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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
MAKE UP EXAMINATIONS, DECEMBER 2022

POWER SYSTEM ANALYSIS [ELE 3154]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 30 DEC 2022** **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. A 100 MVA, 33 kV 3-phase generator has a subtransient reactance of 15%. The generator is connected to the motors through a transmission line and transformers as shown Fig. Q1.A. The motors have rated inputs of 30 MVA, 20 MVA and 50 MVA at 30 kV with 20% subtransient reactance. The 3-phase transformers are rated at 110 MVA, 32 kV/110 kV with leakage reactance 8%. The line has a reactance of 50 ohms. Selecting the generator rating as the base quantities in the generator circuit, determine the base quantities in other parts of the system and draw the corresponding p.u. reactance diagram.

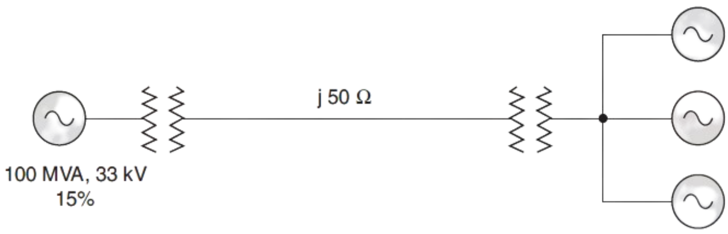

Fig Q1.A.

(04)

1B. The ratings of a three windings transformer is:

Winding 1: 300 MVA, 13.8 kV

Winding 2: 300 MVA, 199.2 kV

Winding 3: 300 MVA, 19.92 kV

The leakage reactances, from short circuit tests are:

X_{12} = 0.10 p.u. on a 300 MVA, 13.8 kV base

X_{13} = 0.16 p.u. on a 50 MVA, 13.8 kV base

X_{23} = 0.14 p.u. on a 50 MVA, 199.2 kV base

Calculate the impedances of the p.u. equivalent circuit using a base of 300 MVA and 13.8 kV for terminal 1. Draw the equivalent circuit. ***(03)***

1C. An alternator and a synchronous motor each rated for 50 MVA, 13.2 kV having subtransient reactance of 20% are connected through a transmission link of reactance 10% on the base of machine ratings. The motor acts as a load of 30 MW at 0.8 p.f. lead and terminal voltage 12.5 kV when a 3-phase fault takes place at the motor terminals. Determine the subtransient current in the alternator, the motor and the fault. Take base quantities as 50 MVA, 13.2 kV. ***(03)***

2A. A generating station having n section busbars each rated at Q kVA with x% reactance is connected on the tie-bars system through busbar reactances of b% as shown in Fig Q2.A. Determine the short-circuit kVA if a 3-phase fault F takes place on one section as shown. Determine the short-circuit kVA when n is very large.

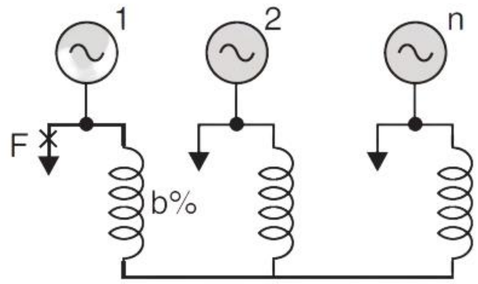

Fig Q2.A. ***(04)***

2B. A 30 MVA, 13.8 kV, 3-phase alternator has a subtransient reactance of 15% and negative and zero sequence reactances of 15% and 5% respectively. The alternator supplies two motors over a transmission line having transformers at both ends as shown in Fig Q2.B on the one-line diagram. The motors have rated inputs of 20 MVA and 10 MVA both 12.5 kV with20% subtransient reactance and negative and zero sequence reactances are 20% and 5% respectively. Current limiting reactors of 2.0 ohms each are in the neutral of the alternator and the larger motor. The 3-phase transformers are both rated 35 MVA, 13.2 Δ-115Y kV with leakage reactance of 10%. Series reactance of the line is 80 ohms. The zero sequence reactance of the line is 200 ohms. Draw the p.u. positive, negative and zero sequence network. Assume base of 30 MVA and base voltage of 13.8 kV in generator circuit.

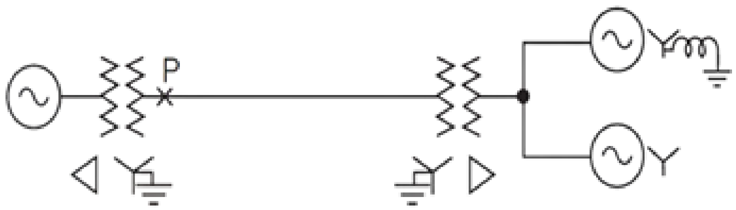

Fig Q2.B. ***(03)***

2C. The system shown in Fig Q2C is delivering 50 MVA at 11kV, 0.8 p.f lag into a bus which may be regarded as infinite. The details of the power system components are as below:

Generator : 60 MVA, 12 kV, X″ = 0.35 pu

Transformer T1, T2 (3-phase) : 80 MVA, 12/66 kV, X = 0.08 pu

Transmission line : X = 12 Ω, negligible resistance

Using internal voltage method, calculate the symmetrical current that the circuit breaker A and B will be called upon to interrupt in the event of a 3 phase fault occurring at point F (receiving end of transmission line).

Fig Q2.C. ***(03)***

3A. A 3 phase, 50 Hz, 50 MVA, 11 kV, alternator has a solidly grounded neutral with zero, positive, negative sequence reactance's of j0.05 p.u , j0.2 p.u and j0.12 p.u respectively. It is desired to limit the double line to ground fault current to that of a three phase fault current. Calculate the ohmic value of reactance that must be placed between the alternator neutral and ground. ***(03)***

3B. Draw the zero sequence networks for the power system described in Fig Q3.B.

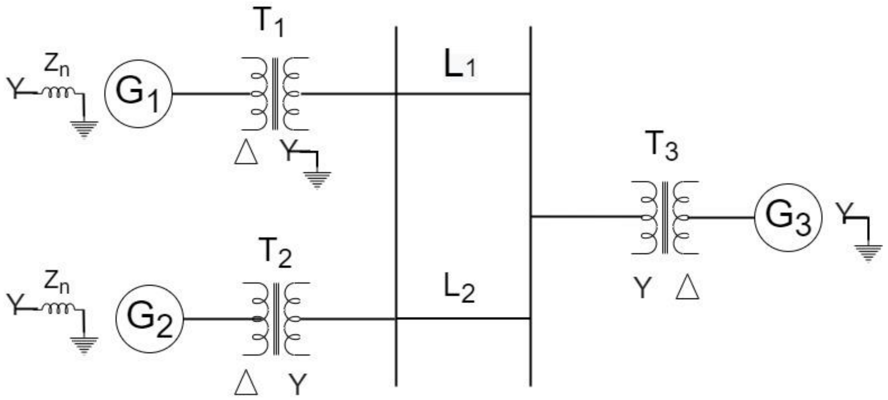

Fig Q3.B. ***(03)***

3C. The power system network shown in Fig Q3.C below is on no load condition when a double line to ground fault occurs at the generator end of the transmission line. Determine the fault current. All the reactances shown are in pu based on 100MVA, 11kV in the generator circuit. The transformers T_1 and T_2 are identical and so are the lines L_1 and L_2.

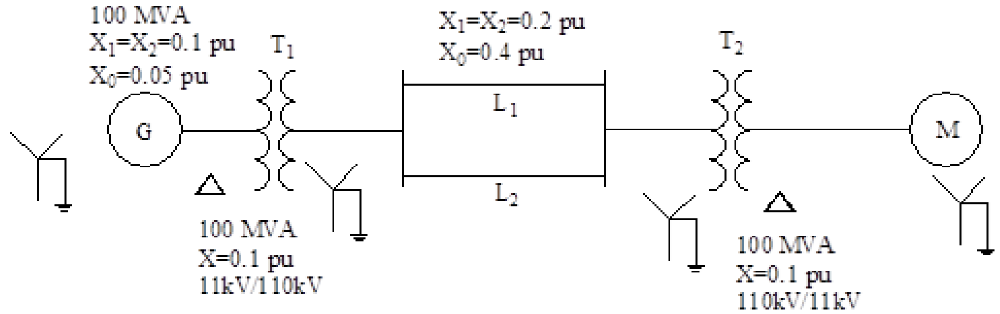

Fig Q3.C. ***(04)***

4A. The moment of inertia of a 4 pole, 100 MVA, 11kV, 3phase, 0.8 power factor, 50 Hz turbo alternator is 10000 kg.m^2. Calculate H and M. ***(03)***

4B. A 50Hz, synchronous generator capable of supplying 400MW of power is connected to a large power system and is delivering 80 MW when a three phase fault occurs at its terminals, determine,

(a) The time in which the fault must be cleared if the maximum power angle is to be -85 degree. Assume H= 7MJ/MVA on a 100MVA base.

(b) The critical clearing angle (in radian). ***(03)***

4C. The system parameters and generation & demand data of a three bus system are given in tables. The voltage at bus 2 is maintained at 1.04 p.u. The maximum and minimum reactive power limits of the generation at bus 2 are 35 and 0 MVAR respectively. Determine one iteration of the load flow solution using the Gauss-Seidel iterative method. Assume bus 1 as slack bus and acceleration factor = 1.6.

(04)

Bus code	Impedances in p.u.	Bus code	Line charging admittance y'ij/2
1-2	0.06 + j0.18	1	j0.05
1-3	0.02 + j0.06	2	j0.06
2-3	0.04 +j0.12	3	j0.06

Bus no.	Bus Voltage	Generation		Demand	
		MW	MVAR	MW	MVAR
1	1.06 +j0	-	-	0	0
2	1.04 +j0	20	-	0	0
3	-	0	0	60	25

5A. If the reactive power constraints on generator 2 is 0.2 p.u. < Q_{G2} < 0.5p.u. in Question 4C, then find voltage of bus 2 at the end of the first iteration. Assume the acceleration factor is 1.6. ***(03)***

5B. Figure Q5 B shows the single line diagram of a simple three-bus system with generation at bus 1. The magnitude of voltages at bus 1 is adjusted to 1.04 per unit. The scheduled loads at bus 2 and 3 are given in the diagram. Determine the bus admittance matrix [Ybus].

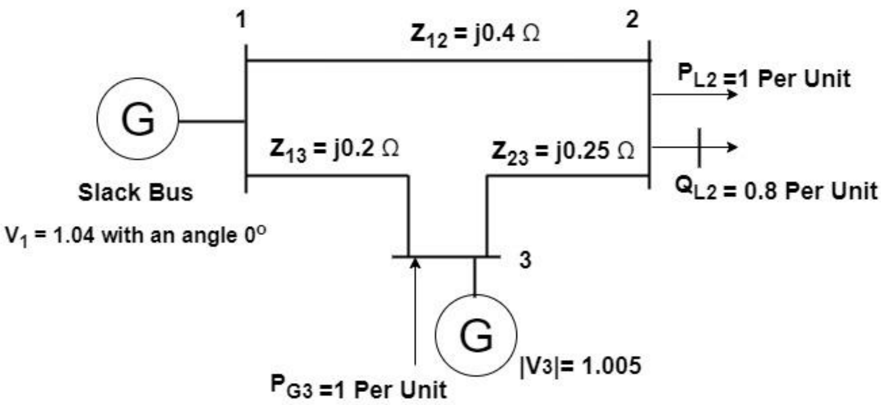

Fig Q5.B. ***(03)***

5C. Develop a diagonal elements of Jacobian matrix with the consideration of data given in Question 5B and figure Q5.B. ***(04)***