Power System Assignment 2
Set 3

<u>Group Members:</u>

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Common Assumptions:
(1) Loads are of constant PQ type.
(2) Y-Y connection of transformers.
(3) Y(grounded) in source and load.
(4) Transformers’ impedances are assumed to be on the High tension side.

Theoretical Solutions for the three problems are attached below::

Q1)

From the theoretical calculation, we got complex power, $S = 60 + 45j$ MVA.

So, we have considered parallel RL load with R consuming active power of 60MW and L consuming reactive power of 45 MVAR.

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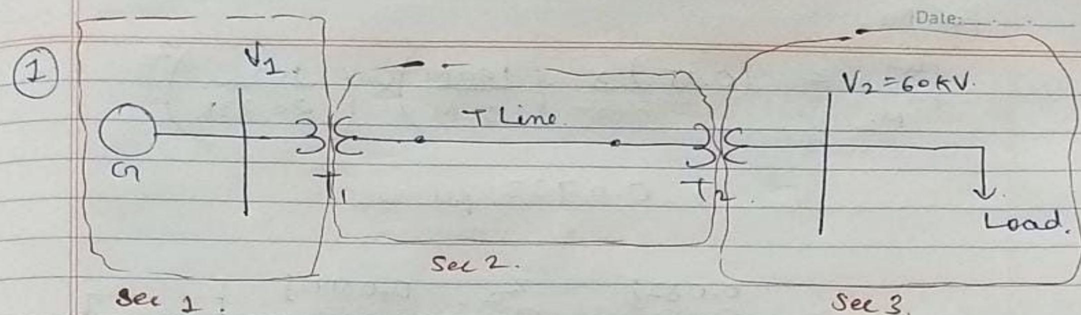
(1)



Common base power for system $= S^b = 100MVA$.

For section 1:

Base voltage, $V_1^b = 11 kV$.

$X_G = 0 pu$

For section 2:

Base voltage, $V_2^b = 132 kV$.

$$X^{pu}_{T_1 new} = (0.1) \times \left(\frac{100M}{100M}\right) \times \left(\frac{132k}{132k}\right)^2 = 0.1 pu.$$

$$X^{pu}_{new\,T_2} = (0.08) \times \left(\frac{100M}{100M}\right) \times \left(\frac{132k}{132k}\right)^2 = 0.08 pu.$$

Transmission line, $X^{actual}_{line} = 0.5(\Omega/km) \times 100 km$
$= 50\Omega$.

$$Z_{base} = \frac{(132k)^2}{(100M)}$$

$$Z^{pu}_{Tline} = \frac{50 \times (100M)}{(132k)^2} = 0.287 pu.$$

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Section 3: Base voltage, $V_3^b = 66kV$

Given active power of load, $P = 60 MW$.
with $pf = 0.8$ lag

We know, Active power $= \begin{pmatrix}\text{Complex} \\ \text{power}\end{pmatrix} \times pf$

$$P = S \times 0.8$$

$$\Rightarrow |\bar{S}| = \frac{60M}{0.8} = 75 \, MVA$$

$$\bar{S} = |\bar{S}| . \angle \cos^{-1}(0.8) = 75 . \angle 36.87 \quad MVA$$
$$= 60 + 45j \quad MVA$$
$$\bar{S}^* = 75 \angle -36.87 \quad MVA$$

$$\bar{Z}_{act} = \frac{|V_{line}|^2}{\bar{S}^*} = \frac{(60k)^2}{75 \angle -36.87 \, (M)}$$

$$\bar{Z}_{act} = 38.4 + 28.8j = 48 \angle 36.87$$

$$Z_{base} = \frac{(66k)^2}{(100M)}$$

$$\bar{Z}_{pu} = \frac{(48 \angle 36.87) \times (100M)}{(66k)^2} = 0.8815 + 0.661j$$

$$\bar{Z}_{pu} = 1.1019 \angle 36.87$$

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$$\frac{\bar{I}_{act}}{\bar{I}_b} = \frac{\left(\frac{\bar{V}_{act}}{\bar{Z}_{act}}\right)}{\left(\frac{\bar{V}_b}{\bar{Z}_b}\right)} = \frac{\left(\frac{60k}{48\angle 36.87}\right)}{\left(\frac{66k \times 100M}{(66k)^2}\right)}$$

$$= \frac{60 \times 66}{100 \times 48\angle 36.87}$$

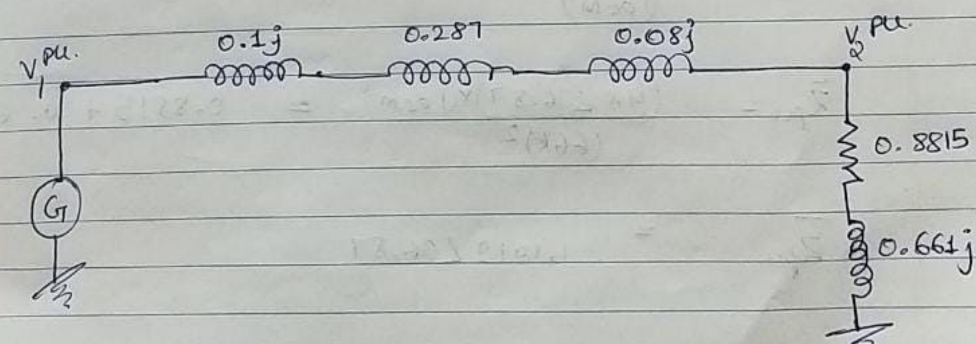
$$\bar{I}_{pu} = 0.825 \angle -36.87$$

$$V_1^{pu} - V_2^{pu} = (0.825\angle -36.87)(0.1j + 0.287j + 0.08j)$$

$$V_1^{pu} - \left(\frac{60k}{66k}\right) = 0.385275 \angle 53.17$$

$$V_1^{pu} = 1.1815 \angle 15.136$$

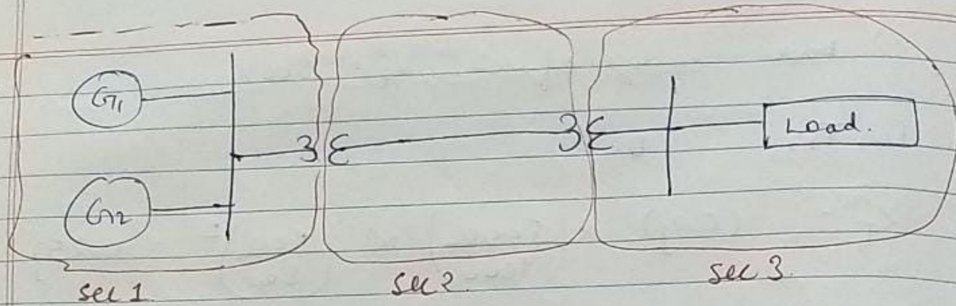
$$\boxed{V_1^{actual} = 12.991 \angle 15.136 \ kV}$$



Line impedance diagram with pu values.

Q2)

(2)



Base power for system, $S^b = 5000$ VA.

<u>For Section 1:</u>

Base voltage, $V_1^b = 250$ V.

For G_1:

$$Z_{new}^{pu} = Z_{old}^{pu} \times \left(\frac{KVA_{new}^b}{KVA_{old}^b}\right) \times \left(\frac{KV_{old}^b}{KV_{new}^b}\right)^2.$$

$$Z_{G_1}^{pu} = (0.2j)\left(\frac{5000}{1000}\right) \times \left(\frac{250}{250}\right)^2 = 1j$$

For G_2:

$$Z_{G_2}^{pu} = (0.3j)\left(\frac{5000}{2000}\right) \times \left(\frac{250}{250}\right)^2 = 0.75j$$

<u>For Section 2:</u>

$$\frac{V_1^b}{V_2^b} = \frac{250}{800}.$$

$$\Rightarrow V_2^b = \left(\frac{800}{250} \times 250\right) = 800V$$

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$\Rightarrow$ Base voltage of sec 2, $V_2^b = 800V$.

For T_1;

$$Z_{T_1}^{pu} = (0.2j) \times \left(\frac{5000}{4000}\right) \times \left(\frac{800}{800}\right)^2 = 0.25j$$

For T_2;

$$Z_{T_2}^{pu} = (0.06j) \left(\frac{5000}{8000}\right) \times \left(\frac{1000}{800}\right)^2 = 0.0586j$$

For T-Line;

$$Z_{TL}^{pu} = \frac{Z^{act}}{Z^b} = \frac{(40+150j) \times (5000)}{(800)^2}$$

$$Z_{TL}^{pu} = 0.3125 + 1.172j = 1.213 \angle 75.07$$

Section 3:

$$\frac{V_2^b}{V_3^b} = \frac{\cancel{1000}\ 2}{\cancel{500}}$$

$\Rightarrow$ $V_3^b = \frac{800}{2} = 400V$ = Base voltage for sec 3.

$$Z_{Load}^{pu} = \frac{Z^{act}}{Z_{base}} = \frac{\frac{\cancel{(400)^2}}{2500}}{\frac{\cancel{(400)^2}}{5000}} = 2\ pu$$

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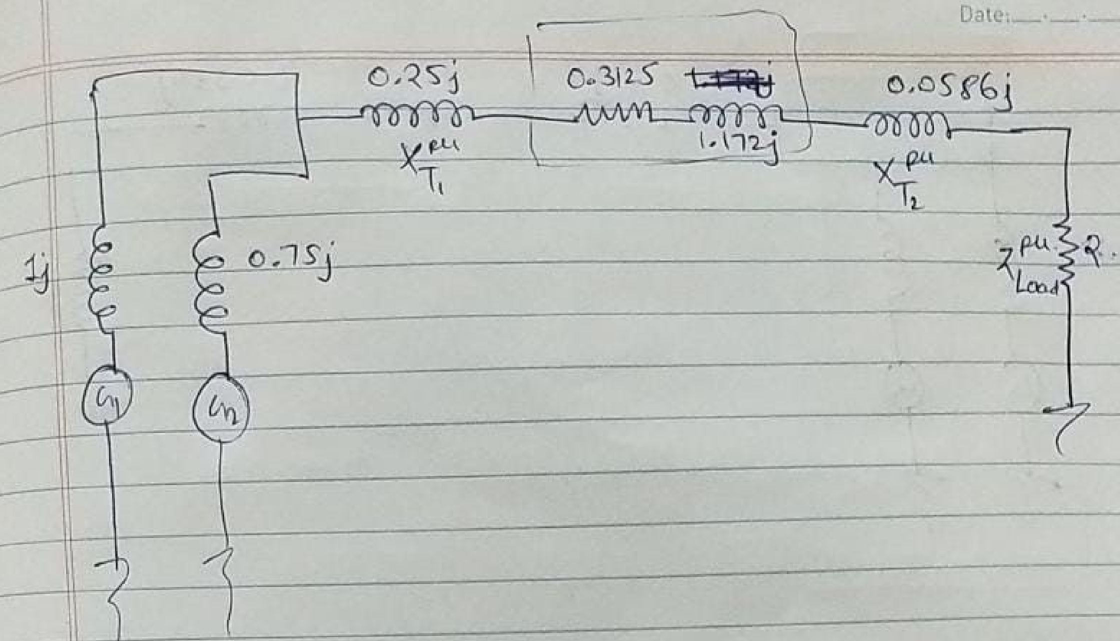

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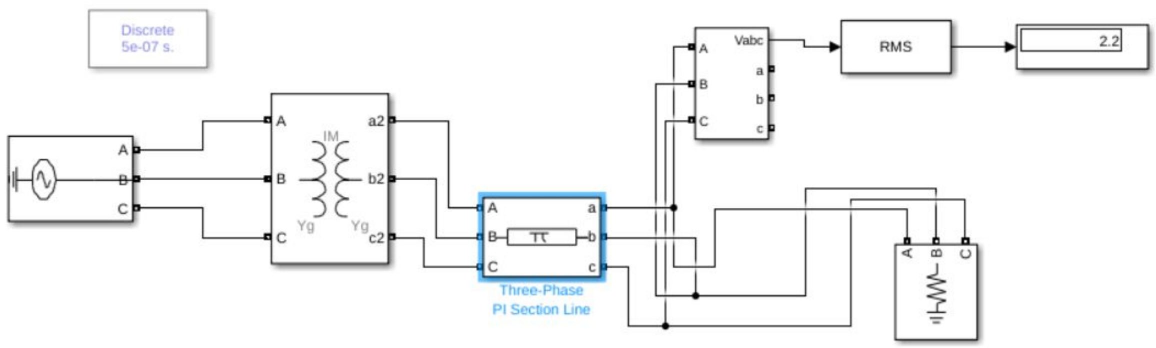
Q.3

Assumptions:

- Source generator configuration : Y connected
- transformer nominal power =100kVA
- Transmission line Length = 1km
- Load: constant PQ
- Nominal phase to phase voltage at load =1000V
- Load: Y(grounded)

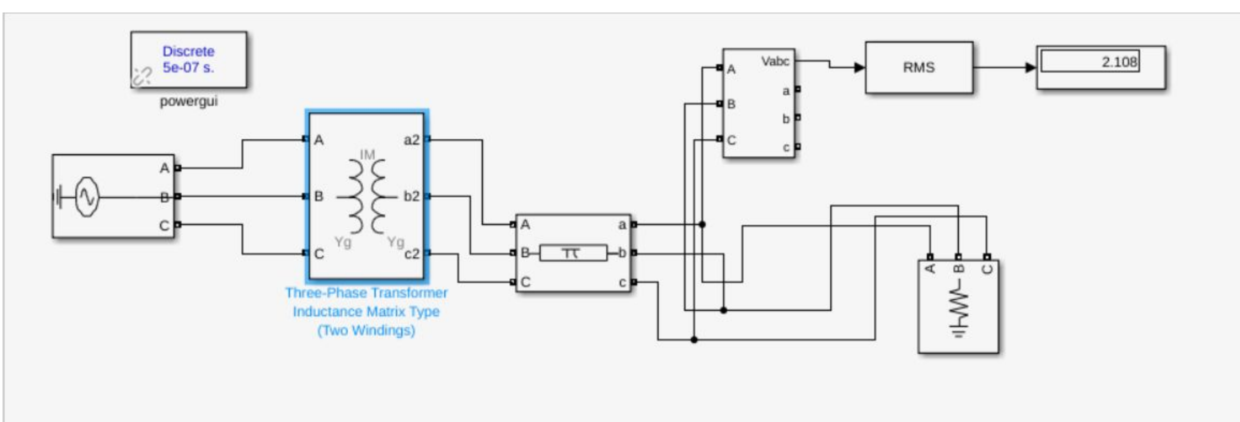
Case 1: Without Tapping

Result of 1:1 transformer



Case 2: With Tapping

Result of 1:0.95



Inference : As turns is decreased at secondary side of tap transformer, output voltage decreases

Conclusion:

Thus in the end we would like to say that the per unit analysis plays an important role in the analysis of Power Systems and comes handy as dealing with the absolute values could become really cumbersome and also different sections of the System deal with different values of Voltage. So, the Per unit analysis is very important.

For the voltage regulations, we use a tap transformer which allows us to vary the turn ratio to obtain required voltage levels on the secondary side.