

1.4. VEKTORSKI DIJAGRAM

- grafika reprezentacija fazora u kompleksnoj ravнини

- ||- merni vektori sinusnih veličina ($I; u$) -||-

2. VRSTE

► kvantitativan / numerički / analitički } izračunavaju i crtavaju fazori napona i struja u \mathbb{C}

► kvalitativan / grafički / simbolički } polazeći od vekt. dijagrama za R, L i C te Kirchhoffovih zakona
↳ određuju i crtavaju odnosni fazora

► Svi vektori izlaze iz ishodišta

- za svaki vekt. dijagram moguće IZRAČUNATI faze \vec{I} i \vec{u} → crtati

x! bitno uvesti ref. veličine

↳ \vec{u} i \vec{I} (početni) - fazi kut 0

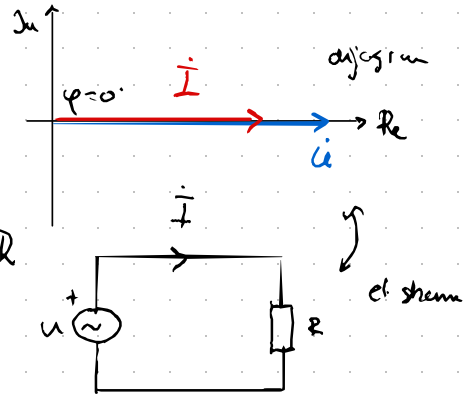
↳ $\vec{u} = u \angle 0^\circ$, $\vec{I} = I \angle 0^\circ$

Primer: vekt. dijagram za čisti omotni otpor R spojen na \vec{u}

→ ref. napon je $\vec{u} = u \angle 0^\circ$

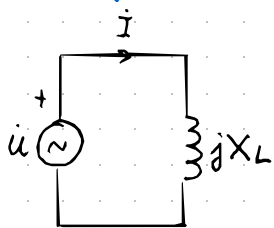
$$\rightarrow \vec{I} = \frac{\vec{u}}{R} = \frac{u \angle 0^\circ}{R} = \frac{u}{R} \angle 0^\circ$$

- na čistom omotnom otporu priključenom na sinusni naponski izvor su napon \vec{u} i struja \vec{I} u fazi jer je njihov pomak $\varphi = \alpha_u - \alpha_i = 0^\circ$



A slični se $j = +\angle 90^\circ$ tj. to će ti trebati

Primer 1.4.2) čisti induktivni otpor X_L

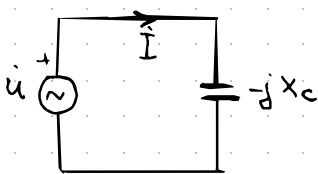


na čistom induktivnom otporu
priključenom na sinusni nap. izvor
struja \vec{I} kasni za naponom \vec{u}
za $90^\circ \rightarrow \varphi = \alpha_u - \alpha_i =$
 $0 - (-90)$
 $+90$

- kažemo da je \vec{u} referentni napon oblika $\vec{u} = U \angle 0^\circ$

$$\rightarrow \underline{Z} = \frac{\vec{u}}{\vec{I}} \quad \underline{Z} = jX_L \quad \left\{ \vec{I} = \frac{\vec{u}}{\underline{Z}} = \frac{U \angle 0^\circ}{jX_L} \right. \begin{array}{l} \text{budući} \\ \text{da je} \\ j = \angle 90^\circ \end{array} = \frac{U \angle 0^\circ}{X_L \angle 90^\circ} = I \angle -90^\circ$$

Primer / čisti kapacitivni otpor

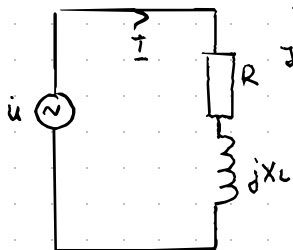


$$\vec{I} = \frac{\vec{u}}{-jX_C} = \frac{U \angle 0^\circ}{X_C \angle -90^\circ} = I \angle 90^\circ$$

struja uranija je za 90°

$$\rightarrow \varphi = \alpha_u - \alpha_i = 0 - 90^\circ = -90^\circ$$

PRIMER: serija RL



= nacrtati vekt. dijagram ako je $\vec{I} = I \angle \alpha_i = I \angle 0^\circ$

• serijski spoj R i L ima istu struju \vec{I}

• u D serijskog spoja RL odredimo
numenke

\rightarrow zadane R i X_L izračunamo
 U_R i U_L te na izvoru \vec{u}

\Rightarrow dobiveni fazor staviti u Φ

• zadane vrijednosti

$$X_L = \frac{3}{7} \Omega \quad R = \frac{4}{7} \Omega \quad \vec{I} = 7 \angle 0^\circ \text{ A}$$

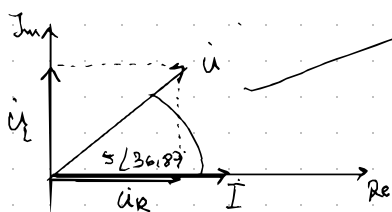
računamo faze napona:

$$\vec{U}_R = R \cdot \vec{I} = \frac{4}{7} \Omega \cdot 7 \angle 0^\circ \text{ A} = 4 \angle 0^\circ \text{ V}$$

$$\vec{U}_L = \vec{I} \cdot jX_L = (7 \angle 0^\circ) \left(\frac{3}{7} \angle 90^\circ \right) = 3 \angle 90^\circ$$

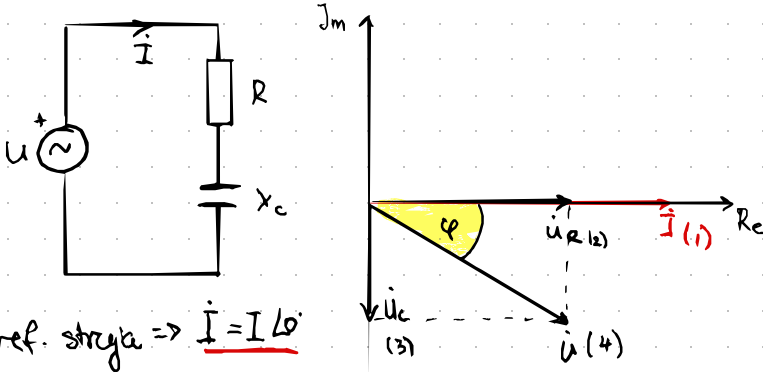
$$\vec{u} = \vec{U}_R + \vec{U}_L = 4 \angle 0^\circ + 3 \angle 90^\circ = 5 \angle 36,87^\circ \text{ V} \quad (\text{ovo možemo u kalkulatoru})$$

$$\vec{u} = \underline{Z} \cdot \vec{I} = \vec{I} (R + jX_L) = \vec{I} \cdot \sqrt{R^2 + X_L^2} \angle \arctan\left(\frac{X_L}{R}\right) = 5 \angle 36,87^\circ \text{ V}$$



sa crteža smo
znali da je $\varphi = \left(\frac{X_L}{R} \right)$ kut, ali trebali smo kut
(pa je \arctan)

PRIMJER: serija RC * grafički postupak, provjera numeričkim



- 1) učitamo $I \angle 0^\circ$
- 2) učitamo $\underline{U}_R \rightarrow$ on je u fazi sa strujom $\rightarrow \angle 0^\circ$
- 3) učitavamo \underline{U}_C , ali da vrijede fazni odnosi na kapacitetu C $I = \frac{U \angle 0^\circ}{X_C \angle -90^\circ} = 90^\circ$
 \rightarrow struja \underline{I} prethodi za 90° naponu \underline{U}_C .
- 4) Za \underline{U} mora vrijediti Kirchhoffovo pravilo $\underline{U} = \underline{U}_R + \underline{U}_C$
- 5) za fazni pomak vrijedi $\varphi \angle 0^\circ$ \rightarrow serija je kapacitivnog karaktera
 \rightarrow između \underline{U} i \underline{I} \rightarrow struja \underline{I} prethodi naponu \underline{U}

numerička provjera postupka: $\underline{I} = 7 \angle 0^\circ \text{ A}$, $R = \frac{4}{7} \Omega$, $X_C = \frac{3}{7} \Omega$

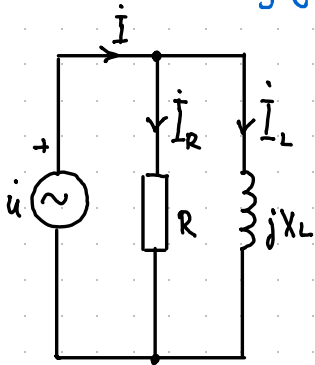
$$\underline{U}_R = \underline{I} \cdot R = 7 \angle 0^\circ \cdot \frac{4}{7} \Omega \Rightarrow \underline{U}_R = 4 \angle 0^\circ \text{ V}$$

$$\underline{U}_C = \underline{I} \cdot jX_C = 7 \angle 0^\circ \cdot \angle 90^\circ \cdot \frac{3}{7} \Omega = 3 \angle 90^\circ \text{ V} \rightarrow \text{kapacitivni karakter} \rightarrow \text{struja } \underline{I} \text{ prethodi}$$

$$\underline{U} = \underline{I} \cdot \underline{Z} = 7 \angle 0^\circ \cdot (R - jX_C) \xrightarrow{\text{kalkulator}} 5 \angle -36,87^\circ \text{ V}$$

$$\varphi = \alpha_u - \alpha_i = -36,87 - 0 = \underline{\underline{-36,87^\circ}}$$

PRIMJER: dijagram za paralelnu RL



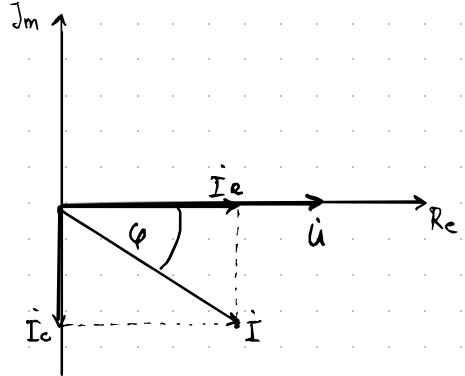
$$\dot{u} = u \angle 0^\circ$$

$$\Rightarrow \dot{u}_R = \dot{u}_L = \dot{u}$$

$$\dot{u} = \dot{I}_R \cdot R$$

$$\dot{u} = \dot{I}_L \cdot jX_L$$

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



$$X_L = \frac{7}{3} \Omega \quad R = \frac{7}{4} \Omega \quad \dot{u} = 7 \angle 0^\circ \text{ V}$$

$$\dot{I}_R = \frac{\dot{u}}{R} = \frac{7 \angle 0^\circ}{\frac{7}{4}} = 4 \angle 0^\circ \text{ A}$$

$$\dot{I}_L = \frac{\dot{u}}{jX_L} = \frac{7 \angle 0^\circ}{\frac{7}{3} \angle 90^\circ} = 3 \angle -90^\circ \text{ A}$$

$$\text{Kirchhoff: } \dot{I} = \dot{I}_R + \dot{I}_L$$

$$\dot{I} = 5 \angle -36,87^\circ$$

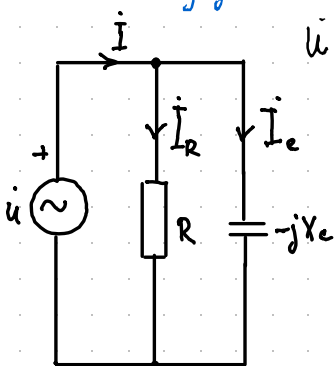
$$\alpha = \alpha_u - \alpha_i = 0 - (-36,87) = +36,87^\circ$$

$$\text{provjera } \dot{I} \Rightarrow \dot{I} = \dot{u} \cdot \underline{Y}$$

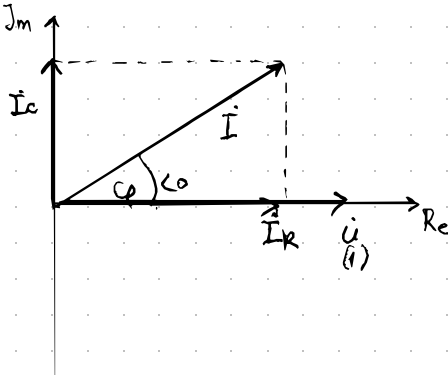
$$\underline{Y} = \frac{1}{Z} = \left(\frac{1}{R} + \frac{1}{jX_L} \right) = \sqrt{\left(\frac{1}{R} \right)^2 + \left(\frac{1}{X_L} \right)^2} \angle \arctan \left(\frac{-\frac{1}{X_L}}{\frac{1}{R}} \right) = \frac{5}{7} \angle -36,87^\circ$$

$$\dot{I} = \dot{u} \cdot \underline{Y} = (7 \angle 0^\circ) \cdot \left(\frac{5}{7} \angle -36,87^\circ \right) \Rightarrow \boxed{\dot{I} = 5 \angle -36,87^\circ}$$

PRIMJER: dijagram za paralelnu RC



$$\dot{u} = 7 \angle 0^\circ$$

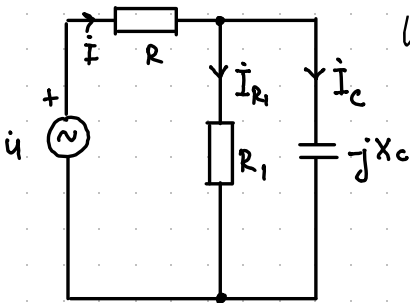


2) struja \dot{I}_R je u fazi sa \dot{u}

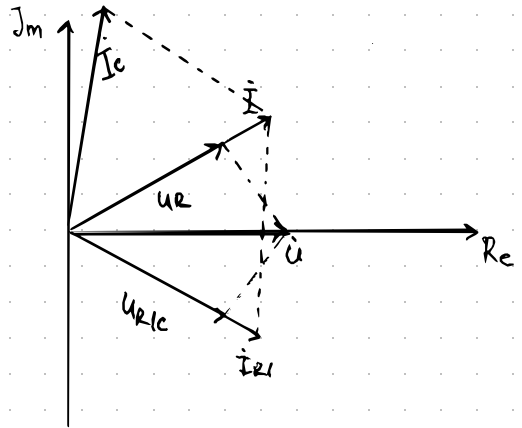
3) struja \dot{I}_C prethodi \dot{u} za 90° $\sqrt{\dot{u}} \quad \dot{I}$

4) $\dot{I} = \dot{I}_R + \dot{I}_C$ 5) $\phi < \varphi \Rightarrow RC$ je kapacitivni karakter

PRIMER: serijsko paralelni spoj



$$u = u \angle 0^\circ$$



$$\dot{u} = u_R + u_{R1} = u_R + u_C = u_R + u_{R1C}$$

$$\dot{I} = \dot{I}_{R1} + \dot{I}_C$$

→ gornja polovica

- 1) \dot{I} je umrežena s kapacitivnim karakterom $\Rightarrow \dot{I}$ prethodi (ali ne znamo za koliko bez računa)
- 2) u_{R1} je u fazi sa \dot{I}
- 3) $u_{R1C} \rightarrow \dot{u} = u_R + u_{R1C}$ (odakle smo j ?)
- 4) u_{R1} je u fazi sa \dot{I}_{R1}
- 5) $\dot{I} = \dot{I}_{R1} + \dot{I}_C \rightarrow \dot{I}_C$
- 6) \dot{I}_C prethodi naponu u_{R1C} za 90°