Electricity and Magnetism
Lab 6
RC Circuits

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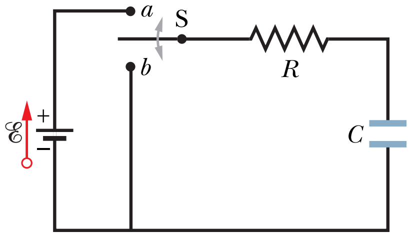
Overview

- reminder about RC circuits
- setup
- making measurements

RC Circuits

Circuits with resistors and capacitors are called “RC circuits.”



Charging a Capacitor

When an uncharged capacitor is first connected to an electrical potential difference, a current will flow.

Once the capacitor is fully charged however, $q = C(\Delta V)$, current has no where to flow and stops.

The capacitor gently "switches off" the current.

RC Circuits: Charging Capacitor

If we replace i in our equation with the derivative:

$$\mathcal{E} - R\,\frac{\mathrm{dq}}{\mathrm{dt}} - \frac{q}{C} = 0$$

This is a differential equation. There is a way to solve such equations to find solutions for how q depends on time. (You do not need to know them.)

The solution is:

$$q = C\mathcal{E}(1 - e^{-t/RC})$$

RC Circuits: Charging Capacitor

Charge:

$$q = C\mathcal{E}(1 - e^{-t/RC})$$

Current:

$$i = \left(\frac{\mathcal{E}}{R}\right) e^{-t/RC}$$

Dividing the charge by the capacitance, C, the potential drop across the capacitor:

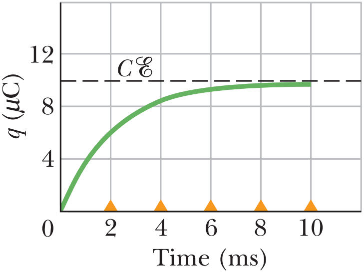
$$\Delta V_C = \mathcal{E}(1 - e^{-t/RC})$$

RC Circuits: Charging Capacitor

How the solutions appear with time:

Charge:

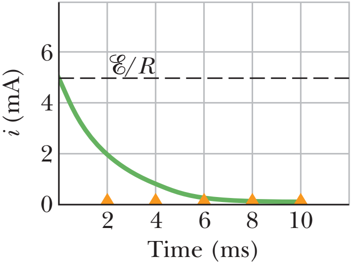
$q = q_0\,(1 - e^{-t/RC})$



where for this circuit $q_0 = C\mathcal{E}$

Current:

$i = i_0\,e^{-t/RC}$

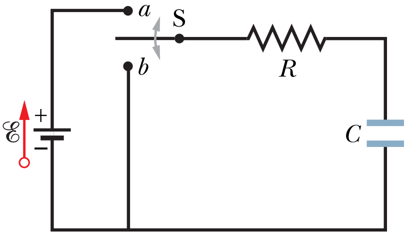


where for this circuit $i_0 = \frac{\mathcal{E}}{R}$

RC Circuits: Discharging Capacitor

Imagine that we have charged up the capacitor, so that the charge on it is q_0.

Now we flip the switch, the battery is disconnected, but charge flows off the capacitor, creating a current:



RC Circuits: Discharging Capacitor

Charge on the capacitor:

$$q = q_0 \, e^{-t/RC}$$

Current:

$$i = i_0 \, e^{-t/RC}$$

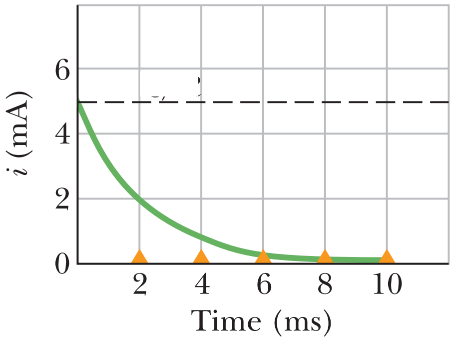
where $i_0 = \frac{q_0}{RC}$.

Again dividing the charge by the capacitance:

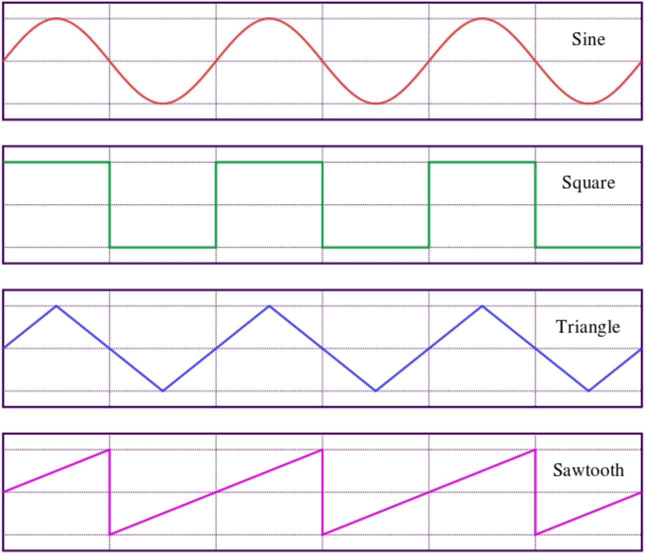
$$\Delta V_C = \Delta V_0 \, e^{-t/RC}$$

where $\Delta V_0 = \frac{q_0}{C} = \frac{i_0}{R}$.

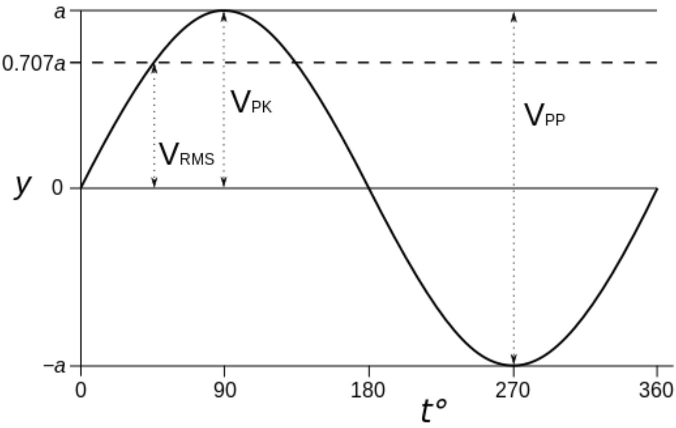
RC Circuits: Discharging Capacitor



Waveforms



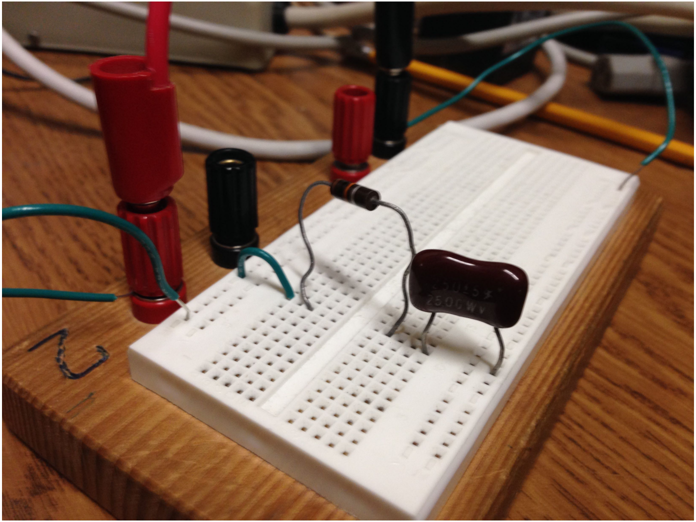
Measures of amplitude-type quantities



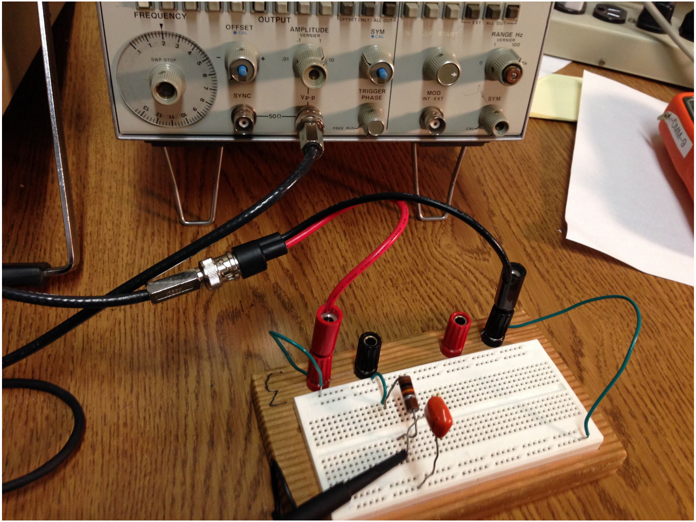
[1]Figure from Wikipedia by AlanM1.

Measurements with the Hand-Held DMM of Capacitance

RC Circuit



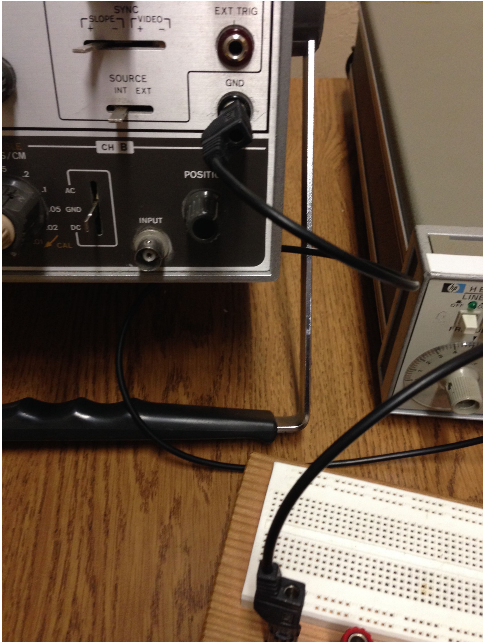
Measuring V_C



Changing Frequency

Changing Frequency

Grounding



SYNC
SLOPE
VIDEO
EXT TRIG
SOURCE
INT EXT
GND
CH B
AC
GND
DC
INPUT