JEF TECHNO SOLUTIONS PVT LTD

WELCOMES YOU FOR A

TECHNICAL PRESENTATION ON

Earthing, Bonding and PQ –Practical approach to avoid PQ issues

JEF
ECO SAFE

Grounding /Bonding and PQ

A common misconception is that grounding and bonding are the same topic.

Though they are related not the same.

Grounding /Bonding and PQ

Grounding : Normally non-current carrying conductive materials enclosing electrical conductors or equipments or forming part of such equipment shall be connected to earth.

Grounding /Bonding and PQ

Bonding: In simple words, connection of two or more conductive objects to one another by means of a conductor or wire.

What is Bonding?

- **Definition: (NEC 250)**

  The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Grounding /Bonding and PQ

How the bonding should be?
In a manner that creates a low impedance path facilitating the operation of the over current device. As per NEC, it is called Effective ground fault current path.

It shall be capable of safely carrying the maximum ground fault current.

The earth shall not be considered as an effective ground –fault current path.

Grounding /Bonding and PQ

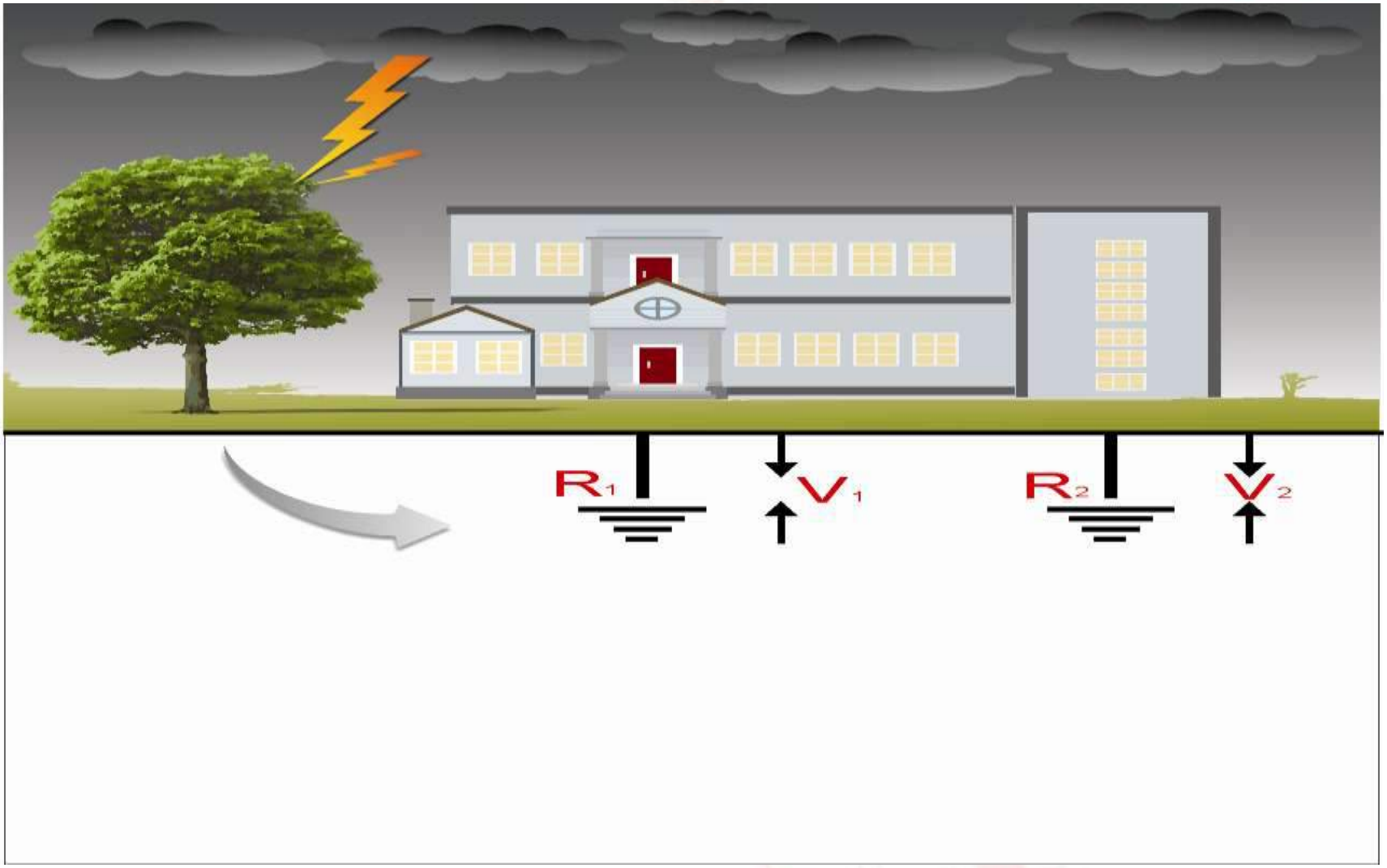
One of the most common errors in a system is bonding the neutral to ground in multiple locations. Whether intentional or unintentional, these ‘extra’ bonding points should be identified and eliminated.

Grounding /Bonding and PQ

Neutral to be grounded only one place at the source or service entrance.

Grounding /Bonding and PQ

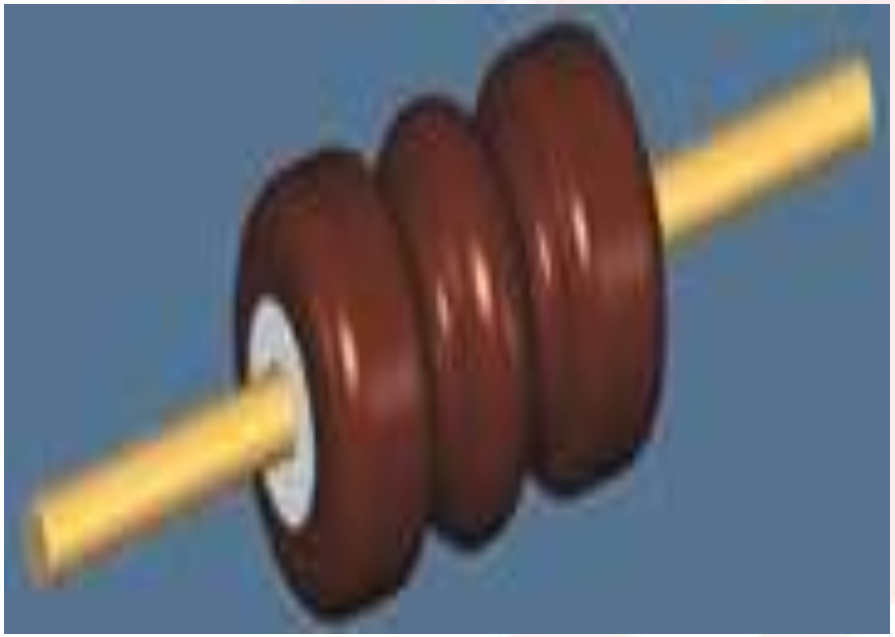
Isolated grounds or electrodes that are physically separate from all other power system and structural grounding electrodes, will inevitably produce common mode noise since it is not referred to the power source ground. The magnitude of the common –mode potential can be destructive to the equipment since a power system fault can raise the power system or structure several thousand volts above other earth reference.


R1
V1
R2
V2

Grounding /Bonding and PQ

Many static problems can be solved by bonding the various parts of the equipment together and grounding the entire system.

EQUIPOTENTIAL EARTHING



- LIGHTNING IMP CURRENT -- 100KA
- RESPONSE VOLTAGE -- ≤ 10KA
- PROTECTION LEVEL -- ≤ 5KA
- CONNECTOR – COPPER LUGS

Why Ground? Personnel Safety

- **Step Potential:** Controlled by properly designed ground electrode system (grid) or the use of wire mesh.

- **Touch Potential:** Controlled by proper bonding and protective systems such as personnel safety mats.

Why Ground?

- Signal Reference Grounding – Noise Control

IEEE Std 1100 (Emerald Book)
Powering and Grounding Electronic Equipment

Bonding

- Interconnect ALL Ground Electrode Systems
  - Electrical Grounding System
  - Lightning Grounding System
  - Telecommunications Grounding System
  - Cable Grounding System
- Interconnect ALL conductive objects together both internal and external to the facility
- Provides near zero voltage difference during GPR

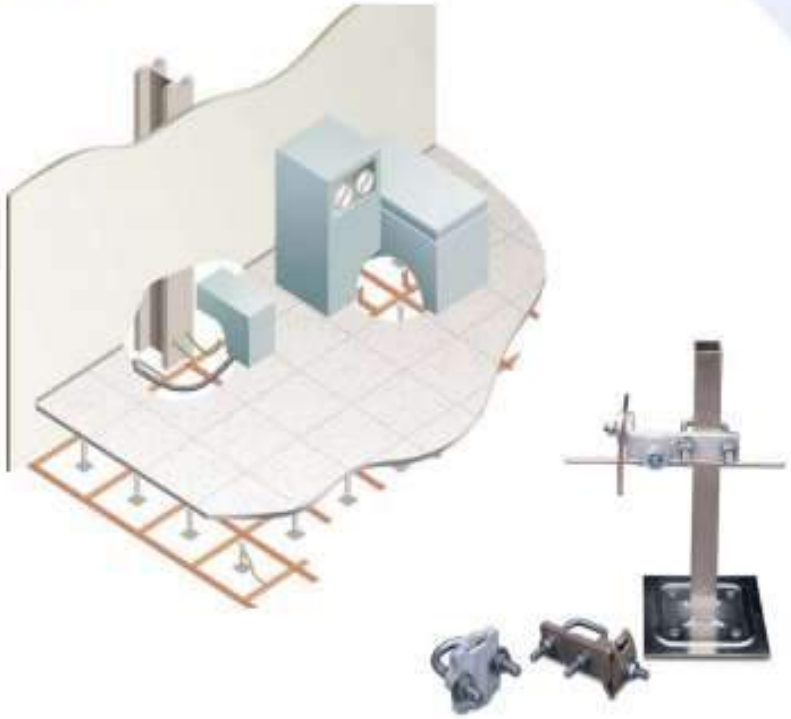
Bonding

- Poor bonding is often the principle cause of many hazardous and noise-producing situations.

- Leading to:
  - Unacceptable Voltage Drops
  - Heat Generation
  - Intermittent Operation
  - Electrical Noise
  - High Resistance Grounds

Bonding Components:

- Signal Reference Grids

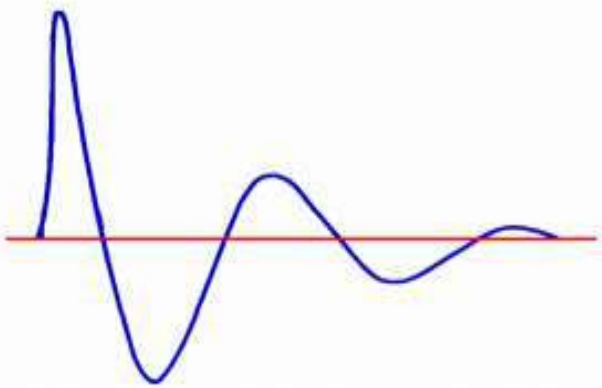


- Coaxial Ground Kits

High Frequency Grounding System

- Reduces or eliminates high frequency transients by achieving a common ground reference for all equipment within a contiguous area.

- Consists of a Signal Reference Grid, low-impedance bonding straps, transient suppression plates and bare copper bonding conductors.



Why a High Frequency Grounding System?

- Most computer systems today run on roughly a 3 volt operating system. A transient of just one volt can cause serious data errors. (Transient Over-Voltages).

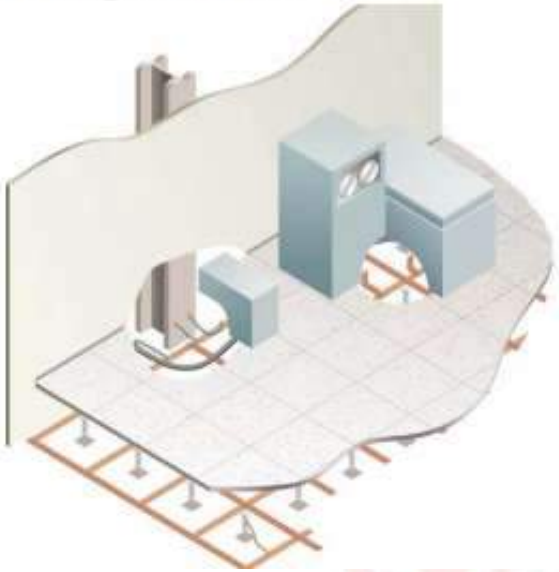
- It is imperative to tie all equipment together with a low impedance "signal reference" bonding system to keep any voltage differences at a minimum.

Sources of Transient Over-voltages

- Lightning Induced Surges
- Power Systems Operations
- Power System Faults
- Reactive Load Switching
- Harmonics
- Ground Potential Rise

Signal Reference Grid (SRG)

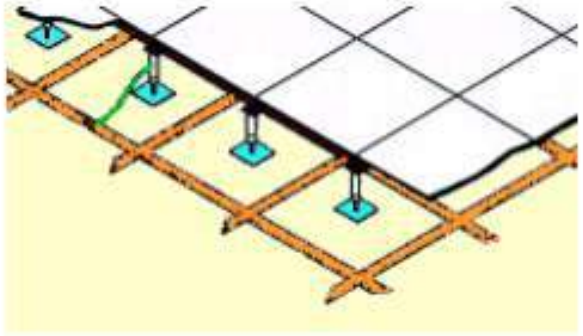
- **Function:** Minimize voltage differences between interconnected equipment by providing a **low impedance equipotential ground plane** for high frequency low voltage noise.



SRG Types

- **Round Conductor**
  - Easier to install when retrofitting an existing raised floor system.

- **Flat Strip**
  - Superior system. (Less impedance than round conductors; very important at high frequencies).
  - Less labor to install.



ELECTRICITY IS A HUMBLE SERVANT BUT A DANGEROUS BOSS

THERE IS NO MERCY & ONLY CAPITAL PUNISHMENT FOR THE WRONG DOERS

ELECTRODE GEOMETRY – TABLE 9,IEEE 142

The resistance geometry of a ground electrode (pipe /rod) is explained as below : Around a grounding electrode the resistance of the soil is the sum of the series Resistances of virtual shells of earth located progressively outward from the rod. The shell nearest the rod has the smallest circumferential area or cross section. So it has the highest resistance. Successive shells outside this one have progressively Larger area and thus lower résistance. As the radius from the rod increases the Incremental resistance per unit of radius decreases effectively to nearly zero.

Experiments with a 10 ft,16 mm rod shows the following reading:

Distance from electrode surface		Approx. % of total resistance
Ft	mtr	
0.1	0.03	25
0.2	0.06	38
0.3	0.09	46
0.5	0.15	52
1.0	0.3	68
5.0	1.5	86
10.0	3.0	94
15.0	4.6	97
20.0	6.1	99
25.0	7.6	100

DESIRED CHARECTERISTICS OF BACKFILL COMPOUND

Resistance of backfilled area must remain consistently low to ensure a reliably low earth resistance.

- Must not be subject to variation due to change in moisture / electrolyte content.
- Backfill must not leach into ground.
- Backfill must not corrode the electrode

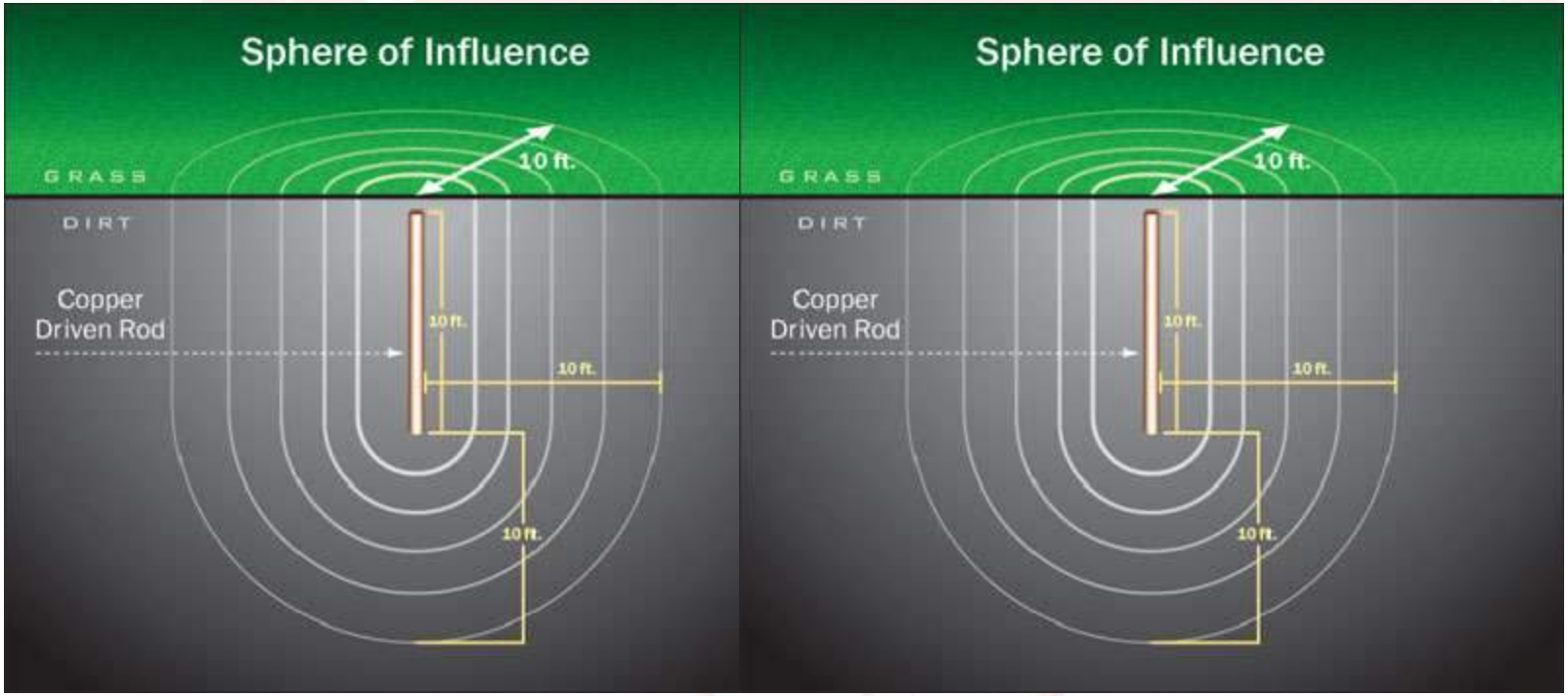
ADVANTAGES OF CARBON BACKFILL

- Highly conductive – resistivity of < 0.1ohm mtr.
- Conducts through flow of electrons like metal – eliminates the need for moisture.
- Contains corrosion inhibitor to protect copper coating and doest not leach into ground.
- Complies with the requirements of IEEE 80 and BS : 7430 for artificial treatment .

ADVANTAGES OF CARBON BACKFILL

- DOES NOT diffuse / leach into ground
- Carbon is highly stable over long duration- does not degrade
- Truly Maintenance Free
- Does not pollute environment - Certified by ANSI / NSF Standard 60 – Safe for use near potable ground water sources.
- POWER SET which has hardening characteristics of cement can be used in areas with high water table.

Spacing between the Electrodes



Copper electrode has a higher current handling capability as compared to the GI / steel electrode.

Also in highly corrosive areas, use of GI / Steel electrode may not be appropriate. Copper or copper coated electrodes have a better resistance to corrosion and hence are better suited in such areas

CONFORMITY TO STANDARDS

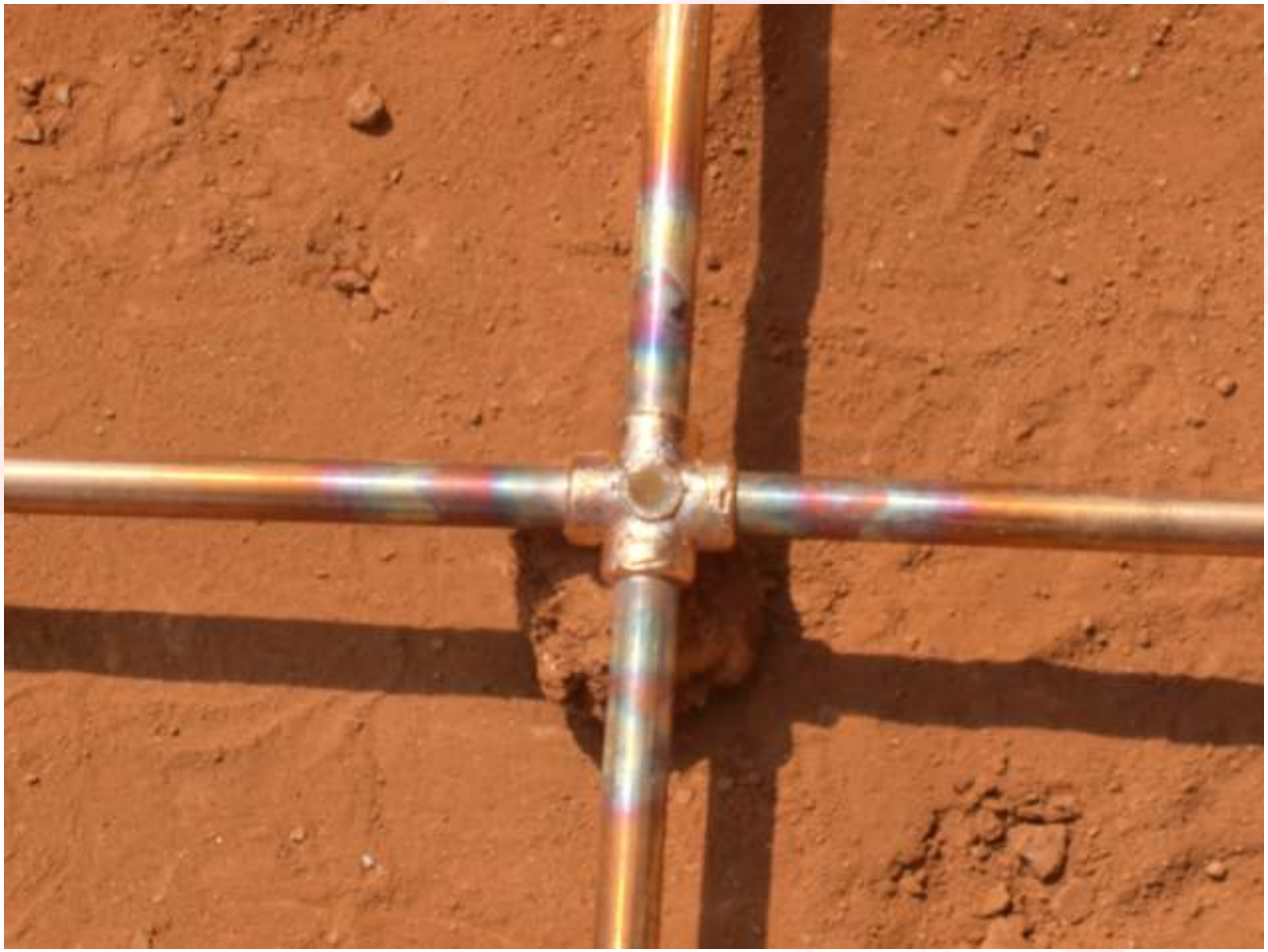
A BRIEF COMPARISON OF EARTHING SYSTEMS RECOMMENDED BY VARIOUS INTERNATIONAL STANDARDS

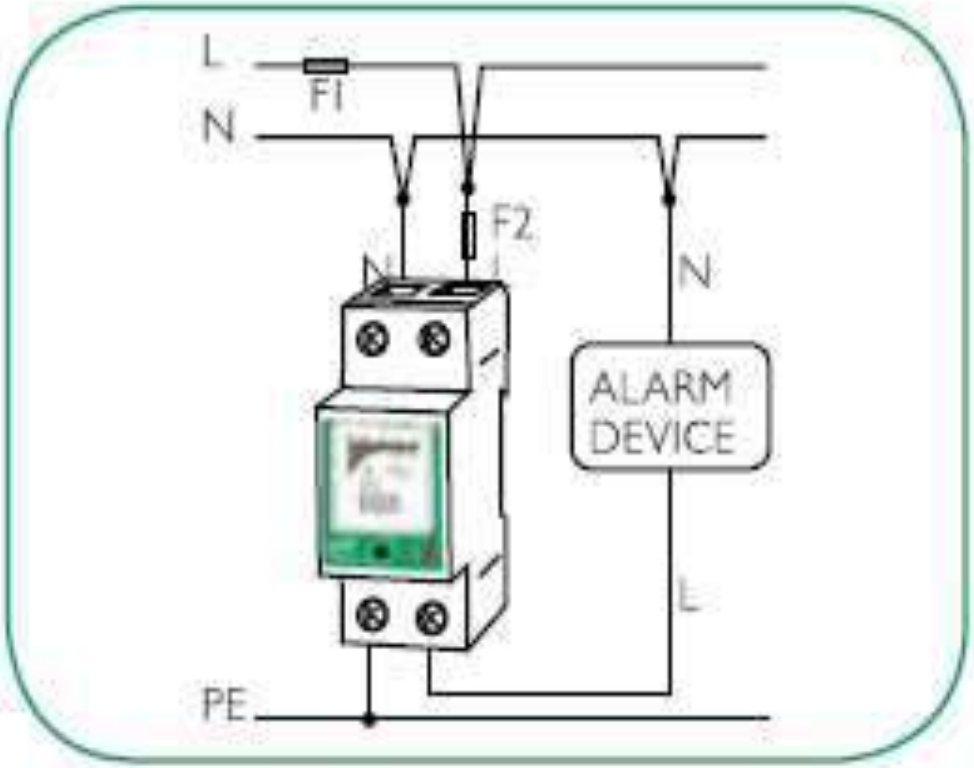
Parameters

Limitations in use of Bentonite clay to improve Earth resistance

IS-3043	BS-7430	IEEE80	REMARKS
The Bentonite clay or similar material may be used in rocky terrain in an insertion around vertical electrode / strip electrode as per clause 8.5 of Page 17	Care should be taken to understand how the soil treatment materials work to ensure that they remain in contact with the rod or strip and do not shrink or swell away after drying out. (Clause 9.2.2 Page 34 BS7430-2011)	• Bentonite a natural clay formed by volcanic action years ago may be used. It has a **resistivity of 2.5 Ω Mtr at 300% moisture. It may not function in a very dry environment because it may shrink away from the electrode increasing the electrode resistance**. (Clause 14.5 Page 68)	• India being a topographical country with a prolonged dry season, use of Bentonite cannot offer a reliable solution due to the limitations brought out in the IEEE & BS

Cross Joint




L
F1
N
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Multi layer soil resistivity

Soil Structure

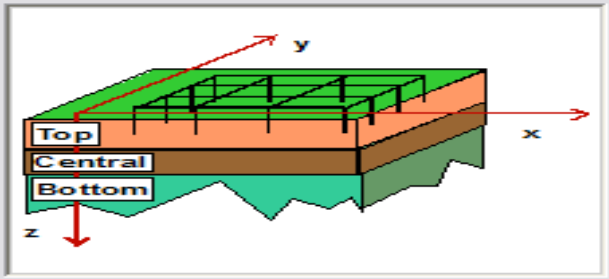
Soil Structure

Soil Type

- Infinite Medium
- Perfect
- Uniform
- Horizontal - 2 Layer
- Horizontal - 3 Layer
- Horizontal - Multilayer
- Vertical - 2 Layer
- Vertical - 3 Layer
- Vertical - Multilayer
- Hemispherical - Multilayer
- Cylindrical - Horizontal
- Cylindrical - Vertical
- Arbitrary Heterogeneities

Computation Method

- Two Layer Method
- Multi-Layer Method



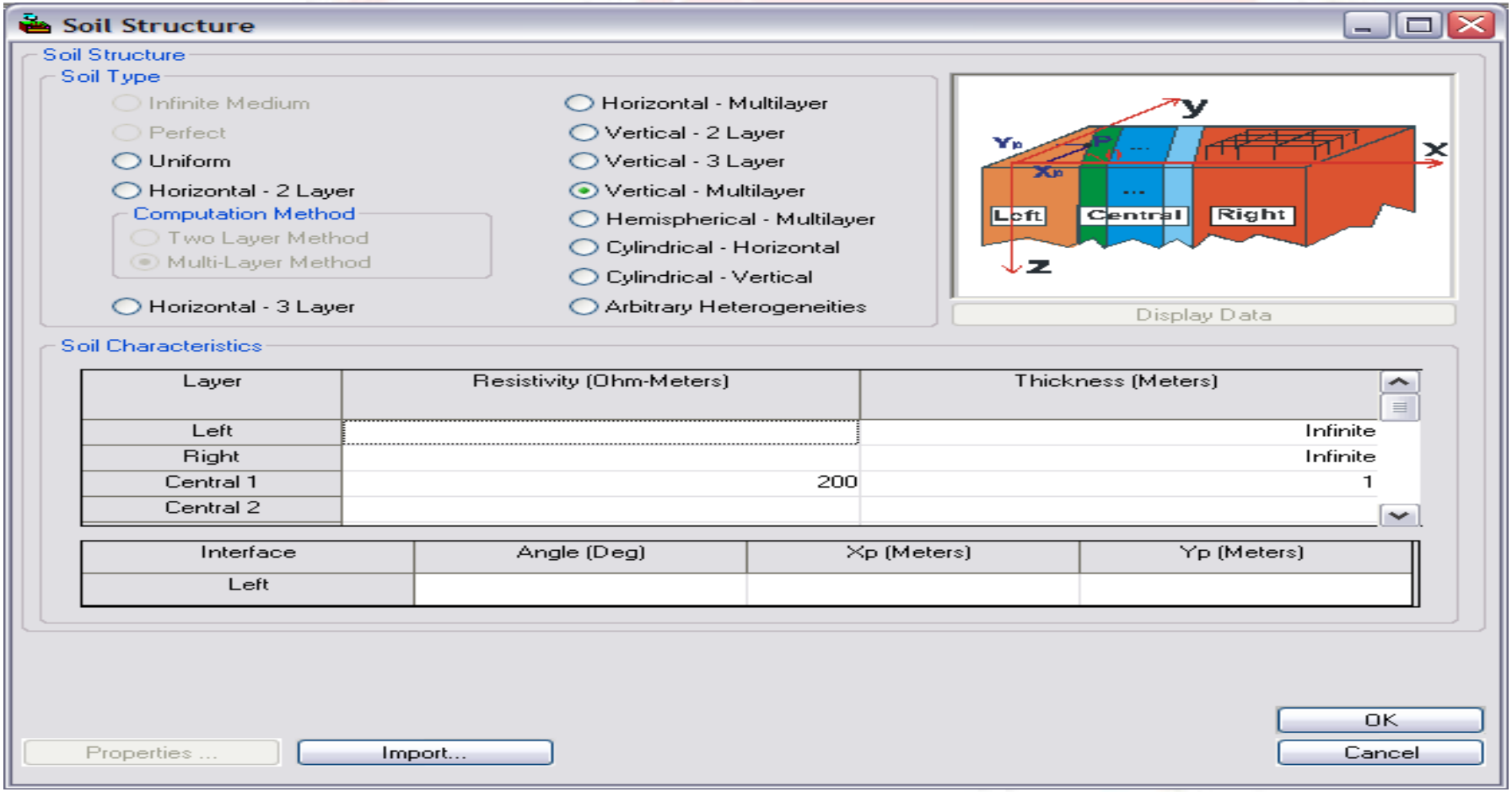
Display Data

Soil Characteristics

Layer	Resistivity (Ohm-Meters)	Thickness (Meters)	Relative (p.u.) Permeability	Relative (p.u.) Permittivity
Air	1E+18	Infinite	1	1
Top	3000	0.15	1	1
Central	200	1	1	1
Bottom	30	Infinite	1	1

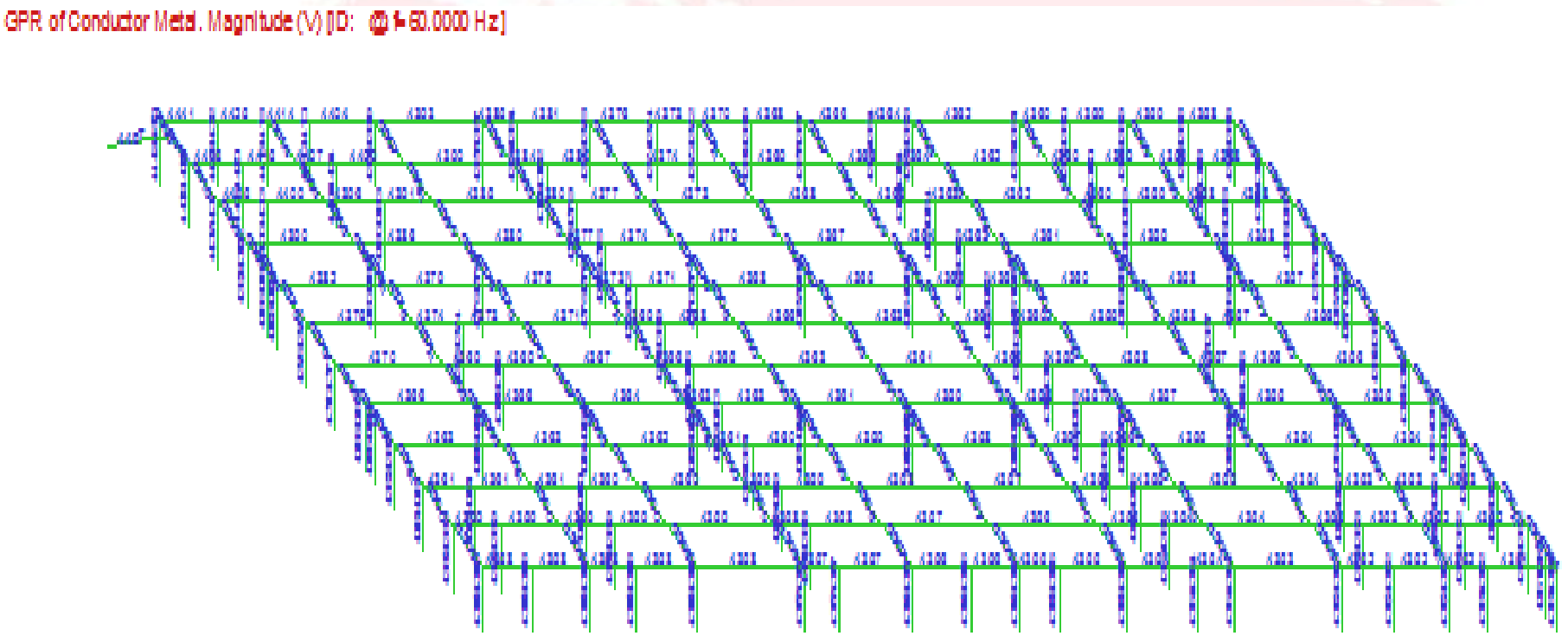
Properties ... | Import... | OK | Cancel

Multi layer soil resistivity – vertical

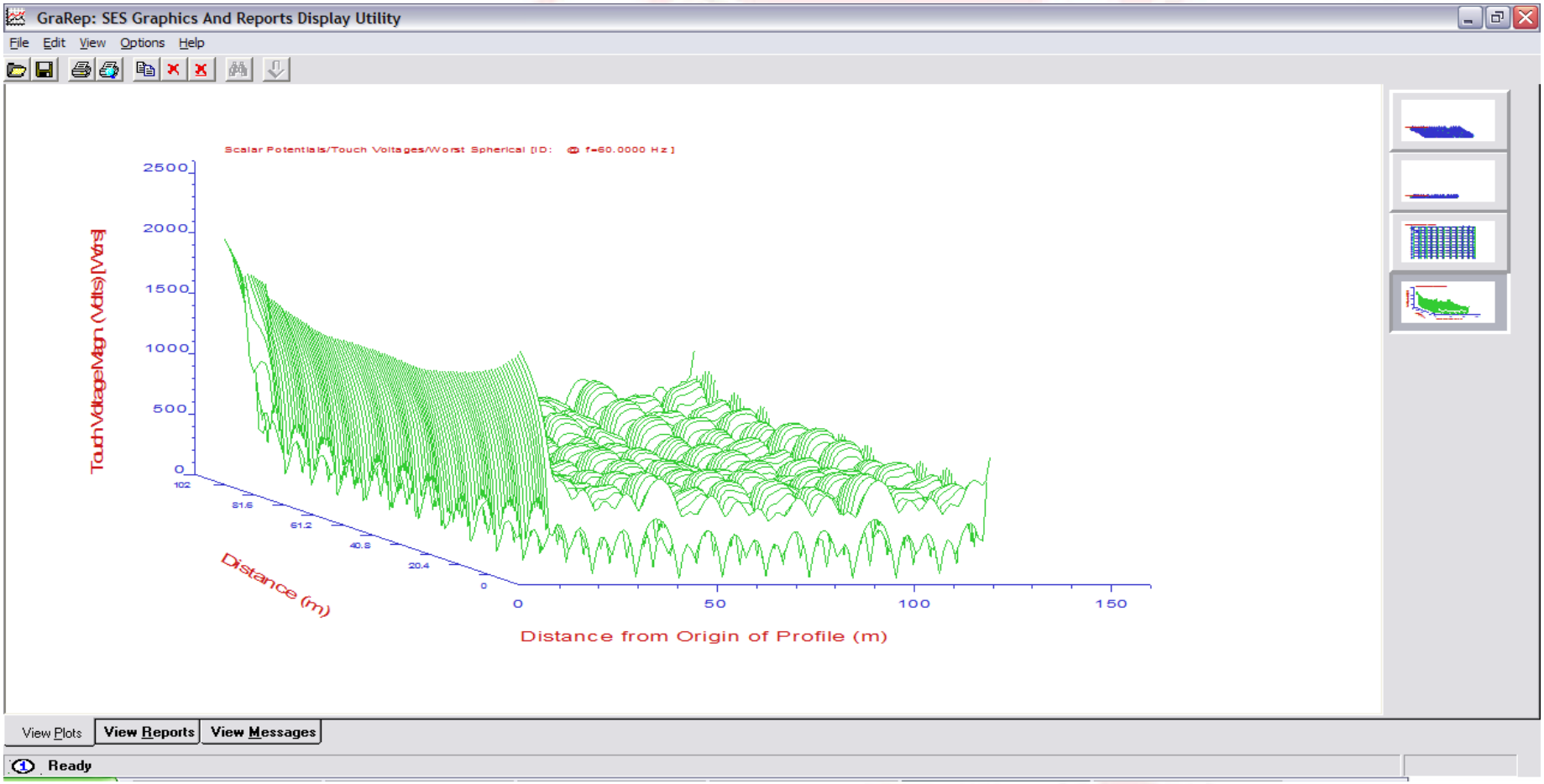


Touch voltage in the Grid & unsafe specific points

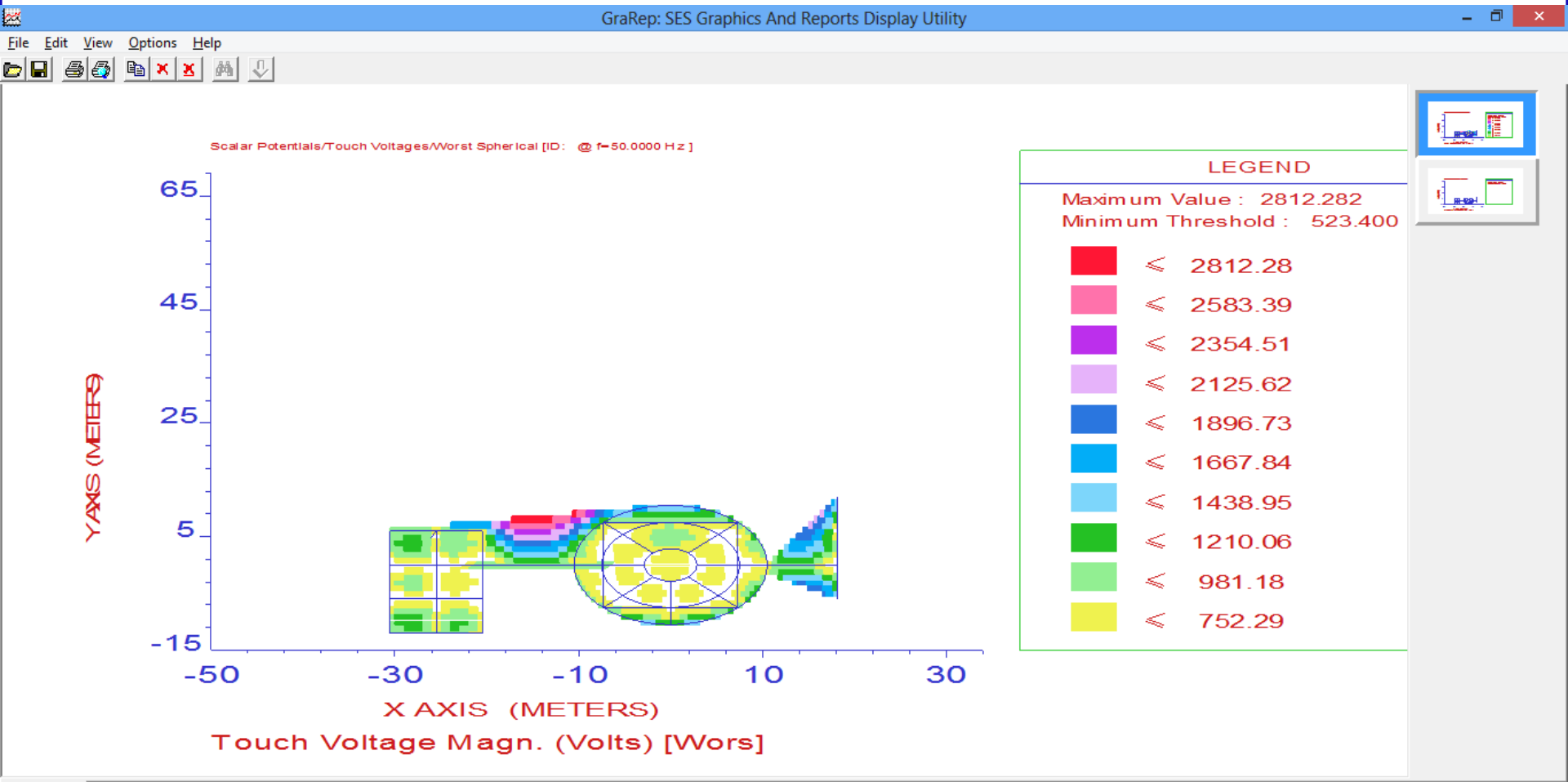
Grid parameters



3D Graph of GPR



TOUCH POTENTIAL



Dispelling myths & ensuring a reliable LV grounding system

MYTH-1 : INIDIVIDUAL EARTH RESISTANCE HAS TO BE LESS THAN 1 Ω FOR ALL APPLICATIONS

TRUTH: The resistance of individual earth pits largely depends on the soil resistivity. Earth resistance of grid shall be ensured to be below 1 Ω.

It is prudent to alter the relay settings based on the practically obtainable earth resistance value to ensure proper coordination as per IS3043.

MYTH-2 LOW RESISTANCE CAN BE OBTAINED BY USING A SPECIAL ELECTRODE

TRUTH: The resistance can be lowered only by altering the medium adjacent to the electrode. The IEEE80, IS3043 and BS7430 have all mentioned as under:

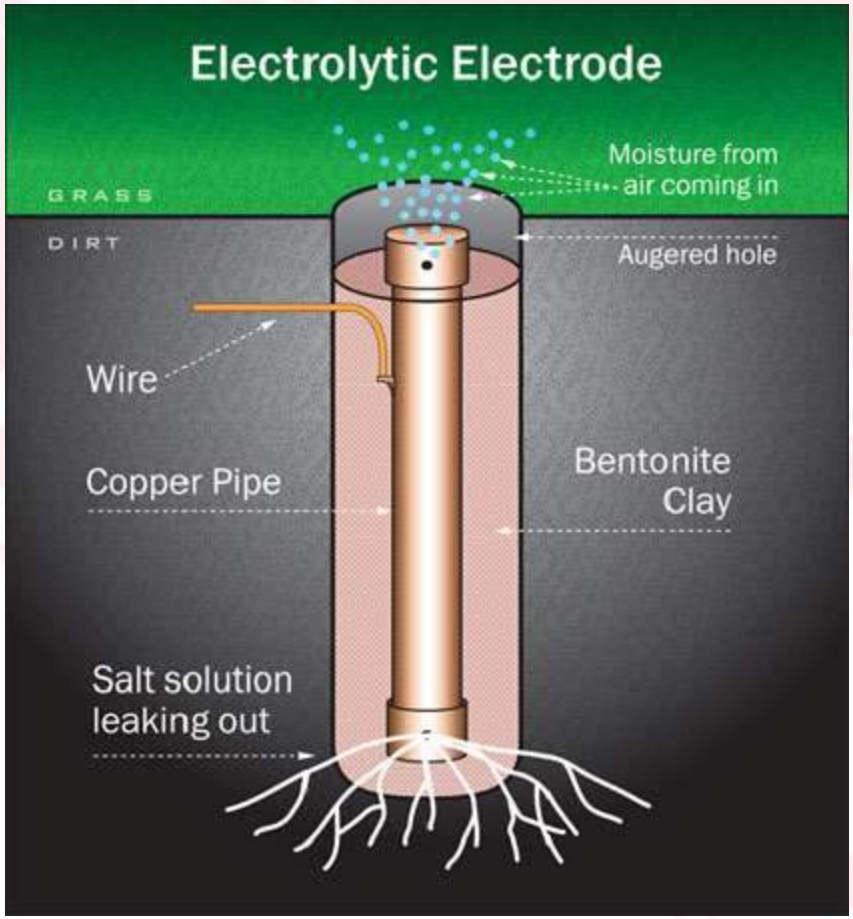
- "To obtain overall low resistance, current density should be as low as possible for the ***MEDIUM ADJACENT TO THE ELECTRODE*** which should be so designed to cause the density to decrease rapidly with distance from the electrode." - The IEEE80 has also mentioned that the soil around the electrode should be modified to obtain a low earth resistance.
- **Thus the most important factor for obtaining low resistance value is SOIL TREATMENT i.e. the material around the electrode -- which is the backfill material and not the electrode itself.**

MYTH-3: SEALED GI PIPE ELECTRODES WITH CHEMICALS INSIDE ARE CALLED CHEMICAL ELECTRODES / CHEMICAL EARTHING

TRUTH: The use of chemicals is not recommended for use in earthing either in IS3043 nor in BS7430. The IEEE80 vide Clause 14.5-C gives a clear definition of the chemical type electrodes. "Chemical type electrodes consist of a copper tube filled with a salt. The holes in the tube allow moisture to enter and dissolve the salts and allow the salt solution to leech into the ground."

It is clearly seen that the design of chemical type electrodes as per IEEE80 does not in any way match the sealed GI pipe electrodes (commonly termed as chemical earthing in India).

CHEMICAL EARTHING AS PER IEEE 80 - CONDUCTION



MYTH-4 : THE EARTH PIT DIMENSION

SHOULD BE ATLEAST 1 MTR X 1 MTR AND THE ENTIRE PIT SHOULD BE BACKFILLED WITH FRESH SOIL

TRUTH: Around a grounding electrode, the resistance of the soil is the sum of the series resistances of virtual shells of earth, located progressively outward from the rod.

If the soil is assumed to be of uniform resistivity, then the resistance of a shell varies inversely as its' cross-section. The shell nearest the rod has the smallest circumferential area so, it has the highest résistance.

This area can be called as critical area.

MYTH-5 PLATE ELECTRODE GIVES LOW RESISTANCE THAN PIPE OR ROD ELECTRODES

TRUTH: The pipe or rod electrodes have a lower resistance than the plate electrodes. This is proven by the formulae of resistance calculation given in IS3043 and BS7430.

MYTH-5 : PLATE ELECTRODE GIVES LOW RESISTANCE THAN PIPE OR ROD ELECTRODES

To examine this, let us consider a Copper plate electrode of size 1.2m x 1.2m x 3.15mm thick. Assuming a soil resistivity of 100 Ω Mtr , the resistance of this electrode to earth will be:

$$R = \frac{\rho}{4}\sqrt{\frac{\pi}{A}} \text{ Ohms} = \frac{100}{4} \times \sqrt{\frac{3.14}{2.88}}$$

$$= 36.27\ \Omega$$

MYTH-5 : PLATE ELECTRODE GIVES LOW RESISTANCE THAN PIPE OR ROD ELECTRODES

Now, consider a Rod Electrode of 17.2 mm Diameter and 3 m Long. Assuming a soil resistivity of 100 Ω Mtr, the resistance of this electrode to earth will be:

$$R = \frac{100\,\rho}{2\,l}\log_e\frac{4l}{d}\ \Omega$$

$$= \frac{100 \times 100}{2 \times 3.14 \times 300} \times \log_e \frac{4 \times 300}{1.72}$$

$$= 34.50\ \Omega.$$

MYTH-6: THE INSTRUMENTATION / ELECTRONIC EARTH IN A FACILITY SHALL BE MAINTAINED SEPARATE FROM THE ELECTRICAL EARTH:

TRUTH: The concept of a separate or clean earth for anelectronic equipment / instrumentation is a fallacy. The IEEE 142 while dealing with the subject of sensitive electronic equipment grounding has clearly advocated the need for a equi-potential grounding system.

If the electrical and electronic equipment earthings are maintained separately, dangerous over voltages maybe induced in the system during lightning / severe fault conditions, thereby causing a catastrophic failure. This aspect has been highlighted in IEEE 142.

MYTH-7: NEUTRAL OF THE SOURCE TRANSFORMER AND LIGHTNING PROTECTION EARTH MUST NOT BE CONNECTED TO THE GENERAL EARTH GRID.

TRUTH: All earth terminations including that of the source transformer neutral and Lightning Protection system shall be connected to the common earth grid. The IS3043 vide Clause 22.1.3 and 22.3.1 has clearly recommended the adoption of Protective Multiple Earthing System (PME system) for all installations with a dedicated source transformer.

MYTH-8: CAN THE NEUTRAL TO EARTH VOLTAGE BE CONTROLLED BY EARTHING ONLY?

TRUTH: A good earthing is only one of the parameters which affect the Neutral to earth voltage. Where problems exist despite having a good earth, other measures like over sizing the neutral, restricting length of neutral, Harmonic filters etc shall be adopted.

MYTH 9: RESISTANCE OF EARTH ELECTRODE WITH OR WITHOUT HIGHLY CONDUCTIVE BACKFILL WILL REMAIN SAME

TRUTH: Electrode Dia 25mm, P=100 Ω Mtr,
L=3mtr with traditional salt / charcoal backfill.

R = 31.1 Ω Mtr as per IS 3043 and BS 7430

Same electrode and location but with carbon backfill of Pc0.01 Ω Mtr for 150mmdia around the electrode

R = 21.6 Ω Mtr as per BS 7430 Cl 8.5
Hence there is an improvement of over 31% in value of resistance by using a Carbon based backfill.

CONCLUSION

- The design of an earthing and bonding system for any installation requires great care. If some of the basic concepts covered above are understood and implemented correctly, it will reduce the overall cost of the installation, **avoid PQ issues** ,minimize outages and significantly reduce the burden of maintenance. It will also help in overcoming various common challenges like space limitations, manpower shortage etc, besides greatly improving the safety & reliability of the electrical installations.
- **References: IS3043, BS7430, IEEE80 & IEEE142.**

Thank You

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