Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	POWER SYSTEM ANALYSIS AND PROTECTION
COURSE CODE	:	BEF 43303
PROGRAMME	:	BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	DECEMBER 2015/JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) List **five (5)** advantages of using per unit system in power system analysis.

(5 marks)

(b) An one-line diagram of a three-phase power system is shown in **Figure Q1(b)**. Line 1 and 2 have reactances of 53.61Ω and 44.11Ω, respectively. The manufacturer's data for each equipment is given in **Table Q1(b)**. Assume a common base of 100MVA and 22kV on the generator side.

(i) Determine the per unit impedances of each device in **Figure Q1(b)**.

(13 marks)

(ii) Construct the per unit impedance diagram representing the system illustrated in **Figure Q1(b)**.

(2 marks)

Q2 (a) The reactance data for the power system, shown in **Figure Q2(a)** in per unit system, on a common base is tabulated in **Table Q2(a)**.

(i) Calculate the Thevenin's sequence impedances for the fault at bus 1.

(5 marks)

(ii) Calculate the fault current in per unit for the following faults:

- A bolted three-phase fault at bus 1
- A bolted single line-to-ground fault at bus 1
- A bolted line-to-line fault at bus 1
- A bolted double line-to-ground fault at bus 1

(7 marks)

(b) (i) Explain the causes and effects of short circuit current in power system operations.

(4 marks)

(ii) State and discuss the **two (2)** main methods in analysing fault in power systems.

(4 marks)

Q3 (a) With the help of one-line diagram, discuss the function of the fundamental components used for a typical protection system.

(6 marks)

(b) **Figure Q3(b)** shows a simplified 275kV power transmission system. **Table Q3(b)** tabulates the positive sequence line impedance of the system and the CT and VT ratios at B_{12}.

(i) Calculate the settings Z_{R1}, Z_{R2}, and Z_{R3} for the B_{12} three-zone, directional relays connected as shown in **Figure Q3(b)**.

(8 marks)

(ii) Verify that B_{12} does not trip during normal and emergency load if the maximum current for the line 1-2 during emergency loading conditions is 1200 A at a power factor of 0.90 lagging.

(6 marks)

Q4 (a) **Figure Q4(a)(i)** shows a one-line diagram of a 34.5kV, 60Hz radial system. The data for the system is tabulated in **Table Q4(a)**. Assume that the coordination time interval for the relay is 0.3 second and the voltage at all bus is 34.5 kV (line-to-line) at all buses during normal operation. Also, assume that the breaker operating time is 5 cycles and the CT ratio is 200:5. Determine the current tap settings (TSs) and time-dial settings (TDSs) to protect the system from fault using CO-8 overcurrent relay. The characteristic of the CO-8 relay is shown in **Figure Q4(a)(ii)**.

(12 marks)

(b) State and briefly describe **four (4)** types of relays typically used in practice.

(8 marks)

Q5 (a) With the aid of one-line diagram, explain in detail about the operation of differential relays for the following application:

(i) Busbar protection

(5 marks)

(ii) Transformer protection

(5 marks)

(b) **Figure Q5(b)** shows an arrangement of differential protection of a three-phase Y-Δ, 45MVA, 33/132kV, two-winding transformer. The CT ratio for 33kV side and 132kV side are 500:5 and 150:5, respectively. Determine currents in the transformer and in the CT at rated conditions to select the relay tap settings of the relay and the percentage mismatch of the settings. Assume that the available relay tab settings are as tabulated in **Table Q5(b)**.

(10 marks)

- END OF QUESTIONS -

FINAL EXAMINATION

SEMESTER / SESSION	: SEM I / 2015 / 2016	PROGRAMME	: BEV
COURSE	: POWER SYSTEM ANALYSIS AND PROTECTION	COURSE CODE	: BEF43303

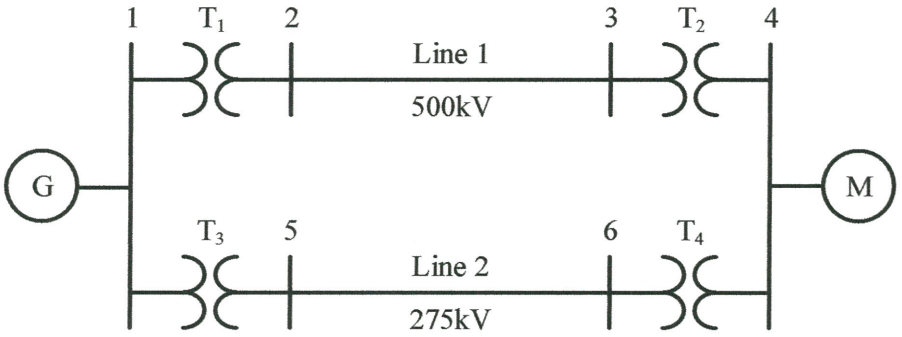

FIGURE Q1(b)

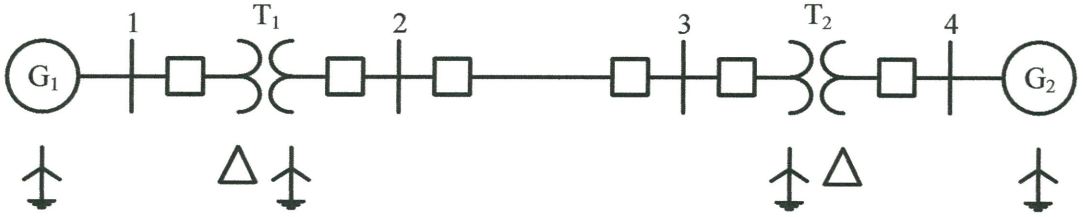

FIGURE Q2(a)

FINAL EXAMINATION

SEMESTER / SESSION	: SEM I / 2015 / 2016	PROGRAMME	: BEV
COURSE	: POWER SYSTEM ANALYSIS AND PROTECTION	COURSE CODE	: BEF43303

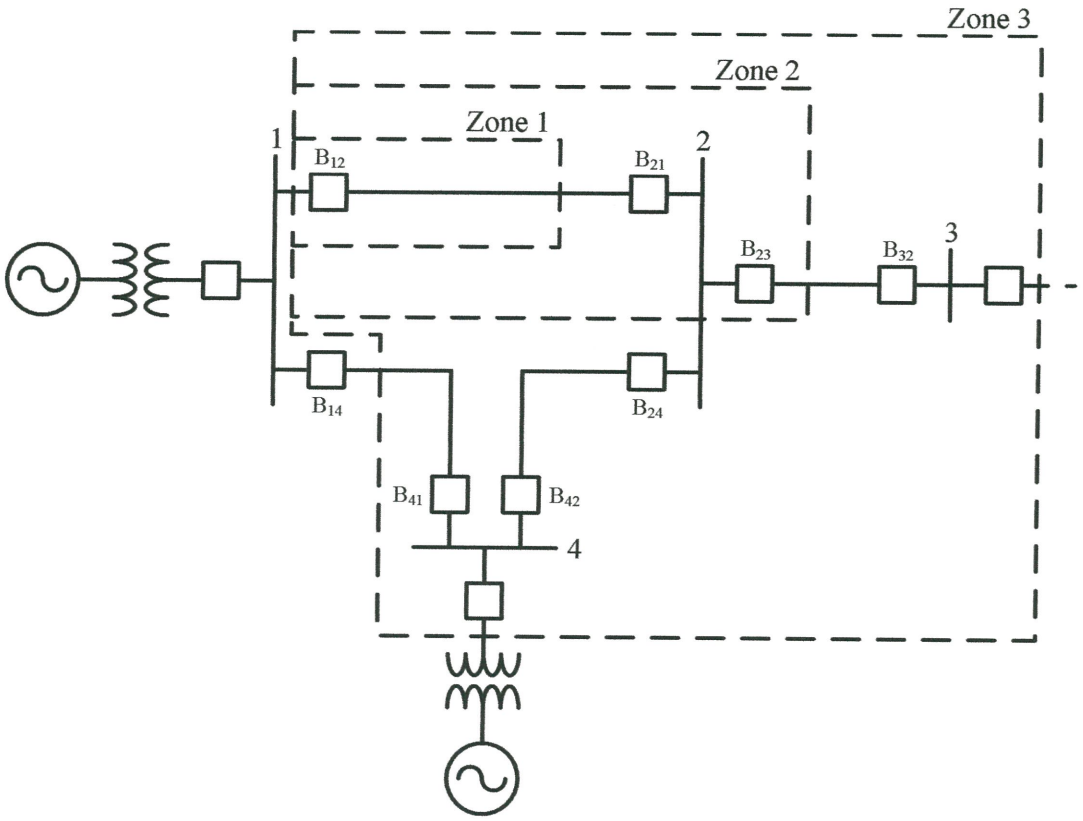

FIGURE Q3(b)

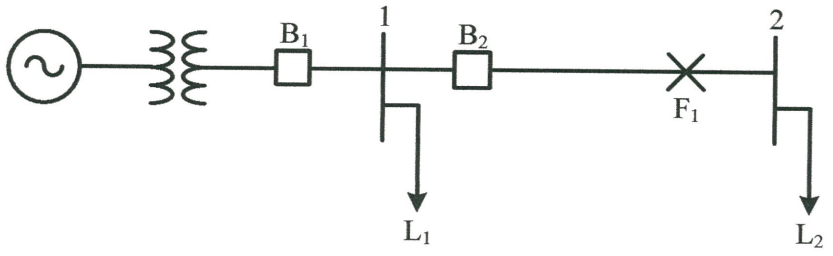

FIGURE Q4(a)(i)

FINAL EXAMINATION

SEMESTER / SESSION	: SEM I / 2015 / 2016	PROGRAMME	: BEV
COURSE	: POWER SYSTEM ANALYSIS AND PROTECTION	COURSE CODE	: BEF43303

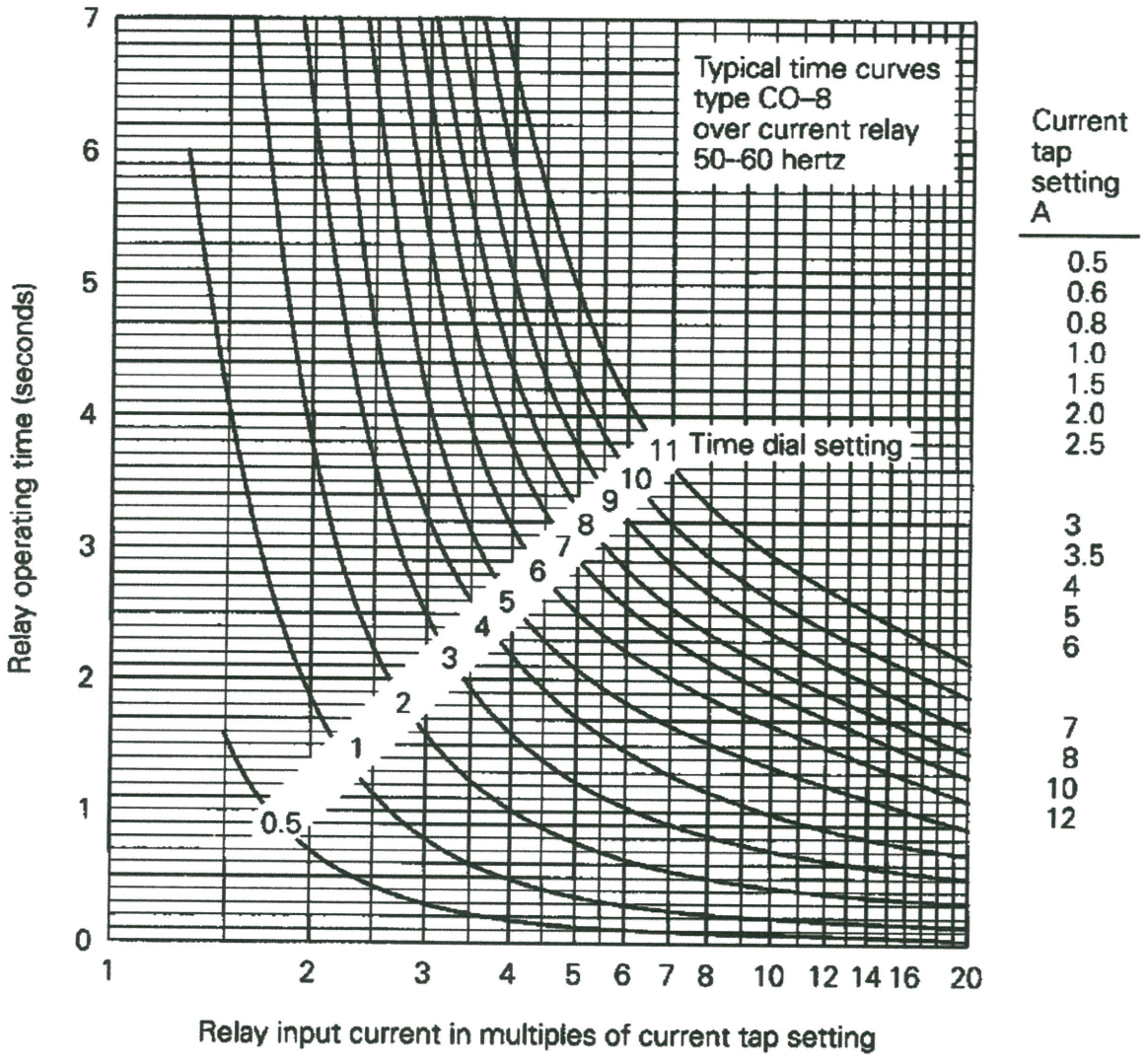

FIGURE Q4(a)(i)

FINAL EXAMINATION

SEMESTER / SESSION	: SEM I / 2015 / 2016	PROGRAMME	: BEV
COURSE	: POWER SYSTEM ANALYSIS AND PROTECTION	COURSE CODE	: BEF43303

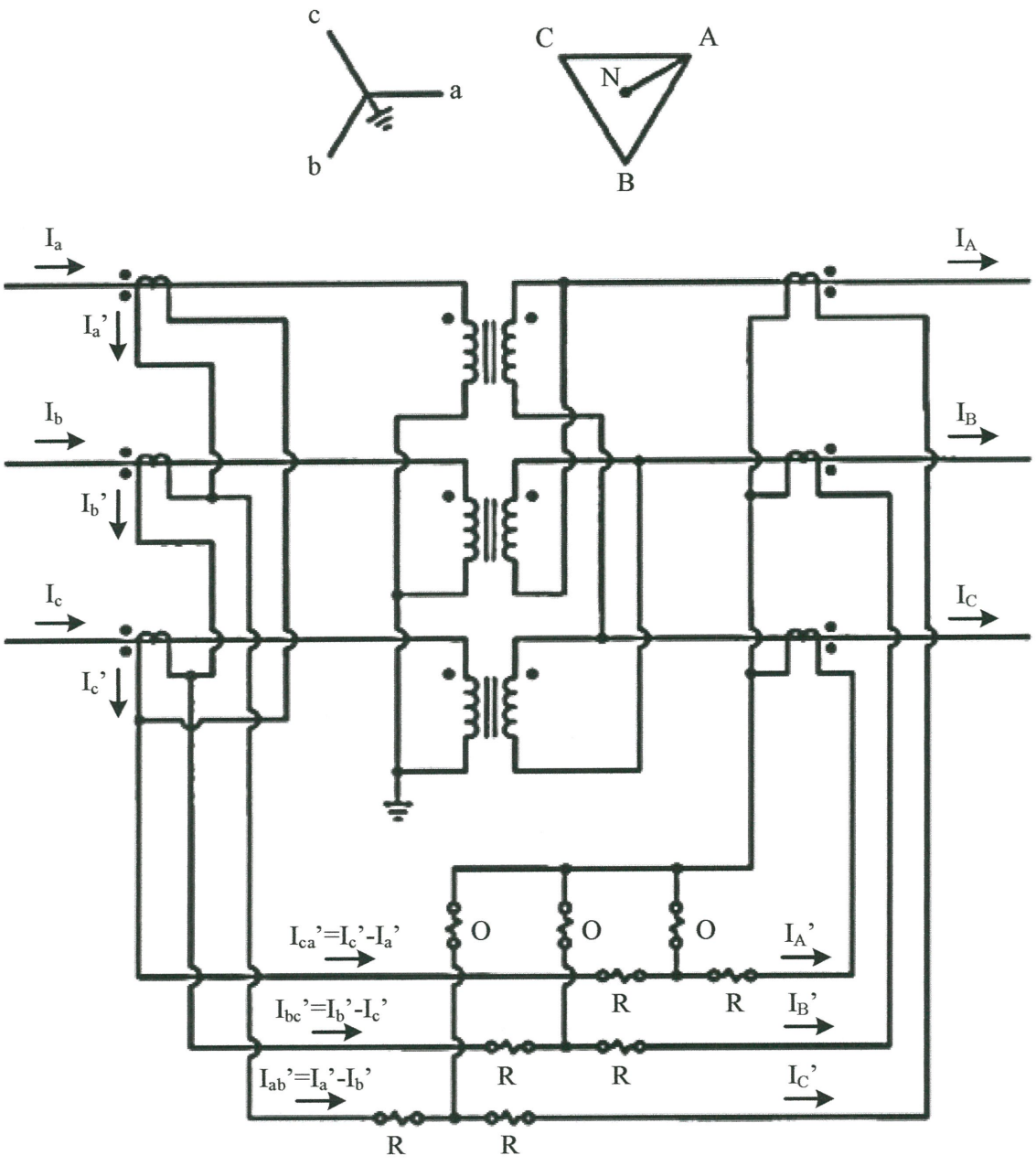

FIGURE Q5(b)

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2015 / 2016
COURSE : POWER SYSTEM ANALYSIS AND PROTECTION
PROGRAMME : BEV
COURSE CODE : BEF43303

TABLE Q1(b)

Device	Rated MVA, S (MVA)	Rated Voltage, V (kV)	Impedance, X (%)
G	110	22	15.0
T1	60	22/500	10.0
T2	60	500/33	7.5
T3	50	22/275	6.5
T4	50	275/33	9.0
M	75.6	34.5	20.0

TABLE Q2(a)

Device	X^0 (pu)	X^1 (pu)	X^2 (pu)
G_1	0.05	0.10	0.10
G_2	0.05	0.10	0.10
T_1	0.10	0.20	0.20
T_2	0.10	0.20	0.20
L_{1-2}	0.20	0.30	0.30

TABLE Q3(b)

Line	Positive Sequence Impedance Z^1 (Ω)	
1-2	$10 + 60i$	
2-3	$10 + 70i$	
2-4	$9 + 45i$	
1-3	$8 + 53i$	
Breaker	CT Ratio	VT Ratio
B_{12}	1500:5	3000:1

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2015 / 2016
COURSE : POWER SYSTEM ANALYSIS AND PROTECTION
PROGRAMME : BEV
COURSE CODE : BEF43303

TABLE Q4(a)

Bus	S (MVA)	Power Factor	Maximum fault current (A)
1	5.0	0.90	2500
2	6.0	0.90	2500

TABLE Q5(b)

Relay tap setting	Relay tap ratio
5:5	1.00
5:5.5	1.10
5:6.6	1.32
5:7.3	1.46
5:8	1.60
5:9	1.80
5:10	2.00