The Open University of Sri Lanka
Diploma in Technology
ECX4234-Electrical Installation
Final Examination 2013/2014

Date 11/08/2014 **Time:9.30-12.30 hrs.**

This paper contains 8 questions. Pages 4 to 10 contain tables and appendices required for answering the questions. Answer only five (5) questions.

1. **a)** How many amendments will be made/published to the original edition of the IEE Regulations before releasing the next/new edition? **[3.5 Marks]**

   b) A 20 A over-current protective device is installed in a radial circuit with 'x' number of socket outlets (55 m^2 floor area). What would be the permitted conductor size? **[3.5 Marks]**

   c) An electric appliance is protected by 13 A mcb. What would be the size of the cable you would recommend, if this cable is installed in a wall enclosed in a conduit and dedicated only for this appliance? Assume that the ambient temperature is 30^0C **[3.5 Marks]**

   d) What would be the diversified current demand of three numbers of 230 V, 4.5 kW, 4-burner electric cookers (3 electric & one gas with a built-in oven) installed in a small hotel. **[3.5 Marks]**

   e) What does the symbols  and  represents in a wiring diagram of an electric installation? **[2.5 Marks]**

   f) With in what cable distance a 230 V, 4.5 kW hot water geezer can be installed in a domestic installation. State any assumptions made during your calculations? **[3.5 Marks]**

2. A 230 V, 10 kW electric cooking appliance is installed. The circuit is wired using a 12 m long **p.v.c.** cable clipped direct to a surface with a 2.5 mm^2 cpc. If the circuit is protected by a BS 1361 fuse, what would be the protective device current rating (I_n) and the size of the cable you would select for this appliance? Is this cable length acceptable? **[5 Marks]**

   If the value of earth fault loop impedance external to the installation is 0.45 Ω and assuming that no rating factors are applicable for grouping or ambient temperature, determine whether the circuit complies with the IEE wiring Regulations for shock protection (i.e. for 0.4s), if the cooker appliance is installed with a socket out let incorporated in control unit? **[10 Marks]**

   Re-calculate and check whether the circuit complies with the IEE Regulations if the socket outlet in control unit is not essential (i.e. for 5s)? **[5 Marks]**

3. A single phase 230 V circuit is run in two core 70 ^{0}C, **p.v.c** insulated and sheathed cable. The conductors (Cu) are being 16 mm^2 and the circuit protective conductor (c.p.c.) is 6 mm^2. If the length of the run is 40 m long, ambient temperature is 30 ^{0}C and the circuit is protected by 80 A BS88 fuse, prove that the protective device will not be functioned properly. Assume that the earth fault loop impedance external to the circuit is 0.36 Ω and the disconnection time is = 0.5 sec **[15 Marks]**
   Find a suitable size for c.p.c. to function the protective device of the above circuit properly and the corresponding disconnecting time? **[5 Marks]**

4. **a)** Which device will operate first in the event of a short circuit fault if a 5A rewireble fuse and a 10A mcb are installed in series in a certain circuit? **[5 Marks]**

b) A jewellery shop has installed following appliances operating at 230V/50 Hz:

- Total of seven (7) Direct heaters 3X2 kW, 2X1.5 kW and 2X1 kW
- 4 burner cooker 4 kW
- Water heater (thermostatic) 3 kW
- Two 30 A ring circuit
- Total shop lighting load of 2 kW

Determine the maximum demand of the jewellery shop? **[10 Marks]**

c) What type of a service would you recommends for the above shop and determines the size of the service cable (main wire)? **[5 Marks]**

5. **a)** Determine the resistance of (l meter long with a cross sectional area A) a rod electrode driven in to the earth using the basic equation $R = \frac{\rho l}{A}$. Symbols have their usual meanings. **[5 Marks]**

b) Compute the expected earth resistance of a 2m long GI pipe of diameter 50 mm firmly driven in to a soil of resistivity 100 Ωm. **[4 Marks]**

c) State three methods that can be adopted to improve earth electrode resistance. **[3 Marks]**

d) How many earth electrodes of (b) above you need and how would you connect those electrodes to reduce the earth resistance of the place (100 Ωm soil resistivity) to 5Ω? **[5 Marks]**

e) State two commonly used method of arrangements for determination of soil resistivity **[3 Marks]**

6. **a)** Considering the conductor loss and the corresponding rice in temperature of an electrical cable, derive the adiabatic equation $t = k^2 \times \frac{A^2}{I^2}$ where $k^2 = \frac{d}{\rho} \times s \times \theta$

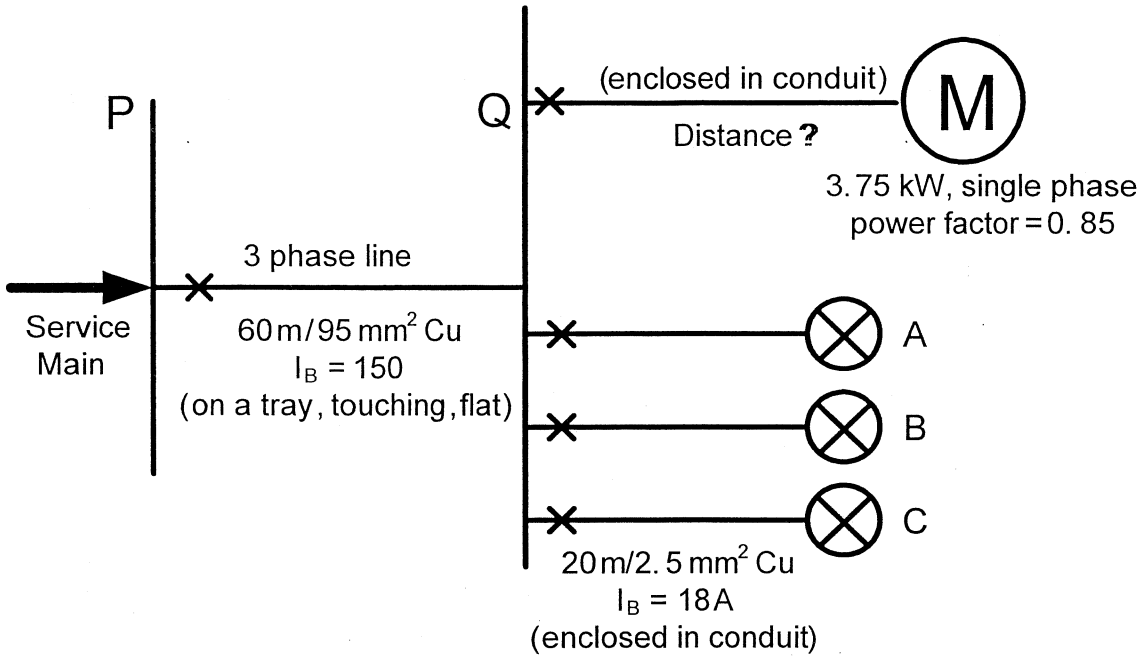
ρ = resistivity of the conductor material
A = Cross sectional area of the conductor
d = density of the conductor material
I = Effective short circuit current
s = Specific heat of the conductor material
θ = Maximum permitted temperature rice

[8 Marks]

b) A 230 V, 5A radial socket outlet is protected by a BS3036 semi-enclosed fuse. The circuit is wired using single core **p.v.c.** cables installed in a 28 m length of conduit pipe. Assuming that no rating factors are applicable determine the adequate conductor size for this circuit. **[6 Marks]**

c) If a separate protective conductor consisting of 1 mm^2 **p.v.c.** cable is used for the circuit described above in (b) and the value of earth fault loop impedance external to this circuit is given as 2.5 Ω, check whether the circuit complies with the adiabatic equation. You may assume the value of k for the cable =143. **[6 Marks]**

7. Conceptual single line diagram of a certain installation is as shown below:



a) A 3 phase line (Cu conductors) of 95 mm^2 and a length of 60 m caries a current of 150 A. The above three phase line supplies 3 single phase lighting circuits A, B and C, each of 2.5 mm^2 (Cu conductors) 20 m long and each conductor caries 18 A. What would be the percentage voltage drop at the end of the lighting circuit? **[10 Marks]**

b) Calculate the distance of the cable (enclosed in conduit) that you would allow for the installation of single phase induction motor M shown above if the permissible voltage drop allowed from P is 2.5%? *Service main is 400 V, 3phase, 50 Hz.* **[10 Marks]**

8. a) A lighting circuit of a hall requires an installation of a conduit system with a conduit length of 9.75m with two bends. The number of cables required for this installation is twelve (12) numbers of 1.5 mm^2 **p.v.c.** insulated cables. What size of a conduit should be chosen for this installation? What is the minimum bending radius that should be observed during the installation? **[10 Marks]**

b) A steel trunking is to be installed in an industrial wiring system consisting of six single phase circuits (assume copper conductor cables with **p.v.c.** insulation). Each circuit is designed to carry of 30 A current protected by Type B circuit-breakers to BS EN 60898. Determine the trunking size required for this wiring system.

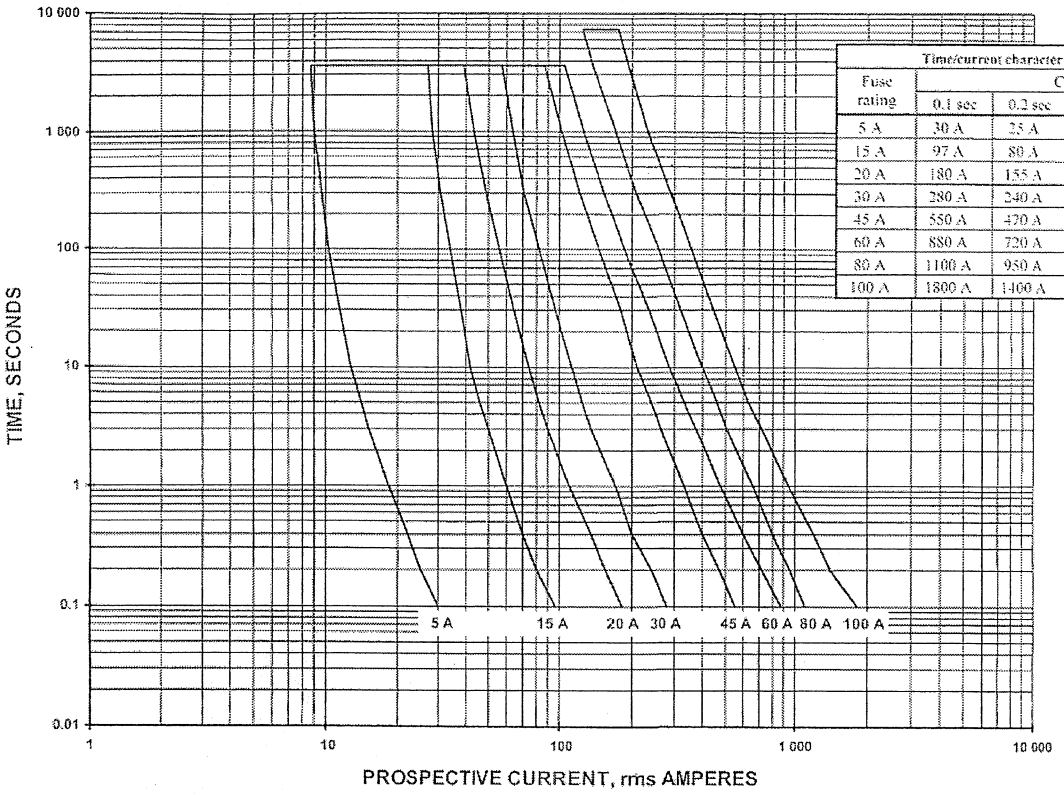
Conductor cross section (mm^2)	Overall diameter (mm)
6	5.4
10	6.8
16	8.0
25	9.8

[10 Marks]

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 utilisation + 40% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation + 75% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation + 75% of current demand of every point in main rooms (dining rooms, etc) + 40% of current demand of every other point of utilisation

BS 1361 Fuse Characteristics

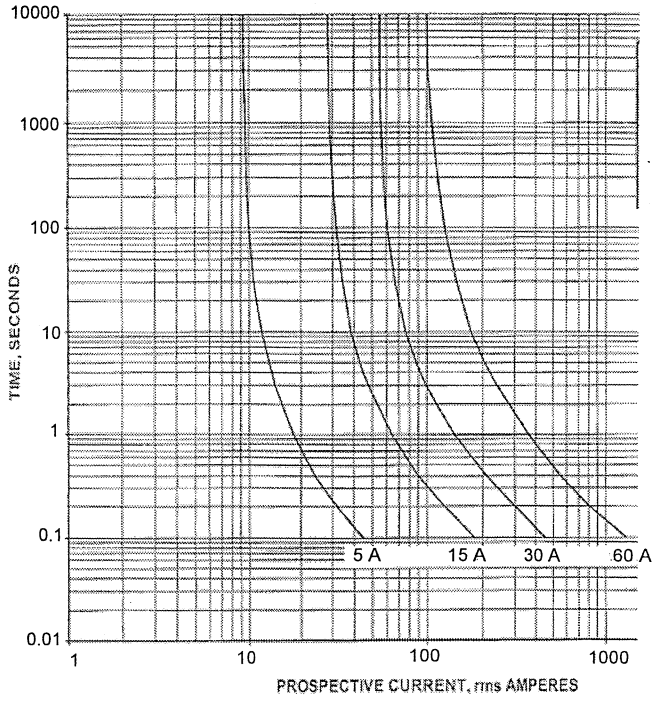


Time/current characteristics for fuses to BS 1361					
Fuse rating	Current for time				
	0.1 sec	0.2 sec	0.4 sec	1 sec	5 secs
5 A	30 A	25 A	22 A	18 A	14 A
15 A	97 A	80 A	70 A	60 A	46 A
20 A	180 A	155 A	135 A	110 A	82 A
30 A	280 A	240 A	200 A	170 A	125 A
45 A	550 A	470 A	400 A	330 A	240 A
60 A	880 A	720 A	600 A	480 A	330 A
80 A	1100 A	950 A	800 A	660 A	460 A
100 A	1800 A	1400 A	1200 A	940 A	630 A

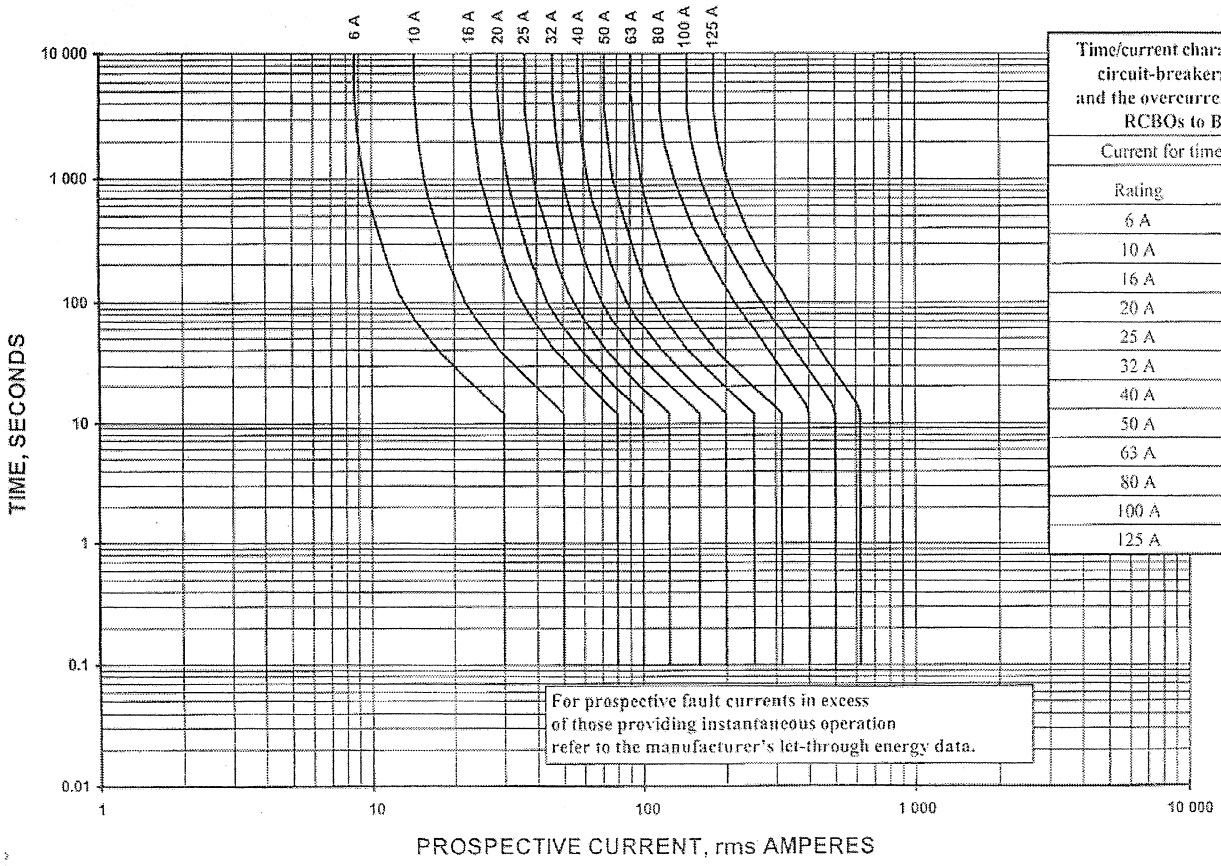
Values of (R_1+R_2) per meter for P.V.C. insulated copper conductors

Cross sectional area mm^2		(R_1+R_2) Ohms/meter
Phase conductor	Protective conductor	
1	1	0.055
1.5	1	0.046
	1.5	0.037
2.5	1	0.039
	1.5	0.03
	2.5	0.022
4	1.5	0.026
	2.5	0.018
	4	0.014
6	2.5	0.016
	4	0.0116
	6	0.0092
10	2.5	0.01375
	4	0.0098
	6	0.0074
	10	0.0055
16	2.5	0.01275
	4	0.00875
	6	0.0064
	10	0.0045
	16	0.0035

BS 3036 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

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

Arrangement (Cable touching)	Number of circuits or multicore cables												To be used with current-carrying capacities 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	0.6	0.57	0.54	0.52	0.5	0.45	0.41	0.38	Method 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	0.7	0.7	0.7	0.7	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	0.73	0.72	0.72	0.72	0.72	0.72	Method E & F
Single layer multicore on cable ladder system or cleats etc.	1.00	0.87	0.82	0.8	0.8	0.79	0.79	0.78	0.78	0.78	0.78	0.78	

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
65	-	0.65
70	-	0.58
75	-	0.50
80		0.41

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

CURRENT-CARRYING CAPACITY (amperes):

Ambient temperature: 30 °C
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, single-phase a.c. or d.c.	3 or 4 cables, three-phase a.c.	2 cables, single-phase a.c. or d.c.	3 or 4 cables, three-phase a.c.	2 cables, single-phase a.c. or d.c. flat and touching	3 or 4 cables, three-phase a.c. flat and touching or trefoil	2 cables, single-phase a.c. or d.c. flat	3 cables, three-phase a.c. flat	3 cables, three-phase a.c trefoil	2 cables, single-phase a.c. or d.c. or 3 cables three-phase a.c. flat	
										Horizontal	Vertical
1	2	3	4	5	6	7	8	9	10	11	12
(mm^2)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
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
400	-	-	546	467	694	634	754	689	656	852	795
500	-	-	626	533	792	723	868	789	749	982	920
630	-	-	720	611	904	826	1005	905	855	1138	1070
800	-	-	-	-	1030	943	1086	1020	971	1265	1188
1000	-	-	-	-	1154	1058	1216	1149	1079	1420	1337

TABLE 4D1B

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

Conductor cross-sectional area	2 cables d.c.	2 cables, single-phase a.c.									3 or 4 cables, three-phase 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		
1	2	3			4			5			6			7			8			9		
(mm^2)	(mV/A/m)	(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(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		
		r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z
25	1.75	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	1.25	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	0.93	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	0.86
70	0.63	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	0.46	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	0.36	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	0.150	0.36	0.32	0.23	0.40	0.32	0.30	0.44
150	0.29	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	0.150	0.30	0.26	0.23	0.34	0.26	0.30	0.40
185	0.23	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	0.180	0.195	0.26	0.33	0.185	0.165	0.25	0.185	0.25	0.31	0.17	0.23	0.29	0.160	0.145	0.22	0.160	0.22	0.27	0.160	0.29	0.34
300	0.145	0.160	0.26	0.31	0.150	0.165	0.22	0.150	0.25	0.29	0.14	0.23	0.27	0.130	0.140	0.190	0.130	0.22	0.25	0.130	0.29	0.32
400	0.105	0.130	0.26	0.29	0.120	0.160	0.20	0.115	0.25	0.27	0.12	0.22	0.25	0.105	0.140	0.175	0.105	0.21	0.24	0.100	0.29	0.31
500	0.086	0.110	0.26	0.28	0.098	0.155	0.185	0.093	0.24	0.26	0.10	0.22	0.25	0.086	0.135	0.160	0.086	0.21	0.23	0.081	0.29	0.30
630	0.068	0.094	0.25	0.27	0.081	0.155	0.175	0.076	0.24	0.25	0.08	0.22	0.24	0.072	0.135	0.150	0.072	0.21	0.22	0.066	0.28	0.29
800	0.053		-		0.068	0.150	0.165	0.061	0.24	0.25		-		0.060	0.130	0.145	0.060	0.21	0.22	0.053	0.28	0.29
1000	0.042		-		0.059	0.150	0.160	0.050	0.24	0.24		-		0.052	0.130	0.140	0.052	0.20	0.21	0.044	0.28	0.28

NOTE: * Spacings larger than one cable diameter will result in a larger voltage drop.

Cable factors for long straight runs > 3 meters, or runs incorporating bends

Type of conductor	Conductor cross-sectional area mm^2	Factor
Solid or stranded	1	16
	1.5	22
	2.5	30
	4	43
	6	58
	10	105

Conduit factors for runs incorporating bonds

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								