Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	POWER SYSTEM PROTECTION
COURSE CODE	:	BEV40103
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	FEBRUARY 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 **SEVEN** (7) PAGES

Q1 (a) List **THREE (3)** generations of relay.

(3 marks)

(b) Determine the maximum symmetrical fault current that can be applied to a 1000/5 *Class C* current transformer (CT) connected to a 1.7 Ω burden without exceeding its 10% ratio error limit. The CT is designed for the protection application. The typical excitation curve for the multi-ratio *Class C* CT is provided in **Figure Q1(b)**.

(8 marks)

(c) **Figure Q1(c)** represents a 500/5 *Class C* CT connected to a meter with resistance of $R_M = 1.2\ \Omega$. The secondary current in the CT is 5.2 A. The wire resistance is given by $R_W = 0.01\ \Omega$ and the secondary resistance is given by $R_S = 0.25\ \Omega$. Please refer to **Figure Q1(b)** for the excitation current of the multi-ratio *Class C* CT.

(i) Determine the primary current of the abovementioned CT configuration.

(5 marks)

(ii) Calculate the voltage developed across the meter.

(2 marks)

(iii) Analyze the percentage ratio error of the CT.

(2 marks)

Q2 (a) Discuss the concept of sequence component utilized for the unbalanced fault analysis in the power system protection application.

(5 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 2.

(5 marks)

(ii) Calculate the fault current in the per unit representation for a bolted single line to ground 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) Define the characteristic of a fuse.

(6 marks)

(b) Discuss the function of time multiplier setting (TMS) in determining of overcurrent relay settings.

(2 marks)

(c) Analyze the settings of the overcurrent relays R_1 and R_2 as shown in **Figure Q3(c)**. The relays need to be set as the main and backup protection. The coordination of time interval (CTI) between the main and backup protection is set to 0.3 s. TMS of relay R_1 is set to 0.025. 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) List **FIVE (5)** bus configurations used in the power system operation.

(5 marks)

(b) Propose a protection scheme required to protect a generator against the following **THREE (3)** abnormal operating situations.

(i) Unbalanced operation.

(5 marks)

(ii) Motoring.

(5 marks)

(iii) Overvoltage.

(5 marks)

-END OF QUESTIONS-

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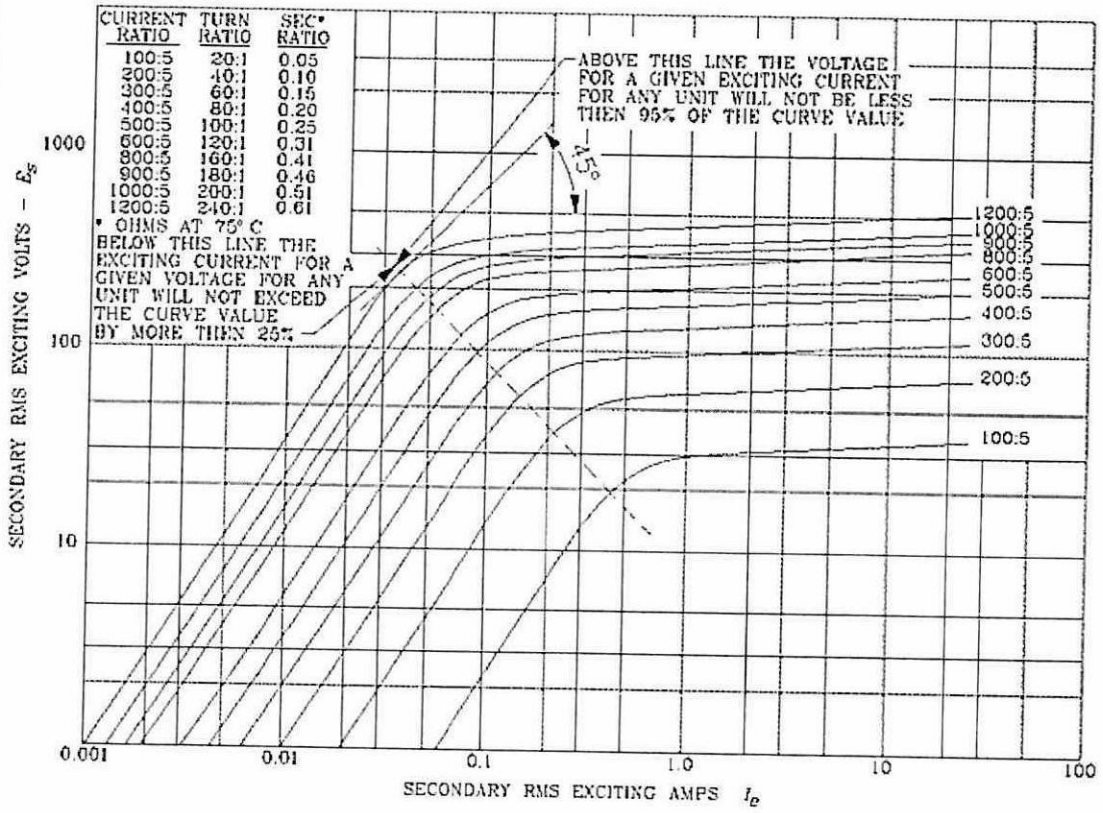

Figure Q1(b)

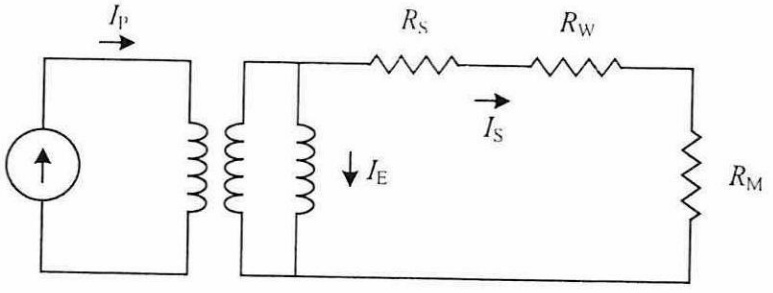

Figure Q1(c)

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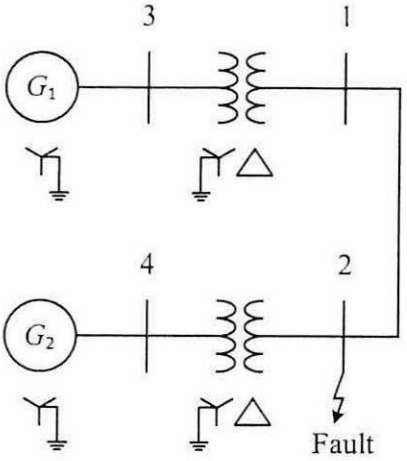

Figure Q2(b)

Table Q2(b)

Item	X^1	X^2	X^0
G_1	0.15	0.15	0.1
G_2	0.15	0.15	0.1
T_1	0.2	0.2	0.2
T_2	0.2	0.2	0.2
Line 1-2	0.25	0.25	0.30

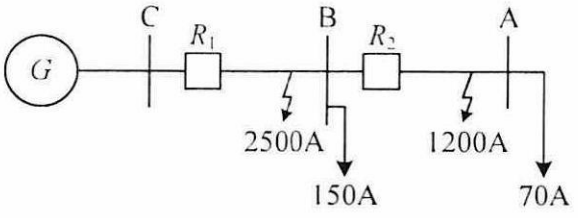

Figure Q3(c)

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Table Q3(c)

Bus	Maximum load	Minimum fault current	Maximum fault current
A	70 A	600 A	1200 A
B	150 A	1000 A	2500 A

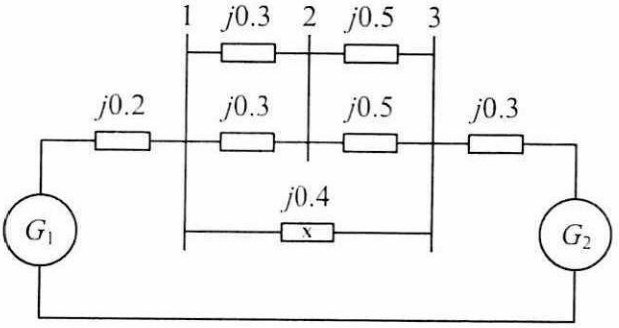

Figure Q4