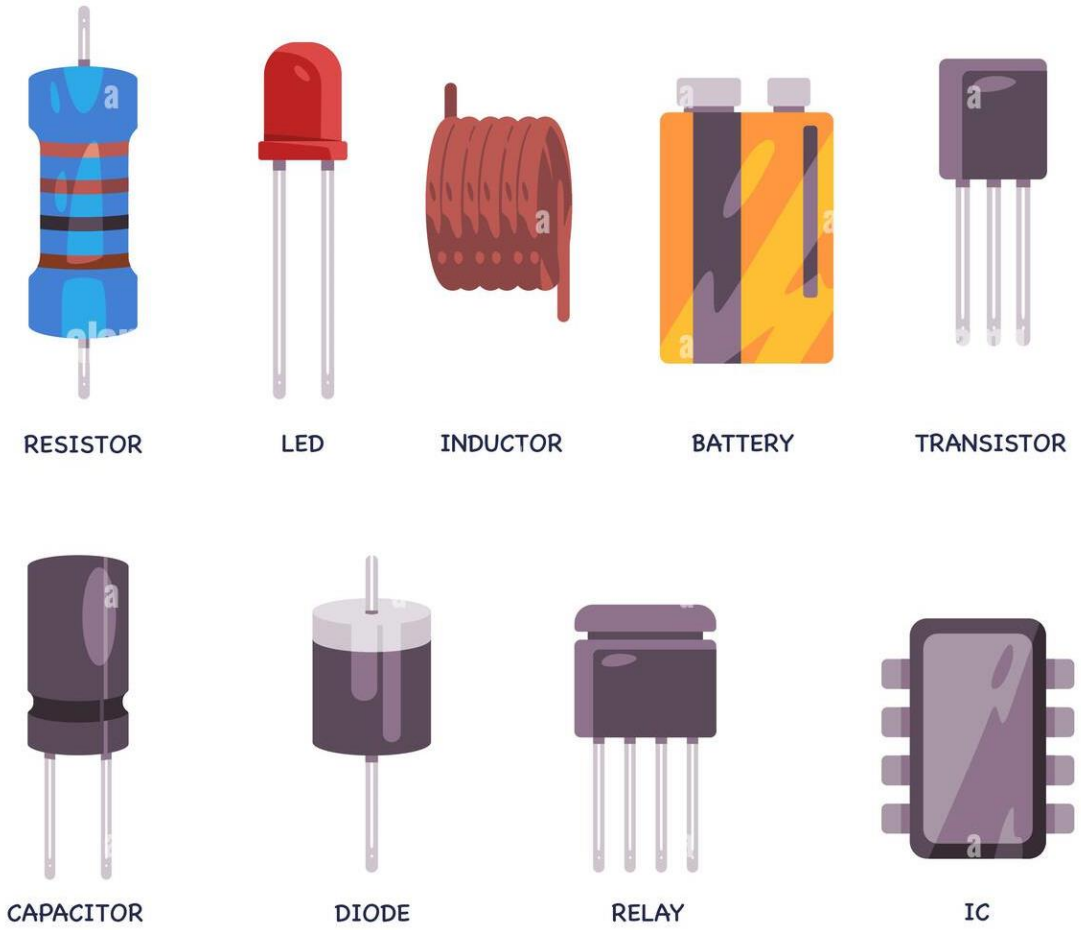
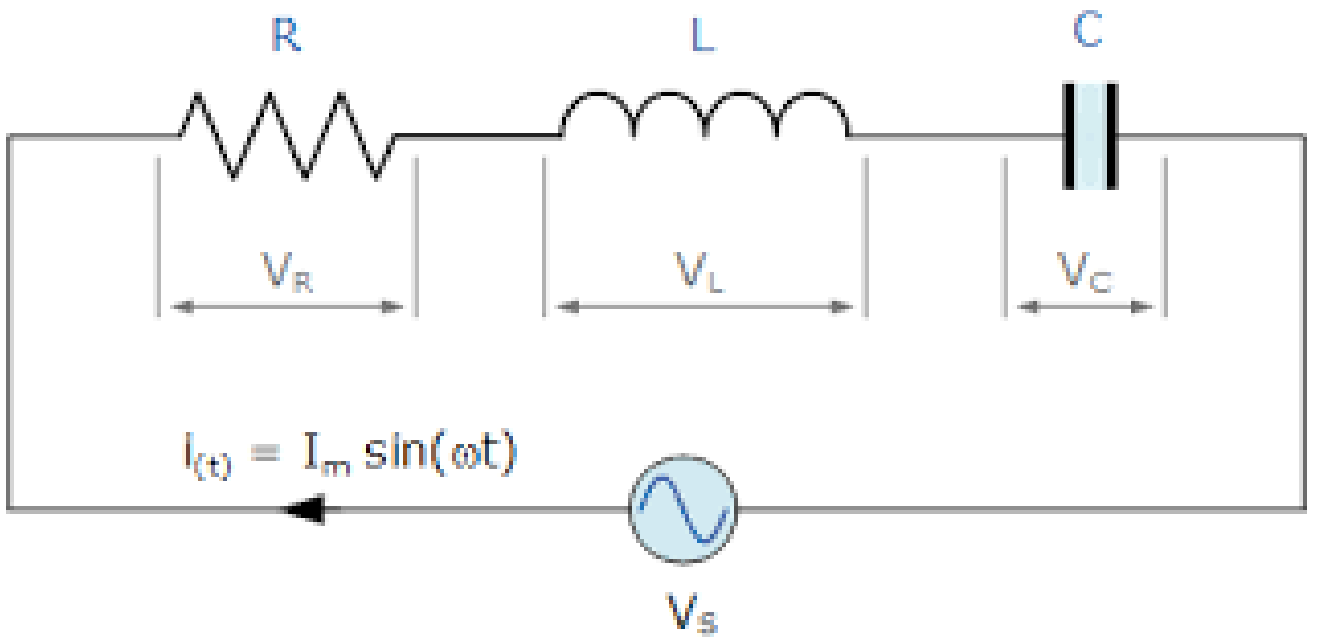
TOPIC #2 RLC


RESISTOR
LED
INDUCTOR
BATTERY
TRANSISTOR
CAPACITOR
DIODE
RELAY
IC

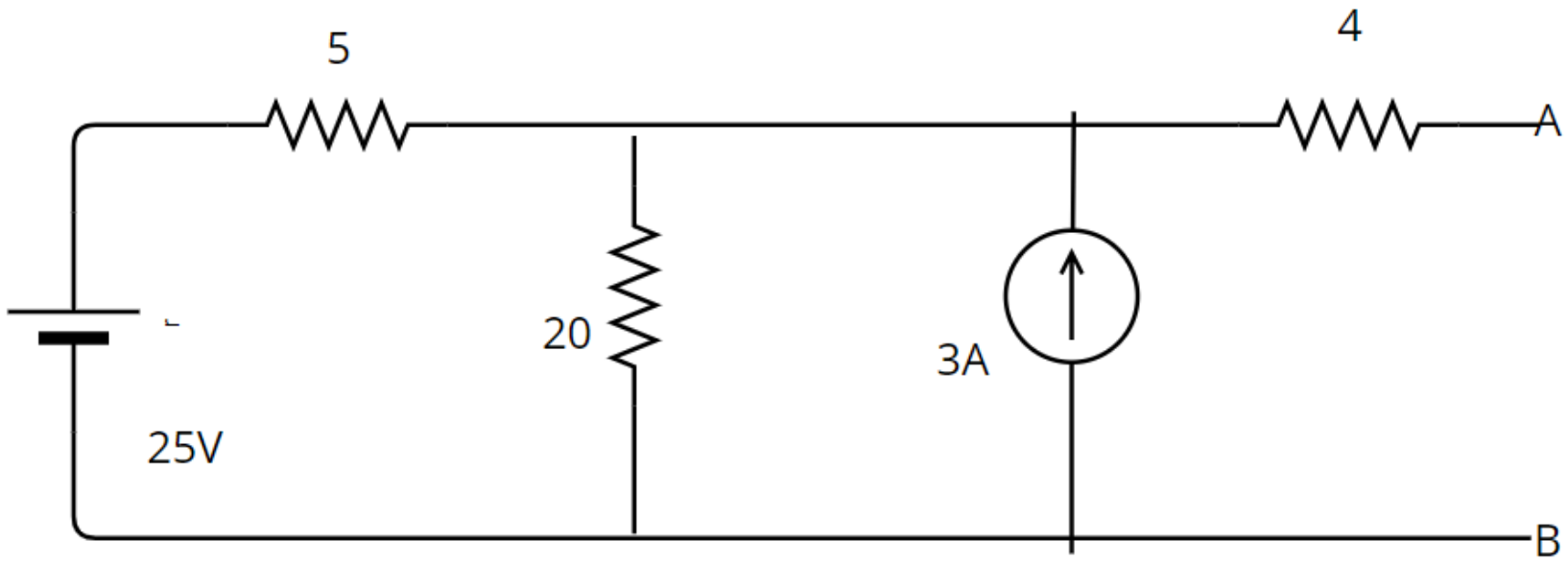
Introduction of RLC

- R : Resistor 電阻
- L : Inductor 電感 <- Lenz’s law
- C : Capacitor 電容



Voltage/ Current

- Def : V= dw/dq, I= dq/dt
- Note: When discussing the voltage, we often simplify the difference of voltage to voltage. Thus, keep in mind that the concept of "difference" is very important to circuit analysis



Resistor

- Always be a passive device (consuming energy)
- Commonly used in all circuit
- Covert the electrical energy to thermal energy
- We usually consider the load as a resistor

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

I = Current in Amperes (A)
V = Voltage in Volts (V)
R = Resistance in Ohms (Ω)

$$R = \frac{\rho L}{A}$$

ρ = resistivity
L = length
A = cross sectional area

Inductor

- Not so important
- Store magnetic energy
- Note: the magnetic theorem is more complex than electrical theorem

  It includes a lot concept of PDE(Partial Derivative Equation)
- Refer to these class
  - General physics
  - Electromagnetic
  - Electrical circuit

Capacitor(1/3)

- Def: C= Q/V
  - C: Capacitance (unit: F), Q: Charge (unit: coulomb) V: Voltage (unit : volt)
  - 白話:

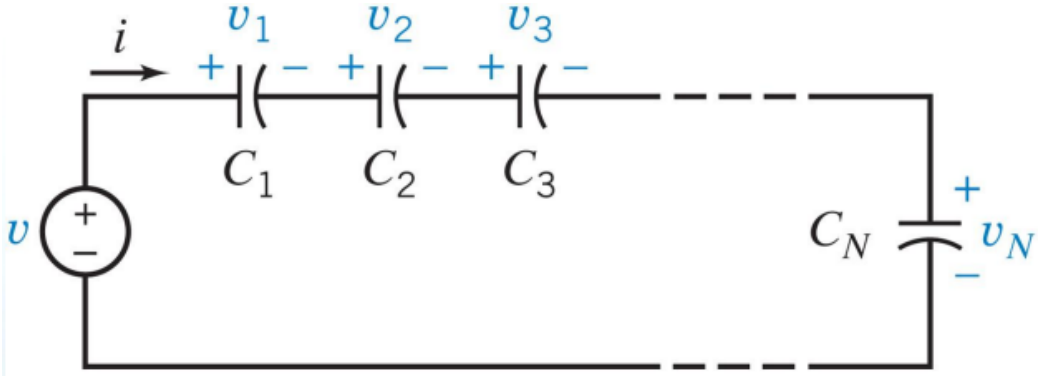
- In parallel plate C = ε $\frac{A}{d}$
- Stores electrical energy

Capacitor(2/3)

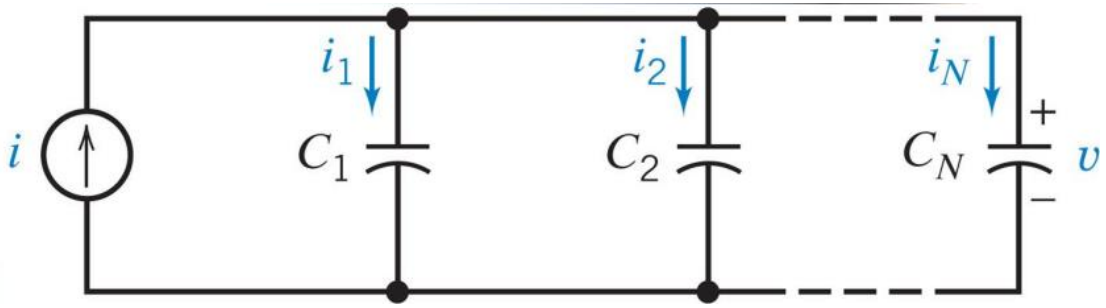
- In CKT: I = C $\frac{dV}{dt}$
- This formula gives us some property of capacitor
  1. Since C is proportional to dV/dt, the voltage difference of capacitors may not vary too much >> Voltage stability
  2. The physical meaning of the above point is that it may take some time to charge/ discharge the capacitor.

Capacitor(3/3)

- Capacitor in series: $\frac{1}{C_{total}} = \sum_i \frac{1}{C_i}$

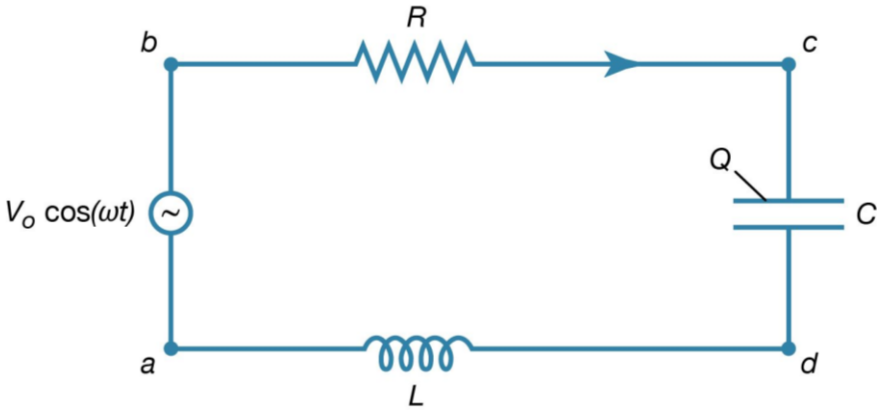


- Capacitor in parallel: $C_{total} = \sum_i C_i$



DC and AC circuit

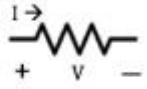
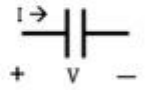
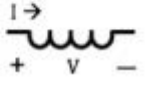
- DC circuit
  - Simpler
  - The input of the signal may not change with time
  - No frequency response



- AC circuit
  - More complex
  - The input of the signal may be the function of time. Ex: sin(t), square wave, etc.
  - Frequency response
- Frequency response
  - It means that the output of the circuit may vary with different frequency input
  - It may contain complex number computation

Impedance(1/7)

- The above discussion put more emphasis on the DC circuit
- However, in AC circuit, there are something difference from DC circuit
- We know that the resistance in DC circuit means the ability to block the current flowing through the resistor at given voltage.
- You can believe that the impedance is the resistance of the electric component in AC circuit
- Hard but very important

Circuit Element	Symbol	Current-Voltage Relationship in Time	Impedance
Resistor		$V = IR$	R
Capacitor		$I = C\frac{dV}{dt}$	$\frac{1}{j\omega C}$
Inductor		$V = L\frac{dI}{dt}$	$j\omega L$

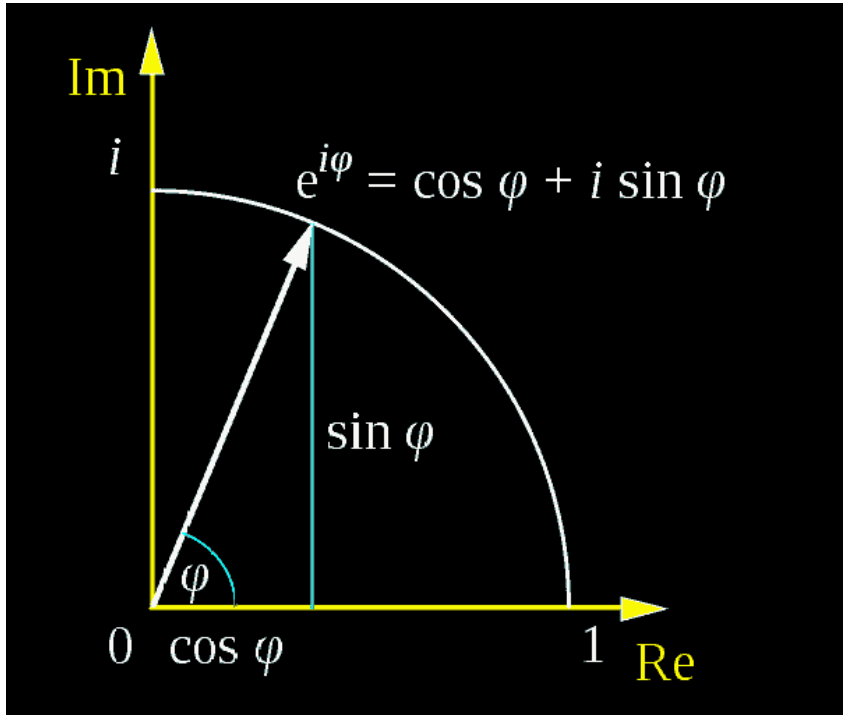
Impedance(2/7)

- Euler formula :

$$e^{j\Theta} = \cos(\Theta) + j\sin(\Theta) \text{ where } j = \sqrt{-1}$$

- It can be proved by Taylor series expansion
- $e^{j\Theta}$ is a unit circle(單位圓) in complex plane
- Θ is the angle between the vector and the real value axis

- $d(e^x)/dx = e^x$



Impedance(3/7)

- Proof of Euler formula

Impedance(4/7)

- Proof of $d(e^x)/dx = e^x$

- Proof of $d \sin(x)/dx = \cos(x)$

Impedance(5/7)

- Frequency response of capacitor

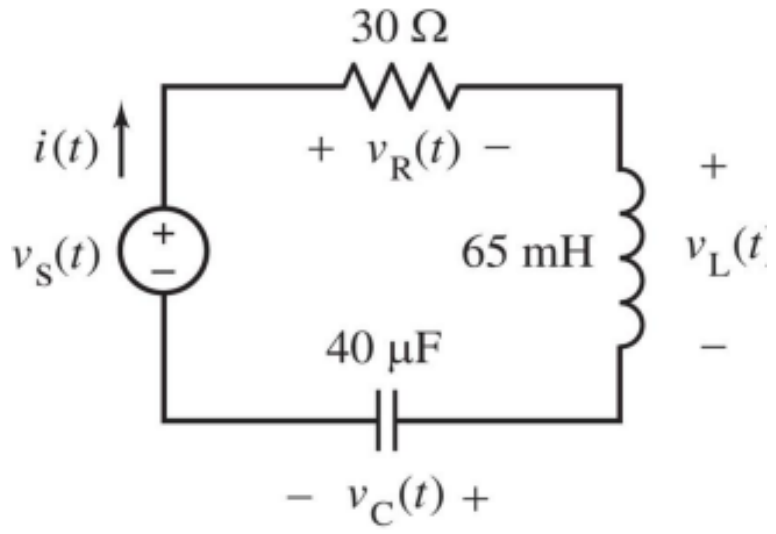
Impedance(6/7)

- Frequency response of inductor

Impedance(7/7)

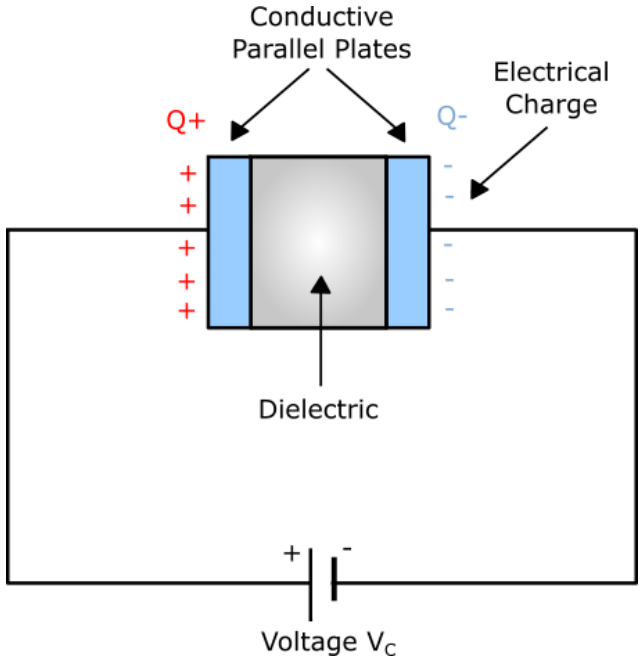
- Determine
  - (a) the impedances of the capacitor, inductor, and resistance and
  - (b) the current i(t)

$$v_S(t) = 12\cos(1000t + 15°)\ \text{V}$$



Take away message

- With DC signal: C can be seen as “open”
  - Because for steady state, C is well charged. The charge on the capacitor will block the current (Z = ∞)
- With AC signal: C can be seen as “short”
  - In AC circuit, the capacitor may keep charging and discharging, there is always current flowing through the capacitor (Z = 0)
- With DC signal: L can be seen as “short”
  - Inductor itself is a curl, so it may be seen as a conductive line for steady state. (Z = 0)
- With AC signal: L can be seen as “open”
  - Because for AC Signal, the curl structure may increase the ability to block the current (Z = ∞)



Application:
Filter (濾波器)