Simulation of Resistor-Inductor and Resistor-Capacitor Circuits

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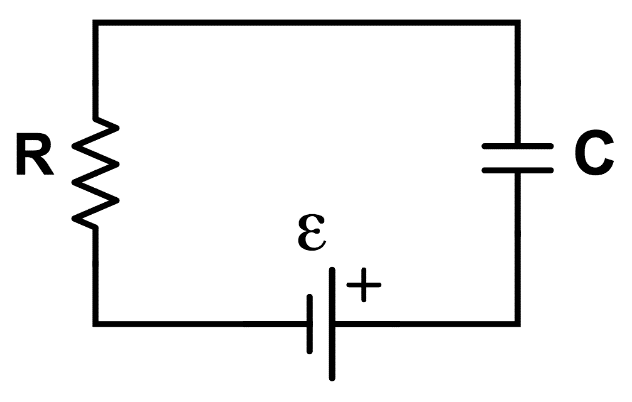
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# Abstract

An RC circuit was built and the voltage across the capacitor was measured. An RC circuit with the same values of capacitance and resistance was numerically simulated from differential equations derived from Kirchhoff’s laws. First the time constant was estimated as ln(2)V0, from the graph, then from the decay of the exponential fit, then from the simulation: the measured results were 3.55ms, 3.546±0.007ms respectively.

# Introduction

Inductor-resistor (RL) and resistor-capacitor (RC) components in series are abundant in modern circuitry. It is important to understand the nature of these circuits for that reason.



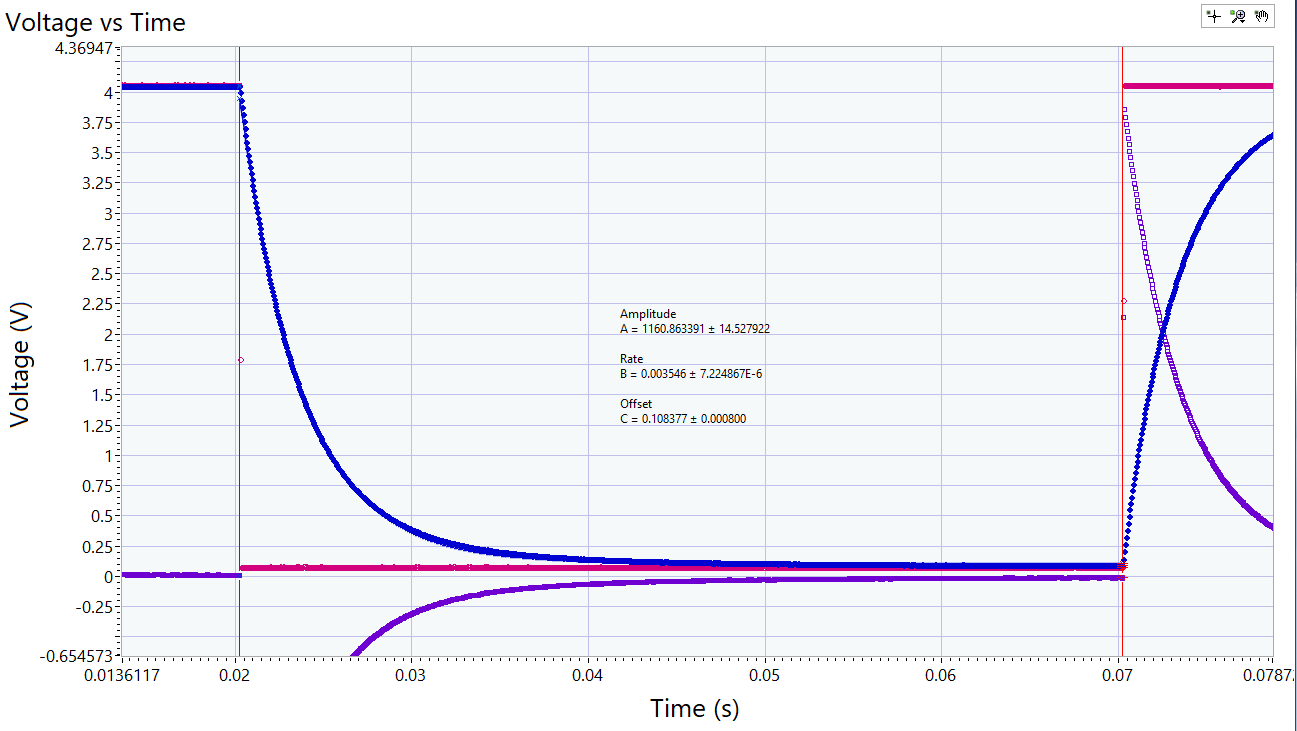
**Figure 1:** Connection diagram of a standard RC circuit.

In RC circuits we find that the voltage across the capacitor “lags behind” the supplied EMF. In IR circuits find that the voltage across the resistor follows a similar pattern. If we supply the emf as a step function, we can fit the supplied voltage to an exponential function and find the decay or time constant. Because of this decay, we can mathematically model each voltage as a function of the input emf. By using differential equations, we can describe the behavior of these circuits. We can then use computers to simulate the results of the experiment by numerically solving the differential equations.

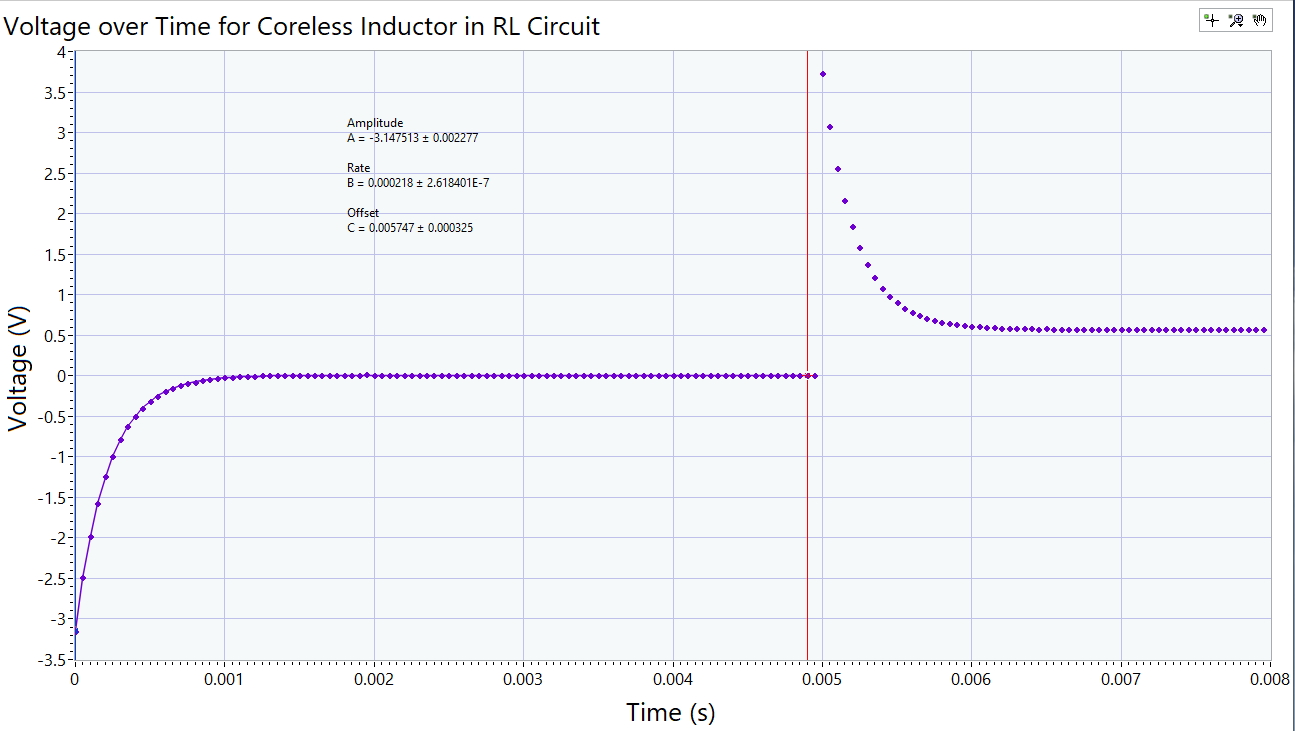
# Method

A 100 μF capacitor and 33Ω resistor are connected in series to a square wave generator. An oscilloscope is connected across the capacitor to measure the voltage. The data is saved to physics data assistant and exponential fits are generated. A series of differential equations are simulated in vPython and the time constant results are compared to the results from the original data.

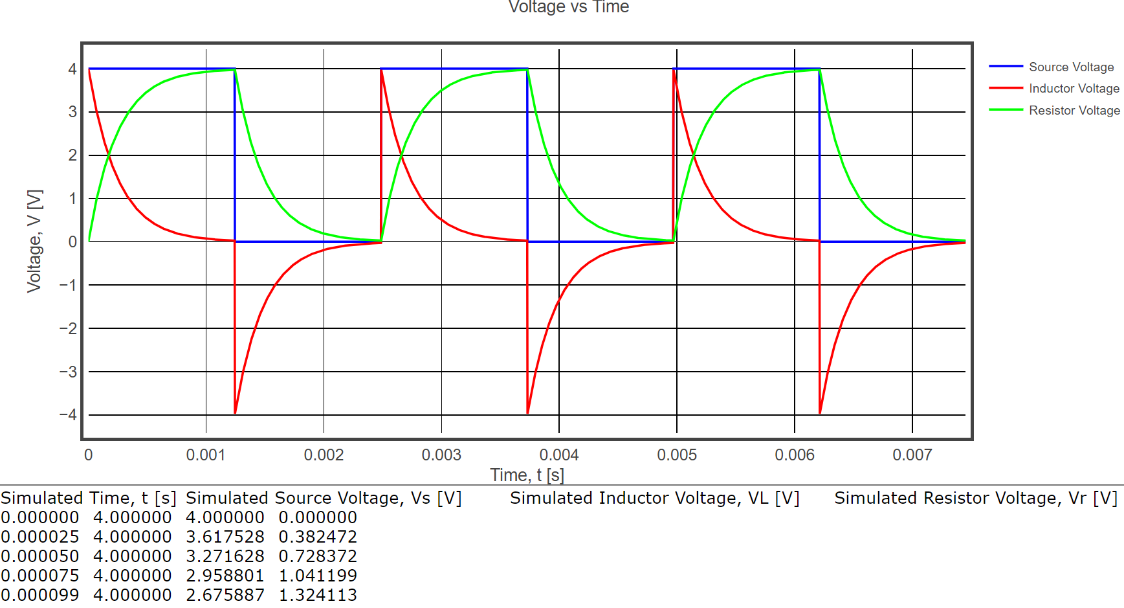
# Results and Data



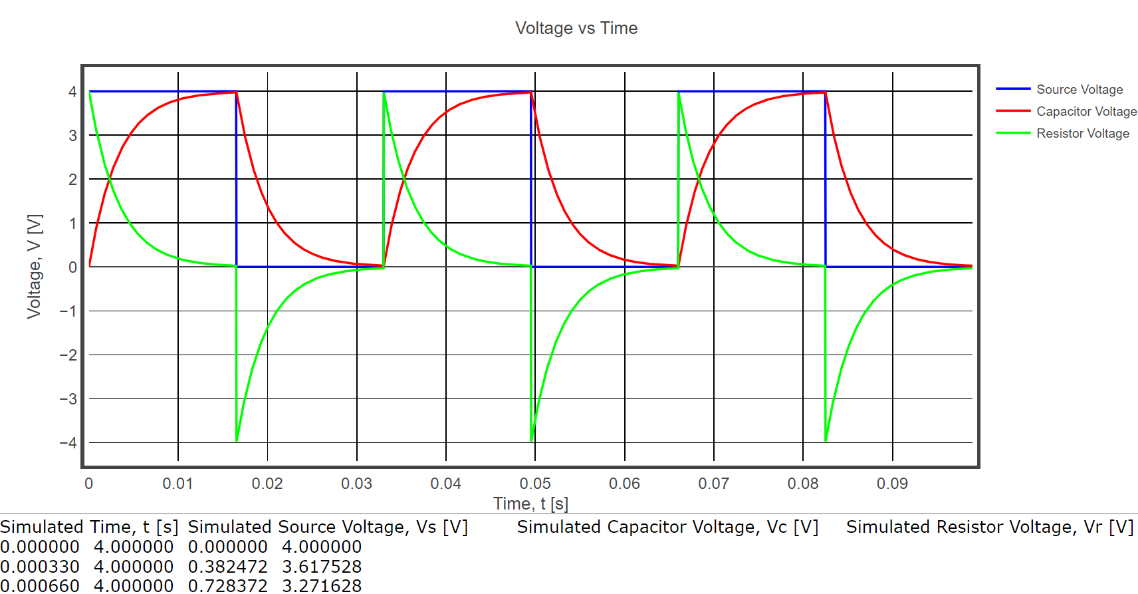
**Figure 1:** Voltage over time plot with exponential fit.



**Figure 2:** Voltage over time plot with exponential fit.



**Figure 3:** Simulated voltage over time plot with exponential fit for the IR circuit.



**Figure 4:** Simulated voltage over time plot with exponential fit for the RC circuit.

# Conclusion

The time constants measured from the exponential fit and from the simulation of the RC circuit are measured as 3.546±0.007ms and 3.55ms. Since these results match within two standard error, we can conclude that the simulation matches real world for the RC circuit.