UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	POWER QUALITY
COURSE CODE	:	BEF 44803
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) Discuss the scope and applicability of the Information Technology industry Computer and Business Equipment Manufacturers Association (ITI CBEMA) curve in power quality.

(4 marks)

(b) Calculate the voltage across the load R for the supply voltage $e(t)$ applied to the circuit shown in **Figure Q1(b)**.

$e(t) = 100 + 30\sin(300t + \pi/6) + 20\sin 900t + 15\sin(1500t - \pi/6) + 10\sin 2100t$

(16 marks)

(c) Consider a synchronous generator, with continuous unbalance capability of 0.10 pu given in **Table Q1(c)**. It is subjected to 5^{th} and 7^{th} harmonic loading of 0.07 and 0.04 p.u. respectively. The Ratio K for average loss to maximum loss based on harmonic pair is given in **Figure Q1(c)**. Analyze whether the unbalance capability is exceeded.

(5 marks)

Q2 (a) Determine the **two (2)** benefits of power quality monitoring.

(4 marks)

(b) A delta–wye connected isolation transformer of 13.8 –2.3 kV is required for a 2.3 kV, 3000-hp drive motor connected to a Load Commutated Inverter (LCI), with the following current spectrum:

$I_1 = 693$ A, $I_5 = 121$ A, $I_7 = 79$ A, $I_{11} = 31$ A, $I_{13} = 20$ A, $I_{17} = 11$ A, $I_{19} = 7$ A, $I_{23} = 6$ A, $I_{25} = 5$ A.

Calculate its harmonic loading.
The loss data for the transformer supplied by the manufacturer, and the harmonic frequencies affecting de-rating of the transformer are given in **Table Q2(b)(i)** and **Table Q2(b)(ii)** respectively.

(21 marks)

Q3 (a) An one line diagram of an industrial plant is given in **Figure Q3(a)**. It is supplied from the utility 11 kV, three-phase, multi-grounded neutral distribution feeder. The short circuit data from the utility indicates a three-phase short circuit MVA of 100MVA and X/R ratio of 3.0. The transformer supplying the plant is rated at 1000kVA, 11 kV/415Y V, R = 1.5 %, and X = 5.5 %. The system frequency is 50 Hz. Analyse the parallel resonant frequencies for the following values of the power factor correction capacitors applied to the 415 V bus:

(i) Equivalent system components.

(8 marks)

(ii) 150 kVAr.

(5 marks)

(iii) 300 kVAr.

(3 marks)

(iv) 450 kVAr.

(3 marks)

(b) Assign respective examples and their corresponding total harmonic distortion of voltage (THD_V) at the Point of Common Coupling (PCC) to:

(i) Special system.

(2 marks)

(ii) General system.

(2 marks)

(iii) Dedicated system.

(2 marks)

Q4 (a) An Uninterruptible Power Supply (UPS) is driving a 600W load which has a lagging power factor of 0.8. The efficiency of the inverter is 80%. The battery voltage is $48V_{dc}$. Assume that there is a separate charger for the battery. Determine the following:

(i) kVA rating of the inverter.

(2 marks)

(ii) Wattage of the rectifier.

(2 marks)

(iii) Ampere Hour (AH) rating of the battery for a backup time of 30 minutes.

(4 marks)

(b) Draw the Pulse Width Modulation (PWM) shunt and series compensator.

(4 marks)

(c) A 2000 kVA, 11kV/415V transformer with a leakage reactance of 6.0% feeds a bus. The bus contains a 1000 hp Variable Speed Drives (VSD) that produces 5^{th} and 7^{th} harmonic currents. A 750 kVAR, Y-connected capacitor bank is installed for load power factor correction. The capacitor bank need to be converted to a detuned 5^{th} harmonic filter. Calculate the value of tuning inductor to tune the capacitor bank to the 4.7^{th} harmonic order.

(13 marks)

- END OF QUESTIONS -

FINAL EXAMINATION

SEMESTER / SESSION : I / 2019/2020
COURSE NAME : POWER QUALITY

PROGRAMME CODE: BEV
COURSE CODE: BEF 44803

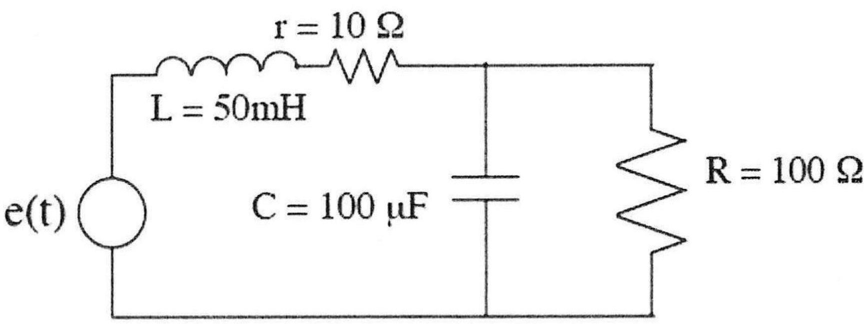

Figure Q1(b)

Table Q1(c)

Type of generator and rating	Permissible I_2 (%)
Salient pole, with connected amortisseur windings	10
Salient pole, with nonconnected amortisseur windings	5
Cylindrical rotor, indirectly cooled	10
Cylindrical rotor, directly cooled	
to 960 MVA	8
961–1200 MVA	6
1201–1500 MVA	5

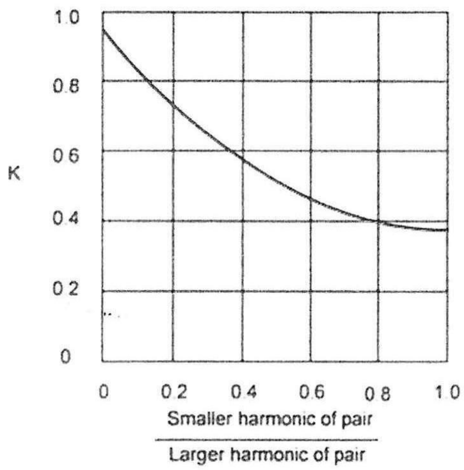

Figure Q1(c)

FINAL EXAMINATION

SEMESTER / SESSION : I / 2019/2020
COURSE NAME : POWER QUALITY

PROGRAMME CODE: BEV
COURSE CODE: BEF 44803

Table Q2(b)(i)

No load loss	3800 W
I^2R loss	20 kW
Eddy current and Stray loss	3200 W
Total load loss	23 kW
Total transformer loss	27 kW
The leakage flux has its maximum concentration between interface of two windings, P_{EC-R}	16% of the I^2R loss

Table Q2(b)(ii)

h	f_h
1	1.0
5	0.175
7	0.111
11	0.045
13	0.029
17	0.015
19	0.010
23	0.009
25	0.008

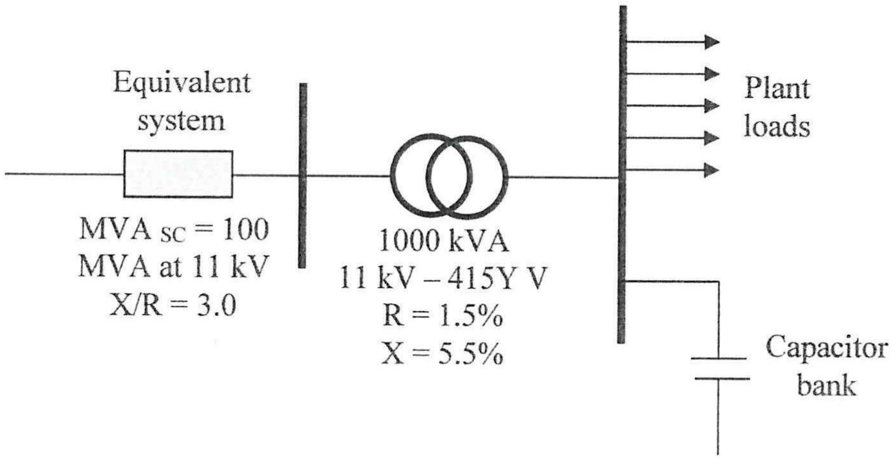

Figure Q3(a)