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MANIPAL INSTITUTE OF TECHNOLOGY
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(A constituent unit of MAHE, Manipal)

V/VII SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, NOVEMBER 2022

POWER SYSTEM ANALYSIS [ELE 3154]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 22 NOV 2022** **Max. Marks: 50**

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

1A. The single line diagram of a three-phase power system is shown in figure Q1.A. Select a common base of 100 MVA and 13.8 kV on the generator side. Draw per-unit impedance diagram

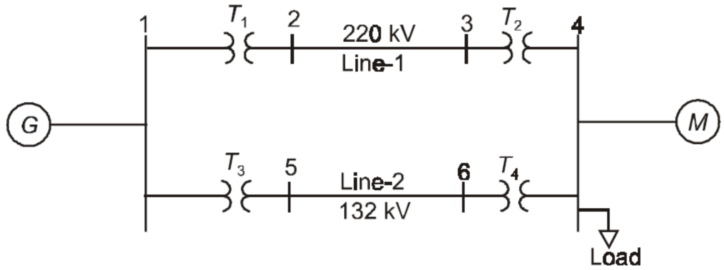

Fig Q1.A.

G: 90 MVA, 13.8 kV, X_g = 18%
T_1: 50 MVA, 13.8/220 kV, X_{T1} = 10%
T_2: 50 MVA, 220/11 kV, X_{T2} = 10%
T_3: 50 MVA, 13.8/132 kV, X_{T3} = 10%
T_4: 50 MVA, 132/11 kV, X_{T4} = 10%
M: 80 MVA, 10.45 kV, X_M = 20%
LOAD: 57 MVA, 0.8 pf (lagging) at 10.45 kV
X_{line1} = 50 OHM
X_{line2} = 70 OHM

(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. A synchronous generator and a synchronous motor each rated 20 MVA, 12.66 KV having 15% sub transient reactance are connected through transformers and a line as shown in figure Q1.C. The transformers are rated 20 MVA, 12.66/66 KV with leakage reactance of 10% each. The line has a reactance of 8% on a base of 20 MVA, 66 KV. The motor is drawing 10 MW at 0.80 leading power factor and a terminal voltage 11 KV when a symmetrical fault occurs at the motor terminals. Determine the generator and motor currents by Thevenin method. Also, determine the fault current.

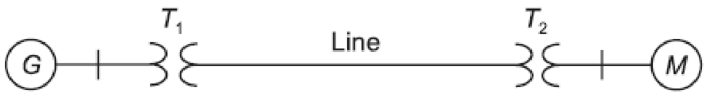

Fig Q1.C. ***(03)***

2A. Three 11.2 KV generators are interconnected as shown in figure Q2.A by a tie-bar through current limiting reactors. A three-phase feeder is supplied from the bus bar of generator A at a line voltage of 11.2 KV. Impedance of the feeder is (0.12+j0.24) ohm per phase. Compute the maximum MVA that can be fed into a symmetrical short circuit at the far end of the feeder.

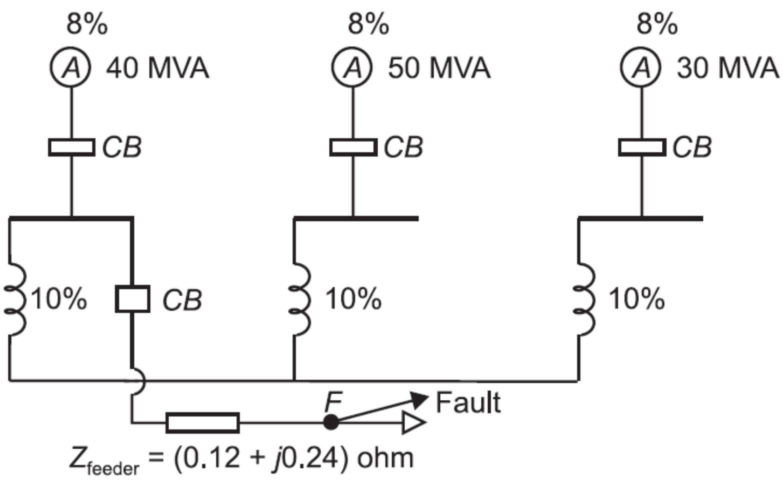

Fig Q2.A. ***(04)***

2B. A 30 MVA, 13.2 KV synchronous generator has a solidly grounded neutral. Its positive, negative and zero sequence impedances are 0.30, 0.40 and 0.05 respectively. Determine the following:

(i) What value of reactance must be placed in the generator neutral so that the fault current for a line-to-ground fault of zero fault impedance shall not exceed the rated line current?

(ii) What value of reactance must be placed in the neutral of the generator to restrict the fault current to ground to rated line current for a double line to ground fault? ***(03)***

2C. The line-to-line voltages in an unbalanced 3 phase supply are V_{ab} = 200 with an angle 0°, V_{bc} = 200 with an angle 245° and V_{ca} = 200 with an angle 105°. A star connected load with a resistance of 10 Ω per phase is connected to the supply. Determine the symmetrical components of line current. ***(03)***

3A. For the system described in Question 2C, determine the power drawn by the load using symmetrical components. Compare this power with the power estimated using phase voltages and currents. ***(03)***

3B. Draw the positive, negative and zero sequence networks for the power system described in Fig Q3.B.

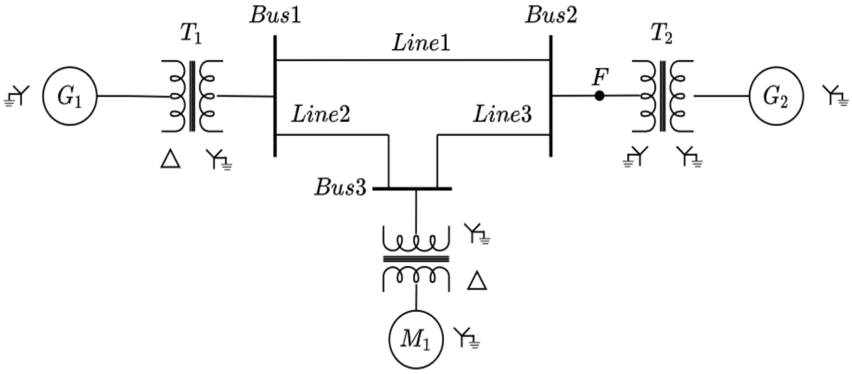

Fig Q3.B.

Unit	**Rating**	**X0 (p.u)**	**X1 (p.u)**	**X2 (p.u)**
G_1, G_2	20 MVA, 11kV	0.08	0.1	0.1
T_1, T_2, T_3	20 MVA, 11/34kV	0.1	0.1	0.1
M_1	20 MVA, 11kV	0.08	0.1	0.1
Line1	-	0.6	0.3	0.3
Line2,	-	0.3	0.15	0.15

(03)

3C. For the power system described in Question 3B, Estimate the fault currents in A, B and C Phase, if a single line to ground fault occurs on phase A. The fault occurs at point F shown in the single line diagram. Refer Fig. Q3B. ***(04)***

4A. The rotor of an alternator is subjected to an acceleration of 15 electrical rad/s^2. If this acceleration exists constantly, compute the change in rotor angle and the speed in rpm at the end of 5 cycles. H = 5 MJ/MVA. Frequency = 50 Hz. Initially the machine is running at a normal speed without any acceleration. Number of poles = 2. ***(03)***

4B. A 2220 MVA, 24 kV and 60 Hz synchronous machine is connected to an infinite bus through transformer and double circuit transmission line, as shown in figure Q4.B. The infinite bus voltage V = 1.0 per unit. The direct axis transient reactance of the machine is 0.3 per unit, the transformer reactance is 0.2 per unit and the reactance of each transmission line is 0.3 per unit, all to a base of the rating of the synchronous machine. Initially, the machine is delivering 0.8 per unit real power and reactive power is 0.074 per unit with a terminal voltage of 1.0 per unit. The inertia constant H = 5 MJ/MVA. All resistances are neglected. A temporary three-phase fault occurs at the sending end of one of the lines. When the fault is cleared, both lines are intact. Determine the critical clearing angle.

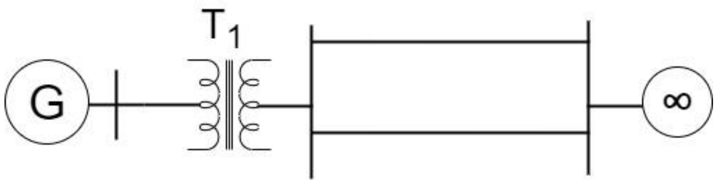

Fig Q4.B. ***(03)***

4C. The following is the system data for a load flow solution:

The line admittances:

Bus code Admittance

1-2	2–j8.0
1–3	1–j4.0
2–3	0.666–j 2.664
2–4	1–j4.0
3–4	2–j8.0

The schedule of active and reactive powers:

Bus code	P	Q	V	Remarks
1	-	-	1.06	Slack
2	0.5	0.2	1+j0.0	PQ
3	0.4	0.3	1+j0.0	PQ
4	0.3	0.1	1+j0.0	PQ

Determine the voltages at the end of first iteration using Gauss-Seidel method. Take α = 1.6. ***(04)***

5A. If in Question 4C, bus 2 is taken as a generator bus with $|V_2|$ = 1.04 and reactive power constraint is

$0.1 \le Q_2 \le 1.0$

What will be the change in the voltage of bus 2 at the end of first iteration using Gauss-Seidel method assuming an accelerating factor of 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 1.05 per unit. The scheduled loads at bus 2 and 3 are given in the diagram. Line impedances are marked in per unit on a 100 MVA base and the line charging susceptances are neglected. Determine the bus admittance matrix [Ybus].

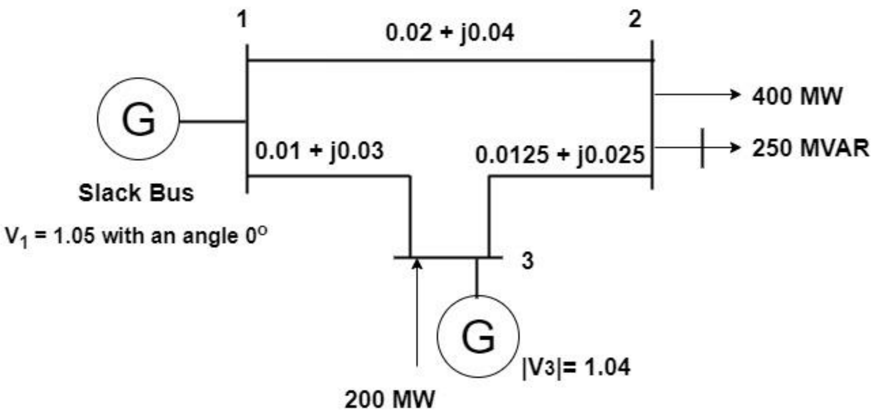

Fig Q5.B. ***(03)***

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