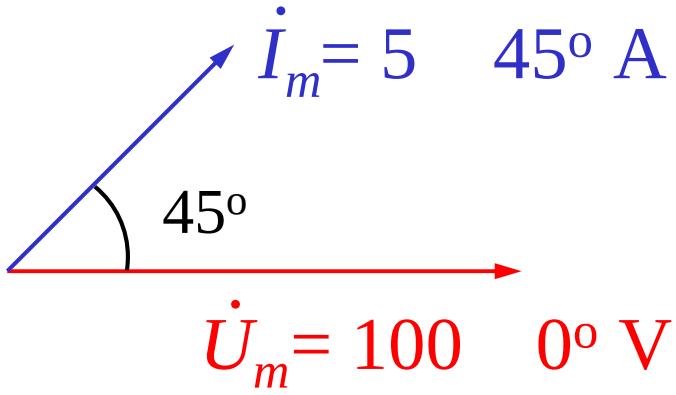
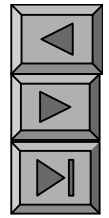
1.

2.

3. VCR



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



§ 8-1

1.

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

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

(2)

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

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

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

$\theta=\mathrm{arctg}\dfrac{b}{a}$

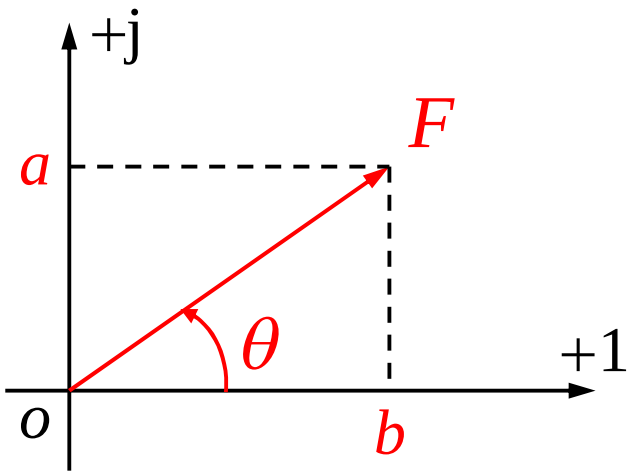
(3)

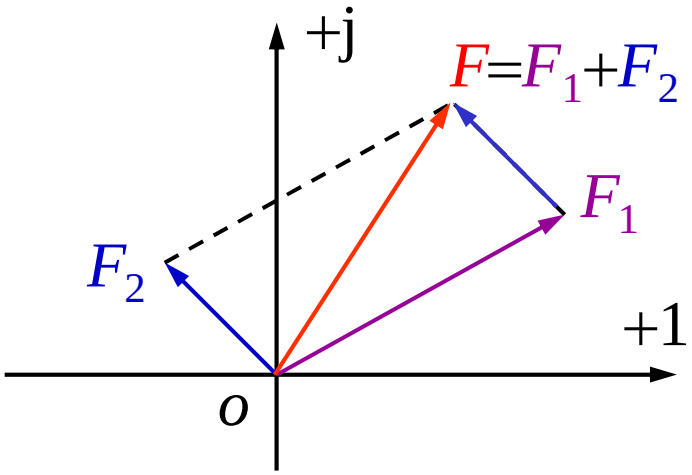
$e^{\mathrm{j}\theta}=\cos\theta+\mathrm{j}\sin\theta$

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

$F=|F|\angle\theta$

(4)



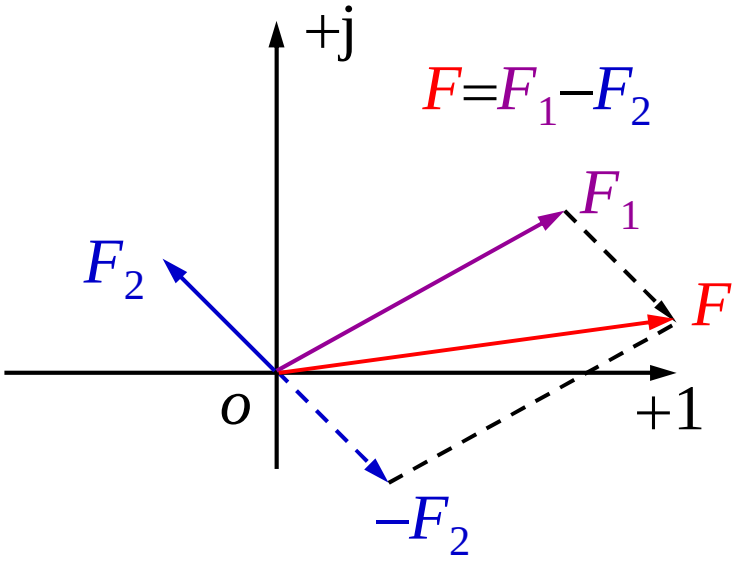


2.

(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)

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

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

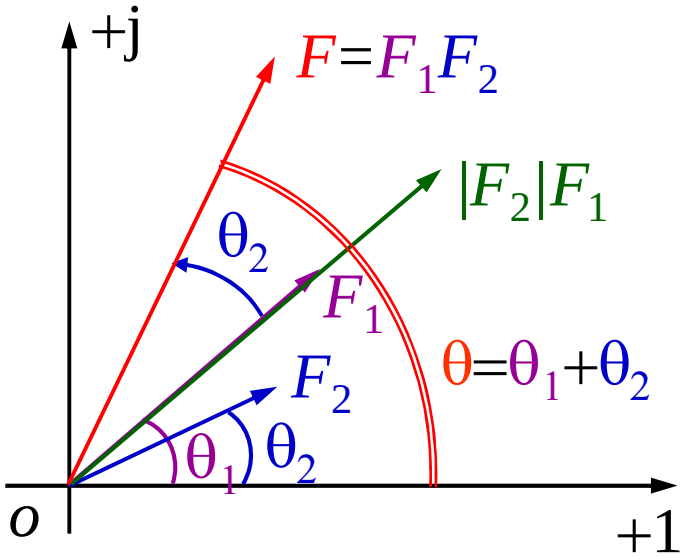
$$F = |F_1||F_2| \angle \theta_1+\theta_2 \qquad F = \frac{F_1}{F_2} = \frac{|F_1|}{|F_2|} \angle \theta_1-\theta_2$$

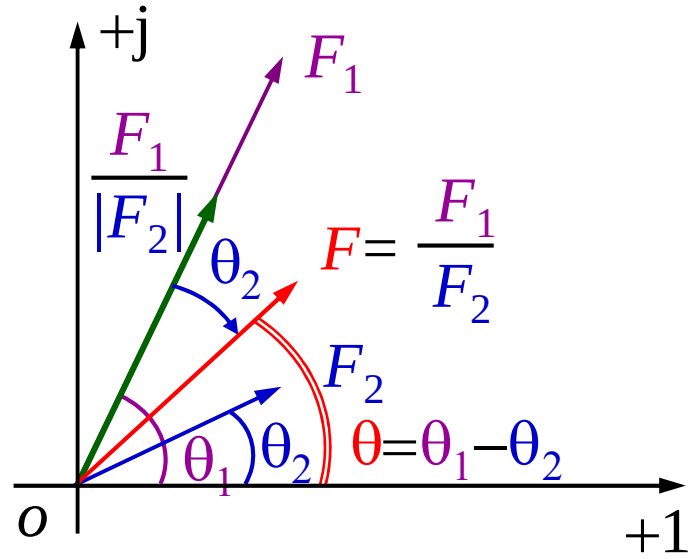
( ) ( ) ( )

$F_1 = F_2$

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

$a_1 = a_2 \quad jb_1 = jb_2$





☞ F_1 $|F_2|$ θ_2

☞ F_1 $|F_2|$ θ_2

3. $e^{j\theta}$

☝ $e^{j\theta}=1$ θ

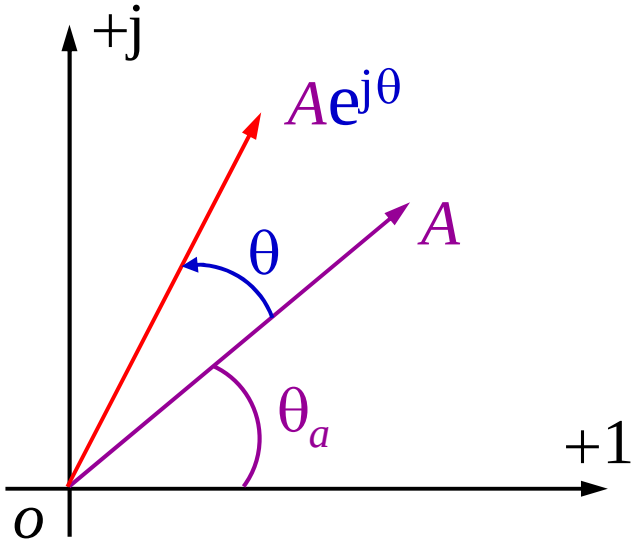
1 θ

✌ $A=|A|e^{j\theta a}$

$e^{j\theta}$ A θ

$|A|$

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



$A \times j = jA$ A

90^o。

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

90^o。

§ 8-2

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

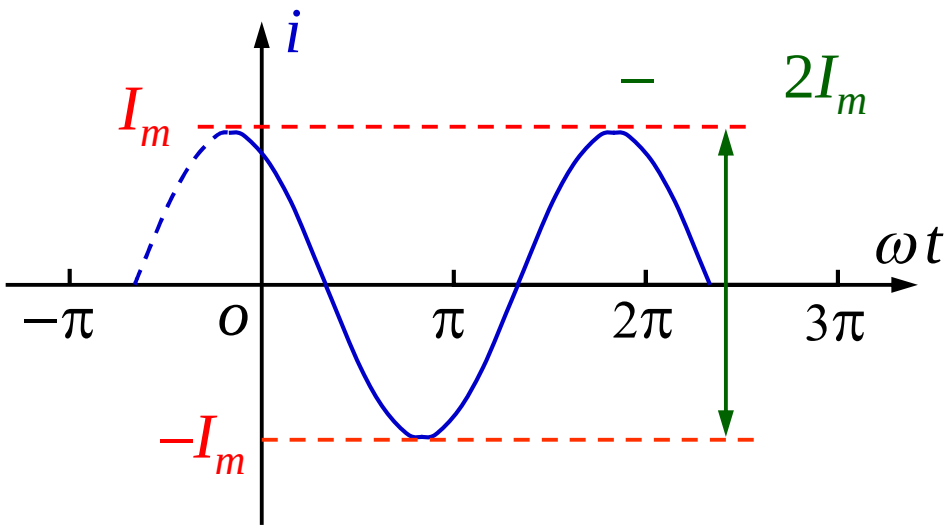
$$i = I_m \sin(\omega t + \phi_i)$$

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

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

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

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

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

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

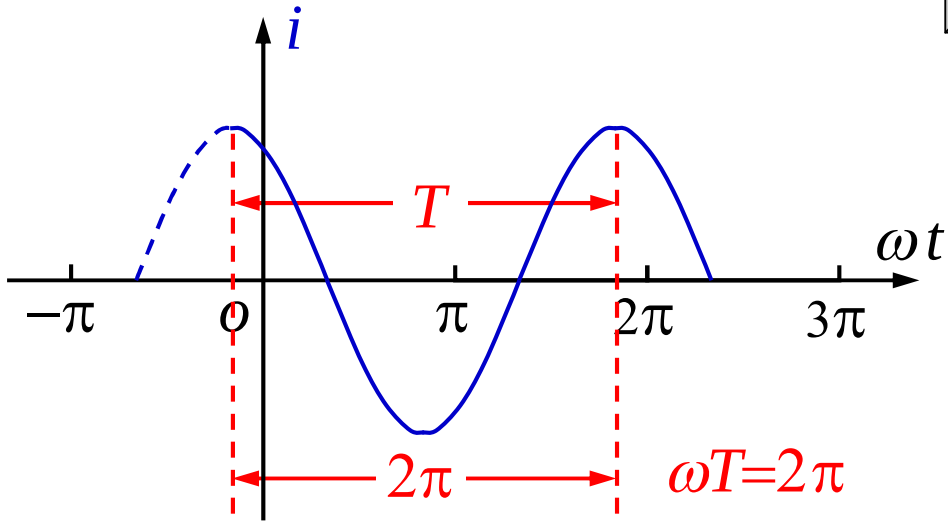
$U = 220\mathrm{V}$ $U_m \approx 311\mathrm{V}$

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

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

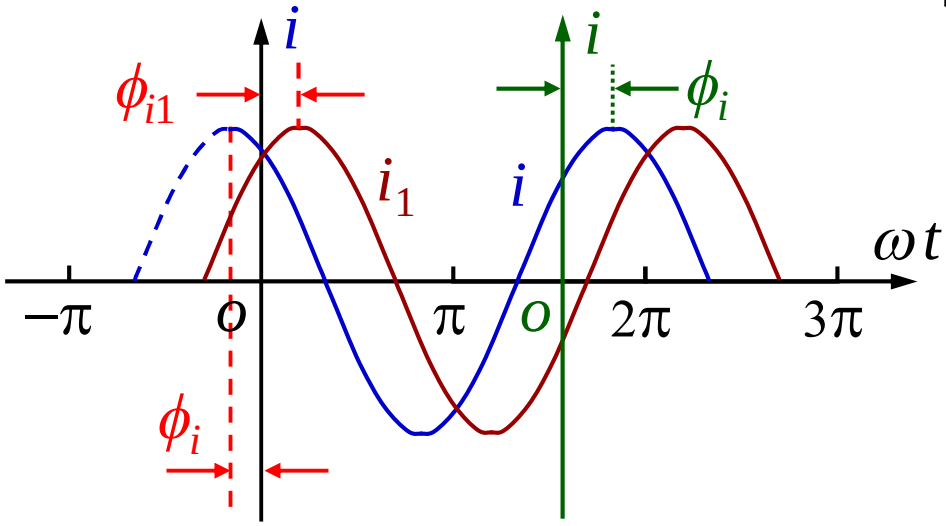
(3) ϕ_i ( )

$(\omega t+\phi_i)$

, :

rad (º)

t=0 ϕ_i



$|\phi_i| \le 180^o$

2.

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

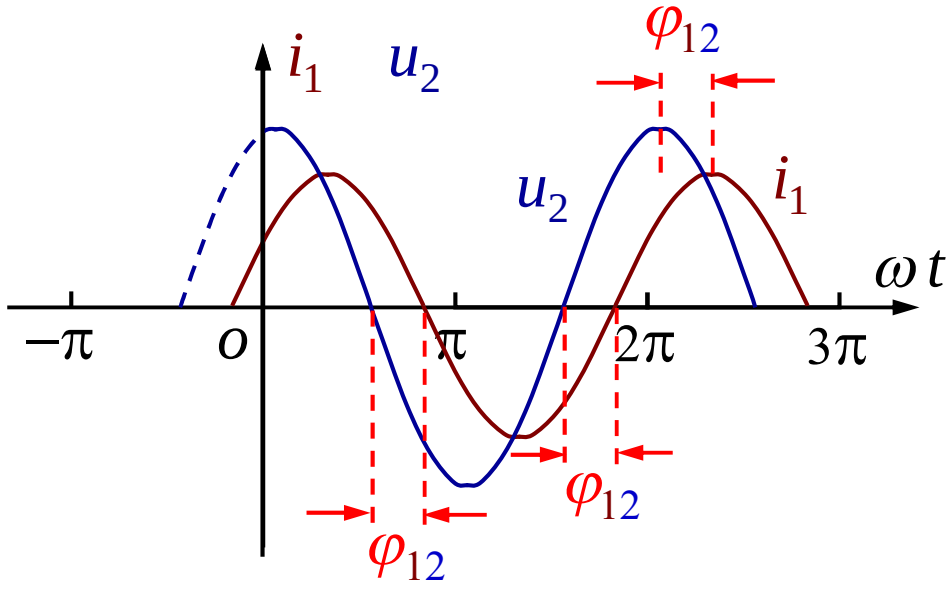
φ_{12} $\varphi_{12}=(\omega t+\phi_{i1})-(\omega t+\phi_{u2})=\phi_{i1}-\phi_{u2}$

(1) φ_{12} 0 i u

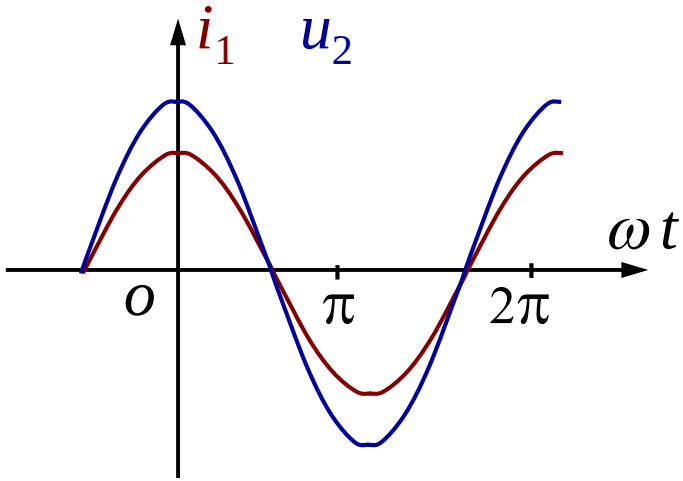
u i i u

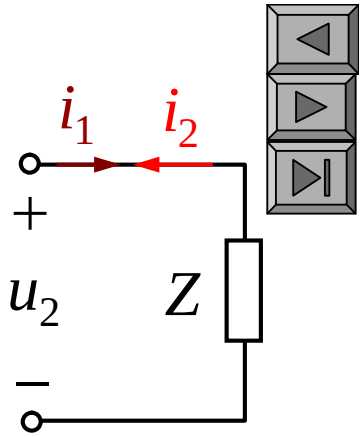
(2) φ_{12} 0 u i

i u u i



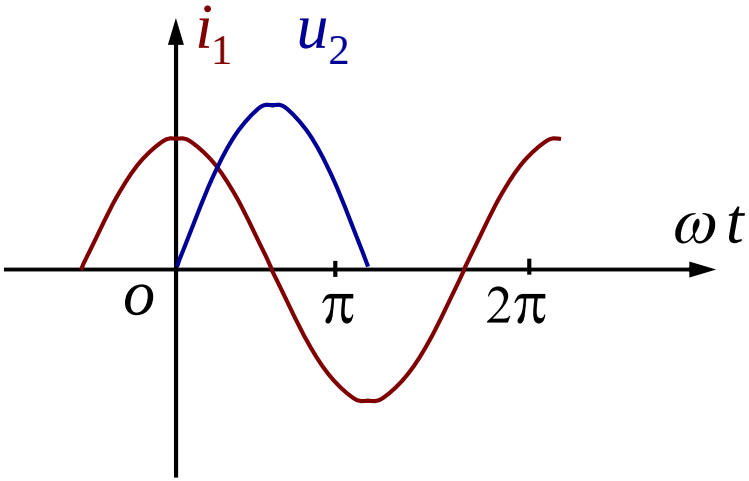
$\varphi_{12} \leq |\pi|$





$\varphi_{12}=0$ i_1 u_2

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



π

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

§ 8–3

( ) ( ) ———

KCL KVL

1.

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

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

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

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

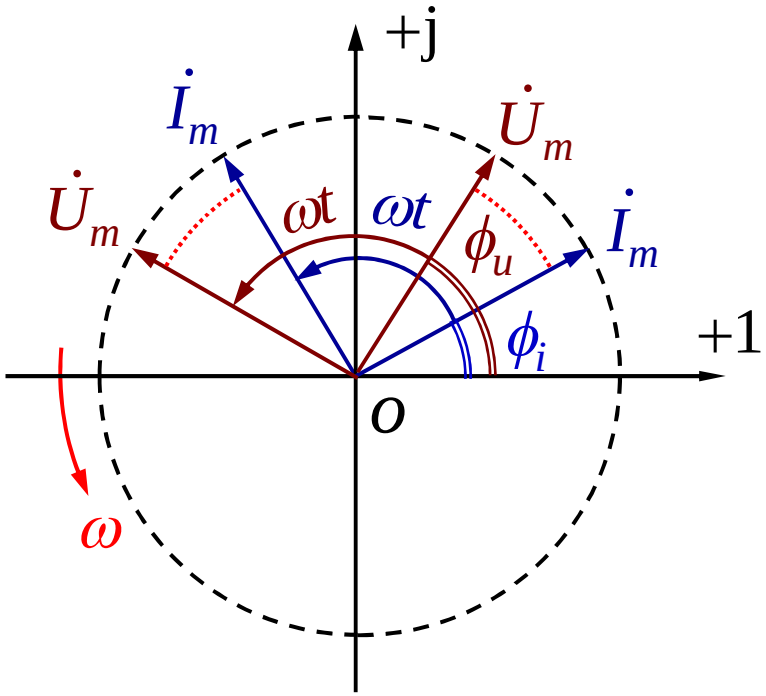
$$= \mathrm{Re}[\dot{I}_m e^{j\omega t}]$$

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

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

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

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


+j
+1
O
$\dot{I}_m$
$\dot{U}_m$
$\dot{U}_m$
$\dot{I}_m$
ωt
ωt
ϕ_u
ϕ_i
ω

(2)

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

$$\frac{di}{dt} = \omega I_m \cos(\omega t + \phi_i + 90^o) = \mathrm{Re}[\omega \dot{I}_m e^{j\omega t} e^{j\frac{\pi}{2}}]$$

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

☞

$j\omega$

ωI_m 90^o

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

(3)

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

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

☞

$j\omega$

(U_m/ω) 90°

n

$$\int\int \cdots \int u\,dt \longleftrightarrow \frac{\dot{U}}{(j\omega)^n}$$

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

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

$$\frac{\mathrm{d}i_1}{\mathrm{d}t} \qquad \int i_2\,\mathrm{d}t \qquad i_1 + i_2$$

$$\frac{\mathrm{d}i_1}{\mathrm{d}t} \longrightarrow \mathrm{j}\omega\,\dot{I}_1 = \mathrm{j}314 \times 10\angle 60^\circ = 3140\angle 60^\circ + 90^\circ$$

$$\frac{\mathrm{d}i_1}{\mathrm{d}t} = 3140\sqrt{2}\cos(314t + 150^\circ)$$

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

$$\int i_2\,\mathrm{d}t = 0.07\sqrt{2}\cos(314t + 120^\circ)$$

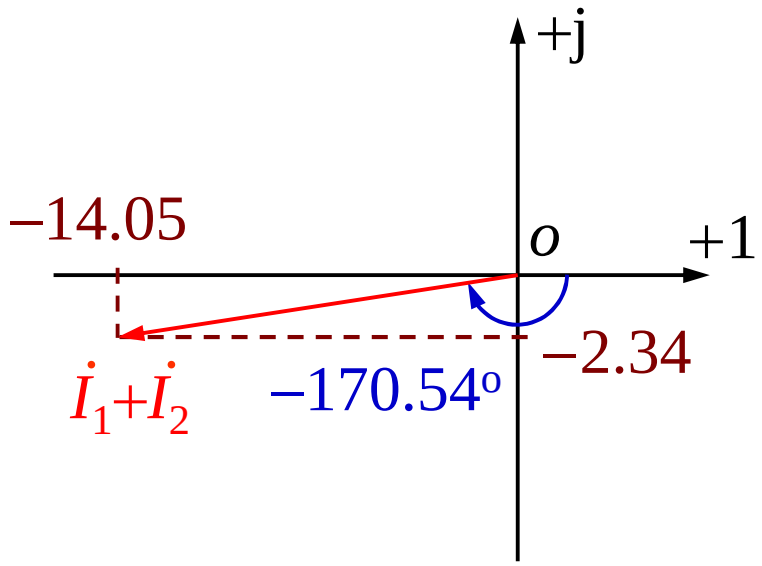
$\dot{I}_1 = 10 \angle 60^o = 5 + j8.66$ A $\quad \dot{I}_2 = 22 \angle -150^o = -19.05 - j11$ A

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

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

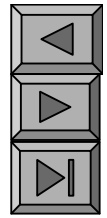
$\phi_i \qquad 3$

$\phi_i = -180^o + \text{arctg}\,\dfrac{-2.34}{-14.05}$



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

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

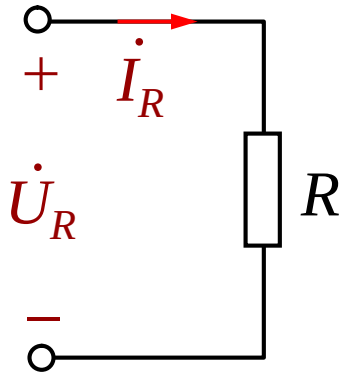


2. VCR

(1)

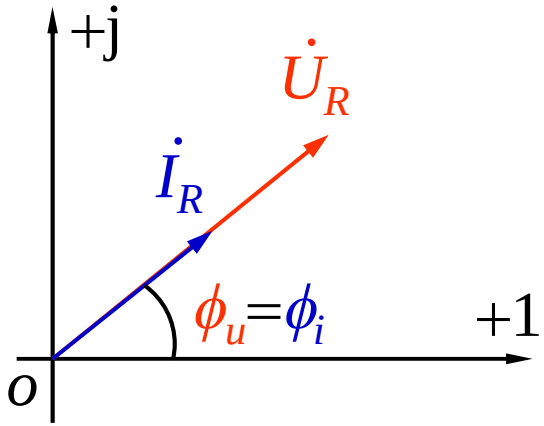
$$u_R = R\, i_R \longrightarrow \dot{U}_R = R\, \dot{I}_R$$

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



☞

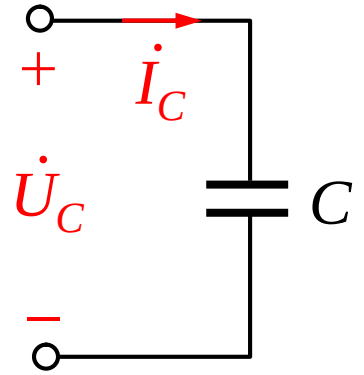
$$U_R = R\, I_R \qquad I_R = G\, U_R$$



2010

(3)

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



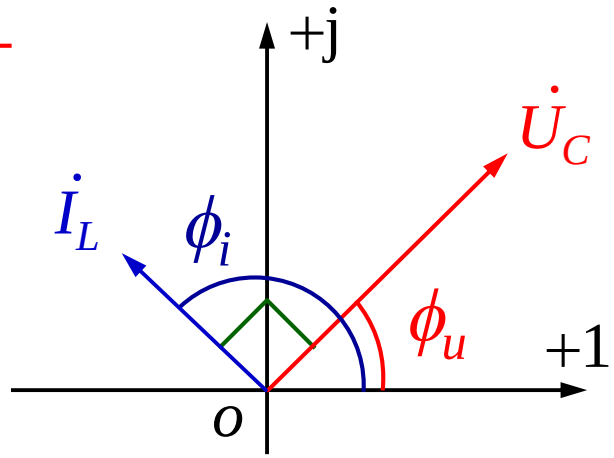
$$\dot{U}_C = \frac{1}{\mathrm{j}\omega C}\dot{I}_C \qquad \dot{U}_C = -\mathrm{j}\frac{1}{\omega C}\dot{I}_C$$

☞ *C* 90° !

90° !

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

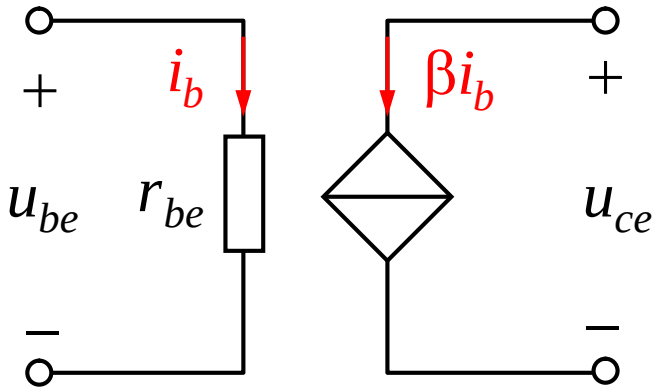
$$\frac{U_C}{I_C} = \frac{1}{\omega C}$$



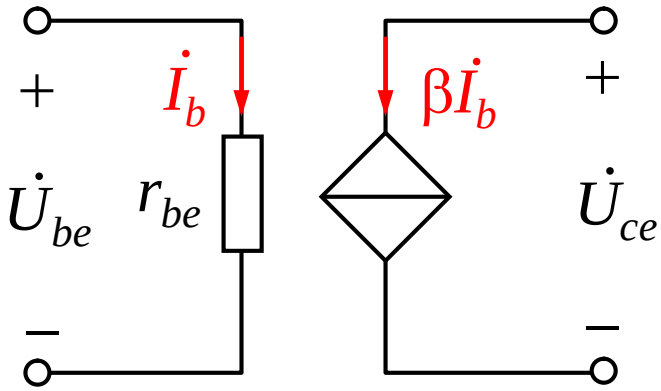
☞ $(1/\omega C)$ *f*

4.

☞ μ g r β

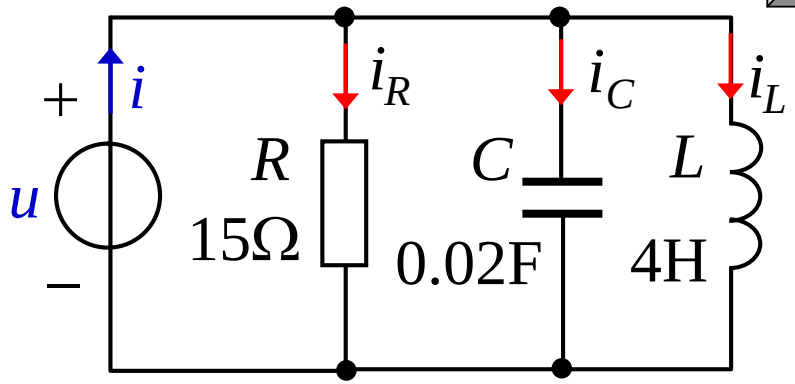


CCCS



CCCS

$u(t)=120\sqrt{2}\cos(5t)$ V　　$i(t)$



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

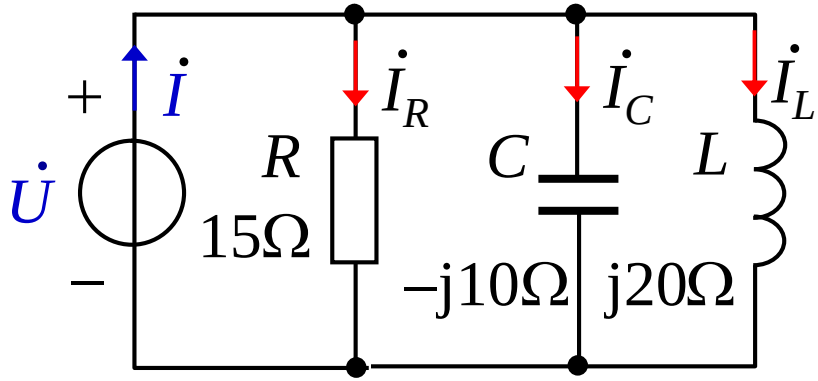
$$\frac{1}{\omega C}=\frac{1}{5\times 0.02}=10\Omega$$

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

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

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

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



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

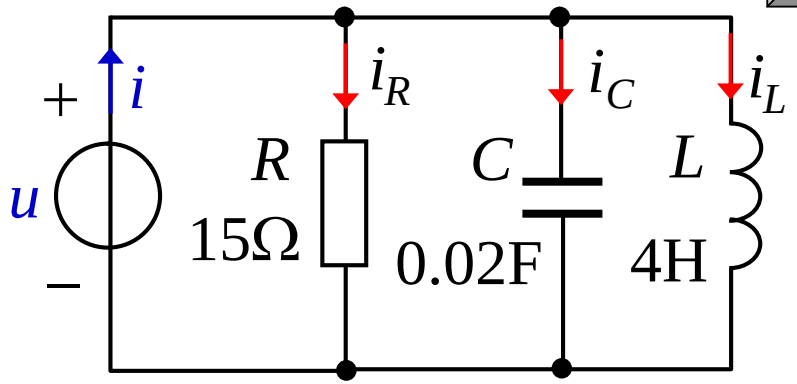
$$=8+\text{j}12-\text{j}6\ \ \text{A}$$

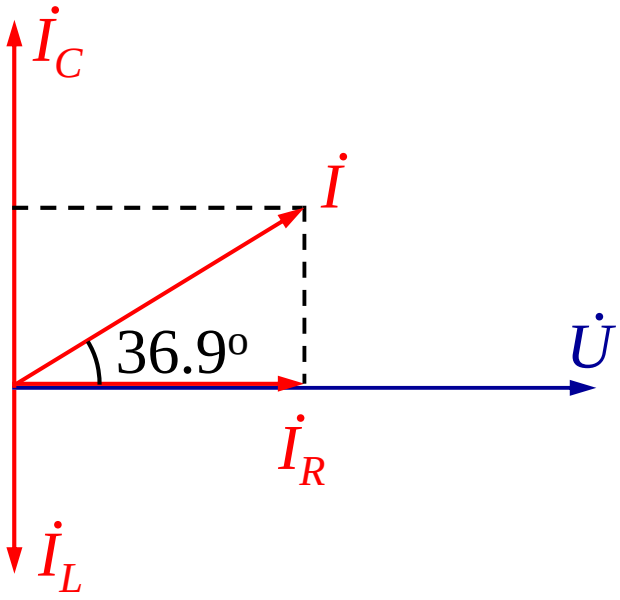
$$u(t)=120\sqrt{2}\cos(5t)\ \text{V}$$

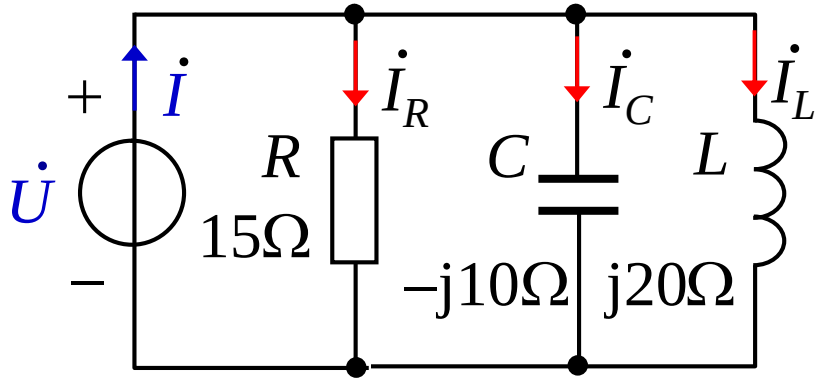
$i(t)$

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

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







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

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