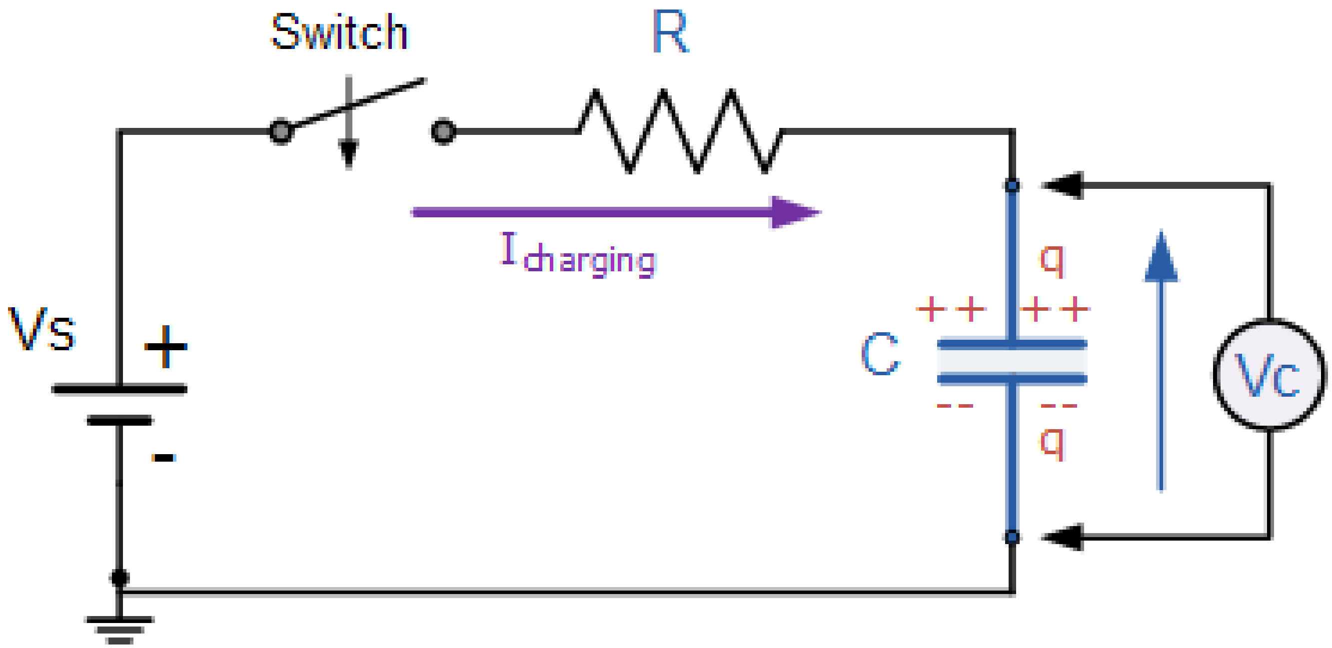
Measurements Lab

RC time constant

NC State University

Basic RC circuit



Consider a capacitor initially charged to V_0, and connected to a resistor Kirchoff Voltage Law (Loop Law): $V_r + V_c = 0$ or $V_r = -V_c$
The same current runs through each element: $i_r = i_c$.
Using voltage laws for the capacitor and resistor give us

$$\mathbf{V}_c = 1/C\ \mathbf{q}_c$$

$$\mathbf{V}_r = R\ \mathbf{i}_r$$

and the relation between charge and current, $\mathbf{q}_c' = \mathbf{i}_c$, together with the voltage and current relations, we can obtain a differential equation of motion

$$\mathbf{q}_c' = -\ (1/RC)\ \mathbf{q}_c$$

To see it in terms of current, take its time derivative:

$$\mathbf{i}_c' = -\ (1/RC)\ \mathbf{i}_c$$

Or in terms of voltage, using

$$\mathbf{V}_c' = -\ (1/RC)\ \mathbf{V}_c$$

All of these equations of motion have an easy solution, e.g.

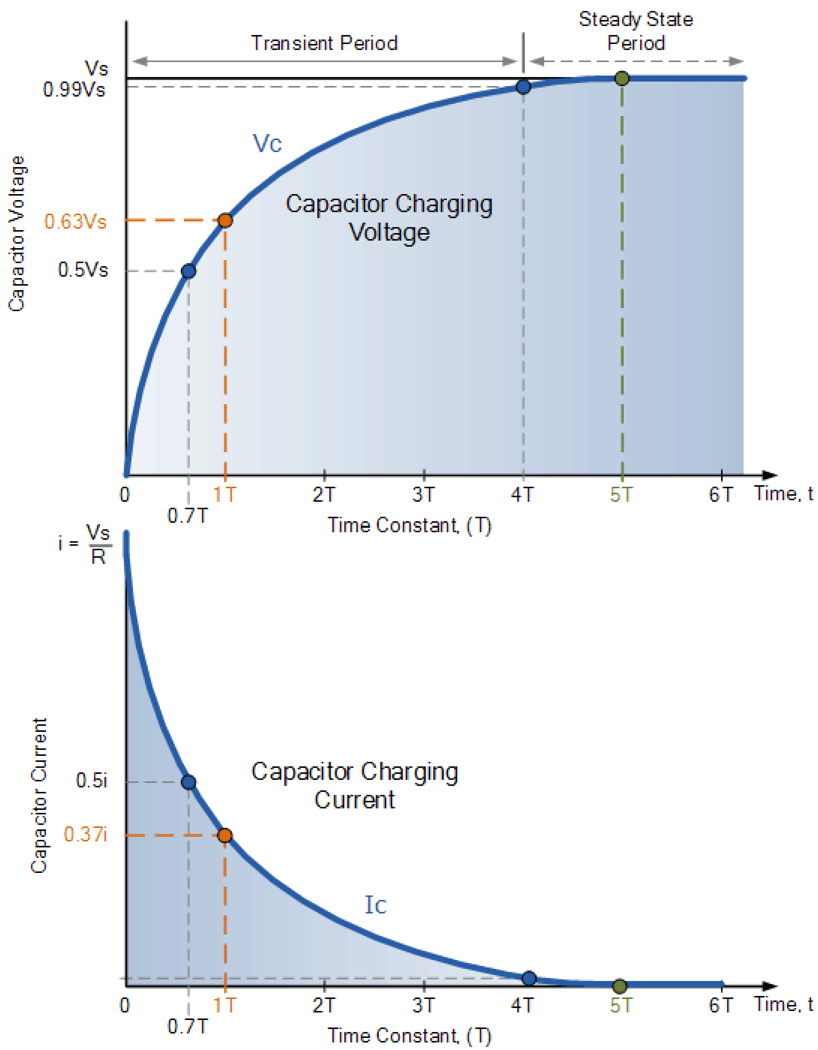
$$\mathbf{V}_c = \mathbf{V}_0\ e^{-t/RC}$$

Charging time response

$$\tau = RC$$

$$V_{charge}(t) = V_0(1 - e^{-t/\tau})$$

$$V_{discharge}(t) = V_0 e^{-t/\tau}$$



Inverting operational amplifier

The principle of operation is that the voltage difference at the + and – inputs will be maintained at zero and no current flows into the input terminals. If the + input is grounded then the – input must satisfy V = 0. The currents through the two resistors must be equal and opposite. Ohm's law gives:

$$\frac{V_{out}}{V_{in}} = \frac{-iR_f}{iR_{in}}$$

The minus sign on the output voltage gives rise to the name "inverting". The gain in signal is:

$$Gain = \frac{R_f}{R_{in}}$$