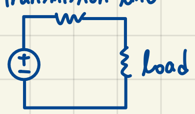
電 $\begin{cases} DC\ (0Hz) \\ AC\ (60Hz) \end{cases}$

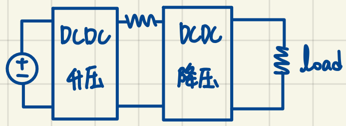
① DC

transmission line



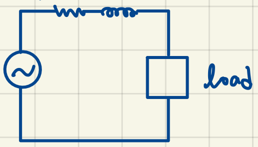
same freq 0Hz
相角 0°

transmission line
P=VI

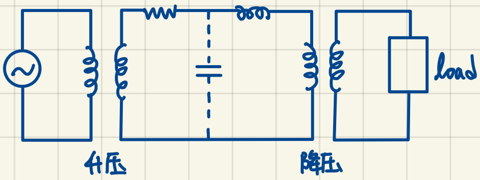


② AC

transmission line



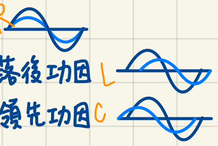
same freq.
所有発电机
転一様快



①DC ：电压.电流.實功率 (有储能元件)

$\begin{cases} V=IR \\ V=L\frac{di}{dt}\approx 0 \\ i=C\frac{dv}{dt}\approx 0 \end{cases}$ $\quad P=VI=\frac{V^2}{R}=I^2R$

② AC：电压.电流 ⟨ 同相位：單位功因 R / 电流落後於电压：落後功因 L / 电流領先於电压：領先功因 C



視在功率 = 實功 + 虛功 (沒有储能)
(R) (L+, C−)

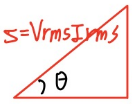
① $V=IR$ 單位功因

② $V=L\frac{di}{dt}$ 电流落後电压90° 落後功因

③ $i=C\frac{dv}{dt}$, $V=\frac{1}{C}\int i\,dt$ 电流領先电压90° 領先功因

$\frac{d\sin t}{dt}=\cos t=\sin(t+90°)$

☆ CH2

直流DC	交流AC
0Hz	60Hz
$V=iR$ 實	$V=iR$
$\begin{cases} V=L\frac{di}{dt}=0 \\ i=C\frac{dv}{dt}=0 \end{cases}$ 虛	$V=L\frac{di}{dt}\neq 0$ $=Lsi$
$P=VI$ $=V^2/R$ $=I^2R$	$i=C\frac{dv}{dt}\neq 0$ $=CsV$
$Q=0$ 虛	 $S=V_{rms}I_{rms}$, $Q=S\sin\theta$, $P=S\cos\theta$, $\sqrt{2}V_{rms}=V_{in}$

☆ 動三角形 (算平均, 非瞬間)

二階常微分方程

穩態：$t \to \infty$，留下的 $y''+3y'+2y = 5u(t)$

非齊次

input $u(t)$，output $y(t)$

方程式：微分方程

- 偏微分方程 (2個以上變數)
- 常微分方程 (單變數 y)
  - 非線性 (有自乘.互乘)
  - 線性
    - 變係數
    - 常係數
      - 齊次 (輸入項=0)
      - 非齊次 (輸入項≠0)

暫態：$t \to \infty$，消失不見

动態：

ex：switch改變時突然的變化

y_H：通解／暫態解 $y''+3y'+2y = 0$

$(D^2+3D+2)y = 0$

$(D+1)(D+2)y = 0$

$y_H = C_1e^{-t} + C_2e^{-2t}$

y_p：特解／穩態解 $y''+3y+2 = 5u(t)$

$y_p = \frac{5}{2}u(t)$，$y_p' = 0$，$y_p'' = 0$

單相：110 V_{rms} / 60Hz (均方根)

cons：电力脈动

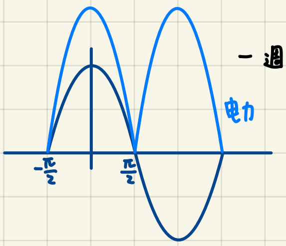
三相 3ϕ 220 V_{rms} / 60Hz (V_{ab}, V_{bc}, V_{ca})

pros：电力常數

$v(t) = \sqrt{2} \times 110 \sin(\underset{377}{\omega t})$

$v(t) = \sqrt{2} \times 110 \cos(\omega t)$ 觀測坐標不同

振幅 $V_m = \sqrt{2}V_{rms} = \sqrt{2} \times 110$



一週期 $360° = 2\pi = 6.28$ rad 徑度

單相

$\cos(\theta+\theta) = \cos^2\theta - \sin^2\theta$

$= \cos^2\theta - [1-\cos^2\theta]$

$= 2\cos^2\theta - 1$

$$\frac{\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{[V_m\cos\theta]^2}{R} d\theta}{\pi} = \frac{V_m^2}{2R} = \frac{V_{rms}^2}{R}$$

V_{max} (振幅)

$\cos^2\theta = \frac{1-\cos 2\theta}{2}$

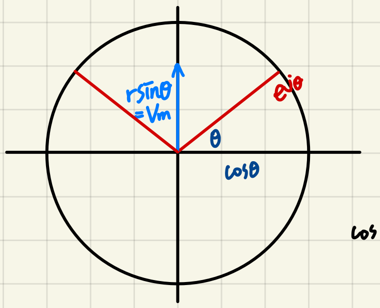
$$\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} (\cos\theta)^2 d\theta = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{1+\cos 2\theta}{2} d\theta = \frac{\pi}{2}$$

只能量一個 freq.

在60Hz同步座標觀察交流得到直流

60Hz ⟶ 0Hz

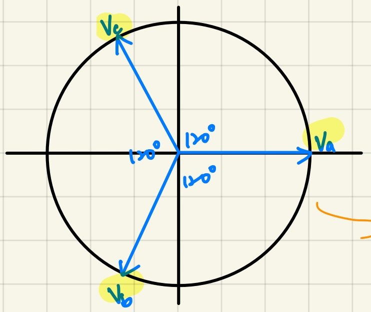
0Hz ⟶ -60Hz



$\cos(\omega t)$ $\omega = 2\pi f = 377$

$V_m e^{j\theta} = [\cos\theta + j\sin\theta]V_m$

三相



$\pi = 180^\circ$

$\frac{2\pi}{3} = 120^\circ$

$V_a(t) = 180 \sin 377t$

$V_b(t) = 180 \sin(377t - 120^\circ)$

$V_c(t) = 180 \sin(377t - 240^\circ)$

$= 180 \sin(377t + 120^\circ)$

$V_a(t) = 180 \cos 377t$

$V_b(t) = 180 \cos(377t - 120^\circ)$

$V_c(t) = 180 \cos(377t - 240^\circ)$

$= 180 \cos(377t + 120^\circ)$

$V_a + V_b + V_c = 0$

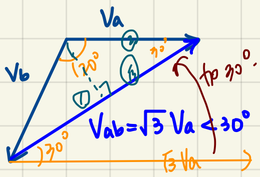
$i_a + i_b + i_c = 0$

$P = V_a i_a + V_b i_b + V_c i_c = 3VI\cos\theta \neq 0$

若 $V_m = 180 \Rightarrow V_{rms} = \frac{V_m}{\sqrt{2}} = 127$

$V_{ab} = V_a - V_b = \sqrt{3}\, V_{a,rms} \angle 30^\circ = \sqrt{3} \times 127 = 220$

加30°



$v(t) = \frac{1}{C}\int i\,dt = \frac{i}{Cs}$	領先功因
$v(t) = i(t) \times R$	單位功因
$v(t) = L\frac{di(t)}{dt}$	落後功因

$$\frac{d\sin(wt)}{dt}$$

$$= \frac{d\sin(wt)}{dwt} \times \frac{dwt}{dt}$$

$$= \cos(wt) \times w = \sin(wt + 90^\circ) \times w = j\sin(wt) \times w \Rightarrow \frac{d}{dt} = s = jw$$

和差化積

$\sin(A+B) = \sin A\cos B + \cos A\sin B$

$\sin(A-B) = \sin A\cos B - \cos A\sin B$

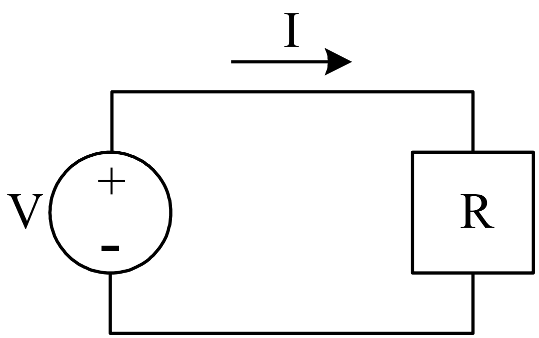
$\cos(A+B) = \cos A\cos B + \sin A\sin B$

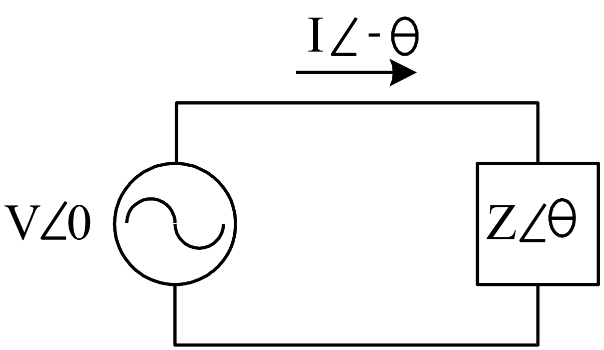
$\cos(A-B) = \cos A\cos B - \sin A\sin B$

積化和差

$2\cos A\cos B = \cos(A+B) + \cos(A-B)$

1.9 REAL, REACTIVE, AND APPARENT POWER IN AC CIRCUITS





DC Power

$$P = VI = V^2 / R = I^2 R \qquad (1-55)$$

AC Power

$$v(t) = \sqrt{2}\, V \cos \omega t \qquad (1-56)$$

$$i(t) = \sqrt{2}\, I \cos(\omega t - \theta) \qquad (1-57)$$

$$p(t) = v(t) i(t) = 2VI \cos \omega t \cos(\omega t - \theta) \qquad (1-58)$$

$$p(t) = VI[\cos\theta + \cos(2\omega t - \theta)]$$

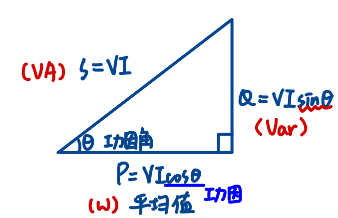
$$= VI \cos\theta \cdot (1 + \cos 2\omega t) + VI \sin\theta \cdot \sin 2\omega t \qquad (1-59)$$

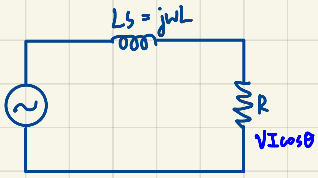
The Power Triangle

$$P_{avg} = V_{rms} I_{rms} \cos\theta \qquad (1-60)$$

$$Q = VI \sin\theta \qquad (1-61)$$

$$S = VI \qquad (1-62)$$





$v(t) = (jwL+R)\,i(t)$

7符號:v_{BE}(總瞬間值)=V_{BE}(直流值)+v_{be}(交流瞬間值)
V_{be}(相量值)

2.1供應單埠的複數功率

(Complex Power Supplied to a One-Port)

$v(t)=V_m\cos(\omega t+\theta_v)=\mathrm{Re}(V_m e^{j(\omega t+\theta v)})$

$i(t)=I_m\cos(\omega t+\theta_i)=\mathrm{Re}(I_m e^{j(\omega t+\theta i)})$

$p(t)=v(t)*i(t)=V_m\cos(\omega t+\theta_v)*I_m\cos(\omega t+\theta_i)$

$\quad =0.5*V_mI_m[\cos(\theta_v-\theta_i)+\cos(2\omega t+\theta_v+\theta_i)]$

Power factor angle: $\theta=\theta_v-\theta_i$

Power factor = $\cos\theta$;(lagging,leading,unity)

Average power$=0.5*V_mI_m\cos\theta=V_{rms}I_{rms}\cos\theta=\mathrm{Re}VI^*$

Power triangle $S=VI^*=P+jQ$;

|S|視在功率(VA) apparent power

S複數功率(VA) complex power

P實功(W) real power

Q虛功(無效功率)(Var) reactive power

EX2.1 Inductor L,Z=jωL,reactive power $Q=\omega L|I|^2$

$i(t)=\sqrt{2}|I|\cos(\omega t+\theta)$

$v(t)=L\,di/dt=-\sqrt{2}\omega L|I|\sin(\omega t+\theta)$

$p(t)=v(t)*i(t)=-2\omega L|I|^2\sin(\omega t+\theta)\cos(\omega t+\theta)$

$=-\omega L|I|^2\sin 2(\omega t+\theta)$

Average Power P=0,

瞬時功不為零(Instantaneous power is not zero)

$S=VI^*=ZII^*=Z|I|^2=j\omega L|I|^2=P+jQ$

所以$P=0, Q=\mathrm{Im}S=\omega L|I|^2$

練習1: Capacitor C,$Z=1/j\omega C$,reactive power $Q=-\omega C|V|^2$

$v(t)=\sqrt{2}|V|\cos(\omega t+\theta)$

$i(t)=Cdv/dt=-\sqrt{2}\omega C|V|\sin(\omega t+\theta)$

$p(t)=v(t)*i(t)=-2\omega C|V|^2\sin(\omega t+\theta)\cos(\omega t+\theta)$

$=-\omega C|V|^2\sin 2(\omega t+\theta)$

Average Power $P=0$,

瞬時功不為零(Instantaneous power is not zero)

$S=VI^*=V(V/Z)^*=|V|^2/(Z)^*=-j\omega C|V|^2=P+jQ$

So $P=0,Q=\mathrm{Im}S=-\omega C|V|^2$

2.2複數功率守恆
(Conservation of Complex Power)

複數功率守恆($S_{in} = S_{out}$):數個頻率相同的獨立電源供應的網路，

由各個獨立電源供應的複數功率的總和會等於網路會等於網路上所有分支接收到的複數功率

供電=用 電(Power of generators are equal Loads)

EX2.3輸入電源並聯電容C
Input voltage with shunt C

$S_{in}=S_c+S_o$

$S_c=VI^*=V(V/Z)^*=VV^*(1/Z)^*=VV^*(Y)^*=|V|^2(SC)^*$

$=-j\omega C|V|^2$

$S_o=S_{in}-S_c=S_{in}+j\omega C|V|^2$

$P_o=P_{in}$

$Q_o=Q_{in}+\omega C|V|^2$

EX2.4輸入電源串聯電感L(假設$|V_2|=|V_1|$)
Series L between two voltage source

$S_1+S_2=S_L=VI^*=j\omega L|I|^2$

$P_1+P_2=0$

$Q_1+Q_2=Q_L=\omega L|I|^2$

$S_1=V_1I^*$

$S_2=-V_2I^*$

$\because |V_2|=|V_1| \Rightarrow |S_1|=|S_2| \Rightarrow (P_1)^2+(Q_1)^2=(P_2)^2+(Q_2)^2$

$\because |P_2|=|P_1| \Rightarrow |Q_2|=|Q_1| \Rightarrow Q_1=Q_2=0.5\omega L|I|^2$

So $P_1=-P_2$，$Q_1=Q_2 \Rightarrow S_2=-(S_1)^*$

EX2.7三相電源(Three-phase voltages)

以n1為基點(n1 is basis point)

$S=V_{an1}I_a^*+V_{bn1}I_b^*+V_{cn1}I_c^*$(三瓦特計法)

以b為基點(b is basis point)

$S=V_{ab}I_a^*+V_{bb}I_b^*+V_{cb}I_c^*=V_{ab}I_a^*+V_{cb}I_c^*$(二瓦特計法)

2.3平衡三相(Balanced Three-Phase)

pros：①无虚功　　pros：①可升降压②传送距离远

直流電與交流電的優缺點

cons ~~cos~~：①无法升降压 ②传送距离短

Advantages and disadvantages of DC and AC voltages

pros：电力常权

單相交流電與三相交流電的優缺點

cons：①电力脉动

Advantages and disadvantages of single-phase voltage and three-phase voltages

$V_a(0^\circ) \rightarrow V_b(-120^\circ) \rightarrow V_c(-240^\circ)$　　$V_a+V_b+V_c \neq 0$

正序與負序(產生旋轉磁場)，零序

$V_a(0^\circ) \rightarrow V_c(-240^\circ) \rightarrow V_b(-120^\circ)$

Positive sequence, negative sequence, zero sequence

平衡與不平衡電壓和負載(線性與非線性負載)

Balanced and unbalanced voltages and loads

在発电机才是real 中性点.其它的摸了会

中性點電壓與電流(voltage and current of neutral point)

Δ-Y

EX2.8三相電源與負載中性點電壓
Three-phase voltages and neutral point voltage

以n1為基點(n1 is basis point)

$I_a=V_{an1}/Z=(V_{an}-V_{n1n})/Z=(V_{an}-V_{n1n})Y$

$I_b=V_{bn1}/Z=(V_{bn}-V_{n1n})/Z=(V_{bn}-V_{n1n})Y$

$I_c=V_{cn1}/Z=(V_{cn}-V_{n1n})/Z=(V_{cn}-V_{n1n})Y$

So $I_a+I_b+I_c=(V_{an}+V_{bn}+V_{cn})Y-3V_{n1n}Y=0$

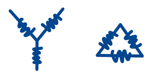
If $(V_{an}+V_{bn}+V_{cn})=0 \Rightarrow V_{n1n}=0$ theoretically, but not likely

EX2.9中性點阻抗不為零時?

Δ-Y

阻抗(Impedance)

$Z_Y = Z_\Delta / 3$



EX2.10線對線電壓與相電壓?

Line-to-line voltages and Phase voltages?

2.4單相分析(平衡三相)Per Phase Analysis

平衡三相(Balanced three-phase)

假設:平衡三相系統；負載與電源是星形連接；電路模型中，相之間無互感存在

所以:所有的中性點電位相同；各相是完全去耦合；所有對應的網路變數和平衡電源系統具有相同相序

EX2.11 Balanced three-phase?

2.5平衡三相功率(瞬時功率為常數)
Power of the balanced three-phase is constant

$S_3=V_aI_a^*+V_bI_b^*+V_cI_c^*$

Balanced three-phase and positive sequency

$S_3=V_aI_a^*+V_ae^{-j2\pi/3}(I_ae^{-j2\pi/3})^*+V_ae^{j2\pi/3}(I_ae^{j2\pi/3})^*=3V_aI_a^*$

Instantaneous Power: $p_3(t)=p_a(t)+p_b(t)+p_c(t)$

$p_3(t)=v_a(t)i_a(t)+v_b(t)i_b(t)+v_c(t)i_c(t)$

$v_a(t)*i_a(t)=V_m\cos(\omega t+\theta_v)*I_m\cos(\omega t+\theta_i)$

$=0.5*V_mI_m[\cos(\theta_v-\theta_i)+\cos(2\omega t+\theta_v+\theta_i)]$

$v_b(t)*i_b(t)=V_m\cos(\omega t+\theta_v-2\pi/3)*I_m\cos(\omega t+\theta_i-2\pi/3)$

$=0.5*V_mI_m[\cos(\theta_v-\theta_i)+\cos(2\omega t+\theta_v+\theta_i-4\pi/3)]$

$v_c(t)*i_c(t)=V_m\cos(\omega t+\theta_v+2\pi/3)*I_m\cos(\omega t+\theta_i+2\pi/3)$

$=0.5*V_mI_m[\cos(\theta_v-\theta_i)+\cos(2\omega t+\theta_v+\theta_i+4\pi/3)]$

$p_3(t)=3*0.5*V_mI_m[\cos(\theta_v-\theta_i)]=3|V||I|\cos(\theta_v-\theta_i)$