Cables

Cables are selected according to:

1) Operating voltage
2) Operating frequency
3) Conductor type
4) Insulation level
5) Core number
6) Neutral and Earthing cable
7) Derating factors
8) Cross section area (mm^2)

[1] Operating voltage:-

- **Low voltage cable [1 V → 1000 V]**

فصيلة كابل الجهد المنخفض (0.6 /1 KV)

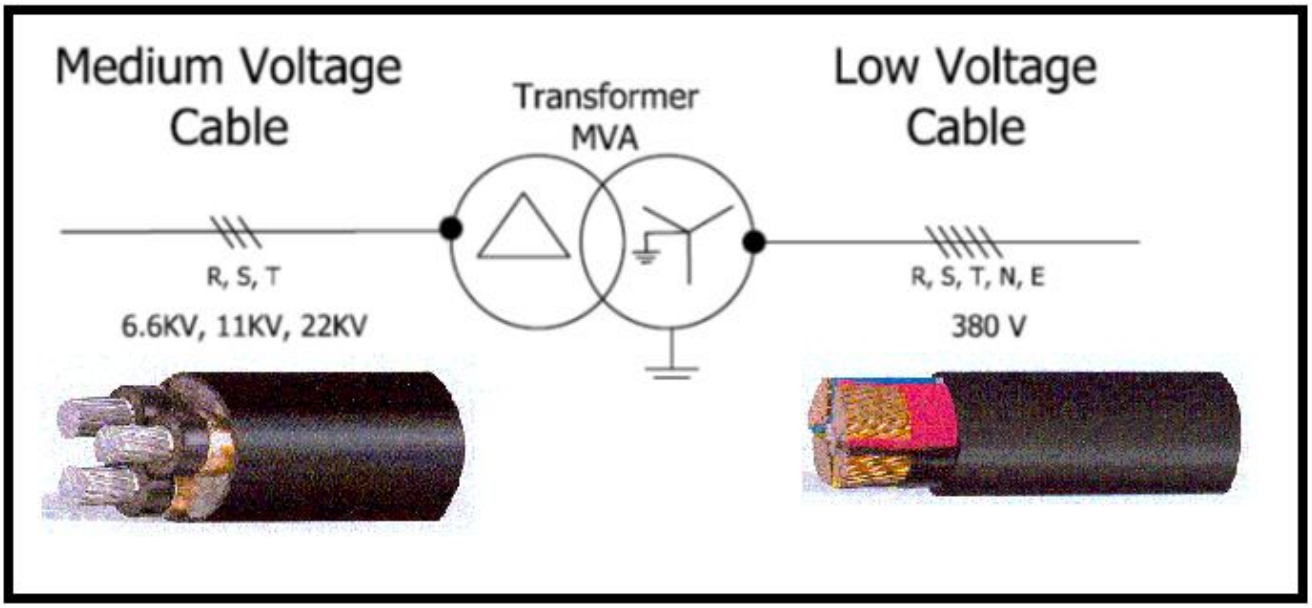
- **Medium voltage cable [1 KV → 66 KV]**

فصيلة كابل الجهد المتوسط 11 KV (12 /20 KV)

فصيلة كابل الجهد المتوسط 22 KV (18 /30 KV)

فصيلة كابل الجهد المتوسط 3.3 KV - 6.6 KV (6 /10 KV)

- **overhead conductor [66 KV → 500 KV]**
- **Control Cable**



For the same C.S.A medium voltage cable insulation higher than low voltage cables **(V α Insulation).**

In general:-

V α Insulation

Iα Cross Section Area

[2] Operating Frequency:-

50 Hz

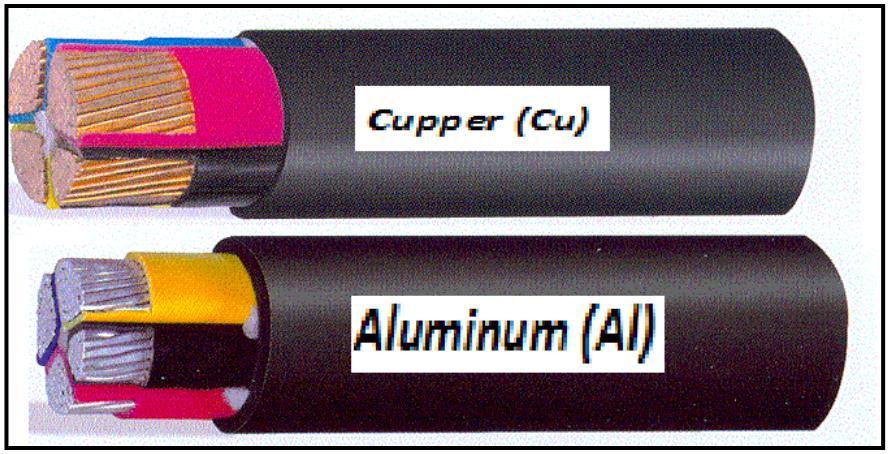
60 Hz

[3] Conductor type:-

Aluminum (Al)

Copper (Cu)

- Conductivity of **Al**= 65% of **Cu** conductivity.
- **Al** is lighter than **Cu** in weight.
- **Cu** is higher cost than **Al**.



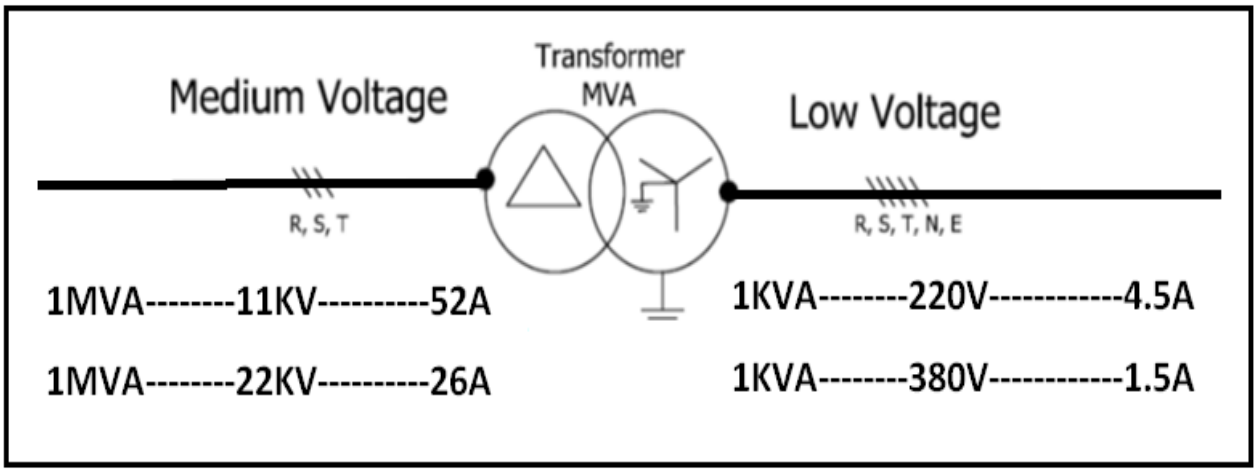
➢ **All medium voltage cables** are made from **Al** because of two reasons:-

1) Low current **I** ↓↓
2) Underground cable **cost** ↓↓

   Except cables used to fed motors load

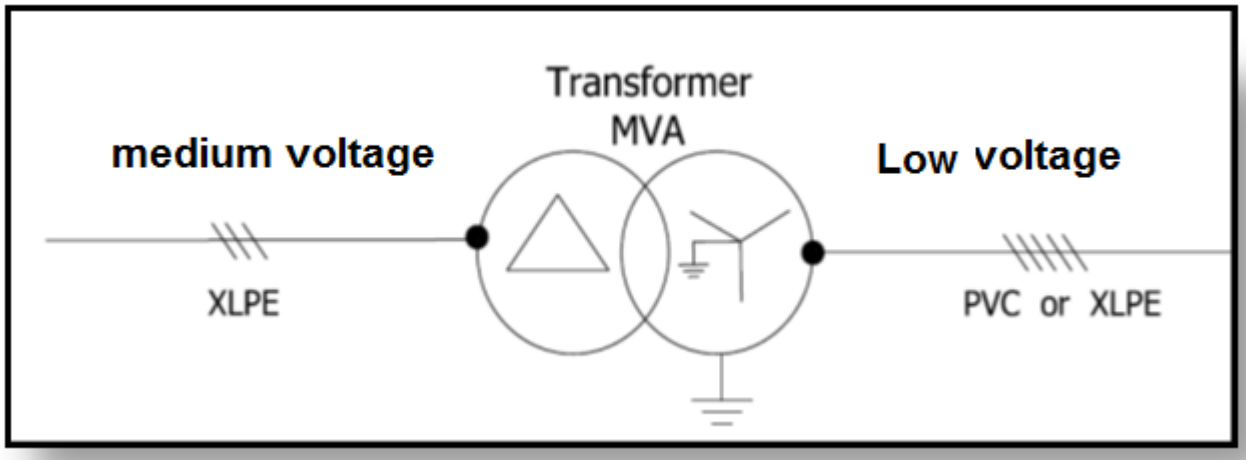
➢ **Low voltage cables** are preferred from **Cu** except underground cables of electrical distribution company for residential area are **Al**.

Note



[4] Insulation Level:-

Type	PVC	XLPE
Standard normal temperature	70°c	90°c
Max Temp. at short circuit level	150°c	250°c
COST (LE/m)	low	High



- All medium voltage cables with XLPE insulation because high short circuit level.

  @ 11 KV Network ----- SC= 500MVA

  @ 22 KV Network ----- SC= 750MVA

- Low voltage cables may be PVC or XLPE (PVC for low current & XLPE for high current).

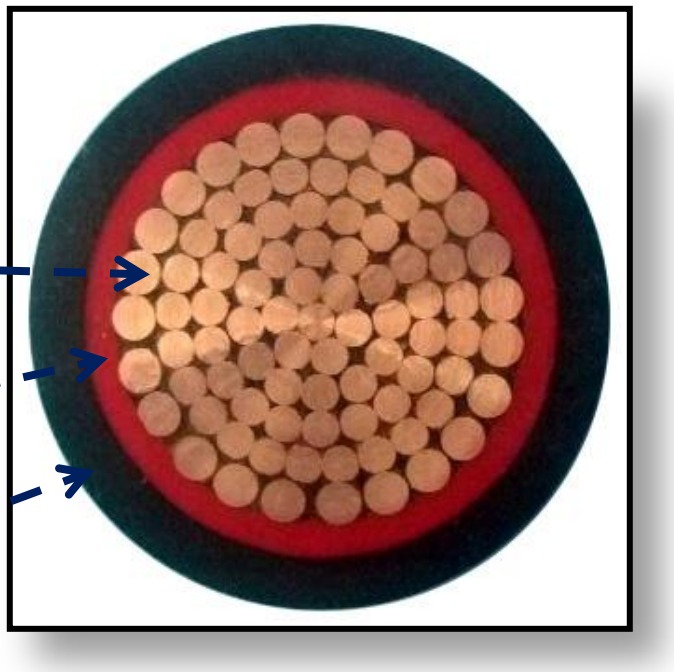
Note:-

Sheath is always made from **PVC.**

Conductor: Cu or Al

Insulation: PVC or XLPE

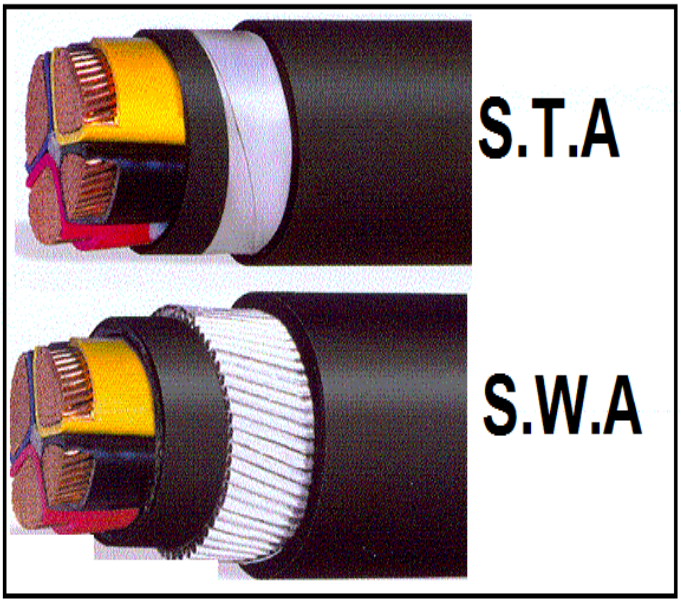
Sheath: PVC



[5] Armouring
- **S.T.A** (Steel Tape Armoured)
- **S.W.A** (Steel Wire Armoured)

Steel Tape Armoured [S. T.A]: Used for underground cables.

- **S.T.A withstands mechanical Stress more than SWA,**
- **but S.W.A more flexible than S.T.A.**

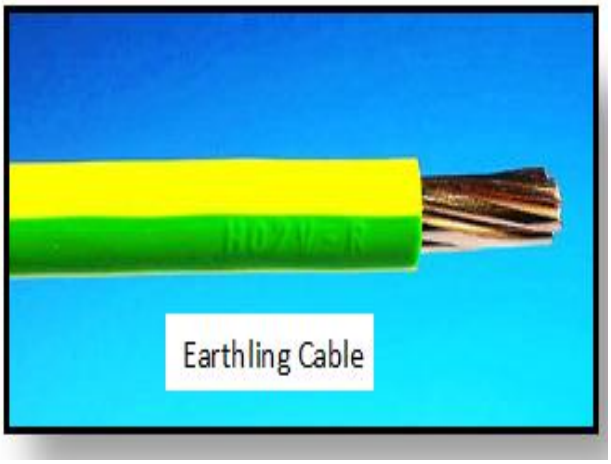


[6] Core number:-

a) Single core cable:

Application of single core cable:-

- If CSA > 300mm^2.
- Residential area. (Riser)
- Earthling cable.



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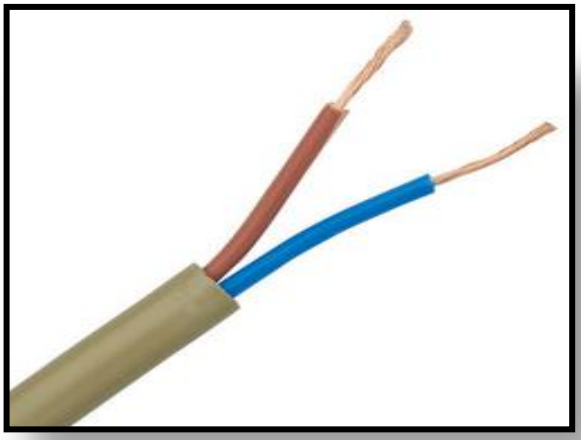
b) Two core cable:

Application of two core cable:-

Used in low voltage in 1Ø where there is no earthing system [L& N only].



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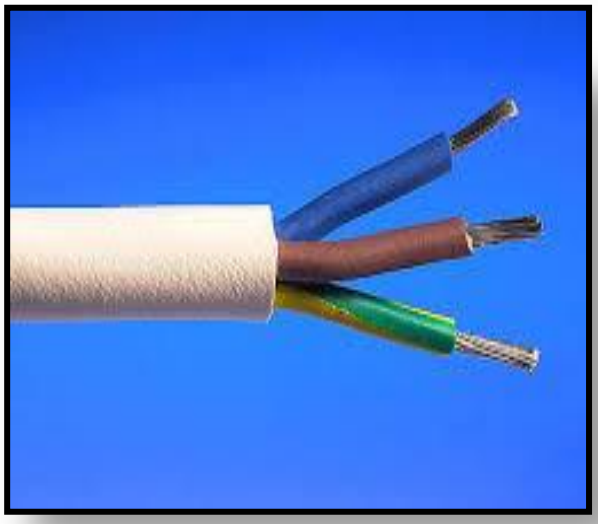
c) Three core cable:

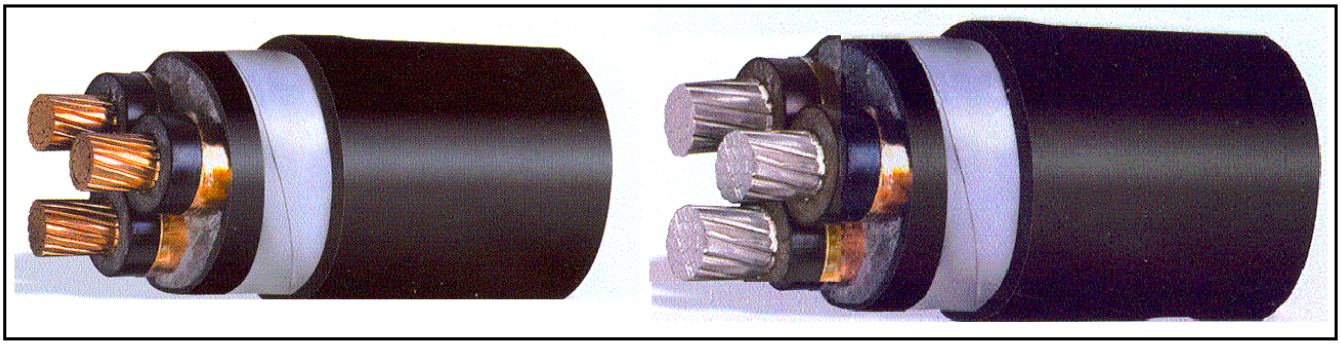
Application of three core cable:-

Used in low voltage in 1Ø where

There is earthling system [L, N and E].



- In medium voltage three phase [R, S, and T].



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d) Four core cable:

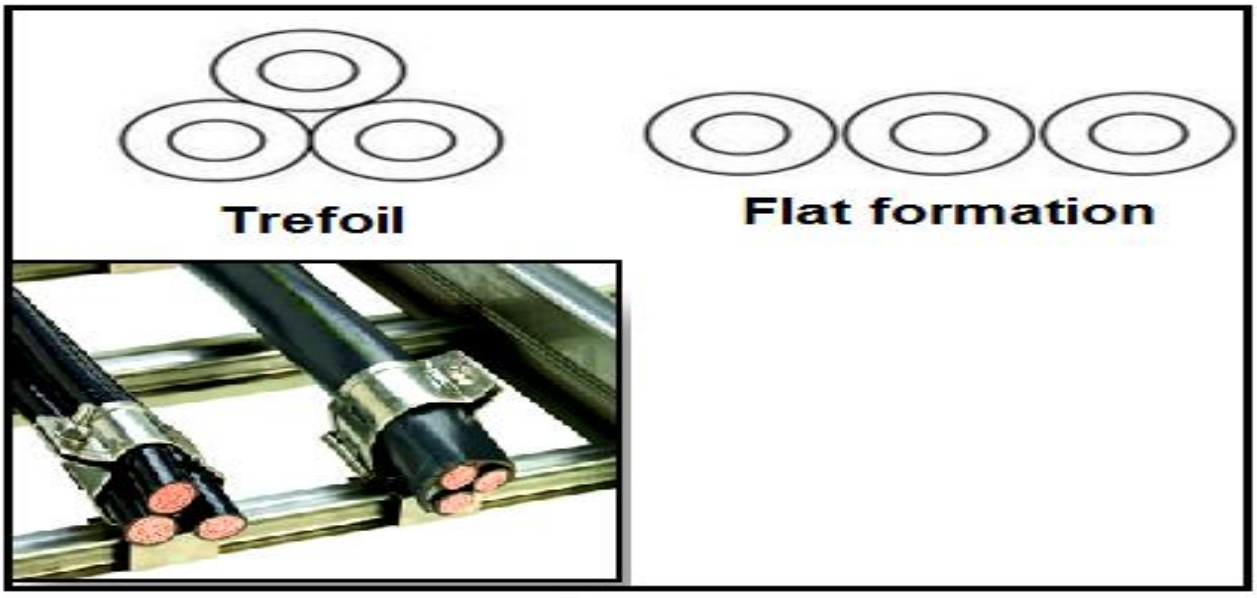
Application of four core cable:-

Used for three phase network

In low voltage system [R, S, T and N].

==========

Cables Formations



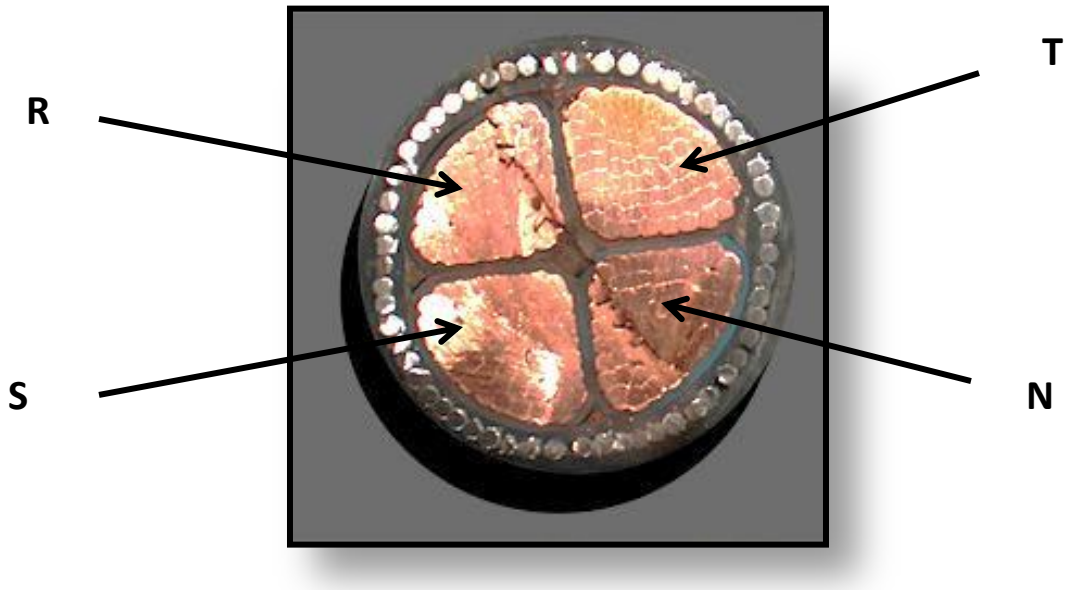
- Trefoil position is preferred than flat position as:

Flat position: Φ↑→ Temp↑→ R↑→Derating in cables.

- Multicore cables are more economic than single core cables.
- Multicore cables designed as trefoil so more technical than single core cables.
- Multicore cables are preferred than single core cables.

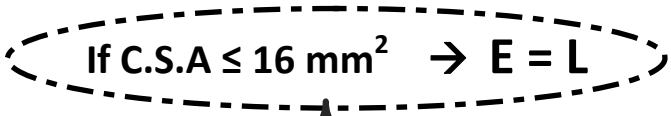
==========

For Neutral Cable:-



IF	C.S.A <=35mm^2	C.S.A > 35mm^2
ACCORDING TO CODE	C.S.A (N) = C.S.A (L)	C.S.A (N) = 1/2 C.S.A (L)

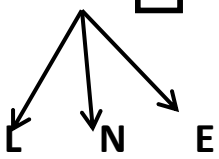
For Earthing Cable:-



1 – Ø

L = N = E

3 x □ mm²

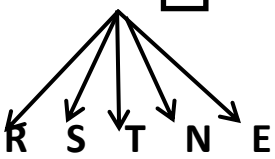


3 x 3 mm²
3 x 4 mm²
3 x 6mm²
3 x 10mm²
3 x 16 mm²

3 – Ø

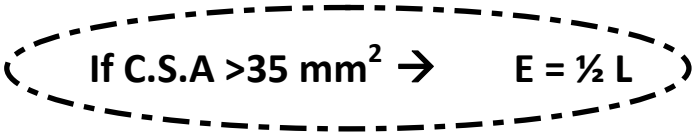
R = S = T = N = E

5 x □ mm²

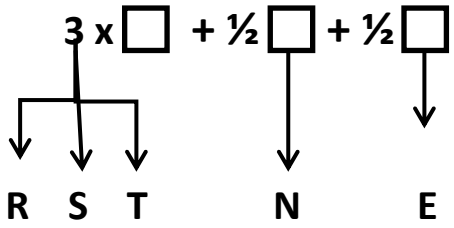


4 x 3+3 mm²
4x 4+4mm²
4x 6+5mm²
4x 10+10mm²
4 x 16+16mm²

If C.S.A =25 mm² OR C.S.A =35 mm² → E = 16 mm²



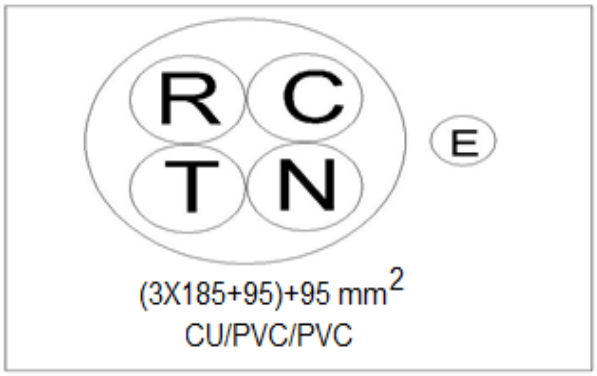
For three phase only E = ½ L

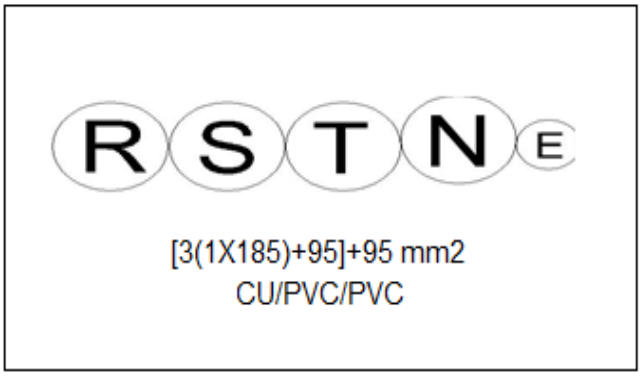


Ex:-

(3x 70 + 35)+35 & (3 x 240 + 120) +120 & (3 x 95 + 50) + 50

يتم معرفة اذا كان الكابل Single core or Multi core عن طريق توصيف كتابة الكابل





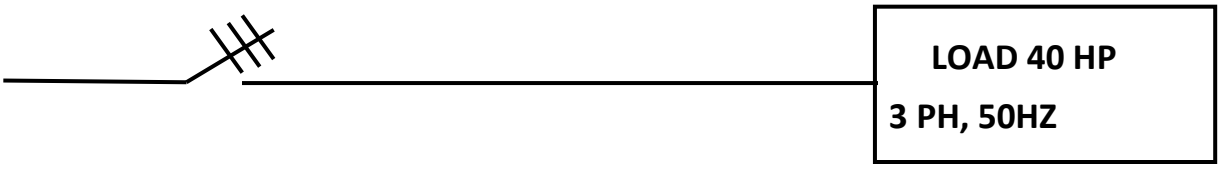
Cable Design

Cables are designed according to:

- Current carry capacity or thermal rating.
- Voltage drop.
- Short circuit level.

[1] Current Carry Capacity:-

C.B = 80 A **Cables C.S.A =??!**



I_{rated} = 40 x 1.5 = 60 Amp as HP = KVA

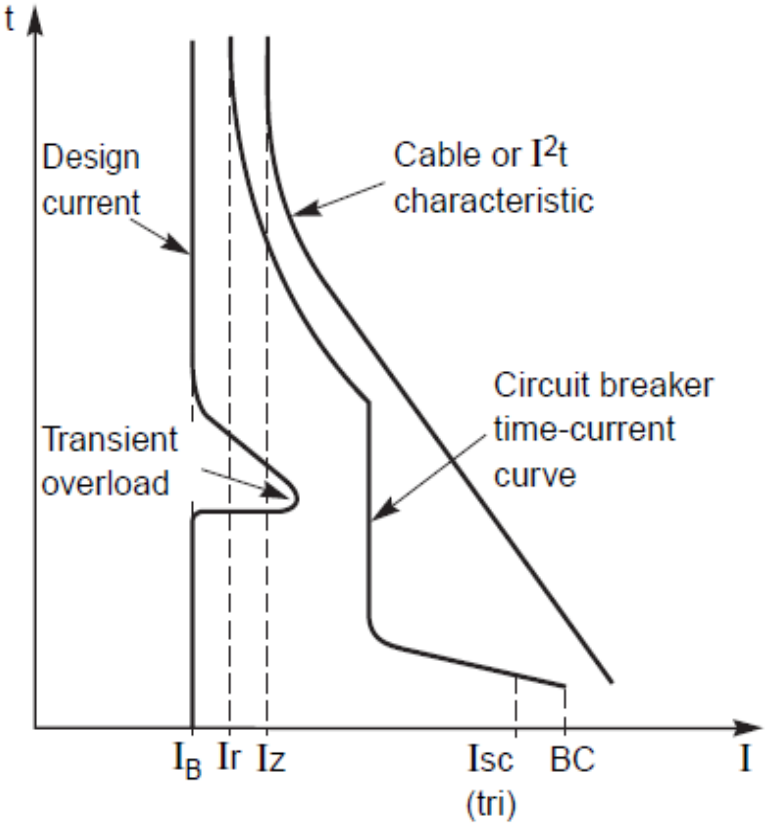
$I_{C.B}$ = 60 x 1.25 = 75 Amp → C.B = 80 Amp

$$I_{cable} = \frac{C.B}{Derating\ Factor}$$

So must select C.B before cable.

C.B rating depends on (KVA of load).

Cable sizing depends on C.B rating.



Types of Derating Factor:-

a) Ambient temperature Derating factor

b) Ground temperature Derating factor

c) Grouping factor

d) Burial depth Derating factor

e) Soil thermal resistivity

Air temperature derating factor

Air temperature °C	25	30	35	40	45	50	55
PVC cables rated 70 °C	1.22	1.15	1.08	1.00	0.95	0.82	0.71
XLPE cables rated 90 °C	1.14	1.10	1.05	1.00	0.90	0.89	0.84

Ground temperature derating factor

Ground temperature °C	25	30	35	40	45	50	55
PVC cables rated 70 °C	1.13	1.07	1.00	0.93	0.85	0.76	0.65
XLPE cables rated 90 °C	1.09	1.04	1.00	0.95	0.90	0.85	0.80

Burial depth derating factor

Depth of laying mt.	Cables cross section		
	Up to 70 mm^2	95 upto 240 mm^2	300 mm^2 & above
0.50	1.00	1.00	1.00
0.60	0.99	0.98	0.97
0.80	0.97	0.96	0.94
1.00	0.95	0.93	0.92
1.25	0.94	0.92	0.89
1.50	0.93	0.90	0.87
1.75	0.92	0.89	0.86
2.00	0.91	0.88	0.85

Soil thermal resistivity derating factor

Soil thermal resistivity in °C. Cm/Watt	80	90	100	120	150	200	250
Rating factor	1.17	1.12	1.07	1.0	0.91	0.80	0.73

معامل تصحيح الكابلات المتجاورة افقيا وراسيا فى الهواء					
عدد الكابلات على الحامل					
اكثر من 9	6-8	4-5	3	2	
0.7	0.72	0.75	0.78	o.85	افقيا
0.66	. 0.68	0.7	.73	0.8	راسيا

De-rating Factor

Air	Ground
→ Temp	→ Temp
→ Grouping Factor	→ Depth
	→Soil Thermal
Take T = 50°c	Take Tg = 50°c
So, for PVC take 0.82	So, for PVC take 0.76
For XLPE take 0.89	For XLPE take 0.85
	(for depth = 80 Cm)

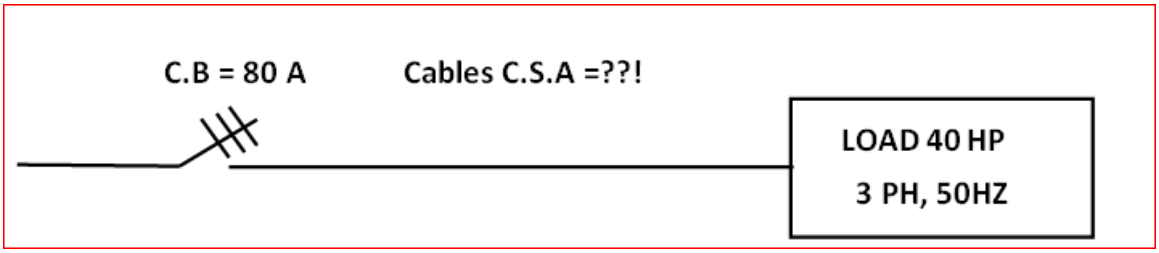
How to calculate Derating Factor for group of cables?

Correction factor for cable laying in cable trays.

If cables are single layer and the distance between two cables is equal to **2 D** of cable and the distance between cable and wall equal **D** this mean:

Derating Factor D.F = 1

Ex:-



$$\mathbf{I_{cable}} = \frac{\boldsymbol{C.B}}{\boldsymbol{D.F}}$$

Temp = 50°c → PVC → $D.F_T = 0.82$

Single cable → $D.F_G = 1$

$$\mathrm{I_{cable}} = \frac{80}{0.82} = 97\ \mathrm{Amp}$$

From Elsewedy Catalogue: chose **<u>Cu/PVC/PVC (4 X 25) + 16 mm²</u>**

Multicore Cables, with Stranded Copper Conductors PVC Insulated and PVC Sheathed

Description

- Multicore cables of stranded Copper conductors are insulated with PVC compound rated 70°C, assembled together, covered with overall jacket of PVC compound.
- Cables are produced according to IEC 60502 or BS 6346.

Application

- For outdoor and indoor installations in damp and wet locations.

Product - Code	Nominal Cross Sectional Area	Max. Conductor Resistance		Current Rating			Approx. Overall Diameter	Approx. Weight
		DC at 20 °C	AC at 70 °C	Laid Direct in Ground	Laid in Ducts	Laid in Free Air		
	mm²	Ω/km	Ω/km	A	A	A	mm	kg/km
Four Core Cables								
CP1-T104-U04	1.5 mm	12.1000	14.6000	21	18	18	11.4	180
CP1-T104-U06	2.5 mm	7.4100	8.8700	27	23	22	12.4	230
CP1-T104-U08	4 mm	4.6100	5.5400	35	30	31	14.8	335
CP1-T104-U09	6 mm	3.0800	3.6900	45	36	39	16.0	425
CP1-T104-U10	10 mm	1.8300	2.1900	60	48	53	17.9	635
CP1-T104-U11	16 mm	1.1500	1.3900	75	60	72	20.3	880
CP1-T104-U12	25 mm	0.7270	0.8700	100	80	94	23.9	1295
CP1-T104-U13	35 mm	0.5240	0.6280	120	95	110	26.6	1700
CP1-T104-U14	50 sm	0.3870	0.4640	145	115	138	29.3	2225
CP1-T104-U15	70 sm	0.2680	0.3220	175	145	171	32.9	3065
CP1-T104-U16	95 sm	0.1930	0.2320	210	165	209	37.8	4175
CP1-T104-U17	120 sm	0.1530	0.1850	240	195	242	41.2	5205

مثال ٢

مطلوب تصميم لوحة كهرباء لتغذية عدد ثلاثة مواتير قدرة الواحد ٣٠ حصان وكذلك عدد ٢ موتور قدرة الواحد ٢٠ حصان مع العلم ان الكابلات كلها على حامل كابلات واحد .

- 30 HP & No. =3

I_{rated} =30 X1.5=45A $I_{C.B}$ = 45 x 1.25 = 56 Amp → C.B = 63 Amp

$$I_{cable} = \frac{C.B}{D.F}$$ Temp = 50°c → PVC → $D.F_T$= 0.82 → $D.F_{G.NO}$= 1

$$I_{cable} = \frac{63}{0.82} = 77\ Amp$$ على اساس ان يوجد مسافات بين الكابلات على الحامل

Egytech - code	Nominal cross sectional area	Max. Conductor resistance		Current rating			Approx. overall diameter	Approx. weight
		DC at 20 °C	AC at 70 °C	Laid direct in ground	Laid in ducts	Laid in free air		
	mm²	Ω/km	Ω/km	A	A	A	mm	kg/km
				Four core cables				
CP1-T104-U04	1.5 rm	12.1000	14.600	21	18	18	11.4	180
CP1-T104-U06	2.5 rm	7.4100	8.870	27	23	22	12.4	230
CP1-T104-U08	4 rm	4.6100	5.540	35	30	31	14.8	335
CP1-T104-U09	6 rm	3.0800	3.690	45	36	39	16.0	425
CP1-T104-U10	10 rm	1.8300	2.190	60	48	53	18.5	650
CP1-T104-U11	16 rm	1.1500	1.390	75	60	72	20.9	910
CP1-T104-U12	25 rm	0.7270	0.870	100	80	94	25.0	1360
CP1-T104-U13	35 sm	0.5240	0.628	120	95	110	25.1	1650
CP1-T104-U14	50 sm	0.3870	0.464	145	115	138	29.3	2225
CP1-T104-U15	70 sm	0.2680	0.322	175	145	171	32.9	3065
CP1-T104-U16	95 sm	0.1930	0.232	210	165	209	37.8	4175
CP1-T104-U17	120 sm	0.1530	0.185	240	195	242	41.2	5205
CP1-T104-U18	150 sm	0.1240	0.151	270	220	275	45.9	6400
CP1-T104-U19	185 sm	0.0991	0.121	300	245	314	50.7	7960
CP1-T104-U20	240 sm	0.0754	0.084	345	290	374	57.0	10330
CP1-T104-U30	300 sm	0.0601	0.077	390	320	440	63.3	12915

From El-sewedy Catalogue: chose **Cu/PVC/PVC 4 X 16 + 16 mm^2**

- 20 HP & No. =2

I_{rated} =20 X1.5=30A $I_{C.B}$ = 30 x 1.25 = 37.5 Amp → C.B = 40 Amp

$$I_{cable} = \frac{C.B}{D.F}$$ Temp = 50°c → PVC → $D.F_T$= 0.82 → $D.F_{G.NO}$= 1

$$I_{cable} = \frac{40}{0.82} = 50\ Amp$$ على اساس ان يوجد مسافات بين الكابلات على الحامل

Egytech - code	Nominal cross sectional area	Max. Conductor resistance		Current rating			Approx. overall diameter	Approx. weight
		DC at 20 °C	AC at 70 °C	Laid direct in ground	Laid in ducts	Laid in free air		
	mm^2	Ω/km	Ω/km	A	A	A	mm	kg/km
				Four core cables				
CP1-T104-U04	1.5 rm	12.1000	14.600	21	18	18	11.4	180
CP1-T104-U06	2.5 rm	7.4100	8.870	27	23	22	12.4	230
CP1-T104-U08	4 rm	4.6100	5.540	35	30	31	14.8	335
CP1-T104-U09	6 rm	3.0800	3.690	45	36	39	16.0	425
CP1-T104-U10	10 rm	1.8300	2.190	60	48	53	18.5	650
CP1-T104-U11	16 rm	1.1500	1.390	75	60	72	20.9	910
CP1-T104-U12	25 rm	0.7270	0.870	100	80	94	25.0	1360
CP1-T104-U13	35 sm	0.5240	0.628	120	95	110	25.1	1650
CP1-T104-U14	50 sm	0.3870	0.464	145	115	138	29.3	2225
CP1-T104-U15	70 sm	0.2680	0.322	175	145	171	32.9	3065
CP1-T104-U16	95 sm	0.1930	0.232	210	165	209	37.8	4175
CP1-T104-U17	120 sm	0.1530	0.185	240	195	242	41.2	5205
CP1-T104-U18	150 sm	0.1240	0.151	270	220	275	45.9	6400
CP1-T104-U19	185 sm	0.0991	0.121	300	245	314	50.7	7960
CP1-T104-U20	240 sm	0.0754	0.084	345	290	374	57.0	10330
CP1-T104-U30	300 sm	0.0601	0.077	390	320	440	63.3	12915

From El-sewedy Catalogue: chose **Cu/PVC/PVC 4 X 10 + 10 mm^2**

- **main cable and circuit breaker**

$$I_{\text{main circuit breaker}} = 1.25 \times I_{\text{largest}} + D.F\left(\sum I_{\text{rated except largest}}\right)$$

$$I_{\text{main circuit breaker}} = 1.25 \times 45 + (45+45+30+30) = 206A$$

C.B = 200 Amp

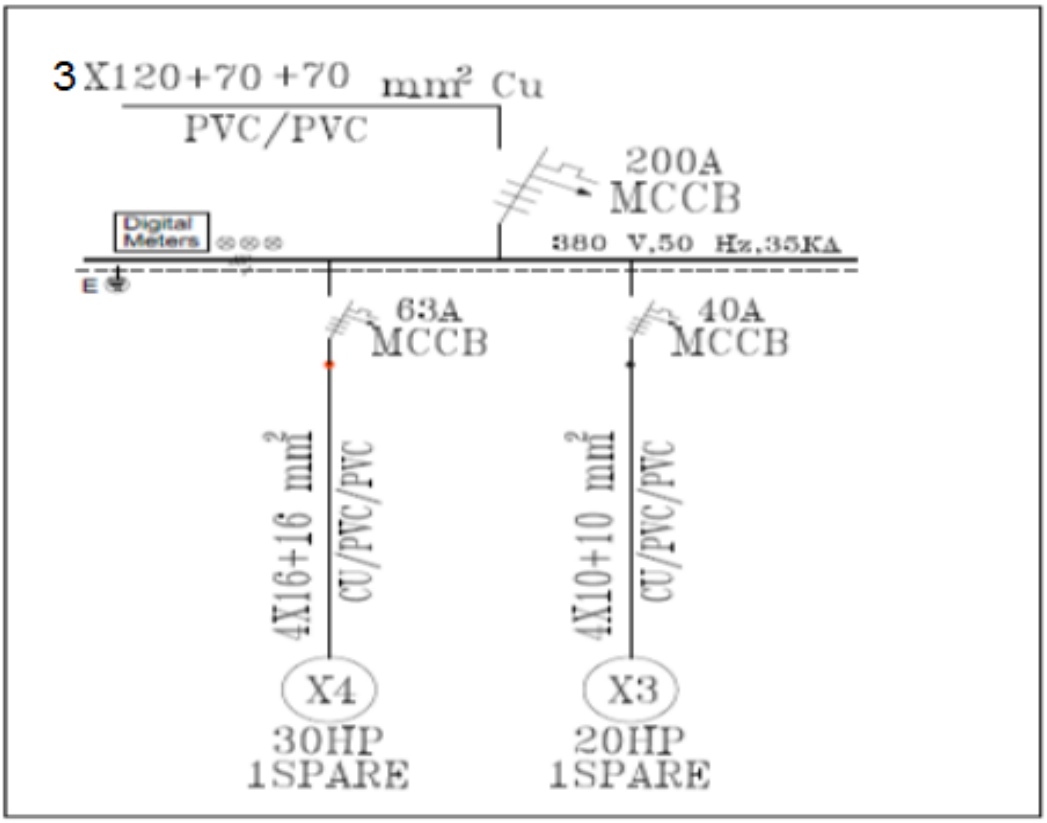
$$I_{cable} = \frac{C.B}{D.F}$$

Temp = 50°c → PVC → $D.F_T = 0.82$

Single cable → $D.F_G = 1$

$$I_{cable} = \frac{200}{0.82} = 250 \text{ Amp}$$

From Elsewedy Catalogue: chose **Cu/PVC/PVC (3 X 120 + 70)+70 mm²**



مثال 3 -: مطلوب تصميم لوحة كهرباء لتغذية عدد ثلاثة مواتير قدرة الواحد 100 حصان وكذلك عدد ٢ موتور قدرة الواحد 300 حصان مع العلم ان الكابلات كلها على حامل كابلات واحد .

➢ **100 HP & No. =3**

I_{rated} =100 X1.5=150A $I_{C.B}$ = 150 x 1.25 = 187.5 Amp → C.B = 200 Amp

$$I_{cable} = \frac{C.B}{D.F}$$ Temp = 50°c → PVC → $D.F_T$= 0.82 → $D.F_{G.NO}$= 1

$$I_{cable} = \frac{200}{0.82} = 250\ Amp$$ على اساس ان يوجد مسافات بين الكابلات على الحامل

Multicore Cables, with Stranded Copper Conductors PVC Insulated and PVC Sheathed

Description

- Multicore cables of stranded Copper conductors are insulated with PVC compound, assembled together, covered with overall jacket of PVC compound.
- Cables are produced according to IEC 60502 of BS 6346.

Application

- For outdoor and indoor installations in damp and wet locations.

Egytech - code	Nominal cross sectional area		Max. Conductor resistance		Current rating			Approx. overall diameter	Approx. weight
			DC at 20 °C	AC at 70 °C	Laid direct in ground	Laid in ducts	Laid in free air		
	mm²		Ω/km	Ω/km	A	A	A	mm	kg/km
Four core cables									
CP1-T104-U04	1.5	rm	12.1000	14.600	21	18	18	11.4	180
CP1-T104-U06	2.5	rm	7.4100	8.870	27	23	22	12.4	230
CP1-T104-U08	4	rm	4.6100	5.540	35	30	31	14.8	335
CP1-T104-U09	6	rm	3.0800	3.690	45	36	39	16.0	425
CP1-T104-U10	10	rm	1.8300	2.190	60	48	53	18.5	650
CP1-T104-U11	16	rm	1.1500	1.390	75	60	72	20.9	910
CP1-T104-U12	25	rm	0.7270	0.870	100	80	94	25.0	1360
CP1-T104-U13	35	sm	0.5240	0.628	120	95	110	25.1	1650
CP1-T104-U14	50	sm	0.3870	0.464	145	115	138	29.3	2225
CP1-T104-U15	70	sm	0.2680	0.322	175	145	171	32.9	3065
CP1-T104-U16	95	sm	0.1930	0.232	210	165	209	37.8	4175
CP1-T104-U17	120	sm	0.1530	0.185	240	195	242	41.2	5205
CP1-T104-U18	150	sm	0.1240	0.151	270	220	275	45.9	6400
CP1-T104-U19	185	sm	0.0991	0.121	300	245	314	50.7	7960
CP1-T104-U20	240	sm	0.0754	0.084	345	290	374	57.0	10330
CP1-T104-U30	300	sm	0.0601	0.077	390	320	440	63.3	12915

From Elsewedy Catalogue: chose **Cu/PVC/PVC (3 X 120 + 70)+70 mm²**

- **<u>300 HP & No. =2</u>**

I_{rated} =300 X1.5=450A $I_{C.B}$ = 450 x 1.25 = 565 Amp → C.B = 630 Amp

$I_{cable} = \frac{C.B}{D.F}$ Temp = 50°c → XLPE → $D.F_T$= 0.9 → $D.F_{G.NO}$= 1

على اساس ان يوجد مسافات بين الكابلات على الحامل $I_{cable} = \frac{630}{0.9} = 700$ Amp

Multicore Cables, with Stranded, Copper Conductors, XLPE Insulated and PVC Sheathed

Description

- Multicore cables of stranded Copper conductors are insulated with XLPE compound, assembled together and covered with an overall jacket of PVC compound.
- Cables are produced according to IEC 60502 or BS 5467.

Application

- For outdoor and indoor installations in damp and wet locations. They are normally used for power distribution in urban networks, in industrial plants, as well as in Thermopower and Hydropower stations.

Egytech - code	Nominal cross sectional area	Max. conductor resistance		Current rating			Approx. overall diameter	Approx. weight
		DC at 20 °C	AC at 90 °C	Laid direct in ground	Laid in ducts	Laid in free air		
	mm²	Ω/km	Ω/km	A	A	A	mm	kg/km
Four core cables								
CX1-T104-U04	1.5 rm	12.1000	15.400	26	23	22	10.6	150
CX1-T104-U06	2.5 rm	7.4100	9.450	35	29	32	11.9	205
CX1-T104-U08	4 rm	4.6100	5.880	45	36	41	13.4	280
CX1-T104-U09	6 rm	3.0800	3.930	57	45	50	14.6	365
CX1-T104-U10	10 rm	1.8300	2.330	75	60	68	17.0	572
CX1-T104-U11	16 rm	1.1500	1.470	97	75	89	19.4	825
CX1-T104-U12	25 rm	0.7270	0.927	128	102	120	23.5	1245
CX1-T104-U13	35 sm	0.5240	0.669	155	120	145	23.6	1530
CX1-T104-U14	50 sm	0.3870	0.494	185	145	179	27.1	2060
CX1-T104-U15	70 sm	0.2680	0.343	220	180	225	31.4	2905
CX1-T104-U16	95 sm	0.1930	0.248	265	210	268	35.1	3910
CX1-T104-U17	120 sm	0.1530	0.197	305	245	310	39.2	4915
CX1-T104-U18	150 sm	0.1240	0.160	335	275	352	43.7	6035
CX1-T104-U19	185 sm	0.0991	0.129	375	310	404	48.7	7540
CX1-T104-U20	240 sm	0.0754	0.099	435	365	483	54.5	9785
CX1-T104-U30	300 sm	0.0601	0.081	490	405	562	60.1	12190

From Elsewedy Catalogue: chose Cu**<u>/XLPE /PVC 2 (3 X 150 + 70)+70 mm²</u>**

- **main cable and circuit breaker**

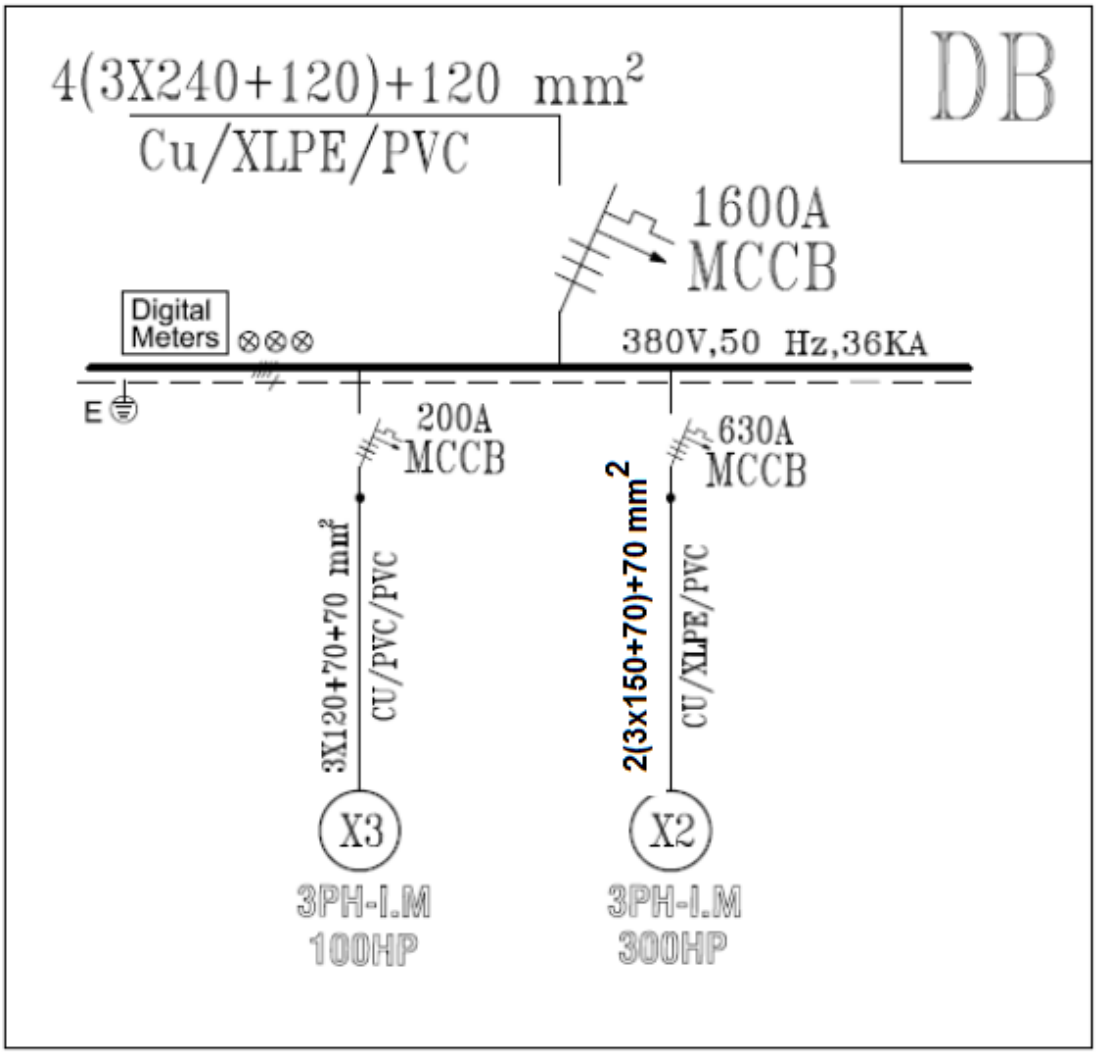
$$I_{\text{main circuit breaker}} = 1.25 \times I_{\text{largest}} + D.F\left(\sum I_{\text{rated except largest}}\right)$$

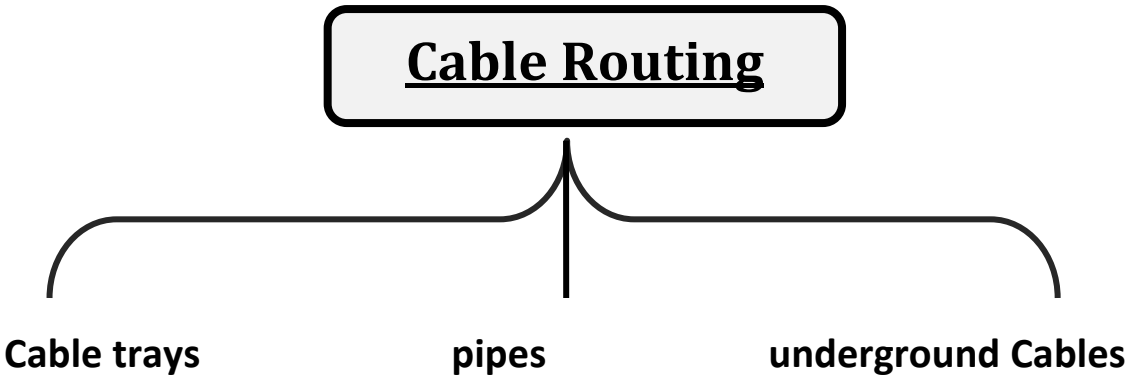
$$I_{\text{main circuit breaker}} = 1.25 \times 450 + (450+3X150) = 1460A$$

C.B = 1600Amp Temp = 50°c → XLPE → $D.F_T = 0.9$

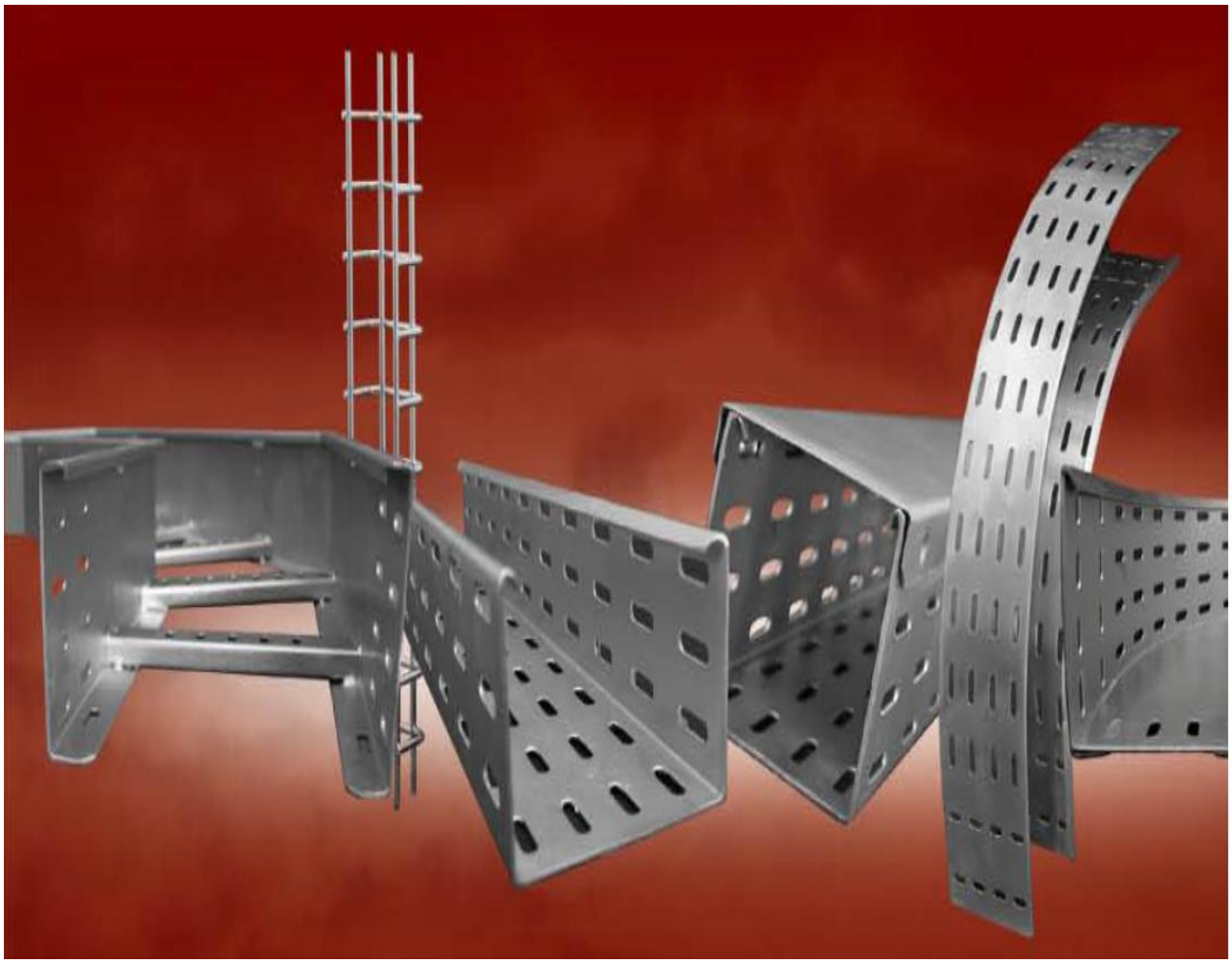
Single cable → $D.F_G = 1$ $I_{cable} = \frac{1600}{0.9} = 1780\ Amp$

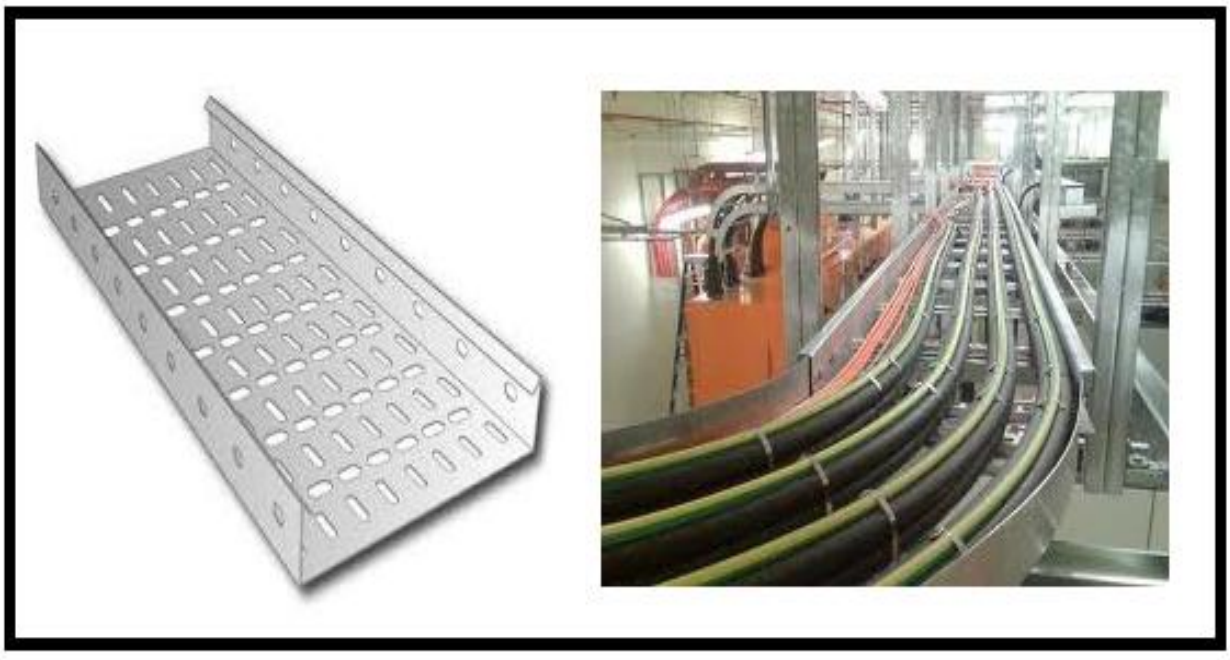
From Elsewedy Catalogue: chose **Cu/XLPE/PVC 4 (3 X 240 + 120)+120 mm²**





1) Cable Tray



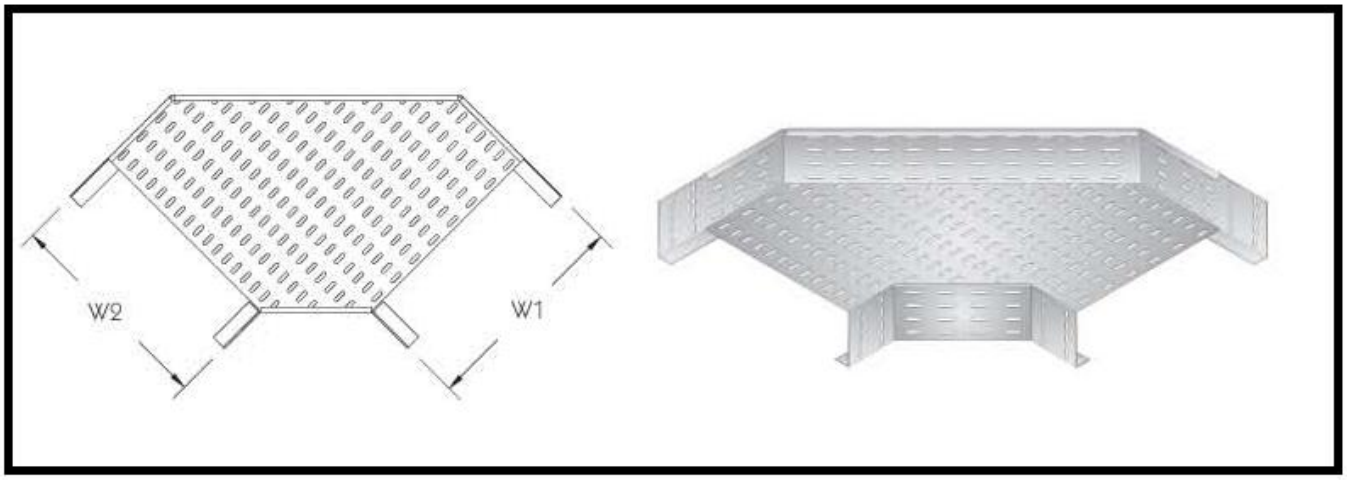


- يراعى ان تكون حوامل الكابلات من الصاج الأبيض المجلفن و ذات غطاء.

- Standard of cable tray dimension.

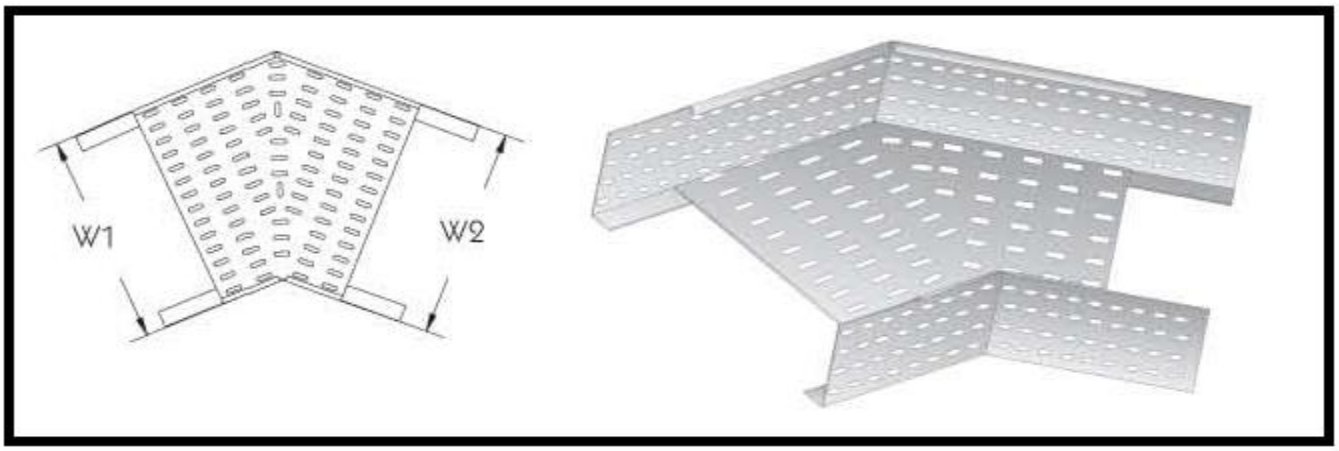
Width (cm)	Height (cm)	thickness	Cover
5 cm	5 cm 7.5 cm 10 cm	1.25 mm 1.5 mm 2 mm	1.25 mm
10 cm			
15 cm			
20 cm			
25 cm			
30 cm			
35 cm			
40 cm			
50 cm			
60 cm			
70 cm			
80 cm			

❖ Standard of cable tray horizontal bend 90^0 connection.



Width (W1)	Width (W2)	Height (cm)	thickness	Cover
5 cm	5 cm	5 cm 7.5 cm 10 cm	1.25 mm 1.5 mm 2 mm	1.25 mm
10 cm	10 cm			
15 cm	15 cm			
20 cm	20 cm			
25 cm	25 cm			
30 cm	30 cm			
35 cm	35 cm			
40 cm	40 cm			
50 cm	50 cm			
60 cm	60 cm			
70 cm	70 cm			
80 cm	80 cm			

- Standard of cable tray horizontal bend 45^0 connection.



Width (W1)	Width (W2)	Height (cm)	thickness	Cover
5 cm	5 cm	5 cm	1.25 mm	1.25 mm
10 cm	10 cm			
15 cm	15 cm			
20 cm	20 cm			
25 cm	25 cm			
30 cm	30 cm	7.5 cm	1.5 mm	
35 cm	35 cm			
40 cm	40 cm	10 cm	2 mm	
50 cm	50 cm			
60 cm	60 cm			
70 cm	70 cm			
80 cm	80 cm			