Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	UTILISATION OF ELECTRICAL ENERGY
COURSE CODE	:	BEF 33203
PROGRAMME	:	BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	DECEMBER 2015 / JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) Express the following terms with brief characteristic and equation for a distribution system:

(i) The load factor.

(2 marks)

(ii) The diversity factor.

(2 marks)

(b) A medium industrial voltage consumer having the following monthly electrical power consumptions data for September 2015 usage.

Time (Hour)	Electricity Consumption per month (kWh)	Reactive Power Consumption per month (kVArh)
0800 – 1200	45,155	75,400
1200 – 1600	48,650	60,800
1600 – 2000	70,655	78,900
2000 – 2200	48,780	55,600
2200 – 0500	27,540	40,600
0500 – 0800	59,750	65,050

Table Q1(b) specifies the corresponds tariff rate (Tariff E2s – TNB) used to calculate the electrical bill on this premise. Assume the load factor of 70 %, analyse:

(i) the monthly maximum load demand of this consumer.

(5 marks)

(ii) the average power factor and the total penalty charge due to the poor power factor.

(9 marks)

(iii) the total monthly bill charge for this consumer.

(2 marks)

Q2 (a) Explain the important of X/R ratio consideration in low voltage short circuit studies.

(3 marks)

(b) A lecture hall has been installed with 60 fluorescent lamps, each with 40 Watts capacity output power (inclusive ballast consumption) using a 35 m length of 1.5 mm^2 cable. Single phase 240 $V_{r.m.s}$ voltage is used from the public low distribution system, and consider the voltage drop standard (17^{th} Edition of IEE Wiring Regulations) such as specified in **Table Q2(b)** is generated. By assuming the average power factor for this lighting system is at 0.95 lagging, calculate:

(i) the voltage drop for this installation.

(8 marks)

(ii) the new cable size.

(2 marks)

(iii) the new voltage drop percentage for new cable size.

(2 marks)

(c) A three phase 65 HP motor code letter K (locked-rotor kVA / HP ratio ranging from 8.0 – 9.0) for induction motor is to be started using three- phase 415 $V_{r.m.s}$ supply voltage, that is taken from the panel distribution board using a 30 m length, 35 mm^2 three-core cable. Evaluate the percentage of voltage drop in the cable during the motor starting, by assuming the locked-rotor power factor is at 0.40 lagging.

(5 marks)

Q3 (a) Power quality is basically concerns about voltage and current qualities. Describe the responsibilities of the utility company in the power quality problem.

(2 marks)

(b) Calculate the value of reactive power produced by capacitor bank Q_c, that caused parallel resonant frequency at 3rd order harmonic on the three-phase 415 $V_{r.m.s}$, 60Hz at the electrical load that having a total system impedance Z_{sys} of $0.05 + j2\pi f(15\mu H)\Omega$.

(4 marks)

(c) A 600 kVA, three-phase 415 $V_{r.m.s}$ power system is supplied to the university student residential premise in Taman Universiti, Parit Raja were having a harmonic generated from the load. Its total impedance Z_{sys} is $0.025 + j2\pi f(10\mu H)\Omega$. **Table Q3(c)** specifies the harmonic spectrum produced in the system.

Calculate:

(i) the root sum squares (RSS) and the total harmonic distortion (THD) voltages produced in the system without the power factor correction connected.

(7 marks)

(ii) the new root sum squares (RSS) and the total harmonic distortion (THD) voltages produced in the system with the power factor correction connected.

(7 marks)

Q4 (a) Explain the concept of harmonic distortion produced by nonlinear load.

(2 marks)

(b) Propose a logical condition of three phase lines that are using the "*Combine Neutral Earthing*" (TNC) type earthing arrangement.

(7 marks)

(c) The spotlights illuminated at UTHM Stadium field area are considered using the metal halide type lamps. The layout is given in **Figure Q4(c)**. The approximate height of the spotlight tower is 30 m. The average brightness receives at point "C" should be 1000 lux as supplied from the light sources of L1, L2, L3 and L4.

Examine:

(i) the total number of lamp used if the following information are considered:

- Lamp wattage = 600 Watts
- Luminous efficacy = 50 lumen / Watt
- Utilisation and maintenance factor = 10 % each

(9 marks)

(ii) the total electricity bill charged if the area is occupied for 4 hours at night. Consider the utility charge to be at RM 0.20 for every single kWh usage.

(2 marks)

Q5 (a) Illustrate the schematic diagram and working concept of the Static VAR Compensator (SVC).

(4 marks)

(b) The main objective for lighting designer is to provide good quality and quantity of light in the area to be illuminated. Thus, is crucial for him/her to have a good understanding about the concept behind the illumination technology.

Explain in brief:

(i) the working concept of illuminance in the light.

(4 marks)

(ii) the working concept of luminus intensity in the light.

(4 marks)

(c) Propose the electro-atomic illumination principle of florescent light.

(8 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER/SESSION	: SEM I / 2015 / 2016	PROGRAMME	: BEV
COURSE	: UTILISATION OF ELECTRICAL ENERGY	COURSE CODE	: BEF 33203

TABLE Q1(b)

(a) Tariff E2s (Special Industrial Tariff)	Unit	Rates
For each kilowatt of maximum demand per month	RM/kW	26.50
For all kWh during peak hour	Sen/kWh	28.5
For all kWh during off peak hour	Sen/kWh	15.1
The minimum monthly charge is RM600.00 Off-peak hours (10.00 p.m. to 8.00 a.m.) every day		
(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).	

TABLE Q2(c)

Tariff E2s – TNB		
Type of Supply	**Lighting**	**Other uses**
(i) Low voltage installation supplied directly from a public low voltage distribution system	3%	5%
(ii) Low voltage installation supplied from private LV supply	6%	8%

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2015 / 2016 PROGRAMME : BEV
COURSE : UTILISATION OF ELECTRICAL ENERGY COURSE CODE : BEF 33203

TABLE Q3(c)

Frequency (Hz)	Harmonic Order	Line Current Magnitude (A)
250	5	70
350	7	30
550	11	15

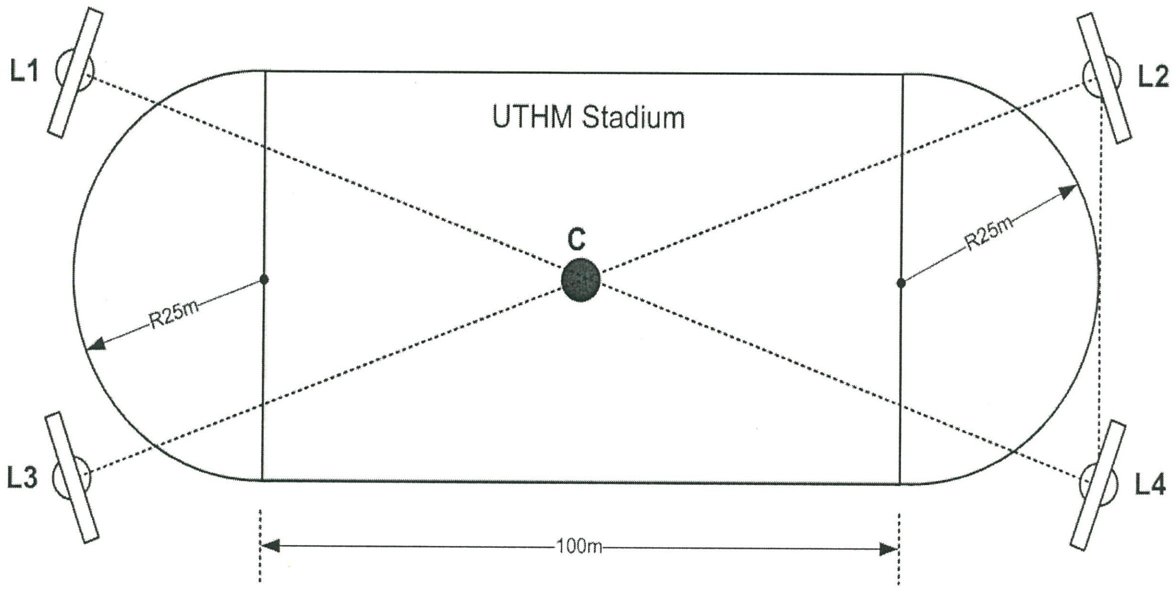

FIGURE Q4(c)

FINAL EXAMINATION

SEMESTER/SESSION	: SEM II/ 2015 / 2016	PROGRAMME	: BEV
COURSE	: UTILISATION OF ELECTRICAL ENERGY	COURSE CODE	: BEF 33203

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

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2015 / 2016 PROGRAMME : BEV
COURSE : UTILISATION OF ELECTRICAL ENERGY COURSE CODE : BEF 33203

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 1	Two-core cable, d.c. 2	Two-core cable, single phase a.c. 3			Three- or four-core cable, three-phase a.c. 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

FINAL EXAMINATION

SEMESTER/SESSION	: SEM I / 2015 / 2016	PROGRAMME	: BEV
COURSE	: UTILISATION OF ELECTRICAL ENERGY	COURSE CODE	: BEF 33203

Appendix C

Table of Asymmetrical Current Factors

System X/R Ratio	Instantaneous Peak Factor	Half-Cycle Factor	Time of Peak tp (ms)
0.0	1.4142	1.000	4.2
0.1	1.4142	1.000	4.4
0.2	1.4142	1.000	4.7
0.3	1.4149	1.000	4.9
0.4	1.4181	1.000	5.2
0.5	1.4250	1.000	5.4
0.6	1.4362	1.000	5.5
0.7	1.4511	1.000	5.7
0.8	1.4692	1.001	5.8
0.9	1.4897	1.002	5.9
1.0	1.5122	1.002	6.1
2.0	1.7560	1.042	6.8
3.0	1.9495	1.115	7.1
4.0	2.0892	1.191	7.4
5.0	2.1924	1.263	7.5
6.0	2.2708	1.304	7.6
7.0	2.3323	1.347	7.7
8.0	2.3817	1.381	7.8
9.0	2.4222	1.412	7.8
10.0	2.4561	1.438	7.9
20.0	2.6256	1.570	8.1
30.0	2.6890	1.618	8.2
40.0	2.7224	1.643	8.2
50.0	2.7427	1.662	8.2
100.0	2.7848	1.697	8.3
infinity	2.8284	1.732	8.3

Appendix D

Table of Standard Protective Devices

(Source: IEE Wiring Regulations (17th Edition, BS7671: 2008)
Type C circuit-breakers to BS EN 60898 with U_0 of 230 V

Rating, I_n (amperes)	6	10	16	20	25	32	40	50	63	80	100	125

FINAL EXAMINATION

SEMESTER/SESSION	: SEM I / 2015 / 2016	PROGRAMME	: BEV
COURSE	: UTILISATION OF ELECTRICAL ENERGY	COURSE CODE	: BEF 33203

Appendix E

Table of standard multicore 70 °C thermoplastic insulated and thermoplastic sheathed cables,
Non-armoured
(COPPER CONDUCTORS)

Ambient temperature: 30 °C

CURRENT-CARRYING CAPACITY (amperes): Conductor operating temperature: 70 °C

Conductor cross-sectonal area	Reference Method A (enlosed in conduit in thermally insulating wall etc.)		Reference Method B (enclosed in conduit on a wall or in trunking etc.)		Reference Method C (clipped directly)		Reference Method E (in free air or on a perforated cable tray etc, horizontal or vertical)	
	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.
1	2	3	4	5	6	7	8	9
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
1	11	10	13	11.5	15	13.5	17	14.5
1.5	14	13	16.5	15	19.5	17.5	22	18.5
2.5	18.5	17.5	23	20	27	24	30	25
4	25	23	30	27	36	32	40	34
6	32	29	38	34	46	41	51	43
10	43	39	52	46	63	57	70	60
16	57	52	69	62	85	76	94	80
25	75	68	90	80	112	96	119	101
35	92	83	111	99	138	119	148	126
50	110	99	133	118	168	144	180	153
70	139	125	168	149	213	184	232	196
95	167	150	201	179	258	223	282	238
120	192	172	232	206	299	259	328	276
150	219	196	258	225	344	299	379	319
185	248	223	294	255	392	341	434	364
240	291	261	344	297	461	403	514	430
300	334	298	394	339	530	464	593	497
400	-	-	470	402	634	557	715	597

* with or without a protective conductor