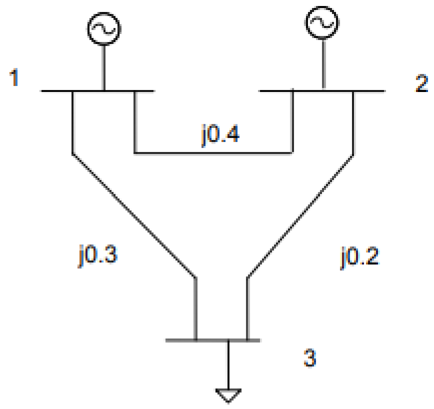
Problems:

1) Fig. shows a three bus power system.
   Bus 1 : Slack bus, V= 1.05/00 p.u.
   Bus 2 : PV bus, V = 1.0 p.u. Pg = 3 p.u.
   Bus 3 : PQ bus, PL = 4 p.u., QL = 2 p.u.
   Carry out one iteration of load flow solution by Gauss Seidel method.



Neglect limits on reactive power generation.

Solution:

Admittance of each line

$$y_{12}=\frac{1}{Z_{12}}=\frac{1}{j0.4}=-j2.5\ p.u$$

$$y_{13}=\frac{1}{Z_{13}}=\frac{1}{j0.3}=-j3.333\ p.u$$

$$y_{23}=\frac{1}{Z_{23}}=\frac{1}{j0.2}=-j5\ p.u$$

$Y11 = y12 + y13 = -j2.5 - j3.333 = -j5.833\ p.u$

$Y22 = y12 + y23 = -j2.5 - j5 = -j7.5\ p.u$

$Y33 = y13 + y23 = -j3.333 - j5 = -j8.333\ p.u$

$Y12 = Y21 = -y12 = - -j2.5 = j2.5\ p.u$

$Y13 = Y31 = -y13 = - -j3.33 = j3.33\ p.u$

$Y23 = Y32 = -y23 = - -j5 = j5\ p.u$

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 voltages to all buses

$V1\ (0) = 1.05\angle 0^0 = 1.05 + j0$ p.u

$V2\ (0) = 1.0 + j0$ p.u

$V3\ (0) = 1.0 + j0$ p.u

Bus 1 is a slack bus

$V1\ (1) = 1.05\angle 0^0 = 1.05 + j0$ p.u

Bus 2 is a generator bus

To calculate reactive power

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

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

$$= (-1) \times Im(1 - j0)[(j2.5)(1.05 + j0) + (-j7.5)(1 + j0) + (j5)(1 + j0)]\}$$

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

The phase of bus -2 voltage in first iteration is given by phase of Vp,temp K+1

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

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

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

$$V_{2,temp}^1 = \frac{1}{Y_{22}} \left[\frac{P_2 - jQ_2}{(V_2^0)^*} - Y_{21} V_1^1 - Y_{23} V_3^0 \right]$$

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

$$V_2^1 = \frac{1}{-j7.5} [3 - j7.5] = 1.077\angle 21.8^0 \text{ V}$$

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

$$|V_2^1| = |V_2|_{spc} \angle \delta 2^1 = 1.0\angle 21.8^0$$

$$|V_2^1| = \mathbf{0.928429 + j0.3713\ V}$$

Bus 3 Load Bus

The specified powers are load powers and so they considered as negative powers

P3= −PL= −4

Q3= −QL= −2

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

$$V_3^1 = \frac{1}{Y_{33}}\left[\frac{P_3 - jQ_3}{(V_3^0)^*} - Y_{31}V_1^1 - Y_{32}V_2^1\right]$$

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

$$V_3^1 = 0.7806\angle - 19.24^0$$

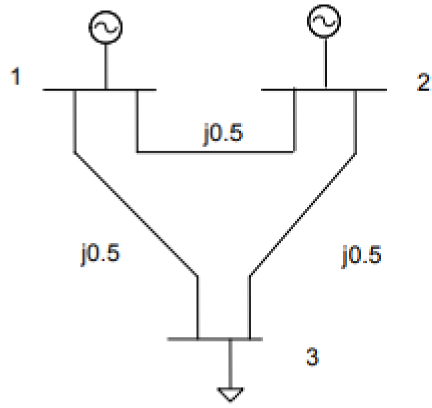
$$V_3^1 = 0.737046 - j0.25724\, p.u$$

2) Carry out one iteration of load flow analysis of the system given below by Gauss-Seidal method

Bus no	**Bus type**	**P**	**Q**	**V p.u**
1	**Slack**	**-**	**-**	**1.02**
2	**P-V**	**0.8**	**0.1 ≤ Q ≤ 1**	**1**
3	**P-Q**	**1.0**	**0.4**	**-**

Line reactance in p.u

Bus code	**Impedance**
1-2	**j0.5**
2-3	**j0.5**
3-1	**j0.5**



Solution:

$y_{12}=\frac{1}{z_{12}}=\frac{1}{j0.5}=-j2\ p.u$

$y_{13}=\frac{1}{z_{13}}=\frac{1}{j0.5}=-j2\ p.u$

$y_{23}=\frac{1}{z_{23}}=\frac{1}{j0.5}=-j2\ p.u$

$Y11 = y12 + y13 = -j2 - j2 = -j4\ p.u$

$Y22 = y12 + y23 = -j2 - j2 = -j4\ p.u$

$Y33 = y13 + y23 = -j2 - j2 = -j4\ p.u$

$Y12 = Y21 = -y12 = - -j2 = j2.\ p.u$

$Y13 = Y31 = -y13 = - -j2 = j2.\ p.u$

$Y23 = Y32 = -y23 = - -j2 = j2.\ p.$U

The admittance matrix is given as

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

$$=\begin{vmatrix} -j4 & j2 & j2 \\ j2 & -j4 & j2 \\ j2 & j2 & -j4 \end{vmatrix}$$

Assume initial voltages to all buses

V1 (0) = $1.02\angle 0^0$ =1.02+j0 p.u

V2 (0)=1.0+j0 p.u

V3 (0)=1.0+j0 p.u

Bus 1 is a slack bus

$V1^{(1)} = 1.02\angle 0^0$ =1.02+j0 p.u

Bus 2 is a generator bus

To calculate reactive power

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

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

$$=(-1)\times Im(1-j0)[(j2)(1.02+j0)+(-j4)(1+j0)+(j2)(1+j0)]\}$$

$$Q_{2cal}^1 = -0.04 p.u$$

This value is not with in the specified limit .so treat this bus as load bus Q2=0.1 P2=0.3 and $V2^0$ =1.0+j0

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

$$= \frac{1}{Y_{22}}\left[\frac{P_2 - jQ_2}{(V_2^0)^*} - Y_{21} V_1^1 - Y_{23} V_3^0\right]$$

$$\frac{1}{-j4}\left[\frac{0.8 - j0.1}{1 - j0} - (j2)(1.02 + j0) - (j2)(1 + j0)\right]$$

=

$$|V_2^1| = \mathbf{1.035 + j0.2 = 1.054\angle 10.93^0\ V}$$

Bus 3 Load Bus

The specified powers are load powers and so they considered as negative powers

P3= –PL= –1

Q3= –QL= –0.4

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

$$V_3^1 = \frac{1}{Y_{33}}\left[\frac{P_3 - jQ_3}{(V_3^0)^*} - Y_{31} V_1^1 - Y_{32} V_2^1\right]$$

$$= \frac{1}{-j4}\left[\frac{-1 + j0.4}{1 - j0} - (j2)(1.02 + j0) - (j2)(\mathbf{01.035 + j0.2})\right]$$