International Islamic University Chittagong
Department of Electrical and Electronic Engineering
B. Sc. Engineering in EEE
Semester End Exam, Spring 2025

Course Code: **EEE3519** Course Title: **Power System Analysis**
Time: 2 hours 30 minutes Full Marks: 50

(i) The figures in the right-hand margin indicate full marks
(ii) Course Outcomes and Bloom's Levels are mentioned in additional Columns

CO	CO Statements
CO1	Reflect a basic understanding of power system modelling, effects of synchronous machines in power systems, one-line diagram, network calculations, bus impedance matrix, different types of power system faults, and fault calculations.
CO2	Understand the application of load flow methods such as the Gauss-Seidel method and the Newton-Raphson method, and the application of symmetrical components in power systems.
CO3	Solve power system networks under different fault and load conditions.

Bloom's Levels (BL) of the Questions						
Letter Symbols	C1	C2	C3	C4	C5	C6
Meaning	Remember	Understand	Apply	Analyze	Evaluate	Create

Part A

[Answer the questions from the following.]

1. a) Write a comparative analysis between the Gauss-Seidel Method (GS) and the Newton-Raphson (NR) method. CO1 C1 4

1. b) The power flow problem of the system shown in **Fig.1** is to be solved using the Gauss-Seidel method. The results of iteration #1 are: CO2 C5 6
$V_2^{(1)} = 0.999 - j0.04$ pu and $V_3^{(1)} = 1.019 + j0.0452$ pu

(i) Calculate V2 and V3 of iteration #2
(ii) Assume the solution of the power flow problem converges to:
$V_2 = 0.9910 - j0.0028$ pu and $V_3 = 1.017 + j0.0776$ pu ,
Determine the real and reactive power produced by the generator at bus #1.

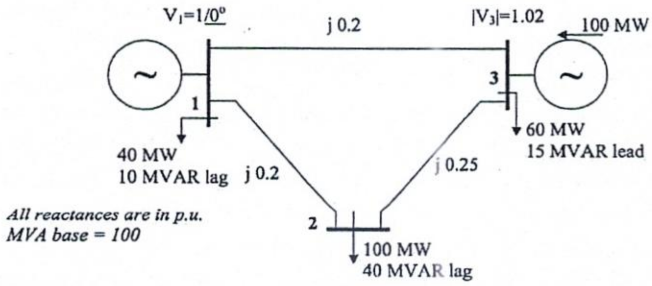
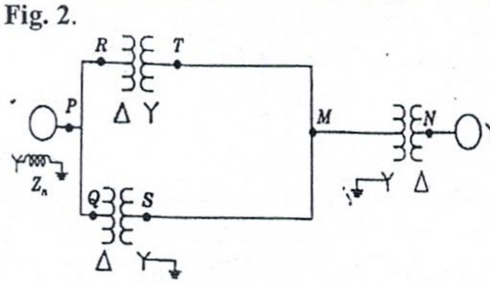


Fig.1: Question 1(b)

2 a) i) Write down the faults in order of severity. What commonly occurs? CO1 C2 5
ii)Draw the zero, positive, and negative sequence network for the circuit diagram shown in **Fig. 2.**



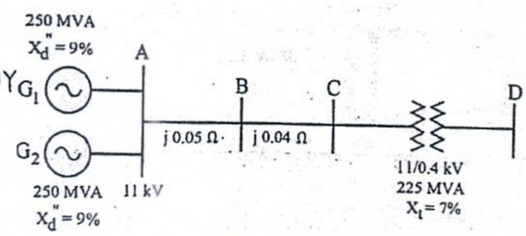


Fig.2: Question 2(a) **Fig.3: Question 2(b)**

2. b) For the power system shown in **Fig. 3**, find the actual current when a 3-phase fault occurs at bus D. Let 300 MVA and 11 kV be the base, and 1<0 p.u. as pre-fault voltage. CO3 C6 5

OR

a) i) A 3-phase, 20 MVA, 10 kV generator has an internal resistance of 5% and negligible resistance. Identify the external reactance per phase to be connected in series with the generator so that the steady current on short-circuit does not exceed 8 times the full load current. CO1 C2 5

ii) Define the following terms:

(a) Percentage reactance b) a-operator

2. b) A 3-phase transmission line operating at 10 kV and having a resistance of 1Ω and a reactance of 4 Ω is connected to the generating station bus-bars through a 5 MVA step-up transformer with a reactance of 5%. The bus-bars are supplied by a 10 MVA alternator having 10% reactance shown in **Fig.4**. Calculate the short-circuit kVA fed to a symmetrical fault between phases if it occurs CO3 C5 5

(i) at the load end of the transmission line

(ii) at the high voltage terminals of the transformer

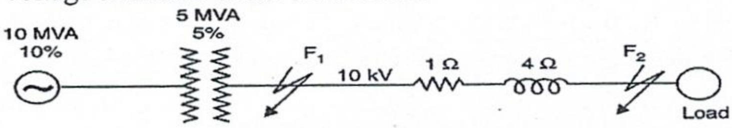


Fig.4: Question 2(b)

Part B

[Answer the questions from the following.]

3. a) Construct the sequence network if **Line-to-Ground (L-G)** fault occurs between two phases of a star-connected Synchronous Machine and show that, CO3 C4 5

$$\mathbf{Ia_1} = \frac{Ea}{Z1+Z2+Z0}$$

3. b) A salient pole generator without dampers is rated 20 MVA, 13.8 kV and has a direct axis sub-transient reactance of 0.25 p.u. The negative and zero sequence reactance are 0.35 p.u. and 0.10 p.u. respectively. The neutral of the generator is solidly grounded. Evaluate the sub-transient currents and line-to-line voltages when **Line-to-Line (L-L)** fault occurs at the terminals of the generator. Assume that the generator is unloaded and operating at rated terminal voltage when the fault occurs. Neglect the resistance. CO3 C5 5

OR

3. a) Construct the sequence network and deduce the expression of currents if **Line-to-Line (L-L)** fault occurs between two phases of a star-connected Synchronous Machine. CO3 C4 5

3. b) A salient pole generator without dampers is rated 20 MVA, 13.8 kV, and has a direct axis sub-transient reactance of 0.25 p.u. The negative and zero sequence reactances are 0.35 p.u. and 0.10 p.u. respectively. The neutral of the generator is solidly grounded. Evaluate the sub-transient currents and line-to-line voltages when **Line-Ground (L-G)** fault occurs at the terminals of the generator. Assume that the generator is unloaded and operating at rated terminal voltage when the fault occurs. Neglect the resistance. CO3 C5 5

4. a) Deduce a mathematical expression for the critical clearing angle (δcr) and critical clearing time (tcr) that can maintain the stability of a synchronous generator. CO1 C3 5

4. b) A generator is delivering 0.6 of its maximum power to an infinite bus through a transmission line. A fault occurs such that the reactance between the generator and infinite bus is increased to three times its pre-fault value. When the fault is cleared, the maximum power that can be delivered is 0.8 of its original value. Determine the critical clearing angle (δcr) and critical clearing time (tcr). Where H is 5 MJ/MVA and ωs = 377 rad/s . CO1 C5 5

5. a) What is Stability? How the multimachine stability is analyzed and improved? CO2 C4 5

5. b) A double circuit 3-phase feeder connects a single generator to a large network. The power corresponding to the limit of steady state stability for each circuit is 100MW. The line is transmitting 80MW when one of the circuits is suddenly switched off. Determine with reference to the appropriate diagram whether the generator is likely to remain in synchronism. CO2 C5 5