

CEEAMA *Live Wire* E-NEWSLETTER

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Topic for April 2026
LIGHTNING PROTECTION & EARTHING

Before you bolt towards this month's topic, revisit the last issue—
take the quiz at the end and see how much you remember.

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From the Editors Desk,

Thank you, readers, for the continued encouragement and insightful feedback we receive month after month on LiveWire. Your appreciation not only validates our efforts but also strengthens our resolve to keep this platform relevant, informative and deeply connected to the needs of our industry.

Our journey of collective learning and engagement continues. Over the past years, LiveWire has evolved into more than a newsletter—it has become a shared space for exchange of ideas, experiences and best practices within the electrical and electro equipment manufacturing ecosystem. Industry visits, technical deliberations and member to member interactions remain at the core of this effort, made possible by the untiring work of the CEEAMA administrative team and the active participation of our members.

As we release the April 2026 edition, the global environment around manufacturing and energy has changed perceptibly. The last month has reminded the world—once again—that geopolitics and energy security are now inseparable from industrial planning. Escalating tensions in energy producing regions, volatility in oil and gas prices, and disruptions in global supply chains have reinforced a hard truth: resilience is no longer optional. For sectors such as power equipment, cables, conductors and electrical infrastructure, these developments directly influence input costs, logistics planning and project execution timelines.

At the same time, there is a strong positive undercurrent. Investments in electrification, grid resilience, renewable integration, storage and industrial infrastructure continue globally, even amid uncertainty. The conversation has clearly shifted—from ambition to execution, from scale alone to reliability, safety and long term system stability. For Indian manufacturers, this phase presents both responsibility and opportunity.

In this backdrop, this month's LiveWire turns attention to an ever relevant and technically critical subject for the electrical industry: Earthing and Lightning Protection. Few topics are as layered—technically, historically and practically—as this one. From ancient beliefs that once viewed lightning as divine wrath, to modern engineering approaches grounded in science, field experience and evolving standards, the subject continues to generate discussion, debate and sometimes, controversy.

While differing philosophies and methods exist, our approach in this edition is clear: to encourage academic understanding, adherence to established standards, and application of sound engineering judgment. As technologies evolve and new products enter the market, it becomes even more important for industry professionals to distinguish between innovation that is supported by scientific validation and practices that merely appear attractive but lack compliance with prevailing codes and regulations.

Looking ahead to the months to come, volatility may persist, but the fundamentals of our industry remain strong. Demand for safe, reliable and efficient electrical systems will only grow as economies invest in infrastructure, urbanisation, data centres and energy transition initiatives. In such an environment, technical rigor, safety consciousness and ethical practices will remain hallmarks of sustainable growth.

CEEAMA remains committed to supporting its members through dialogue, knowledge sharing and collective representation. Together, as an industry, we must continue to learn, adapt and lead—grounded firmly in safety, standards and engineering excellence.

Wishing you all an electrifying, yet always SAFE, period ahead.



Subhash L. Bahulekar
Chief Editor – CEEAMA

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From the President's desk:

Happy New Financial Year!!

The Geo-Politics has taken a very different turn. The US President Mr. Trump has threatened Iran to be transported to the Stone Age. The phrase is used to mean reducing a country to pre-industrial conditions. The plan explicitly mentions targeting power infrastructure, which would break the systems that make modern life possible, such as water supply, hospitals, and communication networks. By targeting "every power plant in the whole country", the strategy seeks to systematically dismantle the regime's ability to sustain its economy. Electricity is so vital to modern life as well as the economy. Trump himself noted that if such destruction occurs, rebuilding Iran could take "20 years if they're lucky, if they have a country".

The volatility in gold and prices have had an impact on the electrical and electronics industry. Let us see how. Rising gold prices increase manufacturing expenses for electronic components such as semiconductors and connectors, particularly affecting the AI and smartphone sectors. Despite higher prices, gold remains crucial for specialized, high-reliability sectors such as satellite communication (Low Earth Orbit satellites), medical devices and aerospace due to its conductivity and corrosion resistance. The high cost of gold has accelerated research and development into substituting gold with less expensive metals or finding ways to use less gold in components. Rising silver prices, driven by high demand in solar, electric vehicles (EVs), and electronics, have significantly increased production costs and tightened profit margins in the electrical industry. Silver-intensive components, such as contacts, have seen costs rise by over 120%, pressuring manufacturers to optimize, substitute or pass costs to consumers. Silver is critical for solar PV cells. Higher prices threaten to increase solar tariffs by 1-3% and raise project capital expenditures, potentially slowing capacity additions, according to experts.

Under these conditions, the industrial mood is changing from 'wait and watch' to explore alternatives. This affects India's growth rate and poses challenges going in to the future.

In March 2026, CEEAMATECH (evening session) was conducted in Sangli-Miraj area and we would like to thank Mr. Veejhay Limaaye for carrying out the event 'from concept to commissioning'.

As Summer has set, the importance of watering the earth pits (compensating loss of moisture) and assessing adequacy of Lightning Protection (before onset of monsoon) is the top most priority of every Electrical Safety professional. We dedicate this month of LiveWire to these crucial topics. Happy reading!

April 2026 has a number of festivals / events. Do have eventful celebrations throughout April.

Hanuman Jayanti	2nd April
Good Friday	3rd April
Easter Sunday	5th April
Ambedkar Jayanti	14th April
Akshaya Tritiya	19th April

In addition to this, I earnestly request you to please share your experience by using the CEEAMA LiveWire platform. Every day we come across many professional challenges. Documenting them helps in honing our reporting skills as well as help the fraternity to learn from your experience. I am sure people will benefit by shared learning. I also request our Associate Members to kindly indicate whether we can have a factory visit conducted at your premises. We could decide based on mutually convenient dates and plan logistics accordingly.

Do keep writing to CEEAMA about your experiences. Have a wonderful April 2026. Be safe be happy.

Mr. Chidambar Joshi
Hon. President
CEEAMA

From the Secretary's desk:

Dear Esteemed Members,

Greetings from CEEAMA.

April marks the beginning of a new financial year and, for many of us, a renewed focus on execution—closing pending deliverables, aligning budgets, and planning project timelines. It is also a timely reminder that our profession continues to carry a dual responsibility: delivering safe, compliant electrical systems while simultaneously responding to rapid changes in technology, regulations, and client expectations.

Over the last few months, we have seen growing emphasis on energy efficiency, power quality, electrical safety audits, and reliability-driven maintenance practices across industrial, commercial, and infrastructure projects. Alongside this, the adoption of renewables, EV charging infrastructure, advanced earthing practices, and digital monitoring is moving from “nice to have” to “must have.” These shifts reinforce the need for consulting engineers to remain current, evidence-based, and documentation-focused—especially in design calculations, test records, and statutory compliance.

CEEAMA remains committed to providing members with platforms that support continuous learning, peer exchange, and professional networking. In the coming weeks, we will continue to strengthen our technical programs and collaborative engagements with industry, testing agencies, utilities, and statutory bodies. Members are encouraged to actively participate, suggest relevant topics, and share field experiences—particularly lessons learned from audits, commissioning, and failure investigations—so that the collective knowledge of our association becomes a practical resource for all.

I also request members to contribute short technical notes, case studies, or updates on noteworthy installations for inclusion in our e-newsletter. Practical write-ups—such as coordination studies, harmonic mitigation approaches, protection settings philosophies, earthing measurement observations, or compliance checklists—are especially valuable for fellow consultants.

As always, your participation is the strength of CEEAMA. Let us continue to uphold high standards of engineering ethics, safety, and technical excellence, and support one another as the consulting role becomes increasingly multidimensional.

Wishing you a productive and safe month ahead.

Warm regards,

Best Regards,

Mr. Ulhas Vajre
Hon. Secretary
CEEAMA

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The information in all the articles of CEEAMA LiveWire is compiled using references from various sources. Although every attempt has been made to ensure the accuracy of this material, neither CEEAMA nor any of its contributors to this publication assumes responsibility for any inaccuracies or omissions in the data presented. For use in practice, we strongly advise that, information utilized from this publication should be verified from the relevant sources and to use document of actual standard published by respective institution.

A brief History of Lightning Protection Design and Equipment Installation (NBC-2016)

The history of lightning protection dates to the 1700's, although there have been a few advancements to the technology since then. In fact, even today, common products being offered are frequently, merely, small traditional lightning rods connected with a maze of exposed wires – technology that dates from the 1800's.

Lightning protection science was first conceived by Benjamin Franklin in 1749 with his invention of the first pointed lightning rod conductor that became known as a “lightning attractor” and much later as the “Franklin Rod.” Franklin spent many years in the lightning protection design process to include his famous kite experiment, which took place as he was waiting for permission to test his theories on the new Christ Church structure in Philadelphia, PA. Although Franklin did not patent any of his inventions, he published advice on lightning protection in Poor Richard's Almanac in 1753. For his “experiment of procuring lightning from the clouds by a pointed rod,” Franklin was made an official member of the Royal Society in 1753.

At that time, the common belief was that lightning was a creation of God and therefore should not be interfered with in anyway. Franklin was finally able to convince the church deacons that they should take precautions against lightning damage by installing the lightning protection he designed, citing that rain was also a creation of God but roofs were still used on buildings to protect people and contents of buildings. The discovery of how electrical current travels brings to mind an image of Benjamin Franklin standing in a thunderstorm holding one end of a kite and waiting for lightning to strike.

For many years, all lightning protection consisted of a Franklin Rod designed to attract lightning and take the charge to ground.

In 1836, the Faraday Cage System came into existence as the first update to the lightning rod. The Faraday Cage System is basically an enclosure formed by a mesh of conducting material on the roof of a building. Named after the English scientist Michael Faraday, who invented them in 1836, this method is not totally satisfactory because it leaves areas in the centre of the roof between the conductors unprotected, unless they are defended by air terminals or roof conductors at higher levels.

In a Faraday Cage System, the lightning protection comprises of multiple lightning rods about 300mm each, fixed on discrete points on the roof. They must be bonded together with roof conductors and many down conductors to form a cage and have air terminals at the intersections of centre roof areas. The Faraday method was considered costly to install, required large amounts of equipment on a rooftop and multiple roof penetrations, but until the mid 1900's, there was nothing better.

During the 19th century, lightning protection became an architectural addition to many public and private structures. The overall pointed rod design was complimented with ornamental solid glass balls, which were not only decorative but were believed to be an integral element in the effectiveness of the lightning

protection of the structure. The theory behind this addition was that since glass is a non-conductor of electricity that they would repel the charge and for a time, because of the erratic behaviour of lightning it was believed this was scientifically proven.

Both, the pointed design and the addition of the solid glass balls were soon proven by Nicola Tesla to be a flawed lightning protection design. Tesla's patented design was a great improvement over Franklin's original lightning protection of the pointed rod. In 1919, years after receiving his patent, Tesla published an article, "Famous Scientific Illusions" in The Electrical Experimenter explaining the logic he used to dispel the science of Franklin's pointed lightning rod and scientific knowledge he used to design his lightning protection device. In his article, Tesla proved that the pointed tip of the iron rod actually ionised the air around it, which rendered that air conductive and raised the probability of a lightning strike.

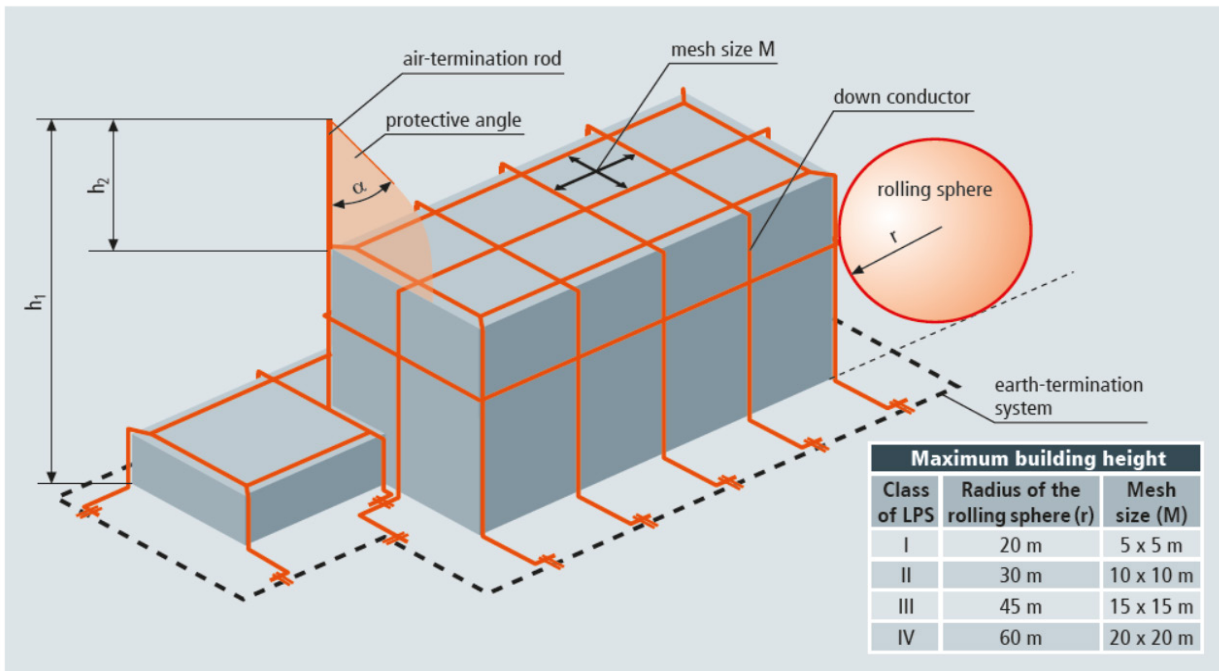
Over the decades, since Franklin and Tesla, there has been much progress in lightning protection systems. Great innovations in design and methodology have advanced the protection of mission critical systems for military and government operations and commercial applications. From transportation system control centres to mobile phone transmission towers, the instances of catastrophic damage to these and other services we had all come to take for granted has been greatly reduced.

In 1953 came the Early Streamer Emission (ESE) type Preventor. The ESE Preventor is an ionizing air terminal which is dynamic in operation. J.B. Szillard began experimenting with ionizing lightning conductors in France, and in 1931, Gustav Capart patented such a device. In 1953, Gustav's son Alphonse improved on his father's revolutionary device, and his invention resulted in what we know today as the ESE Preventor.

Preventors are dynamic in operation, whereas, the former methods are static. For example, when a storm cloud approaches a protected building, the electric ion field between the cloud and ground is increased. The ions constantly flowing from the unit, carry some of the ground ion charges towards the cloud, and this has the effect of temporarily lowering the intensity of the ion field between cloud and ground. It must be clearly understood that it cannot neutralize a cloud. It does no more than reduce the tension for the small time during which the cloud is passing overhead – but this temporary lowering of the tensions is sometimes sufficient to prevent a lightning discharge from triggering off. On the other hand, when this lowering of tension is inadequate to prevent triggering, a conductive ion streamer is provided to conduct the discharge safely to the earth / ground system.

The probability of lightning falling over a structure is determined through a Rolling Sphere Method, these days. The Rolling Sphere Method (RSM) is indeed commonly used in the field of lightning protection engineering. It's employed to determine the protection radius around lightning rods or air terminals, ensuring that they adequately shield a structure from a direct lightning strike.

The principle behind the Rolling Sphere Method is to imagine a sphere rolling over the structure. The radius of this sphere is determined based on the height of the air terminal or lightning rod above the protected structure. The sphere is then rolled along the surface of the structure, and any point that comes within the sphere's reach represents a location where a lightning rod should be placed for protection.



Method of designing air-termination systems for high buildings

While the Rolling Sphere Method is widely used and relatively straightforward, it does have limitations. It assumes a uniform electric field around the structure, which may not always be the case in complex terrain or in the presence of nearby tall objects. Additionally, it doesn't account for factors such as the shape and conductivity of the structure, which can affect the distribution of lightning currents.

As a result, engineers often use computer simulations or more advanced analysis techniques in conjunction with the Rolling Sphere Method to ensure comprehensive lightning protection design. These may include methods like the Electrogeometric Model (EGM) or finite element analysis (FEA) to provide a more accurate assessment of lightning risk and protection effectiveness.

The International Electrotechnical Commission (IEC) standard 62305 series, titled "Protection against lightning," does recommend the use of the Rolling Sphere Method (RSM) as one of the approaches for determining the protection zones for structures. IEC 62305 provides guidance on lightning protection measures for structures and their contents, as well as for the building occupants. India has adopted this IEC 62305 as Indian Standard in 2015, whereas many countries have adopted it as their national standard, many years back.

The Rolling Sphere Method is described in detail in Part 1 of the IEC 62305 series, which covers general principles of lightning protection. Specifically, Annex C of IEC 62305-1 outlines the Rolling Sphere Method and its application for determining the zones of protection around structures. This method is widely used in the lightning protection engineering field and is recognized by various international standards.

While the Rolling Sphere Method is recommended by IEC 62305, the standard also acknowledges other methods and considerations for lightning protection design, such as the mesh method and the collection volume method. Engineers are encouraged to select the most appropriate method based on the specific characteristics of the structure, the lightning risk, and other relevant factors.

Process of Modern Lightning Protection Design and Implementation (in India)

The International Electrotechnical Commission (IEC) provides guidelines for lightning protection design through various standards, including IEC 62305 series. A step-by-step approach is as under:

1. **Risk Assessment:** Identify the structure or installation to be protected. Assess the risk associated with lightning strikes based on factors such as location, topography, structure height, and the consequences of damage.
2. **Protection Level Selection:** Determine the required level of protection (LPS) based on the risk assessment. This involves selecting the appropriate lightning protection level (LPL) according to the IEC 62305 standard. The LPL defines the maximum level of lightning electromagnetic impulse (LEMP) that the lightning protection system (LPS) should be capable of withstanding without failure.
3. **Lightning Protection System Design:** Design the lightning protection system (LPS) components including air termination system (lightning rods or air terminals), down conductors, and earthing system. Ensure that the design meets the requirements specified in the chosen protection level (LPL).
4. **Air Termination System:** Determine the layout and positioning of air terminals (lightning rods) based on the shape, size, and construction of the structure. Ensure adequate coverage of the protected area to intercept lightning strikes.
5. **Down Conductor System:** Design the down conductor system to safely conduct lightning currents from the air terminals to the grounding system. Minimize the risk of side-flashes or secondary strikes by providing a low-impedance path for lightning currents.
6. **Earthing System:** Design the earthing system to safely dissipate lightning currents into the ground. Ensure low impedance connections between all components of the lightning protection system and the ground to minimize the risk of damage due to ground potential rise.
7. **Bonding:** Ensure proper bonding of all metallic components within the structure to prevent potential differences and reduce the risk of damage from lightning-induced surges. An interconnection between earthing conductors and lightning protection system is as indicated in the National Building Code 2016. (Refer Figure extracted from the NBC 2016).
8. **Surge Protection:** Install surge protection devices (SPDs) at vulnerable points within the electrical or electronic systems to prevent damage from transient over-voltages caused by lightning strikes.
9. **Inspection and Maintenance:** Regularly inspect and maintain the lightning protection system to ensure its continued effectiveness. Repair or replace any damaged components promptly to maintain the system's integrity.
10. **Documentation:** Keep detailed records of the lightning protection system design, installation, and maintenance activities for future reference and compliance verification.

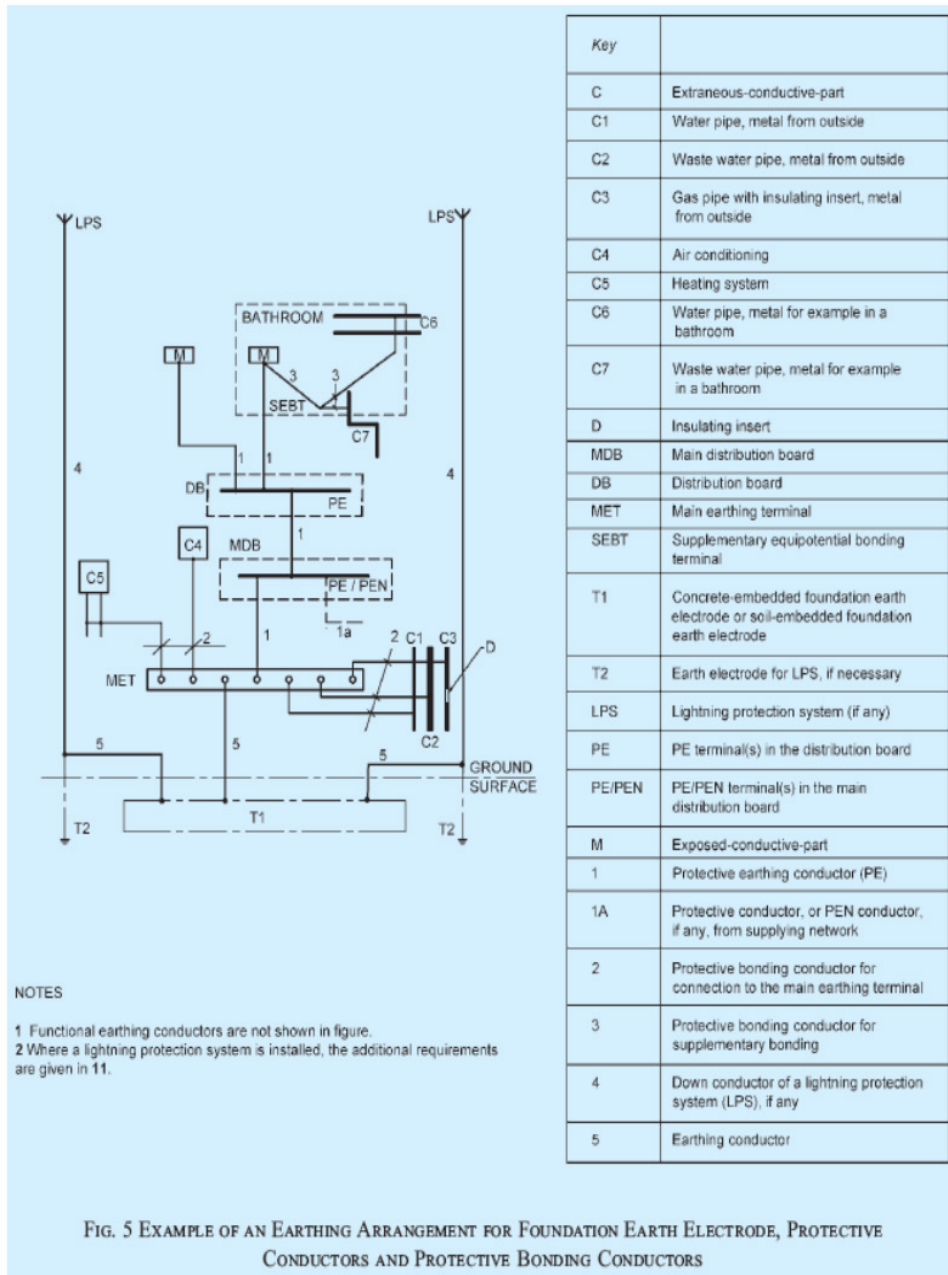
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Earthing and Bonding – extract from NBC 2016



Contributor:



Chidambar V. Joshi

EARTHING AND LIGHTNING PROTECTION

1. Introduction

Earthing and lightning protection systems are essential safety provisions in electrical installations, designed to protect personnel, equipment, and structures from electrical faults, transient over voltages, and lightning effects. These systems control abnormal electrical energy and ensure its safe dissipation, thereby preventing hazards to human life and damage to assets. In the absence of effective earthing and lightning protection, electrical faults and atmospheric discharges may result in electric shock hazards, insulation failure, fire incidents, and severe damage to sensitive electrical and electronic equipment.

Earthing provides a deliberate, low impedance path for fault currents to flow safely into the ground, limiting touch and step voltages to safe levels and preventing exposed conductive parts from reaching dangerous potentials. An effective earthing system also ensures the rapid and reliable operation of protective devices such as fuses, circuit breakers, and residual current devices, enabling prompt isolation of faulty circuits. In addition, earthing stabilizes system voltages and assists in dissipating transient surges caused by switching operations or electrostatic discharge. Lightning protection systems are designed to intercept direct lightning strikes and safely conduct high energy currents to earth through appropriately designed air terminals, down conductors, and earth termination systems. By providing a controlled discharge path, these systems prevent structural damage, fire hazards, and equipment failure. When implemented as an integrated system, earthing and lightning protection significantly enhance electrical safety, system reliability, and compliance with applicable engineering standards and regulations.

2. Design Features & Technical Characteristics

2.1 Earthing System Design

The earthing system is designed to provide a continuous, low impedance path to ground for fault currents under abnormal operating conditions. This ensures safe dissipation of fault currents into the earth, reducing the risk of electric shock and thermal damage to electrical equipment. Proper earthing design considers soil resistivity, conductor sizing, and electrode configuration to achieve earth resistance values in accordance with applicable standards.

A well designed earthing system limits touch and step voltages to permissible safety levels, protecting personnel from exposure to hazardous potential during fault conditions. By maintaining equipotential conditions, it minimizes voltage gradients around equipment and structures. The earthing system also ensures reliable operation of protective devices such as relays, fuses, and circuit breakers by allowing sufficient earth fault current flow. This enables prompt isolation of faulty circuits, thereby preventing further system damage and safety hazards.

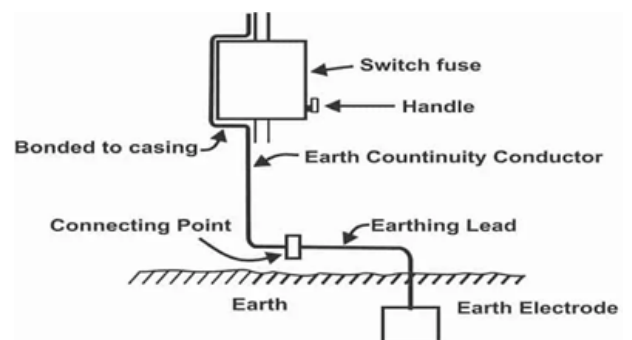


Fig. 1: Basic earthing system components.

2.2 Lightning Protection System (LPS) Design

The lightning protection system (LPS) is engineered to protect structures and electrical installations from the effects of direct lightning strikes and associated electromagnetic surges. It consists of three primary elements: air termination systems, down conductors, and earth termination systems. Air terminals are strategically positioned to intercept lightning discharges, while down conductors provide a low impedance path to safely convey lightning currents from the point of strike to the ground.

The earth termination system is designed to dissipate high energy lightning currents into the soil without causing dangerous ground potential rise or side flashing. The overall LPS layout ensures a controlled conduction path, preventing mechanical damage, fire hazards, and insulation failure within the structure. To address indirect lightning effects, the LPS is coordinated with Surge Protection Devices (SPDs) installed on power, control, and communication lines. This coordinated approach limits transient overvoltages, protects sensitive electronic equipment, and ensures system continuity and reliability during lightning events.

3. Types of Earthing and Lightning Protection Systems

1.1 Types of Earthing

- **Plate Earthing:**
Plate earthing uses copper or GI plates buried in the ground to provide effective dissipation of fault currents. It offers reliable grounding where soil resistivity conditions are moderate.
- **Pipe Earthing:**
Pipe earthing employs perforated GI pipes driven into the ground and is the most common and economical method. It provides good earth resistance and is suitable for general electrical installations.
- **Rod Earthing:**
Rod earthing uses copper or GI rods driven deep into the soil and is ideal for areas with high soil resistivity or limited installation space.
- **Mat / Grid Earthing:**
Mat earthing consists of an interconnected conductor network laid underground and is widely used in substations and data centers to control touch and step voltages.

3.2 Types of Lightning Protection

- **Conventional Lightning Protection (Franklin Rod System):**
This system uses air terminals to intercept lightning and safely conduct current to earth. It is simple, reliable, and widely used.
- **Early Streamer Emission (ESE) Systems:**
ESE systems improve lightning interception efficiency by initiating an earlier upward streamer, providing a wider protection area.
- **Faraday Cage Systems:**
Faraday cage systems use a mesh of conductors to safely distribute lightning currents around large or critical structures, minimizing internal damage.

4. Applications

- Power plants, transmission lines, and electrical substations.
- Industrial facilities, refineries, and manufacturing plants.
- Data centers, hospitals, and telecom installations.
- Residential and commercial buildings.

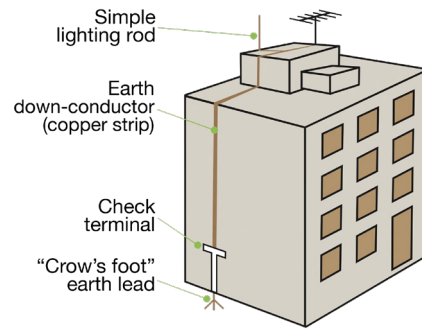
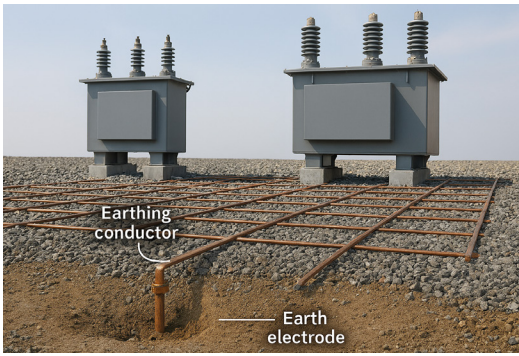


Fig. 2: Substation mat earthing arrangement. Fig. 3: Lightning protection in industrial structures.

5. References

- IEEE Std 80 – Guide for Safety in AC Substation Grounding.
- IEC 62305 – Protection against lightning.
- IS 3043 – Code of practice for earthing.

CONTRIBUTED BY:



Adude Karan Balkishan

PS No. 40048002

Associate Engineer





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Contact Us:

- +91 9765150066
- prabhaenterprises09@gmail.com

www.prabhaenterprises.com

EARTHING AND LIGHTNING PROTECTION SYSTEM

ABSTRACT

Earthing and lightning protection systems are essential safety elements in industrial environments, where high fault levels, sensitive electronic equipment, and hazardous operational conditions demand reliable electrical protection.

A well-designed earthing system ensures safe dissipation of fault currents and minimizes the risk of electric shock, equipment failure, and fire hazards, while an effective lightning protection system intercepts and safely redirects lightning energy to prevent structural damage, operational interruptions, and catastrophic accidents.

This article discusses the fundamental principles, key components, and engineering design considerations necessary for developing robust earthing and lightning protection systems in industries. It further outlines applicable national and international standards, highlights the importance of integrating both systems into a unified protection strategy, and emphasizes the relevance of proper installation, testing, and maintenance practices. By adopting comprehensive and compliant protection systems, industries can significantly enhance personnel safety, ensure equipment reliability, achieve regulatory compliance, and reduce the risk of costly downtime or failures.

EARTHING PROTECTION SYSTEM

An earthing protection system in industry is a comprehensive safety network that ensures fault currents, leakage currents, and lightning surges are safely discharged into the ground, protecting both people and equipment. It typically includes electrodes, conductors, grounding grids, bonding, surge protection, and monitoring systems.

Components:

1. Earth Electrodes

Types: Rods, plates, pipes, or foundation electrodes.

Function: Provide direct contact with soil to discharge fault currents safely.

Industrial Use: Multiple electrodes interconnected to reduce resistance and improve reliability.

2. Earthing Conductors

Materials: Copper, aluminium, or galvanized steel.

Function: Connect equipment frames, neutral points, and structures to the earth electrodes.

Design Consideration: Must have low resistance and withstand high fault currents.

3. Grounding Grid / Mesh

Application: Large industrial plants often use buried grids or meshes.

Purpose: Ensures uniform potential distribution across the site, reducing step and touch voltages.

Benefit: Provides redundancy and minimizes risk of dangerous voltage differences.

4. Surge Protective Devices (SPDs)

Role: Protect sensitive equipment from transient overvoltage caused by lightning or switching surges.

Placement: Installed at power entry points, control panels, and critical machinery.

5. Lightning Protection System (LPS)

Components: Air terminals (lightning rods), down conductors, and bonding to the earthing system.

Function: Safely intercept and discharge lightning strikes into the earth.

6. Bonding & Equipotential Connections

Purpose: Connect all metallic parts (pipes, structures, enclosures) to the earthing system.

Benefit: Prevents dangerous potential differences between equipment surfaces.

7. Monitoring & Testing Tools

Examples: Earth resistance testers, continuous monitoring sensors.

Importance: Regular testing ensures system integrity and compliance with safety standards.

8. Earth Pits & Inspection Chambers

Provide access points for testing and maintenance of electrodes. Allow measurement of earth resistance and easy replacement of electrodes. Common in large plants where multiple electrodes are interconnected.

9. Soil Treatment & Enhancement Materials

Bentonite clay, charcoal, salt, or chemical compounds used to lower soil resistivity. Essential in areas with rocky or sandy soil where natural conductivity is poor. Ensures consistent grounding performance over time.

10. Earth Fault Relays (EFRs)

Detect leakage currents or earth faults in industrial systems. Automatically trip circuits to prevent equipment damage and personnel shock. Often integrated with switchgear and control panels.

11. Equipotential Bonding Network

Extends bonding beyond equipment frames to include pipes, tanks, HVAC ducts, and structural steel.

Prevents dangerous voltage differences between metallic parts. Critical in chemical plants, refineries, and industries with large metallic infrastructure.

12. Ground Resistance Monitoring Systems

Continuous monitoring devices that track resistance of the earthing system.

Provide alarms if resistance rises above safe thresholds (e.g., $>1-5 \Omega$ depending on standards).

13. Dedicated Clean Earth for Electronics

Separate earthing system for sensitive equipment like PLC, SCADA, servers, and instrumentation. Prevents noise and harmonics from power earthing affecting data accuracy. Often connected via isolated copper busbars.

14. Counterpoise & Ring Earth Systems

Counterpoise wires laid horizontally in soil to reduce resistance.

Ring earths encircle a building or substation, ensuring uniform potential distribution. Widely used in substations and large industrial complexes.

Design Considerations:

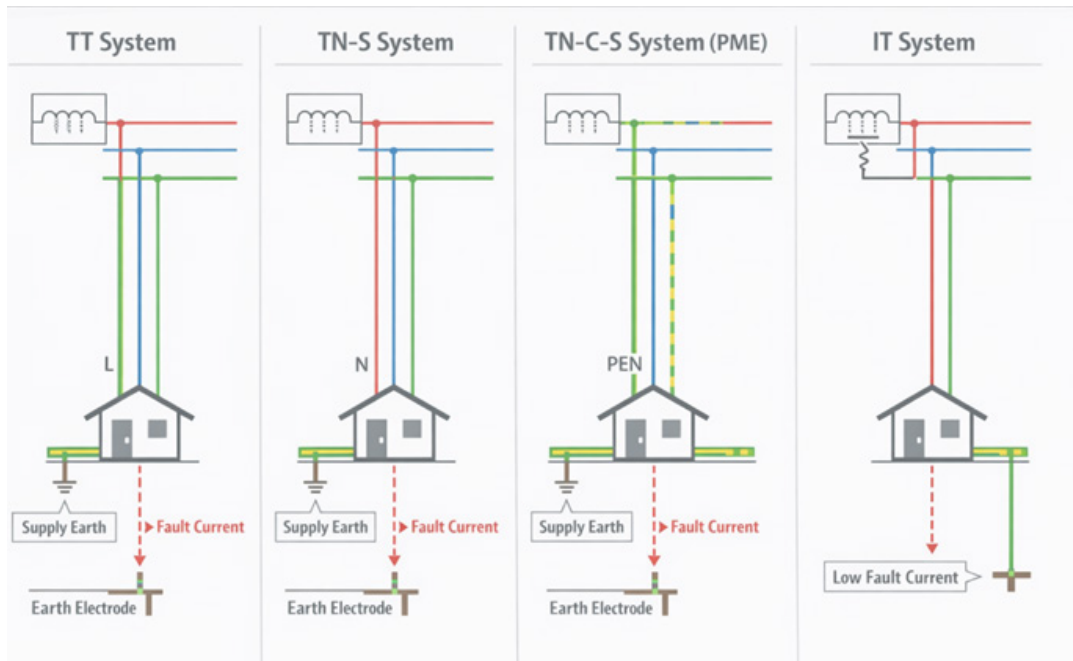
- 1. Soil Resistivity:** Soil resistivity is a measure of how much a soil resists the flow of electric current. It affects earthing system effectiveness; lower resistivity means better earthing. Typical values: (1) Wet soil: 10-100 Ωm (2) Dry soil: 100-1000 Ωm (3) Rocky soil: $>1000 \Omega\text{m}$.
- 2. Fault Current (If):** Calculate prospective fault currents to size conductors and electrodes.
- 3. Earthing System Layout:** Design the earthing grid or network to ensure: Low resistance (typically $<1 \Omega$ for industrial systems) and even current distribution.
- 4. Material Selection:** Choose materials resistant to corrosion and suitable for the environment: Copper, Galvanized iron and stainless steel.
- 5. Electrode Type and Placement:** (1) Rods: driven into the ground (2) Plates: used in areas with high soil resistivity or limited space (3) Rings: used for large earthing systems.
- 6. Connection and Bonding:** Ensure secure connections and bonding between earthing system components.
- 7. Surge Protection:** Consider surge protection devices (SPDs) for equipment protection.
- 8. Corrosion Protection:** Materials and designs should withstand environmental conditions.
- 9. Recommended earth resistance values:**

Area Type	Recommended Resistance
Heavy industries	$<1 \Omega$
Substations	$<1 \Omega$
Commercial buildings	1–5 Ω
Clean earth for electronics	$<0.5 \Omega$
Lightning protection earth	$<10 \Omega$

Types of Earthing Systems

- 1. TN System (Neutral and Earth Combined):** Neutral and earth are combined at the source, commonly used in industrial settings.

2. **TT System (Separate Neutral and Earth):** Separate neutral and earth at the source, often used in rural or specific industrial applications.
3. **IT System (No Direct Earth):** No direct earth connection at the source, typically used in critical applications like medical facilities or data centres.
4. **TN-S System (Separate Neutral and Earth Conductors):** Neutral and earth are separate conductors from the source to the consumer. Common in large industrial plants; provides reliable fault clearance and safety.
5. **TN-C-S System (Combined then Separate Neutral and Earth):** Neutral and earth are combined (PEN) at the source, then split into separate conductors at the consumer end. Widely used in industries as a balance between cost and safety.



Applicable codes & standards

1. IS 3043 - Main Indian standard for earthing design and safety
2. IEC 60364 - Defines earthing systems (TN, TT, IT)
3. IEC 60364-5-54 - Details earthing conductors and bonding
4. IEC 61936-1 - Earthing for high-voltage systems
5. IEEE 80 - Widely used for grounding design in substations

LIGHTNING PROTECTION SYSTEM

Lightning Protection Systems are essential in industrial facilities to safeguard structures, equipment, and personnel from the destructive effects of lightning strikes. Industrial plants contain high-risk assets such as tall structures, storage tanks, process equipment, critical control systems, and sometimes flammable or explosive atmospheres. Because of this, a properly engineered lightning protection system is indispensable for operational safety, continuity, and regulatory compliance.

Components:

1. Air Terminals (Lightning Rods)

Strategically placed on rooftops or tall structures. Their positioning is calculated to create a protective “cone of protection” around the building.

2. Down Conductors

Usually copper or aluminium strips/wires running vertically. Installed along building walls with proper spacing to minimize inductive effects.

3. Grounding System

Designed to achieve low earth resistance (typically <1-5 Ohm Surge Protection Devices (SPDs) depending on standards).

4. Surge Protection Devices (SPDs)

Protect electrical panels, machinery, and communication lines from transient overvoltage. Installed at main distribution boards, control panels, and sensitive equipment.

Type 1: Manages direct lightning currents (installed at service entrance).

Type 2: Protects against switching surges (installed at distribution boards).

Type 3: Protects sensitive electronics (installed near equipment).

5. Bonding and Equipotentialization

Involves connecting all metallic parts (pipes, tanks, ducts, enclosures) to the earthing system. Prevents dangerous voltage differences and reduces risk of arcing or sparks.

6. Strike Counters

Devices installed on down conductors to record the number of lightning strikes. Useful for maintenance planning and risk assessment.

7. Isolated Down Conductors (HVI Technology)

High-voltage-resistant insulated conductors. Prevent dangerous side flashes in chemical plants, refineries, or explosive environments.

8. Equipotential Bonding Bars

Central bonding points where all metallic parts and conductors are connected. Ensures equal potential distribution across the facility.

9. Ground Enhancement Materials (GEM)

Special compounds (bentonite, conductive concrete, carbon-based fillers) used around electrodes. Reduce soil resistivity and improve grounding performance.

10. Exothermic Welding Connections

Permanent molecular bonds between conductors and electrodes. More reliable than mechanical clamps, especially in high-current industrial applications.

11. Lightning Warning Systems

Sensors that detect atmospheric electric field changes. Provide early warnings to shut down sensitive operations or evacuate personnel.

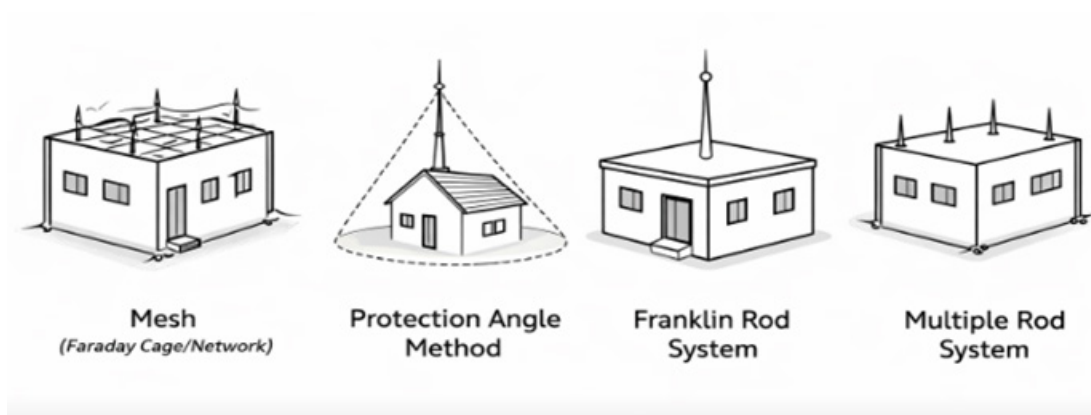
Design Considerations

1. Risk Assessment: Evaluate strike probability based on geography, building height, and surrounding structures.
2. Ground Resistance: Maintain grounding resistance below recommended thresholds (often <10 Ω).
3. Material Selection: Use corrosion-resistant conductors (copper, aluminium) for longevity.
4. Integration with Electrical Systems: Coordinate SPDs with existing power distribution.

- Maintenance: Regular inspections for corrosion, loose connections, and SPD health checks.

Types of Lightning Protection Systems

- Conventional Rod System:** Uses multiple rods and conductors; suitable for most industrial buildings.
- Mesh (Faraday Cage) System:** A network of conductors covering the structure; ideal for large plants and warehouses.
- Early Streamer Emission (ESE) System:** Extends the protective radius by triggering upward streamers earlier; often used in wide industrial complexes.
- Charge Dissipation System:** Reduces the likelihood of strikes by neutralizing charges; less common but used in specialized applications.



Protection Class

Protection classes define the Lightning Protection Level (LPL) a system must withstand. Each class corresponds to specific lightning current parameters, such as peak current, charge, and energy. The lower the class number, the higher the protection level.

- Class I – Highest Protection:** Manages the most severe lightning strikes (up to 200 kA). Used for nuclear plants, explosive storage, chemical industries, and military facilities. Extremely low probability of damage.
- Class II – High Protection:** Designed for strong strikes (up to 150 kA). Suitable for hospitals, schools, data centres, and large public buildings. Low probability of damage.
- Class III – Medium Protection:** Covers moderate strikes (up to 100 kA). Common for offices, warehouses, and residential complexes. Moderate probability of damage.
- Class IV – Basic Protection:** Same current parameters as Class III but applied to low-risk structures like small houses and rural buildings. Higher probability of damage is acceptable.

Lightning Risk Assessment (IEC 62305 2)

Before designing an LPS, a formal lightning risk assessment must be performed. This includes:

- lightning density of the geographical area
- height, shape, and exposure of the structure
- type of industrial processes (flammable, sensitive, critical)
- consequence of a lightning strike (safety, economic, environmental)
- presence of cables, pipelines, storage tanks, and hazardous zones

Applicable code & standards

1. IEC 62305 - Main standard for lightning protection design, risk assessment, and system requirements
2. IS 2309 - Indian standard for protection of buildings against lightning
3. IEC 62561 - Specifies components like air terminals, conductors, connectors
4. IEC 60364-4-44 - Covers protection from lightning-induced overvoltage
5. IEC 60364-5-53 - Includes surge protective devices (SPDs)

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Earthing and Lightning Protection for Solar Power Generation

1. Introduction

Solar photovoltaic (PV) systems are usually installed in open areas such as rooftops and large solar plants. Because they are open to the environment and cover large areas, they can be easily affected by lightning strikes, electrical surges, and ground faults.

To protect the system, proper earthing (grounding) and lightning protection systems are very important. These systems help to:

- Keep people safe.
- Protect solar equipment from damage.
- Ensure the system works reliably with minimum interruptions.

International standards like IEC 62305, IEC 60364, IEC 61643, NEC Article 690, and Indian Standard IS 3043 give clear guidelines on how to design and install these protection systems correctly.

2. Fundamentals of Earthing in Solar PV Systems



2.1 Purpose of Earthing:

Earthing means connecting the metal parts of an electrical system safely to the ground. The main purposes of earthing are:

- To protect people from electric shock
- To provide a safe path for fault current to flow
- To keep system voltage stable
- To safely release lightning and surge energy into the ground

A well-designed earthing system helps the power supply disconnect automatically during a fault, which increases safety for both people and equipment.



2.2 Types of Earthing in PV Systems:

Solar PV systems usually use different types of earthing for safety and proper operation:

A) Equipment Earthing:

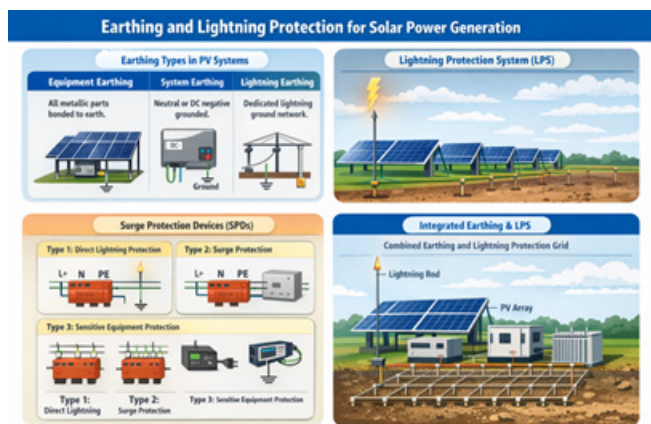
All metal parts of the solar system, such as solar panel frames, mounting structures, and inverter cabinets, are connected to the earth. It helps prevent electric shock if a fault occurs and is required by electrical standards.

B) System Earthing:

In this type, one conductor of the system (usually the neutral wire or the DC negative) is connected to earth, depending on the system design. Modern solar PV systems can be grounded or ungrounded, based on safety and performance requirements.

C) Lightning Earthing:

This is a separate earthing system designed to safely discharge lightning current into the ground. It is usually connected to the main plant earthing grid to ensure overall protection of the solar installation.



2.3 Earthing Design Considerations:

While designing an earthing system, the following points are important:

- **Soil resistivity** – This affects how big and how deep the earth electrodes need to be.
- **Earth resistance** – It is normally kept **between 1 and 10 ohms**, depending on the type of system.
- **Material selection** – Common materials used are **copper, GI (galvanized iron), or copperbonded steel**.
- **Earthing layout** – A **mesh or grid earthing system** is preferred, especially for large solar plants.

It is recommended to use **one common earthing grid** for all equipment, structures, and the lightning protection system. This helps keep the same voltage level everywhere and improves safety.

3. Lightning Protection in Solar Power Plants:

3.1 Why Lightning Protection Is Needed

Solar PV plants are exposed to lightning and electrical surges because they are installed in open areas. They may be affected by:

- Direct lightning strikes
- Voltage surges caused by lightning nearby

- Switching operations in the electrical system

Lightning can damage **solar panels, inverters, transformers, and control systems**, which can cause long and expensive shutdowns.

3.2 Lightning Protection System (LPS)

A complete Lightning Protection System includes the following parts:

a) Air Termination System

This includes **lightning rods or masts** that catch lightning strikes. They are installed **above the solar panels** with safe clearance as per design rules.

b) Down Conductors

These conductors provide a **safe and lowresistance path** for lightning current to flow down to the ground.

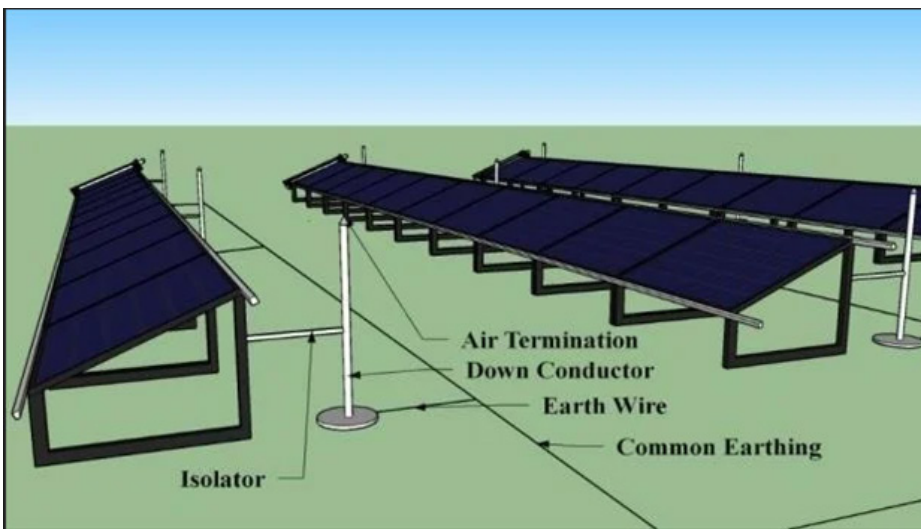
c) Earth Termination System

This system safely **spreads the lightning current into the soil**.

d) Equipotential Bonding

This ensures that all metal parts stay at the **same electrical voltage**, which prevents dangerous electric shocks.

As per **IEC 62305**, proper lightning protection design requires risk assessment, selection of protection level, and correct installation.



3.3 Surge Protection Devices (SPD)

Surge Protection Devices protect electrical and electronic equipment from voltage surges.

- Installed on the **DC side** (between panels and inverter).
- Installed on the **AC side** (between inverter and grid).
- Designed as per **IEC 6164332**.

SPDs are required **even if no external lightning protection system is installed**.

Types of SPDs:

- **Type 1:** For direct lightning currents.
- **Type 2:** For indirect lightning and switching surges.
- **Type 3:** For sensitive electronic equipment.

4. Integrated Earthing and Lightning Protection:

Modern solar plants use an **integrated protection system**, where:

- The earthing grid and lightning system are connected.
- All metal structures are properly bonded.
- SPDs work together with the earthing system.

This approach safely handles both **fault currents and lightning energy**.

In PV systems:

- Lightning arresters must be connected to the **main earthing grid**.
- Separate DC earthing may be used to improve surge protection.

5. Standards and Codes

International Standards

- **IEC 62305** – Lightning protection
- **IEC 60364 (Part 7712)** – Solar PV installations.
- **IEC 6164332** – Surge protection for PV systems.
- **IEC 62446** – Testing and inspection of PV systems.

Indian Standards

- **IS 3043** – Earthing.
- **IS/IEC 62548** – PV array design.
- **NBC 2016** – Electrical safety rules.

NEC (USA)

- **Article 690** – Solar PV systems.
- **Article 250** – Grounding and bonding.

Following these standards ensures **safety, reliability, and regulatory approval**.

6. Best Practices:

- Keep earth resistance **below 1–5 ohms** for large solar plants.
- Use **grid or mesh earthing**.
- Install **Type 1 + Type 2 SPDs** at important points.
- Bond all metal parts together.
- Carry out **regular testing and maintenance**.
- Perform lightning risk study before final design.

7. Conclusion

Earthing and lightning protection are very important parts of solar PV system design. A properly designed system protects people, prevents equipment damage, and improves system life and reliability. As solar installations continue to increase, following **IEC, NEC, and Indian standards** and using integrated protection methods is essential for safe and longterm solar power operation.

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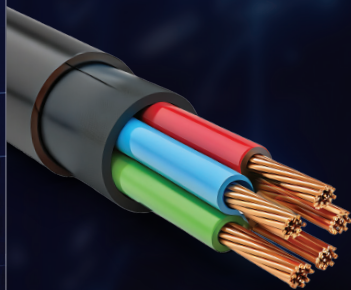
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Earthing Layout

ABSTRACT

The article is intended to understand Preparation of Earthing layout.

The points covered in this article shall be taken care during Earthing Layout preparation.

The purpose of Earthing in electrical systems is crucial for safety and functionality. Even, Step and contact voltages produced have the potential to harm or even kill nearby humans and animals. Earthing serves three main purposes:

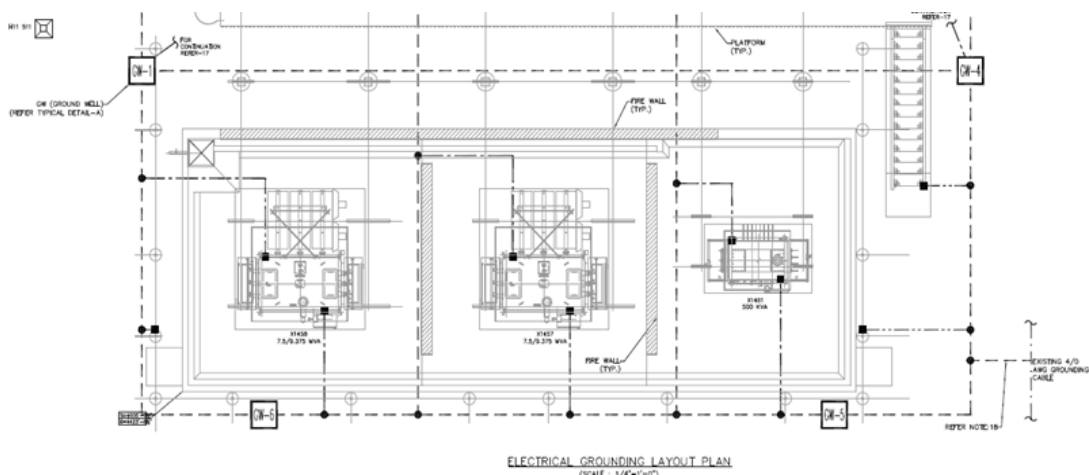
1. **System Earthing:** This aspect focuses on electrical safety throughout the system not caused by a fault. It prevents static buildup, protects against power surges from lightning strikes, and allows for equipotential bonding to prevent potential differences between metal works.
2. **Equipment Earthing:** This type of earthing is essential for electrical safety in the event of a fault. It aims to prevent equipment damage and the risk of electric shock. Equipment earthing ensures that in case of a fault, the current flows to the ground through a protective conductor, triggering the automatic disconnection of supply to prevent harm.
3. **Functional Earthing:** This serves purposes beyond electrical safety, such as electromagnetic interference filtering or using the Earth as a return path in specific systems like single-wire earth return distribution systems.

STANDARDS TO BE FOLLOWED:

- IEC 60364
- BS 7430
- IS 3043

STEPS TO BE FOLLOWED FOR EARTHING LAYOUT PREPARATION:

- 1) According to the requirements of Central Electricity Authority (CEA) rules, all medium voltage equipment shall be earthed by two separate and distinct connections with earth. In case of high voltages, the neutral points shall be earthed by not less than two separate and distinct connections with earth, each having its own electrode.
- 2) Typical Earthing Layout



3) Internationally, Earthing system has been divided into three categories:

- a) TN system
- b) TT system
- c) IT system

For detailed information refer IS 3043.

4) Material and dimensions of the earth electrode shall be selected to withstand corrosion and to have adequate mechanical strength. For commonly used materials, the common minimum sizes from the point of view of corrosion and mechanical strength for earth electrodes, where embedded in the soil are given in the table below.

Material	Surface	Shape	Minimum size				
			Diameter mm	Cross-sectional area mm ²	Thickness mm	Thickness of coating/sheathing	
						Individual value µm	Average value µm
Steel	Hot-dip galvanized ^a or Stainless ^{a, b}	Strip ^c		90	3	63	70
		Sections		90	3	63	70
		Round rod for deep earth electrodes	16			63	70
		Round wire for surface electrode ^g	10				50 ^e
	Pipe	25		2	47	55	
	Copper- sheathed	Round rod for deep earth electrode	15			2 000	
With electro- deposited copper coating	Round rod for deep earth electrode	14			90	100	
Copper	Bare ^a	Strip		50	2		
		Round wire for surface electrode ^g		25 ^f			
		Rope	1,8 for individual strands of wire	25			
		Pipe	20		2		
	Tin-coated	Rope	1,8 for individual strands of wire	25		1	5
	Zinc-coated	Strip ^d		50	2	20	40

^a Can also be used for electrodes to be embedded in concrete.
^b No coating applied.
^c As rolled strip or slit strip with rounded edges.
^d Strip with rounded edges.
^e In the case of continuous bath-coating, only 50 µm thickness is technically feasible at present.
^f Where experience shows that the risk of corrosion and mechanical damage is extremely low, 16 mm² can be used.
^g An earth electrode is considered to be a surface electrode when installed at a depth not exceeding 0,5 m.

The resistance of pipe or rod electrode is calculated by:

$$R = \frac{100\rho \log_e 2l}{2\pi d} \text{ Ohms}$$

Where,

l = length of rod or pipe (in cm)

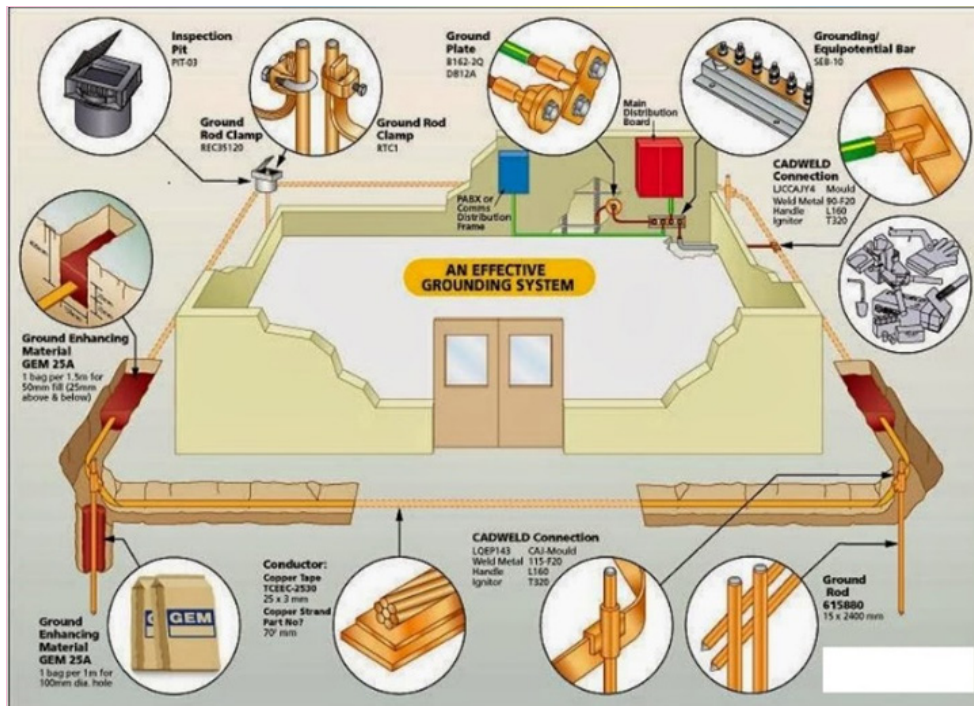
d = diameter of rod or pipe in cm,

ρ = resistivity of the soil (in Ω.m)

The curves are calculated from this equation for electrodes of 13, 25 and 100mm dia. respectively in soil of 100 Ω.m respectively. Change of diameter has a relatively minor effect and size of pipe is generally governed by resistance to bending or splitting. It is apparent that the resistance diminishes rapidly with the first few feet of driving, but less so at depth greater than 2 to 3m in soil of uniform resistivity. A number of rods or pipes may be connected in parallel and the resistance is then partially proportional to the reciprocal of the number employed so long as each is situated outside the resistance area of other.

Where an extensive underground cable system is available, the lead sheath and armour form a most effective earth electrode. Cable sheaths are more commonly used to provide a metallic path to the fault current returning to the neutral.

An effective earthing is teamwork of various parts and accessories:



5) The cross-sectional area of the protective conductor shall be not less than the appropriate value shown in Table. If the application of this table produces non-standard sizes, conductors having the nearest higher standard cross-sectional area are to be used.

TABLE 7 CROSS SECTION OF PROTECTIVE CONDUCTOR

CROSS-SECTIONAL AREA OF PHASE CONDUCTORS OF THE INSTALLATION S (mm ²)	MINIMUM CROSS-SECTIONAL AREA OF THE CORRESPONDING PROTECTIVE CONDUCTOR S_p (mm ²)
$S < 16$	S
$16 < S < 35$	16
$S > 35$	See 12.2.2.1

The above values are valid only if the protective conductor is made of the same metal as the phase conductors. If not so, the cross-sectional area of the protective conductor is to be determined in a manner which produces a conductance equivalent to that which results from the application of table.

- 6) Consideration shall be given to **electrolytic corrosion** when using different materials in an earthing arrangement. Earthing conductors buried in soil have their cross-sectional area according to below table.

	Mechanically protected	Mechanically unprotected
Protected against corrosion	2,5 mm ² Cu 10 mm ² Fe	16 mm ² Cu 16 mm ² Fe
Not protected against corrosion	25 mm ² Cu 50 mm ² Fe	

The connection of an earthing conductor to any earth electrode shall be soundly made and electrically satisfactory. The connection shall be by exothermic welding, pressure connectors, clamps or other mechanical connectors. Mechanical connectors shall be installed in accordance with manufacturer's instructions. Where a clamp is used, it shall not damage the electrode or the earthing conductor.

- 7) Equipment is classified with regard to protection against Electrical shock as per below table.

TABLE 2 CLASSIFICATION OF EQUIPMENT

	CLASS 0	CLASS I	CLASS II	CLASS III
Principal characteristics of equipment	No means of protective earthing	Protective earthing means provided	Additional insulation and no means for protective earthing	Designed for supply at safety extra low voltage
Precautions for safety	Earth free environment	Connection to the protective earthing	None necessary	Connection to safety extra low voltage

TABLE 3 EXAMPLES OF SOIL RESISTIVITY

TYPE OF SOIL (1)	CLIMATIC CONDITION			
	Normal and High Rainfall (for Example, Greater than 500 mm a Year)	Low Rainfall and Desert Condition (For Examples, Less than 250 mm a Year)		Underground Waters (Salids)
	Probable value (2) Ω.m	Range of values encountered (3) Ω.m	Range of values encountered (4) Ω.m	Range of values encountered (5) Ω.m
Alluvium and lighter clays	5	*	*	1 to 5
Clays (excluding alluvium)	10	5 to 20	10 to 100	
Marls (for example, keuper marl)	20	10 to 30	50 to 300	
Porous limestone (for example, chalk)	50	30 to 100		
Porous sandstone (for example, keuper sandstone and clay shales)	100	30 to 300		
Quartzites, compact and crystalline limestone (for example, carboniferous marble, etc)	300	100 to 1 000		
Clay slates and slatey shales	1 000	300 to 3 000	1 000 upwards	30 to 100
Granite	1 000			
Fossile slates, schists gneiss igneous rocks	2 000	1 000 upwards		

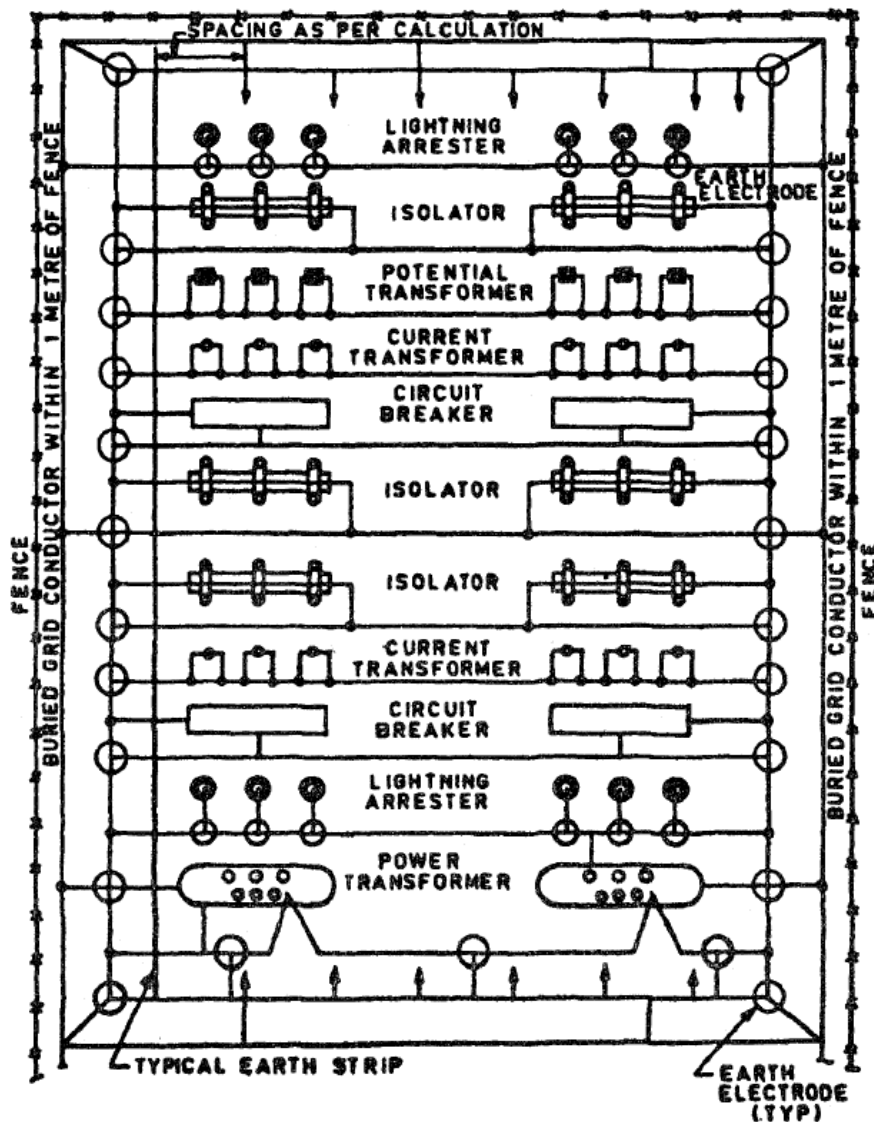
*Depends on water level of locality.

8) Soil Resistivity:

The resistance to earth of a given electrode depends upon the electrical resistivity of the soil in which it is installed.

10) General Earthing Arrangement:

A typical earthing arrangement for an outdoor switchyard is shown in below fig.



11) Protection against indirect contact is achieved by the adoption of one of the following protective measures:

- Safety extra low voltage
- The use of class II equipment or by equivalent insulation.
- A non-conducting location
- Earth free local equipotential bonding
- Electrical separation
- Earthed equipotential bonding and automatic disconnection of the supply.

12) The following **extraneous conductive parts** those are required to be bonded to the main earthing terminal of the installation:

- Gas pipes,
- Other service pipes and ducting
- Risers and pipes of fire protection equipment
- Exposed metallic parts of the building structure.
- Lightning conductors

13) The following **exposed conductive parts** those are required to be connected by means of protective conductors to main earthing terminals of the installation:

- All metalwork associated with wiring system (other than current-carrying parts) including cable sheaths and armour, conduit, ducting, trunking, boxes and catenary wires.
- The exposed metalwork of all Class I fixed and portable current-using equipment. Even here at the

time of the erection of the installation this equipment is of Class II construction or its equivalent, because there is a possibility that in the life of the installation the equipment may be replaced by Class I equipment, all fixed wiring accessories should incorporate an earthing terminal that is connected to the main earthing terminal by means of the protective conductors of the circuits concerned.

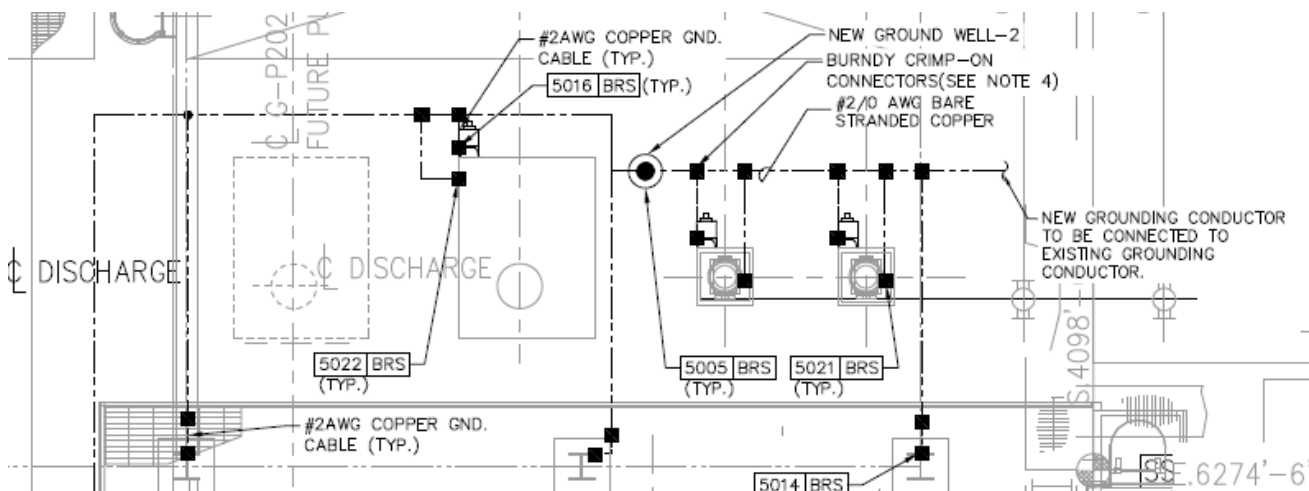
- c) The exposed metalwork of transformers used in the installation other than those that are an integral part of equipment. The secondary windings of transformers should also be earthed at one point of the winding, unless the transformer is a safety isolating transformer supplying a part of the installation where the protective measure 'electrical separation' is being used.

Exposed conductive parts that (because of their small dimensions or disposition) cannot be gripped or contacted by a major surface of the human body (that is a human body surface not exceeding 50 mm x 50 mm) need not be earthed if the connection of those parts to a protective conductor cannot readily be made and reliably maintained. Typical examples of such parts are screws and nameplate, cable clips and lamp caps. Fixing screws for non-metallic accessories need not be earthed provided there is no appreciable risk of the screws coming into contact with live parts.

14) Other exposed conductive parts not required to be earthed are:

- a) Overhead line insulator brackets and metal parts connected to them if such parts are not within arm's reach
- b) Short lengths of metal conduit or other metal enclosures used to give mechanical protection to equipment of Class II or equivalent construction.

Typical Earthing Layout:



Contributed by:



Mrs. PRIYA SHAH



LIGHTNING PROTECTION LAYOUT



ABSTRACT

The article is intended to understand Preparation of lightning protection layout.

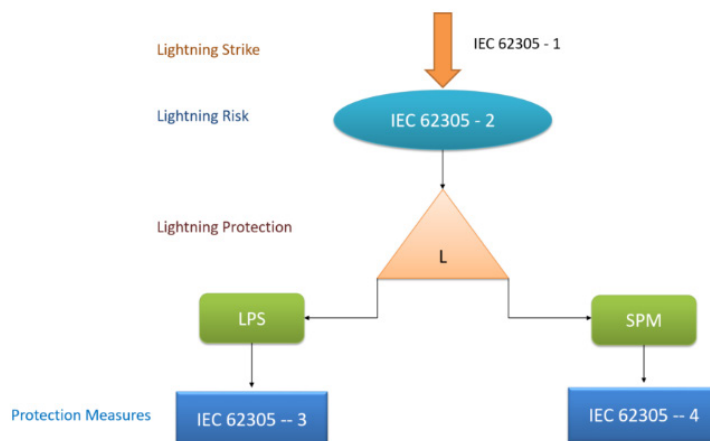
The points covered in this article shall be taken care during Lightning Protection Layout preparation.

1. ABOUT LIGHTNING STRIKES:

1. Lightning strikes can result in mechanical interruptions, chemical spills, flames, explosions, or explosions within or outside of structures. They can also produce electrical discharges caused by neighboring lightning. Step and contact voltages produced by a lightning strike have the potential to harm or even kill nearby humans and animals.
2. Building damage from lightning strikes is prevented or reduced with the installation of lightning protection systems. They guard a building's interior electrical systems, assisting in the prevention of fires and electrocution. A lightning conductor, which is often a metal rod, is installed atop a building to provide lightning protection from lightning strikes. The lightning rod will be struck first by the system, allowing the strike to be transmitted through a wire and safely reach the ground in the event that lightning strikes the structure.

2. STANDARDS TO BE FOLLOWED:

- IEC 62305



- NFPA 780
- IEEE 80

- British Standards (BS 6651)
- German Standards (DIN 57, 185 parti / VDE 0185 part 1.2)

3. STEPS TO BE FOLLOWED FOR LIGHTNING PROTECTION LAYOUT PREPARATION:

1) Lightning protection levels (LPL)

The ideal lightning protection for a structure and its connected services would be to enclose the structure within an earthed and seamlessly conducting metallic shield (box), and in addition provide adequate bonding of any related services at the entrance point into the shield. This in essence would prevent the breach of the lightning current and the induced electromagnetic field into the structure. However, in practice it is not possible or indeed cost effective to go to such lengths. This standard thus sets out a defined set of lightning current parameters where protection measures, adopted in accordance with its recommendations, will reduce any damage and consequential loss because of a lightning strike. This reduction in damage and consequential loss is valid provided the lightning strike parameters fall within defined limits, established as Lightning Protection Levels (LPL).

Each level has a fixed set of maximum and minimum lightning current parameters.

The maximum values have been used in the design of products such as lightning protection components and Surge Protective Devices (SPDs). The minimum values of lightning current have been used to derive the rolling sphere radius for each level.

These parameters are shown in the Table below:

Table Lightning current for each LPL based on 10/350 μ s waveform

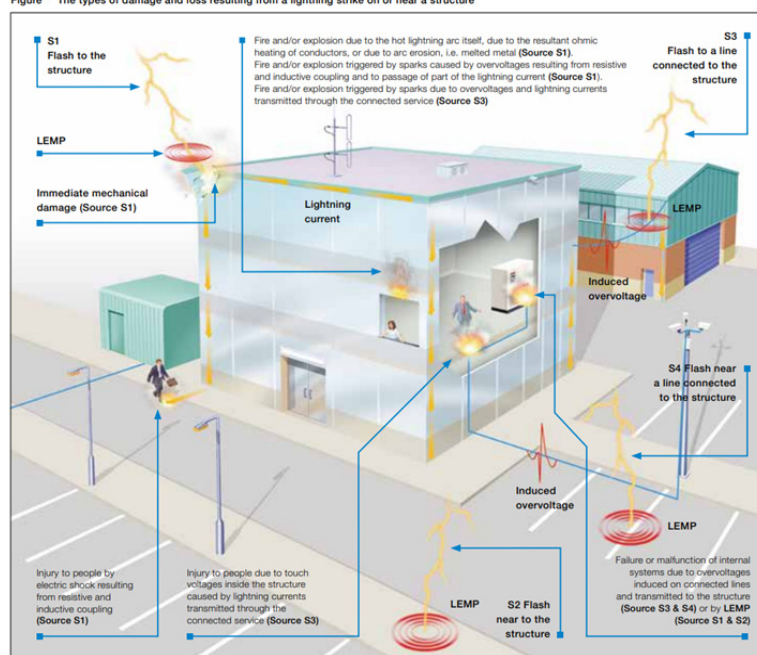
LPL	I	II	III	IV
Maximum current (kA)	200	150	100	100
Minimum current (kA)	3	5	10	16

2) Damage and loss

IEC/BS EN 62305 identifies four main sources of damage:

- S1 Flashes to the structure.
- S2 Flashes near to the structure.
- S3 Flashes to the lines connected to the structure
- S4 Flashes near the lines connected to the structure.

Figure - The types of damage and loss resulting from a lightning strike on or near a structure



Each source of damage may result in one or more of three types of damage:

- D1 Injury of living beings by electric shock
- D2 Physical damage (fire, explosion, mechanical destruction, chemical release) due to lightning current effects including sparking.
- D3 Failure of internal systems due to Lightning Electromagnetic Impulse (LEMP).

The following types of loss may result from damage due to lightning:

- L1 Loss of human life (including permanent injury)
- L2 Loss of service to the public
- L3 Loss of cultural heritage
- L4 Loss of economic value (structure, its content, and loss of activity)

The relationships of all the above parameters are summarized in below Table:

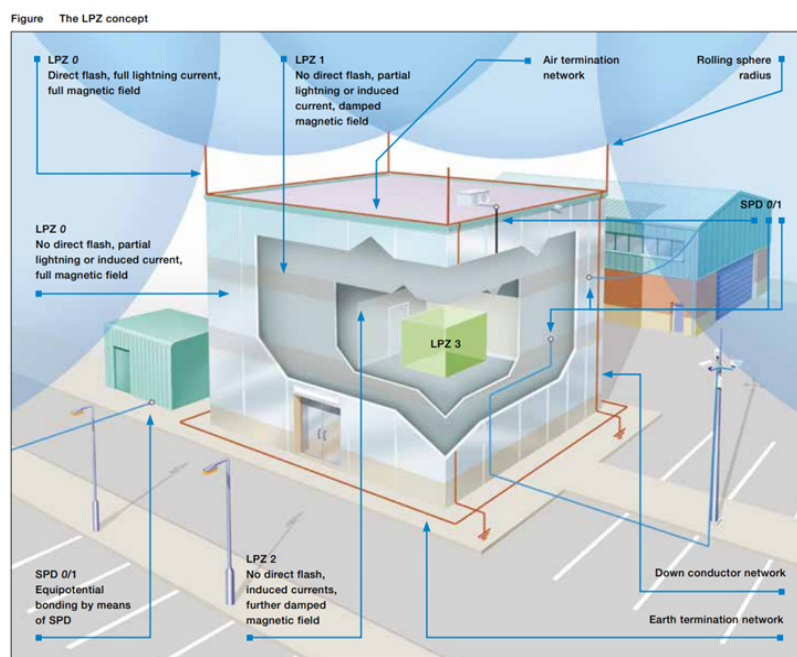
Point of strike	Source of damage	Type of damage	Type of loss
Structure	S1	D1	L1, L4**
		D2	L1, L2, L3, L4
		D3	L1*, L2, L4
Near a Structure	S2	D3	L1*, L2, L4
Lines connected to the structure	S3	D1	L1, L4**
		D2	L1, L2, L3, L4
		D3	L1*, L2, L4
Near a Line	S4	D3	L1*, L2, L4

**Only for properties where animals may be lost.

*Only for structures with risk of explosion and for hospitals or other structures where human life is directly in danger due to internal system failures.

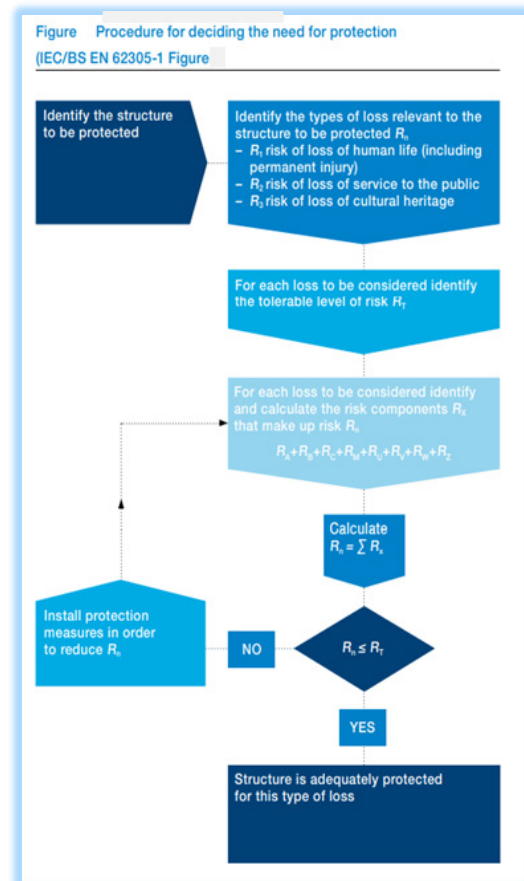
3) Lightning protection zones (LPZ):

The concept of the Lightning Protection Zone (LPZ) was introduced within IEC/BS EN 62305 particularly to assist in determining the protection measures required to establish protection measures to counter Lightning Electromagnetic Impulse (LEMP) within a structure.



- 4) Collect all required input for Lightning quantum assessment.
- 5) The codes provide a simple mathematical overall risk factor analysis for assessing whether a structure needs protection. All the Codes Suggest that an acceptable lightning strike risk factor is 10^{-5} per year i.e. one in 100,000 per year, therefore, having applied the mathematical analysis to a practical set of parameters, the scheme designer will achieve a numerical solution These parameters which should be considered for determining an overall risk factor can be summarized as follows:
 - a) Type of structure
 - b) Type of construction
 - c) Zone identification
 - d) Topography
 - e) Occupant and contents
 - f) Lightning frequency isocerauic level
 - g) Lightning Calculation
 - h) Equipment/component selection as per calculation Type of LA
 - i) Number of Down conductors
 - ii) Number of Grounding Pit
 - iii) Test Link
 - iv) Type of conductor

- R_1 risk of loss of human life (including permanent injury)
- R_2 risk of loss of service to the public
- R_3 risk of loss of cultural heritage
- R_4 risk of loss of economic value



- 6) Building/Structure data for Layout Preparation along with calculation data and selected component.

4. DESIGN CONSIDERATION:

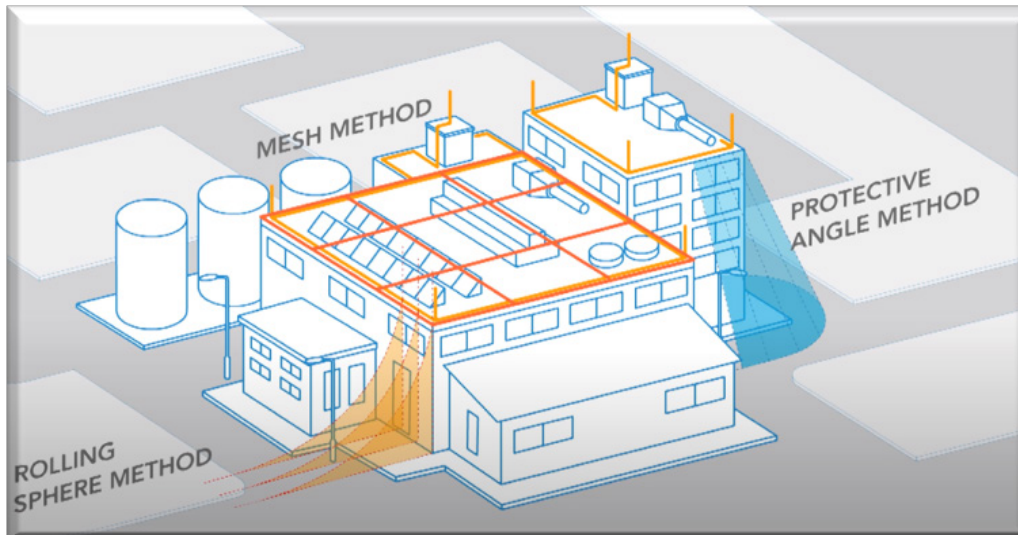
1. Ordinary Structures: An ordinary structure shall be any structure that is used for ordinary purposes, whether commercial, industrial, farm, institutional, or residential.
2. Ordinary structures shall be protected according to 2.1 or 2.2.
 - 2.1. Ordinary structures not exceeding 23 m (75 ft) in height shall be protected with Class I materials.

Type of Conductor	Parameter	Copper		Aluminum	
		SI	U.S.	SI	U.S.
Air terminal, solid	Diameter	9.5 mm	¾ in.	12.7 mm	½ in.
Air terminal, tubular	Diameter	15.9 mm	¾ in.	15.9 mm	¾ in.
	Wall thickness	0.8 mm	0.033 in.	1.63 mm	0.064 in.
Main conductor, cable	Size each strand	278 g/m	17 AWG	141 g/m	14 AWG
	Weight per length	29 mm ²	187 lb/1000 ft	50 mm ²	95 lb/1000 ft
	Cross-section area		57,400 cir. mils		98,600 cir. mils
Bonding conductor, cable (solid or stranded)	Size each strand		17 AWG		14 AWG
	Cross-section area		26,240 cir. mils		41,100 cir. mils
Bonding conductor, solid strip	Thickness	1.30 mm	0.051 in.	1.63 mm	0.064 in.
	Width	12.7 mm	½ in.	12.7 mm	½ in.
Main conductor, solid strip	Thickness	1.30 mm	0.051 in.	1.63 mm	0.064 in.
	Cross-section area	29 mm ²	57,400 cir. mils	50 mm ²	98,600 cir. mils

2.2. Ordinary structures exceeding 23 m (75 ft) in height shall be protected with Class II materials.

Type of Conductor	Parameter	Copper		Aluminum	
		SI	U.S.	SI	U.S.
Air terminal, solid	Diameter	12.7 mm	½ in.	15.9 mm	¾ in.
Main conductor, cable	Size each strand		15 AWG		13 AWG
	Weight per length	558 g/m	375 lb/1000 ft	283 g/m	190 lb/1000 ft
	Cross-section area	58 mm ²	115,000 cir. mils	97 mm ²	192,000 cir. mils
Bonding conductor, cable (solid or stranded)	Size each strand		17 AWG		14 AWG
	Cross-section area		26,240 cir. mils		41,100 cir. mils
Bonding conductor, solid strip	Thickness	1.30 mm	0.051 in.	1.63 mm	0.064 in.
	Width	12.7 mm	½ in.	12.7 mm	½ in.
Main conductor, solid strip	Thickness	1.63 mm	0.064 in.	2.61 mm	0.1026 in.
	Cross-section area	58 mm ²	115,000 cir. mils	97 mm ²	192,000 cir. mils

5. Method for Lightning Protection Calculations:



- ❖ **Rolling Sphere Method (IEC-62305-3):** The rolling sphere method is a simple means of identifying areas of a structure that need protection, considering the possibility of side strikes to the structure. The basic concept of applying the rolling sphere to a structure is illustrated in Figure.

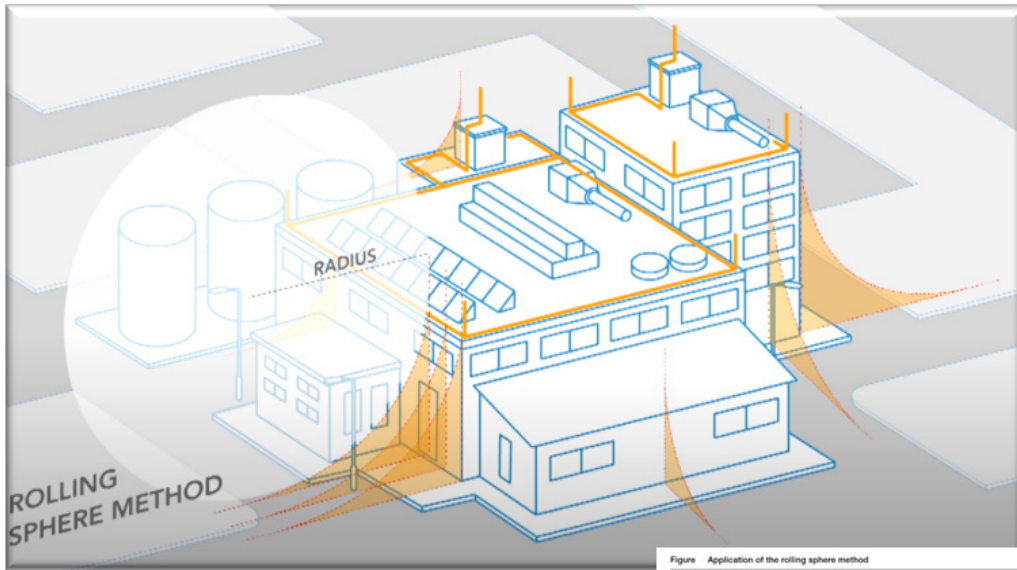
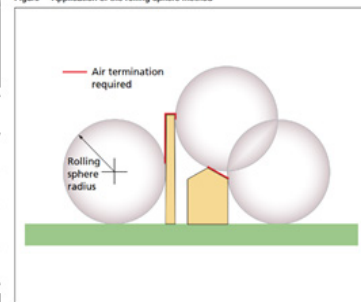


Figure Application of the rolling sphere method

Class of LPS	Rolling sphere radius
I	20 m
II	30 m
III	45 m
IV	60 m



- ❖ **Protection Angle Method (IEC-62305-3):** The protective angle method is a mathematical simplification of the rolling sphere method. The protective angle (α) is the angle created between the tip (A) of the vertical rod and a line projected down to the surface on which the rod sits (see Figure). The protective angle afforded by an air rod is clearly a three-dimensional concept whereby the rod is assigned a cone of protection by sweeping the line AC at the angle of protection a full 360° around the air rod.

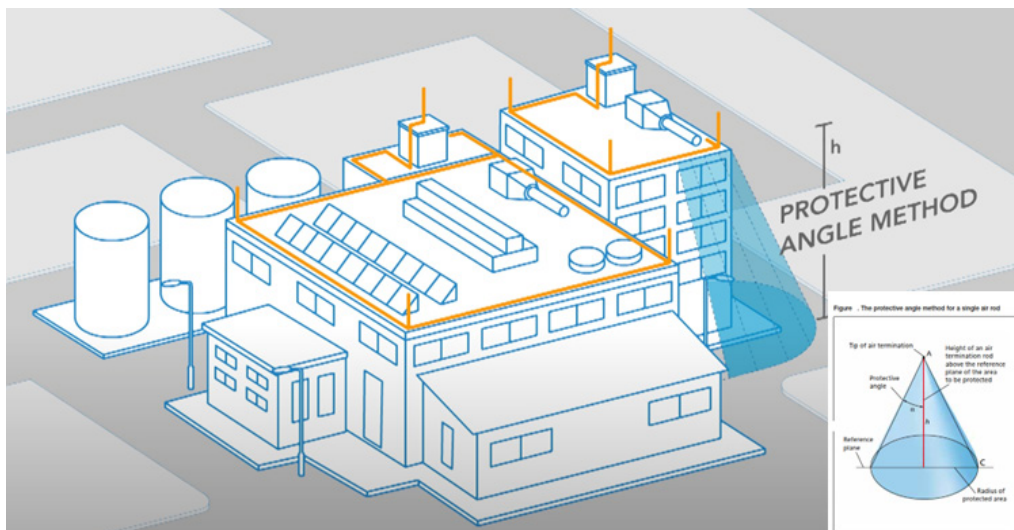
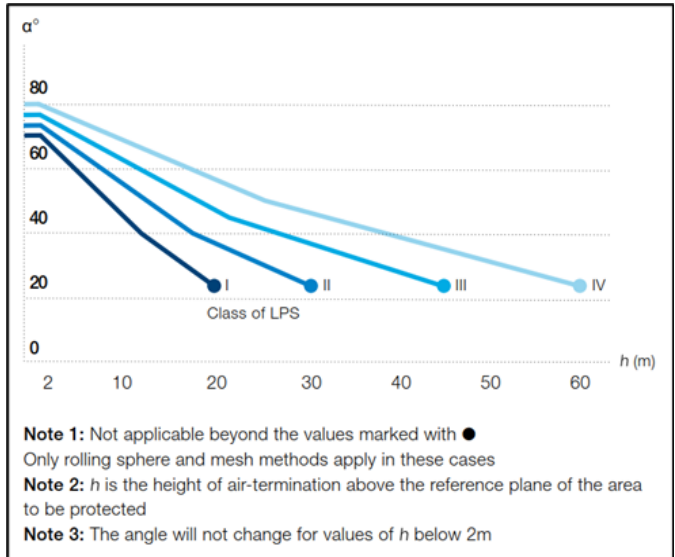


Figure The protective angle method for a single air rod

The protective angle differs with varying height of the air rod and class of LPS. The protective angle afforded by an air rod is determined from Table shown below. Varying the protection angle is a change to the simple 45° zone of protection afforded in most cases in BS 6651. Furthermore, the new standard uses the height of the air termination system above the reference plane, whether that be ground or roof level (shown above).

The protective angle method is better suited for simple shaped buildings. However, this method is only valid up to a height equal to the rolling sphere radius of the appropriate LPL.



❖ **Mesh Method (IEC-62305-3):** IEC/BS EN 62305 lists four different air termination mesh sizes that are defined and correspond to the relevant class of LPS (see below Table). This method is suitable where plain surfaces require protection if the following conditions are met:

– Air termination conductors must be positioned at roof edges, on roof overhangs and on the ridges of roof with a pitch more than 1 in 10 (5.7°)

– No metal installation protrudes above the air termination system Modern research on lightning inflicted damage has shown that the edges and corners of roofs are most susceptible to damage. So, on all structures particularly with flat roofs, perimeter conductors should be installed as close to the outer edges of the roof as is practicable.

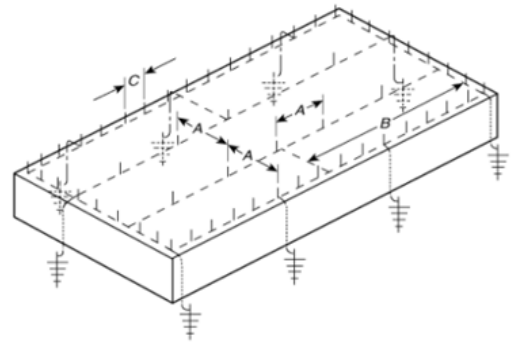
Modern research on lightning inflicted damage has shown that the edges and corners of roofs are most susceptible to damage. So, on all structures particularly with flat roofs, perimeter conductors should be installed as close to the outer edges of the roof as is practicable.

Class of LPS	Mesh size
I	5 x 5 m
II	10 x 10 m
III	15 x 15 m
IV	20 x 20 m

4 levels of down conductor spacing dependent on structural class of Lightning Protection System:

- Class I 10 m
- Class II 10 m
- Class III 15 m
- Class IV 20 m

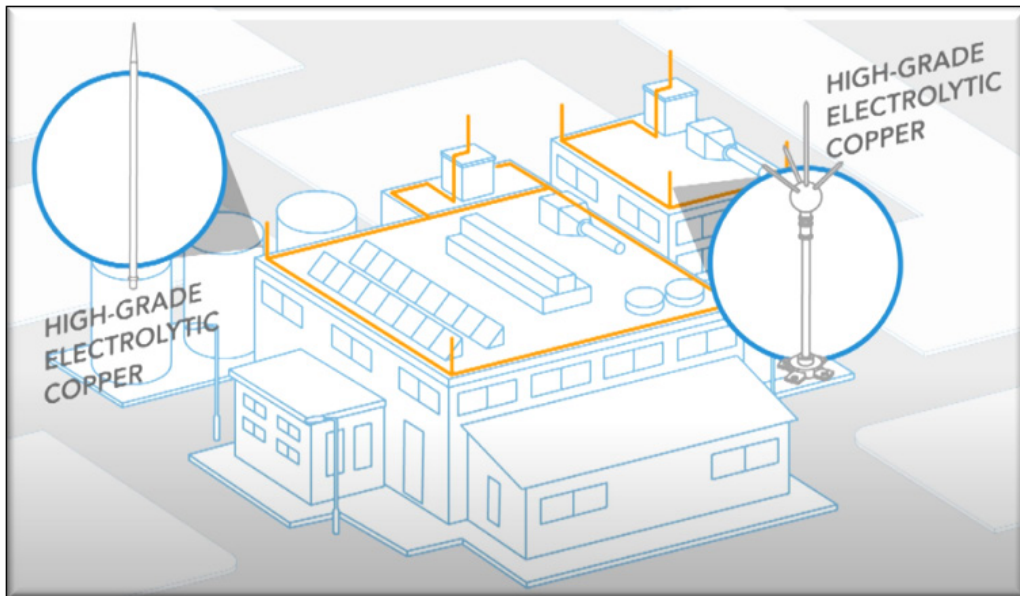
Flat or gently sloping roofs that exceed 15 m (50 ft) in width or length shall have additional strike termination devices located at intervals not to exceed 15 m (50 ft) on the flat or gently sloping areas, as shown in Figure, or such area can also be protected using taller air terminals that create zones of protection using the rolling sphere model so the sphere does not contact the flat roof area.



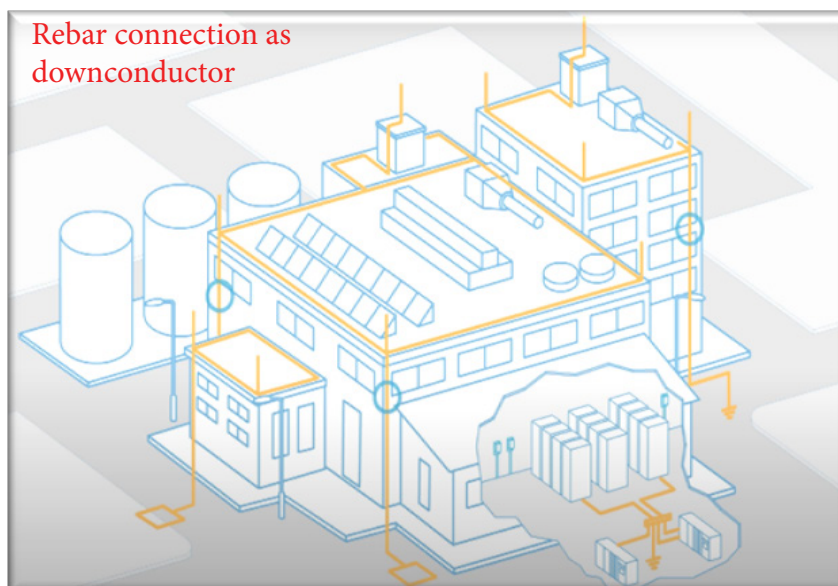
A: 15 m (50 ft) maximum spacing between air terminals
 B: 45 m (150 ft) maximum length of cross run conductor permitted without a connection from the cross run conductor to the main perimeter or down conductor
 C: 6 m (20 ft) or 7.6 m (25 ft) maximum spacings between air terminals along edge

6. Lightning Protection Component

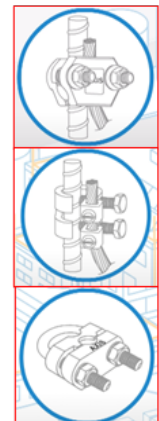
1) Air Termination Rod



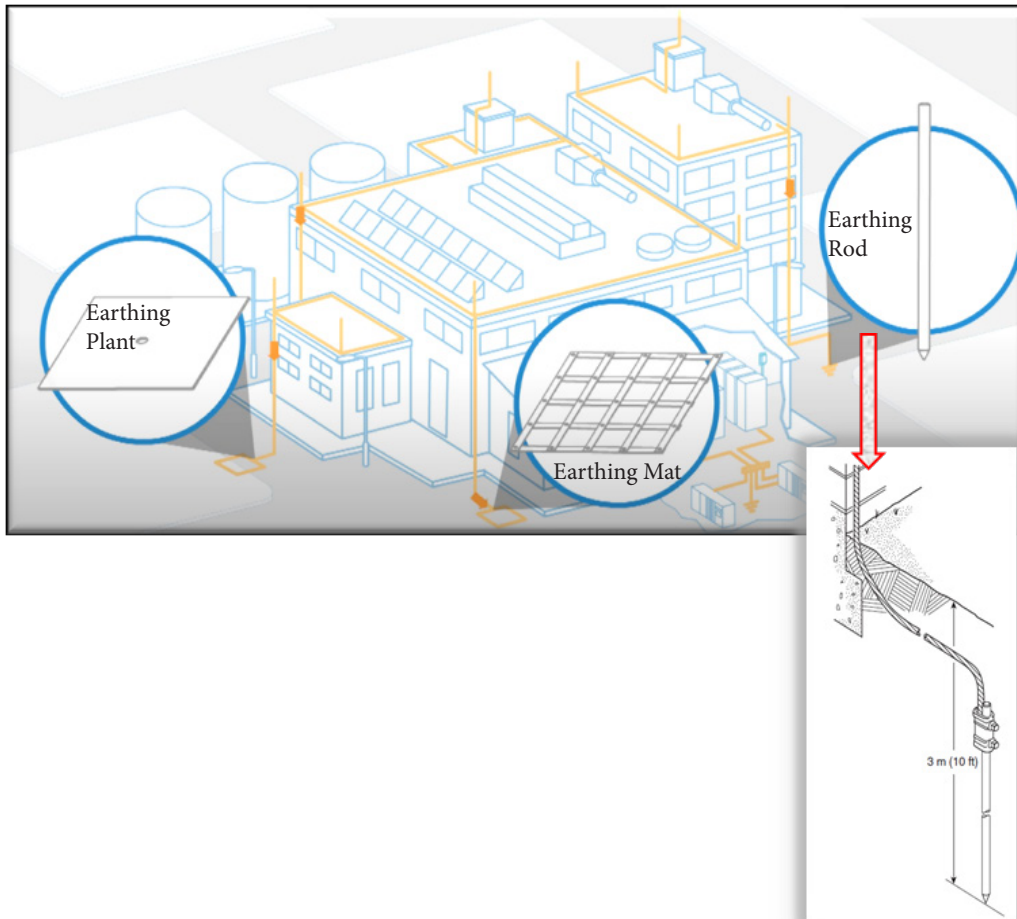
2) Down conductors (Rebar connection as down conductors)Earth termination



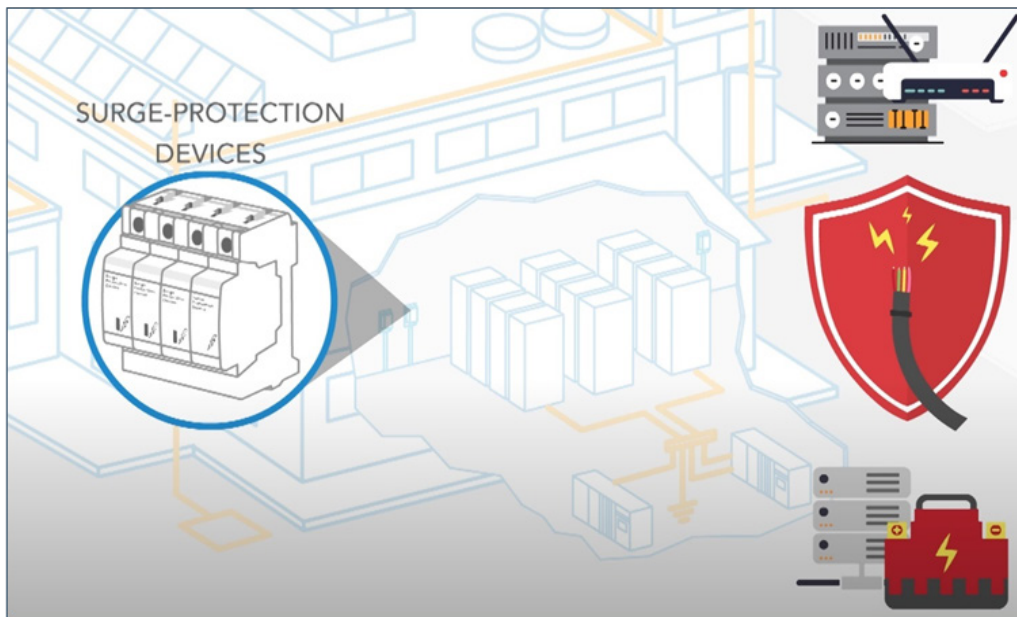
Rebar connection component



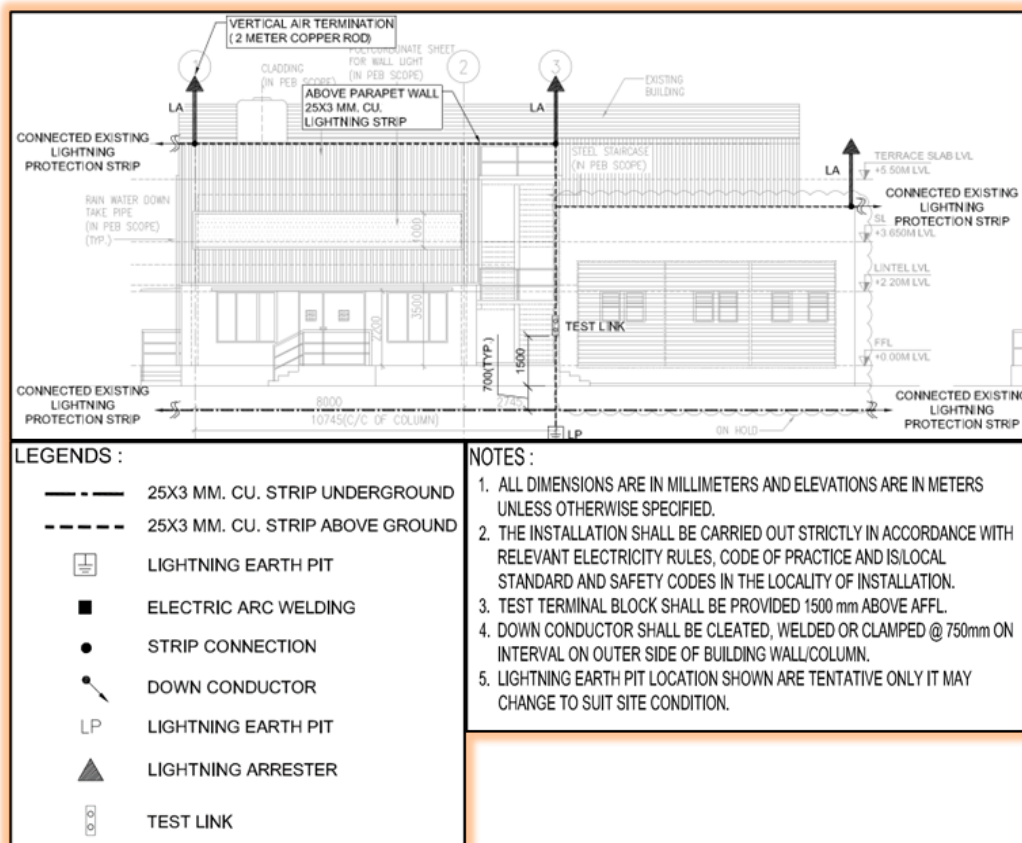
3) Earth Termination



4) SPD (Surge Protective Devices)



7. Lightning Protection Layout (E.g.)



Useful links for component selection details.

<https://axis-india.com/introduction-of-lightning-protection-iec-62305-ul-467-axis->

<https://www.tlpinc.com/>

Contributed by:



UMESH BHATT



EARTHING CALCULATION AS PER IS 3043

1. Reference Standards:
 - IS 3043 : 2018 - code of practice for earthing
 - IEEE-80 - IEEE guide for safety in ac substation grounding
 - BS-7430 - for earth rod resistance

2. Earthing Calculation:
 - Collect the inputs required for earthing calculations :
 - Soil resistivity report
 - As per IS 3043 : 40.3.1 werner four electrode method is recommended for calculating soil resistivity.
 - Werner method arrangement and formula.

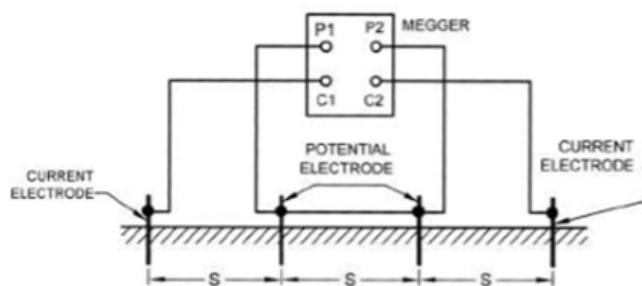


FIG. 47 CONNECTIONS FOR A FOUR-TERMINAL MEGGER

$$\rho = \frac{4s\pi V}{I} \left[1 + \frac{2s}{\sqrt{s^2 + 4e^2}} - \frac{2s}{\sqrt{4s^2 + 4e^2}} \right] \dots(7)$$

where

- ρ = resistivity of soil in ohm-metre,
- s = distance between two successive electrodes in metres,
- V = voltage difference between the two inner electrodes in Volts,
- I = current flowing through the two outer electrodes in amperes, and
- e = depth of burial of electrode in metres.

- Fault current and withstand time
 - Fault current and withstand time shall be calculated based on system study and fault clearing time.
- K – factor: material constant:
 - formula to be used to derive k-factor.

$$k = \sqrt{\frac{Q_c(B+20)}{\delta_{20}} I_n \left(1 + \frac{\theta_f - \theta_i}{B + \theta_i} \right)}$$

where

Q_c = volumetric heat capacity of conductor material ($J/^\circ C \text{ mm}^3$),

B = reciprocal of temperature coefficient of resistivity at $0^\circ C$ for the conductor ($^\circ C$),

δ_{20} = electrical resistivity of conductor material at $20^\circ C$ ($\Omega \cdot \text{mm}$),

θ_i = initial temperature of conductor ($^\circ C$), and

θ_f = final temperature of conductor ($^\circ C$).

Table 10 Material Constants
(Clause 17.2.2.1)

Material	B ($^\circ C$)	Q_c ($J/^\circ C \text{ mm}^3$)	δ_{20} ($\Omega \cdot \text{mm}$)	$\sqrt{\frac{Q_c(B+20)}{\delta_{20}}}$
(1)	(2)	(3)	(4)	(5)
Copper	234.5	3.45×10^{-3}	17.241×10^{-6}	226
Aluminium	228	2.5×10^{-3}	28.264×10^{-6}	148
Lead	230	1.45×10^{-3}	214×10^{-6}	42
Steel	202	3.8×10^{-3}	138×10^{-6}	78

Table 11A Bare Conductor with No Risk of Fire or Danger to any Other Touching or Surrounding Material

Boundary Conditions: Initial Temperature: $40^\circ C$ Final temperature $395^\circ C$ for copper; $325^\circ C$ for aluminium; $500^\circ C$ for steel

Material	Copper	Aluminium	Steel
1 s current rating in A/mm^2 (k_1)	205	126	80

Table 11D Protective Bare Conductors in Hazardous Areas where there is Risk of Fire from Petroleum Bound Oil or Other Surrounding Material

Boundary Conditions: Initial Temperature: $40^\circ C$; Final Temperature $150^\circ C/200^\circ C$.

Material	Copper	Aluminium	Steel
1 s current rating in A/mm^2 (k_1)	131/153	86/101	47/56
3 s current rating in A/mm^2 (k_2)	76/88	50/58	27/32

- select the k-factor based on selected material and area classification.
- Corrosion factor
 - We are considering corrosion factor based on soil resistivity at site.

Sr. No.	Range of soil resistivity	Class of soil	Corrosion factor
1	Less than 25	Severely corrosive	0%
2	25-50	Moderately corrosive	15%
3	50-100	Mildly corrosive	15%
4	Above 100	Very mildly corrosive	30%

- Select the material corrosion factor as per site soil resistivity data.
- Calculate minimum cross section area.
 - Min cross section area :
As per cl. 13.6.1 steel conductor in the soil of other than very mildly corrosive (i.e. Resistivity above 100) should be atleast 6mm thick if it is steel flat and have a diameter of atleast 16mm if

it is in the form of steel rod.

- As per cl. 17.2.2.3 the cross-sectional area of every protective conductor which does not form part of the supply cable or cable enclosure shall be, in any case, not be less than:
 - 2.5 mm², if mechanical protection is provided.
 - 4 mm², if mechanical protection is not provided.
- Formula for calculating minimum cross section area of strip

$$\frac{I}{S} = k \frac{1}{\sqrt{t}}$$

where

S = cross-sectional area, in square millimetres;
 I = value (ac, rms) of fault current for a fault of negligible-impedance, which can flow through the protective device, in amperes;

t = operating time of the disconnecting device, in seconds; and

NOTE — Account should be taken of the current-limiting effect of the circuit impedances and the limiting capability (joule integral) of the protective device.

k = factor dependent on the material of the protective conductor, the insulation and other parts, and the initial and final temperatures. Values of k for protective conductors in various use or service for $t = 1$ s and 3 s respectively are given in Table 11A to 11D.

● Calculate earth electrode resistance.

- The resistance of a plate electrode (R) is calculated based on IS-3043 section 14.2.1
- $R = \rho / 4 (\sqrt{\pi/a})$ (ohms)

Where, ρ = soil resistivity (ohm-m)
 a = area of both sides of the plate (m²)

- The resistance of a pipe electrode (R) is calculated based on IS-3043 section 14.2.2
- $R = 100\rho / 2\pi l (\log_e (2l/d))$ (ohms)

Where, ρ = soil resistivity (ohm-m)
 l = length of pipe electrode (cm)
 d = diameter of pipe electrode (cm)

● Calculate earth strip resistance.

- The resistance of a strip or conductor (R) is calculated based on IS-3043 section 14.2.3
- $R = 100\rho / 2\pi l (\log_e (4l/d))$ (ohms)

Where, ρ = soil resistivity (ohm-m)
 l = length of strip (cm)
 d = width(strip) twice the dia. (conductor) (cm)

- Calculate the overall resistance of the system which includes the resistance of all earth electrodes and earth strips connected in parallel.
- Total resistance of the system should be less than 1 ohm.
- Calculate fault current dissipation.

○ Fault current dissipation as per IS 3043 cl. 15.3 - maximum permissible current density:

$$I = (7.57 \times 10^3) / \sqrt{\rho \times t} \quad \text{A/m}^2$$

Where, t = duration of earth fault (in sec)

ρ = soil resistivity (ohm-m)

- Calculate the fault current dissipated by each rod.
- As per IS 3043 cl. 27.3.1 : the standard earth resistivity values typically vary in the range between 10 and 1000 ohms. In this range of variation, it can be reasonably assumed that the fault current division at the point of entry to the earth grid is 20 to 80 percent.
- Based on fault current and division factor select the number of electrodes required to dissipate fault current.

● **Conclusion:**

Select the total number of electrodes as the total resistance of earthing grid should be less than 1 ohm and it shall be suitable to dissipate fault level of the system.

Size of earth strip shall be based on calculated minimum cross section area.

IS 3043 – 2018 also says that there is no need for providing hundreds of earthpits at site. It is also a standard practice followed by LV side earthing everywhere in the world. In most of the present designs in India – importance of “Fault clearing time” and its relationship with Earth conductor sizing is also not understood properly. Even if one gets Earthpit resistance as 10 ohms, and 10 such earthpits are paralleled, one each located at each load center within the plant (may be two can be provided considering redundancy) are enough. It is high time we should try to impress upon the importance of “Equipotential bonding”, “Earth loop Impedance – meeting requirements of upstream breaker trip” on designers rather than providing hundreds of earthpits generating meaningless business for earth electrode manufacturers and in the process NOT PROVIDING REAL SAFETY.

Consideration should be whether there is adequate coordination between the physically obtainable value of the earth resistance and setting of the protective devices. This aspect is very much relevant in the case of installations where the value of earth resistivity is abnormally high.

Courtesy : IS : 3043 - 2018

Contributed by :



Aagam Vora

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Empanelled FIRE AND LIFE SAFETY AUDITOR
BEE Certified ENERGY AUDITOR
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Mumbai–Pune Expressway Missing Link: Safety Inspection

Mr. Ulhas Vajre, esteemed Director of CEEAMA, carried out an inspection of the firefighting systems in the 8.92 km and 1.75 km Missing Link tunnels on the Mumbai–Pune Expressway, Maharashtra, on behalf of the EPC contractor for MSRDC. This section of the expressway is expected to be opened for traffic by 1st May 2026.



TAS PowerTek Ltd. (A FOX Group Company) – Technology & Innovation Meet.

Leading industry consultants recently participated in the Technology & Innovation Meet on “Reactive Power Compensation Products and Solutions Designed by TAS PowerTek Ltd.” hosted at the company’s manufacturing facility in Nashik. The event brought together consulting electrical engineers from Mumbai, Thane, Pune, Nashik and nearby regions, creating a valuable platform for professional interaction, knowledge exchange, and discussion on emerging challenges in reactive power management and power quality.



The program commenced with a welcome address by Mr. Digambar Gosavi (CMO, TAS PowerTek Ltd.), who highlighted the growing importance of effective reactive power compensation in modern electrical installations. With the increasing presence of non-linear loads, automated industrial processes, and rapidly varying load profiles, maintaining a stable power factor and ensuring reliable reactive power management has become a critical consideration in electrical system design.

Following this, Mr. Shirish Joglekar from FOX Group presented an overview of the FOX Group, highlighting the group’s diverse business presence and its strong footprint in both domestic and international markets. His address provided participants with insight into the organization’s global outlook and the technological capabilities that support its expanding market presence.

During the technical interaction, Mr. Tushar Mogre (CEO & Director, TAS PowerTek Ltd.) shared insights into the company’s experience in designing and



manufacturing advanced Automatic Power Factor Controller (APFC) relays, which form the core of capacitor bank control systems. TAS PowerTek has developed expertise in manufacturing advanced APFC relays that address multiple aspects of reactive power compensation, including accurate measurement of electrical parameters, intelligent stage management, and stable system response.



Particular emphasis was placed on the importance of measurement accuracy and controller reliability, as these factors significantly influence the performance and efficiency of capacitor bank operations. Accurate sensing and responsive control are essential to ensure consistent power factor correction, especially in installations where load conditions fluctuate frequently.

Another highlight of the session was the introduction of a new range of Thyristor Switches designed for capacitor bank applications requiring fast and precise switching. Such technologies are increasingly relevant in installations where load variations occur rapidly and conventional contactor-based switching may not deliver the desired response time.

Participants were also introduced to a New Patented Thyristor Switch developed for SVG applications, aimed at addressing more dynamic reactive power compensation requirements encountered in modern power systems. The concept generated considerable interest among consultants who frequently encounter complex power quality and reactive power challenges in industrial and commercial projects.

The event also included a product overview session, covering various components associated with reactive power compensation systems such as APFC controllers, Thyristor Switching Solutions, Detuned Reactors, and SCADA-based monitoring solutions for APFC systems. The discussions remained interactive, with consultants sharing practical experiences related to harmonic environments, capacitor bank switching behaviour, and reactive power control challenges across different types of installations.

A key highlight of the program was the guided visit to the design, testing, and manufacturing facility. Participants were able to observe the product assembly processes, testing procedures, and quality assurance practices followed during manufacturing. The visit provided useful insight into the engineering approach, product development practices, and manufacturing discipline adopted by the organization.

Many participants appreciated the well-organized production environment, structured testing practices,

and the enthusiasm of the engineering team, reflecting a strong focus on product reliability and continuous technological development.

Overall, the Technology & Innovation Meet on “Reactive Power Compensation Products and Solutions Designed by TAS PowerTek Ltd.” proved to be an informative and engaging session for consultants. The event provided an opportunity to exchange perspectives on practical reactive power and power quality challenges, while also gaining exposure to developments in reactive power compensation technologies.



The program concluded with informal networking over lunch and interactions with Mr. Joy Aloor (Director, FOX Group), followed by high tea, allowing participants to continue discussions and strengthen professional connections within the consulting engineering community.



Earthing Transformer: Design, Application, and Role in Power System Safety

Introduction

Modern power systems rely on effective grounding schemes to ensure system stability, operational reliability, and personnel safety. In many medium and high-voltage networks, especially where deltaconnected systems or ungrounded systems are used, establishing a reliable neutral point becomes a challenge. Earthing transformers play a critical role in such situations by providing an artificial neutral point for grounding purposes.

An earthing transformer ensures controlled earth fault currents, improves system protection sensitivity, and limits transient overvoltage. This article discusses the purpose, design philosophy, construction, applications, standards, testing requirements, and future trends related to earthing transformers in modern power systems.



A grounding transformer, also known as an earthing transformer, is an auxiliary transformer used in three-phase power systems to establish a grounding path for systems that are either ungrounded wye or deltaconnected. It forms an integral part of the network's earthing arrangement by providing a neutral reference point. This allows three-phase deltaconnected systems to support phasetoneutral loads by offering a controlled return path for current to the neutral during normal operation and fault conditions.

Need for Earthing Transformers in Power Systems

In electrical networks where the transformer windings are deltaconnected or where no neutral point is inherently available, earth fault protection becomes ineffective. Ungrounded or isolated systems can experience dangerous overvoltages during ground faults, posing serious risks to equipment and personnel.

Earthing transformers are installed to:

- Provide a neutral point for grounding
- Enable operation of earth fault protection relays
- Limit earth fault current to safe values
- Reduce transient overvoltages
- Improve overall system stability and safety

Working Principle of Earthing Transformer

An earthing transformer is connected to a three-phase system and provides a lowimpedance path for zerosequence currents during earth faults. Under normal operating conditions, the earthing transformer carries negligible current. However, during a single linetoground fault, it allows fault current to flow through the neutral point to earth, enabling protective devices to detect and isolate the fault promptly.

The magnitude of the earth fault current is controlled using:

- Neutral grounding resistors (NGR)
- Neutral grounding reactors (NGRx)



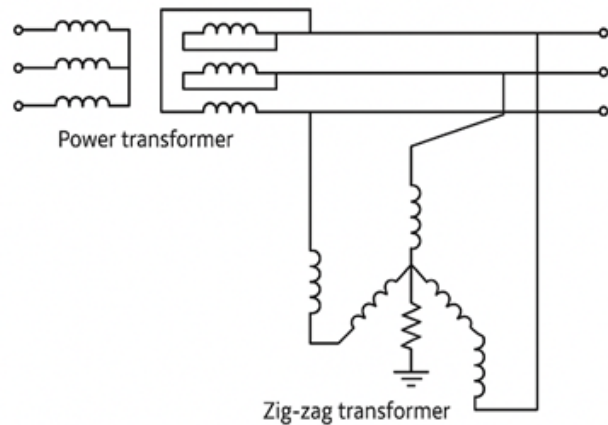
Types of Earthing Transformers

ZigZag Earthing Transformer

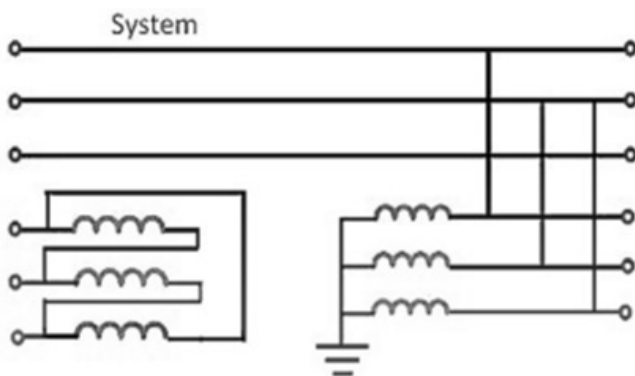
The zigzag earthing transformer, which is the most commonly used type, consists of interconnected windings designed to provide low impedance to zero sequence currents while offering high impedance to balanced threephase currents, thereby ensuring effective grounding without supplying any load power

Due to their compact design, high efficiency, and reliable performance, zigzag transformers are widely used in distribution networks and industrial power systems.

Zig-Zag Earthing Transformer



Star-Delta Earthing Transformer



Star-Delta Earthing Transformer

A stardelta earthing transformer is configured such that the starconnected winding provides a neutral point for effective grounding, while the deltaconnected winding stabilizes the system by circulating and absorbing triple harmonic currents

This configuration is typically employed where greater operational flexibility is required or where integration with auxiliary loads is necessary, making it suitable for complex industrial and utility power systems.

Design Philosophy of Earthing Transformers

The design of an earthing transformer focuses on safety, reliability, and system compatibility. Key design considerations include:

- Rated system voltage and insulation level
- Maximum earth fault current and its duration
- Thermal withstand capability
- Integration with neutral grounding resistors or reactors
- Shorttime current rating as per system fault studies

A properly designed earthing transformer ensures effective fault detection without overstressing system components.

Applications

Earthing transformers are extensively used in:

- Industrial power plants
- Chemical and oil & gas facilities
- Refineries and petrochemical complexes
- Distribution substations
- Renewable energy systems
- Ungrounded or deltaconnected networks

They are especially critical in hazardous installations where controlled grounding directly contributes to fire and explosion prevention.

Standards and Codes

Earthing transformers are designed and tested in accordance with recognized standards such as:

- IEC 60076 – Power transformers
- IEEE C57 series – Transformer standards
- IS 5553 – Power transformer specifications
- IS 3043 – Code of practice for earthing

Conclusion

Earthing transformers serve as a vital component in modern power systems by providing a controlled and reliable grounding path where a natural neutral is unavailable. By enabling effective earth fault protection, limiting overvoltages, and enhancing system safety, earthing transformers contribute significantly to asset protection and operational reliability. Proper selection, design, and maintenance of earthing transformers are essential for ensuring electrical safety in industrial and utility installations.

Contributed By:



Kirti Rawal
PE- Electrical

A festive background of colorful confetti in shades of red, blue, yellow, and green, scattered across the white page. At the top, there is a dark blue horizontal banner with a white circuit-like pattern.

**WINNERS OF QUIZ
FEBRUARY 2026**

MAHESH GHARAT

SUDHANSHU JHA

RUPEN PATEL

PRAKASH POWAR


VINAY YADAV

MANGESH BHOSALE

DINESH KALE

Congratulations

QUIZ - APRIL 2026

1. In an industrial power system, the primary purpose of selective coordination of protection devices is to:
 - A. Reduce short-circuit current
 - B. Protect cables from overheating
 - C. Ensure only the faulted section is isolated
 - D. Improve power factor
 2. Which parameter is most critical for deciding the rating of a transformer neutral grounding resistor (NGR)?
 - A. Transformer impedance
 - B. Earth fault current limitation
 - C. Voltage regulation
 - D. Transformer efficiency
 3. During motor insulation resistance (IR) testing, a reading lower than the acceptable value usually indicates:
 - A. Overvoltage condition
 - B. Moisture or insulation degradation
 - C. Bearing failure
 - D. Phase imbalance
 4. Which type of relay is most suitable for rotor earth fault protection of large synchronous motors?
 - A. Differential relay
 - B. Overcurrent relay
 - C. Restricted earth fault relay
 - D. Rotor earth fault relay
 5. In HT switchgear, contact resistance measurement is primarily done to assess:
 - A. Insulation aging
 - B. Mechanical alignment
 - C. Condition of current-carrying contacts
 - D. Arc quenching ability
 6. For an industrial plant, the most common cause of capacitor bank failure is:
 - A. Under-voltage
 - B. Harmonics and overcurrent
 - C. Low power factor
 - D. Ambient temperature
 7. Which standard is most commonly referred for earthing system design in industrial plants?
 - A. IEC 60034
 - B. IEEE 80
 - C. IEC 60255
 - D. IEC 61439
 8. The purpose of VFD DC bus pre-charging is to:
 - A. Increase motor starting torque
 - B. Prevent inrush current to DC capacitors
 - C. Improve power factor
 - D. Reduce harmonic distortion
- 

9. Which test is performed to verify the dielectric strength of electrical equipment insulation?

- A. Insulation resistance test
- B. Contact resistance test
- C. High voltage (HV) test
- D. Continuity test

10. In a power transformer, sudden pressure relay (SPR) protects mainly against:

- A. Overloading
- B. External short circuit
- C. Internal faults causing rapid oil pressure rise
- D. Overvoltage

Rules for the QUIZ:

- The Quiz will be open for 10 days from the date of EMAIL.
- Each correct answer received on DAY 1 will get 100 points
- Next days the points will reduce as 90 – 80 – 70 and on 10th day points will be ZERO even if the answer is correct.
- All participants will receive E certificate signed by CEEAMA President with the points earned mentioned on the same.

Please use following google form link to participate in this month's QUIZ.

<https://forms.gle/8kD9pfWFg49q4YwT7>

“Thank you all for the overwhelming response to the E-NEWS in general and E-Quiz in particular. MCQ based quiz is always tricky and surprisingly can take us aback when we realise our conceptions (misconceptions) about the subject / system / product.

The aim of the feature was to create inquisitiveness in your mind and help you check your technical quotient quickly. The response will also help us to present articles and webinars on subjects which are important, but which lack enough awareness / knowledge in general.

It can open a pandora box for our discussions and arguments and probable solutions. Engineering evolves with conception. It gets fuelled with community discussions and capitalist actions. All stakeholders start realising the need to take a closer look and help improve standards as we have seen in the past century. Surely it makes the world a better place.

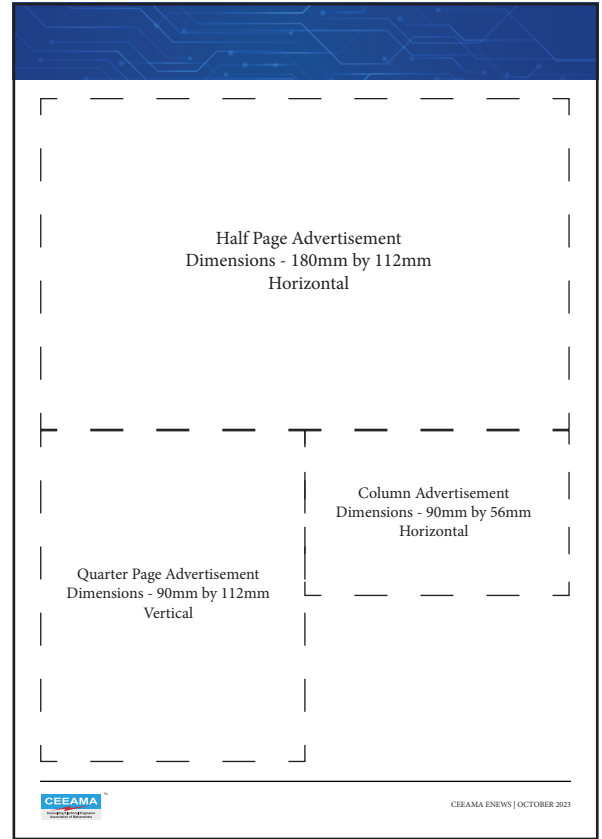
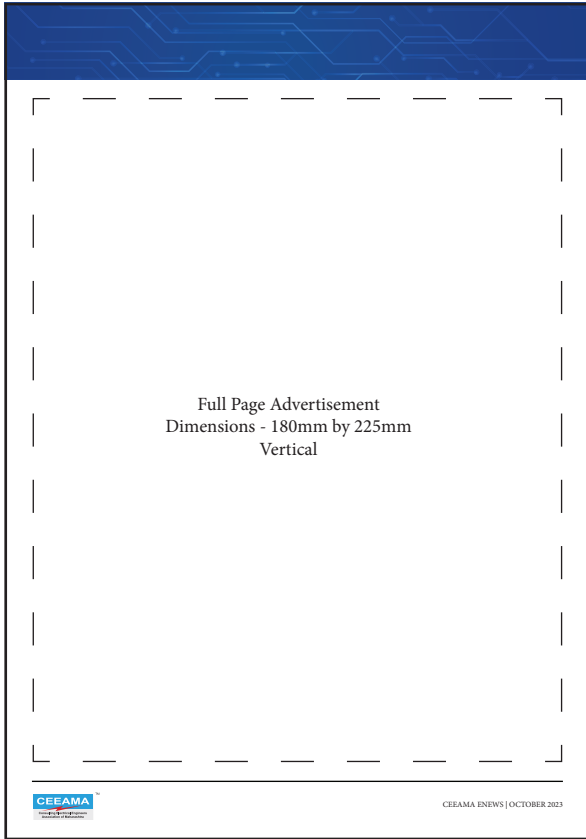
Wish you all a better luck this time.

Do spread the word.

March 2026 Quiz Answers

1. B. Electromagnetic interference
2. C. DC load duty cycle and autonomy requirement
3. C. Overcurrent coordination
4. D. Improve power factor
5. B. PWM modulated waveform
6. C. More sources are added
7. B. Limit ground fault current
8. C. Project Specification
9. B. Maximum current it can interrupt safely
10. B. Dielectric strength

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A-103. Sanpada Railway Station Building, 1st floor Sanpada East, Navi Mumbai – 400705
Email: admin@ceeama.org
