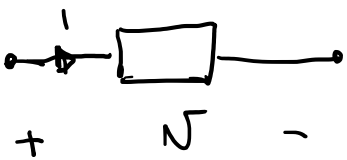


$v(t) = V_M \cos(\omega t + \alpha_v)$ $\qquad \varphi = \alpha_v - \alpha_i$

$i(t) = I_M \cos(\omega t + \alpha_i)$

POT. ASSORBITA ISTANTANEA

$$p(t) = v(t)\, i(t) = V_M I_M \cos(\omega t + \alpha_v) \cos(\omega t + \alpha_i)$$

$$i(t) = I_M \cos(\omega t + \alpha_i + \alpha_v - \alpha_v) = I_M \cos(\omega t + \alpha_v - \varphi) =$$

$$= I_M \cos\varphi \cos(\omega t + \alpha_v) + I_M \sin\varphi \sin(\omega t + \alpha_v) = i_a(t) + i_r(t)$$

$i_a(t) = I_M \cos\varphi \cos(\omega t + \alpha_v)$ CORRENTE ISTANTANEA ATTIVA

$i_r(t) = I_M \sin\varphi \sin(\omega t + \alpha_v)$ " " REATTIVA

$$p(t) = v(t)\left[i_a(t) + i_r(t)\right] = v(t)\, i_a(t) + v(t)\, i_r(t)$$

$p_a(t) = v(t)\, i_a(t) = V_M I_M \cos\varphi \cos^2(\omega t + \alpha_v)$ POT. IST. ATTIVA

$p_r(t) = v(t)\, i_r(t) = V_M I_M \sin\varphi \frac{1}{2} \sin(2\omega t + 2\alpha_v)$ POT. IST. REATTIVA

$$p_e(t) = V_M I_M \cos\varphi \cos^2(\omega t + \alpha_V)$$

$\cos\varphi > 0 \Rightarrow p_e(t) \geq 0$

$\cos\varphi < 0 \Rightarrow p_e(t) \leq 0$

FLUSSO DI POTENZA UNIDIREZIONALE

$$p_2(t) = \frac{V_M I_M}{2} \sin\varphi \sin(2\omega t + 2\alpha_V)$$

FLUSSO DI POTENZA OSCILLANTE

$P_e \Rightarrow (M) \Rightarrow P_m$ = POTENZA MECCANICA $= C\,\omega_m$

$\Downarrow$

P_d = POTENZA DISSIPATA (CALORE)

$\uparrow$

POTENZA ELETTRICA

$$\eta = \text{RENDIMENTO} = \frac{P_m}{P_e} = \frac{\Delta E_m}{\Delta E_e} \cong \frac{\langle P_m \rangle (t_2 - t_1)}{\langle P_e \rangle (t_2 - t_1)}$$

$$\Delta E_m = \int_{t_1}^{t_2} p_m(t)\,dt$$ ENERGIA MECCANICA EROGATA

$t_2 - t_1 \gg T = \frac{1}{f}$

$$\Delta E_e = \int_{t_1}^{t_2} p_e(t)\,dt$$ ENERGIA ELETTRICA ASSORBITA

$$P = \text{POTENZA ATTIVA} = \frac{1}{T}\int_0^T p(t)\,dt \qquad (W)$$

$$P = \frac{1}{T}\int_0^T \left[p_e(t) + p_r(t)\right] dt = \frac{1}{T}\int_0^T p_e(t)\,dt + \frac{1}{T}\int_0^T p_r(t)\,dt =$$

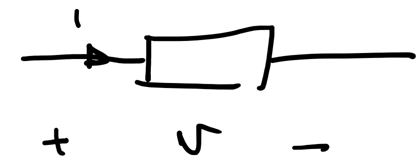
$$= \underbrace{\frac{1}{T}\int_0^T V_M I_M \cos\varphi \cos^2(\omega t + \alpha_v)\,dt}_{= \frac{V_M I_M}{2}\cos\varphi} + \underbrace{\frac{1}{T}\int_0^T \frac{V_M I_M}{2} \sin\varphi \sin(2\omega t + 2\alpha_v)\,dt}_{= 0}$$

$$P = \frac{V_M I_M}{2}\cos\varphi = V_e I_e \cos\varphi$$

$\cos\varphi$ = FATTORE DI POTENZA

$$V_e = \frac{V_M}{\sqrt{2}}, \quad I_e = \frac{I_M}{\sqrt{2}}$$

N = POTENZA COMPLESSA = $\underline{V}\,\underline{I}^*$



$\underline{I}^*$ = COMPLESSO CONIUGATO DI $\underline{I}$

$\varphi = \alpha_v - \alpha_i$

ESEMPIO $\quad \underline{I} = 3 + j2 \qquad \underline{I}^* = 3 - j2$

$$\underline{V} = V_e e^{j\alpha_v} \qquad \underline{I} = I_e e^{j\alpha_i} \qquad \underline{I}^* = I_e e^{-j\alpha_i}$$

$$N = V_e e^{j\alpha_v} I_e e^{-j\alpha_i} = V_e I_e e^{j\varphi} = \underbrace{V_e I_e \cos\varphi}_{P} + j\,\underbrace{V_e I_e \sin\varphi}_{Q}$$

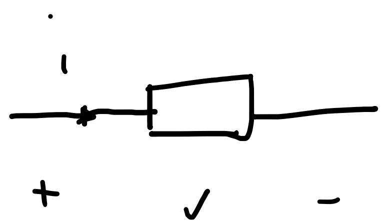
Q = POT. REATTIVA = $V_e I_e \sin\varphi$ (VAR)

VOLT_AMPERE_REATTIVO

BILANCIO ENERGETICO DI UN CIRCUITO IN CORRENTE ALTERNATA

$$\sum_{k=1}^{R} N_k = 0 \qquad \sum_{k=1}^{R} \left(P_k + jQ_k\right) = 0 \quad \begin{cases} \displaystyle\sum_{k=1}^{R} P_k = 0 \\ \displaystyle\sum_{k=1}^{R} Q_k = 0 \end{cases}$$

È NULLA LA SOMMA DELLE POTENZE COMPLESSE ASSORBITE DA TUTTI I COMPONENTI



$$P = \frac{1}{T}\int_0^T p(t)\,dt = V_e I_e \cos\varphi \qquad (W)$$

$$N = \underline{V}\,\underline{I}^* = V_e I_e \cos\varphi + j V_e I_e \sin\varphi = P + jQ$$

$$Q = V_e I_e \sin\varphi \qquad (VAR)$$

$$A = \text{POT. APPARENTE} = |N| = |\underline{V}\,\underline{I}^*| = |\underline{V}|\,|\underline{I}^*| = V_e I_e = \sqrt{P^2 + Q^2}$$

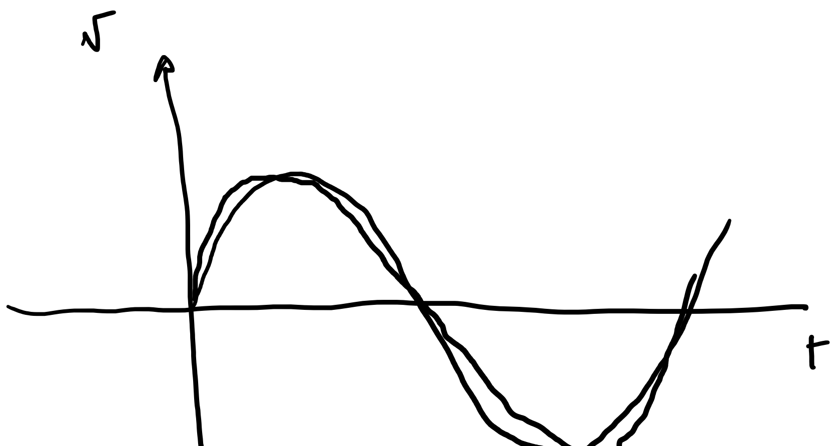
(VA) (VOLT-AMPERE)

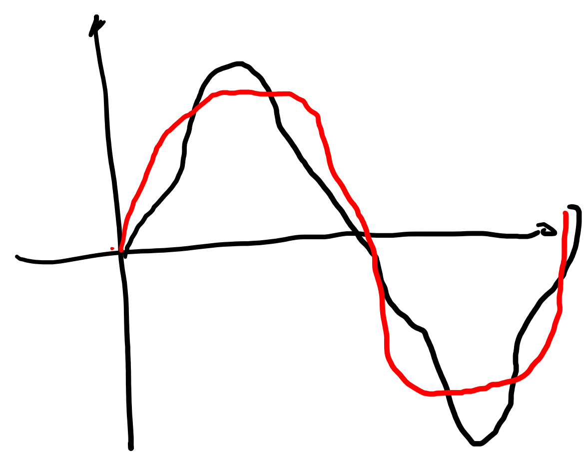
$$\underline{V} = V_e e^{j\alpha_v} \qquad |\underline{V}| = V_e \left| e^{j\alpha_v} \right| = V_e \left| \cos\alpha_v + j\sin\alpha_v \right| =$$

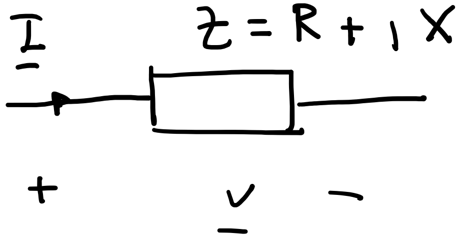
$$= V_e \sqrt{\cos^2\alpha_v + \sin^2\alpha_v} = V_e$$

$$\underline{I} = I_e e^{j\alpha_i} \qquad |\underline{I}| = I_e$$

$$\underline{I}^* = I_e e^{-j\alpha_i} \qquad |\underline{I}^*| = I_e$$







$$\underline{V} = Z\,\underline{I} = (R + jX)\,\underline{I}$$

$$N = \underline{V}\,\underline{I}^* = \left[(R + jX)\,\underline{I}\right]\underline{I}^* = (R + jX)\left[\underline{I}\,\underline{I}^*\right]$$

$$c = a + jb$$

$$c^* = a - jb$$

$$c\,c^* = (a + jb)(a - jb) = a^2 + b^2 = |c|^2$$

$$N = (R + jX)\,|\underline{I}|^2 = (R + jX)\,I_e^2 = R\,I_e^2 + j\,X\,I_e^2 = P + jQ$$

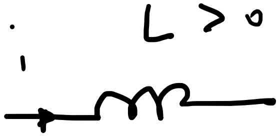
$P = R\,I_e^2$ POT. ATTIVA

$Q = X\,I_e^2$ POT REATTIVA

$R > 0$

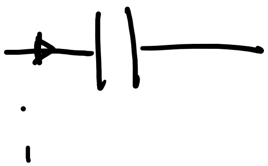
$$Z = R \qquad P = R\, I_e^2 > 0$$
$$Q = 0\, I_e^2 = 0$$

$L > 0$

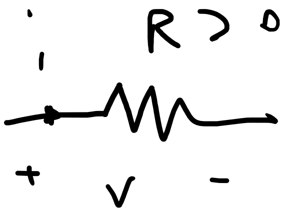


$$Z = j\omega L \qquad P = 0\, I_e^2 = 0$$
$$Q = \omega L\, I_e^2 > 0$$

$C > 0$



$$Z = -\frac{j}{\omega C} \qquad P = 0\, I_e^2 = 0$$
$$Q = -\frac{1}{\omega C}\, I_e^2 < 0$$

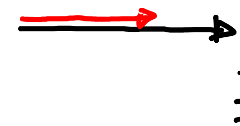


$$\underline{V} = R\,\underline{I}$$

$$\underline{V} = R\,\underbrace{I_e}_{V_e}\,e^{j\alpha_i}$$

$\underline{V}$ IN FASE CON $\underline{I}$

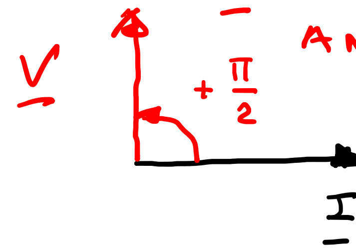
$\underline{V} = R\,\underline{I}$

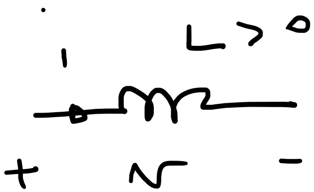


$V_e = R\,I_e$

$\alpha_v = \alpha_i \qquad \varphi = 0$

$\underline{V}$ IN QUADRATURA ANTICIPO





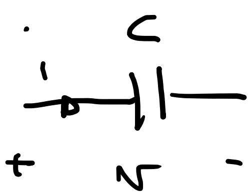
$$\underline{V} = j\omega L\,\underline{I}$$

$$= j\omega L\, I_e e^{j\alpha_i} = e^{j\frac{\pi}{2}}\omega L I_e e^{j\alpha_i} = \underbrace{\omega L I_e}_{V_e}\, e^{j(\underbrace{\alpha_i + \frac{\pi}{2}}_{\alpha_v})}$$

$V_e = \omega L I_e$

$\alpha_v = \alpha_i + \frac{\pi}{2} \qquad \varphi = \frac{\pi}{2}$

$\underline{V}$ IN QUADRATURA RITARDO

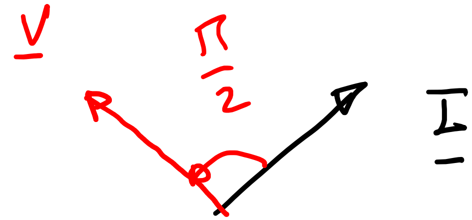


$$\underline{V} = -\frac{j}{\omega C}\,\underline{I}$$

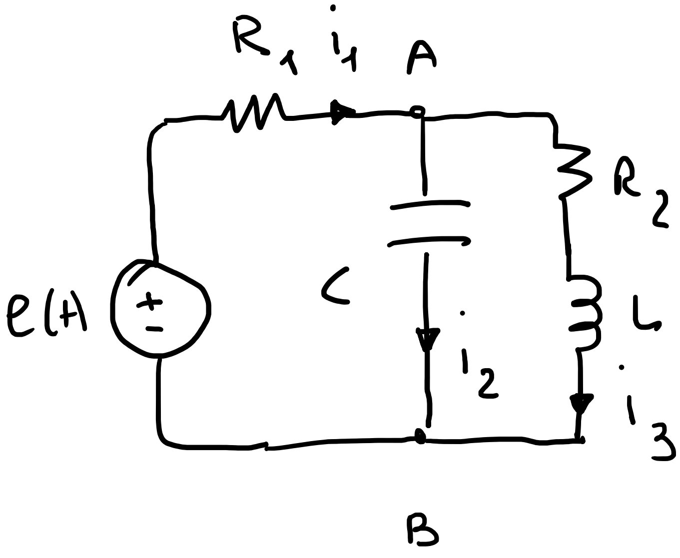
$$= \frac{1}{\omega C}\,e^{-j\frac{\pi}{2}}\, I_e e^{j\alpha_i} = \frac{1}{\omega C}\, I_e e^{j(\alpha_i - \frac{\pi}{2})}$$

$V_e = \frac{I_e}{\omega C} \qquad \alpha_v = \alpha_i - \frac{\pi}{2}$

$\varphi = -\frac{\pi}{2}$



$\underline{V}$
$\frac{\pi}{2}$
$\underline{I}$



$R_1 = 2\ \Omega$, $R_2 = 3\ \Omega$, $C = 0.2\ mF$

$L = 4\ mH$

$e(t) = E_n \cos(\omega t + \alpha)$ $\quad \underline{\underline{\alpha = 0}}$

$E_n = 10\ V \qquad f = 50\ Hz$

$i_1(t) = I_{1n} \cos(\omega t + \alpha_1)$

$i_2(t) = I_{2n} \cos(\omega t + \alpha_2)$

$i_3(t) = I_{3n} \cos(\omega t + \alpha_3)$

$\omega = 2\pi f = 2 \times \pi \times 50 =$

$= 314.2\ \frac{rad}{s}$

$\alpha' - \alpha_1' = \alpha - \alpha_1$

$\alpha' = \alpha + \omega \Delta t$

$\alpha_1' = \alpha_1 + \omega \Delta t$

$t' = t - \Delta t \Rightarrow t = t' + \Delta t$

$e(t') = E_n \cos(\omega t' + \omega \Delta t + \alpha) = E_n \cos(\omega t' + \alpha')$

$i_1(t') = I_{1n} \cos(\omega t' + \omega \Delta t + \alpha_1) = I_{1n} \cos(\omega t' + \alpha_1')$

UNA QUALSIASI GRANDEZZA PUÒ ESSERE PRESA COME GRANDEZZA DI RIFERIMENTO PER GLI ANGOLI DI FASE (FASE = 0)