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SHORT QUESTIONS AND ANSWERS

Year/ Semester/ Class : III/ V/ EEE Academic Year: 2017-2018

Subject Code/ Name: EE6501/ Power System Analysis

UNIT II-POWER FLOW ANALYSIS

PART – A

1. **What is P-Q bus in power flow analysis?**
   A bus is called PQ-bus or load bus when real and reactive components of power are specified for the bus. In a load bus the voltage is allowed to vary within permissible limits.

2. **What is the need for power flow or load flow study?**
   The load flow study of a power system is essential to decide the best operation of existing system and for planning the future expansion of the system. It is also essential for designing a new power system.

3. **Give the advantages of N-R method.**
   - The N-R method is faster, more reliable and the results are accurate.
   - Requires less number of iterations for convergence.
   - The number of iterations are independent of the size of the system(number of buses).
   - Suitable for large size system.

4. **Give the disadvantages of N-R method.**
   - The programming is more complex.
   - The memory requirement is more.
   - Computational time per iteration is higher due to large number of calculations per iteration.

5. **Mention any three advantages of N-R method over G-S method.**
   - The N-R method has quadratic convergence characteristic and so convergence faster than G-S method.
   - The number of iterations for convergence is independent of the size of the system in N-R method.
   - In N-R method the convergence is not affected by the choice of slack bus.

6. **What is the need for slack/swing bus in power system?**
   The slack/swing bus is needed to account for transmission line losses. In a power system the total power generated will be equal to sum of power consumed by loads and losses. In a power system only the generated power and load power are specified for buses. The slack bus is assumed to generate the power required for losses. Since the losses are unknown the real and reactive power are not specified for slack bus. They are estimated through the solution of load flow equations.

7. **What are the advantages of FDLF method?**
   - FDLF method is faster, simple to program, more reliable and requires less memory than NR load flow method.
   - FDLF method requires more iteration than N-R method, but requires less time per iteration.

8. What are the types of buses? or What are the three classes of buses of a power system used in power flow analysis?

- Load bus or PQ-bus (P and Q are specified)
- Generator bus or voltage controlled bus or PV bus (P and V are specified)
- Slack bus or swing bus or reference bus (Voltage magnitude and angle are specified)

9. Why the load flow studies are important for planning the existing system as well as its future expansion?

The load flow studies are very important for planning, economic scheduling, control and operations of existing systems as well as planning its future expansion depends upon knowing the effect of interconnections, new loads, new generating stations, or new transmission lines, etc., before they are installed.

10. What is power flow study or load flow study?

The study of various methods of solution to power system network is referred to as load flow study. The solution provides the voltages at various buses, power flowing in various lines and line-losses.

11. What is the information that is obtained from load flow study?

- The magnitude and phase of bus voltages, real and reactive power flowing in each line and the line losses.
- The load flow solution also gives the initial conditions of the system when the transient behavior of the system is to be studied.

12. What are the quantities to be specified and to be computed for each class during power flow solution?

- Load bus or PQ-bus (P and Q are specified- Voltage magnitude and angle are to be obtained)
- Generator bus or voltage controlled bus or PV bus (P and V are specified- Voltage angle and Q are to be obtained)
- Slack bus or swing bus or reference bus (Voltage magnitude and angle are specified- P and Q are to be obtained)

13. What is swing bus (or slack bus)?

A bus is called swing bus (or slack bus) when the magnitude and phase of bus voltage are specified for it. The swing bus is the reference bus for load flow solution and it is required for accounting line losses. Usually one of the generator bus is selected as the swing bus.

14. What are the methods used for the iterative solution of non-linear algebraic equations?

- Gauss-Seidal Load Flow Method(GSLF)
- Newton-Raphson Load Flow Method(NRLF)
- Fast-decoupled Load Flow Method(FDLF)

15. What do you mean by flat voltage start?

In iterative methods of load flow solution, the initial voltages of all buses except slack bus are assumed as 1+j0 p.u. This is referred to as flat voltage start.

16. What is a bus?

The meeting point of various components in a power system is called as bus.At some of the buses power is being injected into the network, whereas at other buses it is being tapped by the system loads.

17. When the generator bus is treated as load bus?

If the reactive power of a generator bus violates the specified limits then the generator bus is treated as load bus.

18. What technique is used to solve load flow problems using Z-bus (Bus impedance matrix)?

The formulation of load flow problem using Z_{bus} employs Diakoptics techniques which is actually the piecewise solution of the power system problem by using tearing off technique.

19. What is PQ bus?

A bus is called PQ bus or load bus when real and reactive components of power are specified for the bus. In a load bus the voltage is allowed to vary within permissible limits.

20. What are the four quantities that are associated with each bus in a system?

- Real Power
- Reactive Power
- Voltage magnitude
- Phase angle of voltage

Part B

1. Give the flow chart for newton raphson method

Algorithm :

1. Formulate Y bus matrix
2. Assume flat start for starting voltage soln.

$\delta_i^0 = 0$ for $i = 1, \ldots N$ for all buses except slack bus

$|V_i^0| = 1.0$, for $i = M+1, M+2, \ldots N$ (for all PQ buses)

$|V_i| = |V_i|_{(spec)}$ for all PV buses and slack bus

3. for PV buses, check for Q limit violation

If $Q_{(min)} < Q_i^{cal} < Q_{i(max)}$, the bus acts as PV bus

If $Q_i^{cal} > Q_{imax}$, $Q_{i\,spec} = Q_{i(max)}$

If $Q_i^{cal} < Q_{imin}$, $Q_{i(spec)} = Q_{i(min)}$, the PV bus will act as PQ bus

4. For load buses, calculate P_i^{cal} and Q_i^{cal}
5. Compute mismatch vector using

$$\Delta P_i = P_{i(spec)} - P_i^{cal}$$

$$\Delta Q_i = Q_{i(spec)} - Q_i^{cal}$$

6. Compute $\Delta P_{i(max)} = \max |\Delta P_i|$; $i = 1, 2 \ldots N$ except slack

$$\Delta Q_{i(max)} = \max |\Delta Q_i| \; ; \; i = M+1, \ldots N$$

7. Compute Jacobian matrix using

$$J = \begin{bmatrix} \frac{\delta P_i}{\delta \delta} & |V| \frac{\partial P_i}{\partial |V|} \\ \frac{\partial Q_i}{\partial \delta} & |V| \frac{\partial Q_i}{\partial |V|} \end{bmatrix}$$

8. Obtain state correction vector $\begin{bmatrix} \Delta \delta \\ \frac{\Delta V}{|V|} \end{bmatrix} = [J]^{-1} \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix}$

Step 11 : Update the new voltage as

$$V^{new} = V^{old} + \alpha(V^{new} - V^{old})$$

$$V^{old} = V^{new}$$

iter = iter + 1 ; go to step 5.

Step 12 : Compute relevant quantities

Slack bus power, $S_i = P_i - jQ_i = V^* I$

$$= V_i^* \sum_{j=1}^{N} Y_{ij} V_j$$

Line flows $S_{ij} = P_{ij} + jQ_{ij}$

$$= V_i [V_i^* - V_j^*] Y_{ij\,series}^* + |V_i|^2 Y_{ii}^*$$

$$P_{loss} = P_{ij} + P_{ji}$$

$$Q_{loss} = Q_{ij} + Q_{ji}$$

Step 13 : Stop the execution.

Draw the flow chart.

3. Fig shows a three bus system. Bus 1: slack bus $V = 1.05\angle 0^\circ$ pu Bus 2 : PV bus $|V| = 1$ pu $P_g = 3$ pu Bus 3 : PQ bus $P_L = 4$ pu $Q_L = 2$ pu. Carry out one iteration of load flow soln by GS method.

Step 7(a) : If 'i' refers to the slack bus go to step 9. otherwise go to step 7(b)

Step 7(b) : Compute Q_i using

$$Q_i^{cal} = -Im\left[\sum_{j=1}^{N} V_i^{*} Y_{ij} V_j\right]$$

$$Q_{Gi} = Q_i^{cal} + Q_{Li}$$

Check for Q limit violation

If $Q_{i(min)} < Q_{Gi} < Q_{i(max)}$, then $Q_{i(spec)} = Q_i^{cal}$

If $Q_{i(min)} < Q_{Gi}$, then $Q_{i(spec)} = Q_{i(min)} - Q_{Li}$

If $Q_{i(max)} < Q_{Gi}$ then $Q_{i(spec)} = Q_{i(max)} - Q_{Li}$

If Q_{limit} is violated, then treat this bus as P-Q bus till convergence is obtained.

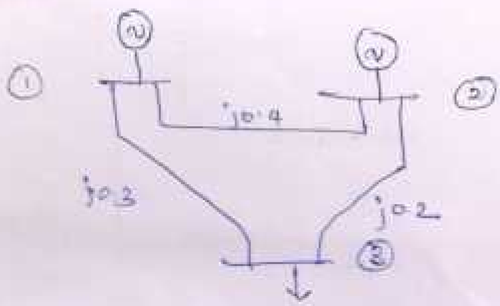
Step 8 : Compute V_i using the eqn

$$V_i^{new} = \frac{1}{Y_{ii}}\left[\frac{P_{i(spec)} - Q_{i(spec)}}{V_i^{old *}} - \sum_{i=1}^{j-1} Y_{ij} V_j^{new} - \sum_{i=j+1}^{n} Y_{ij} V_i^{old}\right]$$

Step 9 : If i is less than no of buses, increment i by 1 and go to step 6.

Step 10 : Compare two successive iteration values for V_i.

If $V_i^{new} - V_i^{old} <$ tolerance, go to Step 12.



Step 1: form Y_{bus}

$$Y_{bus} = \begin{bmatrix} -j5.833 & j2.5 & j3.333 \\ j2.5 & -j7.5 & j5 \\ j3.333 & j5 & -8.333j \end{bmatrix}$$

Step 2: Initialize bus voltage

$V_1^{old} = 1.05\angle 0°$ pu $V_2^{old} = 1.02\angle 0°$ pu

$V_3^{old} = 1\angle 0°$ pu

Step 3: Cal Q for PV bus

$Q_2^{cal} = 0.025$ pu

Q_2^{cal} is within specified limit

Step 4: cal V_i^{new}

$V_2^{new} = 1.0207\ \angle 2.2°$

$V_3^{new} = 1.0071\ \angle -1.37°$,,

4) The system data for a load flow soln are given in tables. Determine the voltages at the end of the first iteration using GS. $\alpha = 1.6$

Bus code	P(p.u)	Q(p.u)	V(p.u)	Remarks
1	–	–	1.06 1+j0	Slack
2	0.5	0.2		PQ
3	0.4	0.3	1+j0	PQ
4	0.3	0.1	1+j0	PQ

Line admittances

Bus code	Admittance
1-2	2-j8
1-3	1-j4
2-3	0.666 - j2.664
2-4	1-j4
3-4	2-j8

$$Y_{bus} = \begin{bmatrix} 3-j12 & -2+j8 & -1+j4 & 0 \\ -2+j8 & 3.666-j14.664 & -0.666+j2.664 & -1+j4 \\ -1+j4 & -0.366+j2.664 & 3.666-j14.664 & -2+j8 \\ 0 & -1+j4 & -2+j8 & 3-j12 \end{bmatrix}$$

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

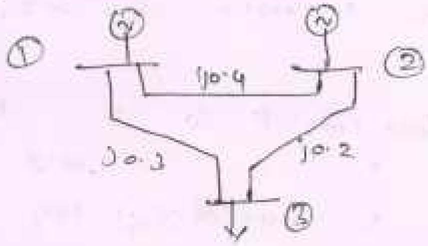
$V_1^1 = 1.06 \angle 0^\circ$ pu

$V_2^1 = 1.0201 \angle -2.61^\circ$ pu

$V_3^1 = 0.9907 - j0.0469$ pu

$V_4^1 = 0.9843 \angle -6.38^\circ$ pu

5. Fig shows a three bus power system



Bus 1 : slack bus, $V = 1.05 \angle 0^\circ$ pu

Bus 2 : PV bus, $|V| = 1$ pu $P_g = 3$ pu

Bus 3 : PQ bus, $P_L = 4$ pu $Q_L = 2$ pu

Carry out one iteration of load flow soln by GS.

$$Y_{bus} = \begin{bmatrix} -5.833j & j2.5 & j3.333 \\ j2.5 & -j7.5 & j5 \\ j3.333 & j5 & -j8.333 \end{bmatrix}$$

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

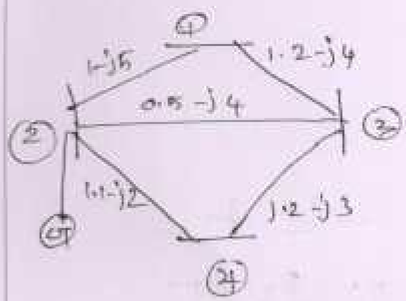
$$Q_{p,cal}^{k+1} = -1\ \mathrm{Im}\left\{(V_p^k)^*\left[\sum_{q=1}^{p-1} Y_{pq}V_q^{k+1} + \sum_{q=p}^{n} Y_{pq}V_q^{k}\right]\right\}$$

$V_1' = 1.05 \angle 0^\circ$ pu

$V_2' = 1.0 \angle 21.8^\circ$ pu

$V_3' = 0.78664 \angle -19.24^\circ$ pu

6. For the s/m shown in fig. determine the voltages at the end of first iteration by G.S. method.



Bus code	P	Q	V	Remarks
1	–	–	$1.06\angle 0^\circ$	Slack
2	0.5	$0.1 \le Q_2 \le 1$	1.04	PV
3	0.4	0.3	–	PQ
4	0.2	0.1	–	PQ

$$Y_{bus} = \begin{bmatrix} 2.2-j9 & -1+j5 & -1.2+j4 & 0 \\ -1+j5 & 2.6-j11 & -0.5+j4 & -1.1+j2 \\ -1.2+j4 & -0.5+j4 & 2.9-j11 & -1.2+j3 \\ 0 & -1.1+j2 & -1.2+j3 & 2.3-j5 \end{bmatrix}$$

$V_1^1 = 1.06\angle 0^\circ$ pu

$V_2^1 = 1.04\angle 2.05^\circ$ pu

$V_3^1 = 1.00$[illegible] $\angle -0.88^\circ$ pu

$V_4^1 = 0.9850\angle -1.04^\circ$ pu