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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	POWER QUALITY
COURSE CODE	:	BNE 32603
PROGRAMME CODE	:	BNE
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3. STUDENT ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

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

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Q1 (a) **Figure Q1(a)** shows the ITIC/CBEMA curve.

(i) In your own words, explain the application of the ITIC/CBEMA curve.
(2 marks)

(ii) A switchgear busbar is subjected to voltage variations of + 19° and -21 ° from its nominal value lasting for up to 0.40 cycles due to the operation of an automatic welding machine. Argue, whether a device that is compliant with the CBEMA curve shown in **Figure Q1(a)** tolerates these voltage deviations.
(4 marks)

(iii) By referring to the CBEMA curve as shown in **Figure Q1(a)**, predict the impact of the voltage variations if the duration lasts for 100 cycles.
(4 marks)

(b) The power quality industry recognizes that power quality standards are critical to the viability/possibility of the industry.

(i) Suggest **ONE (1)** suitable standard code and names, each, for voltage sag, surge, fluctuation, and harmonic.
(4 marks)

(ii) Differentiate the American power quality standard and the international power quality standard.
(2 marks)

(c) Lightning strikes are one of the main causes of transient in a power system. Give the effects of transient on to the user and utility service provider.
(4 marks)

Q2 (a) A non-linear load connected to 33 kV; 50 Hz feeder absorbs an apparent power of 5000 kVA. It produces 5^{th}, 9^{th}, and 17^{th} harmonic currents of 15%, 20%, and 3% with respect to fundamental current respectively. If the feeder at the point of common coupling (PCC) has a short circuit capacity of 100 MVA, determine:

(i) The harmonic voltage at the connected feeder.
(8 marks)

(ii) The RMS value of the voltage at the connected feeder.
(2 marks)

(iii) The total harmonic distortion of voltage and current.
(4 marks)

(b) Design a simple 7^{th} harmonic filter for a 400 V, three-phase, 50 Hz system where harmonics are produced due to a 5 converted supplied load. The power factor correction approach indicates a need for a 40 kVAR shunt capacitor.
(6 marks)

Q3 (a) Differentiate the types of voltage sags based on IEEE1159 standard.

(6 marks)

(b) Describe **THREE (3)** methods for voltage sag mitigation.

(6 marks)

(c) A three-phase supply with AC mains voltage of 2.5 kV at 60Hz has a voltage sag due to a rural feeder and a nearby factory. A hospital needs a three-phase 415 V, 230 kVA, 0.9 lagging power factor. If the supply current after the voltage sag is 130A, determine the line-to-line supply voltage reduction and its percentage after sag.

(8 marks)

Q4 (a) The voltage measurements carried out between the different phases of a three-phase supply gave the following readings:

$$R\text{-}Y = 579\angle 0^0 \text{ V}$$
$$Y\text{-}B = 462\angle 221.4^0 \text{ V}$$
$$B\text{-}R = 400\angle 124.2^0 \text{ V}$$

Calculate the percent voltage unbalance using:

(i) The maximum deviation method.

(3 marks)

(ii) The symmetrical component method.

(9 marks)

(iii) Determine the differences between the results obtained in **Q4(a)(i)** and **Q4(a)(ii)**, and then discuss them.

(3 marks)

(b) Discuss the function of active power filter (APF) and how they overcome the drawbacks of passive power filter (PPF)

(5 marks)

Q5 (a) (i) Explain the term PQ monitoring.

(1 marks)

(ii) Discuss briefly **TWO (2)** common objectives of PQ monitoring.

(4 marks)

(b) Many power quality variations that occur within customer facilities are related to wiring and grounding problems. Classify **TWO (2)** importance of proper grounding in the electrical installation system.

(4 marks)

(c) The ground rod provides the electrical connection from the power system ground to the earth. Differentiate **THREE (3)** basic components of resistance in a ground rod.

(6 marks)

(d) Develop a neat flow chart to show a case study follow up from a consumer complaint until an economical solution established by a PQ technologist.
(5 marks)

- END OF QUESTIONS -

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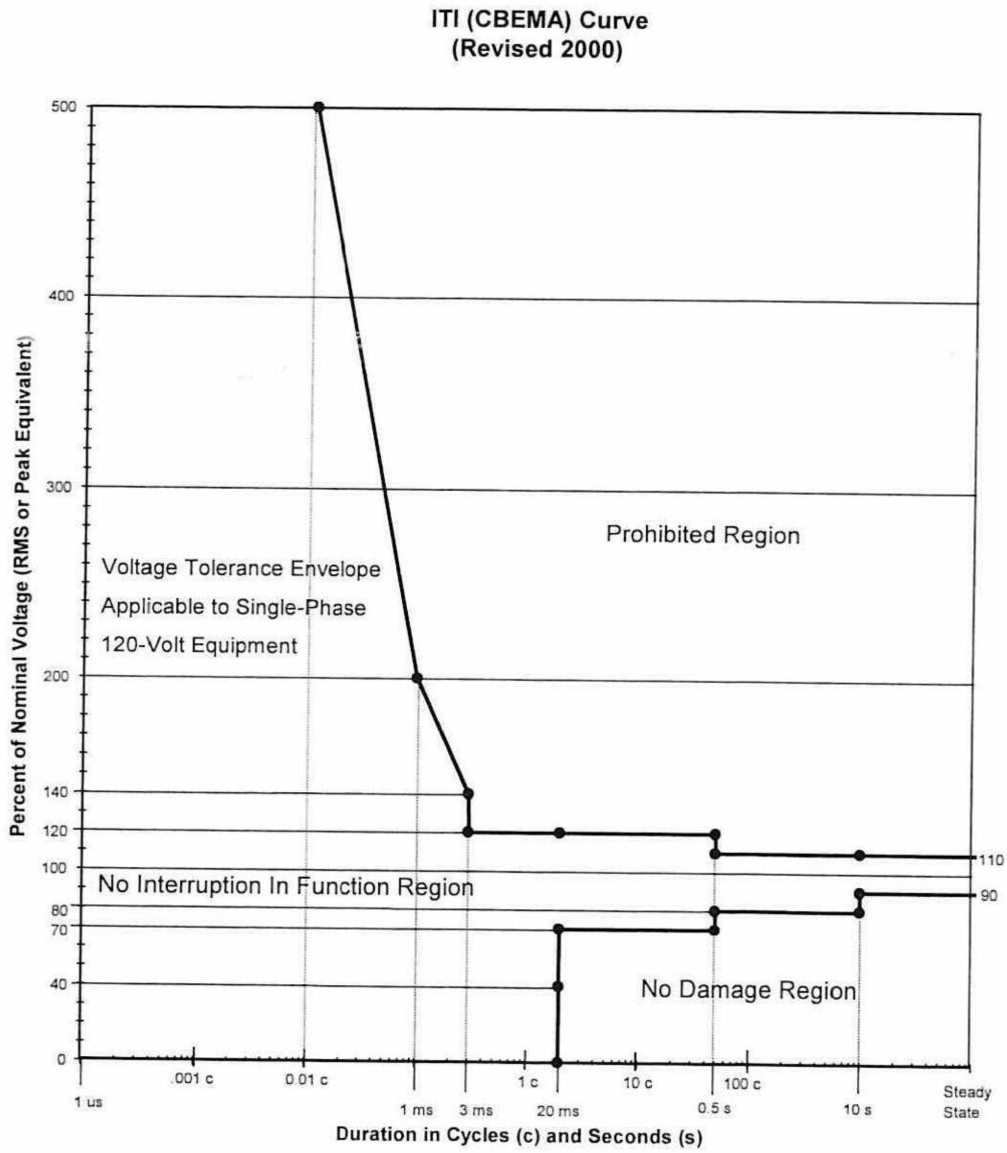

Figure Q1(a)

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APPENDICES

LIST OF EQUATIONS

Average Power	$P_{DC} = V_{DC} I_{avg} = V_{avg} I_{DC}$
Effective values, RMS	$V_{rms} = \sqrt{\sum_{n=1}^{N} V_{n,rms}^2} = \sqrt{V_{1,rms}^2 + V_{2,rms}^2 + V_{3,rms}^2 + \cdots}$ $I_{rms} = \sqrt{\sum_{n=1}^{N} I_{n,rms}^2} = \sqrt{I_{1,rms}^2 + I_{2,rms}^2 + I_{3,rms}^2 + \cdots}$ $V_{rms} = \frac{V_m}{\sqrt{2}}$ $I_{rms} = \frac{I_m}{\sqrt{2}}$
Apparent Power and Power factor	$S = V_{rms} I_{rms}$ $pf = \frac{P}{S} = \frac{P}{V_{rms} I_{rms}} = cos\theta$
Real power	$P = \frac{V_m I_m}{2} cos\theta = \frac{V_m I_m}{2} pf = V_{rms} I_{rms} cos\theta$ $P = \sum_{n=0}^{\infty} P_n = V_0 I_0 + \sum_{n=1}^{\infty} V_{n,rms} I_{n,rms} cos\theta$
Reactive power	$Q = V_{rms} I_{rms} sin\theta$
Distortion factor	$DF = \frac{I_{1,rms}}{I_{rms}} = \sqrt{\frac{1}{1 + THD^2}}$
Total Harmonic Distortion	$THD_i = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1} = \frac{\sqrt{\sum_{n=2}^{\infty} I_{n,rms}^2}}{I_{1,rms}}$ $THD_v = \frac{\sqrt{\sum_{n=2}^{\infty} V_n^2}}{V_1} = \frac{\sqrt{\sum_{n=2}^{\infty} V_{n,rms}^2}}{V_{1,rms}}$