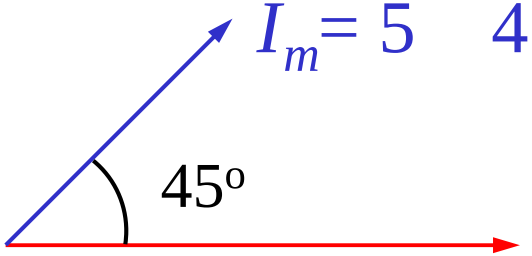
1.

2.

3.   VCR



$\dot{I}_m = 5 \quad 45^o$ A

$\dot{U}_m = 100 \quad 0^o$ V

$$Z = \frac{\dot{U}_m}{\dot{I}_m} = 20 \quad -45^o\ \Omega$$

§ 8-1

1.

(1) $F=a+\mathrm{j}b$

$\mathrm{Re}[F]=a$ $\mathrm{Im}[F]=b$

(2)

$F=|F|(\cos\theta+\mathrm{j}\sin\theta)$

$a=|F|\cos\theta$ $b=|F|\sin\theta$

$$|F|=\sqrt{a^2+b^2}$$

$$\theta=\mathrm{arctg}\,\frac{b}{a}$$

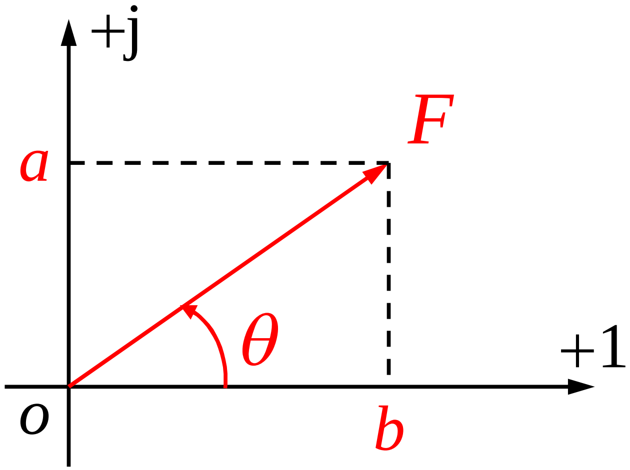
(3)

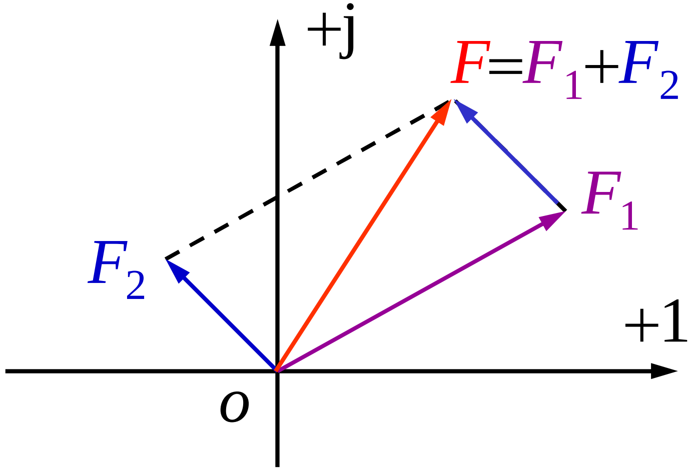
$e^{\mathrm{j}\theta}=\cos\theta+\mathrm{j}\sin\theta$

$$F=|F|e^{\mathrm{j}\theta}$$

$$F=|F|\underline{/\theta}$$

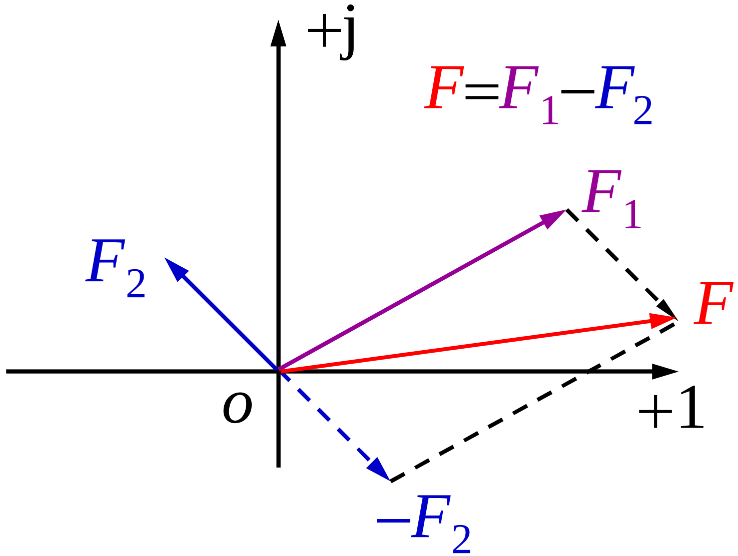
(4)





2.

(1)



$$F_1 = a_1 + \mathrm{j}b_1 \qquad F_2 = a_2 + \mathrm{j}b_2$$

$$F_1 \pm F_2 = (a_1 \pm a_2) + \mathrm{j}(b_1 \pm b_2)$$

(2)

$$F_1 = |F_1| e^{j\theta_1} \qquad F_2 = |F_2| e^{j\theta_2}$$

$$F = F_1 F_2 = |F_1||F_2| e^{j(\theta_1 + \theta_2)}$$

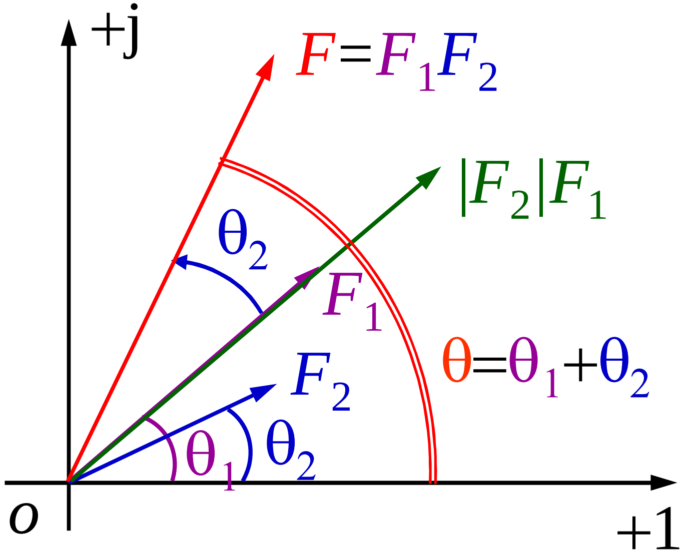
$$F = |F_1|\,|F_2| \angle \theta_1 + \theta_2 \qquad F = \frac{F_1}{F_2} = \frac{|F_1|}{|F_2|} \angle \theta_1 - \theta_2$$

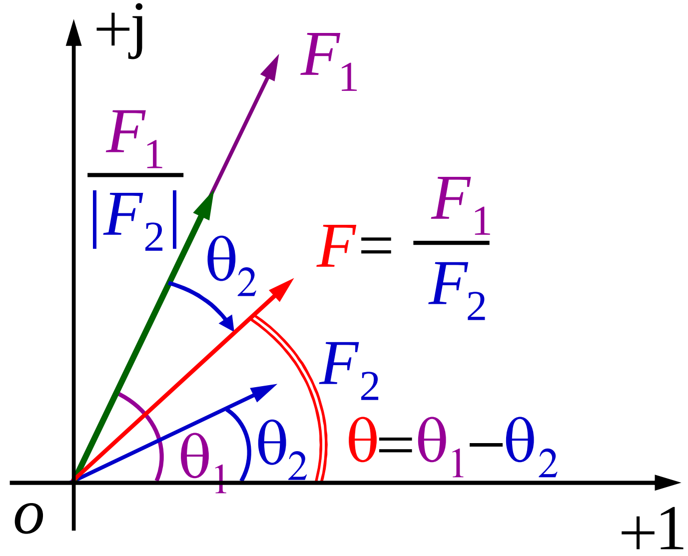
( ) ( ) ( )

$$F_1 = F_2$$

$$|F_1| = |F_2| \qquad \theta_1 = \theta_2$$

$$a_1 = a_2 \qquad jb_1 = jb_2$$





☞ F_1

$|F_2|$

θ_2

☞ F_1

$|F_2|$

θ_2

3. $e^{j\theta}$

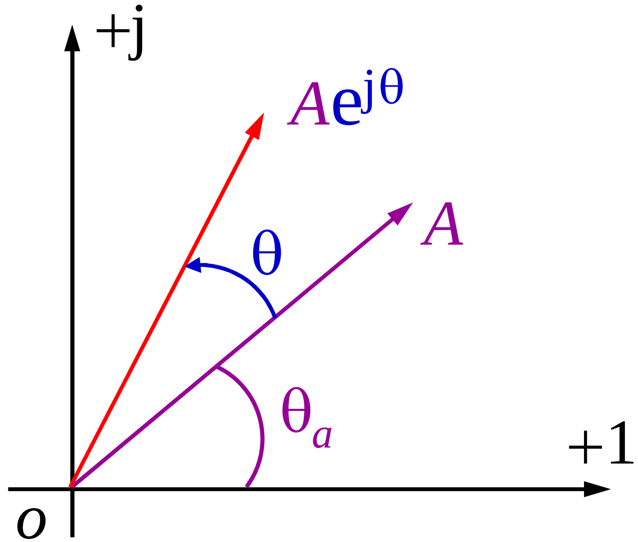
☝ $e^{j\theta} = 1 \quad \theta$

1 θ

✌ $A = |A| e^{j\theta_a}$

$e^{j\theta}$ A θ

$|A|$



$$\left.\begin{array}{l} e^{j\frac{\pi}{2}} = j \\ e^{-j\frac{\pi}{2}} = -j \\ e^{j\pi} = -1 \end{array}\right\}$$

$A \times j = jA$ A

90°。

$\frac{A}{j} = -jA$ A

90°。

§ 8-2

☞

👍

$$i = I_m \cos(\omega t + \phi_i)$$

$$i = I_m \sin(\omega t + \phi_i)$$

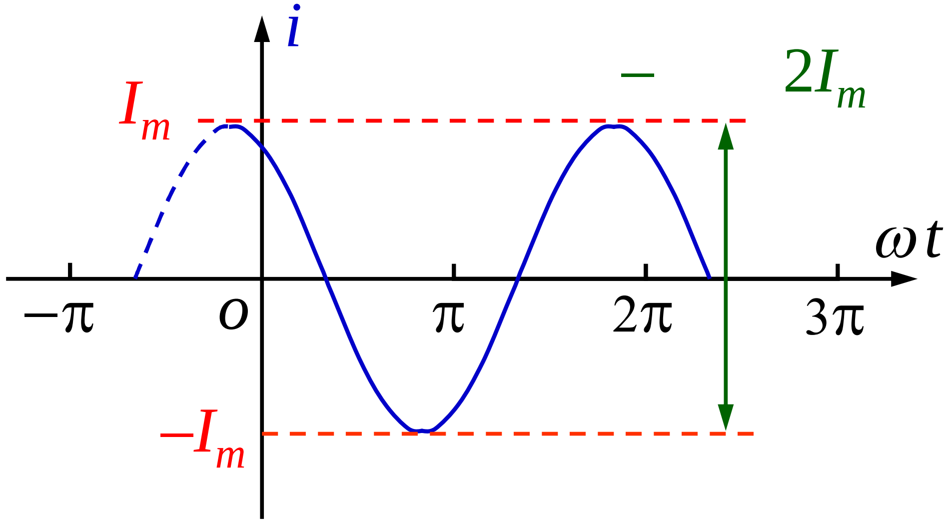
$$i = I_m \cos(\omega t + \phi_i) \qquad u = U_m \cos(\omega t + \phi_u)$$

1.

$$i = I_m \cos(\omega t + \phi_i) \;\; = \sqrt{2}\, I \cos(\omega t + \phi_i)$$

(1)_____ I_m _______ I (   )

\-



I i T

R

$$I^2RT = \int_0^T i^2 R \, dt \longrightarrow I \overset{\text{def}}{=\!=} \sqrt{\frac{1}{T}\int_0^T i^2 \, dt}$$

$$i = I_m \cos(\omega t + \psi_i)$$

$$I_m = \sqrt{2}\, I$$

$$U_m = \sqrt{2}\, U$$

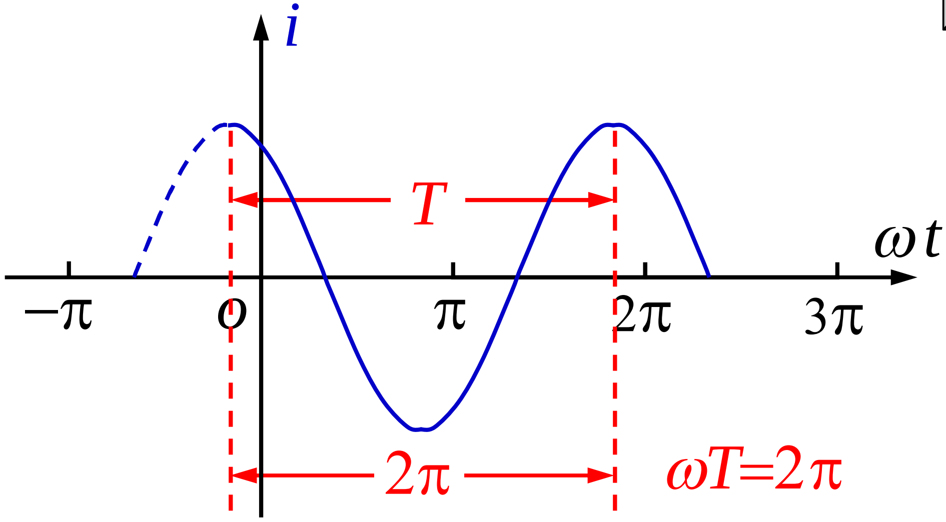
$U = 220\text{V}$ $U_m \approx 311\text{V}$

i u I_{m} U_m

I U $I_{\mathrm{M}}(I_{\mathrm{max}})$

(2) ω f T ( )

$$\omega = \frac{\mathrm{d}}{\mathrm{d}t}(\omega t+\phi_i)$$



f T

Hz

ω f T

$$\omega = 2\pi f \quad f = \frac{1}{T} \quad T = \frac{1}{f}$$

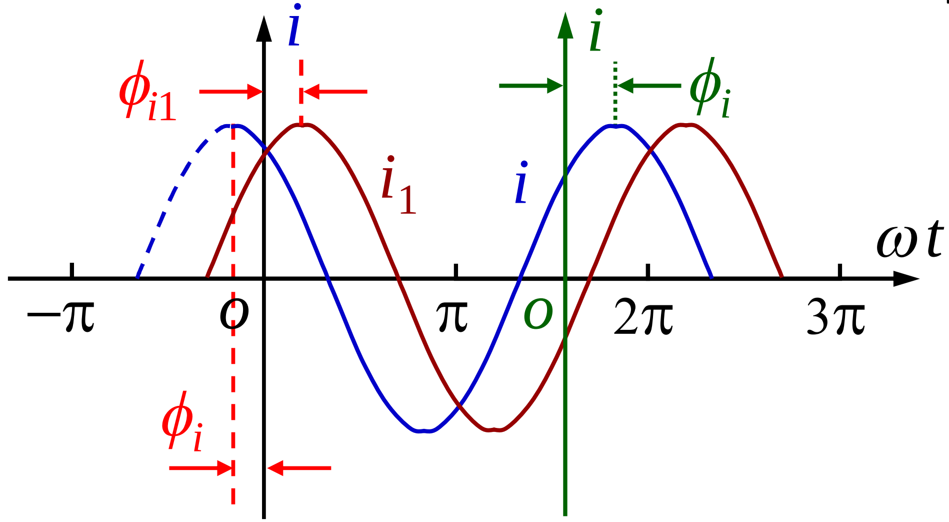
(3) ϕ_i (   )

$(\omega t+\phi_i)$

,   :

rad   (°)

$t=0$ ϕ_i



$|\phi_i| \le 180^\circ$

2.

$i_1=I_m\cos(\omega t+\phi_{i1})$ $u_2=U_m\cos(\omega t+\phi_{u2})$

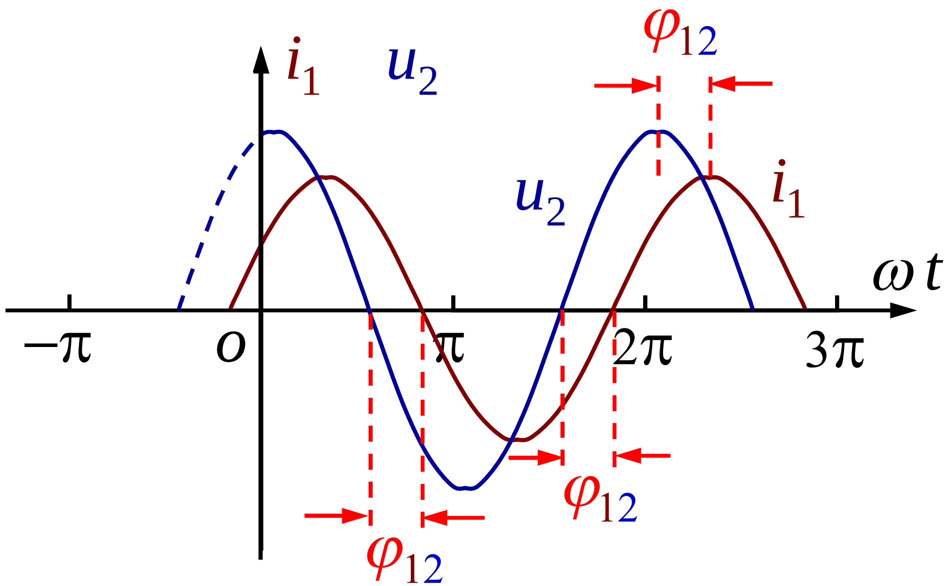
φ_{12} $\varphi_{12}=(\omega t+\phi_{i1})-(\omega t+\phi_{u2})=\phi_{i1}-\phi_{u2}$

(1) φ_{12} 0 i u

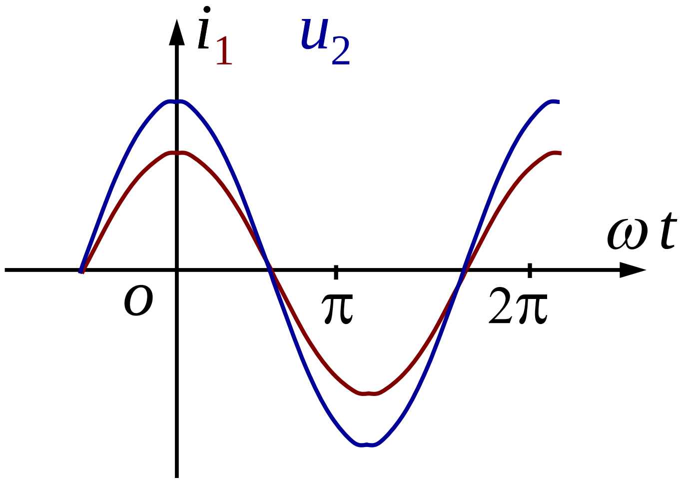
u i i u

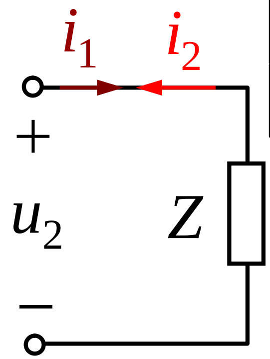
(2) φ_{12} 0 u i

i u u i



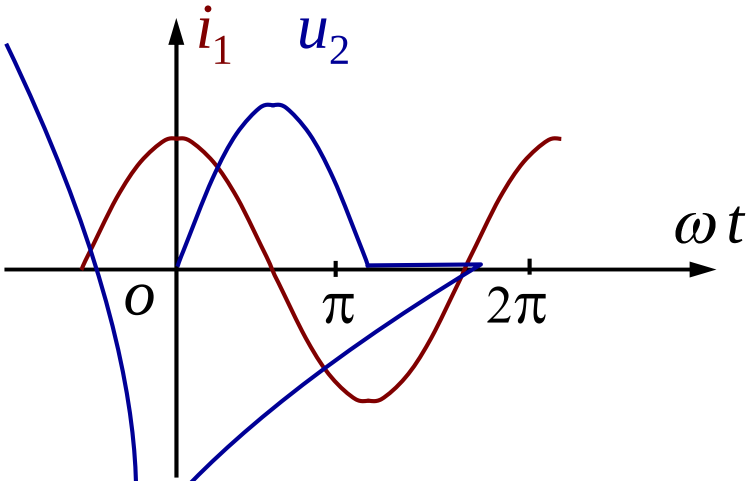
$$\varphi_{12}\le|\pi|$$





$\varphi_{12}=0$ i_1 u_2

$\varphi_{12}=180^o$ i_1 u_2



$\varphi_{12}=90^o$ i_1 u_2

§ 8–3

( ) ( )

KCL KVL

1.

: $e^{j\theta} = \cos\theta + j\sin\theta$

$\theta = \omega t + \phi_i$ $\qquad e^{j(\omega t+\phi_i)} = \cos(\omega t+\phi_i) + j\sin(\omega t+\phi_i)$

$$i = I_m \cos(\omega t + \phi_i)$$

$$i = \mathrm{Re}[I_m e^{j(\omega t+\phi_i)}] = \mathrm{Re}[\underline{\underline{I_m e^{j\phi_i}}} e^{j\omega t}]$$

$$= \mathrm{Re}[\dot{I}_m e^{j\omega t}]$$

$$\dot{I}_m = I_m e^{j\phi_i}$$

$$i = I_m \cos(\omega t + \phi_i) \qquad \dot{I}_m = I_m e^{j\phi_i}$$

$$\dot{I}_m = I_m \angle \phi_i$$

$$\dot{U}_m = 300 \angle 30^{o} \ \text{V} \qquad u = 300 \cos($$

→

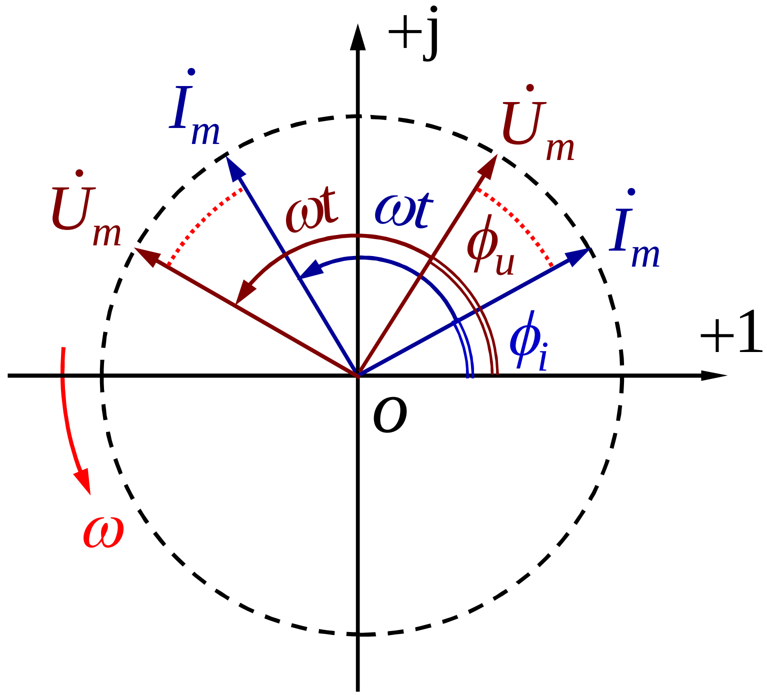
→

$$\dot{I}_m = I_m \angle \phi_i$$

$$[I_m e^{j\phi_i} e^{j\omega t}]$$

$$i = I_m \cos(\omega t + \phi_i)$$

$$[I_m e^{j\phi_i} e^{j\omega t}]$$



$e^{j\omega t}$

(2)

$$i = I_m \cos(\omega t + \phi_i) \quad \longrightarrow \quad \dot{I}_m = I_m \angle \phi_i$$

$$\frac{\mathrm{d}i}{\mathrm{d}t} = \omega I_m \cos(\omega t + \phi_i + 90^{\circ}) = \mathrm{Re}[\omega \, \dot{I}_m \, \mathrm{e}^{\mathrm{j}\omega t} \, \mathrm{e}^{\mathrm{j}\frac{\pi}{2}}]$$

$$= \mathrm{Re}[\mathrm{j}\omega \, \dot{I}_m \, \mathrm{e}^{\mathrm{j}\omega t}] \quad \longrightarrow \quad \mathrm{j}\omega \dot{I}_m = \omega I_m \angle \phi_i + 90^{\circ}$$

☞

$\mathrm{j}\omega$

ωI_m 90°

$$\frac{\mathrm{d}^n i}{\mathrm{d}i^n} \longleftrightarrow (\mathrm{j}\omega)^n \dot{I}_m$$

(3)

$$u = U_m \cos(\omega t + \phi_u) \longrightarrow \dot{U}_m = U_m \angle \phi_u$$

$$\int u \mathrm{d}t = \frac{U_m}{\omega} \cos(\omega t + \phi_u - 90^\circ) = \mathrm{Re}\left[\frac{\dot{U}_m}{\mathrm{j}\omega} \mathrm{e}^{\mathrm{j}\omega t} \right]$$

☞

$\mathrm{j}\omega$

(U_m/ω) 90°

n $$\iint \cdots \int u \mathrm{d}t \longleftrightarrow \frac{\dot{U}}{(\mathrm{j}\omega)^n}$$

$$i_1 = 10\sqrt{2}\cos(314t + 60^{o})\ \text{A} \longrightarrow \dot{I}_1 = 10\angle 60^{o}\ \text{A}$$

$$i_2 = 22\sqrt{2}\cos(314t - 150^{o})\ \text{A} \longrightarrow \dot{I}_2 = 22\angle -150^{o}\ \text{A}$$

$$\frac{di_1}{dt} \qquad \int i_2\, dt \qquad i_1 + i_2$$

$$\frac{di_1}{dt} \longrightarrow j\omega\, \dot{I}_1 = j314 \times 10\angle 60^{o} = 3140\angle 60^{o} + 90^{o}$$

$$\frac{di_1}{dt} = 3140\sqrt{2}\cos(314t + 150^{o})$$

$$\int i_2\, dt \longrightarrow \frac{\dot{I}_2}{j\omega} = \frac{22\angle -150^{o} - 90^{o}}{314} = 0.07\angle 120^{o}$$

$$\int i_2\, dt = 0.07\sqrt{2}\cos(314t + 120^{o})$$

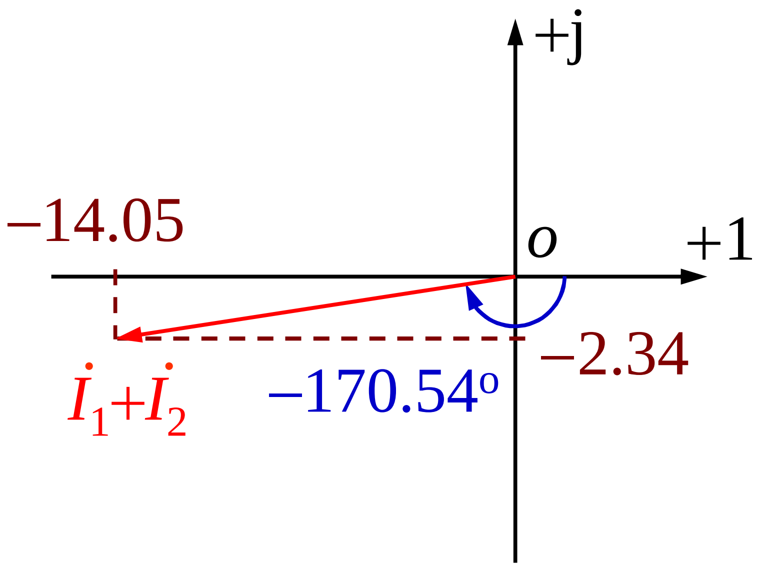
$\dot{I}_1 = 10\angle 60^{\circ} = 5 + j8.66$ A $\dot{I}_2 = 22\angle -150^{\circ} = -19.05 - j11$ A

$\dot{I}_1 + \dot{I}_2 = (5 - 19.05) + j(8.66 - 11) = (-14.05 - j2.34)$ A

$I = \sqrt{14.05^2 + 2.34^2} = 14.24$ A

ϕ_i 3

$\phi_i = -180^{\circ} + \mathrm{arctg}\,\dfrac{-2.34}{-14.05}$



$\dot{I}_1 + \dot{I}_2 = 14.24\angle -170.54^{\circ}$ A

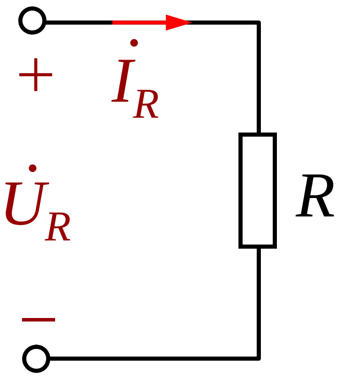
$i_1 + i_2 = 14.24\sqrt{2}\cos(314t - 170.54^{\circ})$ A

2. VCR

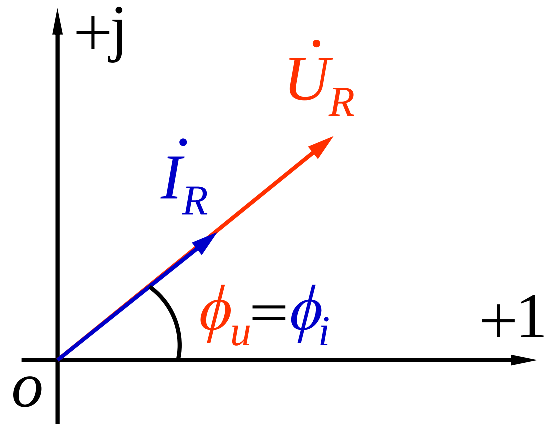
(1)

$$u_R = R\, i_R \longrightarrow \dot{U}_R = R\, \dot{I}_R$$

$$\dot{I}_R = G\, \dot{U}_R$$



☞

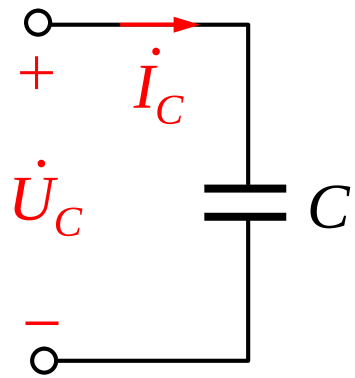


$$U_R = R\, I_R \qquad I_R = G\, U_R$$

2010

(3)

$$i_C = C\frac{\mathrm{d}u_C}{\mathrm{d}t} \longrightarrow \dot{I}_C = C(\mathrm{j}\omega\dot{U}_C)$$



$$\dot{U}_C = \frac{1}{\mathrm{j}\omega C}\dot{I}_C \qquad \dot{U}_C = -\mathrm{j}\frac{1}{\omega C}\dot{I}_C$$

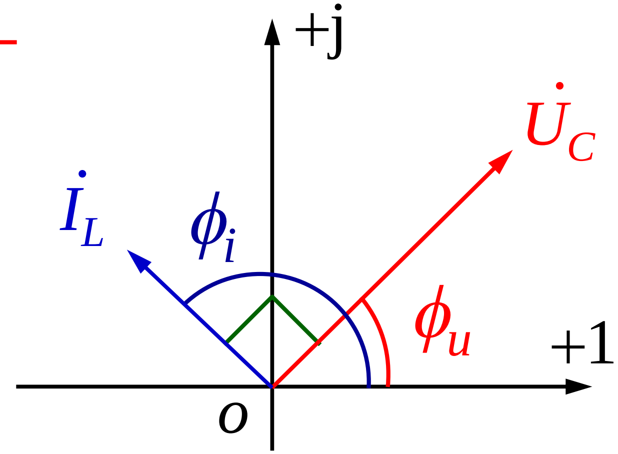
☞ C

90º！

90º！

$$U_C = \frac{1}{\omega C} I_C$$

$$\frac{U_C}{I_C} = \frac{1}{\omega C}$$

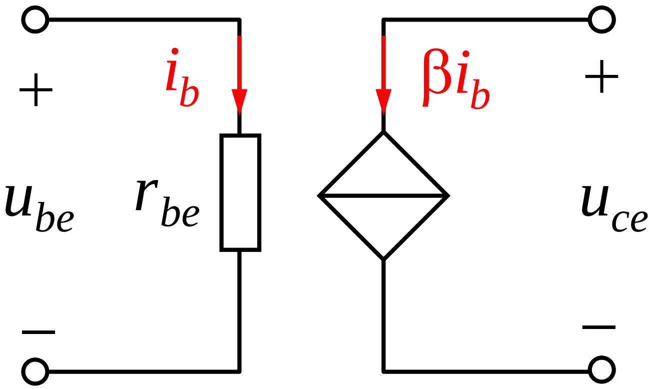


☞(1/ωC)

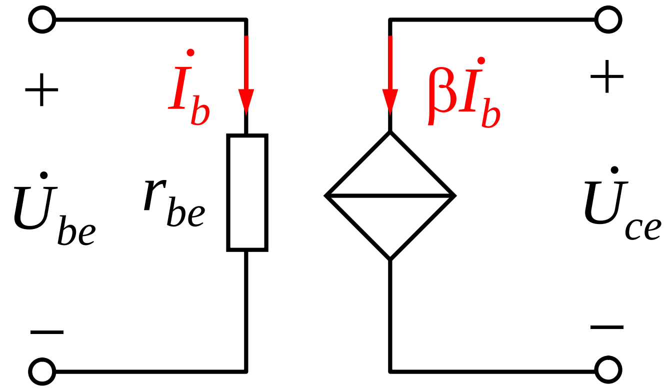
f

4.

☞ μ g r β

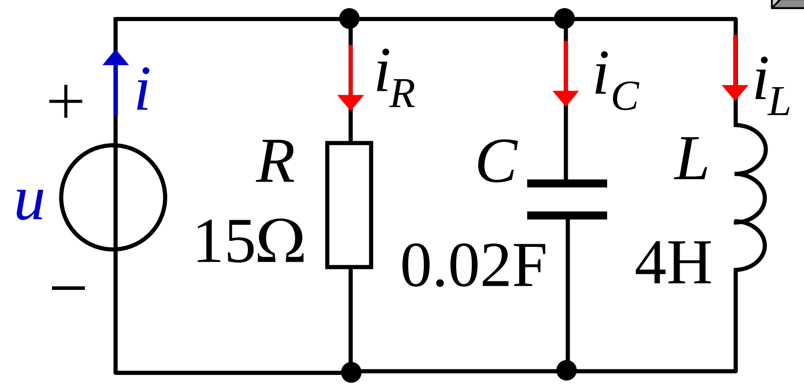


CCCS



CCCS

$u(t)=120\sqrt{2}\cos(5t)$ V　　$i(t)$



$\dot{U}=120\angle 0^{o}$ V

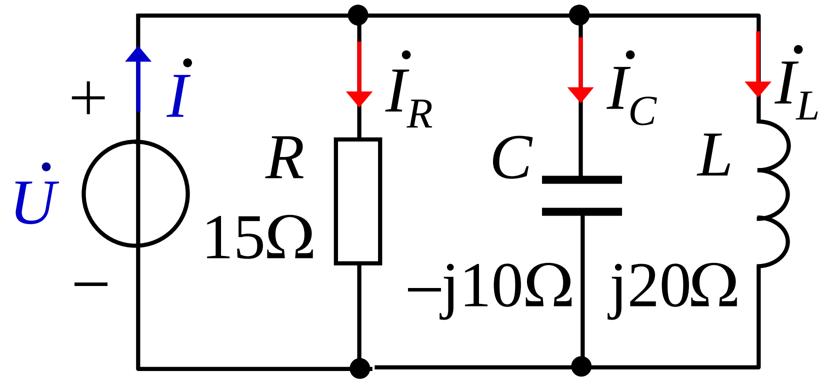
$$\frac{1}{\omega C}=\frac{1}{5\times 0.02}=10\Omega$$

$$\omega L=5\times 4=20\Omega$$

$$\dot{I}_R=\frac{\dot{U}}{R}=\frac{120}{15}=8\ \text{A}$$

$$\dot{I}_C=\frac{\dot{U}}{-\mathrm{j}\frac{1}{\omega C}}=\frac{120}{-\mathrm{j}10}=\mathrm{j}12\ \text{A}$$

$$\dot{I}_L=\frac{\dot{U}}{\mathrm{j}\omega L}=\frac{120}{\mathrm{j}20}=-\mathrm{j}6\ \text{A}$$



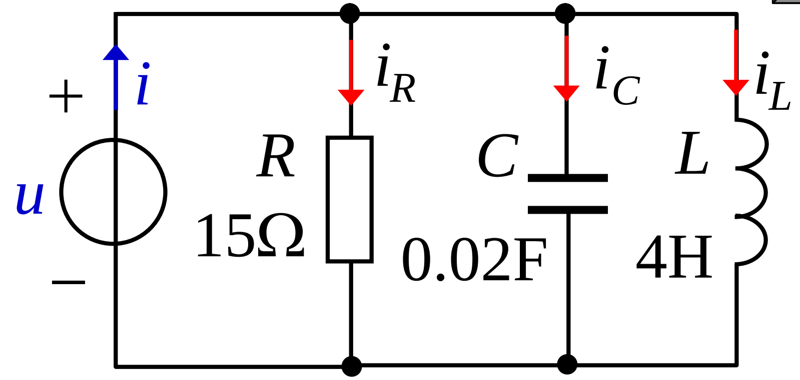
$$\dot{I}=\dot{I}_R+\dot{I}_C+\dot{I}_L$$

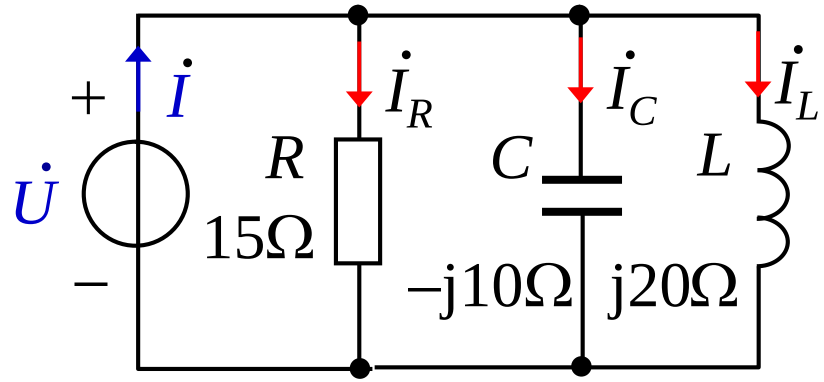
$$=8+\mathrm{j}12-\mathrm{j}6\ \text{A}$$

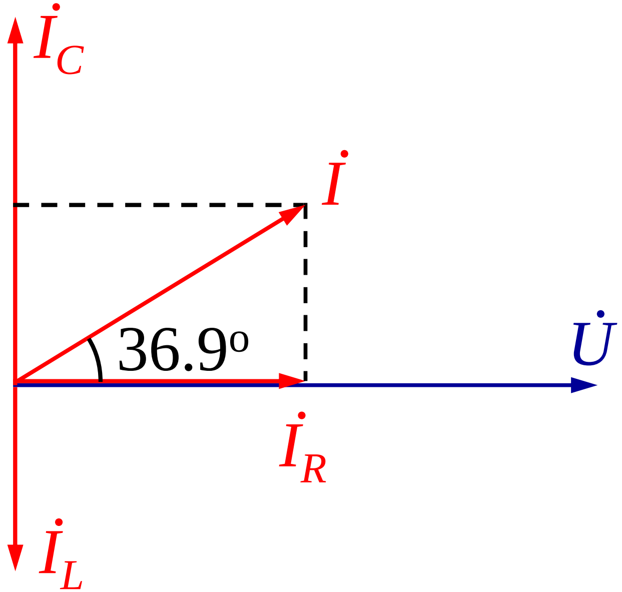
$u(t) = 120\sqrt{2}\cos(5t)$ V $\quad i(t)$

$\dot{I} = 8 + \mathrm{j}6 = 10\angle 36.9^{\circ}$ A

$i(t) = 10\sqrt{2}\cos(5t + 36.9^{\circ})$ A







$$\dot{I} = \dot{I}_R + \dot{I}_C + \dot{I}_L$$

$$= 8 + \mathrm{j}12 - \mathrm{j}6 \text{ A}$$