

KABEL SUBMAINS DAN SUSUTAN VOLTAN

CAWANGAN KEJURUTERAAN ELEKTRIK

Rujukan Rekabentuk

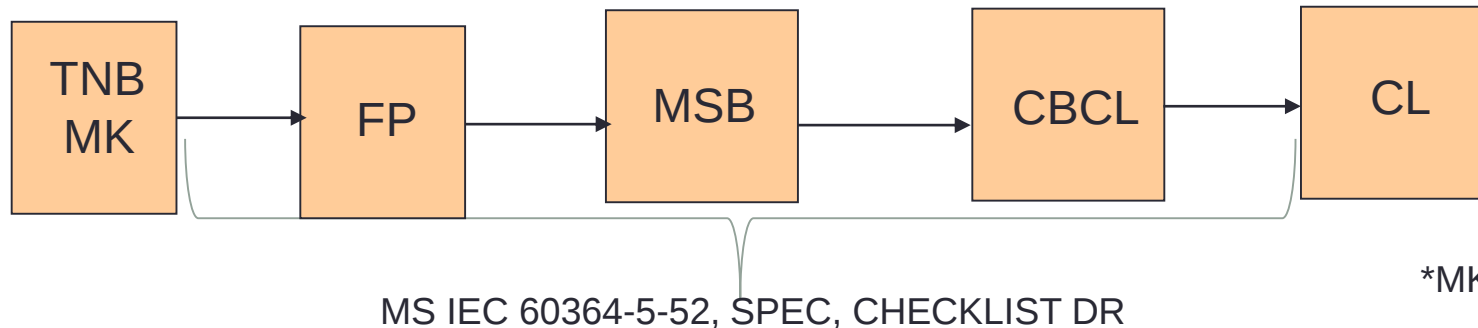
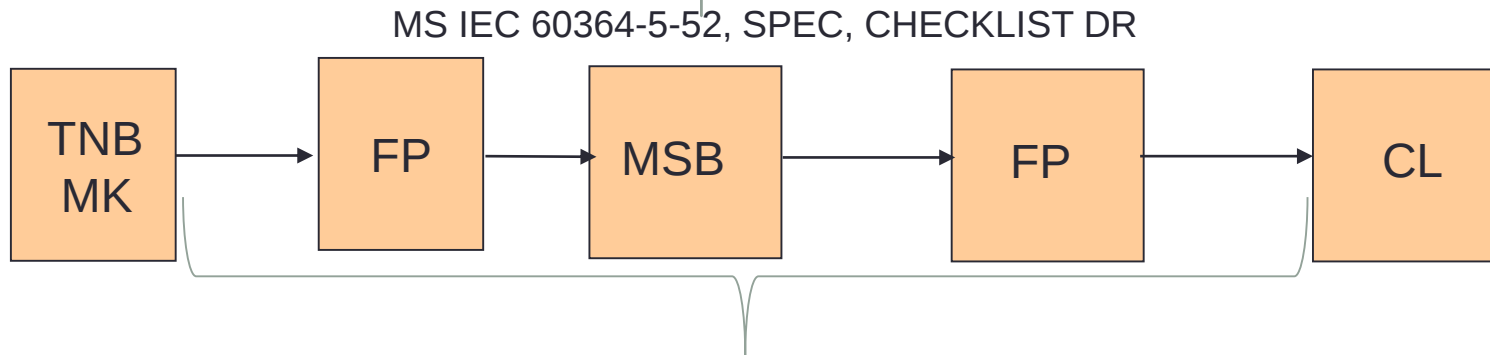
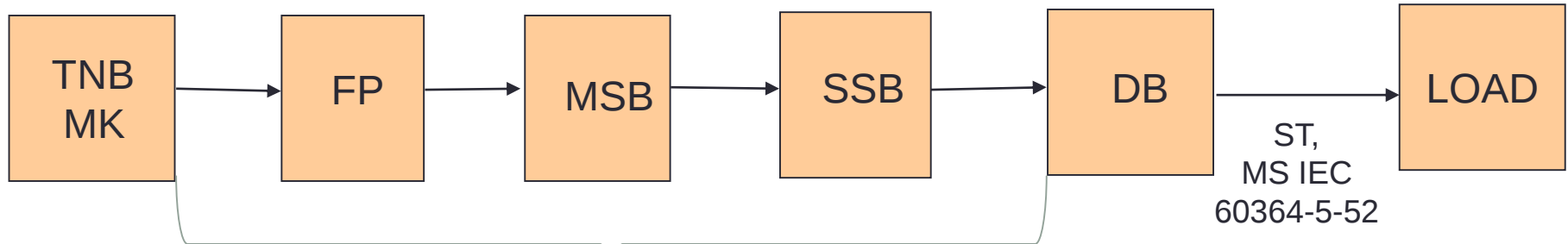
INTERNATIONAL STANDARD	MS IEC 60364-5-52	ELECTRICAL INSTALLATIONS OF BUILDING PART 5-52 SELECTION AND ERECTION OF ELECTRICAL EQUIPMENT – WIRING SYSTEM *Table IEEE WIRING REGULATION 16th EDITION (BS7671:1992 AMD 2004) DIGUNAKAN UNTUK PENGIRAAN VOLTAGE DROP
AKTA & PERATURAN	UBBL	UNIFORM BUILDING BY LAW
	PPE 1994	PERATURAN-PERATURAN ELEKTRIK 1994
KEPERLUAN PIHAK BERKUASA		JABATAN BOMBA DAN PENYELAMAT MALAYSIA
		SURUHANJAYA TENAGA

Rujukan Rekabentuk

SPESIFIKASI JKR	L-S1	LOW VOLTAGE ELECTRICAL INTERNAL INSTALLATION
	L-S3	LOW VOLTAGE UNDERGROUND CABLE
GARIS PANDUAN JKR		PANDUAN TEKNIK EDISI KE 4 2011
		GARIS PANDUAN PEMASANGAN PENDAWAIAN ELEKTRIK DI RUANG TANPA SILING
BEST PRACTISE CKE JKR	SENARAI SEMAK	SENARAI SEMAK REKABENTUK (CHECKLIST DESIGN REVIEW)

Rujukan Rekabentuk

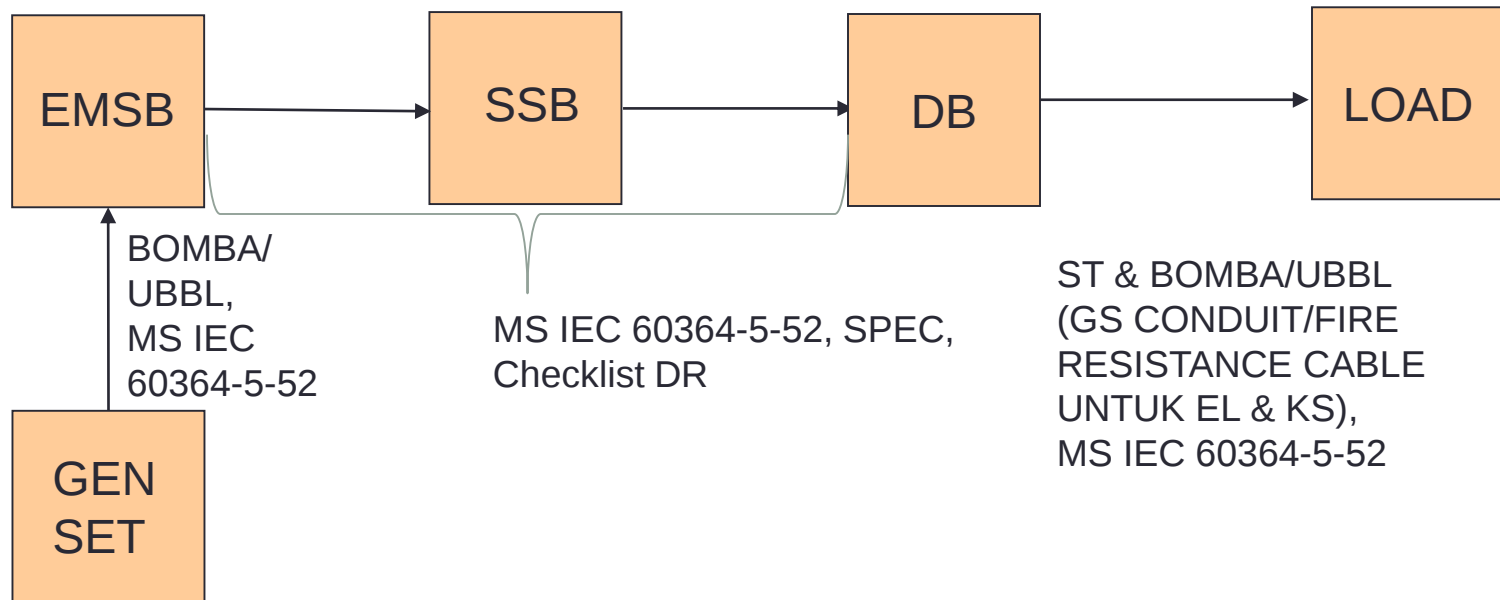
Normal Supply



*MK = METER KIOSK

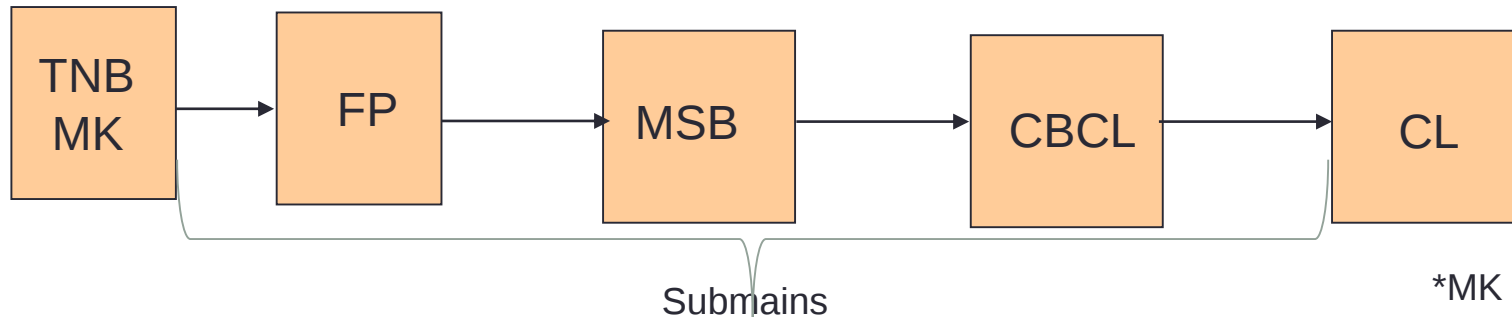
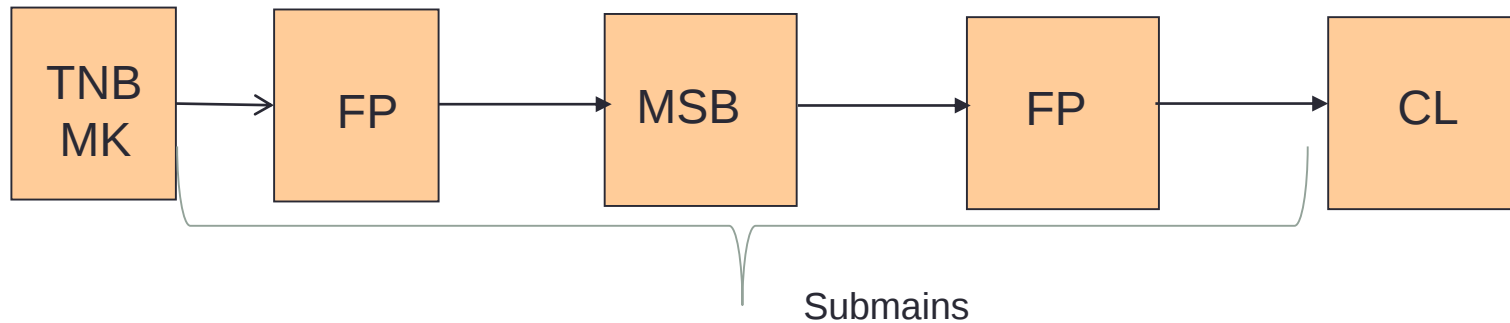
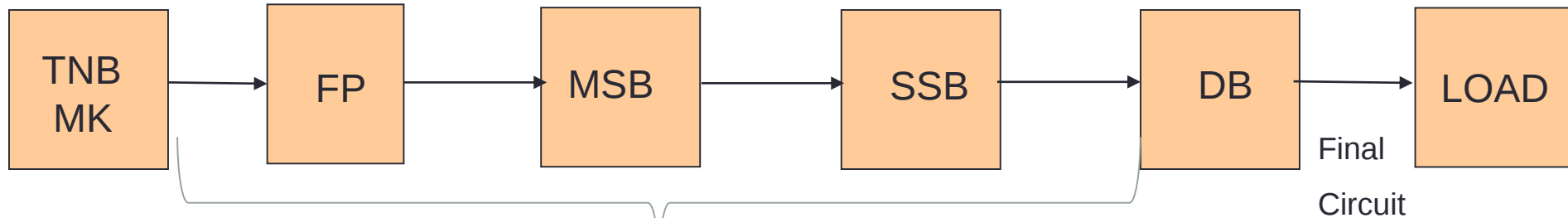
Rujukan Rekabentuk

Essential Supply



Terminologi Kabel LV

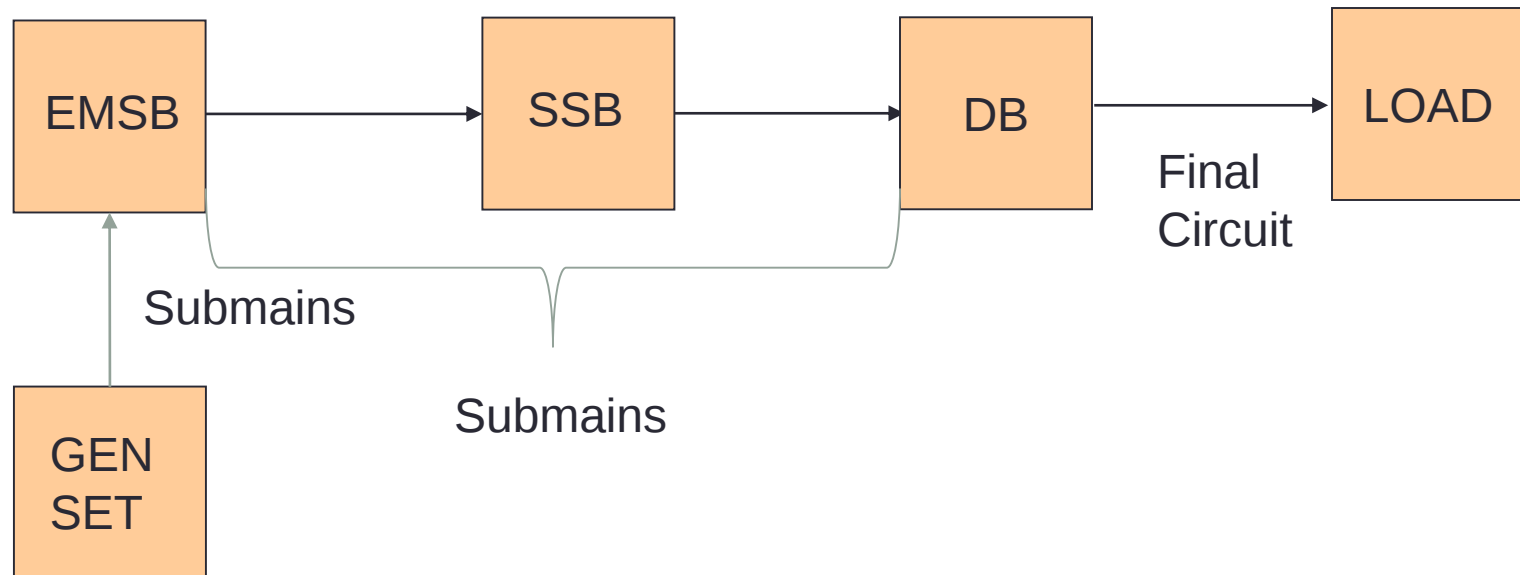
Normal Supply



*MK = METER KIOSK

Terminologi Kabel LV

Essential Supply



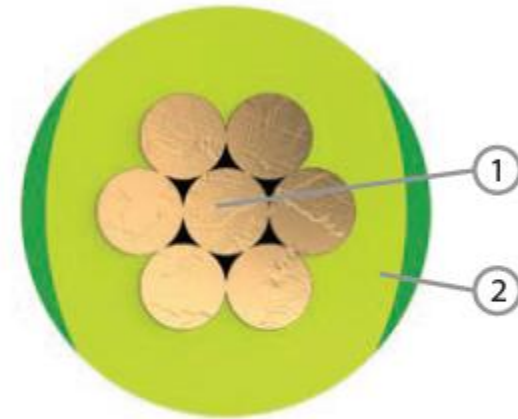
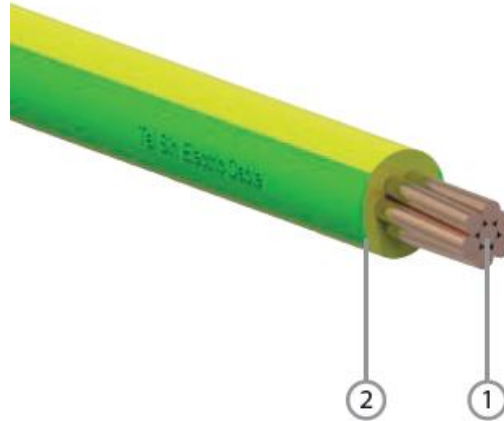
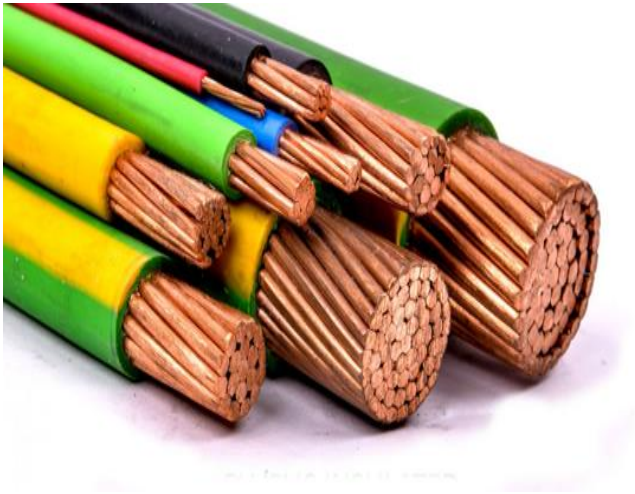
Jenis-jenis Kabel LV

Kabel <i>non-armoured</i>	Kabel <i>armoured</i>	Kabel <i>mineral insulated (fire resistant cable)</i>
PVC	PVC/SWA/PVC	MI/MS
PVC/PVC	PVC/SWA/PVC Multicore	
Flexible Cable	XLPE/SWA/PVC	
XLPE/PVC	XLPE/AWA/PVC (Single Core)	
Dalam bangunan dan luar bangunan (lalu lintas berbumbung)	Luar bangunan (lalu lintas <i>underground/outdoor installation, rooftop</i>)	Dalam bangunan (pendawaian kecemasan, <i>fire fighting system</i>)

*Kabel di atas adalah yang lazim digunakan dalam rekabentuk JKR

Non-Armoured

PVC Cable

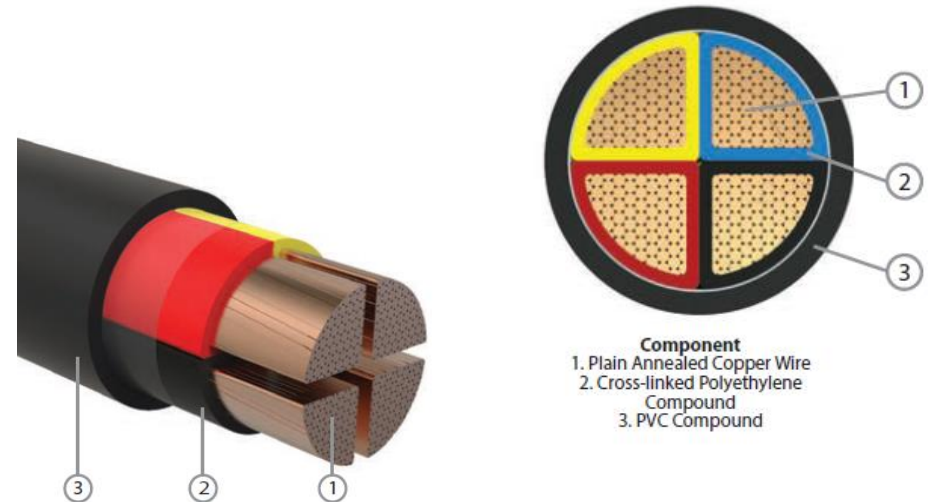
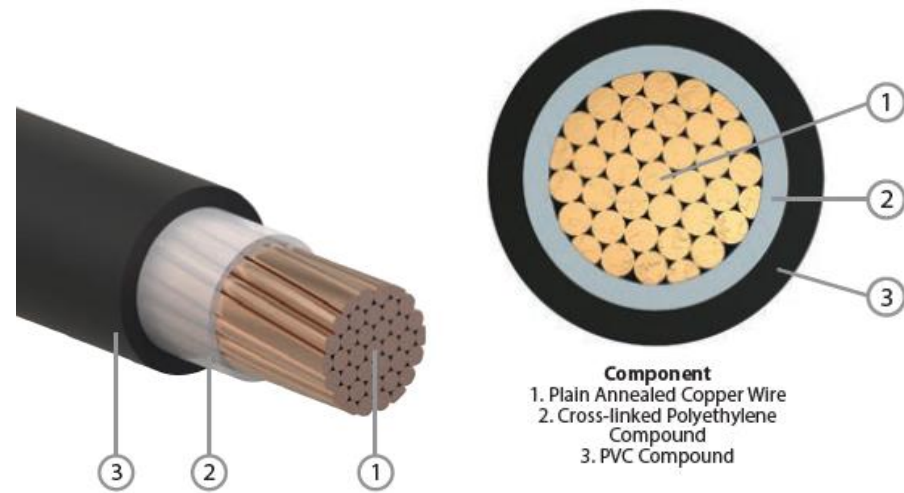


Component
1. Plain Annealed Copper Wire
2. PVC Compound

Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Keperluan ST	Norm JKR
450/750V	1.5, 2.5, 4, 6, 10, 16, 25, 35, 50, 70, 95, 120, 150, 185, 240	1	1. Final Circuit 2. Submains (In conduit/trunking/ underfloor trunking)	Min 1.5mm ² bagi litar lampu (Pekeliling ST Bil 3/2012)	Saiz kabel < 70 mm ²

Non-Armoured

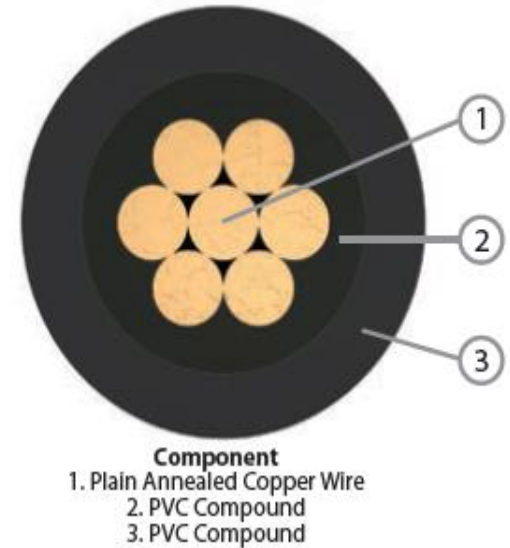
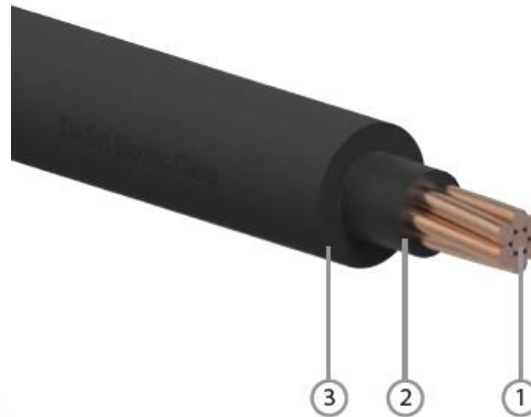
XLPE/PVC Cable



Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Norm JKR
600/1000V	70,95,120,150, 185,240	1, 3 & 5	Submains (In cable tray/cable ladder)	Saiz kabel ≥ 70 mm ²

Non-Armoured

PVC/PVC Cable



Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Norm JKR	Remarks
300/500V 600/1000V	1.5, 2.5, 4, 6, 10, 16, 25, 35, 50, 70, 95, 120, 150, 185, 240	1	1. Final circuit 2. Submains (In cable tray/cable ladder)	Saiz kabel $\geq$ 70 mm ²	Jarang digunakan

Non-Armoured

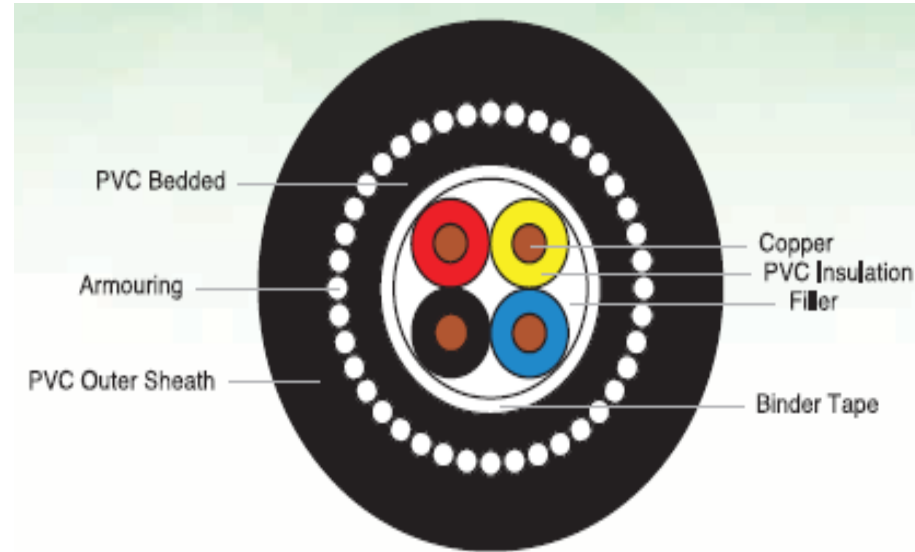
Flexible Cable



Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Norm JKR
600/1000V	1.5, 2.5 & 4	3	Commando socket di bilik server/data centre	

Armoured

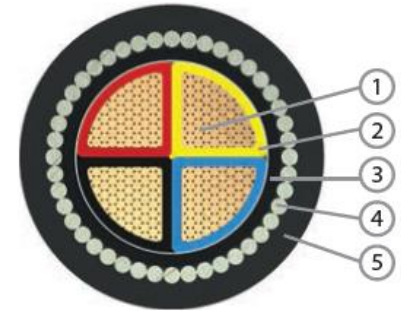
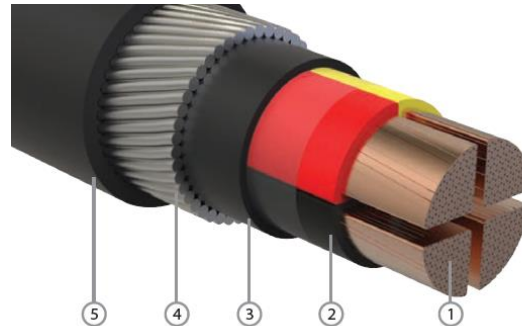
PVC/SWA/PVC Cable



Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Norm JKR
600/1000V	4, 6, 10, 16, 25, 35, 50, 70, 95, 120, 150, 185, 240	2 & 4	1. Submains (in trenches, cable tray, cable ladder, underground) 2. Building to building 3. Lampu kawasan	Saiz kabel < 25 mm ²

Armoured

XLPE/SWA/PVC Cable

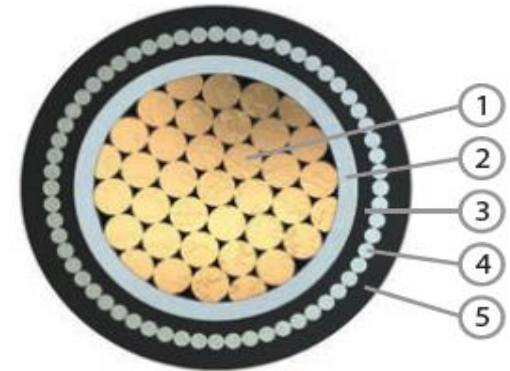
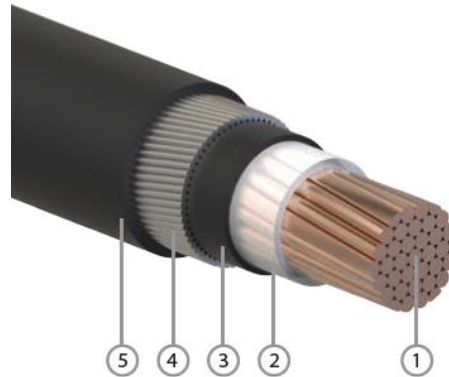


- Component**
1. Plain Annealed Copper Wire
 2. Cross-linked Polyethylene Compound
 3. PVC Compound
 4. Galvanised Steel Wire Armoured
 5. PVC Compound

Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Norm JKR
600/1000V	25, 35, 50, 70, 95, 120, 150, 185, 240	4	Submains (In trenches, cable tray, cable ladder, underground)	Saiz kabel ≥ 25 mm ²

Armoured

XLPE/AWA/PVC Cable

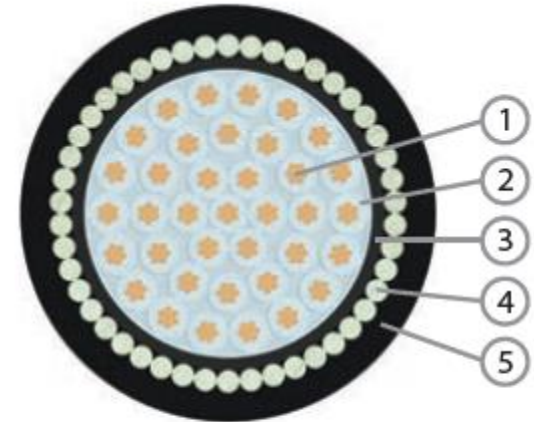
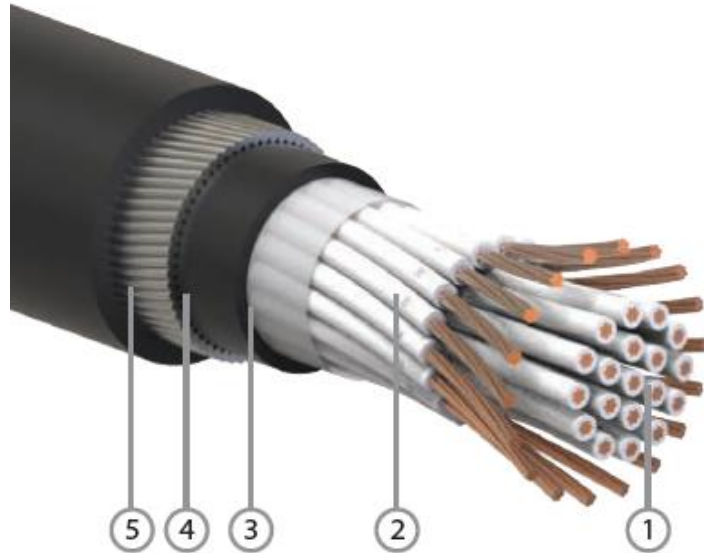


- Component**
1. Plain Annealed Copper Wire
 2. Cross-linked Polyethylene Compound
 3. PVC Compound
 4. Aluminium Wire Armoured
 5. PVC Compound

Rated Voltage	Saiz (sqmm)	Bil. Core	Aplikasi	Norm JKR
600/1000V	150, 185, 240, 300, 400, 500, 630, 800 & 1000	1 (2 x 1C) (4 x 1C)	1. Jarak kabel pendek 2. Beban (load) besar 3. Ada <i>bend</i>	

Armoured

PVC/SWA/PVC Multicore Cable



- Component**
- 1. Plain Annealed Copper Wire
 - 2. PVC Compound
 - 3. PVC Compound
 - 4. Galvanised Steel Wire Armoured
 - 5. PVC Compound

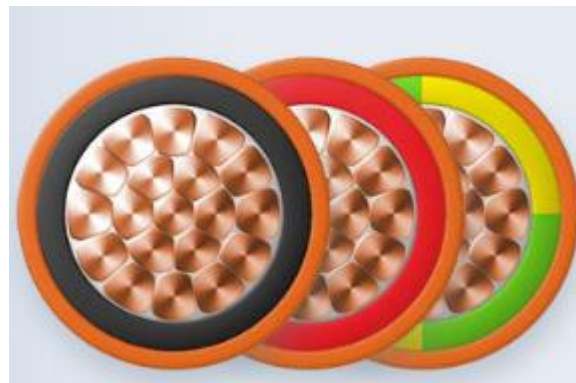
Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Norm JKR
600/1000V	2.5	6, 7, 8, 9,10,11, 12,13,14,15,16,17, 18,19,20,21,24, 27,30,37 & 48	1. Meter TNB 2. Signal Cable	

Mineral Insulated Cables

FR-MI 110 SCDI

0.6 / 1 kV

Single core double insulated



Rated Voltage	Saiz (mm ²)	Bil. Core	Aplikasi	Norm JKR
600/1000V	1.5,2.5,4,6,10,16, 25,35,50,70,95,120, 150,185,240,300, 400,500 & 630	1, 4	1. Genset to AMF Board 2. AMF Board to ATS 3. Fire Fighting System	

Warna Penebat Kabel

- Warna penebat kabel sedia ada: Red, Yellow, Blue, Black (Neutral)
- Berdasarkan IEC 60445 warna penebat kabel adalah Brown, Black, Grey, Blue (Neutral)
- Suruhanjaya Tenaga akan menguatkuasa pelaksanaan warna kabel berdasarkan IEC 60445 secara berperingkat
 - 2022 - 2023 : Pelaksanaan Bersyarat
 - 2023 - 2024 : Pelaksanaan Sepenuhnya

Old Cable Colour Code			New Cable Colour Code		
	Single Phase	Three Phase		Single Phase	Three Phase
Phase Conductor (Line)	 Red or  Yellow or  Blue	 Line 1 Red  Line 2 Yellow  Line 3 Blue		 Brown	 Line 1 Brown  Line 2 Black  Line 3 Grey
Neutral Conductor	 Black			 Blue	
Protective Conductor (Earth)	 Green-and-Yellow			 Green-and-Yellow	

Faktor Pemilihan Kaedah Pemasangan Kabel

- Merujuk kepada Jadual 52-1 (52F) MS IEC 60364-5-52

Table 52-1 (52F) – Selection of wiring systems

Conductors and cables		Method of installation							
		Without fixings	Clipped direct	Conduit	Cable trunking (including skirting trunking, flush floor trunking)	Cable ducting	Cable ladder Cable tray Cable brackets	On in-sulators	Support wire
Bare conductors		–	–	–	–	–	–	+	–
Insulated conductors		–	–	+	+	+	–	+	–
Sheathed cables (including armoured and mineral insulated)	Multi-core	+	+	+	+	+	+	0	+
	Single-core	0	+	+	+	+	+	0	+

+ Permitted.
– Not permitted.
0 Not applicable, or not normally used in practice.

Faktor Pemilihan Kaedah Pemasangan Kabel

Norm/Best Practice CKE JKR

Jenis Penyokong	Jenis Kabel	
Conduit (GS/Heavy Duty uPVC)	1. PVC	
Trunking & Underfloor Trunking (Electrogalvanised/H.D.G)	1. PVC	
Cable Tray (Perforated Hot Dipped Galvanised)	1. PVC/PVC 2. PVC/SWA/PVC 3. PVC/SWA/PVC Multicore	1. XLPE/PVC 2. XLPE/AWA/PVC
Cable Ladder (Hot Dipped Galvanised)		
Ducting for reticulation & road crossing (GI Pipe Class B, uPVC Class D, PN10 HDPE Pipe)	1. PVC/SWA/PVC 2. PVC/SWA/PVC Multicore	1. XLPE/SWA/PVC 2. XLPE/AWA/PVC

Conduit (GS/Heavy Duty uPVC)



Trunking & Underfloor/Raisedfloor/Flushfloor Trunking (Galvanised/HDG)



Perforated Hot Dipped Galvanised Cable Tray



Hot Dipped Galvanised Cable Ladder

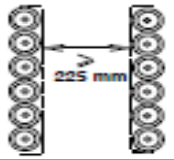
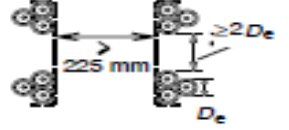
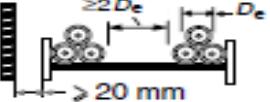


Kawasan Tepi Laut

Rujukan bagi pemasangan dikawasan tepi laut:

- Section 17.0 Specification for Low Voltage Internal Installation LS-1
- Garis Panduan Persisiran Pantai

Susunan kabel atas tray as per MS IEC 62305-5-52

Method of installation in table 52-3			Number of trays	Number of three-phase circuits (note 5)			Use as a multiplier to rating for
				1	2	3	
Perforated trays (note 3)	31	Touching 	1 2 3	0,08 0,06 0,05	0,01 0,87 0,85	0,87 0,81 0,78	Three cables in horizontal formation
Vertical perforated trays (note 4)	31	Touching 	1 2	0,06 0,05	0,80 0,84	— —	Three cables in vertical formation
Ladder supports, cleats, etc. (note 3)	32 33 34	Touching 	1 2 3	1,00 0,08 0,07	0,07 0,03 0,00	0,06 0,80 0,80	Three cables in horizontal formation
Perforated trays (note 3)	31		1 2 3	1,00 0,07 0,06	0,08 0,03 0,02	0,06 0,80 0,80	Three cables in trefoil formation
Vertical perforated trays (note 4)	31	Spaced 	1 2	1,00 1,00	0,01 0,00	0,80 0,80	
Ladder supports, cleats, etc. (note 3)	32 33 34		1 2 3	1,00 0,07 0,06	1,00 0,05 0,04	1,00 0,03 0,00	

Faktor yang mempengaruhi pemilihan jenis kabel

Lokasi pemasangan	Dalam bangunan/luar bangunan
Availability	Ketersediaan dalam pasaran dan kelulusan EMAL
Environment	Lokasi tapak projek; bandar, hutan

Faktor lain: Security, aesthetics, cost, life expectancy, adaptability, flexibility

Faktor pemilihan saiz kabel

- Pemilihan saiz kabel yang betul untuk sesuatu rekabentuk pendawaian adalah penting supaya dapat **menampung kapasiti membawa arus yang bersesuaian**.
- Saiz kabel yang tidak sesuai akan menyebabkan risiko bahaya seperti **kabel menjadi panas** dan boleh **menyebabkan kebakaran**.

Faktor pemilihan saiz kabel

- Saiz kabel dipilih berdasarkan pengiraan susutan voltan (*voltage drop*).
- Faktor yang mempengaruhi nilai susutan voltan adalah:
 - a) Saiz beban
 - b) Saiz pemutus litar (circuit breaker) atau maximum demand
 - c) Jenis kabel yang digunakan
 - d) Jarak/panjang kabel dari sumber bekalan
 - e) Kaedah pemasangan kabel(*buried underground/menggunakan penyokong kabel*)

Penentuan Saiz Kabel

3 terminology penting!

Iz – Arus Keupayaan Kabel

In – Arus Pemutus Litar

Ib – Arus Rekabentuk

Penentuan Saiz Kabel

- Boleh menanggung arus rekabentuk, I_b
- Arus keupayaan kabel, I_z mestilah lebih besar atau sama dengan arus pemutus litar, I_n

Penentuan Saiz Kabel

$$I_z \geq I_n$$

$$I_n \geq I_b$$

$$I_z \geq I_n \geq I_b$$

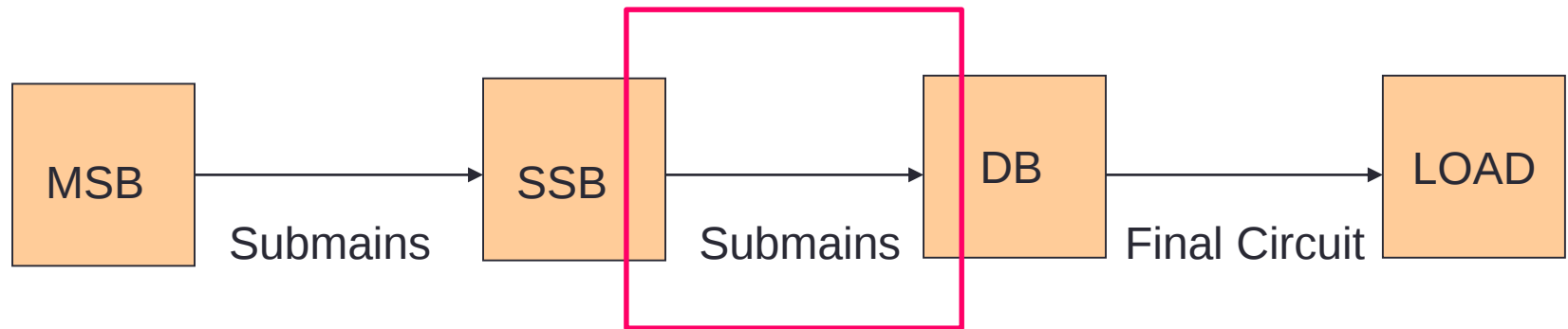
I_z – Arus Keupayaan Kabel

I_n – Arus Pemutus Litar

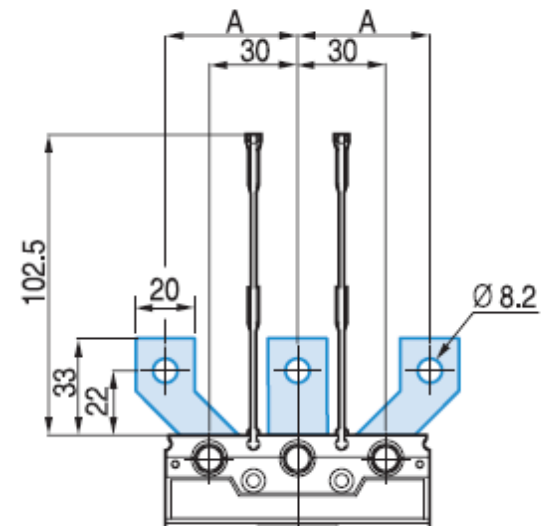
I_b – Arus Rekabentuk

Penentuan Saiz Kabel

Submain Kabel ke DB



- Maksimum saiz kabel hanya 35 mm²
- 40/60A DP/TPN/4P MCCB
- Extended busbar



Susutan Voltan

- Semua kabel mempunyai rintangan.
- Apabila arus mengalir melalui kabel tersebut, akan terhasil susutan voltan. Ini berpandukan pada formula

$$V = I \times R$$

Susutan Voltan

Requirement of MS IEC 60364-5-52:2003

In the absence of other considerations, it is recommended that in practice the voltage drop between the origin of consumer's installation and the equipment should not be greater than 4 % of the nominal voltage of the installation.

Susutan Voltan

Requirement of MS IEC 60364-5-52:2009

Table G.52.1 – Voltage drop

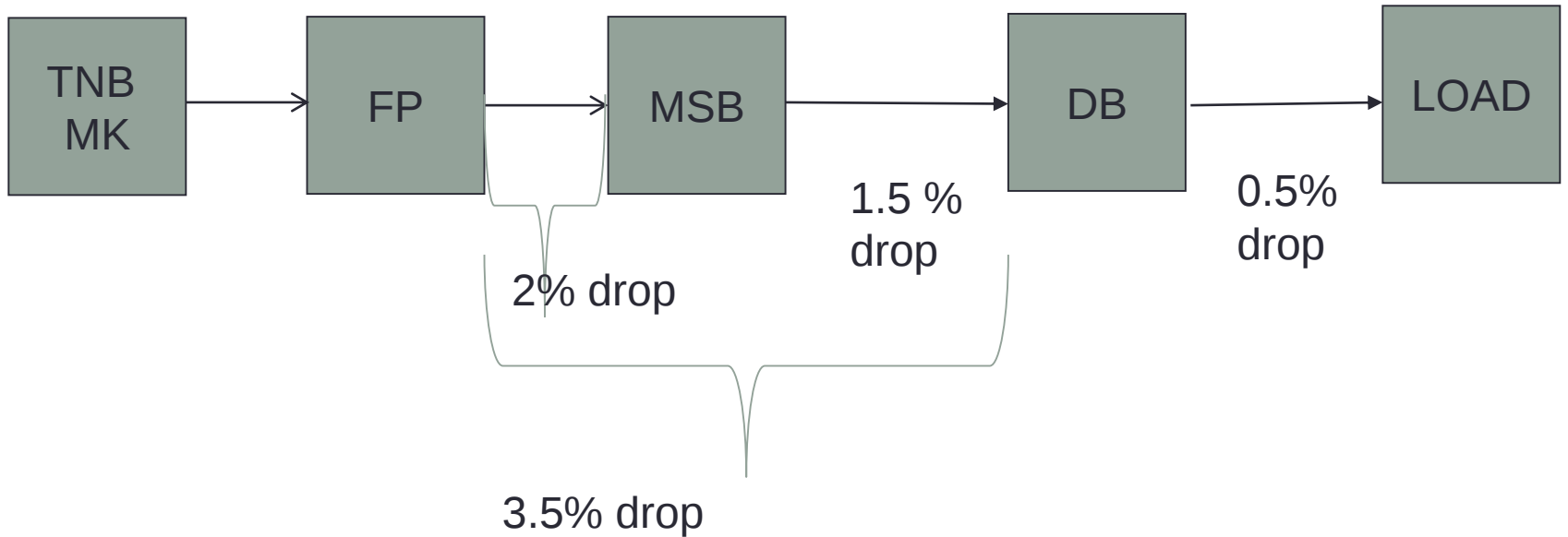
Type of Installation	Lighting %	Other uses %
A – Low voltage installations supplied directly from a public low voltage distribution system	3	5
B – Low voltage installation supplied from private LV supply*	6	8
* As far as possible, it is recommended that voltage drop within the final circuits do not exceed those indicated in Installation type A. When the main wiring systems of the installations are longer than 100 m, these voltage drops may be increased by 0,005 % per metre of wiring system beyond 100 m, without this supplement being greater than 0,5 %. Voltage drop is determined from the demand by the current-using equipment, applying diversity factors where applicable, or from the values of the design current of the circuits.		

Susutan Voltan (Bangunan)

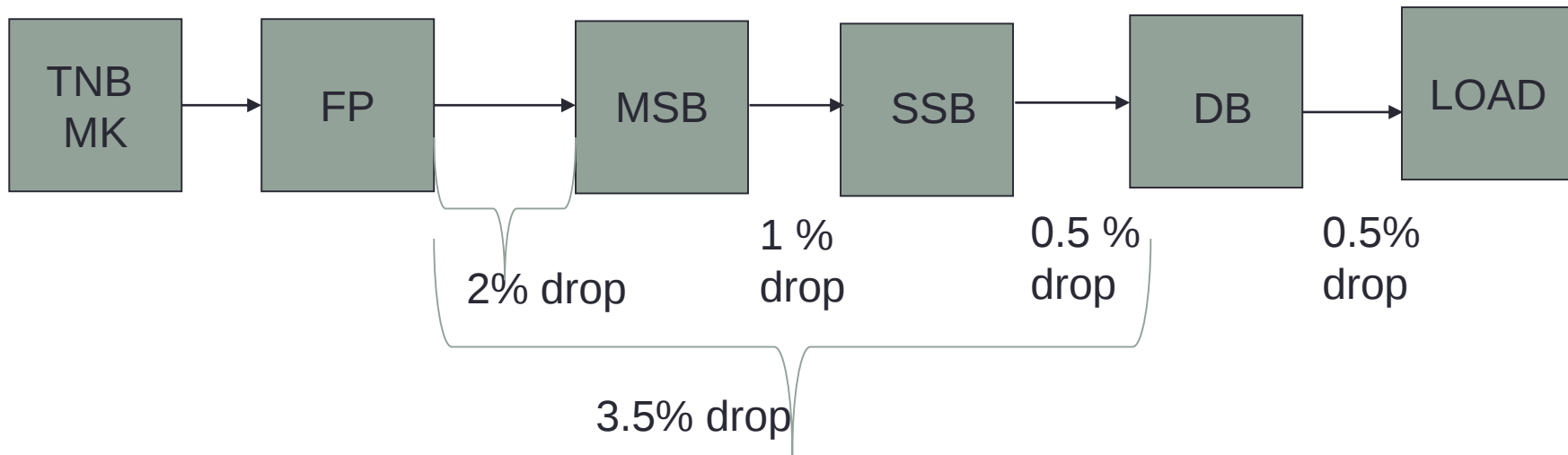
- Susut voltan tidak boleh melebihi 4% daripada nominal voltage
 - *4% of 1 Φ – 4% of 230 V*
9.2 Volt
 - *4% of 3 Φ – 4% of 400 V*
16 Volt

Pengiraan Susutan Voltan

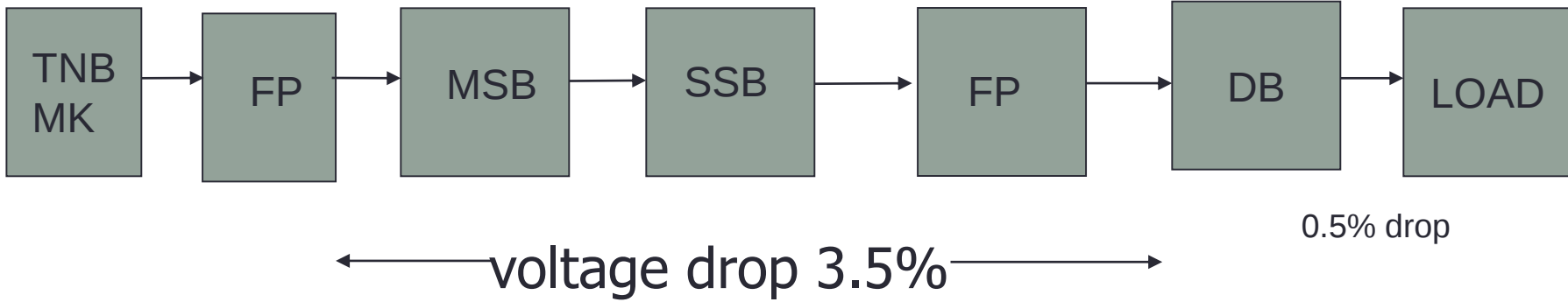
1.



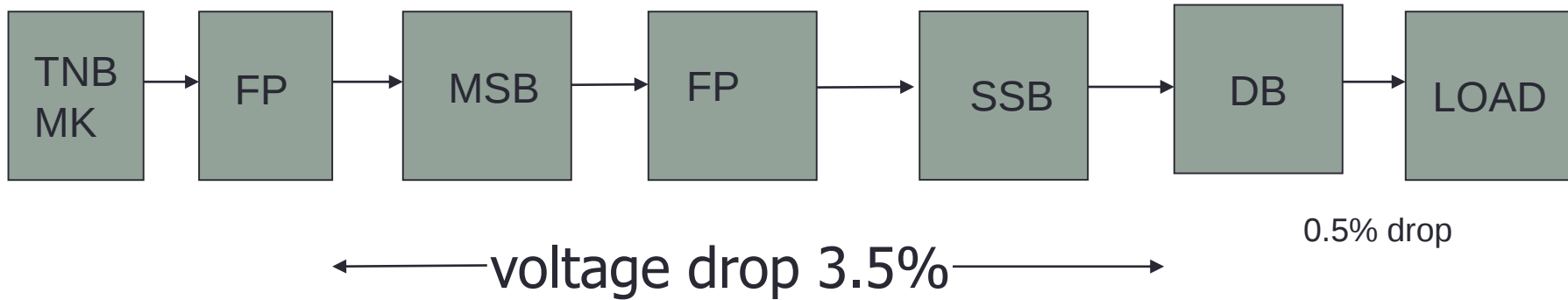
2.



3.



4.



Susutan Voltan berkait Rapat dengan Saiz Kabel

$$V_D = \frac{v_d \times I_n \times L}{1000}$$

V_D - jumlah susut voltan

V_d - susut voltan kabel mV/A/m(rujuk jadual)

I_n - kadar arus breaker (A)

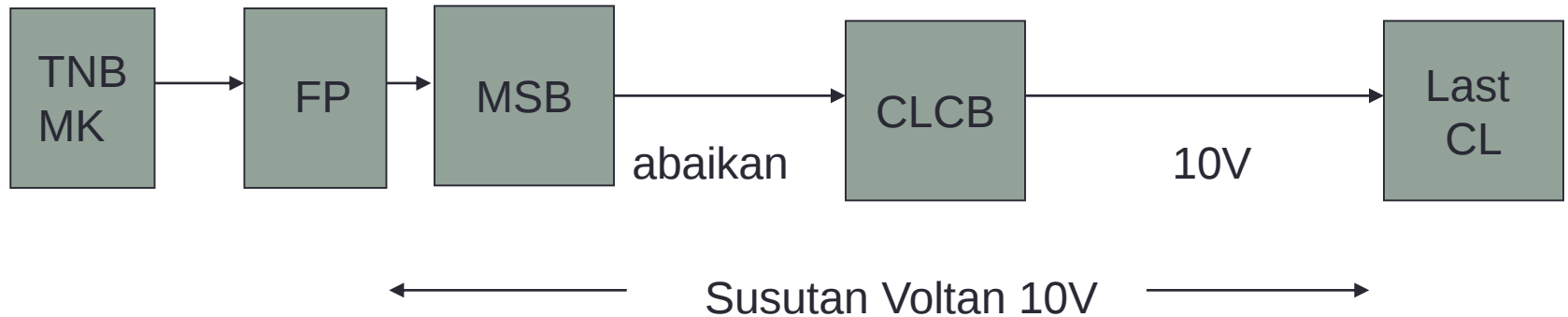
L - panjang kabel (meter)

Susutan Voltan (Luar Bangunan)

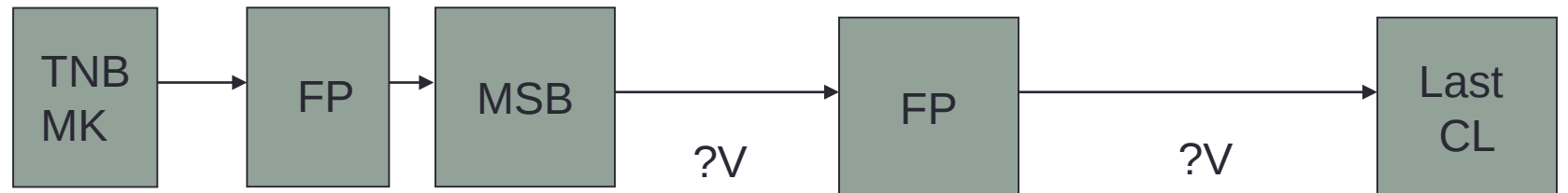
- Susut voltan tidak boleh melebihi 10V daripada nominal voltage
- Lampu akhir mendapat 220V

Pengiraan Susutan Voltan

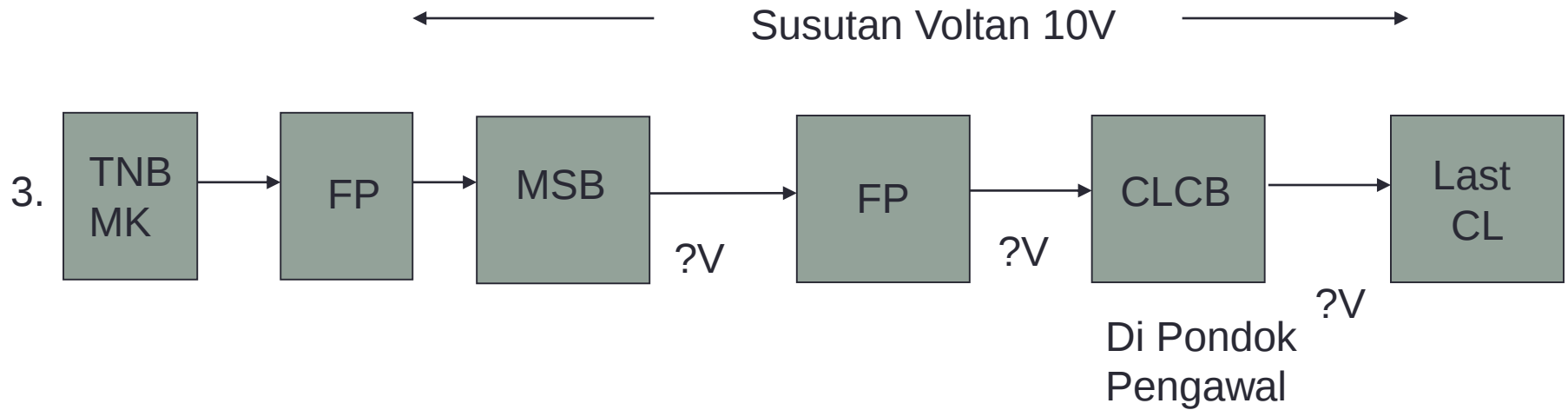
1.



2.



Pengiraan Susutan Voltan



Formula Susutan Voltan

$$V_D = \frac{v_d \times L \times I \times \text{no. of lantern}}{1000}$$

V_D - jumlah susut voltan

V_d - susut voltan kabel mV/A/m(rujuk jadual)

I - arus lampu (A)

L - panjang kabel (meter)

SUSUT VOLTAN LAMPU KAWASAN

- Voltage drop di kira pada setiap jarak antara tiang-tiang lampu

Bagi pemasangan 1 fasa :

$$V_{Dn} = \frac{v_d \times L \times I \times \text{no. of lantern}}{1000}$$

$$V_{D1} = (v_d \times L \times I \times 16)/1000$$

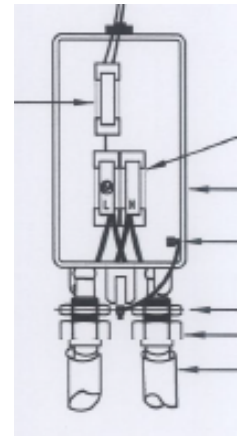
$$V_{D2} = (v_d \times L \times I \times 15)/1000$$

dan seterusnya...sehingga

$$V_{D16} = (v_d \times L \times I \times 1)/1000$$

Kabel Lampu Kawasan

- Kabel Bawah Tanah
 - 2C 6 mm² PVC/SWA/PVC
 - 2C 10 mm² PVC/SWA/PVC
 - 2C 16 mm² PVC/SWA/PVC
- Tertakluk kepada satu kabel masuk dan satu kabel keluar sahaja
- Elak guna 1 kabel masuk dan 2 kabel keluar



Jumlah Susut Voltan

- $V_D = V_{d1} + V_{d2} + \dots + V_{d16}$
= 10V
- Hanya untuk Contoh Pengiraan No. 1
- Berbeza untuk Contoh Pengiraan No. 2 & 3

Lantern Lampu Kawasan

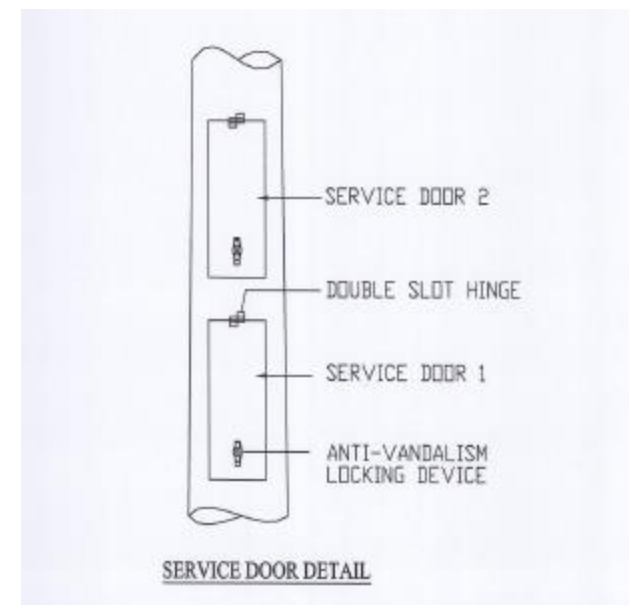
- 70W SON / 35W LED
- Control Gear
 - Choke
 - Ignitor
 - Capacitor
- Remote/Integral Control Gear

Compound Lighting Control Board

- Dalam bilik suis/Pondok Pengawal
- Sebelah MSB
- 2 set timer
 - 7pm to 12 am
 - 7pm to 7am
- Alternate circuit
- Elak letak di luar bangunan

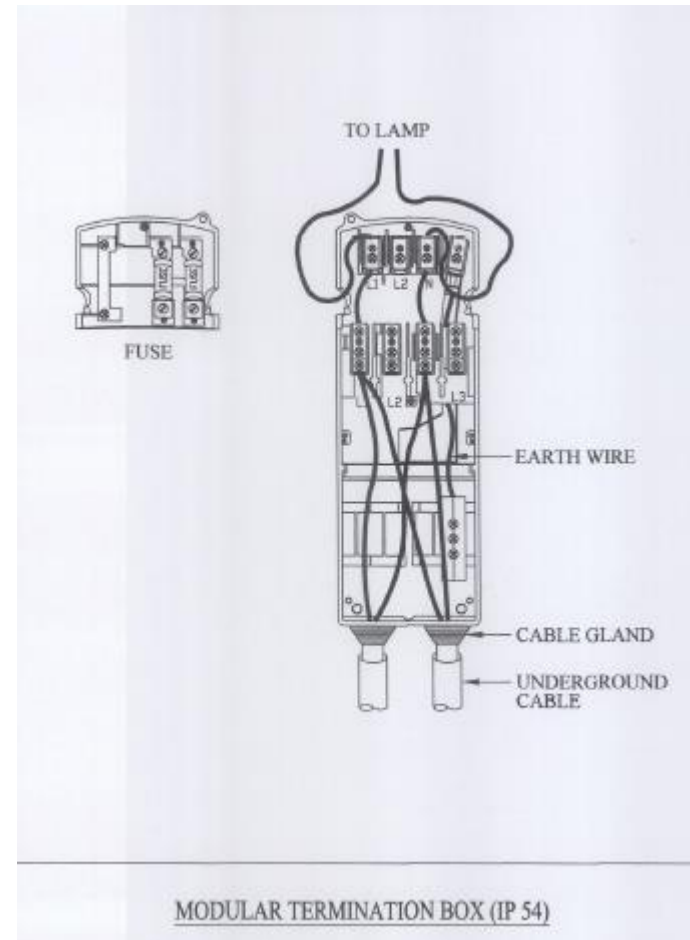
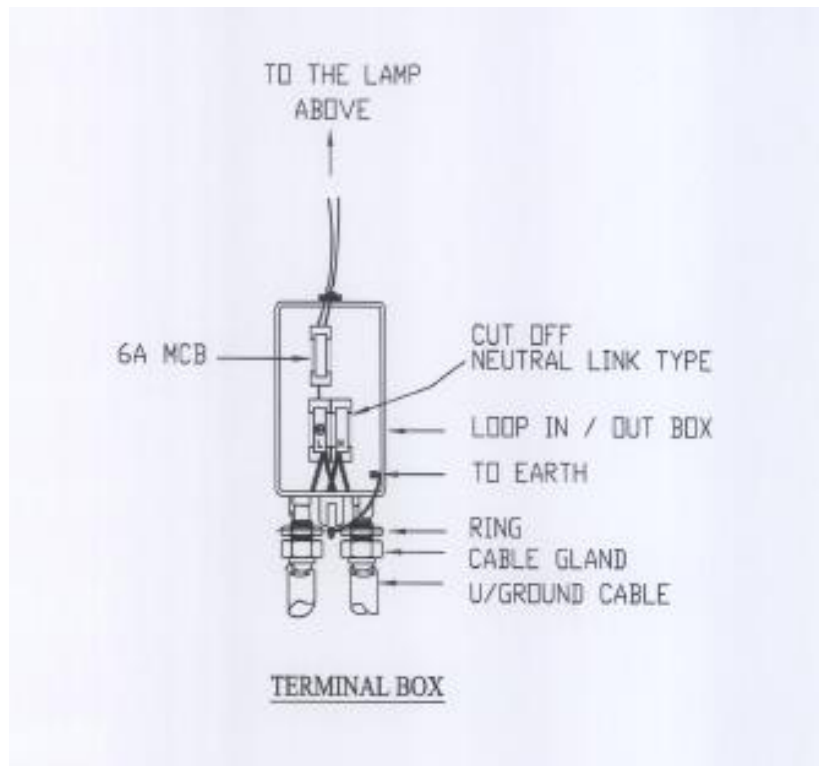
Tiang Lampu Kawasan

- Octagonal / round tapered
- Galvanised / Hot Dipped Galvanised
- Decorative
- Twin service door
- 3.5m – 5m mounting height
- Jarak 15m – 20m



Junction Box

- Konvensional
- Modular



SEKIAN

TERIMA KASIH