Power System Analysis and Stability VTU CBCS Question Paper Set 2018

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10EE61

Sixth Semester B.E. Degree Examination, June/July 2015
Power System Analysis and Stability

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Missing data, if any, may be suitably assumed.

PART – A

1 a. Define per unit quantity. Mention the advantages of per unit system. **(05 Marks)**

b. Show that the per unit reactance is same for both HV and LV side of a two winding transformer. **(05 Marks)**

c. The one line diagram of an unloaded generator is shown in Fig. Q1(c). Draw the PV reactance diagram. Choose a base of 50 MVA, 13.8 KV in the circuit of generator G_1.
The ratings are an follows :

G_1 : 20 MVA, 13.8 KV, x″ = 20% T_1 : 25 MVA, 13.8/220 KV, x = 10%
G_2 : 30 MVA, 18 KV, x″ = 20% T_2 : 30 MVA, 220/18 KV, x = 10%
G_3 : 30 MVA, 20 KV, x″ = 20% T_3 : 35 MVA, 220/22 KV, x = 10%. **(10 Marks)**

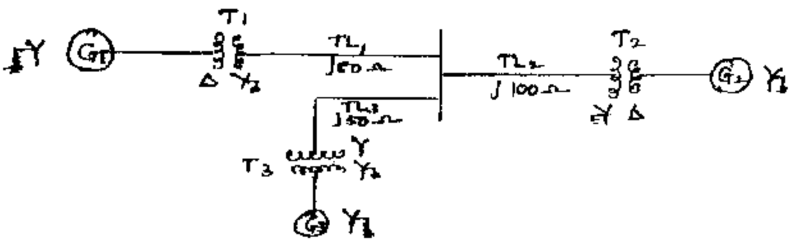


Fig.Q1(c)

2 a. With the oscillogram of the short circuit current of a synchronous machine, define sub transient reactance, transient and steady state reactances. **(10 Marks)**

b. For the system shown in the Fig. Q2(b). The ratings of the various components are :

G : 25 MVA, 12.4 KV, $x_d'' = 10\%$
M : 20 MVA, 3.8 KV, $x_d'' = 15\%$
T_1 : 25 MVA, 11/33 KV, x = 8%
T_2 : 25 MVA, 33/3.3 KV x = 10%
T line : 20 Ω reactance

The system is loaded such that, the motor is drawing 15 MW at 0.9 pf. leading, the motor terminal voltage being 3.1 KV. Find the sub-transient fault current at motor side. Choose 25 MVA as base power, 11 KV in the generator circuit. **(10 Marks)**

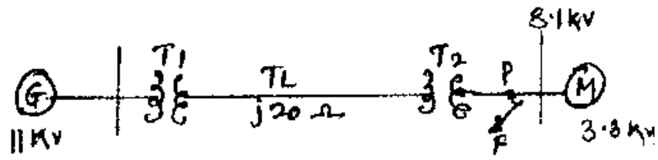


Fig.2Q(b)

3 a. Express symmetrical components interms of unbalanced phasors. **(06 Marks)**

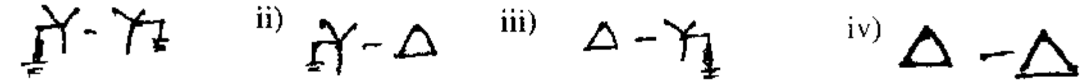
b. Obtain an expression for the three – phase complex power in terms of sequence components. **(08 Marks)**

c. In a 3 phase, 3 wire system the line currents are I_a = 100 ∠0°A and I_b = 100 ∠–100°A. Determine the sequence components of a line currents. **(06 Marks)**

4 a. What are sequence impedances and sequence networks? **(04 Marks)**

b. Draw the zero sequence impedance network of a transformer for the following connection :

i) ii) iii) iv)



(08 Marks)

c. Draw the positive, negative and zero sequence network for the power system shown in Fig. Q4(c).

Choose a base of 50 MVA, 220 KV in the 50 Ω Transmission lines and marks all reactance's in PV. The ratings of the generator and transformers are :

G_1 : 25 MVA, 11 KV, x″ = 20%

G_2 : 25 MVA, 11 KV, x″ = 20%

3ϕ transformers (each) : 20 MVA, 11/220 KV, x = 15%

The negative sequence reactance of each synchronous machine is equal to the sub-transient reactance. The zero sequence reactance of a each machine is 8%. Assume that the zero sequence reactances of lines are 250% of their positive sequence reactances. **(08 Marks)**

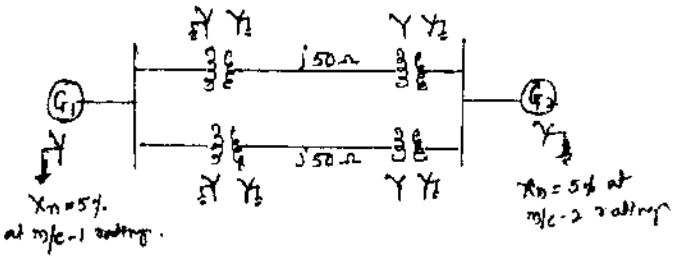


Fig. Q4(c)

PART – B

5 a. Define 'FAULTS' in power system. Give the classification of faults. **(04 Marks)**

b. Derive an expression for fault current, when single line to ground (SLG) fault occurs on an unloaded generator. **(08 Marks)**

c. A three phase generator with an open circuit voltage of 400 V is subjected to an SLG fault through a fault impedance of j2 Ω. Determine the fault current, if Z_1 = j4Ω, Z_2 = j2Ω and Z_0 = j1Ω. Repeat the problem for LL fault. **(08 Marks)**

6 a. Derive expression for fault current if line-line-ground (LLG) fault occurs through fault impedance Z_f in power system. Show the connection of sequence networks to represent the fault. **(10 Marks)**

b. Derive expression for fault currents for i) one conductor open fault ii) tow conductor open fault and draw the sequence network diagrams. **(10 Marks)**

7 a. Define stability pertaining to a power system and classify the different types of stability. **(04 Marks)**

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

c. A 2 pole, 50 Hz, 11 KV turbo alternator has a rating of 100 MW, 0.85 p.f. lagging. The rotor has a moment of inertia of 10000 kg-m^2. Calculate H and M. **(06 Marks)**

8 Write short notes on :

a. Swing equation

b. Steady state and transient stability

c. Equal area criterion for transient stability

d. Analysis of 3 ϕ IM with one line open. **(20 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2016
Power System Analysis and Stability

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Show that per unit impedance of two winding transformer will remain same referred to primary as well as secondary. **(06 Marks)**

b. List the advantages of per unit system. **(04 Marks)**

c. A 300 MVA, 20 KV, 3 phase generator has subtransient reactance of 20%. The generator supplies two synchronous motors through a 64 km transmission line having transformers at both ends as shown in Fig. Q1(c), T_1 is a 3 phase transformer and T_2 is composed of 3 single phase transformers of rating 100 MVA each, 127/13.2 KV, 10% reactance. Series reactance of transmission line is 0.5 ohm/km. Draw the reactance diagram with all reactances marked in per unit. Select generator rating as base values. **(10 Marks)**

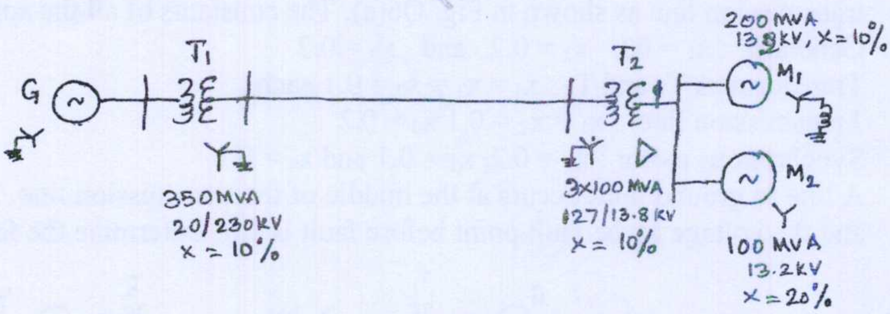

Fig. Q1(c)

2 a. A sudden three phase short circuit takes place at the terminals of an unloaded three phase alternator. Discuss briefly on different reactance's that are met with assuming that the damper windings are provided at the pole faces of the alternator. **(08 Marks)**

b. A synchronous generator and motor are rated 30 MVA, 13.2 KV and both have subtransient reactances of 20%. The line connecting them has a reactance of 10% on the base of the machine ratings. The motor is drawing 20MW at 0.8 power factor leading and a terminal voltage of 12.8 KV when a symmetrical three phase fault occurs at the motor terminals. Find the subtransient current in the generator, motor and the fault by using internal voltages of the machines. **(12 Marks)**

3 a. The phase voltages of a three phase system are $V_a = 100\angle 0$, $V_b = 33\angle -100$, $V_c = 38\angle 176.5$ all in volts. Compute the symmetrical components of voltages. **(06 Marks)**

b. Obtain the relationship between line and phase sequence components of voltages in star connection. Give the relevant phasor diagrams. **(08 Marks)**

c. Obtain an expression for power interms of sequence components of line to neutral voltages and line currents. **(06 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

4 a. A delta connected resistive load is connected across a balanced three phase supply of 400 V as shown in Fig.Q4(a). Find the symmetrical components of line currents and phase currents. **(08 Marks)**

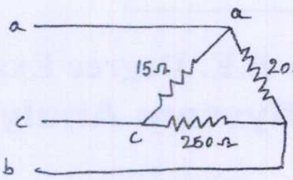

Fig. Q4(a)

b. Show that in symmetrical systems, currents of a given sequence produce voltage drops of the same sequence. **(06 Marks)**

c. Explain measurement of negative sequence impedance of synchronous generator. **(06 Marks)**

PART – B

5 a. For a double line to ground fault on an unloaded generator, derive the equation for the fault current and draw the interconnected sequence network. **(10 Marks)**

b. A 400V, star connected, neutral grounded three phase generator is subjected to various types of faults. The fault currents for various types of faults are:
i) Three phase, 120 ampere ii) Line to line, 150 amp iii) line to ground, 250 amp. If the resistances are neglected, determine the three sequence impedances and fault current for a double line to ground fault. **(10 Marks)**

6 a. An alternator is connected to a synchronous motor through two transformers and a transmission line as shown in Fig. Q6(a). The constants of all the apparatus in p.u are :
Generator : $x_1 = 03$, $x_2 = 0.2$ and $x_0 = 0.2$
Transformers T_1 and T_2 : $x_1 = x_2 = x_0 = 0.1$ each
Transmission line : $x_1 = x_2 = 0.1$ $x_0 = 0.2$
Synchronous motor : $x_1 = 0.2$, $x_2 = 0.1$ and $x_0 = 0.1$
A line to ground fault occurs at the middle of the transmission line. The system is on no load and the voltage at the fault point before fault is 1.0. Determine the fault currents. **(12 Marks)**

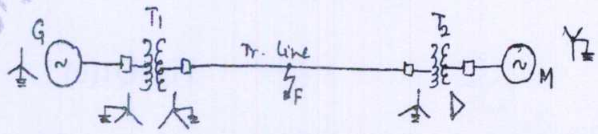

Fig. Q6(a)

b. Explain open conductor faults in power systems. **(08 Marks)**

7 a. Define the following :
i) Steady state stability
ii) Transient stability
iii) Steady state stability limit
iv) Transient stability limit. **(08 Marks)**

b. Derive swing equations with usual notations. **(06 Marks)**

c. Explain equal area criterion concept, when a power system is subjected to sudden increase in load. **(06 Marks)**

8 a. Analyse the operations of three phase induction motor when one line gets opened. Derive the torque and output power equations. **(10 Marks)**

b. A 400V, 6 pole, 50 Hz, 3 phase induction motor with $R_s = R_r = 0.5\Omega$ and $x_s = x_r = 2\ \Omega$ runs at a slip at 0.06. When are line gets open? Determine the power output and torque developed. **(10 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2017
Power System Analysis and Stability

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. What is meant by one line diagram of a power system? With typical example explain its significance. **(08 Marks)**

b. Draw the per unit reactance diagram for the power system shown in Fig Q1(b) on 20MVA, 6.6kV base in the generator 1 circuit.

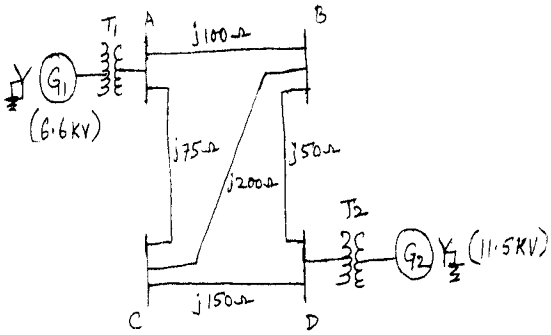

Fig Q1(b)

The rating of the various components.
Gen 1 : 10MVA, 6.6KV, X″ = 0.1 Pu
Gen 2 : 20MVA, 11.5KV, X″ = 0.1 Pu
Transformer 1 : 10MVA, 3phase, 6.6/115KV, X = 0.15Pu
Transformer 2 : 3 1-ϕ units each rated 10MVA, 7.5/75KV, X = 0.1 Pu **(12 Marks)**

2 a. What are symmetrical components and their significance and obtain the equations for their average power and reactive power in terms of symmetrical components. **(08 Marks)**

b. The voltage at the terminals of a three phase balanced load consisting of three (10 + j8)Ω connected in star are $V_{ab} = 100\angle 0^\circ$ V, $V_{bc} = 90\angle 240^\circ$ V and $V_{ca} = 94\angle 120^\circ$ V. Find the power consumed in load using symmetrical components. **(12 Marks)**

3 a. What are sequence impedances and sequence network? Draw the single phase zero sequence networks for the transformers connected in different configuration. **(08 Marks)**

b. A 25MVA, 11KV, 3-ϕ generator has a sub transient reactance of 20%. The generator supplies two motors over a transmission line with transformers at both sides as shown in the one line diagram of Fig Q3(b). The motors have rated inputs of 15MVA and 7.5MVA both at 10KV with 25% sub transient reactance. The three phase transformers are both rated 30MVA, 10.8/121KV, connection Δ-Y with leakage reactance of 10% each. The series reactance of the line is 100Ω. Draw the positive, negative and zero sequence network of the system with all reactances marked in Pu. Assume that the negative sequence reactance of each machine is equal to the sub transient reactance. Select the generator rating as the base in the generator circuit. Assume the zero sequence reactance for the generator and motors are 0.6Pu each. Current limiting reactors of 2.5Ω each are connected in the neutrals of the generator and motors. The zero sequence reactance of the transmission line is 300Ω. **(12 Marks)**

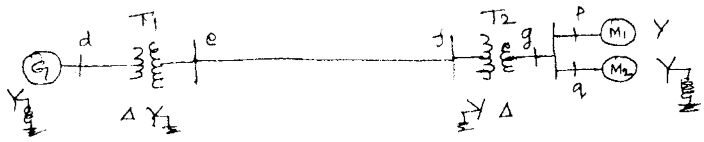

Fig Q3(b)

4 Determine the fault MVA, if a fault takes place at 'F' in the diagram shown in Fig Q4. The P.u values of reactance are given with 100 MVA as base. **(20 Marks)**

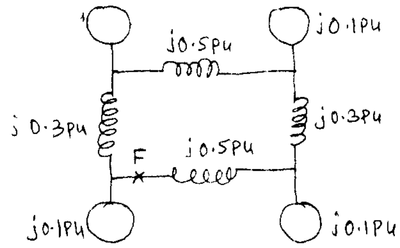

Fig Q4

PART – B

5 a. What are the different types of unsymmetrical faults and explain in brief their frequency of occurrence? **(08 Marks)**

b. 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. **(12 Marks)**

6 a. For one conductor open fault, derive expressions for currents and show the connections of sequence network to represent the fault. **(08 Marks)**

b. A synchronous motor is receiving 10MW of power at 0.8 p.f lag at 6kV. An LG fault takes place at the middle point of the transmission line as shown in Fig Q6(b). Find the fault current. The rating of the generator motor and transformer are as under. **(12 Marks)**

Generator	:	20MVA, 11KV, $X_1 = 0.2$Pu, $X_2 = 0.1$Pu, $X_0 = 0.1$Pu
Transformer T_1	:	18MVA, 11.5Y/34.5Y KV, X = 0.1 Pu
Transmission line	:	$X_1 = X_2 = 5\Omega$, $X_0 = 10\Omega$
Transformer T_2	:	15MVA, 6.9Y/34.5Y KV, X = 0.1 Pu
Motor	:	15MVA, 6.9KV, $X_1 = 0.2$Pu, $X_2 = X_0 = 0.1$Pu

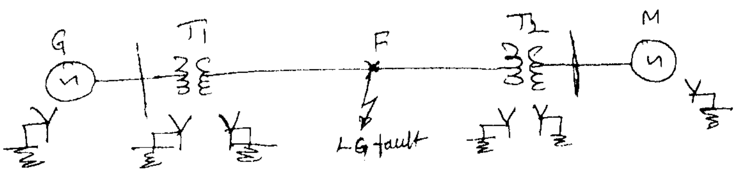

Fig Q6(b)

7 a. Define stability as applied to power system studies and distinguish between i) Steady state stability and ii) Transient stability. **(08 Marks)**

b. The transfer reactance between a generator an infinite bus bar operating at 200KV under various conditions on interconnection are

Pre fault	:	150Ω per phase
During fault	:	400Ω per phase
Past fault	:	200 Ω per phase

If the fault is cleared when the rotor has advanced 60° electrical from the prefault position, determine the maximum load that could be transferred without loss of stability. **(12 Marks)**

8 a. Explain clearly the methods of improving transient stability. **(08 Marks)**

b. Explain the effect of unbalanced voltage on the performance of an induction motor. Find the expressions for power developed and Torque developed under such operating conditions. **(12 Marks)**

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Sixth Semester B.E. Degree Examination, Dec.2014/Jan.2015
Power System Analysis and Stability

Time: 3 hrs. Max. Marks:100

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

PART - A

1 a. Show that the per – unit impedance of a transformer is the same when referred to either its primary side or secondary side. **(04 Marks)**

b. Explain the procedure of drawing per - unit reactance diagram from single line diagram. **(04 Marks)**

c. The one line diagram of an unloaded power system is shown in fig. Q1(c). Reactances of the three sections of transmission line are shown on the diagram. Draw the P.U. impedance diagram. Choose a base of 50MVA, 13.8 kV in the circuit of generator G_1.

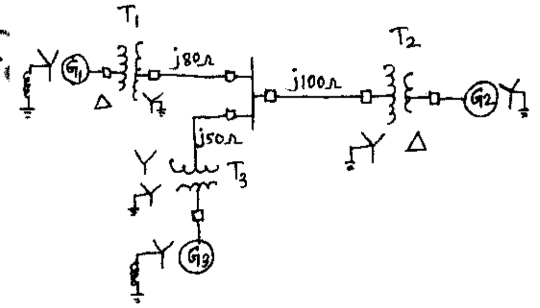


Fig.Q1(c)

The generators and transformers are rated as follows :

G_1 : 20MVA, 13.8kV , X" = 0.2 P.U ; G_2 : 30 MVA, 18kV, X" = 0.2 P.U ;

G_3 : 30MVA, 20 kV, X" = 0.2 P.U ; T_1: 25MVA, 220Y/13.8Δ kV, X = 10%

T_2 : Three single phase units each rated 10MVA, 127/18 kV, X = 10%.

T_3 : 35 MVA, 220Y/22 Y kV, X = 10%. **(12 Marks)**

2 a. With the help of oscillogram of short – circuit current of a synchronous generator , operating at no load, distinguish between sub – transient, transient and steady state reactances. Also show that $X_d'' < X_d' < X_d$ with equivalent circuit diagrams. **(08 Marks)**

b. For the radial network shown in fig. Q2(b), a three phase fault occurs at F'. determine the fault current. Choose a base of 100MVA for the entire system and a base kV of 33kV in the overhead line. **(12 Marks)**

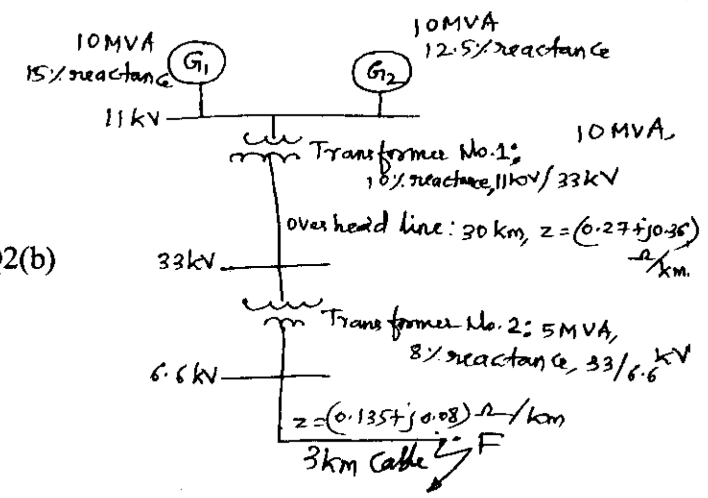


Fig.Q2(b)

3 a. Derive an expression for symmetrical components in terms of phase voltages. **(06 Marks)**

b. In a 3 – φ system, $I_{a_1} = 100\underline{|30^0}$ A , $I_{b_2} = 40\underline{|90^0}$ A and $I_{c_0} = 10\ \underline{|-30^0}$ A. Find the line currents. **(06 Marks)**

c. Explain the phase – shift of symmetrical components in Y - Δ transformers considering voltage relations with vector diagrams. **(08 Marks)**

4 a. What are sequence impedances and sequence networks? Draw the zero sequence networks for different combinations of 3 – φ transformer bank. **(08 Marks)**

b. Draw the positive, negative and zero sequence networks for the power system shown in fig. Q4(b).

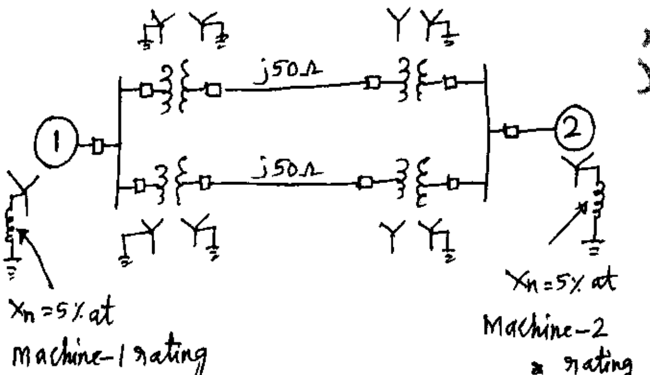


Fig.Q4(b)

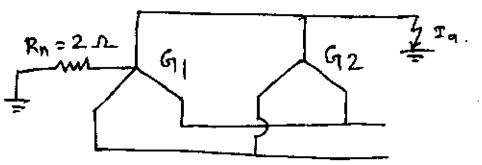
Choose a base of 50MVA, 220kV in the 50Ω transmission lines and mark all reactances in P.U. The ratings of the generators and transformers are :
Generator 1 : 25MVA, 11kV, X" = 20% ; Generator 2 : 25 MVA, 11kV, X" = 20%.
Three phase transformers (each) : 20MVA, 11Y / 220Y kV, X = 15%. The negative sequence reactance of each synchronous machine is equal to the subtransient reactance. The zero sequence reactance of each machine is 8%. Assume that the zero sequence reactance of lines are 250% of their positive sequence reactances. **(12 Marks)**

PART - B

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

b. Two 11kV, 20MVA, 3 – φ, star connected generators operate in parallel as shown in fig. Q5(b), the positive, negative and zero sequence reactances of each being respectively, j0.18, j0.15, j0.10PU. The star point of one of the generators is isolated and that of the other is earthed through a 2 Ω resistor. A single line to ground fault occurs at the terminals of one of the generators. Estimate i) the fault current ii) current in the grounding resistor iii) the voltage across grounding resistor. **(10 Marks)**

Fig.Q5(b)



6 a. Derive an expression for fault current if L – L fault occurs through a fault impedance Z_f in a power system. Show the connections of sequence network to represent the fault. **(08 Marks)**

b. A 3 – φ, 50 MVA, 11kV, star connected neutral solidly grounded generator operating on no load at rated voltage gave the following sustained fault current for the faults specified.
Three phase fault = 2000A ; Line – to – line fault = 1800A ; Line – to – ground fault = 2200A. Determine the three sequence reactances in ohms and P.U. **(12 Marks)**

7 a. Define : i) steady state stability ii) Transient stability. **(04 Marks)**

b. Derive the swing equation of a synchronous machine with usual notations. **(08 Marks)**

c. A 50Hz, 4 pole turbo generator rated 100MVA, 11kV has an inertia constant of 8MJ/MVA.

i) Find the stored energy in the rotor at synchronous speed.

ii) If the mechanical input is suddenly raised to 80MW for an electrical load of 50MW, find rotor acceleration, neglecting mechanical and electrical losses.

iii) If the acceleration calculated in part (ii) is maintained for 10 cycles, find the change in torque angle and rotor speed in revolutions per minute at the end of this period. **(08 Marks)**

8 Write short notes on the following :

a. Methods of improving transient stability.

b. Series type faults.

c. Equal area criteria.

d. Un – balanced operation of 3 – Q induction motor. **(20 Marks)**

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Sixth Semester B.E. Degree Examination, Dec.2015/Jan.2016

Power System Analysis and Stability

Time: 3 hrs. Max. Marks: 100

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

PART – A

1 a. What are the advantages of per unit system? **(04 Marks)**

b. Draw the per phase basis modeling of synchronous machine, transformer, transmission Line and Load. **(04 Marks)**

c. A 300MVA, 20KV three – phase generator has a subtransient reactance of 20%. The generator supplies a number of synchronous motors over a 64km transmission line having transformers of Fig. Q1 (c). The motors, all rated 13.2KV, are represented by just two equivalent motors. The neutral of one motor M_1 is grounded through reactance. The neutral of second motor M_2 is not connected to ground. Rated inputs to the motors are 200MVa and 100MVA for M_1 and M_2 respectively. For both motors X″ = 20% the three – phase transformer T_1 is rated 350MVA, 230/20KV with leakage reactance of 10%. Transformer T_2 is composed of three single phase transformers each rated 127/13.2KV, 100MVA with leakage reactance of 10%. Series reactance of transmission line is 0.5 Ω/km. Draw the reactance diagram with all reactance's marked in per unit. Select the generator rating as base in the generator circuit. **(12 Marks)**

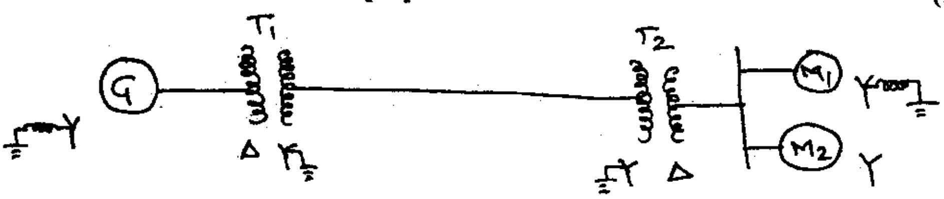


Fig. Q1 (c)

2 a. With the help of waveform at the time of three phase symmetrical fault on 3 – ϕ synchronous generator, define synchronous reactances. (steady state, transient and sub – transient condition). **(06 Marks)**

b. A synchronous generator and synchronous motor each rated 25MVA, 11KV having 15% subtransient reactance are connected through transformers and line as shown in Fig Q2 (a). The transformers are rated 25MVA, 11/66KV and 66/11KV with leakage reactance of 10% each. The line has a reactance of 10% on base of 25MVA, 66KV. The motor is drawing 15MW at 0.8 power factor leading and terminal voltage of 106 KV when a symmetrical three phase fault occurs at the motor terminals. Find subtransient current in the generator motor and fault.

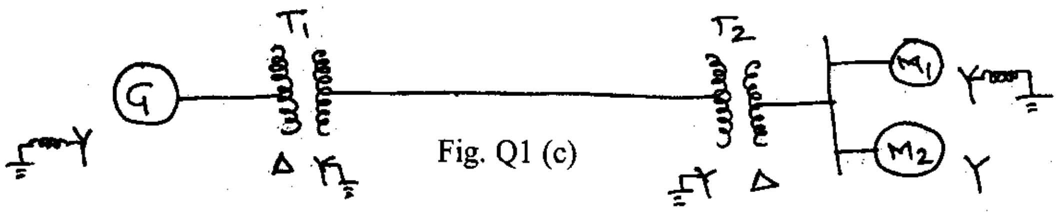


Fig. Q1 (c)

Choose base of 25MVA, 11KV in the generator circuit. **(14 Marks)**

3 a. Derive phase currents of unbalanced system in terms of sequence currents. **(05 Marks)**

b. Develop an expression for three phase power in terms of symmetrical components. **(05 Marks)**

c. A delta connected balanced resistive load is connected across an unbalance three phase supply as shown in Fig Q3 (c). With currents in lines A and B specified, find the symmetrical components of line currents. **(10 Marks)**

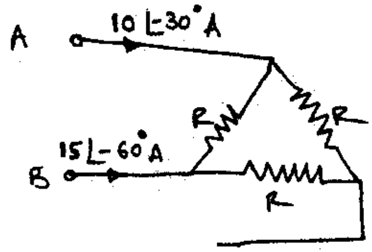
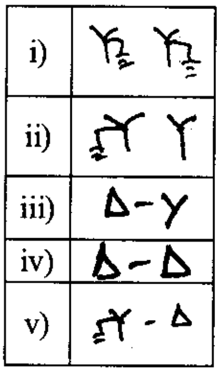


Fig. Q3 (c)

4 a. Draw zero sequence equivalent circuits of three phase transformer banks, together with diagram of connections and the symbols for one line diagram for following configuration. **(06 Marks)**



b. A 25MVA, 11KV, three phase generator has a subtransient reactance of 20%. The generator supplies two motors over a transmission line with transformers at both ends as shown in the one – line diagram of Fig Q4 (b). the motors have rated inputs of 15 and 7.5MVA, both 10KV with 25% subtransient reactance. The three phase transformers are both rated 30MVA, 10.8/121KV, connection Δ - Y with leakage reactance of 10% each. The series reactance of the line is 100ohms. Assume zero sequence reactances for the generator and motors of 0.06 pu – current limiting reactors of 2.5 ohms each are connected in the neutral of the generator and motor No.2. The zero sequence reactance of the transmission line is 300 ohms. Choose base of 25MVA and 11KV in generator circuit. Assume that negative sequence reactance of each machine is equal to its subtransient reactance. Draw the Positive, Negative and zero sequence networks of the system with reactances marked in per unit.

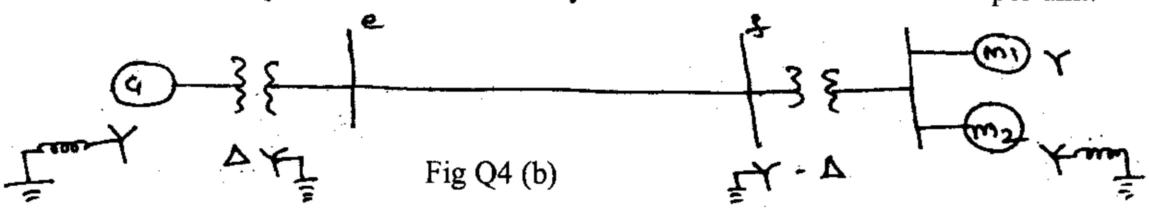


Fig Q4 (b)

(14 Marks)

PART – B

5 a. Derive the equation for the fault current when single – line – to – ground fault occurs on an unloaded generator. **(08 Marks)**

b. A salient – pole generator without dampers is rated 20MVA, 13.8KV and has direct axis subtransient reactance of 0.25 pu. The negatively, 0.35 and 0.10 per unit. The neutral of the generator is solidly grounded. Determine the subtransient current in the generator for subtransient conditions when a double link – to – ground fault occurs at the terminals of the generator. Assume that the generator is unloaded and operating at rated voltage when fault occurs Neglect resistance. **(12 Marks)**

6 a. Write a note on open conductor faults in power system. **(08 Marks)**

b. A two bus system is shown below the generators G_1 and G_2 are identical Neglecting pre – fault current and losses, calculate the fault current for L-G fault at bus – 1. All pu reactances are based on common base values.

Reactances of components (on common box)

Equipment	+ve sequence reactance (pu)	-ve sequence reactance (pu)	Zero sequence reactance (pu)
a_1	0.17	0.14	0.05
a_2	0.17	0.14	0.05
T_1	0.11	0.1[illegible]	0.11
T_2	0.11	0.11	0.11
Line	0.22	0.22	0.60

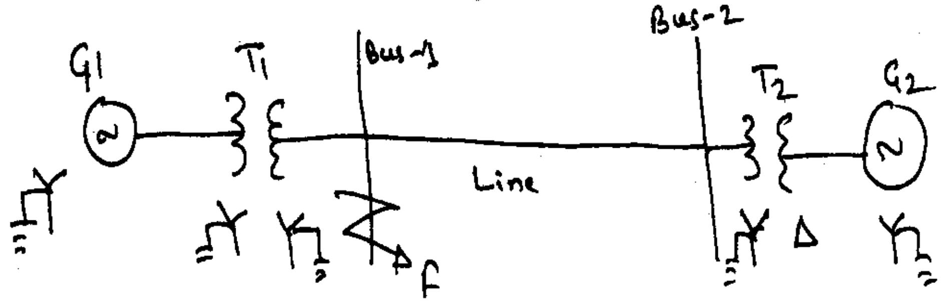


Fig Q6 (b)

(12 Marks)

7 a. Derive the swing equation

$$M\frac{d^2\delta}{dt^2} = P_a = P_s - P_e$$ **(06 Marks)**

b. Derive expression for critical clearing angle. **(08 Marks)**

c. A 50Hz, four pole turbo – generator rated 100MVA, 11KV has an inertia Constance of 2 MJ/MVA.

i) Find the stored energy in the rotor at synchronous speed.

ii) If mechanical input is suddenly raised to 80mw for an electrical load of 50mw, find rotor acceleration, neglecting mechanical and electrical losses. **(06 Marks)**

8 Write short notes on :

a. Operation of 3 – Q Induction motor with one line open.

b. Steady state and transient stability.

c. Line – Line fault on unloaded generator.

d. Concept of equal area criterion. **(20 Marks)**

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Sixth Semester B.E. Degree Examination, Dec.2016/Jan.2017
Power System Analysis & Stability

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Assume missing data, if any suitably.

PART – A

1 a. What is per unit quantity? Mention the advantages of per unit quantities. **(06 Marks)**

b. What is single line diagram? Explain how to obtain impedance and reactance diagrams from single line diagram of a power system. **(06 Marks)**

c. Draw a per unit reactance diagram for the power system shown in Fig.Q1(c).

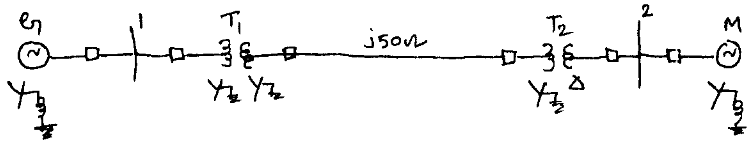

Fig.Q1(c)

Use a base of 100 MVA, 220 kV in 50Ω line.
The ratings of the generator, motor and transformers are
Generator : 40 MVA, 25 kV, X″ = 20%
Motor : 50 MVA, 11 kV, X″ = 30%
Y – Y Transformer : 40 MVA, 33Y / 220Y kV, X = 15%
Y – Δ Transformer : 30 MVA, 11Δ / 220Y kV, X = 15% **(08 Marks)**

2 a. Discuss the different types of faults in Power system. **(04 Marks)**

b. Explain clearly, how circuit breakers are rated? **(08 Marks)**

c. A generator is connected to a synchronous motor through transformer. Reduced to a common base, the per unit subtransient reactances of generator and motor are 0.15 and 0. 35 pu respectively. The leakage reactance of the transformer is 0.1 pu. A 3ϕ short circuit fault occurs at terminals of the motor when terminal voltage of generator is 0.9 pu and output current of generator is 1 pu at 0.8 p.f. leading. Find the subtransient current in the fault, generator and motor. **(08 Marks)**

3 a. What are symmetrical components? How they are useful in solution of power system? **(04 Marks)**

b. Derive an expression for the 3ϕ complex power in terms of symmetrical components. **(08 Marks)**

c. A delta connected balanced resistive load is connected across a balanced 3ϕ supply as shown in Fig.Q3(c). With currents in lines A & B specified. Find the symmetrical components of the currents. **(08 Marks)**

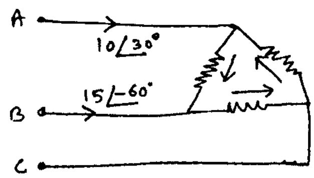

Fig.Q3(c)

4 a. With the help of relevant vector diagrams for voltages and currents establish the phase-shift of symmetrical components in Y-Δ transformer. **(12 Marks)**

b. What are sequence impedances and sequence network? Draw the zero sequence networks for different combinations of 3ϕ transformer bank. **(08 Marks)**

PART – B

5 a. Mention the different types of faults occurring in electrical power system and their probability of occurrence. **(04 Marks)**

b. A double line to ground fault occurs at the terminals of an unloaded generator. Derive an expression for the fault currents. Also draw connection of sequence networks. **(10 Marks)**

c. Discuss briefly about the open-conductor faults in power system. **(06 Marks)**

6 A single line to ground fault occurs at mid point F of transmission line in power system shown in Fig.Q6(a). Determine the fault current in pu and in amperes from generator if the system were on no load and at a voltage of 100 kV at the fault point.

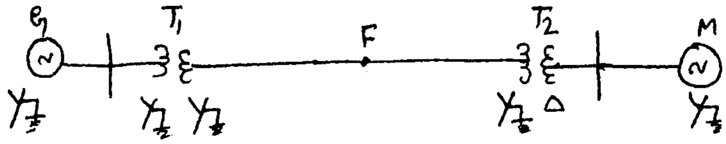

Fig.Q6(a)

The ratings are

Generator : 11.5 kV, 500 MVA, $X_1 = 0.3$ pu, $X_2 = 0.2$ pu, $X_0 = 0.1$ pu

Transformer – T_1 : 11/110 kV, 45 MVA, X = 0.1 pu

Transformer – T_2 : Consists of 3 single phase units each rated 20 MVA, 66/6.6 kV, X = 10%

Motor : 6 kV, 55 MVA, $X_1 = 0.4$ pu, $X_2 = 0.3$ pu, $X_0 = 0.2$ pu

Line : $X_1 = X_2 = 48.5\ \Omega$, $X_0 = 90\ \Omega$

Choose a base of 60 MVA, 110 kV in transmission line. **(20 Marks)**

7 a. Differentiate between steady state and transient state stability of a power system. Can these stability limits have multiple values? **(06 Marks)**

b. Derive swing equation with usual notation. **(08 Marks)**

c. Explain the equal area criterion for investigating the stability of power system. **(06 Marks)**

8 a. An ac 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 500% of the value before fault. The maximum power that can be delivered after clearance of the fault is 75% of the original value. Calculate the critical clearing angle to maintain the stability of the system. **(08 Marks)**

b. Explain the analysis of 3ϕ induction motor with one line open. **(06 Marks)**

c. Explain the analysis of 3ϕ induction motor with unbalanced voltage. **(06 Marks)**

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10EE61

Sixth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Power System Analysis and Stability

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Define per unit quantity? What are the advantages of PU systems? **(06 Marks)**

b. Show that the per unit impedance of a transformer is the same irrespective of the side of which it is calculated. **(04 Marks)**

c. Obtain the impedance diagram of the electrical power system shown in the Fig.Q1(c). The one line diagram of an unloaded generator is as shown in the Fig.Q1(c) choose a base of 50MVA, 13.8KV in the circuit of generator G_1.

The generators and transformers ratings are :

G_1 : 20MVA, 13.8KV, x″ = 0.2p.u

G_2 : 30MVA, 18 KV, x″ = 0.2p.u

G_2 : 30MVA, 20 KV, x″ = 0.2p.u

T_1 : 25MVA, 220KV, Y/13.8ΔKV, x = 10%

T_2 : three single phase units each rated 10MVA, 127/18 KV, x = 10%

T_3 : 35MVA, 220KV Y/22KV, x = 10%. **(10 Marks)**

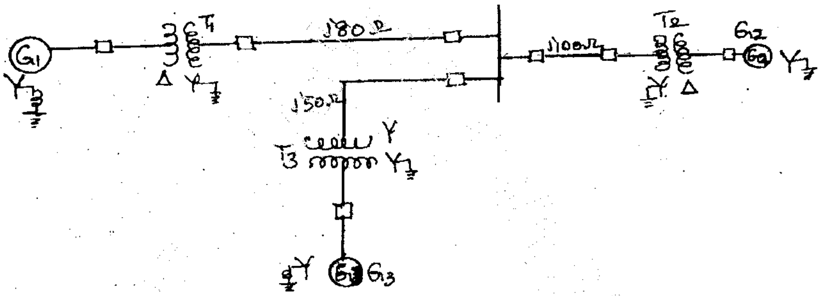

Fig.Q1(c)

2 a. With the oscillogram of the short circuit current of synchronous machine, define direct axis synchoronous reactance, transient and subtransient reactance. **(08 Marks)**

b. A 3-phase, 5MVA, 6.6KV alternator with a reactance of 8% connected to a feeded of series impedance of 0.12 + j0.48Ω/phase/km. The transformer is rated at 3MVA, 6.6KV/33KV and has a reactance of 5%. Determine the fault current supplied by the generator operating under no load with a voltage of 6.9KV, when a 3-phase symmetrical fault occurs at a point 15km from the feeder. **(12 Marks)**

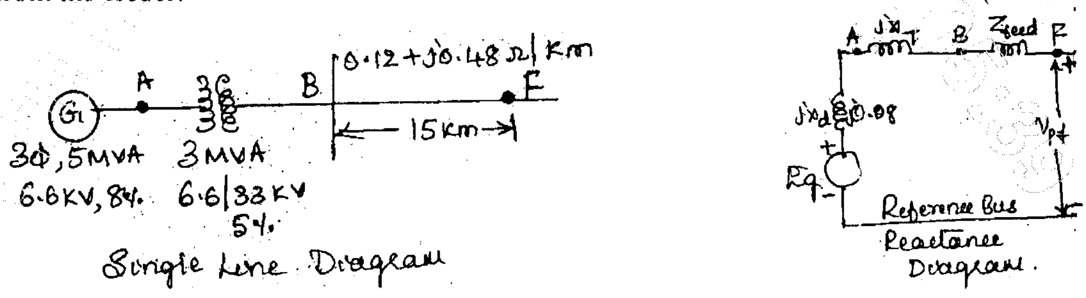

Fig.Q2(b)

3 a. Prove that a balanced set of three phase voltages will have only positive sequence components of voltages only. **(06 Marks)**

b. A balanced delta connected load is connected to a symmetrical supply. The line currents are each 10A in magnitude. If fuse in one of the lines blows out, determine the sequence components of line current. **(08 Marks)**

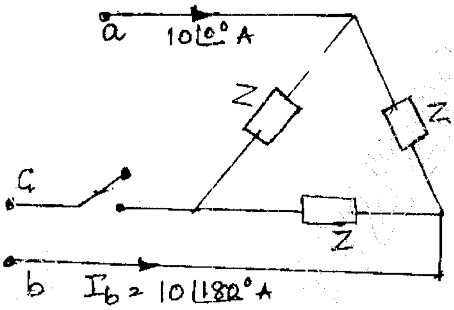

Fig.Q3(b)

c. Derive an extraction for complex power interms of the symmetrical components. **(06 Marks)**

4 a. Draw the zero sequence equivalent circuit for the following conditions of transformer. **(10 Marks)**

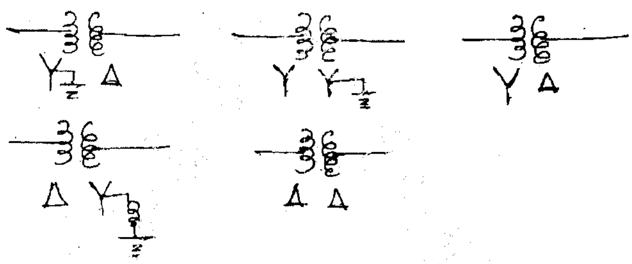

Fig.Q4(a)

b. The one-line diagram of a power system is as shown is the Fig.Q4(b). The ratings of the devices are as follows :

G_1 and G_2 : 104MVA, 11.8V, $x_1 = x_2 = 0.2$p.u, $x_0 = 0.1$p.u

T_1 and T_2 : 125MVA, 11Y – 220YKV, $x_1 = x_2 = x_0 = 0.1$p.u

T_3 and T_2 : 120MVA, 230Y – 6.9YKV, $x_1 = x_2 = x_0 = 0.12$p.u

M_1 : 175MVA, 6.6KV, $x_1 = x_2 = 0.3$p.u $x_0 = 0.15$ p .u

M_2 : 50MVA, 6.9KV, $x_1 = x_2 = 0.3$p.u $x_0 = 0.1$p.u

Transmission line reactance : $x_1 = x_2 = 30\Omega$ $x_0 = 60\Omega$.

Draw the sequence impedance diagram in p.u on a base of 200MVA, 220KV in transmission **(10 Marks)**

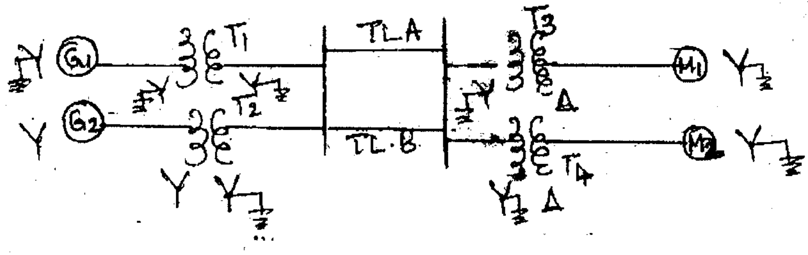

Fig.Q4(b)

PART – B

5 a. Derive an expression for fault current when an line to line (LL) fault occurs on the terminals of an unloaded generator. **(08 Marks)**

b. A synchronous motor is receiving 10MW of power at 0.8pu. lag at 6KV. An LG fault takes place at the middle point of the transmission line as shown in the Fig.Q5(b). Find the fault current. The ratings of the generator, motor and transformer are as given :

Generator	: 20MVA, 11KV, $x_1 = 0.2$p.u, $x_2 = 0.1$p.u, $x_0 = 0.1$ p.u
Transformer : T_1	: 18MVA, 11.5Y – 34.5YKV, x = 0.1p.u
Transmission line	: $x_1 = x_2 = 5\Omega$, $x_0 = 10\Omega$
Transformer T_2	: 15MVA, 6.9Y – 34.5YKV, x = 0.1p.u
Motor	: 15MVA, 6.9KV, $x_1 = 0.2$p.u, $x_2 = x_0 = 0.1$p.u.

(12 Marks)

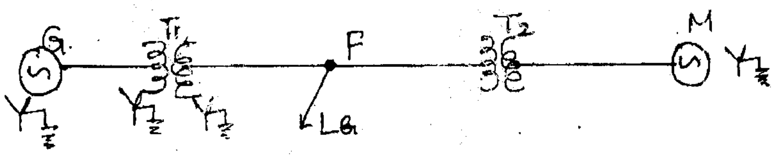

Fig.Q5(b)

6 a. Discuss "open conductor faults". **(10 Marks)**

b. Derive an expression for L–L–G fault occurs through fault impedance (z_f) in a power system. Show the inter connection of sequence networks. **(10 Marks)**

7 a. Derive the expression for swing equation. **(06 Marks)**

b. Explain equal area concept when a power system is subjected to sudden increase in load. **(06 Marks)**

c. A turbo alternator, 6-pole, 50Hz of capacity 80MW working at 0.8p.f has an inertia of 10MJ/MVA. Calculate :

i) The energy stored in the rotor at synchronous speed

ii) Find rotor acceleration if the mechanical input is suddenly raised to 75MW for an electrical load of 60MW

iii) Suppose 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. **(08 Marks)**

8 Write short notes on :

a. Power angle equation of a non salient pole synchronous machine

b. Classification of stability

c. Single phasing of 3 phase induction motor

d. Critical clearing angle and critical clearing time. **(20 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2014
Power System Analysis and Stability

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Draw the impedance diagram for the power system shown in Fig.Q1(a) and mark on it the per unit impedances calculated on a base of 50 MVA, 13 kV in the circuit of generator 1.

Power system component	Rating
Generator G_1	25 MVA, 13 kV, $X_d'' = 0.15$ PU
Generator G_2	35 MVA, 22 kV, $X_d'' = 0.12$ PU
Transformer T_1	30 MVA, 220Y/13.84 kV X = 10%
Transformer T_2	40 MVA, 220/20 kV X = 12%
Transformer T_3	Bank of 1ϕ Transformers, each rated 10 MVA, 127/18 kV X = 8%
Load, L_A	3+j1 Ω
Load, L_B	4+j2 Ω
Transmission Line TL_1	j60 Ω
Transmission Line TL_2	j90 Ω

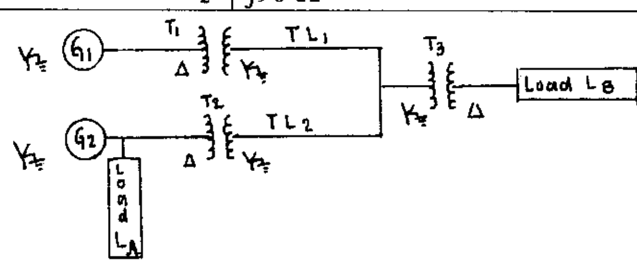


Fig.Q1(a) **(12 Marks)**

b. Write in matrix form, the node equations necessary to solve for the voltages of numbered buses as shown in Fig.Q1(b). All the impedances are marked in per unit. The emf's shown are $E_a = 1.5\angle 0°$, $E_b = 1.5\angle -36.87°$ and $E_c = 1.5\angle 0°$. **(08 Marks)**

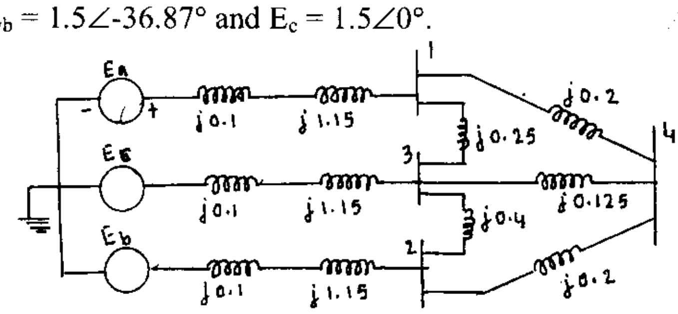


Fig.Q1(b)

2 a. Explain in detail the transients on a transmission line. **(08 Marks)**

b. For the radial network shown in Fig.Q2(a), a 3 phase fault occurs at F. Determine the fault current and line voltage at 11 kV bus under fault condition. Select a base of 100 MVA, 11 kV on generator side. **(12 Marks)**

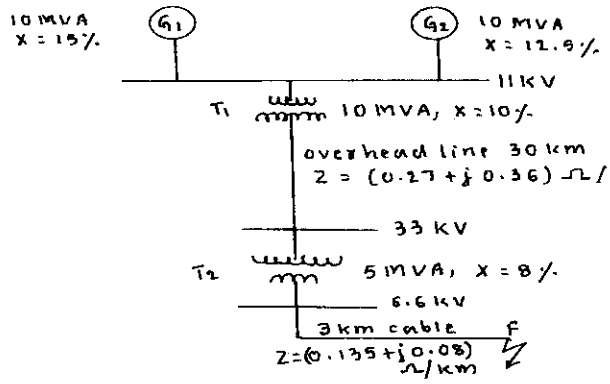


Fig.Q2(a)

3 a. Prove that a balanced set of 3-phase voltages will have only positive sequence components of voltages only. **(06 Marks)**

b. A delta connected balanced resistive load is connected across an unbalanced 3-phase supply as shown in Fig.Q3(b). With currents in lines A and B specified, find the symmetrical components of line currents. Also, find the symmetrical components of delta currents (phase currents). **(14 Marks)**

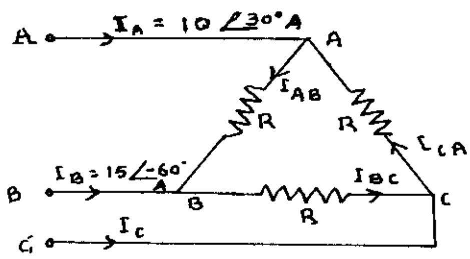
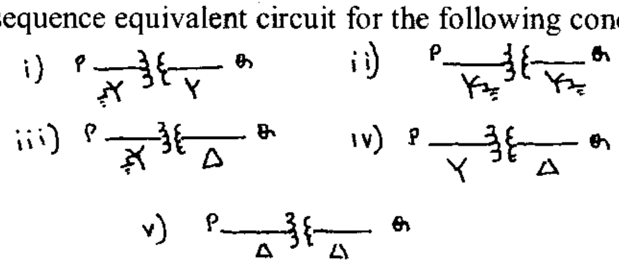


Fig.Q3(b)

4 a. Draw the zero sequence equivalent circuit for the following conditions of transformer:



(10 Marks)

b. Draw the positive, negative and zero sequence networks for the power system shown in Fig.Q4(b). Choose a base of 50 MVA, 220 kV in the 50 Ω transmission lines. Mark all the reactances in p.u. The ratings of the generators and transformers are

Gen G_1 : 25 MVA, 11 kV, X″ = 20%

Gen G_2 : 25 MVA, 11 kV, X″ = 20%

Three phase transformers (each): 20 MVA, 11Y/220Y kV, X = 15%

The negative sequence reactance of each synchronous machine is equal to its subtransient reactance. The zero sequence reactance of each machine is 8%. Assume that zero sequence reactance of lines are 250% of their positive reactances. **(10 Marks)**

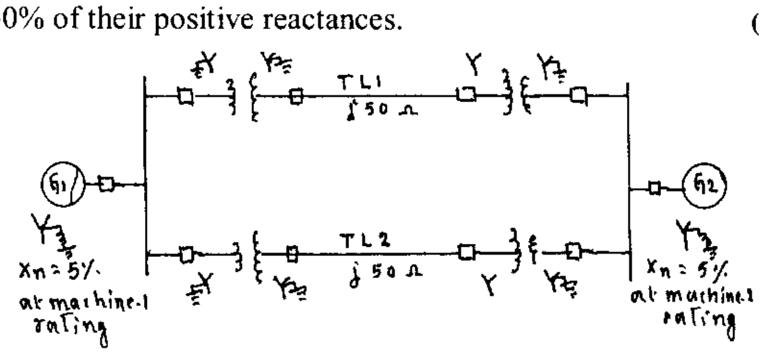


Fig.Q4(b)

PART – B

5 a. Draw the interconnected sequence networks for the following cases:
(i) L-G fault through fault impedance z_f
(ii) L-L fault through fault impedance z_f
(iii) L-L-G fault through fault impedance z_f
clearly indicating positive, negative and zero sequence impedance, symmetrical components of voltages and currents. Also, write the expressions for fault current in the above three cases. **(12 Marks)**

b. A three phase generator with line-to-line voltages of 400 V is subjected to L-L-G fault. If Z_1=j2 Ω, Z_2=j0.5 Ω and Z_0=j0.25 Ω. Determine the symmetrical components of currents and fault current. **(08 Marks)**

6 a. Derive an expression for fault current in case of line-to-ground fault on an unloaded generator. **(10 Marks)**

b. Draw the sequence networks for the system shown in Fig.Q6(b). Determine the fault current if a line-to-line fault occurs at point F. The p.u. reactances all referred to the same base are as follows. Both the generators are generating 1.0 p.u.

Component	X_0	X_1	X_2
G_1	0.05	0.30	0.20
G_2	0.03	0.25	0.15
Line-1	0.70	0.30	0.30
Line-2	0.70	0.30	0.30
T_1	0.12	0.12	0.12
T_2	0.10	0.10	0.10

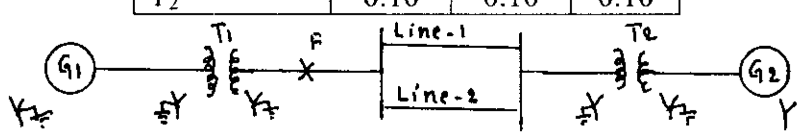


Fig.Q6(b) **(10 Marks)**

7 a. A turbo generator, 6 pole, 50 Hz of capacity 80 MW working at 0.8 p.f. has an inertia of 10 MJ/MVA.
i) Calculate the energy stored in the rotor 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 rotor speed at the end of 6 cycles. **(10 Marks)**

b. Explain the equal area criterion when there is sudden loss of one of the parallel lines. **(10 Marks)**

8 a. A load free alternator supplies 50 MW to an infinite bus, the steady state stability being 100 MW, determine if the alternator will remain stable if the input to alternator is abruptly increased by 40 MW. **(08 Marks)**

b. Write short notes on any three of the following :
i) Analysis if three phase induction motor with unbalanced voltage
ii) Methods of improving steady state stability
iii) Impedance and reactance diagram
iv) Swing curve
v) Selection of circuit breakers. **(12 Marks)**

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