MAINTENANCE HANDBOOK ON
EARTHING & SURGE PROTECTION
FOR S&T INSTALLATIONS

CAMTECH/S/PROJ/10-11/HB-EARTHING/1.0
MAY 2011

Indian Railways
Centre for Advanced Maintenance Technology

MAHARAJPUR, GWALIOR – 474 005
FOREWORD

Railway Signal and Telecommunication installations work in conjunction with a variety of electrical or electronic equipments. Some of the modern S&T equipments have solid state components. Lightning and surges may result in extensive damages to these equipments thereby causing loss to the railways apart from delay to traffic due to indefinite down time. Arrangements have to be provided to protect these equipments from such damages due to lightning and surge as well as prevent electric shock to the personnel who work in their vicinity.

CAMTECH has prepared this handbook on the subject to impart knowledge to S&T personnel about Earthing and Surge protection arrangements for various installations thereby increasing their efficiency and reliability.

I am confident that this handbook apart from updating the knowledge will help the field staff in ensuring their own safety and protecting equipments from damage.

CAMTECH Gwalior
Date: 28 May 2011

S.C.SINGHAL
Executive Director
PREFACE

Railway Signalling system plays a vital role in the movement of trains and the working of any Signal or Telecommunications installation depends upon the efficiency of associated equipments. Lightning and surge are such phenomenons which are likely to occur one or the other time during the whole life of an installation. Lightning can have devastating effects and its strike poses unacceptable risks which can cripple operations. These risks include fire, loss of equipment and infrastructure, communications downtime and loss of life. At the same time surges can cause major equipment damage, critical data loss, equipment malfunction or lockup. Modern equipment is much more susceptible to surge damage than equipment of the past due to more number of solid state components. Thus in the event of lightning strike or occurrence of surge, the operation of whole system is jeopardized if adequate protection arrangements are not provided.

Continuing its efforts in documentation and up-gradation of information on maintenance practices, CAMTECH has prepared this handbook to help S&T personnel understanding the concept of earthing and surge protection. A chapter on ‘Maintenance-free earthing and bonding system’ as per RDSO guidelines have been added along with the concept of earthing in general and conventional earthing arrangement. Different classes of surge protection with special reference to IPS installation have also been given with figures and diagrams.

Since technological up-gradation and learning is a continuous process, you may feel the need for some addition/modification in this handbook. If so, please feel free to write us. We shall be highly appreciating your contribution.

We are sincerely thankful to RDSO Lucknow, M/s McML Secunderabad and maintenance personnel who helped us in preparing this handbook.

CAMTECH Gwalior
Date: 26 may 2011

JAGMOHAN RAM
Director (S&T)
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**ISSUE OF CORRECTION SLIPS**

The correction slips to be issued in future for this handbook will be numbered as follows:

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Where “XX” is the serial number of the concerned correction slip (starting from 01 onwards).

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DISCLAIMER

It is clarified that the information given in this handbook does not supersede any existing provisions laid down in Signal Engineering Manual, Railway Board and RDSO publications. This document is not statutory and instructions given in it are for the purpose of guidance only. If at any point contradiction is observed, then S.E.M., Rly. Board/RDSO guidelines or Zonal Rly. instructions may be followed.
Chapter I

EARTHING

1.1 Introduction

The earth is made up of materials that are conductive such as mineral bodies containing metallic contents. Whenever lightning strikes near a building or structure, or electromagnetic/electrostatic induction is produced due to nearby high voltage power lines, fault currents are generated.

These currents will travel through the metallic bodies of the nearby structures and induce dangerous potential (voltages) in cables or exposed metallic bodies of electrical equipment.

This may give electric shock to the person coming in contact with the metallic bodies and cause extensive damage to the equipment. If these equipments are connected to earth by means of a metallic conductor, the fault current will flow to the earth thereby preventing shock to the user and damage to the equipment. Hence all exposed metal parts of an electrical installation or electrical appliances must be earthed.

1.2 Earthing of Signalling and Telecommunication equipment in 25 KV 50Hz AC Electrified sections

Signal and Telecommunication equipments are installed in the vicinity of an industrial frequency high voltage 25 KV 50 Hz AC traction line i.e. catenary. In AC electrified sections, signalling and Telecommunication circuits are affected by two phenomena namely:

1. Electro-static induction
2. Electromagnetic induction

The objective of earthing may be one or more of the following:

• To complete earth return signalling circuit. For example in block instruments.

• To protect operating/maintenance personnel from electric shock due to the apparatus casing or other exposed parts attaining dangerous potential relative to earth through electromagnetic or electrostatic induction or conductive coupling with the OHE installation. Example- Battery charger earthing.

• To ensure reliable and safe operation of the equipment by limiting or eliminating the induced voltages in signal and Block circuits. Example- Block filter earthing and earthing of metallic cable sheath and armour.

• To protect the equipment against build up of unduly high voltages which can cause dielectric (Insulation) breakdown mostly due to the physical contact with live OHE equipment.
• To reduce the risk of cross talk in telecommunication equipment.

1.3 **Installations to be earthed**  
The following installations shall be provided with separate earthings:

• The lever frame and other metallic frames of the cabin.

• Metallic sheath and armouring of all underground Main cables at every 1 km distance.

  *It is not necessary to earth the sheath and armouring of screened cables or armouring of unscreened cables when they are used as a tail cables except where the length of the tail cable exceeds normal prescribed limits.*

• At every location box where cables terminate.

• Block circuits working on earth return through the respective block filters. A separate earthing shall be provided for each block instrument.

• The surge arrestors provided in block filters and telecomm equipments in switching stations.

• The protection screen of signals falling within 2 meters from the live parts of the OHE.

• Lifting barrier.

• All telecommunication equipment.

*The telecommunication equipment may be connected to the same earth as the lever frames.*

• Where a number of cables are run together, it is advantageous to earth each cable separately.

• The protective earth of Telecom system shall not be connected to the earth of mains power supply system.

• A minimum distance of 10 Meters is desirable.

**The resistance of the earth in all above cases shall not exceed 10 ohms.**

1.4 **Specific Resistance**

• The resistivity or the specific resistance is defined as the resistance between opposite faces of a conductor of unit length and unit cross sectional area.

• The value of resistivity is given in “Ohm- metre”.

• It is indicated by the symbol ‘ρ’ (rho) which is a constant and depends on the length ‘l’ and area ‘a’ of the conductor.
1.5 Soil Resistivity

The soil resistivity depends on

- Moisture content in the soil
- Chemical composition of soil and
- Concentration of salts dissolved in the moisture.

These factors vary locally and seasonally.

- The resistance of the conductor (electrode) buried in the ground depends on the “Resistivity of the soil” or “Soil resistivity”.

- The resistance of the electrode \( R = \frac{\rho}{l/a} \) where \( \rho \) = soil resistivity.

- Therefore to get low earth resistance \( R \) the Resistivity of the soil \( \rho \) must be low.

1.6 Earth Resistance

Total earthing resistance is the sum of

1. The resistance of earth lead wires

2. Contact resistance between the surface of the earth electrode and the soil.

3. The resistance of the body of the soil surrounding the earth electrode.

Among the three, the resistance of the earth is primarily determined by 3 i.e. the nature of the soil.

1.7 Types of earthing arrangements

There are two types of earthing arrangements normally provided for S&T installations of Indian Railways:

1.7.1 Conventional Earthing

- In this type of arrangement, the earthing is achieved with the help of Earth electrode (normally GI pipe) buried in the ground (earth pit).

- The earth electrode is surrounded by filling material (Common salt and Charcoal) and it is connected to the equipment with the help of GI or copper wire to extend earth to the equipment.

- This type of earthing is normally provided for apparatus cases, signalling cables, block instruments, conventional power supply equipments etc.
1.7.2 Effective or Maintenance-free earthing

- This type of earthing is provided with earth electrode of a highly conductive, corrosion-resistant material with low soil resistivity earth enhancement compound around it.

- This arrangement eliminates the drawbacks of conventional earthing such as corrosion of electrode and high and fluctuating earth resistance.

- Maintenance free earthing is provided for signalling and telecomm. equipments with solid state components requiring low earth resistance of the order of 1 Ohm such as Integrated Power Supply, Digital Axle Counter, Data Logger, Electronic Interlocking etc.

Conventional and Maintenance-free earthing are dealt in the following sections.

1.8 Limits of Earth Resistance
Maximum values of earth resistances specified for earthing of Signalling and Telecommunication equipments are as under:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Max. Earth resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Telegraph and Block Instrument using earth return circuit</td>
<td>10 Ω</td>
</tr>
<tr>
<td>2.</td>
<td>Earths for surge arrestors/ lightening dischargers</td>
<td>10 Ω</td>
</tr>
<tr>
<td>3.</td>
<td>Earthing of Signalling equipment</td>
<td>10 Ω</td>
</tr>
<tr>
<td>4.</td>
<td>Earthing of signalling cable screen in AC electrified areas</td>
<td>10 Ω</td>
</tr>
<tr>
<td>5.</td>
<td>Earthing of Telephone Exchange</td>
<td>5 Ω</td>
</tr>
<tr>
<td>6.</td>
<td>Earthing of aluminum sheathed telecom cable in AC electrified area.</td>
<td>1 Ω</td>
</tr>
<tr>
<td>7.</td>
<td>Earthing of equipment in VF repeater stations and cable huts.</td>
<td>5 Ω</td>
</tr>
<tr>
<td>8.</td>
<td>Axle counter cable screened in AC electrified area</td>
<td>1 Ω</td>
</tr>
<tr>
<td>9.</td>
<td>Electronic Interlocking installation</td>
<td>1 Ω</td>
</tr>
<tr>
<td>10.</td>
<td>Integrated Power Supply System &amp; its individual modules</td>
<td>2 Ω</td>
</tr>
<tr>
<td>11.</td>
<td>Digital Axle Counter EJB and its apparatus case connected to same earth</td>
<td>1 Ω</td>
</tr>
<tr>
<td></td>
<td>All cable armours connected to same earth</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Reset box of Digital Axle Counter connected to earth (indoor) near SM’s Room.</td>
<td>1 Ω</td>
</tr>
</tbody>
</table>
Chapter II

CONVENTIONAL EARTHING ARRANGEMENT

2.1 Introduction

The conventional earthing arrangement is mainly provided for earthing of Mechanical & Electrical Block Signalling equipments like lever frames in cabins, cable terminal boxes connecting the ends of the cables, metallic sheathing and armouring of cables, lightning and spark arrestors, signal location boxes, signal screens and block instruments.

The earthing arrangement in this system consists of the following:

- Soil.
- Earth lead wire.
- Earth electrode.
- Connecting wire to extend earth to equipment.

![Fig 2.1: Conventional earthing arrangement for power equipment (Battery Charger)](image)

2.1.1 Soil

The site for earthing should be chosen in the following order:

1. Wet marshy ground and grounds containing refuse such as ashes, cinders.
2. Clay soil or loam mixed with small quantity of sand.
3. Clay mixed with varying properties of sand, gravel and stone.
2.1.2 Treatment of Soil

- The soil is to be prepared to obtain optimum resistivity.
- To reduce the resistivity of soil, some highly conductive substance is required to be dissolved in the moisture normally contained in the soil.
- The most commonly used substances are sodium chloride (common salt), calcium chloride, sodium carbonate, copper sulphate, salt and soft coke and salt and charcoal in suitable proportions.

2.1.3 Earth electrode

It may be a metal plate, pipe or other conductor or an array of conductors electrically connected to the general mass of earth.

<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Length in Mtrs</th>
<th>Dia /Cross section</th>
</tr>
</thead>
<tbody>
<tr>
<td>G.I. Pipe</td>
<td>2.5 to 3.5</td>
<td>above 38 mm (internal)</td>
<td></td>
</tr>
<tr>
<td>G.I. Angle</td>
<td>2.5 to 3.5</td>
<td>50 mm x 50 mm x 5mm</td>
<td></td>
</tr>
<tr>
<td>Copper Rod</td>
<td>2.5 to 3.5</td>
<td>16 mm</td>
<td></td>
</tr>
</tbody>
</table>

GI pipe shall consist of spike at one end and a lug at the other for connecting the earth lead wire.

![GI pipe electrode](image)

*Fig.2.2: Earth electrode (GI pipe)*

2.1.4 Lightning conductor or earth lead wire

It is the metallic wire which connects the earth electrode to the equipment/Installation. Size and metal of the conductor is given below:

<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>G.I. Wire</td>
<td>8 mm Dia</td>
</tr>
<tr>
<td>G.I Strip</td>
<td>20mm x 3 mm</td>
</tr>
<tr>
<td>Copper wire</td>
<td>29 Sq.mm (19 strand wire of 1.4 mm dia)</td>
</tr>
<tr>
<td>ACSR wire</td>
<td>6 / 1 / 2.11 mm</td>
</tr>
</tbody>
</table>
2.2 Procedure of installation

- The hole can be made by manual trenching or by using “Earth auger”.
- The top of the electrode shall be 30 cm above the ground.
- The GI pipe is embedded vertically and the rod/angle electrodes are driven vertically in the ground.
- When rocky soil is encountered at a depth of less than 2.0 metres or the length of electrode, the electrode may be buried inclined to the vertical, the inclination being limited to 30º from the vertical.
- After inserting the electrode, the hole shall be filled with earth properly and water should be spread to ensure good contact between electrode and filling.
- In the soils of high resistivity, can be treated with salt and charcoal in appropriate proportion.
- Earth pit of 600 mm dia and 2.5 mtrs depth shall be formed by excavation and the electrode shall be placed at the center.
- The pit shall be filled alternately with layers of common salt and charcoal each layer of about 2.5 cm thick up to a depth of about 200 cm from the ground level.
- The pit shall be filled with several times with water, and then covered with excavated earth and water shall be poured to ensure good electrical contact.
Fig. 2.3: Conventional earthing arrangement (RDSO drawing no. TCA 565(ADV))
2.3 Inspection and maintenance

- Check earth and its connections periodically at interval of not more than one month, to ensure that all connections are in tact and soldered joints are in proper condition.

- Measure the earth resistance once in a year. Enter the value, date of last test and location of earth should be entered in a register.

- Earth resistance, date of last testing should also be printed suitably on the wall of near by structure or post on a conveniently placed sign board.

- Water to be added every day to the earth electrode in summer and once in two days in other seasons.

- If earth resistance is more than the nominal value either renew the old earth or provide a new earth.

2.4 Precautions

- Earth electrodes shall not be buried in a position likely to cause an obstruction or where it is likely to be damaged.

- Protect the earth lead wire from mechanical damage.

- Apply anti-corrosive paint/ bitumen compound on the portion of wire buried in ground.

- The lead in wire of different earth must be electrically insulated from each other, from metallic structures etc.

- There should not be any possibility of simultaneous human contact with metallic bodies connected to different earthing.

- Whenever it is not possible to provide suitable spacing or partition between various metallic bodies, they must be connected to a common earthing.

2.5 Drawbacks of Conventional Earthing

- The salt poured in pit causes severe corrosion of G.I.pipe and makes the earthing ineffective.

- The earth resistance value depends on “Soil resistivity” which depends on strata so the effect of earthing is dependent on property of soil.

- The earth resistance value is very high, fluctuating & increases heavily with time.
Chapter III

MAINTENANCE-FREE EARTHING AND BONDING SYSTEM

3.1 Introduction

- This type of earthing and bonding system is adopted for S&T equipments with solid state components which are more susceptible to damage due to surges, transients and over-voltages being encountered in the system due to lightning, sub-station switching etc. These equipments include Electronic Interlocking, Integrated Power Supply equipment, Digital Axle Counter, Data Logger etc.

- This type of earthing arrangement requires no maintenance hence it is called as “Maintenance-free earthing.”

- This is also called as “Effective Earthing”.

- Effective earthing electrode eliminates problems of conventional earthing:
  1. By providing highly corrosion resistant Earthing Electrode.
  2. By eliminating the corrosion causing elements in the salt.
  3. By providing uniform non corrosive, low soil resistivity material around the electrode.

3.2 Salient features

- Low resistance and electrical impedance ensures dissipation of energy into the ground in the safest possible manner.

- Adequate current carrying capacity

- Durable and reliable.

- Specially developed anti-corrosive Packing Material having less resistivity, and high moisture retaining capacity is used surrounding the electrode.

- This complete arrangement eliminates any possibilities of corrosion of the electrode unlike conventional system.

- Mechanically robust and reliable.
• Maintenance Free.

• A reliable life of 10 -12 years.

• The packing material helps in maintaining uniformity at different strata and offers less resistance to current dissipation, with good moisture retaining property. The whole system together results in most effective earthing.

The acceptable Earth resistance at earth busbar shall not be more than 1 Ohm.

3.3 Applications

1. House-hold earthing.

2. Transmission & distribution systems.


5. Lightning protection earths in difficult conditions for home as well as industries.


7. Computers & Data processing Centers.

8. Railway Signalling equipments/installations consisting of solid state components.

3.4 Components of Earthing & Bonding system

Following are the components of earthing and bonding system:

• Earth Electrode

• Earth enhancement material

• Earth pit

• Equi-potential earth-busbar

• Connecting cable

• Tape/strip and associated accessories
3.4.1 Earth Electrode

Earth electrode is made up of high tensile low carbon steel circular rods bonded with copper on outer surface.

The earth electrode shall be of minimum 17.0 mm diameter and 3 meter length.

Fig. 3.1 (a) Copper bonded steel earth electrode  
(b) Electrode with coupler  
(c) Enlarged view of coupler
3.4.2 Earth enhancement material

Earth enhancement material is a superior conductive material that improves earthing effectiveness by improving conductivity of the earth electrode and ground contact area. It mainly consists of Graphite and Portland cement. It is supplied in sealed moisture proof bags.

It has following characteristics:

- Highly conductive, improves earth’s absorbing power and humidity retention capability.
- Non-corrosive in nature having low water solubility but highly hygroscopic.
- Resistivity of less than 0.2 Ohms-meter.
- Suitable for installation in dry form or in a slurry form.
- Does not depend on the continuous presence of water to maintain its continuity.
- Permanent and maintenance free and in its “set form”, maintains constant earth resistance with time.
- Does not dissolve decompose or leach out with time.
- Does not require periodic charging treatment nor replacement and maintenance.
- Suitable for any kind of electrode and all kind of soils of different resistivity.
- Does not pollute the soil or local water table and meets environmental friendly requirements for landfill.

![Earth enhancement material](image)

(a) Before setting  
(b) After setting

Fig. 3.2: Earth enhancement material
3.4.3 Backfill material

- The excavated soil is suitable as a backfill but should be sieved (screened) to remove large stones and place around the electrode taking care to ensure that it is wet and compact.
- Material like sand, salt, coke breeze, cinders and ash shall not be used because of its acidic and corrosive nature.

3.4.4 Earth pit

**Construction of unit earth pit**

(Ref: Fig.3.3 Typical installation drawing no. SDO/RDSO/E&B/001)

- A hole of 100 mm to 125 mm dia is to be dug manually or with the help of ‘Earth auger’ to a depth of about 2.8 metres.
- Place the earth electrode into this hole.
- Gently drive on the top of the rod to penetrate it into the soil so that minimum 150 mm of the electrode shall be inserted in the natural soil.
- Now fill the Earth enhancement material (min. approx.30-35 kg) into the augured/dug hole in slurry form and allow it to set. After setting, the diameter of composite structure (earth electrode + earth enhancement material) shall be of minimum 100 mm dia covering entire length of the hole.
- Cover the remaining portion of the hole by backfill soil, which is taken out during auguring/digging.
- A copper strip of 150 mm X 25 mm X 6mm shall be exothermically welded to main earth electrode for taking the connection to the main equi-potential earth bus bar in the equipment room and to other earth pits, if any.
- The main earth pit shall be located as near to the main equi-potential earth busbar in the equipment room as possible.
Fig. 3.3: Installation of maintenance-free earth for S&T installations
(Ref: Typical installation drawing no. SDO/RDSO/E&B/001 dated 19.09.2008)
3.4.5 Construction of loop Earth by providing multiple earth pits

At certain locations, it may not be possible to achieve earth resistance of < 1 Ohm with one earth electrode/pit due to higher soil resistivity. In such cases, provision of loop earth consisting of more than one earth pit shall be done. The number of pits required shall be decided based on the resistance achieved for the earth pits already installed. The procedure mentioned above for one earth pit shall be repeated for other earth pits.

The distance between two successive earth electrodes shall be min. 3 mtrs. and max. upto twice the length of the earth electrode i.e. 6 mtrs. approx.

These earth pits shall then be inter-linked using 25X2 mm. copper tape to form a loop using exothermic welding technique.

The interconnecting tape shall be buried at depth not less than 500 mm below the ground level. This interconnecting tape shall also be covered with earth enhancing compound.

Fig. 3.4: Interlinking of earth pits using copper tape

3.4.6 Inspection Chamber

- The inspection chamber is a concrete box of 300mmX300mmX300 mm (inside dimension) with smooth cement plaster finish provided on top of the pit.
- A concrete lid, painted black, approx. 50 mm. thick with pulling hooks, shall be provided to cover the earth pit.
- Care shall be taken regarding level of the floor surrounding the earth so that the connector is not too deep in the masonry or projecting out of it.
- On back side of the cover, date of the testing and average resistance value shall be written with yellow paint on black background.
3.4.7 Equi-potential earth busbars

- Each equipment room i.e. IPS/Battery Charger room and EI/Relay room is provided with one equi-potential earth bus bar. Such bus bars are termed as Sub equi-potential busbars (SEEB).

- The equi-potential earth busbar provided in the IPS/Battery Charger room and directly connected to Class ‘B’ SPDs and the main earth pit is termed as Main equi-potential earth busbar (MEEB).

- The EEBs have pre-drilled holes of suitable size for termination of bonding conductors.

- The EEBs shall be insulated from the building walls by providing low voltage insulator spacers of height 60 mm between EEB and the wall.

- For ease of inspection and maintenance, EEBs shall be installed at the height of 0.5 mm from the room floor surface.

- Copper lugs with spring washers are used for all terminations on EEBs.

3.4.8 Bonding Connections

- To minimize the effect of circulating earth loops and to provide equi-potential bonding, “star type” bonding connection is required.

- Each of the SEEBs installed in the rooms shall be directly connected to MEEB using bonding conductors. Also, equipment/racks in the room shall be directly connected to its SEEB.
The bonding conductors shall be bonded to their respective lugs by exothermic welding.

All connections i.e. routing of bonding conductors from equipments to SEEB and from SEEBs to MEEB shall be as short and as direct as possible with minimum bends and separated from other wiring. However, connection from SPD to MEEB shall be as short as possible and preferably without any bend.

### 3.4.9 Materials and dimensions

<table>
<thead>
<tr>
<th>Component/Bonding</th>
<th>Material</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main equi-potential earth busbar (MEEB)</td>
<td>Copper</td>
<td>300X25X6 mm (min.)</td>
</tr>
<tr>
<td>Sub equi-potential earth busbar (SEEB)</td>
<td>Copper</td>
<td>150X25X6 mm (min.)</td>
</tr>
<tr>
<td>Individual equipments to SEEB using copper lugs with stainless steel nut and bolts</td>
<td>Multi-strand single core PVC insulated copper cable as per IS:694</td>
<td>10 Sq.mm.</td>
</tr>
<tr>
<td>SEEB to MEEB using copper lugs with stainless steel nut and bolts.</td>
<td>Multi-strand single core PVC insulated copper cable as per IS:694</td>
<td>16 Sq.mm.</td>
</tr>
<tr>
<td>Surge protection devices (SPDs) to MEEB using copper lugs with stainless steel nut and bolts.</td>
<td>Multi-strand single core PVC insulated copper cable as per IS:694</td>
<td>16 Sq.mm.</td>
</tr>
<tr>
<td>MEEB to main earth electrode</td>
<td>Multi-strand single core PVC insulated copper cable as per IS:694 (Duplicated)</td>
<td>35 Sq.mm.</td>
</tr>
<tr>
<td>Main earth pit to other earth pit in case of loop earth.</td>
<td>Copper tape</td>
<td>25X2 mm.</td>
</tr>
</tbody>
</table>
Fig. 3.7: Typical bonding and earthing connections for signalling equipments
(Ref: Typical installation drawing no. SDO/RDSO/E&B/002 dated 19.09.2008)
3.5 Single earth system

- The Telecom installations shall use single earth system in which the different earth connections from equipments, towers, D.C. power supply, metallic structures etc. shall be interconnected to each other through low resistance earthing conductors.
- This method is recommended to keep all the points to be earthed at approximately same potential level.

3.6 Earthing of IPS system

The IPS systems and its individual modules have earth terminals and these should be properly earthed to the IPS cabinet.

Zonal Railways shall provide earthing arrangement as per IS:S 3043. The earth resistance shall not be more than 2 ohm. Earth provided shall preferably be maintenance free using earth resistance improvement material.

No earth shall be connected to the system. The system earth shall be connected to Class B protection module and Class B module only shall be connected to earth. (Class B protection is dealt in Section IV – Lightning & Surge Protection)

---

**Fig. 3.8(a): System directly connected to earth - Incorrect**

**(b): System connected to earth through Class B module – Correct**
Care must be taken so that the distance between earth pit connection and IPS is always higher than that of the distance between earth pit connection and Class B module.

Separate routing and combining of all earths at one point is correct as shown in the Fig. below.

**Fig. 3.9: Separate routing and combining of all earths at one point**

### 3.7 Precautions

- Pour sufficient water so that mixture is in paste / mud form.
- Allow the pit to absorb the water and become compact.
- Test the earth pit before connecting to the electrical circuit.
- Avoid excess watering.
- Do not hammer the earth electrode.
- The surroundings of the earth electrode should be kept moist by periodically pouring water through the pipe in order to keep the resistance below specified value.
- Coke treated electrodes shall not be situated within 6 meters of other metal structure.
- The protective earth of Telecom system shall not be connected to the earth of mains power supply system. A minimum distance of 10 Meters is desirable.
Chapter IV

LIGHTNING AND SURGE-PROTECTION

4.1 Introduction

Lightning occurs throughout the world, but some areas receive far more lightning than others.

A single direct strike can result in physical damage to the structure which may result fire, loss of product, damage to infrastructure, communications downtime and loss of life. Lightning also poses unacceptable risks for electronics and communication systems.

A surge is a very short burst of voltage, which if not suppressed, can cause equipment failure or lockup. The duration of surge is less than 1/1000 of a second.

Surges are induced in nearby AC power lines due to cloud to cloud and cloud to ground strikes.

Surges are also generated due to self-inductance whenever power is switched on or off during a non-zero crossing point of the sine wave.

4.2 Protection of S&T equipments

Nowadays almost all equipments used in S&T department include the electronic devices which operate on low voltages. The low voltage equipments e.g. UPS, Battery Charger, Inverter, control systems, etc are provided with surge components like MOVs, avalanche diodes, gas discharge tubes etc. inside the equipments. The internally used surge protection components prove to be inadequate towards the surge protection solution. Hence to protect these devices from transient over voltages produced due to lightning, switching of inductive loads, ignition and interruption of electronic arcs etc., suitable surge protection arrangement is required to be done at different levels. Before going for different types of surge protection arrangements, let us first understand Surge Protection Devices and their characteristics.

4.3 Surge protection devices (SPDs)

Surge Protection Devices can protect the electronic equipment from the potentially destructive effects of high-voltage transients.

The Surge Protection Devices have following features:

1. Rapid operation,
2. Accurate voltage control and
3. Automatic resetting once the over-voltage has ceased.

4.3.1 Function of SPD

Surge protection devices should ideally operate instantaneously to divert a surge current to ground with no residual common-mode voltage presented at the equipment terminals. Once the surge current has subsided, the SPD should automatically restore normal operation and reset to a state ready to receive the next surge.
4.3.2 Types of SPDs
There are a number of Surge Protection Devices of which the most commonly used are:
- Air or Carbon Sparks Gaps
- Gas discharge tubes (GDTs),
- Voltage-clamping diodes or Zener Diodes
- Metal-oxide varistors (MOVs)
- Fuses
- Circuit breakers

Air or Carbon Spark Gaps
Air spark gaps are generally connected between line and earth in locations where a high voltage transient can flash over to earth.
The protection level is a function of gap distance but it is affected by environmental factors such as air humidity.
They are inexpensive but for modern SPDs these components are not practical and are therefore not used.

Gas discharge tubes
- Typically, low voltage protection devices have electrode spacing of 1mm or so in an argon/hydrogen mixture sealed within a ceramic envelope at about 0.1 bar.
- Gas discharge tubes (GDTs) seek to overcome some of the disadvantages of air or carbon spark gaps by hermetic sealing, thereby eliminating environmental effects.
- Gas filling enables spark discharge conditions to be quite rigorously controlled since the breakdown voltage of such a device is related to gas pressure and electrode separation for a particular set of materials.

Fig. 4.1: 2 element gas discharge tube connection
Zener Diodes
- Semiconductor devices such as zener diodes are fast in operation and are available in a wide range of voltages that provide accurate and repeatable voltage clamping.
- Standard zener diodes can not usually handle surge currents however modified surge suppression diodes are available with capabilities of up to several KV for pulses of less than 1 milli-second.
- Surge diodes with the capacity of several KW can be rather large and expensive, so indiscriminate use is not common.

Fuses
- Fuses can be used to great effect in protecting equipment from over currents. However, as they rely upon thin sections of wire melting, they take a significant time to operate and the current passing through while this occurs can still be sufficient to damage sensitive electronic parts.
- This has a major disadvantage of being usable only once, leaving lines disconnected until the blown fuses are replaced.

Circuit breakers
Circuit breakers are normally designed for power systems and though energy handling capability can be increased to whatever level is considered necessary, speed of response is of the order of 10 milli-seconds.
A comparative table is given below for above protection devices

<table>
<thead>
<tr>
<th>Component</th>
<th>Speed of response</th>
<th>Level of protection</th>
<th>Energy handling capability</th>
<th>Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD tube</td>
<td>Fast (Micro-secs)</td>
<td>Fair</td>
<td>High</td>
<td>Fair</td>
</tr>
<tr>
<td>Air gap</td>
<td>Fast</td>
<td>Poor</td>
<td>High</td>
<td>Poor</td>
</tr>
<tr>
<td>Surge relay</td>
<td>Slow (Milli-secs)</td>
<td>Good</td>
<td>High</td>
<td>Good</td>
</tr>
<tr>
<td>Carbon gap</td>
<td>Fast</td>
<td>Poor</td>
<td>High</td>
<td>Poor</td>
</tr>
<tr>
<td>Zener diode</td>
<td>Very Fast</td>
<td>Very good</td>
<td>Low</td>
<td>Very good</td>
</tr>
<tr>
<td>Circuit breakers</td>
<td>Slow</td>
<td>Fair</td>
<td>High</td>
<td>Fair</td>
</tr>
<tr>
<td>Fuses</td>
<td>Very slow</td>
<td>Good</td>
<td>High</td>
<td>Fair</td>
</tr>
<tr>
<td>Metal oxide varistors</td>
<td>Very Fast</td>
<td>Fair</td>
<td>High</td>
<td>Poor</td>
</tr>
</tbody>
</table>

As can be seen from the table no single device can offer all the best requirements of the lightning protections. It is generally necessary to use more than one type of the above components in a protective network to obtain the best possible combination of desirable characteristics.

4.3.3 SPD parameters

Following parameters are taken into consideration for the performance of SPDs:

**Nominal voltage (Uₐ)**
It corresponds to the nominal voltage of the system to be protected. The nominal voltage is indicated in case of surge protective devices for IT installations for type designation purposes. For AC voltages it is indicated as RMS value.

**Max. Continuous Voltage (Uₑ)**
It is the Root Mean Square (RMS) value of maximum voltage which may be applied to the correspondingly marked terminals of the surge protective device during operation. It is the maximum voltage on the SPD in the defined non-conductive state which ensures that this state is regained after response and discharge.

**Nominal Load Current (Nominal Current) (Iₑ)**
It is the highest permissible operating current which may be permanently conducted via the correspondingly marked terminals.

**Nominal Discharge Current (Iₑ)**
It is the peak value of an impulse current, waveform 8/20 milli-sec, which the surge protective device rated for, according to a certain test programme.

**Max. Discharge Current (Iₑₘₐₓ)**
It is the max. peak value of the impulse current 8/20 milli-sec, which can be safely discharged by the device.
Lightning Impulse Current ($I_{imp}$)
It is the standardized impulse current curve, with a waveform 10/350 milli-sec. Its parameters (peak value, charge, specific power) simulate the loads of natural lightning currents and combined lightning current and surge protectors must be capable of discharging such lightning impulse currents several times without consequential damage to the equipment.

Voltage Protection Level ($U_p$)
The voltage protection level of a surge protective device is the max. instantaneous value of the voltage on the terminals of a surge protective device.

N-PE Surge Arrestors
These are surge protective devices exclusively designed for installation between the N and PE conductor.

Operating Temperature Range
This indicates the range where the devices can be used. In case of devices without self-heating, it is equal to the ambient temperature range. The temperature rise at devices with self-heating, must not exceed the max. value indicated.

Response time $t_A$
Response times generally characterize the response performance of the individual protection elements used in surge protective devices.

Swell
A momentary voltage increase of the power line voltage, lasting up to several seconds.

Transient
An abnormal over voltage of micro-second duration. Also called a surge or spike.

4.4 Different types of protective arrangements
Protection arrangement shall be made for underground cable conductors, by providing gas discharge (GD) tubes and MOVR, at the following places:

- Protection at subscriber premises.
- Metallic sheath or armour of the cable shall be earthed and the sheath should be connected to the body of the metal box.
- At transmission/ switching end the metallic sheath shall be earthed and protective devices shall be provided for each pair.
- At transmission point between overhead lines and underground cables are protected with GD tubes and MOVR if the distance exceeds 500 meters from the cable termination box.

4.4.1 Protection arrangements across A.C mains supply to telecom installations

- Low voltage lightning dischargers of normal rating 650V shall be provided across the 230 V mains power supply as shown in the figure.
- In the case of high tension supply (11 KV or above) are terminated near telecom installation and suitable pole mounted high voltage arrester shall be provided.
4.5 Lightning protection levels

4.5.1 Protection against the lightning on the structure housing the equipment

This type of protection is classified under Class ‘A’ protection.

Class ‘A’ protection

- This is provided with an external lightning conductor on top of the building connected through a down conductor to ground (EARTH). This is known as class ‘A’ protection.

Fig. 4.3: Protection arrangements across A.C mains supply to telecom installations

Fig. 4.4: Sketch showing Class ‘A’ protection
• By this arrangement 50% of lightning energy is connected to ground. Depending on the area, size of the structure to be protected and the type of protection varies.

![Fig. 4.5: A typical lightning conductor](image)

**Power line protection**
The power line of electronic signalling equipment shall have Class B & C type 2-stage protection. Stage 3 protection is also required for protection of power/signaling/data lines. Class ‘B’ and class ‘C’ type protection devices shall preferably be pluggable type to facilitate easy replacement.

**4.5.2 Stage 1 (Power Line Protection at Distribution level)
Class ‘B’ protection**
- The first stage of protection provided before the equipment at mains distribution panel is called class ‘B’ type.
- This type of protection shall be provided against Lightning Electromagnetic Pulse (LEMP) and other high surges at the power distribution panel.
- The modules shall have an indication function to indicate the life and failure mode to facilitate the replacement of failed SPDs.
- The device is a Spark gap type and operate on arc chopping principle and designed to handle lightning current pulses of 10/350 μs.
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameter</th>
<th>Value/Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Line &amp; Neutral</td>
</tr>
<tr>
<td>1.</td>
<td>Nominal voltage (U_0)</td>
<td>230 V</td>
</tr>
<tr>
<td>2.</td>
<td>Maximum operating voltage (U_c)</td>
<td>&gt;255 V</td>
</tr>
<tr>
<td>3.</td>
<td>Lightning impulse current between R/Y/B &amp; N (I_{imp})</td>
<td>&gt;50 kA, 10/350 micro sec. for each phase</td>
</tr>
<tr>
<td>4.</td>
<td>Lightning impulse current between N &amp; E (I_{imp})</td>
<td>--</td>
</tr>
<tr>
<td>5.</td>
<td>Response time (T_r)</td>
<td>≤ 200 n sec.</td>
</tr>
<tr>
<td>6.</td>
<td>Voltage protection level (U_p) between L &amp; N</td>
<td>≤ 1.3 kV</td>
</tr>
<tr>
<td>7.</td>
<td>Voltage protection level (U_p) N &amp; PE</td>
<td>--</td>
</tr>
<tr>
<td>8.</td>
<td>Short circuit withstand and follow up current extinguishing capacity without back-up fuse (I_{sc})</td>
<td>≥ 10 kA</td>
</tr>
<tr>
<td>9.</td>
<td>Operating temperature / RH</td>
<td>70 °C / 95%</td>
</tr>
<tr>
<td>10.</td>
<td>Mounted on</td>
<td>DIN rail</td>
</tr>
</tbody>
</table>

**4.5.3 Stage 2 (Power Line Protection at Equipment level)**

**Class-'C' Protection**

This type of protection is provided against low voltage surges at the equipment input level connected between line and neutral.

The device is a single compact varistor (MOV) which have following additional features:

- Indication (shows red) when device failed.
- Thermal disconnection of device when it starts having heavy leakage current due to ageing / handling several surges.
- Potential free contact for remote monitoring.

A number of MOVs shall in no case be provided in parallel.
Fig. 4.7: A Class ‘C’ Surge arrester

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameter</th>
<th>Value / Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nominal voltage ($U_0$)</td>
<td>230 V</td>
</tr>
<tr>
<td>2.</td>
<td>Maximum continuous operating voltage ($U_c$)</td>
<td>$\geq 300$ V</td>
</tr>
<tr>
<td>3.</td>
<td>Nominal discharge current between R/Y/B &amp; N ($I_n$)</td>
<td>$\geq 10$ kA, 8/20 micro sec. for each phase</td>
</tr>
<tr>
<td>4.</td>
<td>Maximum discharge current between L &amp; N ($I_{max}$)</td>
<td>$\geq 40$ kA, 8/20 micro sec.</td>
</tr>
<tr>
<td>5.</td>
<td>Response time ($T_r$)</td>
<td>$\leq 25$ n sec.</td>
</tr>
<tr>
<td>6.</td>
<td>Voltage protection level ($U_p$)</td>
<td>$\leq 1.6$ kV</td>
</tr>
<tr>
<td>7.</td>
<td>Operating temperature / RH</td>
<td>70º C / 95% RH</td>
</tr>
<tr>
<td>8.</td>
<td>Mounted on</td>
<td>DIN rail</td>
</tr>
</tbody>
</table>

4.5.4 Stage 3 (Protection for Power/Signalling/data lines)

All external Power/Signalling/data lines (AC/DC) shall be protected by using preferably pluggable stage 3 surge protection devices which consists of a combination of varistors/suppressor diodes and GD tube with voltage and current limiting facilities.

4.5.5 Protection of Power line

Class ‘D’ protection

The device for power line protection shall be of Class D type.

This has an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs.

The device is thermal disconnecting type and equipped with potential free contact for remote monitoring.

It consists of a combination of MOVs and GD tube. This should have all the features as mentioned above for Class ‘C’ device.

All external data/signaling (AC/DC) lines connected to electronic equipment should be protected by this arrangement.

One exception where Class “D” device should not be provided is the cable conductors carrying signal lighting feed as leakage in MOVs due to ageing will have adverse effect on working of Lamp Proving Relays (ECRs).
Fig. 4.8: A Class ‘D’ Surge arrester

<table>
<thead>
<tr>
<th>Nominal Voltage (U₀)</th>
<th>24 V</th>
<th>48 V</th>
<th>60 V</th>
<th>110 V</th>
<th>230 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. continuous operating voltage (Uc)</td>
<td>30 V</td>
<td>60 V</td>
<td>75 V</td>
<td>150 V</td>
<td>253 V</td>
</tr>
<tr>
<td>Rated load current (Iₗ)</td>
<td>16 A</td>
<td>16 A</td>
<td>16 A</td>
<td>16 A</td>
<td>16 A</td>
</tr>
<tr>
<td>Nominal discharge current (Iₙ) 8/20 micro sec</td>
<td>≥ 700 A</td>
<td>≥ 700 A</td>
<td>≥ 700 A</td>
<td>≥ 2.0 KA</td>
<td>≥ 2.5 KA</td>
</tr>
<tr>
<td>Max discharge current (Iₘₐₓ) 8/20 micro sec</td>
<td>&gt; 2.0 KA</td>
<td>&gt; 2.0 KA</td>
<td>&gt; 2.0 KA</td>
<td>&gt; 5.0 KA</td>
<td>&gt; 5.0 KA</td>
</tr>
<tr>
<td>Voltage protection level (Uₚ)</td>
<td>≤ 200 V</td>
<td>≤ 350 V</td>
<td>≤ 500 V</td>
<td>≤ 700 V</td>
<td>≤ 1100 V</td>
</tr>
<tr>
<td>Response time (Tᵣ)</td>
<td>≤ 25 nano sec</td>
<td>≤ 25 nano sec</td>
<td>≤ 25 nano sec</td>
<td>≤ 25 nano sec</td>
<td>≤ 25 nano sec</td>
</tr>
</tbody>
</table>

Note: Minor variations from above given parameters shall be acceptable.

4.5.6 Signalling/Data line protection

These devices shall preferably have an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs. If the device has any component which comes in series with data/signaling lines, the module shall have “make before break” feature so that taking out of pluggable module does not disconnect the line.

<table>
<thead>
<tr>
<th>Nominal Voltage (U₀)</th>
<th>5V</th>
<th>12 V</th>
<th>24 V</th>
<th>48 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrester rated voltage (Uc)</td>
<td>6 V</td>
<td>13 V</td>
<td>28 V</td>
<td>50 V</td>
</tr>
<tr>
<td>Rated load current (Iₗ)</td>
<td>≥ 250 mA</td>
<td>≥ 250 mA</td>
<td>≥ 250 mA</td>
<td>≥ 250 mA</td>
</tr>
<tr>
<td>Total discharge current (Iₙ) 8/20 micro sec</td>
<td>≥ 20 KA</td>
<td>≥ 20 KA</td>
<td>≥ 20 KA</td>
<td>≥ 20 KA</td>
</tr>
<tr>
<td>Lightning test current 10/350 micro sec</td>
<td>&gt;2.5 KA</td>
<td>&gt;2.5 KA</td>
<td>&gt;2.5 KA</td>
<td>&gt;2.5 KA</td>
</tr>
<tr>
<td>Voltage protection level (Uₚ)</td>
<td>≤ 10 V</td>
<td>≤ 18 V</td>
<td>≤ 30 V</td>
<td>≤ 70 V</td>
</tr>
</tbody>
</table>
Note: Minor variations from above given parameters shall be acceptable.

If power supply/data/signalling lines (AC/DC) are carried through overhead wires or cables above ground to any nearby building or any location outside the equipment room, additional protection of Stage 2 (Class C) type shall be used at such locations for power supply lines and Stage 3 protection for signal/data lines.

### 4.6 Lightning and Surge protection of IPS installation

- IPS system is provided with Class B and Class C type two stage protection.

- Co-ordinated type B & C arrestor shall be provided in a separate enclosure in IPS room adjacent to each other. This enclosure should be wall-mounting type.

- Class B protection devices (LPD) protect the IPS against lightning. This is separate module of wall mounting type, which is to provided at the power-input point in the IPS room. These devices are of encapsulated type and have self-arc quenching facility.

- Class C protection devices (SPD) are also provided in the LPD Module of wall mounting type. Potential free contacts are provided for failure monitoring of the devices.

- Potential free contacts are provided for health monitoring of SPD and the same can be wired to ASM room or any other place required to monitor the healthiness of SPDs.

- Length of all cable connection from input supply and earth busbar to SPDs shall be minimum possible. This shall be ensured at installation time. The connections shall be as per drawing no.4.9.

- Stage 1 and stage 2 (Class B & C) protection should be from the same manufacturer/supplier. IPS manufacturer shall provide Stage 1 & stage 2 protection along with IPS. Stage 3 protection shall be provided by Railways.

- The cross sectional area of the conductor for first stage protection shall not be less than 16 sq mm and for second stage shall not be less than 10 sq mm.

### 4.7 Inspection and maintenance

In lightning arrestors of Class B, aging phenomena may occur in rare cases, adversely affecting the protective function of the devices, because of frequent overloading/lightning. It is therefore advisable to check the arrestors every two to four years, and after direct lightning strikes.

Surge arrestors of Class C contain varistors having an indicator, which shows whether the device is faulty. The indicators of these should be checked, especially after a period of thunderstorms. If the indicator changes from green to red, the device must be replaced, since it no longer gives protection.
Fig. 4.9: Surge protection for IPS installation
ANNEXURE I

MEASUREMENTS

A1.1 Measurement of Earth Electrode resistance: Fall of potential method

For this type of test, special instruments such as Megger earth testers are recommended for making tests to avoid the effect of back e.m.f. and stray currents.

In this method two auxiliary earth electrodes named as “Current Electrode” (C) and “Potential Electrode (P) are placed at suitable distance from the Test Electrode (E) as given in Fig. A1.1 below.

All the electrodes shall be so placed that they are independent of the resistance area of each other.

The electrode C shall be placed at least 30 meters away from the test electrode E and the auxiliary potential electrode P shall be midway between them.

All the three must be in same straight line.

A measured current is passed between the electrode E to be tested and the auxiliary current electrode C.

The potential difference between the electrode E and the auxiliary potential electrode P is measured.

The resistance of the test electrode E is then given by R=V/I where;

R= resistance of test electrode in ohms,
V= reading of the voltmeter in volts,
I = reading of the ammeter in ampere.

If the test is made at power frequency that is 50 Hz, the resistance of the voltmeter should be high compared to that of the auxiliary potential electrode P and in no case should be less than 20,000 ohms.

The sources of current shall be isolated from the supply by a double wound transformer.

At the time of test, when possible, the test electrode shall be separated from the earthing system.

The auxiliary electrodes usually consist of 12.5 mm diameter mild steel rod driven up to 1 metre in the ground.
Unless three consecutive readings of test electrode resistance with different spacing of electrode agree the test shall be repeated by increasing the distance between the electrodes E and C upto 50 metres and each time placing the electrode P between them.

![Diagram](image-url)

**Fig. A1.1: Measurement of earth electrode resistance with “Fall of potential method”**

**A1.2 Measurement of Earth Electrode resistance with digital earth tester**

- The digital earth tester has four terminals. Short the terminals E1 & P1 and connect to the earth (E) whose resistance has to be found.
- Connect the P2 to the potential spike P, E2 to the current spike C as shown in the figure.
- The distances between “Earth electrode” and “Potential electrode”, d1 and “current electrode” d2 should be equal may range from 20 to 30 meters depending upon the soil.
- First turn the range selector switch to 1000Ω position. The digital display will come in action and will read zero.
- Now press the test switch, the LCD display will indicate the resistance. If the reading is too small the range selector switch may be turned to 10 Ω.
- Record the reading: Earth Resistance = ____________ Ω
- Connect the charging adopter to the instrument and charge it for 12 Hrs. before testing.
A1.3 Measurement of Earth resistivity

Earth tester normally used for these tests comprise the current sources and metres in a single instrument and directly read the resistance.

The most frequently used earth tester is the four terminal megger shown below (Fig. A1.3).

The resistivity may be evaluated from equation as given below:

\[ P = 2\pi SR \]

\( P \) = Resistivity of soil in ohm-metre
\( S \) = Distance between successive electrodes in metre.
\( R \) = Megger reading to ohms.

At the selected test site, four electrodes are driven into the earth along a straight line in a chosen direction at equal intervals \( S \) (unequal spacing may also be used but this will make the formula unnecessarily complicated).

The depth of electrodes in the ground shall be of the order of 10 to 15 cm.

The megger is placed on a steady and approximately level base.

The link between terminals P1 and C1 is opened and the four electrodes are connected to the instrument terminals as shown in Fig.

An approximate range on the instruments is then selected to obtain clear readings, avoiding the two ends of the scale as far as possible. The readings are taken while turning the crank at about 135 rev/min.

Fig. A1.2: Measurement of earth electrode resistance with Digital Tester
Resistivity is calculated by substituting the values of ‘R’ in the equation $P = \frac{2\pi SR}{C}$.

**Fig.A1.3: Measurement of earth resistivity with four terminal megger.**
ANNEXURE II

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ACSR</td>
<td>Alluminium Conductor Steel Reinforced</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>EEB</td>
<td>Equi-potential Earth Bus-bar</td>
</tr>
<tr>
<td>EI</td>
<td>Electronic Interlocking</td>
</tr>
<tr>
<td>EJB</td>
<td>Electronic Junction Box</td>
</tr>
<tr>
<td>GDT</td>
<td>Gas Discharge Tube</td>
</tr>
<tr>
<td>GI</td>
<td>Galvanized Iron</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
</tr>
<tr>
<td>IPS</td>
<td>Integrated Power Supply</td>
</tr>
<tr>
<td>KV</td>
<td>Kilo Volt</td>
</tr>
<tr>
<td>KW</td>
<td>Kilo Watt</td>
</tr>
<tr>
<td>L</td>
<td>Line</td>
</tr>
<tr>
<td>LEMP</td>
<td>Lightning Electromagnetic Pulse</td>
</tr>
<tr>
<td>LPD</td>
<td>Lightning Protection Device</td>
</tr>
<tr>
<td>MEEB</td>
<td>Main Equi-potential Earth Bus-bar</td>
</tr>
<tr>
<td>MOV</td>
<td>Metal Oxide Varistor</td>
</tr>
<tr>
<td>N</td>
<td>Neutral</td>
</tr>
<tr>
<td>OHE</td>
<td>Over Head Equipment</td>
</tr>
<tr>
<td>PE</td>
<td>Protection Earth</td>
</tr>
<tr>
<td>RDSO</td>
<td>Research Designs and Standards Organisation</td>
</tr>
<tr>
<td>RMS</td>
<td>Route Mean Square</td>
</tr>
<tr>
<td>SEEB</td>
<td>Sub Equi-potential Earth Bus-bar</td>
</tr>
<tr>
<td>S&amp;T</td>
<td>Signal and Telecommunication</td>
</tr>
<tr>
<td>SM</td>
<td>Station Master</td>
</tr>
<tr>
<td>SPD</td>
<td>Surge Protection Device</td>
</tr>
<tr>
<td>UPS</td>
<td>Un-interrupted Power Supply</td>
</tr>
<tr>
<td>VF</td>
<td>Voice Frequency</td>
</tr>
</tbody>
</table>

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ANNEXURE III

REFERENCES


OUR OBJECTIVE

To Upgrade Maintenance Technologies and Methodologies and achieve Improvement in Productivity and Performance of all Railway Assets and Manpower which Internally would cover Reliability, Availability, Utilisation and Efficiency.

If you have any suggestions and any specific comments, please write to us:

Contact Person: Director (S&T)

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