SHORT CIRCUIT CURRENT CALCULATION BY OHMIC VALUE METHOD

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COURSE OUTLINES

1. Sources of Fault Current
2. Short Circuit
3. Effect of Short Circuit
4. Protection Against Short Circuit
5. Interrupting Capacity of Protective Device
6. Prospective Short Circuit Current
7. Ohmic Value Method
8. Main Objective of Fault Calculation
9. Ohmic Value of Cable Impedance
10. Adjustment of Operating Temperature of Cable Resistance
11. Value k for Calculation of the Effect of Fault Current
12. Time Current Characteristic of MCB/MCCB/ACB
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1. SOURCES OF FAULT CURRENTS

The basic sources of fault currents are the utility supply system, local generators, synchronous motors and induction motors. All the running generators in the utility system contribute to the fault current in a low-voltage system. However, transmission and distribution lines and transformers introduce impedances between the utility generators and the low voltage system. As a result, the contribution of these generators to the fault current in the low-voltage system is substantially reduced. Nevertheless, the utility system is still the main source of the fault currents. The amount of the short-circuit current from the utility system is normally expressed as the fault level should normally be obtained from the utility. Typical values of fault level at 22 kV are in the range of 300 MVA to 1000 MVA and for 6.6 kV, in the range of 150 MVA to 200 MVA.

2. SHORT CIRCUIT

Short-circuit faults in an electrical installation can arise as a result of:

a) Failure of insulation within equipment or distribution feeders.
b) Wrong connection of terminations.
c) Negligence.

3. EFFECTS OF SHORT CIRCUIT CURRENT

When a short-circuit occurs, a very high fault current flows from the source of supply to the fault point; the two effects of this high short-circuit are:

a) Dissipation of a tremendous amount of heat energy (thermal energy) in the complete distribution system.

   Thermal energy = (I^2R) x Duration of the fault

b) Setting up of a very high oscillating mechanical force (proportional to I^2) between two conductors, which may cause serve mechanical damage to the installation.

4. PROTECTION AGAINST SHORT CIRCUIT

Short-circuit protective devices are circuit breakers or fuses at all voltage levels.

The circuit breakers or fuses selected must be capable of interrupting the fault current at the rated voltages that may flow under any of the following short-circuit conditions:

a) Three Phase Fault
b) Line to Neutral Fault
c) Line to Line Fault

5. INTERRUPTING CAPACITY OF PROTECTIVE DEVICE

When subjected to a short-circuit, protective devices having inadequate interrupting capacity may explode resulting in injury to personnel and causing serious damage to the installation.

The short-circuit rating of a protective device is the maximum fault current that the device can interrupt safely and must therefore not be less than the calculated short-circuit current at the point of installation.

6. PROSPECTIVE SHORT CIRCUIT CURRENT

The configuration in its simplest forms is as shown in Figure 1.

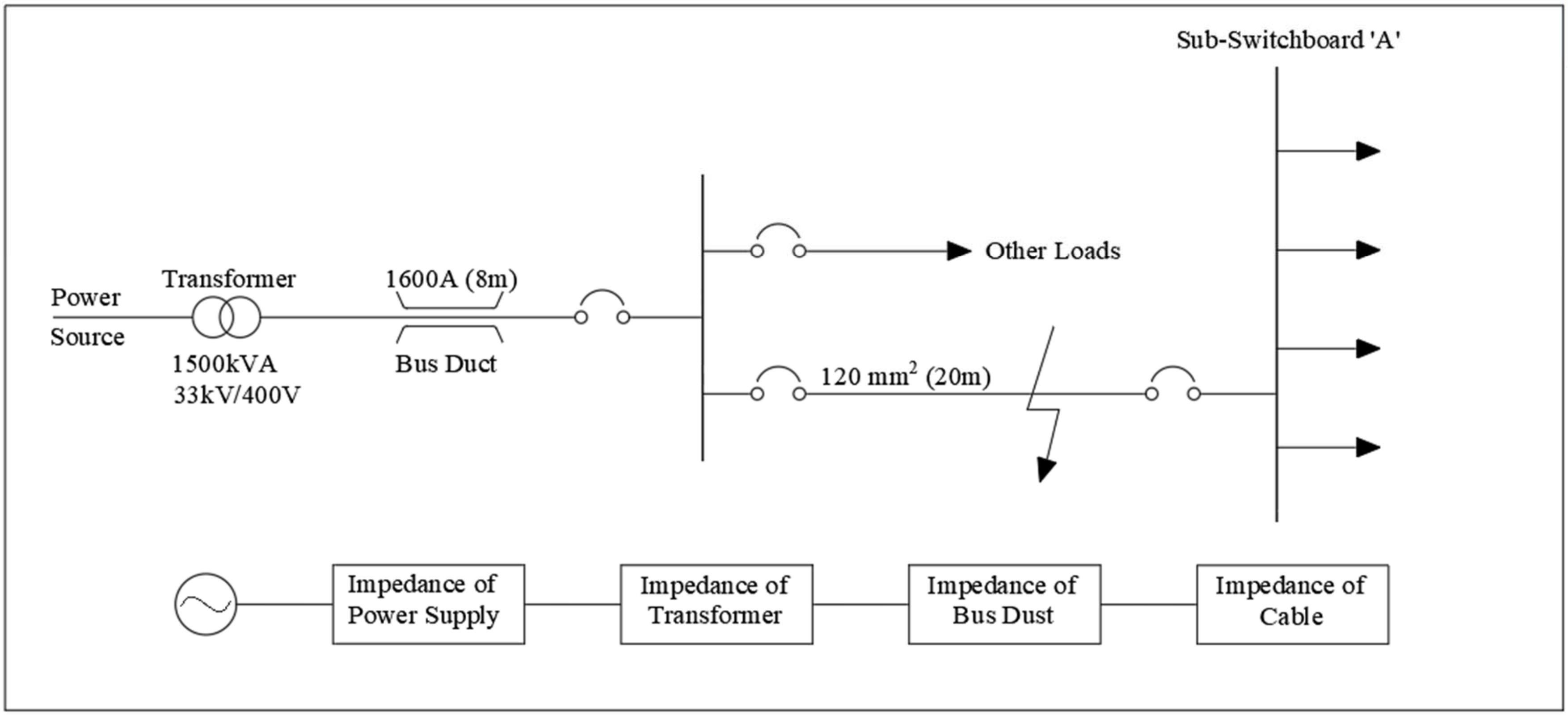


Figure 1 Total system impedance which limits the short circuit current

The ‘prospective’ level of fault current at the point of installation is the r.m.s. symmetrical current that would flow in a circuit due to the nominal applied voltage when a short-circuiting occurs at that point.

Total System Resistance R_T = Resistance of Power Source + Resistance of Transformer + Resistance of Bus Duct + Resistance of Cable

Total System Reactance R_T = Reactance of Power Source + Reactance of Transformer + Reactance of Bus Duct + Reactance of Cable

Total System Impedance $Z_T = \sqrt{R_T{}^2 + X_T{}^2}$

Therefore, r.m.s. value of a 3-phase symmetrical short-circuit current

$$I_r = \frac{\text{Line Voltage}}{\sqrt{3}\ \text{x}\ Z_T}$$

7. OHMIC VALUE METHOD

The above calculation makes use of the ohmic value of impedance of the power source, transformer, bus duct and cables for the fault current calculation and it is therefore known as ohmic value method.

Ohmic value method for fault current is effective for simple system with one voltage level only (i.e. 400V 3-phase or 230V single phase system).

8. MAIN OBJECTIVE OF FAULT CALCULATIONS

a) To determine maximum 3-phase short-circuit currents for the selection of suitable circuit breakers with the necessary interrupting capacities.

b) To determine the time co-ordination of protective relays with the knowledge of the fault currents that must be protected.

c) To ensure that busbars are adequately braced against the short-circuit forces produced by the high fault currents. Short-circuit forces are proportional to the square of the fault current.

d) To select cables with ability to withstand short-circuit heating for the time required to clear circuit by the circuit breakers or fuses.

9. OHMIC VALUE OF CABLE IMPEDANCE

To calculate the fault current by ohmic value method, the ohmic value of cable resistance and reactance can be obtained from the voltage drop section of tables in the code of practice for electrical installations.

An example of this drop table is shown in Table 1 for PVC insulated single core cable and Table 2 for XLPE insulated single core cable.

The phase conductor's resistance R and reactance X for each meter run of the phase conductor can be calculated from the tabulated mV/A/m values of the tables.

For example, actual resistance of conductor at maximum operating temperature (70˚C for PVC insulation and 90˚C for XLPE insulation) can be calculated by:-

$$R_P = ½(mV/A/m)_r \ \& \ X_P = ½(mV/A/m)_x$$

and

$$R_P = (mV/A/m)_r/\sqrt{3} \ \& \ X_P = (mV/A/m)_x/\sqrt{3}$$

If the value of MV/A/m and taken from the 3-phase columns.

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 3 & 4 (enclosed in conduit etc. in or on a wall)			Reference Methods 1 & 11 (clipped direct or on trays, touching)			Reference Method 12 (spaced*)			Reference Methods 3 & 4 (enclosed in conduit etc. in or on a wall)			Reference Methods 1, 11 & 12 (in trefoil)			Reference Methods 1 & 11 (flat and touching)			Reference Method 12 (flat spaced*)		
1	2	3			4			5			6			7			8			9		
(mm²)	(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

Table 1 Voltage drop section of single core PVC cable which mV/A/m as phase to neutral voltage drop for single phase system and line to line voltage drop for 3-phase system

TABLE 4E1B

VOLTAGE DROP (per ampere per meter) — Conduct operating temperature 90°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 3 & 4 (enclosed in conduit etc. in or on a wall			Reference Methods 1 & 11 (clipped direct or on trays, touching)			Reference Method 12 (spaced*)			Reference Methods 3 & 4 (enclosed in conduit etc. in or on a wall)			Reference Methods 1, 11 & 12 (in trefoil)			Reference Methods 1 & 11 (flat, touching)			Reference Method 12 (flat spaced*)		
1	2		3			4			5			6			7			8			9	
(mm)	(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	46		46			46			46			40			40			40			40	
1.5	31		31			31			31			27			27			27			27	
2.5	19		19			19			19			16			16			16			16	
4	12		12			12			12			10			10			10			10	
6	7.9		7.9			7.9			7.9			6.8			6.8			6.8			6.8	
10	4.7		4.7			4.7			4.7			4			4			4			4	
16	2.9		2.9			2.9			2.9			2.5			2.5			2.5			2.5	
		r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z
25	1.85	1.85	0.31	1.90	1.85	0.190	1.85	1.85	0.28	1.85	1.60	0.27	1.65	1.60	0.165	1.50	1.60	0.19	1.60	1.60	0.27	1.65
35	1.35	1.35	0.29	1.35	1.35	0.180	1.35	1.35	0.27	1.35	1.15	0.25	1.15	1.15	0.155	1.15	1.15	0.18	1.15	1.15	0.26	1.20
50	0.99	1.00	0.29	1.05	0.99	0.180	1.00	0.99	0.27	1.00	0.87	0.25	0.90	0.86	0.155	0.87	0.86	0.18	0.87	0.86	0.26	0.89
70	0.68	0.70	0.28	0.75	0.68	0.175	0.73	0.68	0.26	0.73	0.60	0.24	0.65	0.59	0.150	0.61	0.59	0.18	0.62	0.59	0.25	0.65
95	0.49	0.51	0.27	0.58	0.49	0.170	0.52	0.49	0.26	0.56	0.44	0.23	0.50	0.43	0.145	0.45	0.43	0.17	0.46	0.43	0.25	0.49
120	0.39	0.41	0.26	0.48	0.39	0.165	0.43	0.39	0.25	0.47	0.35	0.23	0.42	0.34	0.140	0.37	0.34	0.165	0.38	0.34	0.24	0.42
150	0.32	0.33	0.26	0.43	0.32	0.165	0.36	0.32	0.25	0.41	0.29	0.23	0.37	0.28	0.140	0.31	0.28	0.165	0.32	0.28	0.24	0.37
185	0.25	0.27	0.26	0.37	0.26	0.165	0.30	0.25	0.25	0.36	0.23	0.23	0.32	0.22	0.140	0.26	0.22	0.165	0.28	0.22	0.24	0.33
240	0.190	0.21	0.26	0.33	0.20	0.160	0.25	0.20	0.25	0.31	0.19	0.22	0.29	0.170	0.140	0.22	0.170	0.165	0.24	0.170	0.24	0.29
300	0.155	0.175	0.25	0.31	0.160	0.160	0.22	0.155	0.25	0.29	0.150	0.22	0.27	0.140	0.140	0.195	0.135	0.160	0.21	0.135	0.24	0.27
400	0.120	0.140	0.25	0.29	0.130	0.155	0.20	0.125	0.24	0.27	0.125	0.22	0.25	0.110	0.135	0.175	0.110	0.160	0.195	0.110	0.24	0.26
500	0.093	0.120	0.25	0.28	0.105	0.155	0.185	0.098	0.24	0.26	0.100	0.22	0.24	0.090	0.135	0.160	0.088	0.160	0.180	0.085	0.24	0.25
630	0.072	0.100	0.25	0.27	0.086	0.155	0.175	0.078	0.24	0.25	0.088	0.21	0.23	0.074	0.135	0.150	0.071	0.160	0.17	0.068	0.23	0.24
800	0.056		-		0.072	0.150	0.170	0.06	0.24	0.25		-		0.062	0.130	0.145	0.059	0.155	0.165	0.055	0.23	0.24
1000	0.045		-		0.063	0.150	0.165	0.054	0.24	0.24		-		0.055	0.130	0.140	0.050	0.155	0.165	0.047	0.23	0.24

NOTE * Spacing larger than those specified in Method 12 (see table table 4A) will result in larger voltage drop

Table 2 Voltage drop section of single core XLPE cable which mV/A/m as phase to neutral voltage drop for single phase system and line to line voltage drop for 3-phase system

10. ADJUSTMENT OF OPERATING TEMPERATURE FOR CABLE RESISTANCE

As the $(mV/A/m)_r$ value of cables obtained from voltage section of tables in the code of practice for electrical installations are tabulated for maximum normal operating temperature for respective insulation type (i.e. 70˚C for PVC and 90˚C for XLPE), the actual resistive value of the phase conductor impedance must be adjusted by temperature because the temperature of the phase cable under short circuit condition may be higher and this will affect the resistive value as shown in Figure 2.

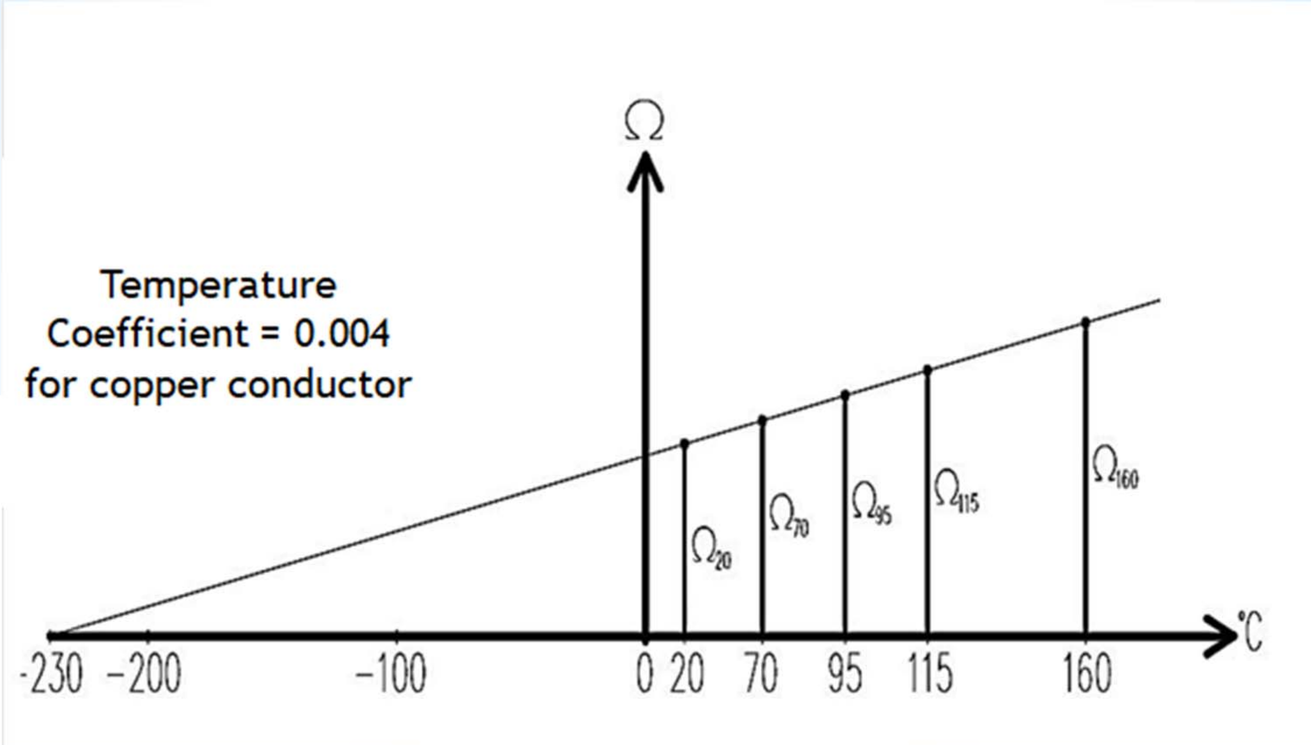


Figure 2 Resistance Value at Various Temperature

For assumed temperature t_g ˚C under short circuit condition, maximum normal operating temperature t_p ˚C may be adjusted by the formula:-

$$R/\text{meter} = (\text{tabulated mV/A/m})_r \text{ at } t_p\,^\circ C \times \left(\frac{230+t_g}{230+t_p}\right)$$

Example 1:

(a) For PVC insulated copper single core cable,

t_p = 70˚C

t_{max} = critical temperature for PVC = 160˚C

Average conductor temperature during fault condition is normally obtained by

$$t_g = \frac{(t_p + t_{max})}{2} = \frac{(70℃ + 160℃)}{2} = 115℃$$

$$\therefore R_{115˚C} = R_{70˚C} \times \left(\frac{230+115}{230+70}\right) = 1.15\ R_{70˚C}$$

15% increase.

(b)For XLPE insulated copper single core cable,

t_p = 90˚C

t_{max} = critical temperature for PVC = 250˚C

Average conductor temperature during fault condition is normally obtained by

$t_g = \frac{(t_p+t_{max})}{2} = \frac{(90℃+250℃)}{2}$ = 170℃

$\therefore R_{170˚C} = R_{90˚C} \times (\frac{230+170}{230+90}) = 1.25\ R_{90˚C}$

25% increase.

11. VALUES OF K FOR CALCULATION OF THE EFFECTS OF FAULT CURRENT

Conductor	Insulation	Q_1 ˚C	Q_F ˚C	k
Copper	PVC	70	160	115
	PVC*	70	140	103
	PVC	30	160	143
	PVC*	30	140	133
	Rubber	85	220	134
	XLPE	90	250	143
Aluminium	PVC	70	160	76
	PVC	30	160	95
Steel	PVC	30	160	52
Bare Copper	-	30	200	159
Bare Aluminium	-	30	200	105

*For conductors larger than $300mm^2$

12. (a)

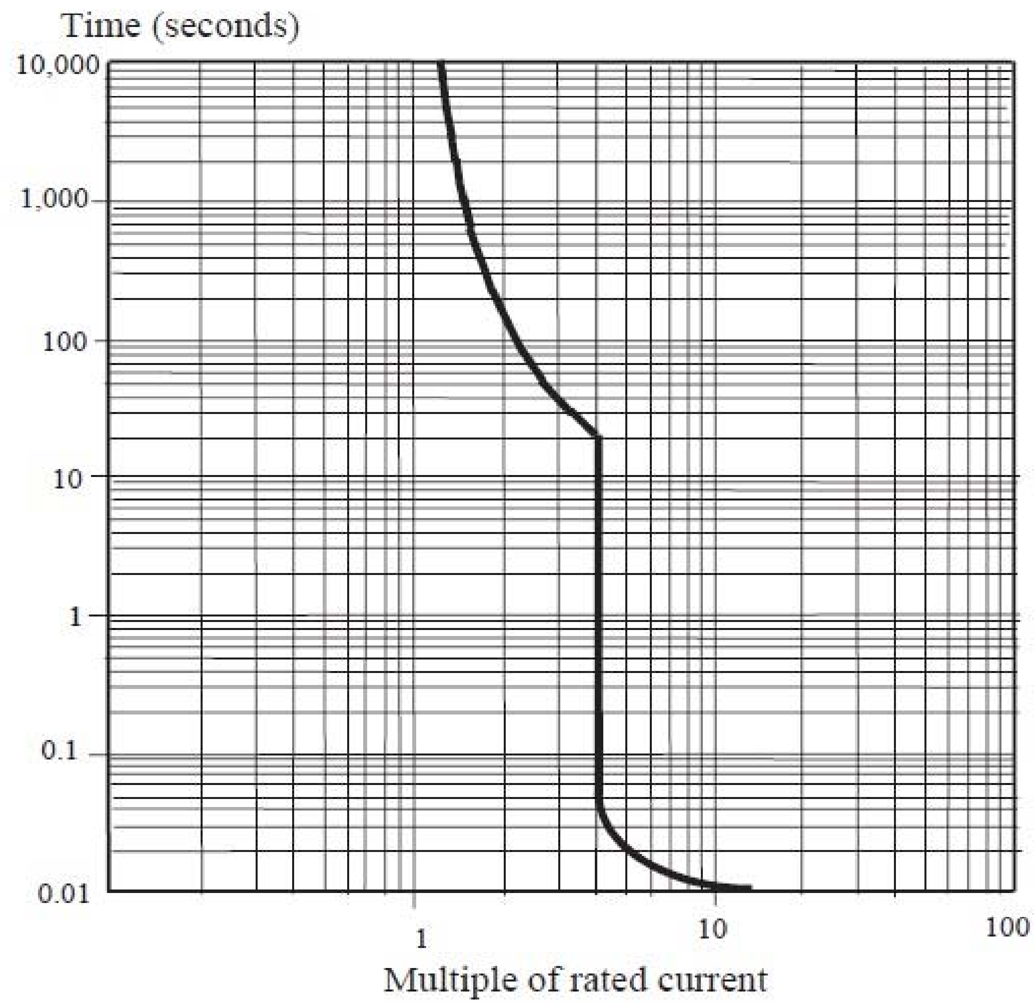


Figure 3 Time current characteristic of the MCB

12. (b)

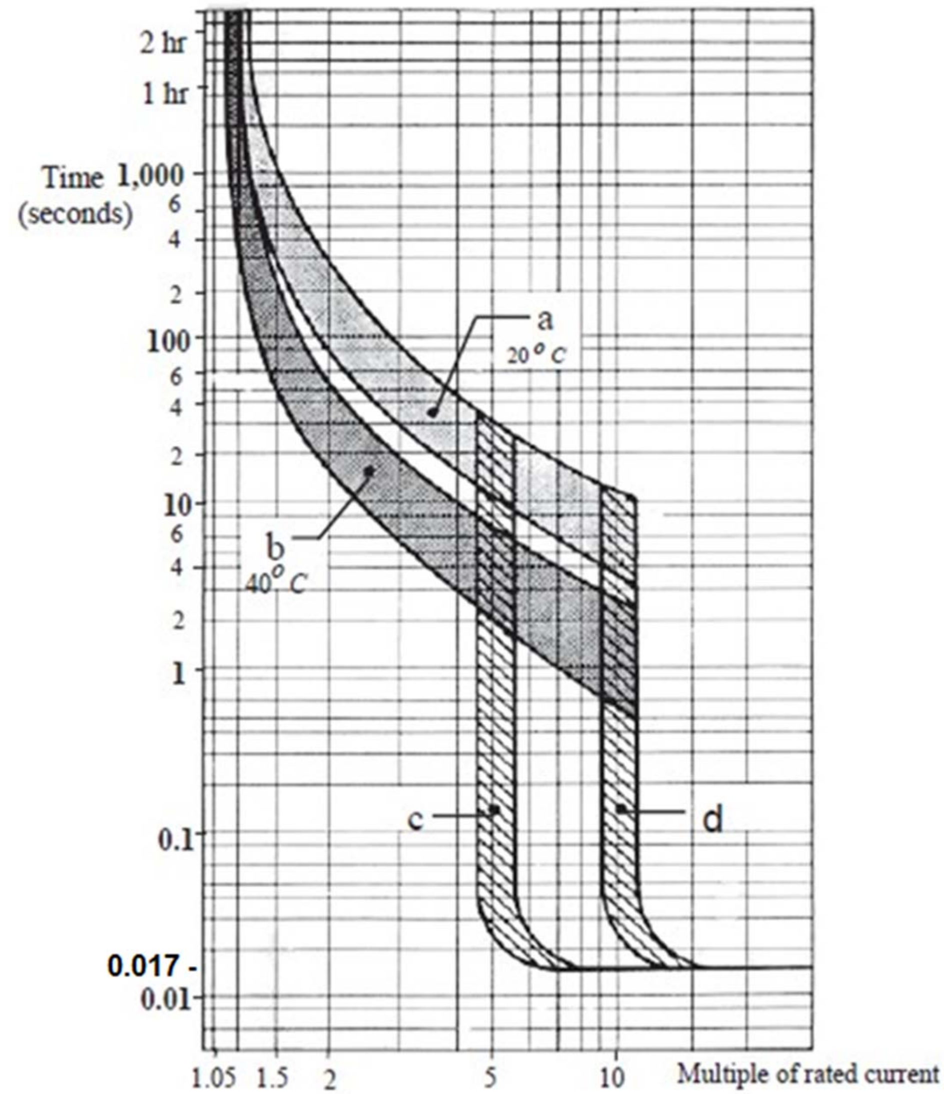


Figure 4 Time-current characteristic of a typical MCCB

12. (c)

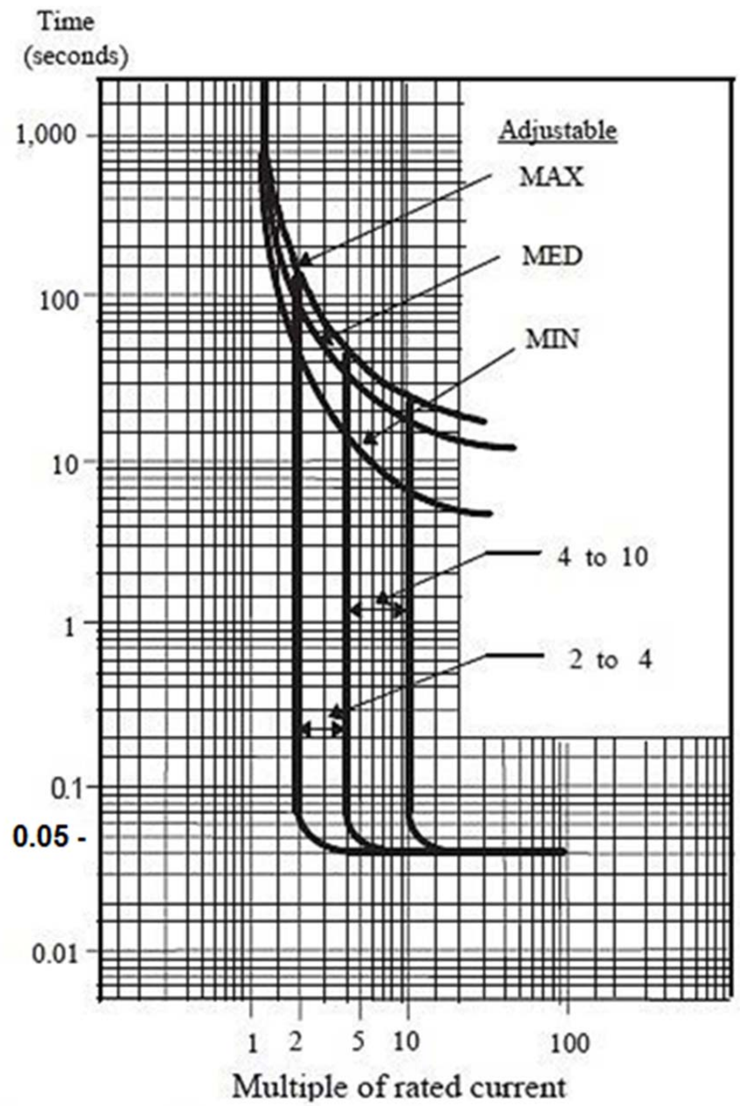
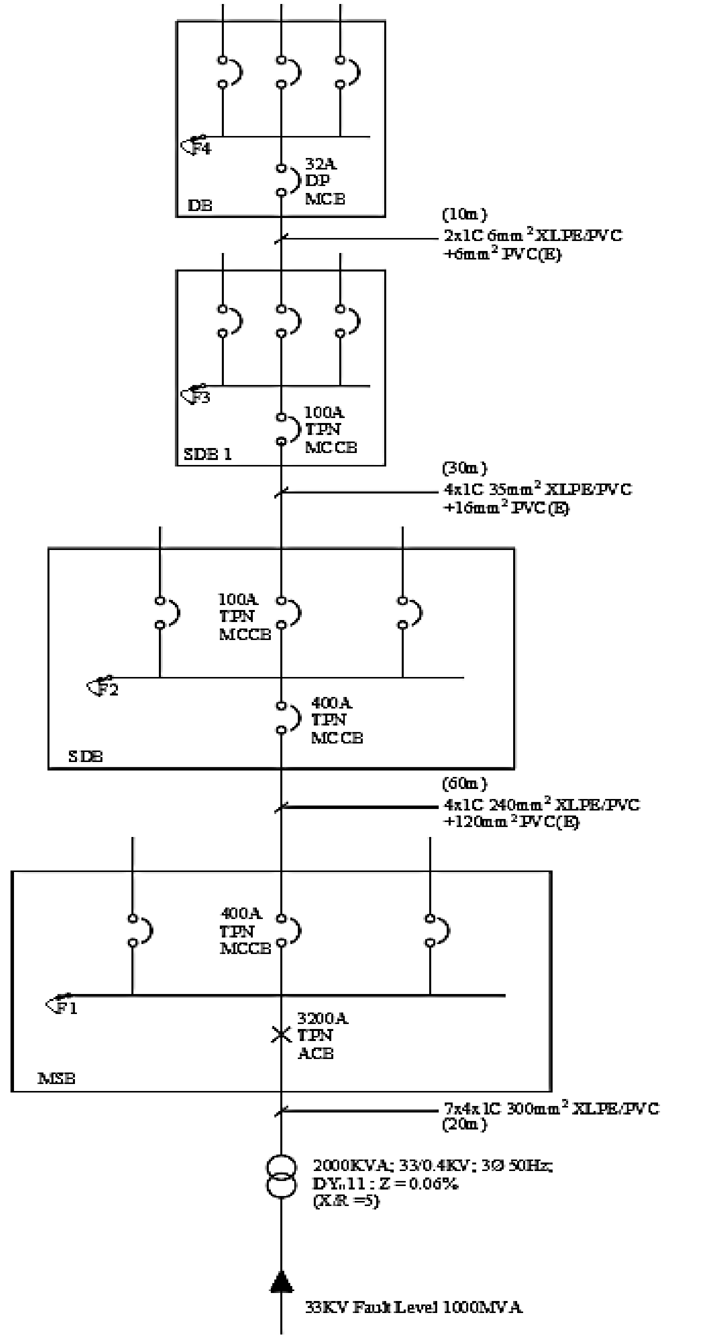


Figure 5 Time-current characteristic of a typical ACB

13. EXAMPLE (I)



F4
32A
DP
MCB
DB
(10m)
2x1C 6mm² XLPE/PVC
+6mm² PVC(E)
F3
100A
TPN
MCCB
SDB 1
(30m)
4x1C 35mm² XLPE/PVC
+16mm² PVC(E)
100A
TPN
MCCB
F2
400A
TPN
MCCB
SDB
(60m)
4x1C 240mm² XLPE/PVC
+120mm² PVC(E)
400A
TPN
MCCB
F1
3200A
TPN
ACB
MSB
7x4x1C 300mm² XLPE/PVC
(20m)
2000KVA; 33/0.4KV; 3Ø 50Hz;
DYn11 : Z = 0.06%
(X/R =5)
33KV Fault Level 1000MVA

I. MSB

3.(a) assuming fault level 1000MVA at 33kV

$$I_{SC} = \frac{1000 \text{ x } 10^6 \text{VA}}{\sqrt{3} \text{ x } 400\text{V}} = 1{,}443{,}418 \text{ A}$$

$$Z_{Source} = \frac{400\text{V}}{\sqrt{3} \text{ x } I_{SC}} = \frac{400\text{V}}{\sqrt{3} \text{ x } 1{,}443{,}418} = j\ 0.00016\ \Omega \quad \#$$

3.(b) 2000KVA Transformer; 33/0.4KV; 50Hz

DY_n11; Impedance 6%

3phase fault level at secondary terminal of 2000KVA transformer

$$\text{fault level T/F} = \frac{2000\text{KVA}}{0.06} = 33.33 \text{ MVA}$$

$$I_{SCTF} \text{ at T/F} = \frac{33.33\text{MVA}}{\sqrt{3}\ x\ 0.4\text{KV}} = 48.11 \text{ KA}$$

$$Z_{TF} = \frac{400\text{V}}{\sqrt{3} \text{ x } I_{SCTF}} = \frac{400\text{V}}{\sqrt{3} \text{ x } 48.11\text{KA}} = 0.0048\ \Omega \quad \#$$

If $\frac{X}{R} = 5$, $X = 5R$

$$Z = \sqrt{R^2 + X^2} = \sqrt{R^2 + (5R)^2} = R\sqrt{26}$$

$$R = \frac{Z}{\sqrt{26}} = \frac{0.0048}{\sqrt{26}} = 0.00094 \ \#$$

$$X = 5R = j\,0.0047 \ \#$$

3.(c) 7 x 4 x 1C 300 300mm^2 XLPE/PVC (length 20m)

From the voltage drop table (300mm^2 XLPE/PVC)

r = $\frac{0.14}{\sqrt{3}}$ mV/amp/meter, x = $\frac{0.14}{\sqrt{3}}$ mV/amp/meter at temperature 90˚C.

Resistance r to be adjusted to average temperature = $\frac{90+250}{2}$ = 170˚C

∴ Effective r = $\frac{0.14}{\sqrt{3}}$ x $\frac{230+170}{230+90}$ = $\frac{0.14}{\sqrt{3}}$ x 1.25

Z_{300} = $\frac{1}{7}$ x [($\frac{0.14}{\sqrt{3}}$ x 1.25)+j $\frac{0.14}{\sqrt{3}}$] x 10^{-3}x 20m

= (0.014433 + j0.011547) x 10^{-3}x 20m

Z_{300} = 0.0002886 + j0.00023094 #

3.(d) $Z_{total} = Z_{SC} + Z_{TR} + Z_{300}$

$= j0.00016+0.00094+j0.0047+0.0002886+j0.00023094$

$= 0.001286+j0.0050909$

$= \sqrt{0.000001509 + 0.00002591}$

$= \sqrt{0.000027419}$

$Z_{total} = 0.005236$ #

3.(e) I_{SC} at MSB $= \frac{400}{\sqrt{3}Z_{total}} = \frac{400}{\sqrt{3} \text{ x } 0.005236} = 43{,}362$ #

∴ 3200A TPN ACB with 50kA breaking capacity is recommended at MSB. #

4.(a) MSB

Protection against short circuit current

7 x 4 x 1C 300mm^2 XLPE/PVC cable connected to the 400V MSB is protected against I_{SC} = 43362 A short circuit current by the direct acting trip (magnetic trip) of ACB with operates within 0.04 sec.

Since critical time , $t_c = \frac{k^2 S^2}{I_{SC}{}^2} = \frac{143^2 x\, (7\ x\ 300)^2}{43362^2}$

For the cable (300mm$^{2)}$= 48 sec

∴ The cable is protected by 3200A TPN ACB because 48 > 0.04sec.

4.(b) To check whether 4 x 1C 240mm^2 XLPE/PVC sub main cable (60m) to SDB 1 is protected against short circuit current.

At the origin of 400A MCCB for 240mm^2 XLPE/PVC submain near MSB, I_{SCmax} = 43362 as calculated earlier.

4.(d) Check from MCCB characteristic for 400A MCCB, it should operate in 0.02 sec on magnetic trip.

Critical time for cable 240mm^2 XLPE/PVC, $t_c = \frac{k^2 S^2}{I_{SC}^2} = \frac{143^2 \text{x } 240^2}{43362^2}$

t_c = 0.62 sec > 0.02 sec (OK)

The cable is protected against short circuit current (240mm^2) by 400A TPN MCCB.

5.(a) SDB

At the remote end of 240mm^2 submain (60m) $I_{SC(max)}$ = 3 phase short circuit current at the remote end. From the table voltage drop (240mm^2 XLPE/PVC) r = $\frac{0.17}{\sqrt{3}}$ mV/amp/meter, x = $\frac{0.14}{\sqrt{3}}$ mV/amp/meter at temperature 90˚C.

r to be adjusted to average temperature = $\frac{90+250}{2}$ = 170˚C

$\therefore$r = $\frac{0.17}{\sqrt{3}}$ x $\frac{230+170}{230+90}$ = $\frac{0.17}{\sqrt{3}}$ x 1.25 = 0.122 mΩ/meter #

Z_{240} = (0.122+j0.08) x 10^{-3}x 60m = 0.00732+j0.0048

5.(b) SDB

$Z_{total(1)} = Z_S + Z_T + Z_{300} + Z_{240}$

$= 0.001286+j0.00509+0.00732+j0.0048$

$= 0.0086+j0.00989$

$= \sqrt{0.0000739 + 0.0000978}$

$= \sqrt{0.0001717}$

$= 0.0131\ \Omega$

$I_{SC(240)} = \frac{400}{\sqrt{3} \times 0.0131} = 17{,}629$ amp

∴ 400 amp TPN MCCB with 20kA breaking capacity is recommended at SDB. #

5.(c) Critical time for cable 240mm^2 XLPE/PVC, $t_c = \frac{k^2 S^2}{I_{SC}^2} = \frac{143^2 x\ 240^2}{17629^2}$

t_c = 3.8 sec

The 240mm^2 XLPE/PVC Cable is protected because 3.8 sec > 0.02 sec (MCCB).

At the origin of 100A MCCB for 35mm^2 XLPE/PVC submain near SDB, I_{SCmax} = 17,629 kA as calculated at SDB.

Critical time for cable 35mm^2 XLPE/PVC, $t_c = \frac{k^2 S^2}{I_{SC}^2} = \frac{143^2 x\ 35^2}{17{,}629^2}$

t_c = 0.08 sec

t_c = 0.08 sec > 0.02 sec

∴ This cable is protected against short circuit current by 100A MCCB.

6. SDB (1)

6.(a) At the remote end of 35mm^2 submain (20m) $I_{SC(max)}$ = 3 phase short circuit current at the remote end. From the table voltage drop (35mm^2 XLPE/PVC) r = $\frac{0.15}{\sqrt{3}}$ mV/amp/meter, x = $\frac{0.155}{\sqrt{3}}$ mV/amp/meter at temperature 90˚C.

r to be adjusted to average temperature = $\frac{90+250}{2}$ = 170˚C

$\therefore r = \frac{0.15}{\sqrt{3}} \times \frac{230+170}{230+90} = \frac{0.15}{\sqrt{3}} \times 1.25 = 0.829$ mΩ/meter #

Z_{35} = (0.829+j0.0894) x 10^{-3}x 20m = 0.01658+j0.001788

6.(b) SDB (1)

$Z_{total(2)} = Z_{total(1)} + Z_{35}$

$= 0.0086+j0.00989+0.01658+j0.001788$

$= 0.02518+j0.011678$

$= \sqrt{0.000634 + 0.0001363}$

$= \sqrt{0.0007703}$

$= 0.02775\ \Omega$

$$I_{SC(35)} = \frac{400}{\sqrt{3}\ x Z_{total(2)}} = \frac{400}{\sqrt{3}\ x\ 0.02775} = 8{,}322 \text{ amp}$$

∴ 100 amp TPN MCCB with 9kA breaking capacity is recommended at SDB 1.

6.(c) Critical time for cable $35mm^2$ XLPE/PVC, $t_c = \frac{k^2 S^2}{{I_{SC}}^2} = \frac{143^2 x\ 35^2}{8322^2}$

t_c = 0.361 sec

The $35mm^2$ XLPE/PVC cable is protected by 100A TPN MCCB because 0.361 sec > 0.02 sec (MCCB).

6.(d) At the origin of 32A DP MCB for $6mm^2$ XLPE/PVC submain near SDB 1, I_{SCmax} = 9 kA as calculated at SDB 1.

Critical time for cable $6mm^2$ XLPE/PVC, $t_c = \frac{k^2 S^2}{{I_{SC}}^2} = \frac{143^2 x\ 6^2}{8322^2}$

t_c = 0.0106 sec

The cable 2x 1C $6mm^2$ XLPE/PVC is protected by 32A DP MCB because t_c = 0.0106 sec > 0.01 sec (MCB) t_c

Thermal limit of cable > MCB tripping time

6.(e) if we choose $10mm^2$ XLPE/PVC for 32A DP MCB

Critical time for cable $10mm^2$ XLPE/PVC $t_c = \frac{k^2 S^2}{I_{SC}{}^2} = \frac{143^2 x\ 10^2}{8322^2}$

$t_c = 0.029$ sec

∴ $10mm^2$ XLPE/PVC is protected because 0.029 > 0.01 sec.

Cable thermal limit time > MCB tripping time

7. DB

7.(a) At the remote end of 2x1C 6mm^2 XLPE/PVC (10m), $I_{SC(max)}$ = Line to Neutral short circuit current at the remote end. From the table voltage drop (6mm^2 XLPE/PVC) r = 7.9 mV/amp/meter, x =0 mV/amp/meter at temperature 90˚C.

r to be adjusted to average temperature = $\frac{90+250}{2}$ = 170˚C

∴ Effective r = $\frac{7.9}{2}$ x $\frac{230+170}{230+90}$ = 3.95 x 1.25 = 4.9375 mΩ/meter #

= 4.9375x 10^{-3}x 10m = 0.0493 Ω

$Z_{total(3)} = Z_1 + Z_2 + Z_3$

Line to Neutral

$Z_{SC} = 0+j0.00016$

$Z_{TR} = 0.00094+j0.0047$

$2 \times Z_{300} = 2x\ [0.0002886+j0.00023094]$

$2 \times Z_{240} = 2x\ [0.00732+j0.0048]$

$2 \times Z_{35} = 2x\ [0.01658+j0.001788]$

$2 \times Z_6 = 2x\ [0.0493+j0]$

$Z_{total} = 0.148067 + j0.018497$

7.(b) $Z_{total(LN)} = 0.148067 + j0.018497$

$$= \sqrt{0.021923 + 0.000342}$$

$$= \sqrt{0.022265}$$

$$= 0.149214\ \Omega$$

$$I_{SC(LN)} = \frac{400}{\sqrt{3}\ \text{x}Z_{total(LN)}} = \frac{400}{\sqrt{3}\ \text{x}\ 0.149214} = 1{,}547 \text{ amp}$$

32A DP MCB with 6kA breaking capacity is recommended at DB.

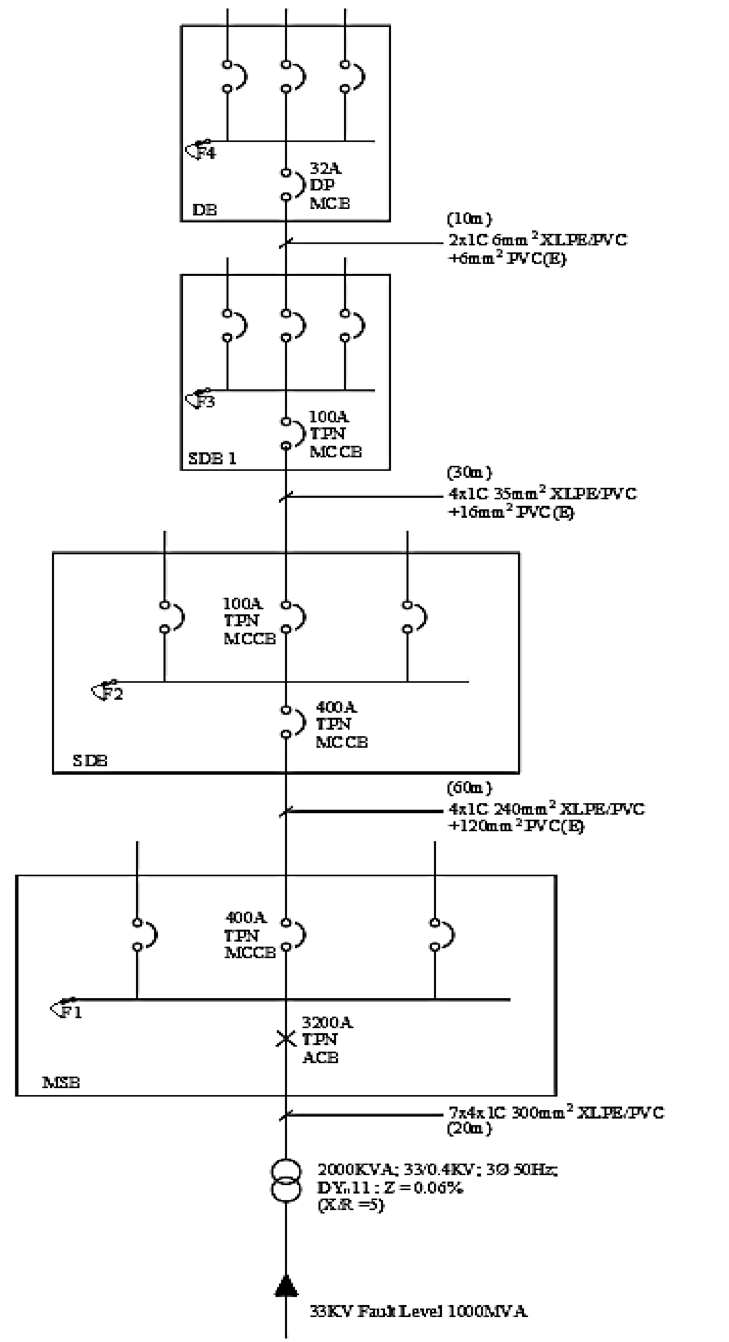
critical time for cable 6mm^2 XLPE/PVC $t_c = \frac{k^2 S^2}{I_{SCLN}{}^2} = \frac{143^2 \text{x}\ 6^2}{1547^2}$

$t_c = 0.3$ sec

MCB magnetic tripping time = 0.01 sec

6mm^2 XLPE/PVC is protected line to neutral short circuit current because 0.3 > 0.01 sec.

13. EXAMPLE (II)



MSB

2.(a) assuming fault level 1000MVA at 33kV

$$I_{SC} = \frac{1000 \text{ x } 10^6 \text{VA}}{\sqrt{3} \text{ x } 400\text{V}} = 1{,}443{,}418 \text{ A}$$

$$Z_{Source} = \frac{400\text{V}}{\sqrt{3} \text{ x } I_{SC}} = \frac{400\text{V}}{\sqrt{3} \text{ x } 1{,}443{,}418} = j\ 0.00016\ \Omega \quad \#$$

2.(b) 2000KVA Transformer; 33/0.4KV; 50Hz

DY_n11; Impedance 6%

3phase fault level at secondary terminal of 2000KVA transformer

$$\text{fault level T/F} = \frac{2000\text{KVA}}{0.06} = 33.33 \text{ MVA}$$

$$I_{SCTF} \text{ at T/F} = \frac{33.33\text{MVA}}{\sqrt{3}\ x\ 0.4\text{KV}} = 48.11 \text{ KA}$$

$$Z_{TF} = \frac{400\text{V}}{\sqrt{3} \text{ x } I_{SCTF}} = \frac{400\text{V}}{\sqrt{3} \text{ x } 48.11\text{KA}} = 0.0048\ \Omega \quad \#$$

2.(c) 7 x 4 x 1C 300mm^2 XLPE/PVC (length 20m)

from the voltage drop table 300mm^2 XLPE/PVC

$$Z_C = \frac{1}{7} \text{ x } \frac{0.195}{\sqrt{3}} \text{ mV/amp/meter x 20m}$$

$$= 0.000321\ \Omega\ \#$$

2.(d) $Z_{total} = Z_{SC} + Z_{TR} + Z_C$

$$= 0.00016+0.0048+0.000321 = 0.005281\ \Omega$$

2.(e) I_{SC} at MSB $= \frac{400V}{\sqrt{3} \text{ x } Z_{total}} = \frac{400V}{\sqrt{3} \text{ x } 0.005281}$

$$= 43{,}731 \text{ amp}$$

∴ 3200A TPN ACB with 50kA breaking capacity is recommended at MSB. #

3.(a) Protection against short circuit current

7 x 4 x 1C 300mm^2 XLPE/PVC cable connected to the 400V MSB is protected against I_{SC} = 50 kA short circuit current by the direct acting trip (magnetic trip) of ACB with operates within 0.04 sec.

Since critical time , $t_c = \frac{k^2 S^2}{I_{SC}{}^2} = \frac{143^2 x\,(7\,x\,300)^2}{43731^2}$

For the cable (300mm$^{2)}$= 47.155 sec > 0.04 sec

3.(b) To check whether 4 x 1C 240mm^2 XLPE/PVC sub main cable (60m) to SDB 1 is protected against short circuit current.

At the origin of 400A MCCB for 240mm^2 XLPE/PVC submain near MSB, I_{SCmax} = 43731 as calculated earlier.

Check from MCCB characteristic for 400A MCCB, it should operate in 0.02 sec on magnetic trip.

Critical time for cable 240mm^2 XLPE/PVC, $t_c = \frac{k^2S^2}{I_{SC}{}^2} = \frac{143^2 x\, 240^2}{43{,}731^2}$

t_c = 0.61 sec > 0.02 sec (OK)

∴ The cable 240mm^2 XLPE/PVC is protected against short circuit current by 400A TPN MCCB.

4.(a) SDB

At the remote end of $240mm^2$ submain (60m).

From the table voltage drop ($240mm^2$ XLPE/PVC)

$Z_{240} = \frac{0.22}{\sqrt{3}}$ mV/amp/meter x 60m

$= 0.007621\ \Omega$

4.(b) $Z_{total} = Z_{SC} + Z_{TR} + Z_{300} + Z_{240}$

$= 0.00016+0.0048+0.000321+0.007621$

$= 0.012902\ \Omega$

4.(c) I_{SC} at SDB $= \frac{400}{\sqrt{3} \times Z_{total}} = \frac{400}{\sqrt{3} \times 0.012902}$ = 17,900 amp

400A TPN MCCB with 20kA breaking capacity is recommended at SDB.

5.(a) Critical time for cable 240mm^2 XLPE/PVC, $t_c = \frac{k^2 S^2}{I_{SC}^2} = \frac{143^2 x\ 240^2}{17{,}900^2}$

t_c = 3.67 sec

∴ The 240mm^2 XLPE/PVC is protected by 400A TPN MCCB.

3.67 sec > 0.02 sec.

5.(b) At the origin of 100A MCCB for 35mm^2 XLPE/PVC submain near SDB, I_{SCmax} = 17,900 amp.

Critical time for cable 35mm^2 XLPE/PVC, $t_c = \frac{k^2 S^2}{I_{SC}^2} = \frac{143^2 x\ 35^2}{17{,}900^2}$

t_c = 0.078 sec

$t_{c(cable)}$ > MCCB tripping time

0.078 sec > 0.02 sec.

∴ This 35mm^2 XLPE/PVC is protected against short circuit current by 100A TPN MCCB.

SDB 1

6.(a) At the remote end of $35mm^2$ (20m).

From the table voltage drop ($35mm^2$ XLPE/PVC)

$Z_{35} = \frac{1.15}{\sqrt{3}}$ mV/amp/meter x 20m = 0.013279 Ω

$Z_{total} = Z_{SC} + Z_{TR} + Z_{300} + Z_{240} + Z_{35}$

= 0.00016+0.0048+0.000321+0.007621+0.013279

=0.026181 Ω

6.(b) I_{SC} at SDB 1 = $\frac{400}{\sqrt{3} \text{ x } Z_{total}} = \frac{400}{\sqrt{3} \text{ x } 0.026181}$ = 8,821 amp

∴ 100amp TPN MCCB with 9kA breaking capacity is recommended at SDB 1.

6.(c) Critical time for cable $35mm^2$ XLPE/PVC, $t_c = \frac{k^2S^2}{I_{SC}^2} = \frac{143^2 x\ 35^2}{8821^2}$

t_c = 0.322 sec

∴ The $35mm^2$ XLPE/PVC is protected by 100A TPN MCCB.

Cable t_c 0.322 sec > 0.02 sec tripping time of MCCB.

6.(d) At the origin of 32A DP MCB for $6mm^2$ XLPE/PVC submain near SDB 1, I_{SCmax} = 8821 amp.

Critical time for cable $6mm^2$ XLPE/PVC, $t_c = \frac{k^2S^2}{I_{SC}^2} = \frac{143^2 x\ 6^2}{8821^2}$

t_c = 0.0094 sec

The cable 2x1C $6mm^2$ XLPE/PVC is not protected against short circuit current by 32A DP MCB because 0.0094 sec < 0.01 sec.

Thermal limit of cable < MCB tripping time.

6.(e) if we choose $10mm^2$ XLPE/PVC for 32A DP MCB

Critical time for cable $10mm^2$ XLPE/PVC $t_c = \frac{k^2 S^2}{I_{SC}{}^2} = \frac{143^2 x\, 10^2}{8821^2}$

$t_c = 0.026$ sec

∴ 2 x 1C $10mm^2$ XLPE/PVC is protected by 32A DP

Cable thermal limit time 0.026 > 0.01 MCB tripping time #

7.(a) At the remote end of $10mm^2$ XLPE/PVC (10m), $I_{SC(max)}$ = Line to Neutral short circuit current.

From the table voltage drop ($10mm^2$ XLPE/PVC),

$r = \frac{4.7}{2} x\ 10^{-3} x$ 10m = 0.0235 Ω #

7.(b) $Z_{total} = Z_{SC} + Z_{TR} + (2 \times Z_{300}) + (2 \times Z_{240}) + (2 \times Z_{35}) + (2 \times Z+_{10})$

Z_{SC}	= 0.00016
Z_{TR}	= 0.0048
$2 \times Z_{300}$	= 2x 0.000321 = 0.000642
$2 \times Z_{240}$	= 2x 0.007621 = 0.015242
$2 \times Z_{35}$	= 2x 0.013279 = 0.026558
$2 \times Z_{10}$	= 2x 0.023500 = 0.047
Z_{total}	= 0.094402

$$I_{SC(LN)} = \frac{400}{\sqrt{3} \text{ x} Z_{total(LN)}} = \frac{400}{\sqrt{3} \text{ x } 0.094402} = 2{,}446 \text{ amp}$$

32A DP MCB with 6kA breaking capacity is recommended at DB.

critical time for cable $10mm^2$ XLPE/PVC $t_c = \frac{k^2 S^2}{{I_{SCLN}}^2} = \frac{143^2 \text{x } 10^2}{2446^2}$

$t_c = 0.34$ sec

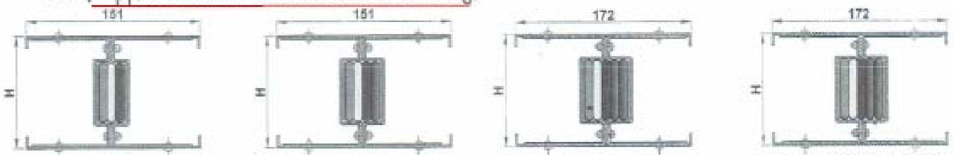
MCB magnetic tripping time = 0.01 sec

$10mm^2$ XLPE/PVC is protected line to neutral short circuit current because 0.34 > 0.01 sec.(OK)

Fault Current Calculated by two methods

S/N	Type of Fault	Location	Example (I) Amp	Example (II) Amp	Cable
1	3 phase	MSB	43362	43731	7x4x1C 300mm^2 XLPE/PVC
2	3 phase	SDB	17629	17900	4x1C 240mm^2 XLPE/PVC
3	3 phase	SDB1	8322	8821	4x1C 35mm^2 XLPE/PVC
4	L-N	DB	1547	2446	2x1C 10mm^2 XLPE/PVC

SBC (Copper Sandwich Insulated Bus Trunking)



3 Phase+50% Internal Earth | 3 Phase+100% Neutral +50% Internal Earth | 3 Phase+200% Neutral +50% Internal Earth | 3 Phase+100% Neutral+100% Isolated Earth+50% Internal Earth

Rated Current (In)	Amps	600	800	900	1000	1200	1350	1600	1800	2000
Product Code	---	SBC 40N1	SBC 50N1	SBC 60N1	SBC 70N1	SBC 80N1	SBC 100N1	SBC 125N1	SBC 150N1	SBC 175N1
Busbar size per phase (No. of busbars)	mm	6x40(1)	6x50(1)	6x60(1)	6x70(1)	6x80(1)	6x100(1)	6x125(1)	6x150(1)	6x175(1)
Overall Height (H)	mm	85	95	105	115	125	145	170	195	220
Rated Three Phase RMS Short Time Current for 1 Second (Icw)	kA	40	50	50	65	65	85	100	100	100
Rated Three phase Peak short time current (Ipk)	kA	84	105	105	143	143	187	220	220	220
Rated Single Phase RMS Short Time Current for 1 Second (Icw)	kA	24	30	30	39	39	51	60	60	60
Rated Single phase Peak short time current (Ipk)	kA	50.4	63	63	81.9	81.9	112.2	132	132	132
Approximate Weight of Bustrunking										
3 Phase + 50% Internal Earth	kg/mtr.	20	22	24	27	29	34	40	46	52
3 Phase + 100% Neutral + 50% Internal Earth	kg/mtr.	22	25	28	31	34	40	47	55	62
3 Phase + 200% Neutral + 50% Internal Earth	kg/mtr.	25	29	32	36	40	47	56	65	74
3 Phase + 100% Neutral + 100% Isolated Earth + 50% Internal Earth	kg/mtr.	25	29	32	36	40	47	56	65	74
Electrical Characteristics for 50 Hz										
AC Resistance at 20°C (R_{20})	miliohms /mtr.	0.0740	0.0592	0.0499	0.0427	0.0378	0.0311	0.0249	0.0207	0.0179
A.C. Resistance at thermal conditions (R_t)	miliohms /mtr.	0.0959	0.0767	0.0645	0.0553	0.0489	0.0403	0.0322	0.0268	0.0232
Reactance (X)	miliohms /mtr.	0.0417	0.0333	0.0278	0.0238	0.0208	0.0170	0.0136	0.0127	0.0109
Impedance at thermal conditions (Z)	miliohms /mtr.	0.1045	0.0836	0.0703	0.0602	0.0531	0.0437	0.0350	0.0297	0.0256
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.1678	0.1342	0.1126	0.0965	0.0850	0.0696	0.0559	0.0482	0.0416
	mV/mtr./A at 0.8 P.F.	0.1761	0.1409	0.1183	0.1014	0.0894	0.0735	0.0588	0.0504	0.0435
	mV/mtr./A at 0.9 P.F.	0.1809	0.1447	0.1216	0.1042	0.0920	0.0756	0.0605	0.0514	0.0444
	mV/mtr./A at 1.0 P.F.	0.1660	0.1328	0.1118	0.0958	0.0847	0.0697	0.0558	0.0465	0.0402
Electrical Characteristics for 60 Hz										
AC Resistance at 20°C (R_{20})	miliohms /mtr.	0.0742	0.0594	0.0500	0.0429	0.0379	0.0313	0.0251	0.0209	0.0181
A.C. Resistance at thermal conditions (R_t)	miliohms /mtr.	0.0961	0.0769	0.0648	0.0556	0.0491	0.0405	0.0325	0.0271	0.0235
Reactance (X)	miliohms /mtr.	0.0500	0.0400	0.0333	0.0286	0.0250	0.0204	0.0163	0.0152	0.0130
Impedance at thermal conditions (Z)	miliohms /mtr.	0.1083	0.0867	0.0729	0.0625	0.0551	0.0454	0.0363	0.0311	0.0268
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.1784	0.1427	0.1198	0.1027	0.0905	0.0743	0.0595	0.0516	0.0446
	mV/mtr./A at 0.8 P.F.	0.1851	0.1482	0.1244	0.1067	0.0941	0.0773	0.0619	0.0533	0.0461
	mV/mtr./A at 0.9 P.F.	0.1876	0.1501	0.1262	0.1082	0.0955	0.0785	0.0629	0.0537	0.0464
	mV/mtr./A at 1.0 P.F.	0.1664	0.1332	0.1122	0.0962	0.0851	0.0702	0.0562	0.0469	0.0407

C&S electric

Technical Parameters

Voltage Drop Calculation Formulae

$$\Delta V = k \times \sqrt{3} \times (R_t \cos \varnothing + X \sin \varnothing) \times I_B \times L$$

Where

ΔV is the composite voltage drop of the system (V);

R_t & X are the mean resistance and reactance values of the system (Ω/m);

I_B is the actual load current of the circuit being considered (A);

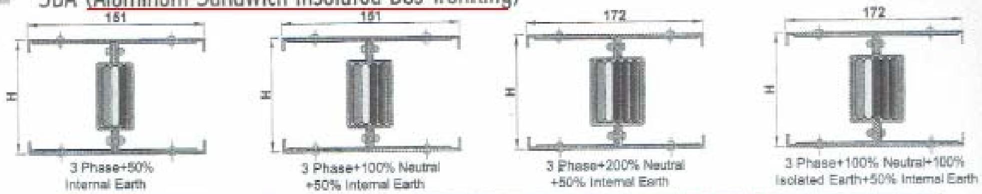
L is the length of the system being considered (M);

Cos Ø is the load power factor being considered;

k is the load distribution factor.
k=1, if full load is concentred at the end of the busbar trunking run;
k=(n+1)/2n, if the load is uniformly spread between n branches.

Rated Current (In)	Amps	2500	2500	3200	3600	4000	4500	5000	6000	6600
Product Code	---	SBC 200N1	SBC 100N2	SBC 125N2	SBC 150N2	SBC 175N2	SBC 200N2	SBC 230N2	SBC 175N3	SBC 200N3
Bus bar size per phase (No. of busbars)	mm	6x200(1)	6x100(2)	6x125(2)	6x150(2)	6x175(2)	6x200(2)	6x230(2)	6x175(3)	6x200(3)
Overall Height (H)	mm	245	290	340	390	440	490	550	660	735
Rated Three Phase RMS Short Time Current for 1 Second (Icw)	kA	100	120	150	150	150	150	150	175	175
Rated Three phase Peak short time current (Ipk)	kA	220	264	330	330	330	330	330	385	385
Rated Single Phase RMS Short Time Current for 1 Second (Icw)	kA	60	72	90	90	90	90	90	105	105
Rated Single phase Peak short time current (Ipk)	kA	132	158.4	198	198	198	198	198	231	231
Approximate Weight of Bustrunking										
3 Phase + 50% Internal Earth	kg/mtr.	58	65	75	87	100	112	127	145	164
3 Phase + 100% Neutral + 50% Internal Earth	kg/mtr.	70	79	90	106	121	136	155	177	200
3 Phase + 200% Neutral + 50% Internal Earth	kg/mtr.	83	94	106	124	142	161	183	209	236
3 Phase + 100% Neutral + 100% Isolated Earth + 50% Internal Earth	kg/mtr.	83	94	106	124	142	161	183	209	236
Electrical Characteristics for 50 Hz										
AC Resistance at 20°C (R_{20})	milohms /mtr.	0.0157	0.0131	0.0124	0.0104	0.0090	0.0078	0.0068	0.0060	0.0052
A.C. Resistance at thermal conditions (R_t)	milohms /mtr.	0.0203	0.019	0.0161	0.0134	0.0116	0.0102	0.0088	0.0077	0.0068
Reactance (X)	milohms /mtr.	0.0095	0.0083	0.0070	0.0064	0.0055	0.0049	0.0042	0.0038	0.0033
Impedance at thermal conditions (Z)	milohms /mtr.	0.0224	0.0198	0.0176	0.0149	0.0128	0.0113	0.0098	0.0086	0.0076
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.0364	0.0316	0.0282	0.0242	0.0209	0.0183	0.0160	0.0141	0.0123
	mV/mtr./A at 0.8 P.F.	0.0380	0.0367	0.0296	0.0252	0.0218	0.0191	0.0166	0.0147	0.0129
	mV/mtr./A at 0.9 P.F.	0.0389	0.0338	0.0304	0.0257	0.0222	0.0195	0.0170	0.0149	0.0131
	mV/mtr./A at 1.0 P.F.	0.0352	0.0306	0.0279	0.0232	0.0201	0.0176	0.0153	0.0134	0.0117
Electrical Characteristics for 60 Hz										
AC Resistance at 20°C (R_{20})	milohms /mtr.	0.0159	0.0138	0.0126	0.0106	0.0092	0.0080	0.0070	0.0062	0.0064
A.C. Resistance at thermal conditions (R_t)	milohms /mtr.	0.0206	0.0179	0.0163	0.0137	0.0119	0.0104	0.0091	0.0080	0.0070
Reactance (X)	milohms /mtr.	0.0114	0.0099	0.0084	0.0077	0.0066	0.0059	0.0051	0.0046	0.0040
Impedance at thermal conditions (Z)	milohms /mtr.	0.0235	0.0205	0.0184	0.0157	0.0136	0.0119	0.0104	0.0092	0.0081
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.0390	0.0340	0.0302	0.0260	0.0225	0.0199	0.0173	0.0153	0.0135
	mV/mtr./A at 0.8 P.F.	0.0403	0.0351	0.0314	0.0269	0.0233	0.0205	0.0179	0.0158	0.0139
	mV/mtr./A at 0.9 P.F.	0.0407	0.0354	0.0318	0.0271	0.0234	0.0206	0.0180	0.0159	0.0140
	mV/mtr./A at 1.0 P.F.	0.0356	0.0310	0.0283	0.0237	0.0205	0.0180	0.0157	0.0138	0.0122

SBA (Aluminum Sandwich Insulated Bus Trunking)



Rated Current (In)	Amps	400	500	630	700	800	1000	1250	1350	1600
Product Code	---	SBA 40N1	SBA 50N1	SBA 60N1	SBA 70N1	SBA 80N1	SBA 100N1	SBA 125N1	SBA 150N1	SBA 175N1
Busbar size per phase (No. of busbars)	mm	6x40(1)	6x50(1)	6x60(1)	6x70(1)	6x80(1)	6x100(1)	6x125(1)	6x150(1)	6x175(1)
Overall Height (H)	mm	85	95	105	115	125	145	170	195	220
Rated Three Phase RMS Short Time Current for 1 Second (Icw)	kA	25	30	40	40	50	65	80	85	100
Rated Three phase Peak short time current (Ipk)	kA	52.5	63	84	84	105	143	166	187	220
Rated Single Phase RMS Short Time Current for 1 Second (Icw)	kA	15	18	24	24	30	39	48	51	60
Rated Single phase Peak short time current (Ipk)	kA	30	36	50.4	50.4	63	81.9	100.8	112.2	132
Approximate Weight of Bustrunking										
3 Phase + 50% Internal Earth	kg/mtr.	15	16	17	18	19	22	25	28	30
3 Phase + 100% Neutral + 50% Internal Earth	kg/mtr.	16	17	18	19	21	24	27	30	34
3 Phase + 200% Neutral + 50% Internal Earth	kg/mtr.	17	18	20	22	23	26	30	34	38
3 Phase + 100% Neutral + 100% Isolated Earth + 50% Internal Earth	kg/mtr.	17	18	20	22	23	26	30	34	38
Electrical Characteristics for 50 Hz										
AC Resistance at 20°C (R_{20})	milohms /mtr.	0.1198	0.0958	0.0806	0.0691	0.0611	0.0503	0.0402	0.0335	0.0290
A.C. Resistance at thermal conditions (R_t)	milohms /mtr.	0.1553	0.1243	0.1046	0.0896	0.0792	0.0652	0.0522	0.0435	0.0376
Reactance (X)	milohms /mtr.	0.0417	0.0333	0.0276	0.0238	0.0208	0.0170	0.0136	0.0127	0.0109
Impedance at thermal conditions (Z)	milohms /mtr.	0.1608	0.1286	0.1082	0.0927	0.0819	0.0674	0.0539	0.0453	0.0392
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.2398	0.1919	0.1612	0.1381	0.1218	0.1001	0.0801	0.0684	0.0591
	mV/mtr./A at 0.8 P.F.	0.2585	0.2068	0.1738	0.1490	0.1314	0.1081	0.0864	0.0734	0.0634
	mV/mtr./A at 0.9 P.F.	0.2736	0.2189	0.1840	0.1577	0.1392	0.1145	0.0916	0.0774	0.0669
	mV/mtr./A at 1.0 P.F.	0.2890	0.2152	0.1811	0.1553	0.1372	0.1130	0.0904	0.0753	0.0652
Electrical Characteristics for 60 Hz										
AC Resistance at 20°C (R_{20})	milohms /mtr.	0.1200	0.0961	0.0809	0.0694	0.0614	0.0506	0.0405	0.0338	0.0293
A.C. Resistance at thermal conditions (R_t)	milohms /mtr.	0.1557	0.1246	0.1050	0.0900	0.0796	0.0656	0.0526	0.0439	0.0380
Reactance (X)	milohms /mtr.	0.0500	0.0400	0.0333	0.0286	0.0250	0.0204	0.0163	0.0152	0.0130
Impedance at thermal conditions (Z)	milohms /mtr.	0.1635	0.1309	0.1101	0.0944	0.0834	0.0687	0.0551	0.0464	0.0402
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.2506	0.2006	0.1685	0.1445	0.1274	0.1048	0.0839	0.0720	0.0622
	mV/mtr./A at 0.8 P.F.	0.2677	0.2143	0.1801	0.1544	0.1363	0.1121	0.0898	0.0766	0.0662
	mV/mtr./A at 0.9 P.F.	0.2805	0.2245	0.1888	0.1619	0.1430	0.1177	0.0943	0.0799	0.0691
	mV/mtr./A at 1.0 P.F.	0.2697	0.2159	0.1818	0.1559	0.1379	0.1137	0.0911	0.0760	0.0659

C&S electric

Technical Parameters

Voltage Drop Calculation Formulae

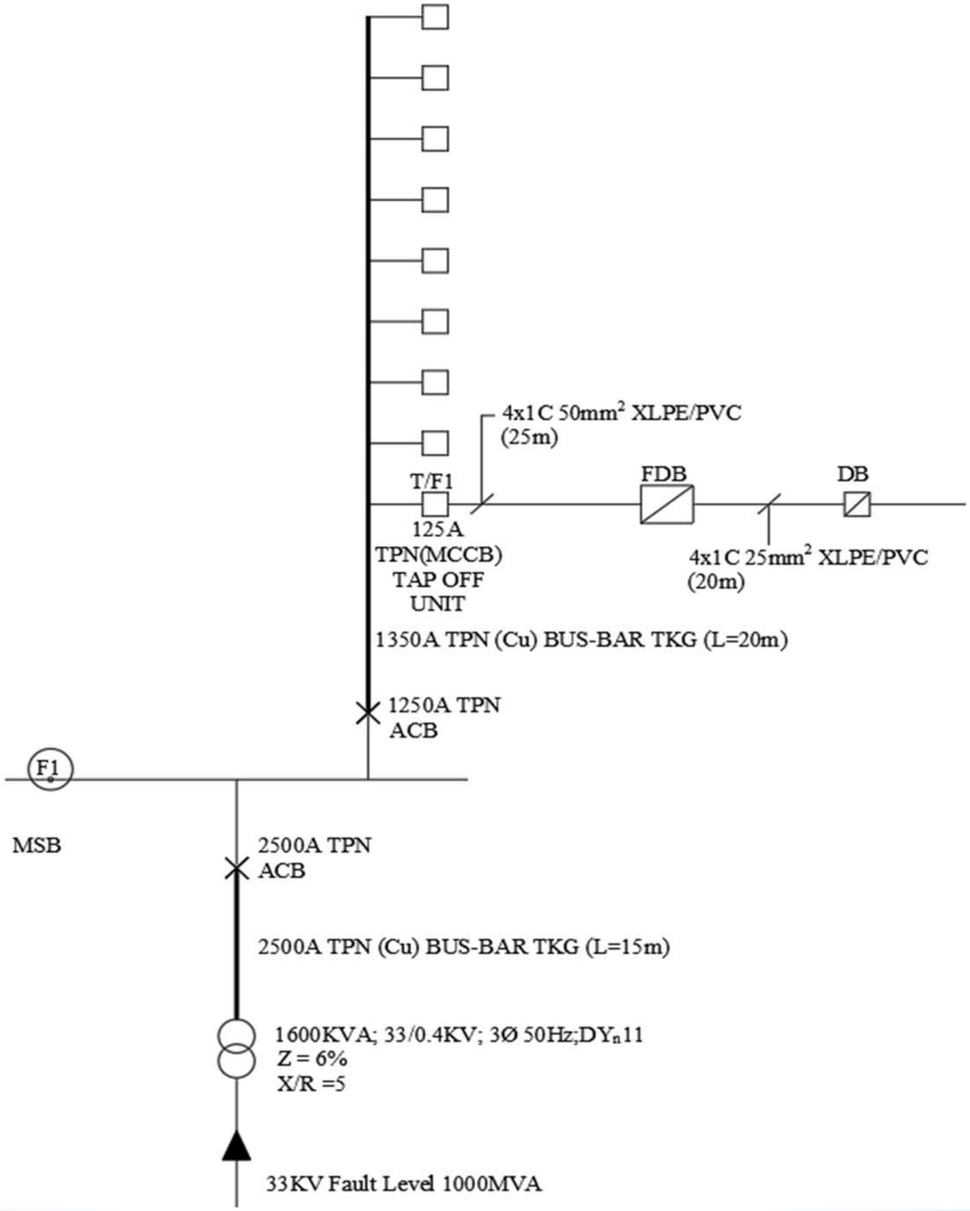
$$\Delta V = k \times \sqrt{3} \times (R_t \cos \varnothing + X \sin \varnothing) \times I_B \times L$$

Where

- ΔV is the composite voltage drop of the system (V);
- R_t & X are the mean resistance and reactance values of the system (Ω/m);
- I_B is the actual load current of the circuit being considered (A);
- L is the length of the system being considered (M);
- $\cos \varnothing$ is the load power factor being considered;
- k is the load distribution factor.
  - k=1, if full load is concentred at the end of the busbar trunking run;
  - k=(n+1)/2n, if the load is uniformly spread between n branches.

Rated Current (In)	Amps	1800	2000	2250	2500	3200	3600	4000	4500	5000
Product Code	---	SBA 200N1	SBA 100N2	SBA 125N2	SBA 150N2	SBA 175N2	SBA 200N2	SBA 150N3	SBA 175N3	SBA 200N3
Busbar size per phase (No. of busbars)	mm	6x200(1)	6x100(2)	6x125(2)	6x150(2)	6x175(2)	6x200(2)	6x150(3)	6x175(3)	6x200(3)
Overall Height (H)	mm	245	290	340	390	440	490	585	660	735
Rated Three Phase RMS Short Time Current for 1 Second (Icw)	kA	100	100	120	120	120	120	175	175	175
Rated Three phase Peak short time current (Ipk)	kA	220	220	264	264	264	264	385	385	385
Rated Single Phase RMS Short Time Current for 1 Second (Icw)	kA	60	60	72	72	72	72	105	105	105
Rated Single phase Peak short time current (Ipk)	kA	132	132	158.4	158.4	158.4	158.4	231	231	231
Approximate Weight of Bustrunking										
3 Phase + 50% Internal Earth	kg/mtr.	33	38	44	50	57	63	71	81	90
3 Phase + 100% Neutral + 50% Internal Earth	kg/mtr.	37	42	49	56	63	71	80	91	101
3 Phase + 200% Neutral + 50% Internal Earth	kg/mtr.	42	46	55	63	71	79	89	101	114
3 Phase + 100% Neutral + 100% Isolated Earth + 50% Internal Earth	kg/mtr.	42	46	55	63	71	79	89	101	114
Electrical Characteristics for 50 Hz										
AC Resistance at 20°C (R_{20})	miliohms /mtr.	0.0254	0.0251	0.0201	0.0168	0.0145	0.0127	0.0112	0.0097	0.0085
A.C. Resistance at thermal conditions (R_t)	miliohms /mtr.	0.0329	0.0326	0.0261	0.0217	0.0188	0.0165	0.0145	0.0125	0.0110
Reactance (X)	miliohms /mtr.	0.0095	0.0088	0.0070	0.0064	0.0055	0.0049	0.0044	0.0038	0.0033
Impedance at thermal conditions (Z)	miliohms /mtr.	0.0343	0.0338	0.0270	0.0227	0.0196	0.0172	0.0152	0.0131	0.0115
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.0517	0.0504	0.0403	0.0343	0.0296	0.0260	0.0231	0.0199	0.0174
	mV/mtr./A at 0.8 P.F.	0.0555	0.0543	0.0434	0.0368	0.0318	0.0279	0.0247	0.0213	0.0187
	mV/mtr./A at 0.9 P.F.	0.0585	0.0575	0.0460	0.0387	0.0335	0.0293	0.0260	0.0224	0.0196
	mV/mtr./A at 1.0 P.F.	0.0570	0.0565	0.0452	0.0377	0.0326	0.0285	0.0251	0.0217	0.0190
Electrical Characteristics for 60 Hz										
AC Resistance at 20°C (R_{20})	miliohms /mtr.	0.0257	0.0254	0.0204	0.0171	0.0148	0.0130	0.0115	0.0100	0.0088
A.C. Resistance at thermal conditions (R_t)	miliohms /mtr.	0.0333	0.0330	0.0265	0.0221	0.0192	0.0169	0.0149	0.0129	0.0114
Reactance (X)	miliohms /mtr.	0.0114	0.0105	0.0084	0.0077	0.0066	0.0059	0.0053	0.0046	0.0040
Impedance at thermal conditions (Z)	miliohms /mtr.	0.0352	0.0346	0.0278	0.0234	0.0203	0.0178	0.0158	0.0137	0.0121
Composite Voltage drop at full Load concentrated at the end of bustrunking run (ΔV)	mV/mtr./A at 0.7 P.F.	0.0546	0.0530	0.0425	0.0383	0.0314	0.0277	0.0246	0.0213	0.0187
	mV/mtr./A at 0.8 P.F.	0.0580	0.0566	0.0454	0.0386	0.0334	0.0294	0.0262	0.0227	0.0199
	mV/mtr./A at 0.9 P.F.	0.0606	0.0594	0.0476	0.0403	0.0349	0.0307	0.0272	0.0236	0.0207
	mV/mtr./A at 1.0 P.F.	0.0577	0.0572	0.0459	0.0383	0.0333	0.0292	0.0258	0.0224	0.0197

13. EXAMPLE (III)



2. (a) fault level 1000MVA at 33kV

$$I_{SC} = \frac{1000 \text{ x } 10^6 \text{VA}}{\sqrt{3} \text{ x } 400\text{V}} = 1{,}443{,}418 \text{ A}$$

$$Z_{Source} = \frac{400\text{V}}{\sqrt{3} \text{ x } I_{SC}} = \frac{400\text{V}}{\sqrt{3} \text{ x } 1{,}443{,}418} = j\ 0.00016\ \Omega \quad \#$$

2. (b) 1600KVA Transformer; 33/0.4KV; 50Hz

DY_n11; Impedance 6%

3phase fault level at secondary terminal of 2000KVA transformer

$$\text{fault level T/F} = \frac{1600\text{KVA}}{0.06} = 26.666 \text{ MVA}$$

$$I_{SCTF} \text{ at T/F} = \frac{26.666\text{MVA}}{\sqrt{3}\ x\ 0.4\text{KV}} = 38{,}491 \text{ A}$$

$$\text{impedance at } Z_{TF} = \frac{400\text{V}}{\sqrt{3} \text{ x } I_{SCTF}} = \frac{400\text{V}}{\sqrt{3} \text{ x } 38{,}491\text{A}}$$

$$Z_{TF} = j0.006\ \Omega \quad \#$$

2.(c) 2500A TPN (Cu) BUS-BAR TKG (L=15m)

Z_{2500} = 0.0367 mV/amp/meter x 15m = 0.00055 Ω

2.(d) $Z_{total} = Z_{Source} + Z_{TF} + Z_{cu}$

$= 0.00016+0.006+0.00055$

$Z_{total(1)}$ = 0.00671 Ω #

2.(e) Short circuit current at MSB

$$I_{SC1} = \frac{400}{\sqrt{3}\, x Z_{total}} = \frac{400}{\sqrt{3}\, x\, 0.00671} = 34{,}418 \text{ amp\#}$$

2.(f) 2500A TPN ACB with 36kA breaking capacity is recommended at MSB. #

3.(a) 1350A TPN (Cu) BUS-BAR Trunking (L=20m)

Z_{1350} = 0.0735 mV/amp/meter x 20m = 0.00147 Ω

3.(b) $Z_{total(2)} = Z_{total(1)} + Z_{1350}$

$= 0.00671+0.00147$

$= 0.00818\ \Omega$ #

3.(c) Short circuit current at Tap off unit

$$I_{SC2} = \frac{400}{\sqrt{3}\ \text{x} Z_{total(2)}} = \frac{400}{\sqrt{3}\ \text{x}\ 0.00818} = 28{,}233 \text{ amp\#}$$

3.(d) 1250A TPN MCCB with 36kA breaking capacity is recommended at Tap off unit (1). #

4.(a) From the table voltage drop 4 x 1C 50mm^2 XLPE/PVC (25m),

$Z_{50} = \frac{0.87}{\sqrt{3}}$ mV/amp/meter x 25m

$Z_{50} = 0.012557\ \Omega$

4.(b) $Z_{total(3)} = Z_{total(2)} + Z_{50}$

$Z_{total(3)} = 0.00818 + 0.012557 = 0.020737\ \Omega$

4.(c) $I_{SC} = \frac{400}{\sqrt{3} \text{ x } Z_{total(3)}} = \frac{400}{\sqrt{3} \text{ x } 0.020737} = 11{,}136$ amp #

4.(d) 125A TPN MCCB with 24kA breaking capacity is recommended at FDB.

5.(a) From the table voltage drop 4 x 1C 25mm^2 XLPE/PVC (20m),

$Z_{25} = \frac{1.6}{\sqrt{3}}$ mV/amp/meter x 20m x 10^{-3}

$Z_{25} = 0.018497\ \Omega$

5.(b) $Z_{total(4)} = Z_{total(3)} + Z_{25}$

$Z_{total(4)} = 0.020737+0.018497 = 0.039234\ \Omega$

5.(c) $I_{SC} = \frac{400}{\sqrt{3}\ x Z_{total(4)}} = \frac{400}{\sqrt{3}\ x\ 0.039234}$ = 5,886 amp #

∴63A TPN MCCB with 6kA breaking capacity is recommended at DB.

6.(a) check thermal limit of cable 50mm^2 XLPE/PVC at tap off unit origin.

$$t_c = \frac{k^2 S^2}{I_{SC}{}^2} = \frac{143^2 x\ 50^2}{28233^2} = 0.064 \text{ sec}$$

125A MCCB magnetic tripping time = 0.02 sec

$\therefore$ 0.064 sec > 0.02 sec

The cable 50mm^2 XLPE/PVC is protected against short circuit current 28233 amp by 125A TPN MCCB.

7.(a) check thermal limit of cable 25mm^2 XLPE/PVC at FDBorigin.

$$t_c = \frac{k^2 S^2}{I_{SC}{}^2} = \frac{143^2 x\ 25^2}{11136^2} = 0.103 \text{ sec}$$

125A MCCB magnetic tripping time = 0.02 sec

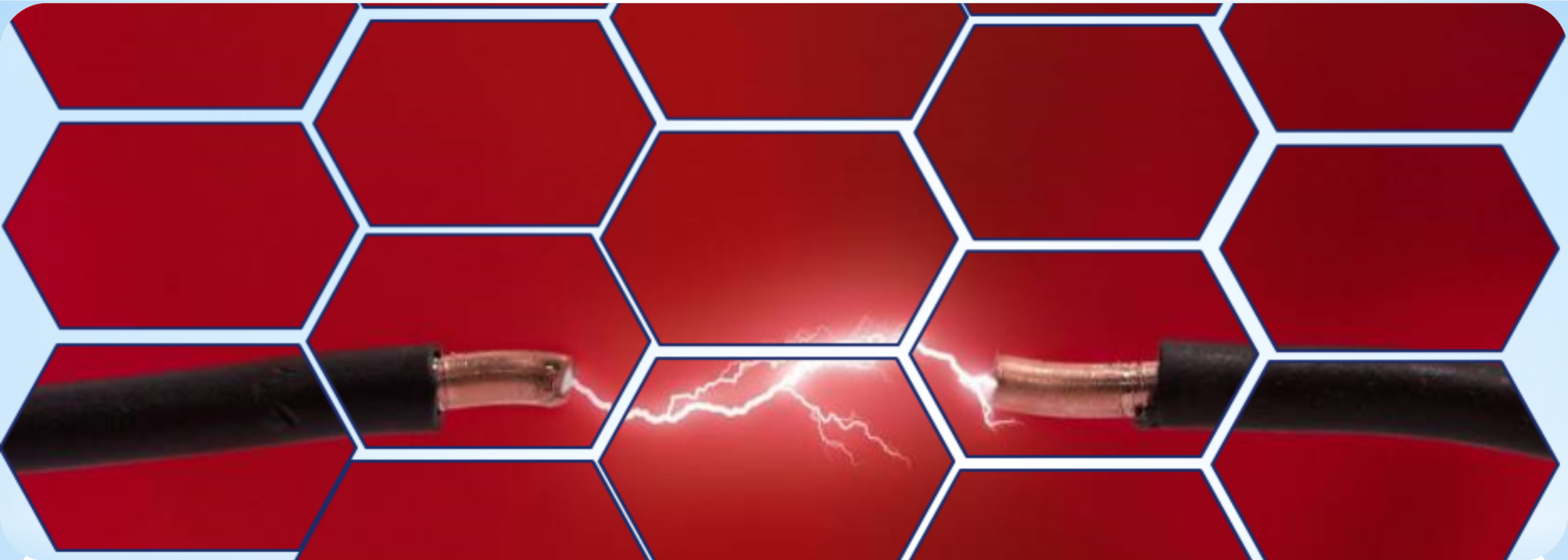
$\therefore$ 0.103 sec > 0.02 sec

The cable 25mm^2 XLPE/PVC is protected against short circuit current 11136 amp by 125A TPN MCCB.

13. EXAMPLE (IV)

Transformer 33kV, 400/230V, 50 Hz

S/N	Capacity (kVA)	Full Load Current $\frac{kVA}{\sqrt{3}x0.4}$	Impendance at 75° C Iz %	Fault Level MVA	Short Circuit Current kA $\frac{MVA}{\sqrt{3}x0.4}$	Transformer Impedence ohm $\frac{400}{\sqrt{3}xIsc}$
1	160	230	4	4	5.77	0.04
2	200	288	4	5	7.21	0.032
3	250	360	4	6.25	9.02	0.025
4	315	454	4	7.875	11.36	0.02
5	400	577	4	10.0	14.43	0.016
6	500	721	4	12.5	18.04	0.0128
7	630	909	4	15.75	22.73	0.0101
8	750	1082	5	15.0	21.65	0.0106
9	800	1154	5	16.0	23.09	0.01
10	1000	1443	6	16.66	24.04	0.009
11	1250	1804	6	20.833	30.07	0.0076
12	1500	2165	6	25.0	36.085	0.0064
13	2000	2886	6	33.33	48.1	0.0048
14	2500	3608	7	35.714	51.55	0.00448
15	3000	4330	7	42.857	61.86	0.00373



THANK YOU