NADAR SARASWATHI COLLEGE OF ENGINEERING AND TECHNOLOGY
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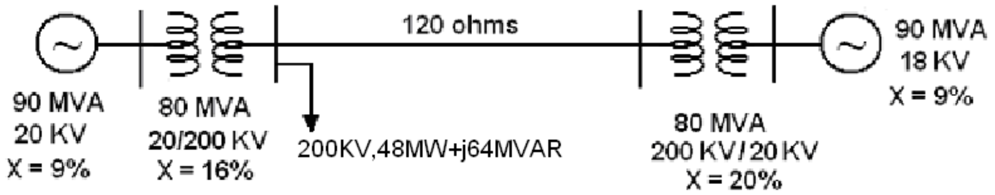
	Question Bank for the Units – I to V
SE00	**5th Semester – B.E. / B.Tech.**
BR00	**Electrical and Electronics Engineering**
SU00	**EE6501 – POWER SYSTEM ANALYSIS**
	Part-A (10 x 2 = 20 Marks)
1.	What are the function of power system analysis?
1.	List the different components of power system.
1.	What is single line diagram?
1.	What is the bus admittance matrix?
1.	What is advantages of per unit representation?
2.	What is the need for system analysis in planning and operation of power system?
2.	A generator rated at 30MVA, 11KVA has a reactance of 20%. Calculate its per unit reactance for a base of 50MVA and 10KV.
2.	Write expression to determine new element of Y-bus after eliminating N-th node using kroon reduction method.
2.	What is meant by Graph of a network?
2.	Define Primitive network.
3.	What is load flow analysis?
3.	Why the load flow studies are important for planning the existing system as well as this future expansion?
3.	What are the data required for a load flow study?
3.	Write the general power flow equation?
3.	Explain bus classification in power flow analysis with known and unknown quantities.
4.	Write the advantages and disadvantages of Newton Raphson method of load flow study.
4.	What is voltage controlled bus?

4.	What is meant by flat voltage start?
4.	When is acceleration factor in gauss seidal method?
4.	What is Jacobian matrix?
5.	What is meant by a fault?
5.	State the applications of short circuit analysis.
5.	What is bolted fault or solid fault?
5.	What are the assumptions made in short circuit studies of large power system network?
5.	List the various types of faults.
6.	Define short circuit capacity of power system or fault level.
6.	What is synchronous reactance?
6.	Define transient reactance.
6.	Draw the oscillation when there is a sudden 3Φ short circuit at the terminals of an unloaded generator.
6.	Why are the prefault current usually neglected in fault computation?
7.	Write the symmetrical components of 3 phase system.
7.	What are positive sequence components?
7.	What are negative sequence components?
7.	Write down the equations to convert symmetrical components into phase quantities.
7.	What are sequence impedances and explain.
8.	Why the zero sequence impedance in transmission lines is more than its sequence impedance?
8.	Draw the zero sequence network diagram of a delta-delta connected transformer.
8.	Draw the equivalent sequence network diagram for a single line to ground fault in a power system for a bolted fault.
8.	Write the relation to determine fault current for L-G fault with fault impedance.
8.	Write the general equations to determine sequence line currents.
9.	What is power system stability?

9.	Distinguish between small disturbance and large disturbance.
9.	What is steady state stability and transient stability?
9.	What is angle stability and voltage stability?
9.	Write swing equation for a single machine connected to an infinite bus bar.
10.	Define Per unit inertia constant.
10.	Write the power angle equation and draw the power angle curve.
10.	Write the expression for maximum power transfer.
10.	State equal area criterion.
10.	What is critical clearing angle and critical clearing time?

Part – B (5 x 13 = 65 Marks)

11.a. Draw the PU impedance diagram for the system shown in figure. Choose Base MVA as 100 MVA and Base KV as 20 KV.



(13)

11.a. i) The parameters of a four bus 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 admittance matrix.

ii) What are impedance and reactance diagram? Explain with assumptions. (13)

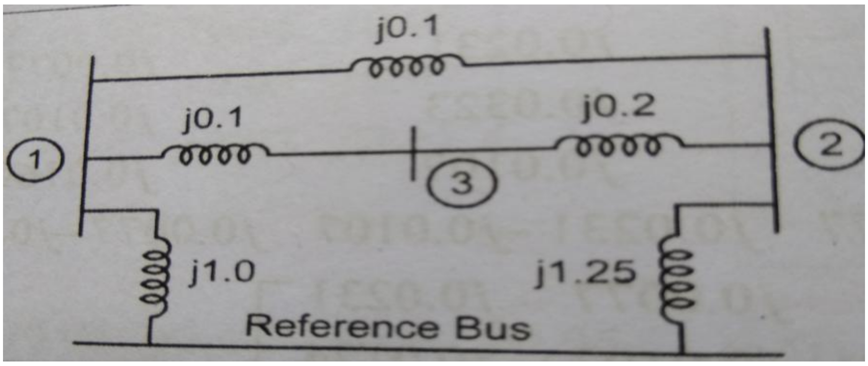
11.a. Explain the modelling of generator, load and transmission line for short circuit, power flow and stability studies. (13)

11.a. For a power system network with the following data, compute the bus admittance matrix by singular transformation method. (13)

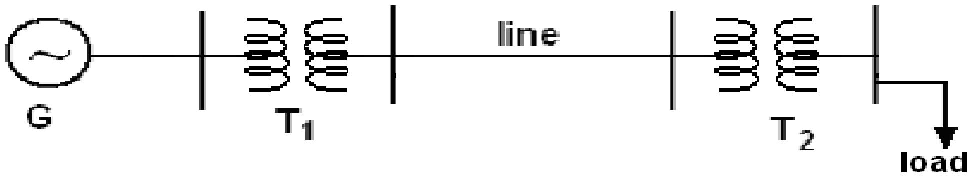
Bus code	P.U.Line impedance	Half line charging admittance
1-2	0.02+j0.8	0
2-3	0.03+j0.12	j0.002

3-4	0.01+j0.1	j0.003
4-5	0.02+j0.6	0
5-1	0.04+j0.15	0

11.a. Determine the Z-bus for a 3 bus system as shown in figure. Where the impedances are shown and the values are in PU (13)



11.b. Obtain PU impedance diagram of the power system of figure. 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



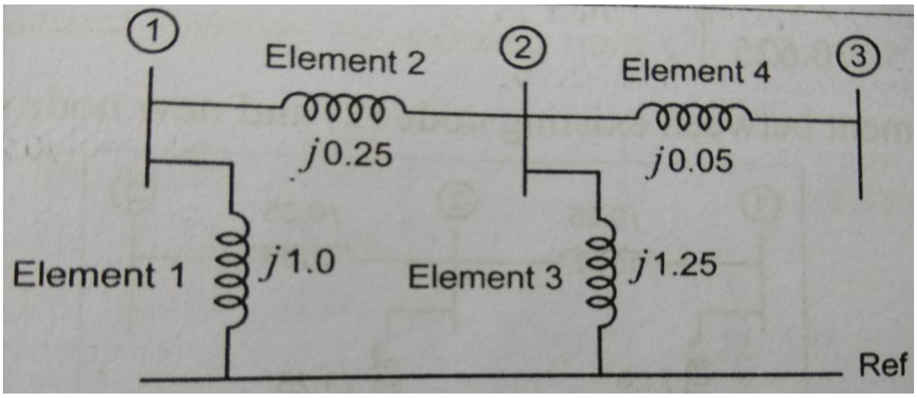
(13)

11.b. For the transmission line with the following data, form the bus admittance matrix (13)

Bus code p-q	Impedance (Zpq)	Line charging Y'pq/2
1-2	0.02+j0.04	j0.02
2-3	0.04+j0.2	j0.02
3-5	0.15+j0.4	j0.025
3-4	0.02+j0.06	j0.01
4-5	0.02+j0.04	j0.01
1-5	0.08+j0.2	j0.02

11.b. Explain the formation of bus impedance matrix with the algorithm, basic equations necessary circuit involved in it (13)

11.b. Determine bus using bus building algorithm by adding the lines as per increasing element number.



(13)

11.b.	(i) Explain the structure of modern power system with neat sketch. (ii) Describe about the representation of loads.	(7) (6)

12.a. 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. Also find the line flows. (13)

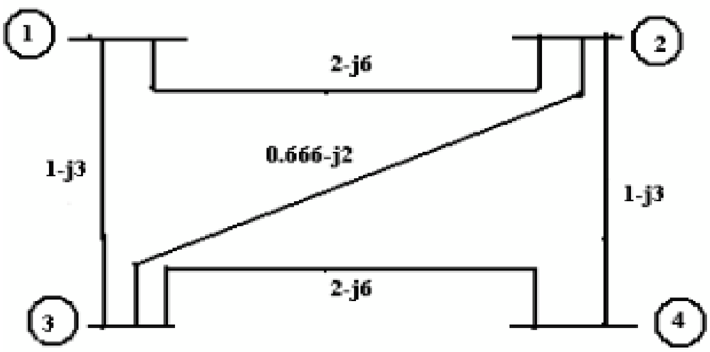
Line no	Bus code	Admittance in pu
1	1-2	2-j8
2	1-3	1-j4
3	2-3	0.6-j2.6

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

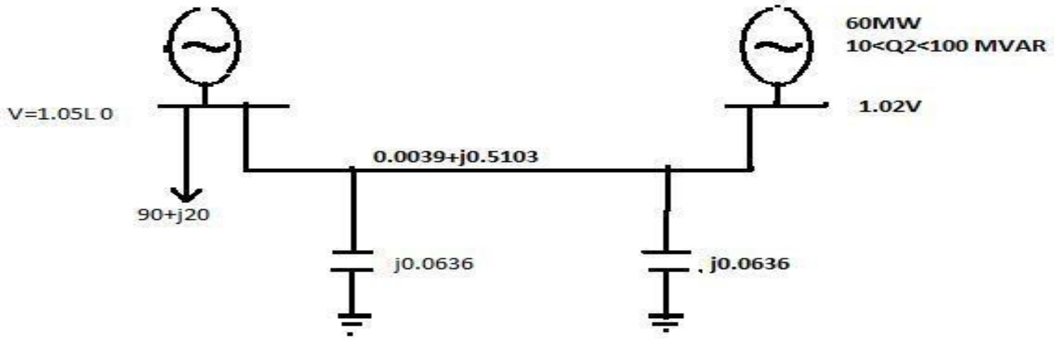
12.a. Derive the load flow algorithm using Gauss Seidal method with flow chart and discuss the advantages of the method. (13)

12.a. 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 $0.2 \le Q2 \le 1$ (13)

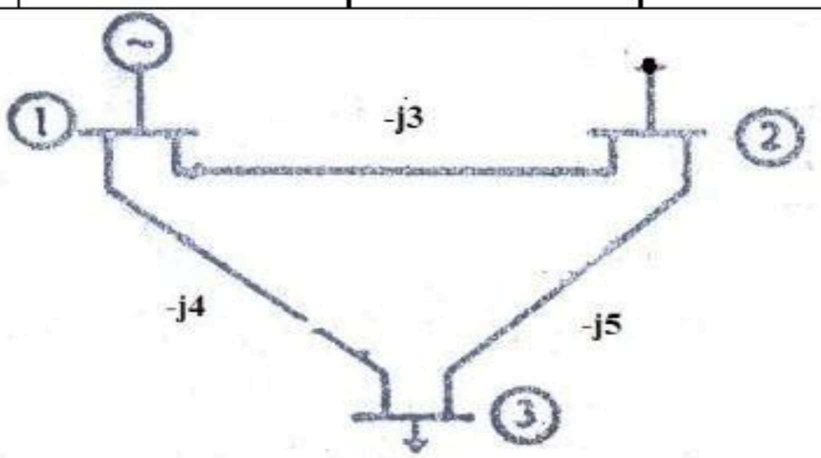
Bus	P in pu	Q in pu	V in pu	Remarks
1	-	-	1.04∟0°	Slack bus
2	0.5	-	1.04pu	PV bus
3	-1.0	0.5	-	PQ bus
4	0.3	-0.1	-	PQ bus



12.a.	Derive N-R method of load flow algorithm and explain the implementation of this algorithm with the flowchart and discuss the advantages of the method. (13)
12.a.	Explain the types of buses and derive the power flow equations in load flow Analysis. (13)
12.b.	(i) Derive the static load flow equations of n-bus system. (8) (ii) Compare GSLF, NRLF Methods. (8)
12.b.	Using Gauss Seidal method examines bus voltages for the fig shown. Take base MVA as100, a=1.1. (13)
12.b.	A three bus power system is shown in fiqure.the relevant per unit line admittance on 100MVA base are indicated on the diagram and bus data are given in table. form Ybus and Give the voltage at bus 2 and bus 3 after first iteration using gauss seidal method. Take the acceleration factor =1.6. (13)



Bus number	Type	Generation P_G (MW)	Generation Q_G(MVAR)	Load P_G (MW)	Load Q_G(MVAR)	Bus voltage V(p.u)	Bus voltage δ deg
1	Slack	-	-	0	0	1.02	0
2	PQ	25	15	50	25	-	-
3	PQ	0	0	60	30	-	-



12.b.	Give one iteration of Newton Raphson load flow method and determine the power flow Solution for the given system. Take base MVA as100. (13)

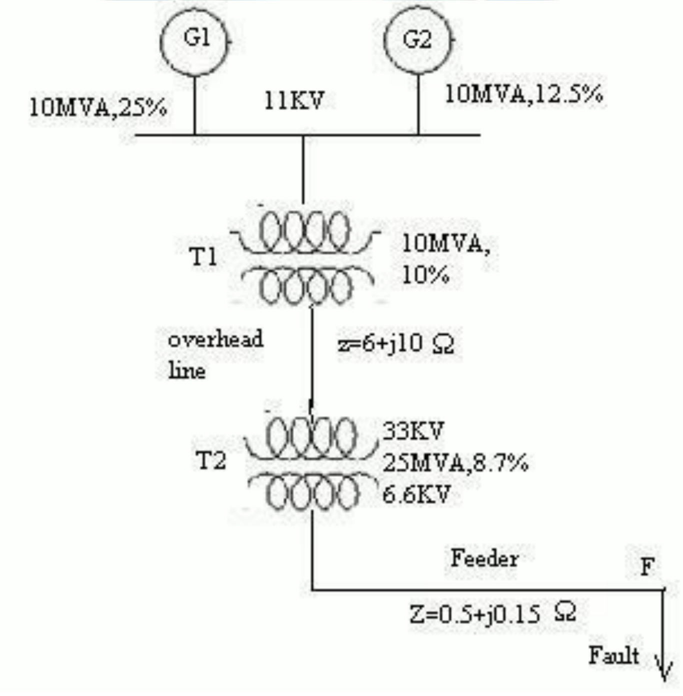
LINE DATA:

Line	Bus		R(pu)	X(pu)	Half line charging admittance in pu
	From	To			
1	1	2	0.0839	0.5183	0.0636

BUS DATA:

Bus	P_L	Q_L
1	90	20
2	30	10

12.b.	The converged load flow solution is available how do you determine the slack bus complex power injection and system total loss? (13)
13.a.	Explain the step by step procedure for systematic fault analysis for a three phase fault using bus impedance matrix. (13)
13.a.	Explain the step by step procedure to find the fault current of three phase symmetrical fault by using thevenin's theorem. (13)
13.a.	For the radial network shown in figure, a 3 phase fault occurs at point F. examine the fault current.



(13)

13.a.	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

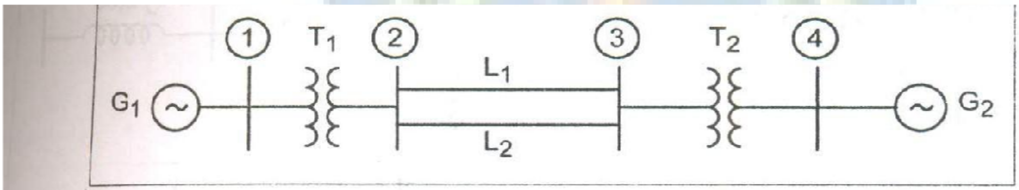
	occurs at a point 15Km along the feeder.	(13)

13.a. Generator G1 and G2 are identical and rated as 11KV 30 MVA and have a transient reactance of 0.3 PU at own MVA base. The transformers T1 and T2 are also identical and are rated 11/66 KV, 10MVA and have a reactance of 0.075 per unit to their own MVA base. Then the line is 60km long, each conductor has a reactance of 0.92Ω/km. the 3 phase fault is assumed at point F, which is 25 km from generator G1. Find the short circuit current. (13)

13.b. A generator is connected through a transformer to a synchronous motor. The sub transient 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 sub transient current in p.u in the fault, generator and motor. Use the terminal voltage of generator as reference vector. (13)

13.b. Derive and explain the necessary equations for finding fault current of three phase symmetrical fault (13)

13.b. A symmetrical fault occurs on bus 4 of system shown in fig. determine the fault current, post fault Voltages and line currents using Thevenin's method. (13)



G_1, G_2 : 100 MVA, 20 KV, $X^+ = 15\%$

Transformer : $X_{leak} = 9\%$

L_1, L_2 : $X^+ = 10\%$

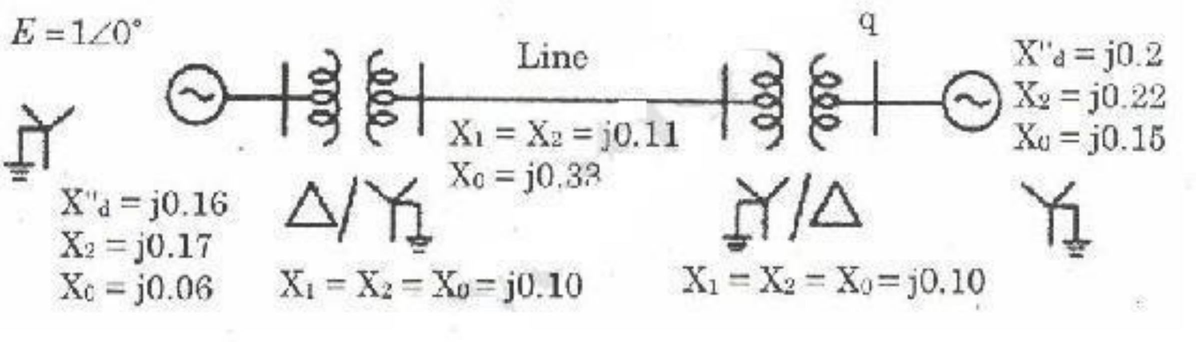
13.b. A generator transformer unit is connected to a line circuit breaker. the unit rating are:
Generator: 10MVA, 6.6KV; Xd"=0.1 p.u, Xd'=0.2 p.u and X=0.8 p.u
Transformer:10mva,6.9/33KV,X=0.08 p.u, The system is operating on no load at a line voltage of 30 KV, when a 3F fault occurs on the line jest beyond the circuit breaker. Solve

(i) The initial symmetrical rms current in the breaker.
(ii) The maximum possible dc offset current in the breaker.
(iii)the momentary current rating of the breaker
(iv) the current to be interrupted by the breaker and the interrupting KVA
(v)the sustained short circuit current in the breaker. (13)

13.b. A 3-phase 6MVA, 6.6 KV alternator with a reactance of 12% is connected to a feeder of series impedance (0.10+j0.5) ohm/phase/Km through a step up transformer. The transformer is rated at 3 MVA, 6.6 KV/33KV and has a reactance of 7%. 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 16Km along the feeder. (13)

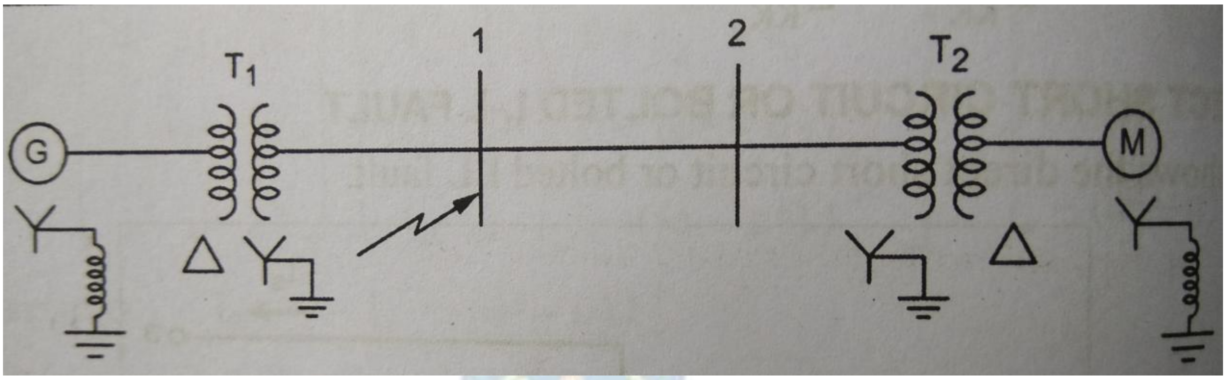
14.a. Show the expression for fault current in line to line fault on unloaded generator. Draw an equivalent network showing the inter connection of networks to simulate double line to line fault. (13)

14.a. Two synchronous machines are connected through three phase transformers to the transmission line. The ratings are reactance's of the machines and transformers are

	Machine1 & 2: 50MVA, 11KV, X”=X1=X2=16%, X0=3%, Xn=4% Transformers T1& T2: 50MVA, 11/220KV, X=6% Both transformers are solidly grounded on two sides on a chosen base of 50MVA, 220KV in the transmission line circuit. The reactances are X1=X2=12% and X0=40%. The system is operating at nominal voltage without prefault currents when a bolted single line to ground fault occurs on phase A at bus 2. Determine the sub transient current to ground at the fault. (13)
14.a.	Discuss 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 (13)
14.a.	Calculate the sub transient current in each phase for a dead short circuit on the one phase to ground at bus ‘q’ for the system shown in figure below. (13) 
14.a.	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 j0.4 ohms respectively. Single line to ground fault occurs at terminals of the 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’ (13)
14.b.	Show 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 (13)
14.b.	A 30MVA 11KV 3phase synchronous generator has a direct sub transient reactance of 0.25pu. the negative and zero sequence reactance are 0.35 and 0.1 pu respectively. The neutral of the generator is solidly grounded. Find the sub transient currents and the line to line voltages at the fault under sub transient conditions when a line to line fault occurs at the terminals of the generator. Assume that the generator is unloaded and operating at rated terminal voltage when the fault occurs. (13)
14.b.	Examine the sequence impedance of synchronous machine, transmission lines and Star connected loads. (13)

14.b. Two synchronous machines are connected through three phase transformers to the transmission line. The ratings are reactance's of the machines and transformers are
Machine1 & 2: 75MVA, 22KV, X"=X1=X2=16%, X0=3%, Xn=4%
Transformers T1& T2: 75MVA, 22/220KV, X=6%
Both transformers are solidly grounded on two sides on a chosen base of 75MVA, 220KV in the transmission line circuit. The reactances are X1=X2=12% and X0=40%. The system is operating at nominal voltage without prefault currents when a bolted single line to ground fault occurs on phase A at bus 2. Determine the sub transient current to ground at the fault. (13)

14.b. A single line to ground fault occurs on the bus 1 of the system of fig. (13)



Find: i) Current in the fault ii) short circuit current on the transmission line in all the three phases iii)voltage of the healthy phase of the bus 1
Given values: Rating of each machine 1200KVA, 600V with X1=X2=10% and X0=5%. Each three phase transformer is rated 1200KVA, 600V/3300V (Δ/Y) with leakage reactance of 5%. The reactances of transmission line are X1=X2=20% and X0=40% on the base of 1200KVA, 3300V. The reactances of neutral grounding reactors are 5% on the KVA and voltage base of the machine.

15.a. Examine swing equation used for stability studies in power system. (13)

15.a. Describe the equal area criterion for transient stability analysis of a system. (13)

15.a. Interpret the computation algorithm for obtaining swing curves using modified Euler's method (13)

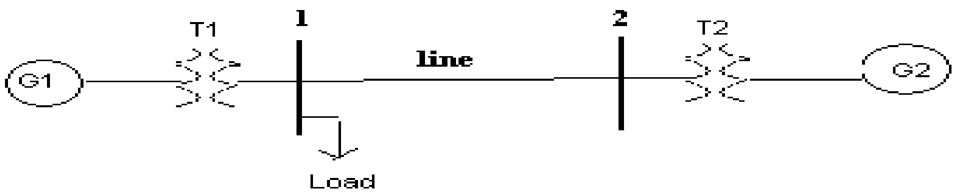
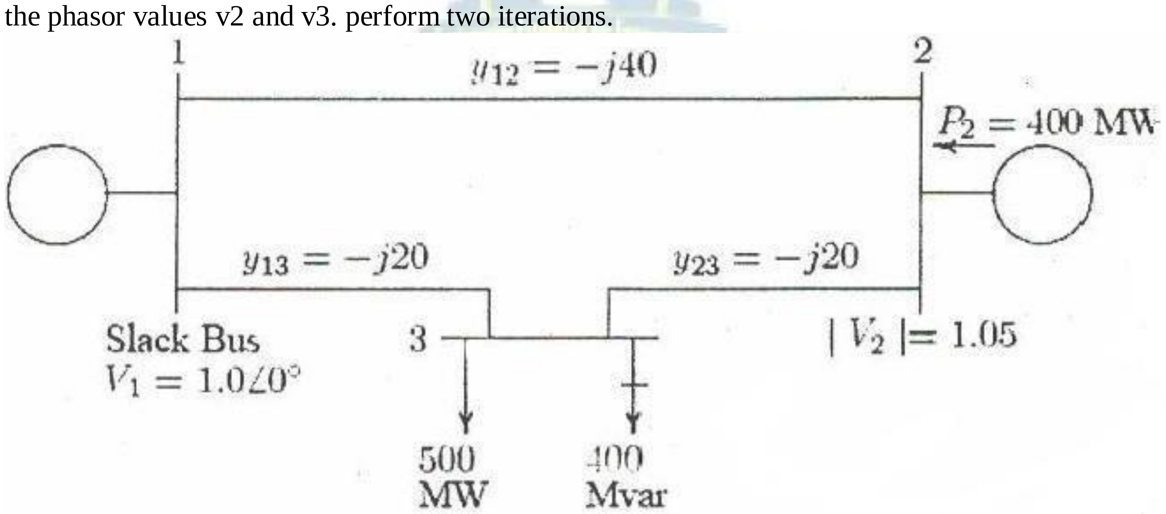
15.a. Examine a short note on
i. Factors influencing transient stability,
ii. Voltage collapse (13)

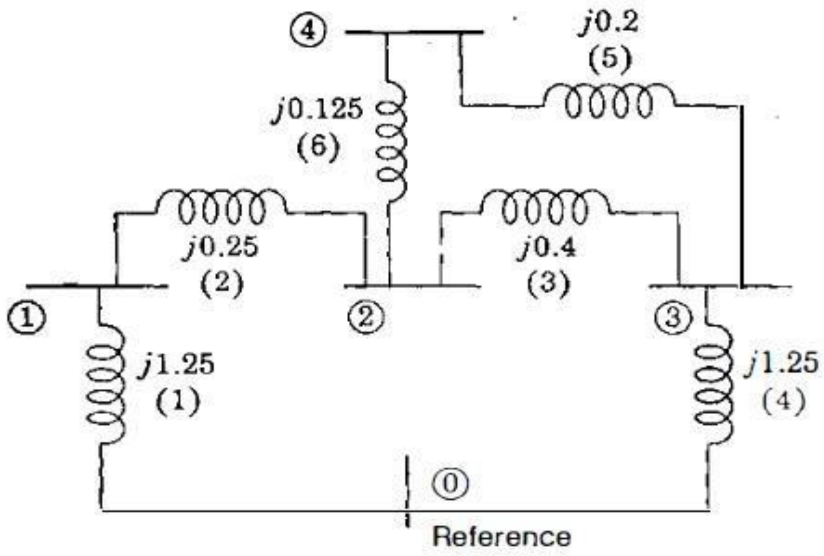
15.a. Examine the swing equation of a synchronous machine swinging against an infinite bus. Clearly state the assumption in deducing the swing equation. (13)

15.b. Derive Expression for critical clearing angle. (13)

15.b. Explain the modified Euler method of analyzing multi machine power system for stability, with neat flow chart. (13)

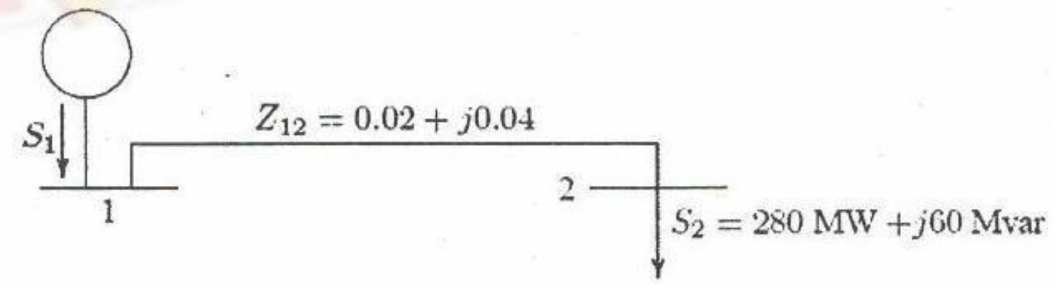
15.b. Develop the Runge-Kutta method of solution of swing equation for multi-machine systems. (13)

15.b.	Explain steady state, dynamic and transient stability.	(13)
15.b.	Explain power angle equation and power angle curve.	(13)
	Part – C (1 x 15 = 15 Marks)	
16.a.	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. G1:90MVA, 20KV, X=9%. G2:90MVA, 18KV, X=9%. T1 : 80MVA, 20/200KV, X=16%. T2 : 80MVA, 200/20KV, X=20%. LINE : 200KV X=120Ω , LOAD: 200KV ,S= 48MW + j64MVAR.  	(15)
16.a.	Figure shows the one line diagram of a simple three bus power system with generation at buses at 1 and 2.the voltage at bus 1 is V=1+j0.0 V per unit. Voltage magnitude at bus 2 is fixed at 1.05 p.u. with a real power generation of 400 MW. A Load consisting of 500MW and 400 MVAR base. For the purpose of hand calculation, line resistance and line charging susceptances are neglected. Using Newton-Raphson method, start with the initial estimates of V20=1.05+j0.0 and V30=1.05+j0.0, and keeping ¦V2¦=1.05 p.u., examine the phasor values v2 and v3. perform two iterations.  	(15)
16.a.	Examine the bus impedance matrix using bus building algorithm for the given network.	(15)



16.a.	A salient pole generator without dampers is rated 25MVA 13.2KV and has a direct axis sub transient reactance of 0.25 PU. The negative and zero sequence reactance's are 0.35 and 0.1PU respectively. The neutral of the generator is solidly grounded. Determine the sub transient current in the generator and line to line voltage for a sub transient conditions when a single line to ground fault occurs at the terminals of an unloaded generator. (15)
16.a.	A 50 Hz, 500 MVA, 400 KV generator (with transformer)is connected to a 400KV 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.b.	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% Examine the impedance diagram and mark all values in p.u choosing a base of 30MVA, 6.6KV in the generator 1 circuit.

16.b. In the power system network shown in figure, bus 1 is slack bus with V1= 1.0 + j0.0 per unit and bus 2 is a load bus with S2 = 280MW = j60MVAR. The line impedance on a base of 100MVA is Z = 0.02 + j0.04 per unit. Using Gauss – seidal method, give V_2.Use an initial estimate of $V_{2(0)}$ = 1.0 + j0.0 and perform four iterations. Also find S1 and the real, reactive power loss in the line, assuming that the bus voltages have converged. (15)



16.b. Generator G1 and G2 are identical and rated as 15KV 35 MVA and have a transient reactance of 0.45 PU at own MVA base. The transformers T1 and T2 are also identical and are rated 15/66 KV, 15MVA and have a reactance of 0.07 per unit to their own MVA base. Then the line is 60km long, each conductor has a reactance of 0.92Ω/km. the 3 phase fault is assumed at point F, which is 25 km from generator G1. Find the short circuit current. (15)

16.b. Two synchronous machines are connected through three phase transformers to the transmission line. The ratings are reactance's of the machines and transformers are
Machine1 & 2: 60MVA, 25KV, X"=X1=X2=12%, X0=4%, Xn=5%
Transformers T1& T2: 75MVA, 25/220KV, X=6%
Both transformers are solidly grounded on two sides on a chosen base of 75MVA, 220KV in the transmission line circuit. The reactance's are X1=X2=13% and X0=42%. The system is operating at nominal voltage without prefault currents when a bolted single line to ground fault occurs on phase A at bus 2. Determine the sub transient current to ground at the fault (15)

16.b. Write short notes on transient stability and methods of improving it. (15)