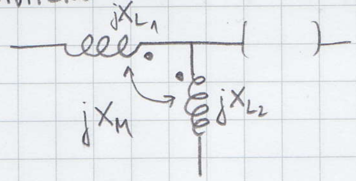
Masovne OE

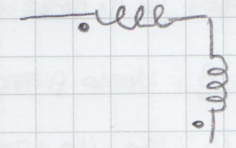
– teorija: transformacija induktiviteta

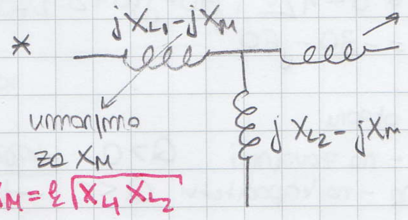
– 2 slučaja: 1)



– na spoju 2 zavojnice je jedna grana

– ako zavojnice skupa gledaju ili ne gledaju taj čvor postupak je *



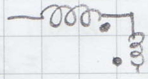


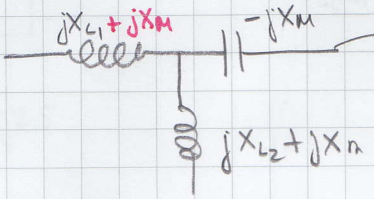
→ dodajemo još jednu zavojnicu

umanjimo za X_M

$X_M = k\sqrt{X_{L_1} X_{L_2}}$

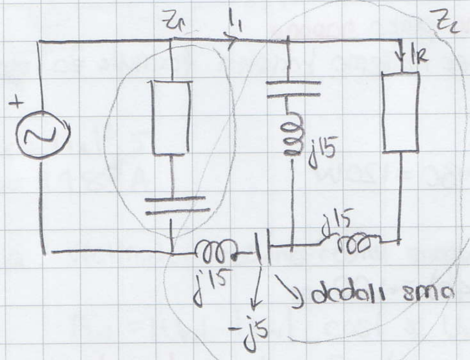
2) točkice ne djeluju isto





→ dodajemo kondenzator

①



$X_M = 0.5 \cdot \sqrt{10 \cdot 10} = 5$

dodali smo kondenzator jer točkice nisu sudjelovale (ili obje prema ili od čvorišta)

$P = |I_R|^2 \cdot R$

na Z_1 i Z_2 isti napon, Z_1 nam uopće ne treba

$I_1 = \frac{100}{Z_2} = 0.6 - j5.8$

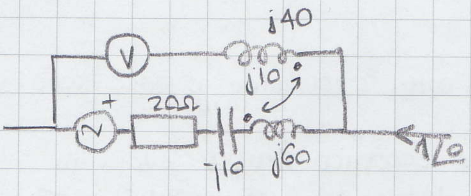
$Z_2 = [j10 \,||\, (15+j5)] + j10 = 17.15 \angle 84° \,\Omega$

$I_R = I_1 \cdot \frac{j10}{j10+15+j15} = 2 \angle 53$

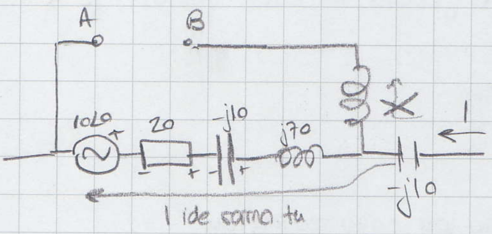
I_1 → ukupna struja; $j10$ → tamo gdje ne ide; $j10+15+j15$ → ukupna impedancija

$P = 2^2 \cdot 15 = \underline{60W}$

② Koliko napon mjeri Ⓥ



– transformacija međuinduktiviteta

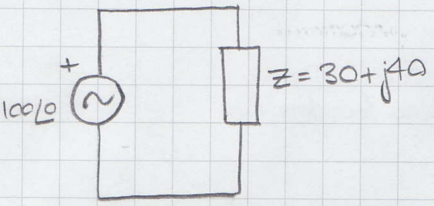


– struje se ne dijeli jer ne može kroz voltmetar

– krenemo od $\underline{B}$ i idemo prema $\underline{A}$ $U_V = |U_{AB}| = 30\sqrt{5}\ V$

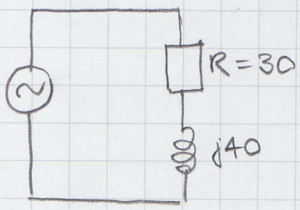
$$U_{AB} = 0 - 1\angle 0\,(j70 - j10 + 20) - 10\angle 0$$
$$= -30 - j60$$

teorija: 3 snage: radna – može se javiti samo na otporu
Jalova – induktivna – pozitivna – na zavojnici $Q > 0$
– kapacitivna – negativna – na kapacitetu $Q < 0$



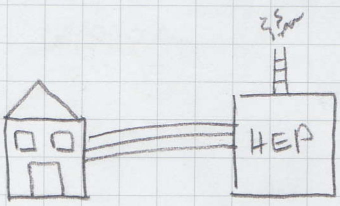
$I = 2\angle -53^\circ$

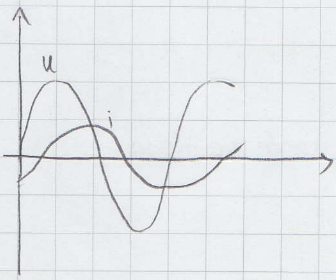
⇓



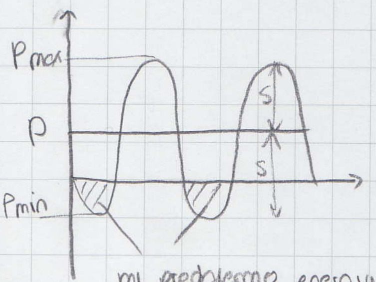
– računati preko **struje**, a **ne** preko **napona**
– naponi na njima nisu isti – ne možemo koristiti formule za istosmjerne krugove

$$P = |I|^2 \cdot \mathrm{Re}(Z) = 2^2 \cdot 30 = 120\,W$$
$$R = Z\cos\varphi$$
$$Q = |I|^2 \cdot \mathrm{Im}(Z) = 2^2\,(+40) = +160\,\text{var}$$





– jedina što postoji je **trenutna snaga**
↓
$p(t) = u(t) \cdot i(t)$



mi predajemo energiju HEP-u

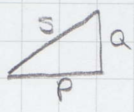
– trenutna snaga ima: pozitivne i negativne dijelove
svoj maksimum i minimum
– mi plaćamo P – srednju vrijednost od Pmax i Pmin
– **amplituda** je **prividna snaga** S

– $P = \dfrac{P_{max} + P_{min}}{2}$

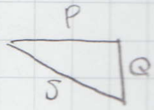
– $S = \dfrac{P_{max} - P_{min}}{2}$

$$S = \sqrt{P^2 + Q^2}$$

induktivni trokut snage



kapacitivni trokut snage



– S nije broj, to je [illegible]
$S = U \cdot I^*$
↳ kompleksni broj

$S = U \cdot I^*$

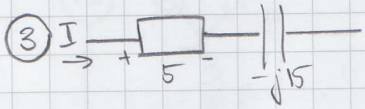
$= 100\angle 0 \cdot 2\angle 53$ → jer je kompl. konj $I = 2\angle -53$, $I^* = 2\angle 53$

$= 200\angle 53$

$= 120 + j160$

$P + jQ$

③



$|I| = \frac{|U_R|}{R} = 6.32$

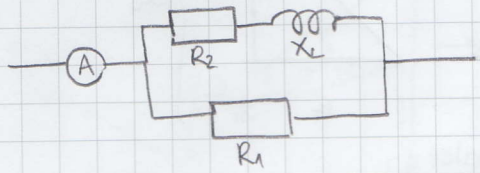
$P = \frac{|U_R|^2}{R} = |I|^2 \cdot R = 200W$

$Q = |I|^2 \cdot X_C = -600\,var$

↓

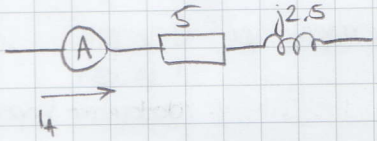
jer je kapacitet

④



sve svesti na jednu impedanciju

$Z_{uk} = 10 \,||\, (6 + j8) = 5 + j2.5$

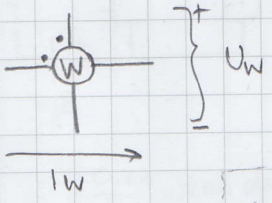


$P_{uk} = |I_A|^2 \cdot 5$

$I_A = 14.83\,A$

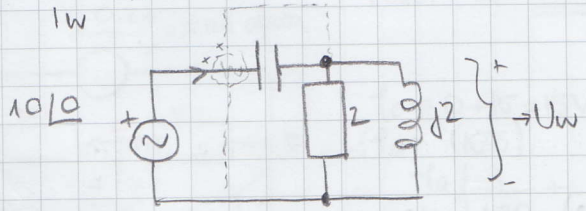
teorija: Wattmetar računa radnu snagu pomoću napona, struje i kuta između

$P_W = |U_W| \cdot |I_W| \cdot \cos(\sphericalangle U_W - \sphericalangle I_W)$



točkice znače kao plus (jedan za U, jedan za I)

⑤



$Z_{uk} = -j2 + [2 \,||\, j2] = 1 - j1\,\Omega$

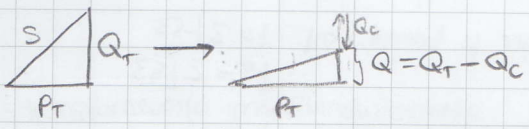
$I_W = I_{uk} = \frac{10\angle 0}{Z_{uk}} = 5\sqrt{2}\angle 45$

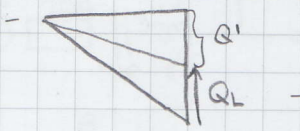
$U_W = I_{uk}\,[2 \,||\, j2] = 10\angle 90°$

$P_W = 10 \cdot 5\sqrt{2} \cdot \cos(90 - 45)$

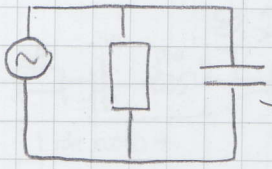
$P_W = 50W$

teorija: kompenzacija jalove snage



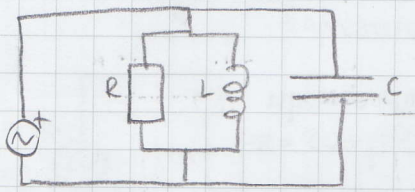


→ onda kompenziramo s Q_L



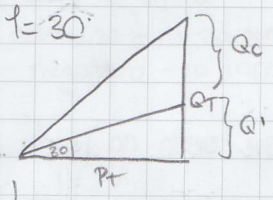
→ dodajemo kondenzator

6.) $\cos\varphi = 0.707$
$R = 22\Omega$

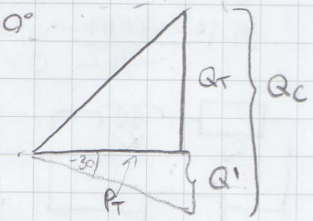


2 slučaja:

$\varphi = 30°$



$\varphi = -30°$



↳ treba nam ovaj slučaj jer trebamo najmanji kapacitet a ↓

$Q_C = \frac{|U|^2}{X_C}$ – samo zato što je direktno spojen na izvor $\quad Q_C \sim C$

$Q_C = -U^2 C\omega \rightarrow -\frac{1}{C\omega}$
$Q_C \sim C$

P_T se ne mijenja jer: U je isti
I je isti
dodajemo kapacitet

$P_T = \frac{220^2}{20} = 2200$ → zato što su spojeni paralelno

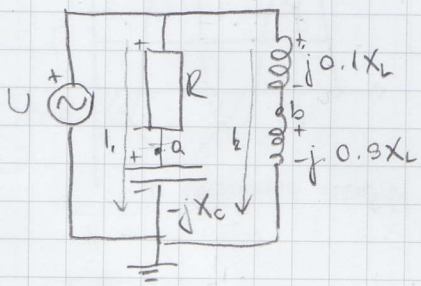
$Q_T = P_T \cdot tg(\arccos 0.707) = +2200\,var$

$Q' = P_T \cdot tg(30°) = 1270\,var$

$Q' = Q_T - Q_C$
$Q_C = Q_T - Q' = -930\,var$

$-930 = -220^2 \cdot C \cdot 2\pi \cdot 50$
$C = 61.16\,\mu F$

7.) $U_{ab} = 6.403\,V$
$I_{ef} = ?$
$R = X_C = X_L = 10\Omega$



$I_1 = \frac{U}{10 - j10}$

$I_2 = \frac{U}{j10}$

$\varphi_A = 0 + I_1 \cdot (-j10) = U \cdot \frac{-j10}{10 - j10}$

$\varphi_B = 0 + I_2 \cdot j9 = U \cdot \frac{9}{10}$

$U_{AB} = \varphi_A - \varphi_B = U\frac{-j10}{10-j10} - U\frac{9}{10} = 6.403$

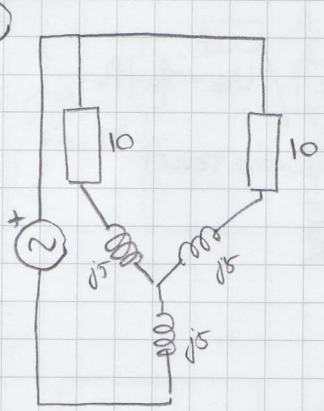
$U\left(\frac{-j10}{10-j10} - \frac{9}{10}\right) = 6.403$

$|U| = 10\,V$

$Z = (10 - j10) \parallel j10$
$= 10 + j10$

$|I| = \frac{10}{10 + j10} = \frac{\sqrt{2}}{2}\,A$

(8)

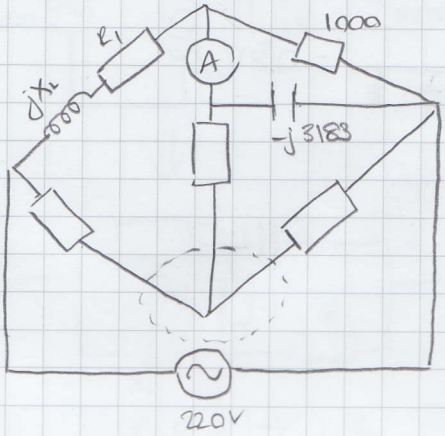


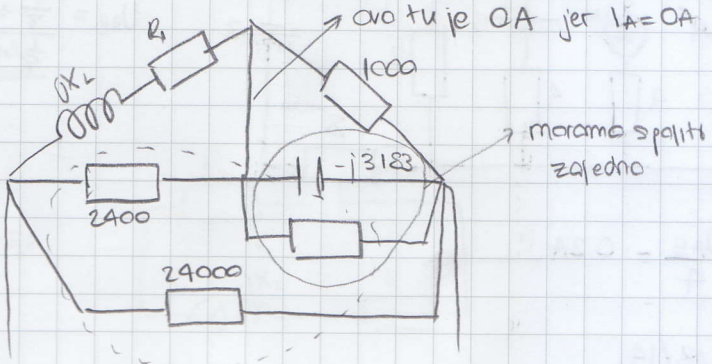
$Z_{uk} = 5 + j2.5 + j5$

- ujedno i mosni spoj

(9) ZI 13./14. Odredite R_1

- pretvorba iz zvijezde u trokut



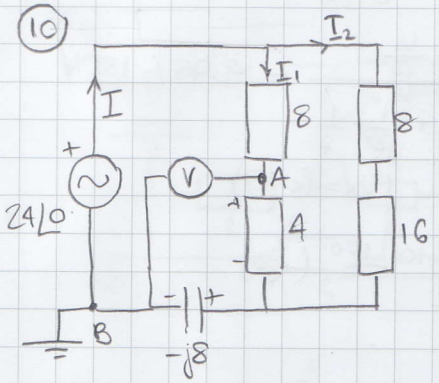


mosni spoj!

$(R_1 + jX_L)(2400 \,||\, -j3183) = 1000 \cdot 2400$

$R_1 + jX_L = 1000 + j754$

(10)



$Z_{uk} = [(8+4) \,||\, (8+16)] - j8 = 8 - j8$

$I = \frac{24\angle 0}{Z_{uk}} = 1.5 + j1.5A$

$I_1 = I \cdot \frac{24}{24+12} = 1 + j \cdot 1A$

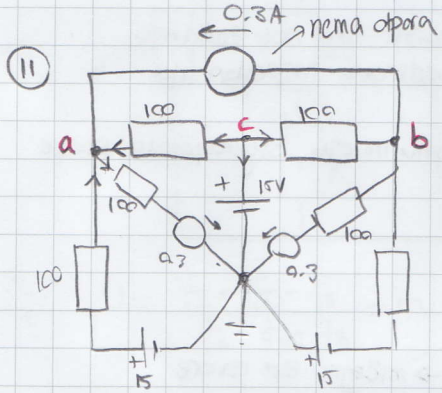
$\varphi_A = 0 + I(-j8) + I_1 \cdot 4 = 16 - j8$

$\varphi_B = 0$

$U_{AB} = 16 - j8 - 0$

$|U_{AB}| = U_V = \underline{\underline{17.9V}}$

(11)



$\varphi_c = 0 + 15 = 15V$

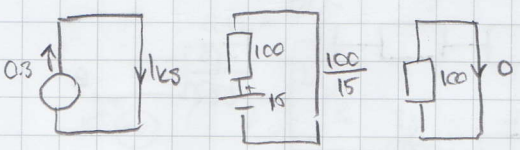
φ_a: (KZS)

$\varphi_a\left(\frac{1}{100} + \frac{1}{100}\right) - \varphi_b\left(\frac{1}{\infty}\right) - \varphi_c\left(\frac{1}{100}\right) - 0\left(\frac{1}{\infty} + \frac{1}{100}\right)$

$= +0.3 + 0 - 0.3 + \frac{15}{100}$

↳ nemamo izvor

$\frac{2\varphi_a}{100} - \frac{15}{100} = \frac{15}{100} \Rightarrow \varphi_a = 15V$

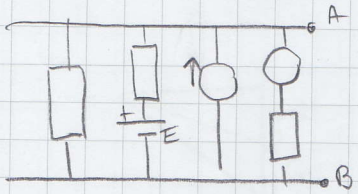


$\varphi_b \cdot \left(\frac{1}{100} + \frac{1}{100}\right) - \varphi_c\left(\frac{1}{100}\right) = -0.3 - 0.3 - \frac{15}{100}$

$\frac{2\varphi_b}{100} - \frac{15}{100} = -0.6 - \frac{15}{100} \Rightarrow \varphi_b = -30V$

$U_{ab} = \varphi_a - \varphi_b = 15 - (-30) = 45V$

Millmanov teorem



$$U_{AB} = \frac{0 + \frac{E}{R} + I + I}{\frac{1}{R} + \frac{1}{\infty} + \frac{1}{R} + \frac{1}{\infty}}$$

(0 → nema izvora; $\frac{1}{\infty}$ → nema otpora (samo izvor))

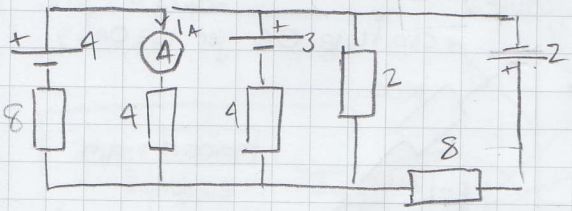
/ · nazivnik / $U_{AB} = \varphi_a - \varphi_b$

$$\varphi_a\left(\frac{1}{R} + \frac{1}{R}\right) - \varphi_b\left(\frac{1}{R} + \frac{1}{R}\right) = I + I + \frac{E}{R}$$

$$(\varphi_a - \varphi_b)\left(\frac{1}{R} + \frac{1}{R}\right) = I + I + \frac{E}{R}$$

$$U_{ab} = \frac{I + I + \frac{E}{R}}{\frac{1}{R} + \frac{1}{R}}$$

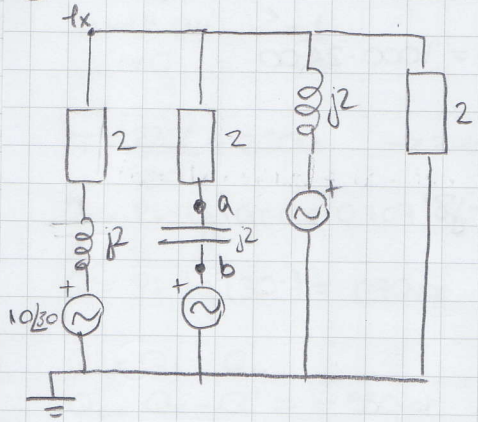
(12) JR 15.

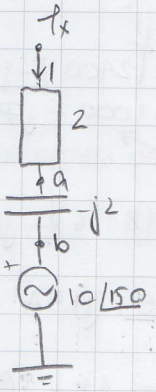


$$U_{AB} = \frac{\frac{4}{8} + \frac{3}{4} - \frac{2}{8}}{\frac{1}{8} + \frac{1}{4} + \frac{1}{4} + \frac{1}{2} + \frac{1}{8}} = 0{,}8\,V$$

$$I_A = \frac{U_{AB}}{4} = 0.2A$$

(13) ZI 13/14.





$$U_{ab} = 1 \cdot (-j2) \rightarrow 1 = \frac{U_{ab}}{-j2}$$

$$1 = \frac{\varphi_x - \varphi_b}{2 - j2} = \frac{4.75\angle -133 - 10\angle -150}{2 - j2}$$

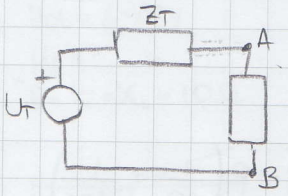
$$U_x = \frac{\frac{U_1}{2+j2} + \frac{U_2}{2-j2} + \frac{U_3}{j2}}{\frac{1}{2+j2} + \frac{1}{2-j2} + \frac{1}{j2} + \frac{1}{2}} = 4.75\angle -133\,V$$

$$\varphi_x = 4.75\angle -133\,V \quad (U_x = \varphi_x - 0)$$

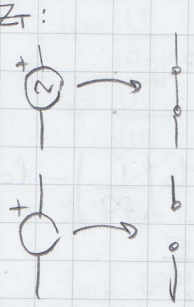
$$U_{ab} = \frac{4.75\angle -133 - 10\angle 150}{2 - j2}(-j2)$$

$$= 7.1\angle -103\,V$$

Theveninov teorem

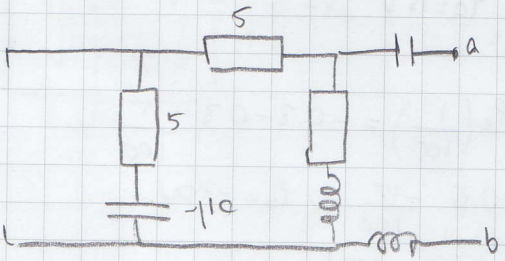


Z_T:

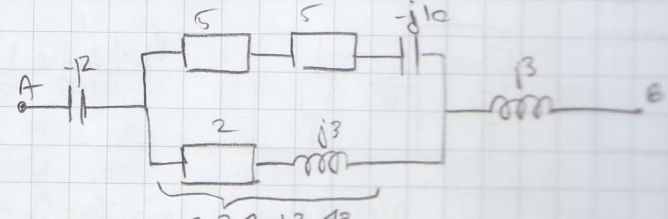


- maknemo element zbog kog nas zanima
- uvodimo Theveninovu impedanciju
- gledamo pasivnu mrežu, isključujemo izvore

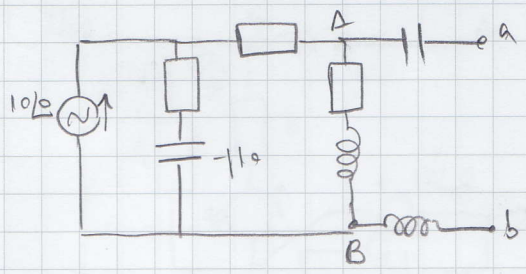
(14)



⇒ tražimo impedanciju → micemo sve izvore



$$Z_T = 2.74 + j3.43\,\Omega$$



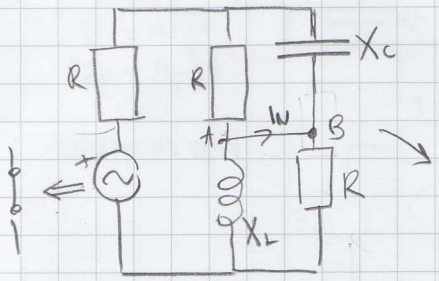
$U_{AB} = I_2 (2+j3)$

$I_2 = 10\angle 0 \left(\frac{5-j10}{5+j10+(5+2+j3)} \right)$

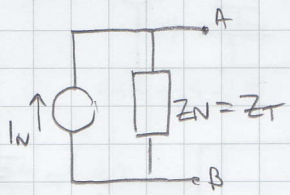
$= 8{,}05\angle -33\ A$

$U_{AB} = U_T = 29\angle 23\ V$

(15)

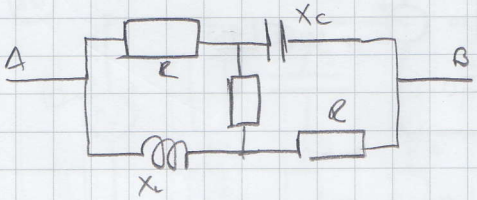


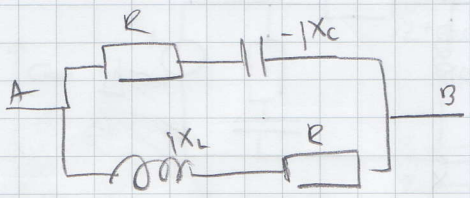
Nortonov teorem



masni spoj u ravnoteži

$I_N = 0A$





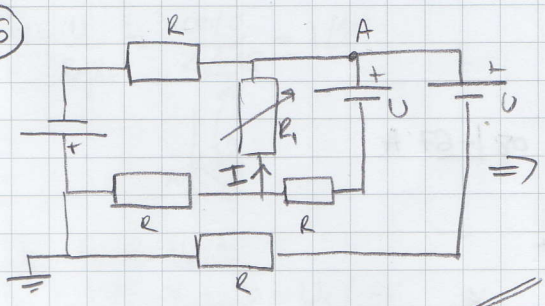
$R \cdot R = (-jX_c) \, jX_L$

$100 = 100\ V$

masni spoj

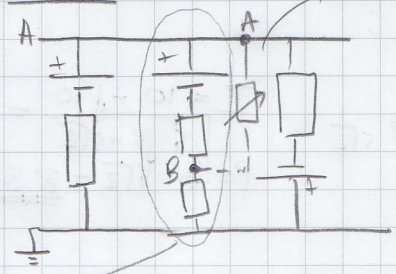
$Z_N = (R-jX_c) \,||\, (R+jX_L) = 10\Omega$

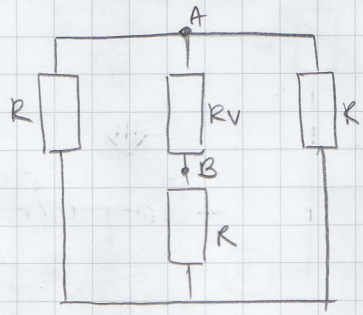
(16)

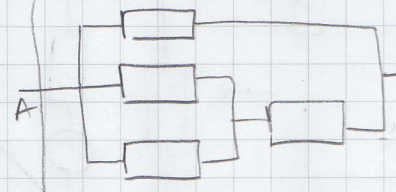


Millman

Thevenin:
mičemo zanimljivi element

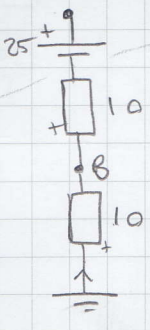






$10 \| 15 = 6\Omega$

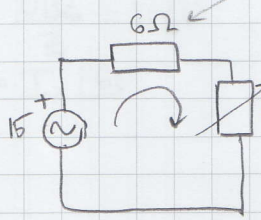
$U = \frac{\frac{25}{10} + \frac{25}{10} - \frac{25}{10}}{\frac{1}{10} + \frac{1}{20} + \frac{1}{10}} = 5V$



$I = \frac{I_x - 0}{10+10} = \frac{-20}{20} = -1A$

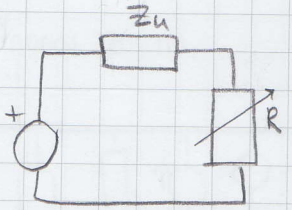
$I_B = -20 + 1 \cdot 10 = -10V$

$U_T = 5 - (-10) = 15V$



$I = \frac{15}{6+R_1}$

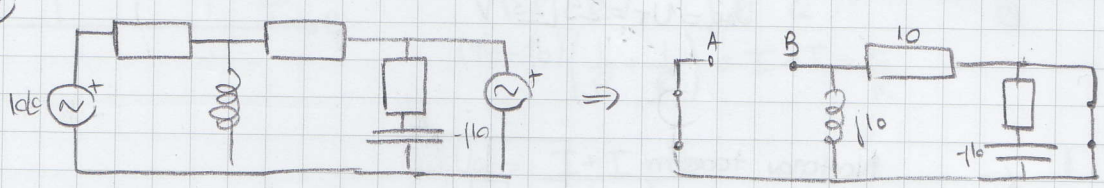
$R_1 = 9\Omega$



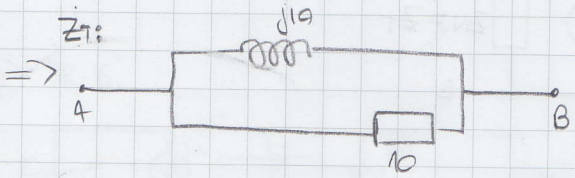
$Z_T = Z_u^*$

$R_T = |Z_u|$

(17)



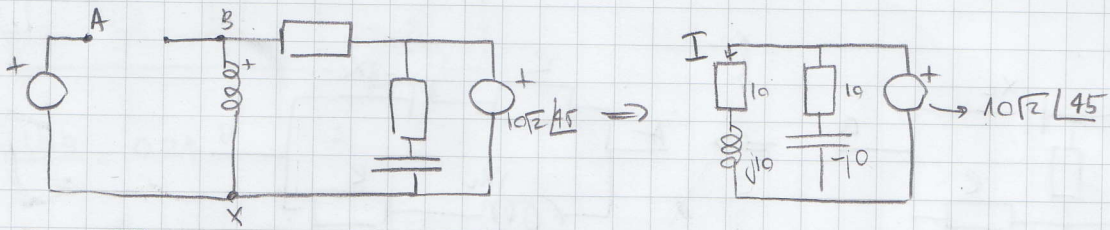
Z_T:



$Z_T = 10 \| j10 = 5+j5$

$R_T = |Z_T| = 5\sqrt{2}$

U_T:

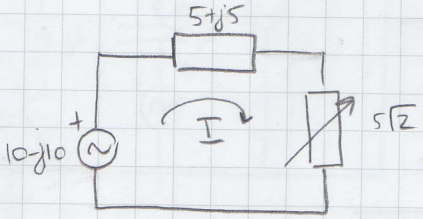


$$I = \frac{10\sqrt{2}\angle 45}{10+j10} = \underline{1A}$$

$V_{ab} = V_a - V_b = V_a$

$V_x = -1 \cdot j10V$

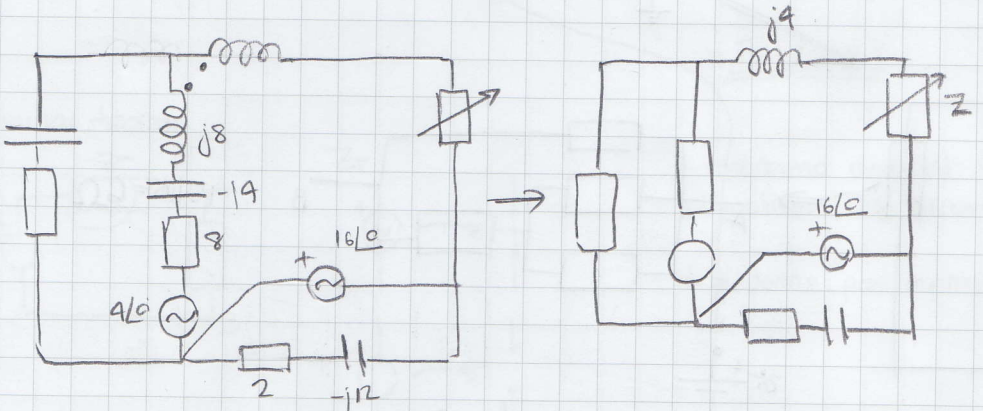
$V_a = V_x + 10\angle 0 = 10 - j10V$

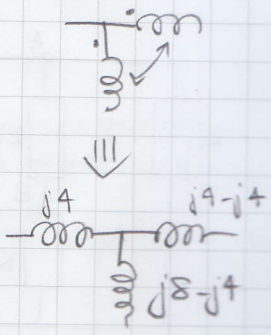


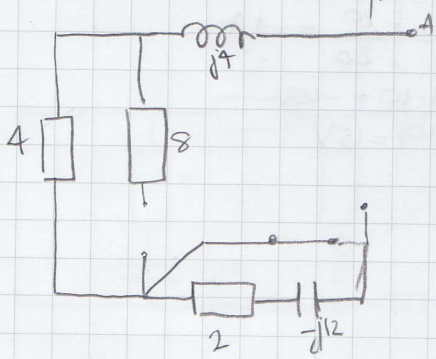
$$I = \frac{10 - j10}{5+j5+5\sqrt{2}} = 1.08\angle -67 \cdot A$$

$P = I^2 \cdot 5\sqrt{2} = \underline{\underline{8.3W}}$

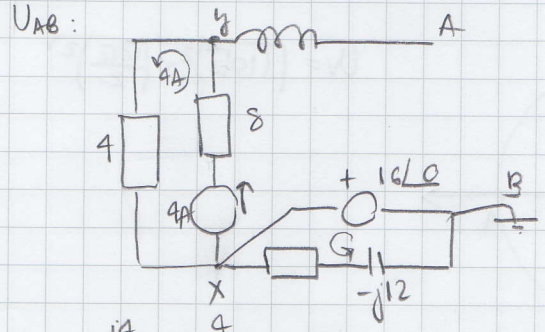
(18)

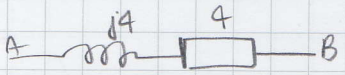






U_{AB}:





$Z_T = 4+j4$

$Z_1 = 4-j4$

$\varphi_B = 0$

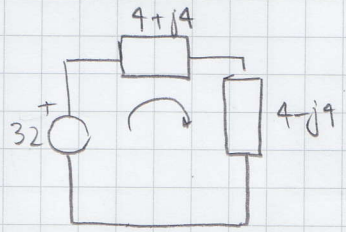
$\varphi_X = \varphi_B + 16\angle 0 = 16\angle 0$

$\varphi_y = \varphi_x + 4A \cdot 4 = 16+16 = 32V$

$\varphi_A + \varphi_y = 32V$

$U_{ab} = \varphi_A - \varphi_B = 32V$

nadomesni spoj:

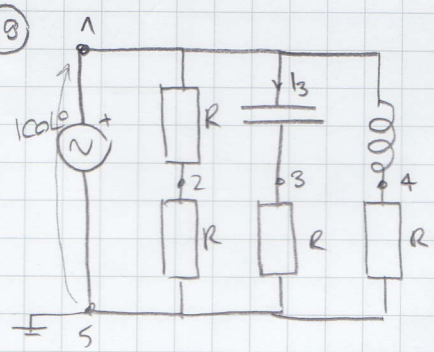


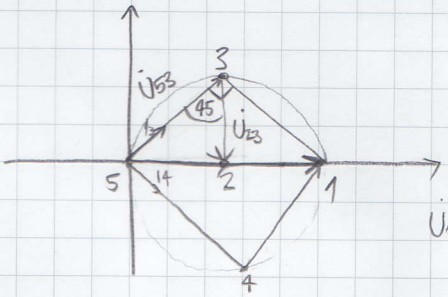
$4+4+j4-j4$

$I = \frac{32}{8} = 4A$

$P = 4^2 \cdot 4 = \underline{\underline{64W}}$

18)





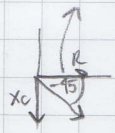
•2 jer je impedancija grane 2R

3 → 2 U_{23}

2 → 3 U_{32}

U_{53} zaostaje za $\underline{\underline{45°}}$

$I_3 = \frac{U}{R-jX_C} = \frac{100\angle 0}{Z\angle -45} = 1\angle 45°$

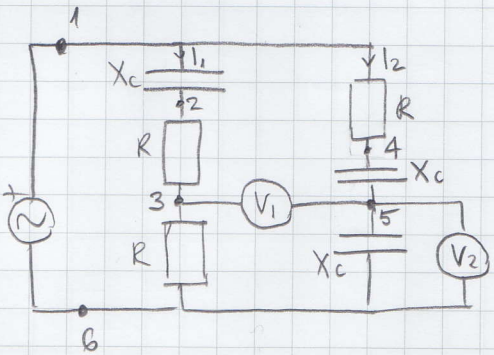


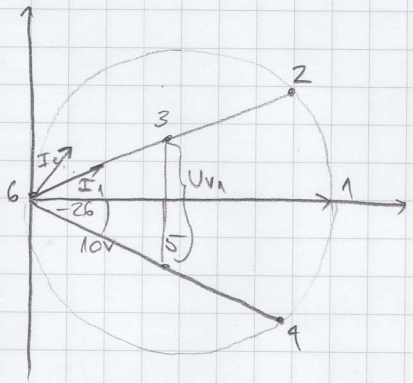
$U_R = I_3 \cdot R = U_R\angle 45$

$U_C = 1\angle 45 \cdot X_L\angle -90 = U_C\angle -45$

$I_4 = \frac{U\angle 0}{Z\angle 45} = 1\angle -45°$

20)





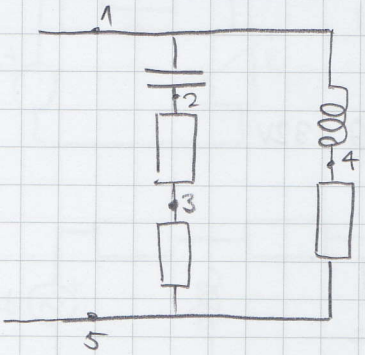
$\frac{U_{V_1}}{2} = 10 \cdot \sin(26)$

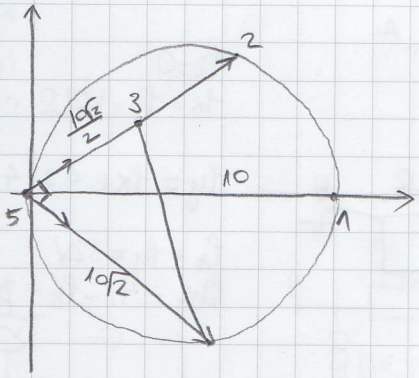
$\underline{\underline{U_{V_1} = 2 \cdot 10 \sin(26)}}$

$I_1 = \frac{U\angle 0°}{Z} = 1_1\angle 26°$

$I_2 = I_2\angle 63°$

(21)





$$U_V = \sqrt{(10\sqrt{2})^2 + \left(\frac{10\sqrt{2}}{2}\right)^2}$$