Name: _____

**ECET 231 - Circuit Analysis I**

# Lab 6
# Series-Parallel DC Circuits

**Objective:** Students successfully completing this lab will accomplish the following objectives:
1. Gain experience analyzing and verifying, by measurements, the characteristics of series-parallel resistive circuits.
2. Increase understanding of the relationship of voltage, current and resistance in a series-parallel circuit
3. Learn to compute currents through the use of voltmeter readings.

**Lab Report:** A formal lab report on lab exercises 5, and 6 will be required. Keep your results from this lab exercise. They will be used as part of the formal report. The formal lab report will be due one week after lab 6 is performed.

**Equipment:** Digital Multimeter (DMM), connecting leads, alligator clips, breadboard, jumper wires, LEDs, resistors (100 Ω, 1 kΩ).

**Procedure:**

In a circuit in which the components are soldered to a circuit board, direct measurement of current can be a nuisance. Doing so requires desoldering a connection, measuring the current in the circuit gap, and re-soldering the connection. If the circuit contains a sufficient number of resistors, it may be possible to use a voltmeter and some simple calculations using Ohm's law to determine circuit currents. In this latter method, no desoldering is required. We demonstrate this technique in the following steps.

1. Select three resistors: $R_1 = R_2 = R_3 = 100\ \Omega$, ½ W. Measure the resistors and record the values in Table 1 below.

Table 1: Measured Values of Resistors

| Resistor | Measured Value |
|---|---|
| $R_1$ | |
| $R_2$ | |
| $R_3$ | |

2. Construct the circuit shown in Figure 1 below. Turn the power supply off and then connect it to the breadboard.

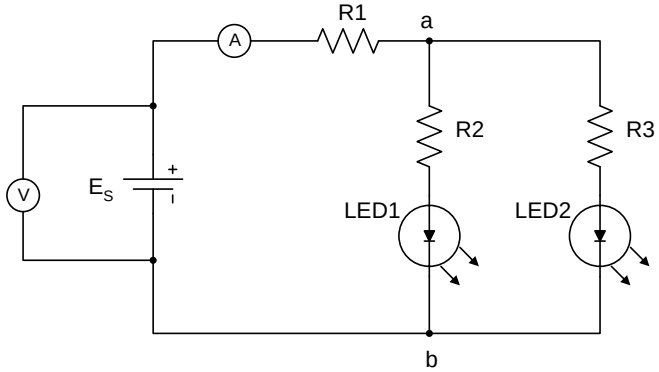


Figure 1: Series-parallel circuit containing LEDs

3. Adjust the power supply to 9 V. Both LEDs should illuminate. Measure and record the resistor and LED voltages in Table 2 below.

Table 2: Measured Resistor and LED Voltages

| Quantity | Measured Value |
|---|---|
| $V_{R1}$ | |
| $V_{R2}$ | |
| $V_{R3}$ | |
| $V_{LED1}$ | |
| $V_{LED2}$ | |

4. Calculate the voltage $V_{ab}$ by adding your measured values of $V_{R2}$ and $V_{LED1}$. Then, calculate $V_{ab}$ by adding your measured values of $V_{R3}$ and $V_{LED2}$. Record your calculations in Table 3 below.

Table 3: Calculated Voltages Across Parallel Branches

| Quantity | Calculation Method | Calculated Value |
|---|---|---|
| $V_{ab}$ | $V_{R2} + V_{LED1}$ | |
| $V_{ab}$ | $V_{R3} + V_{LED2}$ | |

Are the two calculations approximately the same? _____

5. Add the voltages $V_{ab} + V_{R1}$.

$V_{ab} + V_{R1}$ = _____

Based on Kirchhoff's Voltage Law (KVL), what must $V_{ab} + V_{R1}$ be equal to? _____

Does this calculation satisfy KVL? _____

6. With the resistance measurements in step 1 and the voltage measurements in step 3, use Ohm's Law to calculate the various circuit currents.

Table 4: Circuit Currents Calculated from Measured Values

| Quantity | Calculated Value |
|---|---|
| $I_{R1}$ | |
| $I_{R2}$ | |
| $I_{R3}$ | |
| $I_T$ | |

7. Apply Kirchhoff's Current Law (KCL) at node *a*. Write the KCL equation below.

Do the values calculated above for currents $I_{R1}$, $I_{R2}$ and $I_{R3}$ satisfy KCL? _____

8. With the ammeter inserted into the circuit, measure the source current, $I_T$. Record the measured value below.

   $I_T$ = _____

   Are your calculated value for $I_T$ in step 6 and your measured value for $I_T$ in step 8 approximately the same?

   _____

9. Select three resistors: $R_1$ = 100 Ω, $R_2$ = $R_3$ = 1 kΩ. Measure the resistances and record your results in Table 5 below.

Table 5: Measured Resistor Voltages

| Resistor | Measured Value |
|---|---|
| $R_1$ | |
| $R_2$ | |
| $R_3$ | |

10. Connect $R_1$ (100 Ω) in series with $R_2$ (1 kΩ). Attach a 5 V power supply to the series circuit. Measure the resistor voltages. Record your results in Table 6 below.

Table 6: Measured Resistor Voltages

| Quantity | Measured Value |
|---|---|
| $V_{R1}$ | |
| $V_{R2}$ | |

Apply KVL around the circuit loop. Write the KVL equation below.

Do the measured values above satisfy KVL? _____

11. Using the nominal resistor values, show the calculations for the resistor voltages $V_{R1}$ and $V_{R2}$ and the source current $I_T$.

Table 7: Calculated Voltages and Current Using Nominal Resistor Values

| Quantity | Calculations |
|---|---|
| $V_{R1}$ | |
| $V_{R2}$ | |
| $I_T$ | |

12. Connect $R_3$ (1 kΩ) in parallel with $R_2$ (1 kΩ). Measure the resistor voltages and record your results in Table 8 below.

Table 8: Measured Resistor Voltages and Circuit Current

| Quantity | Measured Value |
|---|---|
| $V_{R1}$ | |
| $V_{R2}$ | |
| $V_{R3}$ | |

Since $R_2$ and $R_3$ are in parallel, their voltages should be equal. Are they? _____

Write the KVL equation for this circuit.

Do your measurements support KVL? _____

13. Show calculations for the resistor currents using Ohm's Law along with your measured resistances and resistor voltages.

Table 8: Resistor currents calculated from measured voltages and resistances.

| Quantity | Calculated Value |
|---|---|
| $I_{R1}$ | |
| $I_{R2}$ | |
| $I_{R3}$ | |

Write the KCL equation for these three currents.

Do these calculated values support KCL? _____

14. Using the nominal resistor values, show the calculations for the source current, the resistor currents ($I_1$, $I_2$, $I_3$), the resistor voltages ($V_{R1}$, $V_{R2}$, $V_{R3}$), and powers ($P_{R1}$, $P_{R2}$, $P_{R3}$).

Table 9: Calculated Circuit Currents, Voltages, Powers from Nominal Values

| Quantity | Calculated Value |
|---|---|
| $I_{R1}$ | |
| $I_{R2}$ | |
| $I_{R3}$ | |
| $V_{R1}$ | |
| $V_{R2}$ | |
| $V_{R3}$ | |
| $P_{R1}$ | |
| $P_{R2}$ | |
| $P_{R3}$ | |

15. Compare the voltage $V_{R2}$ in the purely series circuit to $V_{R2}$ in the series-parallel circuit. When $R_3$ is connected in parallel with $R_2$, does the voltage $V_{R2}$:

Increase Decrease Remain the same

**Questions for Lab Report:**

Relevant Theory / Background Information:

- How does a series-parallel circuit work?
- How do the currents flow in series-parallel circuit?
- Which resistor has the most current of the three resistors?
- Current is divided between which two resistors?
- How is the source current related to the resistor currents? Explain using KCL.
- How are the voltages in a series-parallel circuit related? Explain using KVL.
- The source voltage in a series-parallel circuit is divided between which resistor voltages?
- Which resistors in a series-parallel circuit have the same voltage?
- How are powers related in a series-parallel circuit?

Experimental Data / Analysis:

- Were the currents and voltages in the series-parallel circuit close to the calculated values?
- Did the voltages in the series-parallel circuit add up as they should?
- Did the current in the series-parallel circuit add up as they should?
- Did the powers in the series-parallel circuit add up as they should?