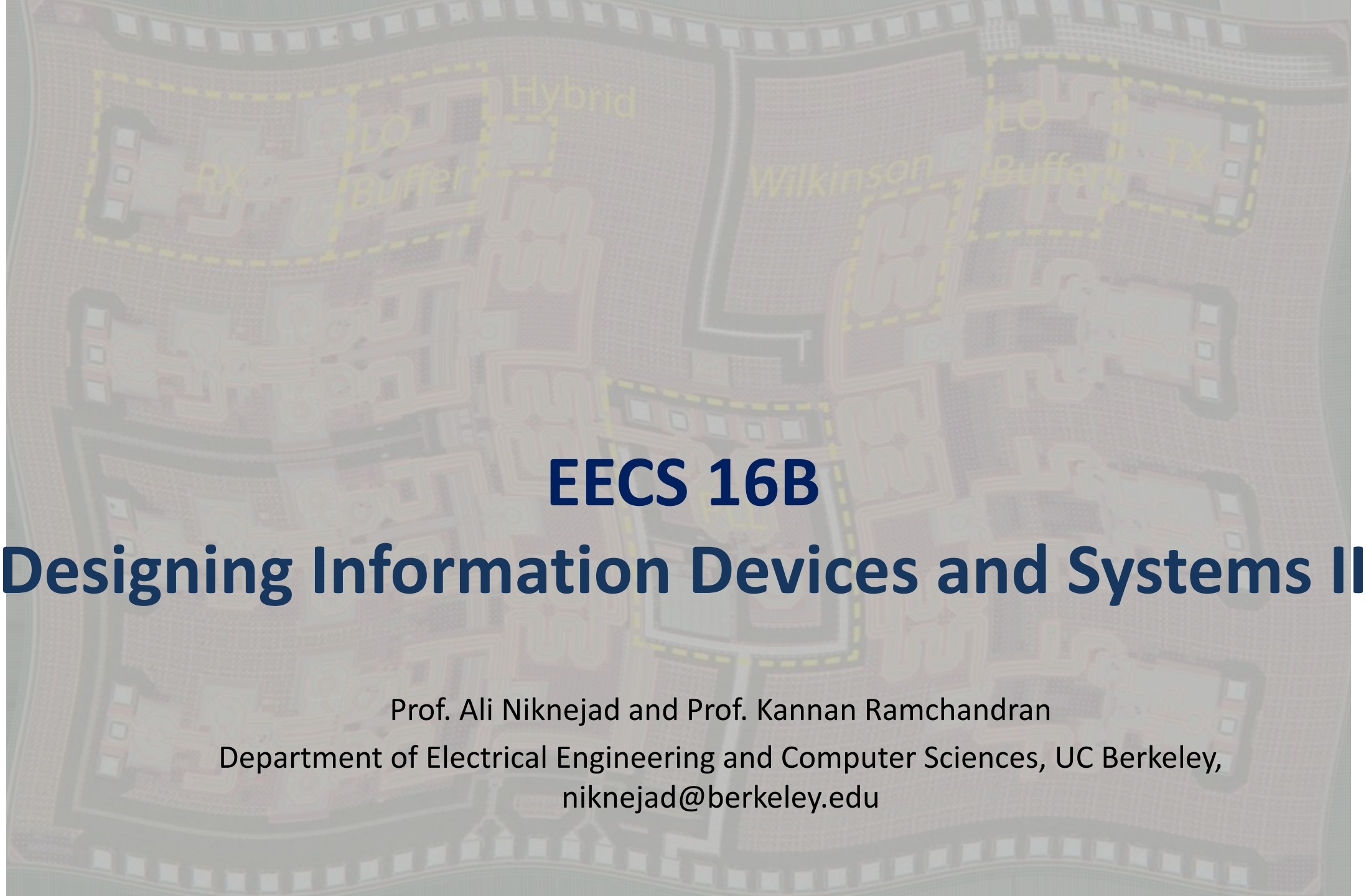

EECS 16B
Designing Information Devices and Systems II

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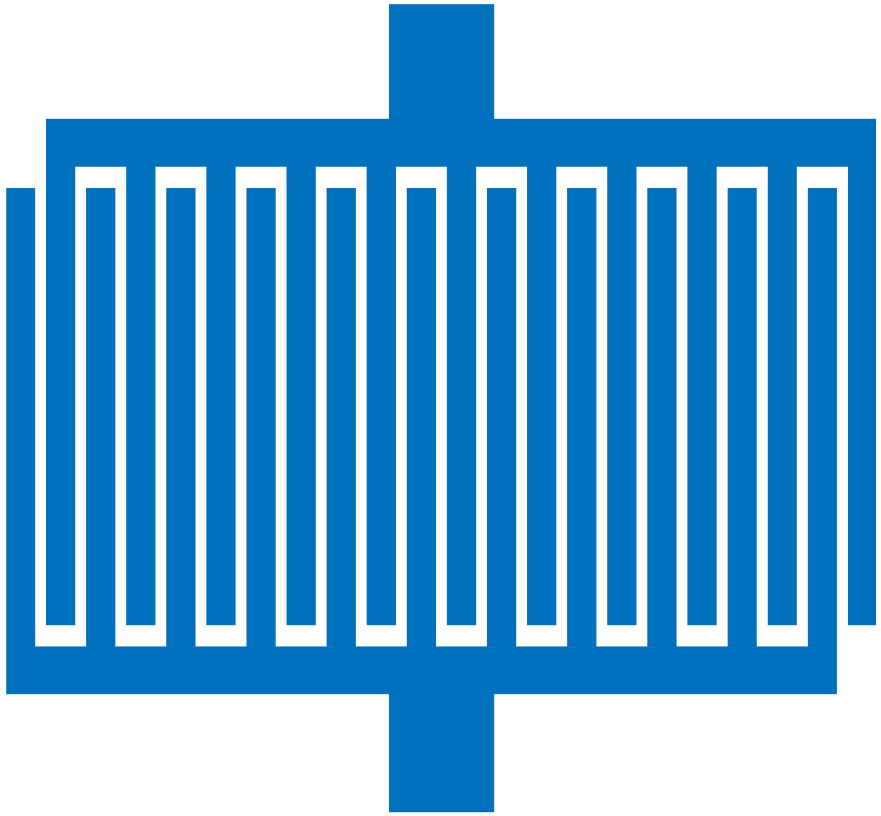
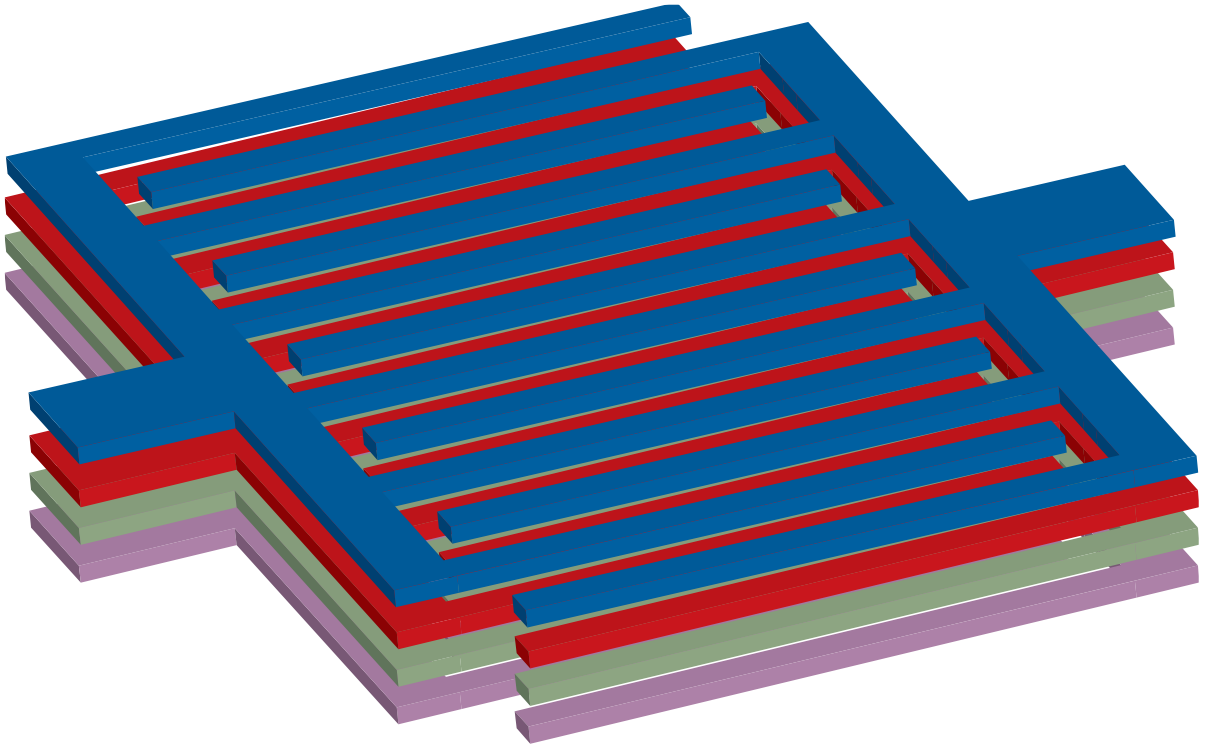
Module 1: Capacitors

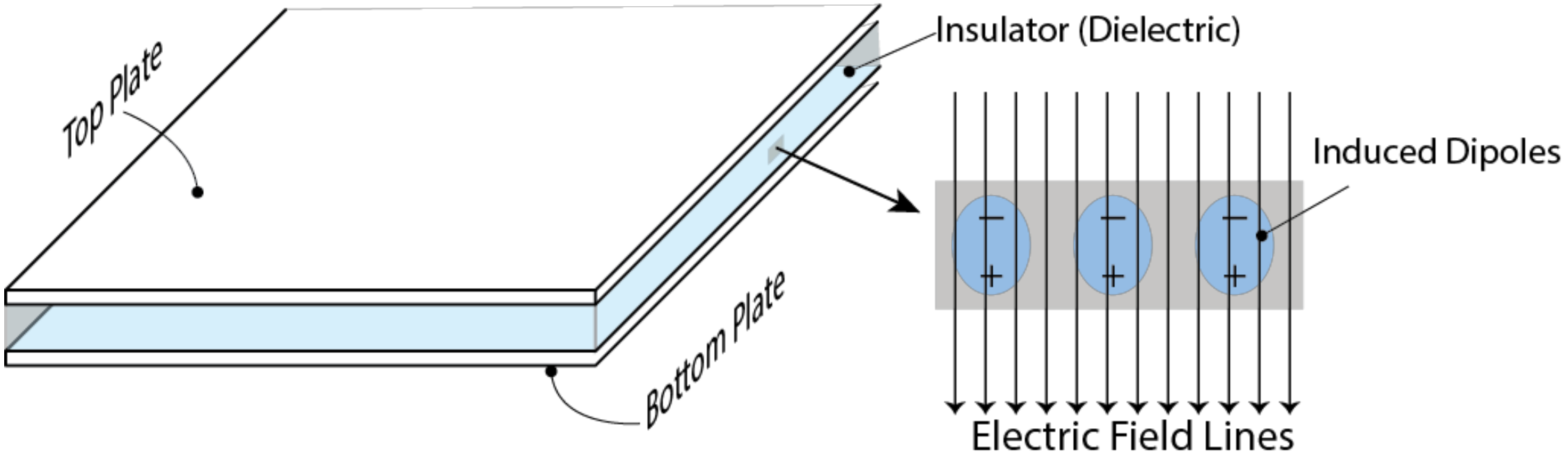
EECS 16B

Integrated Circuit Capacitors



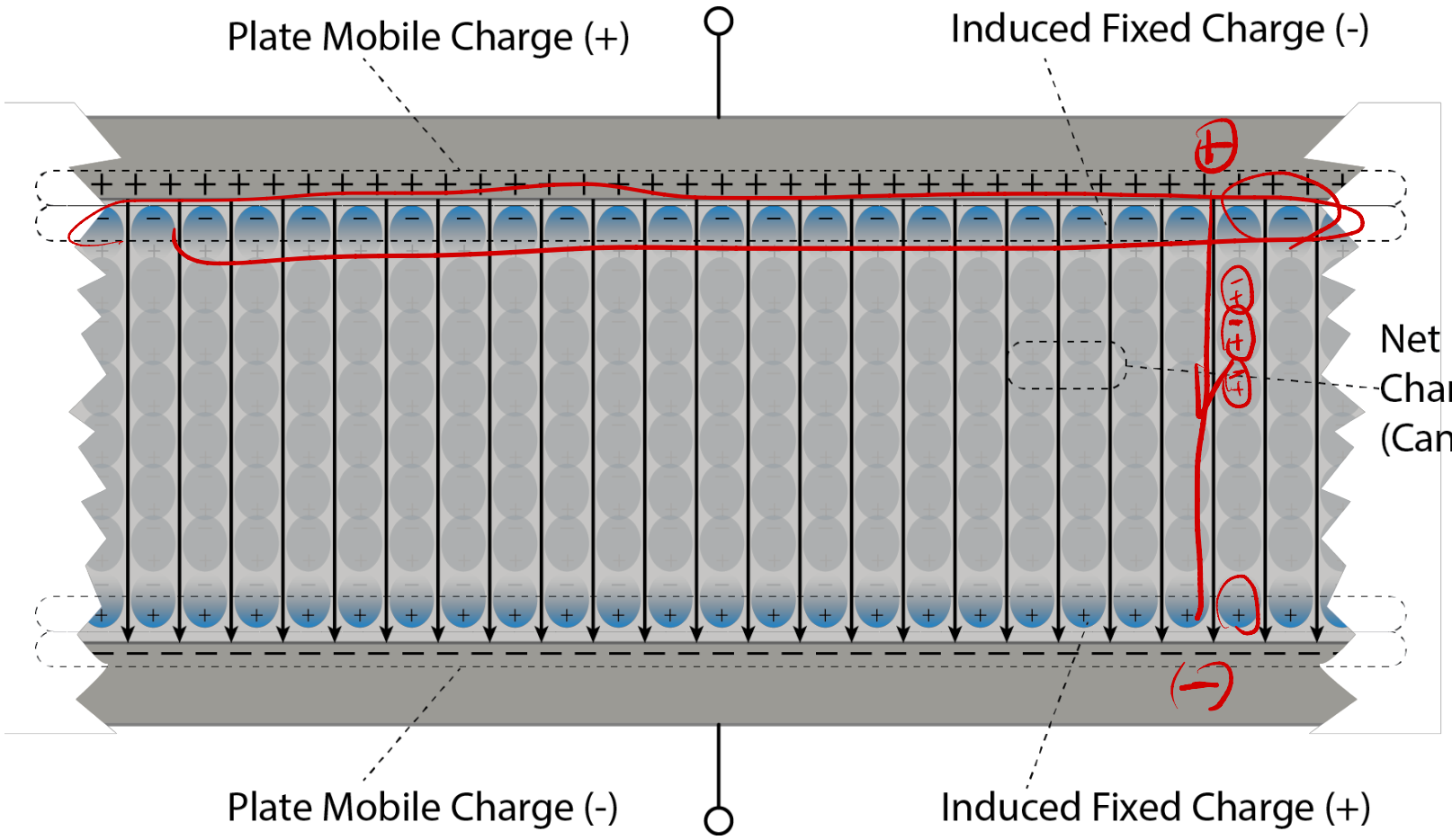


Induced Dipoles



Role of Dielectric

$Q = CV$



$C = \frac{Q}{V}$

$C = \frac{\varepsilon_0 A \varepsilon_r}{t}$

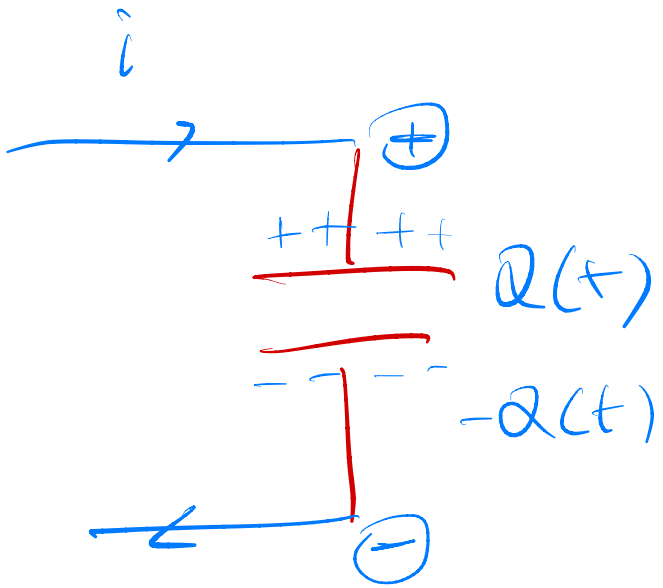
$\varepsilon = \varepsilon_0 \varepsilon_r$

Capacitor Current

$$Q = C\,V$$

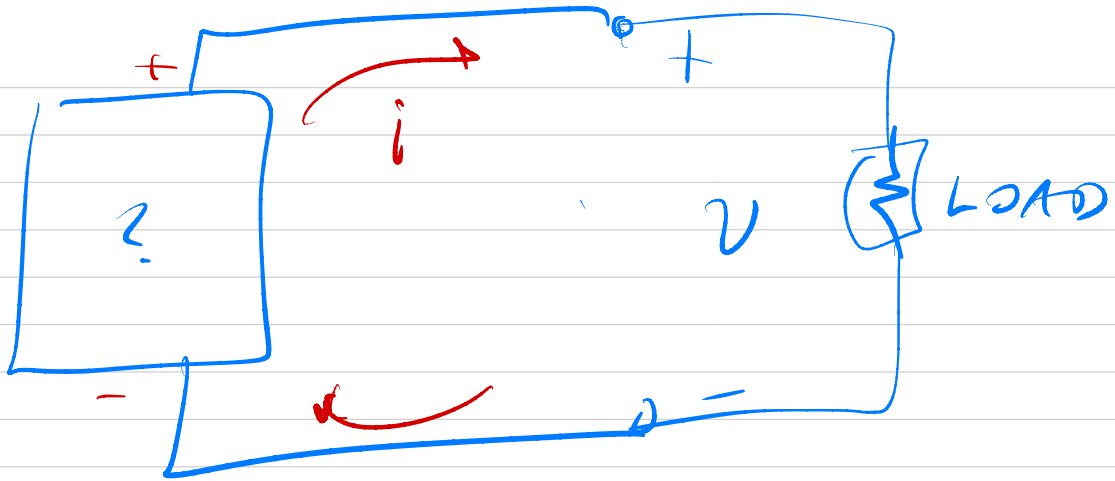
$$i = \frac{dQ}{dt} = C\,\frac{dV}{dt}$$

$$\boxed{i = C\,\frac{dV}{dt}}$$

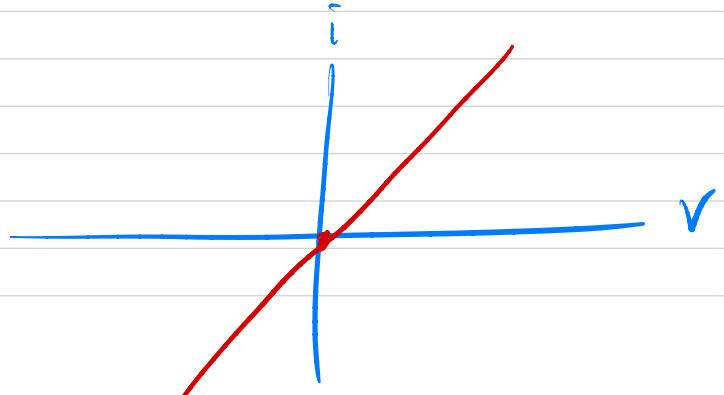


$$\boxed{i = G\,V}$$ Resistor

$$G = 1/R$$

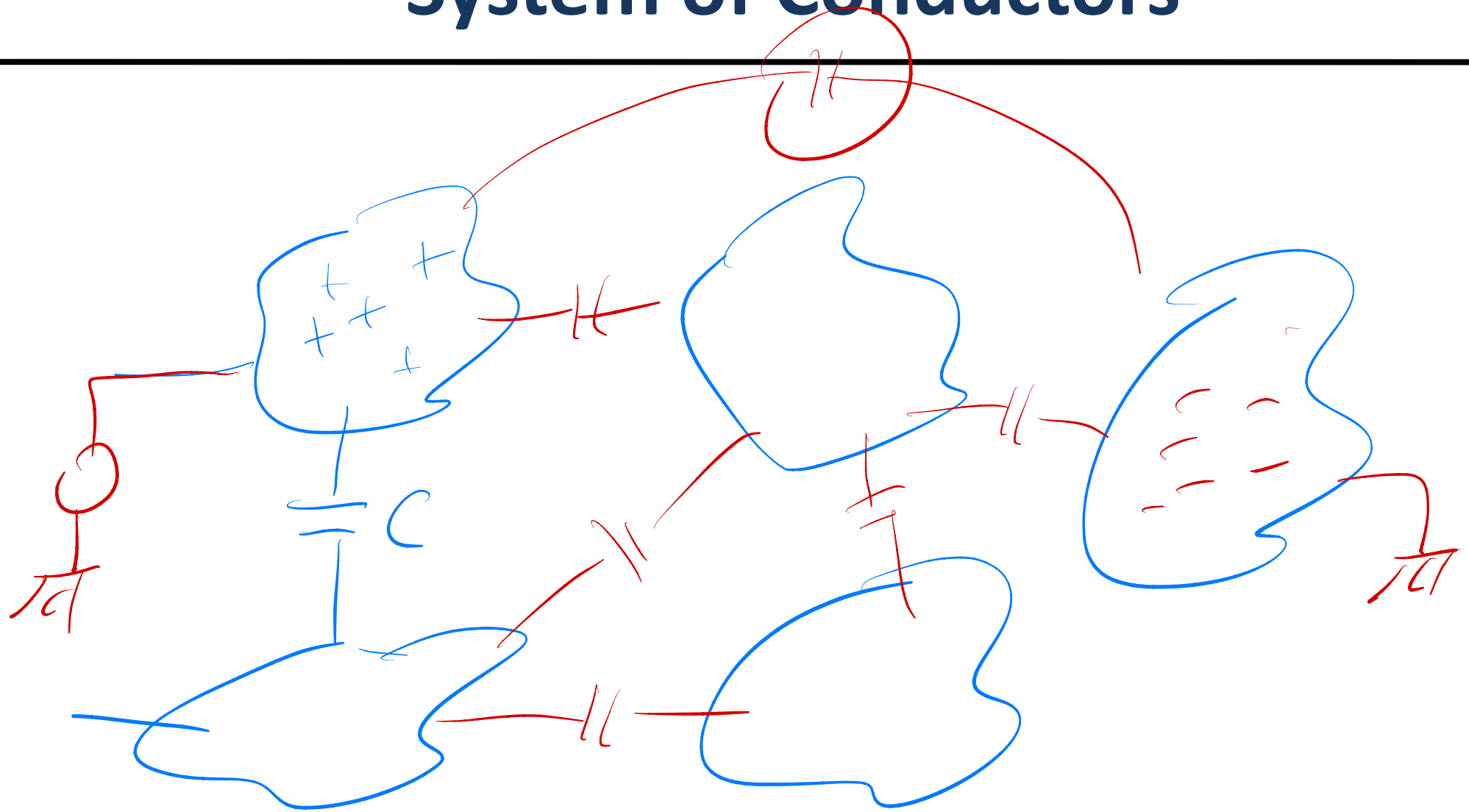


$p(t) = v(t) \cdot i(t) < 0$ sourcing power

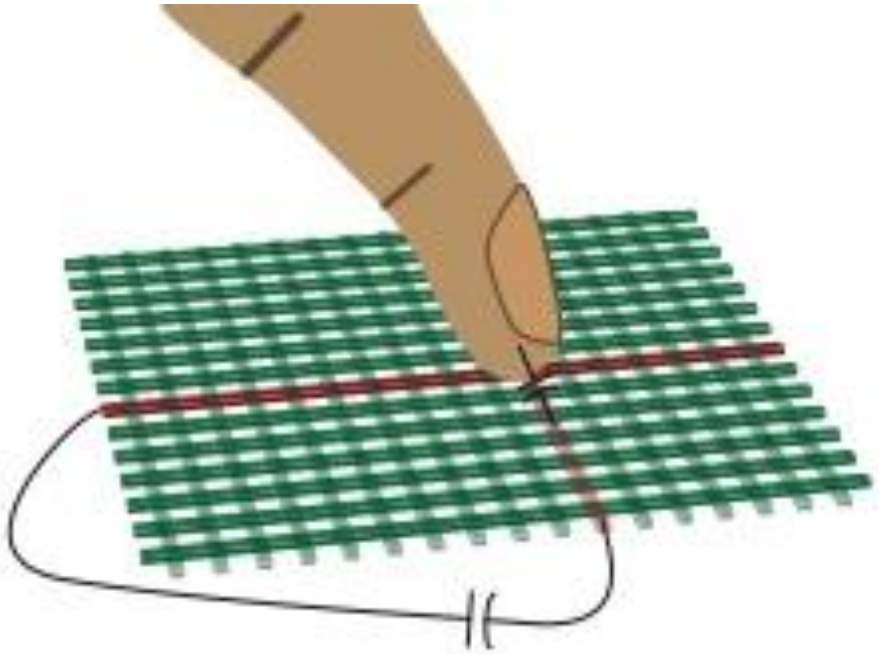


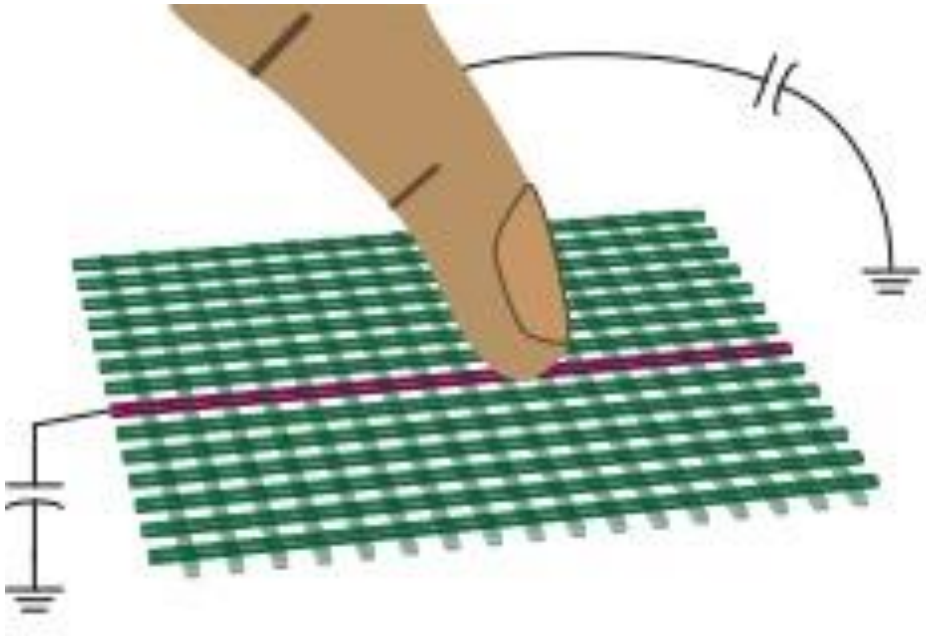
Energy / Power

System of Conductors

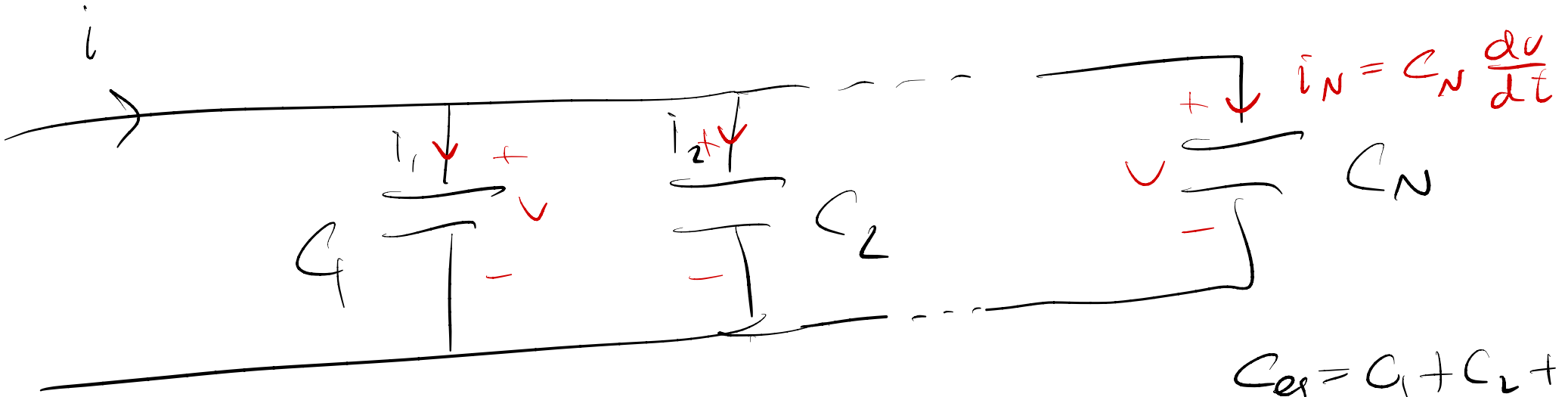


Capacitors are Everywhere



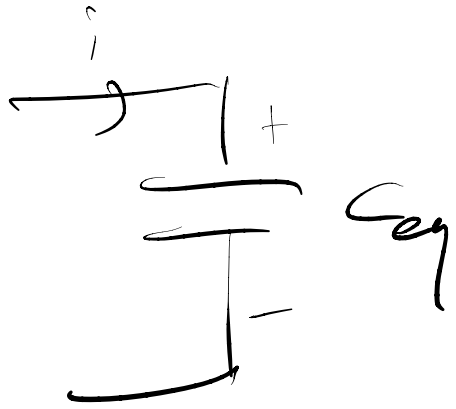


Parallel Capacitors



$$C_{eq} = C_1 + C_2 + \cdots$$

$\equiv$

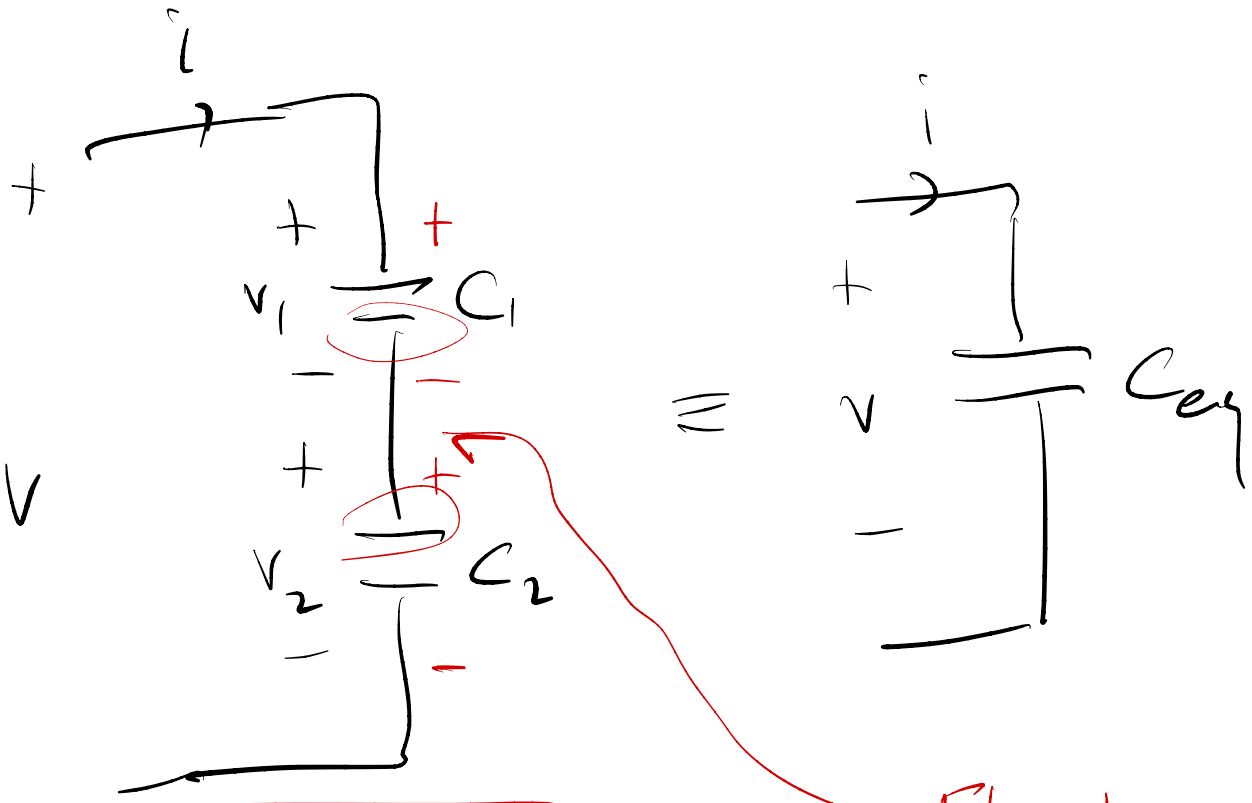


$$i = C_{eq} \frac{dv}{dt}$$

$$i = i_1 + i_2 + \cdots + i_N$$

$$= C_1 \frac{dv}{dt} + C_2 \frac{dv}{dt} + \cdots + C_N \frac{dv}{dt}$$

Series Capacitors



$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

Floating Node

$$q_1 = C_1 V_1$$

$$q_2 = C_2 V_2$$

$$V = V_1 + V_2$$

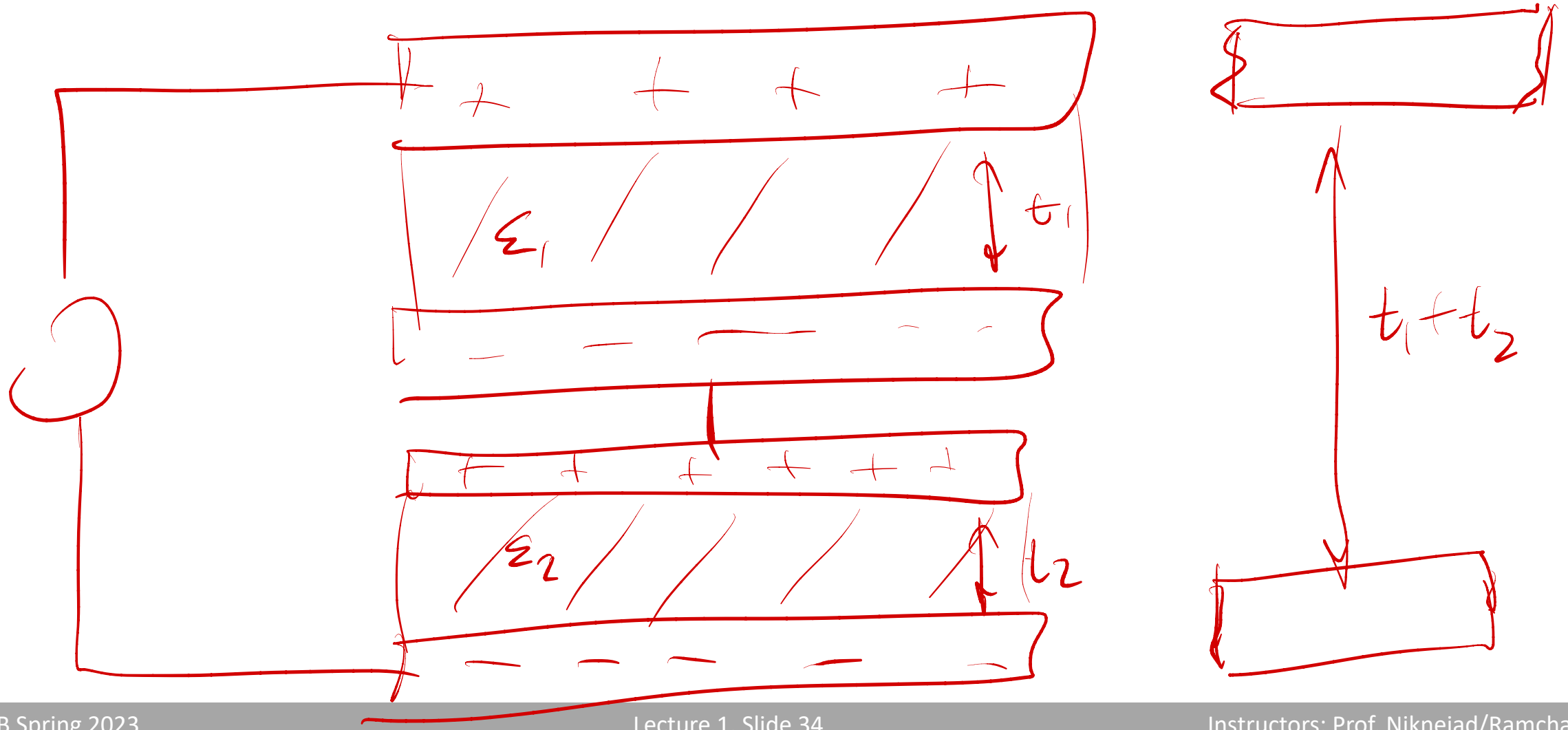
$$\left(q_1^- \equiv q_2^+\right) \Rightarrow$$

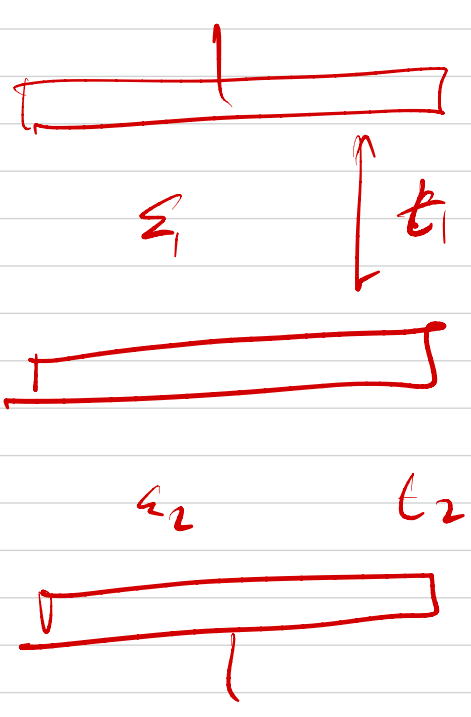
$$q_1 = q_2$$

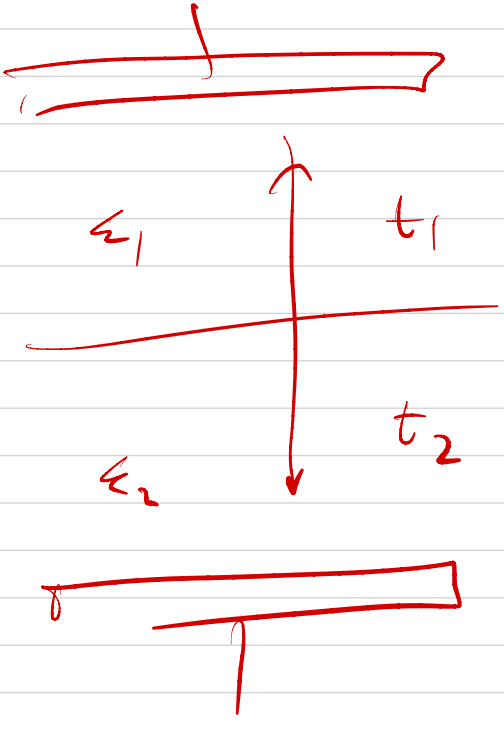
$$q = C_{eq} \cdot V = C_{eq} V_1 + C_{eq} V_2$$

$$= C_{eq}\left(\frac{q}{C_1} + \frac{q}{C_2}\right)$$

Series Capacitor: Physical Picture

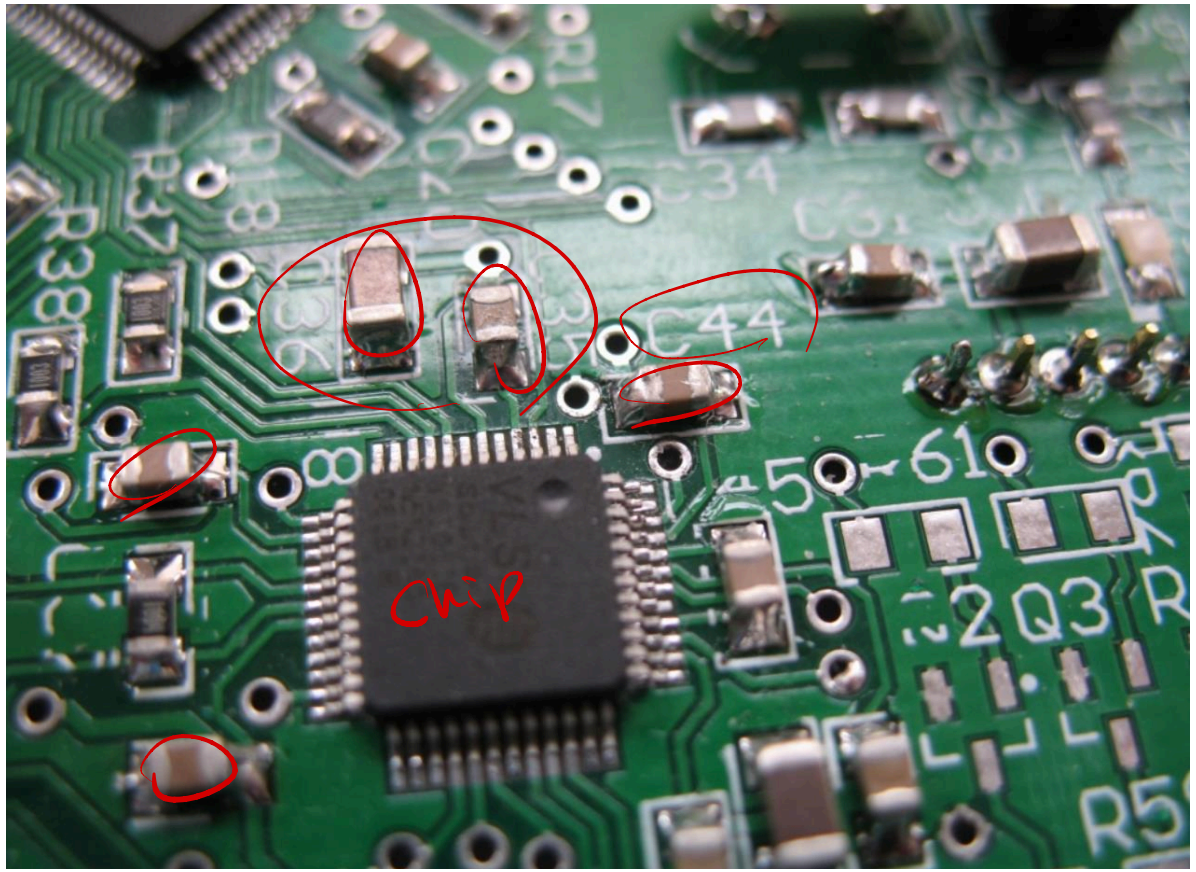


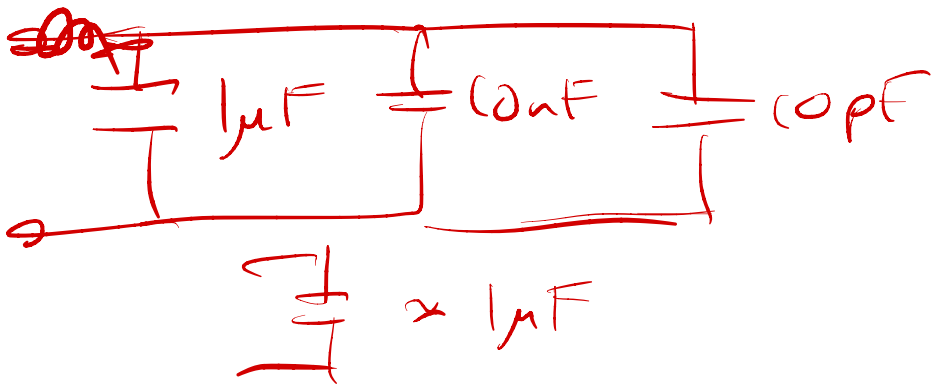

ε_1
t_1
ε_2
t_2


ε_1
t_1
t_2
ε_2

Intentional Capacitors

- Capacitors act like tiny "batteries" that deliver current faster than actual supply
- Essential component in modern electronics





Unintentional Capacitors