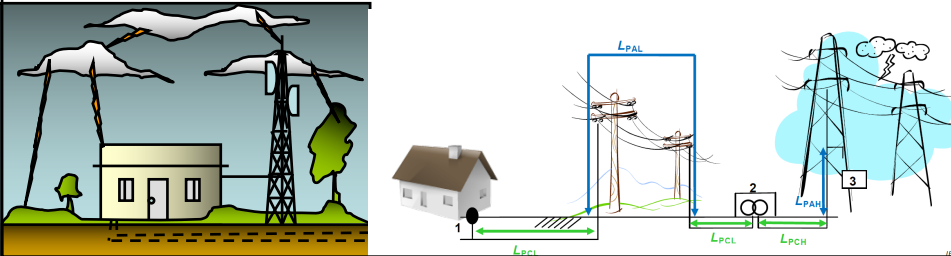











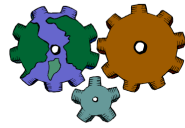
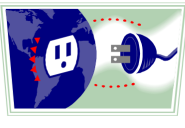



## Lightning Protection using Structural Steel Structural Earthing LV networks and Safety


By S. Gopa Kumar






## Different Earthing used in India

 Earth	 Mother Earth	 Clean Earth	 Dirty Earth	 Computer Earth
 Plant Earth	 Instrument Earth	 Separate Earth	 Structural Earth	
 Power Earth	 Analog Earth	 Digital Earth	 Safety Earth	 Ground

	<h2>Low Voltage Installations</h2> <p>rules for connecting a device</p>
<p>IEC 60364-1 LV installations <b>Fundamental principles and assessment of General Characteristics</b></p>	
<p>IEC 60364-4-44 LV installations <b>Protection against Voltage disturbances and Electromagnetic disturbance</b></p>	
<p>IEC 60364-5-54 LV installations <b>Earthing arrangement and PE conductor</b></p>	
<p>IEC 60364-5-53 LV installations <b>Selection and Erection of Protection device</b></p>	

	<h2>L V Electrical Network: Basic Protection</h2>
<h3>Protection against electric shock</h3>	
<p><b>Basic protection (protection against direct contact)</b></p>	
<ul style="list-style-type: none"><li>• preventing a current from passing through the body of any person or any livestock;</li><li>• limiting the current which can pass through a body to a non-hazardous value.</li></ul>	
<p><b>Fault protection (protection against indirect contact)</b></p>	
<ul style="list-style-type: none"><li>• preventing a current resulting from a fault from passing through the body of any person or any livestock;</li><li>• limiting the magnitude of a current resulting from a fault, which can pass through a body, to a non-hazardous value;</li><li>• limiting the duration of a current resulting from a fault, which can pass through a body, to a non-hazardous time period.</li></ul>	



## L V Electrical Network: Basic Protection

### Protection against thermal effects

The electrical installation shall be so arranged to minimize the risk of damage or ignition of flammable materials due to high temperature or electric arc. In addition, during normal operation of the electrical equipment, there shall be no risk of persons or livestock suffering burns.

### Protection against overcurrent

Persons and livestock shall be protected against injury and property shall be protected against damage due to excessive temperatures or electromechanical stresses caused by any over currents likely to arise in conductors. Protection can be achieved by limiting the overcurrent to a safe value or duration.

### Protection against fault currents

Conductors, other than live conductors, and any other parts intended to carry a fault current shall be capable of carrying that current without attaining an excessive temperature. Electrical equipment, including conductors shall be provided with mechanical protection against electromechanical stresses of fault currents as necessary to prevent injury or damage to persons, livestock or property.

Note: Live conductors shall be protected against over currents arising from faults

Note: Particular attention should be given to PE conductor and earthing conductor currents.

### Protection against Power Supply Interruption

Where danger or damage is expected to arise due to an interruption of supply, suitable provisions shall be made in the installation or installed equipment




## L V Electrical Network: Basic Protection

### Protection against voltage disturbances and measures against electromagnetic influences

Persons and livestock shall be protected against injury and property shall be protected against damage as a consequence of over voltages such as those originating from atmospheric events or from switching. (Surge Protection)

Note: For protection against direct lightning strikes, see IEC 62305 series.

The installation shall have an adequate level of immunity against electromagnetic disturbances so as to function correctly in the specified environment. The installation design shall take into consideration the anticipated electromagnetic emissions, generated by the installation or the installed equipment, which shall be suitable for the current-using equipment used with, or connected to, the installation.



## L V Electrical Network


**System Earthing: Types (TN / TT / IT)**

**First Letter - Relationship of the power system to earth**

- T** - Direct connection of one point to earth
- I** - All live parts isolated from earth  
or  
one point connected to earth through an impedance

**Second Letter - Relationship of the exposed conductive parts to earth**

- T** - Direct electrical connection of exposed conductive parts to earth, independent to the earthing of any point of the power supply
- N** - Direct electrical connection of exposed conductive parts to the earthed point of the power system  
(In a.c. system earthed point of power system is normally the neutral point  
or  
if a neutral point is not available a line conductor)

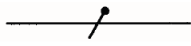
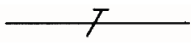
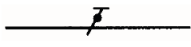



## L V Electrical Network

**System Earthing: Types (TN / TT / IT)**

**Subsequent Letters (if any) - Arrangement of Neutral and Protective Conductors**

- S** - Protective function provided by a conductor separate from the neutral conductor or from the earthed line conductor (or in a.c. system - earthed phase)
- C** - Neutral and protective function combined in a single conductor (PEN Conductor)

Explanation of symbols for Figures 31A1 to 31M according to IEC 60617-11	
	Neutral conductor (N); mid-point conductor (M)
	Protective conductor (PE)
	Combined protective and neutral conductor (PEN)



L V Electrical Network

**System Earthing: TN Systems**

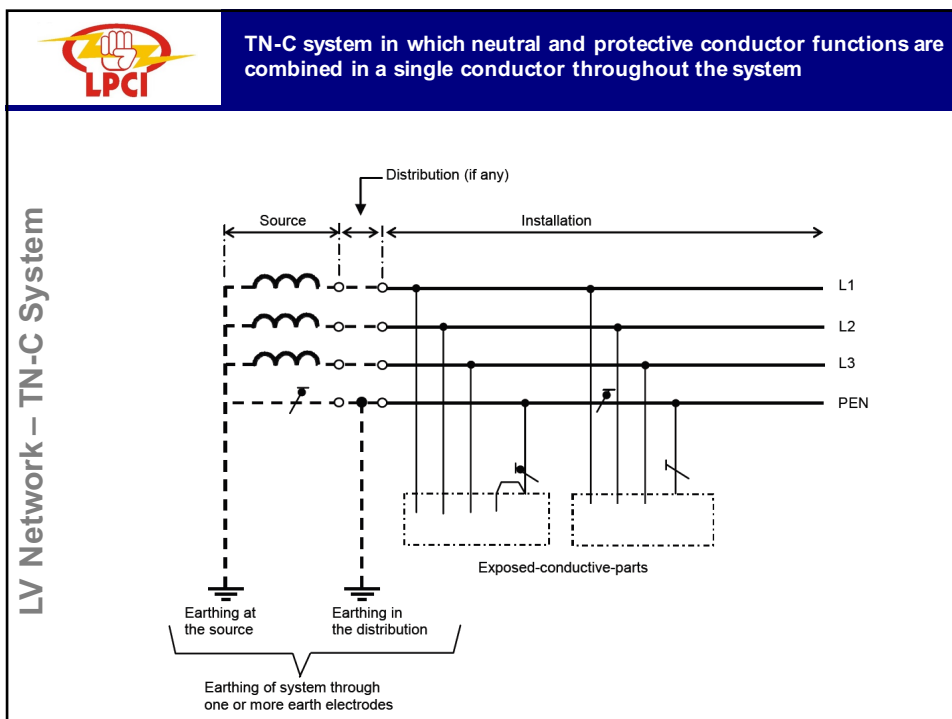
TN power system have one point directly earthed at the source, the exposed conductive parts of the installation being connected to that point by protective conductors. Three types of TN system are considered according to the arrangement of the neutral and protective conductors.

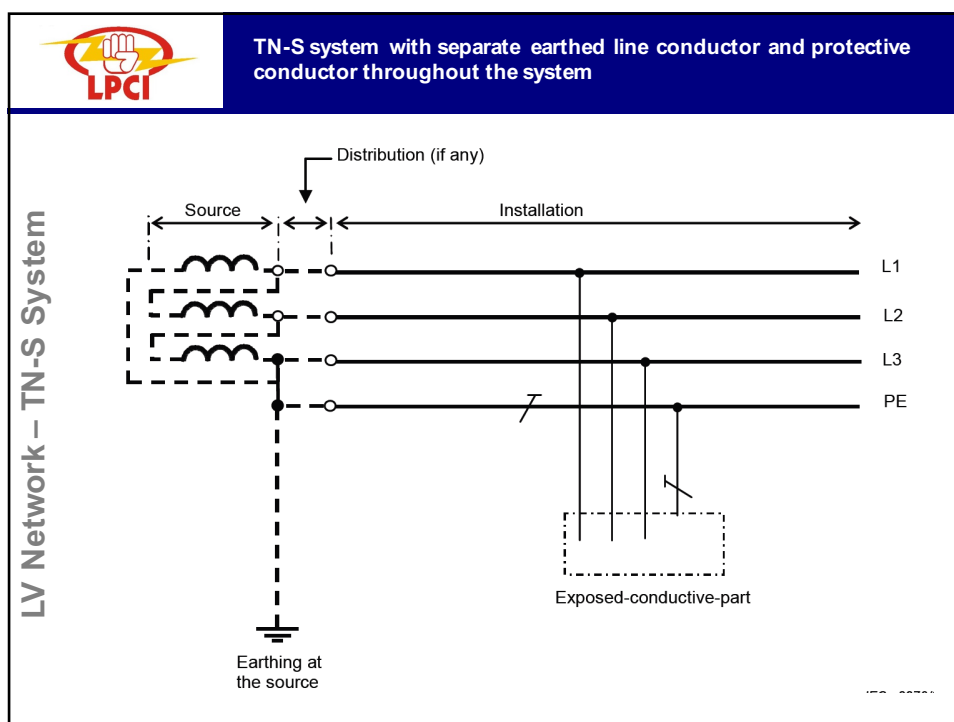
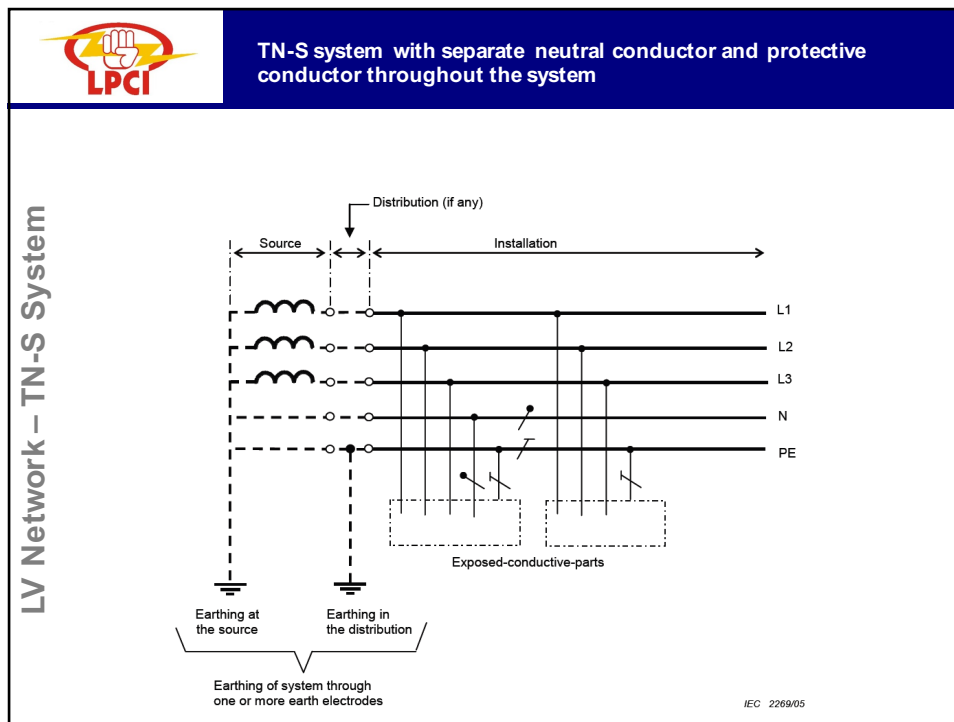
**TN-S** Throughout the system a separate protective conductor is used which is in 3 ways

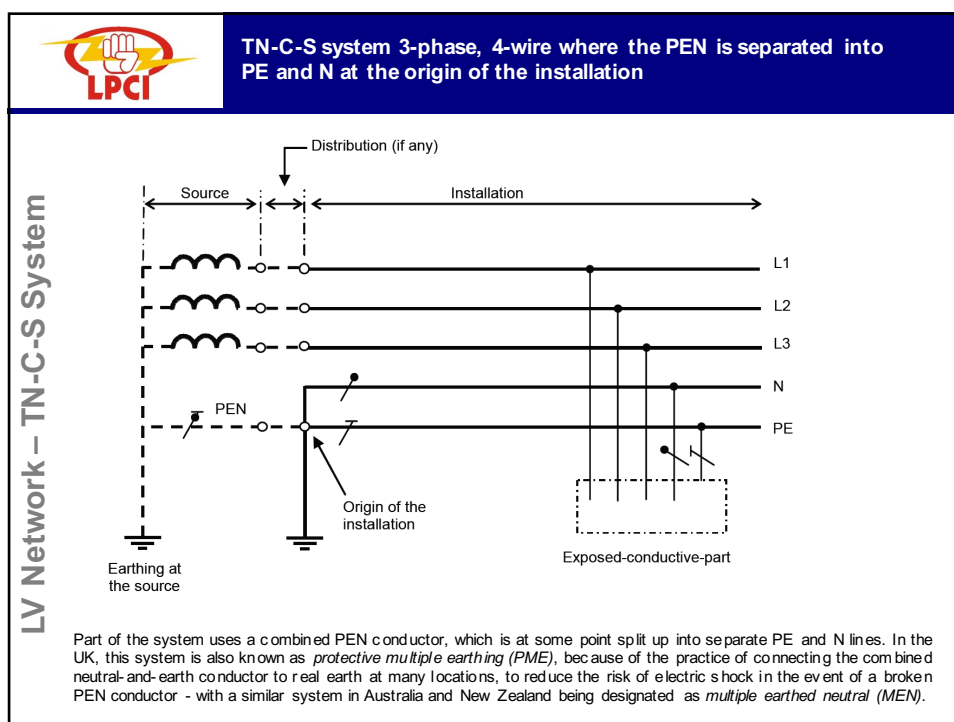
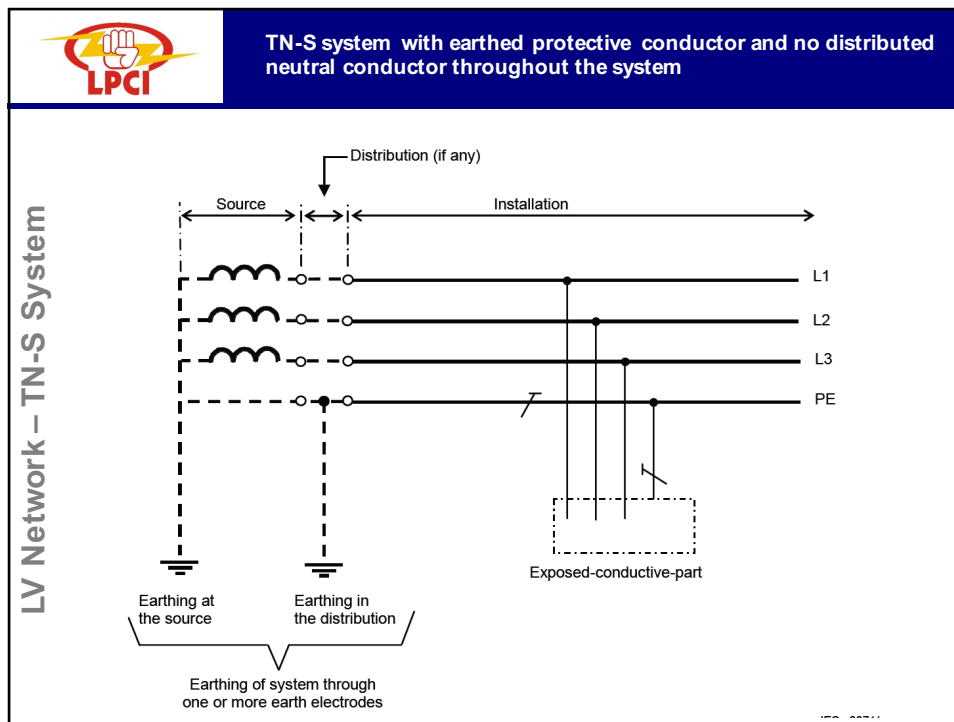
- TN-S system with separate neutral conductor and protective conductor throughout the system
- TN-S system with separate earthed line conductor and protective conductor throughout the system
- TN-S system with earthed protective conductor and no distributed neutral conductor throughout the system

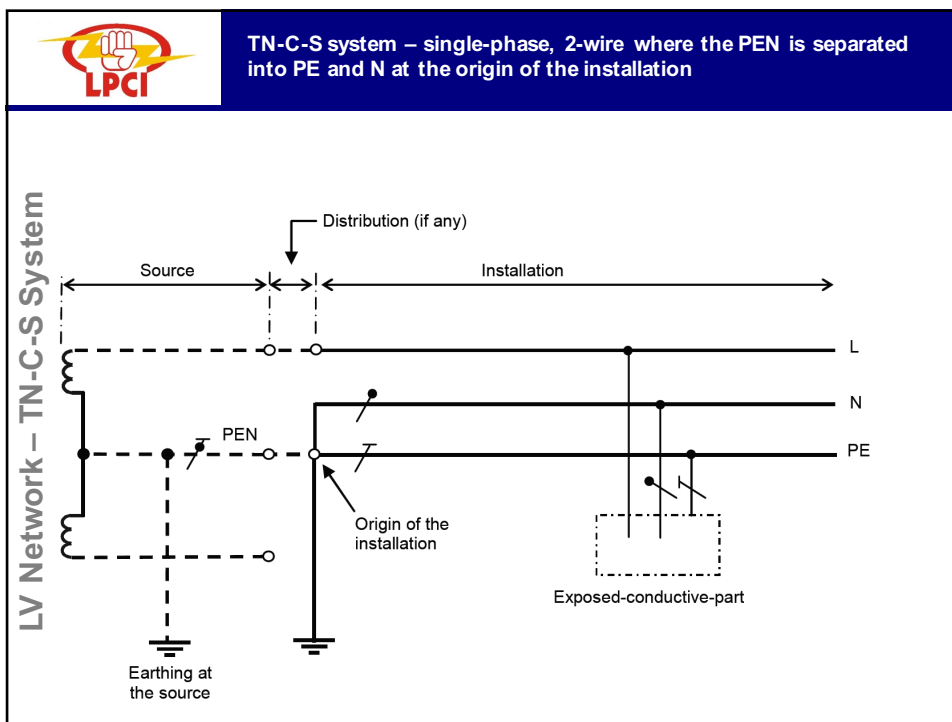
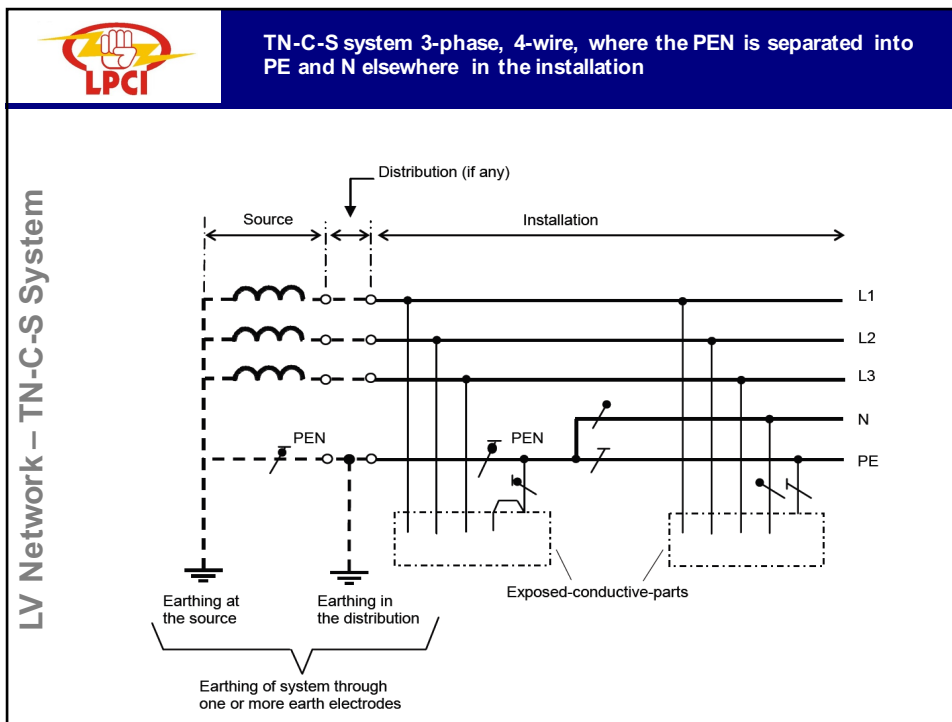
**TN-C-S** system in which neutral and protective conductor functions are combined in a single conductor in a part of the system which is in 3 ways

- TN-C-S system 3-phase, 4-wire, where the PEN is separated into PE and N elsewhere in the installation
- TN-C-S system 3-phase, 4-wire where the PEN is separated into PE and N at the origin of the installation
- TN-C-S system – single-phase, 2-wire where the PEN is separated into PE and N at the origin of the installation

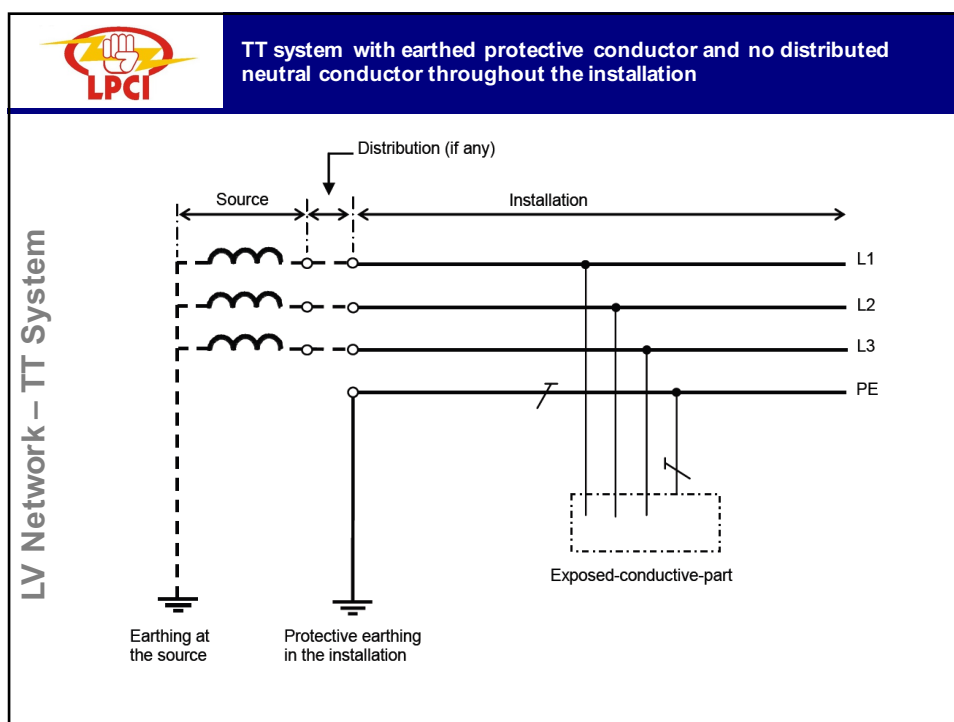
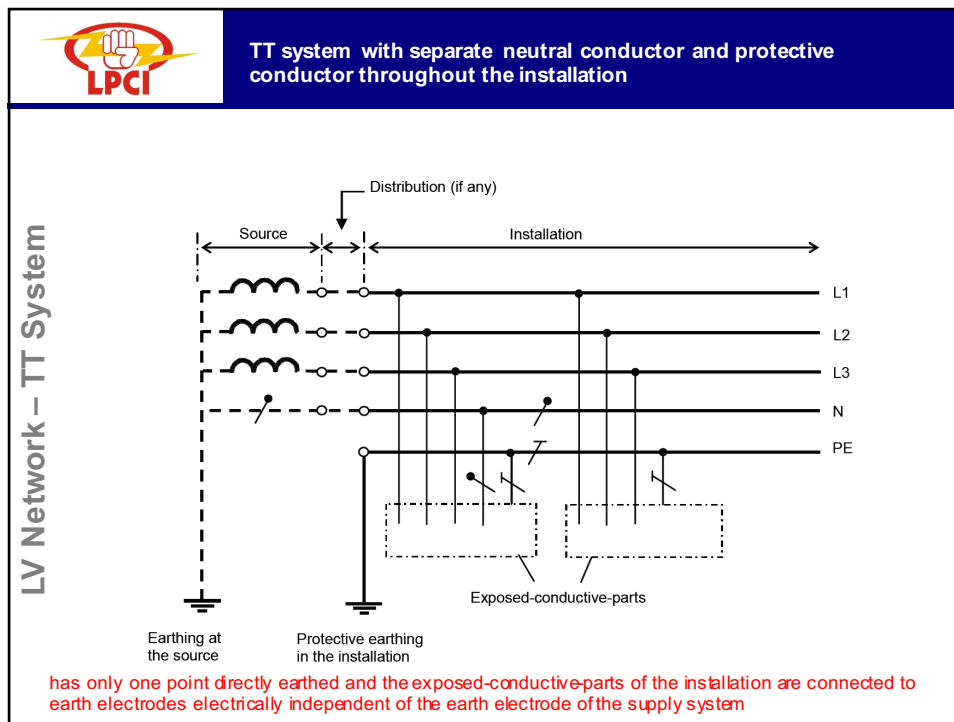


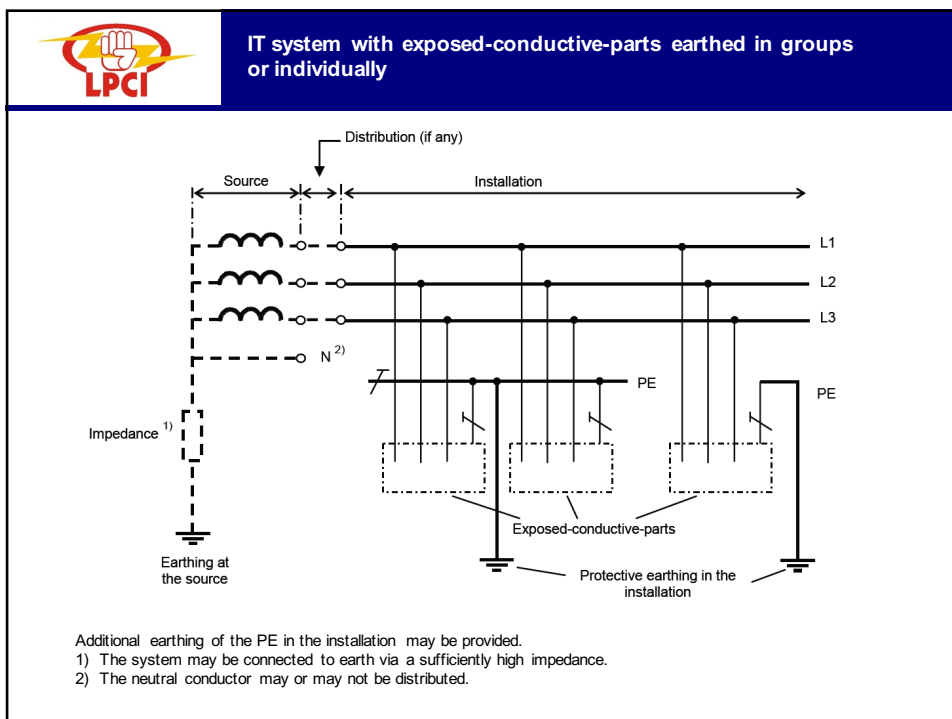
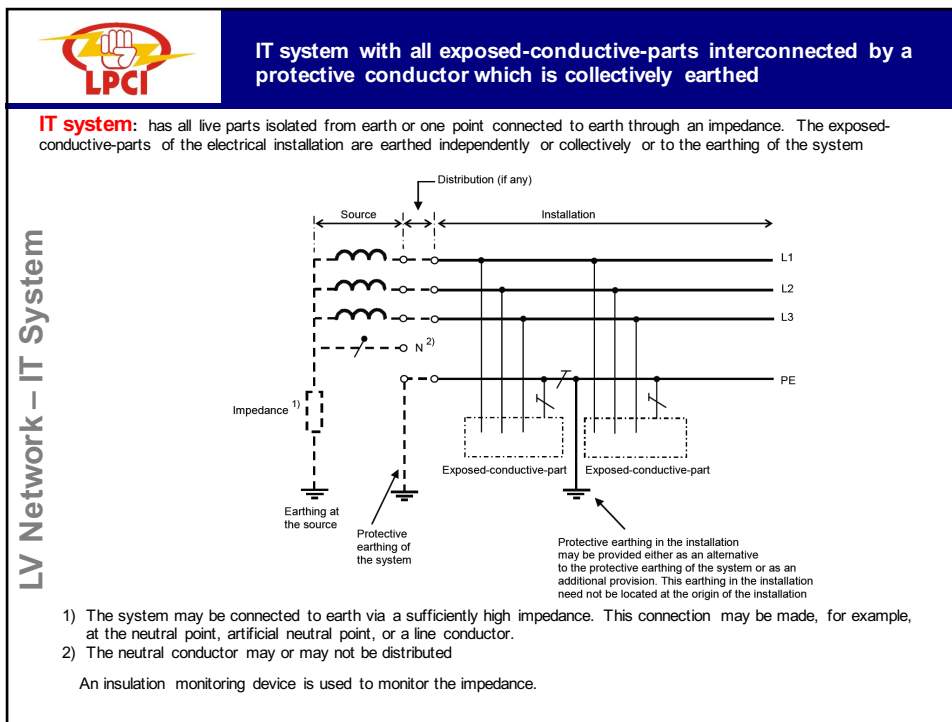









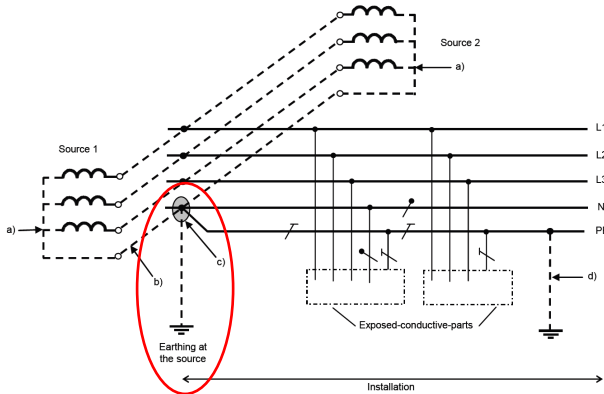







**Multiple Source System**  
TN-C-S with separate protective conductor and neutral conductor to current using equipment

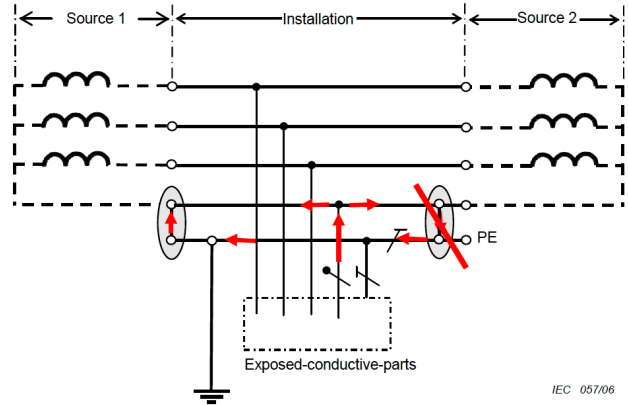
LV Network – TN-C-S System



a) No direct connection from either the transformer neutral point or the generator star point to earth is permitted.  
 b) The interconnection conductor between either the neutral points of the transformers or the generator star points shall be insulated. The function of this conductor is like a PEN; however, it shall not be connected to current-using equipment.  
 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 may be provided.




**TN multiple-source power supply**  
with a non-suitable multiple connection between PEN and earth

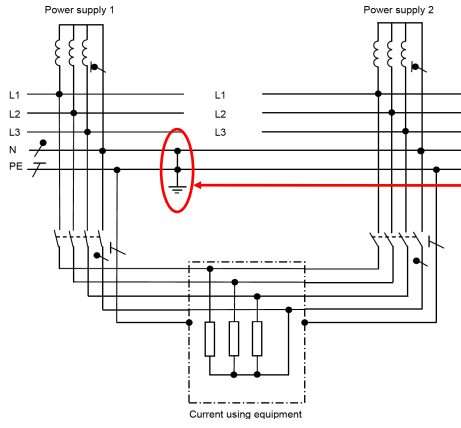


Where multiple earthing of the star points of the sources of supplies is applied, neutral conductor currents may flow back to the relevant star point, not only via the neutral conductor, but also via the protective conductor as shown in Fig. For this reason the sum of the partial currents flowing in the installation is no longer zero and a magnetic stray field is created, similar to that of a single conductor cable.

In the case of single conductor cables, which carry AC current, a circular electromagnetic field is generated around the core conductor that may interfere with electronic equipment. Harmonic currents produce similar electromagnetic fields but they attenuate more rapidly than those produced by fundamental currents.




**Three-phase alternative power supply with a 4-pole switch**

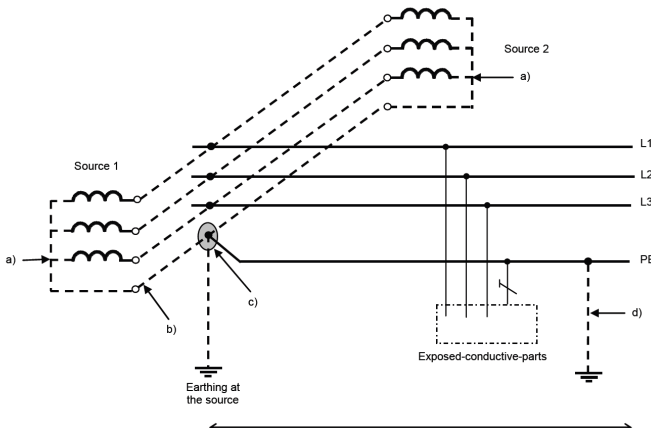


Only one connection between the interconnected neutral points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly.

This method prevents electromagnetic fields due to stray currents in the main supply system of an installation. The sum of the currents within one cable must be zero. It ensures that the neutral current flows only in the neutral conductor of the circuit, which is switched on. The 3rd harmonic (150 Hz) current of the line conductors will be added with the same phase angle to the neutral conductor current.



**TN multiple source system with protective conductor and no neutral conductor throughout the system for 2- or 3-phase load**




a) No direct connection from either the transformer neutral point or the generator star point to earth is permitted.

b) The interconnection conductor between either the neutral points of the transformers or the generator star points shall be insulated. The function of this conductor is like a PEN; however, it shall not be connected to current-using equipment.

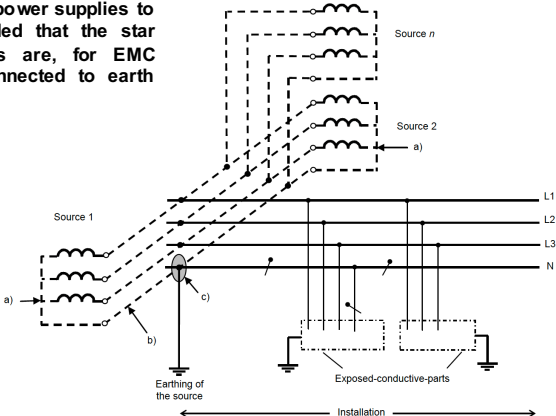
c) Only one connection between the interconnected neutral points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly.

d) Additional earthing of the PE in the installation may be provided.




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

In the case of TT multiple-source power supplies to an installation, it is recommended that the star points of the different sources are, for EMC reasons, interconnected and connected to earth centrally at only one point



- a) No direct connection from either the transformer star points or the generator star points to earth is permitted.
- b) The conductor interconnecting either the star points of transformers, or generator starpoints, shall be insulated. However, it shall not be connected to current-using-equipment and a warning notice to that effect shall be attached to it, or placed adjacent to it.
- c) Only one connection between the interconnected star points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly



**LV Network: Comparison**


The main attraction of a TN network is the low impedance earth path allows easy automatic disconnection (ADS) on a high current circuit in the case of a live-to-PE short circuit as the same breaker or fuse will operate for either L-N or L-PE faults.

It is possible to have both TN-S and TN-C-S supplies taken from the same transformer  
Eg - the sheaths on some underground cables corrode and stop providing good earth connections, and so homes where "bad earths" are found may be converted to TN-C-S.

The big advantage of the TT earthing system is the reduced conducted interference from other users' connected equipment. TT has always been preferable for special applications like telecommunication sites that benefit from the interference-free earthing. Also, TT does not have the risk of a broken neutral. In locations where power is distributed overhead and TT is used, installation earth conductors are not at risk of becoming live should any overhead distribution conductor be fractured by, say, a fallen tree or branch.

In pre-RCD era, the TT earthing system was unattractive for general use because of the difficulty of arranging reliable automatic disconnection (ADS) in the case of a live-to-PE short circuit (in comparison with TN systems, where the same breaker or fuse will operate for either L-N or L-PE faults). But as residual current devices mitigate this disadvantage, the TT earthing system has become much more attractive providing that all AC power circuits are RCD-protected. In some countries (such as the UK) is recommended for situations where a low impedance equipotential zone is impractical to maintain by bonding, where there is significant outdoor wiring, such as supplies to mobile homes and some agricultural settings, or where a high fault currents could pose other dangers, such as at fuel depots or marinas.

The TT earthing system is used throughout Japan, with RCD units in most industrial settings. This can impose added requirements on variable frequency drives and switched-mode power supplies which often have substantial filters passing high frequency noise to the ground conductor.



IEEE Std 80-2000

### 4. Safety in grounding

#### 4.1 Basic problem


In principle, a safe grounding design has the following two objectives:

- To provide means to carry electric currents into the earth under normal and fault conditions without exceeding any operating and equipment limits or adversely affecting continuity of service.
- To assure that a person in the vicinity of grounded facilities is not exposed to the danger of critical electric shock.

A practical approach to safe grounding thus concerns and strives for controlling the interaction of two grounding systems, as follows:

- The intentional ground, consisting of ground electrodes buried at some depth below the earth's surface.
- The accidental ground, temporarily established by a person exposed to a potential gradient in the vicinity of a grounded facility.

People often assume that any grounded object can be safely touched. A low substation ground resistance is not, in itself, a guarantee of safety. There is no simple relation between the resistance of the ground system as a whole and the maximum shock current to which a person might be exposed. Therefore, a substation of relatively low ground resistance may be dangerous, while another substation with very high resistance may be safe or can be made safe by careful design. For instance, if a substation is supplied from an overhead line



IEC 60364-4-44 LV installations  
Protection against Voltage disturbances  
and Electromagnetic disturbance

### Eg: Over Voltages due to fault in HV system

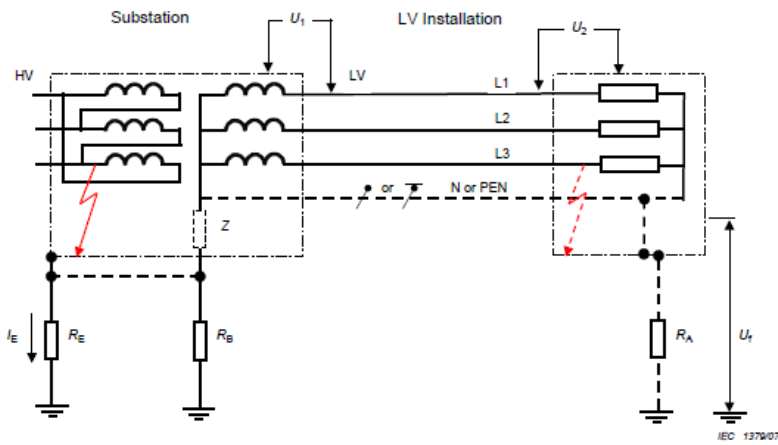



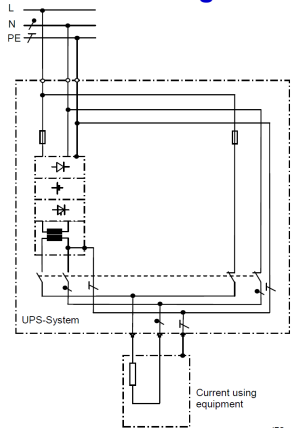
Figure 44.A1 – Representative schematic sketch for possible connections to earth in substation and LV-installation and occurring overvoltages in case of faults



**IEC 60364-4-44 LV installations**  
**Protection against Voltage disturbances**  
**and Electromagnetic disturbance**

IEC 60364-4-44:2007+AMD1:2015 CSV – 35 –  
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Eg: How to connect Earth of a load and an UPS



IEC 062/06

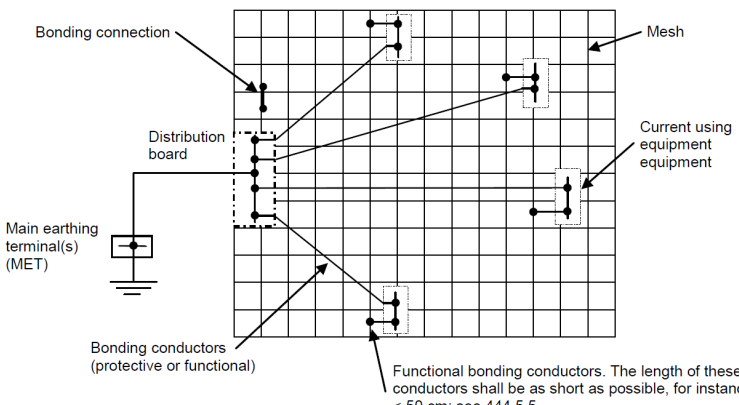
NOTE The earth connection to the secondary circuit of a UPS is not mandatory. If the connection is omitted, the supply in the UPS-mode will be in the form of an IT system and, in by-pass mode, it will be the same as the low-voltage supply system.

Figure 44.R9C – Single-phase alternative power supply with 2-pole switch



**IEC 60364-4-44 LV installations**  
**Protection against Voltage disturbances**  
**and Electromagnetic disturbance**

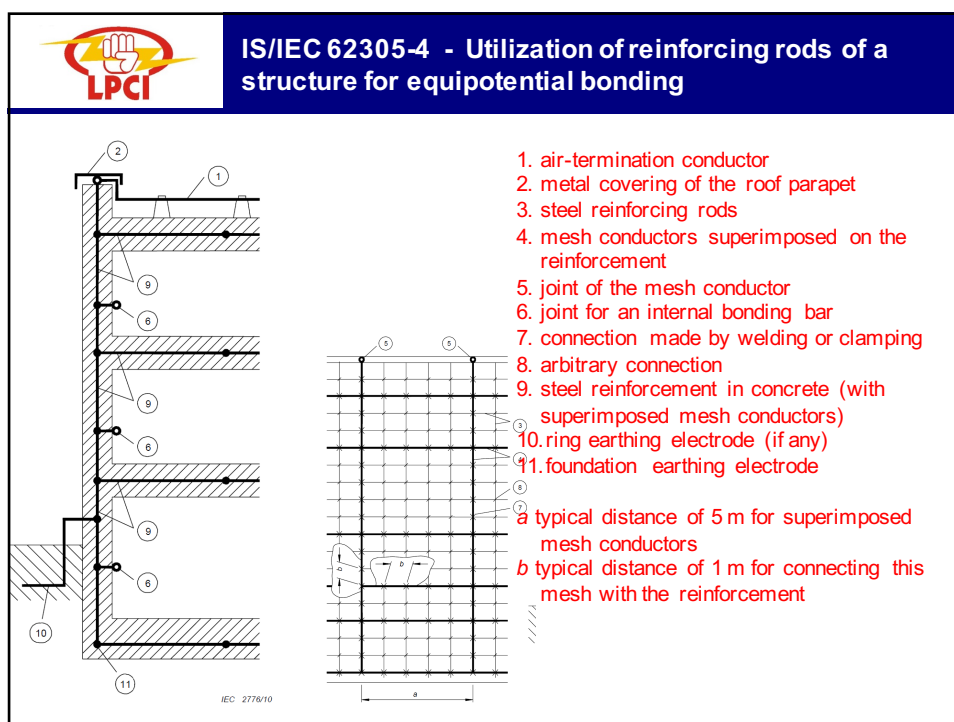
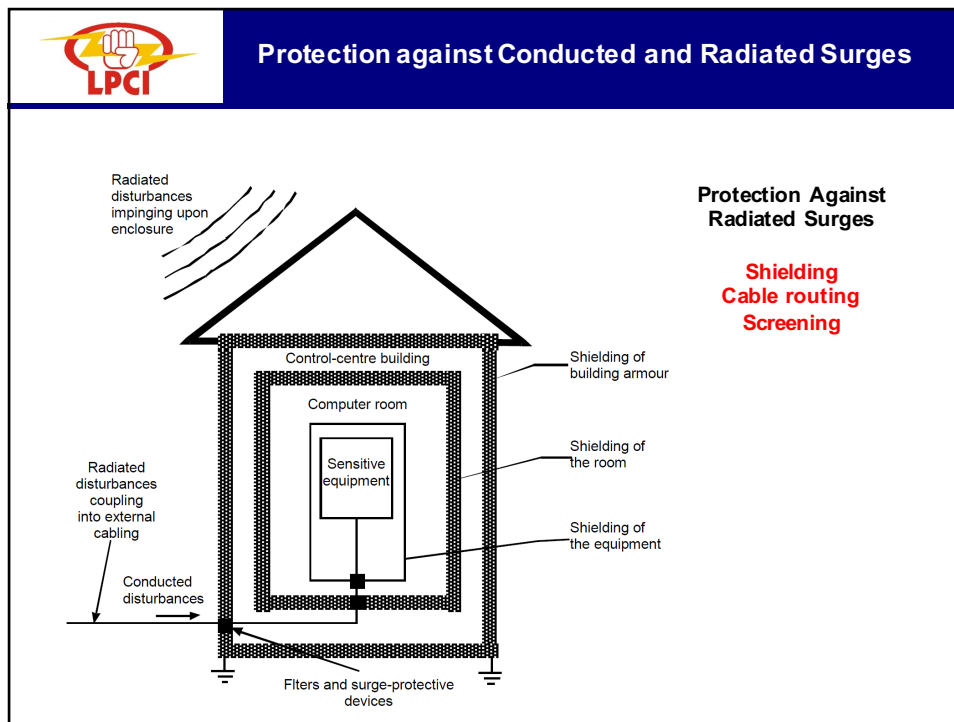
IEC 60364-4-44:2007+AMD1:2015 CSV – 41 –  
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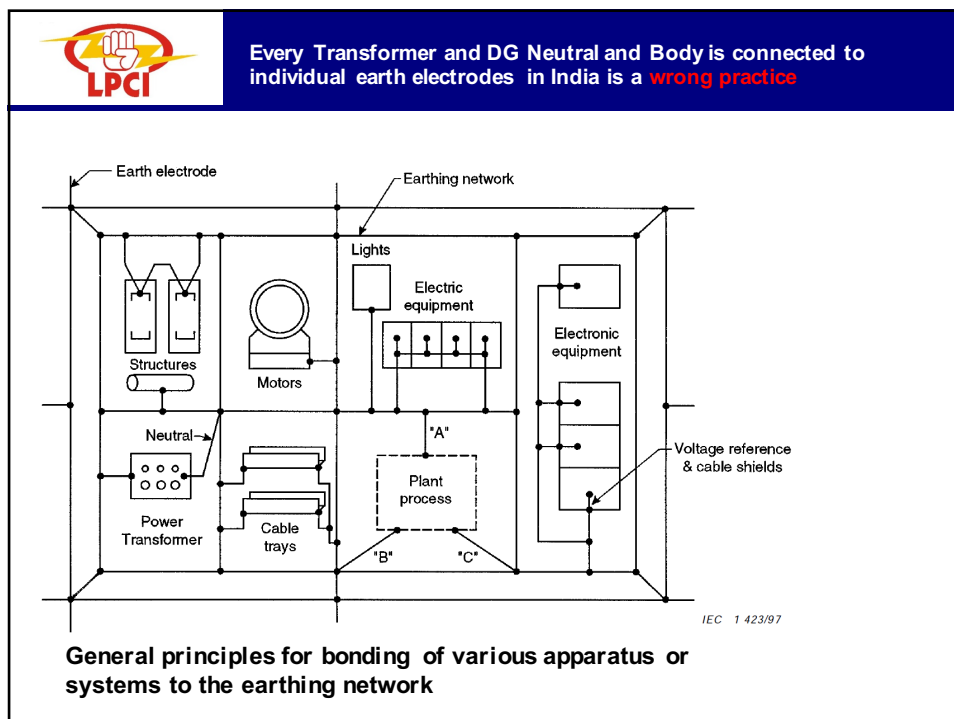
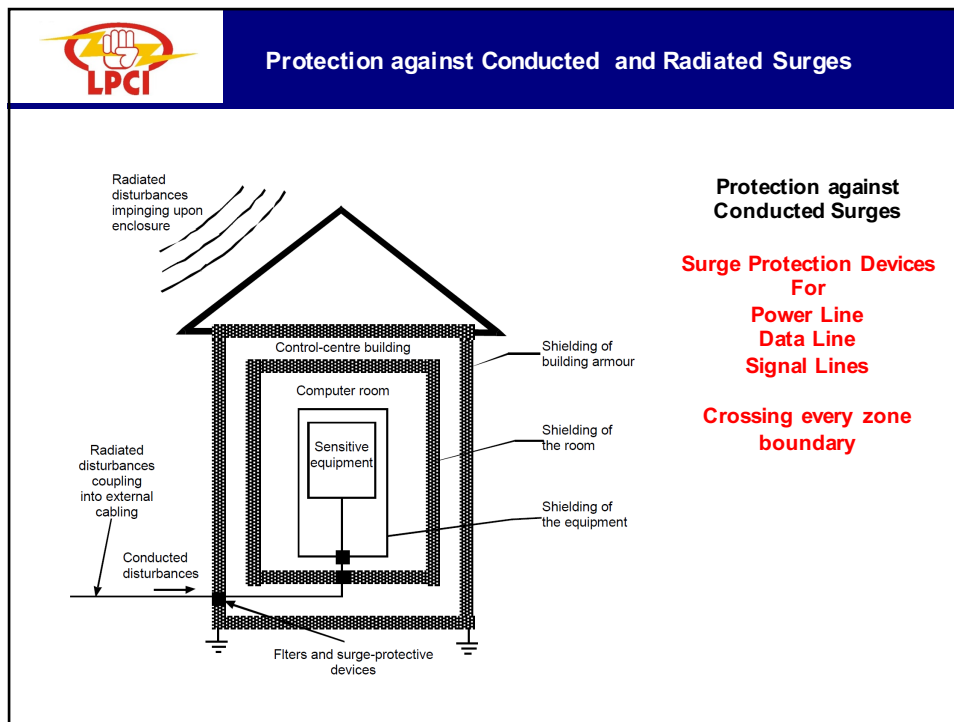
IEC 068/06


The area covered by a mesh shall have overall dimensions; the mesh-size refers to the dimensions of square spaces enclosed by the conductors forming the mesh.









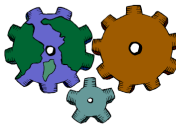
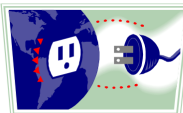




Figure 44.R15 – Example of a common meshed bonding star network








 **Different Earthing used in India**

 Earth	 Mother Earth	 Clean Earth	 Dirty Earth	 Computer Earth
 Plant Earth	 Instrument Earth	 Separate Earth	 Structural Earth	
 Power Earth	 Analog Earth	 Digital Earth	 Safety Earth	 Ground



**Think of Equipotentialisation methods  
One Earth and One earthing during transient**

**Thank you**