Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

COURSE	:	UTILISATION OF ELECTRICAL ENERGY
COURSE CODE	:	BEF 33203
PROGRAMME	:	BEV
EXAMINATION DATE	:	DECEMBER 2016/JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

Q1 (a) Electrical power is delivered to the users through **four (4)** distribution levels. Sketch and label the block diagram of distribution levels with standard voltage rating.

(4 marks)

(b) **Table Q1(b)** gives the connected loads for a new constructed single-storey semi-detached house. The incoming supply is taken from 240 V_{LN}, 50 Hz.

(i) Analyse the maximum demand for this domestic installation. Consider 70% of diversity factor

(2 marks)

(ii) Recommend the proper rating of residual current operated circuit breakers (RCCB) and main switch. Refer to **Table Q1(b)(ii).** Note that two RCCB must be considered, that is for general lighting / fan circuit and power circuit applications

(3 marks)

(iii) Analyse the proper rating of each miniature circuit breaker (MCB) used in accordance with the information shown in the **Table Q1(b)(ii)**. The wiring rule is restricted to the followings:

- One outgoing MCB serving 10 lighting / fan point
- One outgoing MCB serving 3 SSO 13 A / 15 A
- One outgoing MCB serving 1 air conditioning / water heater point

(11 marks)

Q2 (a) There are four types of current in electrical system which are normal, overload, short-circuit and ground-fault current. Compare **two (2)** different condition between short-circuit current and ground-fault current.

(4 marks)

(b) **Figure Q2(b)** shows a three-phase industrial distribution system. A balanced three-phase fault had occurred at *F2.*

Calculate:

(i) The root mean square (r.m.s) fault current

(12 marks)

(ii) The root mean square (r.m.s) instantaneous asymmetrical short circuit magnitude

(2 marks)

(iii) The root mean square (r.m.s) half-cycle asymmetrical short circuit magnitude

(2 marks)

Q3 (a) Discuss **three (3)** possible consequences of poor power quality for industrial plant such as factories.

(6 marks)

(b) A three-phase 415 V commercial installation having the total loading of (88 + j47.5) kVA with the total system impedance of 5%.

(i) Evaluate the total reactive power to be supplied by a capacitor bank in order to improve the overall power factor of the system to unity power factor.

(1 mark)

(ii) If a total reactive power of 72.5 kVAr is accidentally injected into the system, determine the percentage of voltage rise for this system due to the severe over-correct event.

(4 marks)

(c) A 50 Hz, 415 V small-scale industrial plant having a total system impedance (Z_{sys}) of 0.003 + j2πf (30μH) Ohms. The power system supplies a 500 kVA harmonic-producing load that has the harmonic spectrum as given in **Table Q3(c)**.

(i) Determine the reactive power for the power factor correction capacitors that might cause parallel resonant frequency at 5^{th} order harmonic.

(4 marks)

(ii) Suggest the root of the sum of the squares (RSS) and the total harmonic distortion (THD) of the bus voltage without the power factor correction connected.

(5 marks)

Q4 (a) Describe **three (3)** main purposes of having a good earthing system in building installation.

(6 marks)

(b) The purpose of primary protection devices is to protect installations against overvoltage such as direct strokes of lightning.

i) Sketch and label representation of overvoltage characteristic (plot voltage versus time).

(3 marks)

ii) With the help of appropriate illustration, describe **three (3)** types of primary protection that can be used as protection scheme for a building.

(6 marks)

(c) A single phase motor circuit is protected by a 63A circuit breaker. A fault occurs and causes a current of 98 A to flow through the earth continuity path. Due to the poor contact of lock nut and bush connecting a steel conduit to a metal box, the resistance of this conduit connection alone is 0.5 Ω. Regulation D22 regarding the basic earthing requirements is given in **Table Q4(c)**.

(i) Predict whether the protective device will be damaged.

(2 marks)

(ii) Estimate the amount of heat produced at the metal box.

(2 marks)

(iii) Suggest the degree of risk of a fire developing.

(1 marks)

Q5 (a) A circular exhibition hall measuring at 10 meters in diameter is to be illuminated to a level of 350 Lux. Utilisation and maintenance factors are to be taken as 0.65 and 0.85, respectively. Estimate the power required to illuminate the hall if;

(i) using energy-saving T5 fluorescent lamp, having an efficacy of 64 lm/ W.

(3 marks)

(ii) using LED lighting, having an efficacy of 85 lm/ W.

(3 marks)

(b) A commercial building having fluorescent lighting load comprising of 26 Nos. of 18 W and 180 Nos. of 36 W. The building is to be upgraded to "Certified Green Building" status. Considering the following facts listed below and based on the given data in **Table Q5(b)**, predict the total energy savings and payback period if all the fluorescent lamps are to be replaced by 1 x 9 W LED light bulbs.

- Lighting is required for 4380 hours/year
- Cost of electricity is RM 0.312 per kWh.
- Replacement cost is RM 35 per unit
- Each of the fluorescent ballast consumption as 8 W.

(14 marks)

– END OF QUESTIONS –

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Table Q1(b)

No.	Load Type	Quantity (No)
1	Down light point (Take 50 W per Nos)	13
2	Wall light point (Take 50 W per Nos)	3
3	Ceiling fan point (Take 80 W per Nos)	6
4	SSO 13 A (Take 300 W per Nos)	14
5	SSO 15 A (Take 500 W per Nos)	3
6	1.5 kW water heater point	1
7	Air conditioning point (1.5 HP)	1

Table Q1(b)(ii)

Type of Protective Device	Standard Rating (A)
MCB	1, 3, 6, 10, 16, 20, 25, 32, 40, 50, 63
RCCB/ Main switch	40, 63

Table Q3(c)

Frequency (Hz)	Harmonic Order	Line Current Magnitude (A)
250	5	65
350	7	40
550	11	25

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Table Q4(c)

Regulation D22 (Basic Earthing Requirements)
States that earth leakage protection may be provided by means of fuses or excess current circuit breakers if the earth fault current available to operate the protective device and so make the faulty circuit dead exceeds: 1. 3 times the current rating of any semi enclosed fuse or any cartridge fuse having a fusing factor exceeding 1.5, used to protect the circuit, or 2. 2.4 times the rating of any cartridge fuse having a fusing factor not exceeding 1.5, used to protect the circuit, or 3. 1.5 times the tripping current of any excess current circuit breaker used to protect the circuit.

Table Q5(b)

Type of lamp	Luminous flux
18 W fluorescent lamp	1200 lumens
36 W fluorescent lamp	2650 lumens
9 W LED light bulb	1300 lumens

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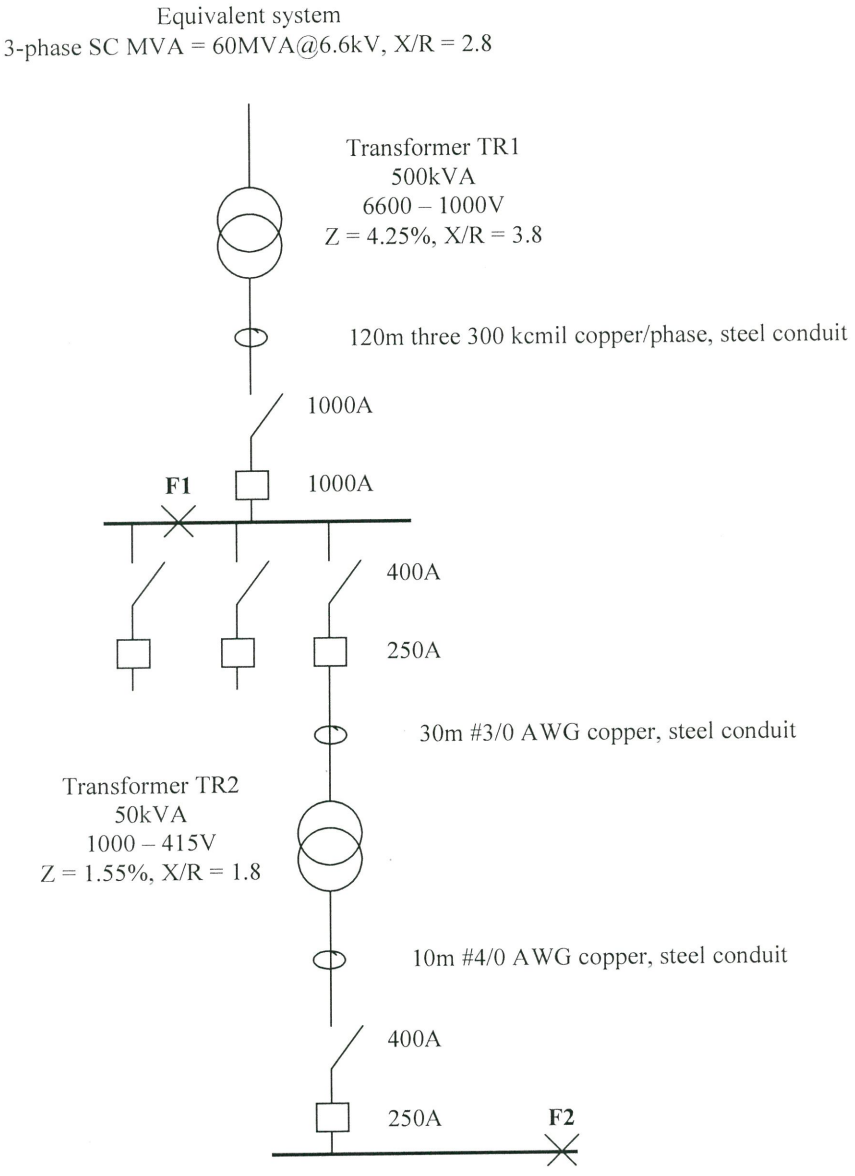

Figure Q2(b)

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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

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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

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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
(mm^2)	(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