B.Sc. Engg. (EE), 4th Sem.
DTE, 2nd Sem.

May 27, 2024 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination
Course No.: EEE 4401/EEE 4495
Course Title: Power System II

Summer Semester, A.Y. 2022-2023
Time: 3 Hours
Full Marks: 150

There are **6 (six)** questions. Answer all **6 (six)** questions. The symbol(s) have their usual meaning(s). Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets. Assume reasonable value for any missing data, if it is required.

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1. The one-line diagram of a simple three-bus power system is shown in Figure 1. Each generator is represented by an emf behind the subtransient reactance. All impedances are expressed in per unit on a common MVA base. All resistances and shunt capacitances are neglected. The generators are operating on no load at their rated voltage with their emfs in phase. A *three-phase fault* occurs at bus 3 through a fault impedance of $Z_f = j0.19$ per unit. [13+12] [CO2] [PO2]
(a) Using ***Thevenin's theorem,*** obtain the impedance to the point of fault and the fault current in per unit. (b) Calculate the bus voltages and line currents during fault.

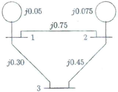

Figure 1

2. The bus impedance matrix for the network shown in Figure 2 is given by [25] [CO2] [PO2]

$$Z_{bus} = j\begin{bmatrix} 0.300 & 0.200 & 0.275 \\ 0.200 & 0.400 & 0.250 \\ 0.275 & 0.250 & 0.41875 \end{bmatrix}$$

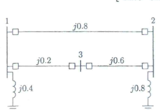

Figure 2

There is a line outage and the line from bus 1 to 2 is removed. Using the method of ***building algorithm***, determine the new bus impedance matrix.

3. (a) One conductor of a three-phase line is open. The current flowing to the delta-connected load through line a is 10 A. With the current in line a as reference and assuming that line c is open, using ***Fortesque theorem*** find the symmetrical components of the line currents. Draw the phasor diagram mentioning all the components including unbalanced phasors. [15] [CO1] [PO1]

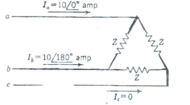

Figure 3: Circuit for 3(a)

(b) A 40-MVA, 20-kV/400-kV, single-phase transformer has the following series impedances: [10] [CO1] [PO1]

$Z_1 = 0.9 + j1.8\ \Omega$ and $Z_2 = 128 + j288\ \Omega$

Using the transformer rating as base, find the per unit impedance of the transformer from the ohmic value referred to the low-voltage side. Compute the per unit impedance using the ohmic value referred to the high-voltage side as well. Justify the results.

4. Figure 4 shows the one-line diagram of a simple three-bus power system with generation at bus 1. The voltage at bus 1 is $V_1 = 1.05\angle 0°$ per unit. The scheduled loads on buses 2 and 3 are marked on the diagram. Line admittances are marked in per unit on a 100 MVA base and line charging susceptances are neglected. [10+5×3] [CO2] [PO2]

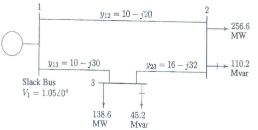

Figure 4

(a) Using ***Gauss-Seidel method*** and initial estimates of $V_2^{(0)} = 1.0 + j0$ pu and $V_3^{(0)} = 1.0 + j0$ pu, calculate V_2 and V_3 accurate to four decimal places. Perform **two iterations**.

(b) If after several iterations the bus voltages converge to $V_2 = 0.98 - j0.06$ pu $V_3 = 1.00 - j0.05$ pu determine the line flows and line losses.

(c) Find slack bus real and reactive power.

(d) Construct a power flow diagram and show the direction of the line flows.

5. A three-phase source with the following phase-to-neutral voltages is applied [5×5] [CO3] [PO3]

$$\mathbf{V}^{abc} = \begin{bmatrix} 200 & \angle 25^\circ \\ 100 & \angle -155^\circ \\ 80 & \angle 100^\circ \end{bmatrix}$$

to the circuit in Figure 5. The load series impedance per phase is $Z_s = 8 + j24$ and the mutual impedance between phases is $Z_m = j4$. The load and source neutrals are solidly grounded. Design for the following(s):

(a) The load sequence impedance matrix, $Z^{012} = A^{-1}Z^{abc}A$.

(b) The symmetrical components of voltage.

(c) The symmetrical components of current.

(d) The load phase currents.

(e) The complex power delivered to the load in terms of symmetrical components, $S_{3\varphi} = 3(V^0_a I^{0*}_a + V^1_a I^{1*}_a + V^2_a I^{2*}_a)$

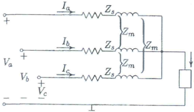

Figure 5

6. The zero-, positive-, and negative-sequence bus impedance matrices for a three-bus power system are [8+8+9] [CO3] [PO3]

$$\mathbf{Z}^0_{bus} = j\begin{bmatrix} 0.20 & 0.05 & 0.12 \\ 0.05 & 0.10 & 0.08 \\ 0.12 & 0.08 & 0.30 \end{bmatrix} \text{ pu}$$

$$\mathbf{Z}^1_{bus} = \mathbf{Z}^2_{bus} = j\begin{bmatrix} 0.16 & 0.10 & 0.15 \\ 0.10 & 0.20 & 0.12 \\ 0.15 & 0.12 & 0.25 \end{bmatrix} \text{ pu}$$

Design the system from the ***per unit fault current and the bus voltages*** during the following(s):

(a) A bolted single line-to-ground fault at bus 2.

(b) A bolted line-to-line fault at bus 2.

(c) A bolted double line-to-ground fault at bus 2.

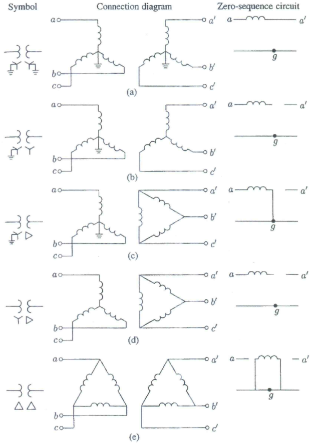

Figure 6: Zero- sequence equivalent circuits