10b. predavanje iz OE

Mreže izmjenične struje

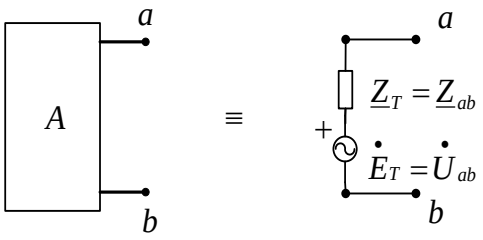
(uredio prof.dr.sc. Armin Pavić)

Metoda superpozicije

Isto kao i u mrežama istosmjerne struje

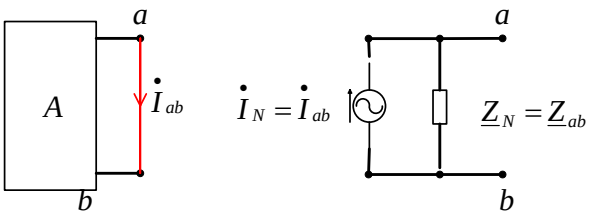
- samo se računa s kompleksnim izrazima!

Theveninov teorem



Sl. 11.8

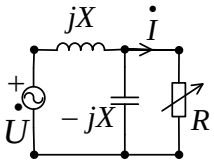
Nortonov teorem



Sl. 11.9

Primjer

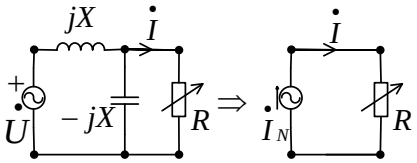
- Odredite kako se struja $\dot{I}$ mijenja s porastom otpora *R*!



.

Rješenje primjera
(opravdanje potrebe Nortonovog teorema)

- Odredite kako se struja $\dot{I}$ mijenja s porastom R!



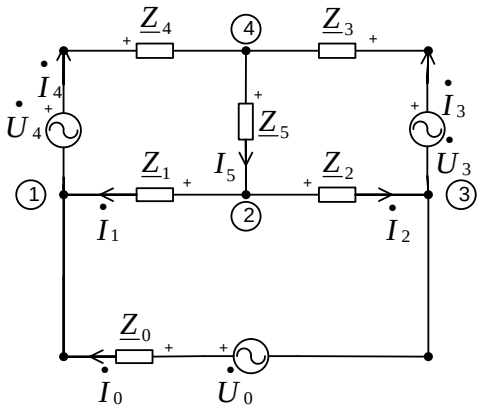
Sl. 11.10

Ovdje je jedino moguće nadomještanje po Nortonu, gdje je nadomjestak aktivne mreže idealni strujni izvor ($Z_N=\infty$).

$$\dot{I}_N = \frac{\dot{U}}{jX} \quad .$$

Metoda potencijala čvorova

Isto kao i u mrežama istosmjerne struje!



Postavljanje jednadžbi potencijala čvorova

- Za mrežu s prethodne slike, uz izbor četvrtoga čvora kao referentnog ($\varphi_4 = 0$), jednadžbe potencijala čvorova glase:

$+\varphi_1 \cdot (\underline{Y}_0+\underline{Y}_1+\underline{Y}_4) - \varphi_2 \cdot \underline{Y}_1 - \varphi_3 \cdot \underline{Y}_0 = +U_0 \cdot \underline{Y}_0 - U_4 \cdot \underline{Y}_4$ (čvor 1)

$-\varphi_1 \cdot \underline{Y}_1 + \varphi_2 \cdot (\underline{Y}_1+\underline{Y}_2+\underline{Y}_5) - \varphi_3 \cdot \underline{Y}_2 = 0$ (čvor 2)

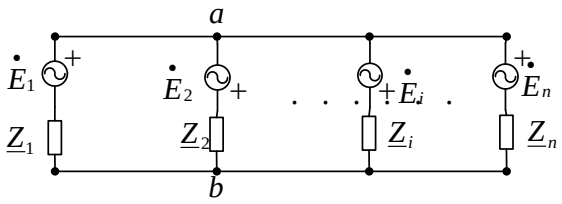
$-\varphi_1 \cdot \underline{Y}_0 - \varphi_2 \cdot \underline{Y}_2 + \varphi_3 \cdot (\underline{Y}_0+\underline{Y}_2+\underline{Y}_3) = - U_0 \cdot \underline{Y}_0 - U_3 \cdot \underline{Y}_3$ (čvor 3)

Gdje je:

$$\underline{Y}_i = 1/\underline{Z}_i,\ i = 0,1,\ldots,5$$

admitancija odgovarajuće grane.

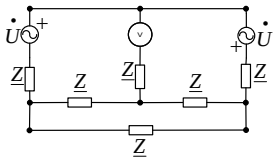
Millmanov teorem



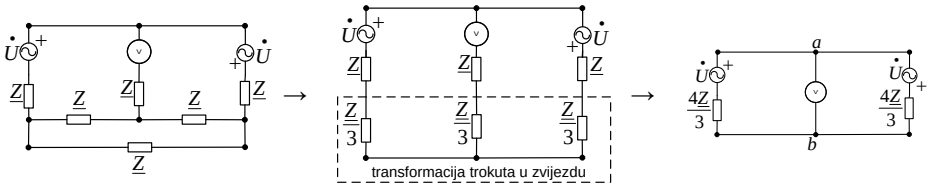
Sl. 11.11

$$\dot{U}_{ab} = \frac{\text{alg}\sum_{i=1}^{n} \frac{\dot{E}_i}{\underline{Z}_i}}{\sum_{i=1}^{n} \frac{1}{\underline{Z}_i}}$$

Primjer 1 – Odredite napon voltmetra!



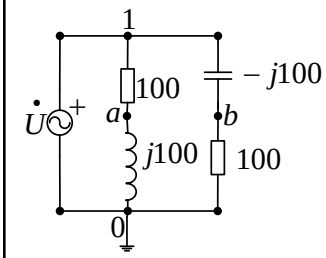
Primjer 1 - Odredite napon voltmetra!



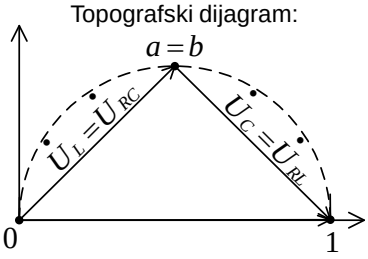
Primjenom Millmanova teorema

$$\dot{U}_{ab} = \frac{\frac{3\dot{U}}{4\underline{Z}} - \frac{3\dot{U}}{4\underline{Z}}}{\frac{3}{4\underline{Z}} + \frac{3}{4\underline{Z}}} = 0 \qquad U_V = \left|\dot{U}_{ab}\right| = 0$$

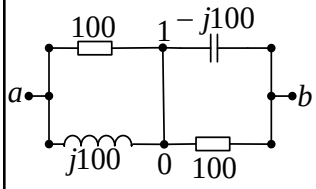
Primjer 2 - Odredite $\dot{E}_T = \dot{U}_{ab}$ i $\underline{Z}_T = \underline{Z}_{ab}$



Topografski dijagram:



$$\Rightarrow \dot{U}_{ab} = \dot{E}_T = 0$$

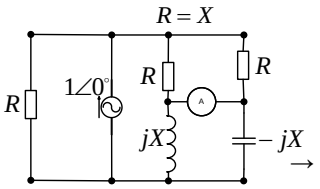


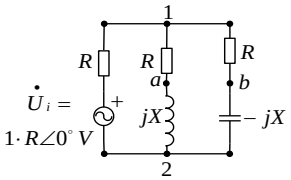
$$\underline{Z}_{ab} = \underline{Z}_T = (100 \parallel j100) + [100 \parallel (-j100)] = 100 + j \cdot 0$$

$$\underline{Z}_T = 100\angle 0^\circ$$

❖ Što se dogodi ako u jednoj grani omski i reaktivni element zamijene mjesta?

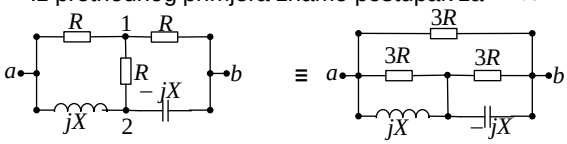
Primjer 3 – Odredite struju ampermetra!





Određivanjem struje ampermetra svodi se na traženje iznosa Nortonove struje. Primijenimo Theveninov teorem i $\dot{I}_N = \frac{\dot{E}_T}{\underline{Z}_T}$

Iz prethodnog primjera znamo postupak za $\underline{Z}_{ab}$



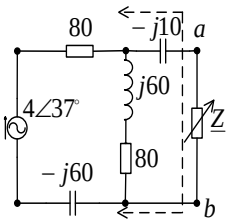
$$\underline{Z}_{ab} = 3R \parallel \left[3R \parallel jX + 3R \parallel (-jX)\right] = \frac{R}{2} = \underline{Z}_T$$

Kako je $\underline{Z}_{12} = (R + jX) \parallel (R - jX) = R \Rightarrow \dot{U}_{12} = \frac{1}{2}\dot{U}_i = \frac{R}{2}\angle 0^\circ\ \mathrm{V}$

Iz prethodnog primjera znamo da je $\dot{U}_{ab} = \dot{U}_{12}\angle 90^\circ = \frac{R}{2}\angle 90^\circ = \dot{E}_T$

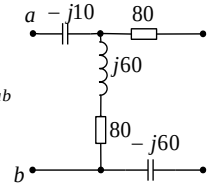
$$\dot{I}_N = \frac{\dot{E}_T}{\underline{Z}_T} = 1\angle 90^\circ\ \mathrm{A} \Rightarrow I_A = 1\ \mathrm{A}$$

Primjer 4 – Odredite najveću moguću snagu na $\underline{Z}$



Theveninov teorem i teorem maksimalne snage na promjenjivoj impedanciji.

$$\dot{E}_T = \dot{U}_{ab} = 4\angle 37^\circ \cdot (80 + j60) = 400\angle 74^\circ\ \mathrm{V}$$



$\underline{Z}_T = \underline{Z}_{ab}$

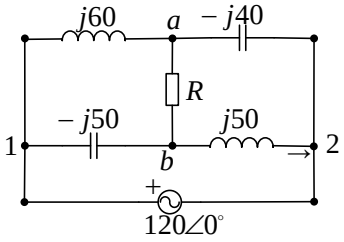
$\underline{Z}_T = 80 + j50$

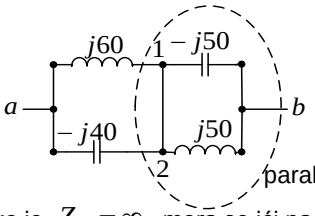
$\underline{Z} = \underline{Z}_T^* = 80 - j50$

(na njoj se razvija najveća snaga)

$$P_{\max} = \left(\frac{\dot{E}_T}{2\,\mathrm{Re}\{\underline{Z}_T\}}\right)^2 \cdot \mathrm{Re}\{\underline{Z}\} = 500\ \mathrm{W}$$

Primjer 5 – Odredite snagu na otporu R=10 Ω!

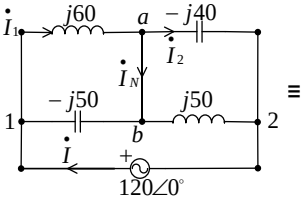




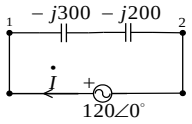
$\underline{Z}_{ab} = \underline{Z}_T = \infty$

paralelna rezonancija

Ako je $\underline{Z}_T = \infty$, mora se ići na Nortonov teorem!



≡

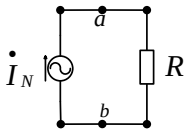


Kapacitivno naponsko djelilo!

$$\dot{I}_1 = \frac{3 \cdot 120}{5} \cdot \frac{1}{j60} = -j \cdot 1{,}2 \text{ A}$$

$$\dot{I}_2 = \frac{2 \cdot 120}{5} \cdot \frac{1}{-j40} = j \cdot 1{,}2 \text{ A}$$

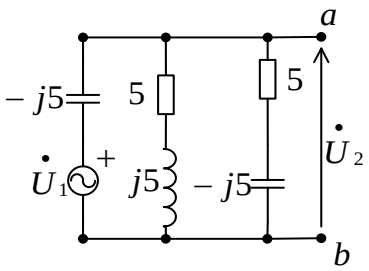
$$\dot{I}_N = \dot{I}_1 - \dot{I}_2 = -j \cdot 2{,}4 \text{ A}$$



Nadomjesna shema po Nortonu!

$$P = I_N^2 \cdot R = 57{,}6 \text{ W}$$

Primjer 6 – Odredite $\dot{U}_2/\dot{U}_1$!

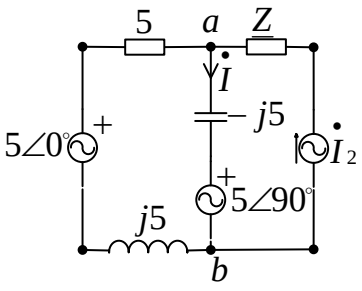


Millmanov teorem!

$$\dot{U}_{ab} = \dot{U}_2 = \frac{\dfrac{\dot{U}_1}{-j5}}{\dfrac{1}{-j5} + \dfrac{1}{5+j5} + \dfrac{1}{5-j5}} = \dot{U}_1 \frac{j}{1+j}$$

$$\frac{\dot{U}_2}{\dot{U}_1} = 0{,}5 + j0{,}5 = \frac{1}{\sqrt{2}} \angle 45°$$

Primjer 7 - Ako je je $\dot{I} = 2\angle 0^\circ$ A , kolika je $\dot{I}_2$



(1) $\dot{U}_{ab} = 5\angle 90^\circ + \dot{I}\cdot(-j5) = -j5$ V

Millmanov teorem (jednadžba po $\dot{I}_2$):

(2) $$\dot{U}_{ab} = -j5 = \frac{\dfrac{5\angle 0^\circ}{5+j5} + \dfrac{5\angle 90^\circ}{-j5} + \dot{I}_2}{\dfrac{1}{5+j5} + \dfrac{1}{-j5}\left(+\dfrac{1}{\infty}\right)}$$

Rješavanjem jednadžbe (2) dobiva se: $\dot{I}_2 = 1\angle 0^\circ$ A

- Utječe li Z na rješenje? Zašto?