

EE 220/220L Circuits I (Fall 2017)

Laboratory 2 Using the Digital Multimeter and Ohm's Law and Laboratory 3 Voltage and Current Division

Background

Digital multimeters (DMMs) measure three main electrical quantities: current, resistance, & voltage. Many DMMs also measure other quantities. Each measurement requires special consideration.

- a) **Resistance** is measured with the DMM (functioning as an *ohmmeter*) connected in **parallel** with the circuit element(s). Before measuring resistance, **de-energize** the circuit (i.e., turn-off any voltage or current sources) and **isolate** (disconnect from rest of circuit) the circuit element(s) being measured! The symbol for an ohmmeter is a circle with an “Ω” inside. Resistance does not have a polarity or direction, i.e., DMM red & black test leads may be connected either way.
- b) **Voltage** is measured with the DMM (functioning as a *voltmeter*) connected in **parallel** with the circuit element(s), i.e., same voltage **across** it. The symbol for a voltmeter is a circle with a “V” inside. On the DMM, the red test lead/terminal is connected to the assumed “+” polarity and the black is connected to the assumed “-” polarity to get a measurement with the correct sign.
- c) **Current** is measured with the DMM (functioning as an *ammeter*) connected in **series** with the circuit element, component, or branch, so it has the same current flowing **through** it. Note, the symbol for an ammeter is a circle with an “A” inside. On the DMM, the current should **enter** through the **red** test lead/terminal (exits black lead) to get a measurement with the correct sign.

Warning! As an ammeter, DMMs have very low input resistances. Connecting it in parallel is like introducing a short circuit into the larger circuit, resulting in large current flows & a blown ammeter fuse. Set DC power supply current limit to **1.5 A** (i.e., 50% of max).

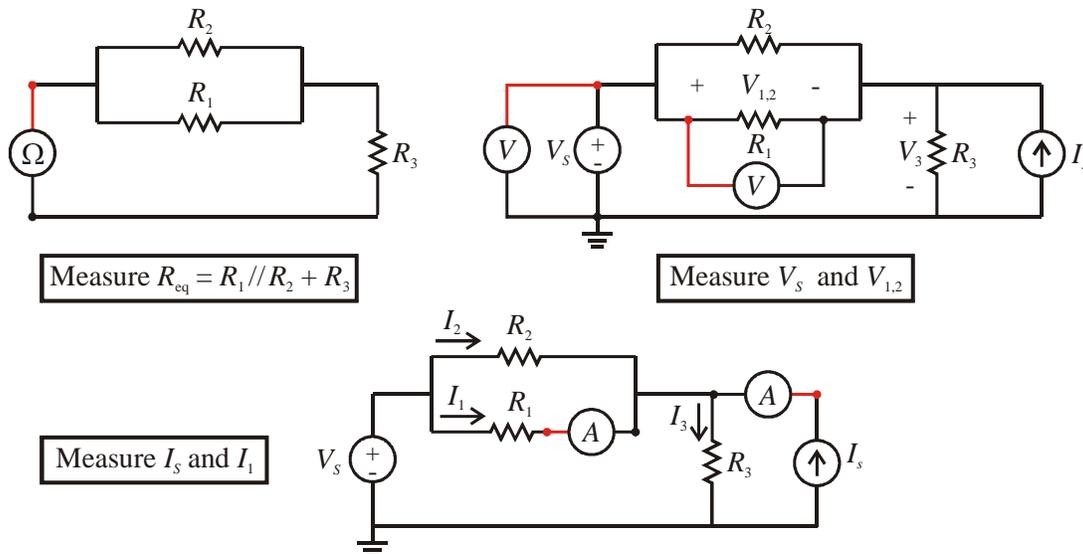


Figure 1 DMM measurement connection examples (**NOT** the circuit used in lab)

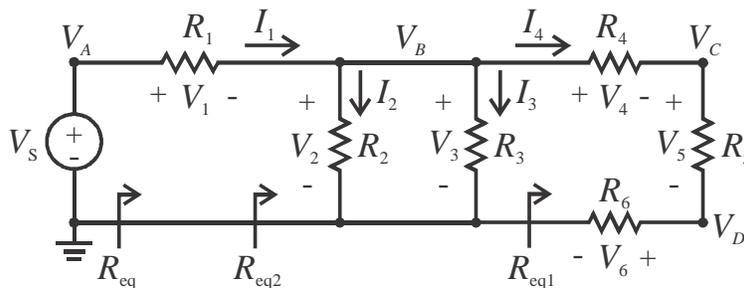


Figure 2 Experimental test circuit

Preliminary

For the circuit shown in Figure 2, let $V_s = 16\text{ V}$, $R_1 = 470\ \Omega$, $R_2 = 2.2\text{ k}\Omega$, $R_3 = 3.3\text{ k}\Omega$, $R_4 = 1\text{ k}\Omega$, $R_5 = 680\ \Omega$, and $R_6 = 1.5\text{ k}\Omega$.

- 1) Given that the resistors in the laboratory are rated for 2 W of power and $\pm 10\%$ tolerance, what are the color bands for the resistors? Put answers in a table. Refer to course web page or internet for references on resistor color bands. Note: use the **four band code**- 1st, 2nd, multiplier, & tolerance [e.g., $250\ \Omega \pm 5\%$ resistor has Red (2) – Green (5) – Brown (x10) – Gold ($\pm 5\%$) bands].
- 2) Sketch the **portion** of the circuit (label all components in circuit sketches) showing the DMM connections (use symbol for an ohmmeter) to measure the equivalent resistance R_{eq2} .
- 3) Sketch the circuit showing the DMM connections (use symbol for a voltmeter) to measure the voltage V_5 . Then, sketch **another** circuit showing DMM connections to measure the voltage V_6 . Label the leads/terminals on the DMM, i.e., red “+” polarity and black “-” polarity.
- 4) Draw the circuit showing the DMM connections to measure the current I_1 . Then, sketch **another** circuit showing DMM connections to measure I_3 . Label the terminals on the DMM (use symbol for an ammeter) to indicate where the current enters and leaves, i.e., enters red and exits black.
- 5) Use parallel/series resistance rules & Ohm’s Law to find resistances R_{eq1} , R_{eq2} , & R_{eq} , and current I_1 .
- 6) Use **current division** to find currents I_2 , I_3 , and I_4 .
- 7) Use **voltage division** to find voltages V_1 , V_2 , V_3 , V_4 , V_5 , and V_6 . Also, find the node voltages V_A , V_B , V_C , and V_D using **KVL** (do NOT use Nodal Analysis).
- 8) Last, calculate the power **absorbed** by each circuit element (including source).
- 9) Have lab instructor/TAs initial your preliminary work before starting the experimental work.

Experimental (NO groups of more than 2)

- 1) Your lab instructor will explain the use of the DMM. Take notes in your logbook.
- 2) Select resistors with values to match those given. Using a DMM, measure and record the resistance of R_1 , R_2 , R_3 , R_4 , R_5 , & R_6 . Then, starting at the right of the circuit, connect the resistors and measure & record R_{eq1} (R_4 , R_5 , & R_6 connected in series), R_{eq2} (parallel combination of R_2 , R_3 , & R_{eq1}), and the overall equivalent resistance R_{eq} seen by the voltage source.
- 3) Add a DC power supply to complete the circuit shown in Figure 2.
- 4) Using a DMM as a voltmeter, adjust DC power supply to specified V_s (record). Measure voltages V_1 , V_2 , V_3 , V_4 , V_5 , & V_6 as well as node voltages V_A , V_B , V_C , & V_D . Record data in logbook.
- 5) Using a DMM as an ammeter, measure currents I_1 , I_2 , I_3 , and I_4 . You must disconnect wire(s) & insert ammeter in **series** to measure current. Be sure to **de-energize** the circuit when making and/or changing connections. Do **NOT** connect an ammeter in parallel! Record data in logbook.
- 6) Have the lab instructor or TA initial your experimental work. Then, disconnect circuit.

Analysis and Conclusions:

- 1) In **four** tables, tabulate the calculated/nominal & measured values for all resistances, currents, voltages, & powers as well as the % difference. Format: col. 1 list variable/quantity names, col. 2 list calculated/nominal values, col. 3 list measured values, and col. 4 list percent differences. Note: % difference = $|\text{measured} - \text{calculated/nominal}| / |\text{calculated/nominal}| * 100\%$.
- 2) Do the measured voltages, currents, and resistances follow Ohm’s Law? Tabulate your check. Format: Col. 1 put measured voltages V_1 through V_6 , col. 2 put V_1 through V_6 calculated by Ohm’s Law, e.g., $I_{x,\text{meas}} R_{x,\text{meas}} = (1.1\text{ A})(5\ \Omega) = 5.5\text{ V}$, and col. 3 list percent differences.
- 3) Discuss and make comparisons between expected and measured results.