Zad. 2. Zadan je regulacijski TR na sljedećim podacima: $S_n = 150\,MVA$, $u_k = 10{,}85\%$, $P_k = 400\,kW$, $m_T = 220 \pm 12 \cdot 1{,}5\%/110\,kV$. Izr. parametre nadomjesne T sheme ukoliko se regul. preklopka TR nalazi na položaju: a) $n=0$, b) $n=+7$, c) $n=-7$

Parametre izrazite u admitantnom obliku u p.u. vrij. koristeći $S_B = 100\,MVA$.

Izr. napon sekundara za sva 3 slič. ukoliko je napon primara jednak nazivnom naponu (220 kV), a transformator je neopterećen (P.H.)

a) $n=0$

$m_T = 220/110\,kV$

$a_2 = a_1 = 1$

$\underline{Z}_T = \frac{S_B}{S_n}\left[\frac{P_k}{S_n} + j\sqrt{u_k^2 - \left(\frac{P_k}{S_n}\right)^2}\right]$

$\underline{Z}_T = 1{,}78 \cdot 10^{-3} + j\,0{,}072$

$\underline{Y}_T = 0{,}34 - j\,13{,}82$

$\underline{Y}_{12} = \underline{Y}_T$

$\underline{Y}_{01} = \frac{\underline{Y}_T}{a_1}\left(\frac{1}{a_1} - 1\right) = 0$

$\underline{Y}_{02} = \underline{Y}_T\left(1 - \frac{1}{a_1}\right) = 0$

b) $n=+7$

$m_T = 243{,}1/110\,kV$

$a_1 = 1{,}105 \quad a_2 = 1$

$\underline{Y}_T = 0{,}34 - j\,13{,}82$

$\underline{Y}_{12} = \frac{\underline{Y}_T}{a_1} = 0{,}308 - j\,12{,}507$

$\underline{Y}_{01} = \frac{\underline{Y}_T}{a_1}\left(\frac{1}{a_1} - 1\right) = -0{,}0282 + j\,1{,}1484$

$\underline{Y}_{02} = \underline{Y}_T\left(1 - \frac{1}{a_1}\right) = 0{,}0323 - j\,1{,}313$

c) $n=-7$

$m_T = 196{,}9/110\,kV$

$a_1 = 0{,}895 \quad a_2 = 1$

$\underline{Y}_T = 0{,}34 - j\,13{,}82$

$\underline{Y}_{12} = \frac{\underline{Y}_T}{a_1} = 0{,}38 - j\,15{,}44$

$\underline{Y}_{01} = \underline{Y}_{12}\left(\frac{1}{a_1} - 1\right) = 0{,}0446 - j\,1{,}8$

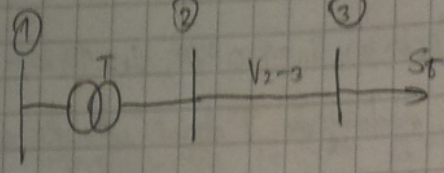
$\underline{Y}_{02} = \underline{Y}_T\left(1 - \frac{1}{a_1}\right) = -0{,}4 + j\,1{,}6$

$U_2 = ?$

ANALIZA EE SUSTAVA

AV 2

Zad. 3.



T	V2-3
$S_n = 300$ MVA	$R_1 = 0,12\,\Omega/km$
$u_k = 12\%$	$X_1 = 0,42\,\Omega/km$
$m_T = 220 \pm 12 \cdot 1,5\%/110$ kV	$l = 50$ km

- reg. sklopka u položaju n = +3

Izračunati parametre mreže korištenjem: a) metode otpora uz bazni napon $U_B = 220$ kV

b) metode jediničnih vrij. uz baznu snagu $S_B = 100$ MVA.

a) $m_T = 229,9 \,|\, 110$ kV

$a_1 = 1,045 \quad a_2 = 1$

$$Z_T = \frac{U_B^2}{S_n} \cdot \left[\frac{P_{Cu}}{S_n} + j\sqrt{u_k^2 - \left(\frac{P_{Cu}}{S_n}\right)^2} \right] = \frac{220^2}{300} \cdot j u_k = j\,19,36\ \Omega$$

$$Y_T = \frac{1}{Z_T} = -j\,0,0517\ S$$

$$Z_V = (R + jX_1) \cdot l = 9,5 + j21\ \Omega \qquad Z_V' = Z_V \cdot \left(\frac{U_B}{U_n}\right)^2 = 8,7 + j\,19,23$$

$$Y_V = 0,0179 - j\,0,0395\ S$$

b) $$Z_T = \frac{S_B}{S_n} \left[\frac{P_k}{S_n} + j\sqrt{u_k^2 - \left(\frac{P_k}{S_n}\right)^2} \right] = j0,04\ p.u.$$

$$Y_T = \frac{1}{Z_T} = -j25\ p.u.$$

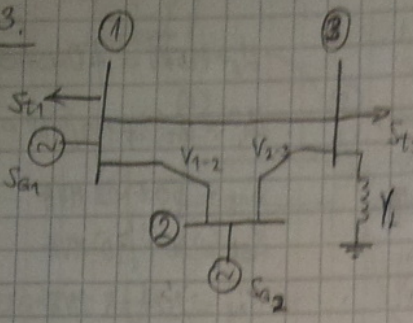
$$Z_V = (R + jX_1) \cdot l \cdot \frac{S_B}{U_n^2} = (9,5 + j21) \cdot \frac{100}{(229,9)^2} = 0,01797 + j\,0,03973\ p.u.$$

$$Y_V = \frac{1}{Z_V} = 9,452 - j\,20,893\ p.u.$$

AV 2. ANALIZA SE U TRAJNIH

Zad. Zad. 3.

AV 5.



GS-Y

$|U_i| = ?$

$\varepsilon = 10^{-3}$

$\alpha = 1,2$

$S_B = 100\ MVA$

$U_1^{(0)} = U_3^{(0)} = 110\angle 0°\ kV = 1 + j0$ p.u.

Vodovi

$U_n = 110\ kV$

$x_1 = 0,40\ \Omega/km$

$l_{12} = l_{23} = 50\ km$

$l_{13} = 100\ km$

$S_{t1} = 1,01 + j15$ $\quad S_{G1} = 80 + j50$

$S_{t3} = 70 + j30$

$U_2 = 1,045$ p.u. $= 115\ kV$

$y_{1L} = -j4,132 \cdot 10^{-3}\ S$

$$Z_{v12} = Z_{v23} = jx_1 \cdot l_{12} \cdot \frac{S_B}{U_n^2} = j0,1653\ p.u.$$

$$Y_{v12} = Y_{v23} = \frac{1}{Z_{v12}} = -j6,05\ p.u.$$

$$Z_{v13} = 2 \cdot Z_{v12} = j0,3306\ p.u.$$

$$Y_{v13} = \frac{1}{Z_{v13}} = -j3,025\ p.u.$$

$$Y_1 = y_{1L} \cdot \frac{U_n^2}{S_B} = -j0,5\ p.u.$$

$$Y = \begin{bmatrix} Y_{v12}+Y_{v13} & -Y_{v12} & -Y_{v13} \\ -Y_{v12} & Y_{v12}+Y_{v23} & -Y_{v23} \\ -Y_{v13} & -Y_{v23} & Y_{v23}+Y_{v13}+Y_1 \end{bmatrix} = \begin{bmatrix} -j9,075 & j6,05 & j3,025 \\ j6,05 & -j12,1 & j6,05 \\ j3,025 & j6,05 & -j9,575 \end{bmatrix}\ p.u.$$

$$S_1 = \frac{S_{G1} - S_{t1}}{S_B} = 0,4 + j0,35\ p.u. \qquad S_3 = \frac{-S_{t3}}{S_B} = -0,7 - j0,3\ p.u.$$

$$KI_1 = \frac{S_1^*}{Y_{11}} = \frac{0,4 - j0,35}{-j9,075} = 0,0386 + j0,0441$$

$$KI_3 = \frac{S_3^*}{Y_{33}} = \frac{-0,7 + j0,3}{-j9,575} = -0,0313 - j0,0731$$

$$YI_{12} = \frac{Y_{12}}{Y_{11}} = -0,667, \quad YI_{13} = \frac{Y_{13}}{Y_{11}} = -0,333, \quad YI_{31} = \frac{Y_{31}}{Y_{33}} = -0,316, \quad YI_{32} = \frac{Y_{32}}{Y_{33}} = -0,632$$

$$U_1^{(1)} = \frac{KI_1}{U_1^{(0)*}} - YI_{12} \cdot U_2 - YI_{13} \cdot U_3^{(0)} = 1,0683 + j0,0411$$

$$U_{1\text{-}ubr}^{(1)} = U_1^{(0)} + \alpha(U_1^{(1)} - U_1^{(0)}) = 1,082 + j0,053$$

$$|U_1^{(1)} - U_1^{(0)}| = 0,0813 > \varepsilon$$

$$U_3^{(1)} = \frac{KI_3}{U_3^{(0)*}} - YI_{31} \cdot U_{1\text{-}ubr}^{(1)} - YI_{32} \cdot U_2 = 0,971 - j0,056$$

$$U_{3\text{-}ubr}^{(1)} = U_3^{(0)} + \alpha(U_3^{(1)} - U_3^{(0)}) = 0,965 - j0,0676$$

$$|U_3^{(1)} - U_3^{(0)}| = 0,0631 > \varepsilon$$

$$U_1^{(2)} = \frac{KI_1}{U_{1\text{-}ubr}^{(1)*}} - YI_{12} \cdot U_2 - YI_{13} \cdot U_{3\text{-}ubr}^{(1)} = 1,0549 + j0,0164$$

$$U_{1\text{-}ubr}^{(2)} = U_{1\text{-}ubr}^{(1)} + \alpha(U_1^{(2)} - U_{1\text{-}ubr}^{(1)}) = 1,0495 + j0,00913$$

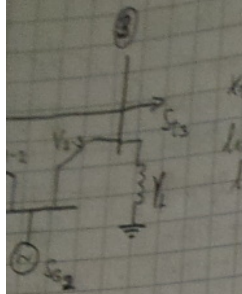
$$|U_1^{(2)} - U_{1\text{-}ubr}^{(1)}| = 0,0155 > \varepsilon$$

$$U_3^{(2)} = \frac{KI_3}{U_{3\text{-}ubr}^{(1)*}} - YI_{31} \cdot U_{1\text{-}ubr}^{(2)} - YI_{32} \cdot U_2 = 0,9648 - j0,0564$$

$$U_{3\text{-}ubr}^{(2)} = U_{3\text{-}ubr}^{(1)} + \alpha(U_3^{(2)} - U_{3\text{-}ubr}^{(1)}) = 0,965 - j0,0621$$

$$|U_3^{(2)} - U_{3\text{-}ubr}^{(1)}| = 0,0072 > \varepsilon$$

Varianti
$U_n = 110\,kV$
$x_1 = 0{,}40\,\Omega/km$
$l_{12} = l_{23} = 50\,km$
$l_{13} = 100\,km$



$S_{T1} = 40 + j15$ $\quad S_{G1} = 80 + j50$

$S_{T3} = 70 + j30$

$U_2 = 1{,}045\ p.u. = 115\,kV$

$q_L = -j\,4{,}132 \cdot 10^{-3}\ S$

$Z_{V12} = Z_{V23} = jx_1 \cdot l_{12} \cdot \frac{S_B}{U_n^2} = j0{,}1653\ p.u.$

$Y_{12} = Y_{V23} = \frac{1}{Z_{12}} = -j6{,}05\ p.u.$

$Z_{V13} = 2 \cdot Z_{V12} = j0{,}3306\ p.u.$

$Y_{V13} = \frac{1}{Z_{V13}} = -j3{,}025\ p.u.$

$Y_L = q_L \cdot \frac{U_n^2}{S_B} = -j0{,}5\ p.u.$

$$\begin{bmatrix} -Y_{V12} & -Y_{V13} \\ Y_{V12}+Y_{V23} & -Y_{V23} \\ -Y_{V23} & Y_{V23}+Y_{V13}+Y_L \end{bmatrix} = \begin{bmatrix} -j9{,}075 & j6{,}05 & j3{,}025 \\ j6{,}05 & -j12{,}1 & j6{,}05 \\ j3{,}025 & j6{,}05 & -j9{,}575 \end{bmatrix} p.u.$$

$+ j0{,}35\ p.u.$ $\quad S_3 = \frac{-S_{T3}}{S_B} = -0{,}7 - j0{,}3\ p.u.$

$\frac{5}{75} = 0{,}0386 + j0{,}0441$

$KI_3 = \frac{S_3^*}{Y_{33}} = \frac{-0{,}7 + j0{,}3}{-j9{,}575} = -0{,}0313 - j0{,}0731$

$YL_{13} = \frac{Y_{13}}{Y_{11}} = -0{,}333$, $\quad YL_{31} = \frac{Y_{31}}{Y_{33}} = -0{,}316$, $\quad YL_{32} = \frac{Y_{32}}{Y_{33}} = -0{,}632$

$U_3^{(0)} = 1{,}0683 + j0{,}0411$

$U_3^{(1)} = \frac{KI_3}{U_3^{(0)*}} - YL_{31} \cdot U_{1\text{-}ubr}^{(1)} - YL_{32} \cdot U_2 = 0{,}971 - j0{,}056$

$) = 1{,}082 + j0{,}053$

$U_{3\text{-}ubr}^{(1)} = U_3^{(0)} + \alpha(U_3^{(1)} - U_3^{(0)}) = 0{,}965 - j0{,}0676$

$> \varepsilon$

$$U_1^{(3)} = \frac{KI_1}{U_{1\text{-}ubr}^{(2)*}} - YL_{12} \cdot U_2 - YL_{13} \cdot U_{3\text{-}ubr}^{(2)}$$

$U_1^{(3)} = 1{,}0544 + j0{,}0163$

$U_{1\text{-}ubr}^{(3)} = U_{1\text{-}ubr}^{(2)} + \alpha(U_1^{(3)} - U_{1\text{-}ubr}^{(2)})$

$U_{1\text{-}ubr}^{(3)} = 1{,}0554 + j0{,}0177$

$|U_1^{(3)} - U_{1\text{-}ubr}^{(2)}| = 4{,}96 \cdot 10^{-3}$

$$U_3^{(3)} = \frac{KI_3}{U_{3\text{-}ubr}^{(2)*}} - YL_{31} \cdot U_{1\text{-}ubr}^{(3)} - YL_{32} \cdot U_2$$

$U_3^{(3)} = 0{,}95577 - j0{,}06714$

$U_{3\text{-}ubr}^{(3)} = U_{3\text{-}ubr}^{(2)} + \alpha(U_3^{(3)} - U_{3\text{-}ubr}^{(2)})$

$U_{3\text{-}ubr}^{(3)} = 0{,}954 - j0{,}0653$

$|U_3^{(3)} - U_{3\text{-}ubr}^{(2)}| = 0{,}0129$

$U_1 = 115{,}65 \angle 1{,}038°$

$U_3 = 105{,}27 \angle -4{,}05°$

$S_{G_1} = 50 + j50$

kV

25

p.u.

$$U_1^{(3)} = \frac{KI_1}{U_{1\text{-ubr}}^{(2)*}} - Y_{12}\cdot U_2 - Y_{13}\cdot U_{3\text{-ubr}}^{(2)}$$

$$U_1^{(3)} = 1{,}0544 + j0{,}0163$$

$$U_{1\text{-ubr}}^{(3)} = U_{1\text{-ubr}}^{(2)} + \alpha\left(U_1^{(3)} - U_{1\text{-ubr}}^{(2)}\right)$$

$$U_{1\text{-ubr}}^{(3)} = 1{,}0554 + j0{,}0177$$

$$\left|U_1^{(3)} - U_{1\text{-ubr}}^{(2)}\right| = 4{,}96\cdot 10^{-3}$$

$$U_3^{(3)} = \frac{KI_3}{U_{3\text{-ubr}}^{(2)*}} - Y_{31}\cdot U_{1\text{-ubr}}^{(3)} - Y_{32}\cdot U_2$$

$$U_3^{(3)} = 0{,}95577 - j0{,}0674$$

$$U_{3\text{-ubr}}^{(3)} = U_{3\text{-ubr}}^{(2)} + \alpha\left(U_3^{(3)} - U_{3\text{-ubr}}^{(2)}\right)$$

$$U_{3\text{-ubr}}^{(3)} = 0{,}954 - j0{,}0653$$

$$\left|U_3^{(3)} - U_{3\text{-ubr}}^{(3)}\right| = 0{,}0129$$

$$U_1 = 1{,}0565\angle 1{,}098^\circ$$

$$U_3 = 1{,}0527\angle -1{,}05^\circ$$

Uvod

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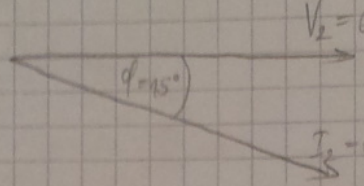
1. III 2014./2015.

1. U TS paralelno su spojena 2 trofazna transformatora prijenosnog omjera $220 \pm 10 \cdot 1{,}5\% / 110\ kV$ sljedećim podacima: $S_n = 150\ MVA$, $u_k = 10{,}5\%$. Gubici u bakru i željezu, te struja magnetiziranja su zanemareni. Regulacijska preklopka tr. T_1 se nalazi u položaju $n_1 = 0$, a T_2 na položaju $n_2 = -5$. Na sekundaru je spojen simetrični trofazni teret za kojeg je vlastom zadan fazorski dijagram jedne faze. Izračunajte napon na primaru $|U_1| \angle \delta\ [kV]$ uz baznu snagu $S_B = 100\ MVA$.



$$a_1'' = \frac{220 - 5 \cdot 1{,}5\% \cdot 220}{220} = \frac{203{,}5}{220} = 0{,}925 \qquad a_1' = \frac{220 + 0 \cdot 1{,}5\%}{200} = 1$$

$$\underline{Z}_T = \frac{S_B}{S_n}\left[\frac{P_c}{S_n} + j\sqrt{u_k^2 - \left(\frac{P_c}{S_n}\right)^2}\right] = \frac{100}{150} \cdot j\sqrt{(10{,}5\%)^2} = j0{,}07\ p.u.$$

$$Y_T = (\underline{Z}_T)^{-1} = -j\,14{,}286\ p.u.$$

$$Y_{12}' = \frac{Y_T}{a_1} = -j\,14{,}286\ p.u.$$

$$Y_{12}'' = \frac{Y_T}{a_1''} = \frac{-j14{,}286}{0{,}925} = -j\,15{,}444\ p.u.$$

$$Y_{01}'' = \frac{Y_T}{a_1' \cdot a_1''}\left(\frac{a_1''}{a_1'} - 1\right) = \frac{Y_T}{0{,}925}(0{,}925 - 1) = +j\,1{,}158\ p.u.$$

$$Y_{02}'' = \frac{Y_T}{a_1' \cdot a_{11}''}\left(\frac{a_1'}{a_{11}''} - 1\right) = -j\,1{,}252\ p.u.$$

$$I = \frac{U}{Z} = U \cdot Y = \begin{bmatrix} U_1 \\ U_2 \end{bmatrix} \cdot \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \qquad \begin{aligned} U_1 \cdot Y_{11} + U_2 \cdot Y_{12} &= I_1 \\ U_1 \cdot Y_{21} + U_2 \cdot Y_{22} &= I_2 \end{aligned}$$

$$U_1 = \frac{I_2 - U_2 \cdot Y_{22}}{Y_{21}}$$

$V_2 = 66{,}282\ kV \rightarrow U_2 = V_2 \cdot \sqrt{3}$

$$\underline{I}_2 = 0{,}556 \angle -15°\ kA = 537{,}055 - j\,143{,}9\ A$$

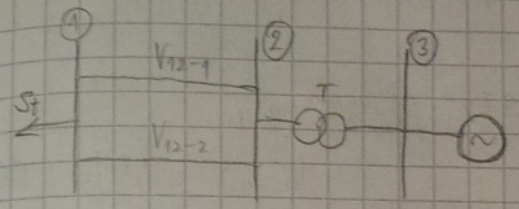
$$U_2 = \frac{U_2\,[kV]}{U_n} = 1{,}044\ p.u.$$

$$I_2^* = \frac{\sqrt{3} \cdot U_n \cdot I_2\,[A]}{S_B} = \frac{\sqrt{3} \cdot 110 \cdot (537{,}055 - j143{,}9)}{100} = -1{,}023 + j\,0{,}274\ p.u.$$

$$S_{12}^* = 3 V_2 \cdot I_2^* = 106{,}22 + j\,28{,}44\ MVA$$

$$\underline{I_2 = \left(\frac{S_2}{U_2}\right)^* = -1{,}023 + j0{,}274}$$

2. Za mrežu zadanu slikom izračunajte napone u čvorištima 1 i 2 u drugoj iteraciji ($|\underline{U}_1^{(2)}|\angle\delta_1^{(2)}$, $|\underline{U}_2^{(2)}|\angle\delta_2^{(2)}$ [kV]) koristeći se GS-Y metodu uz zadan faktor ubrzanja $\alpha = 1{,}1$. Za napone u čvorištima 1 i 2 kontrolete početne vrijednosti $\underline{U}_1^{(0)} = \underline{U}_2^{(0)} = 110\angle 0°$ kV, te $S_B = 100$ MVA.



$S_{t_1} = 70 + j\,30$ MVA

$U_3 = 16$ kV

Transformator T	Vodovi V_{12-1} i V_{12-2}
$S_n = 150$ MVA	$R_1 = 0{,}12\,\Omega/\text{km}$
$U_k = 10{,}5\%$	$X_1 = 0{,}410\,\Omega/\text{km}$
$\frac{U_{n1}}{U_{n2}} = \frac{15 \pm 5}{110}$ kV	$B_1 = 2{,}72\,\mu\text{S/km}$

Transformator T ima nazivni prijenosni omjer. Vodovi su duljine 50 km. U svakom koraku je potrebno provjeriti točnost rješenja.

$U_1^{(0)} = U_2^{(0)} = 1$ p.u.

$$\underline{Z}_T = \frac{S_B}{S_n}\left[\frac{P_0}{S_n} + j\sqrt{U_k^2 - \left(\frac{P_0}{S_n}\right)^2}\right] = \frac{100}{150}\cdot j0{,}105 = j0{,}07 \text{ p.u.}$$

$$Y_T = -j\,14{,}286 \text{ p.u.}$$

$$\underline{Z}_V = (R_1 + jX_1)\,l\cdot\frac{S_B}{U_n^2} = 0{,}0496 + j\,0{,}1654 \text{ p.u.}$$

$$Y_V = \frac{1}{\underline{Z}_V} = 1{,}521 - j\,5{,}137 \text{ p.u.}$$

$$\frac{Y_{0V}}{2} = \frac{jB_1}{2}\cdot\frac{U_n^2}{S_B}\,l = j\,8{,}23 \text{ p.u.}\cdot 10^{-3}$$

$$Y = \begin{bmatrix} +(2Y_V + 2\cdot\frac{Y_{0V}}{2}) & -2Y_V & 0 \\ -2Y_V & 2\cdot Y_V + Y_T + Y_V & -Y_T \\ 0 & -Y_T & Y_T \end{bmatrix} = \begin{bmatrix} 3{,}182 - j\,10{,}857 & -3{,}182 + j\,10{,}874 & 0 \\ -3{,}182 + j\,10{,}874 & 3{,}182 - j\,25{,}143 & j\,14{,}286 \\ 0 & j\,14{,}286 & -j\,14{,}286 \end{bmatrix}$$

$$S_1 = \frac{0 - S_{t_1}}{S_B} = -0{,}7 - j\,0{,}3 \text{ p.u.}$$

$S_2 = 0$

$$U_3 = \left(\frac{15 \pm 5}{16}\right)^{-1} = 1{,}016 \text{ p.u.}$$

$$KL_1 = \frac{S_1^*}{Y_{11}} = \frac{-0{,}7 + j\,0{,}3}{3{,}182 - j\,10{,}857} = -0{,}0113 - j\,0{,}052 \text{ p.u.}$$

$$KL_2 = \frac{S_2^*}{Y_{22}} = 0$$

$$YL_{12} = \frac{Y_{12}}{Y_{11}} = -1{,}001 \qquad YL_{21} = \frac{Y_{21}}{Y_{22}} = -0{,}441 - j\,0{,}071$$

$$YL_{13} = \frac{Y_{13}}{Y_{11}} = 0 \qquad YL_{23} = \frac{Y_{23}}{Y_{22}} = -0{,}559 + j\,0{,}071$$

$$U_1^{(1)} = \frac{KL_1}{(U_1^{(0)})^*} - Y_{12} \cdot U_2^{(0)} - Y_{13} \cdot U_3^{(0)} = 0{,}958 - j\,0{,}052 \text{ p.u.}$$

$$|U_{1\text{-ubr}}^{(1)} - U_1^{(1)}| = 0{,}0754$$

$$U_{1\text{-ubr}}^{(1)} = U_1^{(0)} + \alpha (U_1^{(1)} - U_1^{(0)}) = 0{,}951 - j\,0{,}0572 \text{ p.u.}$$

$$U_2^{(1)} = \frac{KL_2}{(U_2^{(1)})^*} - Y_{21} \cdot U_{1\text{-ubr}}^{(1)} - Y_{23} \cdot U_3 = 0{,}99272 - j\,0{,}0296 \text{ p.u.}$$

$$|U_{2\text{-ubr}}^{(1)} - U_2^{(1)}| = 0{,}0327$$

$$U_{2\text{-ubr}}^{(1)} = U_2^{(0)} + \alpha (U_2^{(1)} - U_2^{(0)}) = 0{,}992 - j\,0{,}0326 \text{ p.u.}$$

$$U_1^{(2)} = \frac{KL_1}{(U_{1\text{-ubr}}^{(1)})^*} - Y_{12} \cdot U_{2\text{-ubr}}^{(1)} - Y_{13} \cdot U_3 = 0{,}945 - j\,0{,}0813 \text{ p.u.}$$

$$|U_{1\text{-ubr}}^{(2)} - U_{1\text{-ubr}}^{(1)}| = 0{,}0341$$

$$U_{1\text{-ubr}}^{(2)} = U_{1\text{-ubr}}^{(1)} + \alpha (U_1^{(2)} - U_{1\text{-ubr}}^{(1)}) = 0{,}944 - j\,0{,}077 \text{ p.u.}$$

$$U_2^{(2)} = \frac{KL_2}{(U_{2\text{-ubr}}^{(1)})^*} - Y_{21} \cdot U_{1\text{-ubr}}^{(2)} - Y_{23} \cdot U_3 = 0{,}99043 - j\,0{,}0435 \text{ p.u.}$$

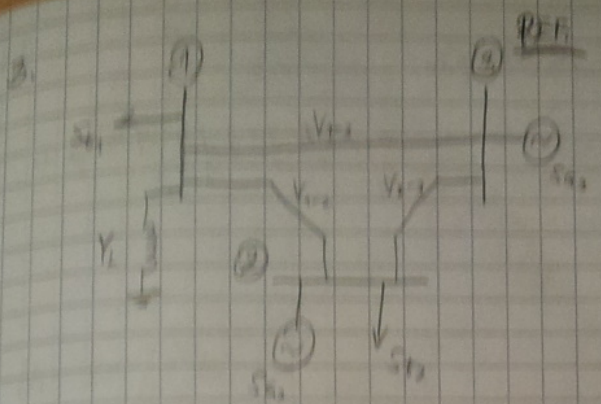
$$|U_{2\text{-ubr}}^{(2)} - U_{2\text{-ubr}}^{(1)}| = 0{,}012$$

$$U_{2\text{-ubr}}^{(2)} = U_{2\text{-ubr}}^{(1)} + \alpha (U_2^{(2)} - U_{2\text{-ubr}}^{(1)}) = 0{,}9903 - j\,0{,}04157 \text{ p.u.}$$

$$U_{1\text{-ubr}}^{(2)} = 104{,}28 \angle -5{,}27^\circ \text{ kV}$$

$$U_{2\text{-ubr}}^{(2)} = 109{,}04 \angle -2{,}58^\circ \text{ kV}$$

3. **PEE**



Vodovi

$U_n = 110\,kV$

$R_1 = 0$

$X_1 = 0{,}4124/km$

$B_1 = 2{,}72\,\mu S/km$

$l_{12} = l_{23} = 25\,km, \quad l_{13} = 50\,km$

$S_{t1} = 30 - j10$

$S_{t2} = 50 + j25 \qquad S_{G2} = 30 + j15$

$U_3 = 120\angle 0^\circ\,kV$

$Y_1 = -j6{,}198 \cdot 10^{-?}\,S \rightarrow$ prigušnica u čv. 1

Odredite napone čvorišta [illegible] metode
Gs-Z uz točnost $\varepsilon = 10^{-?}$ ($|U_i|$ / δ_i [kV]).

$S_B = 100\,MVA$

$U_1^{(0)} = U_2^{(0)} = 110\angle 0^\circ\,kV = 1$ p.u.

$Z_{12} = j x_1 \cdot l_{12} \cdot \frac{S_B}{U_n^2} = j0{,}0867$ p.u.

$Y_{12} = -j11{,}524$ p.u.

$Y_{23} = -j11{,}524$ p.u.

$Y_{13} = -j5{,}762$ p.u.

$\frac{Y_{012}}{2} = \frac{jB_1}{2} \cdot l \cdot \frac{U_n^2}{S_B} = j4{,}114 \cdot 10^{-3}$ p.u.

$\frac{Y_{023}}{2} = j4{,}114 \cdot 10^{-3}$ p.u.

$\frac{Y_{013}}{2} = j8{,}228 \cdot 10^{-3}$ p.u.

$Y_1 = -j y_1 \cdot \frac{U_n^2}{S_B} = -j0{,}075$ p.u.

$$Y = \begin{bmatrix} Y_{12}+Y_{13} & -Y_{12} & -Y_{13} \\ -Y_{12} & Y_{12}+Y_{23} & -Y_{23} \\ \cancel{-Y_{13}} & \cancel{-Y_{23}} & \cancel{Y_{13}+Y_{23}} \end{bmatrix} = \begin{vmatrix} -j17{,}286 & j11{,}524 \\ j11{,}524 & -j23{,}05 \end{vmatrix} \text{ p.u.}$$

$$Y' = \begin{vmatrix} \frac{Y_{012}}{2} + \frac{Y_{013}}{2} + Y_1 \\ \frac{Y_{012}}{2} + \frac{Y_{023}}{2} \\ \cancel{\frac{Y_{013}}{2} + \frac{Y_{023}}{2}} \end{vmatrix} = \begin{vmatrix} -j0{,}938 \\ j8{,}228 \cdot 10^{-3} \end{vmatrix} \text{ p.u.}$$

$$\underline{Z = Y^{-1}} = \begin{bmatrix} j0{,}087 & j0{,}0434 \\ j0{,}0434 & j0{,}087 \end{bmatrix} \text{ p.u.}$$

$S_1 = -0{,}3 + j0{,}1$

$S_2 = -0{,}2 - j0{,}1$

$U_3 = 1{,}091$ p.u.

$I_1^{(0)} = \left(\frac{S_1}{U_1^{(0)}}\right)^* - Y_{11}' \cdot U_1^{(0)} = -0{,}3 + j0{,}638$ p.u.

$I_2^{(0)} = \left(\frac{S_2}{U_2^{(0)}}\right)^* - Y_{21}' \cdot U_2^{(0)} = -0{,}2 + j0{,}917$ p.u.

$U_1^{(1)} = U_3 + Z_{11} \cdot I_1^{(0)} + Z_{12} \cdot I_2^{(0)} = 1{,}032 - j0{,}035$ p.u.

$I_1^{(1)} = \left(\frac{S_1}{U_1^{(1)}}\right)^* - Y_{11}' \cdot U_1^{(1)} = -0{,}268 + j0{,}675$ p.u.

$|U_1^{(1)} - U_1^{(0)}| = 0{,}0774 > \varepsilon$

3. nastavak

$$U_2^{(1)} = U_3 + Z_{21} \cdot I_1^{(1)} + Z_{22} \cdot I_2^{(0)} = 1{,}056 - j\,0{,}025 \text{ p.u.}$$

$$I_2^{(1)} = \left(\frac{S_2}{U_2^{(1)}}\right)^* - Y_{21}' \cdot U_2^{(1)}$$

$$\left|U_2^{(1)} - U_2^{(0)}\right| = 0{,}069$$

2. iteracija:

$$U_1^{(2)} = U_3 + Z_{11} \cdot I_1^{(1)} + Z_{12} \cdot I_2^{(1)} = 1{,}029 - j\,0{,}031 \text{ p.u.}$$

$$I_1^{(2)} = \left(\frac{S_1}{U_1^{(2)}}\right)^* - Y_{11}' \cdot U_1^{(2)} = -0{,}271 + j\,0{,}67 \text{ p.u.}$$

$$\left|U_1^{(2)} - U_1^{(1)}\right| = 4{,}5 \cdot 10^{-3}$$ ✓

$$U_2^{(2)} = U_3 + Z_{21} \cdot I_1^{(2)} + Z_{22} \cdot I_2^{(1)} = 1{,}056 - j\,0{,}024 \text{ p.u.}$$

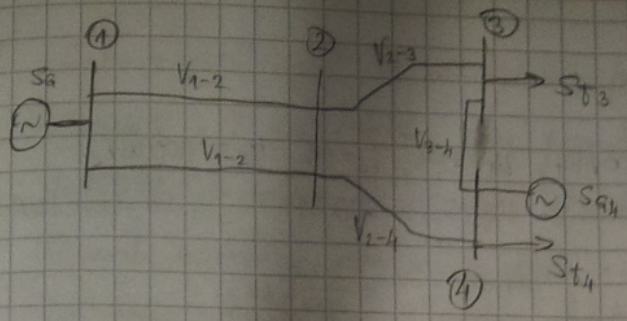
$$\left|U_2^{(2)} - U_2^{(1)}\right| = 7{,}3 \cdot 10^{-4}$$ ✓

$$I_2^{(2)} = -0{,}187 + j\,0{,}09 \text{ p.u.}$$

$$U_1 = 113{,}19 \angle -1{,}7° \text{ kV}$$

$$U_2 = 116{,}12 \angle -1{,}3° \text{ kV}$$

4.



Vodovi

$U_n = 220\ kV$

$R_1 = 0{,}08\ \Omega/km$

$X_1 = 0{,}11\ \Omega/km$

$B_1 = 2{,}7\ \mu S/km$

$l_{12} = l_{34} = 20\ km$

$l_{23} = l_{24} = 25\ km$

$U_1 = 231\angle 0°\ kV = 231\ p.u.$

$U_2 = 229{,}854\angle -0{,}313°\ kV = 229{,}854 - j1{,}256\ p.u.$

$U_3 = 228{,}218\angle -0{,}793°\ kV = 228{,}2 - j3{,}182\ p.u.$

$U_4 = 228{,}370\angle -0{,}606°\ kV = 221{,}354 - j2{,}415\ p.u.$

a) Izr. injekciju djelatne snage u čvorištu 3 (P_3 [MW]).

$Z_{12} = (R_1 + jX_1) \cdot l \cdot \frac{S_B}{U_n^2} = (1{,}3056 \cdot 10^{-2} + j0{,}0159)\ p.u.$

$Y_{12} = Y_{34} = 11{,}095 - j56{,}86\ p.u.$

$Y_{23} = Y_{24} = 8{,}876 - j45{,}488\ p.u.$

$\frac{Y_{012}}{2} = \frac{Y_{034}}{2} = \frac{jB_1}{2} \cdot l_{12} \cdot \frac{U_n^2}{S_B} = j0{,}013\ p.u.$

$\frac{Y_{023}}{2} = \frac{Y_{024}}{2} = j0{,}016834\ p.u.$

a) $S_{32} = U_3 \cdot \left[(U_3 - U_2) \cdot Y_{32} + U_3 \frac{Y_{023}}{2} \right]^* = (228{,}2 - j3{,}182) \cdot \left[(228{,}2 - j3{,}182 - 229{,}854 + j1{,}256) \cdot (8{,}876 - j45{,}488) + (228{,}2 - j3{,}182) \cdot j0{,}016834 \right] = U_3 \cdot (-102{,}24 + j67{,}87)^* = (23{,}53 - j13{,}738)\ kVA$

$S_{34} = U_3 \left[(U_3 - U_4) \cdot Y_{34} + U_3 \frac{Y_{034}}{2} \right]^* = (228{,}2 - j3{,}182) \cdot \left[-45{,}312 + j3{,}38375 \right]^* = (10{,}35036 - 0{,}629)\ kVA$

$S_3 = S_{32} + S_{34} = (-70{,}06 + j29{,}938)\ MVA$

$P_3 = -70{,}06\ MW$

b) $S_{24} = 0{,}315 + j0{,}255\ p.u.$

$S_{42} = -0{,}314 - j0{,}287\ p.u.$

- izr. gubitke djel. snage na vodu V_{2-4} (ΔP_{24} [MW]).

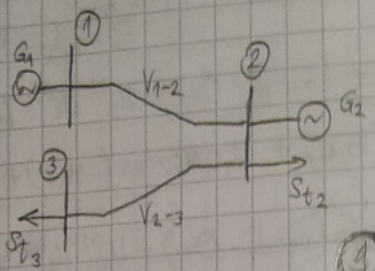
$\Delta S_{24} \cdot S_B = (0{,}066 - j3{,}206)\ MVA$

$\Delta P_{24} = 0{,}066\ MW$

AV 2

Zad. 4. Za mrežu prikazanu slikom odrediti napone [kV] u 1. iteraciji koristeći AV 7 razdvojenu NR metodu. Koristiti baznu snagu $S_B = 100$ MVA i „flat start."

početni kut = 0°



① – referentno čvorište

$S_{t2} = 80 + j30$ $\quad U_1 = 227 \angle 0°$ kV

$S_{t3} = 50 + j10$ $\quad U_2 = 225 \angle \delta_2$ kV

$S_{g_2} = 50 + j Q_2$ $\quad U_3 = U_3 \angle \delta_3$ kV

$P_1 = P_{g1} + j Q_{g1}$

$$Y = \begin{bmatrix} 18{,}19 \angle -84{,}8° & 18{,}26 \angle 95{,}2° & 0 \\ 18{,}26 \angle 95{,}2° & 32{,}8 \angle -84{,}6° & 14{,}61 \angle 95{,}2° \\ 0 & 14{,}61 \angle 95{,}2° & 14{,}61 \angle -84{,}5° \end{bmatrix} \text{ p.u.}$$

$S_2 = \frac{50 - 80 - j30}{100} = -0{,}3 - j0{,}3$ $\qquad S_3 = -0{,}5 - j0{,}1$

F. START: $U_1 = 1{,}032$ p.u., $\delta_1 = 0°$; $U_2 = 1{,}023$ p.u., $\delta_2 = 0°$; F.S.: $U_3 = 1$, $\delta_3 = 0°$

$P_{2r}^{(0)} = U_2^{(0)} \cdot U_1^{(0)} \cdot Y_{21} \cdot \cos(\delta_2 - \delta_1 - \theta_{21}) + U_2^{(0)} \cdot U_2^{(0)} \cdot \cos(\delta_2 - \delta_2 - \theta_{22}) Y_{22} + U_2^{(0)} \cdot U_3^{(0)} \cdot \cos(\delta_2 - \delta_3 - \theta_{23}) \cdot Y_{23} =$

$P_{2r}^{(0)} = 19{,}278 \cdot \cos(-95{,}2°) + 31{,}326 \cdot \cos(84{,}6°) + 14{,}946 \cdot \cos(-95{,}2°) = 0{,}1286$ p.u.

$Q_{2r}^{(0)} = 0{,}0905$ p.u.

$P_{3r}^{(0)} = U_3^{(0)} \cdot [U_1^{(0)} \cdot Y_{31} \cdot \cos(\delta_3 - \delta_1 - \theta_{31}) + U_2^{(0)} \cdot \cos(\delta_3 - \delta_2 - \theta_{32}) \cdot Y_{32} + U_3^{(0)} \cdot Y_{33} \cdot \cos(\delta_3 - \delta_3 - \theta_{33})]$

$P_{3r}^{(0)} = [0 + 14{,}946 \cdot \cos(-95{,}2°) + 14{,}61 \cdot \cos(84{,}5°)] - 0{,}046$ p.u.

$Q_{3r}^{(0)} = -0{,}342$ p.u.

$$\Delta P^{(0)} = \begin{vmatrix} P_2 - P_{2\,rač}^{(0)} \\ P_3 - P_{3\,rač}^{(0)} \end{vmatrix} = \begin{vmatrix} -0{,}1286 \\ -0{,}546 \end{vmatrix} \text{ p.u.} \qquad \Delta Q^{(0)} = \begin{vmatrix} Q_2 - Q_{2r}^{(0)} \\ Q_3 - Q_{3r}^{(0)} \end{vmatrix} = \begin{vmatrix} -0{,}3905 \\ 0{,}242 \end{vmatrix} \text{ p.u.}$$

$J_1^{(0)}$:

$\left(\frac{\partial P_2}{\partial \delta_2}\right)^{(0)} = -U_2^{(0)} \cdot (U_1^{(0)} \cdot Y_{21} \cdot \sin(\delta_1 - \delta_2 - \theta_{21}) + U_3^{(0)} \cdot Y_{23} \cdot \sin(\delta_1 - \delta_3 - \theta_{13})) = -34{,}083$ p.u.

$\left(\frac{\partial P_2}{\partial \delta_3}\right)^{(0)} = U_2^{(0)} \cdot U_3^{(0)} \cdot Y_{23} \cdot \sin(\delta_1 - \delta_3 - \theta_{13}) = -14{,}885$ p.u.

$\left(\frac{\partial P_3}{\partial \delta_2}\right)^{(0)} = U_3^{(0)} \cdot U_2^{(0)} \cdot Y_{32} \cdot \sin(\delta_3 - \delta_1 - \theta_{21}) = -14{,}885$ p.u.

$\left(\frac{\partial P_3}{\partial \delta_3}\right)^{(0)} = -U_3^{(0)} \cdot (U_1^{(0)} \cdot Y_{31} \cdot \sin(\delta_3 - \delta_1 - \theta_{31}) + U_2^{(0)} \cdot Y_{32} \cdot \sin(\delta_3 - \delta_2 - \theta_{32})) = 14{,}885$ p.u.

$$\left(\frac{\partial Q_3}{\partial U_3}\right)^{(0)} = 2 \cdot U_3^{(0)} \cdot Y_{33} \cdot \sin(-\Theta_{33}) + U_1^{(0)} \cdot Y_{31} \cdot \sin(-\Theta_{31}) + U_2^{(0)} \cdot Y_{32} \cdot \sin(-\Theta_{32}) = 14{,}201 \text{ p.u.}$$

$$J_1^{(0)} = \begin{vmatrix} \frac{\partial P_2}{\partial \delta_2} & \frac{\partial P_2}{\partial \delta_3} \\ \frac{\partial P_3}{\partial \delta_2} & \frac{\partial P_3}{\partial \delta_3} \end{vmatrix} = \begin{vmatrix} +34{,}083 & -14{,}885 \\ -14{,}885 & 14{,}885 \end{vmatrix} \qquad J_4^{(0)} = \left|\frac{\partial Q_3}{\partial U_3}\right| = |14{,}201|$$

$$\left(J_1^{(0)}\right)^{-1} = \begin{vmatrix} 0{,}052 & 0{,}052 \\ 0{,}052 & 0{,}1193 \end{vmatrix} \text{ p.u.} \qquad \left(J_4^{(0)}\right)^{-1} = |0{,}0704|$$

$$\Delta\delta^{(0)} = \left(J_1^{(0)}\right)^{-1} \cdot \Delta P^{(0)} = \begin{vmatrix} -0{,}0507 \\ -0{,}0874 \end{vmatrix} \text{rad} = \begin{vmatrix} -2{,}905° \\ -5{,}01° \end{vmatrix}$$

$$\Delta U^{(0)} = \Delta U_3^{(1)} = \left(J_4^{(0)}\right)^{-1} \cdot \Delta Q_2^{(0)} = 0{,}0704 \cdot 0{,}242 = 0{,}017 \text{ p.u.}$$

$$U_3^{(1)} = U_3^{(0)} + \Delta U_3^{(0)} = 1 + 0{,}017 = 1{,}017 \text{ p.u.}$$

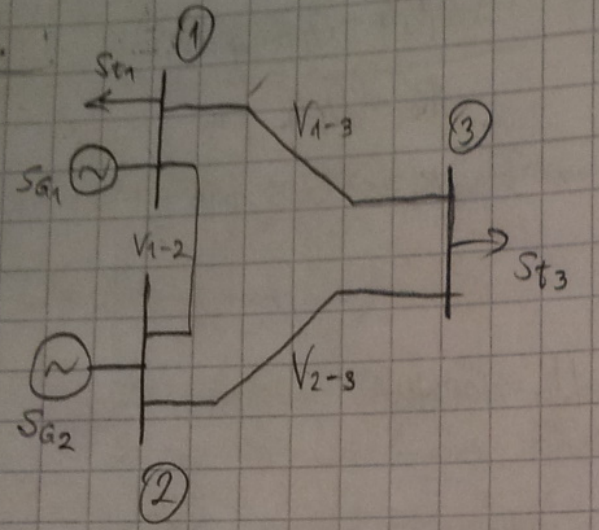
$$\begin{vmatrix} \delta_2^{(1)} \\ \delta_3^{(1)} \end{vmatrix} = \begin{vmatrix} \delta_2^{(0)} \\ \delta_3^{(0)} \end{vmatrix} + \Delta\delta^{(0)} = \begin{vmatrix} -2{,}905° \\ -5{,}01° \end{vmatrix}$$

$$U_2 = 225 \angle -2{,}905° \text{ kV}$$

$$U_3 = 223{,}74 \angle -5{,}01° \text{ kV}$$

Zad. 2.

A AV8.



$x_1 = 0{,}12\ \Omega/km$

$l_{12} = 50\ km$

$l_{13} = l_{23} = 100\ km$

$S_{t1} = 80\ MW$

$S_{t3} = 50\ MW$

$S_{G_2} = 100\ MW$

$U_n = 110\ kV$

$S_B = 100\ MVA$

a) odrediti tokove snaga u granama

$$Z_{12} = j x_1 \frac{S_B}{U_n^2} = j\,0{,}1736\ p.u.$$

$$Z_{13} = Z_{23} = Z_{12} \cdot 2 = j\,0{,}347\ p.u.$$

② - ref. $\Rightarrow$ NE

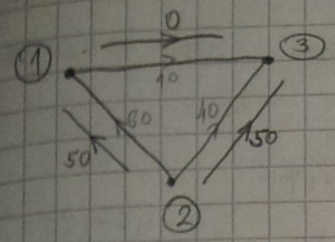
$$Y_{12} = \frac{1}{Z_{12}} = -j\,5{,}762\ p.u. \qquad Y_{13} = Y_{23} = -j\,2{,}881$$

$$Y = \begin{vmatrix} Y_{12}+Y_{13} & -Y_{12} & -Y_{13} \\ -Y_{12} & Y_{12}+Y_{23} & -Y_{23} \\ -Y_{13} & -Y_{23} & Y_{13}+Y_{23} \end{vmatrix} = \begin{vmatrix} -j\,8{,}643 & j\,5{,}762 & j\,2{,}881 \\ j\,5{,}762 & -j\,8{,}643 & j\,2{,}881 \\ j\,2{,}881 & j\,2{,}881 & -j\,8{,}643 \end{vmatrix} = \begin{vmatrix} -j\,8{,}643 & j\,2{,}881 \\ j\,2{,}881 & -j\,8{,}643 \end{vmatrix}$$

$$Z = Y^{-1} = \begin{vmatrix} j\,0{,}139 & j\,0{,}069 \\ j\,0{,}069 & j\,0{,}139 \end{vmatrix}$$

$P_1' =$

b) odredite reaktanciju voda kojeg bi trebalo dodati u paralelni pogon s vodom V_{2-3} tako za zadano stacionarno stanje vodom V_{1-2} ne bi tekla snaga veća od 50 MW.



$P_{12} = -0,5$ p.u.

$P_{13} = 0$ p.u.

$P_{23} = +0,5$ p.u.

$\delta_1 = 0$

$P_{12} = \frac{\delta_1 - \delta_2}{jX_{12}} \Rightarrow \delta_2 = -P_{12} \cdot jX_{12} = 0,5 \cdot j0,174 = j0,087$ p.u.

$P_{13} = \frac{\delta_1 - \delta_3}{jX_{13}} = 0 \qquad \delta_3 = 0$

$P_{23} = \frac{\delta_2 - \delta_3}{jX_{23}} = 0,5 \Rightarrow \delta_2 = P_{23} \cdot jX_{23} + \delta_3 = 0,5 \cdot j0,347 = j0,174$ p.u.

$X_{23} = \frac{X_{23}' \cdot X_{23}''}{X_{23}' + X_{23}''} \Rightarrow X_{23}'' = 0,347$ p.u.

AV. 8 – Zad 2.

a) $X_{12} = 0,174$ p.u. $\rightarrow y_{12} = -j5,762$ p.u.

$X_{13} = X_{23} = 0,347$ p.u. $\rightarrow y_{13} = y_{23} = -j2,881$ p.u.

① → ref $\qquad Y = \begin{vmatrix} Y_{12}+Y_{23} & -Y_{23} \\ -Y_{23} & Y_{13}+Y_{23} \end{vmatrix} = \begin{vmatrix} -j8,643 & j2,881 \\ j2,881 & -j5,762 \end{vmatrix} \qquad Z = Y^{-1} = \begin{vmatrix} j0,1388 & j0,0694 \\ j0,0694 & j0,2083 \end{vmatrix}$

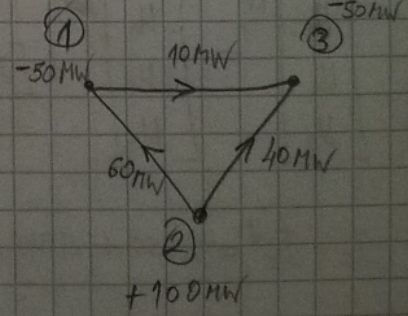
$\delta_1 = 0$

$\begin{vmatrix} \delta_2 \\ \delta_3 \end{vmatrix} = |Z| \cdot \begin{vmatrix} P_2 \\ P_3 \end{vmatrix} = \begin{vmatrix} j0,104131 \\ -j0,0347 \end{vmatrix}$

$P_{1-2} = \frac{\delta_1 - \delta_2}{X_{12}} = \frac{-j0,1041}{j0,174} = -0,598$ p.u. $= -59,8$ MW ≈ 60 MW

$P_{1-3} = \frac{\delta_1 - \delta_3}{X_{13}} = \frac{j0,0347}{j0,347} = 0,1$ p.u. $= 10$ MW

$P_{2-3} = \frac{\delta_2 - \delta_3}{X_{23}} = \frac{j0,13883}{j0,4347} = 0,4$ p.u. $= 40$ MW

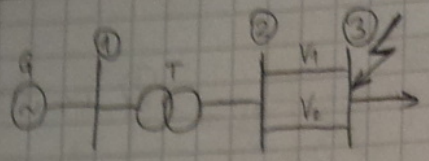


ANALIZA EE SUSTAVA

AV 2

AV 1. Zad. 2

SpKS



Generator	Trafo	Vodovi
$U_{n1} = 10,5$ kV	$\frac{U_{n1}}{U_{n2}} = \frac{10,5}{110}$ kV	$U_n = 110$ kV
$S_n = 25$ MVA	$S_n = 25$ MVA	$x_1 = 0,42\ \Omega/\text{km}$
$x_d'' = 10\%$	$u_k = 15\%$	$l = 100$ km

- odrediti struju SpKS [A] i napone u čvorištima bolesne mreže [V]
- mreža je u trenutku nastanka KS bila neopterećena $\Rightarrow U_1^{\text{zd}} = U_2^{\text{zdr}} = U_3^{\text{zdr}} = 1$ p.u.

$$x_g = x_d'' \cdot \frac{S_B}{S_{n1}} = j0,4 \text{ p.u.} \qquad x_t = u_k \cdot \frac{S_B}{S_{nT}} = j0,6 \text{ p.u.}$$

$$y_g = \frac{1}{x_g} = -j2,5 \text{ p.u.} \qquad y_t = \frac{1}{x_t} = -j1,67 \text{ p.u.}$$

$$x_{23}' = x_{23}'' = jx_1 l \frac{S_B}{U_{n2}^2} = j0,347 \text{ p.u.} \Rightarrow y_{23}' = y_{23}'' = -j2,881 \text{ p.u.}$$

$$Y = \begin{vmatrix} y_g + y_T & -y_T & 0 \\ -y_T & y_T + 2y_{23} & -(2y_{23}) \\ 0 & -2y_{23} & y_{23} \cdot 2 \end{vmatrix} = \begin{vmatrix} -j4,167 & j1,67 & 0 \\ j1,67 & -j7,429 & j5,762 \\ 0 & j5,762 & -j5,762 \end{vmatrix} \text{ p.u.}$$

$$Z = Y^{-1} = \begin{vmatrix} j0,4 & j0,4 & j0,4 \\ j0,4 & j1 & j1 \\ j0,4 & j1 & j1,175 \end{vmatrix} \text{ p.u.}$$

$$U_3^{kv} = 0 = U_3^{zd} + Z_{33} \cdot I_3^{kv} \Rightarrow I_{3kv} = -\frac{U_3^{zd}}{Z_{33}} = \frac{-1}{j1,175} = -j0,852 \text{ p.u.}$$

$$\begin{bmatrix} U_1 \\ U_2 \\ U_3 \end{bmatrix}^{kv} = \begin{bmatrix} U_1 \\ U_2 \\ U_3 \end{bmatrix}^{zdr} + Z_{ii} \cdot \begin{bmatrix} 0 \\ 0 \\ I_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} + \begin{bmatrix} -0,341 \\ -0,852 \\ -1 \end{bmatrix} = \begin{bmatrix} 0,659 \\ 0,148 \\ 0 \end{bmatrix} = \begin{bmatrix} 6,92 \\ 16,28 \\ 0 \end{bmatrix} \text{ kV}$$

(×10,5 kV; ×110)

$$I_3 [\text{kA}] = -I_{kv} \cdot \frac{S_B}{\sqrt{3} \cdot U_n} = -j0,852 \cdot \frac{100}{\sqrt{3} \cdot 110} = -j0,4472 \text{ kA}$$

AV 2.

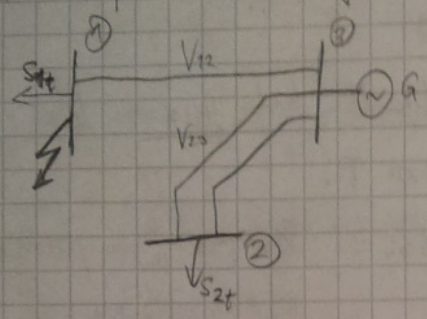
3. zad – ZI 09/10. ⇒ dopušteno struja u odt. čvorištu se dobije tako da se zbroje sve struje koje ulaze u to čvorište

⇓

u čvor 3 ulaze I_{13} i I_{23} ⟶ $I_{1-3} = \frac{U_1 - U_3}{X_{1-3}}$, $I_{2-3} = \frac{U_2 - U_3}{X_{2-3}}$

AV 10.

Zad 3. 2pKS SA ZEMLJOM (generator direktno uzemljen)



G	V_{12}, V_{13}
U_n = 110 kV	U_n = 110 kV
S_n = 25 MVA	$X_{d1} = X_{i1} = 0{,}42\,\Omega/km$
x_d'' = 10%	$X_{01} = 0{,}96\,\Omega/km$
x_i'' = 10%	l = 50 km
x_0'' = 10%	

S_B = 100 MVA

- KS u transformatoru kod je mreža bila neoptarećena

$U_2^T = ?$

$X_G = jx_d'' \cdot \frac{S_B}{S_n} = j0{,}4$ p.u.

$y_G = \frac{1}{x_G} = -j2{,}5$ p.u.

$X_{V_d} = X_{V_i} = j \cdot X_{d1} \cdot l \cdot \frac{S_B}{U_n^2} = j0{,}191$ p.u.

$y_{V_d} = y_{V_i} = \frac{1}{X_{Vd}} = -j5{,}262$ p.u.

$X_{V0} = jX_{01} \cdot l \cdot \frac{S_B}{U_n^2} = j0{,}521$ p.u.

$y_{V0} = \frac{1}{X_{V0}} = -j1{,}921$ p.u.

- Zanemaruju se admitancije tereta, generator direktno uzemljen

$$Y_0 = \begin{bmatrix} y_{V0} & 0 & -y_{V0} \\ 0 & 2 \cdot y_{V0} & -2y_{V0} \\ -y_{V0} & -2y_{V0} & y_G + 3y_{V0} \end{bmatrix} = \begin{bmatrix} -j1{,}921 & 0 & j1{,}921 \\ 0 & -j3{,}842 & j3{,}842 \\ j1{,}921 & j3{,}842 & -j8{,}263 \end{bmatrix}$$

$$Z_0^{-1} = \begin{bmatrix} j0{,}921 & j0{,}4 & j0{,}4 \\ j0{,}4 & j0{,}66 & j0{,}4 \\ j0{,}4 & j0{,}4 & j0{,}4 \end{bmatrix}$$

$$I_{d_1} = \frac{-{}^F U_1^d (Z_{11}^0 + Z_{11}^i)}{Z_{11}^d \cdot Z_{11}^i + Z_{11}^d \cdot Z_{11}^0 + Z_{11}^i \cdot Z_{11}^0} = \frac{-1(j0{,}921 + j0{,}574)}{-2 \cdot 0{,}5286 + (-0{,}3295)} = j1{,}0781 \text{ p.u.}$$

$$I_{i_1} = \frac{{}^F U_1 \cdot Z_{11}^0}{\text{---}} = \frac{1 \cdot (j0{,}921)}{-1{,}3867} = -j0{,}6642 \text{ p.u.}$$

$$I_{0_1} = \frac{{}^F U_1 \cdot Z_{11}^i}{\text{---}} = \frac{\text{---}}{\text{---}} = -j0{,}414 \text{ p.u.}$$

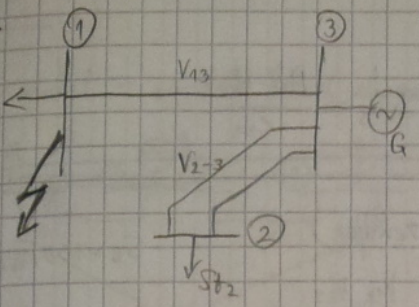
$$\begin{bmatrix} U_1^d \\ U_2^d \\ U_3^d \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} + [Z_d] \cdot \begin{bmatrix} I_{d_1} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0{,}381 \\ 0{,}569 \\ 0{,}569 \end{bmatrix} \text{ p.u.} \qquad \begin{bmatrix} U_1^i \\ U_2^i \\ U_3^i \end{bmatrix} = [Z_i] \cdot \begin{bmatrix} I_{i_1} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0{,}381 \\ 0{,}266 \\ 0{,}266 \end{bmatrix} \text{ p.u.} \qquad \begin{bmatrix} U_1^0 \\ U_2^0 \\ U_3^0 \end{bmatrix} = \begin{bmatrix} 0{,}381 \\ 0{,}166 \\ 0{,}166 \end{bmatrix} \text{ p.u.}$$

$$U_2^T = 1 \cdot U_2^0 + a^2 \cdot U_2^d + a \cdot U_2^i = 0{,}166 + (-0{,}2845 - j0{,}193) + (-0{,}133 + j0{,}23)$$

$$U_2^T = -0{,}2515 - j0{,}2626 \text{ p.u.} = -27{,}665 - j28{,}89 \text{ kV}$$

$$U_2^T = 40 \angle +133{,}76° \text{ kV}$$

AV 10.
Zad. 3



GENERATOR	V_{12}, V_{13}
$U_n = 110\,kV$	$U_n = 110\,kV$
$S_n = 25\,MVA$	$x_{d_1} = 0{,}12\,\Omega/km$
$x_d'' = 10\%$	$x_{i_1} = 0{,}12\,\Omega/km$
$x_i^0 = 10\%$	$l = 50\,km$

$S_B = 100\,MVA$

U mreži prikazanoj slikom nastao je 2p KS u čvorištu 1 u trenutku kada je mreža bila neopterećena. Odredite napone bočne mreže [kV] za stranu T.

$$x_d = jx_d'' \cdot \frac{S_B}{S_{n_G}} = 0{,}1 \cdot \frac{100}{25} = j0{,}4\ p.u. \qquad x_i = jx_i^0 \cdot \frac{S_B}{S_{n_G}} = j0{,}4\ p.u. \qquad x_v = jx_{d_1} \cdot \frac{S_B}{U_n^2} l = j0{,}174\ p.u.$$

$$y_d = -j2{,}5\ p.u. \qquad y_i = -j2{,}5\ p.u. \qquad y_v = -j5{,}762\ p.u.$$

$$Y = \begin{bmatrix} y_v & 0 & -y_v \\ 0 & 2y_v & -2y_v \\ -y_v & -2y_v & y_d + 3y_v \end{bmatrix} = \begin{bmatrix} -j5{,}762 & 0 & j5{,}762 \\ 0 & -j11{,}524 & j11{,}524 \\ j5{,}762 & j11{,}524 & -j19{,}786 \end{bmatrix} p.u.$$

$$Z_d = Z_i = Y^{-1} = \begin{bmatrix} j0{,}574 & j0{,}4 & j0{,}4 \\ j0{,}4 & j0{,}487 & j0{,}4 \\ j0{,}4 & j0{,}4 & j0{,}4 \end{bmatrix}$$

$$I_{d_1} = \frac{-U_1^{d_0}}{Z_{22}^i + Z_{20}^d} = \frac{-1}{j0{,}574 + j0{,}574} = j0{,}8711\ p.u.$$

$$I_{i_1} = -I_{d_1} = -j0{,}8711\ p.u.$$

$$I_{0_1} = 0\ p.u.$$

$$\begin{bmatrix} U_1^d \\ U_2^d \\ U_3^d \end{bmatrix} = \begin{bmatrix} U_1^{d_0} \\ U_2^d \\ U_3^d \end{bmatrix}^{Z_{kr}} + [Z] \cdot \begin{bmatrix} I_{d_1} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} + \begin{bmatrix} -0{,}5 \\ -0{,}348 \\ -0{,}348 \end{bmatrix} = \begin{bmatrix} 0{,}5 \\ 0{,}652 \\ 0{,}652 \end{bmatrix} p.u.$$

$$\begin{bmatrix} U_1^i \\ U_2^i \\ U_3^i \end{bmatrix} = [Z] \cdot \begin{bmatrix} I_{i_1} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0{,}5 \\ 0{,}348 \\ 0{,}348 \end{bmatrix} p.u.$$

$$\begin{bmatrix} U_1^R \\ U_1^S \\ U_1^T \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \cdot \begin{bmatrix} U_1^0 \\ U_1^d \\ U_1^i \end{bmatrix} = \begin{bmatrix} 1 \\ -0{,}5 \\ -0{,}5 \end{bmatrix} \qquad \begin{bmatrix} U_2^R \\ U_2^S \\ U_2^T \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \cdot \begin{bmatrix} U_2^0 \\ U_2^d \\ U_2^i \end{bmatrix} = \begin{bmatrix} 1 \\ -0{,}5 - j0{,}263 \\ -0{,}5 + j0{,}263 \end{bmatrix}$$

$$\begin{bmatrix} U_3^R \\ U_3^S \\ U_3^T \end{bmatrix} = \begin{bmatrix} 1 \\ -0{,}5 - j0{,}263 \\ -0{,}5 + j0{,}263 \end{bmatrix}$$

$$U_{1T} = 55\angle 180°\ kV, \quad U_{2T} = 62{,}14\angle 152{,}26°\ kV, \quad U_{3T} = 62{,}14\angle -152{,}26°\ kV$$