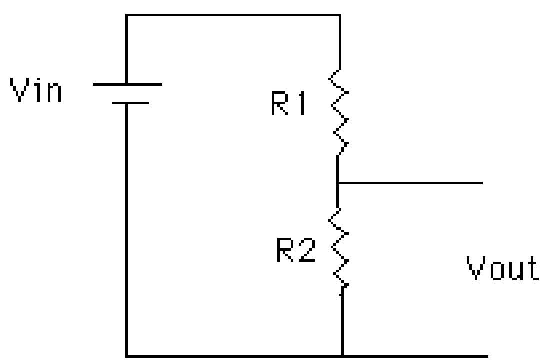
Lab:

Goals:

Learn about voltage dividers and practice using basic electronic equipment.

Part A: Resistive voltage divider

A standard voltage divider is shown below:



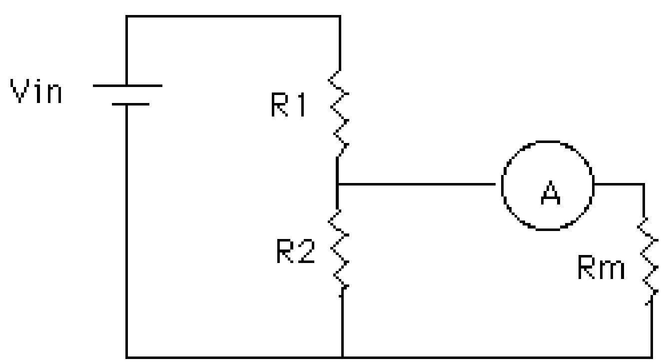
Use a "power supply" provided for the source of the input voltage V_{in}. The circuit is described by the equation $V_{out} = V_{in}\dfrac{R_2}{R_1 + R_2}$.

As long as R_2 is small compared to R_1, the output voltage V_{out} varies almost linearly with R_2, whereas for R_2 large compared to R_1, the output voltage is about equal to the input voltage V_{in}. (Q1) Verify this by working out the appropriate mathematical expressions (first order term + second order correction). Verify the same experimentally, in the following way. First, choose R_1 = 100 kΩ, and let R_2 = 1, 10, 100, 1 k, 10 k, 100 k, and 1 MΩ. Use discrete components, not the resistor boxes, for R_2. Measure each resistor with the multimeter, and compare to the value shown by the color code. Set up the circuit on the prototyping board, and use the power supply to provide V_{in} = 12 V. For each value of R_2, measure V_{in} and V_{out}. Second, reduce R_1 to 100 Ω , and repeat the measurements for all of the values of R_2 equal to and greater than 100 Ω.

For the first set of measurements, graph V_{out}/R_2 vs. log(R_2); this function should be flat in the linear region, where R_2 is small. (Q2) For what values of R_2 is the dependence about linear? For the second set of measurements, graph V_{out} vs. log(R_2). (Q3) For what values of R_2 is $V_{out} \approx V_{in}$? Also put on each plot a smooth curve calculated from the voltage divider equation above.

Loading of a circuit occurs when additional circuitry is connected. To illustrate the concept of loading, consider a voltage divider with V_{in} = 12 V, and $R_1 = R_2$ = 1 kΩ. Rather than directly measuring V_{out}, a 10 kΩ resistor R_m can be put in parallel with R_2, the current through R_m measured, and V_{out} calculated. Draw the circuit, do the measurement, make the calculation, and explain your results (compare to the case with no resistor R_m). Repeat with R_m= 1 kΩ. This demonstrates why a voltage divider is not a very good voltage source. A good voltage source produces output voltage which is independent of the load resistance(R_m , in this case). Remember that an ammeter must be connect in *series* with the circuit being measured.

Caution: It is easy to blow the fuse in the multimeter when measuring current. Do not exceed 30 mA for the input current to the multimeter.



Part. B An LED -- A non-resistive device

In DC networks, we are usually concerned with resistors and voltage sources. Sometimes elements which have a resistance that depends on the applied voltage; in other words, the current is not proportional to the voltage. These are called non-ohmic devices. We will use the light-emitting diode (LED) as an example of a non-ohmic device.

Construct a voltage divider consisting of a resistor R_1 in series with an LED. Choose R_1 = 1 M, 100 k, 10 k, 1 k, and 100 Ω. Be careful when you set up the LED. If the LED is connected without a resistor in series it will burn out, so take care to always have a 100 Ω resistor in series with it. If oriented correctly, current will flow through the LED when the voltage across it is more than about 1 V. If oriented backwards, the voltage across it will be essentially the input voltage, and the current through it will be about 0.

Apply a voltage V_{in} = 5 V. For each value of R_1, measure the current through the circuit, and the voltage across the two elements. Make a plot of voltage across the diode vs. current through it. Calculate the power dissipated in each of the elements. (Q4) For what values of R_1 do you see light from the LED? (Q5) How does the plot demonstrate that the LED does not obey Ohm's Law?