

## EE301L Spring 2009

## Laboratory Project 3: Voltage and Current Division

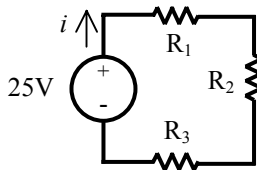


Figure 1: Voltage Divider

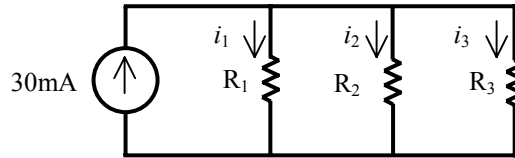


Figure 2: Current Divider

**Preliminary (must be completed before the lab or points are deducted)**

- Given that  $R_1 = 470 \Omega$ ,  $R_2 = 1000 \Omega$ ,  $R_3 = 2200 \Omega$
- Calculate the current and the voltage drops across each resistor as well as the power dissipated by all resistors and record the values in Table 1. These resistors are rated at 2 W, so the maximum power dissipation should be  $<1.5 \text{ W}$  as a safety factor.

Table 1: Voltage Divider Preliminary Calculations

	Calculated Value	Units
$R_{eq}$ (equivalent resistance)		
$i$ (current)		
$v_1$ (voltage drop across $R_1$ )		
$v_2$ (voltage drop across $R_2$ )		
$v_3$ (voltage drop across $R_3$ )		
Percent of $V_s$ dropped across $R_1$		
Percent of $V_s$ dropped across $R_2$		
Percent of $V_s$ dropped across $R_3$		
$P_s$ (power supplied by source)		
$P_1$ (power absorbed by $R_1$ )		
$P_2$ (power absorbed by $R_2$ )		
$P_3$ (power absorbed by $R_3$ )		

- Calculate the voltage and the currents through each resistor as well as the power dissipated by all resistors and record the values in Table 2. These resistors are rated at 2 W, so the maximum power dissipation should be  $<1.5$  W as a safety factor.

Table 2: Current Divider Preliminary Calculations

	Calculated Value	Units
$R_{eq}$ (equivalent resistance)		
$V_{I_s}$ (Voltage drop across all elements)		
$i_1$ (current through $R_1$ )		
$i_2$ (current through $R_2$ )		
$i_3$ (current through $R_3$ )		
Percent of $I_s$ going through $R_1$		
Percent of $I_s$ going through $R_2$		
Percent of $I_s$ going through $R_3$		
$P_s$ (power supplied by source)		
$P_1$ (power absorbed by $R_1$ )		
$P_2$ (power absorbed by $R_2$ )		
$P_3$ (power absorbed by $R_3$ )		

### Experimental – Series Circuit

- Before connecting the circuit measure and record the actual resistance of each resistor.

Table 3: Resistor Values for Voltage Divider

$R_1$	
$R_2$	
$R_3$	

- Construct series circuit on the pegboard.
- Set the voltage source using the DMM (digital multimeter).

- Then connect the power source to the circuit and take voltage and current measurements using the DMM. Also make sure to measure the source voltage. Record these values in Table 4.

Table 4: Voltage Divider Measurements

	Measured Value	Units
$V_s$ (before connecting to the circuit)		
$V_s$ (after connecting to the circuit)		
$i_1$ (current through $R_1$ )		
$i_2$ (current through $R_2$ )		
$i_3$ (current through $R_3$ )		
$v_1$ (voltage drop across $R_1$ )		
$v_2$ (voltage drop across $R_2$ )		
$v_3$ (voltage drop across $R_3$ )		

### Experimental – Parallel Circuit

- Set the current source using the DMM. **NOTE!!!** Start with the current all the way **down**. The fuse in the DMM will blow if you are greater than 25% on some sources. The voltage must be at least as high as the  $V_{IS}$  calculated in Table 2 for the source to work properly.
- Construct parallel circuit on the pegboard and connect the power source. Take voltage and current measurements using the DMM. Also make sure to measure the source current. Record these values in Table 5. See the diagrams on the last two pages regarding how to measure currents. Note: Measuring **ACROSS** a resistor may cause equipment **malfunction**.

Table 5: Current Divider Measurements

	Measured Value	Units
$I_s$ (before connecting to the circuit)		
$I_s$ (after connecting to the circuit)		
$i_1$ (current through $R_1$ )		
$i_2$ (current through $R_2$ )		
$i_3$ (current through $R_3$ )		
$v_1$ (voltage drop across $R_1$ )		
$v_2$ (voltage drop across $R_2$ )		
$v_3$ (voltage drop across $R_3$ )		

## Analysis

1. For the series circuit, **recalculate** the current, voltage drops across the resistors and power absorbed/supplied using the values for resistors recorded in Table 3 and voltage supply recorded in Table 4. Record these values in Table 7.

Table 7: Voltage Divider Calculations (calculated for measured resistors and  $V_s$ )

	Calculated Value	Units
$R_{eq}$ (equivalent resistance)		
$i$ (current)		
$v_1$ (voltage drop across $R_1$ )		
$v_2$ (voltage drop across $R_2$ )		
$v_3$ (voltage drop across $R_3$ )		
Percent of $V_s$ dropped across $R_1$		
Percent of $V_s$ dropped across $R_2$		
Percent of $V_s$ dropped across $R_3$		
$P_s$ (power supplied by source)		
$P_1$ (power absorbed by $R_1$ )		
$P_2$ (power absorbed by $R_2$ )		
$P_3$ (power absorbed by $R_3$ )		

2. Calculate the percent voltage drop across each resistor using the **experimental data recorded in Table 4**.

Table 8: Voltage Divider Experimental Calculations (measured)

	Calculated Value	Units
Percent of $V_s$ dropped across $R_1$		
Percent of $V_s$ dropped across $R_2$		
Percent of $V_s$ dropped across $R_3$		

3. Calculate the percent difference (defined as  $\% \text{ diff} = \frac{|\text{calculated} - \text{measured}|}{|\text{calculated}|} \times 100\%$ ) for the percent dropped across each resistor and record in Table 9. (calculated from Table 7, experimental from Table 8)

Table 9: Voltage Divider Experimental Calculations (measured)

	% Difference
% difference for percent of $V_s$ dropped across $R_1$	
% difference for percent of $V_s$ dropped across $R_2$	
% difference for percent of $V_s$ dropped across $R_3$	

4. For the parallel circuit, **recalculate** the voltage, currents and power absorbed/supplied using the values for resistors recorded in Table 3 and current supply recorded in Table 5. Record these values in Table 10.

Table 10: Current Divider Calculations (calculated for measured resistors and  $I_s$ )

	Calculated Value	Units
$R_{eq}$ (equivalent resistance)		
$V_s$ (Voltage drop across all elements)		
$i_1$ (current through $R_1$ )		
$i_2$ (current through $R_2$ )		
$i_3$ (current through $R_3$ )		
Percent of $I_s$ going through $R_1$		
Percent of $I_s$ going through $R_2$		
Percent of $I_s$ going through $R_3$		
$P_s$ (power supplied by source)		
$P_1$ (power absorbed by $R_1$ )		
$P_2$ (power absorbed by $R_2$ )		
$P_3$ (power absorbed by $R_3$ )		

5. Calculate the percent drop across each resistor using the **experimental data recorded in Table 5**.

Table 11: Current Divider Experimental Calculations (measured)

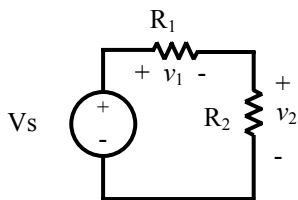
	Calculated Value	Units
Percent of $I_s$ flowing through $R_1$		
Percent of $I_s$ flowing through $R_2$		
Percent of $I_s$ flowing through $R_3$		

6. Calculate the percent difference (defined as  $\% \text{ diff} = \frac{|\text{calculated} - \text{measured}|}{|\text{calculated}|} \times 100\%$ ) for the percent through each resistor and record in Table 12. (calculated from Table 10, Experimental from Table 11)

Table 12: Current Divider Experimental Calculations (measured)

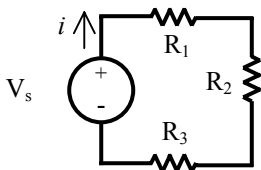
	% Difference
% difference for percent of $I_s$ dropped across $R_1$	
% difference for percent of $I_s$ dropped across $R_2$	
% difference for percent of $I_s$ dropped across $R_3$	

7. For the voltage divider circuit thoroughly understand and explain the following:
- Did the voltage divide in the ratio you had expected? If not, why was there error?
  - Did twice as much voltage drop across a resistor that was about twice as large as another? Hint look at  $R_1$  and  $R_2$ .
  - Did three times as much voltage drop across a resistor that was about three times as large as another? Hint look at  $R_1$  and  $R_3$ .
  - Given the circuit below, determine what percent (or fraction if you prefer) of the source voltage would drop across each of the two resistors. The first one is done as an example.

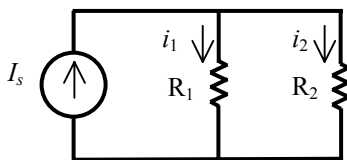


$R_1$	$R_2$	Portion of $V_s$ dropped on $R_1$	Portion of $V_s$ dropped on $R_2$
1000 $\Omega$	1000 $\Omega$	$\frac{1}{2} V_s$ or 50%	$\frac{1}{2} V_s$ or 50%
500 $\Omega$	1.5 k $\Omega$		
2000 $\Omega$	3000 $\Omega$		

- Using Table 4, calculate  $v_1 + v_2 + v_3 = \underline{\hspace{2cm}}$ . Is this close to the value of  $V_s$  calculated proving that the summation of voltage drops/gains around a closed loop must zero (KVL)?
- Check that Ohm's Law hasn't become invalid in the last week by multiplying  $R_1$  from Table 3 and  $i_1$  from Table 4;  $R_1 \times i_1 = \underline{\hspace{2cm}}$  and comparing it to the voltage,  $v_1$  measured in Table 4  $v_1 = \underline{\hspace{2cm}}$ . Are they reasonably close?
- Using Table 7, calculate  $P_1 + P_2 + P_3 = \underline{\hspace{2cm}}$ . Is this close to the value of  $P_s$  calculated proving the amount of power supplied by the voltage source equal the amount of power dissipated by the resistors?
- Using the circuit below and given  $R_2 = 4R_1$  and  $R_3 = R_1$ , determine:
  - The equivalent resistance in terms of  $R_1$ .
  - The current in terms of  $R_1$  and  $V_s$ .
  - The fraction of the source voltage that would be dropped across each resistor.



8. For the current divider circuit thoroughly understand and explain the following:
- Did the current divide in the ratio you had expected? If not, what caused the error?
  - Did twice as much current flow through the resistor that was about half as big as the others?  
Hint: look at  $R_1$  and  $R_2$ .
  - Did about three times as much current flow through the resistor that was about a third as big as the others. Hint: look at  $R_1$  and  $R_3$ .
  - Given the circuit below, determine what percent (or fraction if you prefer) of the source current would flow through each of the two resistors. The first one is done as an example.

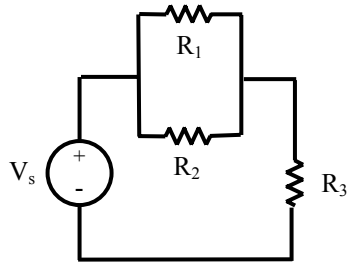


$R_1$	$R_2$	Portion of $I_s$ flowing through $R_1$	Portion of $I_s$ flowing through $R_2$
1000 $\Omega$	1000 $\Omega$	$\frac{1}{2} I_s$ or 50%	$\frac{1}{2} I_s$ or 50%
500 $\Omega$	1.5 k $\Omega$		
2000 $\Omega$	3000 $\Omega$		

- Using Table 5, calculate  $i_1 + i_2 + i_3 = \underline{\hspace{2cm}}$ . Is this close to the value of  $I_s$  calculated proving that the current coming into a node must equal the current leaving the node (KCL)?
- Using Table 10, calculate  $P_1 + P_2 + P_3 = \underline{\hspace{2cm}}$ . Is this close to the value of  $P_s$  calculated proving the amount of power supplied by the voltage source equal the amount of power dissipated by the resistors?
- Using the parallel circuit in Figure 2 and given that  $R_2=4R_1$  and  $R_3=R_1$ , answer the following:
  - What is the equivalent resistance in terms of  $R_1$ .
  - What is the voltage drop across  $R_2$  and  $R_3$  as compared to the voltage drop across  $R_1$ ?
  - What is the voltage across source in terms of  $I_s$  and  $R_1$ .
  - What are the currents through  $R_1$ ,  $R_2$  and  $R_3$  in terms of  $I_s$  and  $R_1$ ? Compare the current through  $R_2$  and  $R_3$  to that going through  $R_1$ .

h.) Given the circuit below and that  $R_2 = \frac{1}{2} R_1$  and  $R_3 = \frac{1}{3} R_1$ . Answer the following:

1. Describe the circuit in terms of series and parallel.
2. Find the equivalent resistance of the  $R_1$  and  $R_2$  combination in terms of  $R_1$ .
3. Find the equivalent resistance of the  $R_1$ ,  $R_2$  and  $R_3$  combination in terms of  $R_1$ .
4. What is the current through the source in terms of  $V_s$  and  $R_1$ ?
5. What is the current through  $R_1$  compared to the current through  $R_2$ ?
6. What is the current through  $R_3$  compared to the sum currents through  $R_1$  and  $R_2$ ?
7. What is the current through  $R_3$  compared to the current through the source?
8. What is the voltage drop across  $R_1$  compared to the voltage drop across  $R_2$ ?
9. What are the voltage drops across the resistors in terms of  $V_s$ ?



Circuit for Problem h

## DMM Used as an Ammeter – Schematics for Measurement

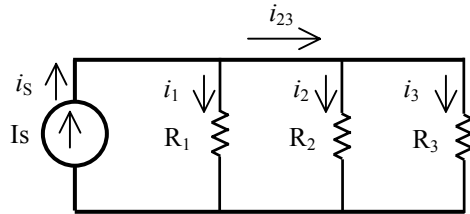


Figure 1: Circuit for Lab 3

If the circuits are wired as shown in the diagram, indicate which current  $i_1$ ,  $i_2$ ,  $i_3$ ,  $i_4$ , or  $i_5$  is being measured by the ammeter. Note wires are only connected at a circle (not crossing)

