

## PHYS245 Lab: Complex d.c. circuits

Purpose:

- Understand the calculations for complex d.c. circuits: mesh analysis, Thevenin and Norton equivalent circuits
- Measure the currents in each branch of a circuit and compared with calculation of mesh analysis.
- Experimentally determine the Thevenin voltage, Norton current, and equivalent source resistance.

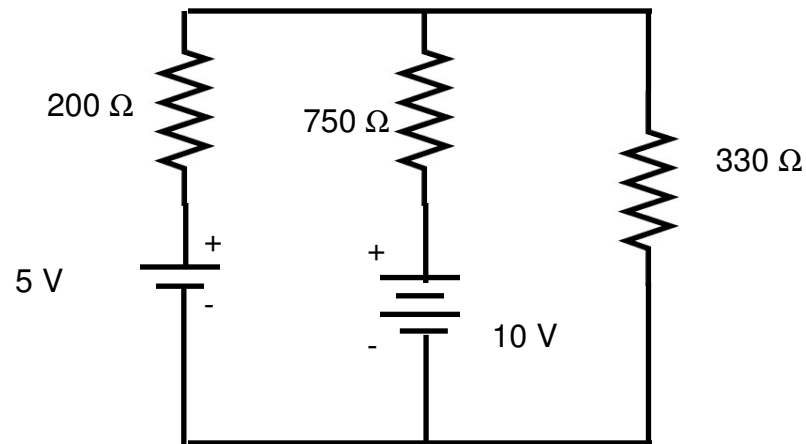
Equipments: ELVIS II, resistors ( $200\ \Omega$ ,  $750\ \Omega$ , and  $330\ \Omega$ ), cables with banana plugs, banana-to-minigrabber cables, and jump wires

A more complex d.c. circuit (involving more than one source and no less than two meshes) may not be easily solved using combination rules. You have learned mesh analysis, Norton and Thevenin equivalent circuits in the lectures. In this Lab, you will be given a chance to apply those theories to a circuit involving two sources and two meshes.



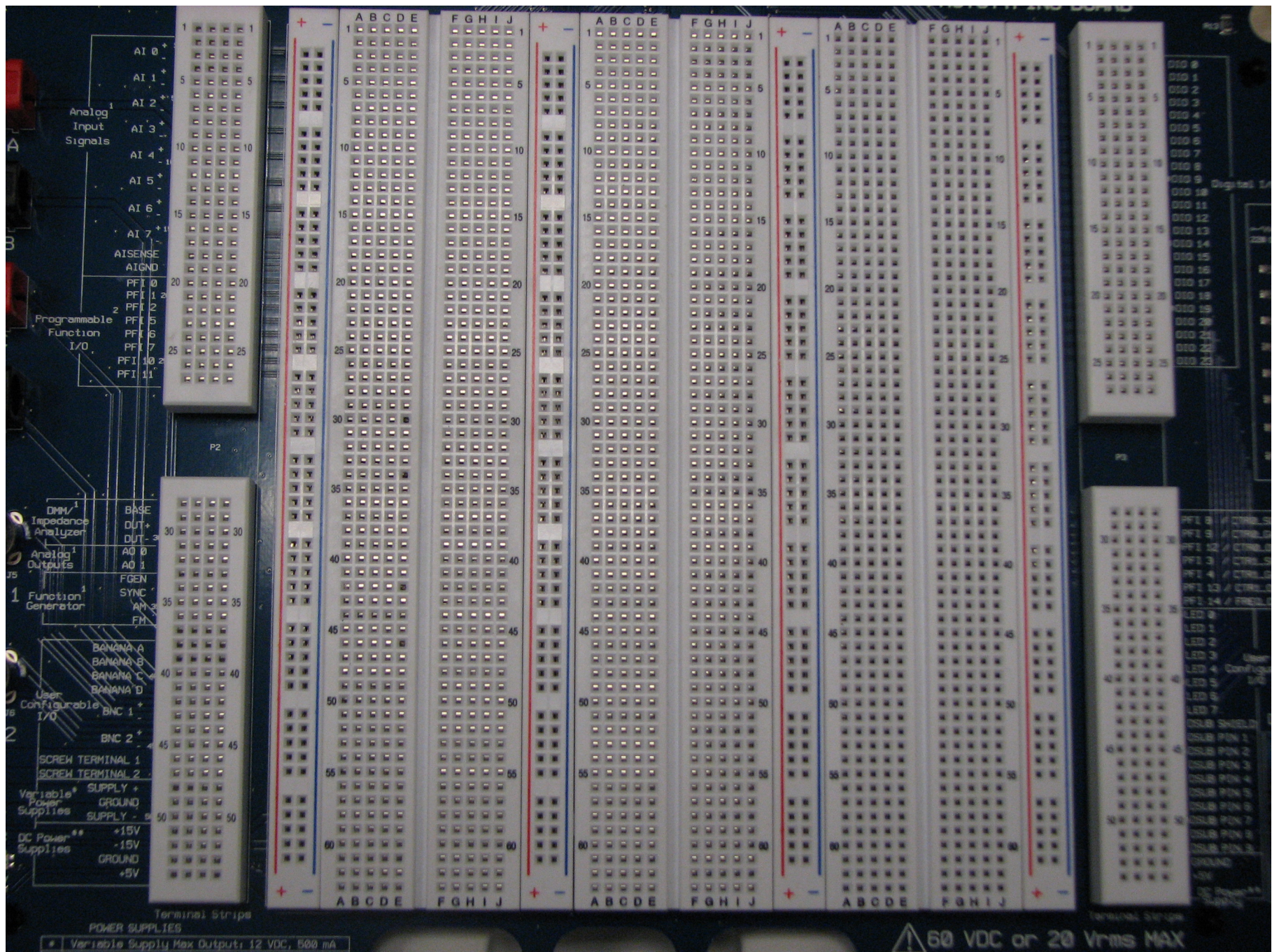
## Pre-Lab exercise

- Use mesh analysis to calculate the currents in each of the three branches in the following two-mesh network
- See the  $330\ \Omega$  resistor as the load. Determine the Thevenin equivalent circuit seen by the load.
- See the  $330\ \Omega$  resistor as the load, determine the Norton equivalent circuit seen by the load.



Thoroughly read through this brochure. Sketch the wirings and placement of resistors on the picture (next page) of the prototyping board. Print out multiple copies of the picture, and use one for each circuit.

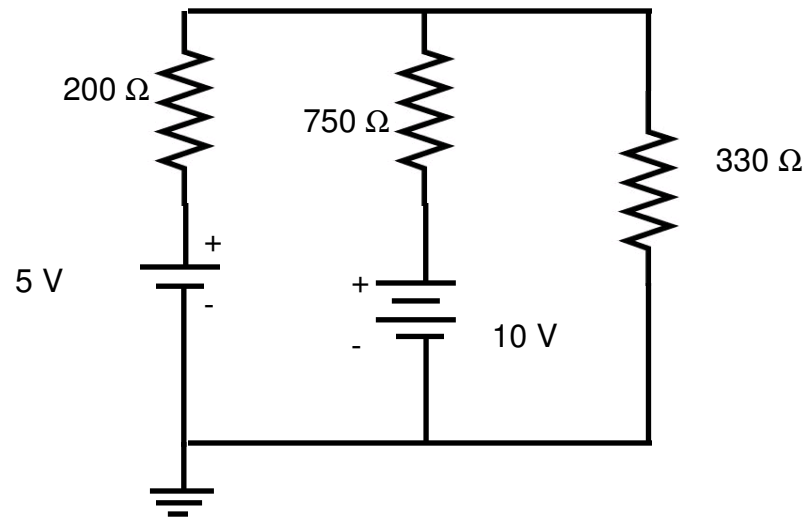






## Experiment I: Verify the mesh analysis theory

Construct the following circuit on ELVIS II. Note that there are two voltage sources. You could use the 5 V source and the 12 V variable power supply to serve the two sources. Identify the resistors provided from the color band. If you are not sure, use the DMM to verify.



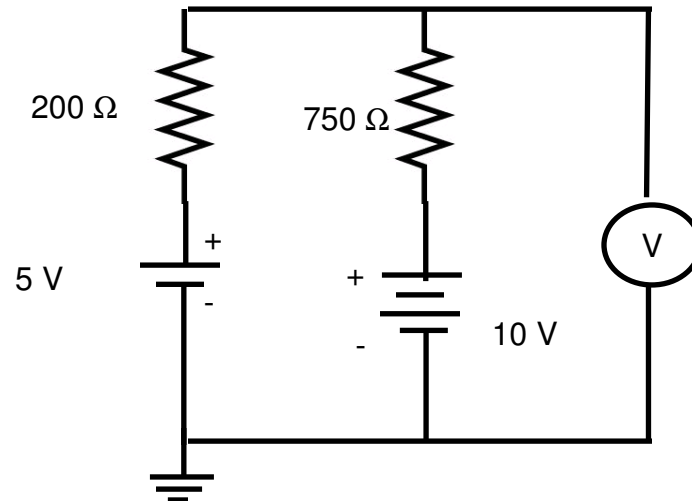
Use the DMM as the Ammeter to measure the current in each of the three branches. Draw the circuit diagram for each measurement on your notebook, and indicate the directions and magnitudes of the current you have measured in each branch. Compare the results of your measurements with the calculations obtained in Pre-Lab.

Hints for circuit construction: There are three branches for this circuit. Choose three separate sections of the terminal stripes and use each section for one branch. This is in a way similar to the circuit with three resistors in series you have done in a previous Lab. Deliver the 5 V power to one bus stripe, and the 10 V power from the VPS to a separate bus stripe. Practice the wirings and placement of resistors in the Pre-Lab.

## Experiment II: Thevenin and Norton equivalent circuits.

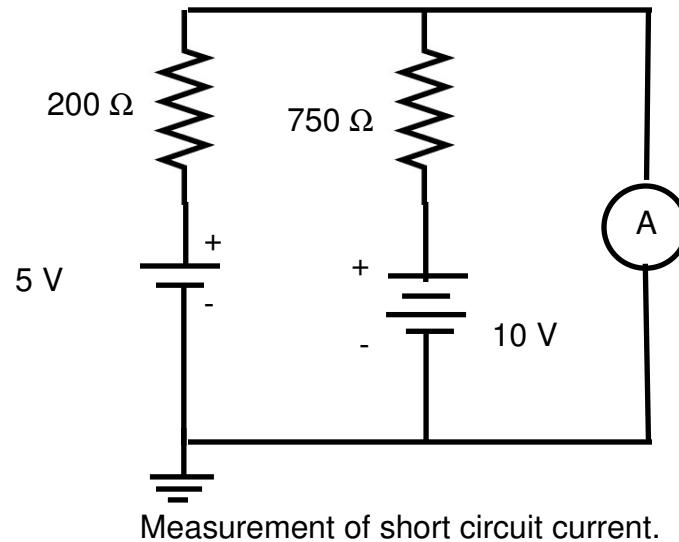
See the  $330\ \Omega$  resistor as the load. The rest of the circuit can be replaced with an equivalent voltage source  $V_{TH}$  in series with an equivalent resistor  $R_{TH}$  (Thevenin equivalent circuit), or a current source  $I_N$  in parallel with an equivalent resistor  $R_N$  (Norton equivalent circuit).

The Thevenin voltage  $V_{TH}$  can be determined experimentally by measuring the open circuit voltage of the network. So replace the  $330\ \Omega$  load with a voltmeter (DMM) and measure this open circuit voltage as shown below.



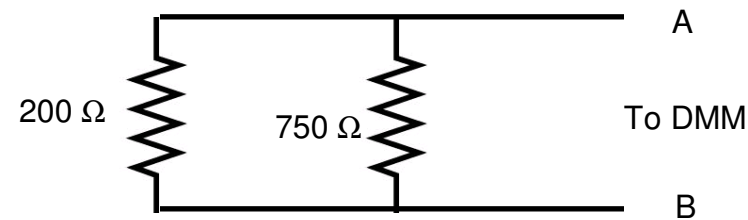
Measurement of open circuit voltage.

The Norton current  $I_N$  can be determined experimentally by measuring the short circuit current of the network. This measurement can be done according to the diagram shown below.



The Norton equivalent resistance is equal to the Thevenin equivalent resistance,  $R_N = R_{TH}$ . Both values equal to the ratio between open circuit voltage and short circuit current. Calculate the  $R_N$  and  $R_{TH}$  from experimental data and compare to the calculations in the Pre-Lab.

The values of  $R_{TH}$  or  $R_N$  can also be determined by “killing the source” and measure the resistance of the network. Rebuilt the circuit according to the following diagram, and measure the resistance between A and B using DMM. Note that the two voltage sources are “killed” by replacing each of them with a piece of wire.



Compare the measured resistance to the equivalent resistance determined earlier using open circuit voltage and short circuit resistance.