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

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, 2023

POWER SYSTEM ANALYSIS [ELE 3154]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 01Dec2023** **Max. Marks: 50**

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

1A. Draw the reactance diagram for the power system shown in figure 1A. Neglect the resistance. ***(02)***

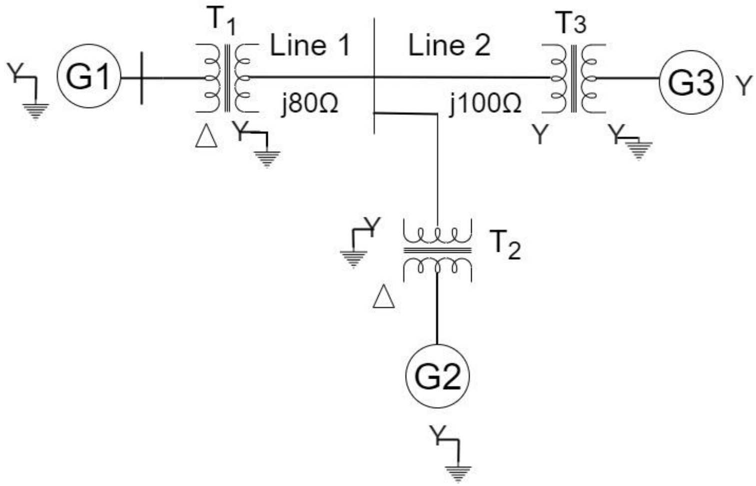

Figure 1 A

1B. A synchronous generator and synchronous motor each rated 30 MVA, 13.2 kV and both have subtransient reactance of 20% and the line reactance 12% on a base of machine ratings. The motor is drawing 25 MW at 0.85 power factor leading. The terminal voltage is 12 kV when a three-phase short-circuit fault occurs at motor terminals. Determine the subtransient fault current using Thevenin's equivalent network. ***(04)***

1C. A 30 MVA, 11 kV, three-phase synchronous generator has direct subtransient reactance of 0.25 p.u. The negative and zero sequence reactance are 0.35 p.u. and 0.1 p.u. respectively. The neutral of the generator is solidly grounded. Determine the subtransient current in the generator and the phase voltages for subtransient condition when a single line to ground fault occurs at the generator terminals with the generator operating unloaded at rated voltage. ***(04)***

2A. The line-to-ground voltages on the high voltage side of a step-up transformer are 100 kV, 33 kV and 38 kV on phases a, b and c respectively. The voltage of phase a lead that of phase b by 100° and lags that of phase c by 176.5°. Determine analytically the symmetrical components of voltage. ***(03)***

$V_a = 100\angle 0°$; $V_b = 33\angle -100°$; $V_c = 38\angle 176.5°$

2B. Derive the expression for direct axis subtransient reactance, transient reactance, and steady state condition reactance under the short circuit on a synchronous machine. ***(03)***

2C. For the power system shown in Fig. 2 C, the two synchronous machines A and B generate 1.0 p.u. voltages. The per unit value of reactances for the components are as given below: ***(04)***

	X_0	X_1	X_2
Generator A	0.5	0.3	0.2
Generator B	0.03	0.25	0.15
Transformer T_1	0.12	0.12	0.12
Transformer T_2	0.1	0.1	0.1
Each Line	0.7	0.3	0.3

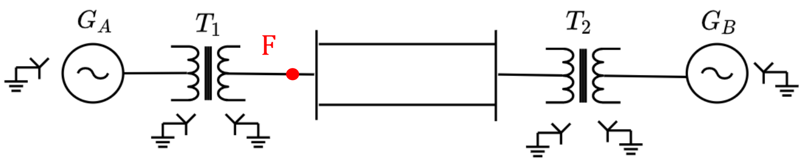

Figure 2 C

Calculate the currents fed into the LL fault from both the generators.

3A. A 200 MVA, 11 kV 50 Hz, 6 pole generator has an inertia constant of 5 MJ/MVA. The machine is operating in the stable region at an electrical load of 120 MW. The electrical load is suddenly increased to 150MW. Find the rotor deceleration. If the deceleration is maintained for 10 cycles, determine the rotor speed at the end of this period. ***(03)***

3B. Find the steady state power limit of a system consisting of a generator of 0.5 pu reactance connected to an infinite bus through a series reactance of 1.0 pu. The terminal voltage of the generator is held at 1.2 pu. and the voltage of the infinite bus is 1.0 pu. ***(03)***

3C. A three-phase cylindrical rotor alternator operating in stable region, supplies power to an infinite bus. The mechanical input to the generator is suddenly increased, derive a swing equation for the synchronous generator. Neglecting constant losses. ***(04)***

4A. A 50 Hz synchronous generator having an inertia constant of 4.0 MJ/MVA represented by a voltage source of 1.05 pu ***(03)***

in series with a transient reactance of 0.15 pu is connected through a transmission line of reactance 0.3 pu to a power network represented by a voltage source of 1.0 pu in series with a transient reactance of 0.2 pu. The generator is transmitting an active power of 1.1 pu. A symmetrical fault occurs at the generator terminals and is cleared in 0.15 seconds. Calculate the critical clearing angle at this instant.

4B. A transmission line has a series reactance of j0.001 p.u./km. Construct the admittance matrix for the bus arrangement given in figure 4 B using the direct inspection method. ***(03)***

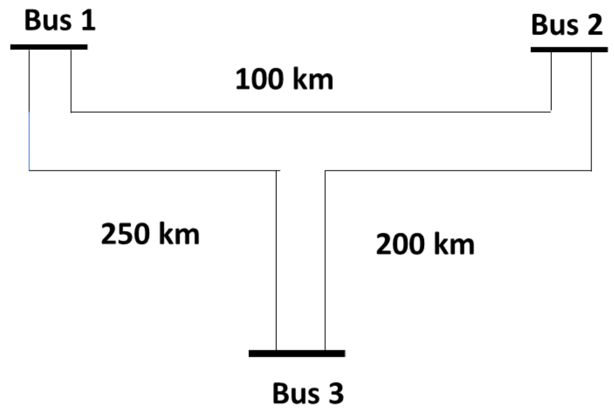

Figure 4 B: Single line diagram of a 3 bus network

4C. ***(04)***

$$Ybus = \begin{bmatrix} 3.92 - j15.61 & -2.94 + j11.76 & -0.98 + j3.92 & 0 \\ -2.94 + j11.76 & 5.78 - j23.59 & -1.42 + j5.88 & -1.42 + j5.88 \\ -0.98 + j3.92 & -1.42 + j5.88 & 8.28 - j33.25 & -5.88 + j23.52 \\ 0 & -1.42 + j5.88 & -5.28 + j23.52 & 7.3 - j29.36 \end{bmatrix}$$

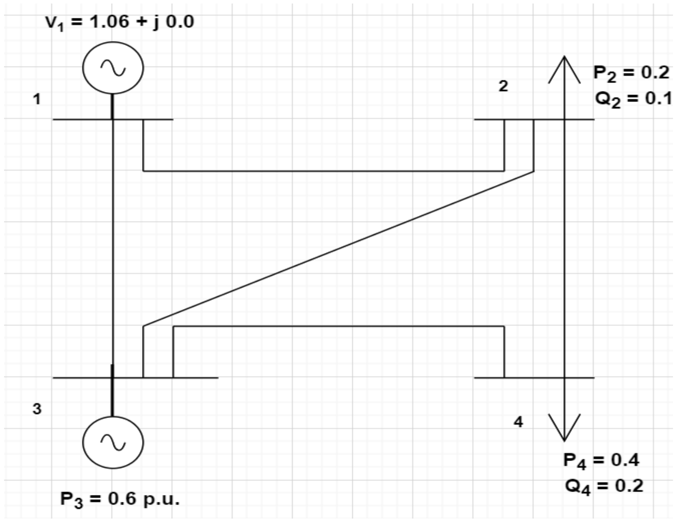

Figure 4 C: Single line diagram of a 4 bus network

The reactive power at bus 3 is specified as $0.4 \leq Q_3 \leq 1.0$ at voltage of 1.04. Assume voltages and angles at load bus is 1 with angle of 0^0. All the values of active and reactive powers are in per unit (p.u.). By using Gauss seidel method, evaluate the voltages of buses 1, 2 and 3 at the end of 1st iteration using the data given in Ybus matrix and figure 4 C. Assume the acceleration factor as 1.6.

5A. Compute the Jacobian matrix for the power system network shown in figure 5A. Assume initial voltage of bus 2 as $0.85\angle -15^0$. ***(03)***

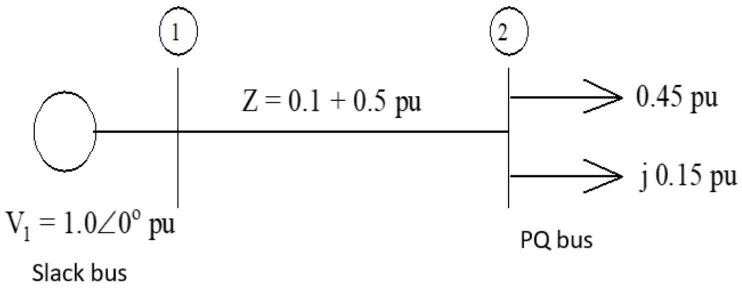

Figure 5 A: 2 Bus power system network

5B. For the Jacobian matrix obtain in question 5A, estimate the values of voltage magnitude and phase angle of bus 2 (i.e, $\Delta\delta_{2,}\ \Delta V_2$) after one iteration using Newton Raphson Method. ***(04)***

5C. Compare the Gauss-Seidel (G-S) and Newton-Raphson (N-R) methods when applied for load flow analysis. ***(03)***