

LOCATION /SWANSEA

LLEOLIAD /ABERTAWE

LEVEL 4

LEFEL 4

**EXAMINATION PERIOD
2019-2020**

**CYFNOD ARHOLIADAU
2019-2020**

**MODULE CODE: M4X00920
DESIGN OF ELECTRICAL INSTALLATIONS**

TIME: 2 HOURS

ANSWER ALL QUESTIONS

Equipment or materials required

– Calculators may be used

- All relevant BS 7671, 18TH EDITION & On Site Guide tables are provided*

Question one (10 marks)

- a) In the context of an electrical installation explain what exposed conductive parts are? Give two example of items that may be used. (4 marks)
- b) PME systems require additional electrodes in the supply system. State a reason for this (1 mark)
- c) With the aid of a sketch, explain the operation of a TN-S earth system during a fault condition (4 marks)
- d) Give two possible advantages of a TN-C-S earth system over a TT earth system (1 mark)

Question two (10 marks)

A single phase 230V a.c. installation is provided with a TN-C-S earthing system, the Distribution Network Operator has declared that Z_e is 0.32Ω . You have installed a shower circuit using 6 mm^2 70°C thermoplastic T&E copper cable. A fault to earth has occurred on equipment 23m from the fuse as shown in figure 1 overleaf. Using the information provided in Table 1 below:-

Line Conductor csa (mm^2)	Protective conductor csa (mm^2)	R/metre ($\text{m}\Omega/\text{m}$)
6	2.5	10.49
6	6	6.16

Table 1

- a) Determine the prospective fault current (5 marks)
- b) Assuming the fuse device is a 40A BSEN 60898 Type B circuit breaker, determine the time until the fuse will break the circuit by applying the chart given in Figure 2 (5 marks)

Figure 1

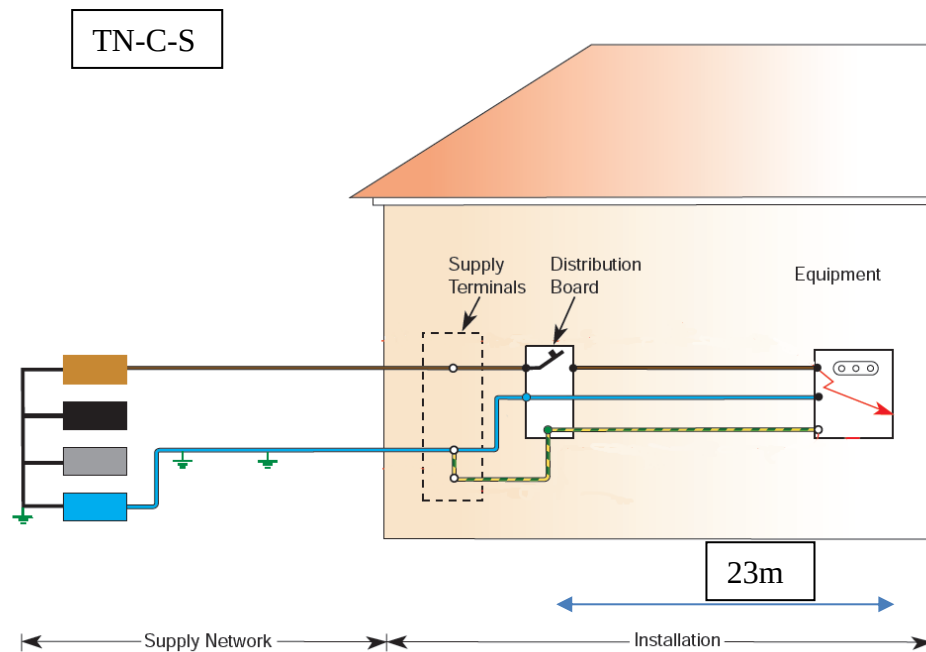
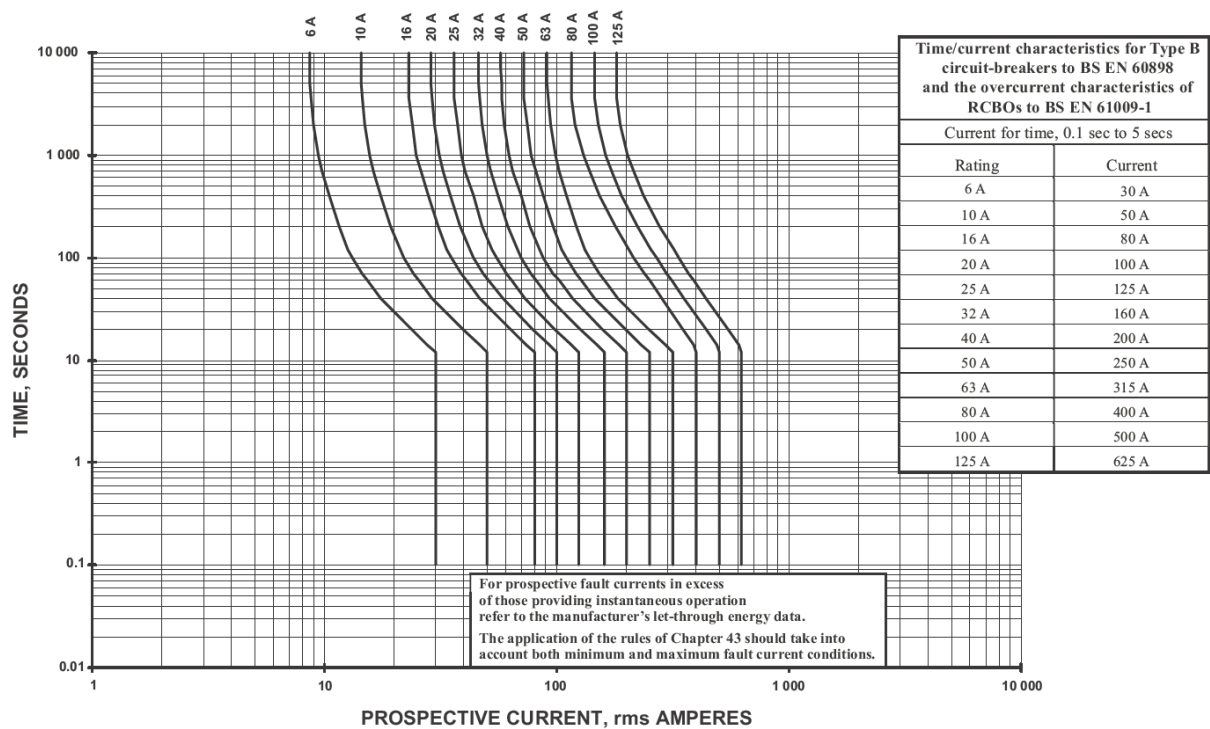


Figure 2

Fig 3A4 – Type B circuit-breakers to BS EN 60898 and RCBOs to BS EN 61009-1



Question three (15 marks)

- a) Using the relevant extracts supplied from BS7671, determine the minimum live conductor and c.p.c. sizes for a factory installation circuit comprising an industrial process heater. The heater has a rated load of 37 A. The heater will be supplied from a distribution board and protected by BS88-2 fuse. It is located 27m away from the distribution board.

The supply will be run in steel conduit using 70°C PVC singles (reference method B) with two other circuits. The run passes through an area where the ambient temperature may reach 33°C.

A TN-S earthing system is employed with a measured $Z_e = 0.6 \Omega$.

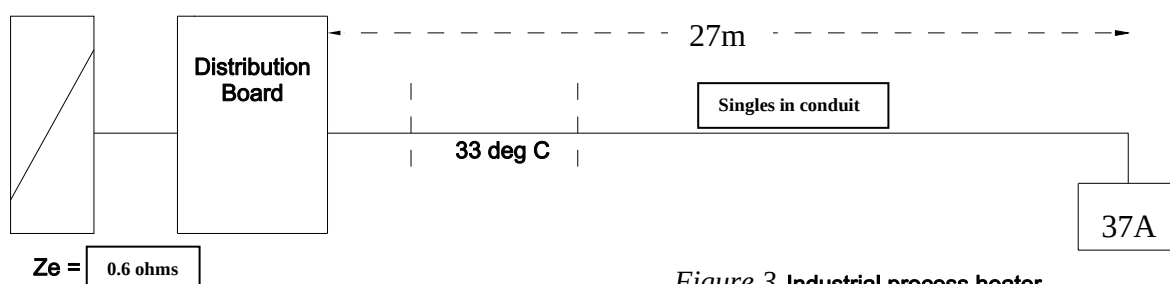


Figure 3 Industrial process heater

(15 marks)

$$\left(Z_s = Z_e + \frac{(R_1 + R_2) * L * 1.2}{1000} \quad s = \frac{\sqrt{I^2 t}}{k} \right)$$

Question four (10 marks)

- a) A school hall measuring 42m by 19 m is required to be lit using lamps with an output of 13,500 lumens each. Using the lumen method, determine the theoretical quantity of lamps required to provide a minimum light level of 300 lux?

(Assume: a Utilisation Factor of 0.8, a Maintenance Factor of 0.7 and the luminaires are pendant types)

(5 marks)

- b) What is the lighting level 6m directly below one of the installed luminaires assuming a luminous intensity of 10000 cd?

(3 marks)

- c) With the aid of a sketch explain how you would arrange the locations of the luminaires

(2 marks)

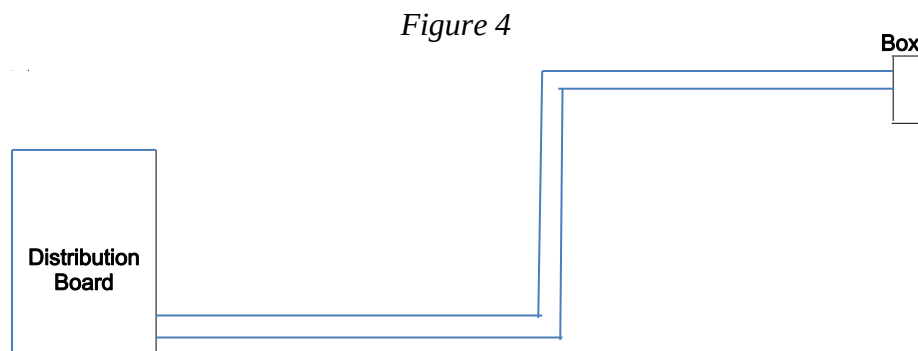
Question five (10 marks)

You are required to determine the size of the neutral conductor in a three phase installation within an office block. In order to do this you need to calculate the size of the neutral current. Investigations reveal that all loads are purely resistive. You also find that the potential loads on each phase will be:-

- 115 Amp on Brown phase.
 - 145 Amp on Black phase.
 - 200 Amp on Grey phase.
- a) Determine the neutral current under normal conditions. (6 marks)
- b) If the loads were to be partly reactive, how would this affect the calculation? (2 marks)
- c) If in order to balance the loads you find that there are two or more phases supplying a single room. Describe 1 action you must make. (2 marks)

Question Six (5 marks)

- a) A radial circuit is installed from a distribution board which is 8 m long with two bends as shown in Figure 4. It is to enclose 6 x 1.5 mm² and 9 x 2.5 mm² and 6 x 6 mm² and 3 x 10mm² stranded cables. With the aid of the tables attached, determine a suitable size trunking. (3 marks)



- b) Due to a change in use of the trunking, it has been calculated that all cables enclosed within the trunking are to be 10mm². Determine the maximum number of 10mm² cables that could be installed in the trunking.

(2 mark)

Type of conductor	Conductor cross-sectional area (mm ²)	PVC BS 6004 Cable factor	Thermosetting BS 7211 Cable factor
Solid	1.5	8.0	8.6
	2.5	11.9	11.9
Stranded	1.5	8.6	9.6
	2.5	12.6	13.9
	4	16.6	18.1
	6	21.2	22.9
	10	35.3	36.3
	16	47.8	50.3
	25	73.9	75.4

Dimensions of trunking (mm × mm)	Factor	Dimensions of trunking (mm × mm)	Factor
50 × 38	767	200 × 100	8572
50 × 50	1037	200 × 150	13001
75 × 25	738	200 × 200	17429
75 × 38	1146	225 × 38	3474
75 × 50	1555	225 × 50	4671
75 × 75	2371	225 × 75	7167
100 × 25	993	225 × 100	9662
100 × 38	1542	225 × 150	14652
100 × 50	2091	225 × 200	19643
100 × 75	3189	225 × 225	22138
100 × 100	4252	300 × 38	4648
150 × 38	2999	300 × 50	6251
150 × 50	3091	300 × 75	9590
150 × 75	4743	300 × 100	12929
150 × 100	6394	300 × 150	19607
150 × 150	9697	300 × 200	26285
200 × 38	3082	300 × 225	29624
200 × 50	4145	300 × 300	39428
200 × 75	6359		

Ambient temperature (°C)	Insulation			
	70 °C thermoplastic	90 °C thermosetting	Mineral	
			Thermoplastic covered or bare and exposed to touch 70 °C	Bare and not exposed to touch 105 °C
25	1.03	1.02	1.07	1.04
30	1.00	1.00	1.00	1.00
35	0.94	0.96	0.93	0.96
40	0.87	0.91	0.85	0.92

Maximum operating time/current characteristics for fuses to BS 88-2 fuse systems E and G					
Fuse rating	Current for time				
	0.1 sec	0.2 sec	0.4 sec	1 sec	5 secs
4 A	18 A	16 A	14 A	12.2 A	10.5 A
10 A	60 A	54 A	47 A	40 A	32 A
16 A	115 A	100 A	90 A	75 A	55 A
25 A	220 A	190 A	170 A	140 A	100 A
40 A	400 A	340 A	290 A	230 A	170 A
63 A	720 A	600 A	500 A	400 A	280 A
100 A	1400 A	1200 A	1000 A	780 A	520 A
160 A	2400 A	2000 A	1600 A	1300 A	820 A

Arrangement (cables touching)	Number of circuits or multicore cables										Applicable reference method for current-carrying capacities
	1	2	3	4	5	6	7	8	9	12	
Bunched in air, on a surface, embedded or enclosed	1.0	0.80	0.70	0.65	0.60	0.57	0.54	0.52	0.50	0.45	A to F
Single layer on wall or floor	1.0	0.85	0.79	0.75	0.73	0.72	0.72	0.71	0.70	0.70	C
Single layer multicore on a perforated horizontal or vertical cable tray system	1.0	0.88	0.82	0.77	0.75	0.73	0.73	0.72	0.72	0.72	E
Single layer multicore on a cable ladder system or cleats, etc.	1.0	0.87	0.82	0.80	0.80	0.79	0.79	0.78	0.78	0.78	E

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)				
	2 cables, single-phase AC or DC	3 or 4 cables, three-phase AC	2 cables, single-phase AC or DC	3 or 4 cables, three-phase AC	2 cables, single-phase AC or DC flat and touching	3 or 4 cables, three-phase AC flat and touching or trefoil	Touching			Spaced by one cable diameter	
							2 cables, single-phase AC or DC flat	3 cables, three-phase AC flat	3 cables three-phase AC trefoil	2 cables single-phase AC or DC or 3 cables three-phase AC flat	
										horizontal	vertical
1 mm ²	2	3	4	5	6	7	8	9	10	11	12
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

Conductor installation	Conductor insulation		
	70 °C Thermoplastic (PVC)	90 °C Thermoplastic (PVC)	90 °C Thermosetting
Not incorporated in a cable and not bunched (note 1)	1.04	1.04	1.04
Incorporated in a cable or bunched (note 2)	1.20	1.28	1.28

Conductor cross-sectional area	2 cables DC	2 cables, single-phase AC				3 or 4 cables, three-phase AC			
		Reference methods A & B (enclosed in conduit or trunking)	Reference methods C & F (clipped direct on tray or in free air) touching	Reference methods C & F (clipped direct on tray or in free air) spaced	Reference methods A & B (enclosed in conduit or trunking)	Reference methods C & F (clipped direct, on tray or in free air) Touching, Trefoil	Reference methods C & F (clipped direct, on tray or in free air) Touching, Flat	Reference methods C & F (clipped direct, on tray or in free air) Spaced*, Flat	
1 mm ²	2 mV/A/m	3 mV/A/m	4 mV/A/m	5 mV/A/m	6 mV/A/m	7 mV/A/m	8 mV/A/m	9 mV/A/m	
1	44	44	44	44	38	38	38	38	
1.5	29	29	29	29	25	25	25	25	
2.5	18	18	18	18	15	15	15	15	
4	11	11	11	11	9.5	9.5	9.5	9.5	
6	7.3	7.3	7.3	7.3	6.4	6.4	6.4	6.4	
10	4.4	4.4	4.4	4.4	3.8	3.8	3.8	3.8	
16	2.8	2.8	2.8	2.8	2.4	2.4	2.4	2.4	
		$z^{\dagger}$	$z^{\dagger}$	$z^{\dagger}$	$z^{\dagger}$	$z^{\dagger}$	$z^{\dagger}$	$z^{\dagger}$	
25	1.75	1.80	1.75	1.80	1.55	1.50	1.55	1.55	
35	1.25	1.30	1.25	1.30	1.10	1.10	1.10	1.15	
50	0.93	1.00	0.95	0.97	0.85	0.82	0.84	0.86	
70	0.63	0.72	0.66	0.69	0.61	0.57	0.60	0.63	
95	0.46	0.56	0.50	0.54	0.48	0.43	0.47	0.51	

Cross-sectional area (mm ²)		Resistance/metre or (R ₁ + R ₂)/metre (mΩ/m)	
Line conductor	Protective conductor	Copper	Aluminium
1	—	18.10	
1	1	36.20	
1.5	—	12.10	
1.5	1	30.20	
1.5	1.5	24.20	
2.5	—	7.41	
2.5	1	25.51	
2.5	1.5	19.51	
2.5	2.5	14.82	
4	—	4.61	
4	1.5	16.71	
4	2.5	12.02	
4	4	9.22	
6	—	3.08	
6	2.5	10.49	
6	4	7.69	
6	6	6.16	
10	—	1.83	
10	4	6.44	
10	6	4.91	
10	10	3.66	
16	—	1.15	1.91
16	6	4.23	—
16	10	2.98	—
16	16	2.30	3.82
25	—	0.727	1.20
25	10	2.557	—
25	16	1.877	—
25	25	1.454	2.40
35	—	0.524	0.87
35	16	1.674	2.78
35	25	1.251	2.07
35	35	1.048	1.74
50	—	0.387	0.64
50	25	1.114	1.84
50	35	0.911	1.51
50	50	0.774	1.28