Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	POWER SYSTEM ANALYSIS AND PROTECTION
COURSE CODE	:	BEF 43303
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) (i) State the definition of power system stability.

(3 marks)

(ii) Explain the difference between steady state stability and transient stability.

(2 marks)

(b) A 60-Hz synchronous generator having inertia constant H = 5 MJ/MVA and a direct axis transient reactance of $x_d = 0.3$ per unit is connected to an infinite bus through a purely reactive circuit as shown in **Figure Q1(b)**. Reactances are marked on the diagram on a common system base. The generator is delivering real power $P_e = 0.8$ per unit and $Q = 0.074$ per unit to the infinite bus at a voltage of $V = 1$ per unit.

(i) A temporary three-phase fault occurs at the sending end of the line at point F. When the fault is cleared, both lines are intact. Determine the critical clearing angle (δ_c) and the critical fault clearing time (t_c).

(16 marks)

(ii) Illustrate the Equal Area Criterion that shows the initial operating angle (δ_0), critical clearing angle (δ_c) and maximum operating angle (δ_{max}) for this stability analysis.

(4 marks)

Q2 (a) Discriminate the protective zones of distance relays for the power system as shown in **Figure Q2(a)** by drawing the zones of protection.

(13 marks)

(b) Consider the transmission system depicted in **Figure Q2(b)**. The system nominal voltage is 132 kV and the positive sequence impedances for the various elements are given in the figure. The transformer impedance is given in ohms as viewed from 132 kV side. Assume that the maximum load at the relay side is 100 MVA. Current transformer (CT) ratio and capacitive voltage transformer (CVT) ratio are 100 and 1100 respectively. The available distance relay has zone 1 and zone 2 settings from 0.2 to 10 Ω, and zone 3 settings from 0.5 Ω to 40 Ω, in increments of 0.1 Ω. The angle of maximum torque can be adjusted to 75° or 80°. Determine the three zone settings for the relay R_{ab} in the system. Zone 3 relay must back up the line BC and the transformer.

(12 marks)

Q3 (a) List **two (2)** types of overcurrent protection.

(2 marks)

(b) **Figure Q3(b)** shows a radial distribution system with primary and backup overcurrent protection. The system is installed with **three (3)** overcurrent relays with IEC Standard Inverse characteristic. The fastest time multiplier setting (TMS) for each relay is 0.025 and the coordination time interval (CTI) between the primary and the backup protection should be set at 0.3s. **Table Q3(b)** shows the maximum load current, the minimum fault current, and the maximum fault current of each feeder in the system, respectively:

(i) Determine the minimum and the maximum pickup current for each relay.

(6 marks)

(ii) Determine the pickup current for each relay.

(3 marks)

(iii) Determine the TMS setting of each relay.

(14 marks)

Q4 (a) Identify **five (5)** applications of the differential protection system.

(5 marks)

(b) **Figure Q4(b)** shows a simple differential protection for a generator. CT_1 and CT_2 are rated at 1000/1. The relay pickup current I_S, the relay primary current I_1, and the relay secondary current I_2 are 0.2 A, 4.7 A, and 5.4 A respectively. The number of turns of the operating coil N_0 is 1 and the relay bias setting p is set to 20%.

(i) Evaluate the operational status of the relay for the fault occurred at F_1.

(4 marks)

(ii) Evaluate the operational status of the relay for the fault occurred at F_2.

(4 marks)

(c) Design a transformer differential protection system by calculating the CT ratio on the both sides (primary and secondary) of a 20 MVA 11/132 kV star-delta transformer. The restraining coil of the relay should be limited to 5 A and the choice of the CT are limited to 100/5, 600/5, 800/5, 900/5, 1000/5, 1500/5, 2000/5 and 3000/5.

(12 marks)

- END OF QUESTIONS -

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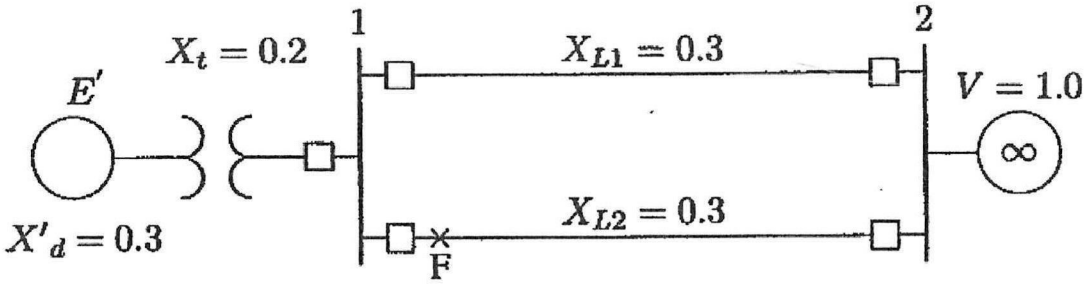

Figure Q1(b)

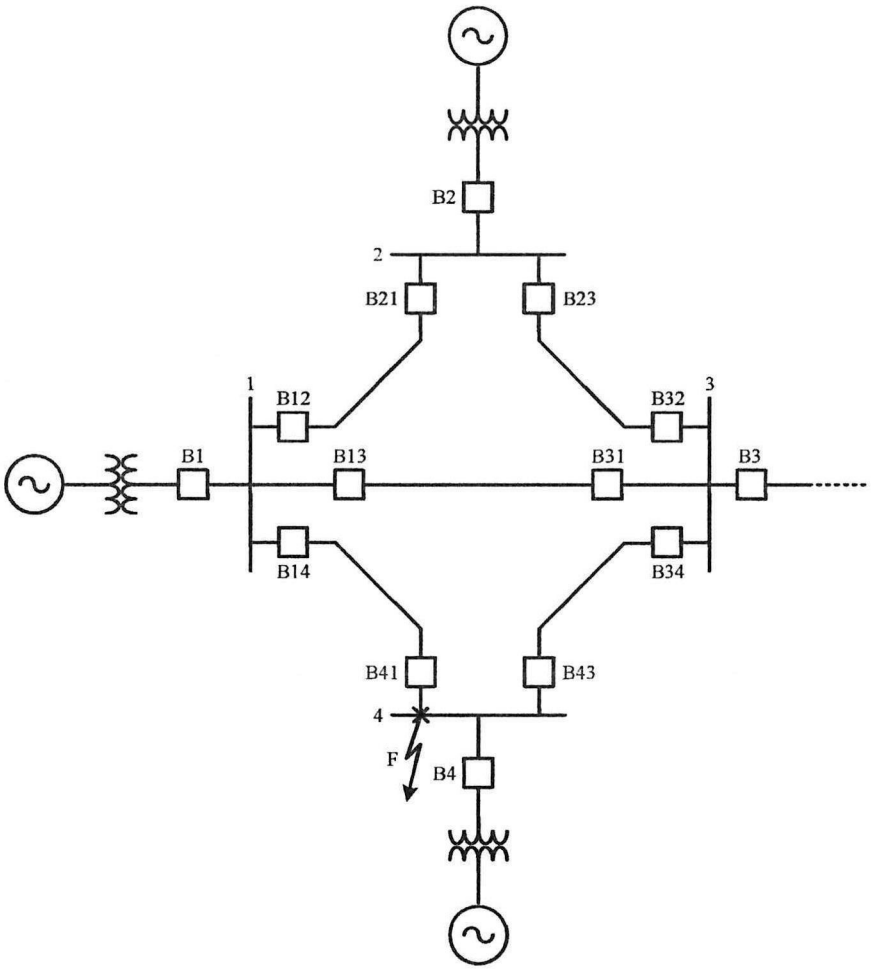

Figure Q2(a)

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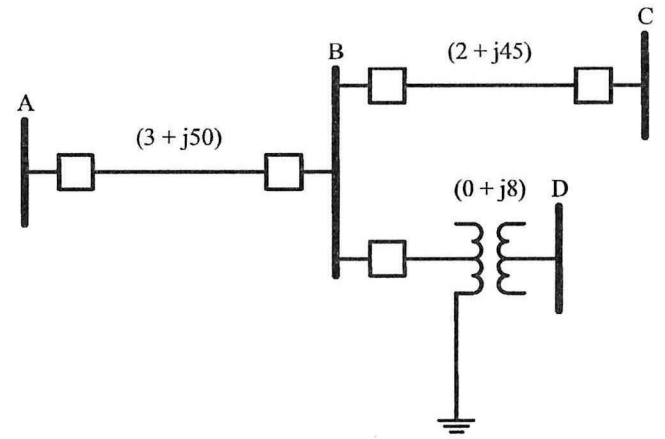

Figure Q2(b)

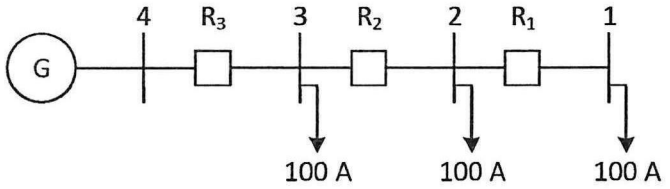

Figure Q3(b)

Table Q3(b)

Relay	Maximum Feeder Load Current (A)	Minimum Fault Current (A)	Maximum Fault Current (A)
R_1	100	300	500
R_2	200	600	1400
R_3	300	1200	2200

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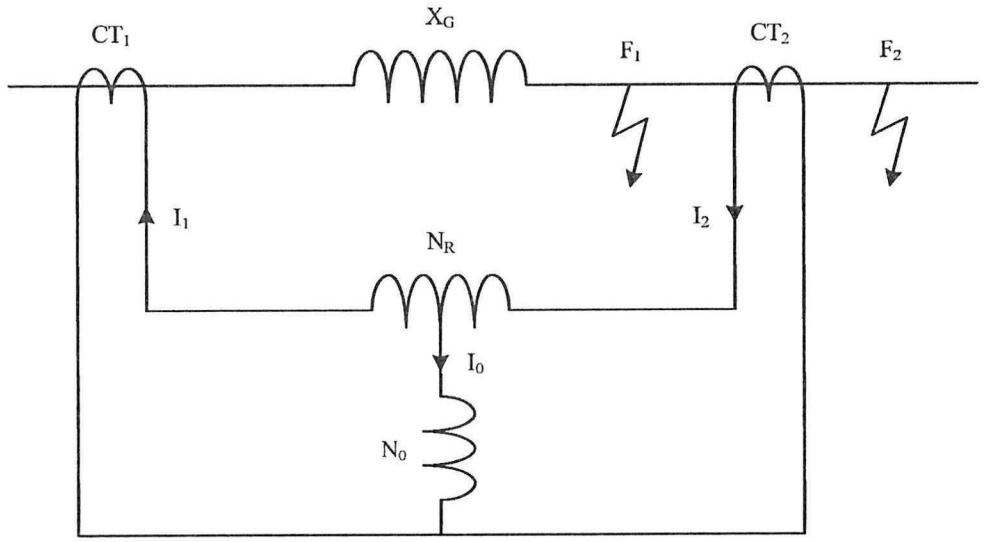

Figure Q4(b)