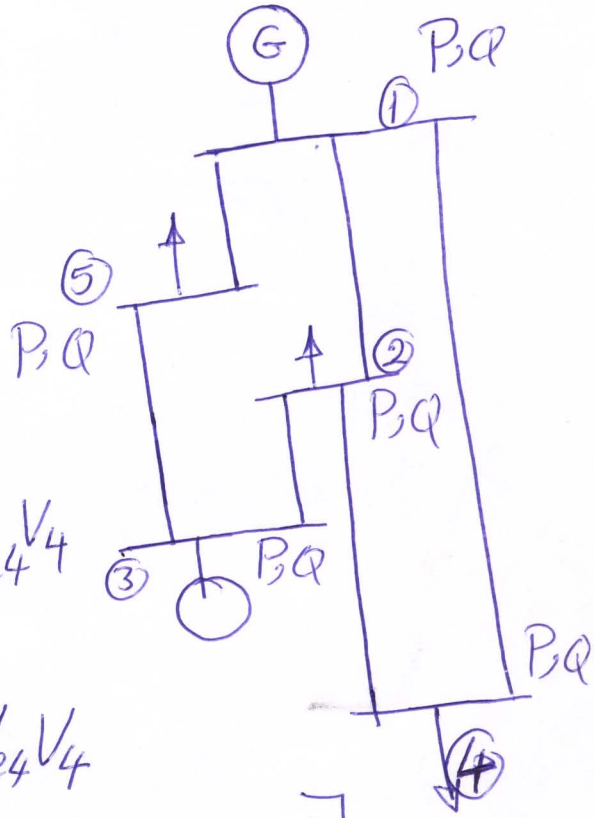
5 Power system Line Analysis

Load flow studies

1 Data for Load-flow studies :-

(a)- self and mutual admittances.
(b) the one-Line diagram and all its values.
(c) Transformer rating and impedance, shunt Capacitor rating
(d) all real power are known at all buses except one
(e) The Swing bus is determined (it is the bus at which the real power is not specified, and it is connected to Gen)
(f)

2 Gauss-seidel Method :-



$$V_2 I_2^* = P_2 + jQ_2$$

$$\therefore I_2 = \frac{P_2 - jQ_2}{V_2^*}$$

$$= Y_{21}V_1 + Y_{22}V_2 + Y_{23}V_3 + Y_{24}V_4$$

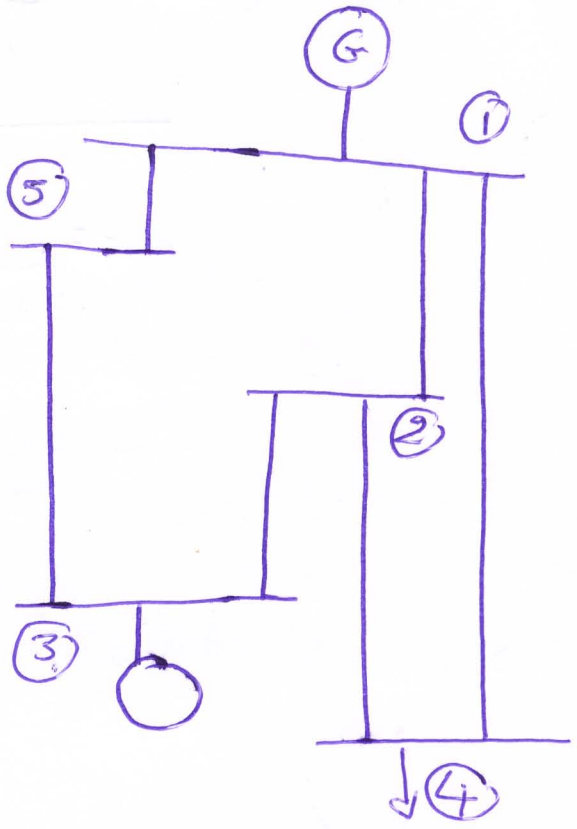
$$\frac{P_2 - jQ_2}{V_2^*} = Y_{21}V_1 + Y_{22}V_2 + Y_{23}V_3 + Y_{24}V_4$$

$$\therefore V_2 = \frac{1}{Y_{22}}\left[\frac{P_2 - jQ_2}{V_2^*} - (Y_{21}V_1 + Y_{23}V_3 + Y_{24}V_4)\right]$$

Example 1 :-

Given Then table 1

bus to bus	R	X
1-2	0.1	0.4
1-4	0.15	0.6
1-5	0.05	0.2
2-3	0.05	0.2
2-4	0.1	0.4
3-5	0.05	0.2



Perunit values

Bus	P	Q	V	Remark
1	—	—	$1.02\angle 0^\circ$	swing bus
2	-0.6	-0.3	$1.0\angle 0^\circ$	Load
3	1	—	1.04	V≠Const
4	-0.4	-0.1	$1.0\angle 0$	load
5	-0.6	-0.2	$1.0\angle 0$	load

After Converting Z = Y, then

Line	G	B
1-2	0.588	-2.359
1-4	0.3921	-1.5686
1-5	1.17647	-4.70588
2-3	1.17647	-4.705882
2-4	0.588235	-2.352941
2-5	1.176471	-4.705882

Test

$Z_{12} = 0.1 + j0.4$

$Y_{12} = \frac{1}{0.1+j0.4}$

$= \frac{0.1}{(0.1)^2+(0.4)^2} - j\frac{0.4}{(0.1)^2+(0.4)^2}$

$Y_{12} = 0.5882 - j2.3529$

We have to find the V_2 for the first iteration

① 1st iteration

$$V_2 = \frac{1}{Y_{22}}\left[\frac{P_2 - jQ_2}{V_2^*} - \left(Y_{21}V_1 + y_{23}V_3 + y_{24}V_4 + y_{25}V_5\right)\right]$$

$$\therefore V_2 = \frac{1}{Y_{22}}\left\{\frac{-0.6+j0.3}{1.0+j0} - \left[1.02(-0.5882+j2.3529) + 1.04(-1.17647+j4.70588) + (-0.588235+j2.3529)\right]\right\}$$

②

$$\therefore V_2 = \frac{1}{Y_{22}}\left(-0.6 + j0.3 + 2.411764 - j9.647058\right)$$

$$= 0.98 - j0.0525 \quad \text{P.U}$$

by the Grection factor $\equiv$ accelerationfactor

V_2 is calculated again by using V_2^*

$$\therefore V_2 = \frac{1}{Y_{22}}\left(\frac{-0.6 + j0.3}{0.98 + j0.0525} + 2.411764 - j9.647\right)$$

$$= 0.976351 - j0.050965$$

$$P_K - jQ_K = \left(Y_{KK}V_K + \sum_{n=1}^{n} Y_{Kn}V_n\right)V_K^*$$

if $n \neq K$

$$\therefore P_K - jQ_K = V_K^* \sum_{n=1}^{N} Y_{KN}V_n$$

$$\therefore Q_K = -Im\left\{V_K^* \sum_{n=1}^{N} Y_{KN}V_n\right\}$$

Example 2 :- find the first iteration of V_3 at the previous example using the last value of V_2

$$Q_3 = -Im\left\{\left[V_3^*\left(Y_{13}V_1 + Y_{23}V_2 + Y_{34}V_4 + Y_{35}V_5 + Y_{33}V_3\right)\right.\right.$$

$$= -Im\left\{\left[\overset{V_3}{1.04}\left(2.352941 - j9.4117\right) + \left(0.97635 - j0.0509\right)\left(-1.1764 + j4.7058\right)\right.\right.$$

$$\left.\left. + \left(-1.17647 + j4.70588\right)\right]1.04\right\}$$

$$= 0.444913$$

$$\therefore V_3 = \frac{1}{y_{33}} \left\{ \frac{1.0 - j0.444913}{1.04} - \left[(-1.176 + j4.70588)(0.9763 - j0.0509) + (-1.176471 + j4.705882) \right] \right\}$$

$$= 1.054984 + j0.059979 \Rightarrow |V_3| = 1.056688$$

This V_3 is recalculated as follows

$$V_3 = \frac{1.04}{1.056688} (1.054984 + j0.059979)$$

$$= 1.038322 + j0.059032 \text{ p.u.}$$