00127

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	**: EEX4434/EEX4534/ECX4234 Electrical Installations**
Academic Year	: 2019/2020
Date	: 29th July 2020
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of two sections, **Section A** and **Section B** with **Eight (8)** questions in **Twelve (12)** pages.
3. Answer **Five (5)** questions selecting only **One (1)** question from **Section B**, All the other questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant figures and tables are provided with the question paper
6. **Zero (0)** marks will be given if formulas used for the computation of factors for cable rating calculations.
7. This is a Closed Book Test **(CBT).**
8. Answers should be in clear hand writing.
9. Do not use red colour pen.

Section A-Electrical Installation

1. A utility supplies three-phase power to a three-phase distribution board power panel. The power panel supplies power to a 50kW three-phase motor operating at 0.85 power factor as shown in figure Q1.

   It is decided to lay a 3-core cable (thermoplastic – PVC) to provide power supply to the motor along a cable ladder and the total cable length from power panel to the motor is estimated to be 12 meters. The aforesaid existing cable ladder already having four numbers of similar three core cables along the path. The cables will be laid as a single layer.

   Along the cable ladder path, the ambient temperature varies from 35 deg. Celsius to 45 deg. Celsius.

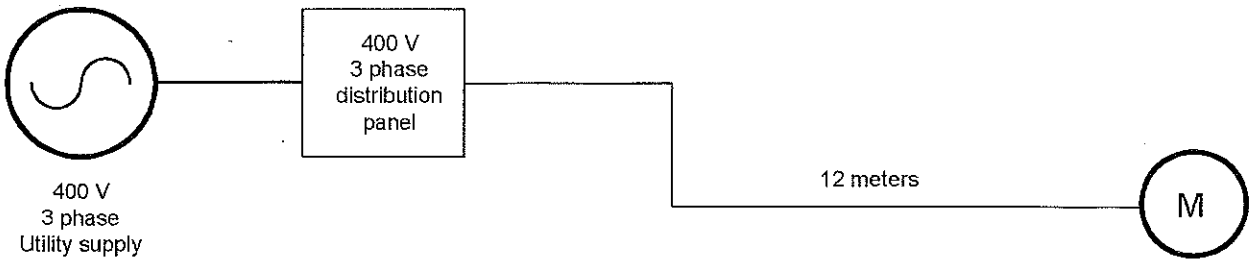


Figure Q1

a) Determine the running current (design current) of the motor? **[2Marks]**

b) If the motor starting current is 5 times the running current which lasts for less than 5 seconds, what would be the rating of 3 pole Type B circuit breaker to BS EN 60898 to be selected for this motor? **[2Marks]**

c) What is the grouping factor (Cg) applicable for the cable selection? **[2Marks]**

d) What is the Ca – rating factor for ambient temperature correction? **[2Marks]**

e) Hence, compute the Current Carrying Capacity of the required cable? **[2Marks]**

f) Select an appropriate cable from the given tables– thermoplastic three core non-armoured cable with copper conductor **[2Marks]**

g) Calculate the voltage drop at the motor and check whether the voltage drop is acceptable or not (2.5% voltage drop allowed from the distribution panel). If not acceptable, select a suitable cable to meet the required voltage drop. **[2Marks]**

h) If the distribution panel and the downstream cable have resistance of 0.06 Ω and reactance of 0.03 Ω, calculate the symmetrical short circuit level for a worst-case scenario? **[2Marks]**

i) What is the disconnection time if above short circuit happens? **[2Marks]**

j) Check whether the cable satisfies the adiabatic equation if a short circuit happens at the downstream. **[2Marks]**

2. A typical domestic house is connected to a 230V, single phase, 50Hz supply. There is a 5A socket outlet circuit in this house protected by a 6A cartridge fuse to BS 88-2. This socket outlet circuit has an internal resistance of 0.08 Ohms. The external earth fault loop impedance of the house is 9.62 Ohms. The house owner connects an electric appliance to the circuit and that appliance has a ground fault which has an effective resistance of 1.8 Ohms across the appliance (the load).

   i. Calculate the prospective earth fault current flowing through the appliance **[4 Marks]**

   ii. Calculate the fault voltage which develops on the appliance body **[4 Marks]**

   iii. The time taken for the fuse to blow **[4 Marks]**

   iv. Assume that the house owner accidently touches the metal part of the appliance which has the ground fault by the time he switches on the appliance. What type of contact the house owner is getting in this instance (Direct or Indirect)? Determine the magnitude of current flowing through his body? (Assume the skin resistance of 1500 Ohms) **[4 Marks]**

   v. What form of a shock will the house owner would get? (Refer figure Q2) **[4 Marks]**

AC-1 zone: Imperceptible: No sensation at all or negligible feeling
AC-2 zone: Perceptible: Prickling sensation and possibly painful effect on muscles of fingers and arms, there is no harmful effect
AC-3 zone: Reversible effects: Respiratory trouble could occur, i.e. there are muscular contraction, cramp like pulling together of arms, difficulty in breathing, no danger of ventricular fibrillation (0.5% probability). This is generally the limit of tolerance.
AC-4 zone: Possibility of irreversible effects
AC-4-1 zone: Up to 5% probability of heart fibrillation
AC-4-2 zone: Up to 50% probability of heart fibrillation
AC-4-3 zone: More than 50% probability of heart fibrillation

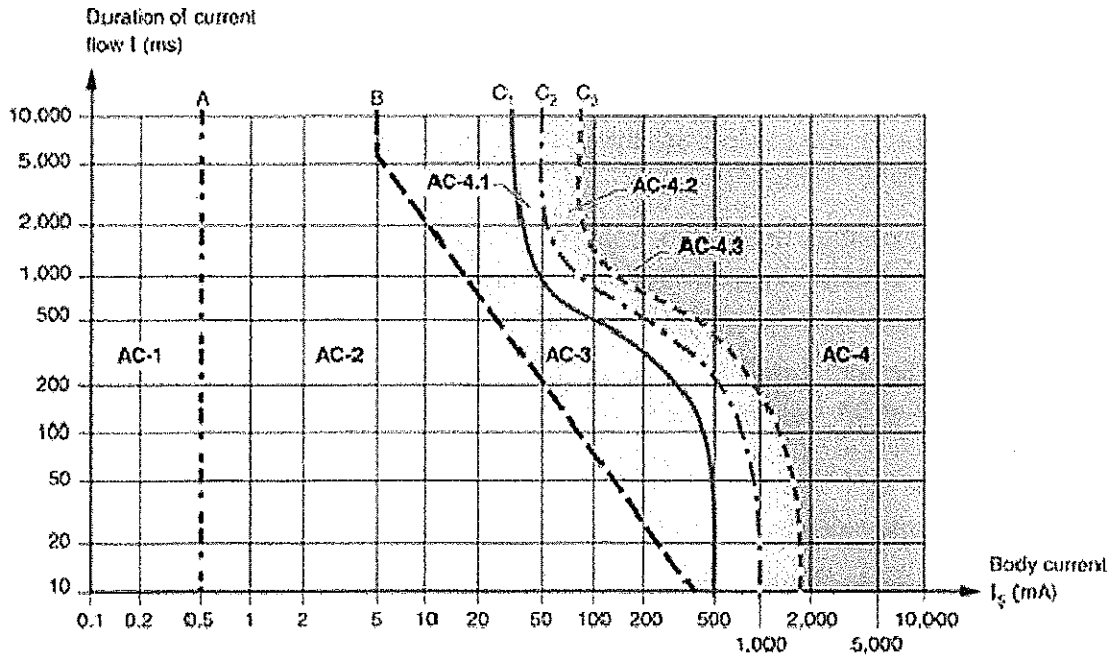


Figure Q2-Time/Current zones of ac effects (15-100 Hz) on human body

3. The resistance to earth by a pipe or a rod electrode is given by:

$$R = \frac{\rho}{2\pi l} \ln \frac{l}{r}$$

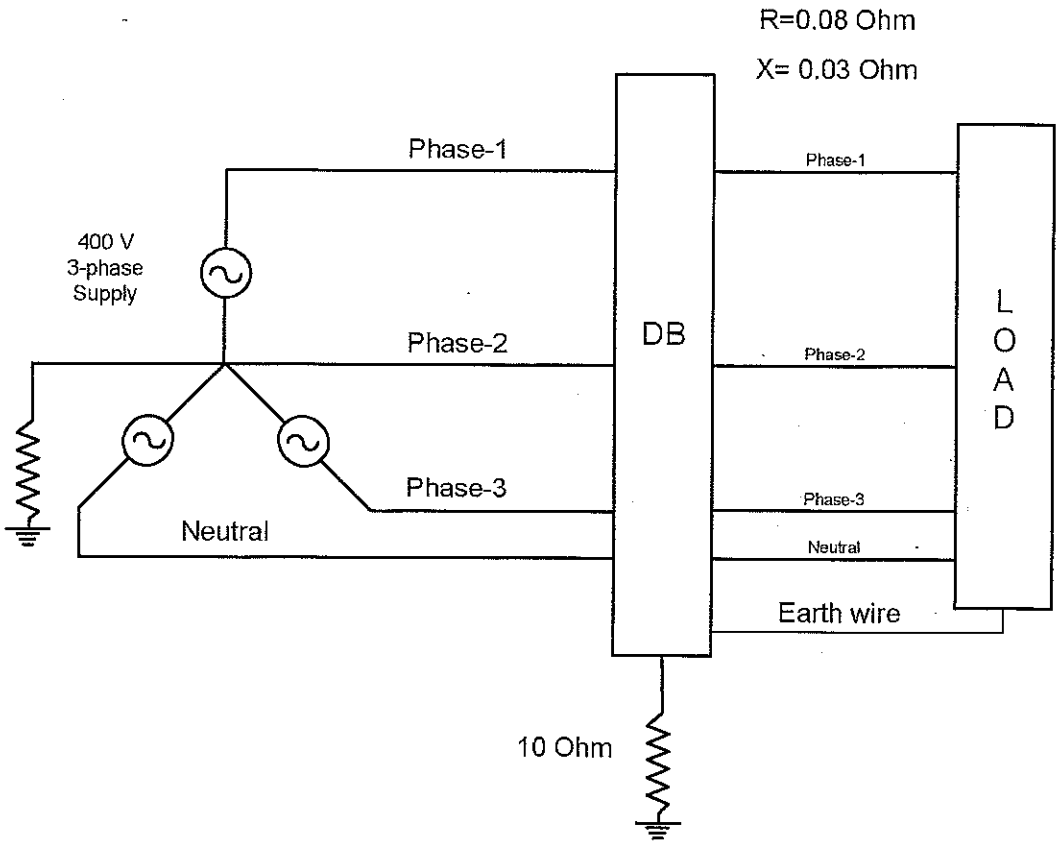
Where l = length of the pipe or rod, r = radius and ρ– soil resistivity)

a. If same dimension copper rod was used instead of a GI pipe for earthing purposes, will the resistance to the earth will vary in two instances? Explain your answer **[8Marks]**

b. 1.5m long copper rod with 30mm diameter was used as an earthing electrode, in sand where the soil resistivity is 300 Ω-m. Compute the effective earth resistance? **[6 Marks]**

c. It was decided to drive another earth electrode nearby and connect two rods in parallel in order to bring down the overall earth resistance. What is the minimum distance that should be kept between the two rods to achieve best results? **[6Marks]**

4. In the diagram shown below in figure Q4, a typical TT installation is shown.



Three-phase transformer is supplying a DB (Distribution Board) and as per the TT earthing system, the installation (i.e. DB side) is having its own earth which has a resistance to earth of 10Ω. At the DB, each phase is having a resistance of 0.08Ω and a reactance of 0.03Ω.

For the installation side, the worst-case earth fault can happen is at a location very close to the DB. At the DB the installation side is protected by a residual current device which operates for current of 300mA with a time delay of 2 seconds.

a. Calculate the earth fault loop impedance for the worst-case scenario **[6Marks]**

b. Calculate the prospective earth fault current (PEFC) **[6 Marks]**

c. If the protective earthing conductor is $4mm^2$, then calculate whether the earthing conductor satisfies the adiabatic equation under the above scenario. (Assume k= 115) **[8 Marks]**

5. a. Explain briefly why if a cable can be protected with a 30A MCB, why the same size of the cable cannot be provided protection with a 30A fuse? **[5 Marks]**

   b. Explain in brief why it is not possible to provide earth fault protection in a TT system with an over current protective device such as MCB, Fuse etc. and why the same is possible in a TN earthing system. **[5 Marks]**

   c. In a TT system, what is the special device used for earth leakage fault protection? What is the rating of the above device which is used in domestic installations? Why is it important to use that rating in domestic installation or any place where human protection is needed? **[5Marks]**

   d. Explain in brief the difference between overload current and short circuit current. **[5 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 and state it on the answer script. **Do not detach pages from the question paper.** **[2.5 X 8 Marks]**

   1. What is the nominal voltage of the installations covered by the BS 7671 - IET wiring regulation?
      - **a.** Up to and including 1500V a.c. or 1500 V d.c.
      - **b.** Up to and including 500V a.c& 500V d.c.
      - **c.** Up to and including 1000V a.c. or 1000V d.c.
      - **d.** Up to and including 1000V a.c. or 1500 V d.c.

   2. In a factory, there is an issue with one machine. That is, the main incoming circuit breaker to the factory trips before the circuit breaker supplying power to the machine trips.
      Which of the following statement is true with regard to the situation here?
      - **a.** The cable selection is not correct
      - **b.** The earthing is not done properly
      - **c.** The incoming power supply from the grid has an issue
      - **d.** Protection co-ordination of the circuit breakers are not done correctly

   3. Under perfect conditions, in which of the following earthing systems, a person touching a live conductor would not get an electric shock?

      a.TT **b.** IT **c.**TN-S **d.**TN-CS

4. What is the color of the cover of the latest BS7671 IET wiring regulation?

   a. Green **b.** Brown **c.** Blue **d.** Red

5. What is the authority in Sri Lanka established and empowered to regulate the electrical energy usage inside the country?

   a. Ceylon Electricity Board (CEB)

   b. Public Utilities Commission of Sri Lanka (PUCSL)

   c. Lanka Electricity Company Limited (LECO)

   d. Sustainable Energy Authority of Sri Lanka (SLSEA)

6. In which of the situation you need to oversize the neutral conductor (compared to the line conductor)?

   a. Perfectly balanced 3 phase system

   b. Single phase system

   c. A load having 14% of third harmonic in the line current

   d. A load having 28% of third harmonic in the line current

7. In which of the following situations using an overload protective device is not recommended?

   a. Office lighting circuit

   b. Power supply to a fire fighting pump

   c. Power supply to a production floor in a factory

   d. Socket outlet Ring circuit of a domestic installation

8. Which of the following device has the highest breaking capacity?

   a. HRC fuse

   b. MCB

   c. Semi-enclosed fuse

Contd.....Section B

Section B-Illumination and Lighting Design

7. Following figure Q7 shows you the layout plan of an accounts section in an office building. All the dimensions are given in meters. Ceiling height of the entire section is 2.7m and work plane is 0.8m from the floor. Design illuminance levels are given inside the bracket of each area. 3 x 14 W, T5 Fluorescent, 600mm x 600mm size, ceiling recessed mounted light fitting and 13W downlight are selected for the lighting of the entire section and the data sheets for above luminaires are given below. Assume 0.7, 0.5 and 0.3 reflection factors for ceiling, wall and floor respectively. Using a maintenance factor of 0.8, answer the following questions.

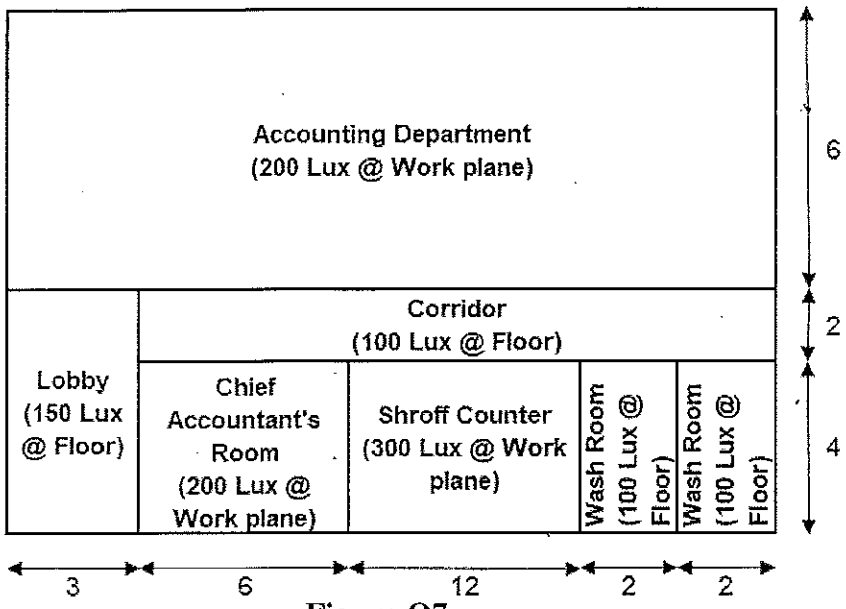


Figure Q7

i. What is the room index of the Accounting Department? **[1Mark]**

ii. If 3X14 W T5, Fluorescent luminaire is selected for above section, what is the utilization factor? **[1Mark]**

iii. Find the Total Lumens Requirement for the Accounting Department? **[2Marks]**

iv. Calculate the total number of lighting fixtures required? **[2Marks]**

v. Based on the answer of (iv), propose suitable lighting fixture layouts? **[2Marks]**

vi. Calculate the Space to height ratio (S/H), lengthwise and widthwise for the selected layout? **[2Marks]**
Compare the answer of (vi) with the values given in the data sheet and propose a layout which comply with the space to height ratio given in datasheet? **[2Marks]**

vii. Calculate the number of lighting fixtures required for the Chief Accountant's Room using 3X14 W, T5 Fluorescent luminaire? **[2Marks]**

viii. Calculate the number of lighting fixtures required for the Chief Accountant's Room using 13 W downlight? **[2Marks]**

ix. If the price of a 3X14 W, T5 Fluorescent luminaire is Rs 7000.00 and 13 W downlight is Rs 2000.00, What is your choice of luminaire for the Chief Accountant's Room? **[2Marks]**

x. Complete Table Q7 and hence, calculate the total lighting loads in Watts? **[2Marks]**

Table Q7

Room Reference	Selected Lamp	No. Of Luminaries (Proposed)
Accounting Department	3X14 W T5 Fluorescent	???
Lobby	13W downlight	8
Corridor	13W downlight	10
Chief Accountant's Room	???	???
Shroff Counter	3X14 W T5 Fluorescent	12
Washroom - 1	13W downlight	3
Washroom - 2	13W downlight	3

8. a. For the MCQ questions 1 to 10, you are requested to select the correct answer and state it on the answer script. **Do not detach pages from the question paper.** **[1 X 10 Mark]**

1. Illumination can be expressed in:
a. radians **b.** lux. **c.** lumens **d.** candela

2. Total flux or lumens required in any lighting scheme depends inversely on:
a. utilization factor **c.** reflection factor
b. reduction factor **d.** none of the above

3. Which of the following will need the highest level of illumination?
a. Proof reading **c.** Hospital wards
b. Bedrooms **d.** Railway platforms.

4. Radiant efficiency of the luminous source depends on:
a. shape of the source **c.** temperature of the source
b. wave length of light rays **d.** all of the above.

5. The illumination at a point of 5 meters below a lamp is 6 lux. The candle power of the lamp is:
a. 30 **b.** 140 **c.** 150 **d.** 200

6. Which of the following lamp gives nearly monochromatic light?
a. Sodium vapor lamp **c.** Tube light
b. GLS lamp **d.** Mercury vapor lamp

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

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

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

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

b. A walkway is illuminated by 250 W lamps each having a luminous intensity of 4750 candela in all directions below the horizontal plane. Each lamp is installed at a height of 6m and the distance between them is 16m. Calculate:

i. The illuminance contributed by each lamp:

a. Directly underneath **c.** 16 meters from the base
b. 8 meters from the base **d.** 32 meters from the base **[4 Marks]**

ii The total illuminance at the base of each lamp post **[6 Marks]**

Contd.. required tables and figures

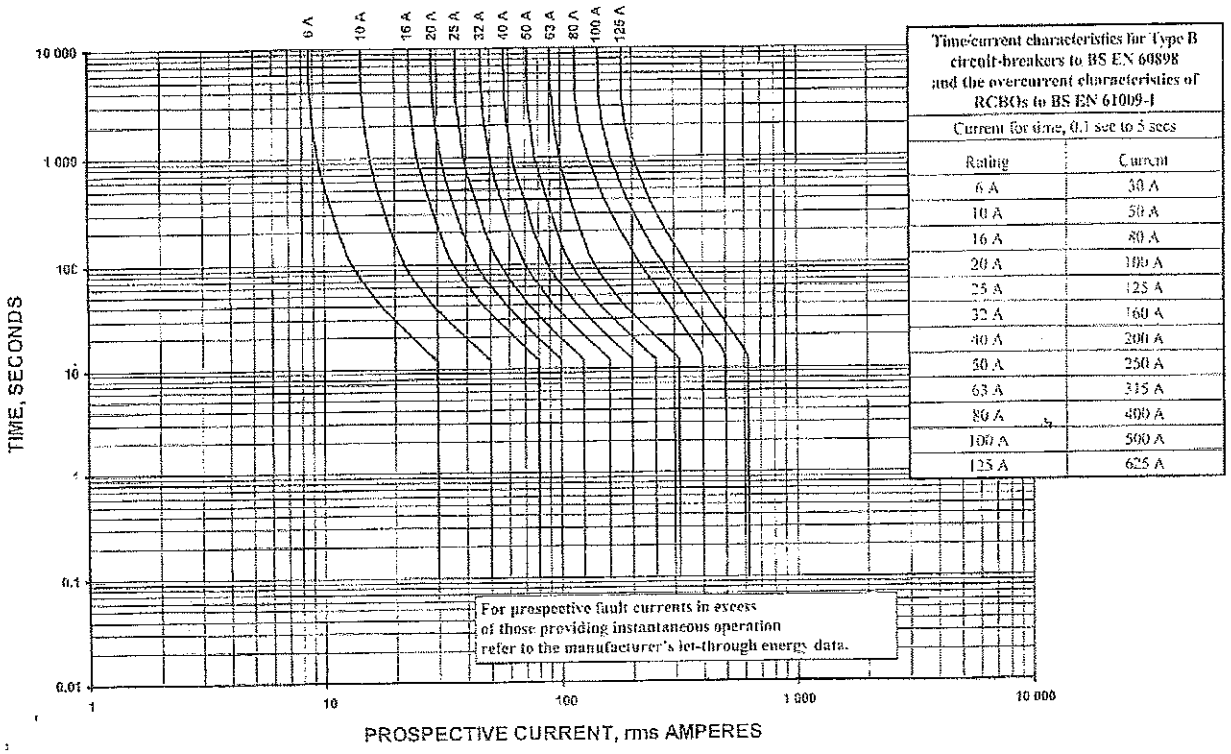
Rating factor (C_a) table for ambient temperature correction

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	

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

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 phasea.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

Fuses to BS 88-2 fuse systems E and G characteristics