UNIVERSITY OF KWAZULU-NATAL
HOWARD COLLEGE CAMPUS
SCHOOL OF ENGINEERING

POWER SYSTEMS 2 (ENEL 4WA H1)

MAIN EXAMINATION

DATE: 30 MAY 2026 **TIME: 2 HOURS** **FULL MARKS: 67**

INTERNAL EXAMINER: AK SAHA

STUDENTS ARE ADVISED TO FOLLOW THE INSTRUCTIONS BELOW:

- **USE BLACK BALL PEN ONLY**
- ***ANSWER ALL THE QUESTIONS AND INDICATE THEM ON THE ANSWER BOOK COVER-PAGE***
- **ALLOCATED MARKS ARE INDICATED IN 'SQUARE BRACKETS' NEXT TO EACH QUESTION**
- **STUDENTS CAN USE SCIENTIFIC CALCULATOR WITH A CLEARED MEMORY**

QUESTION 1 [10]

(a) Briefly explain steady-state stability limit. **[2]**

(b) Two turbo alternators with ratings given below are interconnected via a short transmission line. Inertia constant of these two machines to the single equivalent machine on a base of 200 MVA is 5 MJ/MVA. Determine the moment of inertia of MC_2.
MC_1: 4 pole, 50 Hz, 60 MW, p.f. 0.80 (lag), J=30, 000 kg/m^2
MC_2: 2 pole, 50 Hz, 50 MW, p.f. 0.80 (lag) **[8]**

QUESTION 2 [8]

(a) State the important aspects of an overcurrent relay in power systems. **[2]**

(b) Determine the current setting and plug setting multiplier if operating time of a 5 Ampere standard IDMT overcurrent relay is 3.5 seconds with a time multiplier setting of 0.65. The CT ratio is 1500:5 while the fault current is 6000 Ampere. **[6]**

QUESTION 3 [12]

(a) Mention two most important features of admittance matrix of buses of a power system. **[2]**

(b) For a three-bus power system, corresponding line admittances are given in Table 1. The shunt admittances at all buses are negligible. Assuming a flat voltage start, find the voltages and bus angles at bus 2 and bus 3 at the end of first Gauss-Siedel iteration. The values of real and reactive powers for other buses are given in Table 2. **[10]**

TABLE 1: LINE ADMITTANCES

Bus-to-bus	y (p.u.)
1-2	1-j2
1-3	1-j3
2-3	1-j4

TABLE 2: BUS DATA

Bus	P (p.u.)	Q (p.u.)	V (p.u.)	Bus Type
1	-	-	$1.0\angle 0°$	Slack
2	0.75	-0.40	-	PQ
3	0.25	-0.10	-	PQ

QUESTION 4 **[17]**

(a) What is the common type of fault in power systems and why? **[2]**

(b) For the power system as shown in Fig. 1, find out the fault current I_a in Amperes per MVA for a L-G fault at the point F assuming excitation voltages for the generators to be $1.1\angle 0°$ p.u. The reactances of generators, transformer and line are given in Table 3 on a common base MVA and show all the reactance diagrams. Also, find out the component fault currents in p.u. shared by the generators. **[15]**

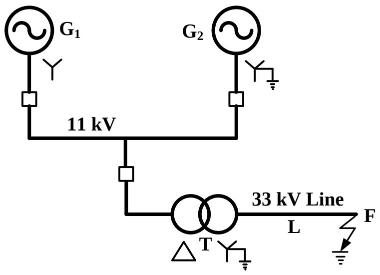

Fig. 1: Power system

TABLE 3: EQUIPMENT REACTANCES

Equipment	X_1	X_2	X_0
G1	0.24 p.u.	0.12 p.u.	0.048 p.u.
G2	0.227 p.u.	0.136 p.u.	0.045 p.u.
T	0.05 p.u.	0.05 p.u.	0.05 p.u.
L	0.015 p.u.	0.015 p.u.	0.059 p.u.

QUESTION 5 **[9]**

(a) Briefly explain earth resistance. **[2]**

(b) An earth electrode consisting of a round section metal pipe of 60 mm diameter is driven in to ground to a depth of 5 m.

  (a) If the resistance of this electrode is found to be 25 Ohm, find the earth resistivity at this point.

  (b) Also find the effective earth resistance if a second similar electrode is placed at a distance of 2 m from this electrode when both the electrodes are bonded together using a bonding wire of negligible resistance. **[7]**

QUESTION 6 **[11]**

(a) What aspects need to be ensured to have proper insulation coordination? **[3]**

(b) A 33 kV CB is located at a point on a 50 Hz, 3-ph transmission line where the fault level is 300 MVA. If this CB operates for a three-phase fault, find the expression for the voltage appearing across the CB contacts on opening in terms of time neglecting resistance in the circuit and assuming a lumped value of 0.025 micro Farad of capacitance. Also, determine the value of the voltage at a time of 3 second. **[8]**

-End-

Formula Sheet

Current at bus i, $I_i = \sum_{k=1}^{n} Y_{ik} V_k$

Voltage at bus i, $V_i^{(x)} = \frac{1}{Y_{ii}}\left[\frac{P_i - jQ_i}{V_i^{(x-1)*}} - \left(\sum_{\substack{k=1\\k\neq i}}^{n} Y_{ik} V_k\right)\right]$

Resistivity from Wenner method: $\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2+4b^2}} - \frac{2a}{\sqrt{4a^2+4b^2}}}$

IEC standard inverse characteristic: $t_{op} = \frac{0.14}{M^{0.02}-1} TMS$

IEC very inverse characteristic: $t_{op} = \frac{13.5}{M-1} TMS$

Critical clearing angle: $\delta_{cr} = cos^{-1}\left(\frac{P_{\max\_fault} \times cos\delta_0 - P_{\max\_postfault} \times cos\delta_{max} - P_{mech}(\delta_{max} - \delta_0)}{P_{\max\_fault} - P_{\max\_postfault}}\right)$