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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

EE 6501 POWER SYSTEM ANALYSIS

UNIT –I: INTRODUCTION

PART: A

1. Define per unit value of an electrical quantity. Write equation for base impedance with respect to 3-phase system.
2. What is bus admittance matrix, bus impedance matrix?
3. What is single line diagram?
4. A generator rated 25MVA, 11KV has a reactance of 15%. Calculate its p.u. reactance for a base of 50MVA and 10KV.
5. What is the need for system analysis in planning and operation of power system?
6. Draw the single phase equivalent circuit of three winding transformer.
7. What are the approximations made in impedance diagram?
8. What are the advantages of per unit system?
9. How is generator in transient analysis represented?
10. Draw the π circuit representation of a transformer with off – nominal ratio ‘α’.
11. Draw a simple per phase model for a cylindrical rotor synchronous machine.
12. What is meant by per phase analysis?
13. What are the functions of power system analysis?
14. What are the applications o Y-bus and Z-bus matrix?
15. What is restructure power system?
16. What is off nominal transformer ratio?
17. Define primitive network ?
18. Give the methods available for forming bus impedance matrix.
19. Why bus admittance matrix is preferred in load flow?
20. What are the restructure Models?

PART: B

1. The single line diagram of a simple power system is shown in Fig. The rating of the generators and transformers are given below:
   Generator 1: 25MVA, 6.6KV, X=0.2p.u
   Generator 2: 15MVA, 6.6KV, X=0.15p.u
   Generator 3: 30MVA, 13.2KV, X=0.15p.u
   Transformer1: 30MVA, 6.9Δ/115Y KV, X=10%
   Transformer2: 15MVA, 6.9Δ/115Y KV, X=10%
   Transformer3: Single phase units each rated 10MVA, 6.9/69 KV, X=10%
   Draw an impedance diagram and mark all values in p.u choosing a base of 30MVA, 6.6KV in the generator 1 circuit.

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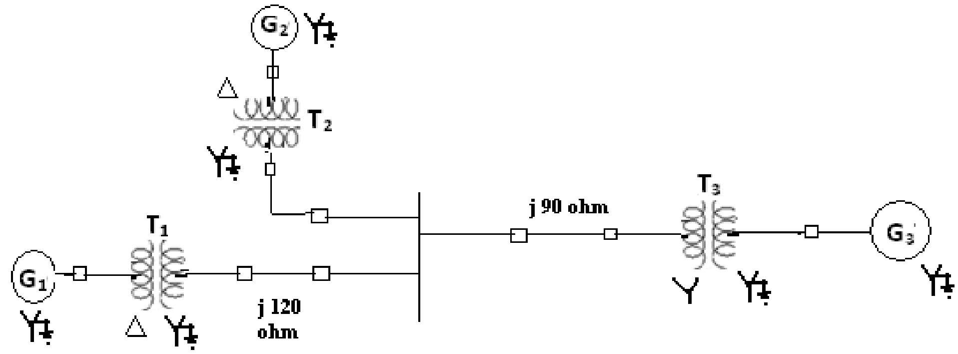
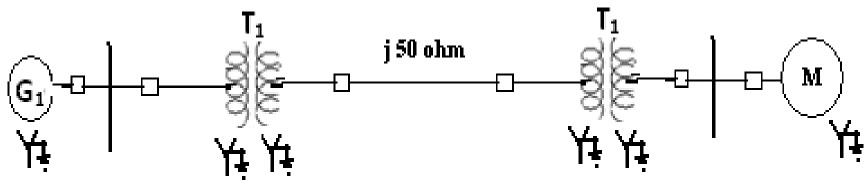


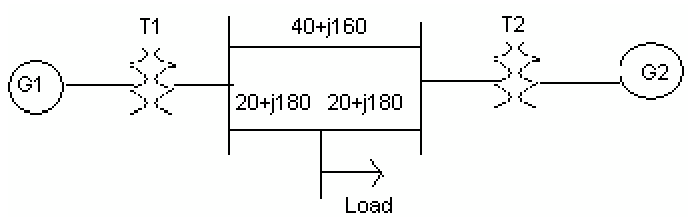
2. Draw the reactance diagram for the power system shown in fig. Neglect resistance and use a base of 100MVA , 220KV in 50KΩ line. The ratings of the generator motor and transformer are give below.



Generator : 40MVA, 25KV ,X'' =20% Synchronous
Motor : 50MVA , 11KV, X'' =30% T1:Y-Y
transformer : 40MVA 33/220KV, X=15% T2:Y- Y
transformer : 30 MVA 11/220KV, X=15%

3. Prepare a per phase schematic of the system in fig. and show all the impedance in per unit on a 100 MVA, 132 KV base in the transmission line circuit. The necessary data are given as follows.

    G1 : 50MVA, 12.2KV, X=0.15 pu.
    G2 : 20MVA, 13.8KV, X=0.15 pu.
    T1 : 80MVA, 12.2/161KV, X=0.1 pu.
    T2 : 40MVA, 13.8/161KV, X=0.1 pu.
    LOAD: 50MVA, 0.8 power factor lag operating at 154KV.Determine the pu impedance of the load.



4. Draw the impedance diagram for the electric power system shown in fig showing all impedances in per unit on 100MVA base. Choose 20KV as the voltage base for generator. The three phase power and line-line ratings are given below. (16)

G1 : 90MVA, 20KV, X=9%.
G2 : 90MVA, 18KV, X=9%.

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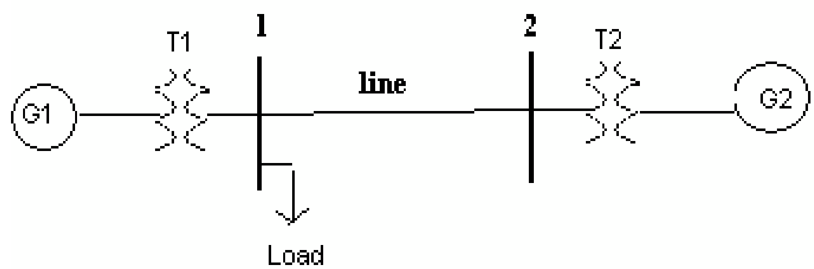
T1 : 80MVA, 20/200KV, X=16%.

T2 : 80MVA, 200/20KV, X=20%.

LINE : 200KV X=120Ω

LOAD: 200KV ,S= 48MW + j64MVAR.



5. i) The parameters of a four system are as under:

Line No.	Line starting bus	Line ending bus	Line impedance(pu)	Line Charging Admittance(pu)
1	1	2	0.2+j0.8	j0.02
2	2	3	0.3+j0.9	j0.03
3	2	4	0.25+j1.0	j0.04
4	3	4	0.2+j0.8	j0.02
5	1	3	0.1+j0.4	j0.01

Draw the Network and find bus admittance matrix. (12)

ii) What are impedance and reactance diagram? Explain with assumptions. (4)

6. i) What is primitive network matrix and represent its forms? Prove $Y_{bus} = A^t[y]A$ using singular transformation? [8]

ii) Form the Y_{bus} for the given network:_

Element	Positive sequence reactance
1-2	j1.0
2-3	j0.4
2-4	j0.2
3-4	j0.2
3-1	j0.8
4-5	j0.08

[8]

7. Form Y_{bus} for the network by singular transformation: [16]

Element	Positive sequence reactance
E-A	
E-B	0.05
A-B	0.04
B-C	0.03
A-D	0.02
C-F	0.07
D-F	0.10

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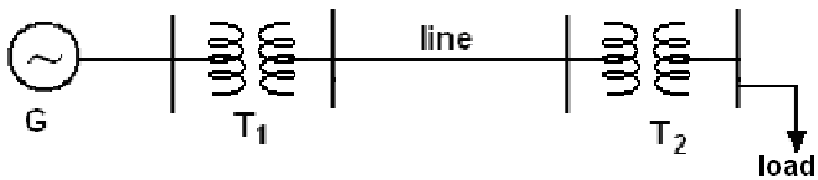
8. Explain modeling of transformer, transmission line, loads and generators for a load flow study. And derive general load flow equations. [16]

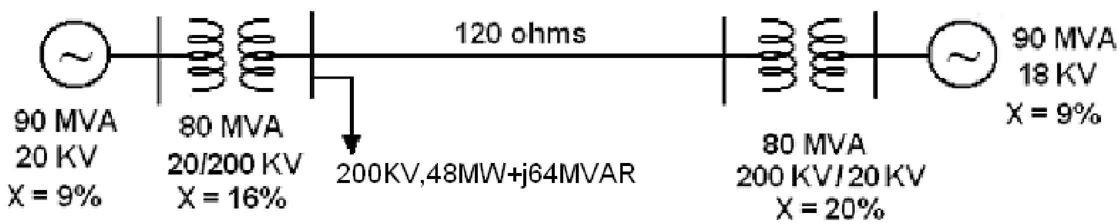
9 .Obtain pu impedance diagram of the power system of figure 5. Choose base quantities as 15 MVA and 33 KV.

Generator: 30 MVA, 10.5 KV, $X'' = 1.6$ ohms.
Transformers T_1 & T_2: 15 MVA, 33/11 KV, X = 15 ohms referred to HV
Transmission line: 20 ohms / phase
Load: 40 MW, 6.6 KV, 0.85 lagging p.f



. [16]

10. Draw the pu impedance diagram for the system shown in figure 5. Choose Base MVA as 100 MVA and Base KV as 20 KV. [16]



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UNIT –II: POWER FLOW ANALYSIS

PART: A

1. What are the types of buses?
2. What is the need for slack bus?
3. When the generator bus is treated as load bus?
4. What is meant by acceleration factor in Gauss Seidal Method?
5. What is load flow analysis? Give its significance in power system analysis.
6. What is load flow?
7. Why the load flow studies are important for planning the existing system as well as the future expansion?
8. Why bus admittance matrix is used in Gauss Seidal instead of bus impedance matrix.
9. Write the general power flow equation.
10. What is the need for power flow study?
11. Compare GSM and NRM with respect to number of iterations taken for convergenceand memory requirement.
12. What is Jacobian matrix?
13. How the buses in power systems are classified?
14. Write the load flow equations of Gauss seidel method.
15. Compare GS and NR method.
16. What do you mean by flat voltage start?
17. Write the polar form of the power flow equations.
18. State practical load flow problem.
19. Define voltage controlled bus and load bus.
20. What are the advantages and disadvantages of Gauss Seidal method.

PART: B

1. Derive the load flow algorithm using Gauss Seidal method with flow chart and discuss the advantages of the method. (16)
2. For the sample system shown in the fig. the generators are connected at all four buses while the loads are at buses 2 and 3. Assuming a flat voltage start, find bus voltages and bus angles at the end of first Gauss seidal iterations and consider the reactive power limit as $0.2 \leq Q_2 \leq 1$ (16)

Bus	P in pu	Q in pu	V in pu	Remarks
1	-	-	$1.04\angle 0^o$	Slack bus
2	0.5	-	1.04pu	PV bus
3	-1.0	0.5	-	PQ bus
4	0.3	-0.1	-	PQ bus

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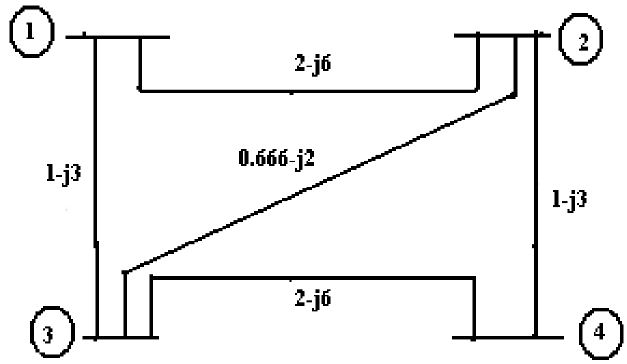

3. Explain the types of buses and derive the power flow equations in load flow analysis[16].
4. Derive N-R method of load flow algorithm and explain the implementation of this algorithm with the flowchart. (16)
5. The system data for a load flow problem are given in table.
   i) Compute Y bus.
   ii) Determine bus voltages at the end of first iteration by G-S method by taking α =1.6. (16)

Line no	Bus code	Admittance in pu
1	1-2	2-j8
2	1-3	1-j4
3	2-3	0.6-j2.6

Bus code	Pd in p.u	Qd in p.u	V in p.u	Remarks
1	--------	-------	1.06	Slack
2	0.5	0.2	-------	PQ
3	0.4	0.3	------	PQ

6. Perform one iteration of Newton Raphson load flow method and determine the power flow solution for the given system. Take base MVA as100. (16)

LINE DATA:

Line	Bus		R(pu)	X(pu)	Half line charging admittance in pu
	From	To			
1	1	1	0.0839	0.5183	0.0636

BUS DATA:

Bus	P_L	Q_L
1	90	20
2	30	10

7. i) Derive the static load flow equations of n-bus system.(8)
   ii) Compare GSLF, NRLF Methods. (8)
8. Using Gauss Seidal method determine bus voltages for the fig shown. Take base MVA as100, α=1.1. (16)

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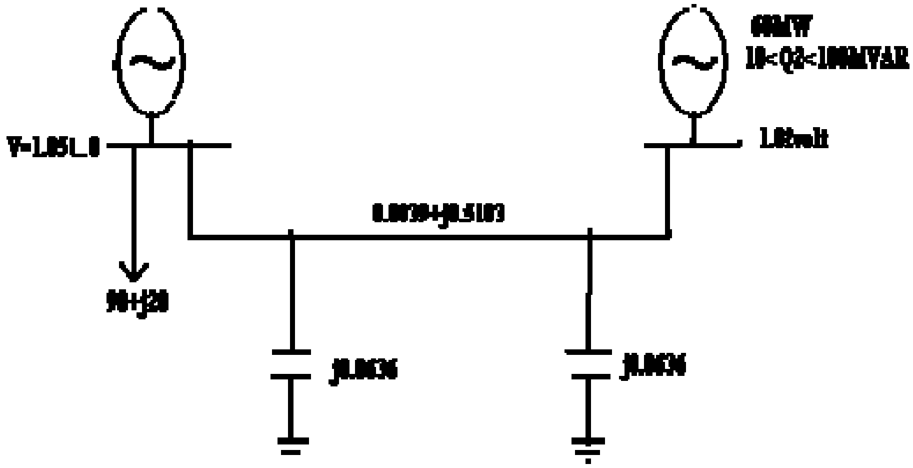

9. Derive necessary expressions for the off-diagonal and diagonal elements of the sub- matrices J_1, J_2, J_3 and J_4 for carrying out a load flow study on power system by using N-R method in Polar form. [16]

10. The converged load flow solution is available how do you determine the slack bus complex power injection and system total loss? [16]

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UNIT –III: FAULT ANALYSIS – BALANCED FAULT

PART: A

1. How do short circuits occur in a power circuit?
2. Define short circuit capacity of power system.
3. Draw the oscillation of short circuit current when an unloaded generator is subjected to a symmetrical fault clearly marking sub-transient, transient and steady state regions.
4. Why the prefault currents are usually neglected in fault computation?
5. What is meant by fault?
6. List the various types of shunt and series faults.
7. Distinguish between symmetrical and unsymmetrical short circuits.
8. What is bolted fault?
9. The Z bus method is very suitable for fault studies on large system why?
10. Mention two approximations made in short circuit studies.
11. How do Short circuit occur in power system and mention two objective of Short circuit analysis.
12. Name the main differences in representation of power system for load flow and short circuit studies.
13. What is meant by doubling effect?
14. What is the need for fault analysis in power system?
15. What is meant by subtransient reactance?
16. What is the reason for transients during short circuit?
17. What is meant by fault calculation?
18. Define synchronous reactance, transient reactance, sub transient reactance.
19. Define fault level.
20. State the applications of short circuit analysis.

PART: B

1. Explain the step by step procedure for systematic fault analysis for a three phase fault using bus impedance matrix. (16)

2. A generator is connected through a transformer to a synchronous motor. The subtransient reactance of generator and motor are 0.15 p.u and 0.35p.u respectively. The leakage reactance of the transformer is 0.1 p.u . All the reactance are calculated on a common base. A three phase fault occurs at the terminal of the motor when the terminal voltage of the generator is 0.9p.u .The output current of generator is 1p.u and 0.8 pf leading. Find the subtransient current in p.u in the fault, generator and motor. Use the terminal voltage of generator as reference vector. (16)

3. Two synchronous motor are connected to the bus of large system through a short transmission line shown in fig. The rating of the various components are given. (16)

MOTOR(each): 1MVA ,440V,0.1 pu. Transient reactance

LINE: 0.05Ω (reactance)

Large system: Short circuit MVA at its bus at 440V is 8

When the motor are operating at 400V ,calculate the short circuit current (symmetrical) fed into a three phase fault at motor bus

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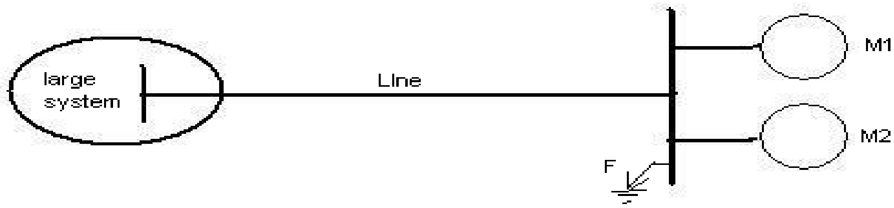
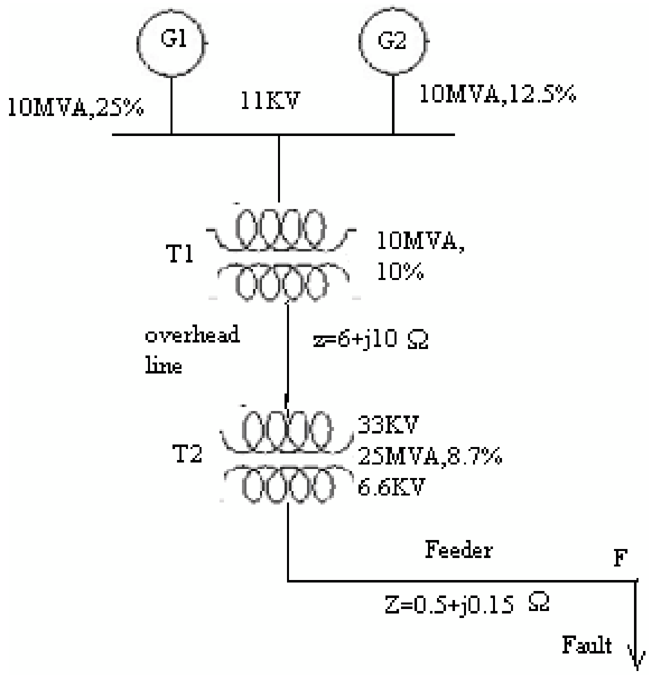


4. Write the step by step procedure to find the fault current of three phase symmetrical fault by using thevenin's theorem. (16)
5. For the radial network shown in figure , a 3 phase fault occurs at point F. Determine the fault current. (16)



6. A symmetrical fault occurs on bus 4 of system shown in figure ,Compute the fault current, post fault voltages, line flows.

Generator G1 ,G2 :100MVA,20KV,X_1=15%.

Transformer T1, T2:, Xleak=9%, Transmission line L1,L2: X_1=10%(16)

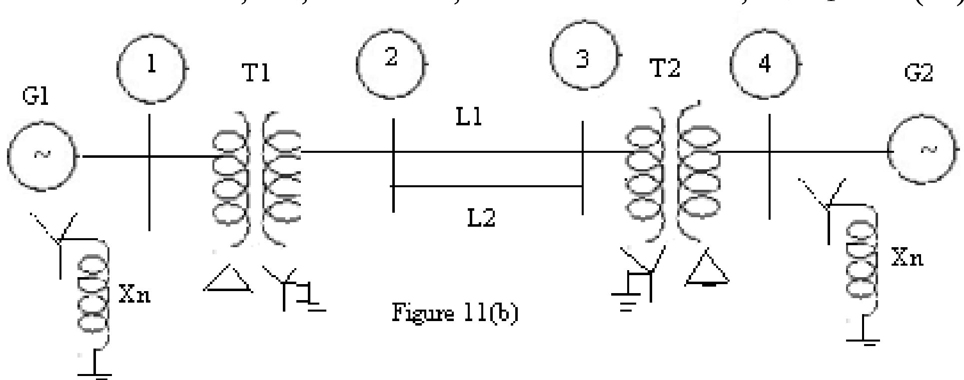


Figure 11(b)

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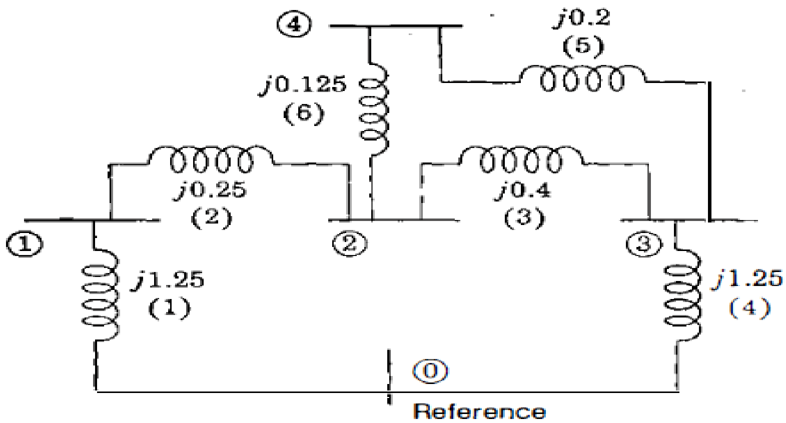
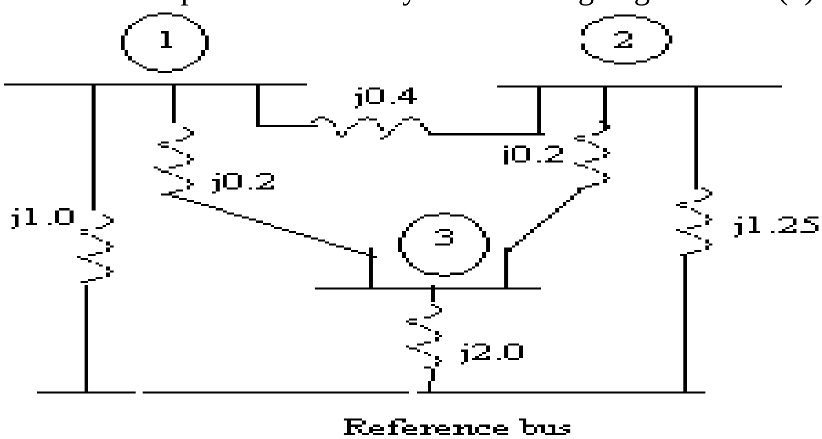
7. Find the bus impedance matrix using bus building algorithm for the given network. (16)



8. (i)Determine Bus Impedance matrix by Bus Building Algorithm. (8)



ii) Define Bus impedance matrix. Describe the construction of Bus impedance matrix Z_{Bus} using Bus building algorithm for lines without mutual coupling.

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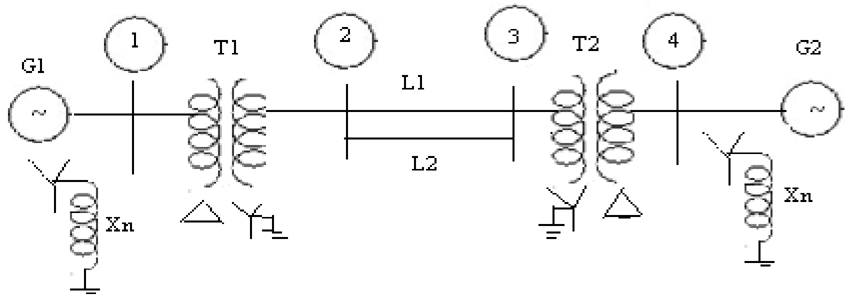
9. A symmetrical fault occurs on bus 4 of system through Z_f=j0.14 pu in figure. Using bus building algorithm, Compute the fault current, post fault voltages, line flows.

G_1,G_2 :100MVA,20kV,X^+=15%
Transformer T_1,T_2: X_{leak}=9%
Transmission line L_1,L_2 : X^+=10%.(16)



10. A 3-phase 5MVA ,6.6 KV alternator with a reactance of 8% is connected to a feeder of series impedance (0.12+j0.48) ohm/phase/Km through a step up transformer. The transformer is rated at 3 MVA, 6.6 KV/33KV and has a reactance of 5%. Determine the fault current supplied by the generator operating under no load with a voltage of 6.9 KV when a three phase symmetrical fault occurs at a point 15Km along the feeder.(16)

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UNIT IV :FAULT ANALYSIS – UNBALANCED FAULTS

PART: A

1. For a fault at a given location, rank the various faults in the order of severity.
2. What is synchronous reactance?
3. Define subtransient reactance.
4. Define transient reactance.
5. What is the significance of subtransient reactance and transient reactance in short circuit studies?
6 Write down the equation determining fault current in a generator when its reactance is known.
7. Write the equation for subtransient and transient internal voltage of the generator.
8. Write the equation for subtransient and transient internal voltage of the motor.
9. Define doubling effect and DC off-set current.
10. Differentiate between subtransient and transient reactance.
11. What are symmetrical components?
12. Write the symmetrical components of three phase system.
13. Define negative sequence and zero sequence components.
14. Express the unbalanced voltages V_a, V_b and V_c in terms of symmetrical components V_{a1}, V_{a2} and V_{a0}.
15. Express the symmetrical components V_{a1}, V_{a2} and V_{a0} in terms of unbalanced vectors V_a, V_b and V_c.
16. What assumption is made at the star / delta transformer?
17. Define positive sequence and negative sequence impedances.
18. Draw the zero sequence network diagram of a delta-delta connected transformer.
19. In which fault, the negative and zero sequence currents are absent?
20. Draw the connection of sequence networks or line –to-line fault without fault impedance.

PART: B

1. Explain the sequence impedance of synchronous machine, transmission lines and star connected loads. (16

. 2. Draw the transformer zero sequence equivalent circuits for the various winding connections (16)

3. A 25MVA, 11KV, three phase generator has a sub transient reactance of 20%. The generator supplies two motors over a transmission line with transformers at both ends as shown in one line diagram a of figure. The motors have rated inputs of 15 and 7.5 MVA both 10KV with 25% sub transient reactance. The three phase transformers are rated 30MVA, 10.8/121KV, and connection delta-star with leakage reactance of 10% each. The series reactance of the line is 100 ohms. Draw the positive and negative sequence networks of the system with reactance marked in

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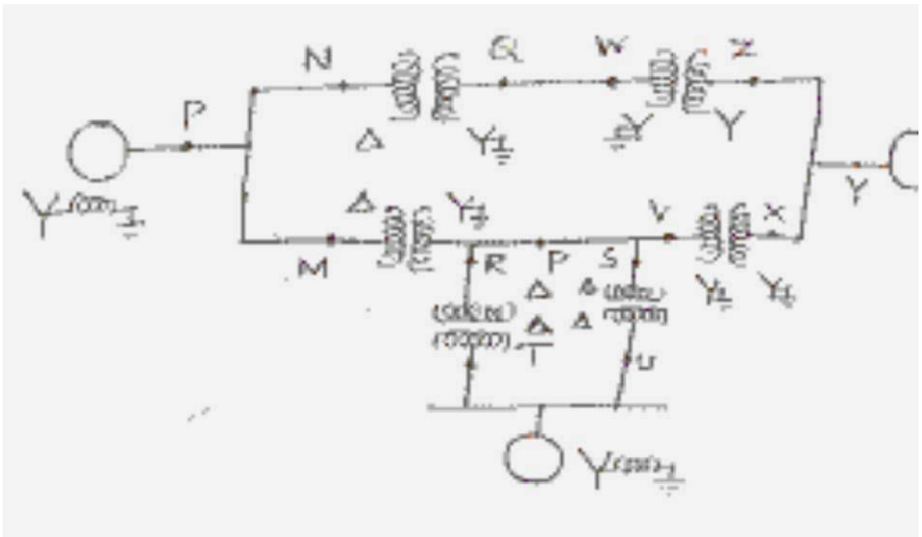
per unit. (16)

4. Develop the sequence network for a double line to ground (LLG) fault. (16)

5. Draw the Zero sequence diagram for the system whose one line diagram is shown in fig. (16)



6. A salient pole generator without dampers is rated 20 MVA, 13.6 KV and has direct axis sub – transient reactance of 0.2 per unit. The negative and zero sequence reactances are, respectively, 0.35 and 0.1 per unit. The neutral of the generator is solidly grounded. With the generator operating unloaded at rated voltage with Ean $=1.0 \angle 0°$ per unit, a single line to ground fault occurs at the machine terminals, which then have per – unit voltage to ground,

$$V_a = 0; V_b = 1.013\angle -102.25°;$$

$$V_c = 1.013\angle 102.25°$$

Determine the sub transient current in the generator and the line to line voltage for sub transient conditions due to the fault. (16)

7. Derive the expression for fault current in single line to ground fault on unloaded generator. Draw an equivalent network showing the inter connection of networks to simulate single line to ground fault (16)

8. Derive the expression for fault current in double line to ground fault on unloaded generator. Draw an equivalent network showing the inter connection of networks to simulate double line to ground fault (16)

9. Derive the expression for fault current in line to line fault on unloaded generator. Draw an equivalent network showing the inter connection of networks to simulate double line to line fault (16)

10. An unloaded star connected solidly grounded 10 MVA, 11 KV, generator has Positive, Negative and zero sequence impedances as j 1.3 ohms, J 0.8 ohms and j 0.4 ohms respectively. Single line to ground fault occurs at terminals of the

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generator.

(i) Calculate the fault current.

(ii) Determine the value of the inductive reactance that must be inserted at the generator neutral to limit the fault current to 50% of the value obtained in

(i) Determine the fault current and MVA at faulted bus for a line to ground (solid) fault at bus 4 as shown in fig

G1, G2 : 100 MVA, 11 KV, X+ = X - 15%, Xn = 6%

T1, T2 : 100 MVA, 11 KV/220 KV, Xleak = 9%

L1, L2 : X+ = X - = 10% on a base of 100 MVA. Consider Fault at phase ‘a’ (16)

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UNIT- V:POWER SYSTEM STABILITY
PART :A

1. What is meant by an infinite bus?
2. DefineStability.
3. Define transient stability.
4. Write any three assumptions upon transient stability.
5. What is meant by steady state stability limit?
6. What is transient stability limit?
7. How to improve the transient stability limit of power system?
8. How do you classify steady state stability limit. Define them.
9. What are the machine problems seen in the stability study.
10. Give the expression for swing equation. Explain each term along with their units.
11. What are the assumptions made in solving swing equation?
12. Define swing curve. What is the use of swing curve?
13. Give the control schemes included in stability control techniques?
14. What are the systems design strategies aimed at lowering system reactance?
15. State equal area criterion.
16. Give the expression for critical clearing time.
17. List the types of disturbances that may occur in a single machine infinite bus bar system of the equal area criterion stability
18. Define critical clearing angle.
19. List the assumptions made in multimachine stability studies.
20. What is Multimachine stability?

PART :B

1. Derive swing equation used for stability studies in power system. (16)

2. Describe the equal area criterion for transient stability analysis of a system. (16)

3. Write the computation algorithm for obtaining swing curves using modified Euler's method (16)

4. Write a short note on i. Factors influencing transient stability, ii. Voltage collapse (16)

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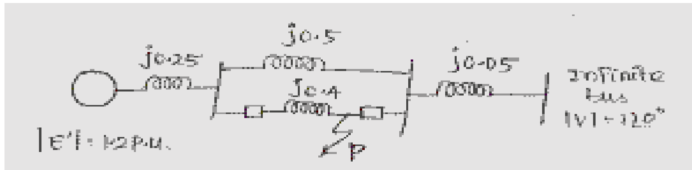
5. Given the system of figure below where a three phase fault is applied at a point P as shown (16)



6. Find the critical clearing angle for clearing the fault with simultaneous opening of the breakers 1 and 2. The reactance vales of various components are indicated on the diagram. The generator is delivering 1.0 p.u power at the instant preceding the fault. The fault occurs at point P as shown in above figure. (16)

7. Explain in detail the equal area criterion. (16)

8. (i) Derive Expression for critical clearing angle. (8)
   (ii) A 150 MVA generator – transformer unit having an overall reactance of 0.3 p.u. is delivering 150 MW to infinite bus bar over a double circuit 220 KV line having reactance per phase per circuit of 100 ohms. A 3 - phase fault occurs midway along one of the transmission lines. Calculate the maximum angle of swing that the generator may achieve before the fault is cleared without loss of stability. (8)

9. A 50 Hz, 500 MVA, 400 KV generator (with transformer) is connected to a 400 KV infinite bus bar through an interconnector. The generator has H = 2.5 MJ/MVA, Voltage behind transient reactance of 450 KV and is loaded 460 MW. The transfer reactances between generator and bus bar under various conditions are :

   Prefault 0.5 Pu
   During Fault 1.0 Pu
   Post fault 0.75 Pu

   Calculate the swing curve using intervals of 0.05 sec and assuming that the fault is cleared at 0.15 sec. (16)

10. Explain the modified Euler method of analyzing multi machine power system for stability, with neat flow chart. (16)