nstructional Objectives

1. Familiarize students with series and parallel equivalent resistances.
2. Predict and measure circuit quantities in circuits with series and parallel components.
3. Design a circuit to deliver a specified voltage according to given constraints.

Procedures

0) Parts list: All 1/4W resistors. 1-1.5K, 1-3.3K, 1-6.2K, 1-6.8K, 2-8.2K, 1-20K, 1-30K, 1-33K.

1) Complicated resistor network analysis and measurement:

a) Measure the values of the resistors using the Digital Multi-Meter (DMM). Record the values of $R_1 – R_6$.

R_1=__1.5036 KΩ, R_2=___29.468 KΩ, R_3=___6.7956 KΩ, R_4=_3.305 KΩ, R_5=___6.1455 KΩ, R_6=__19.929KΩ

b) Build the circuit shown in Figure 4.

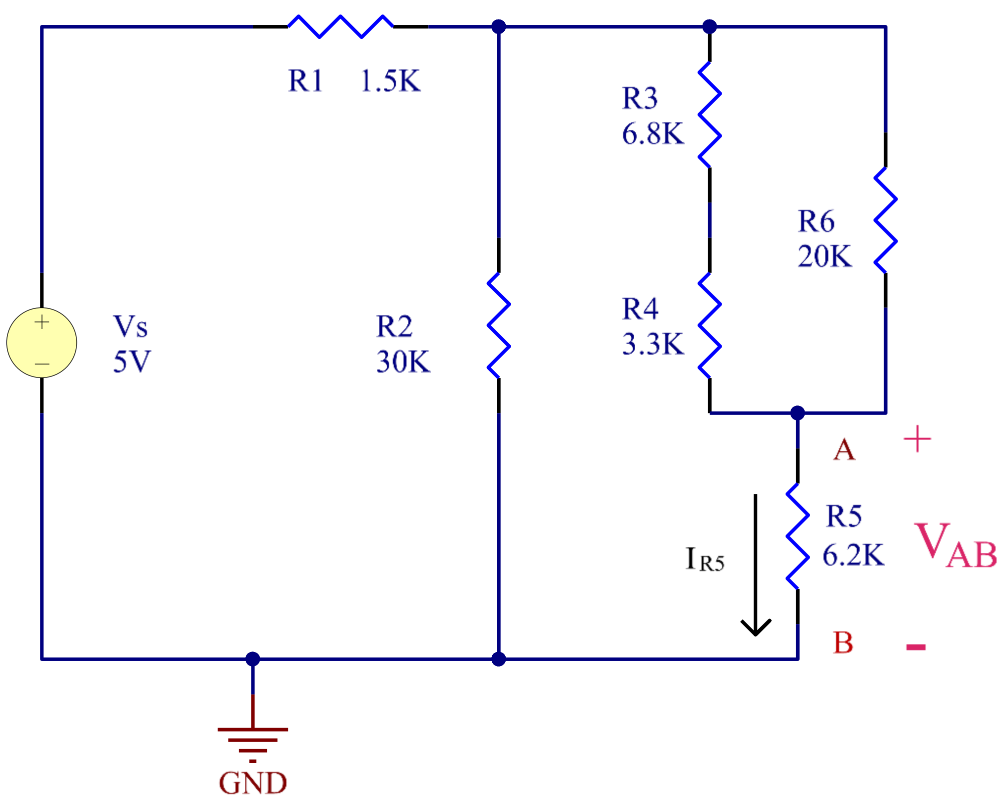


Figure 4: Not So Simple resistor circuit.

Oscilloscope:

c) Set the 6V power supply to 5V DC.

- Connect the 6V power supply terminal to the left side of R1 as shown in Fig 4.
- Connect the COM power supply terminal to GND as shown in Fig 4.

d) Measure the voltage output of the power supply using the DMM. V_S =___5.0118___ V.

e) Use your DMM to measure the voltage drop from point A to point B as well as the current through resistor R_5 (I_{R5}). The procedure to measure current using DMM was covered in Lab 1.

Not So Simple Voltage and Current Division Procedure

V_{AB} =____2.3962V I_{R5} =___.387 mA

f) Use the values of V_{AB} and I_{R5} to calculate the equivalent resistance between points A and B.

Req =______6.19 KΩ.

2) KVL and KCL on a series parallel circuit.

a) Get 2 - 8.2K for R1 and R3 and a resistor between 24K and 39K for R2. Build the circuit in Fig 5. Enter the values in Table 1.

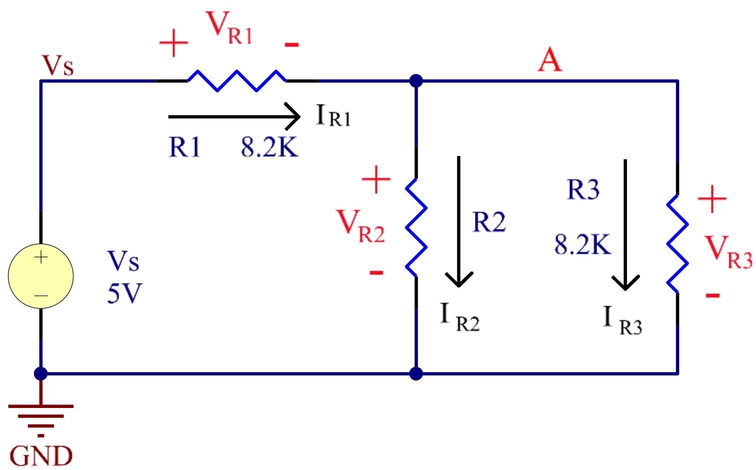


Figure 5

b) Build the circuit in Fig. 5. Use the 6V power supply for $5V_{DC}$.

c) Measure the voltage drop across each resistance (V_{R1}, V_{R2} and V_{R3}) with the DMM. Enter the data in Table 1.

d) Use the measured value of resistance and voltage to “Calculate” I_{R1}, I_{R2} and I_{R3}. (I=V/R). Enter the calculated values of current in Table 1.

e) Determine the values of the current using I=V/R and enter them in the "Theoretical Current” column. (Use the nominal resistor values)

Resistor	Nominal R Value (kΩ)	Measured R Value (kΩ)	Measured Voltage (V)	Calculated Current (mA)	Theoretical Current (mA)
R_1	8.2	8.121	2.804	0.345	.34195
R_2	30	29.946	2.205	0.07363	0.0735
R_3	8.2	8.128	2.205	.2713	0.2689

Table 1: Measured and Calculated Data for Fig. 5.

f) Measure the voltage output of Vs or the power supply using the DMM: V_S=_5.0108 V.

Calculate the % error of your “Calculated Current” values compared to the “Theoretical Current” values. Use the “Calculated Current” values from above in your second column and use the Theoretical values as the reference values for the third column in the % error calculation. Place these results in Table 2.

Resistor	Calculated Current (mA)	Theoretical Current (mA)	Calculated vs Theoretical Error %
R_1	0.345	.34195	0.8919
R_2	0.07363	0.0735	0.17687
R_3	.2713	0.2689	.8925

Table 2: Calculated Data and Errors for Fig. 5.

3) Here is a design problem. Your task is to design a circuit that will deliver 2.0V, or 2.5V, or 3.0V ± 5% across a load resistor of 8.2kΩ. Figure 6 presents the problem.

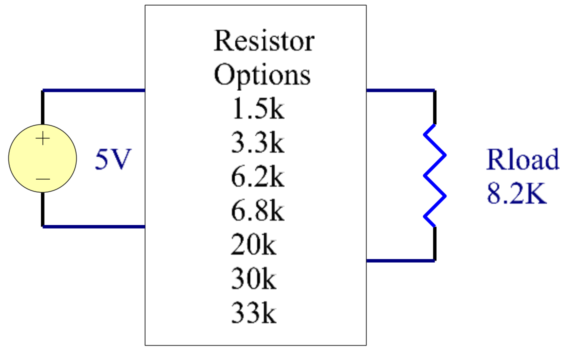


Figure 6: Circuit Design Schematic for Step 3

The resistors available for use are listed in Fig. 6. There are design constraints as with most engineering design problems. In this case, your component cost must be less than 7 cents. You only need to pay for the resistors, which cost 2 cents each. The load resistor is free. Assume your time is free but only this one time ;-).

a) Pick an output voltage across R_{LOAD} of 2.0, 2.5 or 3.0V.
b) Design and document a circuit that will meet the design criteria.
c) Record your proposed solutions and brainstorm until you have found a solution.
d) Construct your proposed circuit. Verify that it meets the design criteria by measuring V_{IN} (5V source) and V_{OUT} (V_{RLOAD}).
e) When your circuit is working, demonstrate the design to the lab instructor/TA. You may use more than one resistor of a particular value.

V_{IN} : 5.018 V V_{OUT} : 2.469

Post Lab Questions

1. Compare the “Theoretical Currents” to the “Measured Currents” for Fig. 5. Explain why they may not be exactly equal. Verify that Kirchhoff’s Current Law applies to this circuit.

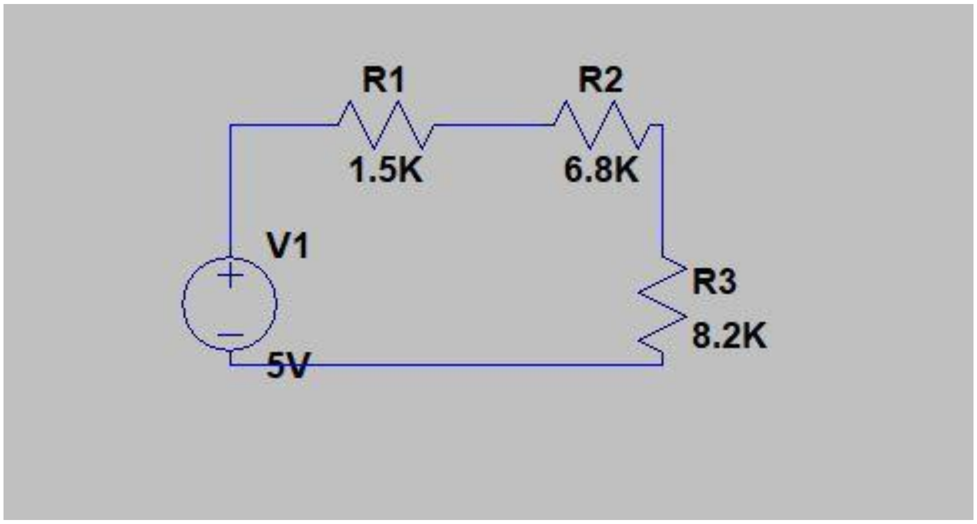
   The currents are not exactly equal due to the standard losses for a non-ideal man-made circuit. Kirchoff’s Current Law definitely applies, as the 2 currents I_{R2} and I_{R3} add up to I_{R1}.

2. For Figure 5, verify KVL for the loop containing Vs, R1 and R2. Use the voltage values that you measured in step 2 of this lab.

   2.205 (V_{R2}) + 2.804 (V_{R1}) – 5.0108 (V_s) = 0 according to the KVL loop. This equation actually comes out to -0.0018, which is reasonably within the range of 0.

3. Verify KCL at Node A of the circuit shown in Figure 5. Use the "Calculated Current" values you entered in Table 1.
   0.345 – 0.07363 – 0.2713 = .00037 mA
   This 0.00037 mA value is close enough to 0 to verify KCL does apply to the currents at Node A.

4. Draw the circuit you designed in step 3. Explain the reasoning you used to get to your final solution and discuss how you verified that the circuit met the design criteria. I recommend you use LTSpice to draw the circuit.



We chose to implement a circuit that cut the 5V source in half. Using the voltage divider equation we were able to find two resistors values that when placed in series had a equivalent resistance that was nearly identical to that of the load resistance. This allowed us to create a circuit that delivered 2.5 V.

5. Assume that the supply voltage was exactly 5V and the resistors were ideal in step 3. What voltage did you choose to put out. For what range of R_{LOAD} will your circuit deliver the voltage you chose $\pm$ 5%? In other words, what is the maximum and minimum resistance of R_{LOAD} for which the circuit will still operate as specified?

We chose to put out 2.5V. The minimum R_{Load} for which the circuit will still operate within 5% as specified would be 7.885 kOhms, while the maximum would be 8.715 kOhms.

6. Refer to Figure 4. Give the currents through R_1, R_2, R_3, R_5 and R_6 when Vs =10V and $R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 1K\Omega$.

I_{R1}	I_{R2}	I_{R3}	I_{R5}	I_{R6}
6.154 mA	3.846 mA	0.769 mA	2.308 mA	1.578 mA