CS1025 Lab Report n°1

Samuel Petit

Student Number: 17333946

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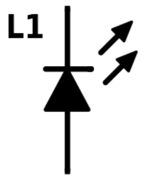
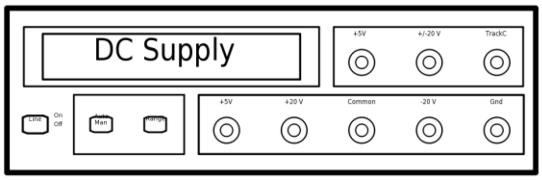
Kirchhoff’s Current, Voltage Law

Introduction

The purpose of this report is to verify both Kirchhoff’s Current and Voltage Laws. During this lab we constructed simple circuits, the first one being in series containing a 5 Volts Direct current (d.c.) power supply, an LED and a 220Ω resistor. The second part added in parallel another resistor (of 50Ω, 100Ω and 200Ω). It is then primordial to understand first the different diagrams.

Understanding Diagrams





A Resistor an LED (Light Emitting Diode) A Direct Current (DC) Power Supply,

During this whole experiment, it was set at 5V

Part 1

The first experiment used the following circuit:

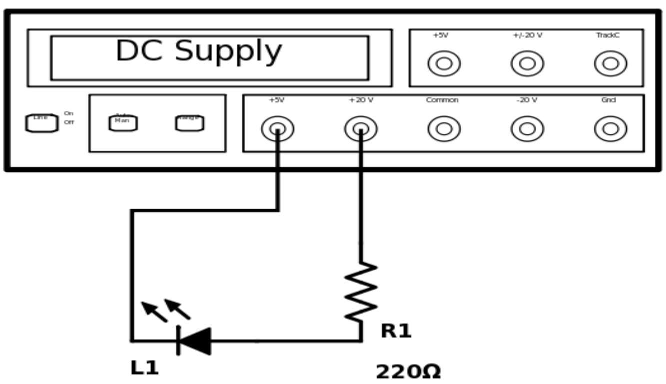


Diagram of the First Circuit built.
With a dc supply of 5V

Once the circuit connected, a multimeter was used to measure:

- The voltage drop across the LED and the (only) Resistor. To measure this, the multimeter was connected in parallel to the component in question.
- The current through the LED and the (only) Resistor. To measure this, the multimeter was connected in series to the component in question.

	Voltage drop(Volts)	**Current(Amps)**	**Does the LED light up?**
Resistor (220 Ω)	1.36V	6.24mA	
LED	3.6V	6.25mA	YES

Measurements for the first experiment, using a 5V dc power supply

Using Ohms law, we can verify the voltage drop across the resistor:

$$V = RI = (220)\ (6.23 * 10^{-3}) = 1.37V$$

A voltage drop across the LED is also noticeable, it occurs as the LED has a higher resistance, which, according to Ohm's law justifies a higher voltage drop than the resistor.

We can calculate the resistance of the LED using Ohm's Law:

$$R = V / I = 3.6 / 6.25*10^{-3} = 576\ \Omega$$

Those results also demonstrate Kirchhoff's Voltage Law:

$$5 - (1.36 + 3.6) = 0.04\ V$$

Taking into account a small margin of error for those measurements, we can consider 0.04V close enough to 0V. This demonstrates Kirchhoff's Voltage Law.

Kirchhoff's Current Law can also be verified as the current entering the resistor is the same as the current entering the LED. That means that the current entering the LED is the same leaving the LED, this also is valid for the resistor. Therefore, Kirchhoff's Current Law is verified for this experiment.

Understanding the formulas useful to these experiments

- Ohm's Law:
  States that: $I = V/R$; $V = I * R$; $R = V/I$.
  Or written: The potential difference across a conductor is proportional to the current through it.
  Where I is the current (in Amperes), V is the potential drop (in Volts) and R is the resistance (in Ohms: **Ω)**
- Kirchhoff's Voltage Law: states that, the sum of all voltages or potential differences in an electrical circuit loop is 0.

The voltage drop across components are given a negative sign while the outward voltage is given a positive. This makes it so that the sum of all is equal to 0.

- Kirchhoff's Current Law:
  States that the sum of all currents that enter an electrical circuit junction is 0. In other words, the sum of currents that enter a junction is equal to the sum of currents that leave the junction.

Lastly, it is important to note the method of calculating the resistance differs for components connected in series and in parallel:

Connected in series:

$$R_{total} = R_1 + R_2 + ... + R_n$$

Connected in parallel

$$1/R_{total} = 1/R_1 + 1/R_2 + ... + 1/R_n$$

Where n is the number of the last resistor connected to the circuit.

Part 2 – Adding a 2nd resistor in parallel

For this second part of the experiment, an extra component was added in parallel to the first circuit: a second resistor. The task was then to measure the voltage drops and current flowing through all the components in the circuit (the 2 resistors and the LED). This had to be done for 3 different value of resistors: 50, 100 and 220Ω

First Circuit – Resistor of 50Ω

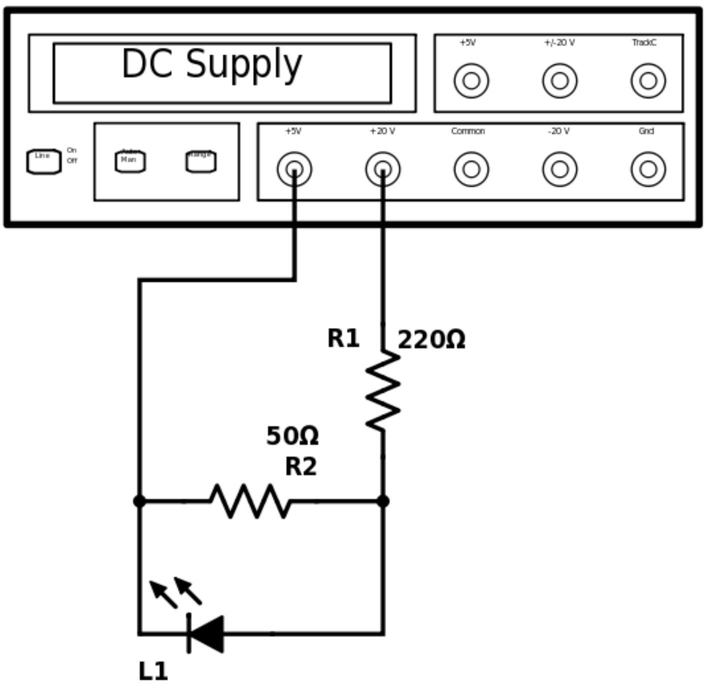


Diagram of the second circuit built with a 50Ω resistor. Using a 5V dc supply

Measurements for this circuit:

	Voltage drop(Volts)	Current(Amps)	Does the LED light up?
Resistor (50 Ω) (R2)	0.93V	18.7mA	
Resistor (220 Ω) (R1)	4.03V	18.6mA	
LED	0.93V	0.1mA	NO

Table of the measurements of the first circuit, using a 5V dc power supply

Verification of Kirchhoff's Voltage Law:

$$5 - (4.03+0.93) = 0.04V$$

Once again, taking into account a margin of error due to measurements, we can consider the value close enough to 0 to verify this law.

Verification of Kirchhoff's Current Law:

$$18.6*10^{-3} + 0.1*10^{-3} = 18.7mV$$

The current out of the first resistor (or the current entering the LED and second resistor) is the same as the sum of currents out of the loop, the law is then verified.

Using the above laws, it is possible to calculate the resistance of the LED:

$R_{total} = V / I = 5 / 18.7*10^{-3} = 267.4\Omega$

$R_{LED+Resistor2} = 267.4 - 220 = 47.4\ \Omega$

$1 / 50 + 1 / R_{led} = 1 / 47.4$; $1 / R_{led} = 1 / 47.4 - 1 / 50$; $R_{led} = 911.5\ \Omega$

The resistance of the LED is too high to allow enough current to pass. This explains why it does not light up and why most of the current is going through the 50 Ω resistor.

Second Circuit – Resistor of 100Ω

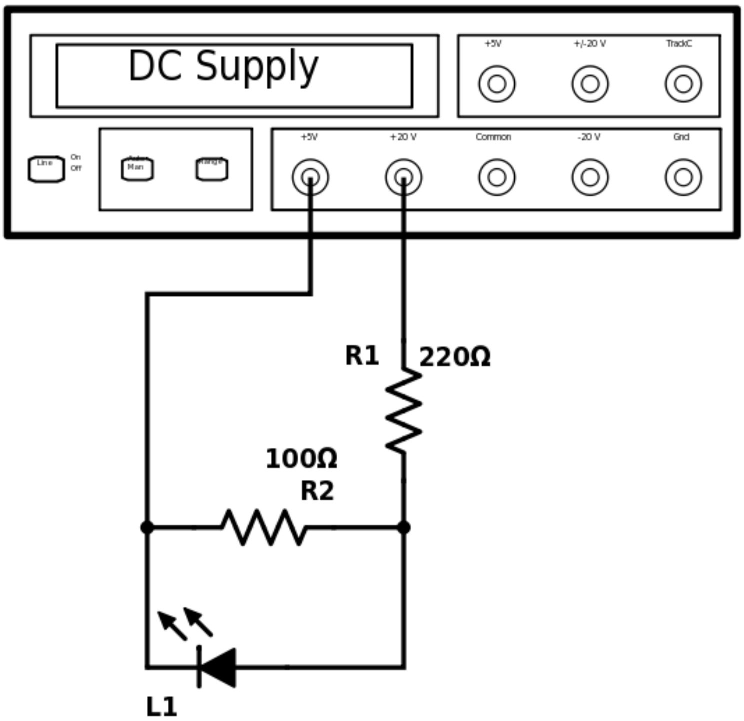


Diagram of the second circuit built with a 100Ω resistor. Using a 5V dc supply

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	Voltage drop(Volts)	Current(Amps)	Does the LED light up?
Resistor (100 Ω)(R2)	1.55V	15.2mA	
Resistor (220 Ω)(R1)	3.41V	15.7mA	
LED	1.55V	0.5mA	NO

Measurements for this second circuit with a resistor in parallel, using a 5V dc power supply

Verification of Kirchhoff's Voltage Law:

$$5 – (3.41 +1.55) = 0.04V$$

Once again, taking into account a margin of error due to measurements, we can consider the value close enough to 0 to verify this law.

Verification of Kirchhoff's Current Law:

$$15.2*10^{-3} + 0.5*10^{-3} = 15.7mV$$

The current out of the first resistor (or the current entering the LED and second resistor) is the same as the sum of currents out of the loop, the law is then verified.

Using the laws for resistance calculation and Ohm's law, it is possible to calculate the resistance of the LED once again:

R_{total} = V / I = 5 / 15.7*10^{-3} = 318.5Ω

$R_{LED+Resistor2}$ = 318.5 -220 = 98.5 Ω

1 / 100 + 1 / R_{led} = 1 / 98.5;   1 / R_{led} = 1 / 98.5 – 1 / 100; R_{led} = 6566.7 Ω

Again, the resistance of the LED is too high to allow enough current to pass. This explains why it does not light up and why most of the current is going through the 100 Ω resistor.

Third Circuit – Resistor of 220Ω

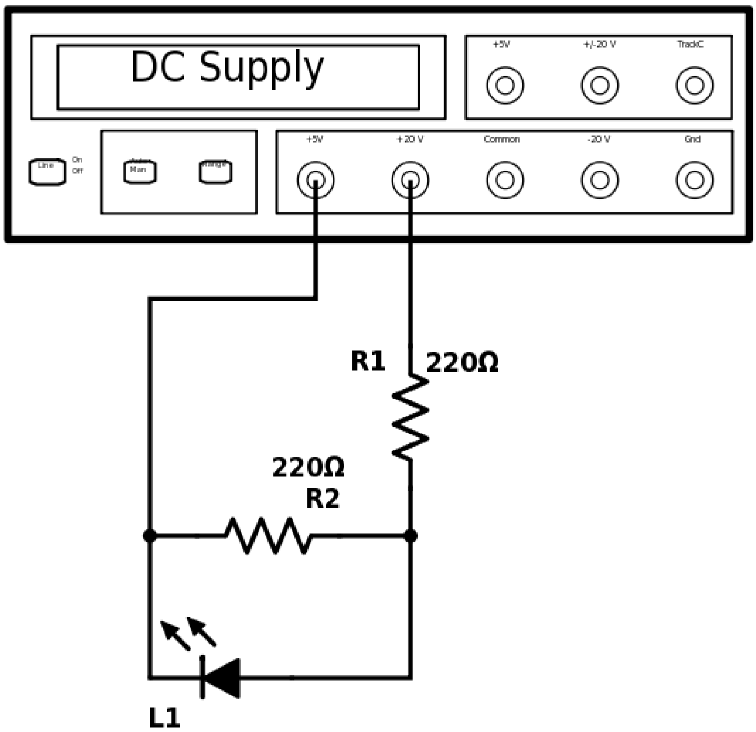

Diagram of the second circuit built with a 220Ω resistor. Using a 5V dc supply

Measurements for this circuit:

	Voltage drop(Volts)	Current(Amps)	Does the LED light up?
Resistor (220 Ω)(R2)	2.29V	14.72mA	
Resistor (220 Ω)(R1)	2.66V	13.05mA	
LED	2.29V	1.67mA	YES

Measurements for this third circuit with a resistor in parallel, using a 5V dc power supply

Verification of Kirchhoff's Voltage Law:

$$5 - (2.66 + 2.29) = 0.05V$$

Once again, taking into account a margin of error due to measurements, we can consider the value close enough to 0 to verify this law.

Verification of Kirchhoff's Current Law:

$$13.05*10^{-3} + 1.67*10^{-3} = 14.72mV$$

The current out of the first resistor (or the current entering the LED and second resistor) is the same as the sum of currents out of the loop, the law is then verified.

Using the laws for resistance calculation and Ohm's law, it is possible to calculate the resistance of the LED once again:

$R_{total} = V / I = 5 / 14.72*10^{-3} = 339.7\Omega$

$R_{LED+Resistor2} = 339.7-220 = 119.7\ \Omega$

$1 / 220 + 1 / R_{led} = 1 / 119.7$; $1 / R_{led} = 1 / 119.7 - 1 / 220$; $R_{led} = 262.6\ \Omega$

This time the resistance of the LED allows enough current to pass. This explains why it lights.