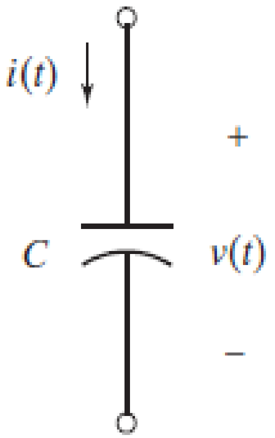
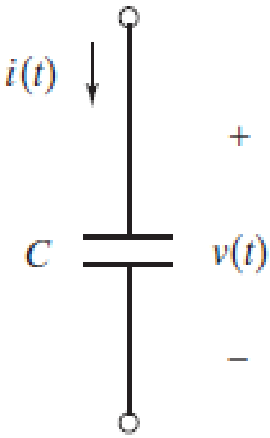
Chapter 7

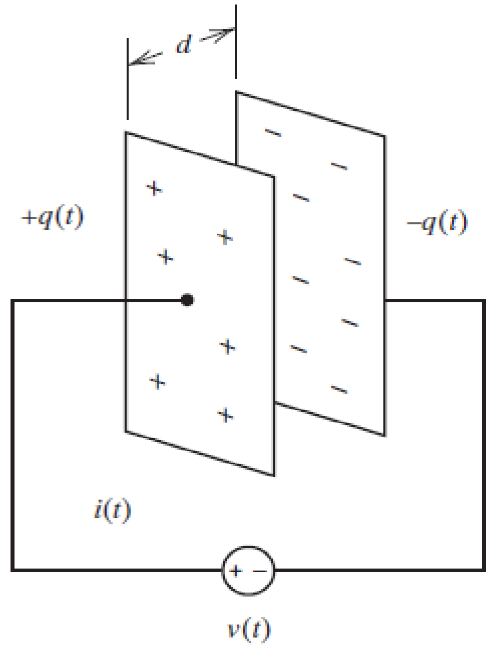
Capacitor and Inductor

Ideal Capacitor Model

$$i(t) = C\frac{d}{dt}v(t)$$







$$C = \frac{\in A}{d}$$

$$q(t) = Cv(t)$$

C: capacitance and measured in Farad

Capacitor is used for Energy storage

Capacitor is storing energy through charging process
and returning energy through discharging process
Over total cycle ideal capacitor never dissipate energy

Capacitor is storing energy in electrostatic field

$$v(t) = \frac{1}{c} \int_{t=t_o}^{t} i(\tau).d\tau + v(t_o)$$

Where t_o: Initial time
$v(t_o)$: initial voltage

If capacitor is completely discharged at t=0 we consider v(0)=0

Important Characteristics of an Ideal Capacitor

1. There is no current through a capacitor if the voltage across it is not changing with time. A capacitor is therefore an *open circuit to dc*.
2. A finite amount of energy can be stored in a capacitor even if the current through the capacitor is zero, such as when the voltage across it is constant.
3. It is impossible to change the voltage across a capacitor by a finite amount in zero time, for this requires an infinite current through the capacitor. A capacitor resists an abrupt change in the voltage across it in a manner analogous to the way a spring resists an abrupt change in its displacement.
4. A capacitor never dissipates energy, but only stores it. Although this is true for the *mathematical model*, it is not true for a *physical* capacitor due to finite resistances associated with the dielectric as well as the packaging.

There is no current through a capacitor if the voltage across it is not changing with time. A capacitor is therefore an *open circuit to dc*.

Derivative is change of v with respect to t

If there is no change in v then derivative will be zero

so under DC voltage current flow through capacitor is zero

Capacitor is said to be open circuit

$$i(t) = C\frac{d}{dt}v(t)$$

A finite amount of energy can be stored in a capacitor even if the current through the capacitor is zero, such as when the voltage across it is constant.

Energy stored in capacitor can be computed by

$$Wc = \frac{1}{2} C V_c^2$$

If V_c is constant say 20v and C=2mF then $i_c=0$

$$W_c = \frac{1}{2} 2m(20)^2 = 400\,mJ$$

It is impossible to change the voltage across a capacitor by a finite amount in zero time, for this requires an infinite current through the capacitor. A capacitor resists an abrupt change in the voltage across it in a manner analogous to the way a spring resists an abrupt change in its displacement.

Capacitor voltage can not be changed instantly (in zero time)

$$\frac{dv}{dt} = \frac{\Delta v}{\Delta t} = \frac{\Delta v}{0} = \infty$$

$$i_c = c\frac{dv}{dt} = \infty$$

7.1 Determine the current flowing through a 5 mF capacitor in response to a voltage $v =$: (*a*) −20 V; (*b*) $2e^{-5t}$ V.

Ans: (*a*) 0 A; (*b*) $-50e^{-5t}$ mA.

a)

$$i(t) = c\frac{dv(t)}{dt}$$

$$i(t) = c.\frac{d(20)}{dt} = 0A$$

b)

$$i(t) = c\frac{dv(t)}{dt} = 5m\frac{d(2.e^{-5t})}{dt} = 10m.(-5).e^{-5t} = -50.e^{-5t}mA$$