



## Voltage and Current Division

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### Purpose:

Apply the theory of voltage and current division.

### Equipment Required:

- 1 - HP 34401A Digital Multimeter
- 1 - HP E3631A Power Supply
- 1 - Protoboard
- 1 - 27 k  $\Omega$ (ohm) 1/4W Resistor
- 2 - 10 k  $\Omega$ (ohm) 1/4W Resistors
- 1 - 10 k  $\Omega$ (ohm) potentiometer

### Prelab:

In your journal, find the voltages  $V_1$ ,  $V_2$  and  $V_3$  in the circuit of Fig. 1, and the currents  $I_1$ ,  $I_2$  and  $I_3$  in the circuit of Fig. 2.

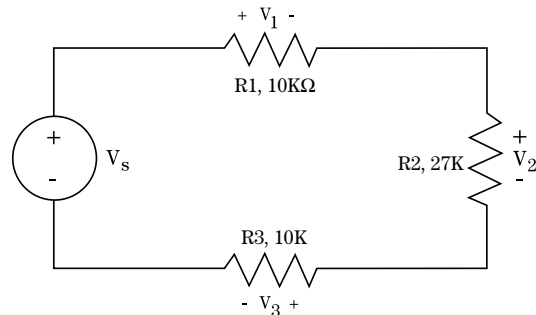


Figure 1

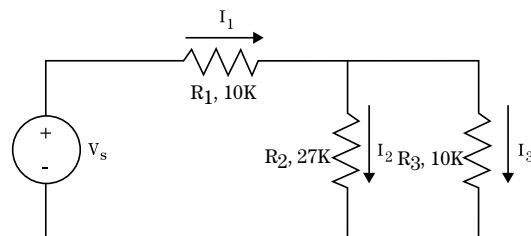


Figure 2

Use a CCA (computer-aided circuit analysis) program to analyze the circuit of Fig. 1 and Fig. 2, using DC analysis. Plot the voltage across all three resistors, as the input voltage is swept from 0 to 5  $V_{DC}$ . Print out the circuit, analysis parameters and the graph of the results. Tape the printout(s) into your lab journal.

### Procedure:

1. Measure element values

Measure and record the actual resistance of each resistor that will be used in constructing the circuits of Fig. 1 and Fig. 2. Label the two 10-k $\Omega$  resistors with their values so that you can keep track of their final locations in the circuits. Measure and record the output voltage of the power supply,  $V_s$ .

## 2. Prepare a data table

Create a table — similar to the one below — for recording your data. Enter the data already collected into the appropriate cells.

**Voltage divider circuit data**

Component label, or signal variable	Nominal R value (From color code)	Nominal voltage (Calc'd in Prelab)	Actual meas. resistance of R's	Actual calc'd volts (from meas. R values)	Actual measured volts	Voltage% error Prelab to actual meas.	Voltage% error Actual Calc'd to act. meas.
$R_1, V_1$	10 k $\Omega$						
$R_2, V_2$	27 k $\Omega$						
$R_3, V_3$	10 k $\Omega$						

Use the measured values for the resistors and  $V_s$  to compute the expected values for the voltages  $V_1$ ,  $V_2$  and  $V_3$ . Enter these results in the column “Actual calc'd volts.” In your lab journal draw a schematic diagram similar to Fig. 1, except label the elements with the measured resistance and computed voltage.

## 3. Collect voltage divider data

- Ensure that the power supply is off. On a protoboard, construct the circuit of Fig. 1. Turn on the power supply and measure the voltages  $V_1$ ,  $V_2$ , and  $V_3$ . Record these values in the data table.
- Fill in the column labeled “% error”. Compare the measured voltage (column F) to the voltage predicted using the actual measured resistance values (column E). The error listed in the last column should be less than 5%. If it is not, try to find the reason. If the error in the last column is not zero, explain why not. Does  $V_1 + V_2 + V_3 = V_s$  for both the computed and measured values? Explain your answer.

## 4. Examine a current divider

Create a table in your journal similar to the one used for the circuit of Fig. 1, but which is modified to record the amperage data for the circuit of Fig. 2. Compute the currents  $I_1$ ,  $I_2$ , and  $I_3$ , and record them in your table. With the power off, construct the circuit of Fig. 2. Use the ammeter to measure  $I_1$ ,  $I_2$  and  $I_3$ . Always turn off the power before making changes in your circuit (such as moving the ammeter to measure current through a different resistor). Record these measured values in your table.

## 5. The potentiometer

- In this part of the exercise you will learn how to use a potentiometer, and why it works. Measure the resistance between the two outermost terminals. With the ohmmeter still connected, rotate the shaft of the device. Record in your lab journal what happens to the measured resistance. Move one of the probes to the center terminal. Rotate the shaft again. Explain what happens in your lab journal.

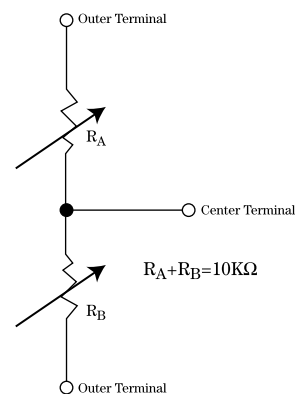


Figure 3



- b. With the power off, construct the circuit of Fig. 4. Turn on the power supply. Adjust the potentiometer so that the output,  $V_{out}$ , is one volt. Shut the power off and disconnect the supply. Carefully, without moving the arm on the potentiometer, measure the value of the resistance between the upper terminal and the center terminal, and again between the lower terminal and the center terminal. Draw the equivalent voltage divider circuit in your journal, and label the resistances with their actual value. Use these measured values and the voltage divider relationship to show that the potentiometer functions as a voltage divider.

## 6. Circuit design

This is a design problem. Ask a lab instructor for a load resistor,  $R_{LOAD}$ . Your task is to design a circuit that will deliver  $1.5\text{ V} \pm 5\%$  across your particular load with the load connected. Figure 4 demonstrates the problem. The resistors available for use in the design are listed in Fig. 4.

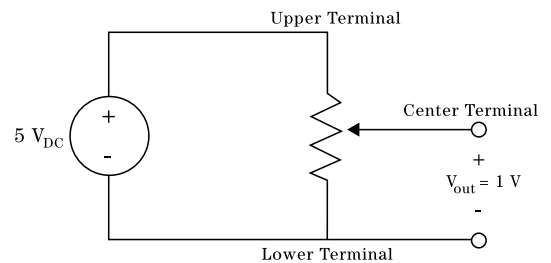


Figure 4

As with most engineering design problems there are constraints. In this case, your design must cost less than 20 cents. Each resistor used in your design costs 6 cents. A potentiometer is available, but costs \$2.32. Assume your time is free.

- a. Design and document in your journal a circuit that will meet the design criteria. Record each of your proposed solutions. If the design is unworkable, explain why. Brainstorm until you have found a solution.
- b. Construct your proposed solution circuit. Verify that it meets the design criteria. When you have the circuit operational, demonstrate the design to your lab instructor. Have your instructor “sign off” on your design in your lab journal.

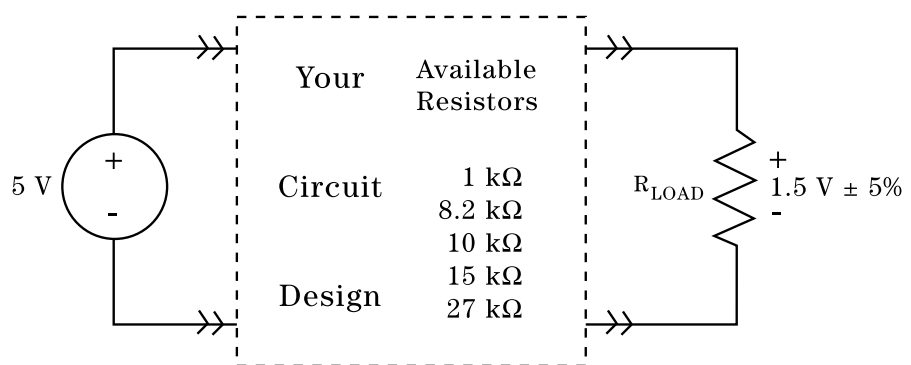


Figure 5

