Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	UTILISATION OF ELECTRICAL ENERGY
COURSE CODE	:	BEF 33203 / BEE 4213 / BEX 42803
PROGRAMME	:	BEV / BEE
EXAMINATION DATE	:	JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) Power Factor is an index used to measure the efficient use of electricity. Describe in brief the important of maintaining high power factor.

(4 marks)

(b) A medium voltage industrial consumer having the following data for its monthly electricity bill:

Time (Hour)	Electricity Consumption per month (kWh)	Reactive Power Consumption per month (kVArh)
8.00am – 12.00pm	40,765	65,456
12.00pm – 5.00pm	43,654	45,811
5.00pm -- 8.00pm	65,654	78,976
8.00pm – 11.00pm	43,781	47,657
11.00pm – 5.00am	22,546	35,678
5.00am- 8.00am	54,758	65,044

The monthly load factor : 71%
Bill date: 1 July 2012
Date of payment: 10 August 2012
Days outstanding :10 days

The penalty charge will be imposed if payment is made later than 30 days after the bill date(The amount is calculated based on 1% (simple interest) of the outstanding bill amount, multiplied by number of days outstanding).

The tariff rate (Tariff E2 – TNB) is shown in Table **Q1 (b)**. Analyse the followings by considering 30 days per month and 4 weeks per month.

(i) The monthly maximum demand for this consumer (assuming 30 days/month)

(5 marks)

(ii) The power factor for this consumer and calculate the total penalty charge due to the poor power factor, if any

(9 marks)

(iii) The total monthly bill charge for this consumer

(7 marks)

Q2 (a) Impedance is a vital factor in voltage drop and short circuit analysis. Define the application of impedance in both type of analysis with its related equation. State two major variables that will give direct effect to impedance.

(4 marks)

(b) A simplified one-line-diagram of a commercial installation is depicted in Figure **Q2(b)**, consisting of a 3-phase motor circuit and two 1-phase load circuits. The details for each component is given in Table **Q2(b)**. Analyse the voltage level received at Load 1 and Load 2 terminals by considering the voltage drop effect. Assume balance 3-phase load at MDP. All calculations must be referred to Appendix A and Appendix B.

(21 marks)

Q3 (a) The presence of harmonics in a motor circuit will cause excessive power losses and torque fluctuation. Elaborate in brief of this power quality phenomenon.

(6 marks)

(b) A 415 V, four-pole, 50-Hz Y-connected induction motor is rated at 5 hp and its equivalent circuit is as shown in Figure **Q3(b)**. Its equivalent circuit components are:

$R_1 = 0.8\ \Omega$, $R_2 = 0.5\ \Omega$, $X_1 = 1.0\ \Omega$, $X_2 = 1.2\ \Omega$ and $X_M = 30\ \Omega$.

The slip of this motor is 5%. The harmonic current spectrum for this motor circuit is given in Table **Q3(b)**.

(i) Determine the base line current (I_1) and the power factor of this motor

(8 marks)

(ii) Obtain the root of the sum of the squares (RSS) and total harmonic distortion (THD) of the current waveform

(6 marks)

(iii) Compare the stator copper losses (given as $3I_1^2R_1$) of this motor between the base current and harmonised current

(5 marks)

Q4 (a) List 4 basic information required in a lighting design for commercial premise.
(4 marks)

(b) A 20 m x 8 m office area is to be illuminated and the illuminance required is 400 lux. Assuming a maintenance factor of 0.8 and utilisation factor of 0.65 for the lighting scheme design. The recommended luminaire for this installation is 2 x 28W T5 fluorescent lamps (total lamp flux is 5250 lumen) comes with high frequency electronic ballasts (with total power consumption of 6 W).

(i) Analyse the total unit of 2 x 28 W T5 fluorescent lamp required
(11 marks)

(ii) Estimate the total power consumed by this installation
(4 marks)

(iii) Draw a scale plan for this office area with proper lamps arrangement
(6 marks)

- END OF QUESTION -

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TABLE Q1(b)

(a) Tariff E2 (Medium Voltage Peak/ Off Peak Industrial Tariff)	**Unit**	**Rates**
For each kilowatt of maximum demand per month	RM/kW	31.70
For all kWh during peak hour	Sen/kWh	30.4
For all kWh during off peak hour	Sen/kWh	18.7
The minimum monthly charge is RM600.00		
(b) Power Factor Penalty Rate		
Below 0.85 and up to 0.75 lagging	1.5% of the bill for that month for each one-hundredth (0.01).	
Below 0.75 lagging, in addition to the charge payable under sub-paragraph (a) above	A supplementary charge of 3% of the bill for that month for each one-hundredth (0.01).	

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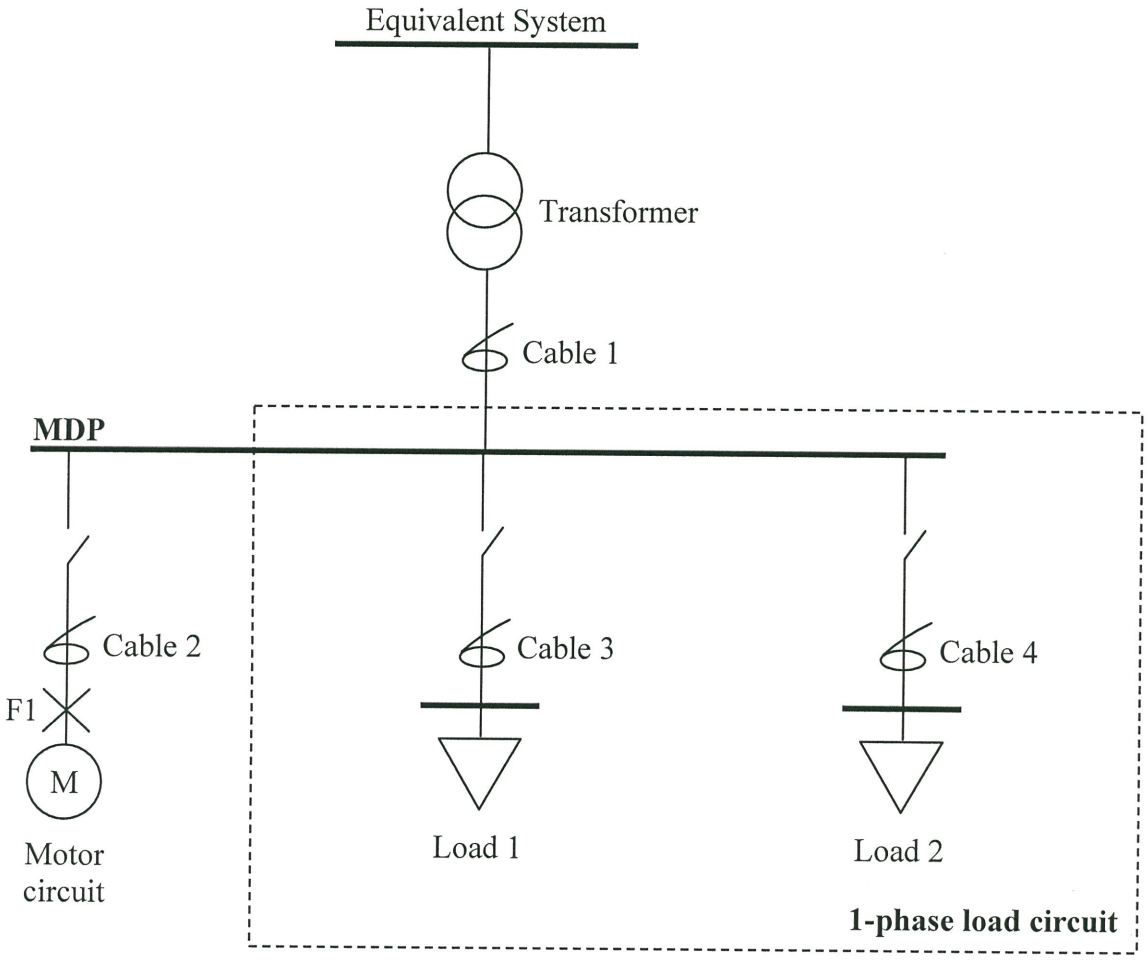

FIGURE Q2(b)

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TABLE Q2(b)

No.	Component	Details
1.	Equivalent system	3-phase MVA = 120 MVA@11 kV, R = 0.3 Ω.
2.	Cable 1	90ft, #4/0 AWG, aluminium conductor, steel conduit.
3.	Transformer	100 kVA, 11kV – 415 V, %Z = 5%, X/R = 3.
4.	Cable 2	30ft, #1/0 AWG, copper conductor, steel conduit.
5.	Cable 3	8 meters, 4 mm^2, enclosed in conduit on a wall.
6.	Motor circuit	Motor: Y-connected, 50 HP@ 415 V, PF = 0.82 lagging, 80% efficiency.
7.	Cable 4	15 meters, 10 mm^2, enclosed in trunking.
8.	Load 1	5 kVA@ 240 V, PF = 0.8 lagging, 70% efficiency.
9.	Load 2	8 kW@ 240 V, PF = 0.9 lagging, 65% efficiency.

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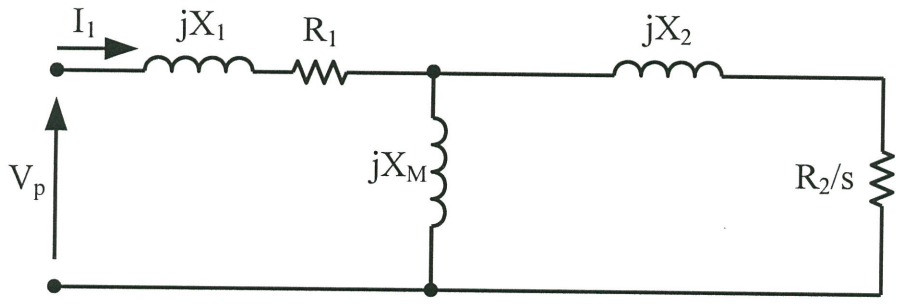

FIGURE Q3(b)

TABLE Q3(b)

Harmonic Order	Amplitude (% of Fundamental)
1	100.0%
5	30.0%
7	13.5%
11	10.5%
13	8.7%

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Appendix A

Alternating-Current Resistance and Reactance for 600-Volt Cables, 3-Phase, 75°C (167°F) – Three Single Conductors in Conduit

Size (AWG or kcmil)	Ohms to Neutral per Kilometer / Ohms to Neutral per 1000 Feet														Size (AWG or kcmil)
	X_L (Reactance) for All Wires		Alternating-Current Resistance for Uncoated Copper Wires			Alternating-Current Resistance for Aluminum Wires			Effective Z at 0.85 PF for Uncoated Copper Wires			Effective Z at 0.85 PF for Aluminum Wires			
	PVC, Aluminum Conduits	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	
14	0.190 0.058	0.240 0.073	10.2 3.1	10.2 3.1	10.2 3.1	- -	- -	- -	8.9 2.7	8.9 2.7	8.9 2.7	- -	- -	- -	14
12	0.177 0.054	0.223 0.068	6.6 2.0	6.6 2.0	6.6 2.0	10.5 3.2	10.5 3.2	10.5 3.2	5.6 1.7	5.6 1.7	5.6 1.7	9.2 2.8	9.2 2.8	9.2 2.8	12
10	0.164 0.050	0.207 0.063	3.9 1.2	3.9 1.2	3.9 1.2	6.6 2.0	6.6 2.0	6.6 2.0	3.6 1.1	3.6 1.1	3.6 1.1	5.9 1.8	5.9 1.8	5.9 1.8	10
8	0.171 0.052	0.213 0.065	2.56 0.78	2.56 0.78	2.56 0.78	4.3 1.3	4.3 1.3	4.3 1.3	2.26 0.69	2.26 0.69	2.30 0.70	3.6 1.1	3.6 1.1	3.6 1.1	8
6	0.167 0.051	0.210 0.064	1.61 0.49	1.61 0.49	1.61 0.49	2.66 0.81	2.66 0.81	2.66 0.81	1.44 0.44	1.48 0.45	1.48 0.45	2.33 0.71	2.36 0.72	2.36 0.72	6
4	0.157 0.048	0.197 0.060	1.02 0.31	1.02 0.31	1.02 0.31	1.67 0.51	1.67 0.51	1.67 0.51	0.95 0.29	0.95 0.29	0.98 0.30	1.51 0.46	1.51 0.46	1.51 0.46	4
3	0.154 0.047	0.194 0.059	0.82 0.25	0.82 0.25	0.82 0.25	1.31 0.40	1.35 0.41	1.31 0.40	0.75 0.23	0.79 0.24	0.79 0.24	1.21 0.37	1.21 0.37	1.21 0.37	3
2	0.148 0.045	0.187 0.057	0.62 0.19	0.66 0.20	0.66 0.20	1.05 0.32	1.05 0.32	1.05 0.32	0.62 0.19	0.62 0.19	0.66 0.20	0.98 0.30	0.98 0.30	0.98 0.30	2
1	0.151 0.046	0.187 0.057	0.49 0.15	0.52 0.16	0.52 0.16	0.82 0.25	0.85 0.26	0.82 0.25	0.52 0.16	0.52 0.16	0.52 0.16	0.79 0.24	0.79 0.24	0.82 0.25	1
1/0	0.144 0.044	0.180 0.055	0.39 0.12	0.43 0.13	0.39 0.12	0.66 0.20	0.69 0.21	0.66 0.20	0.43 0.13	0.43 0.13	0.43 0.13	0.62 0.19	0.66 0.20	0.66 0.20	1/0
2/0	0.141 0.043	0.177 0.054	0.33 0.10	0.33 0.10	0.33 0.10	0.52 0.16	0.52 0.16	0.52 0.16	0.36 0.11	0.36 0.11	0.36 0.11	0.52 0.16	0.52 0.16	0.52 0.16	2/0
3/0	0.138 0.042	0.171 0.052	0.253 0.077	0.269 0.082	0.259 0.079	0.43 0.13	0.43 0.13	0.43 0.13	0.289 0.088	0.302 0.092	0.308 0.094	0.43 0.13	0.43 0.13	0.46 0.14	3/0
4/0	0.135 0.041	0.167 0.051	0.203 0.062	0.220 0.067	0.207 0.063	0.33 0.10	0.36 0.11	0.33 0.10	0.243 0.074	0.256 0.078	0.262 0.080	0.36 0.11	0.36 0.11	0.36 0.11	4/0
250	0.135 0.041	0.171 0.052	0.171 0.052	0.187 0.057	0.177 0.054	0.279 0.085	0.295 0.090	0.282 0.086	0.217 0.066	0.230 0.070	0.240 0.073	0.308 0.094	0.322 0.098	0.33 0.10	250
300	0.135 0.041	0.167 0.051	0.144 0.044	0.161 0.049	0.148 0.045	0.233 0.071	0.249 0.076	0.236 0.072	0.194 0.059	0.207 0.063	0.213 0.065	0.269 0.082	0.282 0.086	0.289 0.088	300
350	0.131 0.040	0.164 0.050	0.125 0.038	0.141 0.043	0.128 0.039	0.200 0.061	0.217 0.066	0.207 0.063	0.174 0.053	0.190 0.058	0.197 0.060	0.240 0.073	0.253 0.077	0.262 0.080	350
400	0.131 0.040	0.161 0.049	0.108 0.033	0.125 0.038	0.115 0.035	0.177 0.054	0.194 0.059	0.180 0.055	0.161 0.049	0.174 0.053	0.184 0.056	0.217 0.066	0.233 0.071	0.240 0.073	400
500	0.128 0.039	0.157 0.048	0.089 0.027	0.105 0.032	0.095 0.029	0.141 0.043	0.157 0.048	0.148 0.045	0.141 0.043	0.157 0.048	0.164 0.050	0.187 0.057	0.200 0.061	0.210 0.064	500
600	0.128 0.039	0.157 0.048	0.075 0.023	0.092 0.028	0.082 0.025	0.118 0.036	0.135 0.041	0.125 0.038	0.131 0.040	0.144 0.044	0.154 0.047	0.167 0.051	0.180 0.055	0.190 0.058	600

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Appendix B

Tabulated Table of Voltage Drop in mV/A/m
(Source: IEE Wiring Regulations (17th Edition, BS7671: 2008, Appendix 4, Table 4D2B)

VOLTAGE DROP (per ampere per metre) — Conductor operating temperature: 70°

Conductor cross-sectional area	Two-core cable, d.c.	Two-core cable, single phase a.c.			Three- or four-core cable, three-phase a.c.		
1	2	3			4		
(mm^2)	(mV/A/m)	(mV/A/m)			(mV/A/m)		
1	44	44			38		
1.5	29	29			25		
2.5	18	18			15		
4	11	11			9.5		
6	7.3	7.3			6.4		
10	4.4	4.4			3.8		
16	2.8	2.8			2.4		
		r	x	z	r	x	z
25	1.75	1.75	0.170	1.75	1.50	0.145	1.50
35	1.25	1.25	0.165	1.25	1.10	0.145	1.10
50	0.93	0.93	0.165	0.94	0.80	0.140	0.81
70	0.63	0.63	0.160	0.65	0.55	0.140	0.57
95	0.46	0.47	0.155	0.50	0.41	0.135	0.43
120	0.36	0.38	0.155	0.41	0.33	0.135	0.35
150	0.29	0.30	0.155	0.34	0.26	0.130	0.29
185	0.23	0.25	0.150	0.29	0.21	0.130	0.25
240	0.180	0.190	0.150	0.24	0.165	0.130	0.21
300	0.145	0.155	0.145	0.21	0.135	0.130	0.185
400	0.105	0.115	0.145	0.185	0.100	0.125	0.160