UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	POWER SYSTEM PROTECTION
COURSE CODE	:	BEV40103
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**. 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) (i) Apply the concept of power system dynamics to elucidate how changes in load affect the operation of power system protection equipment.

(2 marks)

(ii) Explain briefly **THREE (3)** distinct types of protection used in power systems.

(3 marks)

(iii) Outline the characteristics that are important in a power system protection scheme and elucidate how each characteristic contributes to the system's overall operational performance.

(4 marks)

(b) Evaluate the performance of a 600/5 class C current transformer (CT) to ensure whether the CT operates beyond its linear operating region when a 7500 A current flows through the primary circuit. The secondary burden is 4.5 Ω, and the secondary resistance is 0.38 Ω. **Figure Q1(b)** represents the typical excitation curve of multi-ratio class C CT.

(5 marks)

(c) Determine the percentage ratio error of the CT if a 500/5 class C CT is connected to a secondary burden of 2.37 Ω and the secondary current is 71 A. **Figure Q1(b)** represents the typical excitation curve of multi-ratio class C CT.

(6 marks)

Q2 (a) (i) Define the significance of estimating fault current in a power system.

(2 marks)

(ii) Describe the role of positive sequence components in an ideal system's operation.

(3 marks)

(b) **Figure Q2(b)** represents a radial power network in per unit representation on a common base. **Table Q2(b)** shows the reactance data of the system.

(i) Examine the Thevenin sequence impedances for the fault at Bus 1.

(5 marks)

(ii) Calculate the fault current in the per unit representation for a bolted line-to-line fault at Bus 1.

(4 marks)

(iii) Calculate the fault current in per unit representation for a bolted double line-to-ground fault at Bus 1.

(6 marks)

Q3 (a) Summarize the limitations of fuses and how overcurrent relays overcome them by explaining the benefits of using overcurrent relays for protection in power systems.

(8 marks)

(b) Determine the coordination of time interval (CTI) between the overcurrent relays R_1 and R_2 shown in **Figure Q3(c)**. TMS of relay R_1 is set to 0.5, while the TMS of relay R_2 is set to 0.05. The maximum load, minimum fault current, and maximum fault current are tabulated in **Table Q3(c)**.

(12 marks)

Q4 A distance relay is installed for the system shown in **Figure Q4** to protect the transmission line from fault. As a protection engineer, one must ensure that the relay must not operate during power swing, leading to a major blackout in the entire system. All values in the figure are in per unit.

(a) Determine the two-port equivalent across the transmission line X.

(12 marks)

(b) Analyze whether the power swing locus passes through the transmission line X. Provide an appropriate diagram to aid the articulation of the analysis.

(8 marks)

Q5 (a) Explain the importance of ground fault protection for generators.

(5 marks)

(b) Analyze the comparative effectiveness and limitations of high impedance grounding and low impedance grounding in the context of ground fault protection for generators.

(10 marks)

(c) Apply the concept of loss of excitation protection for generators in an power system operational scenario.

(5 marks)

-END OF QUESTIONS-

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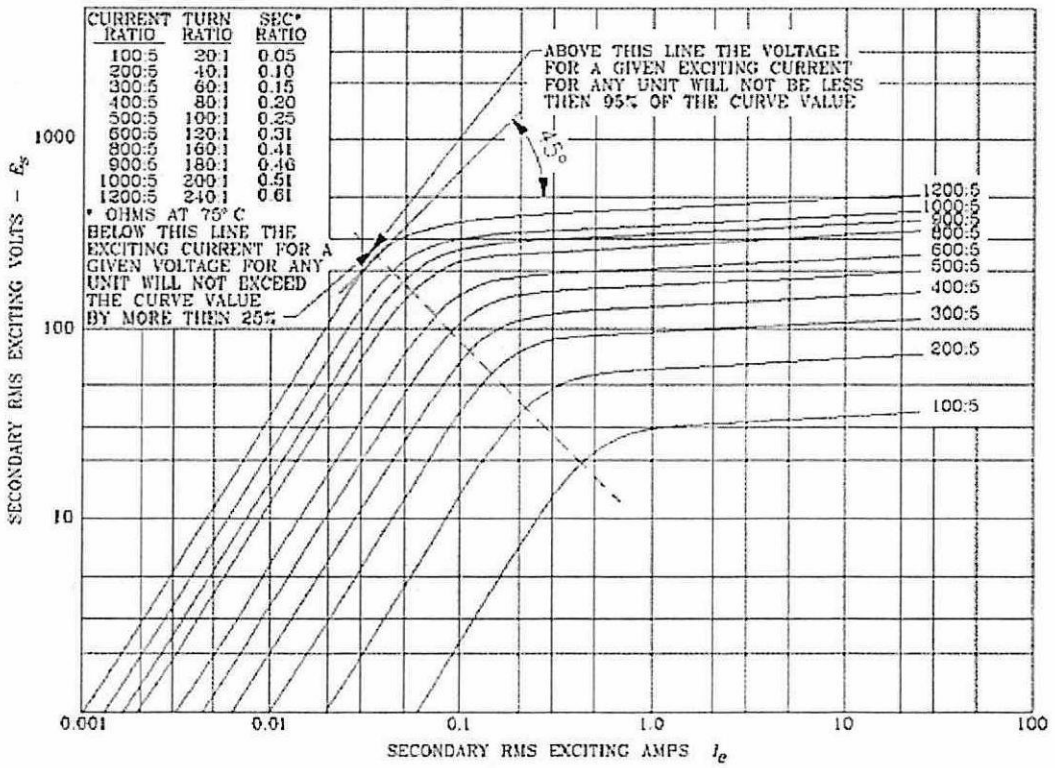

Figure Q1(b)

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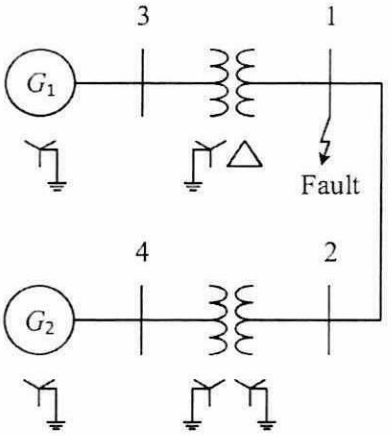

Figure Q2(b)

Table Q2(b)

Item	X^1	X^2	X^0
G_1	0.32	0.32	0.175
G_2	0.32	0.32	0.175
T_1	0.27	0.27	0.275
T_2	0.27	0.27	0.275
Line 1-2	0.273	0.273	0.284

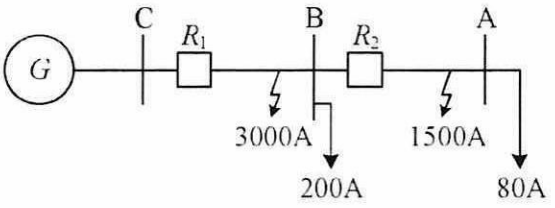

Figure Q3(c)

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Table Q3(c)

Bus	Maximum load	Minimum fault current	Maximum fault current
A	80 A	600 A	1500 A
B	200 A	900 A	3000 A

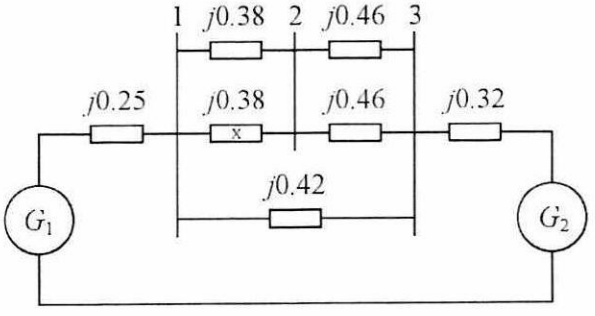

Figure Q4