VALLIAMMAI ENGINEERING COLLEGE

S.R.M Nagar, Kattankulathur – 603 203

DEPAREMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PS7101-Advanced Power System Analysis

Question Bank

Course : ME- Power Systems **Semester : I** **Academic Year: 2014-2015**

UNIT I

PART A

1. List the advantages of flexible packed storage scheme.
2. Define sparsity and near-optimal ordering.
3. What is triangular factorization and back substitution?
4. What is the need of optimal ordering of matrices?
5. Use Gaussian elimination to solve the following linear system
6. List the advantage of sparse matrix technique for large power systems.

   $x - y = 4$

   $2x - 2y = -4$
7. Define sparse matrix
8. What is meant by compact arrays?
9. Write the advantage of sparse matrix?
10. What is meant by pivotal equation?
11. When is matrix said to be sparse?
12. What is ordering?

PART B

1.

(a) What is sparsity? Explain the various optimal ordering schemes for preserving sparsity with suitable examples. (16)

Or

(b) Solve the following equations using bi-factorization method. Give also the factor matrices.

(16)

$$2I_1 + 10I_2 + I_3 = 1$$
$$10I_1 + 3I_2 = 1$$
$$5I_1 + 2I_2 + 14I_3 = 3$$

2.

(a) Explain the effects of optimal ordering schemes for preserving sparsity with the help of graphical illustration considering a four –bus system. How will you observe the sparsity by writing the mismatch equation for a four-bus system? (16)

Or

(b) Discuss the factorization by Bifactorization elimination method. Compare it with the Gauss Elimination methods. (16)

3.

(a) What is called optimal ordering? Describe in detail the optimal ordering schemes for preserving sparsity.

Or

(b) Compare the factorization of power system by Bifactorization and Guass Elimination methods.

4.

(a) (i) Discuss the importance of sparsity in bus admittance matrix

(ii) Write the detail about compact storage and optimal ordering.

Or

(b) Solve the following equations using bi-factorization method. Give also the factor matrices.

$$\begin{bmatrix} 10 & 3 & 0 \\ 4 & 20 & 2 \\ 5 & 2 & 14 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$$

5.

(a) The graph shown in figure 11(a) is for a 10 x 10 Y bus system. Using Scheme 3 ordering determine a sequence in which buses should be numbered so as to minimize the number of fill-ins the LU factors of Y bus.

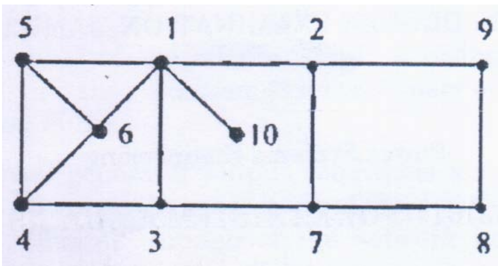


Fig. 11(a)

Or

b. Find the LU factors of the matrix given below.[L] is a lower triangular matrix with Non-unity diagonal element and [U] is upper triangular matrix with unity diagonal Element.

$$\begin{bmatrix} 2 & 4 & 4 \\ 3 & 3 & 12 \\ 2 & 4 & -1 \end{bmatrix}$$

6.

(a) Explain with a neat flow chart, any two of the optimal ordering schemes for preserving sparsity.

(or)

(b) Solve the following equations using bi-factorization method:

$$2x_1 + x_2 + 3x_3 = 6$$

$$2x_1 + 3x_2 + 4x_3 = 9$$

$$3x_1 + 6x_2 + 8x_3 = 14$$

7.

(a) Explain the flexible packed storage scheme for storing matrix as compact arrays.

(Or)

(b) Solve the following equations using bi-factorization method

$$2X_1 + 10X_2 + X_3 = 1$$

$$10X_1 + 3X_2 = 1$$

$$5X_1 + 2X_2 + 14X_3 = 3$$

UNIT II

PART A

1. List any two advantages of fast decoupled power flow method.
2. Write the power flow equation in polar form.
3. Compare the advantages of FDLF and Newtons load flow method?
4. How is power flow different from continuation power flow method?
5. What do you mean by flat voltage start?
6. What is meant by Available Transfer Capability?
7. Why is one of the buses taken as slack bus in load flow analysis?
8. What is called available transfer capability?
9. List any two advantages of fast de-coupled power flow method.
10. Define the term sensitivity factor in power system?
11. What are the three types of buses in the power network?
12. Write the polar form of the power flow equations.
13. What is available transfer capability?
14. Write the power flow equations in real variable form.
15. What are the assumptions made in Fast Decoupled power flow method of power flow analysis?

PART B

1.

a. Derive the power flow equation in real and polar forms. Explain the iterative algorithm for the solution of the load flow problem by the fast decoupled power flow. (16)

Or

b. Discuss the net interchange power control in multi- area power flow analysis. How is available transfer capability (ATC) assessed using repeated power flow method? (16)

2.

a. Fig. 12a shows the one-line diagram of a simple three – bus power system with generators at buses 1 and 2. The line impedances are marked in per unit on a 100 MVA base. Find out the bus voltages after two iterations using Fast Decoupled Power Flow method. (16)

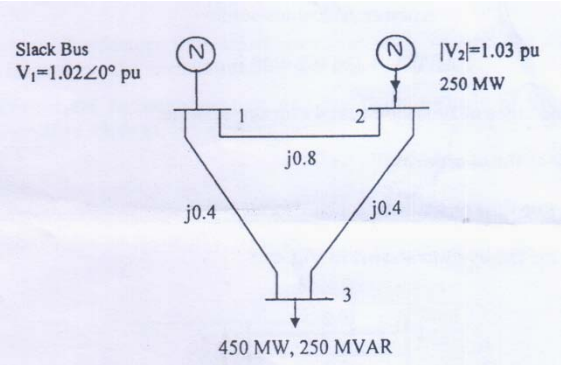


Fig.12a

Or

(b)

(i) Explain the continuation power flow method. (8)

(ii) What is Available Transfer Capability? Explain the assessment of Available Transfer Capability using repeated power flow method. (8)

3.

(a)

(i) Name the classification of buses in load flow studies and explain them. (8)

(ii) Write the algorithm for the solution of load flow equation by Fast decoupled method.(8)

Or

(b) (i) What is meant by sensitivity factors? Name the sensitivity factors for P-V bus adjustment.

(ii) What is called available transfer capability? Explain the assessment of available transfer capability using repeated power flow method. (8)

4.

(a) Derive the algorithm and step by step for fast decoupled load flow analysis of power system . State and justify the assumptions. What are the merits and demerits of this method when compared to other methods of load flow analysis?

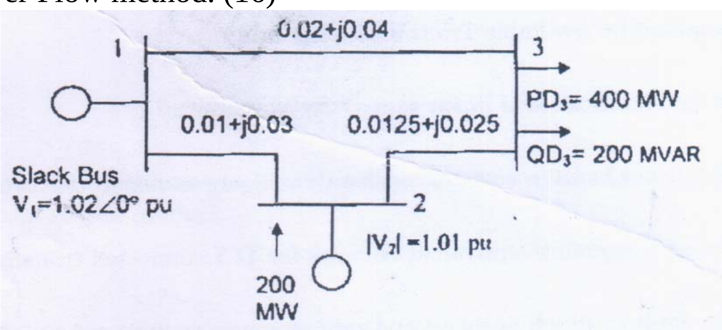
Or

(b) (i) Discuss in detail, the net interchange power control in multi area power flow analysis.

(ii) Explain available transfer capability in power system.

5.

(a) Fig 12(a) a shows the one-line diagram of a simple three bus power system with Generators at buses 1 and 2. The line impedances are marked in per unit on a 100 MVA base. Find out The bus voltages at the end of first iteration using Fast Decoupled power Flow method. (16)

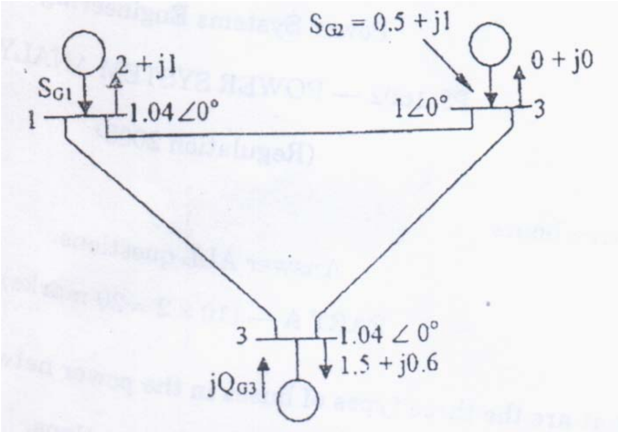


Or

(b) Explain the formation of continuation power flow method and also discuss the detailed algorithmic steps. (16)

6

(a) Consider the three-bus system as shown in figure below. Each of the three lines has a series impedance of 0.02+j0.08 pu and a total shunt admittance of j0.02pu. the specified quantities at the buses are tabulated below:



Bus	Real load demand P_D	Reactive load demand P_D	Real Power Generation P_G	Reactive Power Generation Q_G	Voltage Specification
1	2.0	1.0	Unspecified	Unspecified	$V_1 = 1.04 + j00$ (Slack bus)
2	0.0	0.0	0.5	1.0	Unspecified (PQ Bus)
3	1.5	0.6	0.0	Q_{C3} =?	$V_3 = 1.04$ (PV Bus)

Controllable reactive power source is available at bus 3 with the constraint $0 \leq Q_{C3} \leq 1.5$ pu.Find the load flow solution using the NR method. Use tolerance of 0.01 for power mismatch

Or

(b) Explain the fast decoupled load flow method with a neat block diagram.

7

(a) Explain with neat flow chart , the Newtons method of power flow solution.

Or

(b) Figure shows the one line diagram of a simple three bus system with generators at buses 1 and 2. The line impedances are marked in per unit on a 100 MVA base. Find out the bus voltages after two iteration using Fast Decoupled Power Flow method.

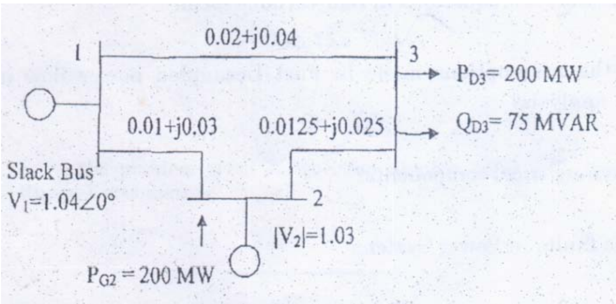


Fig.12b

9.

(a) Explain in detail, the linear sensitivity analysis.

Or

(b) Write short notes on

(i) PQ curves

(ii) P-V curves

UNIT III

PART A

1. Define the term sensitivity factor in power system.
2. What is near-optimal ordering?
3. List the control variables in OPF.
4. What is security constrained optimal power flow?
5. What is unit commitment and load scheduling?
6. List the advantages interior point algorithm.
7. What is the significance of linear sensitivity coefficients?
8. Write the power balance equation with only real power variables.
9. What is the significance of gradient method?
10. Write down the equation of cost function.
11. What is the difference between load flow and optimal power flow?
12. What is meant by bus incremental cost?
13. What is the purpose of optimal power flow program?
14. What is unit commitment?
15. Give the applications of OPF problem.
16. What are the different methods of solving the OPF problem?

PART B

1

(a) (i) Describe the Optimal Power Flow Problem. (4)

(ii) Explain the solution of Optimal Power Flow Problem by Newton's method.(12)

Or

(b) Explain the solution optimal power flow problem by LP method with AC power flow variables. (16)

2.

(a) What is optimal power flow (OPF)? Derive the optimal power flow without inequality constraints using Newton's method. (16)

Or

(b) How does OPF differ from security constrained OPF? Explain security constrained optimal power flow with the help of block diagram and list its advantages. (16)

3.

(a).Describe the solution of load flow equation by Newton's method with a flow chart. (16)

Or

(b) What is meant by bus incremental cost? Explain. Also write the interior point algorithm for the solution of security constrained optimal power flow.(16)

4.

(a) Explain in detail the problem formulation and solution of optimal power flow with an suitable diagram.

Or

(b) Write technical note on:

(i) Linear sensitivity analysis

(ii)Security constraint optimal power flow

(iii)Interior Point algorithm

5.

(a) (i).Describe the solution of optional power flow problem by Newton's method. (8)

(ii).Describe a strategy for solution of optimal power flow problem using linear Programming. (8)

Or

(b) Describe the security constrained optimal power flow problem. Explain the solution of security constrained optimal power flown problem by Interior point algorithm. (16)

6.

(a) Figure below shows a system having two plants 1 and 2 connected to buses 1 and 2 respectively. There are two loads and a network of four branches. The reference bus with a voltage of $1.0\angle 0^{o}$ pu is shown on the diagram. The branch currents and impedances are:

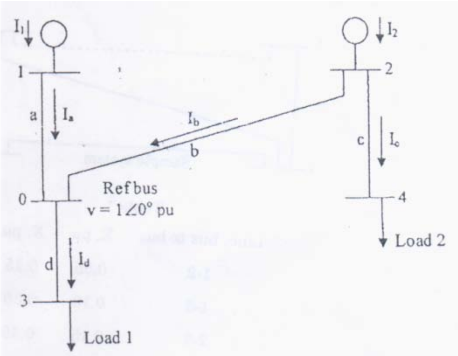
$I_a = 2 - j0.5$pu $\quad\quad Z_a = 0.015 + j0.06$ pu

$I_b = 1.6 - j0.4$pu $\quad\quad Z_b = 0.015 + j0.06$ pu

$I_c = 1 - j0.25$pu $\quad\quad Z_c = 0.01 + j0.04$ pu

$I_d = 3.6 - j0.9$pu $\quad\quad Z_d = 0.01 + j0.04$ pu

Calculate the loss formula co efficient of the systems in pu and in reciprocal megawatts, if the base is 100MVA.



Or

(b) Explain the interior point algorithms for optimal power flow solution

7.

(a) Explain with a neat flowchart the security constrained optimal power flow.

Or

(b) Explain the different methods of compensation

UNIT IV

PART A:

1. Define symmetrical and unsymmetrical faults.
2. List the solution technique for short circuit analysis.
3. What is meant by fault level at a bus and give the expression for the same.
4. List the various types of faults on transmission lines.
5. What are symmetrical component.
6. List out the approximations normally used in modeling for short circuit analysis.
7. Distinguish between 012 frame and abc frame.
8. What is bus impedance matrix ? why it is used in short circuit analysis?
9. State the applications of short circuit analysis.
10. Draw the transient behavior of an unloaded generator , when there is a sudden three phase short circuit at the terminals.
11. Why zero sequence impedance of a transmission line is more than its sequence impedance.
12. Name the method of reducing short circuit capacity.
13. Why the sequence reactance of transformer are equal.
14. Why the pre fault current are usually neglected in fault computation.
15. What are the assumptions made in short circuit studies of large power system network.
16. Name the main difference in representation of power system for load flow and short circuit studies.
17. What are the objectives of short circuit analysis.
18. The three – phase fault level of 220 kV bus is 40 pu on 100 MVA base. What is the positive sequence Thevenin impedance looking into the bus in ohms? Neglect resistance.
19. Draw the zero sequence network of a star –delta (Y/ Δ) connected transformer.
20. What is power invariance in symmetrical components?
21. Define sequence impedance and sequence network of power system.
22. Draw the zero sequence equivalent network for Y/Y connected transformer.

23. Name the fault in which negative and zero sequence current are equal to zero.

24. From Y-bus for the system shown in Fig.4.

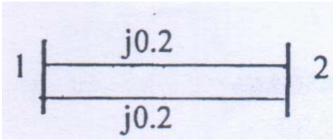


Fig. 4

25. What is meant by mutual coupling?
26. Give the sequence of components in short circuit analysis.
27. What is the most severe fault in the power system?
28. Write the usage of bus building algorithm?
29. List the various types of faults on transmission lines.
30. Define the Fortescue's theorem
31. What are symmetrical components?
32. Classify the faults in power systems

PART B:

1.

(a) Derive the equation for fault current in terms of phase quantities for a single line to ground fault at bus "p" in a power system, with fault impedance Z_f. Also draw the sequence network connection.

Or

(b) State the assumptions made in the short circuit analysis for power system. Explain with a flow chart , the steps involved in the above studies.

2.

(a) A single lilne to ground fault occurs on a phasor. The sequence impedances up to fault point are (0.3+j0.6),(0.3+j0.55) and (1+j0.78) pu. The fault resistance is 0.66pu. If voltage is1.0, find the fault current and voltage of faulty phase at fault point.

Or

(b) The one line diagram of a simple three bus power system is shown inb fig. Each generator is represented by an emf behind the transient reactance. All the impedances are expressed in per unit on a common 100 MVA base. The system is considered on no load with all generators are running at their rated voltage and rated frequency. Determine the Z-bus, the fault current, bus voltages and current supplied from the generators 1 and 2 when a balanced three phase fault with a fault impedance Z_f=j0.1 pu occurs on bus 3.

3.

(a) Consider different types of faults and explain how fault calculation is done using sequence networks.Draw and explain the short circuit current on a transmission line. (16)

Or

(b) Derive the equations for bus voltages, fault current and line currents both in sequence and phase domain using Thevenin's equivalent and Z_{BUS} matrix for different types of faults. (16)

4.

(a) The per unit bus impedance matrix of a four bus system shown in Fig. 14 a is given below :

$$Z_{bus} = \begin{pmatrix} j0.15 & j0.075 & j0.14 & j0.135 \\ j0.075 & j0.1875 & j0.09 & j0.0975 \\ j0.14 & j0.09 & j0.2533 & j0.21 \\ j0.135 & j0.975 & j0.21 & j0.2475 \end{pmatrix}$$

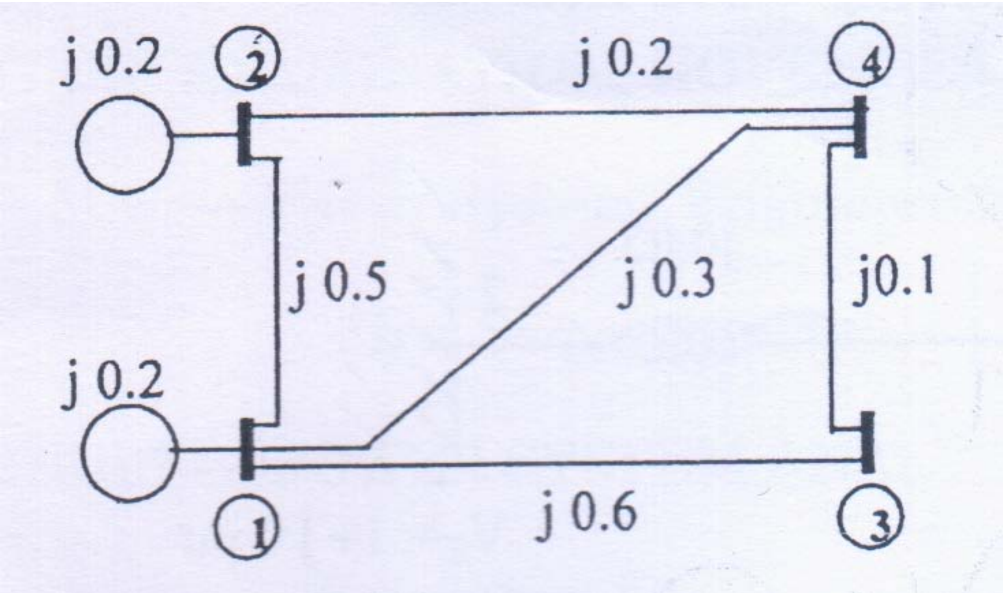


Fig.14a

All the impedances are expressed in per unit on a common 100 MVA base. The system is considered on no – load with all generators are running at their rated voltage and rated voltage and rated frequency. Calculate the fault current, bus voltages, and line currents when a balanced three – phase with a fault impedance Zf = j 0.1 pu occurs on bus 3.

Or

(b) The one line diagram of a simple power system is shown in Fig. 14b.The neutral of each generator is grounded through a current – limiting reactor 0.08 pu on 100 MVA base. The system data expressed in per unit on a common 100 MVA base is tabulated below. The generators are running on no- load at their rated voltage and rated frequency with their emfs in phase. Using bus impedance matrix determine the fault current for a single line to ground fault bus 3 through a fault impedance Z_f=j0.1 (16)

Element	V-rating	X_1	X_2	X_0
G1	20 kV	0.15	0.15	0.05
G2	20 kV	0.15	0.15	0.05
T1	20/220 kV	0.1	0.1	0.1
T2	20/220 kV	0.1	0.1	0.1
L12	220 kV	0.125	0.125	0.3
L13	220 kV	0.15	0.15	0.35
L23	220 kV	0.25	0.25	0.7125

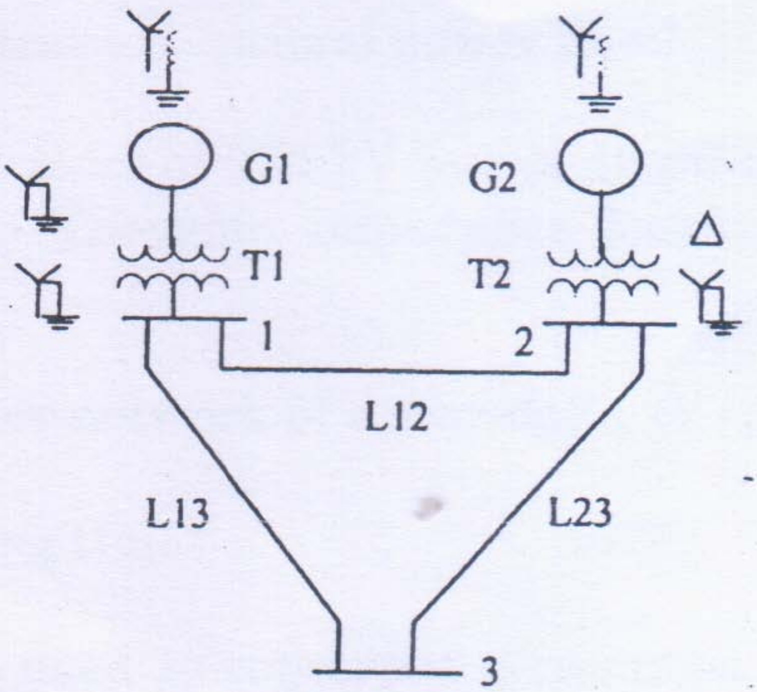


Fig.14b

5.

(a) Define bus impedance matrix. Describe the construction of Bus impedance matrix(Z_{Bus}) using building algorithm for lines with mutual coupling (16)

Or

(b) Derive the necessary equations for calculating the fault current and bus voltages using Z_{Bus} matrix for a three phase fault. (16)

6.

(a) (i) Derive the equation for the fault current in terms of phase quantities for a single line to ground fault at bus “P” in a power system, with fault impedance, Z_f. Also draw the sequence network connection.

(ii) State the assumptions made in the short circuit analysis for power system. Explain with a flow chart the steps involved in the above studies.

Or

(b) A single line to ground fault occurs on a phasor. The sequence impedances up to fault point are (0.3+ j 0.6), (0.3+ j 0.55) and (1 +j 0.78) pu. The fault resistance is 0.66 pu. If voltage is 1.0 , find the fault current and voltage of faulty point.

7.

(a) The one-line diagram of a simple three-bus power system is shown in fig.14a. Each Generator is represented by an emf behind the transient reactance. All the impedances are expressed in per unit on a common 100 MVA base. The system is considered on No-load with all generators are running at their rated voltage and rated frequency. Determine,

(i) the Z-bus.
(ii) the fault current bus voltages and the current supplied from the generators 1 and 2 when a balanced three-phase fault with a fault impedance Z_f=j0.1 pu occurs on bus 3. (12)

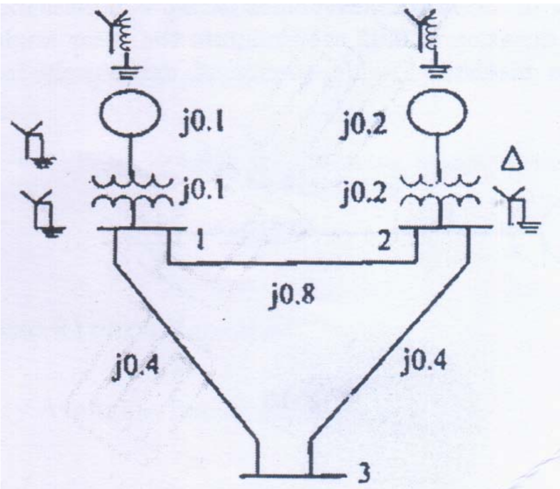


Fig.14a

Or

(b) Figure 14b shows the system representation applicable to a 1000 MVA, 20kV, 60 Hz Generating unit. The transmission data shown in the figure are in Pu on 1000 MVA, 20kV base. Network resistances are assumed to be negligible.

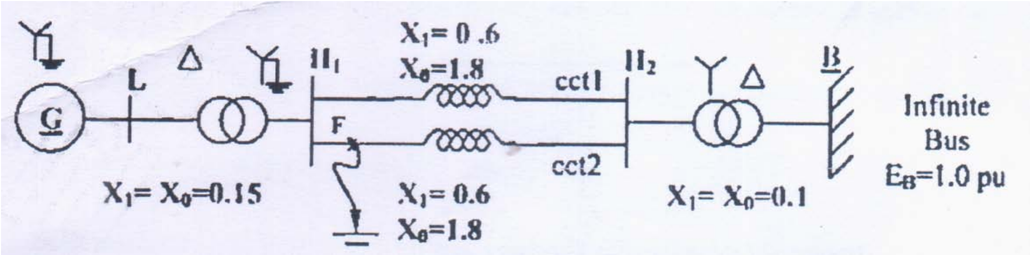


Fig.14b

The generator data in Pu on the rating of the unit are as follows:

$$X_1 = 0.25, X_2 = 0.25, X_0 = 0.04$$

A Double line to ground (DLG) fault occurs on circuit 2 at the point F as shown in fig 14b.

(i) Find the value of the effective fault impedance Z eff which, when inserted in the positive-sequence network, represents the unbalanced fault.

(ii) If the initial generator output conditions are Po=0; Qo=0 and Et=1 compute the magnitude of the positive, negative and zero sequence currents throughout the network immediately after the fault occurs neglecting the effect to the generator resistance

8.

(c) Figure below shows the one line diagram of a simple four-bus system. Table 1 gives the impedance identified by the buses on which these terminate. The shunt admittance at all the buses is assumed negligible.

(i) Find Y_{Bus} assuming that the line shown dotted is not connected.

(ii) What modifications need to be carried out in Y_{Bus} if the line shown dotted is connected?

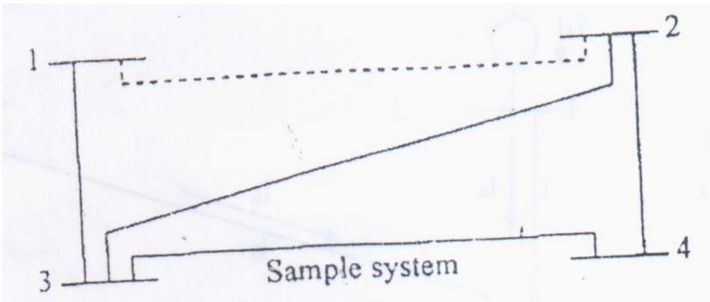


Table 1

Line, Bus to Bus	R, pu	X, pu
1-2	0.5	0.15
1-3	0.10	0.30
2-3	0.15	0.45
2-4	0.10	0.30
3-4	0.05	0.15

Or

(d) A 50 MVA ,11KV three phase alternator was subjected to different types of faults. The fault currents are as under:

3 –phase fault= 2000A
Line to line fault= 2600A
Line to ground fault= 4200A

The generator neutral is solidly grounded. Find the values of three sequence reactances of the alternator. Ignore resistances.

9.

(a) Derive the expression for the fault current of a single line to ground fault both in 012 frame and abc frame.

Or

(b) The per unit bus impedance matrix of a four bus power system shown in Fig.13b is given by

$$Z_{bus} = \begin{bmatrix} j0.15 & j0.75 & j0.14 & j0.135 \\ j0.75 & j0.1875 & j0.09 & j0.0975 \\ j0.14 & j0.09 & j0.2533 & j0.21 \\ j0.135 & j0.0975 & j0.21 & j0.2475 \end{bmatrix}$$

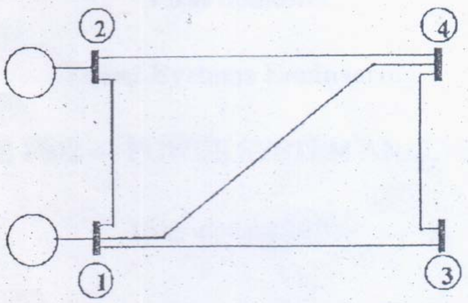


Fig.13b

i) Calculate the fault current for a solid three phase symmetrical fault at bus 4. Calculate the post fault bus voltages and line currents. (10)

ii) A neighboring system bus with a fault level of 12.0pu is to be connected with the above power system at bus 3. Calculate the fault current when a solid three phase symmetrical fault occurs at bus 3 (after the connection). (6)

10.

UNIT V

PART A

1. What is critical clearing time?
2. What are the models used to represent generators and transmission lines in stability analysis?
3. What is the purpose of swing equation?
4. List the factors influencing transient stability.
5. Define: Critical clearing time?
6. Differentiate: Explicit and Implicit methods of numerical integration.
7. What is the advantage of Euler method over Runge-Kutta method?
8. Name the factors that influences transient stability.
9. Draw the single line diagram for single machine infinite bus?
10. Differentiate between transient stability and dynamic stability?
11. Differentiate between voltage stability and voltage collapse.
12. Draw the nature of small disturbance response.
13. Give the expression for maximum deliverable power of a SLIB system
14. What are V-Q curves?

PART B

1.

(a) Explain transient stability. Assume a classical generator model and consider the response of the system to a three-phase fault on transmission circuit and explain the transient stability phenomenon with illustrations. (16)

Or

(b) Consider the first order differential equation and explain how to solve power system stability analysis using Euler's method. (16)

2.

(a) A 50 Hz synchronous generator has a transient reactance of 0.2 pu and inertia constant (H) of 5 MJ/MVA. The generator is connected to an infinite bus through a transmission line as shown in fig.15a.Reactances are marked on the diagram on a common system base. The generator is delivering a real power of 0.8 pu and reactive power of 0.1 pu to the infinite bus at a voltage of V_2 1+ j0 pu. Determine the generator internal voltage and obtain the swing curve from time t = 0 to t =1 sec. assume Δt =0.5 sec. (16)

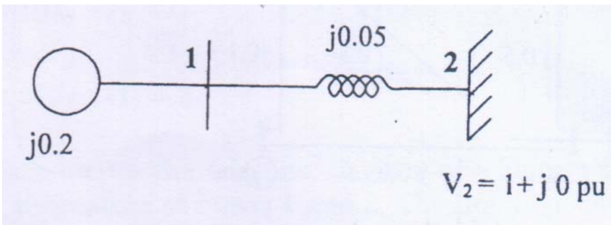


Fig.15a

Or

(b) (i) Discuss the factors that affect transient stability and the methods for improving the transient stability. (12)

(ii) Differentiate between explicit and implicit methods of numerical integration. Give an example of each. (4)

3.

(a) Derive the swing equation of a synchronous machine swinging against and infinite bus. Clearly state the assumptions in deducing the swing equation.

Or

(b) The swing equation of an alternator are described as

$d\delta/dt= \omega 3.14.1593$

$d\omega/dt=62.332(0.9-P_e)$

with $\delta(0)=21.645$ and $\omega(0)=314.1593$ rad/sec. Its power output during the fault is given by : $P_e= 0.88 \sin \delta$

Taking a time step of 0.05 sec., using fourth order R.K. . method, compute $\delta(0.1)$ and $\omega(0.1)$

4.

(a) The synchronous machine shown in fig.15a is generating 100 MW and 75 MVAR. The Voltage of the bus ‘p’ is 1-j0.05 pu. The generator is connected to the infinite bus through aline of reactance 0.08pu on a 100 MVA base. The machine transient reactance is 0.2 pu and the inertia constant is 4 pu on a 100 MVAbase.A 3 phase self clearing fault occurs at bus ‘p’ for a duration of 0.02 sec.compute the rotor angle at t=0.02 sec using Euler’s method. The frequency of the supply is 50Hz. Assume delta t = 0.02 sec. (16)

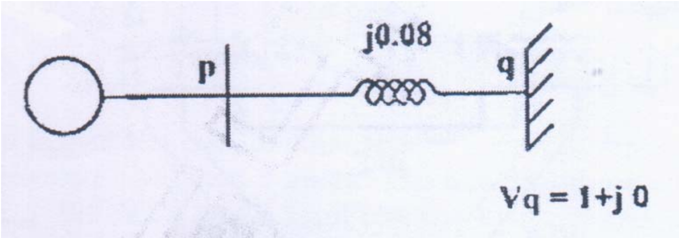


Fig.15a

(b) Solve the problem given in Question number 15(a) using fourth order Runge-Kutta method. (16)

5.

(a) Draw the PQ curves and V-Q curves for a typical line and explain how these curves are related to stability analysis.

Or

(b) Explain the different types of reactive compensating devices and how these devices influence voltage stability