Capacitor & Inductor

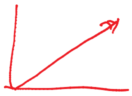
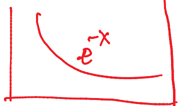
23 มีนาคม 2560
13:29

Chapter 6

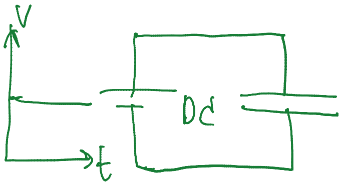
CAPACITOR & INDUCTOR

Super CAP → รถไฟฟ้า

storage element { Capacitor, Inductor (coil) } passive

Resistor	Cap & Ind.
ไม่สะสมพลังงาน	สะสมพลังงาน
Linear 	Non-linear 

dif Integrate

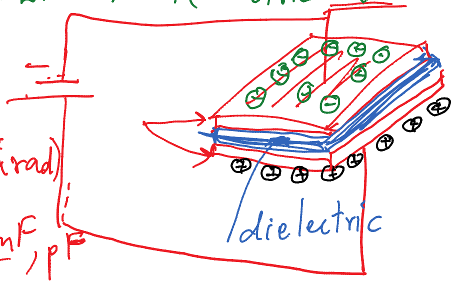


CAPACITORS

CAP เก็บพลังงานโดยเก็บสนามไฟฟ้า (Electric Field)

$$C = \frac{\varepsilon A}{d} \text{ (Farad)}$$

1 μF, mF, pF

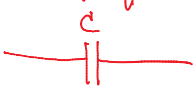


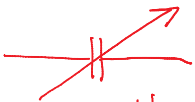
$$\boxed{1\text{F} = 1 \text{ Coulomb} / \text{Volt}}$$

$$\boxed{q(t) = C\, v(t)}$$

เวลา

Symbols





Current – Voltage relationship

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

กระแส

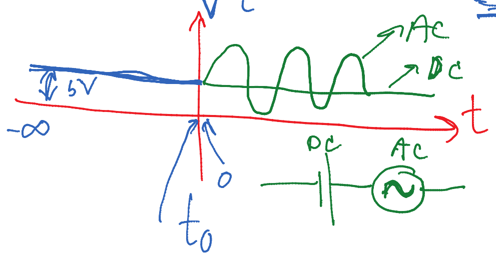
แรงดัน

ระไว

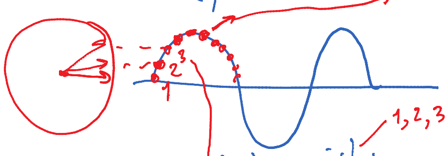
$\overline{\quad dt \quad}$

ค่าของ
ตัวเก็บประจุ

$$v(t) = \frac{1}{C}\int^{t} i(t)\,dt + v(t_0)$$



กำลัง (power) → ชั่วขณะ (instantanous)



1,2,3

$$p(t) = i(t) \times v(t)$$

$$\boxed{p(t) = C\frac{dv(t)}{dt} \times v(t)}$$

p(3) 3 3

พลังงาน (Energy)

$$\boxed{w(t) = \int_{-\infty}^{t} p(t)\,dt}$$

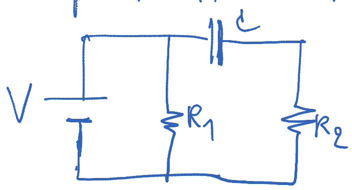
$$w(t) = \int_{-\infty}^{t} i(t)\cdot v(t)\,dt$$

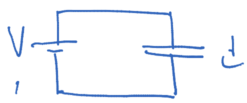
$$= \int_{0}^{t} C\frac{dv(t)}{dt}\cdot v(t)\,dt$$

$$\boxed{w(t) = \frac{1}{2}Cv^2(t)}$$ ※

Remarks:

1. ตัวเก็บประจุจะมีลักษณะเป็นวงจรเปิด (open circuit) เมื่อจ่ายไฟตรง (DC)

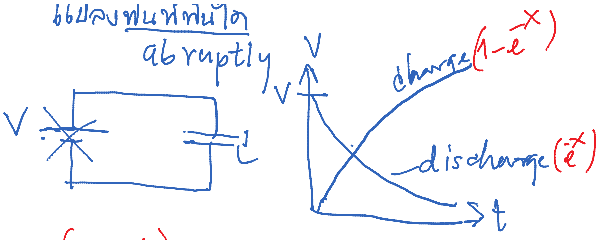




2. แรงดันที่ตกคร่อมตัวเก็บประจุ จะไม่เปลี่ยนแปลงทันทีทันใด
abruptly

charge $(1-e^{-x})$

แปลงพลันทันใด
abruptly



3. (Ideal) อุดมคติ → ตัวเก็บประจุจะไม่ปล่อยพลังงาน

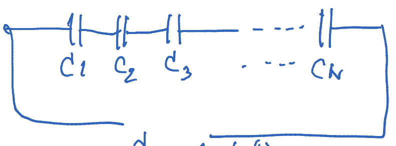
Ex ถ้ามีตัวเก็บประจุขนาด 10 μF ต่ออยู่กับแหล่งจ่ายไฟที่มีแรงดัน $v(t) = 50\cos 2000t$ (V) จะมีกระแสไหลผ่านตัวเก็บประจุเท่าใด

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

$$i = -\sin 2000t \text{ A}$$

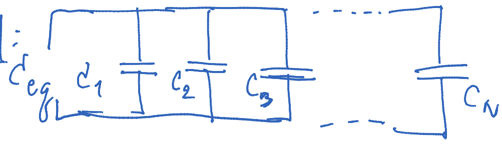
Series and Parallel Capacitors

Series:



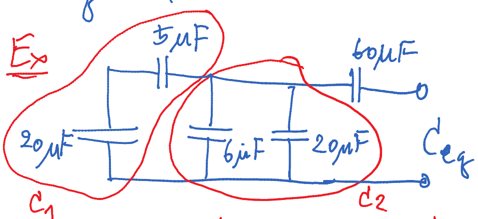
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_N}$$

parallel:



$$C_{eq} = C_1 + C_2 + C_3 + \dots + C_N$$

Ex



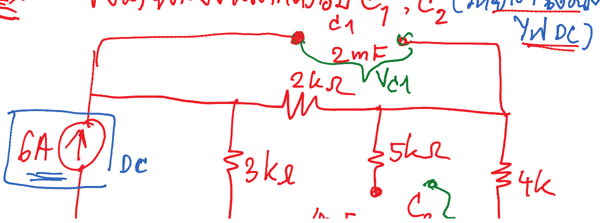
$$C_1 = \frac{5\mu F \times 20\mu F}{5\mu F + 20\mu F} = \frac{100\mu F}{25\mu F} = 4\mu F$$

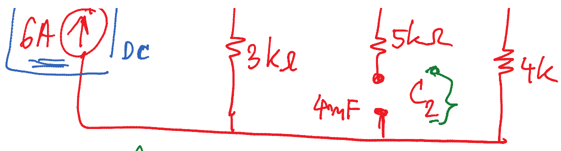
นำ $C_1 + C_2$

$$C_3 = C_1 + C_2 = 4\mu F + 6\mu F + 20\mu F$$
$$= 30\mu F$$

$$C_{eq} = \frac{60\mu F \times 30\mu F}{60\mu F + 30\mu F} = \frac{\cancel{1800}^{2}\mu F}{\cancel{90}\,\mu F} = 20\mu F$$

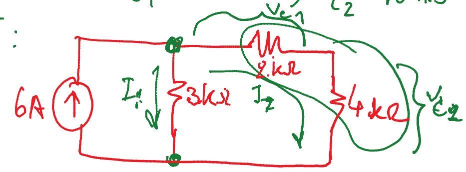
Ex จงหาพลังงานเก็บสะสม C_1, C_2 (ภายใต้เงื่อนไขไฟ DC)

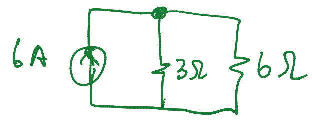




Ans: $W_{C_1} = 128\ mJ$, $W_{C_2} = 16\ mJ$

Hint:

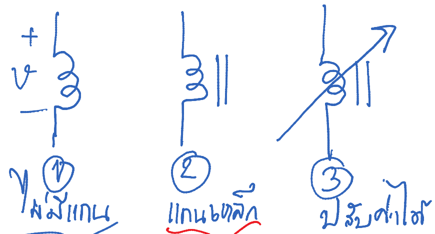




Inductor

Uses : TV, Transformer, Radio, Radar, motor

symbol:



high frequency → Radio, TV

Low frequency → Transformer

Analysis :

$$\boxed{v_L(t) = L\frac{di(t)}{dt}}$$

$$i(t) = \frac{1}{L}\int_{t_0}^{t} v_L(t)\,dt + i(t_0)$$

$$p_L(t) = v(t)\,i(t)$$

$$p_L(t) = L\frac{di(t)}{dt}\cdot i(t)$$

$$w_L(t) = \int_{-\infty}^{t} p(t)\,dt = \int_{-\infty}^{t} L\frac{di(t)}{dt}\cdot i(t)$$

$$\boxed{w_L(t) = \frac{1}{2}L\,i^2(t)}\ \star$$

Remarks :

1. Inductor → short → DC condition
2. I →

$$L_{eq} = L_1 + L_2 + L_3 \ldots$$

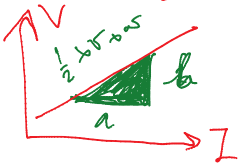
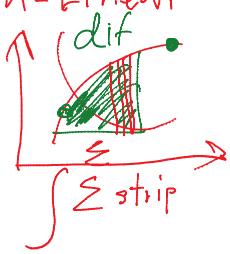
$L_{eq} = L_1 + L_2 + L_3 \ldots$

CHAPTER 6

CAPACITOR AND INDUCTOR

FILTER — RAM — BATTERIES

TV, Radio

Resistor	CAP. & IND. (C, L)
~~storage~~	storage
Linear	Non-Linear
	

- Active (TR, Diode)
- Passive (R, L, C)

$$\boxed{q(t) = C\,v(t)}$$

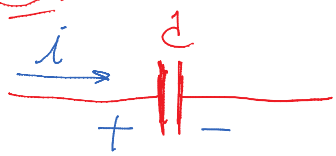
charge (C) — voltage — capacitor (Farad)

$$C = \frac{A\varepsilon_r}{d} \quad (\text{Farad})\ (F)$$

$$\boxed{1\,F = 1\ \text{coulomb}/\text{volt}}$$ ☆

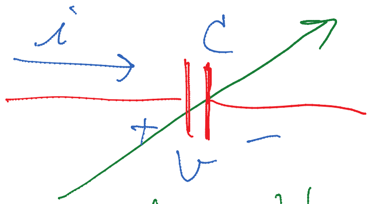
pF, μF, mF

Symbol:



Fixed

Fixed



Variable capacitor

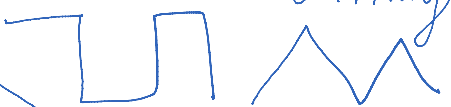
Current - Voltage relationship

ไหลผ่าน C   ตกคร่อม C

☆
$$i(t) = C \frac{dv(t)}{dt}$$

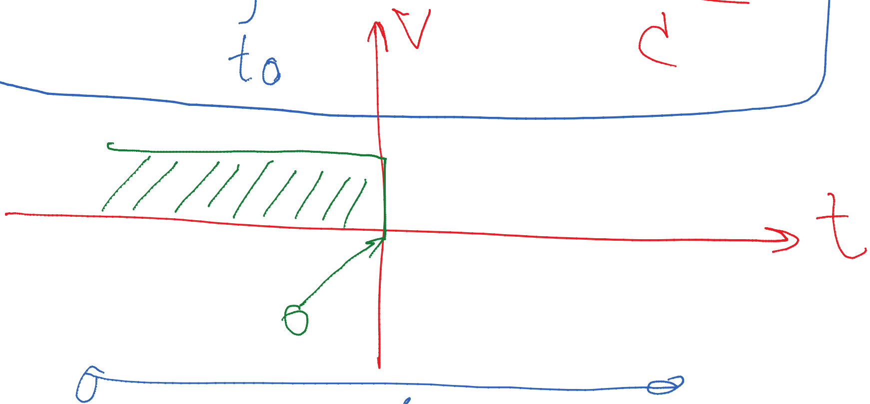
DC ×

AC → square, $\boxed{\text{sinewave}}$, cos, triangle



☆
$$v(t) = \frac{1}{C}\int_{t_0}^{t} i(t)\,dt + v(t_0)$$

C



Power (กำลังงาน)

$$p(t) = v(t) \times i(t)$$

$$\boxed{p(t) = v(t) \times C\frac{dv(t)}{dt}}$$ ☆

พลังงาน (Energy)

t

พลังงาน (Energy)

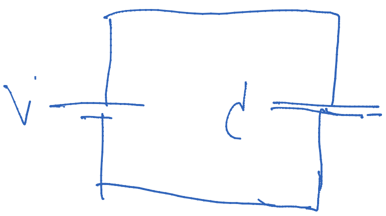
$$w(t) = \int_{-\infty}^{t} p(t)\,dt$$

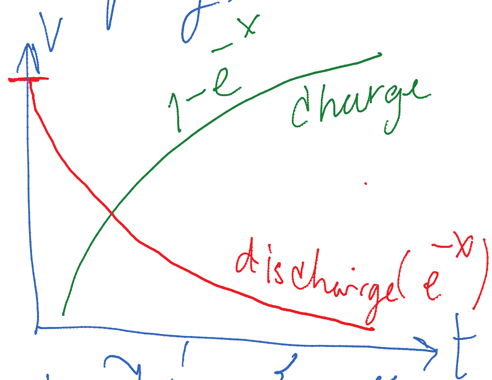
$$= \int_{-\infty}^{t} v(t) \cdot C \frac{dv(t)}{\cancel{dt}} \cancel{dt}$$

$$\boxed{w(t) = \frac{1}{2} C v^2(t)}$$

Remarks :

1. capacitor จะเปิดวงจร เมื่อจ่ายไฟตรง (DC)
2. แรงดันตกคร่อม capacitor จะไม่เปลี่ยนแปลงทันทีทันใด (abruptly)





3. ในทางอุดมคติ C จะไม่สูญเสียพลังงาน

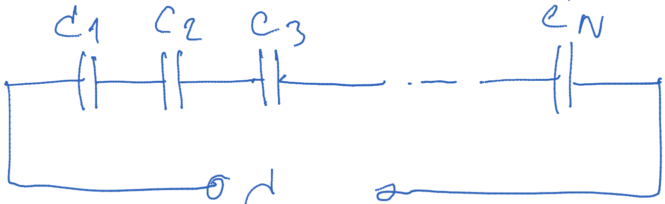
Ex ถ้ามีตัวเก็บประจุขนาด 10μF ต่ออยู่กับแหล่งจ่ายที่มีแรงดัน $v(t) = 50 \cos 2000t$ (V) จะมีกระแสไหลผ่าน C เท่าใด.

$$i = C\frac{dv(t)}{dt} = \frac{10\times10^{-6} \times d}{dt}(50 \cos 2000t)$$

$i(t) = -\sin 2000t$ (A) ✱

Series and Parallel Capacitors

Series:

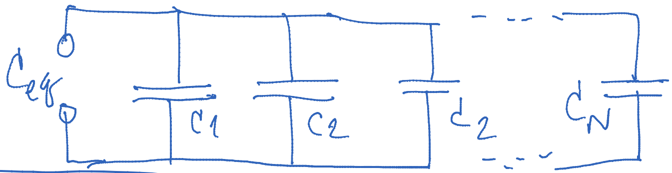


C_{eq} (Total)

$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_N}}$$

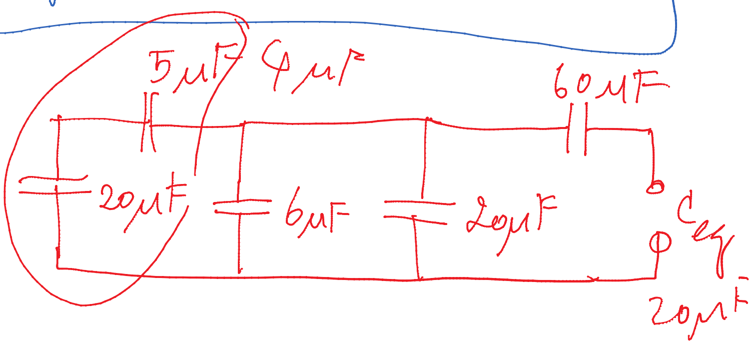
eq → equivalent

Parallel:



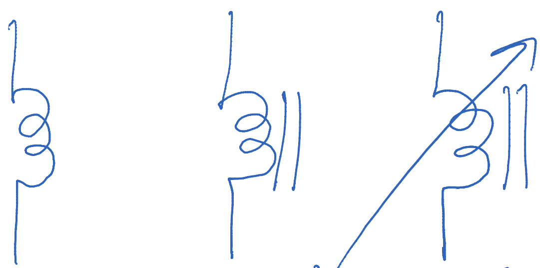
$$\boxed{C_{eq} = C_1 + C_2 + C_3 + \dots + C_N}$$

Ex



Inductors

Symbol:



Analysis: $v_1(t) = L\, d\, i_1(t)$ ✩

([illegible]) : $v_L(t) = L\dfrac{d\,i_L(t)}{dt}$ ☆

$$i_L(t) = \frac{1}{L}\int_{t_0}^{t} v_L(t)\,dt + i_L(t_0)$$

power $\rightarrow$ $p(t) = v(t) \times i(t)$

$$p(t) = L\frac{di(t)}{dt} \times i(t)$$

energy $\rightarrow$ $w(t) = \displaystyle\int_{-\infty}^{t} p(t)\,dt$

$$= \int_{-\infty}^{t} L\frac{d\,i(t)}{\cancel{dt}} \cdot i(t)\,\cancel{dt}$$

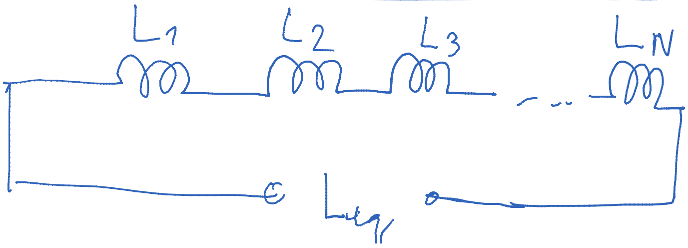
$$\boxed{w(t) = \frac{1}{2}L\,i^2(t)}$$ ☆

Remarks :

1. Inductor $\rightarrow$ short $\rightarrow$ DC
2.
3.

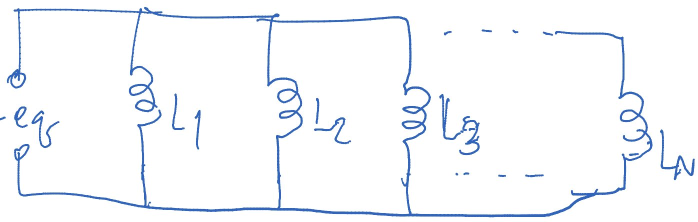
Series & Parallel Inductors

Series :



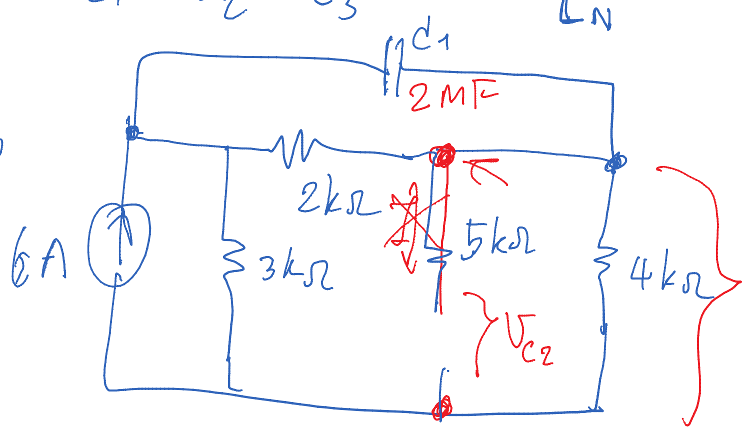
$$L_{eq} = L_1 + L_2 + L_3 + \dots + L_N$$

Parallel :



$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \dots + \frac{1}{L_N}$$

Ex



จงหา W_{C1} , W_{C2}

Answer : $W_{C1} = 128$ mJ

$W_{C2} = 16$ mJ