CH9. 基本交流電路.

9-1 基本元件組成.

純電阻電路.

$$i(t) = \frac{V_{R(t)}}{R} = \frac{V_m}{R}\sin(\omega t + \theta_v)$$

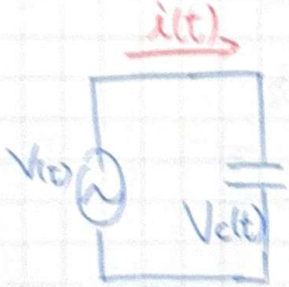
$$= I_m \sin(\omega t + \theta_i)$$

$$\overline{V_R} = \overline{V} = V_{rms} \angle \theta_v \qquad \overline{I_R} = I_{rms} \angle \theta_i$$

$$\overline{R} = \frac{\overline{V}}{\overline{I}} = \frac{V_{rms}}{I_{rms}} \angle 0^\circ = R \angle 0^\circ$$

相位差等於 0 $\theta_v - \theta_i$.

純電容電路.



$\theta_i - 90^\circ$

$$\overline{V_C} = \overline{V} = V_{rms} \angle \theta_v$$

$$\overline{I_C} = \overline{I} = I_{rms} \angle \theta_i$$

電容抗 X_C

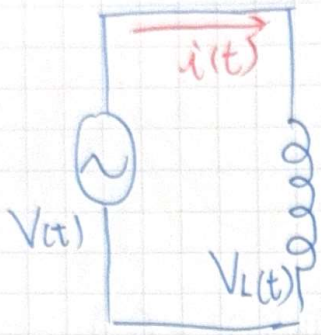
$$\overline{X_C} = -jX_C$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

i 領先 v 90°

$\theta_v - \theta_i = -90^\circ$

純電感電路.



$$\bar{V}_L = \bar{V} = V_{rms}\angle(\theta_i + 90^\circ)$$

$$\bar{I}_L = \bar{I} = I_{rms}\angle(\theta_v - 90^\circ)$$

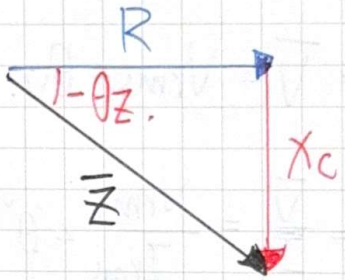
電感抗. X_L.

i 落後 v 90°

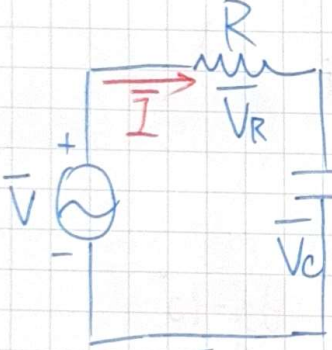
$$\theta_v - \theta_i = 90^\circ$$

$$\bar{X}_L = jX_L$$

$$X_L = \omega L = 2\pi f L.$$



9-2. RC串聯電路.



阻抗

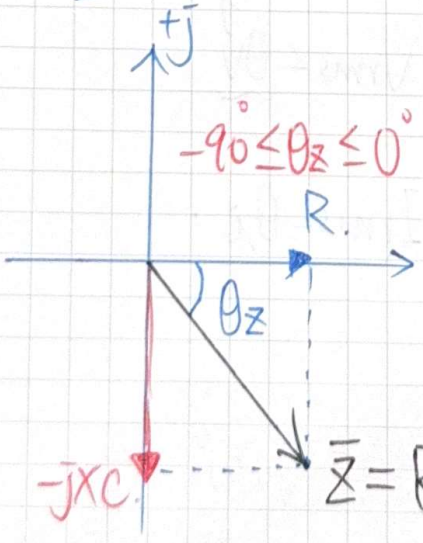
$$\bar{Z} = R + (-jX_C)$$

$$= \sqrt{R^2 + X_C^2}\angle \tan^{-1}\frac{X_C}{R}$$

$$= Z\angle\theta_z$$

$$\bar{I}_R = \bar{I}_C = \frac{\bar{E}}{\bar{Z}}.$$

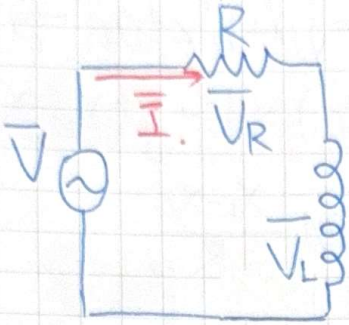
$$\bar{V}_R = \bar{I}_R\bar{R} = (I\angle\theta_i)(R\angle 0^\circ)$$



$$\bar{Z} = R - jX_C.$$

$$\bar{V}_C = \bar{I}_C\bar{X}_C = (I\angle\theta_i)(X_C\angle -90^\circ)$$

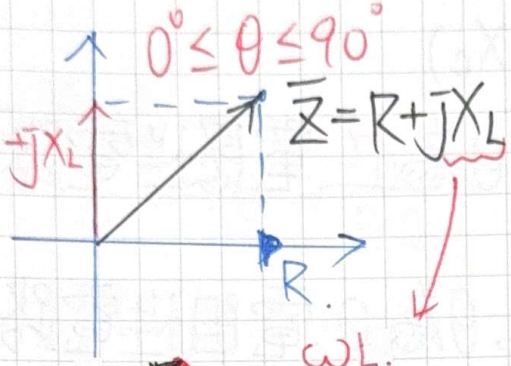
9-3 RL串聯電路.



阻抗.

$$\bar{Z} = R + jX_L = \sqrt{R^2 + X_L^2} \angle \tan^{-1}\frac{X_L}{R}.$$

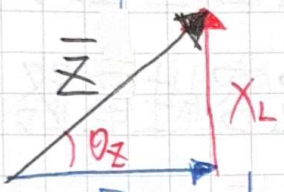
$$= Z \angle \theta_Z.$$



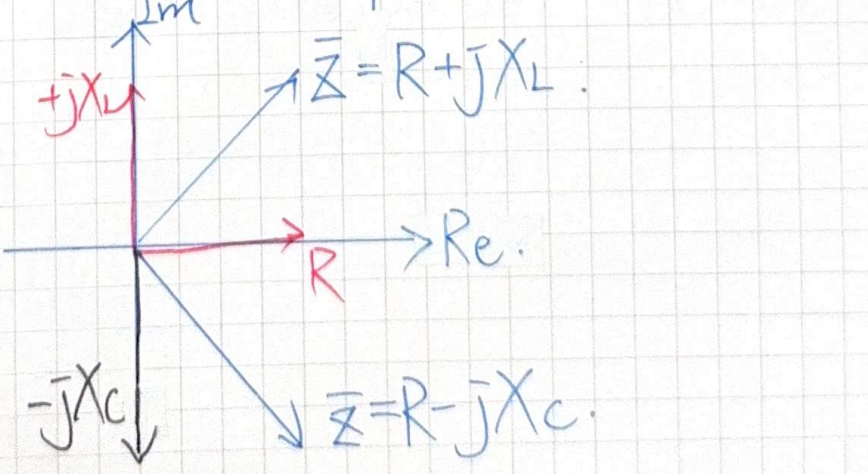
$$\bar{I}_R = \bar{I}_L = \bar{I} = I \angle \theta_i.$$

$$\bar{V}_R = \bar{I}_R \bar{R} = (I \angle \theta_i)(R \angle 0°)$$

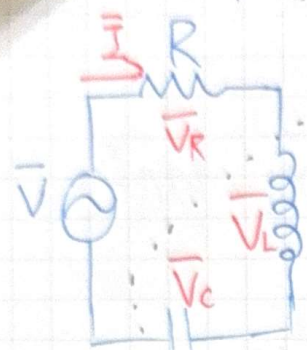
$$\bar{V}_L = \bar{I}_L \bar{X}_L = (I \angle \theta_i)(X_L \angle 90°)$$



	RC 串聯	RL串聯
$\bar{Z}$	$R + (-jX_C)$	$R + jX_C$.
$\bar{I}$	$\bar{I}_{\bar{Z}} = \bar{I}_R = \bar{I}_C$.	$\bar{I}_{\bar{Z}} = \bar{I}_R = \bar{I}_L$.
$\bar{V}_R$	$\bar{I}_R \bar{R} = (I \angle \theta_i)(R \angle 0°)$	$\bar{I}_R \bar{R} = (I \angle \theta_i)(R \angle 0°)$
$\bar{V}_C / \bar{V}_L$	$\bar{I}\bar{X}_C = (I \angle \theta_i)(X_C \angle -90°)$	$\bar{I}_L \bar{X}_L = (I \angle \theta_i)(X_L \angle 90°)$



9-4 RLC串聯電路



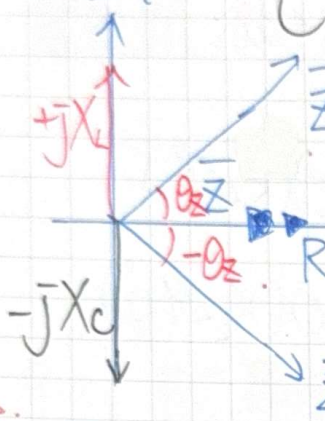
阻抗 $\bar{Z}=a+jb=\sqrt{a^2+b^2}\angle\tan^{-1}\frac{b}{a}$

$\bar{Z}=R+jX_L+(-jX_C)=R+j(X_L-X_C)$

$=\sqrt{R^2+(X_L-X_C)^2}\angle\tan^{-1}\frac{X_L-X_C}{R}$

$\rightarrow jX_L+(-jX_C)$

$-90^\circ\le\theta_{\bar{Z}}\le 90^\circ$



① $X_L>X_C$，θ為正 電感性電路

3種可能

② $X_L=X_C$，θ為0 電阻性電路

③ $X_L<X_C$，θ為負 電容性電路。

☆

$\bar{I}=\bar{I}_R=\bar{I}_L=\bar{I}_C$ RC、RL、RLC的I都一樣 ✓

$=I\angle\theta_i$

$\bar{V}_R=\bar{I}_R\bar{R}=(I\angle\theta_i)(R\angle 0^\circ)=IR\angle\theta_i$

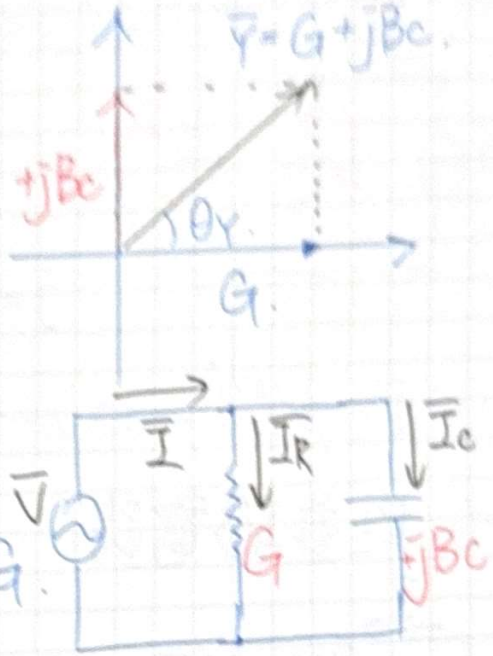
$\bar{V}_L=\bar{I}_L\bar{X}_L=(I\angle\theta_i)(X_L\angle 90^\circ)=IX_L\angle\theta_i+90^\circ$

$\bar{V}_C=\bar{I}_C\bar{X}_C=(I\angle\theta_i)(X_C\angle -90^\circ)=IX_C\angle\theta_i-90^\circ$

9-5 RC並聯電路

導納 阻抗的倒數 (S) Y

電納 電抗的倒數



① 電導：

$$\bar{G}=\frac{1}{R}=\frac{1}{R\angle 0^\circ}=\frac{1}{R}=G.$$

② 電容納：

$$\bar{B_C}=\frac{1}{X_C}=\frac{1}{X_C\angle -90^\circ}=\frac{1}{X_C}\angle 90^\circ=-jB_C.$$

③ 導納：

$$\bar{Y}=\frac{1}{\bar{Z}}=G+jB_C=\sqrt{G^2+B_C^2}\angle \tan^{-1}\frac{B_C}{G}=Y\angle\theta_Y.$$

✓

＊並聯 V相同. $\bar{V_R}=\bar{V_C}=\bar{V}=V\angle\theta_V.$

④ 電流：

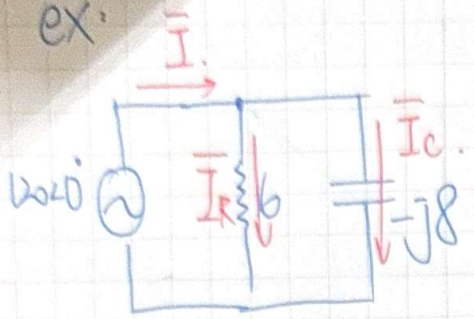
$$\bar{I_R}=\frac{\bar{V_R}}{R}=\bar{V}\bar{G}=(V\angle\theta_V)(G\angle 0^\circ)=VG\angle\theta_V.$$

$$\bar{I_C}=\frac{\bar{V_C}}{X_C}=\bar{V}\bar{B_C}=(V\angle\theta_V)(B_C\angle 90^\circ)=VBC\angle\theta_V+90^\circ.$$

$$\bar{I}=\frac{\bar{V}}{\bar{Z}}=\bar{V}\bar{Y}=(V\angle\theta_V)(Y\angle\theta_Y)$$

$$=\bar{I_R}+\bar{I_C}$$ ✱

ex:



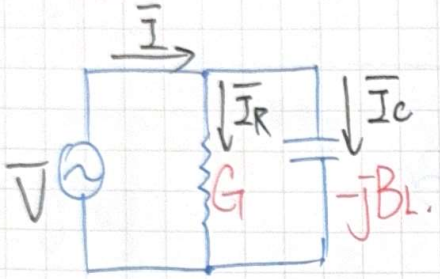
(1) $\bar{I}_R = \frac{120\angle 0^\circ}{6\angle 0^\circ} = 20\,A$

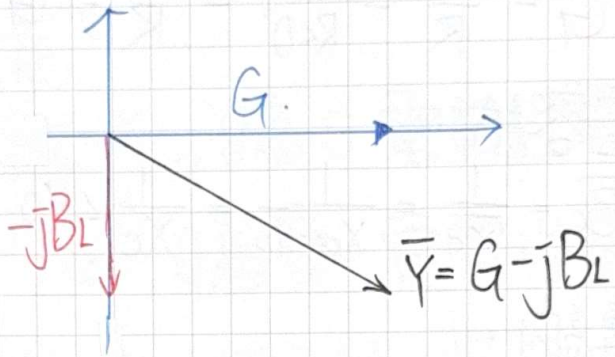
$\bar{I}_C = \frac{120\angle 0^\circ}{8\angle -90^\circ} = 15\angle 90^\circ = j15A$

$\bar{I} = 20 + j15 = 25\angle 37^\circ A$

(2) $\bar{Z} = \frac{120\angle 0^\circ}{25\angle 37^\circ} = 4.8\angle -37^\circ \Omega$

9-6. RL並聯電路





① 電導:

$\bar{G} = \frac{1}{\bar{R}} = \frac{1}{R} = G$

② 電感納:

$\bar{B}_L = \frac{1}{\bar{X}_L} = \frac{1}{X_L\angle 90^\circ} = -jB_L$

③ 導納:

$\bar{Y} = \frac{1}{\bar{Z}} = G - jB_L = \sqrt{G^2 + B_L^2}\angle -\tan^{-1}\frac{B_L}{G}$

④ 電流:

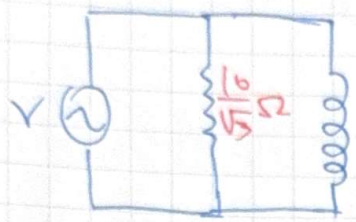
$\bar{I}_R = \frac{\bar{V}_R}{R} = (V\angle\theta_V)(G\angle 0^\circ)$

$\bar{I}_L = \frac{\bar{V}_L}{X_L} = (V\angle\theta_V)(B_L\angle -90^\circ)$

$\bar{I} = \frac{\bar{V}}{\bar{Z}} = (V\angle\theta_V)(Y\angle\theta_Y) = \bar{I}_R + \bar{I}_L$

ex:

$v = 100\sqrt{2}\sin(500t + 60^\circ)\,V$.



$$B_L = \frac{1}{X_L} = \frac{1}{500\times 20\times 10^{-3}} = \frac{1}{10}\,S$$

$$G = \frac{\sqrt{3}}{10}\,S.$$

$$\bar{Y} = \frac{\sqrt{3}}{10} - j\frac{1}{10} = \frac{1}{5}\angle -30^\circ\,S$$

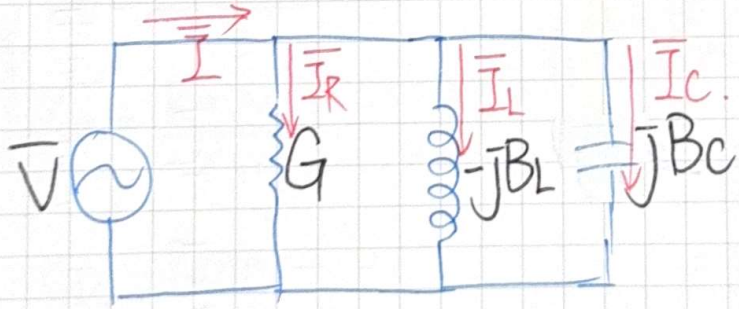
$$\bar{V} = 100\angle 60^\circ\,V.$$

(1) $\bar{I} = (100\angle 60^\circ)\left(\frac{1}{5}\angle -30^\circ\right)$

$= 20\angle 30^\circ\,A.$

$i(t) = 20\sqrt{2}\sin(500t + 30^\circ)\,A$ #.

9-7 RLC並聯電路.



$$\bar{G} = \frac{1}{R} = \frac{1}{R\angle 0^\circ} = \frac{1}{R} = G.$$

$$\bar{B}_L = \frac{1}{\bar{X}_L} = \frac{1}{X_L\angle 90^\circ} = \frac{1}{X_L}\angle -90^\circ = -jB_L.$$

$$\bar{B}_C = \frac{1}{\bar{X}_C} = \frac{1}{X_C\angle -90^\circ} = \frac{1}{X_C}\angle 90^\circ = jB_C.$$

$$\overline{Y}=\frac{1}{\overline{Z}}=\overline{G}+\overline{B_L}+\overline{B_C}$$

$$=G+j(B_C-B_L)$$

$$=\sqrt{G^2+(B_C-B_L)^2}\angle\tan^{-1}\frac{B_C-B_L}{G}$$

$$-90^\circ\le\theta_Y\le 90^\circ$$

並聯電壓相同

電阻電流

$$\overline{I_R}=\frac{\overline{V_R}}{R}=(V\angle\theta_V)(G\angle 0^\circ)=VG\angle\theta_V$$

電感電流

$$\overline{I_L}=\frac{\overline{V_L}}{X_L}=(V\angle\theta_V)(B_L\angle -90^\circ)$$

電容電流

$$\overline{I_C}=\frac{\overline{V_C}}{X_C}=(V\angle\theta_V)(B_C\angle 90^\circ)$$

- 電感性 $\theta_V>\theta_i$
- 電容性 $\theta_V<\theta_i$
- 電阻性 $\theta_V=\theta_i$

9-8 RLC串並聯電路

串 ⟷ 轉換 ⟷ 並

電路阻抗：

串 $\overline{Z_S} = R_S + jX_S$ ($-X_C$, $+X_L$)

並 $G_P + jB_P$ ($-B_L$, $+B_C$)

導納 $\overline{Y_S} = \dfrac{1}{\overline{Z_S}}$

$= \dfrac{1\,(R_S - jX_S)}{(R_S + jX_S)(R_S - jX_S)}$

$= \dfrac{R_S - jX_S}{R_S^2 + X_S^2}$

$= \dfrac{R_S}{R_S^2 + X_S^2} - j\dfrac{X_S}{R_S^2 + X_S^2}$

$= G_S + B_S$

串 $\begin{cases} R_P = \dfrac{R_S^2 + X_S^2}{R_S} \\ Y_{1P} = \dfrac{R_S^2 + X_S^2}{X_S} \end{cases}$

並 $\begin{cases} R_S = \dfrac{R_P X_P^2}{R_P^2 + X_P^2} \\ X_S = \dfrac{R_P^2 X_P}{R_P^2 + X_P^2} \end{cases}$

導納 $\overline{Y_S} = \overline{Y_P} \rightsquigarrow \dfrac{1}{R_P + j\frac{1}{X_P}}$

$\therefore G_S = G_P = \dfrac{1}{R_P}$

$= \dfrac{R_S}{R_S^2 + X_S^2}$

$R_P = \dfrac{R_S^2 + X_S^2}{R_S}$

$\overline{Z_P} = \dfrac{1}{\overline{Y_P}} = \dfrac{1\,(R_P)}{\left(\frac{1}{R_P} + j\frac{1}{X_P}\right)(R_P)}$

$= \dfrac{R_P\left[1 - j\left(\frac{R_P}{X_P}\right)\right]}{\left[1 + j\left(\frac{R_P}{X_P}\right)\right]\left[1 - j\left(\frac{R_P}{X_P}\right)\right]}$ ✓

$= \dfrac{R_P\left[1 - j\left(\frac{R_P}{X_P}\right)\right](X_P)}{\left[1 + \left(\frac{R_P}{X_P}\right)^2\right](X_P)}$

$(R_P^2 + X_P^2)$

$= \dfrac{R_P X_P^2}{R_P^2 + X_P^2} + j\dfrac{R_P^2 X_P}{R_P^2 + X_P^2}$

R_S ↓ $R_P \,//\, \dfrac{X_P^2}{R_P}$

X_S ↓ $R_P \,//\, \dfrac{R_P^2}{X_P}$