Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	POWER QUALITY
COURSE CODE	:	BEV 40603
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUTED VIA **CLOSED BOOK** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUTED VIA **CLOSED BOOK**

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) (i) Explain any **two (2)** types of power quality (PQ) problems.

(2 marks)

(ii) Mark and write the names of **four (4)** regions of operation of the ITIC curve shown in **Figure Q1(a)(ii).**

(4 marks)

(b) (i) State the full names of the following abbreviations:
a) CBEMA
b) IEC
c) ITIC
d) ANSI

(4 marks)

(ii) Explain the differences between voltage sag and undervoltage. State the cause of this type of PQ.

(3 marks)

(c) (i) Explain the nature of linear and nonlinear loads and plot its I-V characteristics.

(6 marks)

(ii) A sinusoidal voltage source $Vs(t) = 325.27Cos(314.2t)$ is applied to a nonlinear load, resulting in a non-sinusoidal current which is expressed in Fourier series shown below:

$$i(t) = 10 + 7Cos(314.2t + 28°) + 5Cos(314.2t + 30°) + 1Cos(314.2t + 40°)\ \text{A}$$

Determine:
a) The power absorbed by the load
b) The power factor of the load
c) Distortion factor

(6 marks)

Q2 (a) Demonstrate the significance of total harmonic distortion (THD) with the formula used to calculate it.

(3 marks)

(b) Calculate the percent voltage unbalance, if voltage measurements carried out between the different phases of a three-phase supply gave the following readings:

R-Y = 470 V
Y-B = 472 V
B-R = 450 V

(10 marks)

(c) A Δ-Y 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:

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

The following loss data are supplied by the manufacturer:
No load loss= 3800 W, I^2R loss = 20 kW, Eddy current and stray loss = 3200 W, Total load loss = 23 kW, and Total transformer loss = 27 kW, the leakage flux has its maximum concentration between interface of two windings, PEC-R=16% of the I^2R loss.
Calculate its harmonic loading and the percentage derating.

(12 marks)

Q3 (a) A 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 100 MVA and an X/R ratio of 3.0. The transformer supplying the plant is rated at 1000 kVA, 11 kV – 415Y V, R = 1.5 %, 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) 150 kVAr.

(13 marks)

(ii) 300 kVAr.

(3 marks)

(iii) 450 kVAr.

(3 marks)

(b) Assign respective examples and their corresponding %THD 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) A 3985 kVA load with a 0.7 power factor (PF) produces 5^{th} and 7^{th} harmonic currents. A 7.5 MVA transformer, with 7.16 % impedance, supplies the load at 4160 V. Primary service is 13.8 kV from a utility system having a source impedance of (0.052 + j0.187) Ω. A 2400 kVAR capacitor bank is placed on the 4,160 V secondary to correct the power factor to ≥ 95%.

(i) Draw the system one line diagram.

(2 marks)

(ii) Convert the existing power factor correction capacitor bank to a simple notch filter to remove the lowest order harmonic from the system.

(9 marks)

(iii) Calculate the parallel resonant frequency of the system and sketch its equivalent circuit as seen by a harmonic source.

(3 marks)

(iv) With the help of IEEE regulation of harmonics, comment whether harmonic distortion for this filter is acceptable or not.

(1 mark)

(b) A 37 kW (50 HP), 415 V, three-phase squirrel cage induction motor is started against full load using a direct-on-line starter with rated voltage applied from a source whose impedance including the impedance of the cable is 0.01 + j0.025 Ω/Φ phase. Assuming a locked rotor power factor of 0.4 lagging and locked rotor kVA per HP of 6.

(i) Deduce constant impedance model of the motor.

(8 marks)

(ii) Calculate the voltage drop during starting.

(2 marks)

- END OF QUESTIONS -

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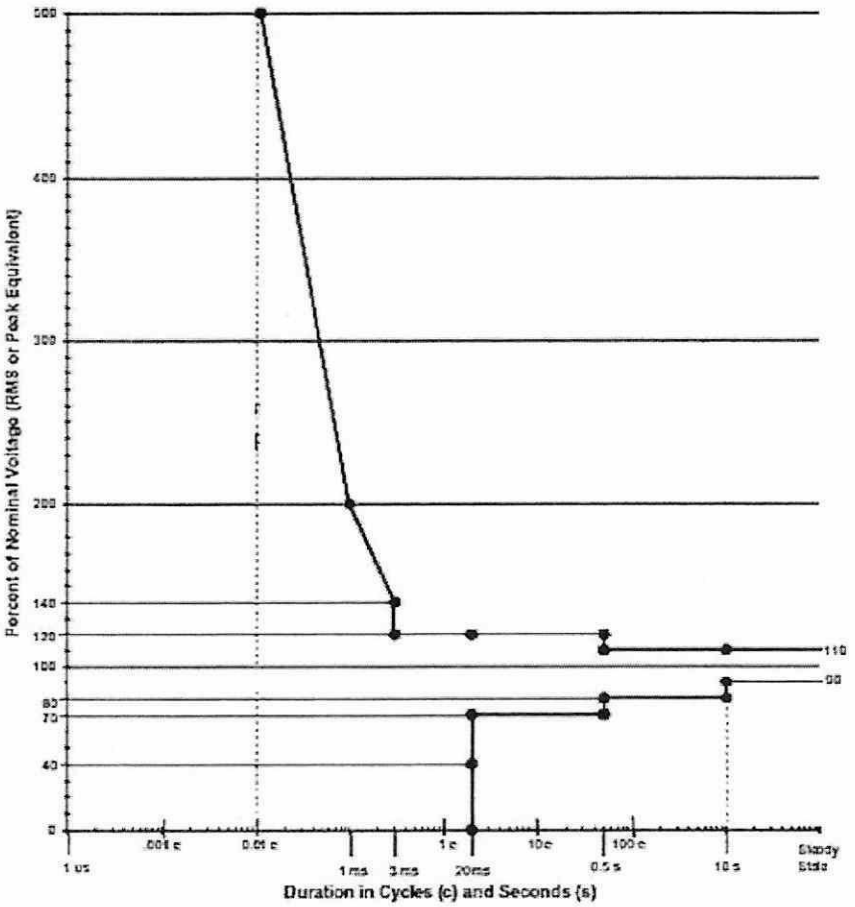

Figure Q1(a)(ii)

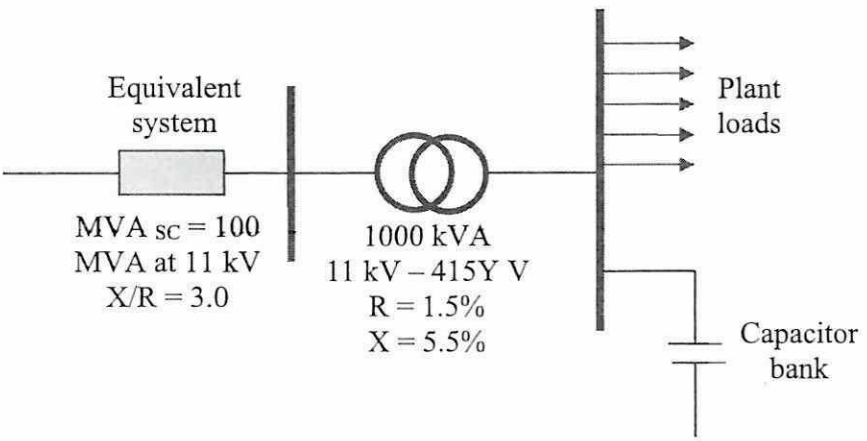

Figure Q3(a)