385L/5585 - Laboratory 1 - Introduction to DC Measurements – 23 JAN 2017
Report Due: 06 FEB 2017

Objectives:
1. Proper use of a digital multimeter for resistance, voltage, and current measurements
2. Introduction to the breadboard and power supply.
3. Demonstration of Kirchhoff's laws.
4. Loading of a circuit by the measuring device.

Equipment and Parts:
1. Digital multimeter, probes, and operations handbook.
2. ELENCO breadboard and power supply.

Prior to attempting any of the following procedures, read the manual for the Keithley 2000 digital multimeter (DMM); the concepts presented there are applicable to all the multimeters available in the lab. Be sure all precautions are followed when using the DMM and that the meter is properly connected to the circuit for the measurement being made.

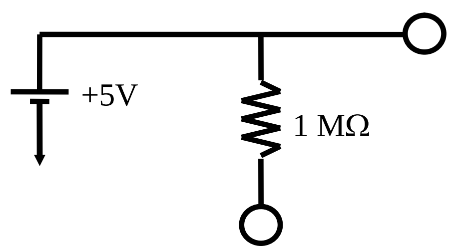
1-1 Resistance measurements
Select various resistors ranging from 10 Ω to 10 MΩ, increase the resistance values by a factor of 10. Measure the resistance using the DMM. Note any discrepancy between the measured value and the value stamped or marked in bands on the resistor. Be sure the resistor is firmly grasped by the lead clips before making your measurement. What effect is observed if you hold the resistor leads in both hands while making the measurement? Is the effect different for the various resistors? Select 2 resistors types (e.g., metal film vs. carbon) in the 10 kΩ range. Using a heat gun warm the resistor and measure the resistance as the temperature increases. Compare this value to the resistance at room temperature.

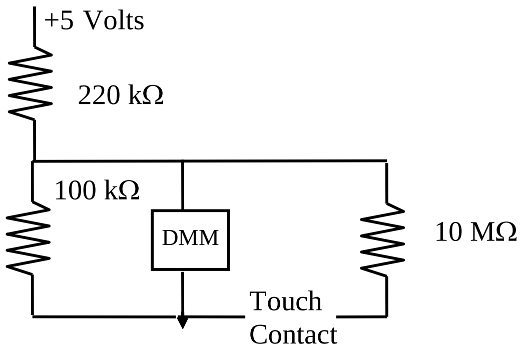
1-2 Introduction to the breadboard frame
Use the DMM in resistance mode to verify the interconnections of the breadboard (the breadboard should not be electrically energized). Please describe and/or draw the interconnections in the lab report.

1-3 DC Voltage measurements
Apply power to the breadboard from the ELENCO power supply and verify the voltage outputs and their ranges. Be sure to change the DMM from resistance to DC voltage modes. Using an empty breadboard connect the associated power supply pins. You should get in a habit of using the banana and BNC connectors to provide a method of connecting an external measuring device. Be sure to place the DMM on the most precise scale without over-ranging the meter.

1-4 Current measurements
Using a 1 kΩ resistor and the +/- 20 Volt variable output, wire a simple resistor circuit. Connect one DMM to measure the charge that flows (current) through the resistor. Connect a second DMM to measure the voltage. <u>Double check all of the wiring to verify it is correct. Be sure neither of the inputs of the DMM used for measuring the current are grounded.</u> Turn on the power and using the adjustment of the voltage source vary the charge through the resistor and monitor the effect with the meters. Does the measured current follow Ohm's law? What influence if any does the non-ideal nature of the meter have on the measurements?

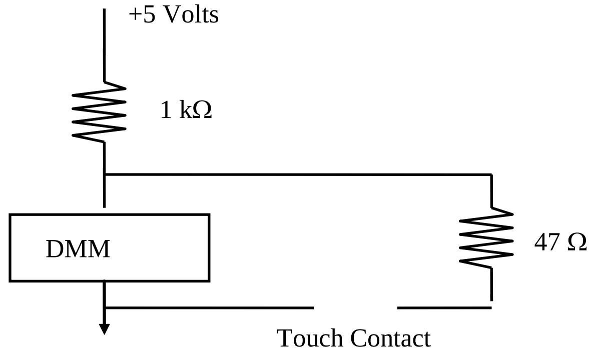
1-5 Meter resistance
Connect a 1 MΩ resistor to the +5 Volt supply. Using the DMM measure the voltage of both sides of the resistor with respect to ground. Are the voltage readings different? If so, why?





Select three resistors, nominally 100 kΩ, 220 kΩ, and 10 MΩ. Assemble the resistor network shown in the figure below. Leave one end of the 10 MΩ resistor unconnected. Measure the voltage across the 100 kΩ resistor with and without the 10 MΩ resistor connected. Describe the results and explain the measured values in terms of a non-ideal voltage source and volt meter.

Select a 1 kΩ and 47 Ω resistor and wire the circuit shown right. Measure the current with and without the 47 Ω resistor. Using Kirchoff's laws, determine the internal resistance of the DMM in current mode. A refresher on Kirchoff's laws is located in the supplementary information on blackboard. Repeat the measurement on a less sensitive scale.



1-6 Voltage dividers

Select two resistors with magnitudes in the 10kΩ to 50 kΩ resistance range. Measure their respective resistance. Place them on the breadboard such that the two are connected in series. Apply the +/- 20 Volt variable output across the resistor network. Using a DMM measure the charge flowing through the resistors and the voltage drop across each resistor. Compare the measured values to those obtained using Kirchhoff's laws. Are there any discrepancies? If so, why? Repeat the measurements for several voltage settings ranging from a positive voltage to a negative voltage. What effect does the negative voltage have on the current and voltage drops?

1-7 Resistors in parallel

Rewire the circuit of 1-6 such that the two resistors are now in parallel. Repeat the current and voltage measurements and compare the results to theoretically computed values.

1-8 Complex circuits

Wire one complex circuit of at least 4 resistors connected in series and parallel. Measure the potential across each resistor and the current through each branch. Verify your measurements using Kirchhoff's laws.

1-9 Charging a capacitor

Place a 5 μF capacitor on the breadboard (BE CAREFUL OF POLARITY IF USING AN UNIPOLAR ELECTROLYTIC CAPACITOR). Connect a jumper to +1 Volt (set from the variable supply) but do not connect the other end of the jumper to anything. Connect the DMM across the capacitor and set it on the low volt range with the low of the DMM on the other end of the capacitor grounded. Turn the power supply on and touch the free end of the capacitor with the free end of the jumper wire which is connected to the +1 Volt supply for 10 seconds. Remove the jumper and record the voltage readings on the DMM as a function of time. The t = 0 s time occurs when you remove the jumper. The capacitor should discharge through the DMM and the voltage should decrease exponentially with time. Fit the exponential decrease and determine the internal resistance from the rate at which the capacitor discharges. (See the appendix.)

Appendix - Least Square fit to an exponential decaying function

Many calculators currently have the capability to perform a linear least square fit to a set of data. These routines can be used for more complex fits by manipulating the expression prior to using the fitting routine. In the case of discharging a capacitor the potential across the capacitor will decrease exponentially with time given by the following equation:

$$V = V_o * e^{t/RC}$$

This equation can be made linear by taking the natural logarithm of both sides giving:

$$\ln(V) = \ln(V_o) + \left(\frac{t}{RC}\right)$$

The graph of this function is linear in the discharge time and the slope is inversely proportional to the constant RC. The x and y data values to be input into the linear fitting routine are t and ln(V), respectively.