Lab 4
Kirchhoff's Laws and Superposition

In this lab, Kirchhoff's laws will be investigated using a more complex circuit than in the previous labs. Two voltage sources and seven resistors are included in the circuit. Kirchhoff's voltage law will be verified for several loops of this network and Kirchhoff's current law will be verified for several nodes.

Superposition will be also investigated in this experiment. Superposition states that, for a linear circuit, the effect on each individual component due to each source separately activated is algebraically summed when all sources are activated.

To make the measurements:

1. Measure the resistance of each of the resistors, which will be used in the circuit with the digital multimeter. Enter these values into Table 1.
2. Assemble the circuit as in Figure 1 (next page). Recall that the protoboard's connections are as shown in Diagram 1 where every dot that is connected with a line in the diagram represent a hole that is connected on the board.

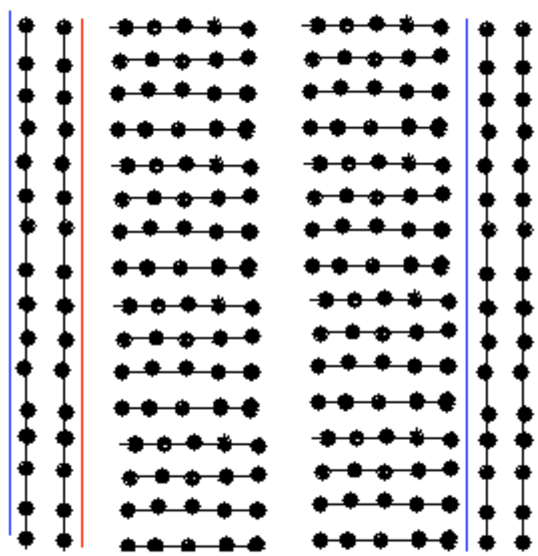

Diagram 1

3. To properly hook up the power supply, be sure that the positive banana cable is connected to the +25V terminal (red) and negative banana cable is connected to the COM (black) terminal. Connect the other ends of the banana cable to the positive and negative ends of the circuit. This will be your +15 volt supply. Turn on the DC power supply and adjust the output voltage to about 15 V. Measure and record the voltage obtained. Do not change this voltage.
4. Measure each of the branch voltages with the digital voltmeter and enter them into Table 1. A branch voltage is the voltage between indicated nodes ($V_{1,0}$ = measure between nodes 1 and 0). **Be sure** to maintain polarity.

5. Measure the current in the R1 branch and enter this value into Table 1. As in previous labs, to measure current you must connect the amp meter **in series** with the component that is being measured (in this case, the amp meter should be in series with R1 as seen in the diagram below).

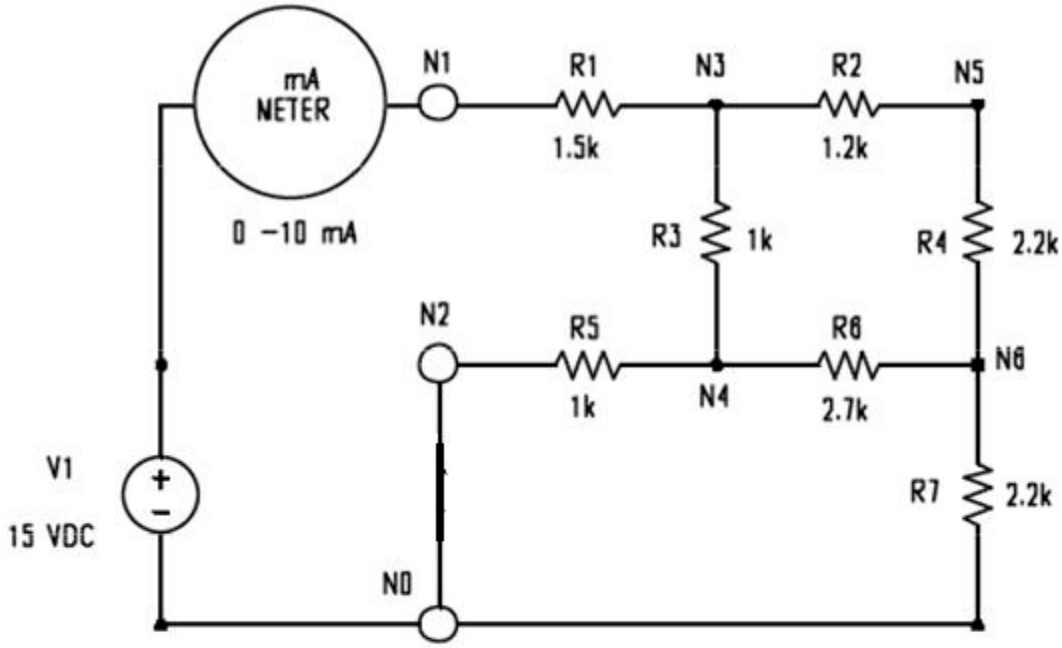

Figure 1

6. Turn the output of the power supply off before disconnecting/reconnecting any portion of the circuit. This should always be done in any lab.
7. Reconnect the circuit as shown in Figure 2. Be sure to note the polarity and magnitude of the new voltage being supplied.
8. Repeat steps 4 and 5.

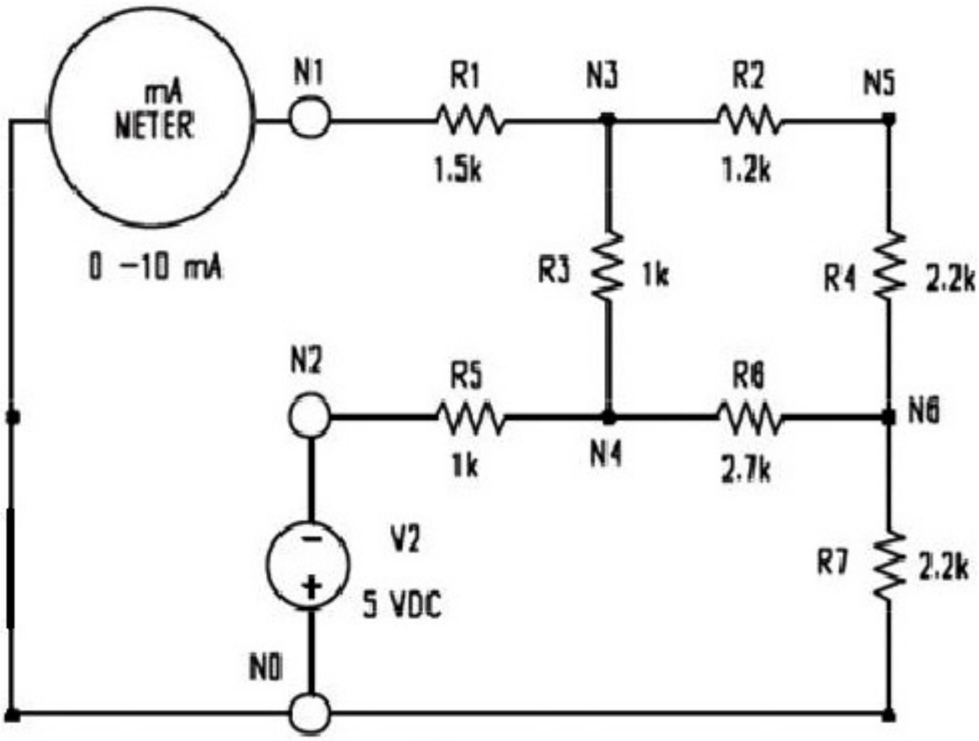

Figure 2

9. Once again, turn the output of the power supply off before changing the circuit.
10. Reconnect the circuit as shown in Figure 3. In order to have both supply voltages connected at the same time, you will need to utilize both the +25V AND the -25V terminals on the power supply. Each terminal is adjusted separately, so you must press the +25V or -25V buttons to adjust each of them. Connect the ground (COM) to node N0. Connect the positive (+) terminal to V1 and the negative (-) terminal to V2.
11. Repeat steps 4 and 5.

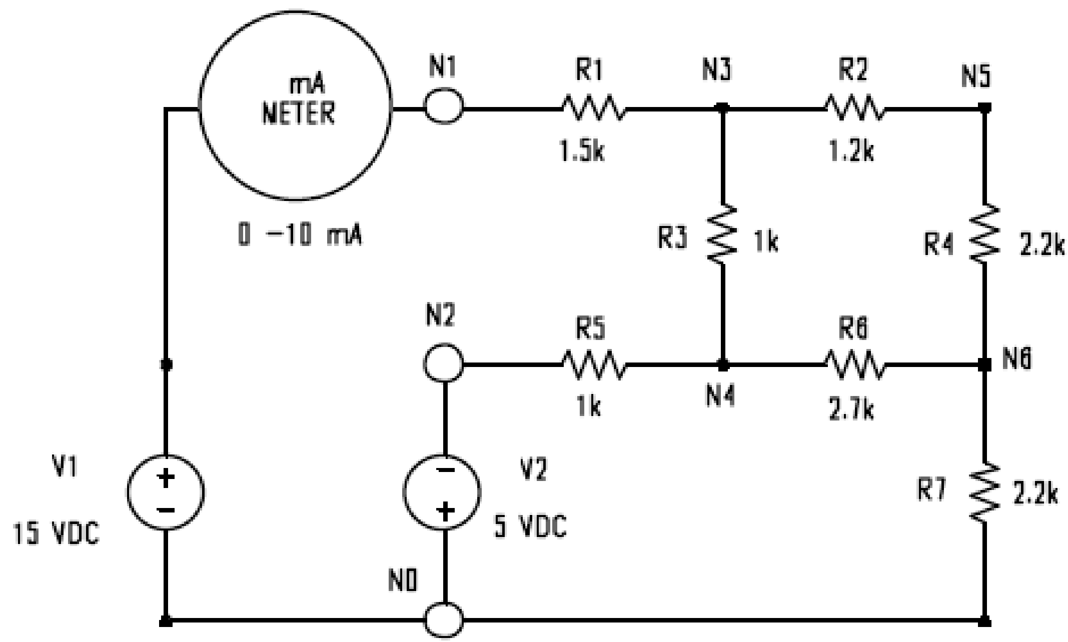

Figure 3

12. Turn off all the power and disassemble the circuit. BE SURE TO PUT THE RESISTORS BACK IN THE **APPROPRIATE** BIN!!

DATA AND REPORT SHEETS FOR LAB 5

Student Name (Print): ____________________ Student ID: _________________________

Student Signature: _______________________ Date: ______________________________

Student Name (Print): ____________________ Student ID: _________________________

Student Signature: _______________________ Date: ______________________________

Lab Section: ____________________________

Table 1. Superposition

Nominal value	Measured value	Circuit 1 (Figure 1)	Circuit 2 (Figure 2)	Circuit 3 (Figure 3)	Sum of Circuits 1 and 2	% difference between last two columns
V1=15V	$V_{1,0}$=	$V_{1,0}$=	$V_{1,0}$=	$V_{1,0}$=	$V_{1,0}$=	
V2=-5V	$V_{2,0}$=	$V_{2,0}$=	$V_{2,0}$=	$V_{2,0}$=	$V_{2,0}$=	
R1=1.5K	R1=	$V_{3,1}$=	$V_{3,1}$=	$V_{3,1}$=	$V_{3,1}$=	
R2=1.2K	R2=	$V_{5,3}$=	$V_{5,3}$=	$V_{5,3}$=	$V_{5,3}$=	
R3=1.0K	R3=	$V_{4,3}$=	$V_{4,3}$=	$V_{4,3}$=	$V_{4,3}$=	
R4=2.2K	R4=	$V_{6,5}$=	$V_{6,5}$=	$V_{6,5}$=	$V_{6,5}$=	
R5=1.0K	R5=	$V_{4,2}$=	$V_{4,2}$=	$V_{4,2}$=	$V_{4,2}$=	
R6=2.7K	R6=	$V_{6,4}$=	$V_{6,4}$=	$V_{6,4}$=	$V_{6,4}$=	
R7=2.2K	R7=	$V_{6,0}$=	$V_{6,0}$=	$V_{6,0}$=	$V_{6,0}$=	
		I1=	I1=	I1=	I1=	

Table 2. Kirchhoff's Voltage Law

Loop (0,2,4,6,5,3,1,0)	Loop (6,4,3,5,6)	Your loop _______________
$V_{2,0}$=	-	
$V_{4,2}$=	-	
$V_{6,4}$=	-	
$V_{5,6}$=	$V_{4,6}$=	
$V_{3,5}$=	$V_{3,4}$=	
$V_{1,3}$=	$V_{5,3}$=	
$V_{0,1}$=	$V_{6,5}$=	
$\Sigma V_{n,m}$=	$\Sigma V_{n,m}$ =	$\Sigma V_{n,m}$=

% error	% error	% error

Questions

1. Add the Circuit 1 and the Circuit 2 voltages for each branch and calculate the percent difference of these from the Figure 3 values. **Show work for the first three cases.**

2. Fill in the first two columns of Table 2 from the Table 1 entries. Keep in mind that $V_{ab} = -V_{ba}$.

3. Pick your own loop and fill in the last column in Table 2 from the Table 1 entries. Be sure to denote your loop.

4. Calculate the sum for each of these three loops and enter it on the table.

5. Calculate the percent error for each loop as the sum divided by the largest branch voltage in that loop times 100 and enter the data in the table.

6. **Calculate** all the currents flowing into node 4 from your voltage measurements and sum them. **Calculate** the currents flowing out of node 4 from your voltage measurements and sum them. Calculate the percent error of current in to current out, as in step 5. Does this agree with Kirchhoff's current law?

   Current in (sum) = ________________

   Current out (sum) = ________________

   % error between current in and current out = ____________________

7. Table 1 shows that we may use superposition for voltages in the circuits used in this lab. Let P4 be the power (P=v*i) dissipated by resistor R4. Can you use superposition of P4 from Figures 1 and 2 to correctly determine P4 for the circuit of Figure 3? Why or why not?