Department of Electrical Engineering
Assignment
Date: 20/04/2020

Course Details

Course Title: Power System Analysis **Module:** 6th
Instructor: Engr . Muhammad Aamir Aman **Total Marks:** 30

Student Details

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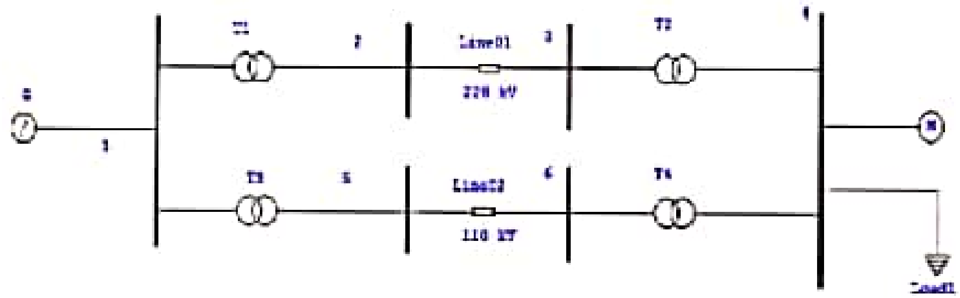
Q1.	(a)	A 3Φ transformer is connected with a residential load of 28.56 KV; the primary side of a transformer is connected with 130 KV feeder while secondary side is stepped down to 10 KV. The transformer is rated with 30 MVA. Find impedance Z_b.	Marks 05 CLO 1
	(b)	Find the Per Unit equivalent impedence of an 11/132 KV transformer having 10 Ω and 1440 Ω, the equivalent impedence. The primary and secondary currents are 909 Amp and 75.75 Amps respectively.	Marks 05 CLO 1
.Q2	(a)	Single line diagram of a 3Φ power system is shown in the below figure. Draw an impedance and reactance diagram in P.U. 	Marks 10 CLO 2
Q3	(a)	For the single line diagram shown below, Generators are connected to high tension buses 1 and 2 and supply to load connected at bus 3. Find the reactance diagram, then convert it into equivalent current sources and shunt admittances. Then find the admittance matrix and find the total current.	Marks 10 CLO 2

Q No:- 1 (Part A)

Ans:-

Solution:-

given data:-

- ↳ Primary Voltage = V_{base} = 130 kV
- ↳ Secondary Voltage = 10 kV
- ↳ T/F Rated = S_{base} = 30 MVA

Requried data:-

Find → the impedance

Z_{base}

Formula:-

$$Z_{base} = \frac{V_{base}}{S_{base}}$$

$$Z_{base} = \frac{(130 \times 10^{3})^{2}}{(30 \times 10^{6})}$$

$$\boxed{Z_{base} = 563.33\,\Omega}$$

Q No:- 1 (Part B)

Ans :-

Solution:-

- Base impedance of primary $= Z_p = \frac{V_p}{I_p}$

$$Z_p = \frac{11 \times 10^3}{909} = \boxed{12.1\ \Omega}$$

- Base impedance in secondary $= Z_s = \frac{V_s}{I_s}$

$$Z_s = \frac{132 \times 10^3}{75.75} = \boxed{1742.57\ \Omega}$$

- Now in per unit:-

$$Z_{1(P.U)} = \frac{\text{Actual value}}{\text{Base value}} = \frac{10\ \Omega}{12.1\ \Omega}$$

$$\boxed{Z_{1(P.U)} = 0.826\ P.U}$$

$$Z_{2(P.U)} = \frac{\text{Actual value}}{\text{Base value}} = \frac{1440}{1742.57}$$

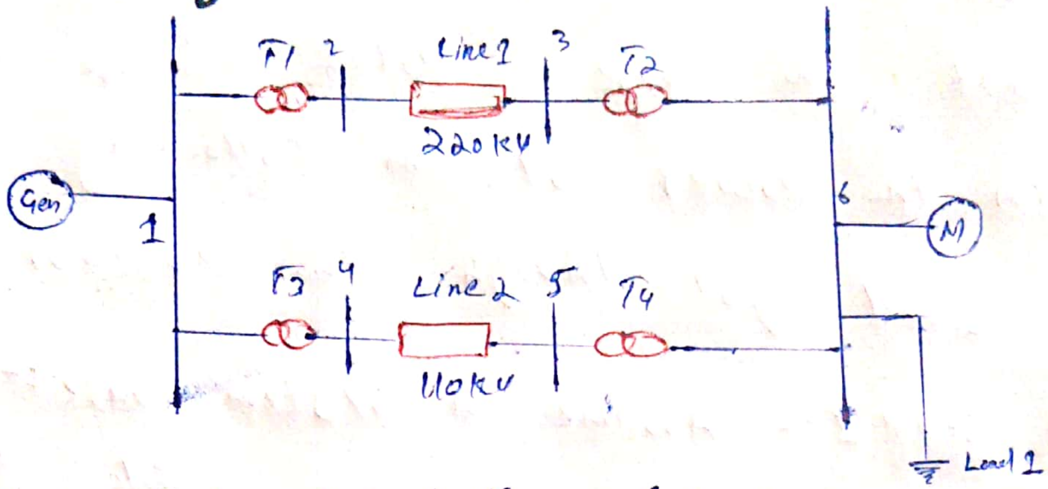
$$\boxed{Z_{2(P.U)} = 0.826\ P.U}$$

∴ Hance:- $Z_1 = Z_2$

Equivalent of impedance of T/F is same value in the primary & secondary.

Q No:- 2

Ans:- Single line diagram of Power system



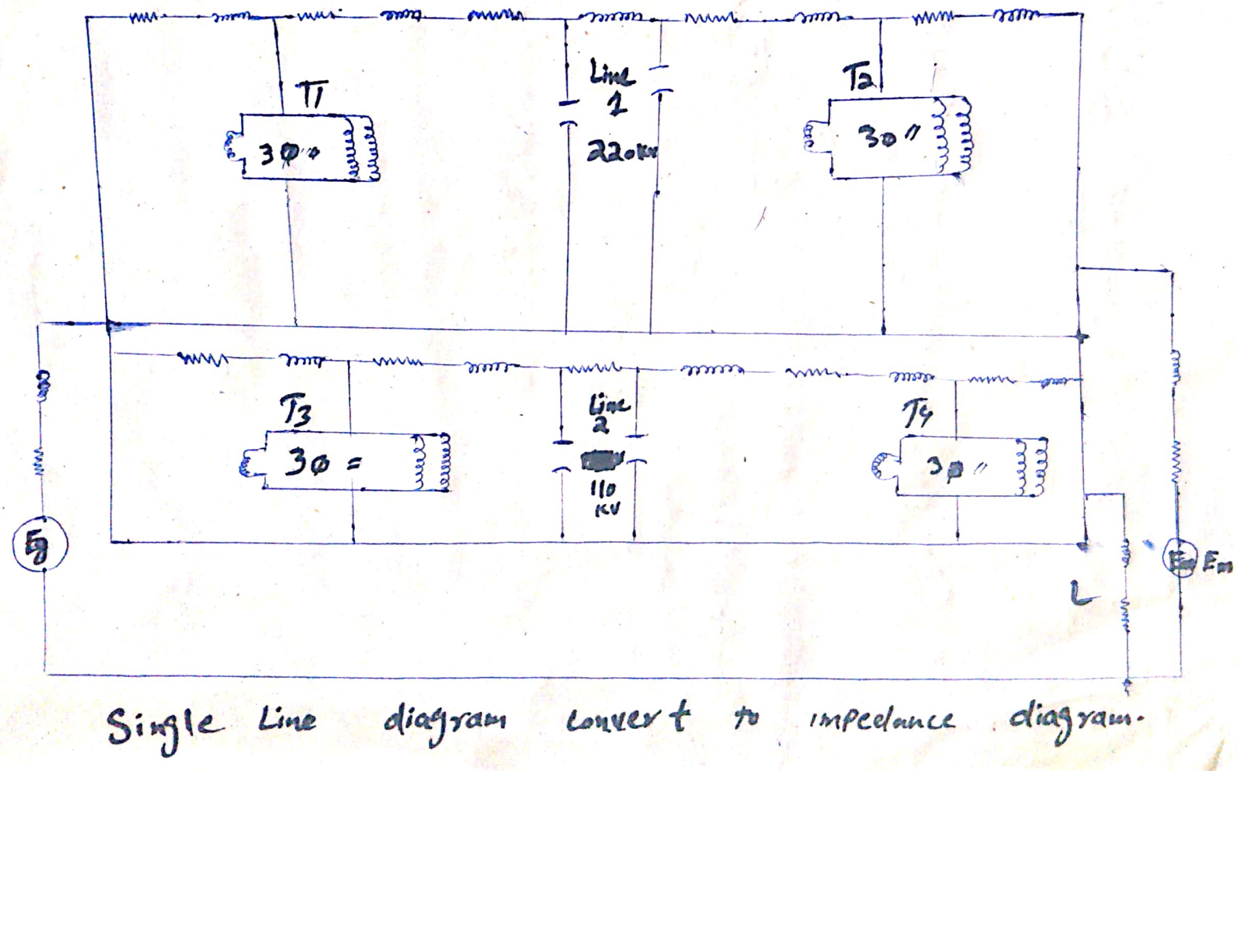
Now that you have carefully examined the system and its parameters, the equivalent impedance diagram for the above system would look someting like the following

* Impedance Diagram of A Power System.

* Resistive impedance for most components have been ignored.

* rotating machines have been replaced with a voltage source behind their internal reactance.

* capacitive effects between lines and to ground are ignored as will



Single Line diagram convert to impedance diagram.

to obtain the New normalized per unit impedance, first we need to figure out the base value (S_{base}, V_{base}, Z_{base}) in the power system. Following step will lead you through the process

* **Step 1:- Assume A system base:-**

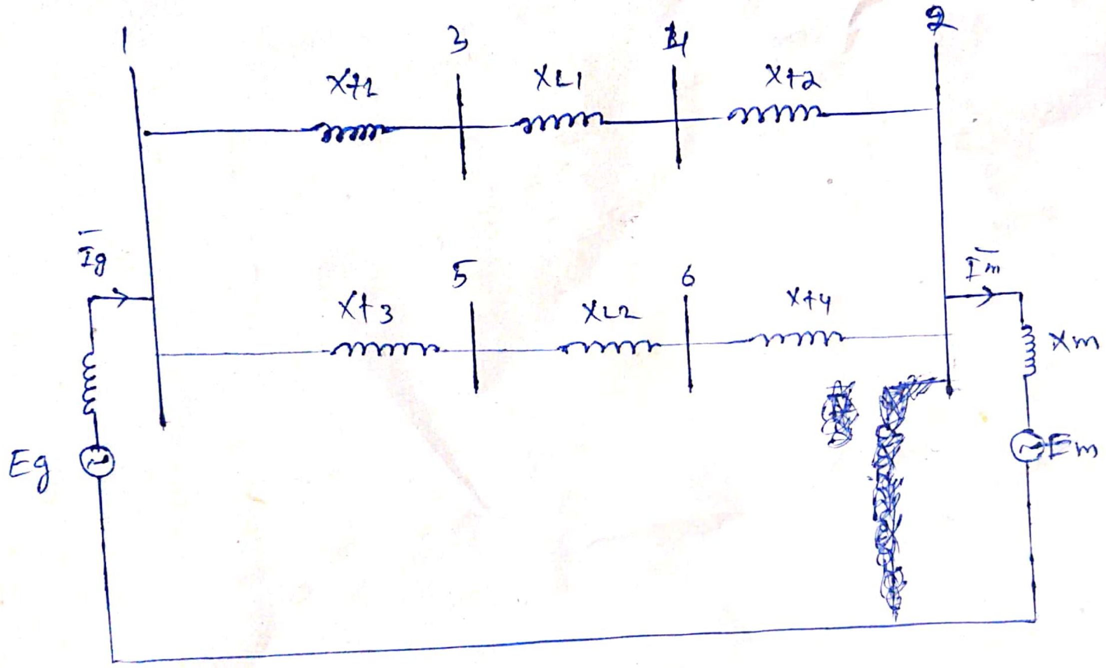
Assume a system wide S_{base} of 100 MVA. This is a random assumption and chosen to make calculations easy when calculating the per unit impedance

So $S_{base} = 100\,MVA$

* **Step 2:- Identify the voltage base:-**

Voltage base in the system is determined by the transformer

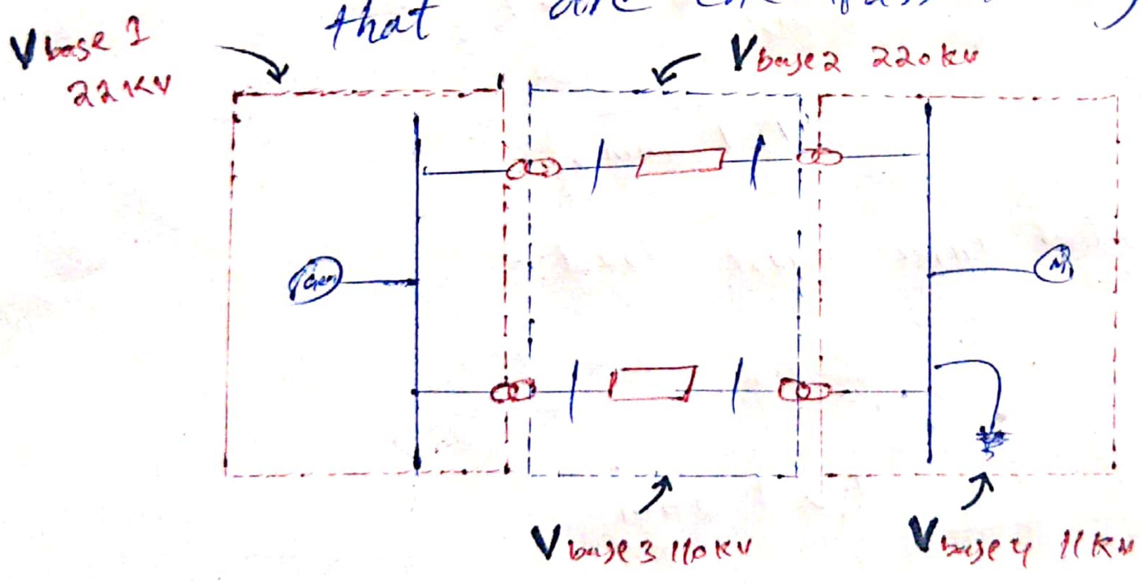
For Example:- with a 22/220kV Voltage



per. unit impedance diagram.

rating of T_1 transformer the V_{base} of the primary side of T_1 is 22KV while the Secondary Side is 220KV ~~the voltage rating of the other Component~~

it does not Matter what the voltage rating of the other Components are that are encompassed by the V_{base} zone



Voltage base in Power System.

Step:-3 calculate the base impedance:-

the base impedance is calculated using the following Formula:-

$$Z_{base} = \frac{KV_{base}^2}{S_{base}\ MVA} \text{ ohms} \longrightarrow (1)$$

* Fo T Line 1 =

$$Z_{base} = \left(\frac{220}{100}\right)^2$$

$$= \boxed{484 \text{ ohm}}$$

* For T Line 2 =

$$Z_{base} = \frac{(110)^2}{100} =$$

$$\boxed{= 121 \text{ ohms}}$$

* For three phase load:-

$$Z_{base} = \frac{(11)^1}{100}.$$

$$\boxed{= 1.21 \text{ ohm}}$$

* Step:- 4 Calculate the per unit impedance:-

the per unit impedance is calculated using the following Formula:-

$$Z_{p.u} = \frac{Z_{actual}}{Z_{base}} \rightarrow (2)$$

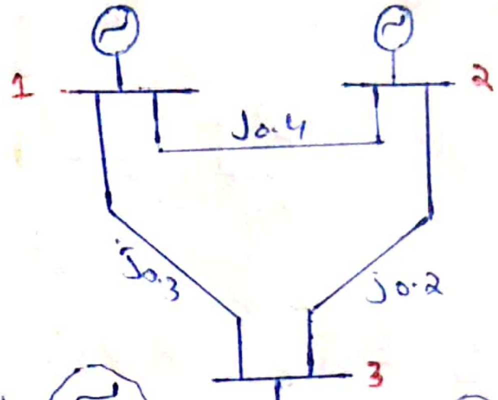
$$Z_{p.u\ New} =$$

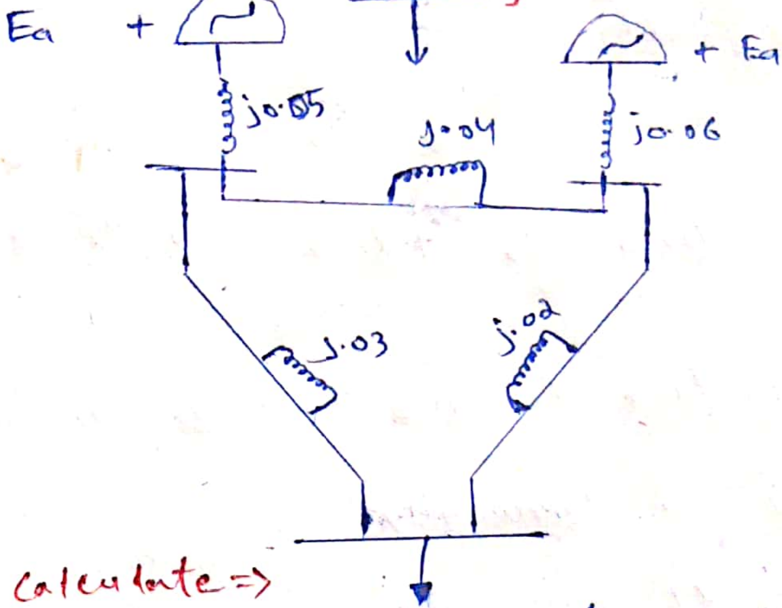
$$Z_{p.u\ old} = \left(\frac{S_{base\ New}}{S_{base\ old}}\right)\left(\frac{S_{base\ old}}{V_{base\ New}}\right)^2 \rightarrow (3)$$

the voltage ratio in equation (3) is not equivalent to Transformers voltage ratio. It is the ratio of the transformers voltage ratings on the primary or secondary side to the system nominal voltage on the same side.

Q No:- 3 (A)

Ans:- Find the ractance diagram:-



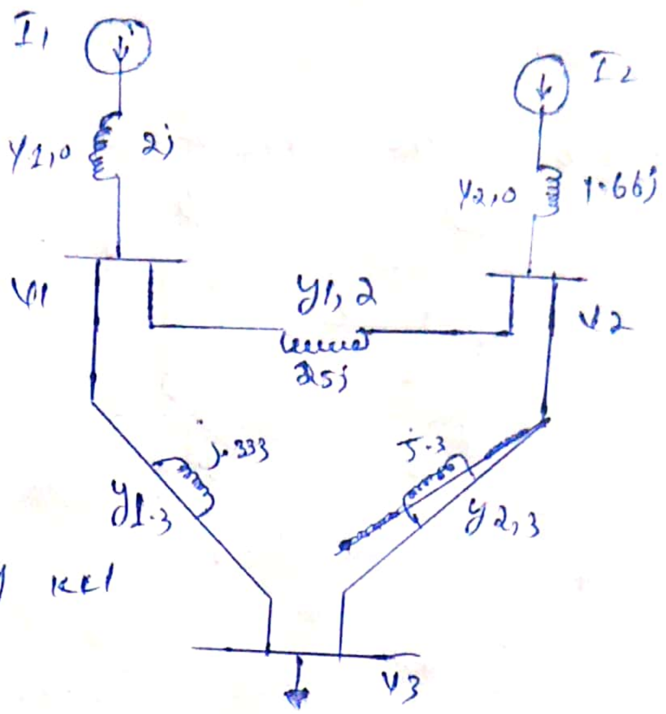


* Now calculate =>

$\frac{1}{J.06} = 160$ $\quad \frac{1}{J.05} = 2$ $\quad \frac{1}{J0.4} = 25$ $\quad \frac{1}{j0.3} = 333$

$\frac{1}{J0.2} = 5$

=> So Now we k convert the ractance diagrame into Admittance.



* Now we Apply KCL in Node 1

So $I_1 = y_{1,0} V_2 + y_{1,2}(V_1 - V_2) + y_{1,3}(V_1 - V_3)$

$[y_{1,0} V_1 + y_{1,2} V_1 - y_{1,2} V_2 + y_{1,3} V_1 \quad y_{1,3} V_3]$

Now V_1 is common =>

$V_1 = V_1 (y_{1,0} + y_{1,2} + y_{1,3}) - y_{1,2} V_2 - y_{1,3} V_3$

$I_1 = V_1 [y_{1,0} + y_{1,2} + y_{1,3}] - y_{1,2} V_2 - y_{1,3} V_3]$

* Now Node 2

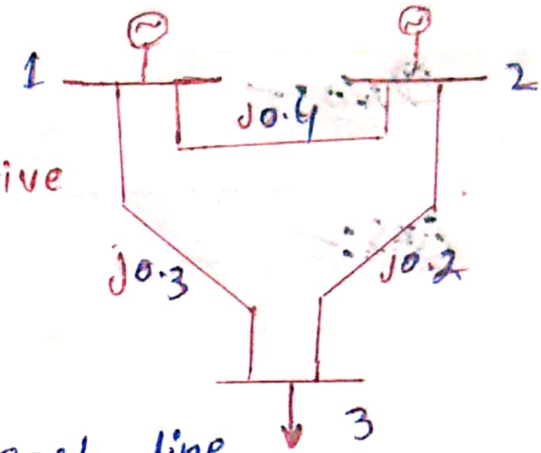
$= y_{2,0} V_2 + y_{1,2} (V_2 - V_1 + y_{2,3} (V_2 - V_3)$ eq 2

Common $\rightarrow [-y_{1,2} V_1]$

$-y_{1,2} V_1 \quad (y_{2,0} + y_{1,2} + y_{2,3}) \quad [V_1 - V_{2,3} - V_3]$

[redacted]

Neglect limits on reactive power generation.



Solution:-

Admittance of each line

$$y_{12} = \frac{1}{z_{12}} = \frac{1}{j0.4} = -j\,2.5 \text{ P.U}$$

$$y_{13} = \frac{1}{z_{13}} = \frac{1}{j0.3} = -j\,3.333 \text{ P.U}$$

$$y_{23} = \frac{1}{z_{23}} = \frac{1}{j0.2} = j5 \text{ P.U}$$

$$Y_{11} = y_{12} + y_{13} = -j2.5 - j\,3.333 = -5.833 \text{ P.U}$$

$$Y_{22} = y_{12} + y_{23} = -2.5 - j5 = -j7.5 \text{ P.U}$$

$$Y_{33} = y_{13} + y_{23} = -j\,3.333 - j5 = -j\,8.333 \text{ P.U}$$

$$Y_{12} = Y_{21} = -y_{12} = -(-j2.5) = j\,2.5 \text{ P.U}$$

$$Y_{13} = Y_{31} = -y_{13} = -(-j3.33) = j\,3.33 \text{ P.U}$$

$$Y_{23} = Y_{32} = -y_{23} = -(-j5) = j5 \text{ P.U}$$

the admittance Matrix is given as

$$Y_{bus} = \begin{vmatrix} y_{12}+y_{13} & -y_{12} & -y_{13} \\ -y_{21} & y_{21}+y_{23} & -y_{23} \\ -y_{31} & -y_{32} & y_{32}+y_{31} \end{vmatrix}$$

$$= \begin{vmatrix} -j5.833 & j2.5 & j3.33 \\ j2.5 & -j7.5 & j5 \\ j3.33 & j5 & -j8.333 \end{vmatrix}$$

Assume initial voltage to All buses

$$V_1^{(0)} = 1.05 \angle 0^\circ = 1.05 + j0 \text{ p.u}$$

$$V_2^{(0)} = 1.0 + j0 \text{ p.u}$$

$$V_3^{(0)} = 1.0 + j0 \text{ p.u}$$

bus 1 is a slack bus

$$V_1^{(1)} = 1.05 \angle 0^\circ = 1.05 + j0 \text{ p.u}$$

$$Q_{p,cal}^{k+1} = (-1) \times Im\left\{ (V_p^k)^* \left[\sum_{q=1}^{p-1} Y_{pq} V_q^{k+1} + \sum_{q=p}^{n} Y_{pq} V_q^k \right] \right\}$$

$$Q_{2cal}^{1} = (-1) \times Im\left\{ (V_2^0)^* \left[Y_{21} V_1^1 + Y_{22} V_2^0 + Y_{23} V_3^0 \right] \right\}$$

$$= (-1) \times Im (1-j0) \left[(j\,2.5)(1.05+j0) + (-j7.55)(1+j0) + (j5)(1+j0) \right] \}$$

$$Q_{2cal}^{1} = 0.125 \text{ p.u}$$

the phase of bus-2 voltage in first iteration is given by phase of $V_{p.temp}^{k+1}$

when $p=3$ $Q_2^1 = -0.125$ p.u and $k=0$

$$V_{p,temp}^{k+1} = \frac{1}{Y_{pp}} \left[\frac{P_p - jQ_p}{(V_p^k)^*} - \sum_{q=1}^{p-1} Y_{pq} V_q^{k+1} - \sum_{q=p+1}^{n} Y_{pq} V_q^k \right]$$

$$V_{2,temp}^{0+1} = \frac{1}{Y_{22}} \left[\frac{P_2 - jQ_2}{(V_2^0)^*} - \sum_{q=1}^{2-1} Y_{2q} V_q^{0+1} - \sum_{q=2+1}^{3} Y_{2q} V_q^0 \right]$$

$$V_2^1{,temp} = \frac{1}{Y_{22}}\left[\frac{P_2 - jQ_P}{(V_2^0)^*} - Y_{21}V_1^1 - Y_{23}V_3^0\right]$$

$$= \frac{1}{-j7.5}\left[\frac{3+j0.125}{1-j0} - (j2.5)(1.05+j0) - (j5)(1+j0)\right]$$

$$V_2^1 = \frac{1}{-j7.5}\left[3 - j7.5\right] = 1.077 \angle 21.8^\circ \, V$$

$$\delta_2^1 = \angle V^1_{2,temp} = 21.8^0 \, V$$

$$|V_2^1| = |V_2|\, spc \angle \delta_2^1 = 1.0 \angle 21.8^\circ$$

$$|V_2^1| = 0.928429 + j0.3713 \, V$$

* Bus 3 load Bus

the specified powers are load powers and so they considered as negative powers.

$$P_3 = -P_L = -4$$

$$Q_3 = -Q_L = -2$$

$$V_p^{k+1} = \frac{1}{Y_{pp}}\left[\frac{P_q - jQ_p}{(V_p^k)^*} - \sum_{q=1}^{p-1} Y_{pq} V_q^{k+1} - \sum_{q=p+1}^{n} Y_{pq} V_q^k\right]$$

$$V_3' = \frac{1}{Y_{33}}\left[\frac{P_3 - jQ_3}{(V_3^0)^*} - Y_{31} V_2^1 - Y_{32} V_2^1\right]$$

$$= \frac{1}{-j8.333}\left[\frac{-4+j2}{1-j0} - (j3.33)(1.05+j0) - (j5)(0.928429 + j0.37135)\right]$$

$$V_3' = 0.7806 \angle -19.24^\circ$$

$$V_3' = 0.737046 - j0.25724 \text{ P.U}$$

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