Lab 2

Getting started with Ohm's Law, KVL, KCL,
and Multi-Meter Measurements

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1 Introduction

The lab had a few primary purposes: practicing Ohm's law, KVL (Kirchhoff's voltage law), and KCL (Kirchhoff's current law), and learning how to use a Multimeter. The Keysight power supply and digital multimeter were used in this lab, which taught a necessary skillset for all electrical engineers.

2 Results

2.1 A Very Simple DC Circuit

Figure 1: Simple resistor circuit

During this lab section, a very simple circuit (Figure 1) was built on a breadboard.

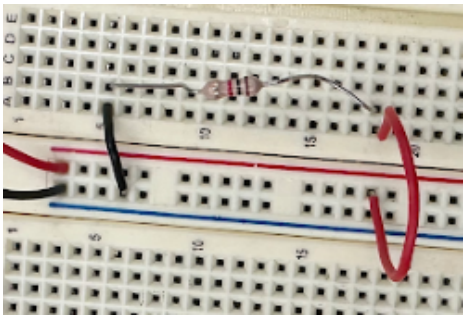

Figure 2: Simple resistor circuit built on breadboard. The red wire is +5V while the black wire is ground.

Figure 2 shows the circuit that was built. The theoretical amperage flowing through the resistor can be calculated using Ohm's Law. This calculation is shown in Equation (1).

$$I = \frac{V}{R}, \text{ where } V = 5V \text{ and } R = 1k\Omega \tag{1}$$

The actual value of the resistor used was found to be $1.0004k\Omega$. When connected to a multimeter the voltage drop was measured to be $4.9986\,V$. The loop current was measured to be $4.9942\,mA$. The measured values were close to the calculated values, which is expected due to the accuracy of the equipment used. The discrepancy between the calculated and measured values can be attributed to the tolerance of the resistor and the accuracy of the multimeter. If the voltage over the resistor doubles then, so will the loop current.

2.2 KCL

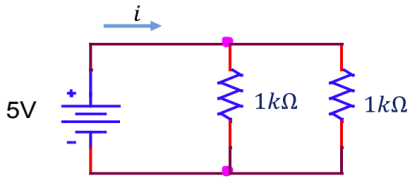

Figure 3: Parallel resistor circuit

During this lab section, a parallel resistor circuit (Figure 3) was built on a breadboard.

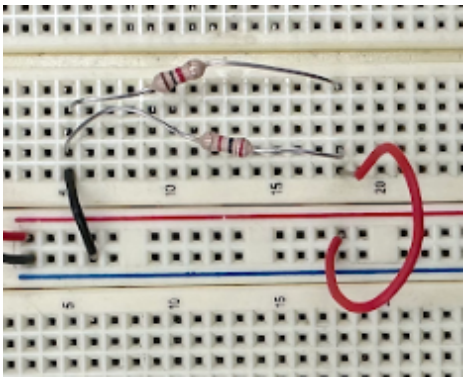

Figure 4: Parallel resistor circuit built on breadboard. The red wire is +5V while the black wire is ground.

Figure 4 shows the circuit that was built. The theoretical amperage flowing through each resistor can be calculated using KCL. This calculation is shown in Equation (2).

$$I_{total} = I_1 + I_2 = \frac{V}{R_1} + \frac{V}{R_2} \tag{2}$$

After plugging in the values, the theoretical current through each resistor was calculated to be 5 mA each.
The actual value of the resistors was found to be:

Resistor	Value ($k\Omega$)
R_1	1.0002
R_2	0.98635

Table 1: Values of R_1 and R_2

After measuring the current through each resistor using the digital multimeter, the values were found to be:

Resistor	Value (mA)
R_1	4.9938
R_2	5.06119
$Total$	10.0501

Table 2: Current Running Through R_1 and R_2

These measured values were close to the calculated values, which is expected due to the accuracy of the equipment used. They also satisfy KCL, as the total current through the circuit is equal to the sum of the currents through each resistor.

After changing R_1 to $2k\Omega$, which was measured to be $1.9419k\Omega$. The current through R_1 was measured to be $2.5714mA$ and the current through R_2 was measured to be $5.0671mA$. The total current was measured to be $7.6329mA$. These values also satisfy KCL.

2.3 KVL

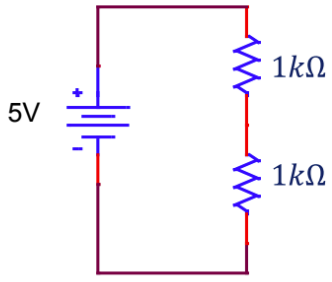

Figure 5: Series resistor circuit

During this lab section, a series resistor circuit (Figure 5) was built on a breadboard.

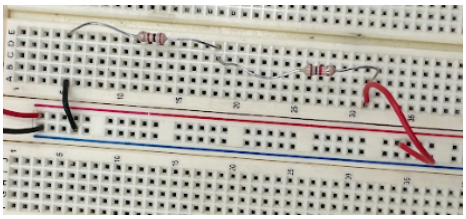

Figure 6: Series resistor circuit built on breadboard. The red wire is +5V while the black wire is ground.

Figure 6 shows the circuit that was built. The theoretical voltages across each resistor can be calculated using KVL. This calculation is shown in Equation (3).

$$V_{total} = V_1 + V_2 \tag{3}$$

After plugging in the values, the theoretical voltage across each resistor was calculated to be $2.5\,V$ each.
The actual value of the resistors was found to be:

Resistor	Value ($k\Omega$)
R_1	0.98601
R_2	0.99970

Table 3: Values of R_1 and R_2

The voltages measured across the resistors were found to be:

Resistor	Value (V)
R_1	2.4822
R_2	2.5172
$Total$	4.9995

Table 4: Voltage Across R_1 and R_2

The results were close to the calculated values, which is expected due to the accuracy of the equipment used. They also satisfy KVL, as the total voltage across the circuit is equal to the sum of the voltages across each resistor.

After changing R_1 to $2k\Omega$, which was measured to be $1.9420k\Omega$. The voltage across R_1 was measured to be $3.3004V$ and the voltage across R_2 was measured to be $1.6990V$. These values also satisfy KVL. Finally, if the two resistors are disconnected from the circuit.

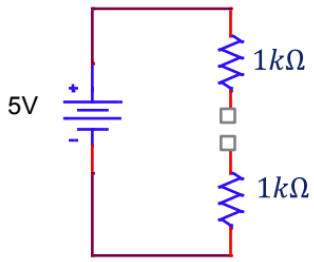

Figure 7: Disconnected (open) circuit

The voltage across the open circuit was measured to be $4.9995V$. The ammount of current flowing through the circuit was $5.000mA$. This measurement implies that the multimeter has a very high resistance, which is why the voltage across the open circuit is the same as the voltage across the circuit with the resistors. In addition, the current flowing through the circuit is the same as the current flowing through the circuit with the resistors.

3 Discussions and Conclusions

In this lab, we successfully verified Ohm's Law and Kirchhoff's Voltage Law (KVL) through practical measurements and calculations. The measured voltages across resistors R_1 and R_2 were consistent with the theoretical values, demonstrating the accuracy of our equipment and the validity of the laws in a real-world scenario.

When R_1 was changed to $2k\Omega$ (measured as $1.9420k\Omega$), the measured voltages across R_1 and R_2 were $3.3004V$ and $1.6990V$ respectively. These values also satisfied KVL, further confirming the reliability of our measurements and the theoretical principles.

Additionally, the voltage across the open circuit was measured to be $4.9995V$, and the current flowing through the circuit was $5.000mA$. These measurements indicate that the multimeter used has a very high internal resistance, which explains why the voltage across the open circuit remained the same as when the resistors were connected.

Overall, the experiment demonstrated the fundamental principles of Ohm's Law

and KVL, and highlighted the importance of accurate measurements in electrical circuit analysis. The results obtained were in close agreement with the theoretical predictions, validating the experimental setup and the procedures followed.

4 References

[1] Dr. Iman Salama. "Lab 2 – Getting started with Ohm's Law, KVL, KCL, and Multi-Meter Measurements" Northeastern University. 9 September 2024.