Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	POWER QUALITY
COURSE CODE	:	BEF 44803
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JUNE/JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) Sketch and explain power quality (PQ) phenomena of harmonic distortion and transient.

(4 marks)

(b) Consider the following voltage and current in single phase system.

$$v(t) = V_{dc} + \sum_{n=1}^{\infty} \frac{\sqrt{2}V_n}{n^2} sin(n\omega t - \emptyset_{vn})$$

With

$$V_{dc} = 10V, {}^{V_n}/_{n^2} = 230\, {}^{\sqrt{2}}/_{n^2} \; and \; \emptyset_{vn} = 0 \; for \; n = 1,3,5,7, \ldots$$

The voltage source supplies a nonlinear current of,

$$i(t) = I_{dc} + \sum_{n=1}^{\infty} \frac{\sqrt{2}\, I_n}{n} sin(n\omega t - \emptyset_{in})$$

with

$$I_{dc} = 2A, I_n = {}^{20}/_{n}\; A \; and \; \emptyset_{in} = n \; x \; 30^0 \; for \; n = 1,3,5,7, \ldots$$

Determine the following:

(i) Instantaneous power {p(t)} W, instantaneous active power {$p_{active}(t)$}, instantaneous reactive power {$p_{reactive}(t)$}, DC power {P_{dc}}, and non-similar frequency terms power {$p_{rest}(t)$}.

(6 marks)

(ii) Active power (P) W, fundamental active power (P_1) W, and harmonic power (P_{II}) W.

(3 marks)

(iii) Reactive power (Q) VAr, fundamental reactive power (Q_1) VAr, and harmonic reactive power (Q_H) VAr.

(3 marks)

(iv) Apparent power (S) VA, fundamental apparent power (S_1) VA, harmonic apparent power (S_H) VA, non-active power (N) VAr, and distortion power (D) VAr.

(9 marks)

Q2 (a) PQ monitoring is the process of gathering, analysing, and interpreting raw measurement data into useful information. Explain the need for PQ monitoring and give **two** (**2**) common objectives of PQ monitoring.

(4 marks)

(b) In today's industrial workplace, the proliferation of solid state devices (lighting ballasts, motor drives and controls, communications equipment, and other DC-powered loads) has created a major problem for specifying engineers, contractors and building owners. The non-linear nature of their switched-mode power supplies

generate harmonic currents that cause transformers and system neutrals to overheat and destroy themselves. K-factor transformers are designed to reduce the heating effects of harmonic currents created by loads. Explain the importance of K-factor and how it can reduce the heating effects in transformer.

(2 marks)

(c) A one line diagram of an industrial plant is given in **Figure Q2(c)**. It is supplied from the utility 11 kV, three-phase, multi-grounded neutral distribution feeder. The short circuit data from the utility indicate 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 %, 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) 150 kVAr
(ii) 300 kVAr
(iii) 450 kVAr

(19 marks)

Q3 (a) Give any **two (2)** sources of harmonics and their respective typical harmonics.

(4 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)

(c) 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 volts. 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 volt 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) Sketch an equivalent circuit of the parallel resonant frequency system 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)

Q4 (a) Draw travelling waves caused by lightning strike.

(4 marks)

(b) With the help of event magnitude with respect to event duration analyse the characteristic of types of interruptions for:

(i) Instantaneous

(2 marks)

(ii) Momentary

(2 marks)

(iii) Temporary

(2 marks)

(iv) Sustained

(2 marks)

(c) 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 ohm per 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

(10 marks)

(ii) Calculate the voltage drop during starting.

(3 marks)

- END OF QUESTIONS -

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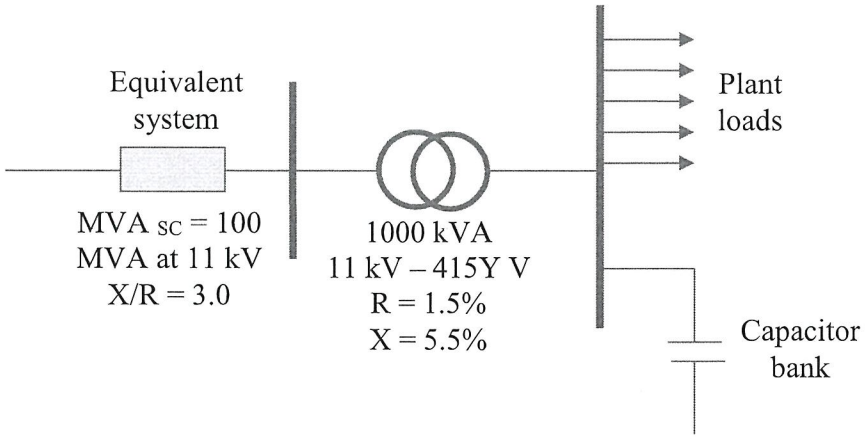

Figure Q2(c)