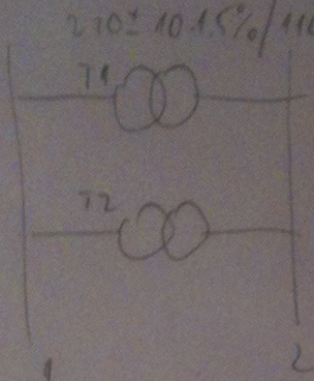
AES - MI 13/14

1.



$S_n = 150\,MVA$

$u_k = 10.5\%$

$P_0 = 0,\ P_{Cu} P_k = 0$

$T_1: n_1 = 15$

$T_2: n_2 = 0$

Trasf. a vuoto lato 1

$U_1 = 220\,kV$

$S_0 = 100\,MVA$

$U_1 = ?$ $\quad U_n = U_2 = 110\,kV$

$Y_0 = 0$

$$Z_T[p.u.] = \frac{S_0}{U_0^2} \cdot \frac{U_n^2}{S_n} \cdot \left[\frac{P_k}{S_n} + j\sqrt{u_k^2 - \left(\frac{P_k}{S_n}\right)^2} \right] = 0.667 \left[0 + j\,0.105 \right]$$

$Z_T = j\,0.09\ p.u$

$Y_T = -14.286j\ p.u$

$a_{1-T1} = \frac{220(1+5\cdot 0.01)}{220} \quad a_{1-T2} = \frac{220(1+0\cdot 0.015)}{220} = 1$

$a_{2-T1} = 1 \qquad a_{2-T2} = 1$

$a_1 \equiv a_{1-T1} = 1.05$

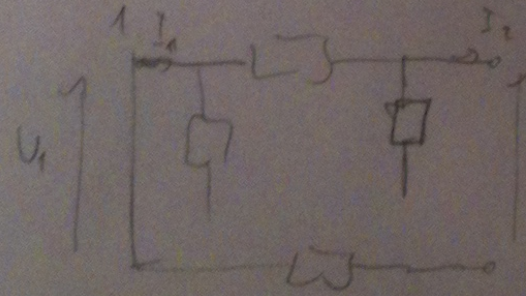
$Y_{12-1} = \frac{Y_T}{a_1} = -13.289j\ p.u$

$Y_{12-2} = -14.286j\ p.u$

$Y_{01-1} = Y_T \cdot \frac{1}{a_1}\left(\frac{1}{a_1} - 1\right) = 0.927j\ p.u$

$Y_{01-2} = Y_{02-2} = 0$

$Y_{02-1} = Y_T\left(1 - \frac{1}{a_1}\right) = -0.9967j\ p.u$



$$|Y| = \begin{vmatrix} Y_{12-1} + Y_{12-2} + Y_{01-1} & -(Y_{12-1} + Y_{12-2}) \\ -(Y_{12-1} + Y_{12-2}) & Y_{12-1} + Y_{12-2} + Y_{02-1} \end{vmatrix}$$

$$|Y| = \begin{vmatrix} -28.1526j & 28.3606j \\ 28.3606j & -28.5703j \end{vmatrix}$$

$$\begin{vmatrix} I_1 \\ I_2 \end{vmatrix} = \begin{vmatrix} -76.648j & 27.575j \\ 27.575j & -28.5917j \end{vmatrix} \begin{vmatrix} U_1 \\ U_2 \end{vmatrix}$$

$U_1 = 231 kV$

$U_1 = 1.05 p.u$

$I_1 = Y_{11} U_1 + Y_{12} U_2$

$I_2 = Y_{21} U_1 + Y_{22} U_2 = 0$

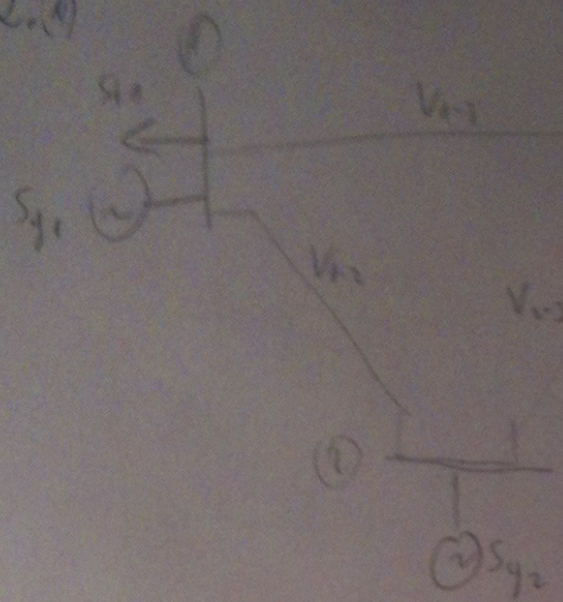
$$U_2 = \frac{-Y_{21} U_1}{Y_{22}} = \frac{-28.3606j}{-18.8418j}$$

$U_2 = 1.0134 p.u$

$$U_2[p.u] = \frac{U_2}{U_{2n}} \Rightarrow U_2 = U_2[p.u] \cdot 110 kV$$

$U_2 = 111.471 kV$

2.(1)



$|U_1^{(0)}| \angle \delta_1^{(0)} = ?$

$|U_3^{(0)}| \angle \delta_3^{(0)} = ?$

G-S-Y, 2-1

$S_{t_1} = 40 + j\,10\,MVA$

$S_{t_3} = 60 + j\,15\,MVA$

$S_{g_1} = 50 + j\,10\,MVA$

$U_n = 115kV$

$U_1^{(0)} = U_3^{(0)} = 110 \angle 0° kV = 1 pu$

Podaci: $X_1 = 0.42\ \Omega/km$

$l = 50\ km$

$S_B = 100\,MVA$ $\quad U_B = 110kV$

$Z_V = j21\ \Omega$

$S_1 = 10\,MVA = 0.1\,p.u$

$S_3 = -60 - 15j\,MVA = -0.6 - 0.15j\,p.u$

$Y_V = -0.04762j\,S$

G-S-Y:

$$U_i^{(k+1)} = \frac{KL_i}{U_i^{(k)*}} - \sum_{j=1}^{i-1} YL_{ij} U_j^{(k+1)} - \sum_{j=i}^{k} YL_{ij} U_j^{(k)}$$

$$KL_i = \frac{S_i^*}{Y_{ii}}, \quad YL_{ij} = \frac{Y_{ij}}{Y_{ii}}$$

$Y_V[pu] = Y_V \cdot \frac{U_B^2}{S_B} = -5.762\,07j\,pu$

$$Y = \begin{vmatrix} Y_{V1-3} + Y_{V1-2} & -Y_{V1-2} & -Y_{V1-3} \\ -Y_{V1-2} & Y_{V1-2} + Y_{V2-3} & -Y_{V2-3} \\ -Y_{V1-3} & -Y_{V2-3} & Y_{V1-3} + Y_{V2-3} \end{vmatrix} = \begin{vmatrix} -0.09524j & 0.04762j & 0.04762j \\ 0.04762j & -0.09524j & 0.04762j \\ 0.04762j & 0.04762j & -0.09524j \end{vmatrix}$$

2(2)

$$KL_1 = \frac{S_1^*}{Y_{11}} = 8.6795\,45^\circ j = 0.0086795\,j$$

$$U_2 = \frac{115}{110} = 1.0345\,\text{pu}$$

$$KL_3 = \frac{S_3^*}{Y_{33}} = -0.013 - 0.0521\,j$$

$$Y[\text{pu}] = \begin{vmatrix} -11.57504\,j & 5.76707\,j & 5.76707\,j \\ 5.76701\,j & -11.57504\,j & 5.76707\,j \\ 5.76707\,j & 5.76707\,j & -11.57504\,j \end{vmatrix} [\text{pu}]$$

$$YL_{12} = \frac{Y_{12}}{Y_{11}} = YL_{13} = YL_{21} = YL_{23} = YL_{31} = YL_{32} = 0.5$$

$$U_1^{(1)} = \frac{KL_1}{U_1^{(0)*}} - YL_{12}U_2 - YL_{13}U_3^{(0)} = 1.0277 + 0.0086795\,j$$

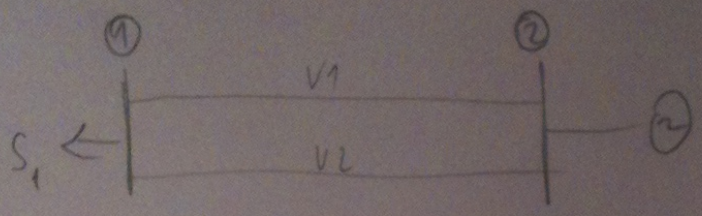
$$U_3^{(1)} = \frac{KL_3}{U_3^{(0)*}} - YL_{32}U_2 - Y_{31}U_1^{(1)} = 1.021075 - 0.04276\,j$$

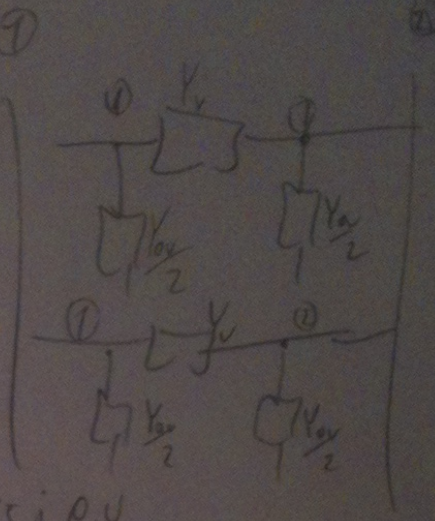
$$U_1^{(2)} = \frac{KL_1}{U_1^{(1)*}} - YL_{12}U_2 - YL_{13}U_3^{(1)} = 1.03314 - 0.0154\,j = 1.0333\angle -0.85^\circ = 1.1463\angle -0.85^\circ$$

$$U_3^{(2)} = \frac{KL_3}{U_3^{(1)*}} - Y_{32}U_2 - Y_{31}U_1^{(2)} = 1.02587\angle -3.242^\circ = 1.12854\angle -3.242^\circ$$

3.

	R[Ω]	X[Ω]	B[mS]
V1	4	21	0.14
V2	4	21	0.14





$U_0 = 110kV$

$S_0 = 100MVA$

$U_1^{(0)} = 110\angle 0° kV$

$U_2 = 110kV = 1 p.u$

$S_1 = -50 - j15MVA = -0.5 - 0.15j\ p.u$

G-S-Z, $U_1 = ?$ u_2 $\varepsilon = 10^{-2}$.

$Z_v = 4 + j21\ \Omega$

$Y_{ov} = j0.00014\ S$

$Z_v[p.u] = Z_v \cdot \frac{S_0}{U_0^2} = 0.03306 + 0.17355j\ p.u$

$Y_{ov}[p.u] = Y_{ov} \cdot \frac{U_0^2}{S_0} = 0.01694j\ p.u$

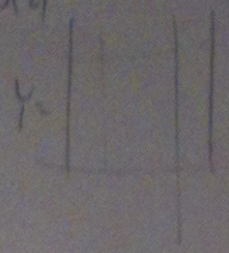
$Y_{v1} = Y_{v2} = 1.0581 - 5.5602j\ p.u$

$\frac{Y_{ov}}{2} = 0.00847j\ p.u$

$$Y = \begin{vmatrix} Y_v + Y_v & -(Y_v + Y_v) \\ -(Y_v + Y_v) & Y_v + Y_v \end{vmatrix} = \begin{vmatrix} 2.1182 - 11.1204j & -2.1182 + 11.1204j \\ -2.1182 + 11.1204j & 2.1182 - 11.1204j \end{vmatrix}$$

$$Y' = \begin{vmatrix} \frac{Y_{ov}}{2} + \frac{Y_{ov}}{2} & \\ & \frac{Y_{ov}}{2} + \frac{Y_{ov}}{2} \end{vmatrix} = \begin{vmatrix} Y_{ov} & \\ & Y_{ov} \end{vmatrix} = \begin{vmatrix} 0.01694j & \\ & 0.01694j \end{vmatrix}$$

3(2)



$Y_{11} = 7.1182 - 11.1206j$

$Z_{11} = 0.01653 + 0.08679j$

$Y_1' = 0.01694j$

$$I_1^{(0)} = \frac{S_1^*}{U_1^{*(0)}} - U_1^{(0)} \cdot Y_1' = -0.5 + 0.13306j$$

$U_1^{(1)} = U_2 + Z_{11} I_1^{(0)} = 0.98019 - 0.01185j$ p.u. $|U_1^{(1)} - U_1^{(0)}| = 0.0459 > \varepsilon$

$$I_1^{(1)} = \frac{S_1^*}{U_1^{*(1)}} - U_1^{(1)} Y_1' = -0.50348 + 0.15055j$$

$U_1^{(2)} = U_2 + Z_{11} I_1^{(1)} = 0.99887 \angle -2.4051°$ $|U_1^{(2)} - U_1^{(1)}| = 2.18585 \cdot 10^{-3} < \varepsilon$ V

$= 0.998 - 0.0411j$

$U_1^{(2)} = 107.6757 \angle -2.4054°$ kV

4.11)

$U_1 = 10.5 \angle 0° kV = 1$ p.u

$U_2 = 106.03 \angle -4.07° kV = 0.96148 - 0.06841j$ p.u $= 0.9639 \angle -4.09°$

$U_3 = 100.16 \angle -9.60° kV = 0.901 - 0.14416j$ p.u $= 0.9133 \angle -9.40°$

$P_2 = P_1 = 1 \left[0.9639 \cdot 12.9055 \cdot \cos(0 + 4.09 - 276.55) \right] = 0.5383$ p.u $= 538.3$ MW

$P_1 = P_3 = 0.9133$

$$Y = \begin{vmatrix} 12.9055 \angle 276.55° & 12.9055 \angle 96.55° & 0 \\ 12.9055 \angle 96.55° & & \end{vmatrix}$$

-86.743

$$Y = \begin{vmatrix} Y_T & -Y_T & 0 \\ -Y_T & Y_T + Y_V & -Y_V \\ 0 & -Y_V & Y_V \end{vmatrix} = \begin{vmatrix} 12.9055 \angle 273.257 & 12.9055 \angle 93.257° & 0 \\ \angle 93.257 & 12.9055 \angle 276.55° & \\ 0 & 5.66 \angle 100.98° & 5.66 \angle 80.98° \end{vmatrix}$$

$P_1 = 1 \cdot 0.9639 \cdot 12.9055 \cdot \cos(0 + 4.09 - 93.257) = +0.09548$ p.u $=$

$P_2 = 0.9639 \left[1 \cdot 12.9055 \cdot \cos(-4.09 - 0 - 93.257) + 0.9133 \cdot 5.66 \cdot \cos(-4.09 + 96 - 100.98) \right]$

$= 0.9639 \left[-0.8255 - 0.4409 \right] = -1.2042$ p.u

4.(2)

$$P_g = P_1 = 1 \cdot [1 \cdot 7.2727 \cdot \cos(-273.257) + 0.9639 \cdot 7.2727 \cdot \cos(4.07 - 93.257)]$$

$$= 0.51266 \text{ p.u}$$

$$P_2 = 0.9639 \cdot [1 \cdot 7.2727 \cdot \cos(-4.07 - 93.257) + 0.9639 \cdot 12.9055 \cdot \cos(-276.55)$$

$$+ 0.9133 \cdot 5.66 \cdot \cos(-4.07 - 9.4 - 100.78)]$$

$$= 0.9639 \cdot [-0.9295 + 1.418989 - 0.4904]$$

$$= 5.071 \cdot 10^{-4} \text{ p.u} \quad 5.0541 \cdot 10^{-4} \text{ p.u}$$

$$P_t = P_3 = 0.9133 \cdot [0.9639 \cdot 5.66 \cdot \cos(-9.4 - 4.07 - 100.78)$$

$$+ 0.9133 \cdot 5.66 \cdot \cos(-280.78)]$$

$$= -0.49937 \text{ p.u}$$

$P_g = 51.266 \text{ mw}$

$P_t = -49.959 \text{ mw}$

$P_{Los} = \sum_i P_i = 0.01359 \text{ p.u}$

$= 1.36 \text{ mw}$

5.19 $P_{gen}[MW] = ?$

T

$S_n = 80\,MVA$

$u_k = 11.0\%$

$P_k = 0.5\,MW$

$U_{n1}/U_{n2} = 105/110\,kV$

V

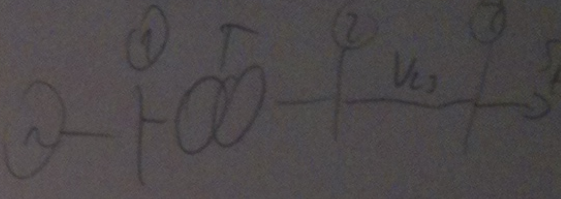
$U_n = 110\,kV$

$R_1 = 0.08\,\Omega/km$

$X_1 = 0.42\,\Omega/km$

$B_1 = 0\,\mu S/km$

$l = 50\,km$



$U_0 = 110\,kV$

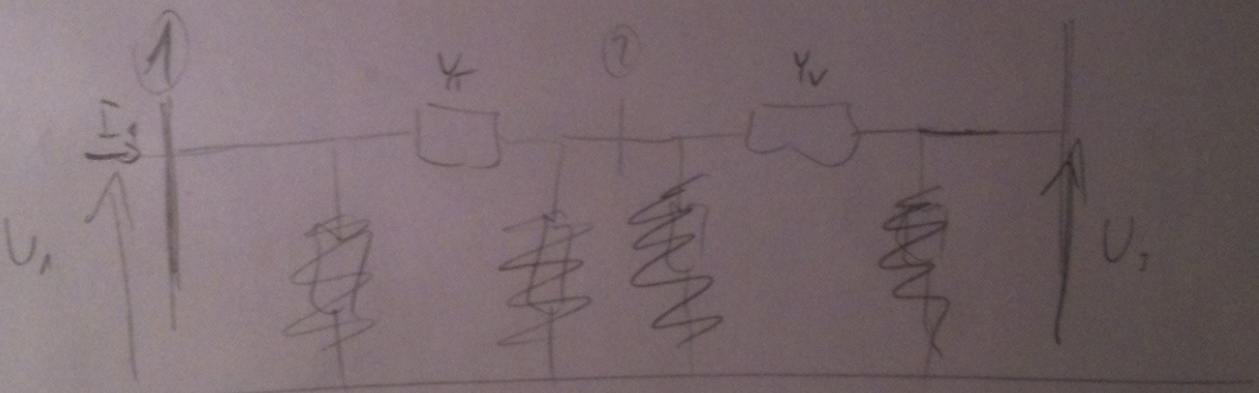
$S_0 = 100\,MVA$

$P_0 = 0 \quad \varphi_0 = 0$

$G_1 = B_1 = 0$

$U_1 = 11.0\,\angle 0°\,kV$

$U_3 = 110.05\,\angle -4.88°\,kV$



$$Z_T = \frac{S_0}{S_n}\cdot\frac{U_n^2}{S_0}\left[\frac{P_k}{S_n} + j\sqrt{u_k^2 - \left(\frac{P_k}{S_n}\right)^2}\right] \Rightarrow Y_T = 0.4132 - 9.7604\,j\ p.u$$

$Y_0 = 0$

$a_1 = a_2 = 1$

$Y_{11} = Y_T$

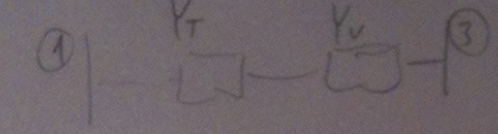
$Z_V = (0.08 + j0.42)\cdot 50 = 4 + j21\,\Omega$

$Y_V = 8.7\cdot 10^{-3} - j0.0459\,S$

$Y_V[p.u.] = Y_V \cdot \frac{U_n^2}{S_0} = 1059 - 5.5602\,j\ p.u$

$Y_{22} = 0$

5.



$$Y = \begin{vmatrix} 12.9055 \angle 276.55^\circ & 12.9055 \angle 96.551^\circ \\ 12.9055 \angle 96.551^\circ & 12.9055 \angle 276.55^\circ \end{vmatrix} \qquad \begin{aligned} U_1 &= 1.04762 \angle 0^\circ \\ U_3 &= 1.00045 \angle -4.88^\circ \end{aligned}$$

$$P_1 = 1.04762 \cdot \left[1.04762 \cdot 12.9055 \cdot \cos(-276.55^\circ) + 1.00045 \cdot 12.9055 \cdot \cos(4.88 - 96.551)\right]$$

$$= 1.22125 \text{ p.u}$$

$$P_3 = 1.00045 \cdot \left[1.04762 \cdot 12.9055 \cdot \cos(-4.88 - 96.551) + 1.00045 \cdot 12.9055 \cdot \cos(\quad -276.55)\right]$$

$$= -1.20725 \text{ p.u}$$

$$P_{gos} = \sum_i P_i = 0.01399 \text{ p.u}$$

$$P_{gos} = 1.4 \text{ MW}$$