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## Lab Report: Understanding the Speed of Electrical Signals in a Circuit

### Abstract

This experiment tests how quickly a light bulb turns on after flipping a switch in a circuit. The idea was that the bulb would light up in  $1/c$  seconds (where  $c$  is the speed of light) because the electric field travels at the speed of light. A smaller version of the circuit was built, and a high-speed oscilloscope was used to measure the voltage across a resistor (which acted like the bulb). The results showed that voltage appeared across the resistor in just a few nanoseconds, proving that the bulb would light up almost instantly. This experiment shows that energy travels through the electric field, not just by moving electrons.

### Introduction

A common misconception is that electricity is delivered by electrons physically moving through wires from a power source to a light bulb. But this experiment shows that energy is actually carried by electric and magnetic fields, not just electrons. The experiment used a huge circuit with wires as long as the distance light travels in one second. The question was: How long does it take for the bulb to light up after the switch is closed? The guess was that it would take about  $1/c$  seconds because the electric field moves at the speed of light. This experiment helps explain how energy really moves in circuits.

### Materials:

10-meter-long wires (to act like the circuit)

Resistor (to act like the light bulb)

Battery (to power the circuit)

Switch (to turn the circuit on and off)

High speed oscilloscope (to measure voltage)

Pulse generator (to create a quick signal)

Simulation software (to model the circuit)

Method:

**Build the Circuit:** A circuit made with 10-meter-long wires, a switch, and a resistor (acting like the bulb). The resistor was placed one meter away from the switch.

**Set Up Measurements:** A high-speed oscilloscope was connected to the resistor to measure the voltage and current.

**Flip the Switch:** The switch was flipped, and the oscilloscope recorded the voltage across the resistor.

**Simulate the Circuit:** The circuit was simulated using software to see how the electric field and current would behave.

**Collect Data:** The time between flipping the switch and seeing the voltage across the resistor was recorded. The amount of voltage and current was also measured.

## Results

The oscilloscope showed that a voltage of about 4 volts appeared across the resistor just a few nanoseconds after flipping the switch. This meant a current of 4 milliamps was flowing, and about 14 milliwatts of power were being transferred. The simulation confirmed that the electric field traveled at the speed of light, causing the resistor to get power almost instantly.

## Key findings:

The voltage across the resistor appeared very quickly, much faster than expected if electrons had to travel the whole distance.

The time delay matched the speed of light, showing that the electric field was responsible for the energy transfer.

The simulation showed the electric field moving through the circuit and reaching the resistor almost immediately.

## Discussion

The results support the hypothesis that the bulb lights up in  $1/c$  seconds after flipping the switch. This occurs because energy is transmitted through the electric field at the speed of light, rather than by electrons traveling through the wires. This challenges the idea that electrons physically transport energy from the battery to the bulb. Instead, the electric field, established by charge distributions on the wires and battery, is the primary mechanism enabling the bulb to illuminate.

Additionally, the measured voltage and current across the resistor were significantly higher than leakage currents, confirming that the bulb would produce visible light almost instantly. Similar experiments conducted by researchers such as Alpha Phoenix and Ben Watson got similar results in their experiments, which helps confirm these findings.

## Conclusion

This experiment proves that a light bulb turns on almost instantly after flipping a switch because the electric field travels at the speed of light. The results show that energy is transferred through the electric field, not just by moving electrons. This helps us better understand how electricity works in circuits.

## References

Veritasium. (2023). How Long Does It Take for a Light Bulb to Light Up? [Video]. YouTube.

 [How Electricity Actually Works](#)