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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: ECX4234/EEX4534 Electrical Installations**
Academic Year	: 2017/18
Date	: 22nd January 2019
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. This question paper consists of two sections, **Section A** and **Section B** with **Eight (8)** questions in **Fourteen (14)** pages.
2. Answer **Five (5)** questions selecting only **One (1)** question from **Section B.**
3. **Question #1** carry **36** marks. All the other questions carry **16 equal marks.**
4. **Attach Page [8] of [14] to your answer script, if answered.**
5. Answer for each question should commence from a new page.
6. Relevant figures and tables are attached to this question paper
7. **Zero (0)** marks will be given if formulas used for the computation of factors for cable rating calculations.
8. This is a Closed Book Test (CBT).
9. Answers should be in clear hand writing.
10. Do not use Red colour pen.

Section A-Electrical Installation

1. A single phase 230 V, electric appliance is to be fed from a distribution board as shown in figure Q1. The PVC insulated copper (thermo-plastic) cable circuit recommended for this installation is enclosed in a conduit with 2 other similar size cable circuits embedded in a wall. The maximum and minimum ambient temperatures at the installation are observed to be 30^0C and 32 ^{0}C respectively.

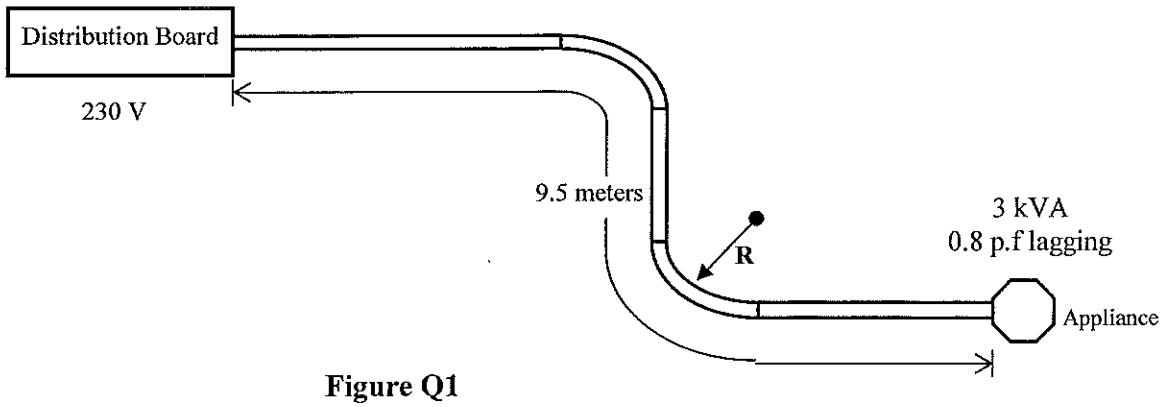


Figure Q1

a. Determine the design current for the appliance **[3 Marks]**

b. Select, rating of the device if it is to be protected by type-B circuit breaker to BS EN 60898 **[3 Marks]**

c. Calculate the value $\mathbf{C_a}$ for computing the cable rating **[3 Marks]**

d. What is the suitable value of $\mathbf{C_g}$ for computing the cable rating **[3 Marks]**

e. Compute the required ampere rating of this cable **[3 Marks]**

f. What should be its cross sectional area **[3 Marks]**

g. What voltage would you experience at the appliance **[3 Marks]**

h. What diameter would you recommend for the conduit **[3 Marks]**

i. Calculate the minimum value for bending radius **R** **[3 Marks]**

j. Had it been protected by a 6A type-B circuit breaker to BS EN 60898 by mistake, what would have been the tripping time of the breaker **[3 Marks]**

k. If the earth fault loop impedance external to the installation is 0.8 Ω and size of the cpc is 2.5 mm^2, check whether the circuit is satisfying the adiabatic equation.

(Assume that the parameter k to be 115) **[3 Marks]**

l. Calculate the maximum time the conductor can withstand as per the adiabatic equation, if one wished to introduce an internal time delay for the circuit breaker. **[3 Marks]**

2. The owner of a premise to be provided with electrical wiring has the following requirements for his premises:

- 12 Nos. of fluorescent lamps 60 W each.
- 15 Nos. of incandescent lamps 100 W each.
- 3 Nos. of air-conditioners 1.25 kW at 0.85 p.f. lagging on full load
- 2 Nos. of refrigerators consuming 0.5 kW at 0.9 p.f. lagging on full load
- 3 Nos. of instantaneous type geysers rated at 3.2 kW
- One, electric. cooker with 3 elements each rated at 1.2 kW & an oven rated at 2.0 kW.
- Two, ½ h.p water pump operating at 0.8 p.f. lagging. (1 h.p. = 746 W)
- One colour television rated at 120 W
- 2 Nos. of 20 A ring circuit to cater for unspecified number of appliances

The supply to the premises would be 3-phase, 400 V, 50 Hz. What is your recommendation for the rating of the service wire for the premises? **[12 Marks]**

- Compute the voltage drop/phase along the service main wire if the premise is about 25 m away from the pole fuse. **[4 Marks]**

3. a. A 10.75 kW load operating at 0.85 and 230 V, is supplied through a single-phase circuit running in flat two-core cable (with cpc) 70°C non-armored thermoplastic insulated and sheathed, having copper conductors. The cable is clipped direct and about 25 m away from the source. The voltage at the load should be maintained at 2.5% of the rated voltage.

1. Determine the suitable cable size for this load? **[4 Marks]**
2. What would be the operating voltage at the load? **[4 Marks]**

b. If the earth fault impedance external to the circuit i.e. $Z_E = 0.32\ \Omega$ and the circuit is to be protected against overload and short circuit by a 63 A BS 88–2.2 fuse, select suitable cross-sectional area for the cpc cable that complies with the requirements of IET Regulation 543.1.3. **[8 Marks]**

4. a. Horizontal electrodes have special advantage where high resistivity soil has a shallow layer of low resistivity soil above it, such as soil above a rock. Consider a rod electrode of circular cross-section buried horizontally such that hemispherical section is below the soil as shown below Figures Q4a and Figure Q4b.

Prove that the earth electrode resistance would be:

$$R = \frac{\rho}{\pi l} \ln \frac{1+2r}{2r} \quad \Omega$$

Where r and l are the rod radius and length in meters respectively. **[12 Marks]**

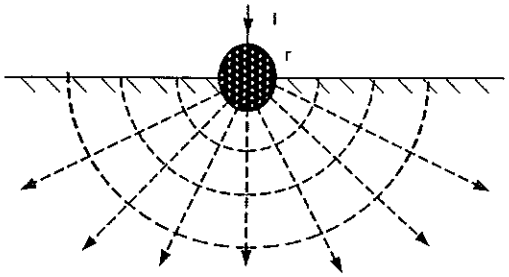


Figure Q4a-Cross sectional elevation

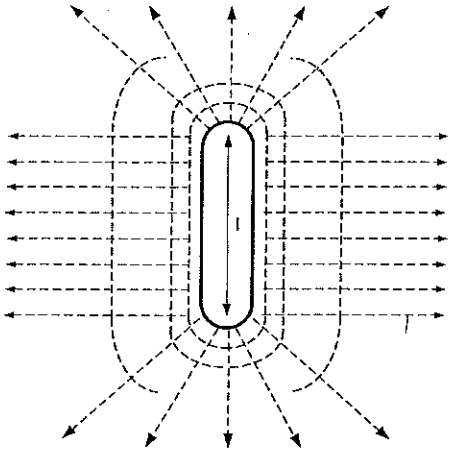


Figure Q4b-Plan

b. Indicate methods available for lowering the earth resistance of an 'Earth Electrode' **[4 Marks]**

5. a. Explain briefly why it is usually necessary to use a residual current device to protect against indirect contact in a TT system, but not in a TN system. **[4 Marks]**

b. Why it is required for the overload protective device to operate within 0.4 s protection against indirect contact, but not specified for residual current device. **[4 Marks]**

c. Explain the significance of the first two numerals of IP code. **[4 Marks]**

d. Explain the major difference between MCB and RCCB **[4 marks]**

6. Question #6 comprises either a direct question or a statement followed by several suggested answers. Only one of these responses is correct. In general, four responses are provided, and you are requested to select the correct response. **[16 Marks]**

a. A person is receiving an electric shock while still in contact with the live equipment. The following action can be taken:

1. Send for medical assistance
2. Switch off the supply of electricity
3. Treat burns
4. Apply artificial respiration
5. Keep victim warm

Which order is the correct safety procedure to give?

A. 1,5,3,2,4 B. 2,4,1,5,3 C. 2,3,1,4,5 D. 1,4,2,3,5

b. When a fluorescent lamp continuously flickers it generally means that the:

1. Stater switch in the control circuit is faulty
2. Ballast is provided with low voltage
3. Control circuit is not fitted with a p.f. capacitor
4. Lamp has reached the end of this life

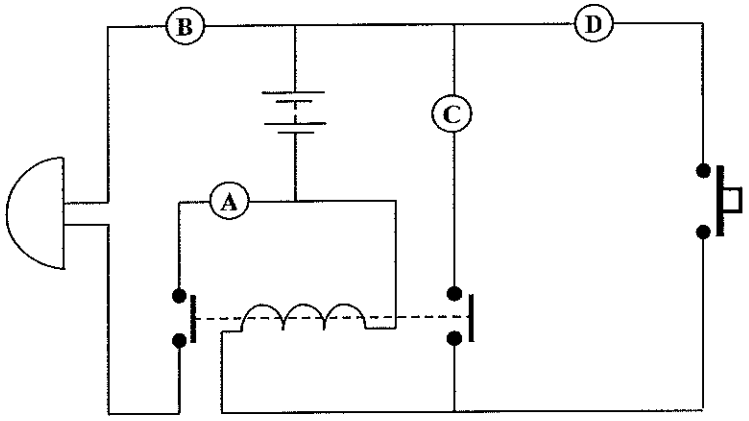
c. The continuity test voltage must not exceed:

1. 50 V 2. 40 V 3. 45 V 4. 25 V

d. An influencing factor when selecting a cable for a particular circuit is:

1. Circuit protection 2. Length of the run 3. Type of sheath 4. Type of main earthing

e.



Above figure shows the circuit of a continuously ringing bell. To control the circuit, a reset button should be inserted at a position:

1. A 2. B 3. C 4. D

f. When bending a PVC conduit, permanent kinking may be prevented by:

1. Initially heating the conduit
2. Heating the conduit during the process
3. Using a coiled steel spring inside the conduit
4. Using a hydraulic bending machine

g. When using a Class II drill outdoors, it is essential that it is supplied from:

1. A double-wound transformer
2. A reduced voltage source
3. An RCD protected socket outlet
4. An MCB distribution board

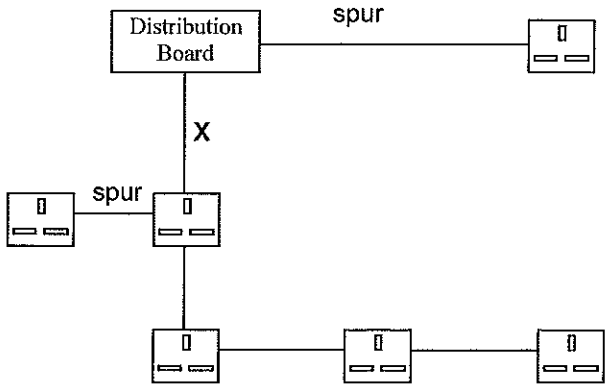
h. Which of the following circuit protective devices has a relatively high fusing factor?

1. BS 3036 2. BS 1362 3. BS 1361 4. BS 88

i. In some discharging lighting installations, rotating machinery may appear to be stationary because of:

1. Unbalanced loading of circuits
2. Poor circuit power factor
3. Mixing types of lamp
4. Stroboscopic effect

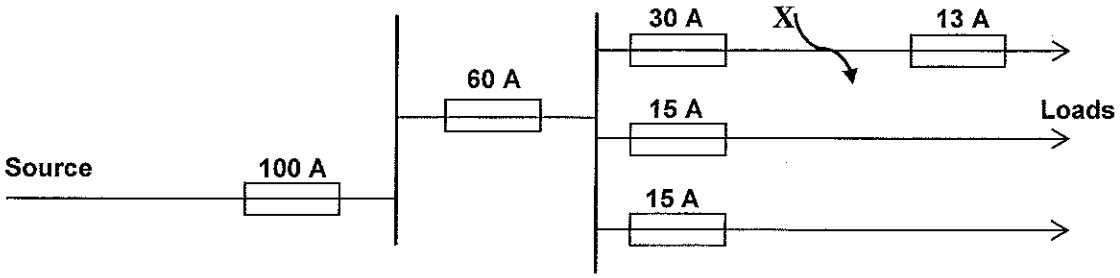
j.



Above figure shows a 30 A ring final circuit wired in PVC conduit. The number of single-core PVC-insulated cables found in section X is:

1. Nine 2. Four 3. Six 4. Three

k.



Discrimination of operation of the fuses shown in above figure is said to have occurred if, when there is a short circuit at point X, the

1. 13 A fuse ruptures
2. 30 A fuse ruptures
2. 60 A fuse ruptures
4. 100 A fuse ruptures

l. Sri Lankan Government Decides on a Single Standard for Plugs and Socket Outlets from 1st January 2019. Architects, Engineers, Technicians and Electricians are advised to use only 13 ampere Standard Sockets in all new buildings with immediate effect. What type is it?

1. Type D 2. Type G 3. Type C 4. Type A

Section B-Lighting and Illumination

7. Figure Q7a shows the layout of a Garment Factory with all dimension in meters. Building height is 4 m with white walls. 36 W LED tube light fitting (T5 Instant fitting) having 5200 lumen output is proposed to be used as the light fitting. Photometric data of for fixing of light fitting are given in Table Q7a and Table Q7b. Design a lighting scheme for the given building with lighting layout by Filling the Table Q7c as required. Clearly state any assumption you made during calculations. **[16 marks]**

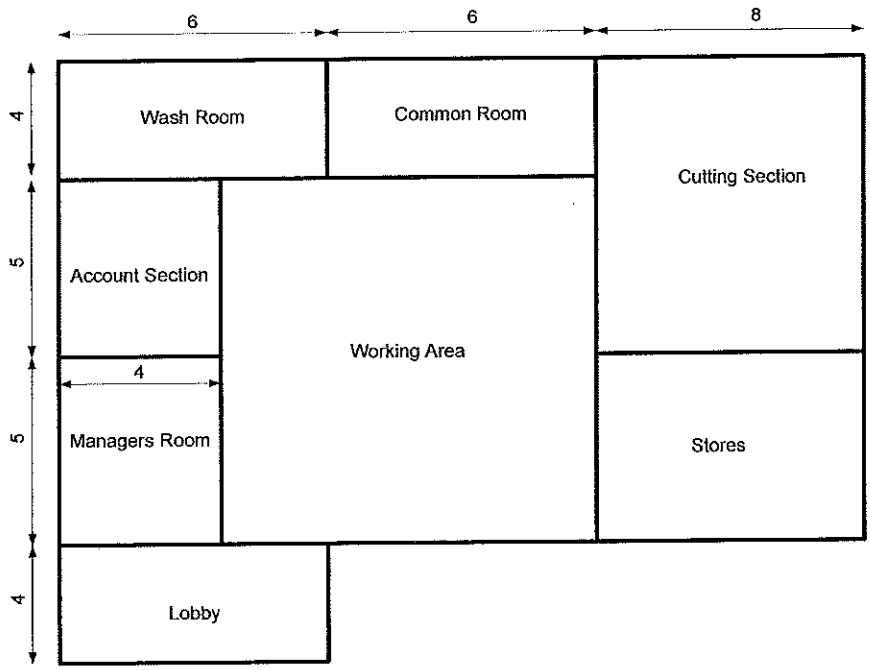


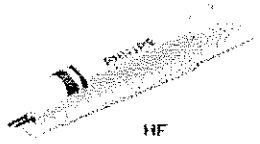
Figure Q7a - Factory Layout

Table Q7a – Coefficient of Utilization

Room Reflectance (%)			ROOM INDEX									
Floor	Ceiling	Wall	0.6	0.8	1.0	1.25	1.5	2.0	2.5	3.0	4.0	5.0
10	**70**	50	0.28	0.33	0.36	0.39	0.41	0.44	0.45	0.46	0.48	0.49
		30	0.25	0.31	0.34	0.36	0.38	0.41	0.43	0.44	0.46	0.47
		10	0.23	0.28	0.31	0.34	0.36	0.39	0.41	0.43	0.45	0.46
10	**50**	50	0.28	0.33	0.36	0.38	0.40	0.42	0.44	0.45	0.47	0.48
		30	0.25	0.30	0.33	0.36	0.38	0.40	0.42	0.43	0.45	0.47
		10	0.23	0.28	0.31	0.34	0.36	0.39	0.41	0.42	0.44	0.46
10	**30**	30	0.25	0.30	0.33	0.36	0.37	0.40	0.42	0.43	0.45	0.46
		10	0.23	0.28	0.31	0.34	0.36	0.39	0.40	0.42	0.44	0.45

Table Q7b - LED tube fitting data

MASTER LEDtube T5



HF

InstantFit

Product type	LED	Lumen output	Operation	Dimmable	Rotatable end cap	Beam angle	CRI	Color temp.	Lifetime	Energy-label	Dimensions	EOC 1 pcs (C)*
MASTER LEDtube (HF)	W	lm	lm/W			°		K	Hrs.		H x W	8718696
600mm HE 8W 830 T5 NEW	8	1000	HF	No	No	200	83	3000	50,000	A+	21 x 600	74323200
600mm HE 8W 840 T5 NEW	8	1050	HF	No	No	200	83	4000	50,000	A+	21 x 600	74325600
600mm HE 8W 865 T5 NEW	8	1050	HF	No	No	200	83	6500	50,000	A+	21 x 600	74327000
1200mm HE 16.5W 830 T5 NEW	16.5	2300	HF	No	No	200	83	3000	50,000	A+	21 x 1200	74329400
1200mm HE 16.5W 840 T5 NEW	16.5	2500	HF	No	No	200	83	4000	50,000	A++	21 x 1200	74331700
1200mm HE 16.5W 865 T5 NEW	16.5	2500	HF	No	No	200	83	6500	50,000	A++	21 x 1200	74333100
1500mm HE 20W 830 T5 NEW	20	2800	HF	No	No	200	83	3000	50,000	A+	21 x 1500	74335500
1500mm HE 20W 840 T5 NEW	20	3000	HF	No	No	200	83	4000	50,000	A++	21 x 1500	74337900
1500mm HE 20W 865 T5 NEW	20	3000	HF	No	No	200	83	6500	50,000	A++	21 x 1500	74339300
1500mm UO 36W 830 T5 Instant Fit	36	5200	HF	No	No	160	80	3000	50,000	A++	21 x 1500	70599500
1500mm UO 36W 840 T5 Instant Fit	36	5600	HF	No	No	160	80	4000	50,000	A++	21 x 1500	70603900
1500mm UO 36W 865 T5 Instant Fit	36	5600	HF	No	No	160	80	3000	50,000	A++	21 x 1500	70605300
1500mm HO 26W 830 T5 Instant Fit	26	3700	HF	No	No	160	83	3000	50,000	A+	21 x 1500	68552500
1500mm HO 26W 840 T5 Instant Fit	26	3900	HF	No	No	160	83	3000	50,000	A++	21 x 1500	68554900
1500mm HO 26W 865 T5 Instant Fit	26	3900	HF	No	No	160	83	6500	50,000	A++	21 x 1500	68556300
1200mm HO 26W 830 T5 Instant Fit	26	3700	HF	No	No	160	80	3000	50,000	A+	21 x 1200	70527800
1200mm HO 26W 840 T5 Instant Fit	26	3900	HF	No	No	160	80	6500	50,000	A++	21 x 1200	70529200
1200mm HO 26W 865 T5 Instant Fit	26	3900	HF	No	No	160	80	6500	50,000	A++	21 x 1200	70531500

Table Q7c - Lighting design

Location	Average. Illuminance Required E (Lux)	Length L (m)	Width W (m)	Mounting Height H (m)	Floor Area A(m^2)	Room Index	Utilization Factor	Maintenance. Factor	LLD	No of Lamps / luminaire	Lamp Luminous Flux (F)	Required no. of Luminaries	Proposed no of Luminaries(N)

8. Following are the multiple type questions. Underline the correct answer **[1*16 marks]**

1. Which of the following sources would be most appropriate for the warehouse portion of a large furniture dealership?
   a) high-pressure sodium
   b) metal-halide
   c) cool-white deluxe fluorescent
   d) mercury-vapor

2. What is the most important criterion for lighting a fabric showroom?
   a) visual comfort probability
   b) coefficient of utilization
   c) color rendering index
   d) apparent color temperature rating

3. Radiant efficiency of the luminous source depends on
   a) shape of the source
   b) wavelength of light rays
   c) temperature of the source
   d) all of the above.

4. The unit of solid angle is in
   a) solid angle b) radian c) steradian d) candela

5. Candela is the unit of
   a) Luminous flux b) Luminous intensity c) Wavelength d) None of the above

6. Illumination level required for precision work is around
   a) 50 lm/m^2 b) 100 lm/m^2 c) 200 lm/m^2 d) 500 lm/m^2

7. Which lamp has the best Colour Rendering Index (CRI)?
   a) LED b) Fluorescent c) Incandescent d) High pressure sodium vapour

8. What will be the total flux emitted by a source of 90 candle power?
   a) 1131 lumens b) 90 lumens c) 1.13 lumens d) None of these.

9. Illumination can be expressed in
   a) radians b) lumens c) lux d) candela

10. A 200-candle power lamp is hung 4 m above the centre of circular area of 5 m diameter. The illumination at centre of the area is
   a) 13.5 lux b) 17.5 lux c) 12.5 lux d) 18.5 lux

11. Light consists of:
   a) electromagnetic waves b) ultraviolet waves c) infrared waves d) gamma rays

12. Illumination of a surface due to a source of light as per the first law of illumination is:
   a) Inversely proportional to the distance between the surface and the source of light.
   b) Inversely proportional to the $(distance)^2$ between the surface and the source of light
   c) Directly proportional to the distance between the surface and the source of light
   d) Directly proportional to the $(distance)^2$ between the surface and the source of light

13. Colour of light depend upon
   a) Frequency b) Both **a)** and **b)** c) Wavelength d) speed of light

14. Illumination of one lumen per square meter is called
   a) Lumen meter b) Lux c) Foot candela d) candela

15. Lumen/watt is the unit of
   a) Light flux b) Brightness c) Luminous Intensity d) Luminous efficiency

16. Which of the following surface has the lowest reflection factor for white light?
   a) Aluminium sheet b) Blue curtains c) White plaster work d) White oil paint

Rating factor (C_a) table for ambient temperature correction

Ambient Temp. ^{0}C	Insulation 70 ^{0}C thermoplastic	Insulation 90 ^{0}C thermosetting
25	1.03	1.02
30	1.00	1.00
35	0.94	0.96
40	0.87	0.91
45	0.79	0.87
50	0.71	0.82
55	0.61	0.76
60	0.50	0.71

Rating factor (C_g) table for one circuit or for a group of circuits

Arrangement of cables (touching)	Number of circuits or multicore cables												Laying Methods Reference
	1	2	3	4	5	6	7	8	9	12	16	20	
Bunched in air, on a surface, embedded or enclosed	1.00	0.80	0.70	0.65	0.60	0.57	0.54	0.52	0.50	0.45	0.41	0.38	Methods A to F
Single layer on wall or floor	1.00	0.85	0.79	0.75	0.73	0.72	0.72	0.71	0.70	0.70	0.70	0.70	Method C
Single layer multicore on a perforated horizontal or vertical cable tray system	1.00	0.88	0.82	0.77	0.75	0.73	0.72	0.72	0.72	0.72	0.72	0.72	Methods E & F
Single layer multicore on cable ladder system or cleats.	1.00	0.87	0.82	0.80	0.80	0.79	0.79	0.78	0.78	0.78	0.78	0.78	

FACTORS FOR TRUNKING

Cable factors for Trunking

Type of conductor	Conductor cross-sectional area mm^2	Factor
Solid	1	7.1
	2.5	10.2
Stranded	1.5	8.1
	2.5	11.4
	4	15.2
	6	22.9
	10	36.3

Factor for Trunking

Dimension of trunking (mm x mm)	Factor	Dimension of trunking (mm x mm)	Factor
50 x 37.5	767	100 x 37.5	1542
50 x 50	1037	100 x 50	2091
75 x 25	738	100 x 75	3189
75 x 37.5	1146	100 x 100	4252
75 x 50	1555		
75 x 75	2371		
100 x 25	993		

Source: IEE wiring Regulations 18th & 15th edition

FACTORS FOR CONDUITS

Cable Factors for straight runs ≤ 3 m

Type of conductor	Conductor cross-sectional area mm²	Factor
Solid	1	22
	1.5	27
	2.5	39
Stranded	1.5	31
	2.5	43
	4	58
	6	88
	10	146

Conduit factors for straight runs ≤ 3 m

Conduit diameter (mm)	Factor
16	290
20	460
25	800
32	1400

Cable factors for long straight runs > 3 m or runs incorporating bends

Type of conductor	Conductor cross-sectional area mm²	Factor
Solid or stranded	1	16
	1.5	22
	2.5	30
	4	43
	6	58
	10	105

Conduit factors for runs incorporating bends

Length Of run (m)	Conduit diameter, mm																			
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
	Straight				One bend				Two bends				Three bends				Four bends			
1	290	460	800	1400	188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
1.5	290	460	800	1400	182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
2	290	460	800	1400	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
2.5	290	460	800	1400	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
3	290	460	800	1400	167	270	487	857	143	233	422	750	111	182	333	600				
3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563				
4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529				
4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500				
5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474				
6	167	270	487	857	143	233	422	750	111	182	333	600								
7	162	263	475	837	136	222	404	720	103	169	311	563								
8	158	256	463	818	130	213	388	692	97	159	292	529								
9	154	250	452	800	125	204	373	667	91	149	275	500								
10	150	244	442	783	120	196	358	643	86	141	260	474								

Source: IEE wiring Regulations 15th edition

Table 4D1A – Single-core 70°C thermoplastic insulated cables, non-armoured, with or without sheath (COPPER CONDUCTORS)

Ambient temperature: 30 °C

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

Conductor Cross Sectional area	Reference Method A (Enclosed in conduit in thermally insulating wall etc.)		Reference Method B (Enclosed in conduit on a wall or in trunking etc.)		Reference Method C (clipped direct)		Reference Method F (in free air or on a perforated cable tray horizontal or vertical)				
							Touching			Spaced by one diameter	
	2 cables. 1Φ a.c. or d.c.	3 or 4 cables. 3Φ a.c.	2 cables. 1Φ a.c. or d.c.	3 or 4 cables. 3Φ a.c.	2 cables. 1Φ a.c. or d.c. flat & touching	3 or 4 cables. 3Φ a.c. flat & touching or trefoil	2 cables. 1Φ a.c. or d.c. flat	3 cables. 3Φ a.c. flat	3 cables. 3Φ a.c. trefoil	2 cables, 1Φ a.c. or d.c. or 3 cables 3Φ a.c. flat	
										Horizontal	Vertical
mm^2	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.
1	11	10.5	13.5	12	15.5	14	-	-	-	-	-
1.5	14.5	13.5	17.5	15.5	20	18	-	-	-	-	-
2.5	20	18	24	21	27	25	-	-	-	-	-
4	26	24	32	28	37	33	-	-	-	-	-
6	34	31	41	36	47	43	-	-	-	-	-
10	46	42	57	50	65	59	-	-	-	-	-
16	61	56	76	68	87	79	-	-	-	-	-
25	80	73	101	89	114	104	131	114	110	146	130
35	99	89	125	110	141	129	162	143	137	181	162
50	119	108	151	134	182	167	196	174	167	219	197
70	151	136	192	171	234	214	251	225	216	281	254
95	182	164	232	207	284	261	304	275	264	341	311
120	210	188	269	239	330	303	352	321	308	396	362
150	240	216	300	262	381	349	406	372	356	456	419
185	273	245	341	296	436	400	463	427	409	521	480
240	321	286	400	346	515	472	546	507	485	615	569
300	367	328	458	394	594	545	629	587	561	709	659

Table 4D1B – Single-core 70°C thermoplastic insulated cables, non-armoured, with or without sheath (COPPER CONDUCTORS)

VOLTAGE DROP (per ampere per meter): **Conductor operating temperature: 70 °C**

Conductor Cross Sectional area	2 cables 1Φ a.c.			3 or 4 cables, 3 Φ a.c.																		
	Reference Methods A & B (Enclosed in conduit or trunking)			Reference Methods C & F (clipped direct, on tray or in free air)						Reference Methods A & B (Enclosed in conduit or trunking)			Reference Methods C & F (clipped direct, on tray or in free air)								
				Cables touching			Cables spaced						Cables touching, Trefoil			Cables touching, Flat			Cables spaced*, Flat		
mm^2	mV/Amp/meter			mV/Amp/meter			mV/Amp/meter			mV/Amp/meter			mV/Amp/meter			mV/Amp/meter			mV/Amp/meter		
1	44			44			44			38			38			38			38		
1.5	29			29			29			25			25			25			25		
2.5	18			18			18			15			15			15			15		
4	11			11			11			9.5			9.5			9.5			9.5		
6	7.3			7.3			7.3			6.4			6.4			6.4			6.4		
10	4.4			4.4			4.4			3.8			3.8			3.8			3.8		
16	2.8			2.8			2.8			2.4			2.4			2.4			2.4		
	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z
25	1.80	0.33	1.80	1.75	0.20	1.75	1.75	0.29	1.80	1.50	0.29	1.55	1.50	0.175	1.50	1.50	0.25	1.55	1.50	0.32	1.55
35	1.30	0.31	1.30	1.25	0.195	1.25	1.25	0.28	1.30	1.10	0.27	1.10	1.10	0.170	1.10	1.10	0.24	1.10	1.10	0.32	1.15
50	0.95	0.30	1.00	0.93	0.190	0.95	0.93	0.28	0.97	0.81	0.26	0.85	0.80	0.165	0.82	0.80	0.24	0.84	0.80	0.32	0.85
70	0.65	0.29	0.72	0.63	0.185	0.66	0.63	0.27	0.69	0.56	0.25	0.61	0.55	0.160	0.57	0.55	0.24	0.60	0.55	0.31	0.63
95	0.49	0.28	0.56	0.47	0.180	0.50	0.47	0.27	0.54	0.42	0.24	0.48	0.41	0.155	0.43	0.41	0.23	0.47	0.40	0.31	0.51
120	0.39	0.27	0.47	0.37	0.175	0.41	0.37	0.26	0.45	0.33	0.23	0.41	0.32	0.15	0.36	0.32	0.23	0.40	0.32	0.30	0.44
150	0.31	0.27	0.41	0.30	0.175	0.34	0.29	0.26	0.39	0.27	0.23	0.36	0.26	0.15	0.30	0.26	0.23	0.34	0.26	0.30	0.40
185	0.25	0.27	0.37	0.24	0.170	0.29	0.24	0.26	0.35	0.22	0.23	0.32	0.21	0.145	0.26	0.21	0.22	0.31	0.21	0.30	0.36
240	0.195	0.26	0.33	0.185	0.165	0.25	0.185	0.25	0.31	0.17	0.23	0.29	0.16	0.145	0.22	0.16	0.22	0.27	0.16	0.29	0.34
300	0.160	0.26	0.31	0.150	0.165	0.22	0.150	0.25	0.29	0.14	0.23	0.27	0.13	0.14	0.19	0.13	0.22	0.25	0.13	0.29	0.32

1Φ – Single phase; 3Φ – Three phases; Note: * - Spacing larger than one cable diameter will result in a larger voltage drop.

Source: IEE wiring Regulations 18th edition

Table 4D2A – Multi-core 70°C thermoplastic insulated and thermo-plastic sheathed cables, non-armoured, with or without sheath
(COPPER CONDUCTORS)

Ambient temperature: 30 °C
Conductor operating temperature: 70 °C

CURRENT-CARYING CAPACITY (amperes):

Conductor Cross Sectional area	Reference Method A (Enclosed in conduit in thermally insulating wall etc.)		Reference Method B (Enclosed in conduit on a wall or in trunking etc.)		Reference Method C (clipped direct)		Reference Method E (in free air or on a perforated cable tray etc. horizontal or vertical)	
	1 two-core cable*. 1Φ a.c. or d.c.	1 three-core cable* or 1 Four-core Cable, 3Φ a.c.	1 two-core cable*. 1Φ a.c. or d.c.	1 three-core cable* or 1 Four-core Cable, 3Φ a.c.	1 two-core cable*. 1Φ a.c. or d.c.	1 three-core cable* or 1 Four-core Cable, 3Φ a.c.	1 two-core cable*. 1Φ a.c. or d.c.	1 three-core cable* or 1 Four-core Cable, 3Φ a.c.
mm^2	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.
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

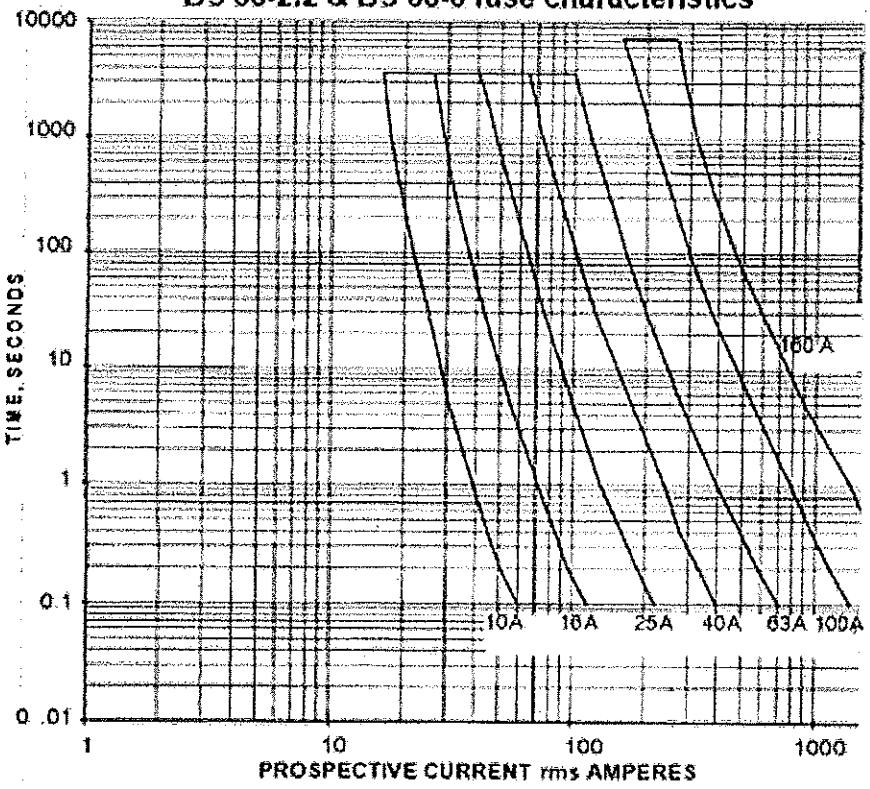
* With or without a protective conductor 1Φ – Single phase; 3Φ – Three phases

Table 4D2B – Multi-core 70°C thermoplastic insulated and thermo plastic sheathed cables, non-armoured, with or without sheath
(COPPER CONDUCTORS)

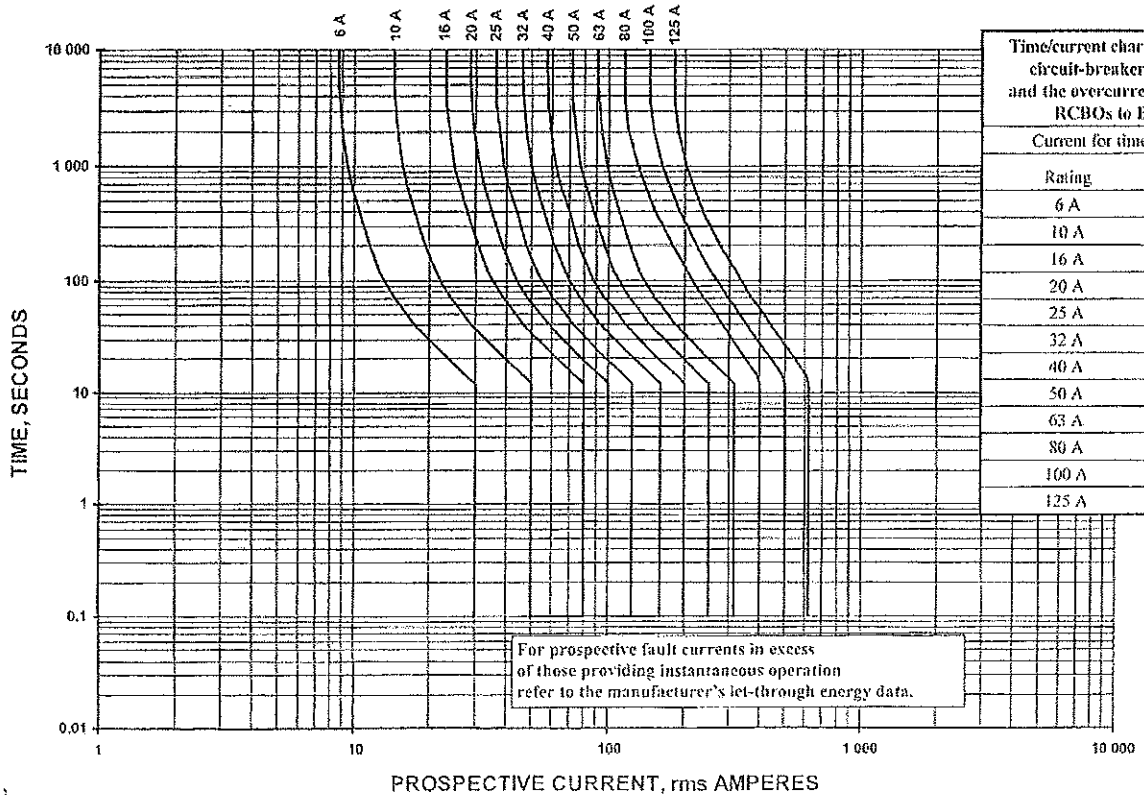
VOLTAGE DROP (per ampere per meter): **Conductor operating temperature: 70 °C**

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.		
mm^2	mV/Amp/meter	mV/Amp/meter			mV/Amp/meter		
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	0.135	1.5
35	1.25	1.25	0.165	1.25	1.10	0.145	1.1
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	0.39	0.38	0.155	0.41	0.33	0.135	0.35
150	0.31	0.30	0.155	0.34	0.26	0.130	0.29
185	0.25	0.25	0.150	0.29	0.21	0.130	0.25
240	0.195	0.190	0.155	0.24	0.165	0.130	0.21
300	0.160	0.155	0.145	0.21	0.135	0.130	0.185
400	0.105	0.115	0.145	0.185	0.10	0.125	0.16

BS 88-2.2 & BS 88-6 fuse characteristics



Type B circuit-breaker to BS EN 60898 and RCBOs to BS EN 61009-1 characteristics



Time/current characteristics for Type B circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1	
Current for time, 0.1 sec to 5 secs	
Rating	Current
6 A	30 A
10 A	50 A
16 A	80 A
20 A	100 A
25 A	125 A
32 A	160 A
40 A	200 A
50 A	250 A
63 A	315 A
80 A	400 A
100 A	500 A
125 A	625 A

Source: IEE wiring Regulations 18th edition

Diversity factor table

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of premises		
	Individual household installations, including individual dwelling of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
1. Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2. Heating and power	100% of total current demand up to 10 A + 50% of any current demand in excess of 10 A.	100% f.l. of largest + 75% of f.l. of remaining appliances.	100% f.l. of largest + 80% f.l. of 2nd largest + 60% f.l. of remaining appliances.
3. Cooking appliances	10 A + 30% f.l. of connected cooking appliances in excess of 10 A + 5 A if socket outlet incorporated in unit.	100% f.l. of largest + 80% f.l. of 2nd largest + 60% f.l. of remaining appliances.	
4. Motors (other than lift motors which are subject to special consideration)		100% f.l. of largest + 80% f.l. of 2nd largest + 60% f.l. of remaining motors.	100% f.l. of largest + 50% f.l. of remaining motors
5. Water-heaters (instantaneous type)	100% f.l. of largest + 100% f.l. of 2nd largest + 25% f.l. of remaining appliances		
6. Water-heaters (thermostatically controlled)	No diversity allowable		
7. Floor warming installations	No diversity allowable		
8. Thermal storage space heating installations	No diversity allowable†		
9. Water pumps	100% f.l. of the largest pump motor and 25% of the remaining		
10. Standard arrangements of final circuits	100% of current demand of largest circuit + 40% of current demand of every other circuit	100% of current demand of largest circuit + 50% of current demand of every other circuit	
11. Socket outlets other than those included in 9 above and stationary equipment other than those listed above (e.g. Air conditioners)	100% of current demand of largest point of utilization + 40% of current demand of every other point of utilization	100% of current demand of largest point of utilization + 75% of current demand of every other point of utilization	100% of current demand of largest point of utilization. + 75% of current demand of every point in main rooms (dining rooms, etc.) + 40% of current demand of every other point of utilization