भारत सरकार **GOVERNMENT OF INDIA**
रेल मंत्रालय MINISTRY OF RAILWAYS

MAINTENANCE FREE EARTH
&
RING EARTH

CAMTECH/ S/PROJ/13-14/Rg & MFEth/1.0
September, 2013

महाराजपुर, ग्वालियर – 474 005
Maharajpur, GWALIOR - 474 005

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MAINTENANCE-FREE EARTH & RING EARTH

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 so called as “Maintenance free earthing or “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.

1.1 Importance of Earthing

- Efficiently dissipate electric surge to protect equipments thus minimize downtime, service interruption & replacement cost.
- Provide a stable reference for electrical and RF circuits to minimize noise during normal operation.
- Protect staff from dangerous electric shock.

1.2 Characteristics of good Earthing System

- Low resistance and electrical impedance
- Conductors of sufficient dimensions capable of withstanding high fault current.
- Lower earth resistance ensures that energy is dissipated into the ground in the safest possible manner
- Lower the earth circuit impedance
- High corrosion resistance
- Mechanically robust and reliable.

1.3 Location for earth

- Low lying areas close to building or equipment
- Close to existing water points but not naturally well drained
- Avoid Dry sand, lime stone, granite, stony ground and high bank.

2. Applications

- House-hold earthing.
- Transmission & distribution systems.
- Substation & Power Generators Transformer.
- Telecomm Towers & Microwave Antennas.
- Lightning protection earths in difficult conditions for home as well as industries.
- Manufacturing Facilities & Refineries.
- Computers & Data processing Centers.
- Railway Signalling equipments / installations consisting of solid state components.

3. 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
- Reliable life : 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 acceptable Earth resistance shall not be more than 1 Ohm.

4. Components

Following are the components of earthing and bonding system:

- Earth Electrode
- Earth enhancement material
- Earth pit
- Equi-potential earth-busbar
- Tape/strip and associated accessories

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 as shown in figure :1.

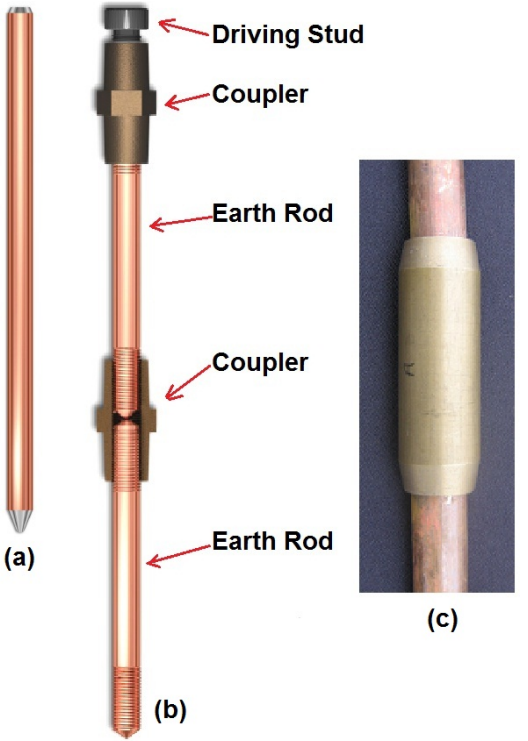

Figure:1(a) Copper bonded steel earth electrode (b) Electrode with coupler (c) Enlarged view of coupler

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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.

(a) Before setting (b) After setting

Figure 2:Earth enhancement material

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.

4.4 Earth pit

Construction of unit earth pit

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

- Prepare a hole of 100 mm to 125 mm dia manually or with the help of 'Earth auger' to a depth of about 2.8 meters.
- Place the earth electrode into the centre 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.
- Figure 3 shows the installation of maintenance free earth for S&T installations with reference to typical installation drawing no. SDO/RDSO/E&B/ 001 dated 19.09.2008.

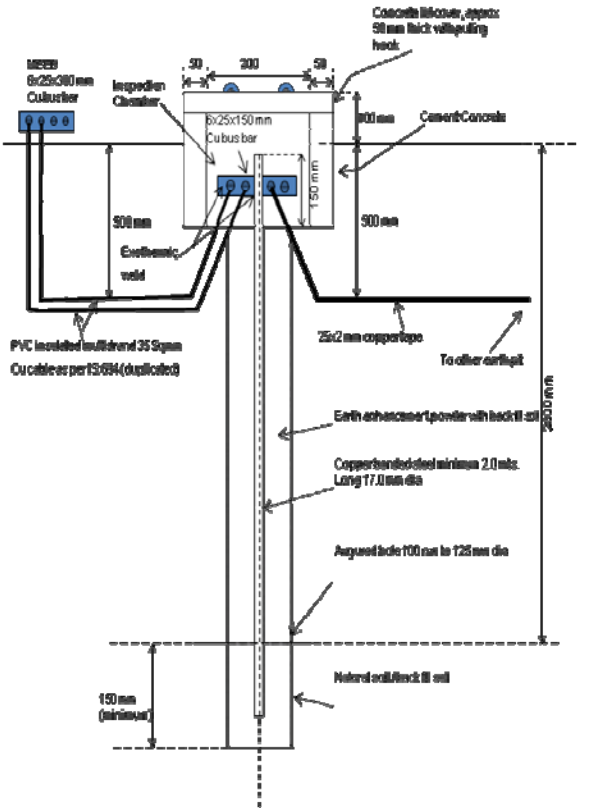

Figure 3: Installation of maintenance-free earth

5. Construction of Ring/ loop Earth

At certain locations, it may not be possible to achieve earth resistance of $\leq$ 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.

Figure 4 : Interlinking of earth pits using copper tape

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.

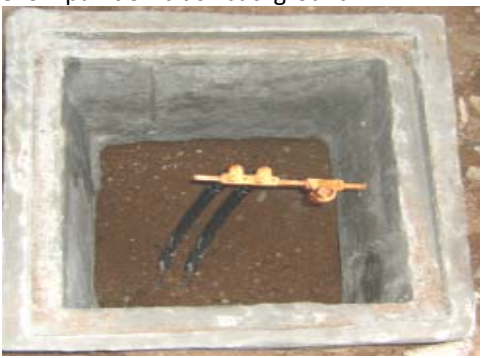

Figure 5: Inspection chamber

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 busbsar 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.

- **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.

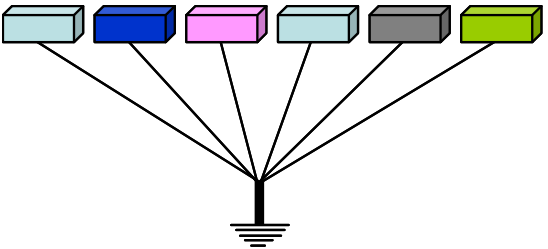

Figure 6: Star type bonding connection

- 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.

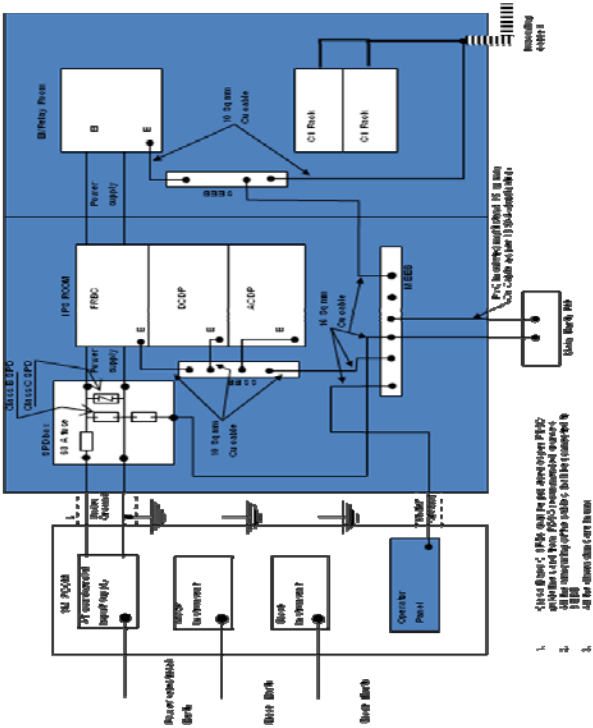

Figure 7 : Typical bonding and earthing connections (Ref: Typical installation drawing no. SDO/RDSO/E&B/002 dated 19.09.2008)

8. Materials and Dimensions

Component /Bonding	**Material** [as per IS:694]	**Size**
Main equi-potential earth busbar (MEEB)	Copper	300X25X6 mm (min.)
Sub equi-potential earth busbar (SEEB)	Copper	150X25X6 mm (min.)
Individual equipts to SEEB using copper lugs with stainless steel nut and bolts	Multi-strand single core PVC insulated copper cable	10 Sq.mm.
SEEB to MEEB using copper lugs with stainless steel nut and bolts.	Multi-strand single core PVC insulated copper cable	16 Sq.mm.
Surge protection devices (SPDs) to MEEB using copper lugs with stainless steel nut and bolts.	Multi-strand single core PVC insulated copper cable	16 Sq.mm.
MEEB to main earth electrode	Multi-strand single core PVC insulated copper cable	35 Sq.mm.
Main earth pit to other earth pit in case of loop earth.	Copper tape	25X2 mm.

9. 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.

10. Earthing of IPS system [An example]

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)

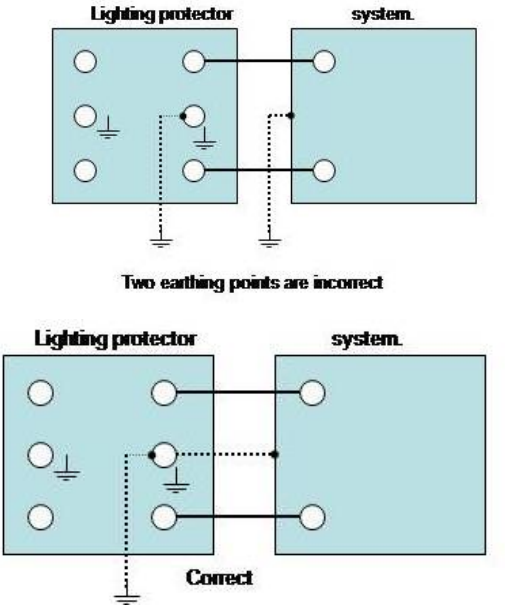

Figure 7(a): connected to earthdirectly - Incorrect
(b): connected to earth through Class B – Correct

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.

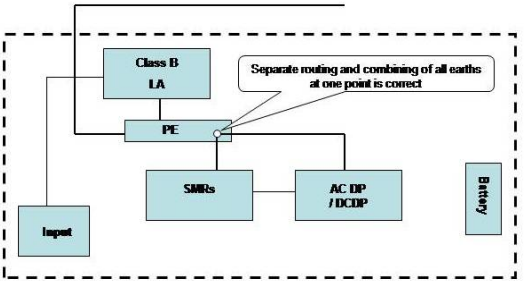

Figure 8 : Separate routing and combining of all earths at one point

11. 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.

12. Limits of Earth Resistance

Maximum values of earth resistances specified for earthing of S&T equipments are as under:

Sr.	Description	Max. Earth resistance
1.	Telegraph and Block Instrument using earth return circuit	10 Ω
2.	Earths for surge arrestors/ lightening dischargers	10 Ω
3.	Earthing of Signalling equipment	10 Ω
4.	Earthing of signalling cable screen in AC electrified areas	10 Ω
5.	Earthing of Telephone Exchange	5 Ω
6.	Earthing of AL sheathed telecom cable in AC electrified area.	1 Ω
7.	Earthing repeater and cable huts.	5 Ω
8.	Axle counter cable screened in AC RE area	1 Ω

Sr.	Description	Max. Earth resistance
9.	Electronic Interlocking installation	1 Ω
10	Integrated Power Supply System & its individual modules	2 Ω
11	Digital Axle Counter EJB and its apparatus case connected to same earth. All cable armours connected to same earth.	1 Ω
12	Reset box of Digital Axle Counter connected to earth (indoor) near SM's Room.	1 Ω

13. Checklist for earthing and bonding system [As per RDSO/SPN/197/2008]

Sr.	Description of the activity	Remarks
1.	Location of the earth pit: it Should be located as near to the main Equi-potential earth busbar in the equipment room as possible.	
2.	Earth electrode: Earthing electrode should not be installed on high bank or made up soil.	
3.	The earth electrode (copper bonded steel cored rod) shall be of minimum 17 mm diameter and minimum 3 meters long.	

Sr.	Description of the activity	Remarks
4.	Measure the thickness of the copper bonding with micron gauge. The minimum copper bonding thickness shall be 250 microns.	
5.	Should have UL making, manufacturer's name or trade name, length, diameter, catalogue number punched on every earth electrode	
6.	Earth enhancement material: Shall be supplied in sealed, moisture proof bags. These bags shall be marked with manufacturer's name or trade name, quantity etc.	
7.	The excavated soil can be used as backfill but should be sieved to remove any large stores and placed around the electrode taking care to ensure that it is well compacted.	
8.a	Constructions of unit earth pit: A hole of 100 mm to 125 mm dia shall be augured/dug to a depth of about 2.8 meters.	

Sr.	Description of the activity	Remarks
8.b	Earth enhancement material minimum approx. 30-35 kg shall be filled into the augured /dug hole in slurry form and allowed to set.	
8.c	A copper strip of 150mmx25mm x 6mm shall be exothermically welded to main earth electrode for taking connection to the main equi-potential earth bus bar in the equipment room and to other earth pits, If any.	
8.d	The other end connection inside the equipment room shall also be of exothermic type.	
8.e	Exothermic weld material shall be UL listed and tested as pr provisions if IEEE 837 by NABL/ ILAC member labs.	
9.	Measure the earth resistance value. (the earth resistance shall be measured at the main equi-potential earth bus bar (MEEB) with all the earth pits interconnected using fall of potential method), it shall be less than 1 ohm.	

Sr.	Description of the activity	Remarks
10.	If more than one earth pit is being prepared ensure than	
a.	The distance between two successive earth electrodes shall be min. 3 meters and max. up to twice the length of the earth electrode i.e. 6 meters approx.	
b.	The earth pits shall then be interlocked using 25x2 mm. copper tape to form a loop using exothermic welding techniques.	
c.	The interconnecting tape shall be buried at depth not less than 500mm below the ground level.	
d.	The interconnecting tape shall also be covered with earth enhancing compound.	
11.	Inspection chamber: A 300x300x300 mm inside dimension concrete box with smooth cement plaster finish shall be provided on the top of the pit. A concrete lid, painted black, approx. 50 mm thick shall be provided with pulling hooks, shall be provided to cover earth pit. Date o the testing and resistance value shall be written with yellow paint on black background.	

Sr.	Description of the activity	Remarks
12.	Equi-potential earth bus bar and its connection to equipments and surge protection devices in the equipment room. Refer typical bonding connections drawing no. SDO/RDSO/ E&B /002	
13.	Equi-potential earth bus bar: the equip-potential earth bus bar for each of the equipment room i.e. IPS/Battery charger room and EE relay room to be provided. Connection from main earth pit shall be terminated in IPS/Charger room where B&C class SPD is provided.	
14.	The equi-potential earth bus bar located in the IPS /battery charger room and directly connected to class SPDs and the main earth pit shall be termed as main equi-potential earth bus bar (MEEB). The equi-potential earth bus bars located in individual rooms shall be termed as sub equi-potential bus bars (SEEB).	
15.	Each EEB shall be installed on the wall with insulators spares of height 60 mm and shall be installed at a height of 50 cms from floor level.	

Sr.	Description of the activity	Remarks
16.	All termination on the EEBs shall be done using copper lugs with spring washers.	
17.	Each of the SEEBs installed in the rooms shall be firmly connected to MEEB using copper bonding.	
18.	Equipment racks in the room shall be directly connected to SEEB	
19.	The warranty of such system shall be 60 months from the date of commissioning (Date of commissioning shall be jointed to main earth pit and near MEEB).	

14. Material and dimensions of bonding components for connection of individual equipments with equi-potential bus bar and earth electrode shall be summarized below:

Component/ bonding	Material	Size
Main equi-potential earth bus bar MEEB	Copper	300x25x6 mm (min)
Sub equi-potential earth bus bar SEEB	Copper	150x25x6 mm (min)
Individual equipment to SEEB using copper lug with stainless steel nut and bolts	Multi strand single core PVC insulated copper cable as per IS:694	10 sq.mm

Component/ bonding	Material	Size
SEEB to MEEB using copper lugs with stainless stell nut and bolts	Multi strand single core PVC insulated copper cable as per IS:694	16 sq.mm
Single protection device (SPD) to MEEB using copper lugs with stainless steel nuts and bolts	Multi strand single core PVC insulated copper cable as per IS:694	16 sq.mm
MEEB to main earth electrode	Multi strand single core PVC insulated copper cable as per IS:694 (duplicated)	35 sq.mm
Main earth pit to other earth pit in case of loop earth	Copper tape	25x2 mm

15. INSPECTION & TESTING

[As per telecom manual chapter XXIII para 33, 34 & 35]

- The complete protection arrangement should be inspected and tested by ASTE/DSTE/Sr.DSTE to ensure that the work has been completed in a satisfactory manner and the material and components used conform to the standard.
- Routine inspection of the installation, particularly the earth resistance shall be taken twice a year by

the SE/SSE incharge of the station and Earth connections of all installation should be checked thoroughly two months in advance of every monsoon season and remedial measures should be taken well in advance of monsoon.

- A log book shall be kept in which details of the measurement and inspection should be recorded for scrutiny by higher officials.

16. Source of Suppliers

i. JMV LPS LIMITED
W-50, Sector-11, Noida, Ghaziabad, Uttar Pradesh,
www.copperbondedrods.com,www.jmv.co.in

ii. True Power Earth Solution
D-10, Vibhuti Khand, 2nd Floor, Gomti Nagar,
LUCKNOW - 226002 Call: (0522) 4071125, 9838352487

iii. Arcon Power System
32, 5th Floor, Room No. 512, South Block, Tea
Board, Ezra Street, Kolkata 700001, (033) 66342138

iv. Signet Engineers
65 Navi Peth, Near Patrakar Bhavan, Sadashiv peth Pune - 411030 , **(020) 66827332,** www.signetengineers.com

v. ERICO
705, 7th Floor, Padma Tower-I, Rajendra Place
New Delhi, Phone: +91 11 4153 9164

vi. Globetel Technologies**,** No. 52, Bhavani Towers, 1st Floor, Opp. Indane Gas Agency, Anand Bagh X Roads,

Safilguda, Ecil X Croads, , Hyderabad, Andhra Pradesh - 500047, http://www.globeteltechnologies.com/

vii. A. N. Electricals, Delhi
2107, 2nd Floor, Chah Indira, Behind Jubliee Cinema, Bhagirath Palace, , Delhi, 110006, India
www.anelectricals.com

viii. Sor Enterprise, Ahmedabad
4910/4911, Gidc, Phase-Iv, Opposite Water Tank, Vatva, , Ahmedabad, Gujarat -382445
sor.tradeindia.com/ Sba Power & Earthing Equipments

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