

M1 2014/2015

1.  $U_n = 220 \pm 10\% / 15\% / 110 \text{ kV}$

$S_n = 150 \text{ MVA}$

$U_K = 10,5\%$

$n_1 = 0$

$n_2 = -5$

$S_B = 100 \text{ MVA}$

$a_1'' = 0,925$

$Z_T = j 0,07$

$Y_T = -j 14,286$

$Y_{12}' = Y_T$

$Y_{12}'' = -j 15,144 = \frac{Y_T}{a_1''}$

$Y_{01}'' = -j 9,252$

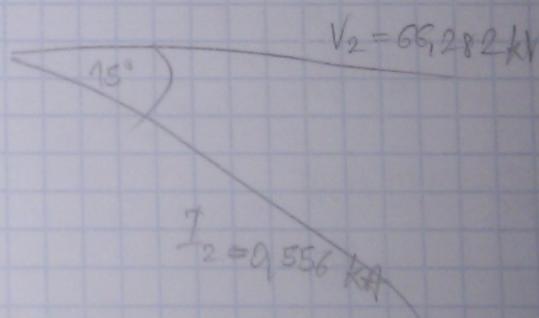
$Y_{02}'' = j 11,58$

$I = Y \cdot U$

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

$V_2 = 66,282 \text{ kV}$

$U_2 = V_2 \cdot \sqrt{3}$



+ ... + 100 - (577,000 - j 113,9) A

$$V_2 = 66,282 \text{ kV}$$

$$U_2 = V_2 \cdot \sqrt{3}$$

$$I_2 = 9556 \angle -15^\circ \text{ kA} = (537,055 - j143,9) \text{ A}$$

$$U_2 = \frac{U_2(\text{kV})}{U_n} = 1,044$$

$$I_2 = \frac{\sqrt{3} \cdot U_n \cdot I_2[\text{A}]}{S_B}$$

$$I_2 = -9,023 + j9,274$$

$$S_{2T}^* = 3 V_2 \cdot I_2^*$$

$$S_{2T} = 106,8 + j28,02 \text{ MVA}$$

$$I_2 = \left( \frac{S_2}{U_2} \right)^* = -9,023 + j9,274$$

$$2. \quad \frac{U_1^{(2)}}{\underline{d_1}^{(2)}} = ?$$

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GS-Y

$$\alpha = 1,1$$

$$U_1^{(2)} = U_2^{(2)} = 110 \angle 10^\circ \text{ kV}$$

$$S_0 = 100 \text{ MVA}$$

$$S_{T_1} = 70 + j30 \text{ MVA}$$

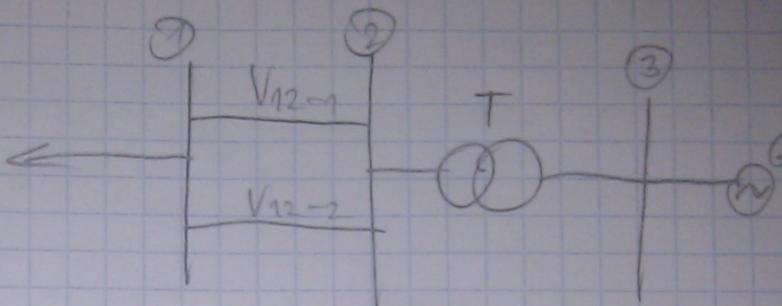
$$U_3 = 16 \text{ kV}$$

$$S_n = 150 \text{ MVA}$$

$$T \Rightarrow U_k = 10,5\%$$

$$\frac{U_{n_1}}{U_{n_2}} = \frac{15,75}{110} \text{ kV}$$

$$U_{n_1} = 16 \text{ kV}$$



$$Y_T = -j14,286$$

$$Y_V = 1,591 - j5,437$$

$$\frac{Y_{nV}}{2} = j8,23 \cdot 10^{-3}$$

$$3,182 - j10,587 \quad -3,182 + j10,873 \quad 0$$

$$Y = \begin{vmatrix} 3,182 - j25,143 & j14,286 & 0 \\ 0 & j14,286 & -j14,286 \end{vmatrix} \text{ p.u.}$$

$$S_1 = 0 + j0,3$$

Vodovod  $V_{12-1}, V_{12-2}$

$$S_1 = 0.7 - j 0.3$$

$$R_1 = 0.12 \Omega/km$$

$$S_2 = 0$$

$$X_1 = 0.41 \Omega/km$$

$$d_3 = \frac{16}{15.75} = 1.016$$

$$B_1 = 2.72 \mu S/km$$

$$l = 50 km$$

$$KL_1 = \frac{S_1^*}{Y_{11}} = -0.013 - j 0.052$$

$$KL_2 = 0$$

$$YL_{12} = \frac{Y_{12}}{Y_{11}} = -1.001$$

$$YL_{21} = \frac{Y_{21}}{Y_{22}} = -0.441 - j 0.071$$

$$YL_{13} = \frac{Y_{13}}{Y_{11}} = 0$$

$$YL_{23} = \frac{Y_{23}}{Y_{22}} = -0.553 + j 0.071$$

$$U_1^{(1)} = \frac{KL_1}{(U_1^{(0)})^*} - YL_{12} \cdot U_2^{(0)} - YL_{13} \cdot U_3^{(0)} = 0.953 - j 0.057 \text{ p.u.}$$

$$\underline{U_1 - u_{br}}^{(1)} = U_1^{(0)} + \alpha (U_1^{(1)} - U_1^{(0)}) = 0.954 - j 0.058 \text{ p.u.}$$

$$|U_1^{(1)} - U_1^{(0)}| = 0.0734$$

2. nastavak

$$U_2^{(1)} = \frac{KL_2}{(U_2^{(0)})^*} - YL_{21} \cdot U_{1-Ubr}^{(1)} - YL_{23} \cdot U_3$$

$$U_2^{(1)} = 0,9935 - j0,0298 \text{ p.u.}$$

$$U_{2-Ubr}^{(1)} = U_2^{(0)} + \alpha (U_{2-Ubr}^{(1)} - U_2^{(0)}) = 0,993 - j0,033$$

$$|U_{2-Ubr}^{(1)} - U_2^{(0)}| = 0,034$$

$$U_1^{(2)} = \frac{KL_1}{(U_1-Ubr)^*} - YL_{12} \cdot U_{2-Ubr}^{(1)} - Y_{13} \cdot U_3 = 0,946 - j0,087 \text{ p.u.}$$

$$U_{1-Ubr}^{(2)} = U_{1-Ubr}^{(1)} + \alpha (U_1^{(2)} - U_{1-Ubr}^{(1)}) = 0,945 - j0,087 \text{ p.u.}$$

$$|U_{1-Ubr}^{(2)} - U_{1-Ubr}^{(1)}| = \dots$$

$$U_1^{(2)} = KL_1 - Y_1 \cdot U_1^{(2)} - Y_{13} \cdot U_3 = 0,992 - j0,041 \text{ p.u.}$$

$$\left( \begin{array}{c} U_1 - U_{br} \\ U_2 - U_{br} \end{array} \right) = \dots$$

$$U_2^{(2)} = \frac{KL_2}{\overline{(U_2 - U_{br})^{(1)}}^*} - YL_{21} \cdot U_1 - U_{br}^{(2)} - YL_{23} \cdot U_3 = 0,992 - j0,044 \text{ p.u.}$$

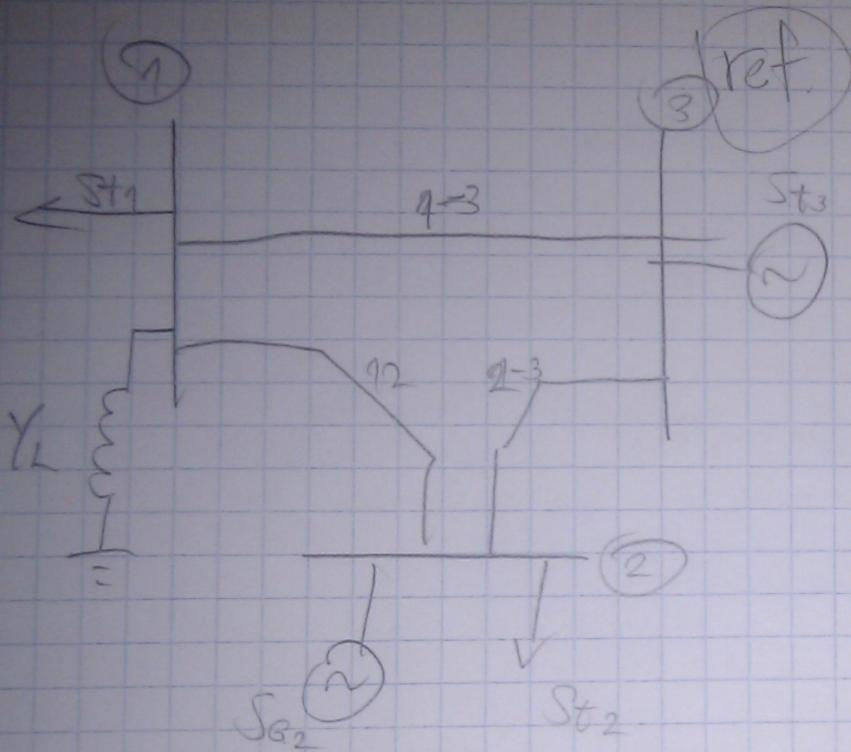
$$U_2 - U_{br}^{(2)} = U_2 - U_{br}^{(1)} + \alpha (U_2^{(2)} - U_2 - U_{br}^{(1)}) = 0,991 - j0,045 \text{ p.u.}$$

$$\left| U_2 - U_{br}^{(2)} - U_2 - U_{br}^{(1)} \right| = 0,012$$

$$U_1 - U_{br}^{(2)} = 104,4 \angle -53^\circ \text{ kV}$$

$$U_2 - U_{br}^{(2)} = 109,2 \angle -216^\circ \text{ kV}$$

3.



$$U_n = 110 \text{ kV}$$

$$X_1 = 0.42 \sqrt{2} / \text{km}$$

$$B_n = 2.72 \mu\text{s}/\text{km}$$

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

$$S_{1T} = 30 - j10 \text{ MVA}$$

$$S_{2T} = 50 + j25$$

$$S_{2G} = 30 + j15$$

$$U_3 = 120 \angle 10^\circ \text{ kV}$$

65-2

$$Y_L = -j6,198 \cdot 10^{-3} \text{ S}$$

$$\epsilon = 10^{-2} \text{ tochnost}$$

$$U_1^{(0)} = U_2^{(0)} = 110 \angle 0^\circ$$

$$\underline{U_1 \angle 5^\circ} = ? \text{ kV}$$

$$Y_{12} = -j11,524$$

$$Y_{23} = Y_{12}$$

$$Y_{13} = -j5,762$$

$$U_{n2}$$

$$Y_1 = -j6,198 \cdot 10^{-3} \cdot \left( \frac{110^2}{110} \right) = -j0.75 \mu\text{u}$$

$$\frac{Y_{012}}{2} = j 4,114 \cdot 10^{-3}$$

$$\frac{Y_{013}}{2} = j 8,123 \cdot 10^{-3}$$

$$Y =$$

$$\begin{vmatrix} -j 17,286 & j 11,521 \\ j 11,521 & -j 23,048 \end{vmatrix}$$

$$Y' = \begin{vmatrix} \frac{Y_{012}}{2} + \frac{Y_{013}}{2} + Y_1 & \\ & \frac{Y_{012}}{2} + \frac{Y_{013}}{2} \end{vmatrix}$$

$$Y' = \begin{vmatrix} -j 0,738 & \\ & j 8,123 \cdot 10^{-3} \end{vmatrix}$$

$$Z = Y^{-1} = \begin{vmatrix} j 0,087 & j 0,043 \\ j 0,043 & j 0,065 \end{vmatrix}$$

$$S_1 = -0,3 + j 0,1$$

$$S_2 = -0,2 - j 0,1$$

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

$$I_1^{(0)} = \left( \frac{S_1}{U_1^{(0)}} \right)^* - Y_{11}' \cdot U_1^{(0)} = -0,3 + j 0,9638 \text{ p.u.}$$

$$I_2^{(0)} = \left( \frac{S_2}{U_1^{(0)}} \right)^* - Y_{21}' \cdot U_1^{(0)} = -0,2 + j 0,093 \text{ p.u.}$$

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

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

$$I_2^{(0)} = \left( \frac{S_2}{U_2^{(0)}} \right)^* - Y_{21}^* \cdot U_2^{(0)} = -0,2 + j 0,093 \text{ p.u.}$$

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

$$I_1^{(1)} = \left( \frac{S_1}{U_1^{(1)}} \right)^* - Y_{11} \cdot U_1^{(1)} = -0,268 + j 0,674 \text{ p.u.}$$

$$|U_1^{(1)} - U_1^{(0)}| = 0,047 > \epsilon$$

### 3. nastavak

$$U_2^{(1)} = U_3 + Z_{21} \cdot I_1^{(1)} + Z_{22} \cdot I_2^{(0)} = 1,056 - j 9,025 \text{ p.u.}$$

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

$$|U_2^{(1)} - U_2^{(0)}| = 0,061$$

2. iteracija:

$$U_1^{(2)} = U_3 + Z_{11} \cdot I_1^{(1)} + Z_{12} \cdot I_2^{(1)} = 1,029 - j 9,31 \text{ p.u.}$$

$$I_1^{(2)} = \left( \frac{S_1}{U_1^{(2)}} \right)^* - Y_{11}^{-1} \cdot U_1^{(2)} = -0,251 + j 0,67 \text{ p.u.}$$

$$|U_1^{(2)} - U_1^{(1)}| = 4,5 \cdot 10^{-3} \text{ V}$$

$$U_2^{(2)} = U_3 + Z_{21} \cdot I_1^{(2)} + Z_{22} \cdot I_2^{(1)} = 1,056 - j 9,024 \text{ p.u.}$$

$$|U_2^{(2)} - U_2^{(1)}| = 7,3 \cdot 10^{-4} \text{ V}$$

$$I_2^{(2)} = -0,187 + j 0,03 \text{ p.u.}$$

$U_1 = 113,49 \angle -17^\circ \text{ kV}$   
 $U_2 = 116,12 \angle -9,3^\circ \text{ kV}$

$$4. \quad U_n = 220 \text{ kV}$$

$$R_1 = 0,0812 \text{ /km}$$

$$X_1 = 0,41 \text{ } \Omega/\text{km}$$

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

$$U_1 = 231,00 \angle 0^\circ \text{ kV}$$

$$U_2 = 229,85 \angle -0,31^\circ \text{ kV}$$

$$U_3 = 228,218 \angle -0,799^\circ \text{ kV}$$

$$U_4 = 228,870 \angle -0,606^\circ \text{ kV}$$

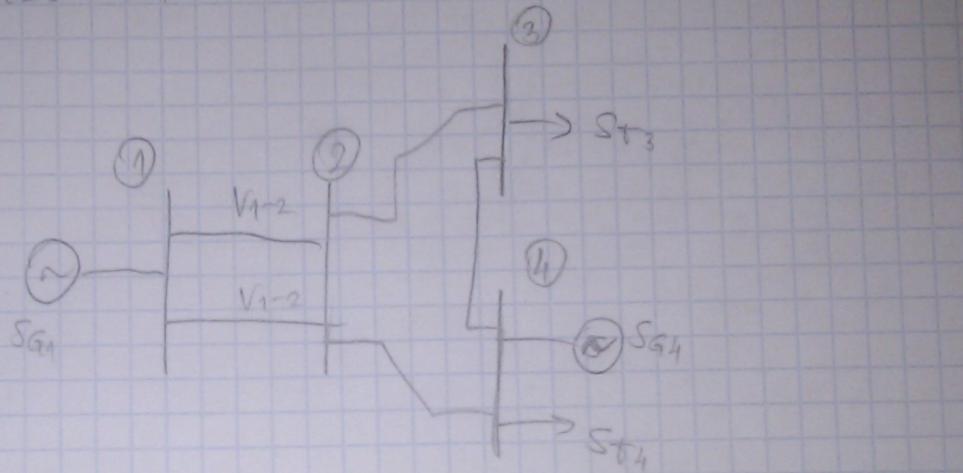
$$Y_{12} = 11,05 - j56,86$$

$$Y_{34} = Y_{12}$$

$$Y_{23} = 8,876 - j45,49 \text{ p.u.}$$

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

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



a) iziskani snage u čvoristu 3 ( $P_3 [\text{MW}]$ )

b) gubitci dodatne snage na radu  $V_{2-4}$  ( $\Delta P_{24} [\text{MW}]$ )

$$\frac{Y_{012}}{2} = j0,073$$

$$\frac{Y_{023}}{2} = j0,016$$

$$\frac{Y_{034}}{2} = \frac{Y_{012}}{2}$$

$$\frac{Y_{024}}{2} = \frac{Y_{023}}{2}$$

$$Y_{23} = 8,876 - j45,49 \text{ p.u.}$$

$$\frac{Y_{034}}{2} = \frac{Y_{012}}{2}$$

$$\frac{Y_{024}}{2} = \frac{Y_{023}}{2}$$

$$Y_{24} = Y_{23}$$

- najbrz<sup>y</sup> na<sup>ch</sup>:

$$U_1 = 1,05 \angle 0^\circ$$

a)

$$S_{32} = U_3 \cdot \left[ (U_3 - U_2) \cdot Y_{32} + U_3 \cdot \frac{Y_{023}}{2} \right]^*$$

$$S_{34} = U_3 \cdot \left[ (U_3 - U_4) \cdot Y_{34} + U_3 \cdot \frac{Y_{034}}{2} \right]^*$$

$$S_3 = + S_{32} + S_{34}$$

$$U_4 = 1,038 \angle 0,006^\circ$$

$$S_3 = -70,06 + j29,998 \text{ MVA}$$

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

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

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

$$\Delta S_{24} \cdot S_B = 0,066 - j 3,206 \text{ MVA}$$

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