Q&A until Berkeley Time
Concept Dependencies

Capacitor I-V Relationships

\[ Q = CV \]

Capacitor Equivalences

Series

\[ \frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} \]

Parallel

\[ C_{\text{eq}} = \frac{C_1 C_2}{C_1 + C_2} \]

Areas add so capacitors add
“Physics” of Charge on Capacitors
Capacitors Charging by Voltage Source

At time $t = 0$, uncharged ($Q = 0$)

$$Q = CV = C V(t = 0)$$

$$Q = 0 \implies V(t = 0) = 0 \text{V}$$

A full cup
Capacitors Charging by Voltage Source

Examples

1. In series

   q = \text{same} \quad \text{(both uncharged)}

\[ V_{c_1+c_2} = V_1 + V_2 \]
\[ = \frac{Q_1}{C_1} + \frac{Q_2}{C_2} \]
\[ V_S = \frac{Q}{C_1} + \frac{Q}{C_2} \]

Q_1 = C_1 V_S
Q_2 = C_2 V_S

- Q_1
- Q_2
Capacitors Charging by Current Source

Current is a flow of charge → builds up charge on cap → builds up voltage on cap over time

\[ i = \frac{\text{d}V}{\text{d}t} \]

\[ \int_{t=0}^{t_f} \frac{\text{d}V}{C} \, dt = \int_{V(0)}^{V(t_f)} \text{d}V \]

\[ t = 0 \text{ sec} \quad t = 1 \mu \text{sec} \quad t = 2 \mu \text{sec} \]

\[ V(0) = 1 \text{ V} \]

\[ \frac{i}{C} (t_f - 0) = V(t_f) - V(0) \]

\[ V(t) = \frac{i}{C} t + V(0) \]
Capacitors Charging by Current Source

\[ i = -I_s \]

\[ v(t) = - \frac{I_s}{C} t + v(0) \]

What happens if \( C \) changes?

\[ I_s \text{ goes in (charging)} \]

\[ \begin{align*}
C &= 1 \text{ mF} \\
C &= 2 \text{ mF} \\
C &= \frac{1}{2} \text{ mF}
\end{align*} \]

\[ v(t) = v(0) + \frac{I_s}{C} t \]

(Discharging)
Identifying Floating Nodes

Def: A floating node is a node from which charge cannot escape → charge conservation applies

Q_{start} = Q_{end}

top node is the floating node (which charge was conserved)

start

end

i = 0

Y/N

Y/N

i = 0

Y/N

Y/N
Charge Sharing Algorithm

1. Label Q’s, V’s in cut
2. Draw each eq. cut for each phase (label Q’s, V’s)
3. Identify floating nodes (in phases for which we want to find Δ)
4. Apply Q conservation @ each floating node (one eqn per each floating node)
Charge Sharing Algorithm

1. $V_S$, switches closed
2. $\phi_1$, switches closed
3. Find floating nodes, node is floating
4. Write Q const. eqns

$Q_{\text{slave}} = Q_{\text{lead}}$

$Q_1 + Q_2 = Q_1 + Q_2$

$C_1(V_S - O) + C_2(0 - O) = C_1(U - V_S) + C_2(U - O)$

Goal: find all node voltages after $\phi_1$, $\phi_2$

Find $V_J'$s here

$U = \frac{2C_1V_S}{C_1 + C_2}$
Charge Sharing Algorithm