CAPE ELECTRIC

Earthing & Equipotential Bonding

This Technical Presentation is based on

- IS 3043: Code practice of Earthing
- IEEE 142: Grounding of Industrial and Commercial Power System
- IS/IEC 62305: Lightning Protection (Internal and External Protection)
- IEC 60364-5-53, 54 & 4-44 (Low Voltage Electrical Installation: Earthing, Bonding and Protective Devices
- ISO/IEC 30129: Bonding Networks & Earthing for Telecom and DATA Centers
- IEC 62561 - 2, 7: Components for Earthing and LPS
- IS 732 – 2016 (draft): Code practice of Electrical Wiring Installations

LV system

Cape Electric Pvt Ltd
A-41(B), SIPCOT, Oragadam
Kanchipuram, Chennai – 602105
Tamilnadu
Ph. +91 44 7101 8100 (30 lines)
Mob - +91 99625 22244

CAPE and Lightning Protection ……………..Since 1997……….

CAPE ELECTRIC

Most experienced company in India in the subject of LPS, Structural Protection, SPD, Earthing ……
We are continuously training the market with the modern ways since 1997 ………

Dr. Chandima Gomes, Dr. Muralidas, Mr. Varadarajan & Mr. Gopakumar with participants during 2 days seminar at cochin in 2006

Dr. Shriram Sharma, Dr. Chandima Gomes, Mr. Gopakumar & participants during 2 days Lightning Protection workshop in Nepal, June 2016 along with former Prime Minister Hon. Shri Jhala Nath Khanal

Participants during 2 days Seminar at CPRI in 2016

Participants during 5 days EMI/EMC training program at Malaysia

2 days EMI/EMC training program for railway installations at RDSO Lucknow

Mr. Ganesan and Mr. Gopakumar with Railway S&T offi cials at IRISET, Secunderabad during 2 days EMI/EMC program on Railway System

Earthing - Application

1. Earthing for safety (Automatic Disconnection of Power Supply)
2. Voltage Reference of System (Neutral)
3. Dissipation of Lightning current
4. Base for Equipotentialisation
5. Shielding against Electro Magnetics

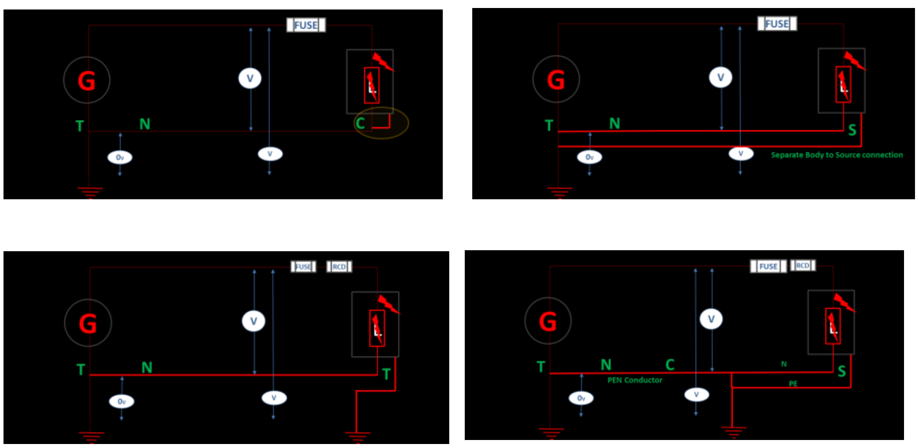
Wrong - Separate Connection to a low resistance earth electrode in soil

Right - Separate and Low resistance connection to an earthing system

In this presentation we discuss about

- Earthing for Safety and return of fault current back to source enabling quick "Automatic Disconnection of power supply"
- System Earthing – Neutral
- Base for Equipotentialisation – Safety in Hospitals (NEC-2011) or Telecom Equipment

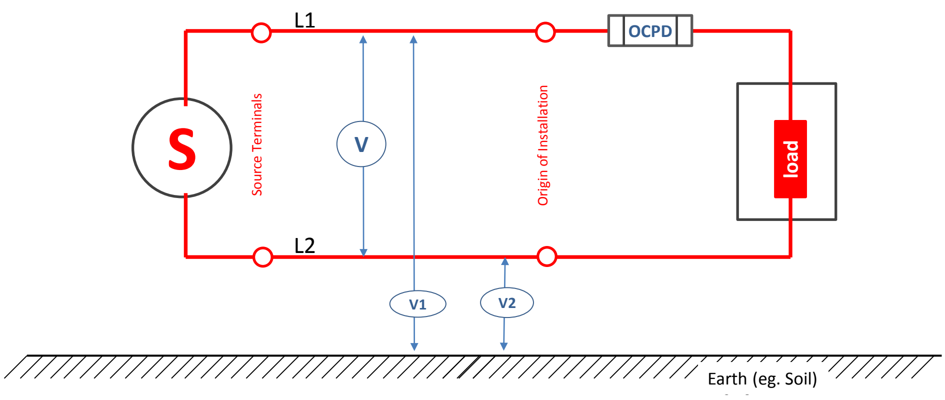
LV System Earthing: TN-C, TN-S, TN-C-S, TT, IT



- Safety – Automatic disconnection of Power Supply during a fault
- Earthing – Return current back to source and ensure protective device is able to "Automatic disconnection of Power Supply" in case of a line to Body fault
- How – Loop impedance shall be adequately lesser so that enough fault current flows within a short time so that protective device operate faster

System earthing – Why??

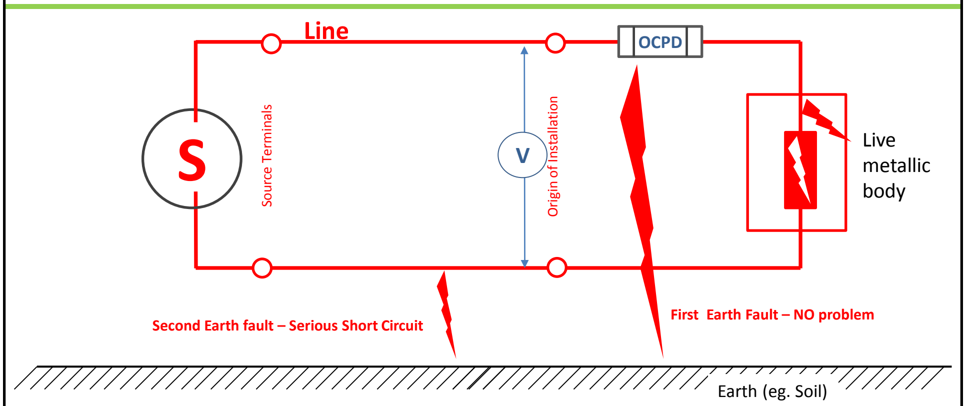
CAPE ELECTRIC



UN earthed System with OCPD
There are two Lines. voltage between them drives the load
OCPD protect the circuit from further failures by breaking the supply voltage
V1 and V2 are unstable.

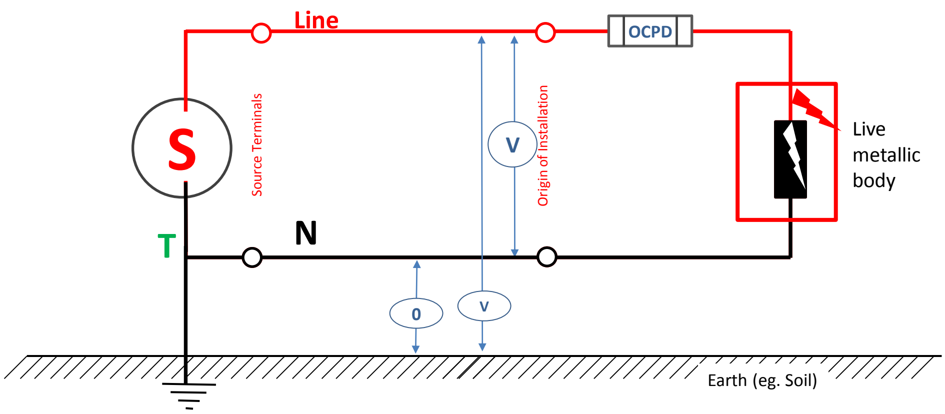
System earthing – Why??

CAPE ELECTRIC



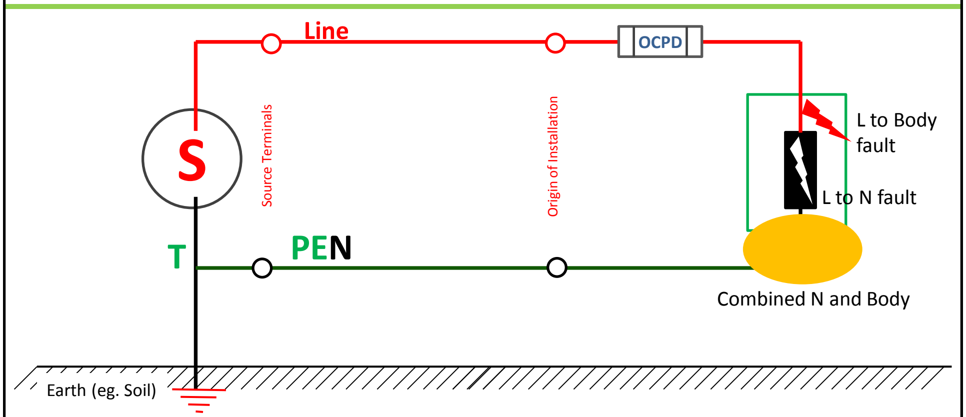
UN earthed System
First Fault do not create Hazard
Second Fault creates serious short circuits

System earthing & Equipment Earthing



Earthing one of the line created NEUTRAL and Stable voltage from each line to earth
Earthed Source Become "T" (TERRA - T Stands for direct connection to earth. Earthing via Resistor / Inductor is also "T")
earthed line become in "NEUTRAL" potential with earth which is "N"
OCPD Protects against Line to Neutral fault
Due to earthing of one of the line Earth fault will create electrocution

System earthing & Equipment Earthing

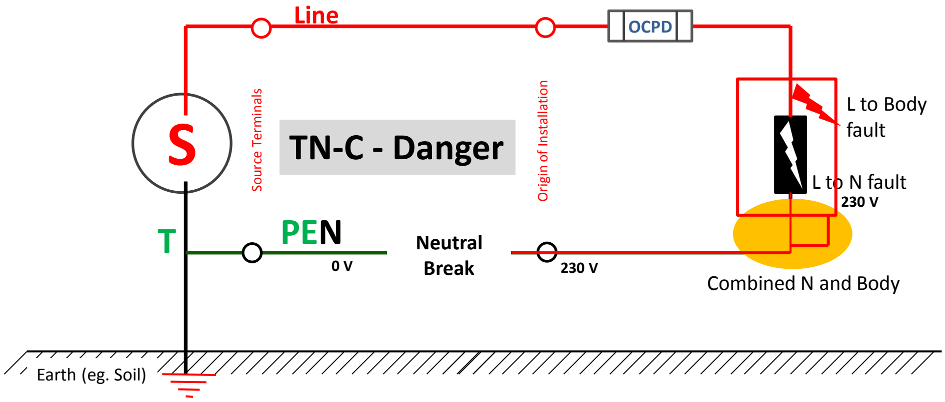


TN-C Network – OCPD is the primary protector

Earth Fault was solved by connecting the body to Neutral wire.
Circuit Breaker protects against for L to N and Earth fault

System earthing & Equipment Earthing

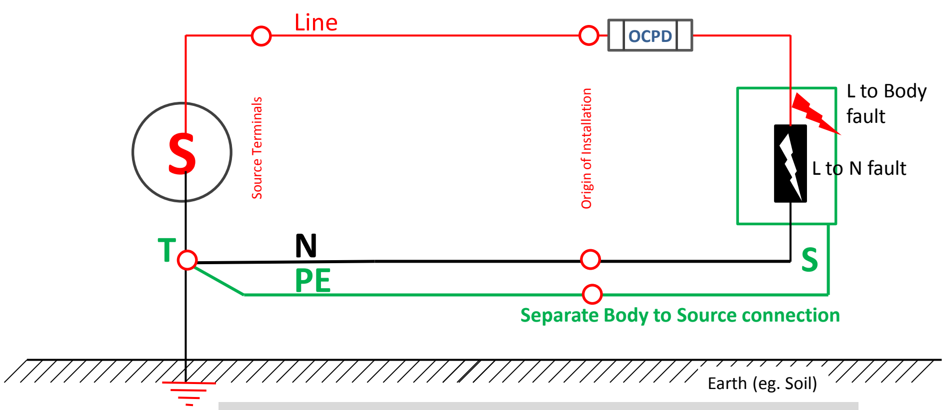
CAPE ELECTRIC



TN-C Neutral Break **"exposed conductive parts become Live"**
Live Body of equipment in case of broken (combined) **N** was more dangerous

System earthing & Equipment Earthing

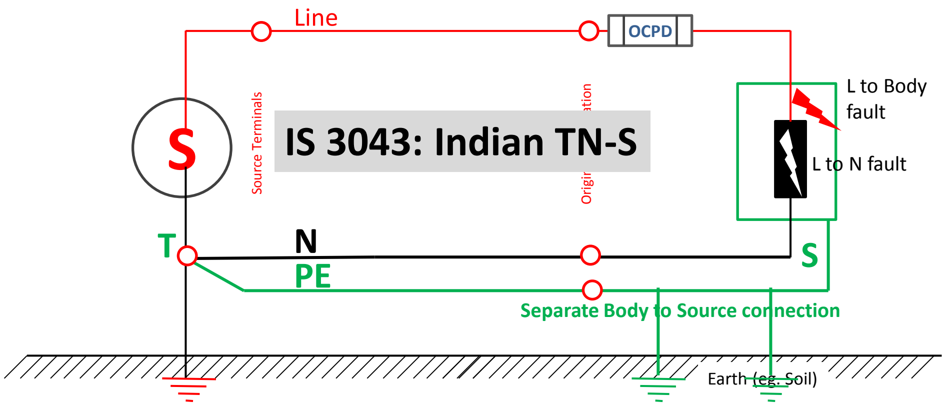
CAPE ELECTRIC



TN-S Network – OCPD is the primary protector

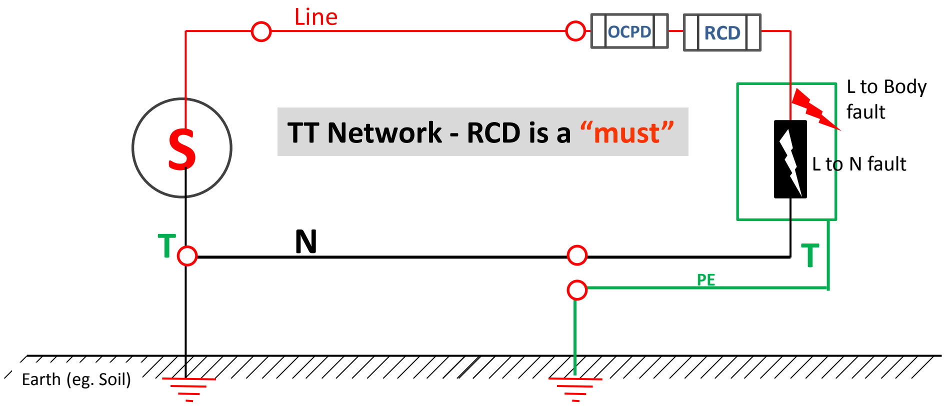
Separate Body to Earthed Neutral of source was started. This solved the problem of "Neutral breakdown"
Fuse / OCPD continued to protect the circuit against L to N and Earth Faults
For public electricity distribution 3 (or 5) wires need to run form source to all consumers
"cost of 3rd wire"

System earthing & Equipment Earthing



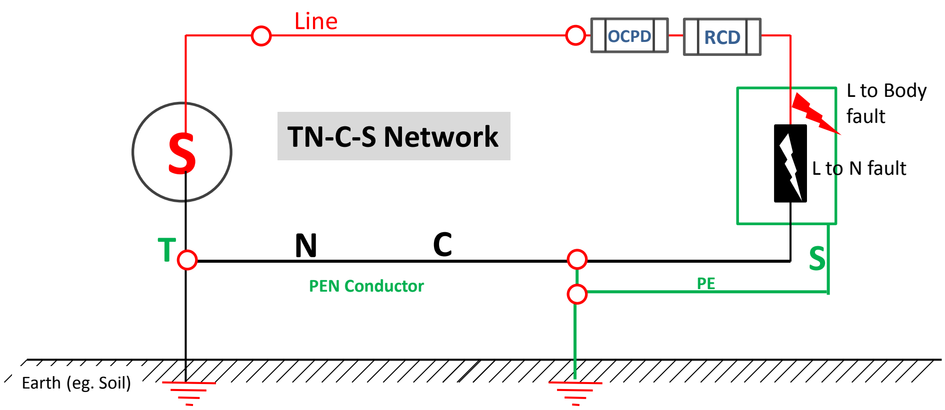
Indian TN-S reduces Fault Voltage (∆U) in PE conductor
∆U - created between Exposed conductive parts and Extraneous conductive parts

System earthing & Equipment Earthing



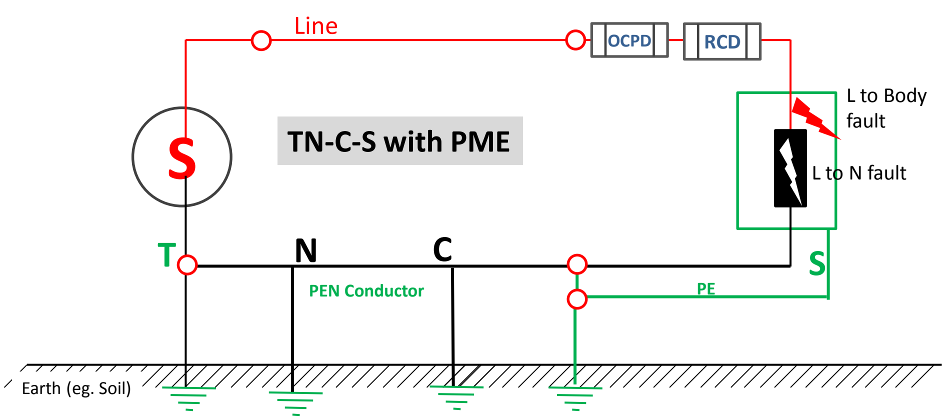
During 1970's RCD (earlier ELCB) has been invented.
RCD (RCCB/ELCB) measures the current in Line and Neutral.
If there is an unbalance (due to leakage) the device trips and opens the circuit
Instead of running 3rd wire (PE) from load to source, PE is connected to the local earth.
During earth fault, **Leakage current flows to local earth**. RCD trips.

System earthing & Equipment Earthing



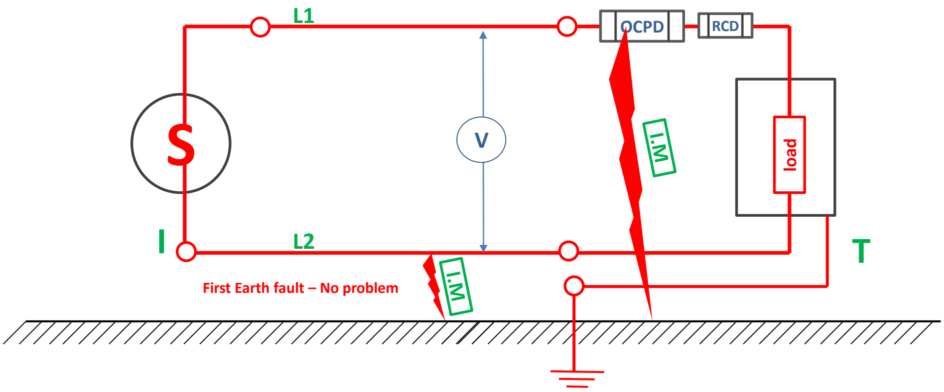
TN-C-S is used in Public Electricity Network
Combined Neutral and PE conductor runs form Source to an installation (PEN conductor)
At the origin of installation, PEN is divided to PE and N
OCPD is the only primary protection.

System earthing & Equipment Earthing



OCPD is the primary protector. RCD is an additional Protector. Earthing at the origin of installation is in the scope of power supplier. RCD required for load more than 2 KW (1 KW in future)

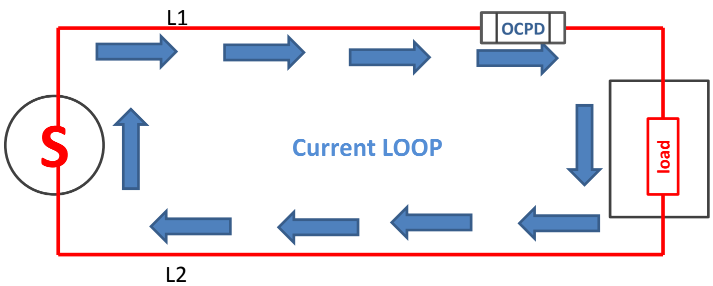
LV System Protection Basics **IT Network**



I – Unearthed Source **T – Solidly earthed Installation**

The impedance of the power system earth shall be such that on the occurrence of a single fault to exposed conductive parts or to earth, the fault current is of low value. Disconnection of the supply is not essential on the occurrence of the first fault. Protective measures must, however, prevent danger on the occurrence of two simultaneous faults involving different live conductors.

System Earthing Conditions



Low Loop impedance = High fault current = Efficient operation of OCPD = Automatic Disconnection of Power Supply with in the prescribed time

Loop Impedance is important in a network to ensure that the switchgears are working and is "Automatically disconnecting the power supply" during a fault and protect from further failures

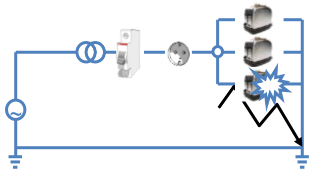
Acc. to IS 3043: The characteristics of the protective devices and the cross-sectional area of conductors shall be so chosen that if a fault of negligible impedance occurs any where between a phase conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within the minimum possible safe time. The time of operation would depend on the magnitude of the contact potential. As a general rule, 65 V may be cleared within 10 seconds and voltages of the order of 240 V and above shall be cleared instantaneously.

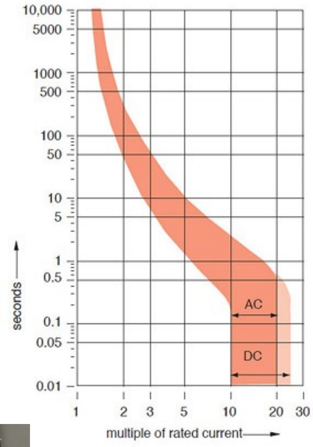
Functionality of a Short-Circuit Protective Device

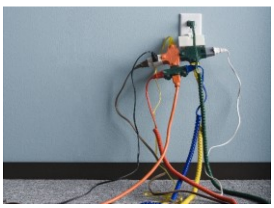
CAPE ELECTRIC

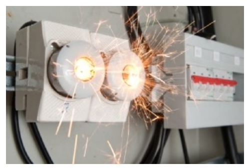
Short-circuit

Occurs when any lines come in contact with each other or the earth



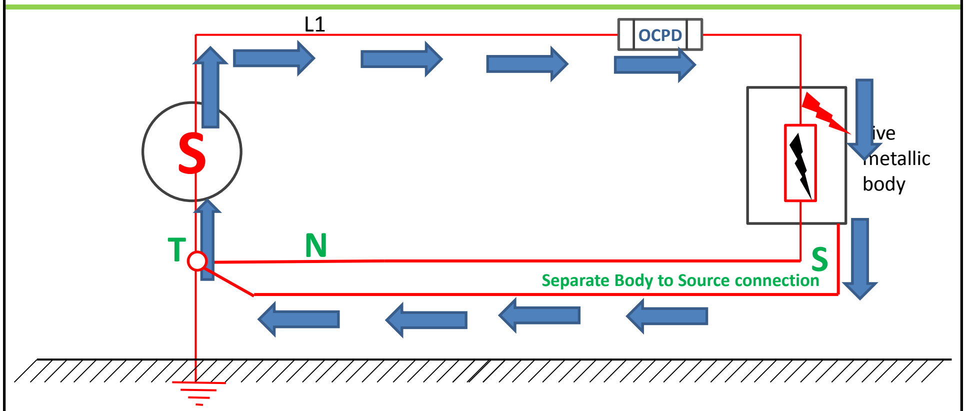






System Earthing Conditions TN-S Network

CAPE ELECTRIC



$Z_s \times I_a \leq U_o$ or $Z_s \leq U_o / I_a$

Z_s = fault loop impedance,
I_a = current ensuring the automatic operation of disconnecting device
U_o = conventional voltage limits.

PE conductor immediately after installation

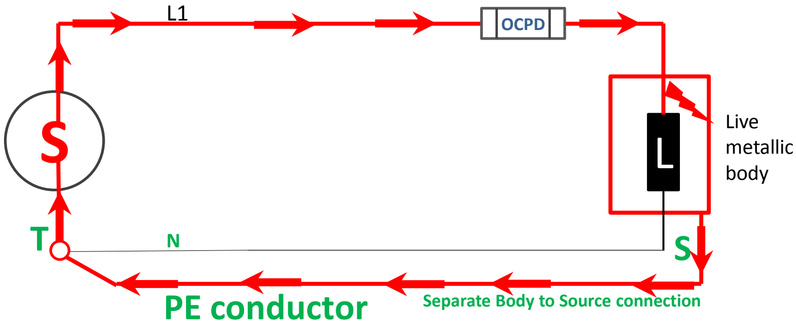
CAPE ELECTRIC

PE conductor after 6 months of installation

CAPE ELECTRIC

Accident - Example

CAPE ELECTRIC

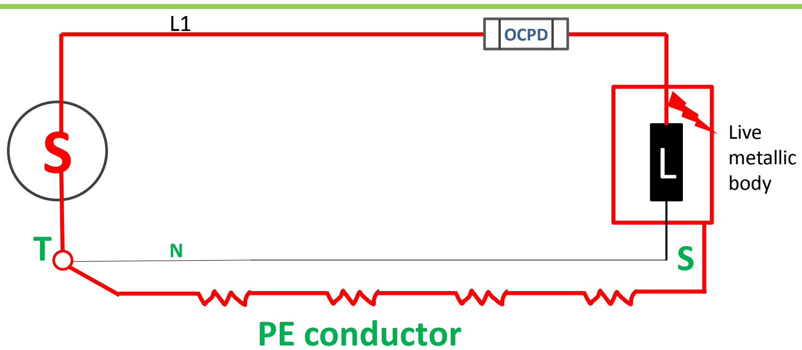


Low Loop resistance = More Fault current = Fast operation of Protective Device

Resistance of PE conductor plays a major role in a TN-S Network during an earth fault

Accident - Example

CAPE ELECTRIC

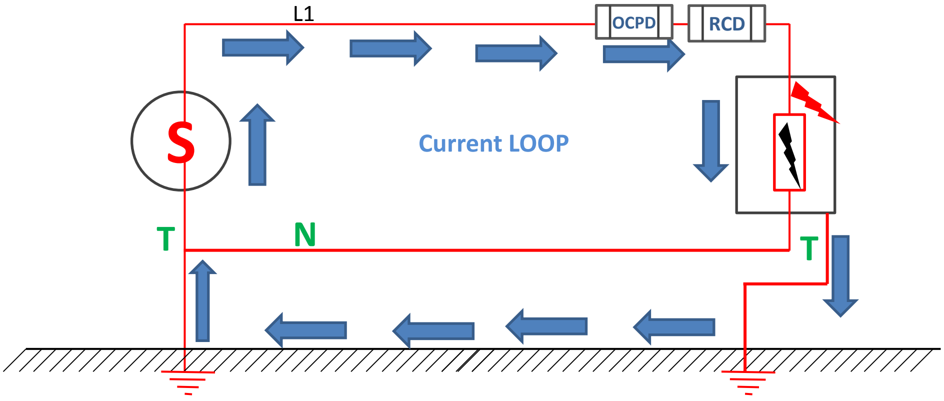


All joints corroded in 6 months
Corrosion will increase resistance of PE conductor
More resistance = Less fault current = More tripping time

Problem No – 1: Switchgear will take more time to trip
Problem no – 2: Joints are not strong enough to handle Short Circuit current

(result – fire, flash over, accident)

System Earthing Conditions TT Network



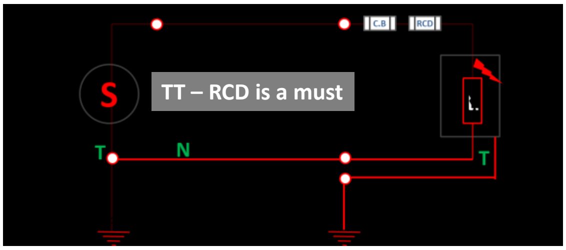
$R_A \times I_a \le U_c$ Or $R_A \le U_c / I_a$

R_A = resistance of the earthed system for exposed conductive parts,
I_a = operating currents of the disconnecting series device or settings of shunt relays, and
U_c = conventional voltage limit (32 V in case of relays with time lag).

LV Network: **Application**

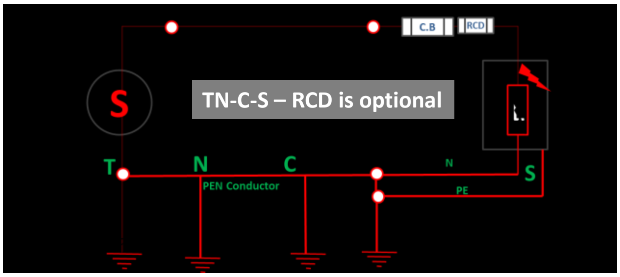
TT	Over head power distribution for residential / commercial from a common Transformer. Every installation shall have an RCD and an earth electrode at Origin of installation
TN-S	Industrial / commercial / IT Buildings with electronic systems and Transformer with in facility (transformer operated by the owner)
TN-C	Over Head Power Distribution up to Origin of an Installation.
TN-C-S	Over head power distribution for residential / commercial from a common Transformer. RCD and earth electrode at origin of installation are optional.
IT	Hospitals / IT installation for a building or part of a building. Not suitable for different buildings with same supply

Delay in Fault clearance result in fire / accident



Practice – TT Network
(without RCD)

Legal – TN-C-S Network
(RCD more than 2 KW)



Indian Regulations & Standards

CEA: Regulation

1. CEA safety Regulations insist TN-C-S network for public distribution. Utilities are free to decide.
2. As per CEA regulation, RCD is necessary for loads above 2 KW (1 kw in 2015 amendment draft regulation)
3. RCD is a must for TT network irrespective of Load and Capacity.
4. Due to un-defined networks, TT is used with out RCD

Problem: TT network with out RCD create safety Hazards

Indian Standard

1. IS 3043 Recommends to use TN-S network for Industrial and Commercial application. TN-S with PME recommended in IS 3043 is one of the safest networks.
2. IS 3043 recommends Double earthing – Eg Transformer Neutral in an Industrial premise, One connection to common Earth Busbar and another to PME grid
3. Double Earthing of a panel – One connection to PE conductor and another to PME grid
4. DG's Neutral and Body Double earthing – One to Earth Bar and another to PME grid

Problem: Meaning of Independent Earth Electrode is not understood well. As a result every earth conductor is connected to one vertical electrode

SAFETY - Testing of L.V electrical installation

CAPE ELECTRIC

a. continuity of conductors
b. insulation resistance
c. insulation resistance testing to confirm the effectiveness of protection by SELV, PELV or electrical separation
d. insulation resistance testing to confirm the effectiveness of floor and wall resistance/impedance
e. polarity test
f. testing to confirm effectiveness of automatic disconnection of supply
g. testing to confirm the effectiveness of additional protection
h. test of phase sequence
i. functional tests
j. voltage drop

In Europe and USA – L.V System is energized after this test

Test Report formats are uniform which is provided in relevant National Standards / IEC standards

Parameters tested and confirmed

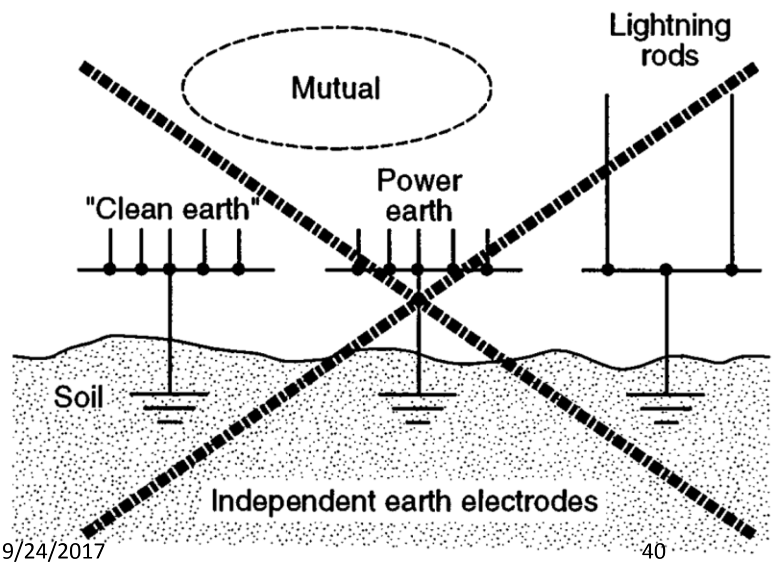
CAPE ELECTRIC

a. method of protection against electric shock
b. presence of fire barriers and other precautions against propagation of fire and protection against thermal effects
c. selection of conductors for current-carrying capacity
d. choice, setting, selectivity and coordination of protective and monitoring devices
e. selection, location and installation of suitable overvoltage protective devices (SPD) where specified
f. selection, location and installation of suitable isolating and switching devices
g. selection of equipment and protective measures appropriate to external influences and mechanical stresses
h. identification of neutral and protective conductors
i. presence of diagrams, warning notices or similar information
j. identification of circuits, overcurrent protective devices, switches, terminals etc.
k. adequacy of termination and connection of cables and conductors
l. selection and installation of earthing arrangements, protective conductors and their connections
m. accessibility of equipment for convenience of operation, identification and maintenance
n. measures against electromagnetic disturbances
o. exposed-conductive-parts are connected to the earthing arrangement
p. selection and erection of the wiring systems

One system ……………… One earthing

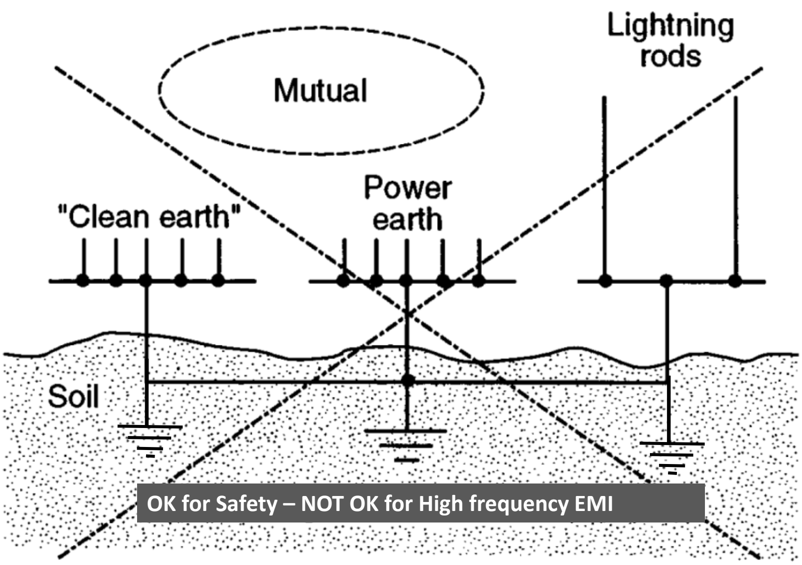
Stable voltage …………….

Mis concept of “dedicated”, “independent”, or “isolated” earth electrodes

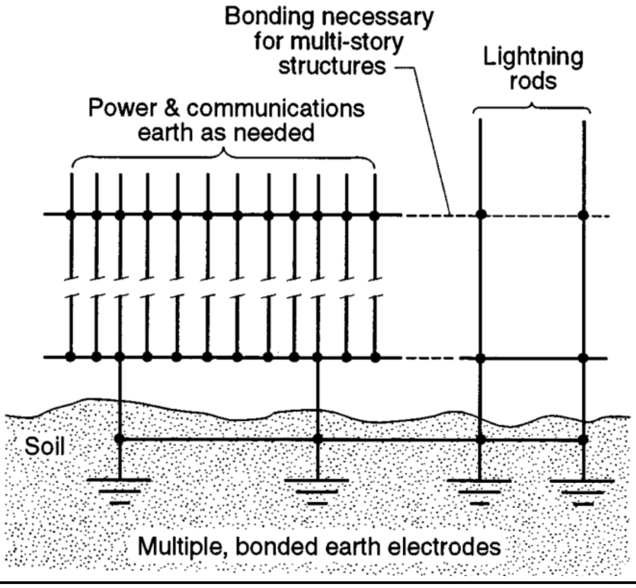


9/24/2017 40

The concept of a single earth electrode



Recommended configuration earth electrodes and earthing network for Electronic Installations



Earth Farm : 22 separated vertical earth electrodes

Separate for Neutral, Separate from Body – 8 nos for 2 DG's, 4 nos for one Transformer, separate for UPS, Separate for …………….. Total 22 nos in 500 Sqft

Commercial Buildings: Transformer, DG, Lift, UPS,……………….

Every client in a modern IT building need several separate earth electrodes

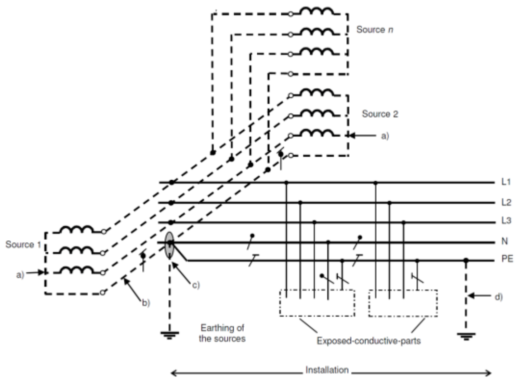
Result: Switchgear will not trip (or takes more time to trip) resulting in an accident, fire……

NO SPACE ……………..Lets keep it above Soil

CAPE ELECTRIC

Neutral Earthing (Single point Earthing) IS 732 (draft – 2016) & IEC 60364-4-44 :

CAPE ELECTRIC



Multiple source systems

In case of inappropriate design of an installation forming part of a TN system with multiple sources some of the operating current may flow through unintended paths. These currents may cause

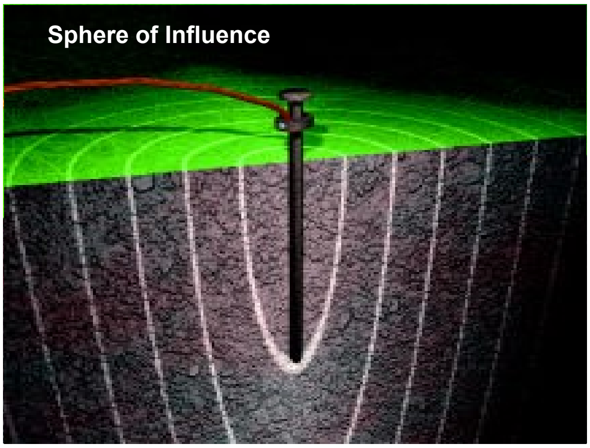
fire
corrosion
electromagnetic interference.

a. No direct connection from either transformer neutral points or generator star points to earth is permitted.
b. The conductor interconnecting either the neutral points of transformers, or the star -points of generators, shall be insulated. ………………… & this conductor is like a PEN conductor
c. Only one connection between the interconnected neutral points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly.
d. Additional earthing of the PE in the installation must be provided.

TN multiple source power supplies to an installation with connection to earth of the star points at one and the same point

Earthing – General Idea

CAPE ELECTRIC



1. Earth Conductor
2. Connector
3. Electrode

This is only a part of Earthing system !!!!!!!!!!!!

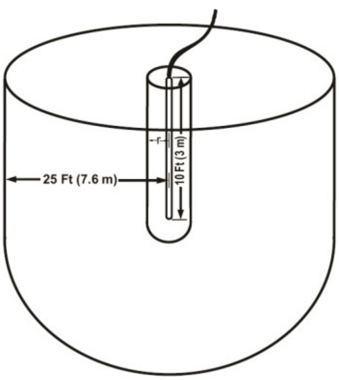
The resistance of a earthing system depends on

1. The resistance of the Electrode
2. The contact resistance of the electrode with soil
3. The resistance of soil surrounding Electrode

Sphere of Influence

CAPE ELECTRIC

Electrode Resistance Development: IEEE 142



Distance from Electrode Surface *(r)*		Approximate Percentage of Total Resistance
mm	m	
30.48	0.03	25
60.96	0.06	38
91.44	0.09	46
152.4	0.15	52
304.8	0.3	68
1524	1.5	86
3048	3.0	94
4572	4.6	97
6096	6.1	99
7620	7.6	100
(30480)*	30.5	(104)
(304800)*	305.0	(117)

Table: Electrode Resistance at a Radius r in m from a 3 m Long, 16 mm Dia Rod
Total Resistance at r = 7.6 m = 100%

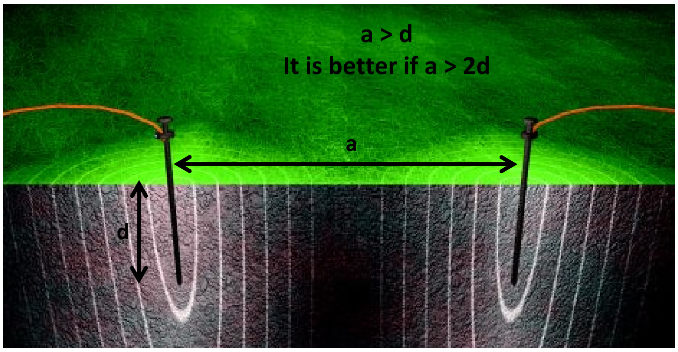
*** These figures show that for the most practical reasons the majority of the resistance to remote earth occurs within 25 ft of the electrode, i.e., at 1000 ft the resistance is only 17% higher than that of 25 ft.**

Multiple Earth electrodes.

In this system more than one electrode is driven into the ground and connected in parallel to lower the resistance.

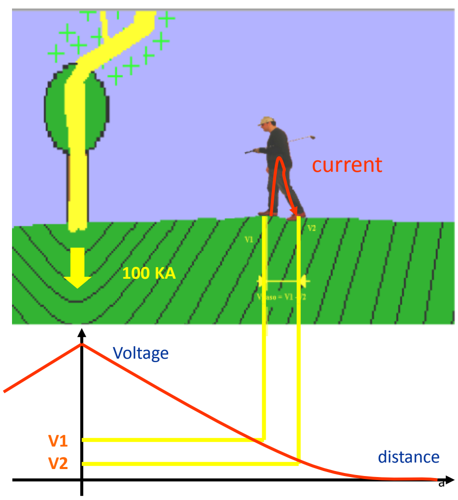
Each earth electrode has it's own sphere of influence and for additional electrodes to be effective the spacing of additional rods needs to be at least equal to the depth of the driven rod.

Without proper spacing of earth electrodes the spheres of influence will intersect and the lowering of the resistance will be minimal and of little value.



STEP VOLTAGE

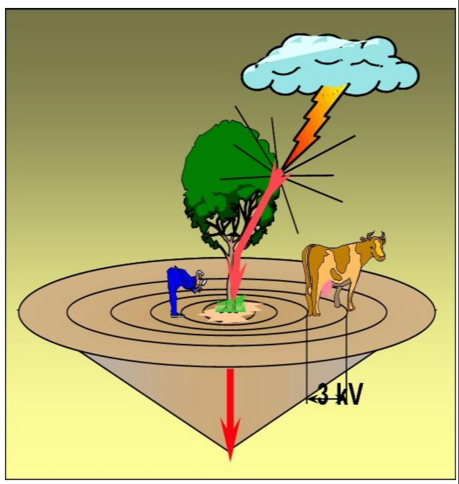
STEP VOLTAGE Vs= V1-V2



Indirect Impact

People: High voltages on the ground

Structures: inductive and capacitive coupling

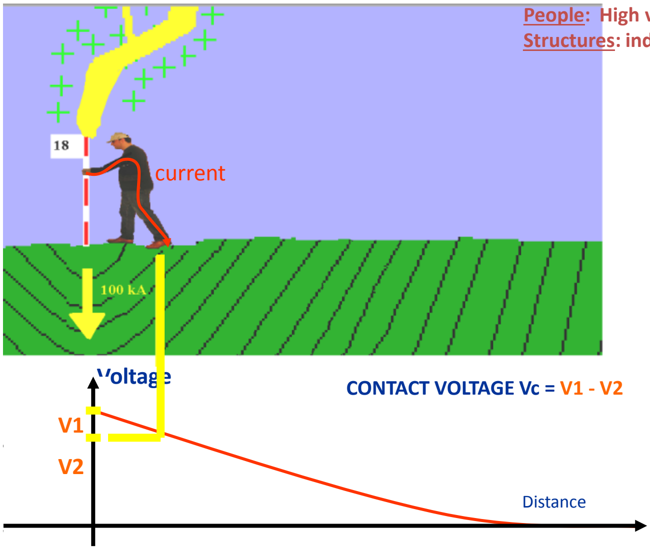


VOLTAGE CONTACT (Touch Voltage)

Indirect Impact

People: High voltages on the ground

Structures: inductive and capacitive joining



CONTACT VOLTAGE Vc = V1 - V2

IS 3043 – Earth Resistance Value in a TT Network

TABLE 14

MAXIMUM EARTH ELECTRODE RESISTANCE FOR DIFFERENT TYPES OF CIRCUIT BREAKER

Type of Breaker	Operating Current	Maximum Earth Electrode Resistance (Ω)
RCD	300 mA	166
RCD	30 mA	1666
	—	500

In British Standard – Value more than 200 ohms treated as Unstable

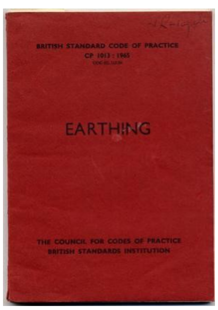
CAPE ELECTRIC

One system ……………. One earthing

- Earthing for safety
- Double earthing for redundancy and reduction of fault loop resistance

CAPE ELECTRIC

IS3043: Code practice of Earthing



(Reaffirmed 2006)

IS : 3043 - 1987
(Reaffirmed 2006)

Indian Standard
CODE OF PRACTICE FOR EARTHING
(First Revision)

Fourth Reprint JUNE 2007
(Including Amendment No. 1)

UDC 621.316.99 : 006.76

IS 3043 – took support from
CP1013 (British Standard)
IEEE 142
IEC 364

© Copyright 1988
BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

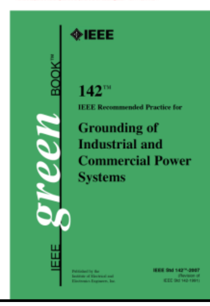
Price Rs 650.00 September 1988

INTERNATIONAL STANDARD IEC 60364-1

Low-voltage electrical installations –

Part 1:
Fundamental principles, assessment of general characteristics, definitions

This English-language version is derived from the original bilingual publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.



IS3043 - Safety

CAPE ELECTRIC

19. SELECTION OF DEVICES FOR AUTOMATIC DISCONNECTION OF SUPPLY

19.1 General - In general, every circuit is provided with a means of overcurrent protection. If the earth fault loop impedance is low enough to cause these devices to operate within the specified times (that is, sufficient current can flow to earth under fault conditions), such devices may be relied upon to give the requisite automatic disconnection of supply. If the earth fault loop impedance does not permit the overcurrent protective devices to give automatic disconnection of the supply under earth fault conditions, the first option is to reduce that impedance. It may be permissible for this to be achieved by the use of protective multiple earthing or by additional earth electrodes. There are practical limitations to both approaches.

IS 3043: Industrial and commercial Installation

CAPE ELECTRIC

22.1.2 Above 240 V should be designed as a PME system with separate protective conductor. The neutral of the transformer should be connected to be earth electrodes by duplicate connections and adequate number of earth electrodes should be provided with interlinking earth bus for getting an optimum value of the earth resistance depending upon the setting of the earth fault/earth leakage relays and also to limit the extent of rise of potential. The earth fault current can be of the order of symmetrical short-circuit current and hence the thermal design of the earth bus and the earthing system should depend upon the maximum symmetrical short circuit current available. The duration of the earth fault current according to the existing design practice is 3 seconds. However, in case of installations where adequate protective arrangements have been incorporated so as to instantaneously isolate the system in the event of an earth fault, a lesser duration can be considered for design purposes.

TN-S with PME
Transformer "Neutral" 2 connections to Earth "Double Earthing"
Interlinking Earth Bus
Short Circuit duration can be less than 3 seconds

IS 3043: Industrial and commercial Installation

22.1.3 As far as the value of the earth resistance is concerned, the objective from the point of **safety** consideration is **not** to attain **minimum value** of the **earth resistance** as is sometimes understood. But the consideration should be whether there is **adequate co-ordination** between the practically **obtainable value** of the earth resistance and **setting of the protective devices**. ….. Placement of electrode, area and size of grid depend on electrical installation, earth grid continuity resistance with in the limit. ……… However, in the case of a protective multiple earthing system where the **neutral of the supply transformer and the non-current carrying metal parts** in the system **are interconnected by the common earth grid**, which is designed for the prospective fault current, there is no reason to design the earth electrodes assuming that total earth fault current is dissipated through the earth electrodes. However, depending upon the value of the earth resistivity, a percentage of the current may flow through the mass of the earth as well…………..

Earth resistance…… coordinated to tripping of protective device
Common Earth Grid interconnects Neutral of transformer and Body of load
No need to design earth electrode for total fault current

IS 3043: Industrial and commercial Installation

22.2.1 The main earthing conductor will be run in between standard earth electrodes conforming to specifications and distributed uniformly around the working area. **All the non-current carrying metal parts of the equipment, switchboards, etc., will be solidly connected to this earth grid and equipotential bonding conductor by duplicate earth connections of adequate size**. For interconnecting switchboards protected by HRC fuses to this earth grid, the size of interconnection need not be more than 75 mm^2 copper or its equivalent. In laying out the earth electrodes and the earth conductors, all efforts should be made to maintain a uniform potential gradient in and around the work area. **The transformer neutral should be solidly connected to this grid by duplicate earth connections, one going directly to earth electrodes and other going to the common earth bus.** The size of the neutral earthing conductor should in no case be less than that of the size of the main earthing conductor.

Double Earthing of equipment and switchboards
One to Grid, another to Earth Bonding Conductor (PE conductor)

Double Earthing of Transformer
One to Grid, another to Earth Bus bar

IS 3043: Industrial and commercial Installation

22.2.2 The earth grid should be run at a minimum depth of 50 cm below ground. When bare conductors are used as earth grid, this can also be assumed to dissipate the fault current to the mass of the earth

22.2.3 **The continuity resistance of the earth return path through the earth grid should be maintained as low as possible and in no case greater than one ohm.**

22.2.4 In the case of EHT substations, where there is possibility of the ground potential attaining very high values (of the order of 5 kV and above) in the event of an earth fault, the earth grid design should be based on the tolerable limits of the potential gradient in the substation area, and the step and touch potential due to fault conditions.

Earth Grid is the Earth Electrode

Periodic inspection of Continuity Resistance of Earth grid ensures the metal grid in soil is not corroded and disconnected

IS 3043: Industrial and commercial Installation

22.3.1 The earth electrodes are provided to dissipate the fault current in case of earth faults and to maintain the earth resistance to a reasonable value so as to avoid rise of potential of the earthing grid. Practice, which has been followed until now, is to design the earth electrodes for the appropriate thermal withstand capacity, assuming the total fault current to be passing through the earth electrodes. This is true in the case of an earthing system which is not interconnected with neutral earthing (TT/IT system). **But with the adoption of PME system in industrial distribution where the neutral is solidly connected to the earthing grid**, the above practice requires revision as has already been pointed out in 22.1.3 in order to avoid redundancy and thereby to avoid unnecessary expenditure.

One connection of Neutral to Earth Grid

IS 3043: Section 7 - Medical Establishments.

CAPE ELECTRIC

24.0.3 Generally a power supply system including a separated protective conductor is required. (TN-S System) in medical establishment

(g) IT system with Insulation monitoring for specific areas (eg Operation theatre)

IS : 3043 - 1987

TABLE 10 SAFETY PROVISIONS

(*Clause* 24.1.1)

PROVISIONS (1)	PRINCIPAL REQUIREMENTS (2)	INSTALLATION MEASURES (3)
P0	Duration of touch voltage restricted to a safe limit	TN-S, TT or IT system (*see* 6.1.1)
P1	As P0 but additionally : Touch voltages in patient environment restricted to a safe limit	Additional to P0 Supply system with additional requirements for protective earthing, etc
P2	As P1 but additionally : Resistance between extraneous conductive parts and the protective conductor busbar of the room not exceeding 0·1 Ω	Additional to P1 : Supplementary equipotential bonding
P3	As P1 or P2 but additionally : Potential difference between exposed conductive parts and the protective conductor busbar not exceeding 10 mV in normal condition (*see* Note)	As P1 or P2: Measurement necessary, corrective action possibly necessary
P4	As P1 or P2. Additional protection against electric shock by limitation of disconnecting time	Additional to P1 or P2 : Residual current operated protective device
P5	Continuity of the mains supply maintained in case of a first insulation fault to earth and currents to earth restricted	Additional to P1, P2 or P3 : Isolated supply system with isolation monitoring

NOTE — Normal condition means 'without any fault' in the installation.

Special requirement Earth Resistance: 0.1 ohm

Special requirement less than 10 mV

IS 3043: Section 7 - Medical Establishments.

CAPE ELECTRIC

25.1.2.4 A main equipotential bonding with a main earthing bar shall be provided near the main service entrance. Connections shall be made to the following parts by bonding conductors:

a) lightning conductor;
b) earthing systems of the electric power distribution system;
c) the central heating system;
d) the conductive water supply line;
e) the conductive parts of the waste water line;
f) the conductive parts of the gas supply; and
g) the structural metal frame-work of the building, if applicable.

Note: Don't forget to ensure recommended safety measures in different areas of the hospital starting from massage room up to Intensive care unit

IS 3043: Section 9 – Miscellaneous installations

CAPE ELECTRIC

28. EARTHING IN POTENTIALLY HAZARDOUS AREAS

28.2 Permissible Type of Earthing System

28.2.1 Guidance on permissible power systems is given below:

a) if a power system with an earthed neutral is used, the type TN -S system with separate neutral (1'.4) and protective conductor (PE) throughout the system is preferred.

   The neutral and the protective conductor shall not be connected together or combined in a single conductor in a hazardous area.

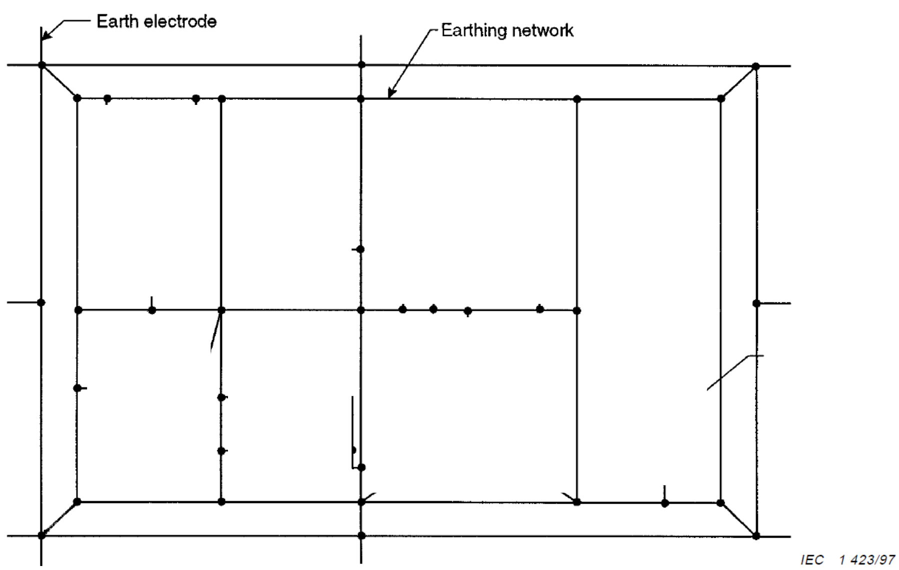
   A power system of type Indian TN-C (having combined neutral and protective functions in a single conductor throughout the system) is not allowed in hazardous area.

b) If IT power system is used in Zone I, it shall be protected with a residual current device even if it is an SELV circuit .

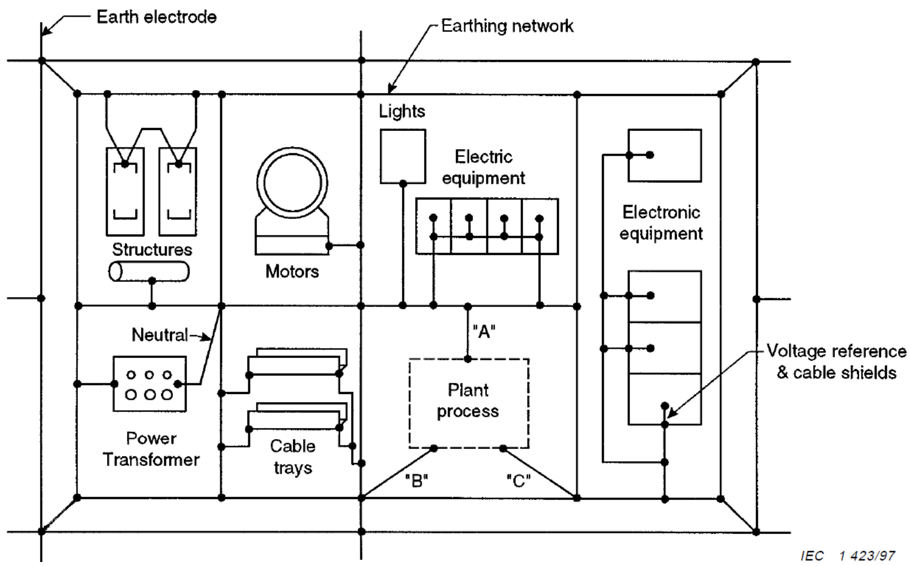
   The type TT power system is not permitted in Zone O.

IS 3043: Recommended approach for the earthing network (PME GRID)

CAPE ELECTRIC



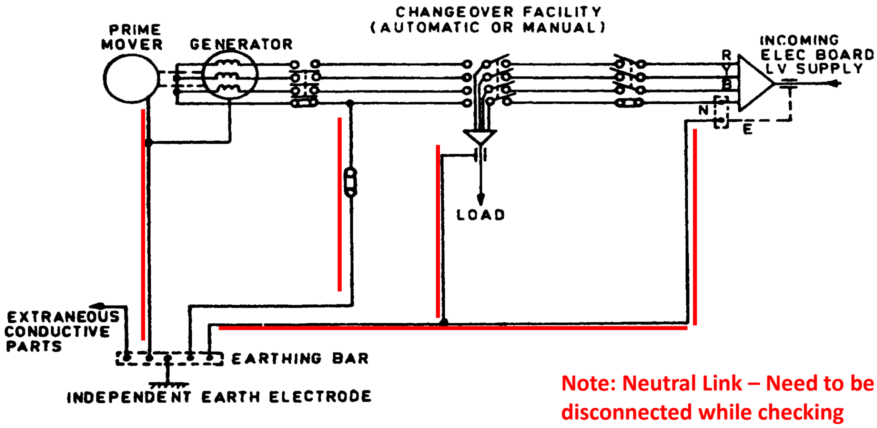
Recommended approach for the earthing network (PME Grid)



One Connection of Body and Neutral of Transformer to GRID

Where is the other connection??? & How Does it work???

Earthing of Generator: IS 3043 Single LV DG (without Synchronizing facility)



Note: Neutral Link – Need to be disconnected while checking loop impedance Line to Neutral

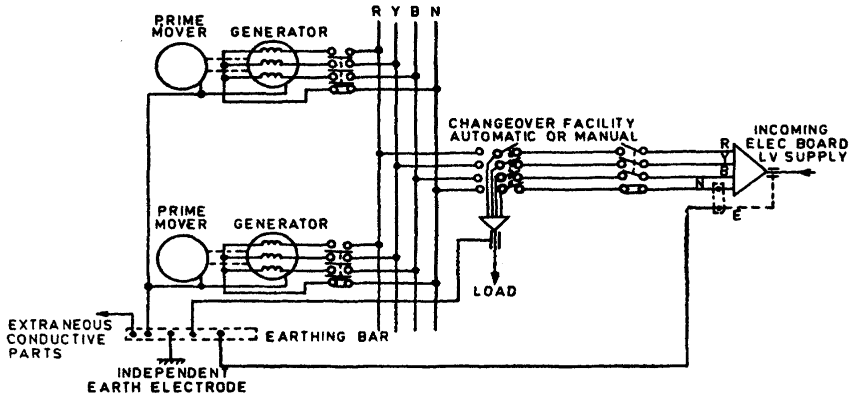
1. Cable sheath earth if provided/ shown - - -
2. PNE link if provided/shown
3. Changeover switch could be 3-pole with linked neutral.

Connected to an Earthing Bus Bar
Bus Bar is connected to Earth Electrode

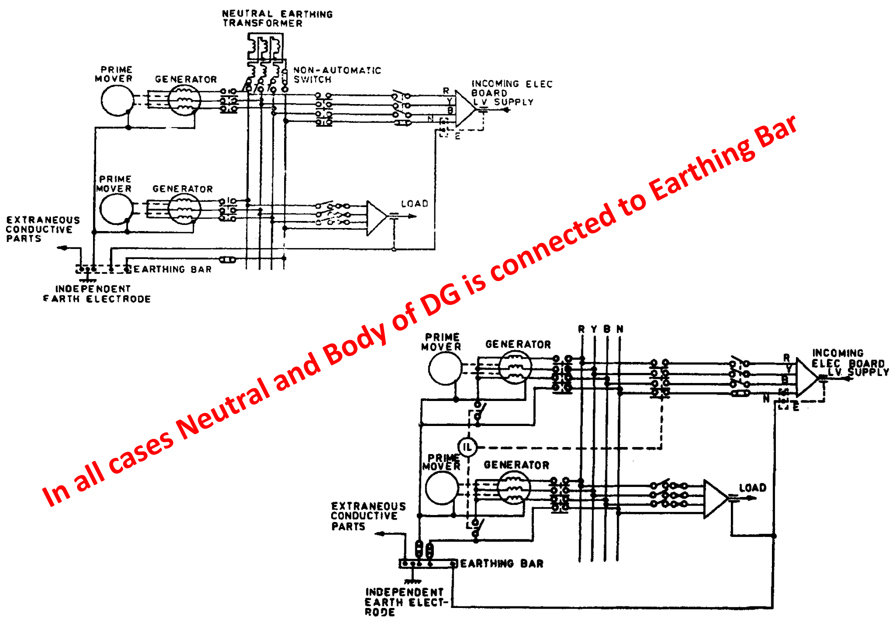
Multiple Generators

Standby generators (without mains paralleling facility) 3 methods are practiced

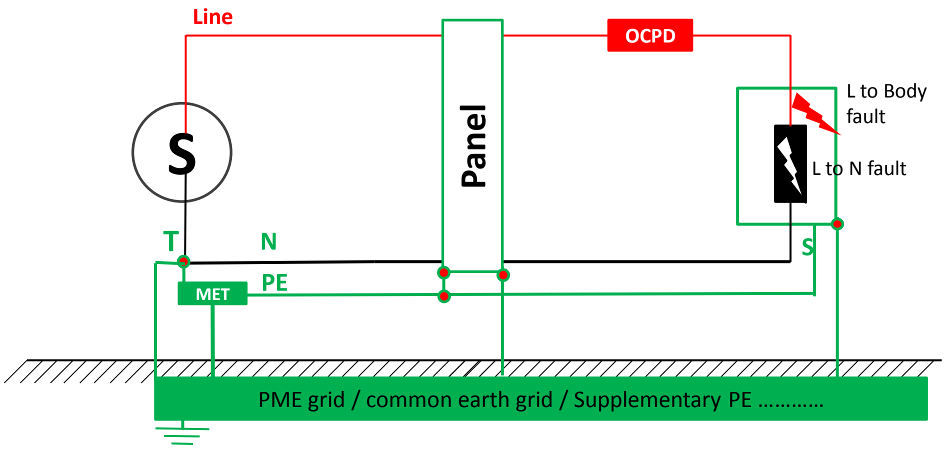
All generator neutrals connected (below fig) , Neutral earthing transformer & Alternator star-point switching



IS 3043: Neutral earthing transformer & Alternator star-point switching



TN-S Network with separate protective conductor

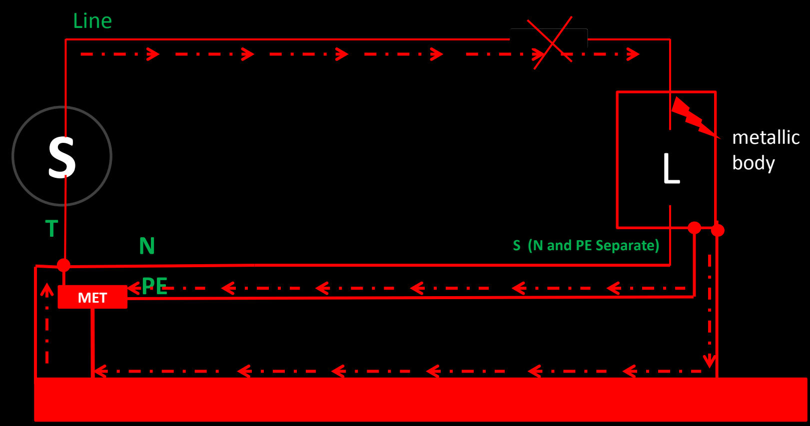


Two Parallel paths for the fault return current ensure Low loop impedance and fast tripping of protective device

PE conductors should be installed in close proximity (i.e. in the same conduits, on the same cable tray, etc.) along with the live cables of the related circuit

TN-S Network with separate protective conductor

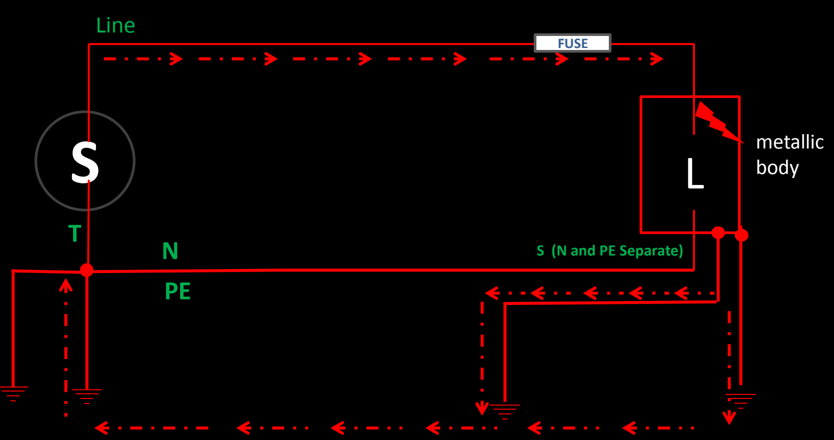
CAPE ELECTRIC



Quick Disconnection of Power supply
More safe
Less chance of fire

Present Scenario

CAPE ELECTRIC

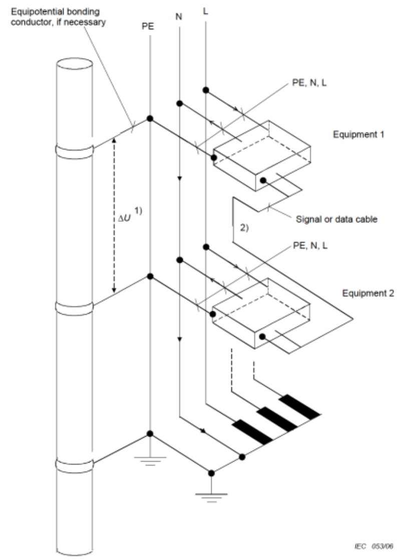


Every equipment or part of installation is connected to separate earth electrode
Often These earth electrodes are interconnected under soil. After few years this interconnection corrodes
Earth resistance of Electrodes are measured. But never continuity resistance of 1 OHM as per IS 3043.

Result: Protective device will take longer time to trip, which creates hazard

Application examples. TN-S network for IT installations

CAPE ELECTRIC



oltage drop ΔU along the PE conductor under normal operation conditions
s of limited area formed by signal or data cables

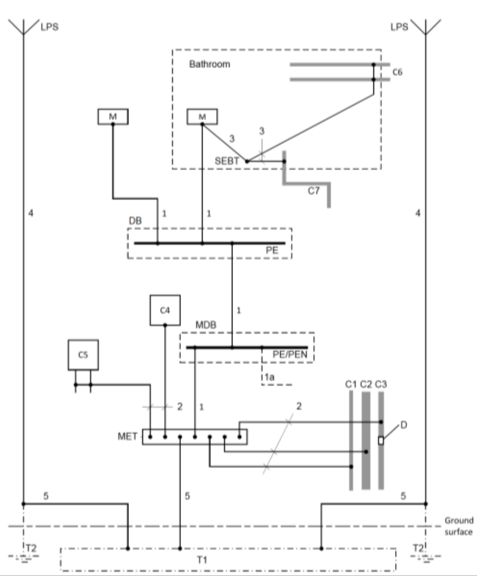
444.4.3.3

In existing buildings where the complete low-voltage installation including the transformer is operated only by the user and which contain, or are likely to contain, significant amounts of information technology equipment, TN-S systems should be installed;

Pic: Avoidance of neutral conductor currents in a bonded structure by using a TN-S system downstream of a consumer's private supply transformer

Earthing IEC 60364-5-54

CAPE ELECTRIC



C	Extraneous-Conductive-part
C1	Water pipe, metal from outside
C2	Waste water pipe, metal from outside
C3	Gas pipe with insulating insert, metal from outside
C4	Air-conditioning
C5	Heating system
C6	Water pipe, metal e.g in a bathroom
C7	Waste water pipe, metal e.g in a room
MDB	Main Distribution Board
DB	Distribution Board
MET	Main Earth Terminal
SEBT	Supplementary Equipotential Bonding terminal
T1	Concrete-embedded foundation earth electrode or soil-embedded foundation earth electrode
T2	Earth electrode for LPS if necessary
LPS	Lightning Protection system (if any)
PE	PE terminal(s) in the distribution board
PE/PEN	PE/PEN terminal(s) in the main distribution board
M	Exposed-conductive part
1	Protective Earthing conductor (PE)
1a	Protective Conductor, or PEN conductor, if any, from supplying network
2	Protective bonding conductor for connection to the main earthing terminal
3	Protective bonding conductor for supplementary bonding
4	Down conductor of a lightning protection system (LPS) if any
5	Earthing conductor

Earthing IEC 60364-5-54

542.2.3 The following are examples of earth electrodes which may be used:

– concrete-embedded foundation earth electrode;

NOTE For more information see Annex C.

– soil-embedded foundation earth electrode;
– metallic electrode embedded directly in soil vertically or horizontally (e.g. rods, wires, tapes, pipes or plates);
– metal sheath and other metal coverings of cables according to local conditions or requirements;
– other suitable underground metalwork (e.g. pipes) according to local conditions or requirements;
– welded metal reinforcement of concrete (except pre-stressed concrete) embedded in the earth.

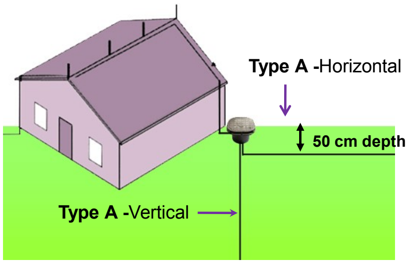
One system .... One earthing

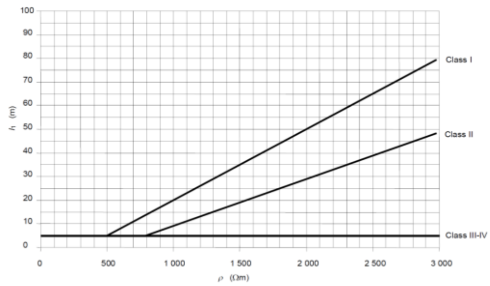
Earthing for Lightning Protection

LPS Earthing - Type A arrangement (IS/IEC 62305)

This type of arrangement comprises horizontal or vertical earth electrodes installed outside the structure to be protected connected to each down conductor. In type A arrangements, the total number of earth electrodes shall be not less than two. (minimum 2 down conductors for a building)

Suitable for small building with electricity connection

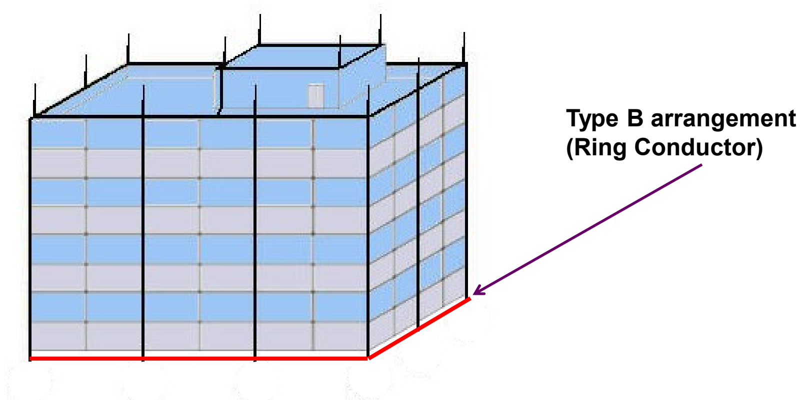




The minimum length of each earth electrode for each down-conductor as per graph
– l_1 for horizontal electrodes, or – 0.5 l_1 for vertical (or inclined) electrodes, For combined (vertical or horizontal) electrodes, the total length shall be considered

Resistance of 10 OHM is also recommended, but can be ignored with the above length

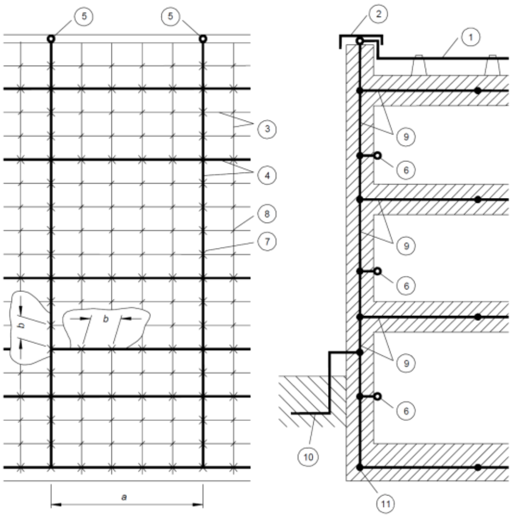
LPS Earthing: Type B arrangement (Ring / Foundation Earthing)



This type of arrangement comprises either a ring conductor external to the structure to be protected, in contact with the soil for at least 80 % of its total length, or a foundation earth electrode.
Such earth electrodes may also be meshed.
Recommended for buildings with Electronic Installation

LPS Earthing: Type B arrangement (Ring / Foundation Earthing)

Conductor inside an RCC structure (or under an RCC structure) can be used for Earthing & equipotential bonding.



1. air-termination conductor
2. metal covering of the roof parapet
3. steel reinforcing rods
4. mesh conductors superimposed on the reinforcement
5. joint of the mesh conductor
6. joint for an internal bonding bar
7. connection made by welding or clamping
8. arbitrary connection
9. steel reinforcement in concrete (with superimposed mesh conductors)
10. ring earthing electrode (if any)
11. foundation earthing electrode

a typical distance of 5 m for superimposed mesh conductors
b typical distance of 1 m for connecting this mesh with the reinforcement

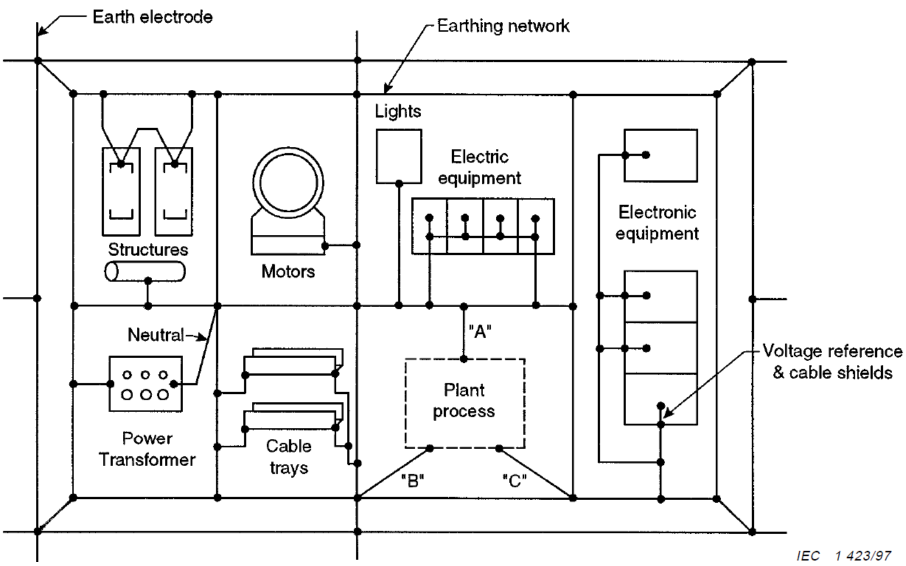
Nothing Exposed
Do not affect aesthetics
Most efficient for electronics

Use of Structural steel for earthing is not new in India

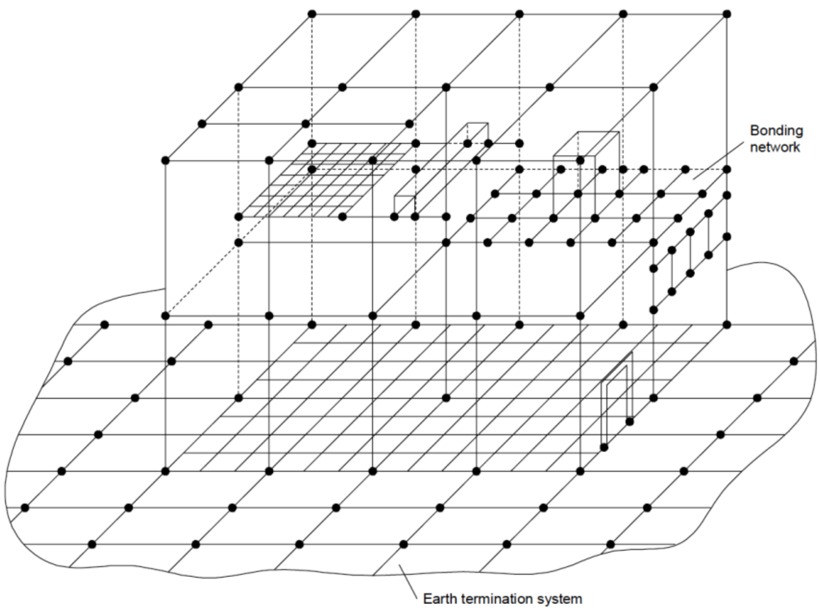
IS 3043: SECTION 4 POWER STATIONS, SUBSTATIONS AND OVERHEAD LINES

At power stations and substations the steel reinforcement in foundations and piles can be used to provide an effective electrode system, without necessity to provide further buried electrodes. Where piles are used they should be bonded by welding and connected to earth bonding bars at least four points.

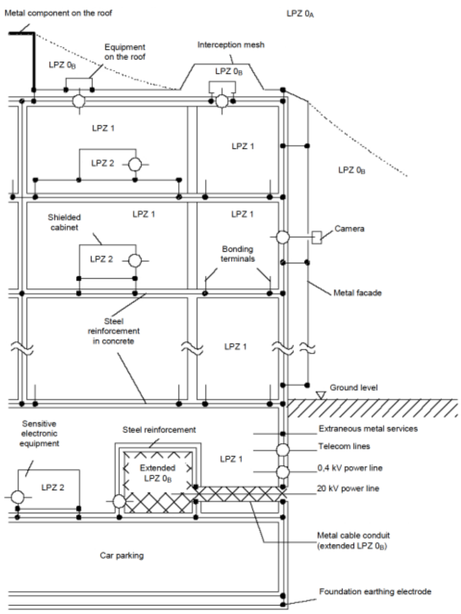
Recommended approach for the earthing network



3 D schematic of the recommended approach for the earthing network



Practical example as per IS/IEC 62305 and NBC-1026



No extended vertical earth electrode in soil
Transformer and Dg inside building
All 5 purposes of earthing is achieved

Further questions are

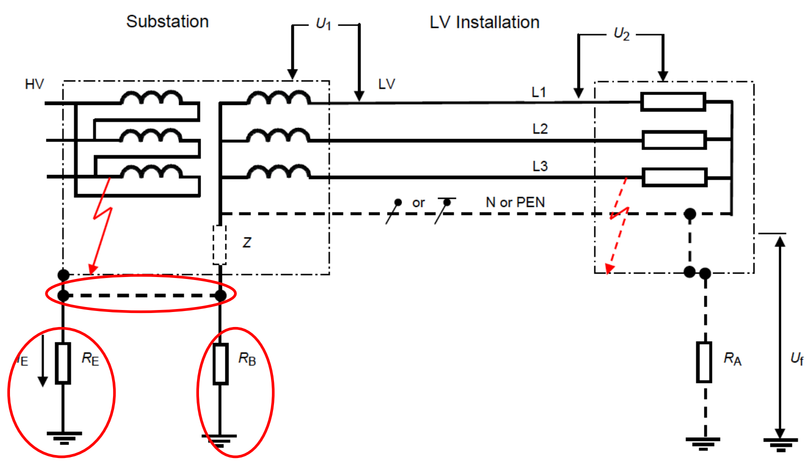
How to Earth HT side of transformer

How to connect UPS

How to connect sensitive equipment

Earthing of Transformer: Influences in LV Supply due to a fault in HV side

Possible connections to earth in substation and LV-installation and occurring overvoltage in case of faults



R_E: Transformer Body Earthing
R_B: Star Point – Neutral earthing
R_E and R_B connection method will have an influence in LT system

R_E and R_B connection method will have an influence in LT system (TOV)

CAPE ELECTRIC

Types of system earthing	Types of earth connections	U_1	U_2	U_f
TT	R_E and R_B connected	U_o *)	$R_E \times I_E + U_o$	0 *)
	R_E and R_B separated	$R_E \times I_E + U_o$	U_o *)	0 *)
TN	R_E and R_B connected	U_o *)	U_o *)	$R_E \times I_E$ **)
	R_E and R_B separated	$R_E \times I_E + U_o$	U_o *)	0 *)
IT	R_E and Z connected R_E and R_A separated	U_o *)	$R_E \times I_E + U_o$	0 *)
		$U_o \times \sqrt{3}$	$R_E \times I_E + U_o \times \sqrt{3}$	$R_A \times I_h$
	R_E and Z connected R_E and R_A interconnected	U_o *)	U_o *)	$R_E \times I_E$
		$U_o \times \sqrt{3}$	$U_o \times \sqrt{3}$	$R_E \times I_E$
	R_E and Z separated R_E and R_A separated	$R_E \times I_E + U_o$	U_o *)	0 *)
		$R_E \times I_E + U_o \times \sqrt{3}$	$U_o \times \sqrt{3}$	$R_A \times I_d$

*) No consideration needs to be given.

**) See 442.2.1 second paragraph.

(shaded) With existing earth fault in the installation.

U_0 – Line Voltage U_1: Over voltage at Source U_2: Over Voltage at Load

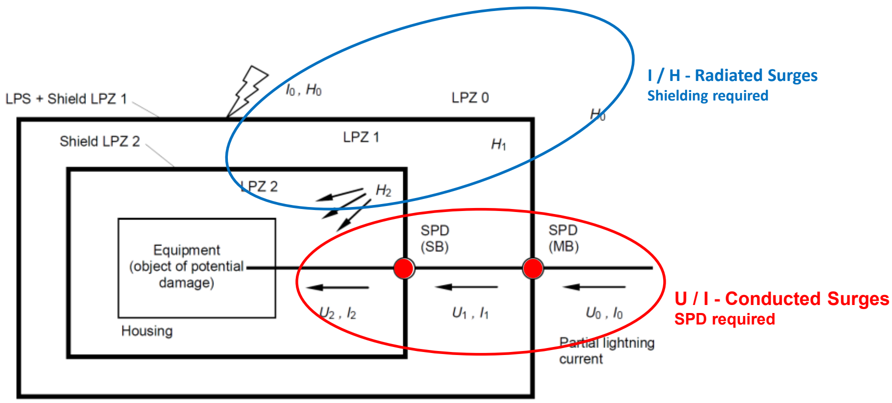
U_f: Power frequency Fault Voltage

CAPE ELECTRIC

One system ……………… One earthing

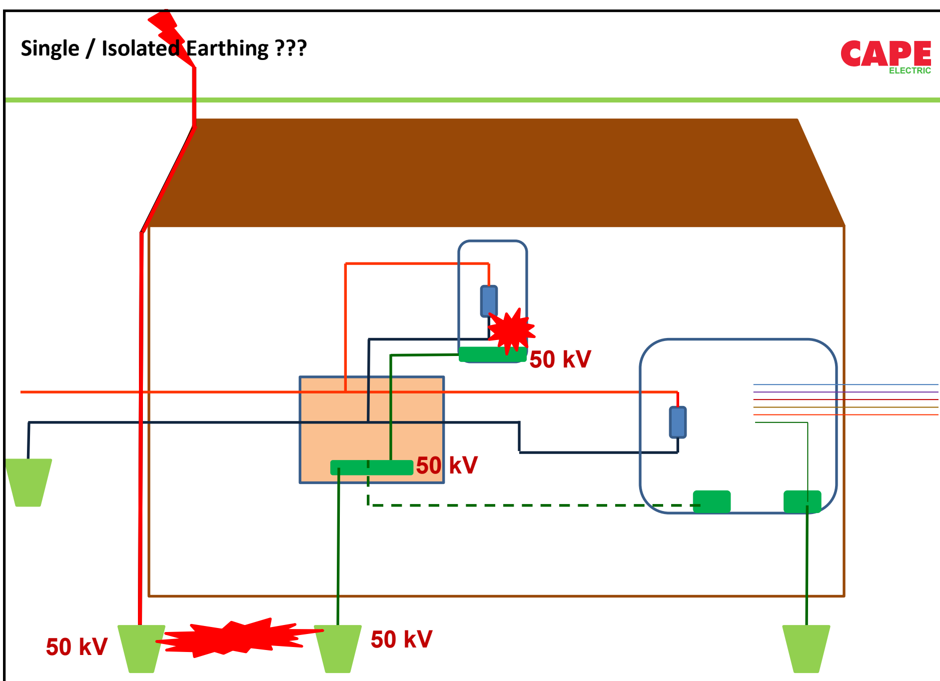
Equipotentialisation

Conducted and Radiated Surges Equipotentialisation & ZONAL Concept



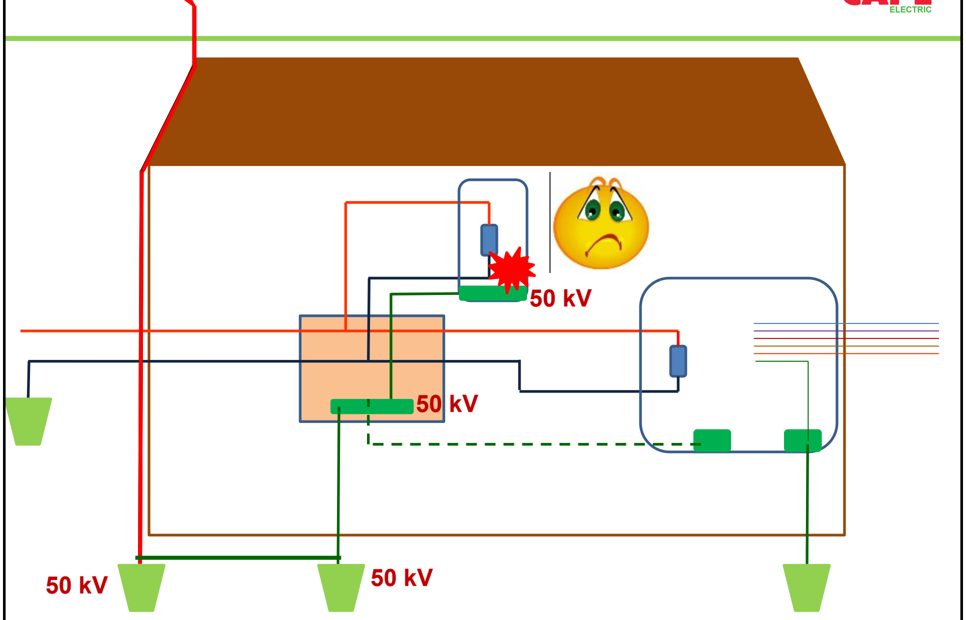
Equipotentialisation – NO Potential difference between metallic installations / parts Equal at every ZONE Boundaries

Single / Isolated Earthing ???



Single / Isolated Earthing ???

CAPE ELECTRIC

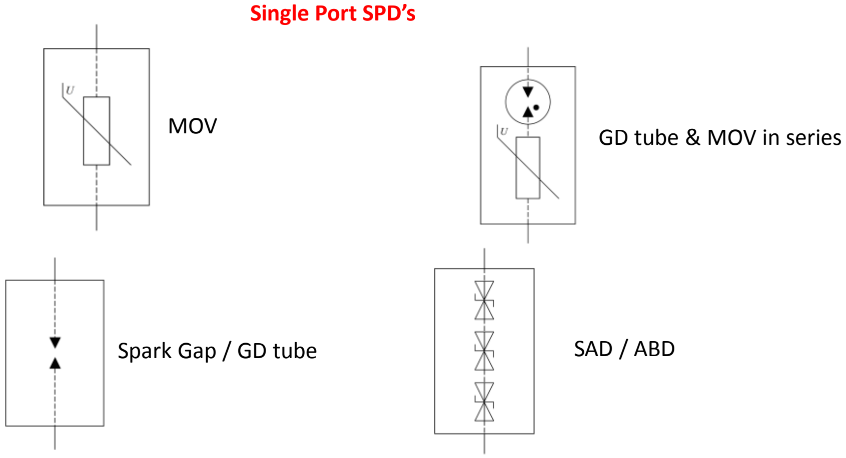


Surge Protective Device (SPD). What is inside an SPD ??

CAPE ELECTRIC

SPD's are devices that contains atleast one non-Lenear component, which is intended to limit surge voltage and divert surge current

Single Port SPD's



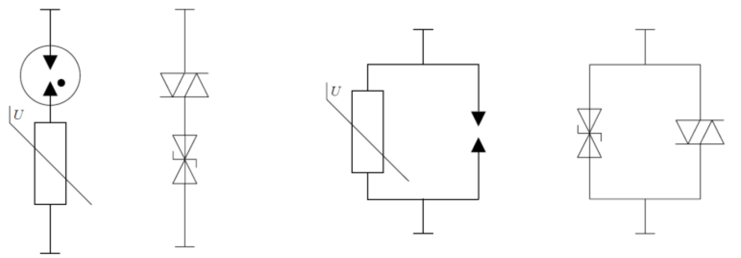
SPD's are connected in Parallel. They reduce the resistance during an over voltage

Type of SPD's by Construction

CAPE ELECTRIC

Voltage limiting Component

Voltage switching Component

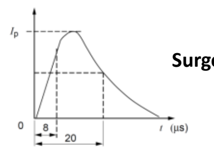


Voltage switching in series with voltage limiting Component

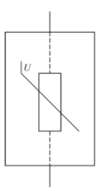
Voltage switching in parallel with voltage limiting Component

How SPD works ???

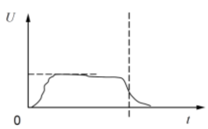
CAPE ELECTRIC



Surge Voltage - Several times Nominal Voltage

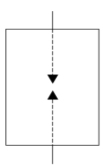


MOV /SAD

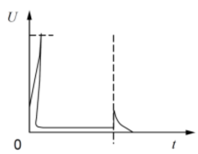


Voltage Clamping (limiting) device – SPD that has a high impedance when no surge is present, but will reduce it continuously with increased surge current and voltage

Limits the Voltage depending upon the Surge Current



Spark Gap / GD tube



Voltage Switching Device – SPD that has a high impedance when no surge is present, but can have a sudden change in impedance to a low value in response to a voltage surge

Eg - Short-Circuit during transient Voltage

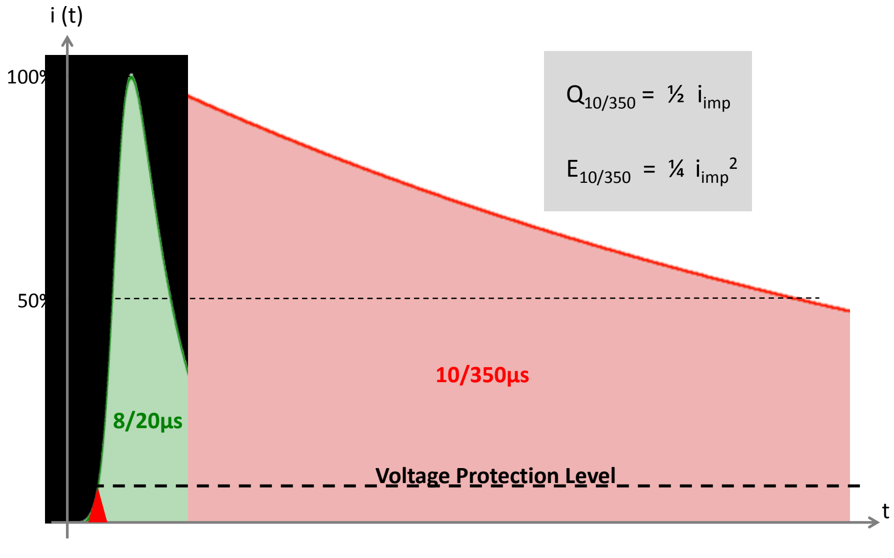
Basic functions of SPDs

- In the absence of surges the SPD shall not have a significant influence on the operational characteristics of the system to which it is applied.
  Problem – MOV based SPD. TOV's will influence SPD (Short-circuit in SPD)
- During the occurrence of surges: the SPD responds to surges by lowering its impedance and thus diverting surge current through it to limit the voltage to its protective level. The surges could initiate a power follow current through the SPD.
  Problem – Spark-Gap based SPD. Follow current may create dangerous situation
- After the occurrence of surges: the SPD recovers to a high-impedance state after the surges and extinguishes any possible power follow current
  Problem – Spark-Gap based SPD. Follow current may create dangerous situation

Additional requirement

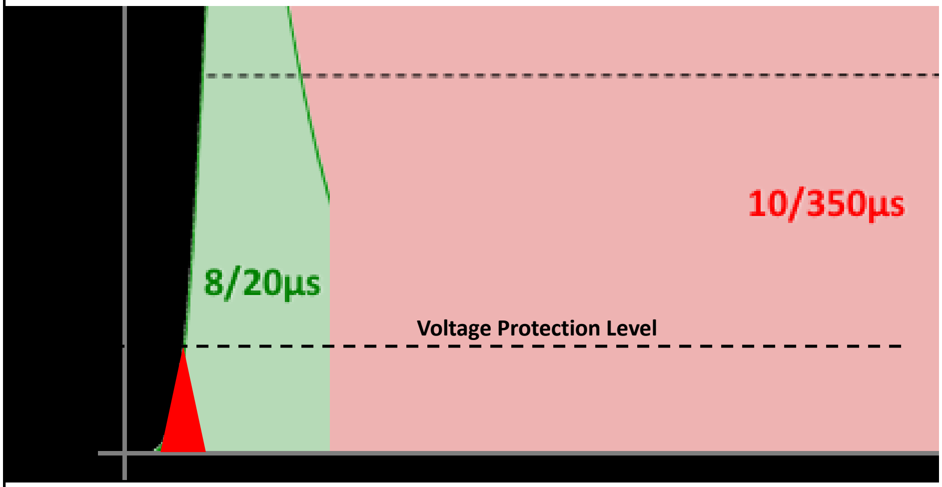
- protection of SPDs against direct contact
- safety in the event of SPD failures.

Test pulses asa per IEC 61643-11



Test pulses asa per IEC 61643-11

CAPE ELECTRIC

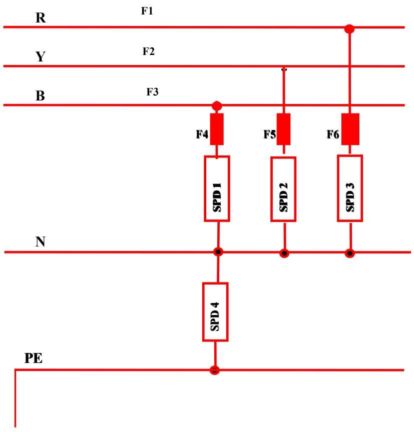


Connection diagram for SPD for 3 phase 4 wire network

CAPE ELECTRIC

Connection 3 + 1

Before RCCB



F1, F2, F3 - : Incoming ACB/MCCB/SFU

F4, F5, F6 -: Back up fuse for Surge Arrester

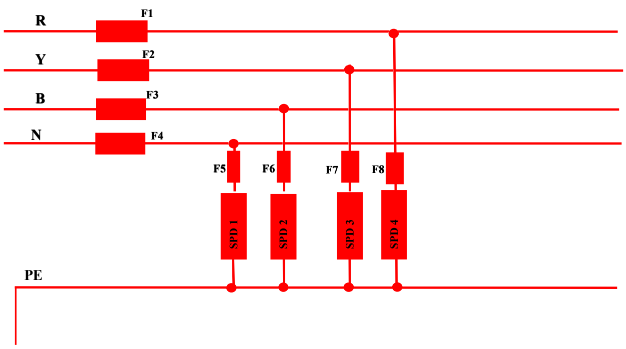
PE - : Panel Earth

For backup fuse rating refer manufacturers catalogue

Connection diagram for SPD for 3 phase 4 wire network

Connection R,Y,B,N to PE

After RCCB



F1, F2, F3 - : Incoming ACB/MCCB/SFU

F4, F5, F6 -: Back up fuse for Surge Arrester

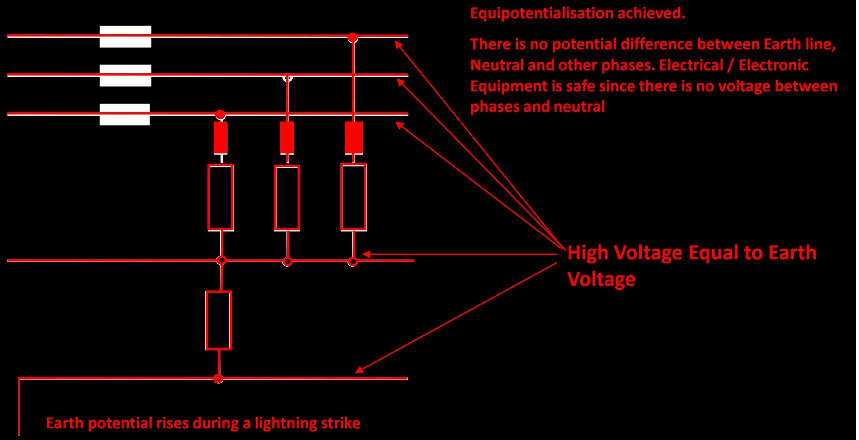
PE - : Panel Earth

For backup fuse rating refer manufacturers catalogue

Connection diagram for SPD for 3 phase 4 wire network

Connection 3 + 1

Spark Gap Arresters are considered



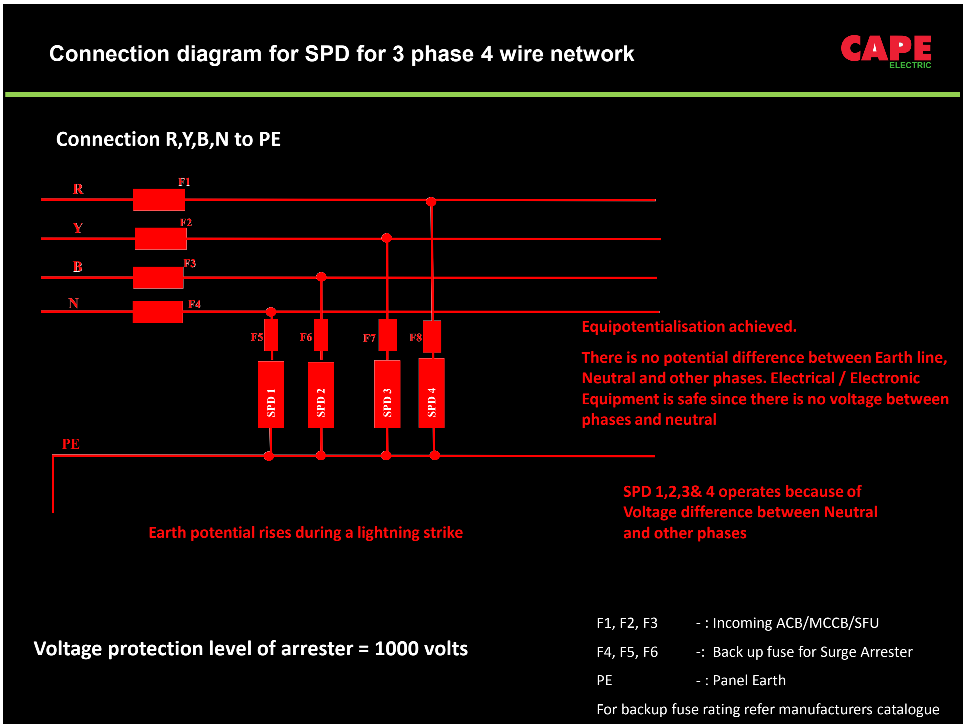
Voltage protection level of arrester = 1000 volts

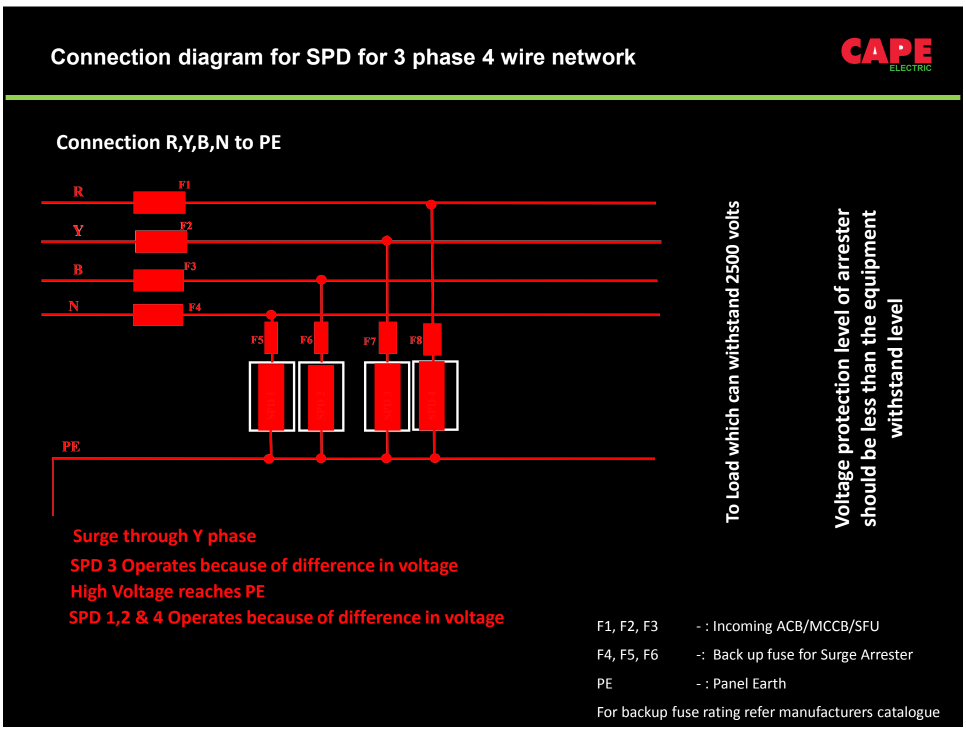
F1, F2, F3 - : Incoming ACB/MCCB/SFU

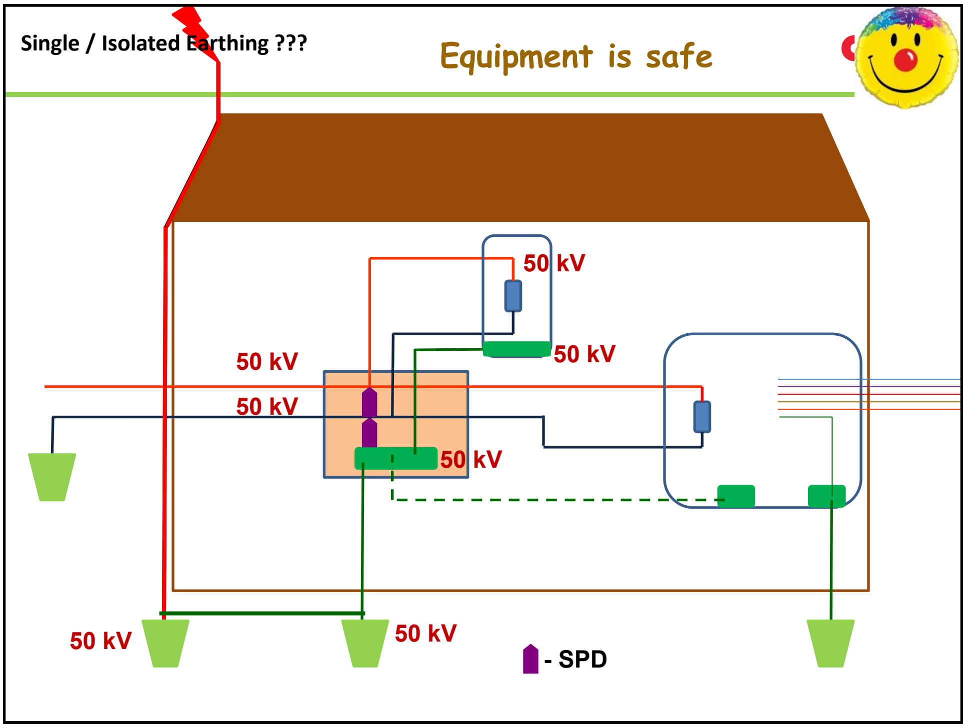
F4, F5, F6 -: Back up fuse for Surge Arrester

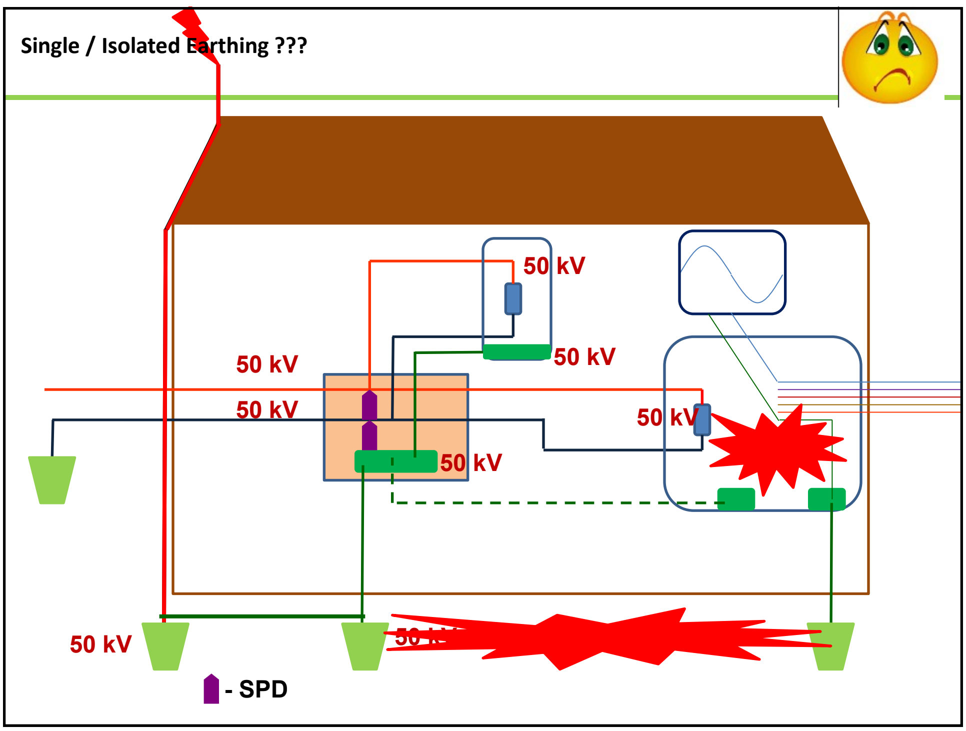
PE - : Panel Earth

For backup fuse rating refer manufacturers catalogue

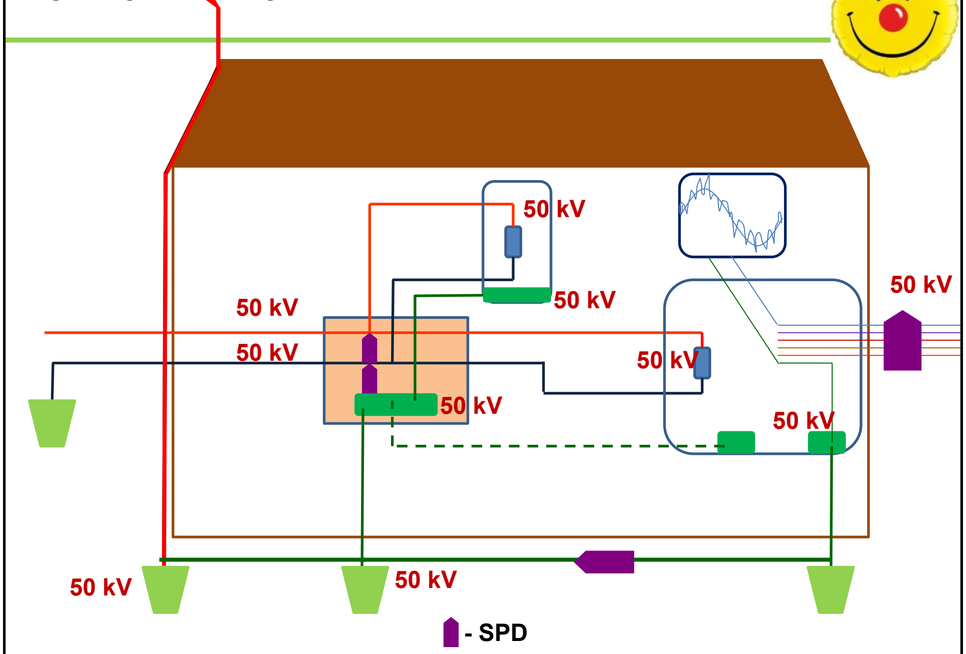

Connection diagram for SPD for 3 phase 4 wire network
CAPE ELECTRIC
Connection R,Y,B,N to PE
R
Y
B
N
F1
F2
F3
F4
F5
F6
F7
F8
SPD 1
SPD 2
SPD 3
SPD 4
PE
Equipotentialisation achieved.
There is no potential difference between Earth line, Neutral and other phases. Electrical / Electronic Equipment is safe since there is no voltage between phases and neutral
SPD 1,2,3& 4 operates because of Voltage difference between Neutral and other phases
Earth potential rises during a lightning strike
Voltage protection level of arrester = 1000 volts
F1, F2, F3 - : Incoming ACB/MCCB/SFU
F4, F5, F6 -: Back up fuse for Surge Arrester
PE - : Panel Earth
For backup fuse rating refer manufacturers catalogue


Connection diagram for SPD for 3 phase 4 wire network
CAPE ELECTRIC
Connection R,Y,B,N to PE
R
Y
B
N
F1
F2
F3
F4
F5
F6
F7
F8
PE
To Load which can withstand 2500 volts
Voltage protection level of arrester should be less than the equipment withstand level
Surge through Y phase
SPD 3 Operates because of difference in voltage
High Voltage reaches PE
SPD 1,2 & 4 Operates because of difference in voltage
F1, F2, F3 - : Incoming ACB/MCCB/SFU
F4, F5, F6 -: Back up fuse for Surge Arrester
PE - : Panel Earth
For backup fuse rating refer manufacturers catalogue


Single / Isolated Earthing ???
Equipment is safe
50 kV
50 kV
50 kV
50 kV
50 kV
50 kV
50 kV
- SPD

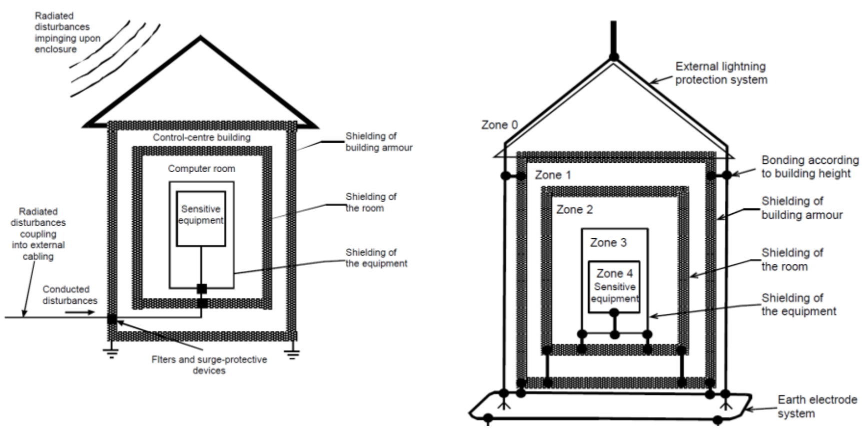

Single / Isolated Earthing ???
50 kV
50 kV
50 kV
50 kV
50 kV
50 kV
50 kV
- SPD

Single Integrated Earthing with SPD is the best



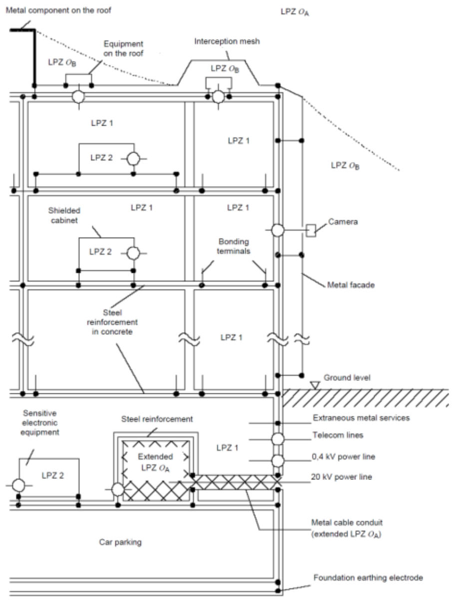
Conducted and Radiated Surges Equipotentialisation & ZONAL Concept

CAPE ELECTRIC



Protection of Equipment in an office complex (IS/IEC 62305)

CAPE ELECTRIC



IS 62305 - 4

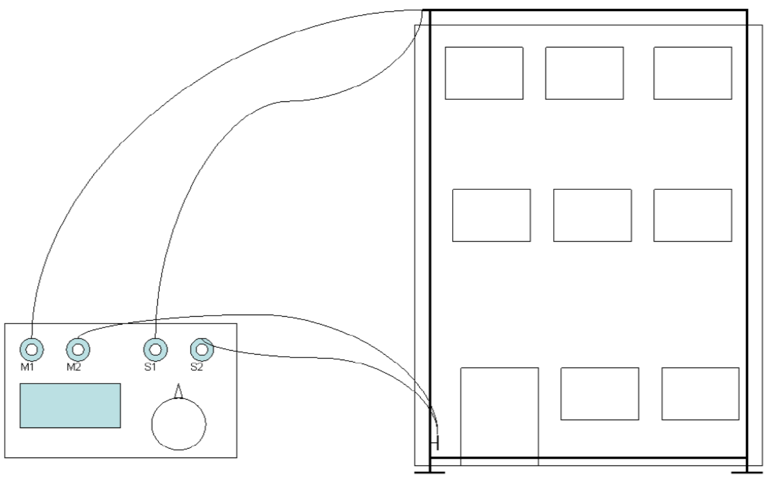
HV Transformer inside Large Buildings
Generators inside structure
Lightning Protection
Electrical System
Electronic System

STILL ONE EARTHING
Concrete Embedded Foundation Earthing

Remember – Water proof membrane under foundation

Structural Earthing – Testing Provisions need to be provided at top and bottom

CAPE ELECTRIC



Resistance Less than 0.2 Ohm

Corrosion Bi-Metallic & Galvanic effects

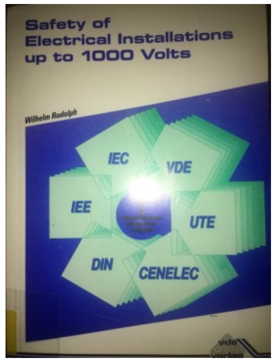
CAPE ELECTRIC

Electro chemical influence on and between earth electrodes

Metals laid in soil or water may be corroded by the following influence

- DC Leakage current in the soil
- Chemical components and their concentration in soil or water
- Galvanic cells formed by interconnected earth electrodes of different metals

Protection by means of non metallic covering of electrodes is not suitable because of the high electrical resistance of such materials.



Very important is the case where the earth electrodes form galvanic cells with other earth electrodes or with buried steel pipes and conduits. With underground metallic structures or building foundations provided they are metallically interconnected.

Courtesy: Safety of electrical installation up to 1000 volts by Mr. Wilhelh Rudolph

Corrosion Bi-Metallic & Galvanic effects
Potential Difference of metals in electrolyte

CAPE ELECTRIC

Table 54-C Potential differences of metals in electrolytes [5, 6, 7]

Metal in soil with moisture content	Cupric-sulphate, Cu/Cu SO_4, comparison electrode		
	Values acc. to K. Vögtli, Bern	Values acc. to E. Hönninger, Graz	DIN VDE 0151/06.86
Zinc and galvanized steel	−0,7 V … −1,0 V	… −1,15 V	−0,9 V … −1,1 V
Copper	0,0 V … −0,2 V	… −0,15 V	0 V … −0,1 V
Steel	−0,5 V … −0,8 V	… −0,95 V	−0,5 V … −0,8 V
Steel, rusty	−0,4 V … −0,6 V		
Steel in humus		−0,6 V … −0,8 V	
Steel in clean sand		−0,4 V … −0,5 V	
Steel in concrete	−0,1 V … −0,3 V	−0,05 V … −0,2 V	−0,1 V … −0,4 V
Zinc			−0,9 V … −1,1 V
Lead			−0,5 V … −0,6 V

IS 3043: The possibility on damage to cables and other underground services and structural metalwork in the vicinity of earth-electrode due to electrolytic action between dissimilar materials should not be overlooked when the material for earth-electrodes is selected. Materials compatible with other metal structures in the vicinity should be selected or other remedial action taken

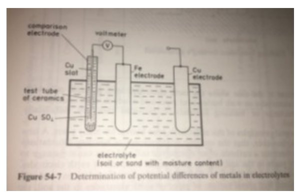


Figure 54-7 Determination of potential differences of metals in electrolytes

The fundamental principle of this effect have been known for many years.

Courtesy: Safety of electrical installation up to 1000 volts by Mr. Wilhelh Rudolph

Corrosion Bi-Metallic & Galvanic effects

CAPE ELECTRIC

A DC current between anode and cathode in the electrolyte results form the influence of the potential difference of the galvanic cell (fig 54-8), formed by the different materials of the earth electrodes by the electrolyte of the moisture content of the soil, and through the bonding of the anodic and cathodic earth electrodes. With in the anodic range, this current leaves the surface of the electrode towards the electrolyte, thus dissolving the metal of the anode. This current enters the metallic surface of the electrode in the cathodic area.

This electrolytic current passes losses of the mass of the anodic earth electrode. The speed of the the metallic looses (corrosion rate) depends mainly on the voltage of the galvanic cell.

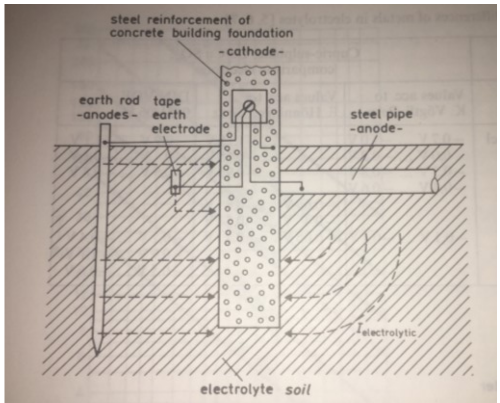


Figure 54-8 Earthing installation forming a galvanic cell

Courtesy: Safety of electrical installation up to 1000 volts by Mr. Wilhelh Rudolph

Corrosion Bi-Metallic & Galvanic effects

CAPE ELECTRIC

Interconnection of all earth electrodes for different purpose with other earthed construction is recommended for increased electrical safety. Electrical isolation of various electrodes is no solution for protection of the electrodes against corrosive effect. The only reliable solution is the correct selection and installation of electrodes. The basic of this selection rule is the knowledge of the potential difference of different metals in an electrolyte.

A new experience is however that the metallic reinforcement of building foundations may likewise become a cathode of an electrolytic cell and thus cause damage to other metallic parts in the soil. Eg to water pipes, conduits or earth electrodes. With the ever increasing size of buildings and their foundations and the relatively reduced free metallic surface of pipes or earth electrodes in the soil, the surface relationship of anode to cathode becomes increasingly unfavorable. The danger of corrosion must necessarily increase when using metals with large potential differences according to table 54-C.

Courtesy: Safety of electrical installation up to 1000 volts by Mr. Wilhelh Rudolph

Corrosion Bi-Metallic & Galvanic effects

Metallurgy (anodic Index) (courtesy – www.corrosion-doctors.org)	Index (Volt)
Gold, solid and plated & Gold-platinum alloy	0.00
Silver, solid or plated, monel metal & High nickel-copper alloys	0.15
Nickel, solid or plated, titanium and alloys & Monel	0.30
Copper, solid or plated, low brasses or bronzes, copper-nickel-chromium alloys	0.35
Brass and bronzes	0.40
High brasses and bronzes	0.45
Lead, solid or plated, high lead alloys	0.70
Iron, wrought, gray or malleable, plain carbon and low alloy steels	0.85
Hot-dip-zinc plate, galvanized steel	1.20
Zinc, wrought, zinc-base die-casting alloys, zinc plated	1.25
Magnesium & magnesium-base alloys, cast or wrought	1.75

Corrosion is an electrochemical process. Copper plated materials are less corrosive than Galvanised steel. Corrosion resistance of copper plated material is equal to or better than copper (due to Nickel copper alloy)

Anodic Voltage of GI – 1.2 V
Anodic Voltage of copper – 0.30
Due to 0.9 to 1 volt difference copper (or steel in concrete) will absorb GI in soil

Selection of Materials for Structural Earthing
(ref IS/IEC 62305-3)

E.4.3.4 Materials

Galvanised Material inside concrete is a problem

The ... otection purposes: steel, mild steel, galvanized steel, stainless steel, copper and copper coated steel".

The behavior of a galvanized layer on steel in concrete is very complicated, particularly in concrete with chlorides, the zinc will corrode quickly on contact with the reinforcement, and can under certain conditions cause damage to the concrete. Galvanized steel should therefore not be used in coastal areas and where there may be salt in the ground water. As the use of galvanized steel in concrete requires evaluation of many external factors this material should be used only after careful analysis. With this in mind the use of the other mentioned materials is preferred over the use of galvanized steel.

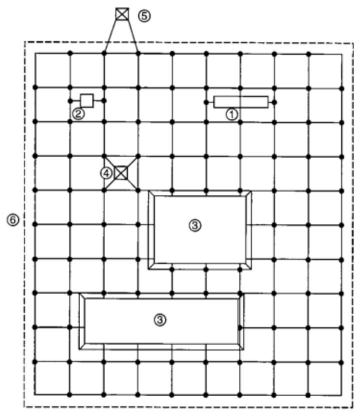
In order to avoid confusion between the different types of steel rods in concrete, it is recommended that round steel rods of at least 8 mm diameter with a smooth surface be used as additional conductors in contrast to the ordinary ribbed surface of the reinforcing rods.

Galvanic corrosion between steel in RCC and steel in soil

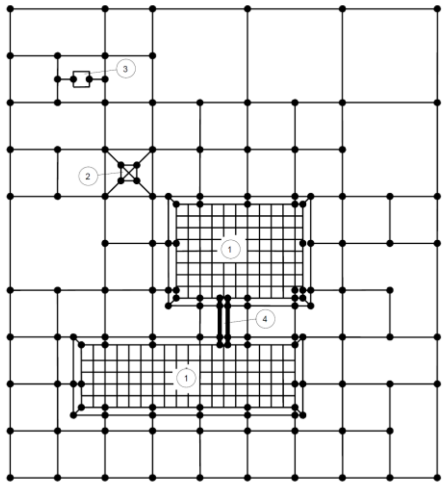
From Clause E.5.4.3.2
A further problem arises from electrochemical corrosion due to galvanic currents. Steel in concrete has approximately the same galvanic potential in the electrochemical series as copper in soil. Therefore, when steel in concrete is connected to steel in soil, a driving galvanic voltage of approximately 1 V causes a corrosion current to flow through the soil and the wet concrete and dissolve steel in soil.

Copper / Stainless Steel / Copper coated Steel are the best

Schematic plan view of a typical earth electrode for an industry / building complex



① Metallic frame
② Stand-alone apparatus or system
③ Building
④ High- or medium-voltage tower inside the plant
⑤ High- or medium-voltage tower near the plant
⑥ Fence



1) building with meshed network of the reinforcement
2) tower inside the plant
3) stand-alone equipment
4) cable trenches

Signal Earthing
Communication / Sensitive electronic Equipment Earthing

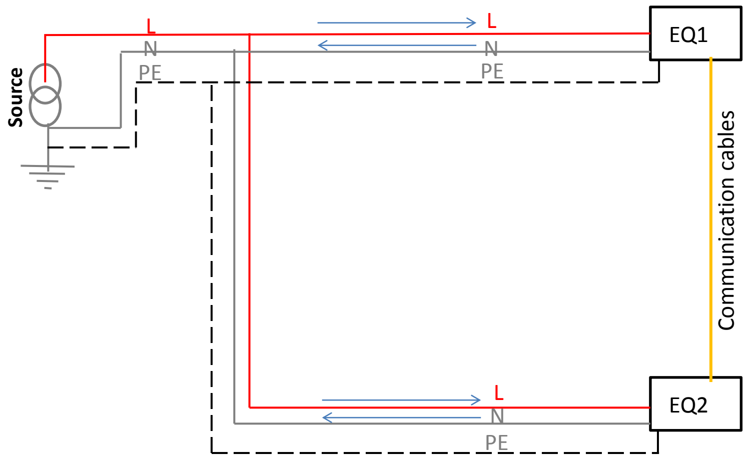
microprocessor-based systems such as computers, PLC's,
industrial process plant DCS's,
telecommunications systems,
medical diagnostic imaging
other related sensitive electronic equipment

IEEE 142:

Isolated equipment ground:

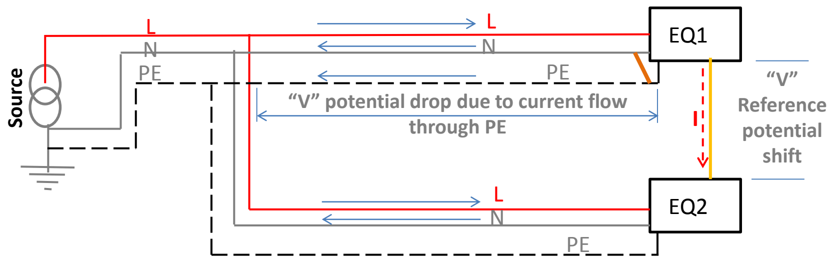
An insulated equipment grounding conductor (EGC) run in the same conduit or raceway as the supply conductors. This conductor is insulated from the metallic raceway and all ground points throughout its length. It originates at an isolated ground type receptacle or equipment input terminal block. The conductor may pass through one or more panel boards without connection to the panel-board grounding terminal, and terminates at an EGC terminal at the applicable derived system or service.

TN-S system. Two electronic devices connected with a communication cable powered form the same source



Microprocessors in sensitive electronic equipment operate at very low voltage. They need reference voltage. Reference of voltage is mostly the Earth Terminal of the equipment.
PE conductor used for safety purpose will substitute signal reference also during normal operation

Signal Earthing requirement.



Under **several conditions**, signal reference may change due to measurable voltage difference in the earth conductor.

Eg Connection between N and PE near EQ1. Partial Neutral current flows back to source through PE conductor

"V" voltage drop in PE conductor is created

This potential difference "V" is experienced between EQ1 and EQ2. Reference potential of the equipment changes

Reference potential shift creates an undesired current flow in the signal cable.

Quote from IEEE 142:

It is not unusual to find the branch circuit distribution panel neutral bus bar connected to the metallic panel frame (ground), which is a violation of the NEC. One study showed 20% of the neutral conductors accidentally faulted to ground in circuits supplying lighting fixtures. With multiple connections of the neutral conductor to ground on the same power system, a portion of the load current flowed on the equipment grounding system to which the electronic equipment was referenced. This current flow transferred voltages into the grounding system of the electronic equipment, causing errors or worse.

Quote from IEEE 142:

Electronic equipment: Like the electrical power supply system, electronic equipment has diversified systems to be grounded, as follows:

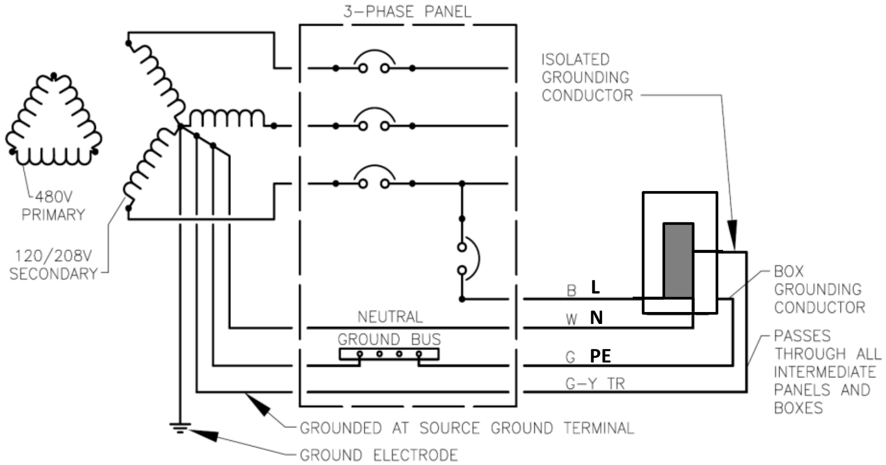
a) ***Signal common grounding***. The signal common is also referred to as the *dc signal common*. The zero reference system for data lines, and the signal portion in general, represents the sensitive neutral of the electronic equipment. This is one of the systems that is sensitive to transient voltages and requires a stable reference point, with respect to a voltage potential.

b) ***DC power supply reference ground bus***. The electronic equipment may have several different dc voltage systems, such as + 12 / 0 / – 12 V, + 5 / 0 / – 5 V.

c) ***Equipment ground bus***. This is the metallic enclosure, or frame, of the electronic equipment. This may include the chassis of the electronic equipment elements, as well as the outer enclosure or cabinet. Some electronic equipment manufacturers refer to the equipment ground bus as the *safety ground bus.*

In addition to these terms for the various ground bus systems, you may encounter such terms as: *ac safety (mains) grounds, computer reference ground, dc signal common, earth common, dc ground bus, dc master ground point*, and *power supply common ground point.* It appears that each electronic equipment company has generated its own term for various grounded parts of their systems. There is no uniformity in the terminology, although as you will see later, they all must end up connected together.

Solution: Single Point Earthing. (courtesy IEEE142)



To prevent stray continuous currents or circulating currents from affecting the electronic equipment signals and operation, it is necessary to keep the electronic equipment ground system separate from the equipment ground components and connected together *at only one point*

Recommended practice in NBC - 2016

[redacted]

1. Isolation Transformer
2. Core
3. Shield
4. All earthing connections made at a point
5. Connection to building steel / earth pits / ring earthing
6. Conduit earthing
7. Neutral (approximately 60 to 100 % larger than phase conductor)
8. 230 / 400 volt power panel
9. Neutral BUS *
10. Earth BUS *
11. Earth Connection for Socket / work station / computers
12. 3 pin sockets with isolated earth pin

* both bus bars isolated from panel enclosure. No bonding connection between Neutral and Earth.

Note:

a. Each Branch circuit shall have a separate neutral and earth wire. No daisy Chaining Permitted
b. Only computer or control system should be served from this panel

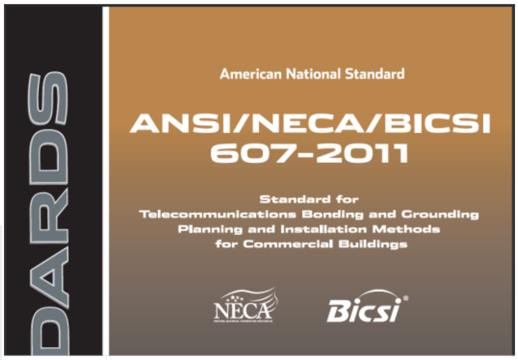
Case Studies - Examples

Special Installations
Hospitals & IT Installations

Wrong - Separate Connection to a low resistance earth electrode in soil

Right - Low resistance and separate connection to an earthing system

Reference from



Separate and Low resistance connection to Earthing system

Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings **NECA/BICSI 607**

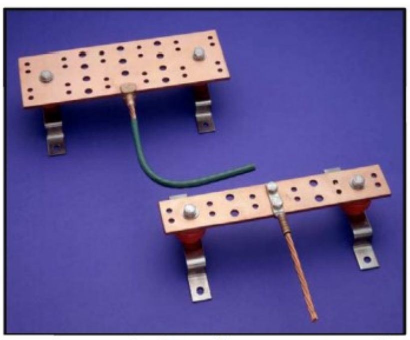


Figure 9. Example of an exothermic connection and a two-hole lug connection to a busbar

a) Trim the insulation back so that the bared conductor is slightly longer (recommended not to exceed 1.6 mm [0.0625 in] of the barrel) than the barrel *(see figure 11)*.

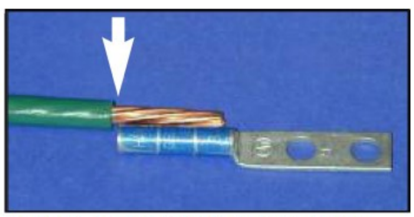


Figure 11. Example of trimmed insulation from a conductor

Separate and Low resistance connection to Earthing system

conductor. The two-hole lug shall also be the long barrel type with an inspection port *(see figure 10)*.

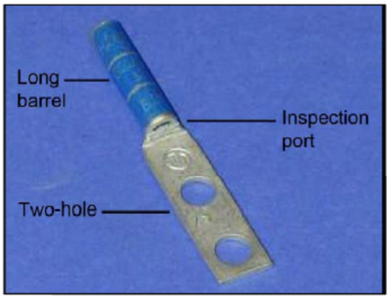


Figure 10. Example of a two-hole lug

7.5.2 Installation

7.5.2.1 **Crimp connection of a two-hole lug to a bonding conductor**

Select the lug size, configuration, and material applicable to the conductor size and fastening conditions. The following steps ensure a reliable connection between the two-hole lug and the bonding conductor using a crimp connection:

b) After applying an antioxidant compound on the exposed conductors, insert the conductor so that it "butts up" against the end of the barrel as viewed through the inspection port. The inspection port allows the installer to visually ensure appropriate conductor insertion *(see figure 12)*.

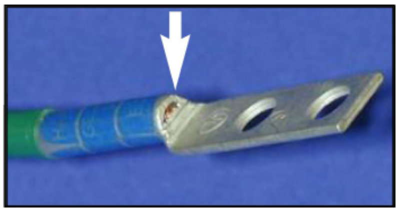


Figure 12. Example of a conductor seen through the inspection port

c) Ensure the end of the conductor remains at the end of the barrel; make the first crimp nearest the tongue end (flat end), working toward the conductor with the remaining crimps *(see figure 13)*. The lug manufacturer's instructions shall be followed for the number of crimps and their location on the barrel *(see figure 14)*.

Separate and Low resistance connection to Earthing system

NECA/BICSI 607 Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings

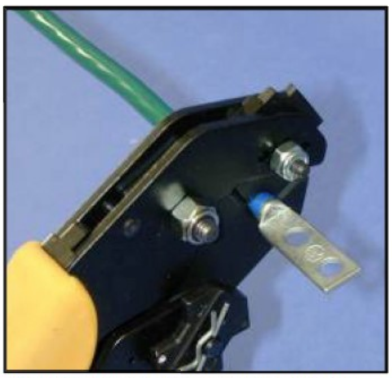


Figure 13. Example of crimping a conductor in the barrel of the lug

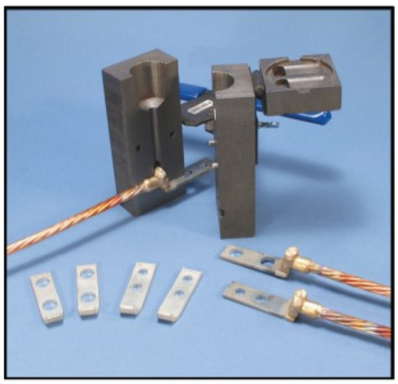


Figure 15. Example of a mold for an exothermic weld

Separate and Low resistance connection to Earthing system

CAPE ELECTRIC

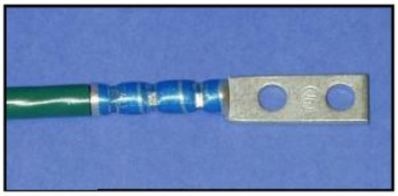


Figure 14. Example of a barrel with three crimps

7.5.2.2 Exothermic weld of a two-hole lug to a bonding conductor

The following steps ensure a reliable connection between the two-hole lug and the bonding conductor using an exothermic weld:

a) Select the mold and weld metal applicable to the conductor size and lug configuration.

b) Clean and torch-dry the conductor and the mold. Then insert the conductor and lug into the mold *(see figure 15)*.

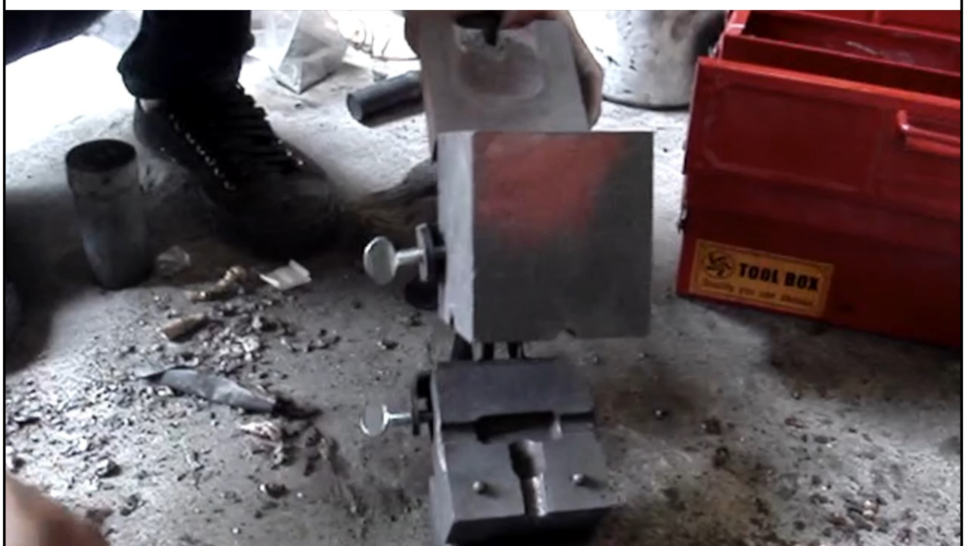
c) Close the handle clamp, lock the mold and then insert the disk into the mold *(see figure 16)*.

Figure 16. Mold being locked and disk inserted

d) Pour the weld metal into the mold. Sprinkle starting material over the weld metal and on the lip of the mold *(see figure 17)*.

Low resistance connection

CAPE ELECTRIC



Separate and Low resistance connection to Earthing system

Table 5 – TBB conductor sizing

Maximum PBB-SBB length l m	Conductor cross-se area minimum (see Annex B
$l \leq 4$	B
$4 < l \leq 6$	C
$6 < l \leq 8$	D
$8 < l \leq 10$	E
$10 < l \leq 13$	F
$13 < l \leq 16$	G
$16 < l \leq 20$	H
$20 < l \leq 26$	J
$26 < l \leq 32$	K
$32 < l \leq 38$	L
$38 < l \leq 46$	M
$46 < l \leq 53$	N
$53 < l \leq 76$	P
$76 < l \leq 91$	Q

For lengths in excess of those shown above, the cross-sectional area should be calculated as 3,3 mm² p

Table B.1 – Bonding conductor cross-sectional areas

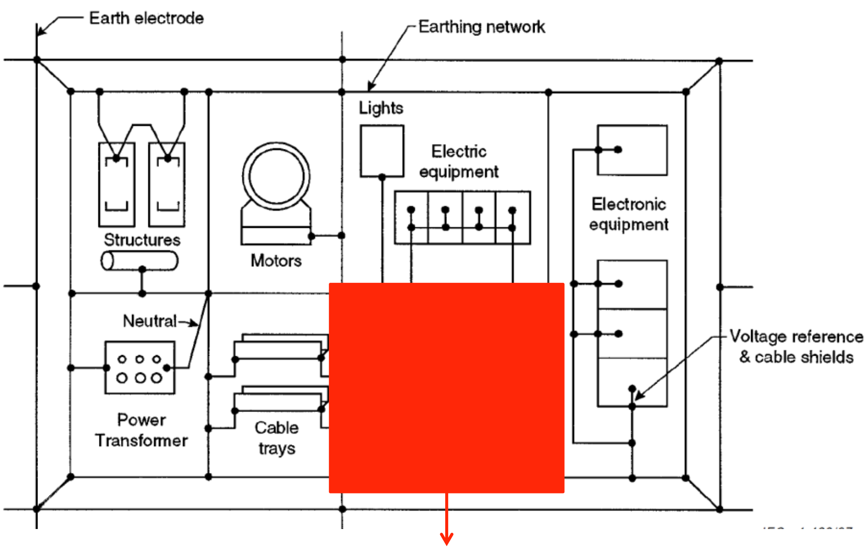
Conductor cross-sectional area specified in this standard mm²	Nominal international conductor mm²	Nominal AWG/NEC conductor[a]
A	4	12
B	16	6
C	25	4
D	35	3
E	35	2
F	50	1
G	60	1/0
H	70	2/0
J	95	3/0
K	120	4/0
L	150	250 kcmil
M	150	300 kcmil
N	185	350 kcmil
P	250	500 kcmil
Q	300	600 kcmil

AWG = American Wire Gauge

NEC = National Electrical Code (US).

[a] These non-SI values have been added for the convenience of the user.

General principles for bonding of various apparatus or systems to the earthing network



Bonding Networks for sensitive Equipment

Hospital – Earthing and Bonding

Rules - IS3043 and NEC: 2011

Electrical & Electronic systems design in health care facility is an extraordinary challenge. Required technical knowledge exceeds typical residential and industrial construction.

Patients may be undergoing surgery and in life support systems. Any break in electrical supply for more than few seconds could be fatal for them.

Further some patients may have conductive instruments in contact with the bloodstream or heart muscle where the possibility for serious injury and/or death if that metal becomes energized (even to a very low level). Other dangers include wet areas, hazards due to flammable liquids and the presence of oxygen.

Technical requirement of equipment are not considered / provided while designing electrical system. Most equipment are connected to redundant UPS / Generators, to take care in case of a supply failure, but we forget to think what will happen if a circuit breaker trips due to a fault. This means electrical work must be designed and installed to an unusual level of safety and redundancy.

Hospital – Earthing and Bonding

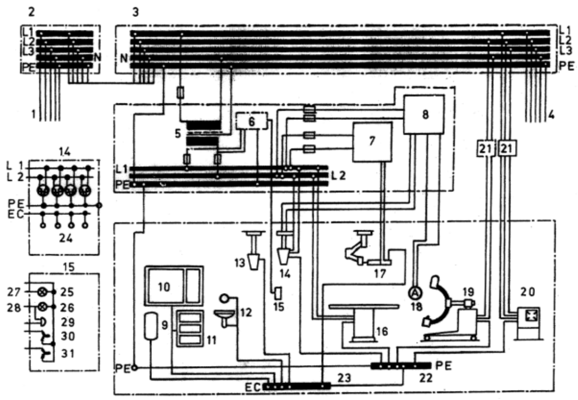
Rules - IS3043 and NEC: 2011

Similar to normal buildings, grounding and bonding issues create much confusion. Earthing and bonding systems distinctly differ from residential and industrial wiring systems. NEC-2011 (National Electric Code - Bureau of Indian standards) explains a hospital environment as

- The patient may not be in a condition to react normally to the effects of hazardous events
- The electrical resistance of the skin, which is normally an important protection against harmful electric currents is bypassed in certain examinations or treatments
- Medical electrical equipment may often be used to support or substitute vital body functions, the breakdown of which may cause a dangerous situation
- Specific locations in medical establishments where flammable atmosphere exists, call for special treatment
- Electric and magnetic interference may disturb certain medical examinations or treatments.

SCHEMATIC PRESENTATION OF PROTECTIVE CONDUCTORS AND EQUIPOTENTIAL BONDING IN OPERATING THEATRES

CAPE ELECTRIC



Legend

1 = Feeder from the main service entrance (main distribution board)
2 = Distribution of the floor
3 = Operating theatre distribution panel
4 = Safety supply system
5 = Medical isolating transformer
6 = Insulation monitoring device
7 = Special safety supply system, E_2
8 = Special safety supply system E_1
9 = Central heating
10 = Metal window-frame
11 = Metal cabinet for instruments
12 = Meal washing-basin and water supply
13 = Ceiling stand with outlets for gas supply
14 = Ceiling stand with mains socket outlets (with terminals for equipotential bonding, enclosure connected to the protective conductor bar)
15 = Alarm device for the insulation monitoring device (example)
16 = Operating table (electrically driven)
17 = Operating lamp
18 = Ampere meter for special safety supply system
19 = X-ray equipment
20 = Sterilizer
21 = Residual-current protective device
22 = Protective conductor bar
23 = Equipotential conductor bar
24 = Terminals for equipotential bonding

PE = protective conductor
EC = equipotential bonding
L_1, L_2, L_3 = phase conductors
N = neutral conductor

25 = Operation
26 = Warning
27 = Green
28 = Red
29 = Buzzer
30 = Stop button for buzzer
31 = Test button

Hospital – Earthing and Bonding

CAPE ELECTRIC

IS3043 & NEC 2011 - Recommendations

LV Earthing TN-S with PME double earthing: IT earthing for specific areas

- Ground potential equipotentialisation in critical care areas using special bonding Techniques.
- IT system earthing increases reliability of power supply in areas where an interruption of power supply may cause hazard to patient.
- Separate circuits shall be provided for X-ray, electrotherapy, diathermy, electrocardiograph, etc
- Main Earthing Terminal for individual rooms as well as Local Equipotential bonding for patient environments.
- Screening requirements against interference in rooms where measurements of bioelectric potentials are performed.
- Electrical wiring inside walls, floor and ceiling of rooms should be screened by means of metal shielding of cables to reduce Interference Caused by Mains-Induced Electric Fields
- Room screening inside wall structure for ECG and EEG monitoring.

Hospital – Special Earthing Requirements

Special Bonding and Earthing requirements are mandatory for hospitals as per NEC - 2011 & IS 3043. But are generally not followed due to unawareness of system requirements. Implementing these special bonding requirements is easy if structural PME earthing measures are implemented while constructing the building.

Implementing these bonding and earthing requirements, patient's exposure to unwanted voltage on normally non-current-carrying conductive surfaces can be controlled so that their lives and health are not endangered by the electrical environment

Hospital – Special Earthing Requirements

Safety Provisions

#	Provisions	Principal Requirements	Installation Measures
i)	P_0	Duration of touch voltages restricted to a safe limit	TN-S, TT or IT system
ii)	P_1	As P_0 but additionally: Touch voltages in patient environment restricted to a safe limit	Additional to *P*0: Supply system with additional requirements for protective earthing, etc.
iii)	P_2	As *P*1 but additionally: Resistance between extraneous conductive parts and the protective conductor bus bar of the room not exceeding 0.1Ω	Additional to *P*1: Supplementary equipotential bonding
iv)	P_3	As P1 or P2 but additionally: Potential difference between exposed conductive parts, extraneous conductive parts and the protective conductor bus bar not exceeding 10 mV in normal condition	As *P*1 or *P*2: Measurement necessary, corrective action possibly necessary
v)	P_4	As *P*1 or *P*2. Additional protection against electric shock by limitation of disconnecting time	Additional to *P*1 or *P*2: Residual current operated protective device
vi)	P_5	Continuity of the mains supply maintained in case of a first insulation fault to earth and currents to earth restricted	Additional to *P*1, *P*2 or *P*3: IT supply system with insulation monitoring

Hospital – Special Earthing Requirements

CAPE ELECTRIC

Safety Provisions

#	Provisions	Principal Requirements	Installation Measures
vii)	P_6	Reduction of fault currents and touch voltages in case of a fault in the basic insulation	Additional *P*1 or *P*2: Medical isolating transformer supplying one individually piece of equipment
viii)	P_7	Prevention of dangerous touch voltages in normal condition and in single fault condition	Additional to *P*1 or *P*2: Supply with medical safety, extra low voltage
ix)	*G E*	No interruption of the power supply of the essential circuits of the hospital for more than 15 s	Safety supply system
x)	E_1	No interruption of the power supply of life-supporting equipment for more than 15 s	Special safety supply system
xi)	E_2	No interruption of the power supply of the operating lamp for more than 0.5 s	Special safety supply system for operating lamp
xii)	*A*	Prevention of explosions, fire and electrostatic charges	Measures concerning explosion and fire hazards
xiii)	*I*	No exercise interference from electric and magnetic fields	Layout of building and installation, screening

Hospital – Special Earthing Requirements

CAPE ELECTRIC

Examples of Application of Saftey Provisions

#	Medically Used Room	Protective Measures							Safety Supply System			Explosions & Fire	Measures Against EM Fields
		P_o/P_1	P_2	P_3	P_4	P_5	P_6	P_7	*GE*	*E1*	*E2*	*A*	*I*
i)	Massage room	M	O					O	X				
ii)	Operating wash room	M	X					O	X				
iii)	Ward general	M	O					O	X				
iv)	Delivery room	M	X		X	O		O	X	O	X	O	O
v)	ECG, EEG, EMG room	M	X		X			O	X				X
vi)	Endoscopic room	M	X		X			O	X		O		
vii)	Examination or treatment room	M	O		X	O		O	X		O		
viii)	Labour room	M	X		X	O		O	X				O
ix)	Operating sterilization room	M	O		X			O	X				
x)	Urology room	M	X		X			O	X		O		
xi)	Radiological diagnostic and therapy room, other than mentioned under Sl No. (xx) and (xxiv)	M	X		X			O	X				
xii)	Hydrotherapy room	M	X		X		O	O	X				
xiii)	Physiotherapy room	M	X		X	O		O	X				

M = Mandatory measure, X = Recommended measure, X1 = As X, aditionally insulation resistance measurement, O = Additional measure, may be considered desirable.

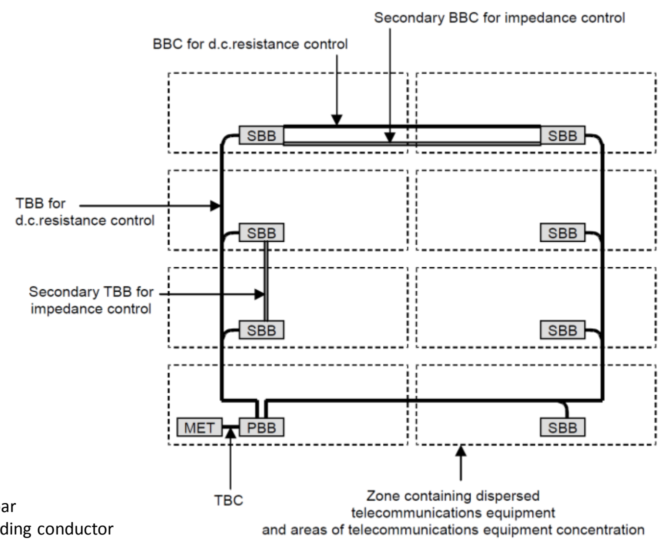
Hospital – Special Earthing Requirements

Examples of Application of Saftey Provisions

#	Medically Used Room	Protective Measures							Safety Supply System			Explosions & Fire	Measures Against EM Fields
		P_o/P_1	P_2	P_3	P_4	P_5	P_6	P_7	GE	E1	E2	A	I
xiv)	Anaesthetic room	M	X	X	X_1	X		O	X	X	X	O	O
xv)	Operating theatre	M	X	X	X_1	X		O	X	X	X	X	X
xvi)	Operating preparation room	M	X	X	X_1	X		O	X	X	X	X	X
xvii)	Operating plaster room	M	X		X_1	X		O	X	X	X	X	X
xviii)	Operating recovery room	M	X	X	X_1	X		O	X	X	X	X	X
xix)	Outpatient operating theatre	M	X		X_1	X		O	X	X	X	X	X
xx)	Heart catheterization room	M	X	X	X_1	X		O	X	X	X		X
xxi)	Intensive care room	M	X	O	X_1	X		O	X	X	X		X
xxii)	Intensive examination room	M	X	O	X_1	X		O	X	O	O		X
xxiii)	Intensive monitoring room	M	X	O	X_1	X		O	X	X	X		X
xiv)	Angiographic examination room	M	X	O	X_1	X		O	X	O	O		O
xxv)	Hemodialysis room	M	X	X	X_1	X			X				
xxvi)	Central monitoring room	M	X	O	X_1	X		O	X				O

M = Mandatory measure, X = Recommended measure, X1 = As X, aditionally insulation resistance measurement, O = Additional measure, may be considered desirable.

ISO / IEC 30129: IT infrastructure – Telecommunication Bonding Network example of a large building



PBB - primary bonding bus bar
SBB - secondary bonding bus bar
TBC - telecommunications bonding conductor
TBB - telecommunications bonding backbone
BBC - backbone bonding conductor

Table 5 – TBB conductor sizing

Maximum PBB-SBB length l m	Conductor cross-sectional area minimum (see Annex B)
$l \leq 4$	B
$4 < l \leq 6$	C
$6 < l \leq 8$	D
$8 < l \leq 10$	E
$10 < l \leq 13$	F
$13 < l \leq 16$	G
$16 < l \leq 20$	H
$20 < l \leq 26$	J
$26 < l \leq 32$	K
$32 < l \leq 38$	L
$38 < l \leq 46$	M
$46 < l \leq 53$	N
$53 < l \leq 76$	P
$76 < l \leq 91$	Q
For lengths in excess of those shown above, the conductor cross-sectional area should be calculated as 3,3 mm^2 per meter	

Bonding conductor cross-sectional area

Table B.1 relates the letter references of this standard to the typically available products in various markets.

Table B.1 – Bonding conductor cross-sectional areas

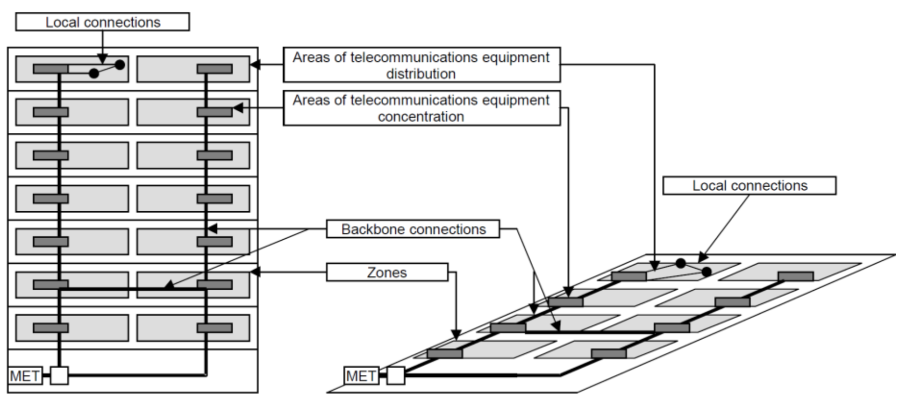
Conductor cross-sectional area specified in this standard mm^2	Nominal international conductor mm^2	Nominal AWG/NEC conductor[a]
A	4	12
B	16	6
C	25	4
D	35	3
E	35	2
F	50	1
G	60	1/0
H	70	2/0
J	95	3/0
K	120	4/0
L	150	250 kcmil
M	150	300 kcmil
N	185	350 kcmil
P	250	500 kcmil
Q	300	600 kcmil

AWG = American Wire Gauge

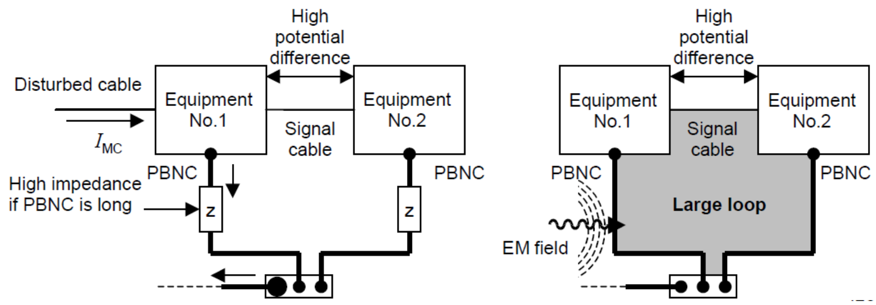
NEC = National Electrical Code (US).

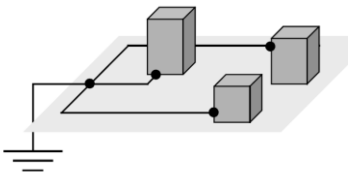
[a] These non-SI values have been added for the convenience of the user.

ISO / IEC 30129, ANSI 702: telecommunications equipment distribution and associated bonding connections



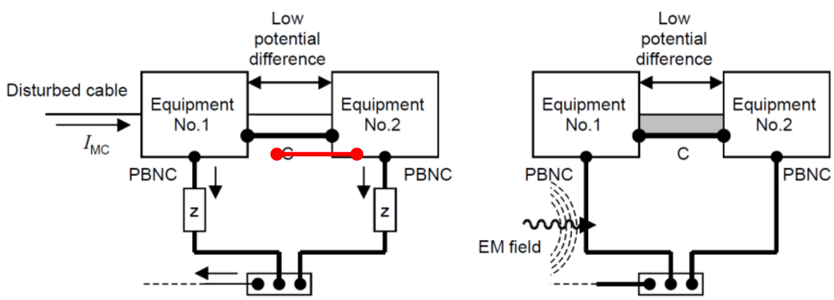
ISO / IEC 30129 Equipotential Bonding Networks STAR – BN (STAR Topology)





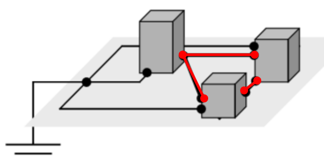
More vulnerable to electromagnetic disturbances
Can be used for Residential / Less Electronics

ISO / IEC 30129 Equipotential Bonding Networks STAR – BN (STAR Topology) with Supplementary Bonding Conductors

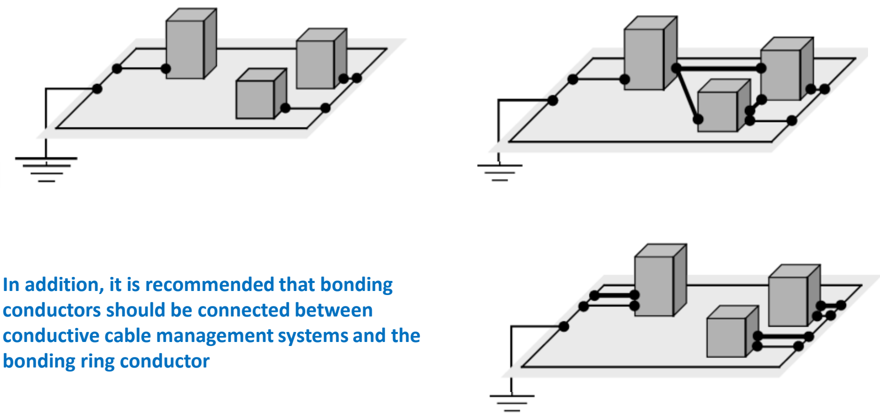


An additional bonding conductor (C) reduces the common impedance between equipment

An additional bonding conductor (C) reduces the area of the sensitive loop

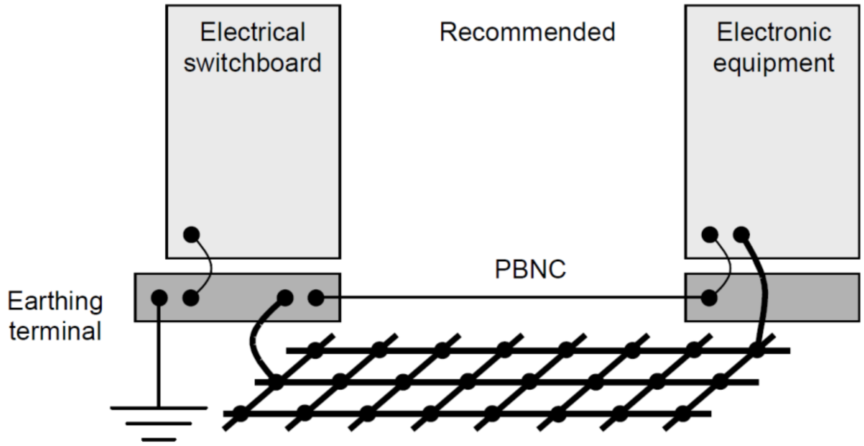


ISO / IEC 30129 Equipotential Bonding Networks **RING – BN (RING Topology)**
with Supplementary Bonding Conductors



In addition, it is recommended that bonding conductors should be connected between conductive cable management systems and the bonding ring conductor

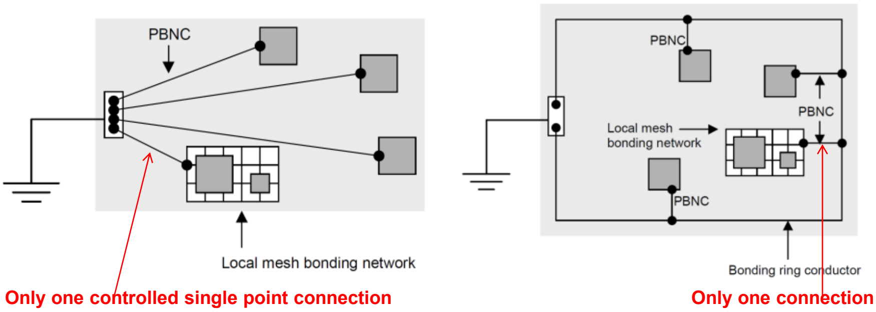
ISO / IEC 30129 Equipotential Bonding Networks **Mesh Bonding Network**



Multiple bonds, including those using building structures, should be used rather than a single bond since this reduces the impedance (inductance) of the resulting bond

ISO / IEC 30129 Equipotential Bonding Networks

Local Mesh Isolated Bonding Network - (MESH-IBN)



The MESH-IBN is typically limited to a restricted area within a building such as in areas of concentration of IT equipment. The MESH-IBN is not typical (but can be utilized) for a commercial environment but is recognized and sometimes utilized in areas of concentration of IT equipment in access provider premises

Components such as associated equipment cabinets, frames, racks and cabling pathways are insulated from the protective bonding network except for one controlled single point of connection (SPC) location, The MESH-IBN is said to be "insulated or isolated" from the protective bonding network

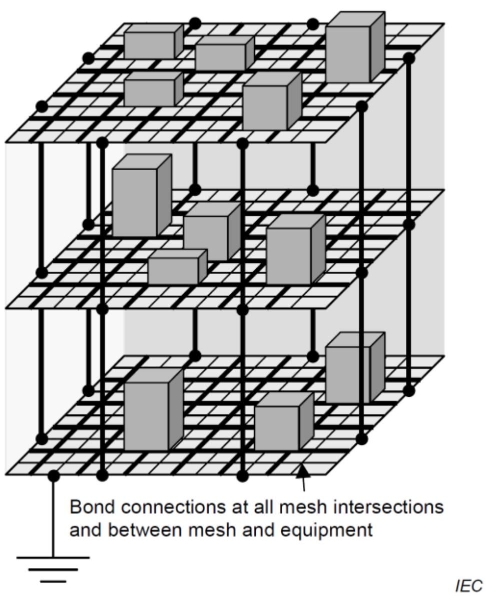
ISO / IEC 30129 Equipotential Bonding Networks

Mesh Bonding Network - (MESH-BN) for a multi floor building

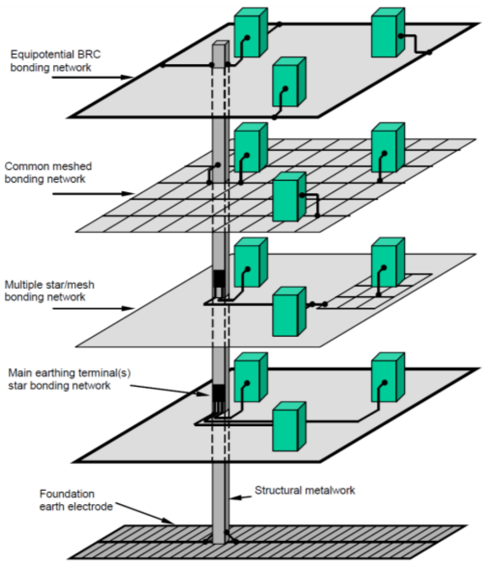
A MESH-BN with equipment cabinets, frames, racks and CBN bonded together

A merged MESH-BN and protective bonding network in buildings shall include the interconnections to the following installations, if present

a. "integrated lightning protection system" according to IEC 62305-4,
b. bonding measures of antenna installations (including satellite receiving equipment under private property) and cable networks according to series IEC 60728,
c. bonding measures of information technology cabling according to ISO/IEC 14763-2,
d. bonding in hazardous areas, e.g. according to IEC 60079-14.



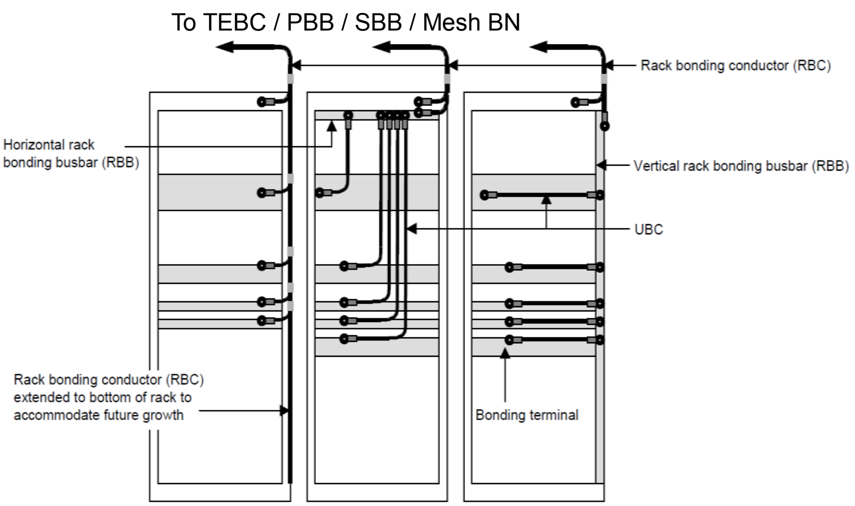
Equipotential Bonding Networks in a Multi Floor building



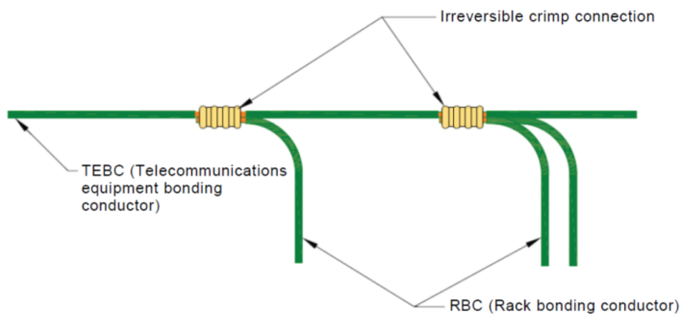
Different Bonding Networks (BN)

STAR BN
Mesh BN
Bonding Ring Conductor BN
Common Mesh BN
Multiple Star /Mesh BN

Example of three methods of equipment and rack bonding

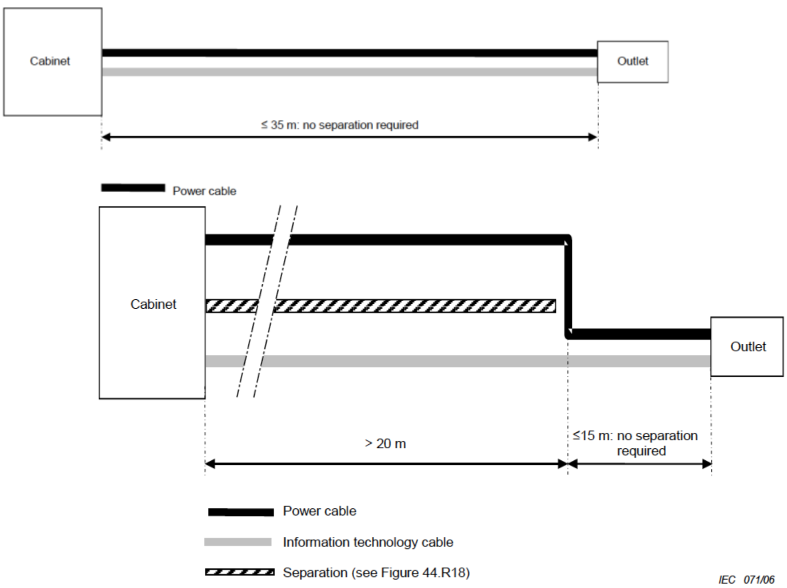


Telecommunication Equipment Bonding Conductor

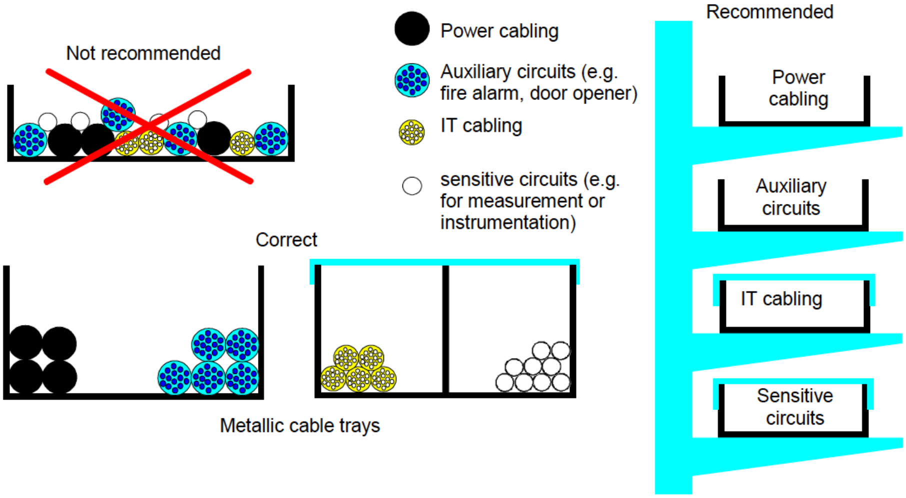


The TEBC shall be connected to the cabinets/equipment racks, to a RBC or to a vertical/horizontal RBB. Connections to the TEBC shall be made with irreversible compression connectors and with the rack bonding conductors (RBCs) routed toward the PBB/SBB

Separation between power and information technology cables

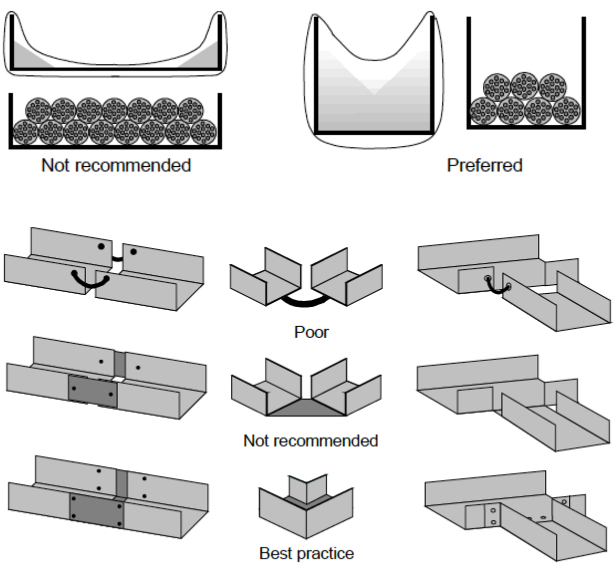


Separation of cables example

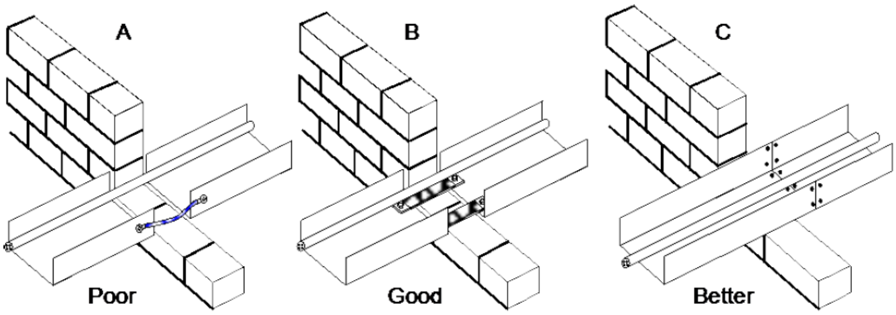


Thickness of metal used shall be minimum 1.5 mm

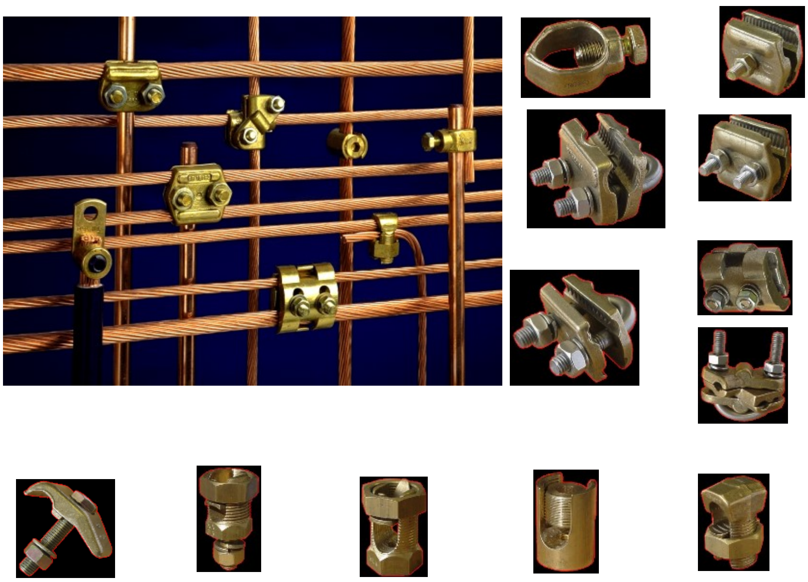
Cable Supports: Recommendation



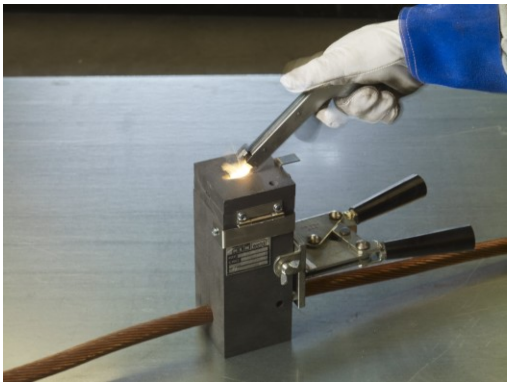
Cable Supports Termination in Buildings: Recommendation



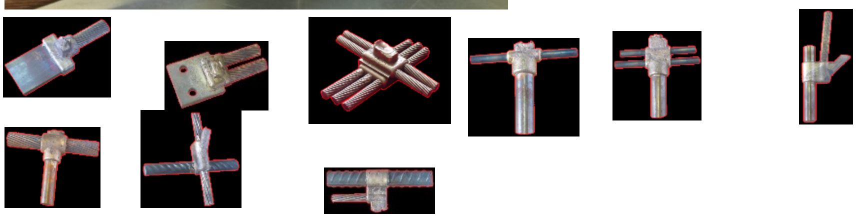
Bonding Connectors and Components: Use only Tested Components



Exothermic Welding:

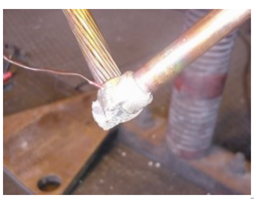


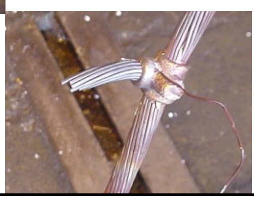
- Molecular connection
- Copper-Copper
- Steel-Copper
- Steel-Steel



Exothermic Welding

- Main characteristics:
  - Fusion temperature equals to copper
  - Double cross section than welded cables
    - Ampacity equal or greater than welded conductors
    - Withstand short-time and overload currents do without affecting the connection
    - Conductors melts before the connection itself (Short-time current tests CPRI)





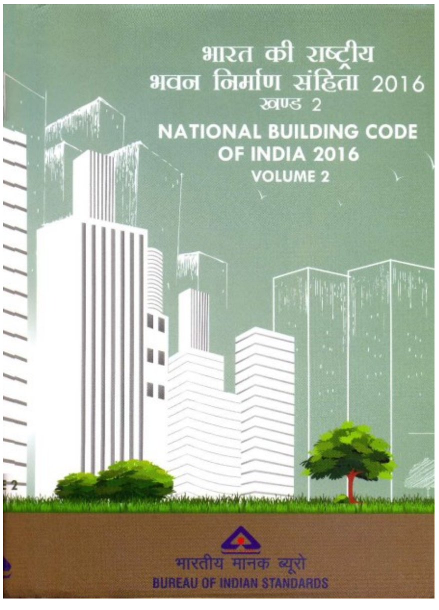
Wrong Practices in India

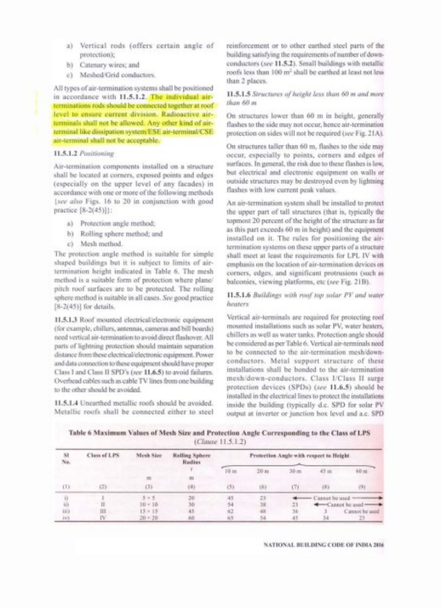
CAPE ELECTRIC

- Lightning Protection: ESE Lightning Protection is used widely in India
- This is not confirming IS standards
- NBC-2016 Banned usage of ESE rods for lightning protection
- CEA safety regulation – 2016 draft recommend to install lightning protection as per IS/IEC 62305 for building higher than 15 meters

ESE rods shall not be used. NBC-2016

CAPE ELECTRIC





a) Vertical rods (offers certain angle of protection);
b) Catenary wires; and
c) Meshed/Grid conductors.

All types of air-termination systems shall be positioned in accordance with **11.5.1.2**. The individual air-terminations rods should be connected together at roof level to ensure current division. Radioactive air-terminals shall not be allowed. Any other kind of air-terminal like dissipation system/ESE air-terminal/CSE air-terminal shall not be acceptable.

11.5.1.2 *Positioning*

Air-termination components installed on a structure shall be located at corners, exposed points and edges (especially on the upper level of any facades) in accordance with one or more of the following methods [*see also* Figs. 16 to 20 in conjunction with good practice [8-2(45)]]:

a) Protection angle method;
b) Rolling sphere method; and
c) Mesh method.

The protection angle method is suitable for simple shaped buildings but it is subject to limits of air-termination height indicated in Table 6. The mesh method is a suitable form of protection where plane/pitch roof surfaces are to be protected. The rolling sphere method is suitable in all cases. *See* good practice [8-2(45)] for details.

11.5.1.3 Roof mounted electrical/electronic equipment (for example, chillers, antennas, cameras and bill boards) need vertical air-termination to avoid direct flashover. All parts of lightning protection should maintain separation distance from these electrical/electronic equipment. Power and data connection to these equipment should have proper Class I and Class II SPD's (*see* **11.6.5**) to avoid failures. Overhead cables such as cable TV lines from one building to the other should be avoided.

11.5.1.4 Unearthed metallic roofs should be avoided. Metallic roofs shall be connected either to steel reinforcement or to other earthed steel parts of the building satisfying the requirements of number of down-conductors (*see* **11.5.2**). Small buildings with metallic roofs less than 100 m^2 shall be earthed at least not less than 2 places.

11.5.1.5 *Structures of height less than 60 m and more than 60 m*

On structures lower than 60 m in height, generally flashes to the side may not occur, hence air-termination protection on sides will not be required (*see* Fig. 21A).

On structures taller than 60 m, flashes to the side may occur, especially to points, corners and edges of surfaces. In general, the risk due to these flashes is low, but electrical and electronic equipment on walls or outside structures may be destroyed even by lightning flashes with low current peak values.

An air-termination system shall be installed to protect the upper part of tall structures (that is, typically the topmost 20 percent of the height of the structure as far as this part exceeds 60 m in height) and the equipment installed on it. The rules for positioning the air-termination systems on these upper parts of a structure shall meet at least the requirements for LPL IV with emphasis on the location of air-termination devices on corners, edges, and significant protrusions (such as balconies, viewing platforms, etc (*see* Fig. 21B).

11.5.1.6 *Buildings with roof top solar PV and water heaters*

Vertical air-terminals are required for protecting roof mounted installations such as solar PV, water heaters, chillers as well as water tanks. Protection angle should be considered as per Table 6. Vertical air-terminals need to be connected to the air-termination mesh/down-conductors. Metal support structure of these installations shall be bonded to the air-termination mesh/down-conductors. Class I/Class II surge protection devices (SPDs) (*see* **11.6.5**) should be installed in the electrical lines to protect the installations inside the building (typically d.c. SPD for solar PV output at inverter or junction box level and a.c. SPD

Table 6 Maximum Values of Mesh Size and Protection Angle Corresponding to the Class of LPS
(*Clause* 11.5.1.2)

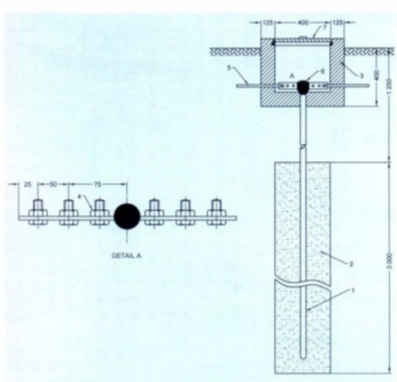
Sl No.	Class of LPS	Mesh Size m	Rolling Sphere Radius r m	Protection Angle with respect to Height 10 m	20 m	30 m	45 m	60 m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	I	5 × 5	20	45	23	← Cannot be used →		
ii)	II	10 × 10	30	54	38	23	← Cannot be used →	
iii)	III	15 × 15	45	62	48	36	3	Cannot be used
iv)	IV	20 × 20	60	65	54	45	34	23

NATIONAL BUILDING CODE OF INDIA 2016

Wrong Practices in India: **Earthing**

- **Almost every user want less than 1 ohm resistance and Chemical Earthing**
- **Suppliers make use of it claiming lot of advanced features in earth electrodes**
- **Non Standard practices like Pipe-in-pipe, Rod-in-pipe …………….etc are used**

Maintenance free Earthing as per NBC - 2016



Key
1 Copper/copper bonded steel rod (see Table 3 for sizes)
2 Earth enhancement material [conforming to IEC 62561-7:2011 'Lightning protection system components (LPSC) — Part 7: Requirements for earthing enhancing compounds']
3 Inspection chamber
4 M10 bolts and nuts
5 Copper strip — 25 x 6 mm or higher
6 Exothermic welding
7 CI lid/cover

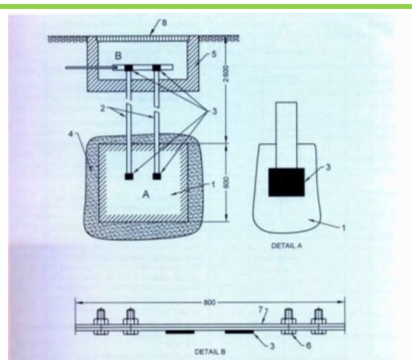
All dimensions in millimetres.

NOTE — Inspection housing can also be of FRP materials with CI cover tested according to IEC 62561-5:2011 'Lightning protection system components (LPSC) — Part 5: Requirements for earth electrode inspection housings and earth electrode seals'.

7B TYPICAL ARRANGEMENT OF EARTHING WITH COPPER/COPPER BONDED ELECTRODE WITH EXOTHERMIC WELDING (MAINTENANCE FREE ARRANGEMENT)

FIG. 7 TYPICAL ARRANGEMENT OF ELECTRODE EARTHING

PART 8 BUILDING SERVICES — SECTION 2 ELECTRICAL AND ALLIED INSTALLATIONS



Key
1 600 × 600 × 3 mm copper plate
2 30 × 6 mm copper strip
3 Exothermic welding
4 Earth enhancement material [conforming to IEC 62561-7:2011 'Lightning protection system components (LPSC) — Part 7: Requirements for earthing enhancing compounds']
5 Inspection chamber
6 M12 × 40 stainless steel bolts and nuts
7 50 × 6 mm copper strip
8 CI lid/cover

All dimensions in millimetres.

NOTE — Inspection housing can also be of FRP materials with CI cover tested according to IEC 62561-5:2011 'Lightning protection system components (LPSC) — Part 5: Requirements for earth electrode inspection housings and earth electrode seals'.

8B TYPICAL ARRANGEMENT OF COPPER PLATE EARTHING WITH EXOTHERMIC WELDING (MAINTENANCE FREE ARRANGEMENT)

FIG. 8 TYPICAL ARRANGEMENT OF PLATE EARTHING

PART 8 BUILDING SERVICES — SECTION 2 ELECTRICAL AND ALLIED INSTALLATIONS

Maintenance free Earthing in NBC - 2016

CAPE ELECTRIC

1. Copper coated rods tested as per IEC 62561-2 or copper plate
2. Exothermically welded to copper flat
3. Earth enhancing material tested as per IS/IEC 62561-7

This will provide long life for the installation

IS/IEC 62305 recommend to use copper/copper coated steel in place of GI to avoid corrosion due to galvanic effect

Copper/copper coated rods provide long life compared to GI
Exothermic welding is non corrosive, long life
Earth enhancing material shall not pollute soil

Highlights

CAPE ELECTRIC

National Building Code – 2016

- ESE lightning protection is banned
- Maintenance free earthing - Defined and tested as per IEC 62561
- Earthing using structural steel accepted
- Test joints for measuring earth resistance not required if structural steel is used
- Surge Protective Devices are a must in the electrical system

IS/IEC 62305: Lightning Protection System: 2015

- 4 parts of IS/IEC 62305
- 4 classes of Lightning protection defined
- Selection of class depends on risk assesment
- External protection and SPD's are a must
- For PEB buildings, no need for an isolated down conductor
- Earthing using structural steel accepted
- As per risk assesment, Generally every building need SPD, only few need external LPS

Conclusion

CAPE ELECTRIC

- Double earthing means two distinct and separate fault return path for safety
- TN-S network is recommended in IS3043 for industrial and commercial use
- Testing of LV network before energizing will improve reliability
- Earthing integrating structural steel is a modern method accepted in IS standards as well as NBC-2016 (means no earth electrodes in soil)
- Copper coated steel for earthing provide long life
- Exothermic welding is a reliable, corrosion free and very strong connection
- ESE rods are banned in NBC-2016
- Lightning protection standards are IS/IEC 62305
- Surge Protective Devices are mandatory in almost every installation
- Maintenance free earthing uses components tested as per IEC 62561

CAPE ELECTRIC

Earthing is for Safety: Return of fault current and quick operation of switchgear.
Earthing for Dissipation of Lightning current to soil
Earthing for Voltage reference and Equipotential base
Earthing for EMI and protection of electronics

Improvement in Bonding Techniques is necessary for Protection of electronics

THANK YOU

Cape Electric Pvt Ltd
A-41(B), SIPCOT, Oragadam
Kanchipuram, Chennai – 602105
Tamilnadu
Ph. +91 44 7101 8100 (30 lines)
Mob - +91 99625 22244