EE6T3

USN

Sixth Semester B.E. Degree Examination, July/August 2005

Electrical & Electronics Engineering

(Old Scheme)

Power System Analysis and Stability

Time: 3 hrs.] [Max.Marks : 100

Note: *Answer any FIVE full questions.*
All questions carry equal marks.

1. (a) Explain the advantages of per unit system. **(8 Marks)**

(b) Figure Q.1(b) shows the one line diagram of a power system for which the details of system components are as follows.

G : Synchronous generator, 80MVA, 6KV, $x''_d = 8\%$

T_1 : 3ϕ transformer, 85 MVA, 110KV(Y) /6.6KV(Δ), x=10%

T L : Transmission line, series reactance 20 ohms

T_2 : Bank of 3 single phase transformers, each rated 30 MVA 63.5 KV/6.6KV, leakage reactance 8%

M_1 : Syn. motor 35 MVA, 6.2KV, $x'_d = 12\%$

M_2 : Syn. motor 40 MVA, 6.2KV, $x'_d = 10\%$

Draw the reactance diagram for the system and mark the per unit reactances of respective components, choosing a base of 100 MVA, 120 KV in the transmission line circuit. **(12 Marks)**

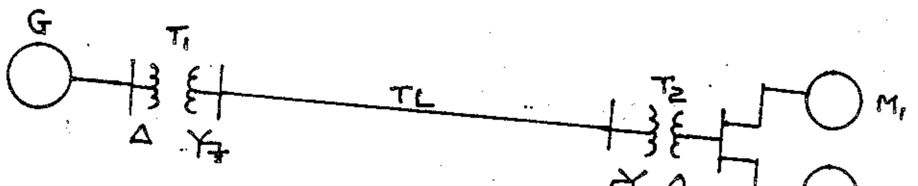


Fig Q.1.b

2. (a) Draw the typical waveform for the armature current in one of the phases of a previously unloaded 3 phase synchronous generator subjected to sudden, symmetric 3 phase short circuit at its terminals, and explain its salient features. How are x''_d, x'_d & x_d determined from this waveform? **(10 Marks)**

(b) Following data gives the series impedances in per unit on a common base for each transmission line of a four bus power system. Obtain the Y_{Bus} for the system.

Sl.No.	Transmission line between buses	Series impedance
1	1-2	$0.1 + j0.40$
2	2-3	$0.15 + j0.75$
3	3-4	$0.2 + j0.80$
4	4-1	$0.08 + j0.40$
5	4-2	$0.1 + j0.4$

Line charging admittances may be neglected. **(10 Marks)**

3. (a) The HV winding of a 3ϕ transformer is star connected and the LV winding is Delta connected. Establish the relation between positive sequence voltages and currents on the delta side with corresponding variables on the star side. Voltages refer to line neutral voltages and currents refer to line currents. State the convention used regarding tabelling the transformer terminals, dot convention etc. **(12 Marks)**

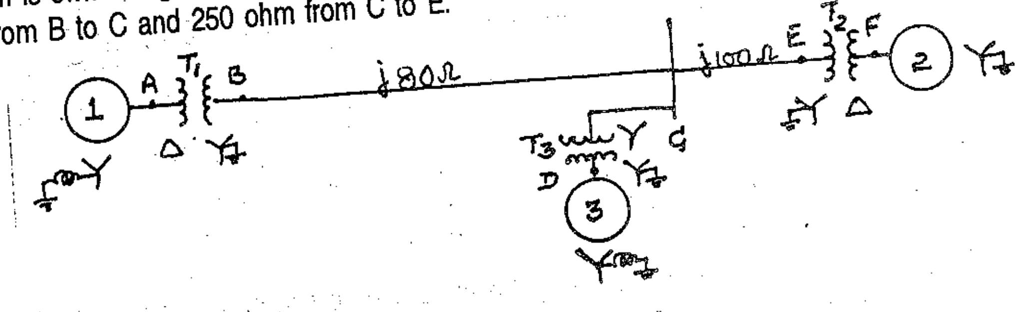
(b) In a 3 phase 3 wire system, with phase sequence RYB, the current in two of the lines are

$$I_R = 10\angle 30 \;\; A, \;\; I_Y = 20\angle -60 \;\; A.$$

Find the symmetrical components of the three line currents. **(8 Marks)**

4. (a) All the three sequence impedances are the same for a transformer but not so for synchronous machines and transmission lines in a power system, explain the reasons. **(8 Marks)**

(b) Draw the negative and zero sequence impedance network for the power system shown in the Fig.Q.4(b). Mark the values of all reactances in Pu on a base of 50 MVA, 13.8KV in the circuit of generation 1. Letter the networks to correspond to the one line diagram. The neutrals of generators 1 and 3 are connected to ground through current limiting reactors having a reactance of 5% each on the base of the machine to which it is connected. Each generator has negative and zero sequence reactances of 20% and 5% respectively on is own rating, as base. The zero sequence reactance of transmission line is 210 ohm from B to C and 250 ohm from C to E. **(12 Marks)**



Generator 1	: 20 MVA, 13.8 KV, $X'' = 0.2PU$
Generator 2	: 30 MVA, 18 KV, $X'' = 0.2PU$
Generator 3	: 30 MVA, 20 KV, $X'' = 0.2PU$
Transformer T_1	: 25 MVA, 220kV Y/13.8KV Δ, X=10%
Transformer T_2	: Single phase units, each rated 10 MVA, 127/8 KV, X=10%
Transformer T_3	: 35 MVA, 220 Y / 22Y KV, X=10%
TL BC	: j80 ohm and TL CE : j100Ω for negative sequence.

Contd.... 3

5. (a) A double line to ground fault occurs on lines band C of a previously unloaded 3 phase alternator through a fault impedance z_f. Derive necessary equations and develop the interconnection of sequence networks.

(10 Marks)

(b) Obtain the interconnection of sequence networks for the following types of open conductor faults on power systems :

i) One conductor open ii) Two conductor open.

(10 Marks)

6. (a) Explain how the effect of prefault current in included in calculation of currents in different parts of a power system during the occurrence of an unsymmetrical fault at a specified location.

(6 Marks)

(b) A generator supplies a motor through a $Y - \Delta$ transformer. The generator is connected to the Y side of the transformer. A fault occurs between the motor terminals and the transformer. The symmetrical components of the substransient current in the motor flowing towards the fault are

$I_{a1} = -0.8 - j2.6pu,\ I_{a2} = -j2.0,\ I_{a0} = -j3.0Pu$

From the transformer towards the fault

$I_{a1} = 0.8 - j0.4Pu,\ I_{a2} = -j1.0Pu,\ I_{a0} = 0.$

Assume $X_1'' = X_2$ for both motor and generator.

i) Describe the type of fault

ii) Determine the prefault current, if any in the line a

iii) Determine the subtransient fault current tin Pu

iv) Determine the subtransient current in the phase a of the generator in Pu. **(14 Marks)**

7. (a) What is swing equation? Derive the same for a syn. generator connected to infinite bus.

(8 Marks)

(b) A synchronous motor connected to an infinite bus is driving a load corresponding to its rated capacity, with a torque angle of 30^0. If the load is suddenly increased to $\sqrt{2}$ times the rated load. Determine the stability of the motor.

(12 Marks)

8. Write explanatory notes on :

(a) Rating and selection of circuit breakers

(b) Inertia constants M and H

(c) Difference between steady state stability and transient stability

(d) Calculation of torque developed in a 3 phase induction motor operating on 3 phase, unbalanced voltages.

(4×5=20 Marks)

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(b) A balanced star connected load takes 30 amps from balanced $3\phi 4$ wire supply. If the fuses in one and two lines are removed, find the symmetrical components of the line currents, before and after the fuses removed. **(10 Marks)**

4. (a) Prove that only in power systems having balanced impedances, currents of a given sequence produce voltage drops of the same sequence. **(5 Marks)**

(b) In a three phase four wire system, the sequence components of currents and voltages are :

$$I_{a0} = (0.1 + j0.2)pu \qquad V_{a0} = (0.1 + j0.2)pu$$
$$I_{a1} = (0.8 + j0.2)pu \qquad V_{a1} = (1 + j0)pu$$
$$I_{a2} = (0.2 - j0.2)pu \qquad V_{a2} = (0.2 + j0.2)pu$$

Determine the total three phase complex power in MVA if the base is 100 MVA. **(7 Marks)**

(b) Explain the phase shift of symmetrical components in star - delta transformer bank with respect to voltage relations and current relations. **(8 Marks)**

5. (a) A double line to ground (DLG) fault takes place at the terminals of an unloaded alternator. Show that how the sequence networks are to be inter connected to represent the fault and also obtain for the fault current. **(10 Marks)**

(b) Draw the sequence networks for the system shown in figure. Determine the fault current for a line to line fault occurs at F. The p.u. reactances all referred to the same base are as follows :

Components	X_0	X_1	X_2
Gen. G_1	0.05	0.30	0.2
Gen. G_2	0.03	0.25	0.15
Line- 1	0.7	0.30	0.30
Line - 2	0.7	0.30	0.30
Tfr. T_1	0.12	0.12	0.12
Tfr. T_2	0.10	0.10	0.10

Both the generators are generating at 1.0pu. **(10 Marks)**

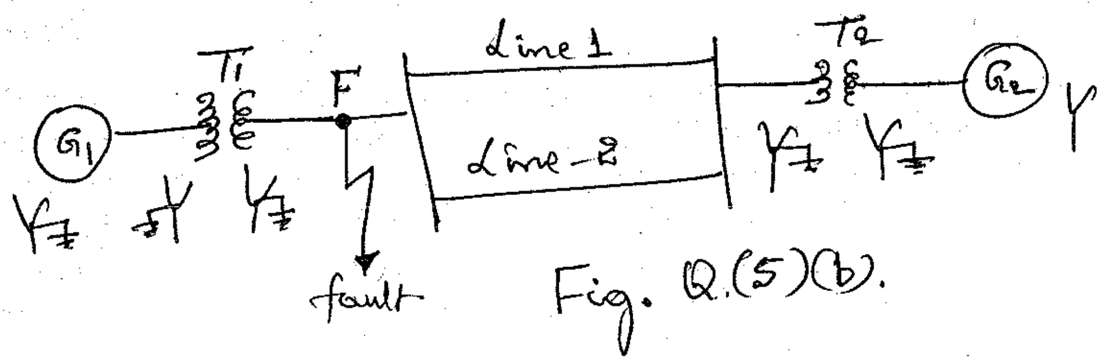

Fig. Q.(5)(b).

6. (a) Explain the following terms:

i) Steady state stability

ii) Dynamic stability

ii) Transient state stability

(6 Marks)

(b) Derive the steady state stability limit (SSSL) of a two terminal pair network represented by ABCD constants.

(8 Marks)

(c) A 60 Hz, 4 pole turbogenerator rated 500MVA, 22 KV has an inertia constant of H = 7.5 MJ/MVA. Find :

i) Kinetic energy stored in rotor at synchronous speed

ii) Find the angular acceleration if electrical power developed is 400 MW when the input minus rotational losses is 740,000 HP.

(6 Marks)

7. (a) Derive the expression for critical clearing angle when the fault occurs on one of the double circuit lines. Explain the importance of critical clearing time. **(10 Marks)**

(b) The generator of figure is delivering 1.0pu power to the infinite bus $[@V_\infty = 1.0pu]$. The generator terminal voltage is $|V_i| = 1.0pu$. Calculate the generator e.m.f behind transient reactance. Find the maximum power that can be transmitted under the following conditions.

i) system healthy

ii) one line shorted (3 in ϕ) in the middle

iii) one line open

iv) plot all the three power angle curves

(10 Marks)

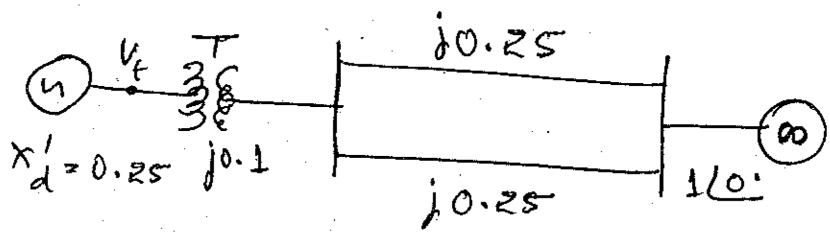

Fig. Q(7)(b)

8. Write short notes on any FOUR of the following : **(5×4=20 Marks)**

a) Per unit impedance of three winding transformer

b) Swing equation

c) Zero sequence networks for various transformer connections

d) Selection of circuit breakers

e) Equal area criterion

** * **

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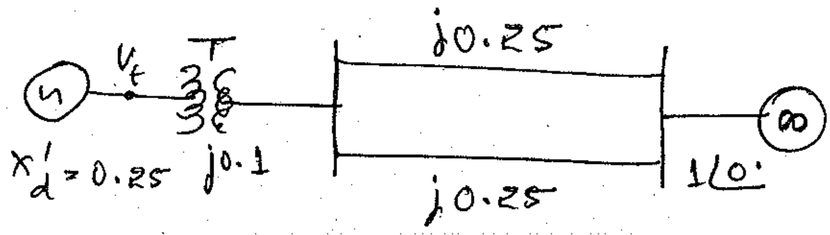

Fig. Q(7)(b)

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a) Per unit impedance of three winding transformer

b) Swing equation

c) Zero sequence networks for various transformer connections

d) Selection of circuit breakers

e) Equal area criterion

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EE61

USN

NEW SCHEME

Sixth Semester B.E. Degree Examination, July 2006
E & EE
Power System Analysis and Stability

Time: 3 hrs.] [Max. Marks:100

Note: *1. Answer any FIVE full questions.*
2. Assume the missing data, if any, suitably.

1 a. i) List any three advantages of per unit system of computations.
ii) State the criteria for the selection of base quantities. **(05 Marks)**

b. Show that the per-unit impedance of a transformer is the same when referred to either its primary side or the secondary side. **(05 Marks)**

c. Draw the per unit impedance diagram for the system shown in fig.1(c), by taking a base of 100 MVA, 11 KV in the generator circuit. The various component ratings are: Transformer T1: 3 phase unit 90 MVA, 11/110 KV, X=10%, Transformer T2: made up of 3 single-phase units each rated 33.33 MVA, 68/6.6 KV, X=10%, Synchronous Generator: 80 MVA, 10 KV, X=10%, Synchronous Motor: 95 MVA, 6.3 KV, X=15% and the line reactance is 20 ohms. **(10 Marks)**

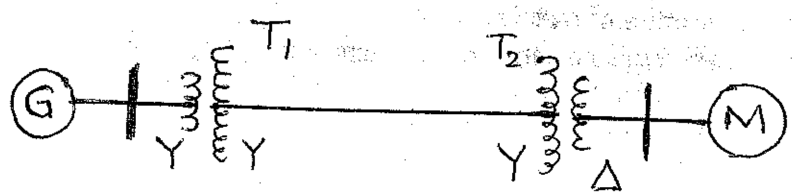

Fig.1(c)

2 a. A sudden 3-phase short circuit takes place at the terminals of an unloaded three-phase alternator. Discuss briefly on the different reactances that are met with assuming that the damper windings are provided at the pole faces of salient pole synchronous machine. **(07 Marks)**

b. By stating the generalized algorithmic equations for determining the elements of the bus admittance matrix by the rule of inspection, obtain the matrix, Y_{BUS} for the resistive network shown in fig.2(b). All the values shown are in Ohms. **(05 Marks)**

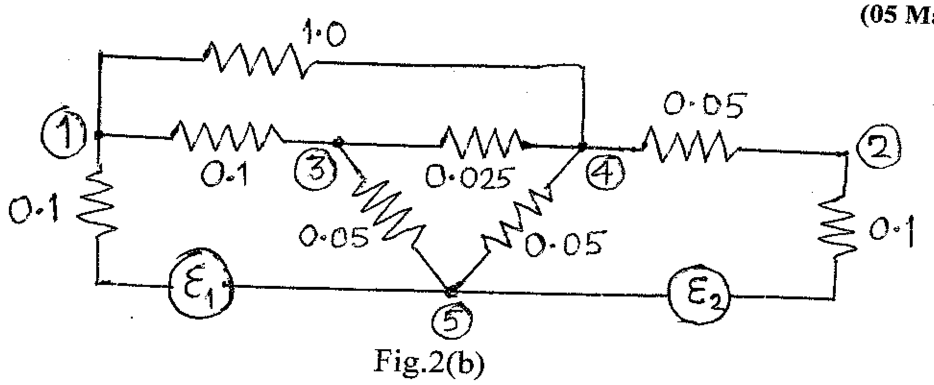

Fig.2(b)

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c. A transmission line of inductance, L = 0.1 Henry and resistance, R = 5 Ohms, is suddenly short circuited at t = 0, at the far end of line as shown in fig.2(c). If the source voltage is: $v = 100 \sin(100\pi t + 15^0)$, obtain the following:
   i) Expression for the short circuit current, i(t).
   ii) Exact value of the first current maximum and
   iii) Instant of short circuit at which the DC off-set current is zero. **(08 Marks)**

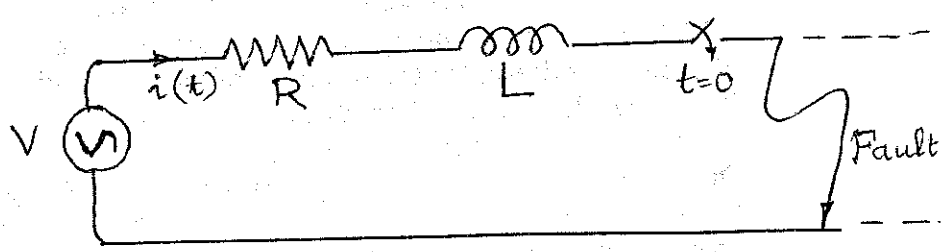

Fig.2(c)

3 a. Derive an expression for the three phase complex power in terms of the sequence components and hence show that the symmetrical component transformation is power invariant. **(06 Marks)**

b. A balanced delta connected load is connected to a symmetrical three-phase system and supplied to it is a current of 15 amps. If the fuse in line-C melts, determine the symmetrical components of the line currents. **(08 Marks)**

c. A synchronous generator rated 500 KVA, 440 V, 0.1 pu sub-transient reactance is supplying a passive load of 400 KW at 0.8 pf (lag). Calculate the initial symmetrical (rms) current for a three-phase fault at the generator terminals. **(06 Marks)**

4 a. With the help of the relevant phasor diagrams of voltages, show that there exists a phase shift of positive and negative sequence components in a three-phase Y - Δ transformer bank. Assume the HT side to be Y – connected and LT side, Δ - connected. **(08 Marks)**

b. Discuss on the sequence reactance – diagrams of transformers for their winding connections as follows: i) Y - Δ ii) Y - Y iii) Δ - Y iv) Δ - Δ **(06 Marks)**

c. Obtain the zero sequence diagrams for the system shown in fig.4(c). **(06 Marks)**

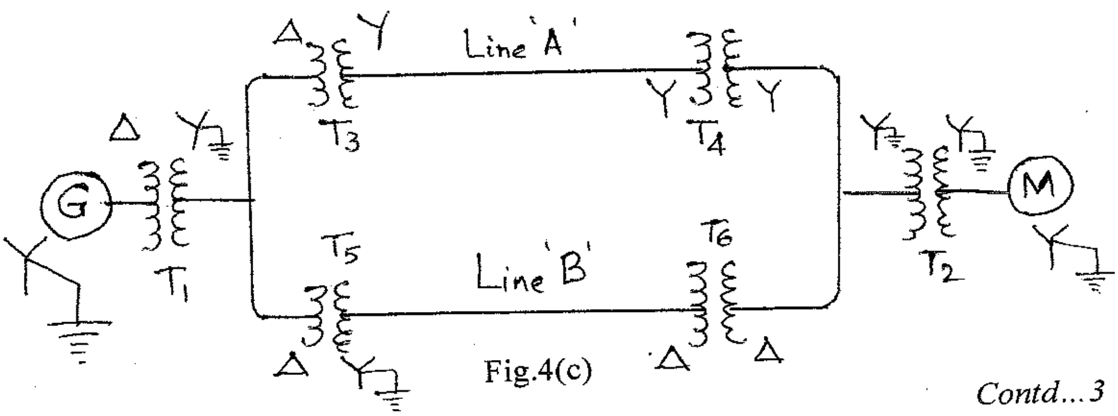

Fig.4(c)

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5 a. Show that the impedance Z_n between the Y-neutral and ground of a three-phase machine is represented equivalently as $3Z_n$ in its zero sequence diagram. **(04 Marks)**

b. Derive the expression for the fault current in terms of the sequence impedances and hence obtain the connection diagram of the sequence networks for a line-to-line (LL) fault through the fault impedance, Z_f at the terminals of a Y–connected alternator. **(10 Marks)**

c. A three-phase generator with constant internal voltages gave the fault currents under two different unsymmetrical faults as follows:
L-L fault : 1400 Amperes and L-G fault : 2200 Amperes.
If E_{a1} = 2 KV, and the positive sequence reactance is 2 Ohms, find the negative-sequence and zero-sequence impedance values. **(06 Marks)**

6 a. Discuss briefly about the open-conductor faults in electric power systems. **(06 Marks)**

b. Three 6600 Volts, 10 MVA, 3-phase alternators are connected to a common set of bus-bars. Each has a positive-sequence reactance of 15%. The negative-sequence and zero-sequence reactances are respectively equal to 75% and 30% of the positive-sequence value. Find the fault current for L-G fault at the bus terminals if:
i) Only one of the generator neutrals is solidly grounded.
ii) Only one of the neutrals is earthed through a resistance of 0.3 Ohm. **(14 Marks)**

7 a. Distinguish between steady state stability and transient stability in power systems. Also elaborate on the corresponding power limits. **(06 Marks)**

b. Develop the swing equation of a synchronous machine working on an infinite bus. **(06 Marks)**

c. A 50 Hz, 4-pole turbo-alternator, rated 20 MVA, 11 KV has an inertia constant of H = 9 KWs/KVA. Find the acceleration if the input less the rotational losses is 26,800 HP and the electrical losses developed amount to 16 MW. **(08 Marks)**

8 a. Bring out the importance of the inertia constants M and H. **(04 Marks)**

b. Explain the Equal Area Criterion of stability for a two-machine power system. State the assumptions made. **(08 Marks)**

c. Obtain the power angle characteristic equations for a two-machine loss-less power system connected by a series impedance. **(08 Marks)**

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EE61

USN

NEW SCHEME

Sixth Semester B.E. Degree Examination, Dec. 06 / Jan. 07
Electrical and Electronics Engineering
Power System Analysis and Stability

Time: 3 hrs.] [Max. Marks:100

Note: *1. Answer any FIVE full questions.*

1 a. Explain the importance of impedance and reactance diagram for the analysis of a power system. **(05 Marks)**

b. A 90 MVA, 11 kV, 3 phase generator has a reactance of 25%. The generator supplies two motors through transformers and transmission line as shown in the fig1(b). The transformer T_1 is a 3 phase transformer, 100 MVA, 10/132 kV, 6% reactance. The transformer T_2 is composed of 3 single phase units each rated at 30 MVA, 66/10 kV, with 5% reactance. Taking the generator rating as base, draw the reactance diagram and indicate the reactances in per unit. The reactance of line is 100 Ohms. The ratings of the motors are given on the diagram. **(08 Marks)**

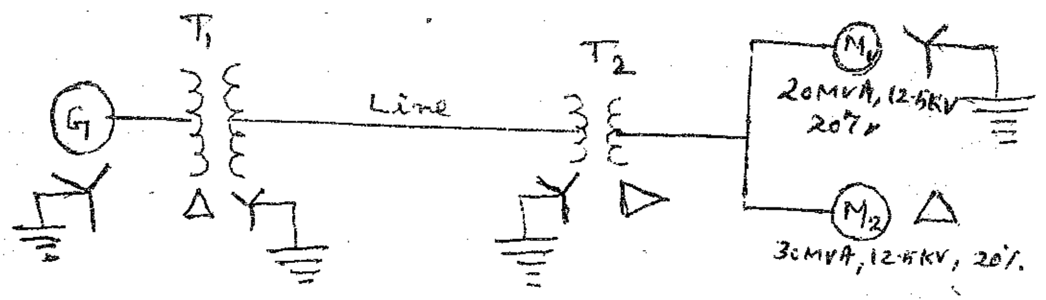

Fig.1(b)

c. Bring out the advantages of Per Unit System. Show that the Per Unit Impedance of a transformer is the same whether computed from primary or secondary side so long as the voltage bases on the two sides are in the ratio of transformation. **(07 Marks)**

2 a. Show that the power in a three phase circuit can be computed from symmetrical components. **(08 Marks)**

b. Fig.2(b) shows a Delta Connected load. The current flowing through the line 'A' is 1000 Amperes while line 'C' is open. With the current in line 'A' as reference, calculate the currents in all the lines and then symmetrical components. **(08 Marks)**

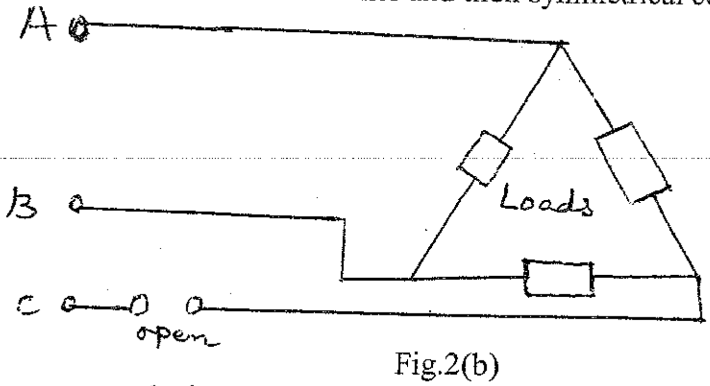

Fig.2(b)

c. Write a note on the importance of short circuit calculations. **(04 Marks)**

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3 a. What do you understand by positive, negative and zero sequence impedances? Discuss them with reference to synchronous generators, transformers and transmission lines. **(10 Marks)**

b. A 3 phase, 30 MVA, 6.6 kV alternator having 10% reactance is connected through a 30 MVA, 6600 / 33000 Volt delta star connected transformer of 5% reactance to a 33 kV transmission line having a negligible resistance and a reactance of 4 Ohms. At the receiving end of the line there is a 30 MVA, 33000/6600 Volt delta star connected transformer of 5% reactance stepping down the voltage to 6.6 kV. Both the transformers have their neutral solidly grounded.

Draw the one line diagram and the positive, negative and zero sequence networks of this system and determine the fault current when all the three phases are short circuited at the receiving station L.V. bus bars.

For generator, assume negative sequence reactance is 70% that of positive sequence. **(10 Marks)**

4 a. What is a 3 phase unsymmetrical fault? Discuss the different types of unsymmetrical faults that can occur on a three phase system. **(06 Marks)**

b. The currents in a 3-phase unbalanced system are

$\vec{I}_R = (12+J6)$ Amps, $\vec{I}_Y = (12-J12)$ Amps, $\vec{I}_B = (-5+J10)$ Amps.

The phase sequence is RYB. Calculate the zero, positive and negative sequence components of the currents. **(08 Marks)**

c. Why do we prefer to analyze unsymmetrical faults by symmetrical components method? **(04 Marks)**

5 a. Derive an expression for fault current for double line to ground fault by symmetrical components method. **(08 Marks)**

b. A 30 MVA, 11 kV generator has $Z_1 = Z_2 = J0.2$ p.u., $Z_0 = J0.05$ p.u.

i) A line to ground fault occurs on the generator terminals. Find the fault current and line to line voltages during fault conditions. Assume that the generator neutral is solidly grounded and that the generator is operating at no load and at rated voltage at the occurrence of fault.

ii) Find also the line current for a 3 phase fault. **(08 Marks)**

c. Write a note on open conductor faults in power system. **(04 Marks)**

6 a. Define stability of a power system. **(02 Marks)**

b. Explain clearly the difference between steady state stability and transient stability. **(06 Marks)**

c. Starting from first principle, derive the swing equation of a synchronous machine. **(08 Marks)**

d. Draw a swing curve and a power angle curve with relevant details. **(04 Marks)**

7 a. Using equal area criterion method, derive an expression for critical clearing angle for a system having a generator feeding a large system through a double circuit line. **(08 Marks)**

b. Fig.7(b) represents the single line diagram of a generator connected to an infinite bus through a pair of transmission lines. The transient reactance of the generator is included in the diagram along with other reactances. Assume a 3 phase fault at 'F' when the generator is delivering 1.0 p.u. of power. Find the value of critical clearing angle, assuming the voltage behind the transient reactance to be 1.2 p.u. and the voltage at the infinite bus as 1.0 p.u. **(12 Marks)**

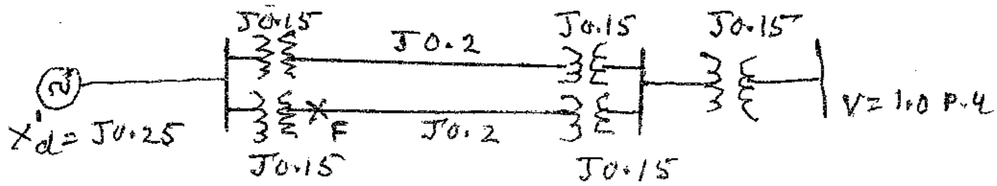

Fig.7(b)

8 Write notes on the following:

a. Selection of circuit breakers.
b. Methods used to improve transient stability.
c. Reactances of synchronous machine.
d. Representation of synchronous machine. **(20 Marks)**

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USN | | | | | | | | | |

NEW SCHEME

Sixth Semester B.E. Degree Examination, July 2007
Electrical and Electronics Engineering
Power System Analysis and Stability

Time: 3 hrs.] [Max. Marks:100

Note : *1. Answer any FIVE full questions.*
2. Assume missing data, if any, suitably.

1 a. What are single line diagrams? Hence explain the procedure of finding reactance diagrams, by listing all the assumptions involved. **(08 Marks)**

b. State the rule of inspection for finding bus admittance matrix, giving the expression for the matrix elements. Also indicate the situations where in this rule is not applicable. **(04 Marks)**

c. Draw the per unit reactance diagram for the system of fig.1(c). Choose a base of 30 MVA, 13.8 kV in the generator circuit. Assume the line reactance to be 80 Ohms. **(08 Marks)**

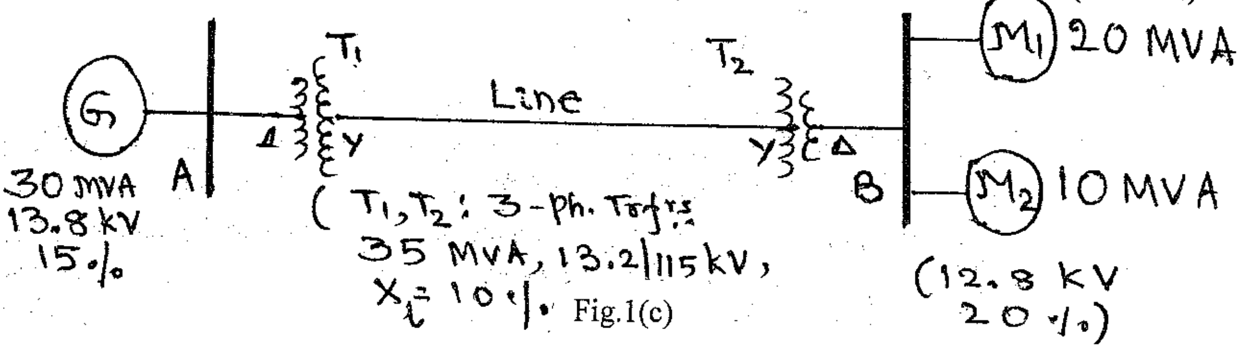

Fig.1(c)

2 a. State the advantages of per unit system of computations. **(04 Marks)**

b. Explain why with reference to a synchronous machine, $X_d'' < X_d' < X_d$, with usual notations. **(08 Marks)**

c. For the circuit on fault as shown in fig.2(c), with the source voltage, $V(t) = \sqrt{2}(11000)\text{Sin}(314t)$, determine the expression for the short circuit current, i(t). If now the voltage equation is changed to; $V(t) = \sqrt{2}(11000)\text{Sin}(314t + 20^0)$, determine the maximum momentary current i_{mm} and the instance of its occurrence. **(08 Marks)**

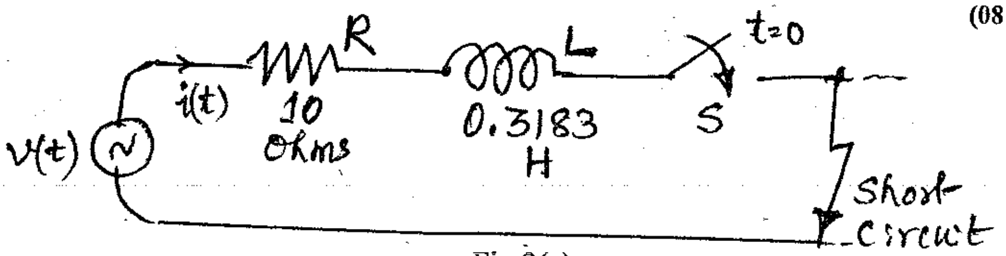

Fig.2(c)

3 a. Write a note on selection of current brakers. **(06 Marks)**

b. Show that the symmetrical component transformation is power invariant. **(06 Marks)**

c. A synchronous generator rated 500 kVA, 440 V, 10% subtransient reactance is supplying a passive load of 400 kW at 0.8 pf(lag). Calculate the initial symmetrical rms current for a 3-phase fault at the generator terminals. **(08 Marks)**

4 a. Write brief note on: i) The significance of the operator "a", ii) Establishing the relation: $I_\eta = 3I_{ao}$ with usual notations. **(08 Marks)**

b. Given the sequence components of phase voltages: $V_{b_1} = 100$, $V_{c_2} = j10$ and $V_{a_0} = 10$; determine the phase voltages, V_a, V_b and V_c. **(06 Marks)**

c. The phase – A of a three-phase circuit is open and the currents are $I_B = I$, $I_C = -I$ units. Find the symmetrical components of all the three-phase currents, I_A, I_B and I_C, in terms of I. **(06 Marks)**

5 a. Define sequence impedances and sequence networks. Hence indicate the zero sequence diagrams for various primary and secondary winding connection of a three-phase transformer. **(06 Marks)**

b. Obtain the sequence diagrams for the system of fig.5(b). (X: Midpoint of line). **(06 Marks)**

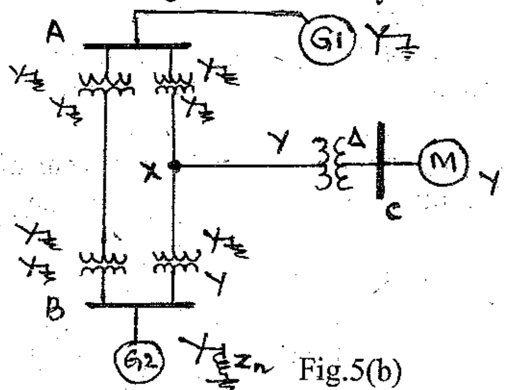

Fig.5(b)

c. Four generators are connected to a common bus-bar, to run in parallel. Each generator has: $Z_1 = j0.6$ pu, $Z_2 = j0.4$ pu; $Z_0 = j0.15$ pu and $\epsilon_{a_1} = 0.95\angle 0$ pu. If a line-to-ground fault occurs at a point on the line just after the bus-bar, determine the: i) Sequence impedances of fault current ii) Fault current, $I_{f(LG)}$ iii) Sequence currents in each machine. **(08 Marks)**

6 a. Derive an expression for the fault current in terms of the sequence impedances and hence arrive at the connection diagram of sequence networks for a L-L fault at the terminals of a star connected generator. **(08 Marks)**

b. Write a note on the significance of unsymmetrical fault analysis by symmetrical component transformations. **(04 Marks)**

c. A 3-phase generator with constant internal voltages gave the fault current values of: 1.4 kA for a line-to-line fault and 2.2 kA for a line-to-ground fault. If $\epsilon_a = 2$ kV, $X_1 = 2$ Ohms, determine the reactances X_2 and X_0. **(08 Marks)**

7 a. Write a note on open conductor faults in power systems. **(08 Marks)**

b. Distinguish between steady state stability and transient stability and the corresponding power limits. **(06 Marks)**

c. A 60 Hz turbo alternator is rated 500 MVA, 22 kV. It is star connected and solidly grounded. It is operating at rated voltage and at no load. Its reactances are as under: $X_1'' = X_2 = 0.15$ pu; $X_0 = 0.05$ pu. Find the ratio of sub transient line current for a LG fault to that for a symmetrical 3-phase fault. **(06 Marks)**

8 a. Write briefly on:
i) Power angle equation ii) Equal area criterion of stability. **(12 Marks)**

b. An a.c. generator is delivering 50% of maximum power to an infinite bus. Due to a sudden short circuit, the reactance between generator and infinite bus increases to 300% of the value before fault. The maximum power that can be delivered after clearance of fault is 70% of the original maximum value. Calculate the critical clearing angle to maintain the stability of the system. **(08 Marks)**

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EE61

Sixth Semester B.E. Degree Examination, June / July 08
Power System Analysis and Stability

Time: 3 hrs.

Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. Define per unit quantity. Mention the advantages of per unit system. **(06 Marks)**

b. Show that the per unit reactance is same for both HV and LV side of a transformer. **(06 Marks)**

c. Draw the reactance diagram of the power system shown in fig.1(c). Use a base of 100 MVA, 220 kV in line circuit to mark per unit quantities on the reactance diagram.

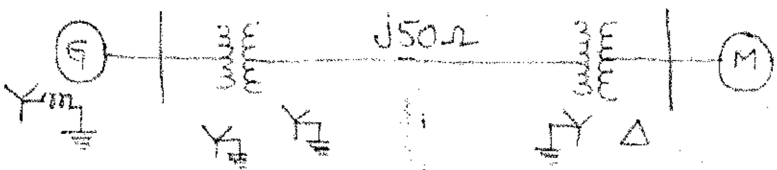

Fig. 1(c)

The ratings are : Generator (G) : 40 MVA, 25kV, $X'' = 20\%$;

Motor (M) : 50MVA, 11kV, $X'' = 30\%$;

Y – Y transformer : 40 MVA, 33/220kV, X = 15% ;

Y - Δ transformer : 30 MVA, 11Δ/220 Y kV, X = 15%. **(08 Marks)**

2 a. Define symmetrical components. Resolve an unbalanced 3-phase voltages of a power system into symmetrical components and also in vice versa. **(10 Marks)**

b. Prove that a balanced three phase voltages of a power system will have only positive sequence components. **(04 Marks)**

c. In a 3-phase, 3 wire system with phase sequence abc, the current in two of the lines are $I_a = 10\angle 30^0$ A, $I_b = 20\angle -60^0$ A. Find the symmetrical components of the three line currents. **(06 Marks)**

3 a. Derive an expression for 3-phase power in terms of symmetrical components. **(10 Marks)**

b. Show that the zero sequence impedance of the neutral impedance (Z_n) is equal to thrice the neutral impedance ($3\ Z_n$). **(10 Marks)**

4 a. Following data gives the series impedance and line charging admittance in p.u. on a common base for each line of a four bus power system. Obtain Y_{BUS} for the system. **(12 Marks)**

BUS Code	Line impedance (P.U)	Line charging admittance P.U.
1 - 2	0.2 + j 0.8	j 0.02
2 – 3	0.3 + j 0.9	j 0.03
2 – 4	0.25 + j 1.0	j 0.04
3 – 4	0.20 + j 0.80	j 0.02
1 – 3	0.10 + j 0.40	j 0.01

b. Draw the single phase zero sequence equivalent circuits of three phase transformer bank along with connection diagrams and symbols for the following types of corrections.

i) ⏚Y Y ii) ⏚Y Δ iii) ⏚Y Y⏚ iv) Y Δ **(08 Marks)**

5 a. A double line to ground fault occurs at the terminals of an unloaded generator. Derive the expression for the fault currents. Draw the connection of sequence network. **(10 Marks)**

b. A salient pole generator without dampers is rated 20MVA, 13.8kV and has a direct – axis sub transient reactance of 0.25 P.U. The negative and zero sequence reactances are 0.35P.U, and 0.10 P.U respectively. The neutral of the generator is solidly grounded. Determine the sub transient current in the generator and the line – to – line voltage for sub transient conditions when a single line to ground fault occurs at the terminals of the generator when operating under no load at rated voltage. Neglect resistance. **(10 Marks)**

6 a. Obtain the interconnection of sequence networks for the following types of open conductor faults on power systems. i) ONE conductor open ii) TWO conductors open. **(08 Marks)**

b. A synchronous motor is receiving 60MW at 0.8p.f . lag at 6kV. A line to ground fault occurs at the mid point "F" of the transmission line through a fault impedance of 0.05Ω as shown in fig.6(b). Determine the fault current. Choose base values of 100MVA and 11kV on generator circuit. **(12 Marks)**

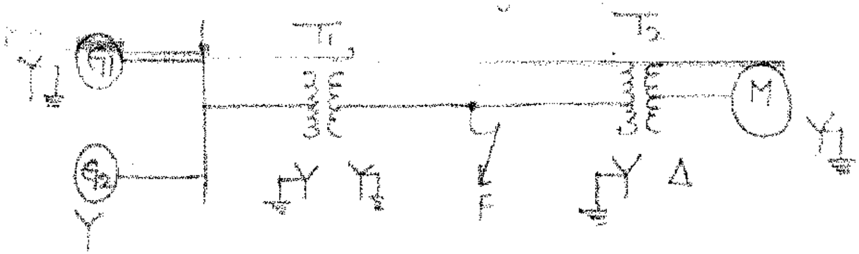

Fig.6(b)

G_1, G_2 : 100MVA, 11kV, $X_1 = 0.2$ P.U ; $X_2 = 0.1$ P.U ; $X_0 = 0.1$ P.U.

M : 160 MVA, 6.3kV, $X_1 = X_2 = 0.3$ P.U ; $X_0 = 0.1$ P.U.

T_1 : 180 MVA, 11.5Y | 115Y, X = 0.1 P.U

T_2 : 170 MVA, 110Y | 6.6Δ, X = 0.1 P.U.

Transmission line : $X_1 = X_2 = 30\ \Omega$; $X_0 = 60\Omega$.

7 a. Explain the following terms as applicable to a power system. **(08 Marks)**
i) Stability ii) Steady state stability iii) Dynamic stability iv) Transient stability.

b. Derive the swing equation of a synchronous machine with usual notation. Mention the uses of swing equation. **(12 Marks)**

8 Write short notes on any four of the following :

a. Selection of circuit breakers.
b. Methods of improving transient stability.
c. Equal area criterion of transient stability.
d. Formation of Y_{BUS} by inspection method.
e. Inertia constants M and H. **(20 Marks)**

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06EE61

Sixth Semester B.E. Degree Examination, June-July 2009

Power System Analysis and Stability

me: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

a. Define per unit quantity. Mention the advantage of p.u. system. **(04 Marks)**

b. Show that per unit impedance of a transformer remains same whether it is referred to H. V. or L. V. side. **(04 Marks)**

c. A 15 MVA, .5 kV, 3 - ϕ generator has a sub transient reactance of 20%. It is connected through a Δ – Y transformer to a high voltage transmission line having a total series reactance of 70Ω. The load end of the line has Y – Y step down transformer. Both transformer banks are composed of single phase transformers connected for 3 – phase operation. Each of three transformers composing 3 - ϕ bank is rated 6667 kV, 10/100 kV, with a reactance of 10%. The load represented as impedance, is drawing 10 MVA at 12.5 kV and 0.8 p.f. lagging. Draw the single line diagram of the power network. Choose a base of 10 MVA, 12.5 kV in the load circuit and determine the reactance diagram. Determine also the voltage at the terminals of the generator. **(12 Marks)**

a. For the network shown in Fig. Q2(a), form the admittance matrix. The values are marked in p.u. **(08 Marks)**

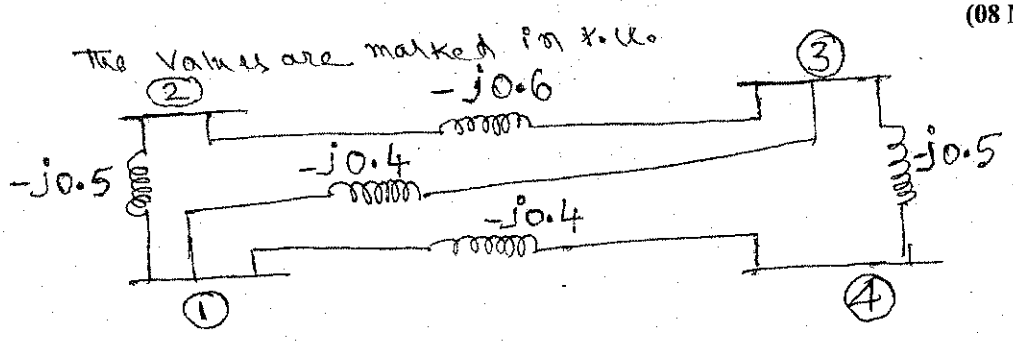

Fig. Q2(a)

b. A 25 MVA, 13.2 kV synchronous generator is connected to a synchronous motor of same rating. Both have a sub-transient reactance of 15%. The line connecting them has reactance of 10% on the machine base. The motor is drawing a power of 18 MW at 0.8 pf lead, at 12.9 kV, when a short circuit occurs at its terminals. Find the sub-transient currents in the motor, generator and at fault points. **(12 Marks)**

a. Determine the symmetrical components of the asymmetrical phasors below :

$$V3\varphi = \begin{vmatrix} 100 & \underline{|250} \\ 50 & \underline{|-1550} \\ 40 & \underline{|100} \end{vmatrix}.$$ **(06 Marks)**

b. Show that the symmetrical component tr. sformation is power invariant. **(06 Marks)**

c. Discuss on the phase shift of currents or voltages in Y – Δ transformers. **(08 Marks)**

4 a. Obtain an expression for the fault current for a LG fault at the terminals of an unloaded generator, through a fault impedance Z_f. **(08 Marks)**

b. The single line diagram is shown in Fig. Q4(b). Draw the sequence networks. Mark all reactances in p.u. on a base of 50 MVA, 13.8 kV in circuit of generator 1. The neutrals of generators 1 and 3 are connected to ground through reactors having a reactance of 6% on the machine base. Each generator has a negative sequence reactance of 20% and zero sequence reactance of 5% on its own rating. The zero sequence reactance of the transmission lines are 2.5 times the positive sequence reactance. The other ratings are given below.
G_1 : 20 MVA, 13.8 kV, X''_d = 0.2 p.u. G_2 = 30 MVA, 20 kV, X''_d = 0.2 p.u G_3 = 30 MVA, 20 kV, X''_d= 0.2 p.u, T_1 : 25 MVA, 220 Y /13.8 Δ kV, T_2 = 1 - ϕ units, each rated 10 MVA, 132/22 kV, X = 10%, T_3 = 35 MVA, 220 Y/22 Y kV. X = 10%. **(12 Marks)**

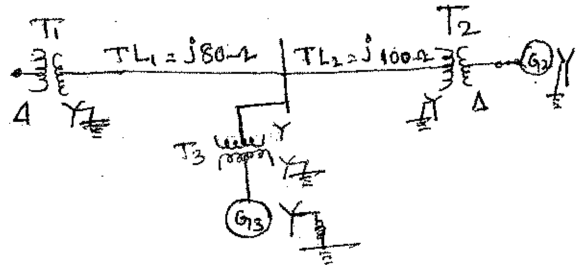

Fig. Q4(b)

5 A 30 MVA, 13.8 kV, 3 - ϕ alternator has, a sub transient reactance of 15% and negative and zero sequence reactance of 15% and 5% respectively. The alternator supplies two motors over a transmission line having transformers at both ends as shown in Fig. Q5. On the one line diagram. The motors have rated in puts of 20 MVA, and 10 MVA. Both 12.5 kV with 20% sub-transient reactance and negative and zero sequence reactions are 20% and 5% respectively. Current limiting reactors of 2.0 Ω each are in the neutral, of the alternator and the larger motor. The 3 - ϕ transformers are both rated 35 MVA, 13.2 Δ – 115 Y kV, with leakage reactance of 10%. Series reactance of the line is 80 Ω. The zero sequence reactance of the line is 200 Ω. Determine the fault current when i) L – G fault ii) L – L fault and iii) L-L-G fault takes place at point P. assume V_{pf} = kV. **(20 Marks)**

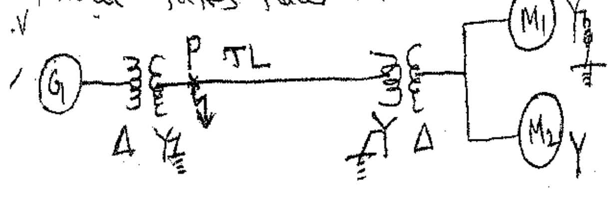

Fig. Q5

6 a. A Double line to ground fault occurs at the terminals of an loaded generator. Derive an expression for the fault currents, draw the connection of sequence networks. **(10 Marks)**

b. Derive expression for fault current if L – L fault occurs through a fault impedance Z_f in a power system. Show the connections of sequence networks to represent the fault. **(10 Marks)**

7 a. Derive the power angle equation of a salient pole synchronous machine connected to an infinite bus. Draw the power angle curve. **(10 Marks)**

b. A turbo generator, 6 pole 50 Hz of capacity 80 MW working at 0.8 pf has an inertia of 10 MJ/ MVA. I) Calculate the energy stored in the later at synchronous speed
ii)Find rotor acceleration if the mechanical input is suddenly raised to 75 MW for an electrical load of 60 MW.
iii)Supposing the above acceleration is maintained for a duration of 6 cycles, calculate the change in torque angle and the rotor speed at the end of 6 cycles. **(10 Marks)**

8 Write short notes on : a. Methods of improving transient stability b. Selection of circuit breakers c. Solution of swing equation d. Series type of faults. **(20 Marks)**

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06EE61

Sixth Semester B.E. Degree Examination, Dec.09/Jan.10
Power System Analysis and Stability

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

Part – A

1 a. Show that the per unit impedance of a transformer is the same, whether computed from primary or secondary side, so long as the voltage bases on the two sides are in the ratio of transformation. **(08 Marks)**

b. The one line diagram of an unloaded power system is shown in figure Q1 (b). Choose a base of 30 MVA, 6.9 KV in G1 circuit. Draw the reactance diagram. If a fault involving ground occurs at point 'E', determine the Thevenin's reactance of the network viewed from E.

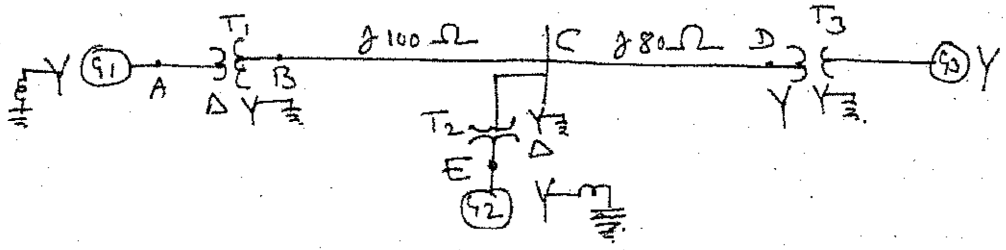

Fig. Q1 (b)

G_1 : 20 MVA, 6.9 KV, $x'' = 0.15$ pu
G_2 : 10 MVA, 6.9 KV, $x'' = 0.15$ pu
G_3 : 30 MVA, 13.8 KV, $x'' = 0.15$ pu
T_1 : 25 MVA, 6.9 Δ/115 Y KV, $x = 0.1$ pu
T_2 : 12.5 MVA, 6.9 Δ/115 Y KV, $x = 0.1$ pu
T_3 : single phase units each rated 10 MVA, 7.5/75 KV, $x = 0.1$ pu **(12 Marks)**

2 a. With the help of oscillograms of short circuit current, of a synchronous generator, operating on no load, distinguish between sub-transient, transient and steady state periods. Also write the corresponding equivalent circuits, which are used in computing x''_d , x'_d and x_d. **(08 Marks)**

b. A synchronous generator and motor are rated 30 MVA, 13.2 KV and both have $x''_d = 20\%$. The line connecting them has a reactance of 10% on the base of the machine ratings. The motor is drawing 20 MW at 0.8 PF leading at a T.V. of 12.8 KV, when a symmetrical 3 phase fault occurs at the motor terminals. Find the sub-transient current in the generator motor and fault using the internal voltages of the machines. Verify the value of sub-transient current in the fault. **(12 Marks)**

3 a. Show that the symmetrical component transformation is power invariant. **(08 Marks)**

b. The current flowing to the Δ connected load through line 'a' is 10 A. Line 'c' is open. Find the symmetrical components of the line currents. **(04 Marks)**

c. Three identical resistors are star connected. The magnitude of the voltages at the terminals are V_{ab} = 2000 V, V_{bc} = 2900 V and V_{ca} = 2500 V. Determine the sequence components of the line to neutral voltages of phase 'a'. **(08 Marks)**

4 a. The sequence components of the line to neutral voltages of a 3 phase system are,
$Va_1 = 100\underline{|0^\circ}V$, $Vb_2 = (10 - J15)V$, $Vc_0 = J15V$
Determine line to neutral voltages. **(08 Marks)**

b. Show that +ve and –ve sequence voltages and currents undergo a phase shift, in passing through Y-Δ transformer and the phases shift is dependent on labeling of terminals. **(12 Marks)**

Part – B

5 a. A single L-G fault occurs on phase 'a' of an unloaded synchronous generator. Derive an expression for the fault current and for the post fault line to line voltages. Also prove that the equivalent circuit under fault conditions comprises of +ve, -ve and zero sequence networks in series. **(10 Marks)**

b. Two 11 KV, 30 MVA, 3 phase star connected synchronous generators operate in parallel, x_1, x_2 and x_3 of each being 0.2, 0.18 and 0.12 pu respectively. The star point of one of the generators is isolated and that of the other is earthed through a 3 Ω resistor. A single LG fault occurs at the terminals of one of the generators. Calculate the fault current, current in grounding resistor and voltage across the grounding resistor. **(10 Marks)**

6 a. A synchronous generator has its neutral grounded through a reactance x_n. Zero sequence reactance of the generator is larger than the +ve and –ve sequence reactances.

i) Show that if the neutral is grounded solidly, single LG fault current would be more than the 3 phase fault current.

ii) Obtain expression for x_n such that single LG fault current is less than the 3 phase fault current. **(10 Marks)**

b. A synchronous generator has an O.C. voltage of 1.1 pu behind its transient reactance. The magnitude of fault currents for different types of faults at its terminals are 3 phase fault 5 pu, LL fault 4.55 pu and LG fault 3.3 pu. Calculate per unit values of the sequence reactances of the generator. **(10 Marks)**

7 a. Define inertia constants M and H for a synchronous machine. How are they related to each other? **(04 Marks)**

b. What are the assumptions made in stability studies? How do you justify them? **(06 Marks)**

c. A synchronous motor is receiving 25% of the power, it is capable of receiving from an infinite bus. If the load on the motor is doubled, calculate the maximum value of δ during the swing of the motor around the new equilibrium position. **(10 Marks)**

8 a. Distinguish between steady state stability limit and transient stability limit. **(04 Marks)**

b. Explain point-by-point solution of the swing equation. **(06 Marks)**

c. An ac generator is delivering 50% of the maximum power which it can deliver to an infinite bus. Due to a sudden short circuit, the reactance between the generator and infinite bus increases to 325% of the value before the fault. The maximum power that can be delivered after clearance of the fault is 75% of the original maximum value. Determine the critical clearing angle, to maintain the stability of the system. **(10 Marks)**

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