POWER FLOW SOLUTION USING GAUSS SEIDEL METHOD

Load Flow by Gauss-Seidel Method

The basic power flow equations (4.6) and (4.7) are nonlinear. In an n -bus power system, let the number of P-Q buses be np and the number of P-V (generator) buses be ng such that n = np + ng + 1. Both voltage magnitudes and angles of the P-Q buses and voltage angles of the P-V buses are unknown making a total number of 2np + ng quantities to be determined. Amongst the known quantities are 2np numbers of real and reactive powers of the P-Q buses, 2ng numbers of real powers and voltage magnitudes of the P-V buses and voltage magnitude and angle of the slack bus. Therefore there are sufficient numbers of known quantities to obtain a solution of the load flow problem. However, it is rather difficult to obtain a set of closed form equations from power flow equations. We therefore have to resort to obtain iterative solutions of the load flow problem.

At the beginning of an iterative method, a set of values for the unknown quantities are chosen. These are then updated at each iteration. The process continues till errors between all the known and actual quantities reduce below a pre-specified value. In the Gauss-Seidel load flow we denote the initial voltage of the i th bus by Vi(0) , i = 2, ... , n . This should read as the voltage of the i th bus at the 0th iteration, or initial guess. Similarly this voltage after the first iteration will be denoted by Vi(1) . In this Gauss-Seidel load flow the load buses and voltage controlled buses are treated differently. However in both these type of buses we use the complex power equation ifor updating the voltages. Knowing the real and reactive power injected at any bus we can expand.

$$P_{i,inj} - jQ_{i,inj} = V_i^* \sum_{k=1}^{n} Y_{ik} V_k = V_i^* \left[Y_{i1} V_1 + Y_{i2} V_2 + \cdots + Y_{ii} V_i + \cdots + Y_{in} V_n \right]$$

We can rewrite as

$$V_i = \frac{1}{Y_{ii}} \left[\frac{P_{i,inj} - jQ_{i,inj}}{V_i^*} - Y_{i1} V_1 - Y_{i2} V_2 - \cdots - Y_{in} V_n \right]$$

ALGORITHM OF GAUSS SEIDAL METHOD

Step1:

Assume all bus voltage be 1+ j0 except slack bus. The voltage of the slack bus is a constant voltage and it is not modified at any iteration

Step 2:

Assume a suitable value for specified change in bus voltage which is used to compare the actual change in bus voltage between K th and (K+1) th iteration

Step 3:

Set iteration count K = 0 and the corresponding voltages are V10, V20, V30, …… Vno except slack bus

Step 4:

Set bus count P = 1

Step 5:

Check for slack bus. It is a slack bus then goes to step 12 otherwise go to next step

Step 6:

Check for generator bus. If it is a generator bus go to next step. Otherwise go to step 9 `

Step 7:

Set |VPK|= |VP| specified and phase of |VPK| as the K th iteration value if the bu generator bus where |VP| specified is the specified magnitude of voltage for bus P. Calculate reactive power rating P-1 n QP K+1 Cal = (-1) Imag [(VPK)A (Σ Y pqVq k+1 +Σ Y pqVq K q=1 q =P

Step 8:

If calculated reactive power is within the specified limits then consider the bus as generator bus and then set QP = QPK+1 Cal for this iteration go to step 10

Step 9:

If the calculated reactive power violates the specified limit for reactive power then treat this bus as load bus.

If QPK+1 Cal < QPmin then QP = QPmin

QPK+1 Cal > QPmax then QP = QPmax

Step10:

For generator bus the magnitude of voltagedoes not change and so for all

Iterations the magnitude of bus voltage is the specified value. The phase of the

bus voltage can be calculated using

$V_{PK+}1$ temp = 1 / Y_{PP} [(P_P –jQ_P / VPK *) - ΣYpqVqK+1 - ΣYpqVqK]

Step 11:

For load bus the (k+1)th iteration value of load bus P voltage V_P^{K+1} can be calculated using V_P^{K+1} temp = $1 / Y_{PP} [(P_P - jQ_P / V_P^{K*}) - \Sigma Y_{pq} V_q^{K+1} - \Sigma Y_{pq} V_q^K]$

Step 12:

An acceleration factor α can be used for faster convergence. If acceleration factor is specified then modify the (K+1)th iteration value of bus P using

$V_{Pacc}^{K+1} = V_P^K + \alpha (V_P^{K+1} - V_P^K)$ then Set $V_P^{K+1} = V_{Pacc}^{K+1}$

Step 13:

Calculate the change in bus-P voltage using the relation

$\Delta V_P^{K+1} = V_P^{K+1} - V_P^K$

Step 14:

Repeat step 5 to 12 until all the bus voltages have been calculated. For this increment the bus count by 1 go to step 5 until the bus count is n

Step 15:

Find the largest of the absolute value of the change in voltage

$|\Delta V_1^{K+1}|, |\Delta V_2^{K+1}|, |\Delta V_3^{K+1}|, \ldots\ldots\ldots\ldots |\Delta V_n^{K+1}|$

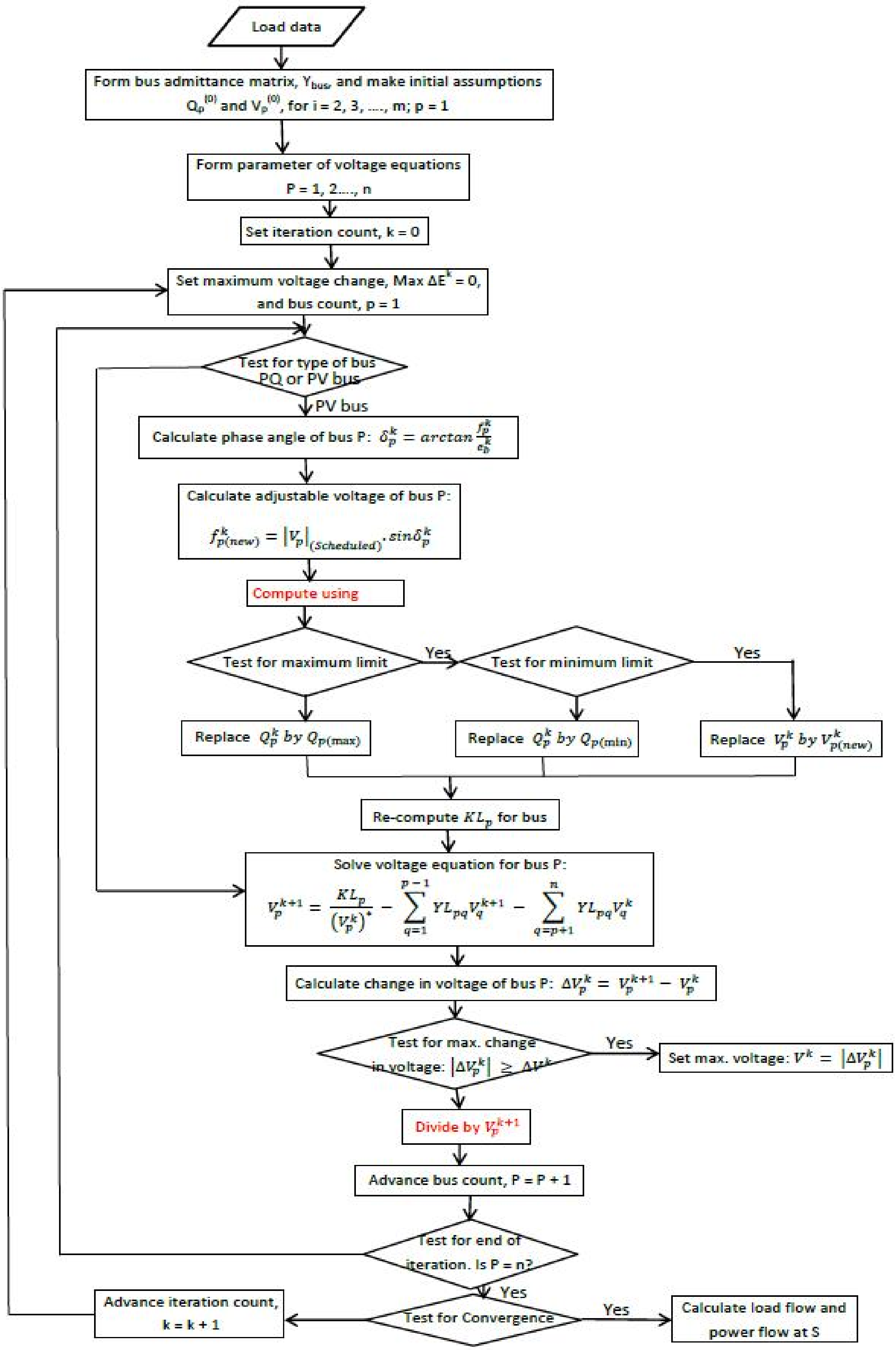
Let this largest value be the $|\Delta V_{max}|$. Check this largest change

$|\Delta V_{max}|$ is less than pre specified tolerance. If $|\Delta V_{max}|$ is less go to next step. Otherwise increment the iteration count and go to step 4

Step 16:

Calculate the line flows and slack bus power by using the bus voltages

GAUSS - SEIDAL METHOD FLOW CHART


Load data
Form bus admittance matrix, Ybus, and make initial assumptions Qp(0) and Vp(0), for i = 2, 3, ..., m; p = 1
Form parameter of voltage equations P = 1, 2...., n
Set iteration count, k = 0
Set maximum voltage change, Max ΔEk = 0, and bus count, p = 1
Test for type of bus PQ or PV bus
PV bus
Calculate phase angle of bus P:
Calculate adjustable voltage of bus P:
Compute using
Test for maximum limit
Yes
Test for minimum limit
Yes
Replace
Replace
Replace
Re-compute for bus
Solve voltage equation for bus P:
Calculate change in voltage of bus P:
Test for max. change in voltage:
Yes
Set max. voltage:
Divide by
Advance bus count, P = P + 1
Test for end of iteration. Is P = n?
Yes
Advance iteration count, k = k + 1
Test for Convergence
Yes
Calculate load flow and power flow at S

Advantages and disadvantages of Gauss-Seidel method

Advantages:

- Calculations are simple and so the programming task is lessees.
- The memory requirement is less.
- Useful for small systems

Disadvantages:

- Requires large no. of iterations to reach converge .
- Not suitable for large systems.
- Convergence time increases with size of the system

Problems:1

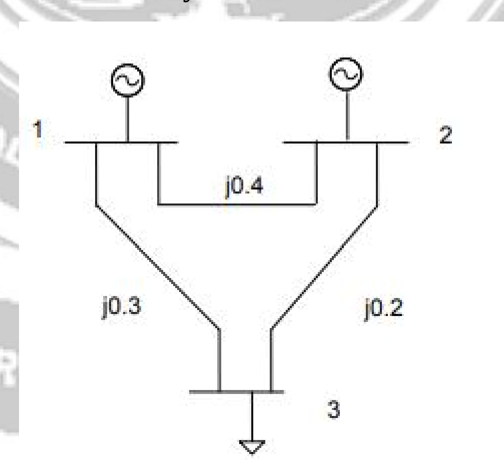
1) Fig. shows a three bus power system.

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

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

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

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

$Y_{11} = y_{12} + y_{13} = -j2.5 - j3.333 = -j5.833\ p.u$

$Y_{22} = y_{12} + y_{23} = -j2.5 - j5 = -j7.5\ p.u$

$Y_{33} = y_{13} + y_{23} = -j3.333 - j5 = -j8.333\ p.u$

$Y_{12} = Y_{21} = -y_{12} = - -j2.5 = j2.5\ p.u$

$Y_{13} = Y_{31} = -y_{13} = - -j3.33 = j3.33\ p.u$

$Y_{23} = Y_{32} = -y_{23} = - -j5 = j5\ p.u$

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

$V_1\ (0)= 1.05\angle 0^0\ =1.05+j0$ p.u

$V_2\ (0)=1.0+j0$ p.u

$V_3\ (0)=1.0+j0$ p.u

Bus 1 is a slack bus

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

Bus 2 is a generator bus

To calculate reactive power

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

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

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

$Q2cal1$ = − 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 $Q21$ = − 0.125 p.u and k=0