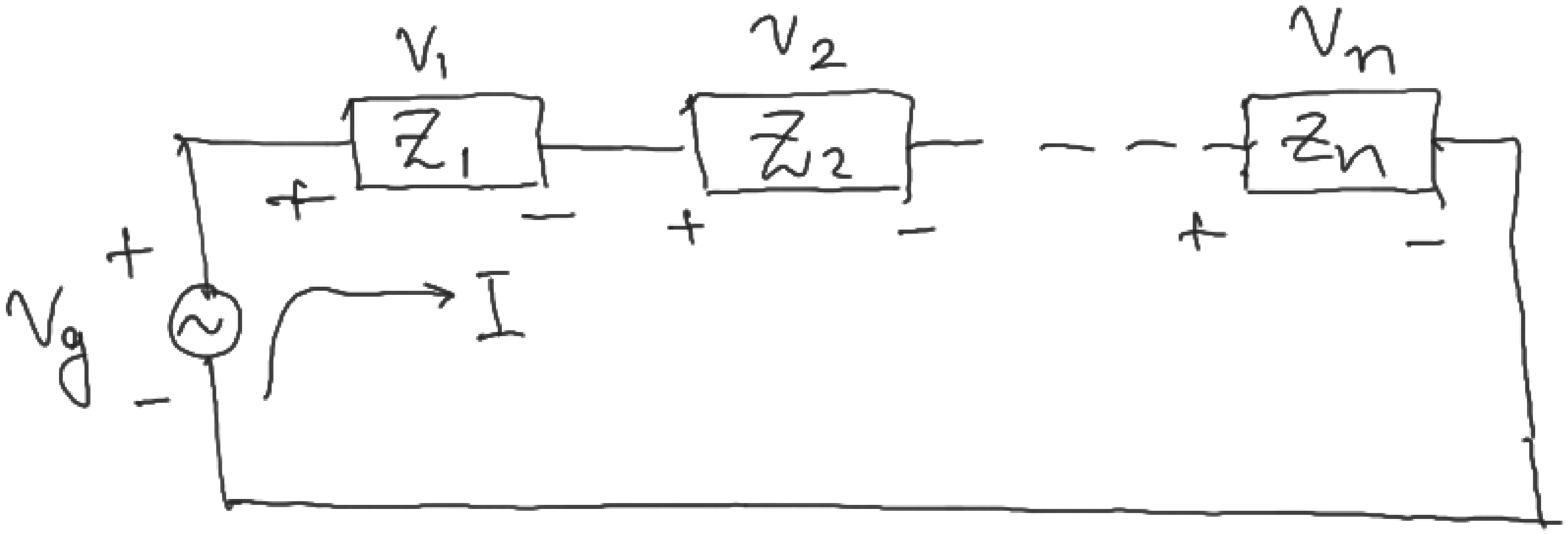
KVL

Algebric sum of voltage drops in a closed path of a circuit is zero.



$\boxed{\text{* Conservation of Energy.}}$

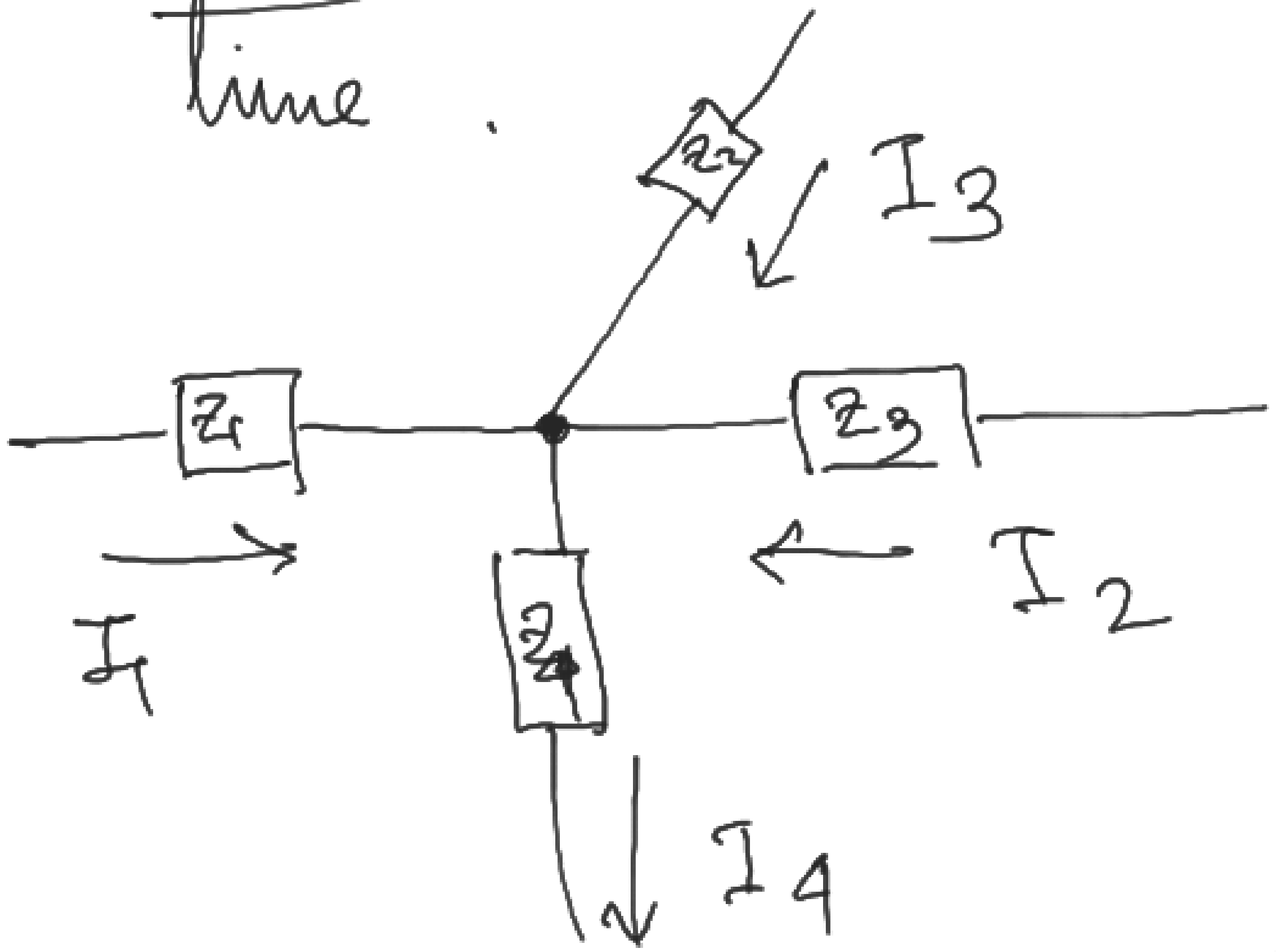
$$+V_1 + V_2 + V_3 \ldots\ldots + V_n - V_g = 0$$

$$\boxed{V_g - V_1 - V_2 \ldots\ldots - V_n = 0}$$

$$\boxed{V_g = V_1 + V_2 + \ldots + V_n}$$

KCL

Algebric sum of the currents entering a given node of a circuit is zero for all instants of time.



$$\boxed{I_1 + I_2 + I_3 - I_4 = 0}$$

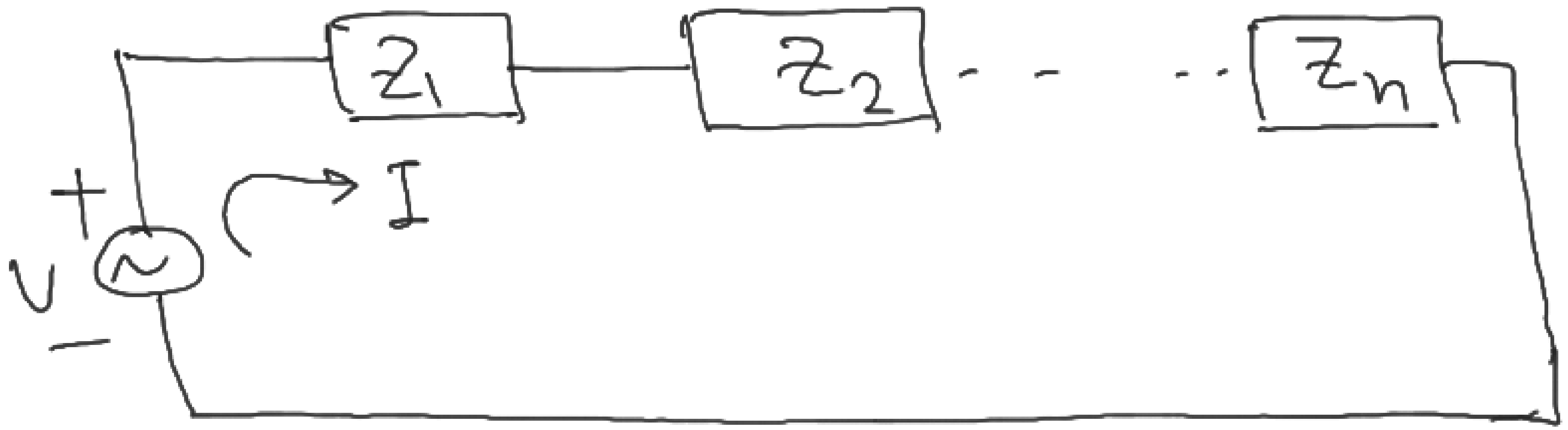
$$\sum_i I_i = 0.$$

* Conservation of charge

$$\sum I = 0.$$

$$\sum \frac{dq}{dt} = 0.$$

q is constant.



$$Z = |Z| e^{j\theta}$$

$$\theta = \tan^{-1}\left(\frac{X}{R}\right)$$

$$Z = R + jX$$

Resistance Reactance

X

$j\omega L$ $1/j\omega C$

$$V = V_0 \cos\omega t \,/\, V_0 \sin\omega t$$

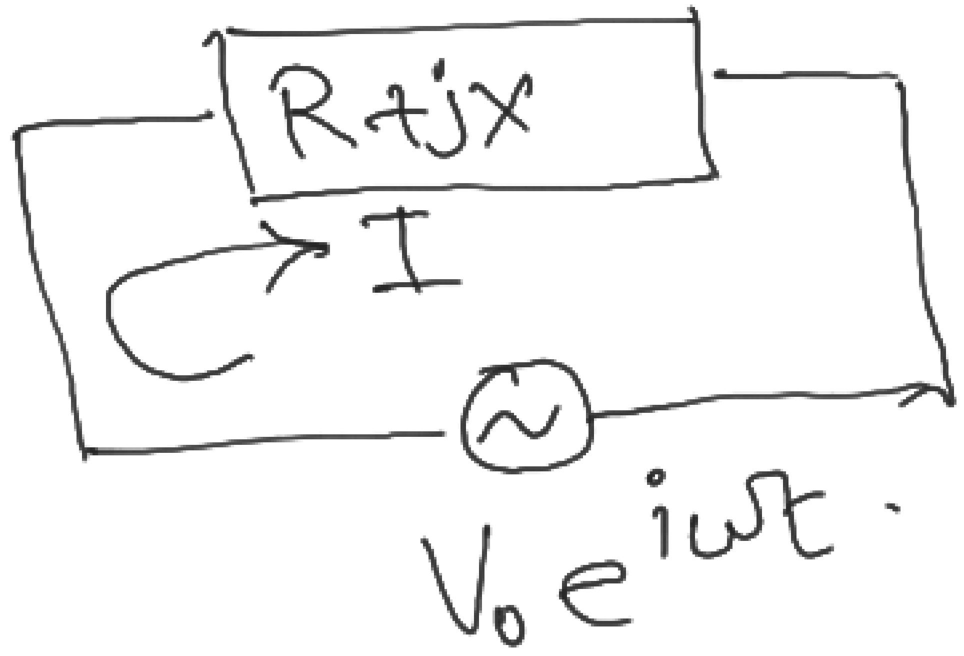
$$V = V_0 e^{j\omega t}$$

$$I = I_0 e^{j\omega t}$$

Voltage and current are in phase.

$$V = V_0 e^{j(\omega t + \theta)}$$ and $$I = I_0 e^{j\omega t}$$

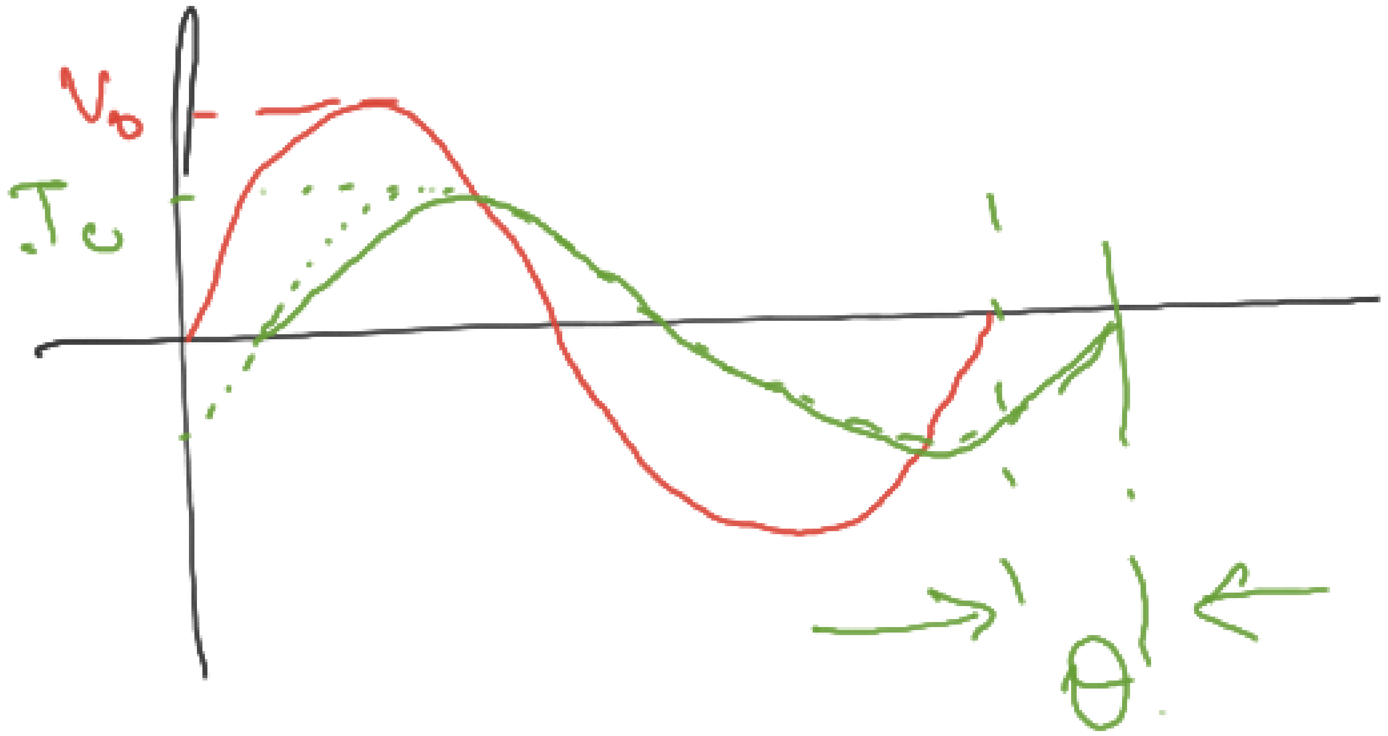
Then voltage and current are 'θ' out of phase.



$$I = \frac{V}{Z} = \frac{V_0 e^{j\omega t}}{R + jx}$$

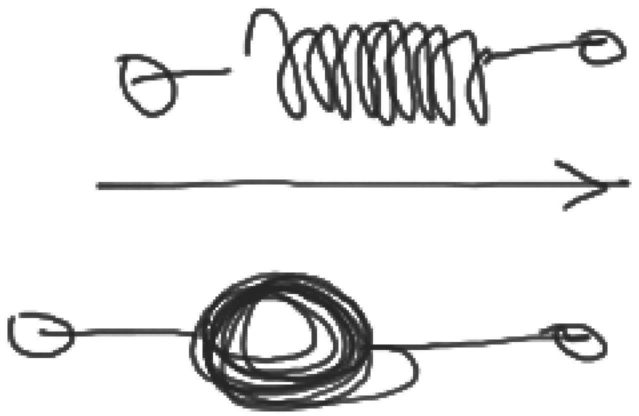
$$I = \frac{V_0}{\sqrt{R^2 + x^2}} \cdot e^{j\omega t} \cdot e^{-j\tan^{-1}\left(\frac{x}{R}\right)}$$

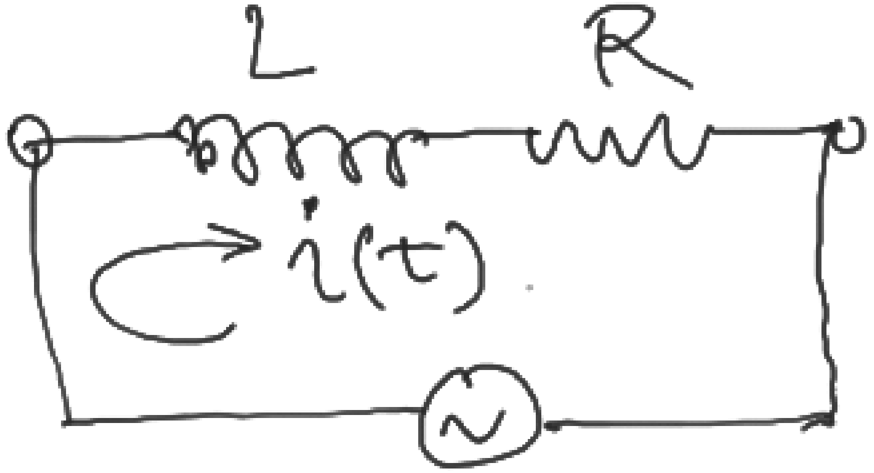
$$I = I_0 e^{j(\omega t - \theta)}$$



$$I_0 = \frac{V_0}{\sqrt{R^2 + x^2}}$$

Inductor





$i(t)\Big|_{max} = I_0$.

$V = V_0 \cos\omega t$.

$\boxed{Q = \frac{\omega L}{R}}$ → high then low loss.

R → Lossy part.

L → Energy storage

At any instant of time energy stored

$= \frac{1}{2}\cdot L\cdot i^2(t)$

Max energy stored $= \underline{\underline{\frac{1}{2} L I_0^2}}$

Quality factor (Q) $= 2\pi \cdot \frac{\text{Maximum energy stored per cycle}}{\text{Energy dissipated per cycle.}}$

$P_{Loss} = \frac{1}{2\pi}\int^{2\pi} R\cdot I_0^2 \cos^2\omega t\, dt = \frac{1}{2}\cdot I_0^2 R$

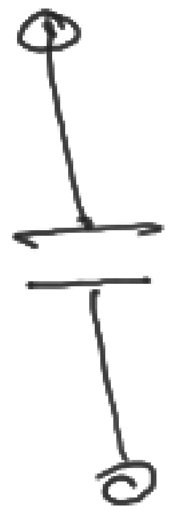
Avg. energy loss $= \frac{1}{2} I_0^2 R$.

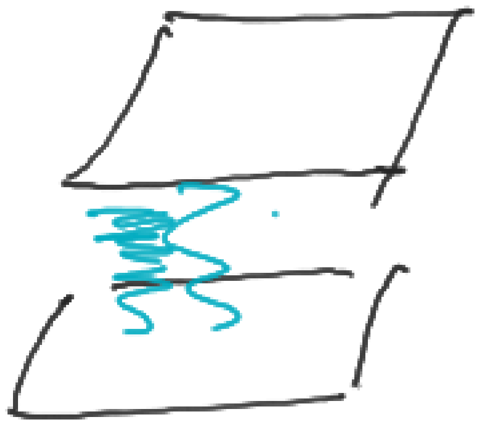
frequency $f = \frac{\omega}{2\pi}$.

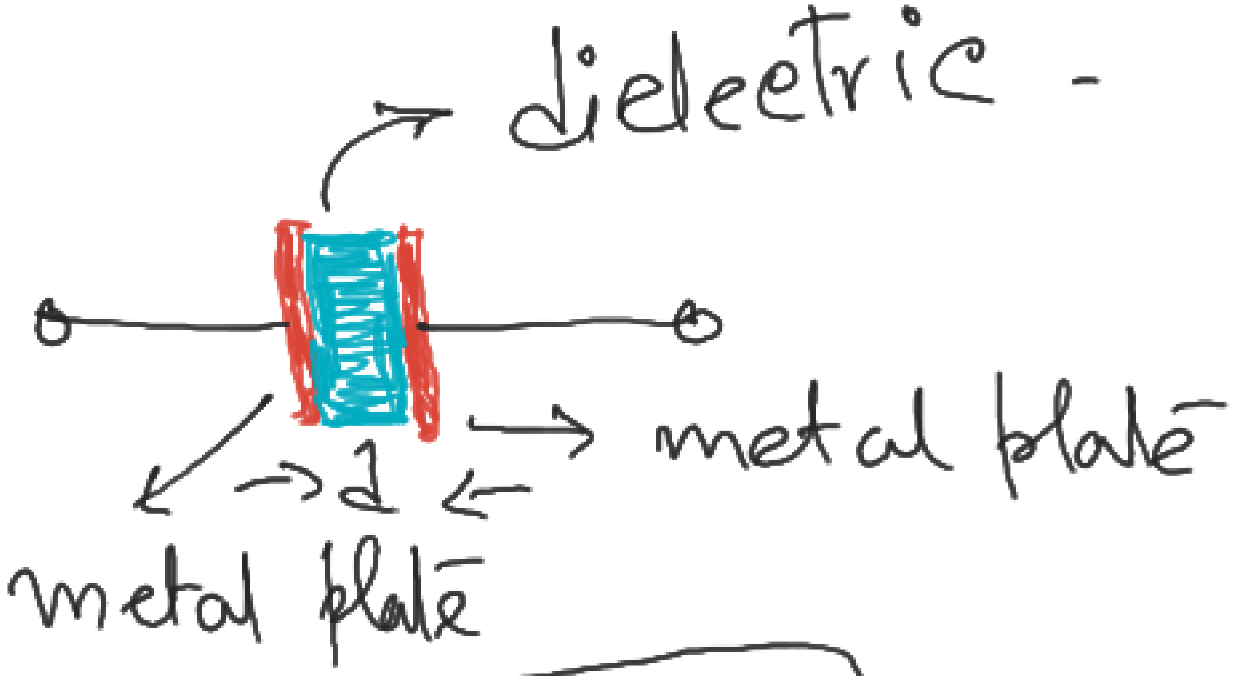
Energy dissipated per cycle $= \frac{P_{Loss}}{\omega} 2\pi$

Capacitor

Capacitor stores energy in the form of electrical energy.







$$E = \frac{V}{d} = \frac{V_0 \cos\omega t}{d}$$

$$\boxed{J_d = \epsilon \frac{\partial E}{\partial t}}$$

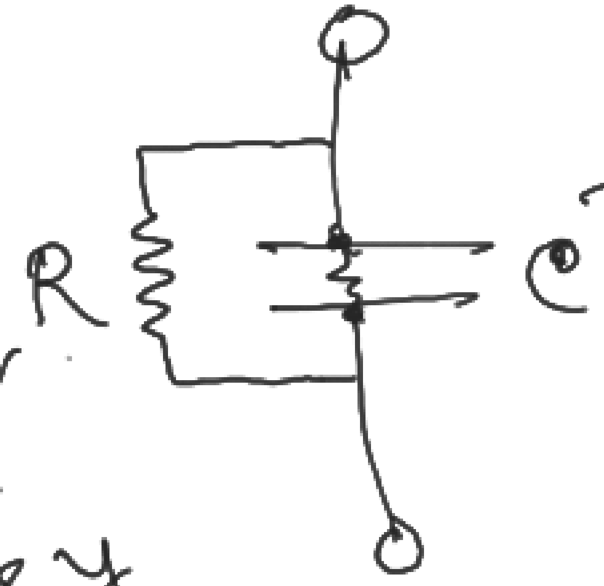
$$J_d = \frac{\partial E}{\partial t} = -\frac{V_0}{d}\,\omega \sin\omega t$$

ω

$$I = \frac{V}{X_c}$$

$$\boxed{X_c = \frac{1}{j\omega C}}$$

$V_\circ = V_0 \cos \omega t$



energy storing part

Lossy part

$J_d = \epsilon \frac{\partial E}{\partial t}$

$J_c = \sigma E$

$\sigma = \frac{1}{R}$

Maximum energy stored per cycle $= \frac{1}{2} C V_0^2$

Avg. energy dissipation $= \frac{V_0^2}{2R} = P_{Loss}$

Energy dissipation per cycle $= \frac{P_{Loss}}{\left(\frac{\omega}{2\pi}\right)}$

C perfect

Ceq

$$\boxed{Q = \omega RC}$$

$X_c =$