UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)

SEMESTER II
SESSION 2020/2021

COURSE NAME	:	POWER QUALITY
COURSE CODE	:	BEF 44803
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2021
DURATION	:	4 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS (OPEN BOOK EXAMINATION)

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

Q1 (a) You are attending a job interview for the position of power quality engineer. During the interview, one of the interviewers which has no technical background have asked a question regarding the importance of this position. Hence you are required to explain the reasons why both electric utilities and end users of electric power should be very concerned about the quality of electric power.

(5 Marks)

(b) Your first task after being accepted as a power quality engineer is to analyze the situation where a sinusoidal voltage of instantaneous value $v(t) = 200\sqrt{2}\ sin\ (\omega t)$ is applied to a nonlinear load impedance. The resulting instantaneous current is given by:

$$i(t) = \sqrt{2}[20Sin(\omega t - 45^o) + 10Sin(2\omega t + 60^o) + 10Sin(3\omega t + 60^o)]$$

You must determine the following quantities to be included in your analysis report:

(i) Active Power, P

(1 Mark)

(ii) Reactive Power, Q

(1 Mark)

(iii) Distortion Apparent Power, D

(4 Marks)

(iv) Displacement factor, DPF

(2 Marks)

(v) Distortion factor, DF

(1 Mark)

(vi) Power factor, PF

(1 Mark)

(c) Solving any power quality problem requires the right tools and the ability to use them. Like doctors trying to solve a health problem, power quality engineers and technicians need meters and other measurement tools to solve electrical facility health problems. Differentiate **three (3)** methods of measuring the RMS value of a pure sine wave with suitable diagrams.

(10 marks)

Q2 (a) Miss Fanem has performed an analysis for a non-linear load that is connected to 33 kV, 50 Hz feeder absorb an apparent power of 5000 kVA. It produces 5^{th}, 9^{th} and 27^{th} harmonic current of 15%, 20% and 3% with respect to fundamental current respectively. The feeder at the point of common coupling (PCC) has short circuit capacity of 100 MVA. She has found out in her analysis that the total harmonic distortion of voltage and current is around 5% and 25%, respectively. As Miss Fanem's supervisor you must deduce that her analysis is correct or wrong.

(14 Marks)

(b) A one-line diagram of an industrial plant is given in **Figure Q2(b)**. 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 if the value of the power factor correction capacitors applied to the 415 V bus is set to 150 kVAr.

(11 marks)

Q3 (a) A 2000-kVA, 11kV/415V transformer as shown in **Figure Q3(a)** has a leakage reactance of 6.0% feeding a bus containing a 1000-hp Variable Speed Drive (VSD) that produces 5^{th} and 7^{th} harmonic currents. Your predecessor has installed a 750 kVAR Y-connected capacitor bank on the 415-V bus for power factor correction. It is now proposed that the capacitor bank be converted to a detuned 5th harmonic filter. Determine the inductance value of tuning inductor to tune the bank to the 4.7^{th} harmonic order.

(10 marks)

(b) A transient can be defined as the response of an electrical network to a sudden change in network conditions, either intended or accidental. Differentiate impulsive transient and oscillatory transients.

(10 Marks)

(c) An overhead power line is a structure used in electric power transmission and distribution to transmit electrical energy across large distances. Explain overvoltage effects due to a direct stroke to an overhead line.

(5 marks)

Q4 (a) Voltage sag is defined by the IEEE 519 as a sudden reduction of supply (RMS) voltage down from 90% to 10% of nominal. As a research and development engineer, you are required to present your research findings on the things that can be done by the utility, end user and equipment manufacturer to reduce the sensitivity of equipment against voltage sag.

(10 marks)

(b) You and your team engineers have been given a task to size the ampere hour (AH) rating of a backup battery for an uninterruptible power supply (UPS) system. When main fails, the battery supplies power to the inverter for 30 minutes. The UPS is driving a 700 W load which has a lagging power factor of 0.8. The efficiency of the inverter is 85 %. The battery voltage is 48 V_{dc}.

(5 marks)

(c) A three-phase supply with AC mains voltage of 400 V at 50 Hz has a voltage sag of -25 % due to a rural feeder and a nearby factory. A hospital needs a three-phase 415 V, 100 kVA, 0.8 lagging power factor. If a right-shunt unified power quality conditioner (UPQC) is used as a unified power quality compensator as shown in **Figure Q4(c)**, calculate the rating of the shunt and series components of the UPQC to provide rated voltage across the load and to realize unity power factor at the AC mains. Assume both voltage-source converters (VSC) have the same ratings.

(10 marks)

-END OF QUESTIONS -

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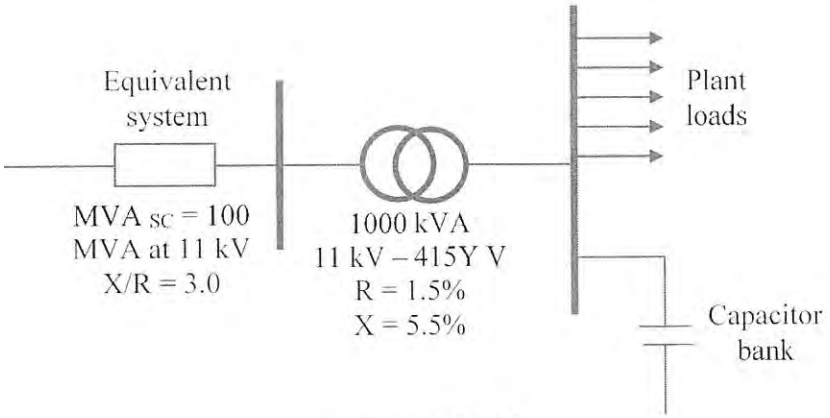

Figure Q2(b)

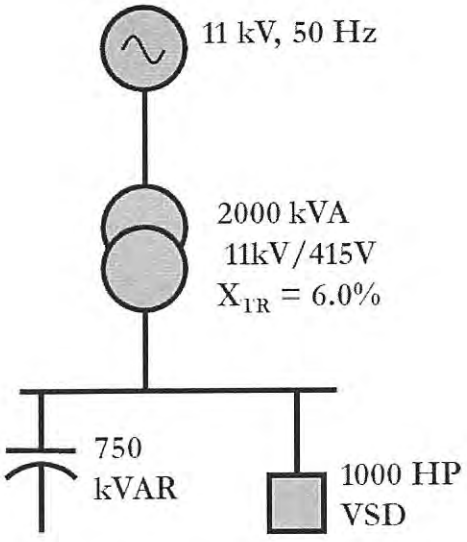

Figure Q3(a)

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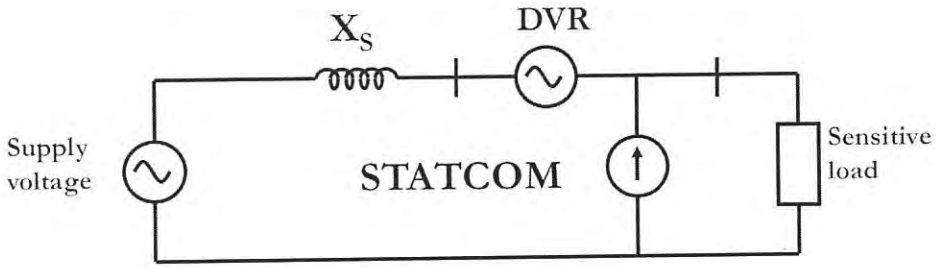

Figure Q4(c)