Simple resistive circuits: measurements and calculations.

We continue our study of oddly useless circuits as we develop and practice our understanding of basic circuit analysis techniques. This week's lab is part of two-week set in analyzing, measuring, and simulating simple circuits. During this first week, you will build seven different circuits and measure voltages or currents in each. Also, you will analyze each circuit mathematically, using one of the formal methods (node-voltage, mesh-current, superposition). You should be able to use the node-voltage and mesh-current methods now. Since we will not be learning about superposition until the end of the week, you will not be able to do those calculations before lab, unless you read ahead.

Finally, there is a "design it" circuit. Use whatever circuit methods you choose to carry out the design.

During the second week, you will use SPICE (Simulation Program with Integrated Circuit Emphasis) to "build" and simulate each of the circuits on the computer.

The measurements to be done during the first week are quite easy – you can probably complete all the bench work in an hour or two, if you are proficient at building and measuring the circuits. Note that the circuits use the same 5 or 6 resistors over. For the circuits that have multiple DC sources, be careful with the +/– connections. Ask your lab supervisor for assistance if you are unsure about hooking the sources into your circuits.

1. Node-voltage circuits

Analyze circuits 1 – 3 using the node-voltage method. Build each circuit and apply the described DC voltages. In the circuits, suggested nodes to use as ground as indicated. Identify all of the other "unknown" nodes, and use the voltmeter to measure the DC node voltages with respect to the ground. Note: As discussed in class, you are free to choose a different node to serve as ground – you do not need to follow the suggestions. In fact, you should try using different grounds to see how the measurements differ. Of course, the node voltages may change depending on the choice of ground, but the voltage differences across the resistors should be the same.

Figure 1. Node-voltage circuit A.

The source is 10 V DC. (Note that this is a Wheatstone bridge configuration, as described in section 3.6 of the text. The bridge circuit is important historically for its use with resistance-type sensors. In this case, R_4 is the bridging resistor and the circuit is extremely unbalanced – so it is not a particularly good Wheatstone bridge.)

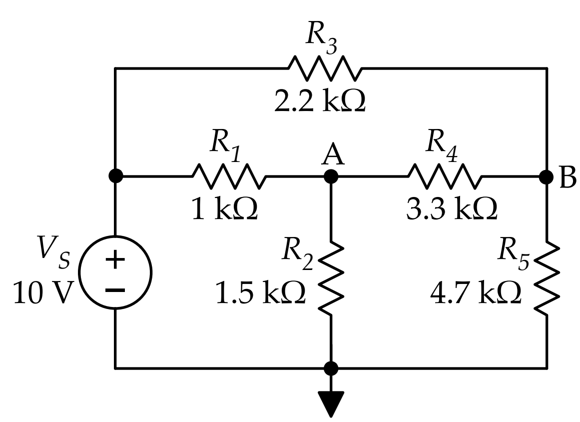


Figure 2. Node-voltage circuit B.

Use the 6-V source and the 20-V source, with negative terminals connected.

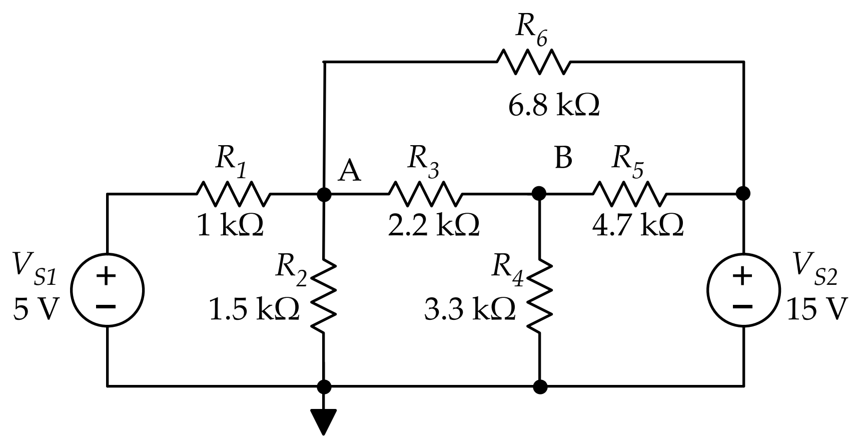
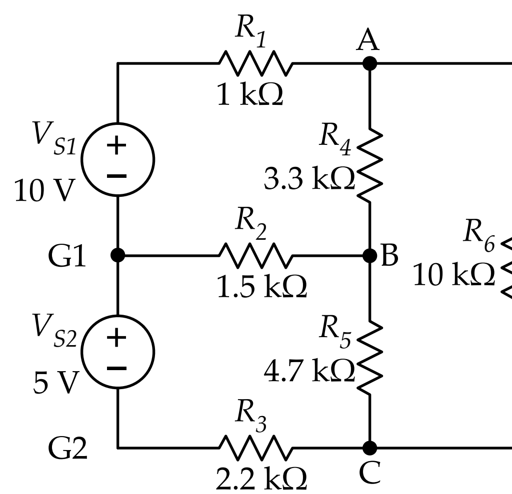


Figure 3. Node-voltage circuit C.

When building the circuit, use the +25-V source for V_{S1} and the +6-V source for V_{S2}. In this case, you will need to connect the positive terminal of the 6-V source to the negative terminal of the 25-V source. Note that the circuit has six nodes, so with even ground and two voltage sources, there will be at least 3 unknown nodes – three simultaneous equations. Nodes G1 and G2 are suggested points for ground for your measurements and calculations. Take your pick. Of course, you can pick one of the other nodes to be ground, but you will run into the "super-node" issue, which adds one more unknown to the analysis.



2. Mesh-current circuits

Analyze the following two circuits in figures 4 & 5 using the mesh-current method. In lab, build each circuit and apply the described DC voltages. Identify each of the mesh currents in the circuit. Measure the current in each resistor, using either the ammeter (inserted in series) or the voltmeter + Ohm's Law.

Figure 4. Mesh-current circuit A.

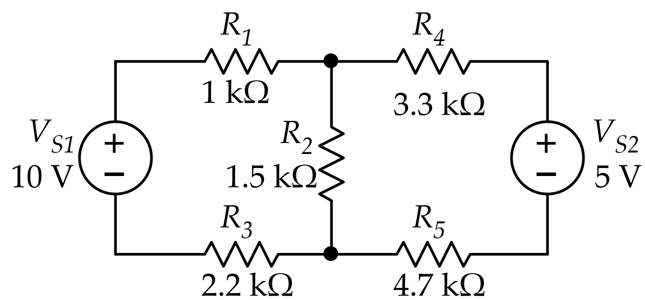
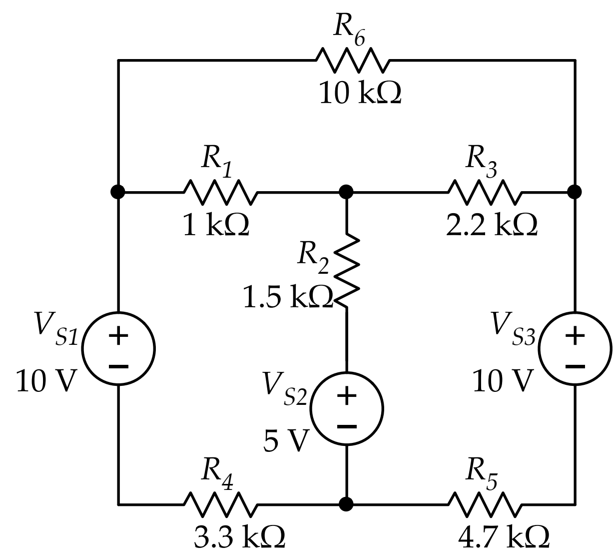


Figure 5. Mesh current circuit B. Note that you will need both triple-output power supplies at the bench – use the +25-V and +6-V sources from one and the +20-V source from the other. The circuit has three meshes in three unknowns, so when calculating the results, the algebra will be a bit tedious.



3. Superposition

Analyze the two circuits in Figures 6 and 7 below using the superposition method to find each resistor voltage. (Use superposition to find the node voltages at points *A* and *B* and then determine the resistor voltages from there.)

In lab, build each circuit and use the voltmeter to measure the voltage at nodes A and B, relative to ground (the bottom node).

Then, use superposition at the lab bench. For the circuit in Fig. 6, remove V_{S2} and replace it with a short circuit – remove the source first and then put in the short circuit. Measure the voltages A and B with respect to ground with only V_{S1} powering in the circuit. Then remove V_{S1}, replacing it with a short circuit, and put V_{S2} back in place. Measure the resistor voltages again. Of course, the sum of the two "partial" measurements should add to the total voltage measured above when both sources were in place. Use the same approach for the circuit in Fig. 7, except that that you will need three partial measurements, one for each source with other two removed and shorted. When measuring the partial voltages, be sure to measure using the same polarity each time.

Note: It is possible to "remove" the source by simply setting the voltage to zero with the source still connected in the circuit. However, he surest way to know what is happening is to physically remove the source and short together the terminals where it had been connected.

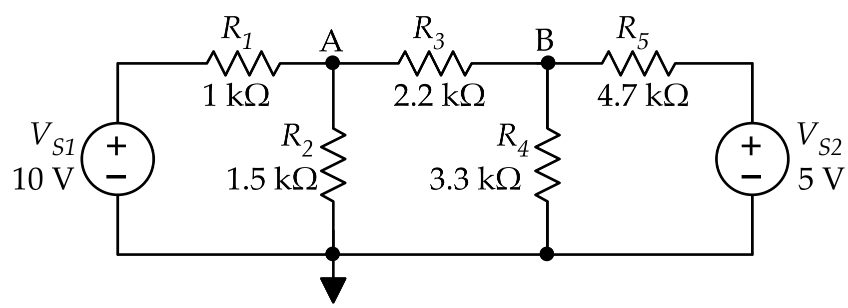


Figure 6. Superposition circuit A.

Use the +25-V supply for V_{S1} and the +6-V supply for V_{S2}. Be sure to connect both negative supply terminals together.

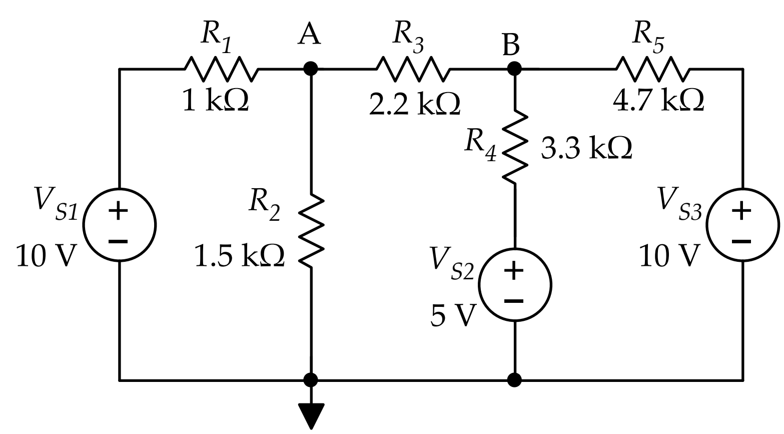
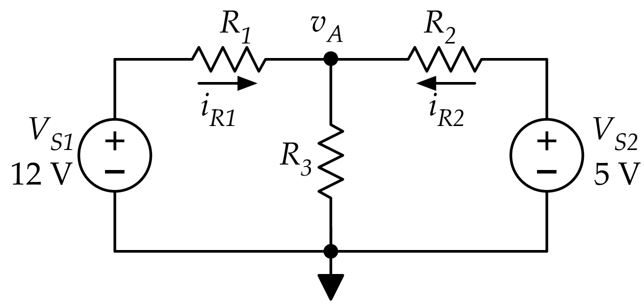


Figure 7. Superposition circuit B.

In building the circuit, you will need both triple-output power supplies at the bench – use the +25-V and +6-V sources from one and the +20-V source from the other.

Design it

Design the circuit shown at right, so that v_A = 2 V, i_{R1} = 1 mA and i_{R2} = 3 mA. In this case, designing means choosing the correct resistor values. Note that you may need to use combinations of resistors to achieve the desired values. It is also permissible to use a potentiometer to get a particular resistor value.



Build the circuit and perform measurements to confirm that it meets the design goals. The voltage and currents don't have to be exact, but they should be within 5% of the specifications.

Demonstrate your circuit to one of your lab instructors.

In the lab report, include the equations and analysis that you used in designing the circuit.

Reporting

Each lab group should prepare a report for the work done in this lab. A template for report can be downloaded from the web site. Be sure to fill in all of the measured data, calculated values, and answer all of the questions. To complete the report, add an introduction and a conclusion (about one paragraph each). The report is due in one week.