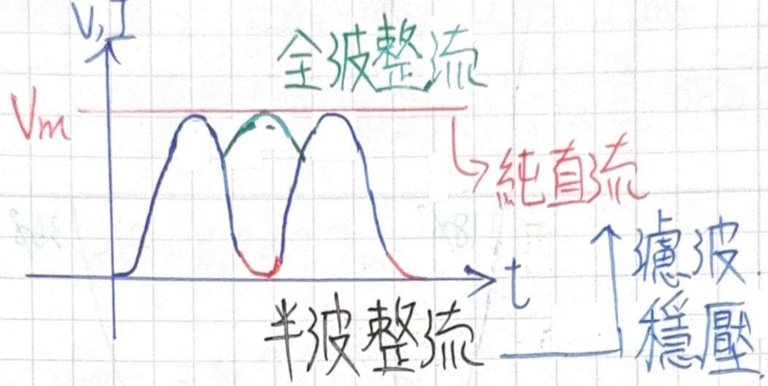
CH8. 交流電

8-1 電力系統的認識

1. 直流：所提供之電壓其大小極性不隨時間變化



2. 交流：其大小和極性隨時間變化

(1) 優：
- ① 成本低
- ② 效率高，保養費用便宜
- ③ 昇降V調整容易

8-2. 波形

有正弦、脈波、方波、鋸齒波、三角波.

ω：角速度 / rad 弧度

$\sin 30^\circ = \frac{1}{2}$

$\sin 37^\circ = \frac{3}{5}$

$\sin 45^\circ = \frac{1}{\sqrt{2}}$

$\sin 53^\circ = \frac{4}{5}$

$\sin 60^\circ = \frac{\sqrt{3}}{2}$

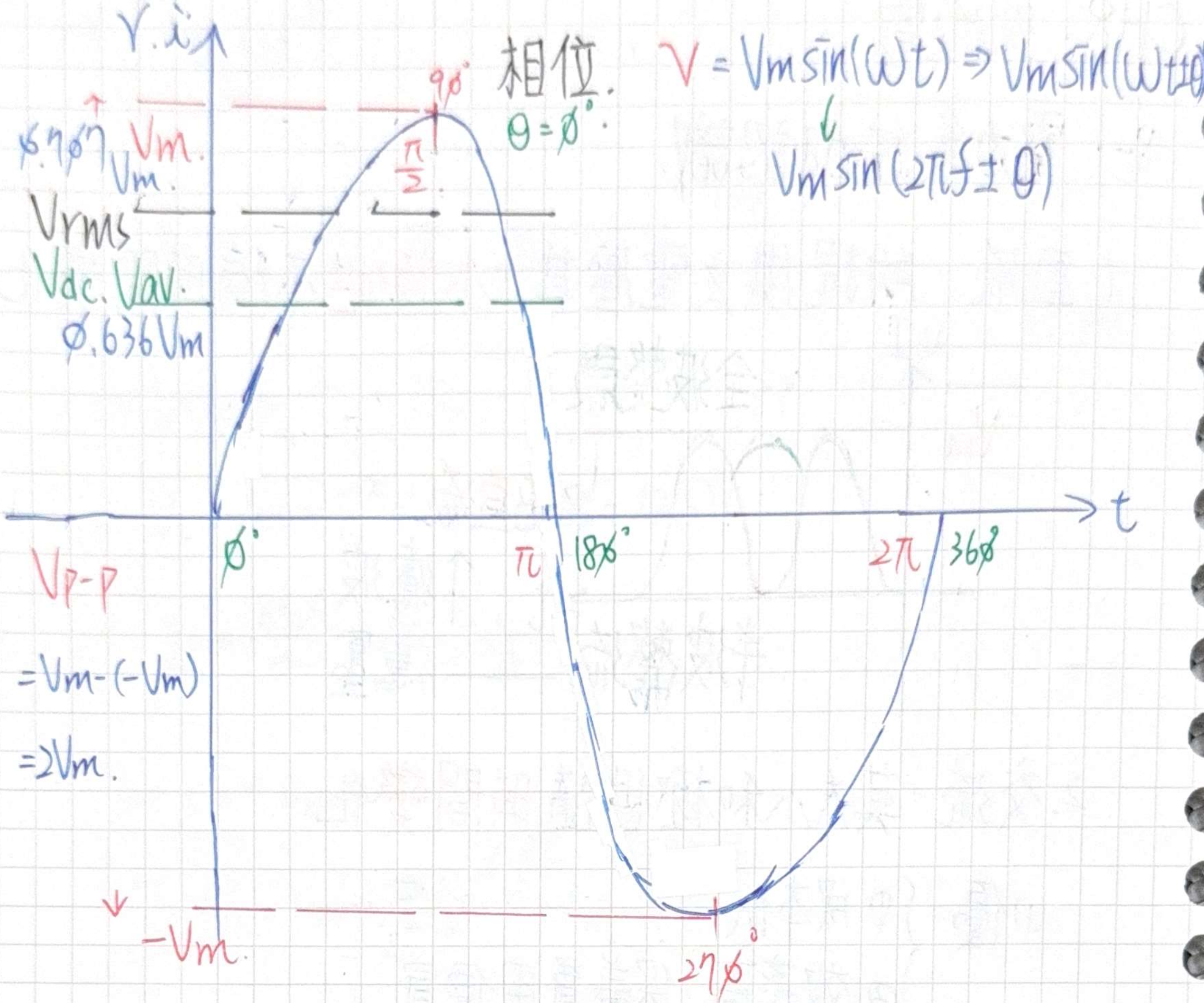
$\sin 90^\circ = 1$

1. 正弦波

頻率

$$\omega = \frac{\theta}{t} \Rightarrow \frac{2\pi}{T} = 2\pi f$$

$$\begin{cases} 377t = 60HZ \\ 314t = 50HZ \end{cases}$$



(1) 瞬時值：交流 v 或 i，隨時間改變大小，在波形中某一瞬間之數值.

(2) 峰間值：波峰到波谷之間的值.

$V_{p-p} = 2V_m$　　$I_{p-p} = 2I_m$.

(3) 最大值：波形中最大瞬時值 (V_m. I_m)

(4) 平均值

三用電表 DCV 檔所量測交流電數值.

△一個週期內所包含的總平均面積之值.

$V_{av}、V_{dc} = \frac{2}{\pi} V_m = 0.636\, V_m$

$I_{av}. I_{dc} = 0.636\, V_m.$

(5) 均方根值，$V_{eff}. V_{rms}$、$I_{eff}. I_{rms}$

三用電表ACV檔量測交流電所得數值

$I_{eff}. I_{rms} = 0.707\, I_m.$

$V_{eff}. V_m = 0.707\, V_m.$

$V_{(t)} = V_m \sin \omega t$

$V_{p\text{-}p} = V_m - (-V_m) = 2V_m$

$V_{av}. V_{dc} = \frac{2V_m}{\pi} = 0.636\, V_m$

$V_{eff}. V_{rms} = \frac{V_m}{\sqrt{2}} = 0.707\, V_m$

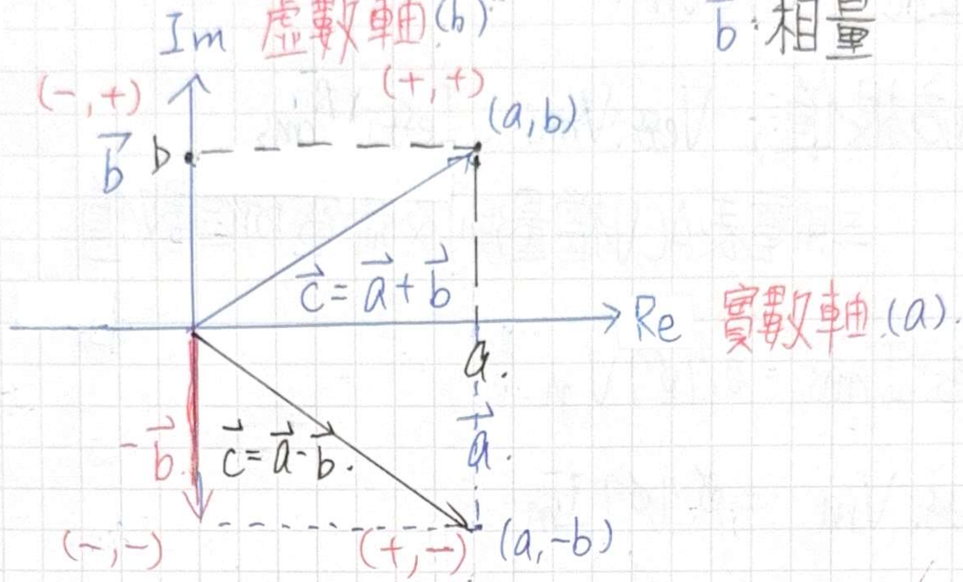
141
0.707) 110000
707
2930
2828
1020
707
313

8-5. 相量和向量

$\vec{a}$：向量

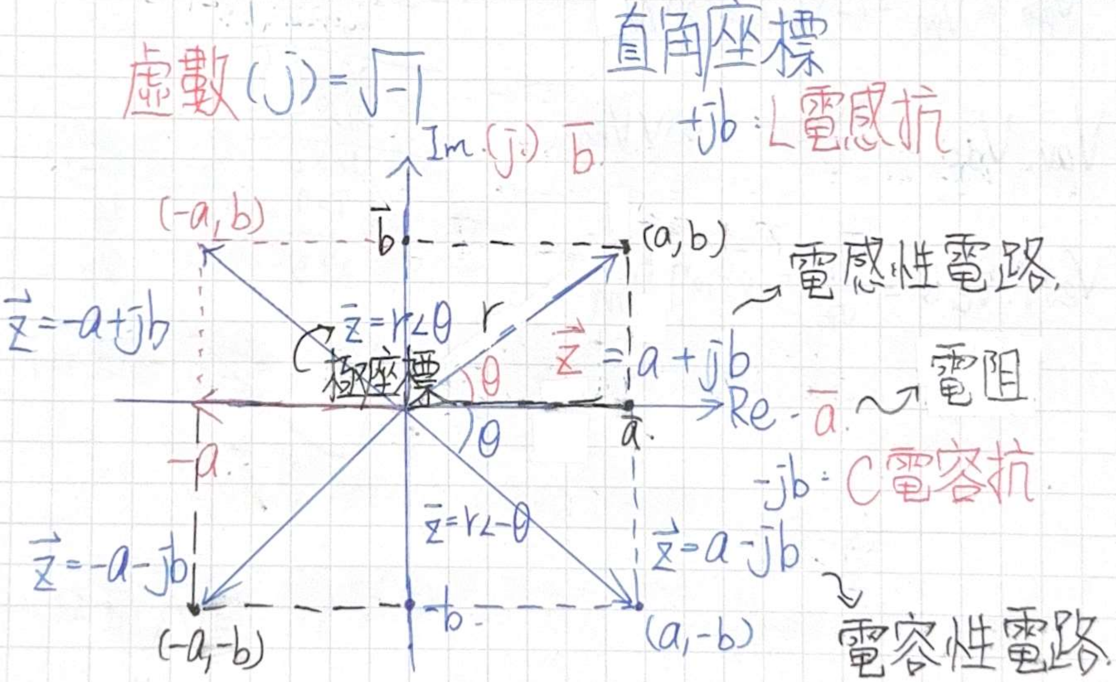
$\bar{b}$：相量

8-5-1 向量



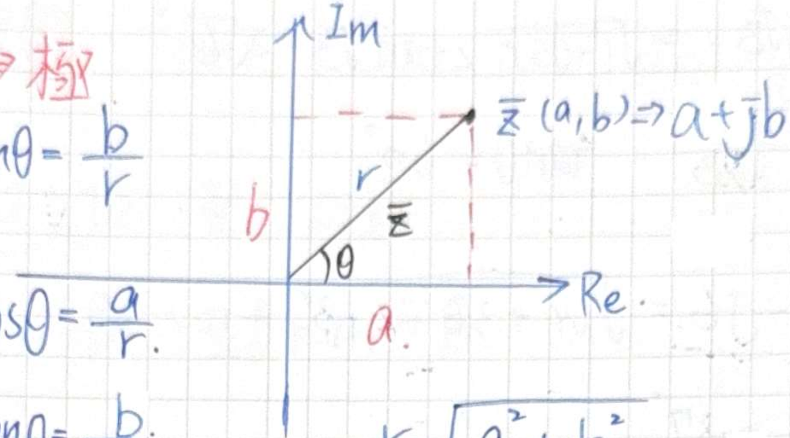
8-5-2 複數

虛數 $(j)=\sqrt{-1}$



直⇒極

$\sin\theta = \frac{b}{r}$



$\cos\theta = \frac{a}{r}$.

$\tan\theta = \frac{b}{a}$.

$r = \sqrt{a^2 + b^2}$

$\tan^{-1} \Rightarrow \arctan$

極⇒直

$\tan 30^\circ = \frac{1}{\sqrt{3}}$.

$\tan^{-1}\frac{1}{\sqrt{3}} = 30^\circ$

$b = r\sin\theta$.

$a = r\cos\theta$.

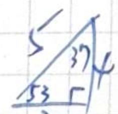
$r\cos\theta + j\,r\sin\theta$.

(1) $\bar{Z} = 2\sqrt{2}\angle 45^\circ$.

$r = 2\sqrt{2} \quad \theta = 45^\circ$.

$\vec{Z} = \cancel{2\sqrt{2}} \times \frac{1}{\cancel{\sqrt{2}}} + j \times \cancel{2\sqrt{2}} \times \frac{1}{\cancel{\sqrt{2}}}$

$= 2 + j2$.



(2) $\bar{Z} = 10\angle -53$.

$\vec{z} = 10 \times \cos(-53^\circ) + j10\sin(-53^\circ) = 6 + j8$.

(3) $\bar{Z} = 4\angle 120$.

$\vec{Z} = 4 \times \cos 120^\circ + j4\sin 120^\circ = 2\sqrt{3} + j2$.

$\sin 60^\circ$ $\cos 60^\circ$

(1) $\bar{z} = 1 + j\sqrt{3} = \sqrt{1^2 + (\sqrt{3})^2} \angle \tan^{-1}\sqrt{3} = 2\angle 60^\circ$

$\tan\theta^{-1} = \sqrt{3}$ $\quad \tan\theta = 60^\circ$

(2) $\bar{z} = 8 - j6 = \sqrt{64 + 36} \angle -37 = 10\angle -37^\circ$

$\tan^{-1} -\frac{3}{4} = -37^\circ$.

複數運算

$j = \sqrt{-1}$ $\quad j^2 = -1$ $\quad j^3 = -j$ $\quad j^4 = 1$

$\frac{1}{j} = j^{-1}$

$\bar{z}_1 = a + jb$ $\quad \bar{z}_2 = c + jd$.

$r_1\angle\theta_1$ $\quad r_2\angle\theta_2$.

加法.

$$\bar{z}_1 + \bar{z}_2 = (a+jb) + (c+jd) = \underbrace{(a+c)}_{Re} + j\underbrace{(b+d)}_{Im}$$

減法.

$$\bar{z}_1 - \bar{z}_2 = (a+jb) - (c+jd) = (a-c) + j(b-d)$$

乘法.

$$\bar{z}_1 \cdot \bar{z}_2 = (r_1\angle\theta_1)(r_2\angle\theta_2) = r_1 r_2 \angle(\theta_1 + \theta_2)$$

除法.

$$\frac{\bar{z}_1}{\bar{z}_2} = \frac{r_1\angle\theta_1}{r_2\angle\theta_2} = \frac{r_1}{r_2}\angle(\theta_1 - \theta_2).$$

共軛複數.

$\bar{z} = a \pm jb \quad \bar{z} = r\angle \pm\theta$

$\bar{z}^* = a \mp jb \quad \bar{z}^* = r\angle \mp\theta$

$|\bar{z}| = |3+j4| \Leftrightarrow |\bar{z}^*| = |3-j4|$

$|\bar{z}| = |\bar{z}^*| = \sqrt{a^2+b^2} = \sqrt{3^2+4^2} = 5.$

$\bar{z}\bar{z}^* = (a+jb)(a-jb) = a^2+b^2$

$j^2 = -1$

$$\bar{z}^n \begin{cases} (a+jb)_1 (a+jb)_2 \times \cdots (a+jb)_n \\ (r\angle\theta)^n \Rightarrow (r\angle\theta)_1 \times (r\angle\theta)_2 \times \cdots \times (r\angle\theta)_n \end{cases}$$

$= r^n \angle n\theta.$

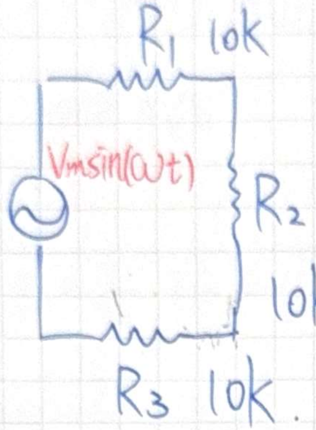
$\theta_1 + \theta_2 + \cdots + \theta_n = n\theta$

$r_1 \times r_2 \times \cdots \times r_n.$

$\bar{z}^{\frac{1}{n}} = r^{\frac{1}{n}} \angle \frac{1}{n}\theta. \qquad \bar{z}^{-1} = \frac{1}{z} = (r\angle\theta)^{-1} = \frac{1}{r}\angle -\theta$

$$= (a+jb)^{-1} = \frac{1\,(a-jb)}{a+jb\,.(a-jb)} = \frac{a-jb}{a^2+b^2}$$

$$= \frac{a}{a^2+b^2} - j\frac{b}{a^2+b^2}$$

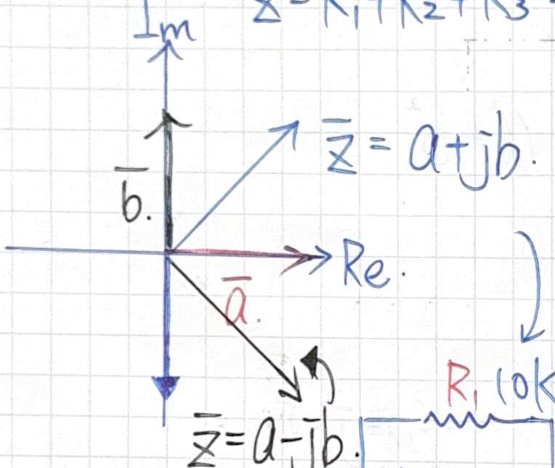


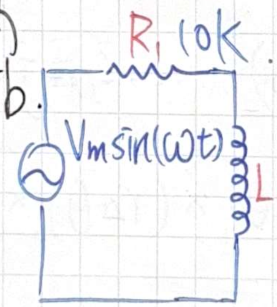
$v_{(t)} = V_m \sin(\omega t)$

電阻性電路

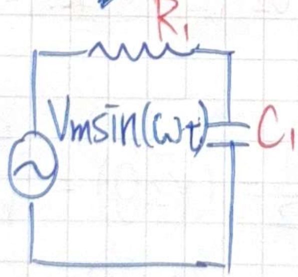
(1) $R_1 = 10,\ \bar{R} = 10\angle 0^\circ$

$\bar{Z} = R_1 + R_2 + R_3 = 30$ or $30\angle 0^\circ$





X_L = 電感抗 $+jX_L$



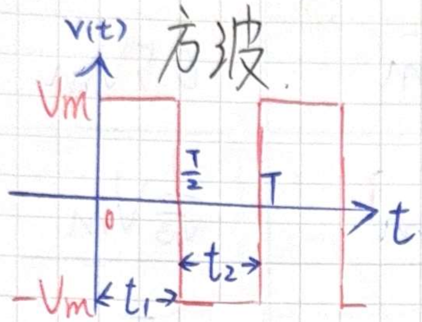
X_C = 電容抗 $-jX_C$

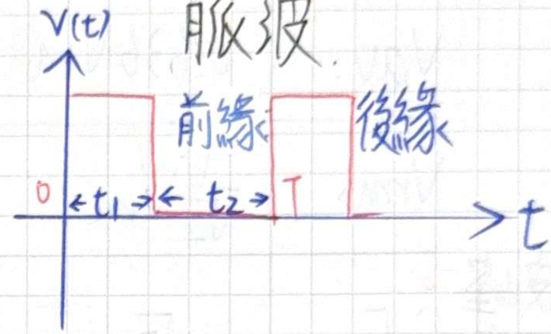
$$\bar{V} = \frac{V_m}{\sqrt{2}} \angle \pm\theta = V_{rms} \angle \pm\theta$$

8-2 波形

1. 方波、脈波.

僅在正負半週交替瞬間才會變化且垂直變化





平均值

$V_{av} = V_m$

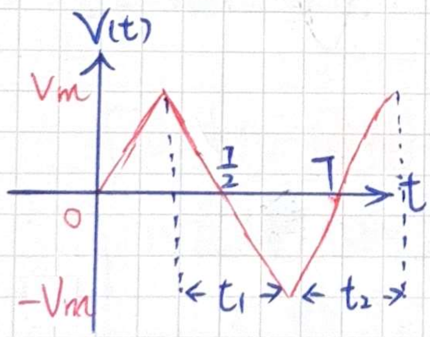
$I_{av} = I_m$

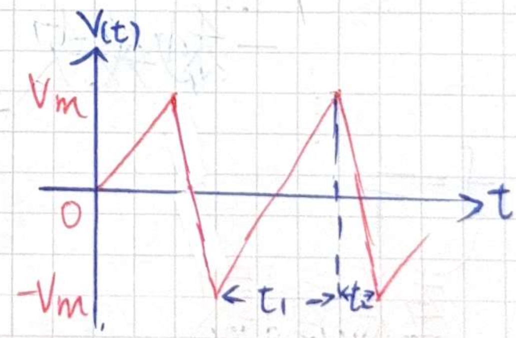
有效值

$V_{rms} = V_m$

$I_{rms} = I_m$

2. 三角波、鋸齒波.





平均值

$V_{av} = \frac{1}{2} V_m$

$I_{av} = \frac{1}{2} I_m$

有效值

$V_{rms} = \frac{1}{\sqrt{3}} V_m$

$I_{rms} = \frac{1}{\sqrt{3}} I_m$

波峰因素 C.F.

$C.F. = \frac{V_m}{V_{rms}}$

波形因素 F.F.

$F.F. = \frac{V_{rms}}{V_{av}}$

	正弦	方	三角
V_m	V_m	V_m	V_m
$V_{av.}$	$0.636V_m$	V_m	$0.5V_m$
V_{rms}	$\frac{1}{\sqrt{2}}V_m$	V_m	$\frac{1}{\sqrt{3}}V_m$
波峰因素 C.F.	$\sqrt{2}$	1	$\sqrt{3}$
波形因素 F.F.	1.11	1	$\frac{2}{\sqrt{3}} \doteqdot 1.155$

f　T

8-3 頻率與週期 → 一次幾秒

頻率 → 重覆發生的次數

一秒幾次

$f = \frac{1}{T}$

互為倒數

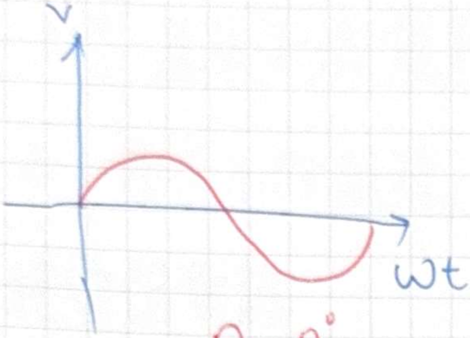
8-4 相位

描述波形變化的

↳ 呈週期性的

瞬時表示式

$V(t) = V_m \sin(\omega t \pm \theta)$

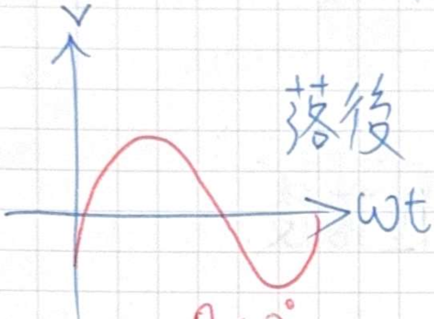


$\theta=0^\circ$

超前

$\theta>0^\circ$

落後



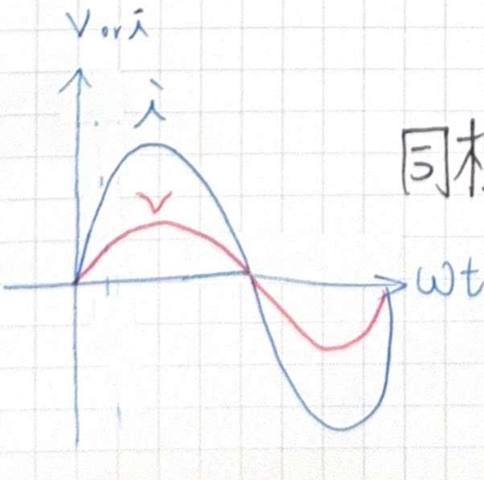
$\theta<0^\circ$

角速度

$$\omega = \frac{\theta}{t} = \frac{2\pi}{T} = 2\pi f \ \text{rad/s}.$$

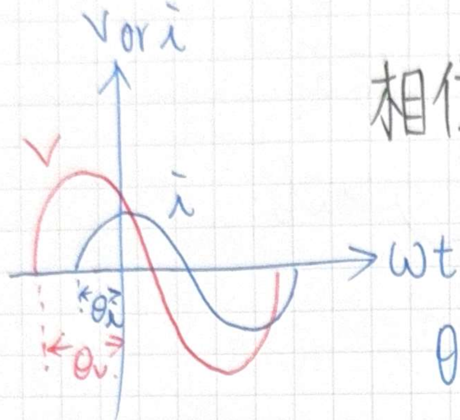
* 符合相位差三條件：

(1) f必須相同
(2) 函數必須相同
(3) 函數正負必須相同.



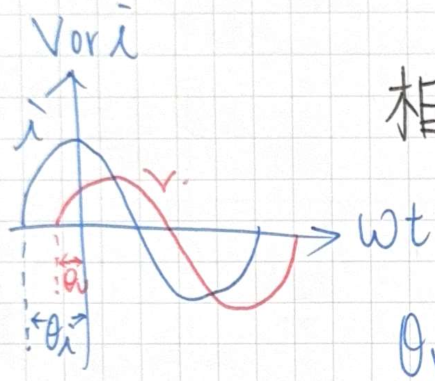
同相位.

$\theta_v - \theta_i = 0$.



相位超前

$\theta_v - \theta_i > 0.$



相位落後.

$\theta_v - \theta_i < 0.$

正弦波的相量:

$$\overline{V} = \frac{V_m}{\sqrt{2}} \angle \pm\theta = V_{rms} \angle \pm\theta.$$