Basic Applications of Design, Installation, Testing & Commissioning of Low Voltage (LV) & Extra Low Voltage (ELV) Works for Construction Projects

Session 01: LV Installations

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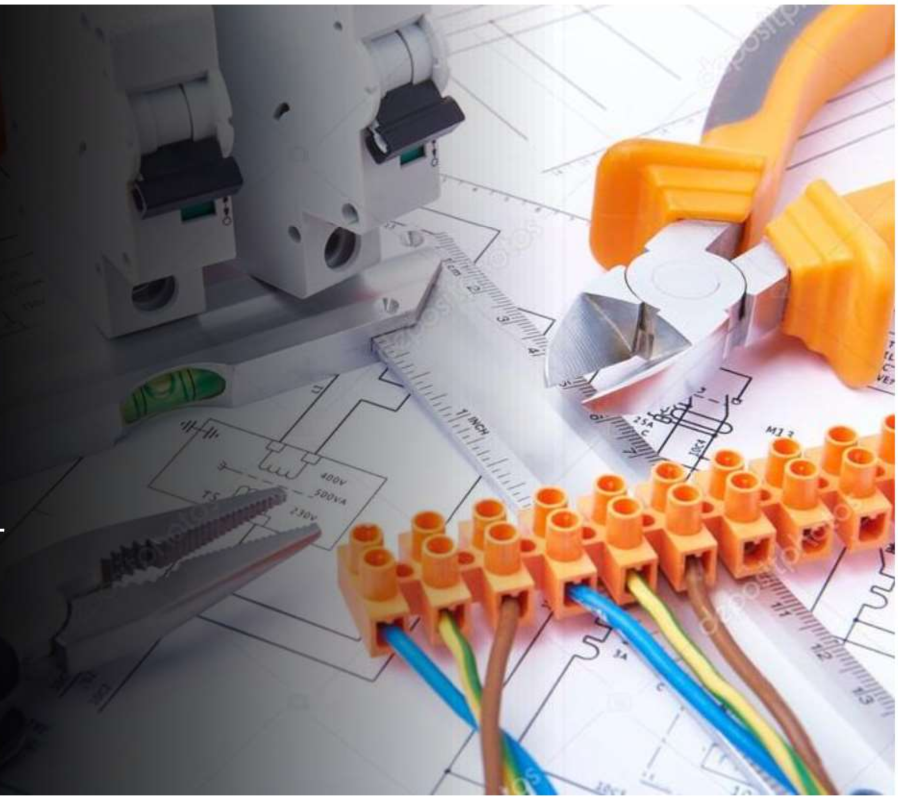

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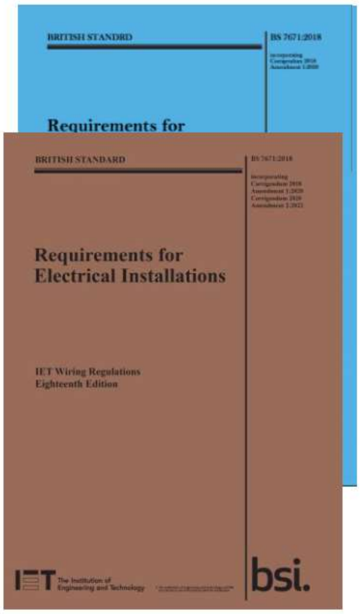
The Regulation

- **BS 7671 - 18th Edition**

  The IET Wiring Regulations
- **Latest version : 2018 July (Light Blue Cover)**
  - **All Installations designed after 31st December 2018**
  - **Amendment 1: 2020 –Issued on 1st February 2020**

    Amends Section 722-Electric Vehicle Charing Installations
  - **Amendment 2: 2022 –Issued on 24th January 2022**
- **IET Wiring Regulation is based on:**
  - European Commission of Electrotechnical Standardization
  - International Electrotechnical Commission (IEC)



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History of IET Wiring Regulation (BS 7671)

- First Edition: In 1882
  - “Rules and Regulations for Prevention of Fire Risks Arising from Electric Lighting”
- Third Edition: In 1897
  - “General Rules Recommended for Wiring for the Supply of Electric Energy”
- Fifth Edition : In 1907
  - “Wiring Rules”
- Eight Edition: In 1924
  - “Regulation for Electrical Equipment of Building”
- **Fifteen Edition: In 1966**
  - **“Regulations for Electrical Installations”**
- **Sixteen Edition: Requirements for Electrical Installations**
  - **1991 (Red Cover)**
  - **1994 (Green Cover)**
  - **1997 (Yellow Cover)**
  - **BS 7671:2001 (Blue Cover)**
    - **2004 (Brown Cover)**
- **Seventeen Edition:**
  - **2008 (Red cover)**
  - **Amendment No 1: 2011 (Green cover)**
  - **Amendment No 2: 2013 (Yellow cover)**
  - **Amendment No 3: 2015 (Dark Yellow cover)**
- **Eighteen Edition : 2018 (Blue)**
  - **Amendment 1: 2020**
  - **Amendment 2: 2022**

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Why IET Wiring Regulation/ BS 7671 to SL?

- Legal Status:

  In Sri Lanka, the Use of Electrical Energy is Regulated by:

  Earlier : “Electricity Act No 19 of 1950” and its amendments (1987)

  New : “Electricity Act No 20 of 2009

  Latest: SRI LANKA ELECTRICITY (AMENDMENT) ACT, No. 31 OF 2013

  Electricity Regulations of 2016:

  The Electricity (Safety, Quality and Continuity) Standards.


The Gazette of the Democratic Socialist Republic of Sri Lanka
EXTRAORDINARY
No. 1975/44 - WEDNESDAY, JULY 13, 2016
PART I : SECTION (I) — GENERAL
Government Notifications
REGULATIONS MADE UNDER SECTION 54 OF THE SRI LANKA ELECTRICITY ACT, No. 20 OF 2009
Sri Lanka Electricity Act, No. 20 of 2009

> “Sri Lanka Standard requirements” means the Sri Lankan standard requirement for electrical installations specified by the Sri Lanka Standard Institute or 17th Edition of “British Standard Requirements for electrical installations” (BS 7671:2008) or latest;

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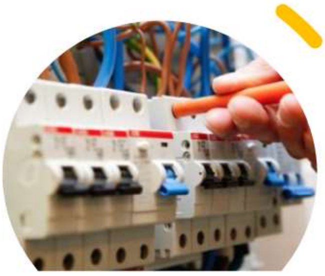
Scope of the Regulation

- Regulation apply to **Design, Selection, Erection, Inspection** and **Testing** of Electrical Installations.
- Regulation **apply to** electrical installations such as:
    - Residential/ Commercial/ Public/ Industrial Premises
    - Construction sites/Exhibitions/Temporary Buildings
    - Highways
    - Circuits supplied at nominal voltage up to 1000V a.c. or 1500V d.c.
- Regulation **do not apply** to following Installations
    - Suppliers' works/Distributor's equipment
    - Railway, Rolling and Signalling equipment
    - Ships, Air crafts and Offshore equipment



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Fundamental Principle

- To provide for the safety of
    - persons,
    - livestock and
    - property

  against dangers and damage which may arise in the reasonable use of electrical installations,
    - shock currents
    - excessive temperatures
    - ignition of a potentially explosive atmosphere
    - undervoltages, overvoltages and electromagnetic disturbances
    - mechanical movement of electrically actuated equipment
    - power supply interruptions and/or interruption of safety services
    - arcing or burning

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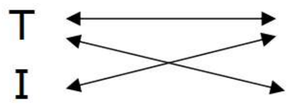
Classification of LV Distribution Systems

Distribution systems are classified in internationally accepted “**Two Letter Code (XY)”.**

“X” for Source grounding characteristic

“Y” for Installation exposed conductive parts grounding characteristic

Source **Installation**



Three Types of Distribution Systems

1. **TT**
2. **TN→ TN-C, TN-S, TN-C-S**
3. **IT**

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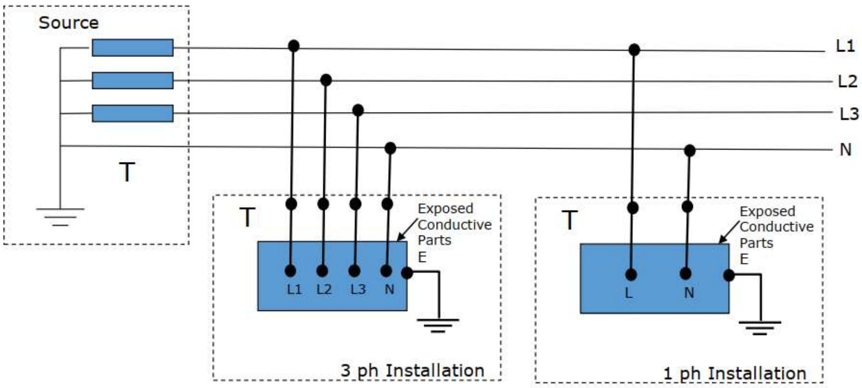
TT System

A system having one point of **source** of energy **directly earthed**, the **exposed conductive parts of the installation** being connected to **earth electrodes** electrically independent of the source earth electrode.



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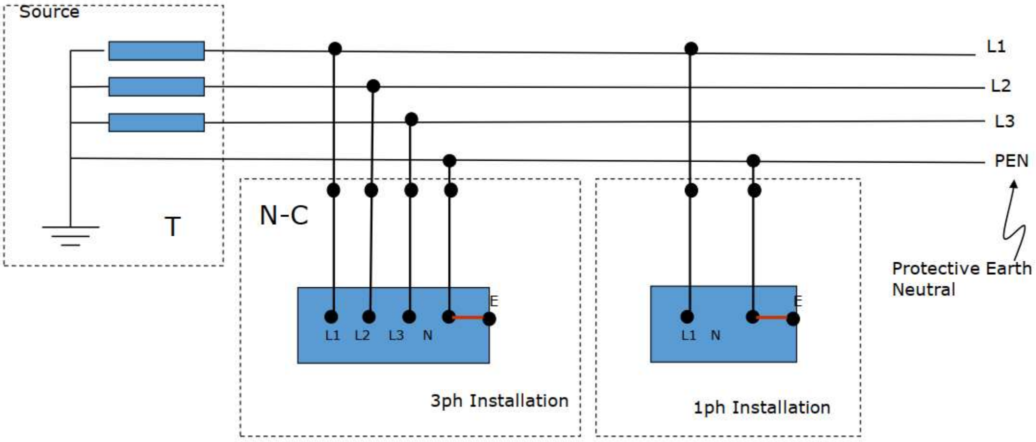
TN-C System

A system having one or more points of **source** of energy **directly earthed**, the **exposed conductive parts** of the installation being connected to the Neutral. [Neutral and Protective conductors are combined throughout the system]



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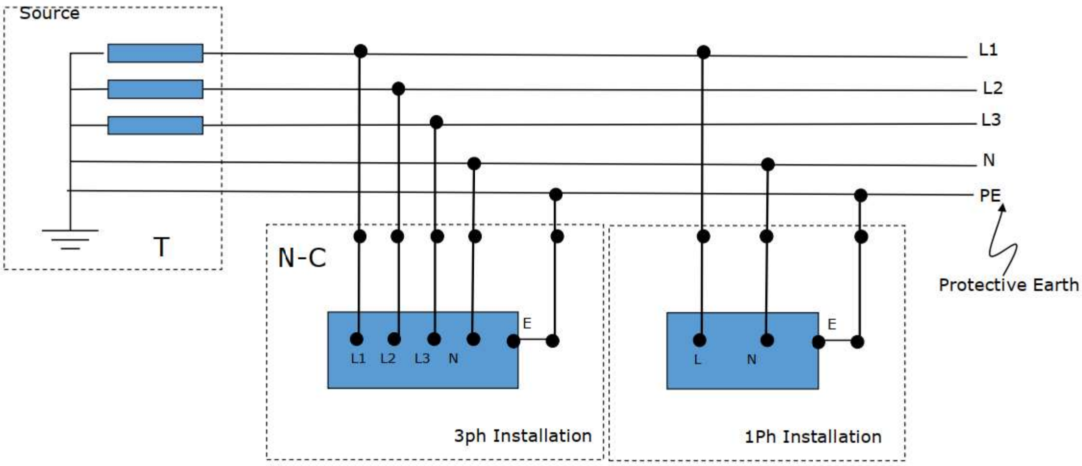
TN-S System

A system having one or more points of **source** of energy **directly earthed**, the **exposed conductive parts** of the installation being connected to the source neutral using separate conductor.

[Separate Neutral and Protective conductors throughout the system]



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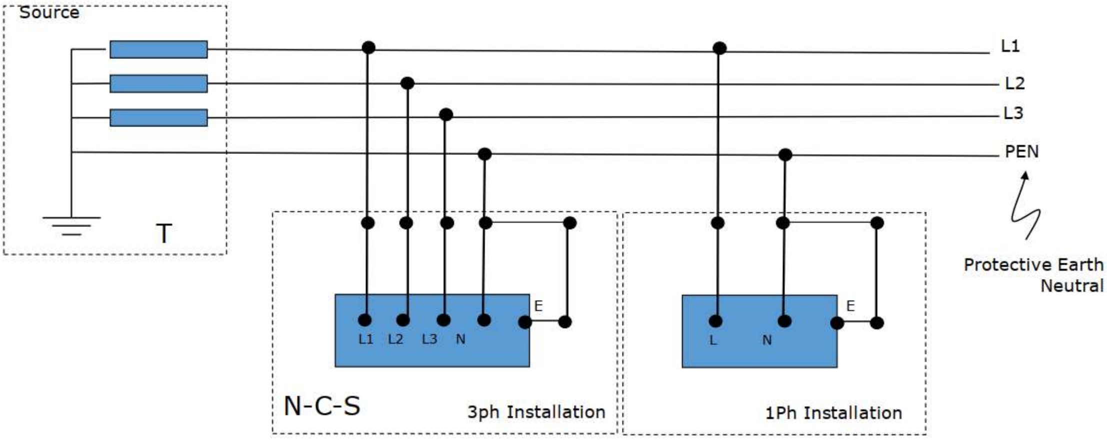
TN-C-S System

A system having one or more points of **source** of energy **directly earthed**, the **exposed conductive parts** of the installation being connected to the PEN conductor via the main earthing terminal and neutral terminal, these terminals being linked together.

[Neutral and Protective conductors are combined in a single conductor in part of the system and separate elsewhere]



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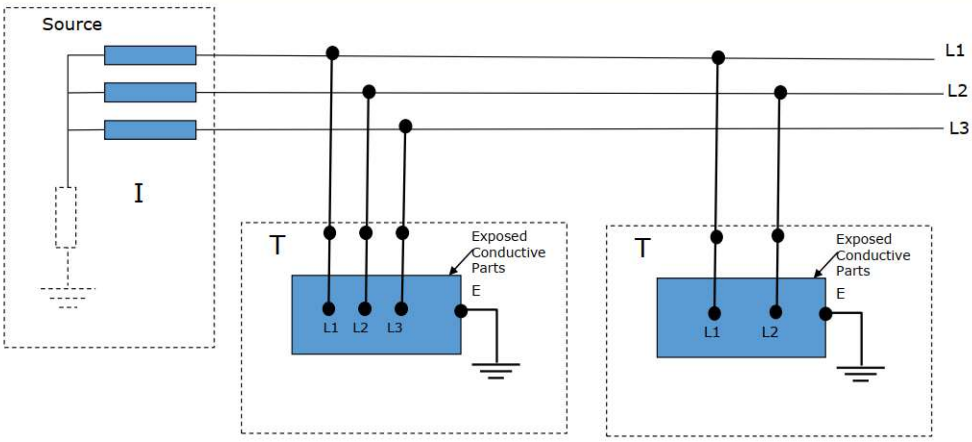
IT System

A system having a **source** of energy **unearthed** or **earthed through a high impedance**, the **exposed conductive parts of the installation** being connected to **earth electrodes** electrically independent of the source earth.



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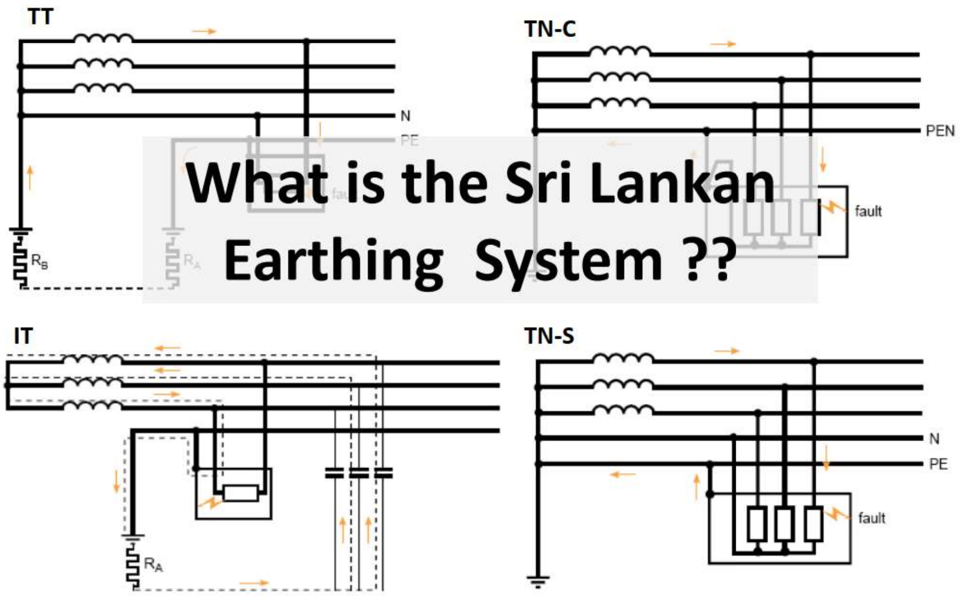
Earthing Systems



What is the Sri Lankan Earthing System ??

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Applicable Earthings in SL

Less than or equal to 42 kVA 15 A single phase connection (230 V) 30 A single phase connection (230 V) 30 A three phase connection (400 V) 60 A three phase connection (400 V)	**Only TT**
LV Bulk (42 kVA upto 1000/1500 kVA)	TT or TN
HT Bulk (Above 1000/1500 kVA)	TT or TN
IT system is not allowed for public Installations and can be used for special/dedicated installations	

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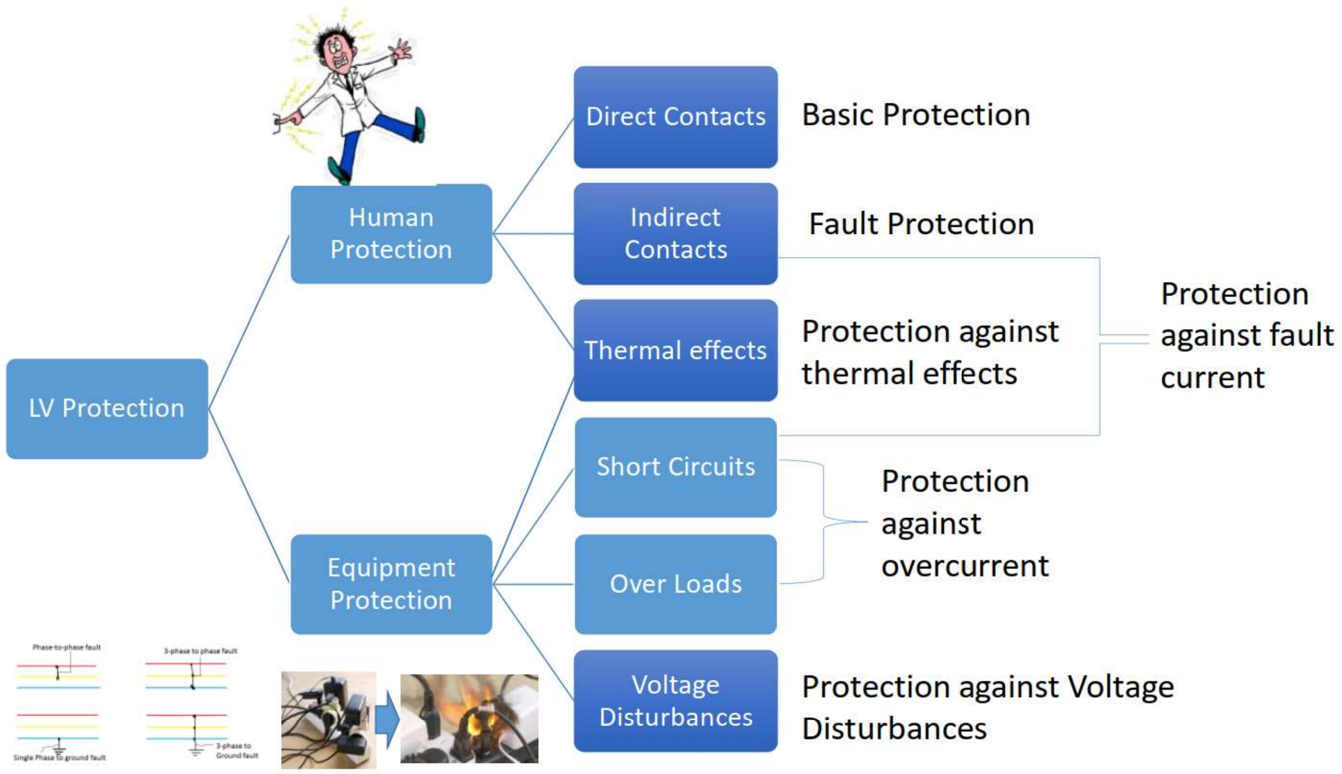
LV Protection
Human Protection
Equipment Protection
Direct Contacts
Indirect Contacts
Thermal effects
Short Circuits
Over Loads
Voltage Disturbances
Basic Protection
Fault Protection
Protection against thermal effects
Protection against fault current
Protection against overcurrent
Protection against Voltage Disturbances

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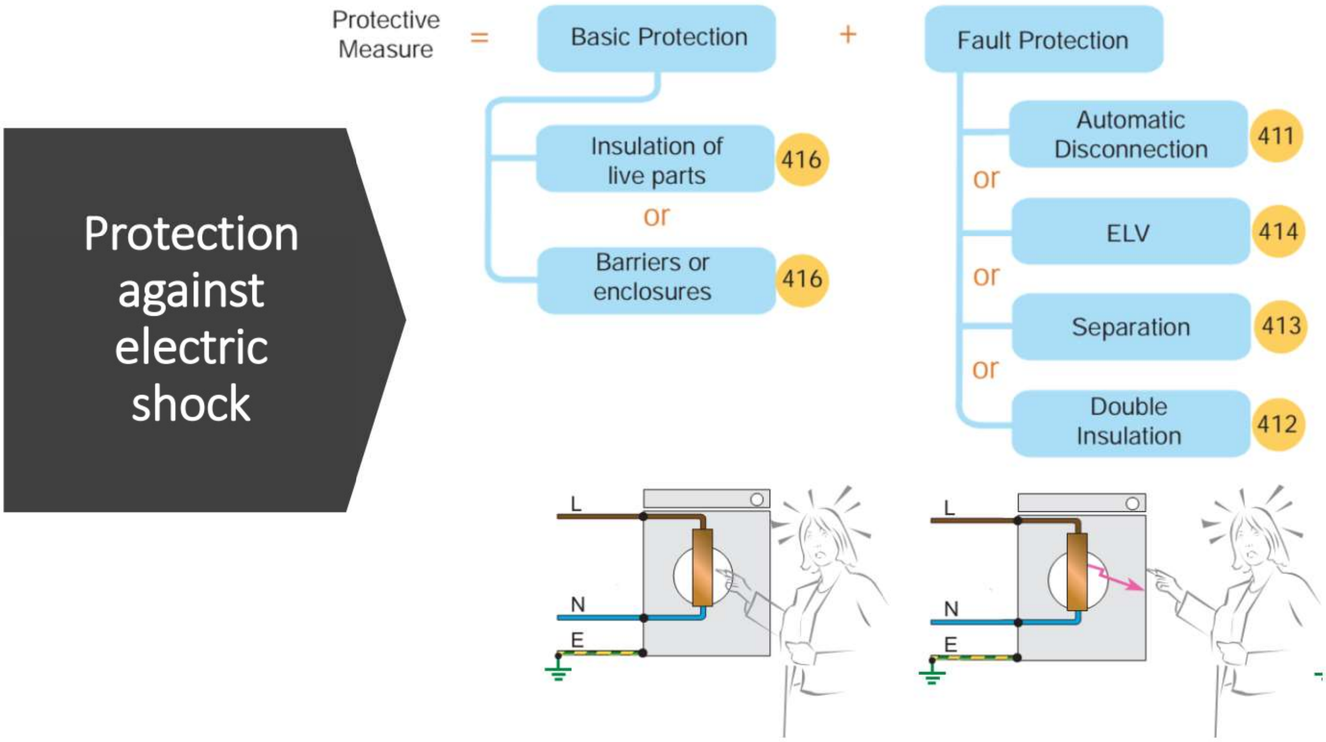
Protection against electric shock
Protective Measure
=
Basic Protection
+
Fault Protection
Insulation of live parts
416
or
Barriers or enclosures
416
Automatic Disconnection
411
or
ELV
414
or
Separation
413
or
Double Insulation
412
L
N
E
L
N
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Devices For Protection Against Electric Shock By Automatic Disconnection Of Supply

- In TN, TT and IT systems the following protective devices may be used:
  - overcurrent protective devices, in accordance with Regulation 531.2
  - residual current devices (RCDs), in accordance with Regulation 531.3.
- In addition, in IT systems the following monitoring devices may be used to detect insulation fault conditions:
  - insulation monitoring devices (IMDs), in accordance with Regulation 538.1
  - equipment for insulation fault location, in accordance with Regulation 538.2
  - residual current monitors (RCMs), in accordance with Regulation 538.4.

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Co-ordination of Distribution System with Protective Device

System	Protective Device	Application	Breaking Condition
TT	Residual Current Insulation Monitoring Over Current	 Not Always	$R_A.I_a \leq 50V$
TN-C	Over Current		$Z_s.I_a \leq U_o$
TN-S	Residual Current Over Current		$Z_s.I_a \leq U_o$
TN-C-S	Residual Current Over Current		$Z_s.I_a \leq U_o$
IT	Residual Current Insulation Monitoring Over Current	Not Always	$R_A.I_d \leq 50V$

R_A=Earth Resistance, Z_s= Earth loop impedance,
I_a= Operating current of Device, I_d= Fault current,
U_o= Rated Voltage against earth

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Maximum disconnection times

411.3.2.2 The maximum disconnection time stated in Table 41.1 shall be applied to final circuits not exceeding 32 A.

TABLE 41.1
Maximum disconnection times

System	$50 V < U_0 \leq 120 V$ seconds		$120 V < U_0 \leq 230 V$ seconds		$230 V < U_0 \leq 400 V$ seconds		$U_0 > 400 V$ seconds	
	a.c.	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.	d.c.
TN	0.8	NOTE 1	0.4	5	0.2	0.4	0.1	0.1
TT	0.3	NOTE 1	0.2	0.4	0.07	0.2	0.04	0.1

Where, in a TT system, disconnection is achieved by an overcurrent protective device and protective equipotential bonding is connected to all the extraneous-conductive-parts within the installation in accordance with Regulation 411.3.1.2, the maximum disconnection times applicable to a TN system may be used.
U_0 is the nominal a.c. rms or d.c. line voltage to Earth.

NOTE 1: Disconnection is not required for protection against electric shock but may be required for other reasons, such as protection against thermal effects.

NOTE 2: Where compliance with this regulation is provided by an RCD, the disconnection times in accordance with Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD (typically $2 I_{\Delta n}$).

411.3.2.3 In a TN system, a disconnection time not exceeding 5 s is permitted for a distribution circuit and for a circuit not covered by Regulation 411.3.2.2.

411.3.2.4 In a TT system, a disconnection time not exceeding 1 s is permitted for a distribution circuit and for a circuit not covered by Regulation 411.3.2.2.

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Selection of the rated residual operating current of the RCD

- An RCD shall not be used in a TN-C system.
- RCDs shall be erected at the origin of that part of the installation to be protected.
- For TT System

Table 53.1 – Correlation between the maximum value of earth resistance R_A and the maximum rated residual operating current $I_{\Delta n}$ of the RCD

Maximum value of R_A (Ω)	Maximum $I_{\Delta n}$ of the RCD
2.5	20 A
5	10 A
10	5 A
17	3 A
50	1 A
100	500 mA
167	300 mA
500	100 mA
1667	30 mA

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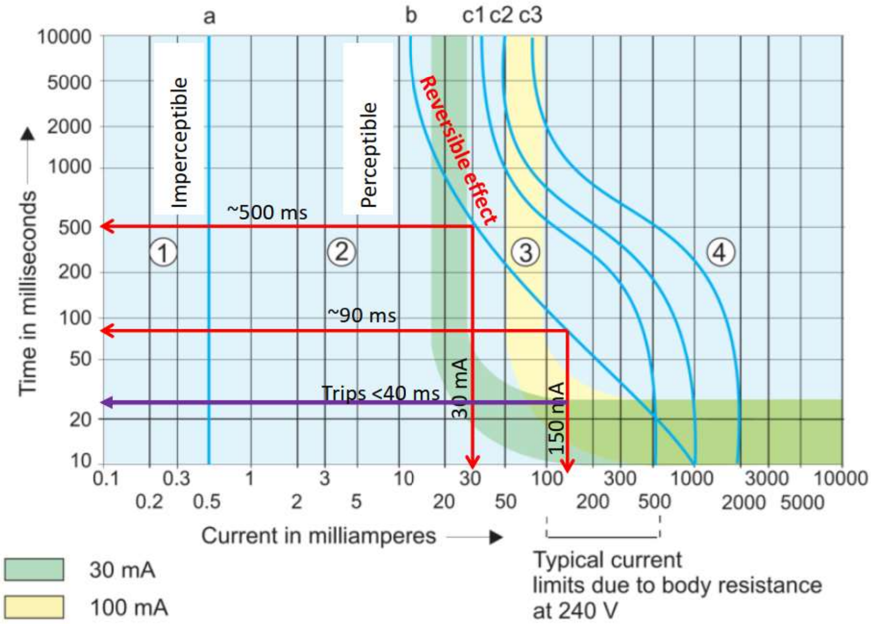
Can the RCD Prevent “Electric Shock Currents”?



- Say direct contact (230V)
  - Body resistance ~1.5 kΩ
  - $Body\ Current = \frac{230\ V}{1.5\ k\Omega} = 153\ mA$
- RCD do not prevent shock currents flowing through the body.
- However, providing a RCD, sufficiently sensitive and functionally tested periodically, will operate sufficiently quickly to prevent injury.

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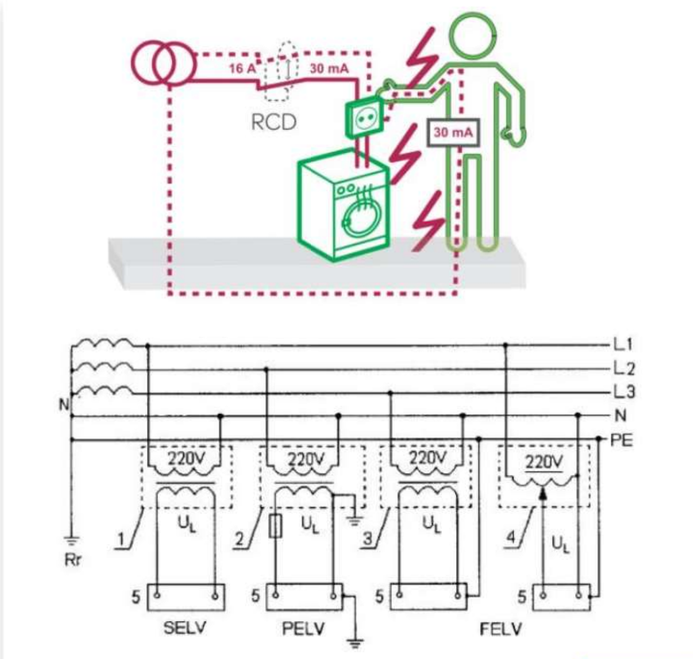
411.3.3 Additional requirements has been revised

- In AC systems, **additional protection** by means of an **RCD** with a rated residual operating current not exceeding **30 mA** shall be provided for:
  - i. **socket-outlets with a rated current not exceeding 32A, and**
  - ii. **mobile equipment with a rated current not exceeding 32A for use outdoors.**
- The requirements of Regulation 411.3.3 **do not apply to FELV** systems
- There is an **exception** to omit RCD protection where, **<u>other than a dwelling</u>**, if a documented risk assessment is determined that RCD protection is not necessary.



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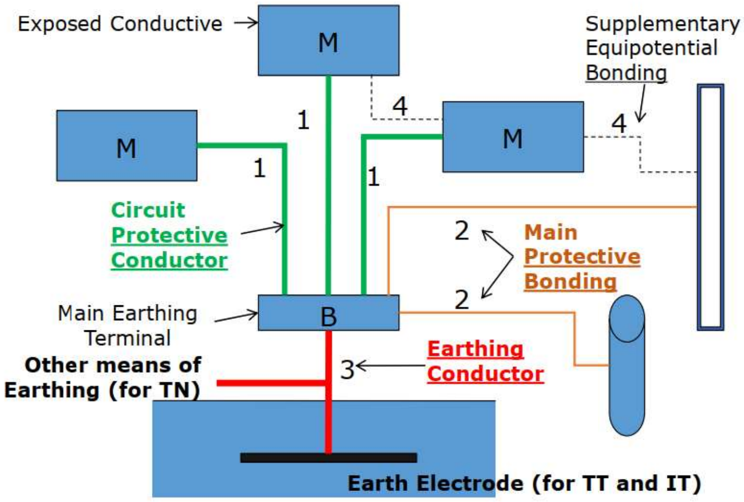
Earthing System in LV installation



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How to Select Protective Conductor ?

543 PROTECTIVE CONDUCTORS

543.1 Cross-sectional areas

543.1.1 The cross-sectional area of every protective conductor, other than a protective bonding conductor, shall be:

(i) calculated in accordance with Regulation 543.1.3, or

(ii) selected in accordance with Regulation 543.1.4.

Calculation in accordance with Regulation 543.1.3 is necessary if the choice of cross-sectional area of line conductors has been determined by considerations of short-circuit current and if the earth fault current is expected to be less than the short-circuit current.

	c.s.a. of phase conductors Sph (mm^2)	Minimum c.s.a. of PE conductor (mm^2)	Minimum c.s.a. of PEN conductor (mm^2)	
			Cu	Al
Simplified method (1)	$S_{ph} \leqslant 16$	S_{ph} (2)	S_{ph} (3)	S_{ph} (3)
	$16 < S_{ph} \leqslant 25$	16	16	
	$25 < S_{ph} \leqslant 35$			25
	$35 < S_{ph} \leqslant 50$	$S_{ph}/2$	$S_{ph}/2$	
	$S_{ph} > 50$			$S_{ph}/2$
Adiabatic method	Any size	$S_{PE/PEN} = \frac{\sqrt{I^2 \cdot t}}{k}$ (3) (4)		

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Type of Protective Conductor

- Single core cable
- A conductor in a cable
- Conductor (insulated or bare) in a common enclosure with insulated live conductor
- Fixed (insulated or bare) conductor
- Metal covering (sheath, screen or armouring) of a cable
- Metal conduit, metal cable management system or enclosure
- If above cross-section is 10 mm^2 or less, they shall be copper.

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Protective Bonding

TABLE 54.8
Minimum cross-sectional area of the main protective bonding conductor *in relation to the neutral of the supply*

NOTE: Local distributor's network conditions may require a larger conductor.

Copper equivalent cross-sectional area of the supply neutral conductor	Minimum copper equivalent* cross-sectional area of the main protective bonding conductor
35 mm^2 or less	10 mm^2
over 35 mm^2 up to 50 mm^2	16 mm^2
over 50 mm^2 up to 95 mm^2	25 mm^2
over 95 mm^2 up to 150 mm^2	35 mm^2
over 150 mm^2	50 mm^2

* The minimum copper equivalent cross-sectional area is given by a copper bonding conductor of the tabulated cross-sectional area or a bonding conductor of another metal affording equivalent conductance.

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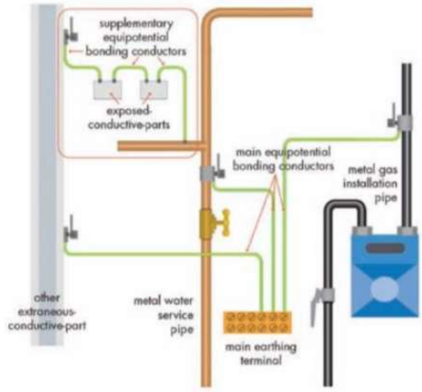
Supplementary Bonding

- Minimum size = 2.5mm^2 with mechanical protection
- Minimum size = 4.0mm^2 without mechanical



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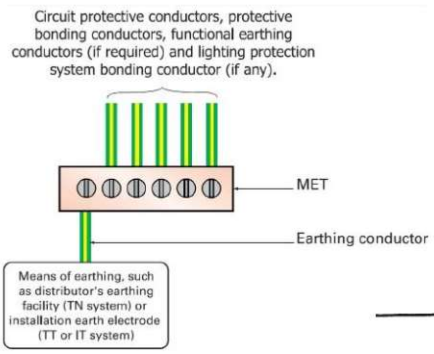
How to Select Earthing Conductor



Minimum cross-sectional area of a buried earthing conductor

	Protected against mechanical damage	Not protected against mechanical damage
Protected against corrosion by a sheath	2.5 mm^2 copper 10 mm^2 steel	16 mm^2 copper 16 mm^2 coated steel
Not protected against corrosion	25 mm^2 copper 50 mm^2 steel	

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Is there SOMETHING called '**CLEAN**' and '**DIRTY**' earth ?

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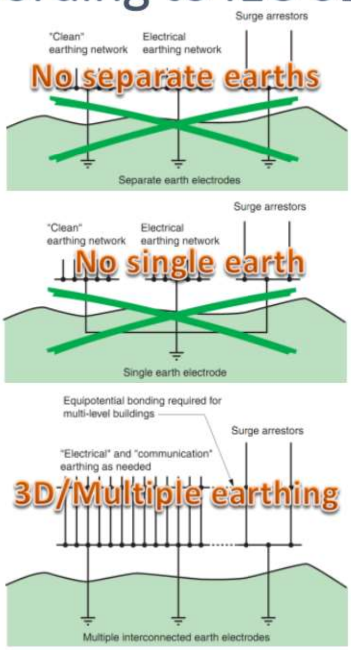
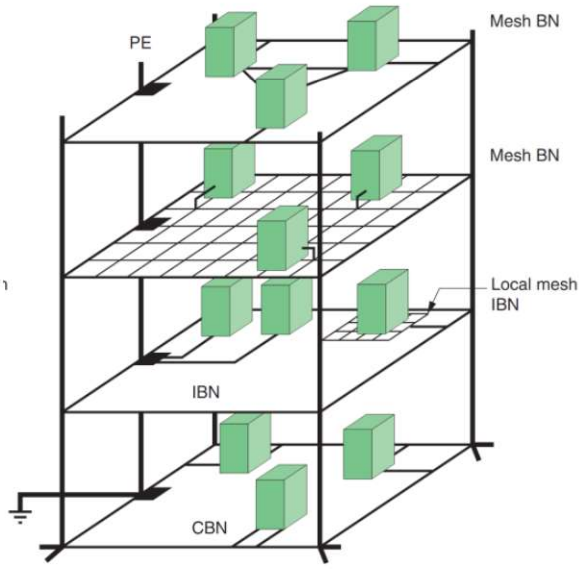
According to IEC 61000-5-2





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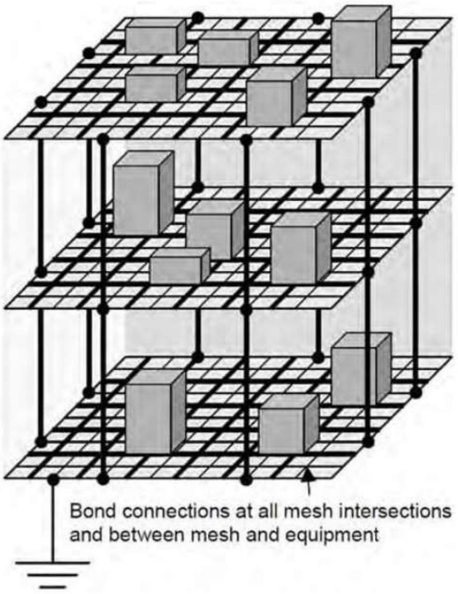
Structural Earthing



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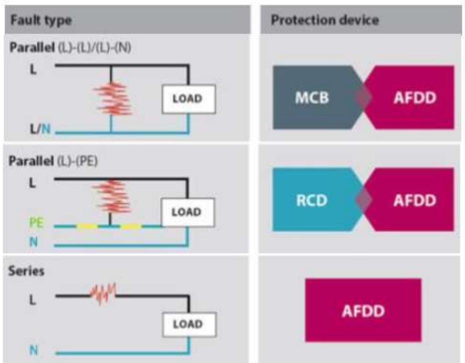
Protection Against thermal effects



- A **NEW** Regulation 421.1.7 has been introduced recommending the installation of **arc fault detection devices (AFDDs)** to mitigate the risk of fire in **AC final circuits** of a fixed installation due to the effects of arc fault currents.

- Recommended Locations :
  - premises with **sleeping accommodation**
  - locations with **a risk of fire** due to the nature of processed or stored materials, i.e. BE2 locations (e.g. barns woodworking shops, stores of combustible materials)
  - locations with **combustible constructional materials**, (e.g. wooden buildings)
  - fire propagating structures, locations with endangering of irreplaceable goods.

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Protection against overcurrent

- **Overload Protection:**

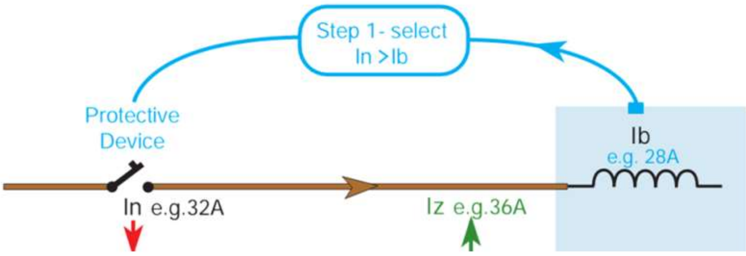
$$I_b \leq I_n$$

where

I_b is the design current of the circuit,

I_n is the nominal current or current setting of the protective device,

I_z is the current-carrying capacity of the conductor in the particular installation conditions.



- **Fault Protection:**

$$I_2 \leq 1.45\ I_z$$

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Chapter 44: Protection against voltage disturbances and electromagnetic disturbances

- **Within the 17th Edition** of the Wiring Regulations, the requirements of surge protection were determined **through risk assessment methods**.

- **Now, overvoltage protection is required in certain circumstances**.
  - Example, where there is risk of serious injury or of loss of life,
    where many co-located people are affected,
    where there is an interruption to public services, or commercial / industrial activity.
- For circumstances where overvoltage protection is not required, a risk assessment can be carried out.
- **If a risk assessment is not carried out, overvoltage protection must be provided.**

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534: Devices for Protection Against Overvoltages

- Section 534 has been completely revised
- This section focuses mainly on the requirements for the selection and erection of SPDs for protection against transient overvoltages where required by Section 443, the BS EN 62305 series, or as otherwise stated.

- 17th Edition

534 *Not used*

535 DEVICES FOR PROTECTION AGAINST UNDERVOLTAGE

A device for protection against undervoltage shall be selected and erected so as to allow compliance with the requirements of Section 445.

- 18th Edition

534 DEVICES FOR PROTECTION AGAINST OVERVOLTAGE

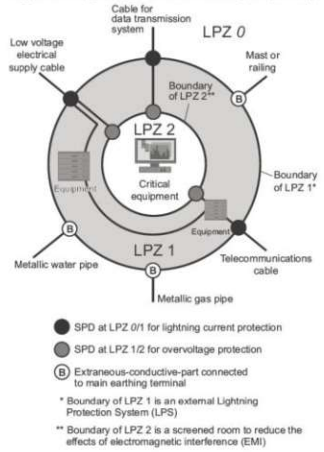
For further information see Appendix 16.

534.1 General

This section contains provisions for the application of voltage limitation in order to obtain insulation coordination in the cases described in Section 443, BS EN 60664-1, BS EN 62305 series and BS EN 61643 series. This section focuses mainly on the requirements for the selection and erection of SPDs for protection against transient overvoltages where required by Section 443, the BS EN 62305 series, or as otherwise stated.

BS EN 62305-4 and BS EN 61643-12 series deal with the protection against the effects of direct lightning strokes or strokes near to the supply system. Both documents describe the selection and the application of surge protective devices (SPDs) according to the Lightning Protection Zones (LPZ) concept. The LPZ concept describes the installation of Type 1, Type 2 and Type 3 SPDs. See Figure 534.1.

Fig 534.1 – Lightning Protection Zones (LPZ) concept



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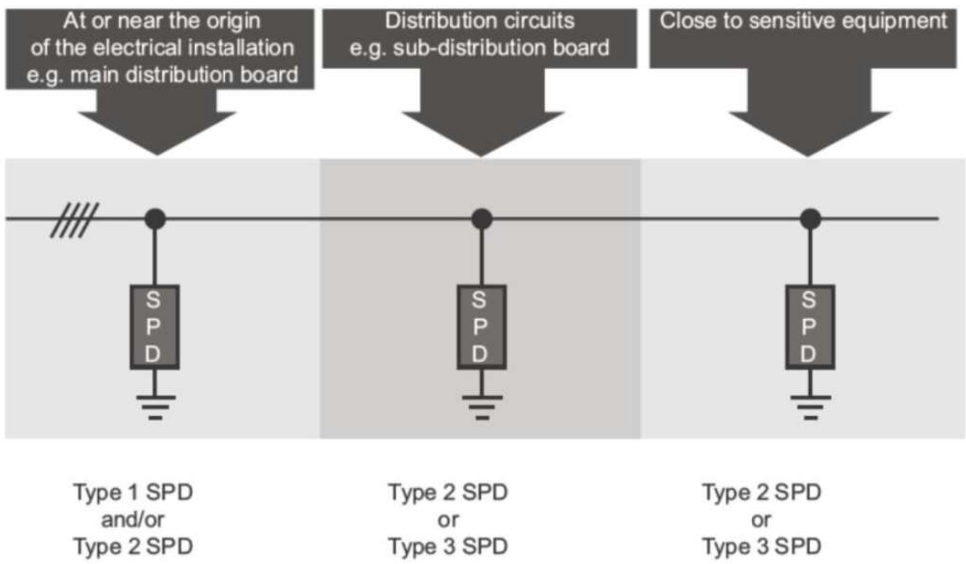
534.4 Selection and Erection of SPDs



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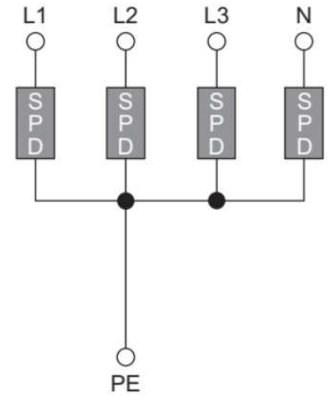
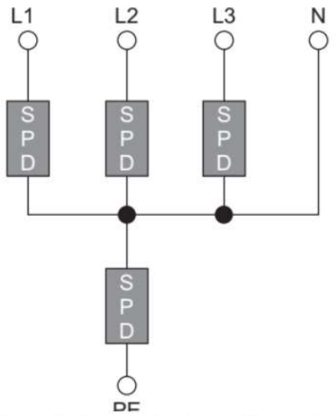
SPD Connection Types



Type CT1 (4+0-configuration)



Type CT2 (e.g. 3+1-configuration)

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Table 534.5 – Connection of the SPD dependent on supply system

Supply system at the connection point of the SPD assembly	Connection Type	
	CT1	CT2
TN system	Y	Y
TT system	SPD only downstream of RCD	Y
IT system with neutral	Y	Y
IT system without neutral	Y	N/A
NOTE 1: Y = applicable **NOTE 2:** N/A = not applicable		

Where SPDs are installed in accordance with Regulation 534.4.1 and are on the load side of an RCD, an RCD having an immunity to surge currents of at least 3 kA 8/20 shall be used.

NOTE 1: Type S RCDs in accordance with BS EN 61008-1 and BS EN 61009-1 satisfy this requirement.

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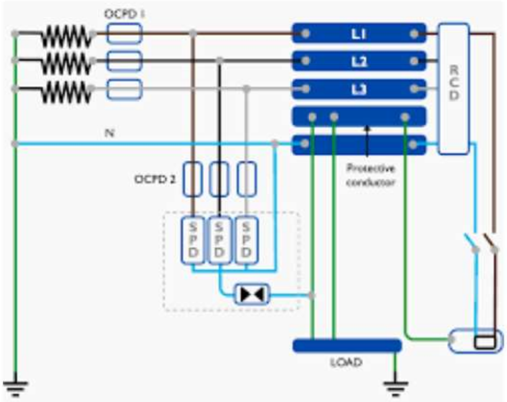
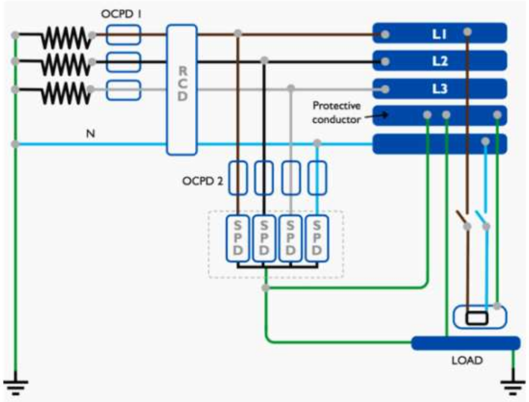
(3+1) vs (4+0)

- For TN→ (3+1) or (4+0)
- For TT → (3+1) is recommended

  (4+0) can only be used if RCDs are on upstream





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Minimum separation between power and signal cables (m)

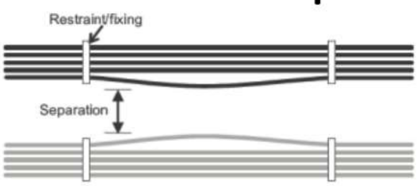

TABLE A444.2 – Minimum separation between power and signal cables (m)

Power Cable Voltage (V)	Minimum Separation between Power and Signal Cables (m)	Power Cable Current (A)	Minimum Separation between Power and Signal Cables (m)
115	0.25	5	0.24
240	0.45	15	0.35
415	0.58	50	0.5
3300	1.1	100	0.6
6600	1.25	300	0.85
11000	1.4	600	1.05

NOTE 1: The values in Table A444.2 can be used specifically for long parallel runs of cables.

NOTE 2: The worst-case separation based on voltage or current should be used.

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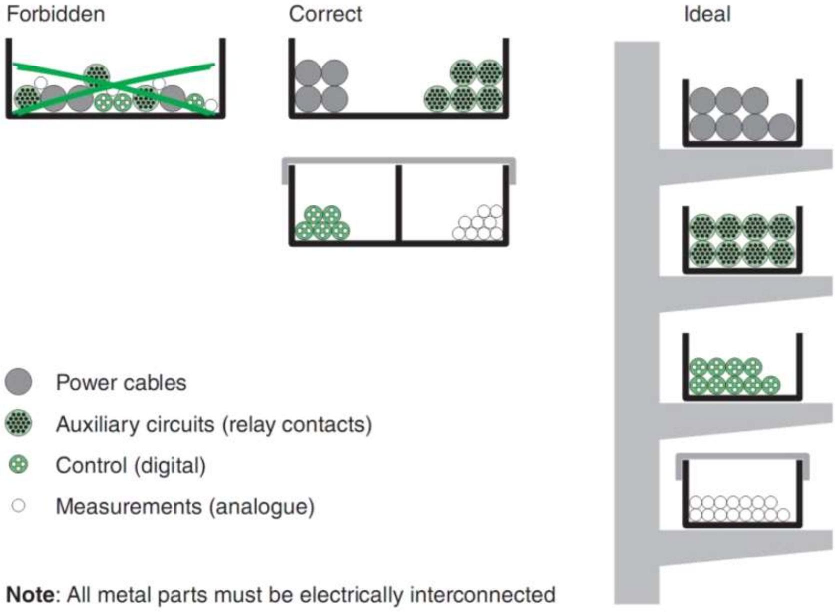
Groups of Cables



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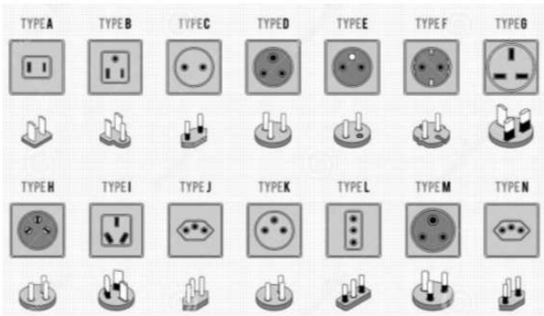
Socket Outlet Circuits



- Type G socket outlets are approved by the Cabinet as "**Single Standard Socket Outlet in SL**" on 16th August 2016.
- **From 16th August 2017**, import of any socket, plug, converters or extension cord not conforming to SLS and type G, prohibited.
- **From 1st January 2019**, manufacture and sale allowed only for sockets, plugs, extension cords (must be all type G) or converters (all type G, or type D to G and vice versa), all conforming SLS. **Everything else is prohibited,**
- **From 1st January 2019**, all appliances sold MUST carry a type G (13 A) plug top.

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Type G: Ring or Radial ?
How many S/O per circuit?

- 433.1.4 Accessories to BS 1363 may be supplied through a **ring final circuit**, with or without unfused spurs, protected by a 30 A or 32 A protective device
- Regulation do not directly limit on the number of outlets, but recommended a maximum floor area (**historically**, limited to) .
  - **Ring circuit** with 30A (or 32A) protective device : **100m^2** of floor area, (10mx10m)
  - **Radial circuit** with 30A (or 32A) protective device : **75 m^2** of floor area, (~8.6 mx8.6m)
  - **Radial circuit** with 20A protective device can serve maximum **of 50m^2** of floor area. (~7mx7m)

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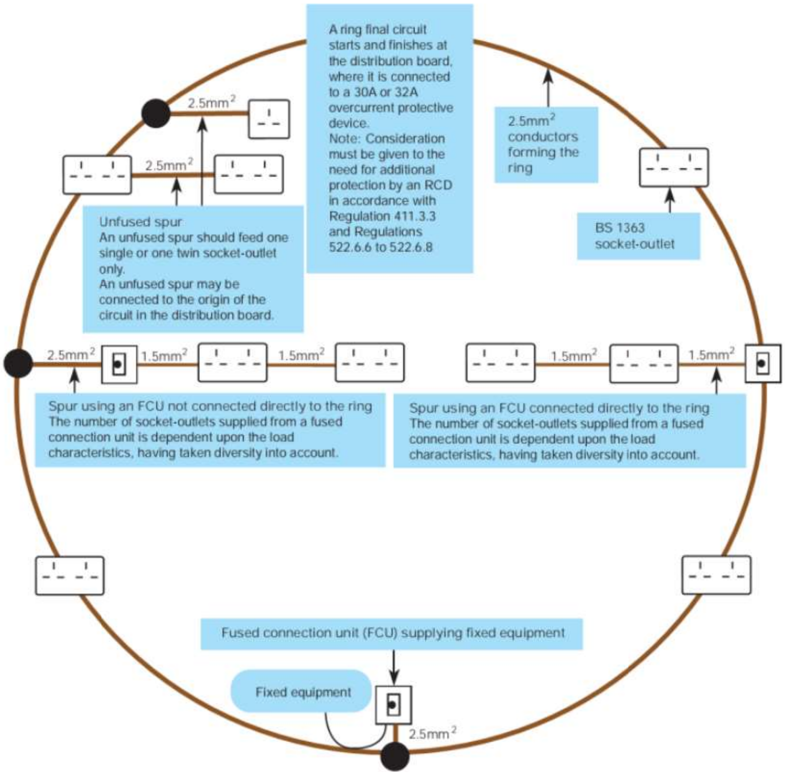
Ring Cct



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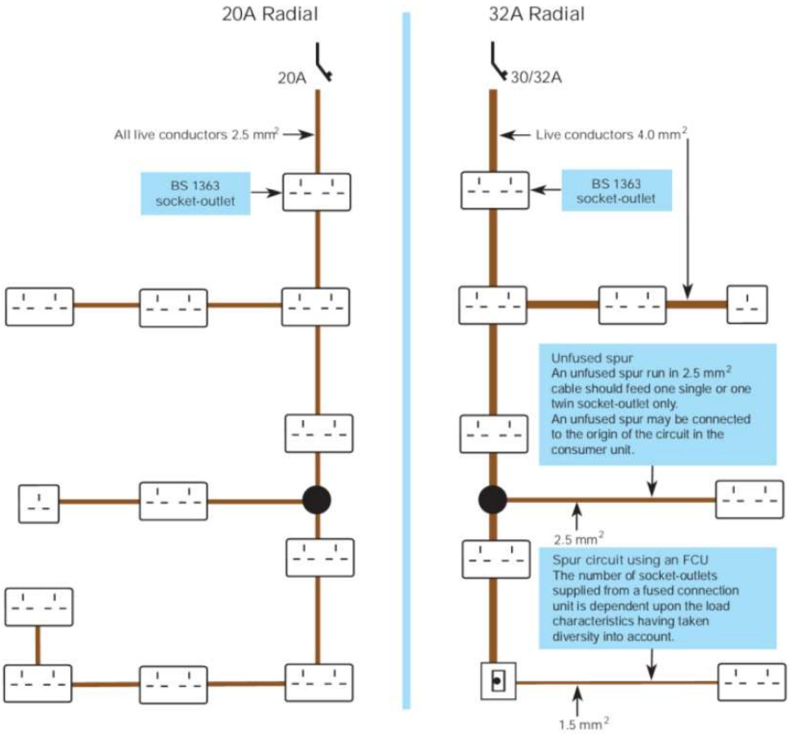
Radial Cct



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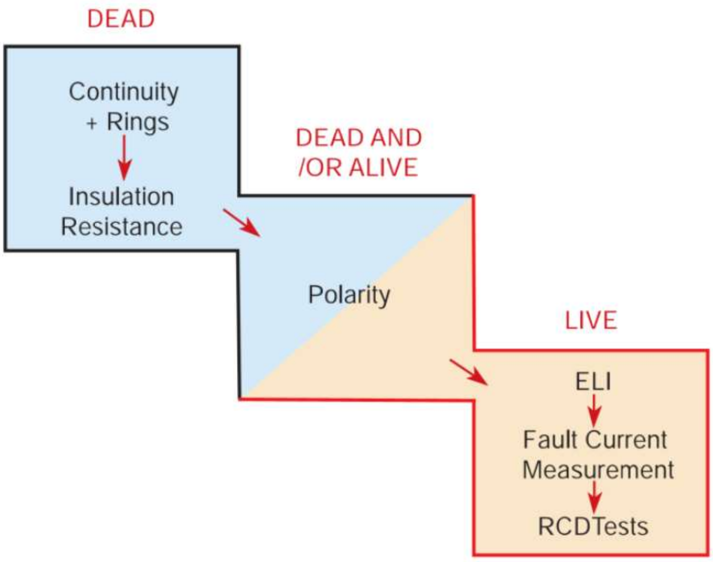
‘Everyday tests’ order and state



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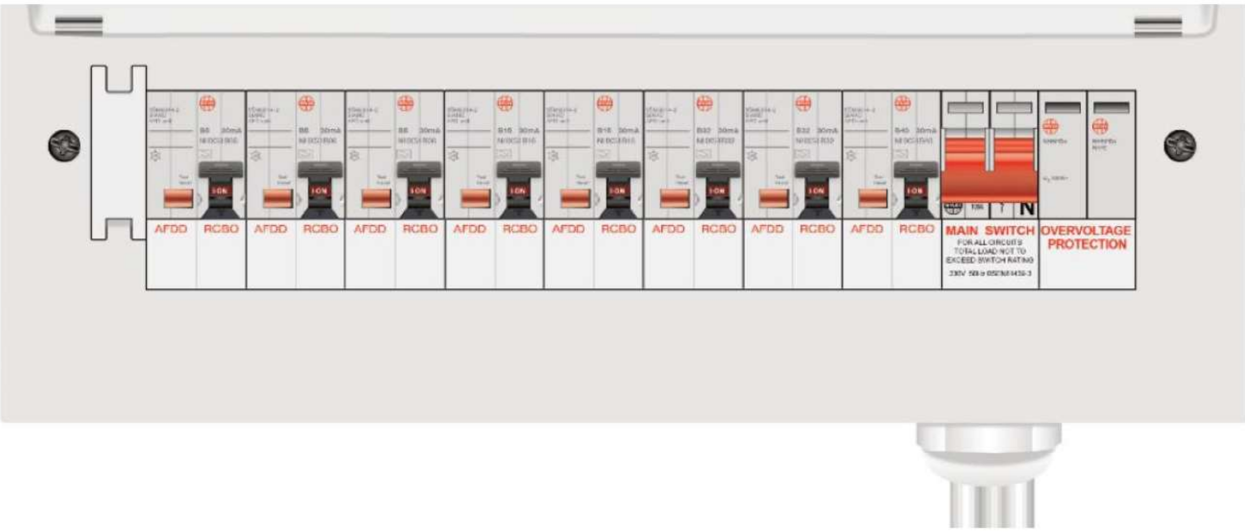
Future Consumer Unit



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Thank You

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