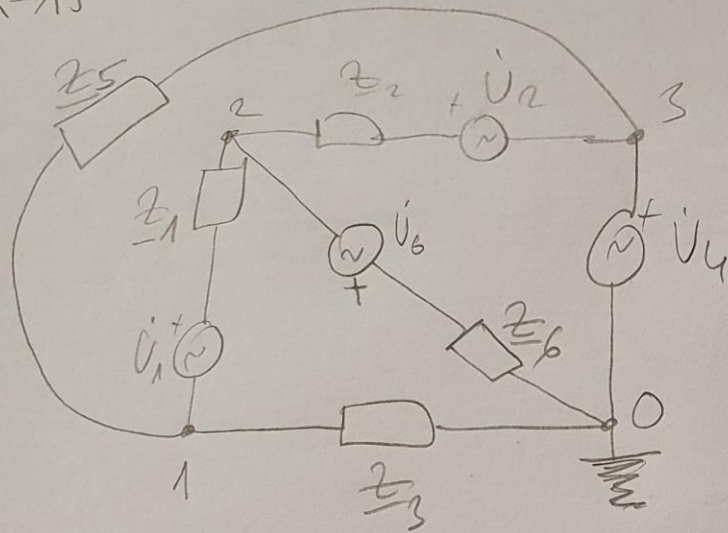


OE - konzultacije

15. svibnja 2020.

PRIMER 2.010
X-15



$$\dot{U}_1 = 4V \quad \dot{U}_2 = j8V \quad \dot{U}_4 = 4 - j4V$$

$$\dot{U}_6 = -j4V \quad z_1 = 1 + j\Omega \quad z_2 = -j2\Omega$$

$$z_3 = 1\Omega \quad z_5 = j\Omega \quad z_6 = j2\Omega$$

TOČKA 0 → UZEMLJENA (REFERENTNA TOČKA) → $\dot{\varphi}_0 = 0V$

TOČKA 3 → VIDI MO DA JE NA POTENCIJALI $\dot{\varphi}_3 = \dot{U}_{30} = \dot{U}_4 = 4 - j4V$

NEPOZNANICE $\dot{\varphi}_1$ I $\dot{\varphi}_2$

POSTAVLJAMO JEDNAŽBE POTENCIJALA EVOROVA:

$$\begin{cases} \text{I} & \dot{\varphi}_1 \left(\frac{1}{z_3} + \frac{1}{z_1} + \frac{1}{z_5} \right) - \dot{\varphi}_2 \left(\frac{1}{z_1} \right) - \dot{\varphi}_3 \left(\frac{1}{z_5} \right) = -\frac{\dot{U}_1}{z_1} \\ \text{II} & -\dot{\varphi}_1 \left(\frac{1}{z_1} \right) + \dot{\varphi}_2 \left(\frac{1}{z_6} + \frac{1}{z_1} + \frac{1}{z_2} \right) - \dot{\varphi}_3 \left(\frac{1}{z_2} \right) = \frac{\dot{U}_1}{z_1} - \frac{\dot{U}_6}{z_6} + \frac{\dot{U}_2}{z_2} \\ \text{III} & -\dot{\varphi}_1 \left(\frac{1}{z_5} \right) - \dot{\varphi}_2 \left(\frac{1}{z_2} \right) + \dot{\varphi}_3 \left(\frac{1}{z_2} + \frac{1}{z_5} + \frac{1}{0} \right) = -\frac{\dot{U}_2}{z_2} + \frac{\dot{U}_4}{0} \end{cases}$$

NEPOTREBNA
JER $\infty = \infty$

2 JEDNAŽBE
S 2 NEPOZNANICE

$$\text{I} \quad \dot{\varphi}_1 \left(\frac{2}{2} - j\frac{3}{2} \right) - \dot{\varphi}_2 \left(\frac{1}{2} - j\frac{1}{2} \right) + j(4 - j4) = -2 + j2 \quad | +$$

$$\text{II} \quad -\dot{\varphi}_1 \left(\frac{1}{2} - j\frac{1}{2} \right) + \dot{\varphi}_2 \left(\frac{1}{2} - j\frac{1}{2} \right) + j\frac{1}{2}(4 - j4) = -j2$$

$$j1(1 - j) + j4 + 4 - j2 - 2 = -2$$

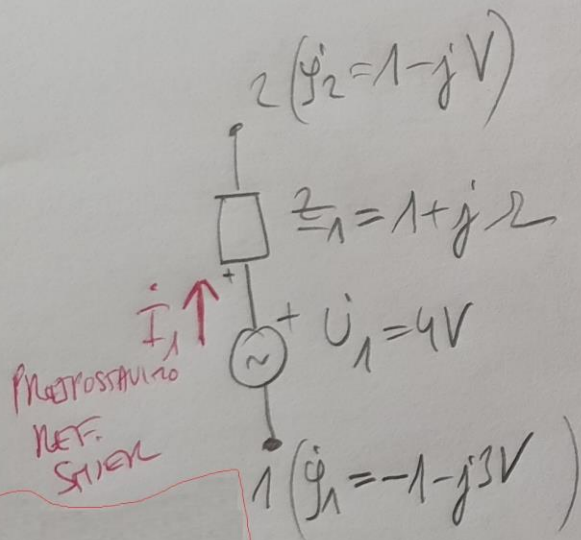
$$\dot{\varphi}_1 = \frac{-4 - j2}{1 - j}$$

$$\dot{\varphi}_1 = -1 - j3V$$

$$\begin{aligned}
 & -\dot{\varphi}_1\left(\frac{1}{2}-j\frac{1}{2}\right)+\dot{\varphi}_2\left(\frac{1}{2}-j\frac{1}{2}\right)-j2-2=-j2 \\
 & -(1-j3)\left(\frac{1}{2}-j\frac{1}{2}\right)+\dot{\varphi}_2\left(\frac{1}{2}-j\frac{1}{2}\right)=2 \\
 & -\left(-\frac{1}{2}+j\frac{1}{2}-j\frac{3}{2}-\frac{3}{2}\right)+\dot{\varphi}_2\left(\frac{1}{2}-j\frac{1}{2}\right)=2 \\
 & \dot{\varphi}_2\left(\frac{1}{2}-j\frac{1}{2}\right)=2-2-j
 \end{aligned}$$

$$\dot{\varphi}_2 = \frac{2-j}{\frac{1}{2}-j\frac{1}{2}}$$

$$\dot{\varphi}_2 = 1-j \text{ V}$$



ali
u zadatku nije zadan
referentan smjer pa nećemo
računati

FAZOR \dot{I}_1 nego samo
EFAKTIVNU VRIJEDNOST
STRUJE $|I_1|$!

$$\begin{aligned}
 \dot{\varphi}_2 &= \dot{\varphi}_1 + U_1 - \dot{I}_1 \cdot Z_1 \\
 1-j &= -1-j3 + 4 - \dot{I}_1 \cdot (1+j) \\
 -2+j2 &= -\dot{I}_1 (1+j)
 \end{aligned}$$

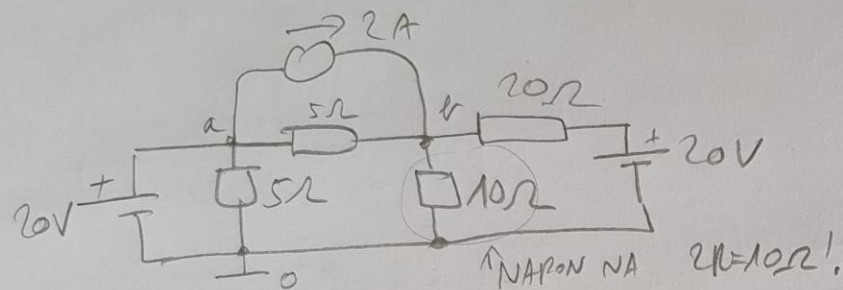
$$|\dot{I}_1| = \left| \frac{2-j2}{1+j} \right|$$

$$|\dot{I}_1| = \frac{2\sqrt{2}}{\sqrt{2}} \text{ A} = 2 \text{ A}$$

YAVIC-TEWA 2. Dio

X-8

$R=5\Omega$ $I=2A$ $U=20V$



$\varphi_a = U_{a0} = +20V$

$\varphi_a \left(\frac{1}{0} + \frac{1}{5} + \frac{1}{5} + \frac{1}{\infty} \right) - \varphi_r \left(\frac{1}{5} + \frac{1}{20} \right) = -2 + \frac{20}{5} \rightarrow \text{OPET } \infty = \infty$ NIE KREBRO
KAP VEC ZMAGO φ_a

$-\varphi_a \left(\frac{1}{20} + \frac{1}{5} \right) + \varphi_r \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{20} \right) = 2 + \frac{20}{20}$

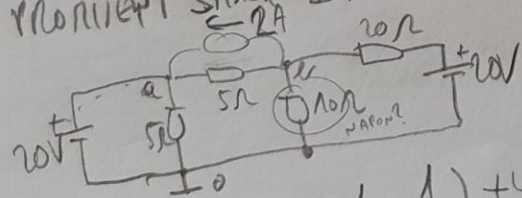
$-20 \cdot \frac{1}{5} + \varphi_r \cdot \frac{7}{20} = 2 + 1$

$\varphi_r \cdot \frac{7}{20} = 7$

$\varphi_r = 20V$

$U_{2R} = \varphi_r - \varphi_0 = 20 - 0 = 20V$

A Ako se promijeni snaga I:



$\varphi_a = 10V$

POVOLJNO:

$-\varphi_a \left(\frac{1}{20} + \frac{1}{5} \right) + \varphi_r \left(\frac{1}{20} + \frac{1}{5} + \frac{1}{10} + \frac{1}{20} \right) = -2 + \frac{20}{20}$

$-10 \cdot \frac{1}{5} + \varphi_r \cdot \frac{7}{20} = -1$

$\varphi_r = \frac{3}{\frac{7}{20}} = \frac{60}{7}V$

$U_{2R} = \varphi_r - \varphi_0 = \frac{60}{7} - 0 = \frac{60}{7}V$

$U_{2R} = 8.57143V$

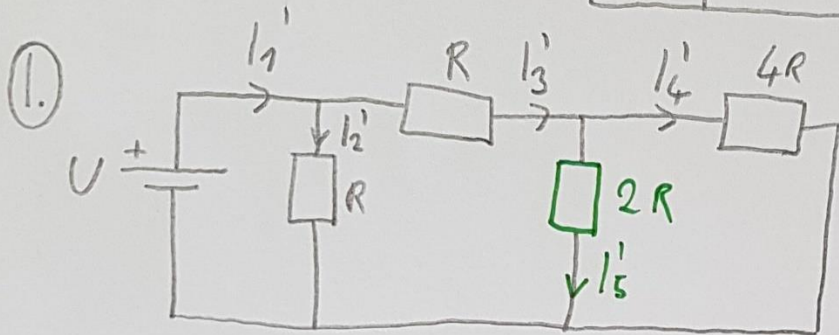
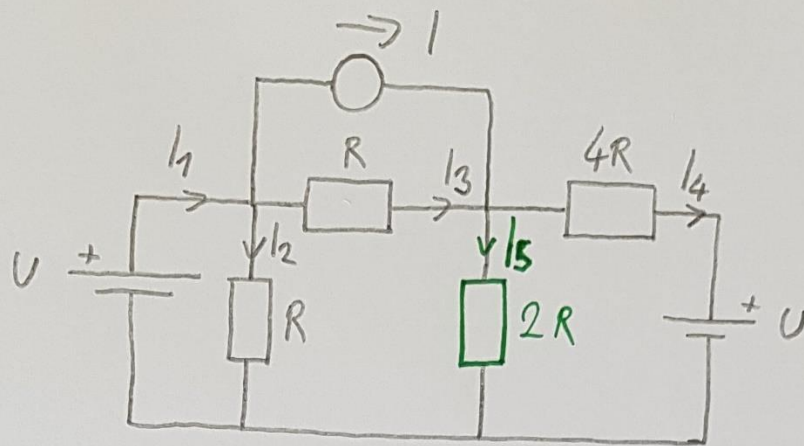
1V-9

$$R = 5 \Omega$$

$$I = 2 A$$

$$U = 20 V$$

$$U_{2R} = ?$$



$$R_{eq} = R \parallel (R + 4R \parallel 2R)$$

$$R_{eq} = R \parallel \left(R + \frac{4R \cdot 2R}{4R + 2R} \right)$$

$$R_{eq} = R \parallel \left(R + \frac{4}{3}R \right) = R \parallel \frac{7}{3}R$$

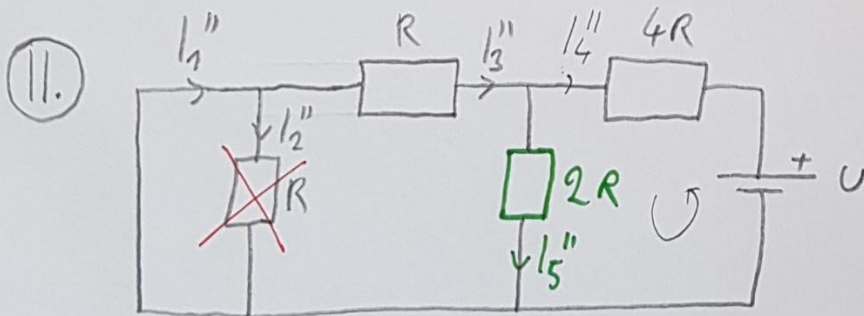
$$R_{eq} = \frac{R \cdot \frac{7}{3}R}{R + \frac{7}{3}R} = \frac{\frac{7}{3}R^2}{\frac{10}{3}R} = \frac{7}{10}R = 3,5 \Omega$$

$$I_1' = \frac{U}{R_{eq}} = \frac{20V}{3,5 \Omega} = 5,714 A$$

$$I_2' = \frac{U}{R} = \frac{20V}{5 \Omega} = 4 A$$

$$I_3' = I_1' - I_2' = 5,714 A - 4 A = 1,714 A$$

$$I_5' = I_3' \cdot \frac{4R}{2R + 4R} = 1,714 A \cdot \frac{2}{3} = 1,143 A$$



$$R_{eq} = 4R + 2R \parallel R$$

$$R_{eq} = 4R + \frac{2R \cdot R}{2R + R} = 4R + \frac{2}{3}R$$

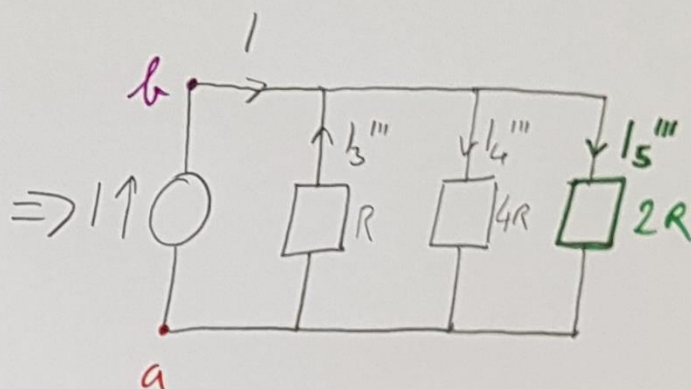
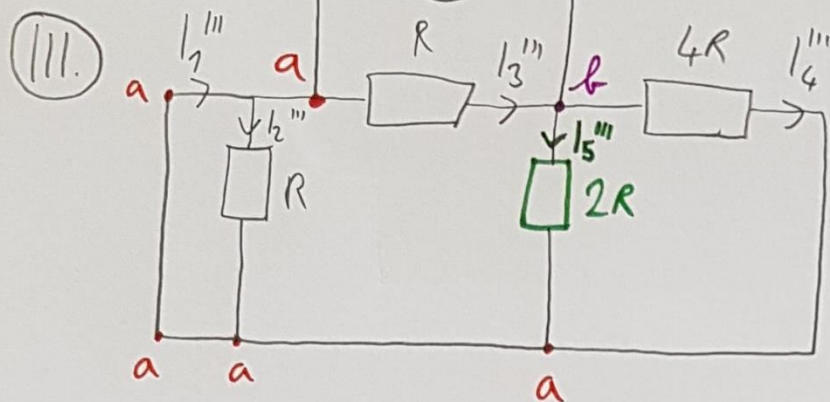
$$R_{eq} = \frac{14}{3}R = 23,333 \Omega$$

$$I_4'' = - \frac{U}{R_{eq}} = -0,857 A$$

$$U + I_4'' \cdot 4R - I_5'' \cdot 2R = 0$$

$$I_5'' = \frac{U + I_4'' \cdot 4R}{2R} = \frac{20V - 0,857 A \cdot 4 \cdot 5 \Omega}{2 \cdot 5 \Omega} = 0,286 A$$

IV-9 - DROGI
DIO



$$\frac{1}{R_{\text{eq}}} = \frac{1}{R} + \frac{1}{4R} + \frac{1}{2R} = \frac{4+1+2}{4R} = \frac{7}{4R} \Rightarrow 7R_{\text{eq}} = 4R \Rightarrow R_{\text{eq}} = \frac{4}{7}R$$

$$R_{\text{eq}} = 2,857 \Omega$$

$$U = I \cdot R_{\text{eq}} = 2A \cdot 2,857 \Omega = 5,714 V$$

$$I_5''' = \frac{U}{2R} = \frac{5,714 V}{10 \Omega} = 0,571 A$$

$$I_5 = I_5' + I_5'' + I_5''' = 1,143 A + 0,286 A + 0,571 A = 1 A$$

ANO PROMIENIMO SMJER STRUJNOG IZVORA:

$$I_5''' = -0,571 A$$

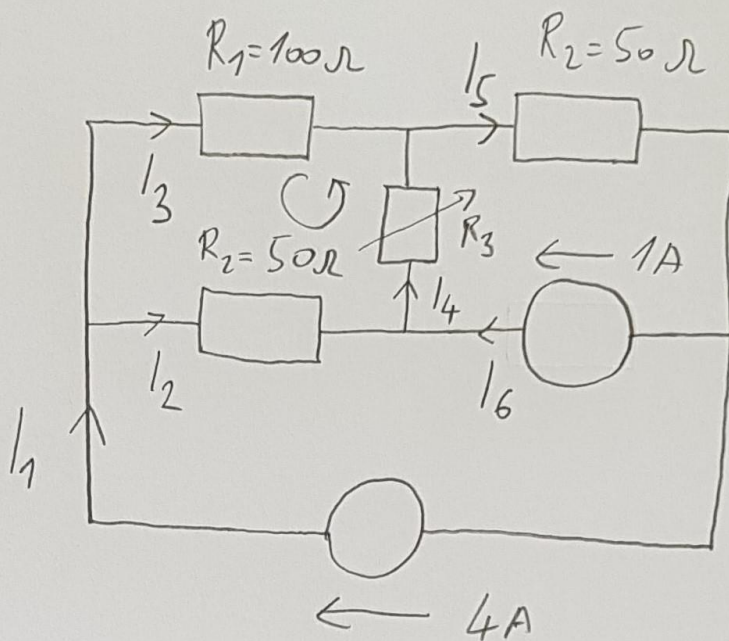
I_5' ; I_5'' OSTAJU ISTI

$$I_5 = I_5' + I_5'' + I_5''' = 1,143 A + 0,286 A - 0,571 A = 0,858 A$$

IV.-11.

$$I_2 = I_3$$

$$R_3 = ?$$



$$I_1 = I_2 + I_3, \quad I_2 = I_3 \Rightarrow I_2 = \frac{I_1}{2} = \boxed{2A}; \quad I_3 = \boxed{2A}$$

$$I_4 = I_2 + I_6 = 2A + 1A = 3A$$

$$I_3 \cdot R_1 = I_2 \cdot R_2 + I_4 \cdot R_3 \Rightarrow R_3 = \frac{I_3 \cdot R_1 - I_2 \cdot R_2}{I_4}$$

$$R_3 = \frac{2A \cdot 100\Omega - 2A \cdot 50\Omega}{3A} = \boxed{33,33\Omega}$$

XIII. 1-6

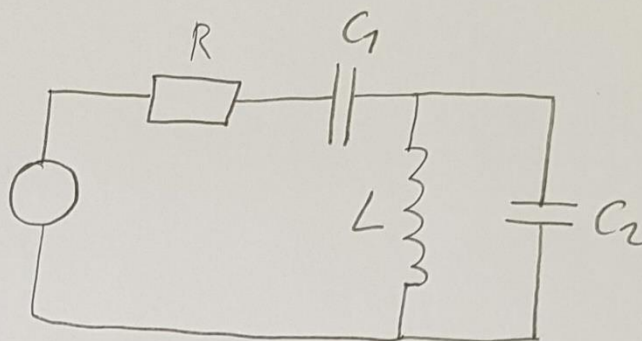
$$M(t) = 100 + 141 \sin(\omega t) + 14,1 \sin(3\omega t)$$

$$R = 2,5 \Omega$$

$$\frac{1}{\omega C_1} = 1,125 \Omega$$

$$\frac{1}{\omega C_2} = 9 \Omega$$

$$\omega L = 1 \Omega$$



$$I_{EF}, U_{RC1EF}, U_{LC2EF} = ?$$

0. $I_{OEF} = 0 A$

1. $\underline{\omega}$

$$\underline{X}_L = j \Omega$$

$$\underline{X}_{C1} = -1,125j \Omega$$

$$\underline{X}_{C2} = -9j \Omega$$

$$\underline{Z}_{wP} = \underline{X}_L \parallel \underline{X}_{C2} = \frac{j \cdot (-9j)}{j - 9j} = \boxed{\frac{9}{8} j \Omega}$$

$$\underline{Z}_w = \underline{R} + \underline{X}_{C1} + \underline{Z}_{wP} = 2,5 \Omega - 1,125j \Omega + \frac{9}{8}j \Omega$$

$$\underline{Z}_w = \boxed{2,5 \Omega}$$

$$I_{1EF} = \frac{U_{1EF}}{|\underline{Z}_w|} = \frac{\frac{141}{\sqrt{2}}}{2,5} = \boxed{39,88 A}$$

2. $\underline{3\omega}$

$$\underline{X}_L = j3\omega L = j3 \Omega$$

$$\underline{X}_{C1} = j\frac{1}{3} \frac{1}{\omega C_1} = \boxed{-0,375j \Omega}$$

$$\underline{X}_{C2} = j\frac{1}{3} \frac{1}{\omega C_2} = \boxed{-3j \Omega}$$

$$\underline{Z}_{wP} = \frac{\underline{X}_L \cdot \underline{X}_{C2}}{\underline{X}_L + \underline{X}_{C2}} = \infty$$

$\underline{X}_L + \underline{X}_{C2} = 0$

$$I_{2EF} = \boxed{0 A}$$

$$I_{EF}^2 = I_{OEF}^2 + I_{1EF}^2 + I_{2EF}^2 = I_{1EF}^2$$

$$I_{EF} = I_{1EF} = \boxed{39,88 A}$$

XIII. 1-6 - Drugi
dio

$$U_{RC1EF} = ?$$

$$U_{ORC1EF} = \boxed{100 V}$$

$$U_{WRC1EF} = I_{WEF} \cdot |Z_{WRC1}| = 39,88 A \cdot |2,5 - 1,125j| \Omega = \boxed{109,33 V}$$

$$U_{3WRC1EF} = \boxed{0 V}$$

$$U_{RC1EF} = \sqrt{U_{ORC1EF}^2 + U_{WRC1EF}^2 + U_{3WRC1EF}^2} = \boxed{148,17 V}$$

$$U_{LC2EF} = ?$$

$$U_{OLC2EF} = \boxed{0 V}$$

$$U_{WLC2EF} = I_{WEF} \cdot |Z_{WL}| = 39,88 A \cdot \frac{9}{8} \Omega = \boxed{44,87 V}$$

$$U_{3WLC2EF} = \frac{14,1 V}{\sqrt{2}} = \boxed{9,97 V}$$

$$U_{LC2EF} = \sqrt{U_{OLC2EF}^2 + U_{WLC2EF}^2 + U_{3WLC2EF}^2} = \boxed{45,96 V}$$

XIII.1-11

$$i(t) = I_{1m} \sin(\omega t) + I_{3m} \sin(3\omega t)$$

$$I_{3m} = \frac{I_{1m}}{2}$$

$$U_{EF} = 115 \text{ V}$$

$$U_0 = ?$$

ω

$$U_{1EF} = |U_1| = |40 \text{ V} + 10j \text{ V} + 20 \text{ V} - 90j \text{ V}| = \boxed{100 \text{ V}}$$

$$U_{1R1EF} = R_1 \cdot \frac{I_{1m}}{\sqrt{2}} = 40 \text{ V}$$

$$U_{1R2EF} = R_2 \cdot \frac{I_{1m}}{\sqrt{2}} = 20 \text{ V}$$

$$U_{1LEF} = \omega L \cdot \frac{I_{1m}}{\sqrt{2}} = 10 \text{ V}$$

$$U_{1CEF} = \frac{1}{\omega L} \cdot \frac{I_{1m}}{\sqrt{2}} = 90 \text{ V}$$

3 ω

$$U_{3R1EF} = R_1 \cdot \frac{I_{3m}}{\sqrt{2}} = R_1 \cdot \frac{I_{1m}}{\sqrt{2}} \cdot \frac{1}{2} = 20 \text{ V}$$

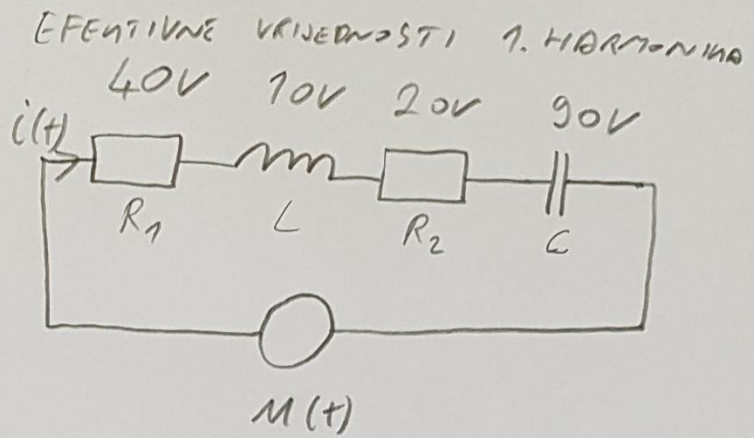
$$U_{3R2EF} = R_2 \cdot \frac{I_{3m}}{\sqrt{2}} = R_2 \cdot \frac{I_{1m}}{\sqrt{2}} \cdot \frac{1}{2} = 10 \text{ V}$$

$$U_{3LEF} = 3 \omega L \cdot \frac{I_{3m}}{\sqrt{2}} = 3 \cdot \frac{1}{2} \omega L \cdot \frac{I_{1m}}{\sqrt{2}} = 15 \text{ V}$$

$$U_{3CEF} = \frac{1}{3} \frac{1}{\omega C} \cdot \frac{I_{3m}}{\sqrt{2}} = \frac{1}{6} \frac{1}{\omega C} \cdot \frac{I_{1m}}{\sqrt{2}} = 15 \text{ V}$$

$$U_{3EF} = |20 + 10 + 15j - 15j| = \boxed{30 \text{ V}}$$

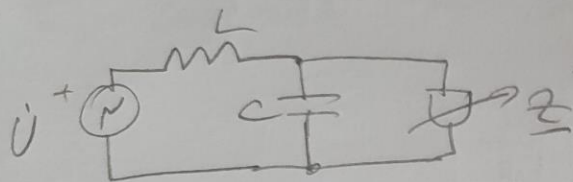
$$U_{EF}^2 = U_0^2 + U_{1EF}^2 + U_{3EF}^2 \Rightarrow U_0 = \sqrt{U_{EF}^2 - U_{1EF}^2 - U_{3EF}^2} = \boxed{48,22 \text{ V}}$$



X-19

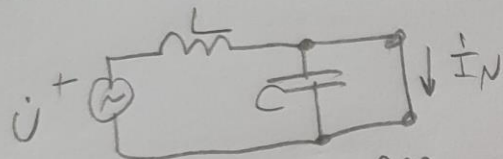
$$U = 120 \text{ V}$$

$$f = 50 \text{ Hz}$$

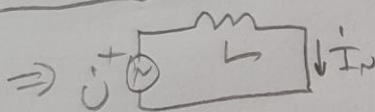
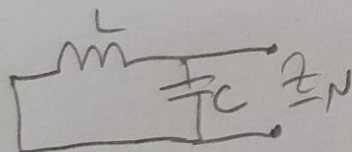


OPABRATI L I C TAKO DA STRUJA KROZ Z UVIJEK BUDE $0,1 \text{ A}$

NORTONOV TEOREM:

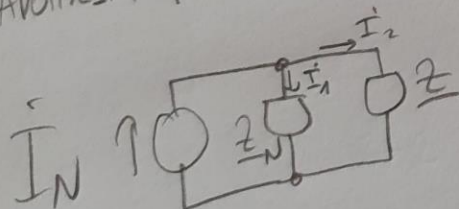
NORTONOVA
STRUJA

$$I_N = \frac{U}{jX_L}$$

C KRAJNJO
SPOJEN
SA ZILCOMNORTONOVA
IMPEDANCIJA

$$Z_N = \frac{-jX_C jX_L}{j(X_L - X_C)} = -j \frac{X_C X_L}{X_L - X_C}$$

NAPOMENI NORTONOV IZVOR:



ČEKLINO DA $Z_N = \infty$ ONDA JE $I_2 = I_N \Rightarrow I_2 = I_N$
 AKO $X_L = X_C$ UVIJEK KROZ Z BEZ OBZIRA NA Z !

DAVE ČEKLINO DA I_2 BUDE RAS $0,1 \text{ A}$
 ONDA $I_2 = I_N = \frac{U}{X_L} \Rightarrow 0,1 = \frac{120}{X_L}$

$$X_L = 1200 \Omega$$

$$X_L = 1200 \Omega \rightarrow L = \frac{1200}{\omega}$$

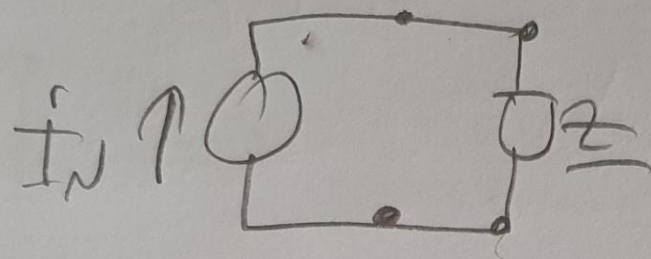
$$L = \frac{1200}{2\pi f} = 3,8197 \text{ H}$$

$$X_C = X_L \rightarrow X_C = 1200$$

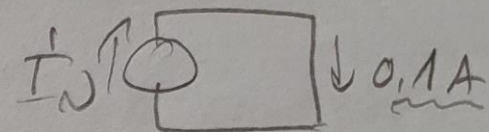
$$\frac{1}{\omega C} = 1200 \rightarrow C = \frac{1}{2\pi f \cdot 1200}$$

$$C = 2,6526 \mu\text{F}$$

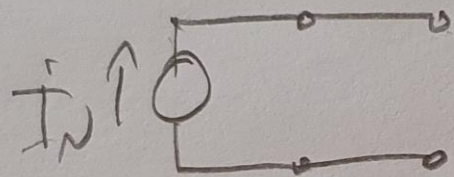
$Z_N = \infty$ ONDA JE OVO IDEALNI ^{STROMI} IZVOR:



Z MOŽE BITI 0Ω
ONDA JE ^{STROMI} IZVOR KRATKOSPORA

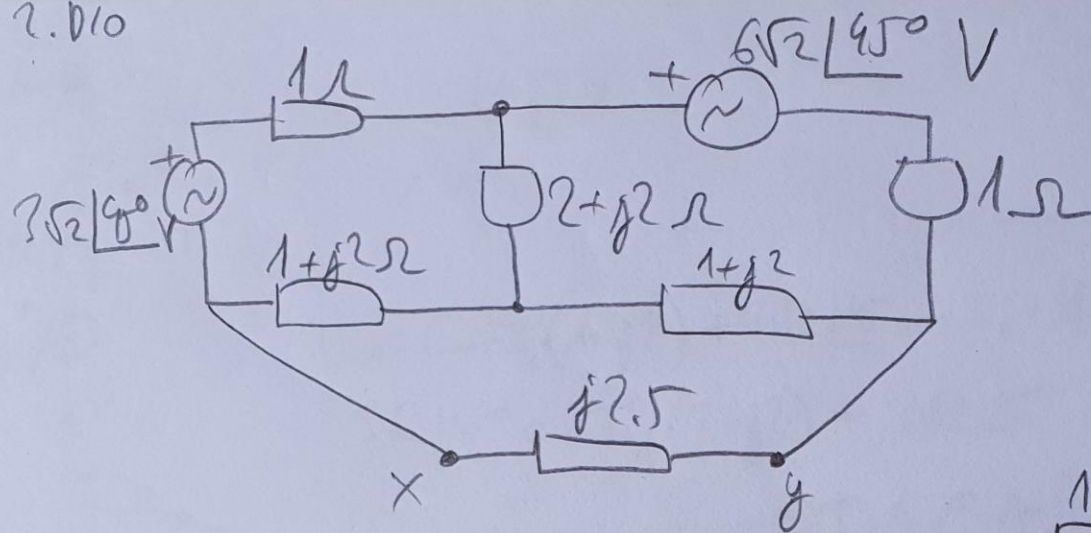


Z NE MOŽE BITI ∞

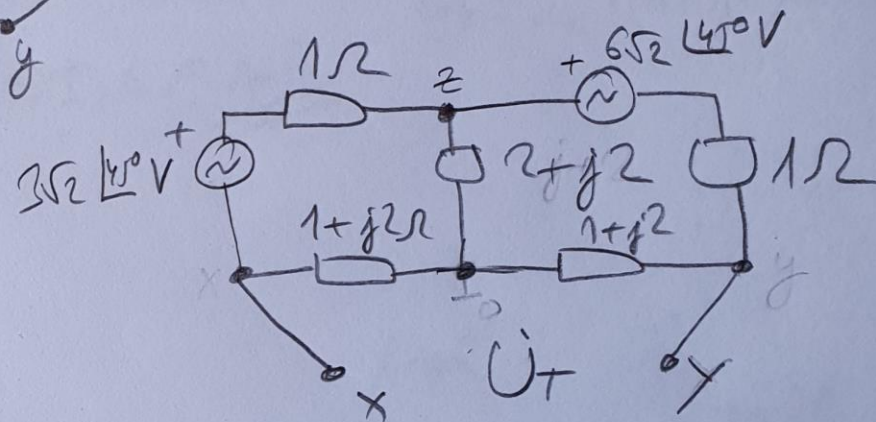


← PRECID KRUGA - ONDA NE TECE STROMA!

PANIC-FELJA 2. D10
X-20



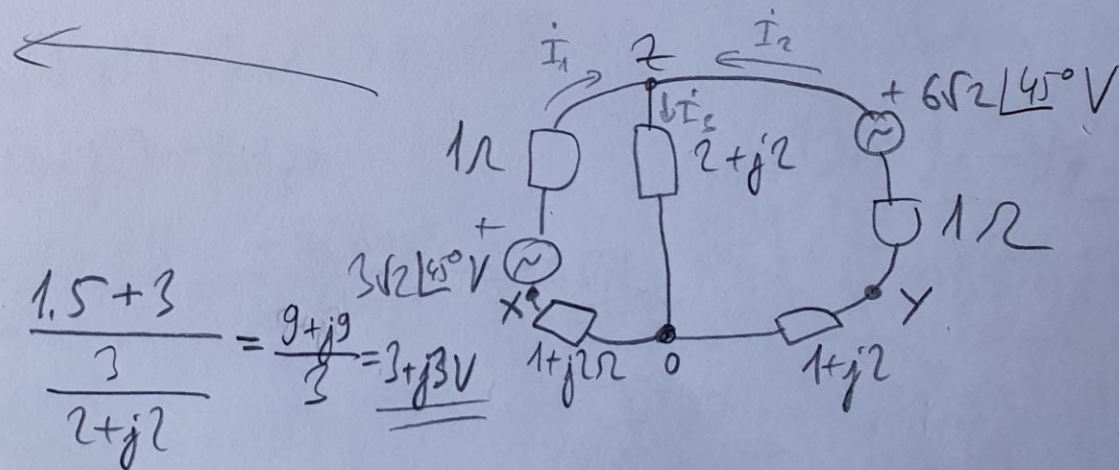
THEVENIN
IZNAU X i Y
MČENO $j2.5\Omega$



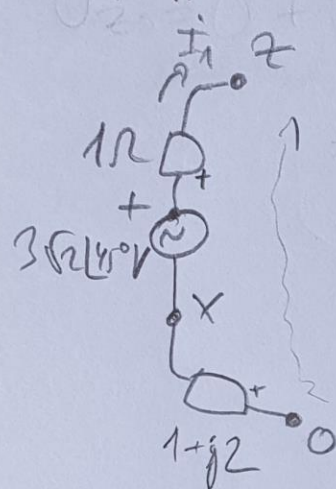
MILLMAN:

$$\dot{U}_{20} = \frac{\frac{3\sqrt{2}\angle 45^\circ}{1+j2} + \frac{6\sqrt{2}\angle 45^\circ}{1+1+j2}}{\frac{1}{1+1+j2} + \frac{1}{2+j2} + \frac{1}{1+1+j2}}$$

$$\dot{U}_{20} = \frac{\frac{3\sqrt{2}\angle 45^\circ}{2\sqrt{2}\angle 45^\circ} + \frac{6\sqrt{2}\angle 45^\circ}{2\sqrt{2}\angle 45^\circ}}{\frac{3}{2+j2}} = \frac{1.5+3}{2+j2} = \frac{9+j9}{2+j2} = \underline{\underline{3+j3V}}$$



1. GRANA



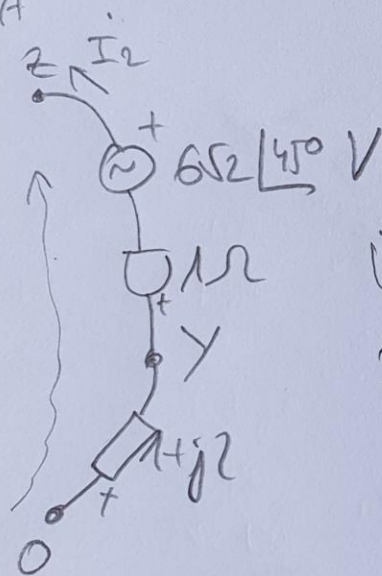
$$\dot{U}_{20} = 0 - \dot{I}_1(1+j2) + 3\sqrt{2}\angle 45^\circ - \dot{I}_1 \cdot 1$$

$$3\sqrt{2}\angle 45^\circ = -\dot{I}_1(2+j2) + 3\sqrt{2}\angle 45^\circ$$

$$-\dot{I}_1 = \frac{0}{2+j2} \Rightarrow \dot{I}_1 = \underline{\underline{0A}}$$

$$\dot{\varphi}_x = \dot{I}_1 \cdot (1+j2) = \underline{\underline{0V}}$$

2. GRANA



$$\dot{U}_{20} = 0 - \dot{I}_2(1+j2) - \dot{I}_2(1) + 6\sqrt{2}\angle 45^\circ V$$

$$3+j3 = -\dot{I}_2(2+j2) + 6+j6$$

$$-\dot{I}_2 = \frac{-3-j3}{-2-j2} = \frac{-3(1+j)}{-2(1+j)} = \underline{\underline{+1.5A}}$$

$$\dot{\varphi}_y = \dot{I}_2(1+j2) = +1.5(1+j2) = \underline{\underline{+1.5+j3V}}$$

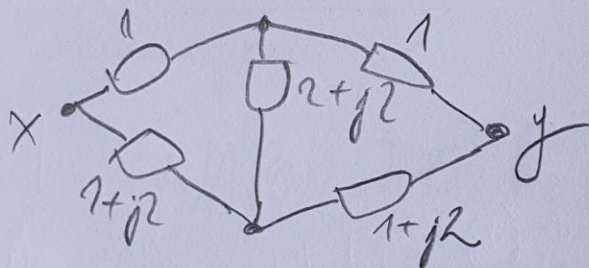
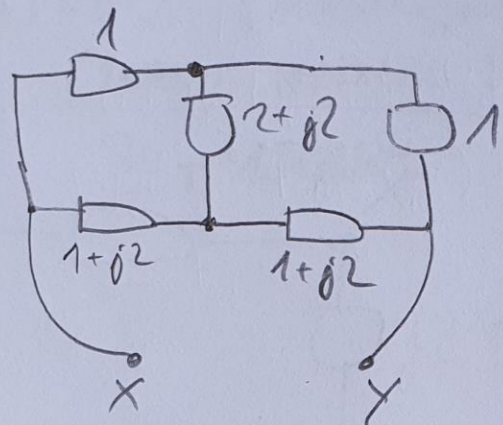
ONDA JE
 \dot{U}_T :

$$\dot{U}_T = \dot{\varphi}_x - \dot{\varphi}_y$$

$$\boxed{\dot{U}_T = -1.5-j3V}$$

THEVENINOVA IMPEDANCIJA:

NABNSICE ZAMJENJIVO S KRATKIM SPOJEM, STAKUJNE ODSPOLNO



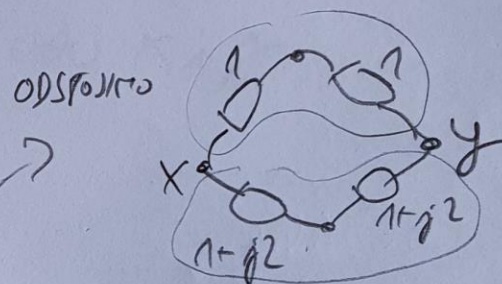
MOST JE U RAVNOSTEŽI?

$$1 \cdot (1 + j2) = 1 \cdot (1 + j2) \quad \underline{\text{OK}}$$

$$\begin{matrix} \text{W} \\ 1 + j2 = 1 + j2 \end{matrix}$$

U RAVNOSTEŽI

$$\underline{Z_{Th} = Z_{xy} = 1.5 + j0.5 \Omega}$$



$$Z_{xy} = \frac{(1+1)(1+j2+1+j2)}{1+1+1+j2+1+j2}$$

$$Z_{xy} = \frac{2(2+j4)}{4+j4} =$$

$$= \frac{4(1+j2)}{4(1+j)} = \frac{(1+j2)(1-j)}{(1+j)(1-j)} =$$

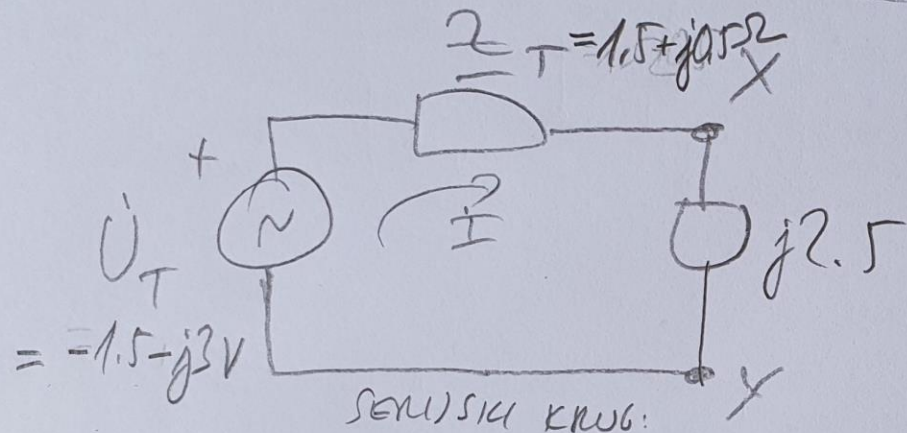
$$= \frac{1-j+j2+2}{2} =$$

$$= \frac{3+j}{2} = 1.5 + j0.5 \Omega$$

ODSPOLNO
U
KRATKOSPOLNO
2 + j2
U DIAGONALI MOSTA

KRA):

THEVENINOV NAPONSKI IZVOR
(REALNI NAPONSKI IZVOR)



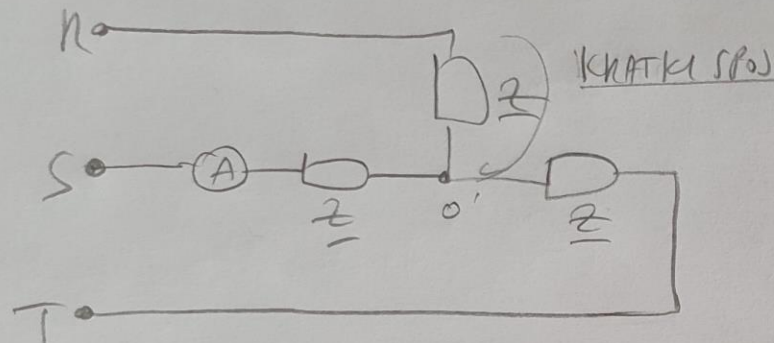
VRACAMO $j2.5$ KOJI JE
BIO IZMEĐU X I Y

$I = \frac{U_T}{Z_T + j2.5} = \frac{-1.5 - j3}{1.5 + j0.5 + j2.5} = \frac{-1.5 - j3}{1 + j3}$

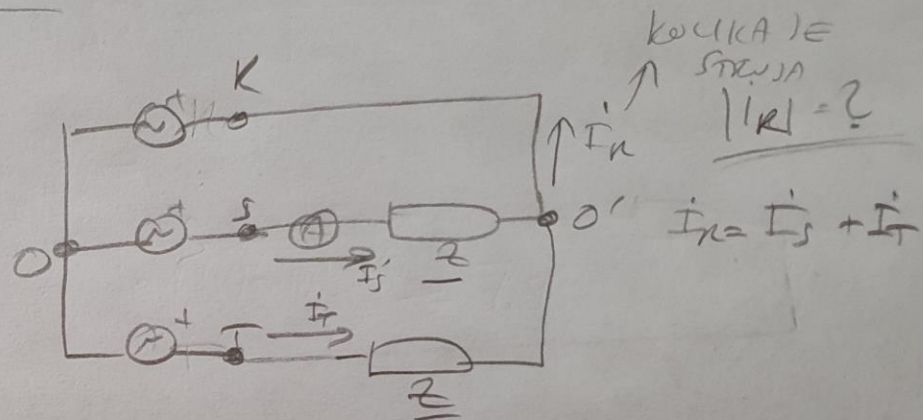
$U_{XY} = U_T \frac{j2.5}{Z_T + j2.5} \Rightarrow U_{XY} = U_T \frac{2.5}{\sqrt{1.5^2 + 3^2}} =$

$= \frac{\sqrt{1.5^2 + 3^2}}{\sqrt{1.5^2 + 3^2}} \cdot 2.5 = 2.5V$

XI-TEST 18



$$U_f = 220V \quad Z = R = 100\Omega$$



$$\dot{I}_n = \dot{I}_s + \dot{I}_T$$

$$\dot{I}_n = -3.3 - j1.1\sqrt{3} - 3.3 + j1.1\sqrt{3}$$

$$\dot{I}_n = -6.6 A$$

$$|\dot{I}_n| = 6.6 A$$

$$\dot{U}_{O'0} = \dot{U}_{N0}$$

$$\dot{U}_{S0'} = \dot{U}_{S0} - \dot{U}_{O'0} = \dot{U}_{S0} - \dot{U}_{N0} = 220\angle 120^\circ - 220\angle 0^\circ =$$

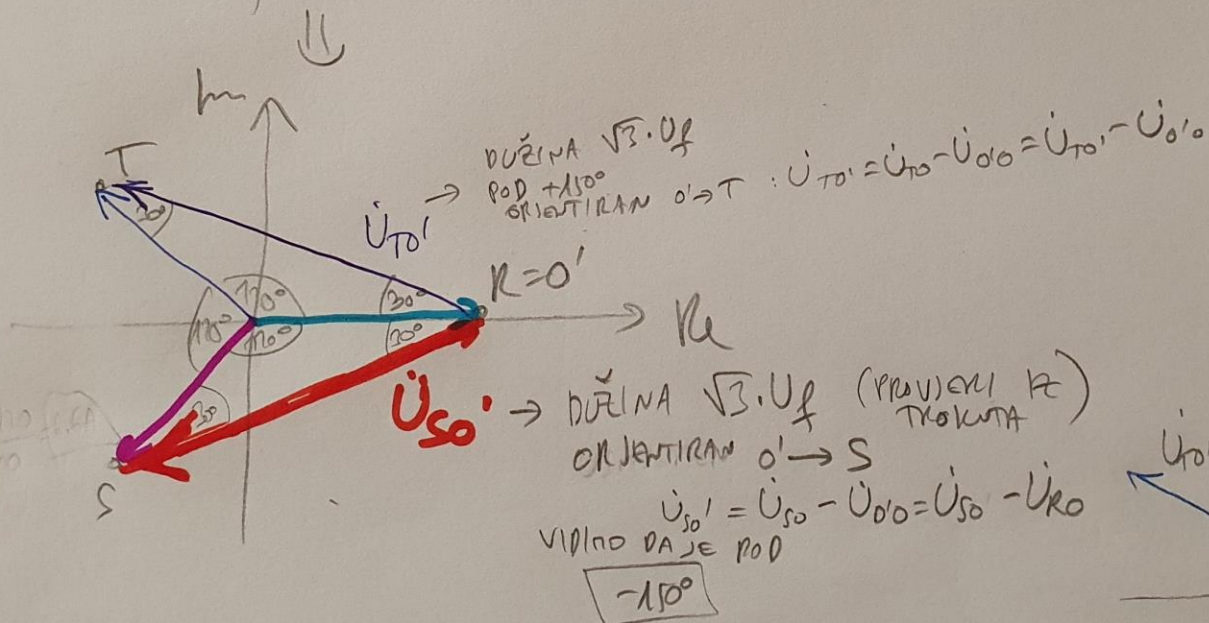
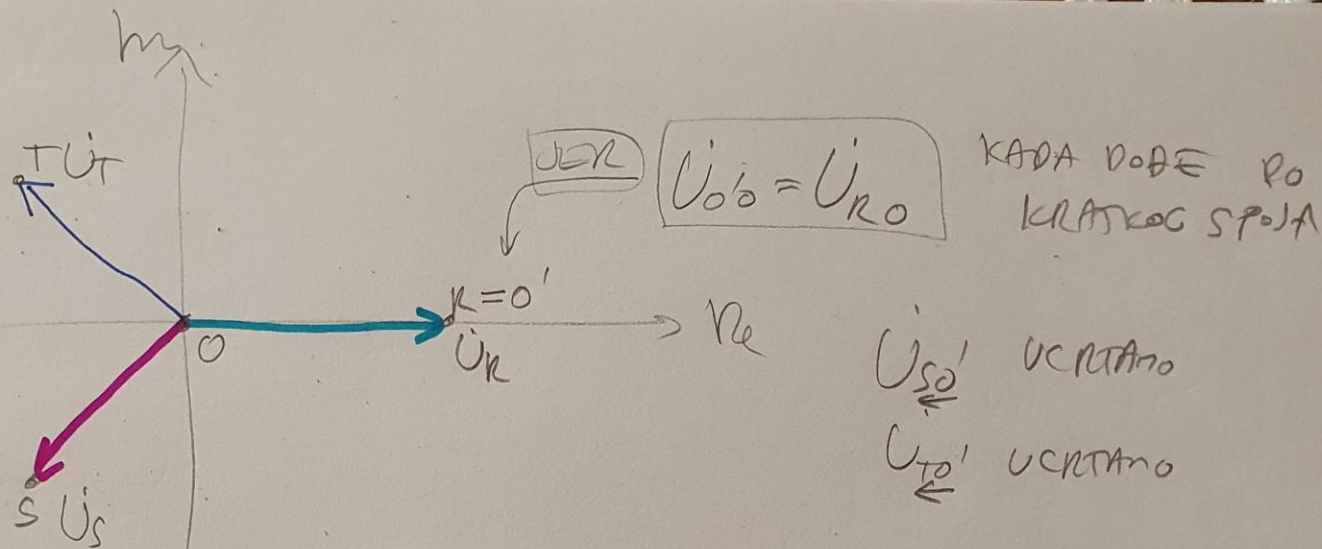
$$= 220\left(-\frac{1}{2} - j\frac{\sqrt{3}}{2}\right) - 220 = -330 - j110\sqrt{3} V$$

$$\dot{I}_s = \frac{\dot{U}_{S0'}}{R} = -3.3 - j1.1\sqrt{3} A$$

$$\dot{U}_{T0'} = \dot{U}_{T0} - \dot{U}_{O'0} = \dot{U}_{T0} - \dot{U}_{N0} = 220\angle 240^\circ - 220\angle 0^\circ =$$

$$= 220\left(-\frac{1}{2} + j\frac{\sqrt{3}}{2}\right) - 220 = -330 + j110\sqrt{3} V$$

$$\dot{I}_T = \frac{\dot{U}_{T0'}}{R} = -3.3 + j1.1\sqrt{3} A$$



PRESLOŽENO
DA REŽE IZ ISHODISTA

