

a) Δ -Y connection is selected for T_2 in order to provide neutral connection to the load.

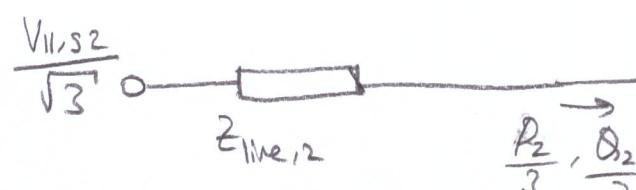
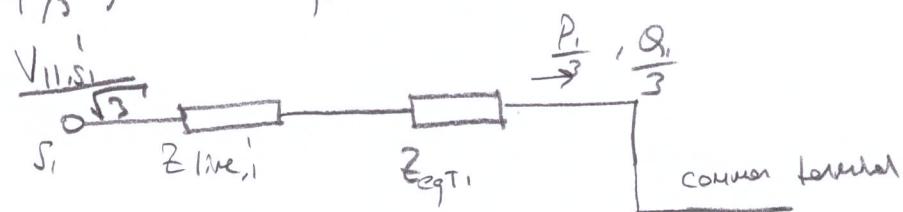
b) Let us first refer the left side of T_1 to the right side.

$$V'_{II,S1} = V_{II,S1} \frac{6.9}{15} \quad Z'_{line,1} = Z_{line} \left(\frac{6.9}{15} \right)^2$$

$$Z'_{T_1-HV} = \frac{Z_{T_1-HV}}{3} \quad Z'_{T_1-LV} = \frac{Z_{T_1-LV}}{3}$$

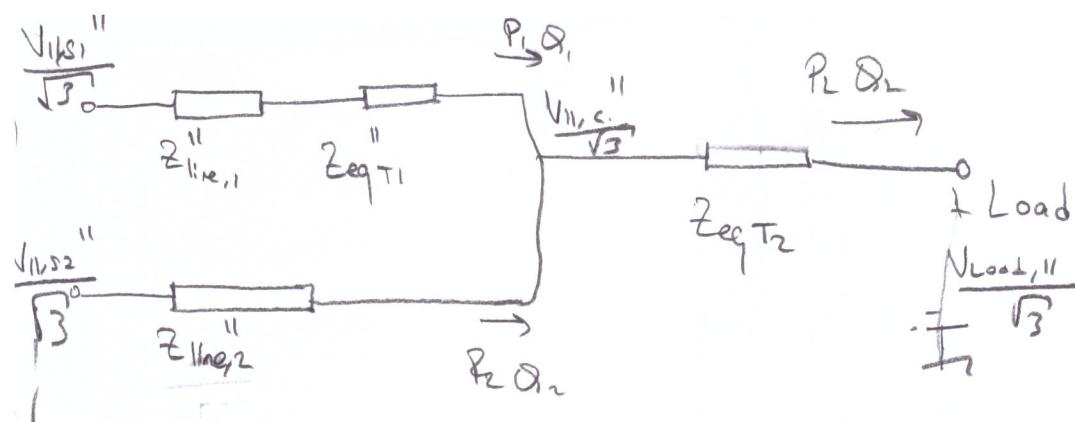
$$Z'_{T_1-HV} = \frac{Z_{T_1-HV}}{3} \left(\frac{6.9}{15} \right)^2 \quad Z_{eq,T_1}^{(Y)} = Z_{T_1-LV} + Z_{T_1-HV}$$

- for upper leg
the per-phase circuit
- for lower leg
the per-phase



For the reference of T_2 let us first find the rated voltage ratio of T_2 . Since it is $(\Delta-Y)$ connected ratio = $6.9kV : 230\sqrt{3}V$.

The line to neutral single phase referred circuit is given as follows;



$$V_{11,s1}'' = \left(\frac{6.9}{15}\right) \left(\frac{230\sqrt{3}}{6.9 \times 10^3}\right) V_{11,s1} \quad V_{11,s2}'' = \left(\frac{230\sqrt{3}}{6.9 \times 10^3}\right) V_{11,s2}$$

$$V_{11,c}'' = \left(\frac{230\sqrt{3}}{6.9 \times 10^3}\right) V_{11,c} \quad Z_{line,1}'' = \left(\frac{6.9}{15}\right)^2 \left(\frac{230\sqrt{3}}{6.9 \times 10^3}\right)^2 Z_{line,1}$$

$$Z_{eq,T_1}'' = \left(\frac{230\sqrt{3}}{6.9 \times 10^3}\right)^2 Z_{eq,T_1} \quad Z_{line,2}'' = \left(\frac{230\sqrt{3}}{6.9 \times 10^3}\right)^2 Z_{line,2}$$

$$Z_{eq,T_2} = Z_{+z-HV}^{(Y)} + Z_{T_2-W} \quad Z_{+z-HV}^{(Y)} = \frac{Z_{T_2-W}}{3} \left(\frac{230\sqrt{3}}{6.9 \times 10^3}\right)^2$$

so numerically;

$$Z_{line,1}'' = 3.5 \times 10^{-3} (1+j)$$

$$Z_{eq,T_1}'' = 7.4 \times 10^{-3} j$$

$$Z_{line,2}'' = 3.3 \times 10^{-3} (1+j)$$

$$Z_{eq,T_2} = 6.3 \times 10^{-3} (1+j)$$

b) Since nominal voltage adjusted to the load; $\frac{V_{load,11}}{\sqrt{3}} = 230V$

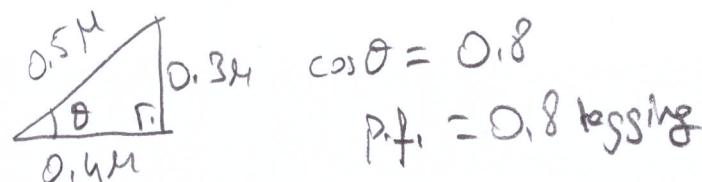
for 1 phase $P_{L\phi} = 0.4 \text{ MW} \quad Q_{L\phi} = 0.3 \text{ MVar}$

$$[8] = 20.5 \text{ MW} \quad i = 230^\circ \cdot I_{load,1line}$$

$$I_{load,1line} = 172.1739 \text{ kA} \quad \angle \alpha = \tan^{-1}\left(\frac{0.3}{0.4}\right)$$

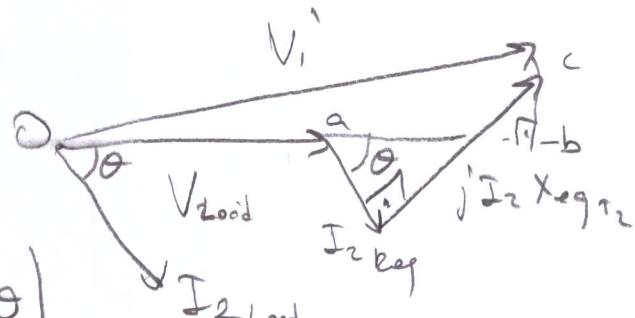
$$I_{load,1line} = (1.7391 - j 1.8043) \text{ kA}$$

c) From the power triangle



e) For T_2 line to neutral

assuming $|I_{ob}| \approx |I_{oc}|$



$$V'_1 = V_2 + I_2' (R_{egT2} \cos \theta + j X_{eg} \sin \theta)$$

$$V'_1 = 230 + 2,1739 k (6,3 \times 10^{-3}) (0,8 + 0,6)$$

$$V'_1 = 248,7328$$

$$\text{Regulation} = \frac{248,7328 - 230}{230} \times 100 = 8,1447$$

f) From previous part we know that $\frac{V_{11,c}''}{\sqrt{3}} = 248,7328 V$

$$P_{2,\phi} = \frac{0,4 \text{ MW}}{3} \quad Q_{2,\phi} = 0,1 \text{ MVar}$$

$$I_{e,2}'' \cdot \frac{V_{11,c}''}{\sqrt{3}} = |S_{e,2}| \Rightarrow I_{e,2}'' = 670,0631 A$$

$$P_{line,2} = (I_{e,2}'')^2 3,3 \times 10^{-3} \quad Q_{line,2}'' = (I_{e,2}'')^2 3,3 \times 10^{-3}$$

$$S_{line,2} = 134,81,6 (1+j) \text{ VA}$$

$$\text{So; } S_{e,\phi} + S_{line,2} = S_{source,2} \Rightarrow (134,81 + j191,48) \text{ kVA}$$

$$P_{1,\phi} = \frac{0,8 \text{ MW}}{3} \quad Q_{1,\phi} = 0,2 \text{ MVar}$$

$$I_{e,1}'' \cdot \frac{V_{11,c}''}{\sqrt{3}} = |S_{e,1}| \Rightarrow I_{e,1}'' = 1340,1 A$$

$$Q_{line,1} = (I_{e,1}'')^2 (3,5 + 7,4) \times 10^{-3} \quad P_{line,1} = (I_{e,1}'')^2 (8,5) \times 10^{-3}$$

$$S_{line,1} = 135,45 (1+j) \times 14 (6,285 + 195,76j) \text{ kVA}$$

$$S_{e,\phi} + S_{line,1} = S_{source,1} \Rightarrow (272,95 + j395,76) \text{ kVA}$$

So; in 3 phase \Rightarrow

$$S_{s1} = (818,855 + j1187,28) \text{ kVA}$$

$$S_{s2} = (404,44 + j304,44) \text{ kVA}$$

$$g) \text{ Efficiency } \gamma = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100$$

$$\frac{1.2 \times 10^6}{(1818.85 + 404.44) \times 10^3} \Rightarrow \% 98.096$$

h) from part f we have power values;

$$\frac{V_{11,s1}''}{\sqrt{3}} \cdot I_{s1}'' = |S_{s1}| \Rightarrow \frac{V_{11,s1}''}{\sqrt{3}} = 499.001 \quad V_{11,s1}'' = 864.2935$$

$$V_{11,s1} = \left(\frac{15}{6.9}\right) \left(\frac{6.9 \times 10^3}{230\sqrt{3}}\right) V_{11,s1}'' \Rightarrow V_{11,s1} = 32543 \text{ V}$$

$$(V_{11,s1}/\sqrt{3}) I_{1,1} = |S_{s1}| \Rightarrow I_{1,1} = 35.5905 \text{ A}$$

i) similarly; from part f we have power values;

$$\frac{V_{11,s2}''}{\sqrt{3}} \cdot I_{s2}'' = |S_{s2}| \Rightarrow \frac{V_{11,s2}''}{\sqrt{3}} = 251.8215 \quad V_{11,s2}'' = 436.1676$$

$$V_{11,s2} = \left(\frac{6.9 \times 10^3}{230\sqrt{3}}\right) V_{11,s2}'' \Rightarrow V_{11,s2} = 7554.6 \text{ V}$$

$$\left(\frac{V_{11,s2}}{\sqrt{3}}\right) I_{1,2} = |S_{s2}| \Rightarrow I_{1,2} = 116.0608 \text{ A}$$