<u>Introduction to Capacitor Circuits</u>

(Tom Co 2/14/2008)

I. Capacitors

Basics:

1. <u>Components:</u>

   a. Two conducting plates
   b. Dielectric material (e.g. ceramic, air, etc.) Figure 1

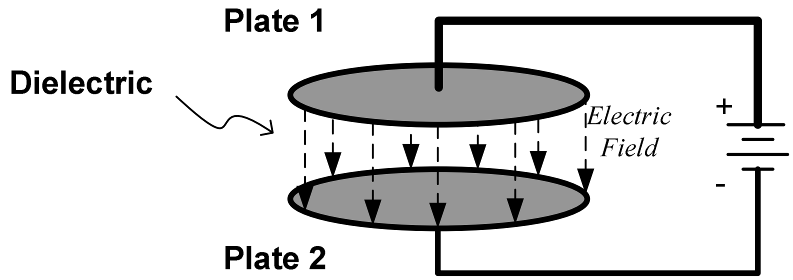

Figure 1. Capacitor charging configuration.

2. <u>Charging Operation:</u>

   a. Applying a voltage across the plates will pump electrons out of negative battery terminal.
   b. The electrons then collect on the lower plate while electrons are drawn away from the upper plate.
   c. The top plate will reach a charge +Q, while the lower plate will reach a negative charge –Q.
   d. This continues until equilibrium is reached.
   e. The electric field between the plates will remain even after the battery has been removed.

3. <u>Definitions and Units</u>

   Capacitance (C) = ratio of electrical charge (Q) to voltage (V)
   Units: 1 farad (F) = 1 coulomb/volt

4. Capacitors Formulas: (Note: capacitor will have constant capacitance)

$$C = \frac{Q}{V} = \frac{dQ/dt}{dV/dt} = \frac{I}{dV/dt}$$

$$\rightarrow \quad I = C\frac{dV}{dt}$$

5. Symbols

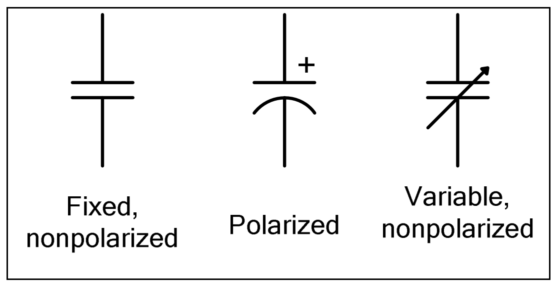

Figure 2. Symbols for capacitors.

II. RC Circuit

Example: Find the dynamic model of the voltage across the capacitor, V_{be}.

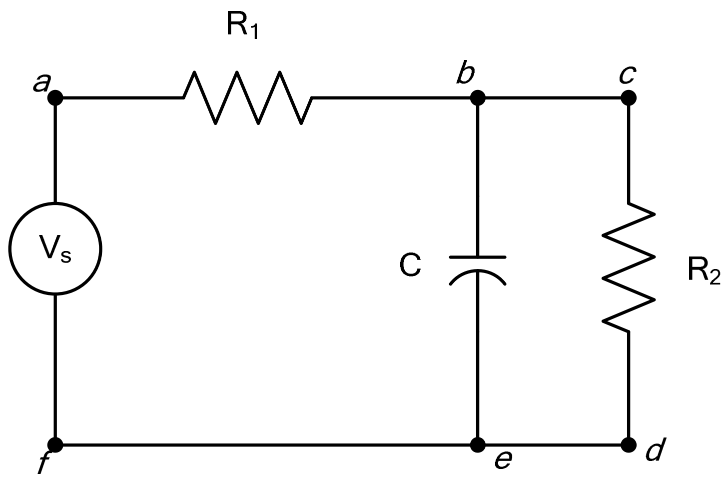

Figure 3. An RC circuit.

Solution:

Applying Kirchoff's Laws:

$$V_s = V_{ab} + V_{be}$$
$$V_{cd} = V_{be}$$
$$I_{ab} = I_{be} + I_{cd}$$

Next, apply Ohm's law and the capacitor equation:

$$\frac{V_{ab}}{R_1} = C\frac{dV_{be}}{dt} + \frac{V_{cd}}{R_2}$$

Put everything in terms of V_{be}, V_s, R_1, R_2 and C:

$$\frac{V_s - V_{be}}{R_1} = C\frac{dV_{be}}{dt} + \frac{V_{be}}{R_2}$$

which can be rearrange into the standard form:

$$\left(\frac{C}{\frac{1}{R_1}+\frac{1}{R_2}}\right)\frac{dV_{be}}{dt} + V_{be} = \left(\frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}}\right)V_s$$

Reference:

Paul Scherz, **Practical Electronics for Inventors 2nd Editon**, McGraw Hill, New York, 2007.