RC Circuit

Lab #3

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RC Circuit

Objective

Infer the relationship between the time constant τ, resistance R, and capacitance C of an RC circuit.

1 Introduction

An RC circuit is a type of circuit made of a resistor and a capacitor connected in series, like so:

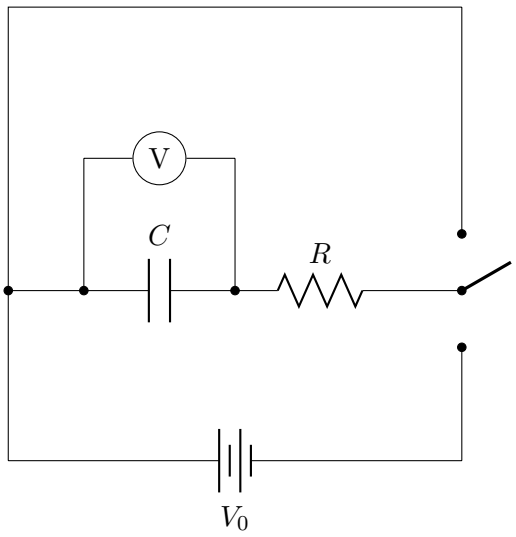

Figure 1: RC circuit

When a constant DC voltage V_0 is applied to the circuit, an electric field builds up inside the capacitor as it gradually charges. By Kirchhoff's voltage law, the circuit's behavior as a function of time is given by the first-order differential equation

$$V_0 - \frac{Q}{C} - R\dot{Q} = 0 \tag{1}$$

The solution to this equation is

$$V(t) = V_0\,(1 - e^{-t/RC}) \tag{2}$$

As t approaches infinity, $V(t)$ approaches V_0.
The time constant τ of an RC circuit is defined such that

$$V(\tau) = V_0\,(1 - e^{-1}) \approx 0.63\,V_0. \tag{3}$$

Therefore,

$$\tau = RC. \tag{4}$$

Note that τ does not depend on V_0: the greater the applied voltage, the faster the capacitor charges.

When a capacitor is discharging into an RC circuit, it produces an exponentially decaying direct current. As a function of time, this is

$$V(t) = V_0\, e^{-t/\tau} \tag{5}$$

We can graph the logarithm of voltage as a linear function of time. From Eq. 2, we obtain

$$\ln(V_0 - V) = -\frac{t}{RC} + \ln V_0 \tag{6}$$

and from Eq. 5, we get

$$\ln V = -\frac{t}{RC} + \ln V_0 \tag{7}$$

2 Procedures and Results

We set up the circuit shown in Figure 1.

3 Discussion

You

4 Conclusion

Today