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PROPOSED EARTHING SYSTEMS FOR INDIA

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ABSTRACT

Earthing have safety as the primary motive. It is an integral part of any electric distribution system. This report reveals why the prevailing earthing system in Indian distribution sector is defective. Various problems of the existing system and their corrective measures have been discussed. A detailed qualitative and quantitative approach has been taken to point out all significant factors. A new model of earthing has been proposed which will be very effective. A large number of precious lives could be saved in India if we adopt an earthing system that is testable, observable and controllable. So, the earth network proposed in this report is amenable to simple and safe means and is best suited for the overhead distribution system prevailing in India.

KEYWORDS: *earthing system, Terra, neutral, electrical load, safety, risks, cost*

1. INTRODUCTION

Earthing system has 'safety' as its prime motive. It is an indispensible component of distribution sector. But in India, we have faulty systems which have caused many accidents and will carry on in future, if new techniques are not adopted.**The process of connecting metallic bodies of all the electrical apparatus and equipment to huge mass of earth by a wire having negligible resistance is called system-earthing.** Not only it provides shock protection, but also carries current under normal conditions. Earthing provides a low impedance path to fault currents. So, an accidental contact with live conductive surface does not cause an electric shock.

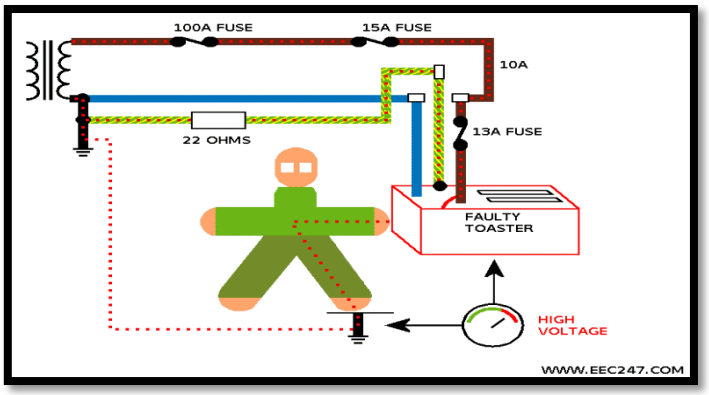

Fig. 1 : Earthing example

The conductor that connects the exposed metallic parts of the consumer's electrical installation is called *protective earth* (**PE**). A protective earth avoids electric shocks by keeping the exposed conductive surfaces at earth potential. (In USA, it is called **grounding)** The process of connecting a PE to the non- current carrying metal parts of the device is called equipment-earthing. In normal condition, no current allowed to flow in PE conductor. During a fault, high short circuit current will trip the circuit breaker or blow the fuse. In case of high impedance line-to-ground fault, a residual-current device (RCD) may operate. The conductor connected to the star point in a three-phase system, or that carries the return current in a single-phase system, is called *neutral* (**N**). A functional earth or Neutral conductor in distribution systems serves a purpose other than shock protection and may normally carry current. Neutral is normally used as return conductor for the current.

2. CLASSIFICATION OF EARTHING ARRANGEMENTS

According to IEC60364, earthing systems can be distinguished into three main arrangements- TN, TT and IT. For describing the different earthing arrangements, the following notations are used:-**T:** Terra, direct connection of a point with earth **I:** Isolated, or no point is connected with earth, **N**: Direct connection to neutral . The first letter indicates the connection between earth and the power supply equipment (normally a generator or transformer), the second letter indicates the connection between earth and the electrical load being supplied (consumer premises).The TN networks are further classified as- TN-S, TN-C, TN-CS on the basis of the neutral (N) and protective earth (PE) connections.

3. COMPARISON OF EARTHING CONNECTION SYSTEMS

We have classified earthing systems on the basis of their connection scheme. Now, in this section, we shall see the comparison of all systems in accordance with different characteristics like safety, risks, cost etc. From the following table, we can draw a few conclusions:

- Firstly, from safety point of view, the TN-S system is seen to be the safest. And we also see that, it is the most expensive system due to the addition of separate PE conductor.
- On the other hand, the least expensive earthing system is the TN-C. As the name suggests, it has a combined PE and N conductor (PEN) that fulfils the functions of both PE and N conductor. Inspite of the cost benefit, TN-C is rarely used, as the neutral potential rises to a hazardous level during faults or owing to flow of return currents.

Sr. no.	Parameter	TT	IT	TN-S	TN-C	TN-C-S	MEN/PME
1.	**Earth fault loop impedance**	High	Highest	Low	Low	Low	Low
2.	**Is RCD preferred?**	Yes	No	Yes	No	No	After N and PE separates
3.	**Need of Earth Electrode**	Yes	Yes	No	No	No	No
4.	**PE conductor cost**	Low	Low	Highest	Least	High	Least cost. Earth conductor size is 2-6mm^2
5.	**Risk of broken neutral**	No	No	No	Highest	High	No
6.	**Electromagnetic Interference**	Least	Least	Low	High	Low	Low
6.	**Safety**	Safe	Less safe	Safest	Least safe	Safe	Needs periodic checking
7.	**Safety risks**	High loop impedance	Double fault overvoltage	Broken PE	Broken neutral	Broken neutral	Polarity may reverse
9.	**Advantages**	Safe & reliable	Continuity of operation cost	Safest	Cost is low	Safety & cost	Inexpensive if well-maintained

Table 1: Comparison of earthing connection systems

4. CURRENT SCENARIO

According to Indian Distribution Standards, TT system is widely being used with overhead wiring. So, basically, the "so-called" TT system is actually working as TN-C system which is least safe .The reason for majority fatal accidents is that India has the potentially most dangerous earthing system. Another problem with the existing system is that, we cannot check the functionality of earthing system effectively .The PE connections must be given prime importance in order to minimise faults and accidents.

5.SAFETY ISSUES WITH TN-C SYSTEM

TN-C system is banned worldwide since it is the least safe earthing system .In TN-C system, protective earth (PE) and neutral (N) are one and the same. In case of occurrence of some fault, the fault current passes through PEN. This may result in accidents because of faulty earthing systems. In case of an unbalanced three phase system, fault current would move towards the most loaded live conductor. In case of 2 wire/ plug/ socket system, if 'L' and 'N' exchanged, TN-C earthing system results into injection of fault currents into PE.

6. STATISTICS

Data of 10 years was collected, compiled and segregated based on location and its reasons. A study of this data helps to find measures for improvement, reliability and safety.

(I)Various locations of accidents: This data is about the no. of accidents that occurred at various location. Especially, the transmission and distribution lines (below and above 11KV) had major accidents. All these accidents can be prevented with suitable arrangements in the distribution network, i.e. mainly protection devices and earthing.

Sl. No.	LOCATION	NO. OF ACCIDENTS									
		1999 - 2000	2000 - 2001	2001 - 2002	2002 - 2003	2003 - 2004	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	Total
1	Generating Station	0	3	0	0	2	0	5	1	2	13
2	T & D lines - 11KV & above	129	151	139	69	142	111	144	143	163	1191
3	T & D lines - below 11KV	97	103	213	88	158	189	269	261	222	1600
4	Industrial Installations - Govt./semi Govt.	13	16	8	43	0	1	18	1	17	117
5	Industrial Installations – Private	7	5	9	105	21	1	2	9	16	175
6	Other Installations - Govt./ Semi Govt.	17	27	6	1	7	4	0	2	1	65
7	Other Installations –Private	54	37	58	39	68	43	0	0	25	324
	TOTAL	317	342	433	345	398	349	438	417	446	3485

Table 2: Various locations of accidents

Major causes of accidents:-

From the statistical data analysis, the major causes of accidents can be covered under the following main categories-

Non Standard Erection- 35%

Poor Maintenance- 20%

Human Error- 45%

- Installation itself being defective or not done at all at distribution premises.
- If at all in consumer premises is installed, it is never maintained properly.
- And no actions are being taken in this regard. So, an effective maintenance free safe system needs to be installed.

Where the whole world is trying to bring in PE connections universally, India and a few more Asian countries are still struggling with TN-C systems. So, a new model for safe earthing practice which can be observed, tested and controlled is much needed.

9. NEED FOR PROTECTIVE EARTH (PE) INSTALLATION

Improper earthing leads to various hazards like electrocution, voltage instability, bonding etc. 'PE' is required to safeguard devices and human beings from electrocution due to fault. It provides a low-impedance path-to-ground. It provides system stability and reliability.

10. MISCONCEPTIONS RELATED TO PE INSTALLATION

(i) MEN system limits and beyond:-

- **Myth-** It is generally considered that if the earth fault loop impedance is high, preference must be given to TN/ TT/ IT system. But in terms of safety accounted, protective earthing if given multiple earths, faults are corrected effectively.
- **Justification-** Effective methods which are cost- friendly can be applied so that PE-MEN earthing system has a low earth loop impedance, that can activate the automatic circuit protection device to rectify the earth fault.

(ii) Protective Earthing Design with Earth Leakage Protection Relay:-

- **Myth-** Improper MEN cannot operate under leakage or fault condition and hence must be replaced by TN/ IT.
- **Justification-** But if PE-MEN prove to be safer as well as efficient if RCD's and ELCB's are used along with them.

(iii) Risk of insulation breakdown of telecommunications:-

- **Myth-** PLCC is working wonders today. The TT/ IT system is said to be the best working system as far as cost is concerned.
- **Justification-** But ground potential rise due to power system ground fault may cause telecommunications insulation breakdown. Protective earthing provides a barrier to telecommunication system by isolating fault necessary for its safety and integrity.

(iv) Protective Earthing Design for Ground Fault damage control:-

- **Myth-** It is also observed that PE shall eliminate any potential hazardous ground voltage rise during ground fault and control the ground fault damages to humans and devices.
- **Justification**- If not given timely check against degradation, damage control cannot be materialized. It must be done effective over time. Periodic testing is must.

11. STREET-LIGHTING PROBLEMS

- Sometimes, even during the daytime, we see street-lights flashing/ flickering every 10 to 20 seconds. This is because of completion of earth loops.

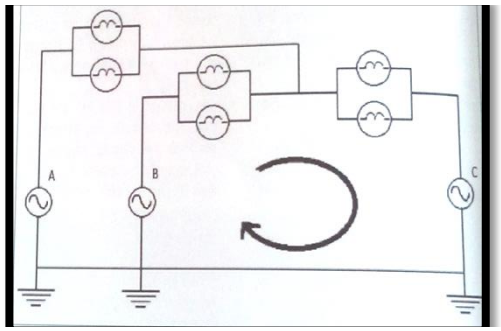

Fig. 4: Street-Lighting problems

As shown in the figure, earth loops are formed. The path from B to C is completed, which results into current in that loop causing unwanted constant flickering of lamps. Continuous flow of street-light current deteriorates the earth and increases the earth resistance alarmingly. In conjunction with distribution system if SL feeds are connected, they might cause current injection into local earths. Of course, it is an expensive scheme. But, provisions can be made to prove that it is effective.

12. PROPOSED MODEL - ARRANGEMENTS AND PROVISIONS

So, from all the factors that we have discussed by now, we shall consider the following points while designing an all new advanced earthing system:

- Proper earthing meachanism
- Inclusion of seperate Protective Earth (PE)
- Earth electrodes- Design and Maintenance
- PE with Earth Leakage Circuit Breaker (ELCB's)
- Lightening arrestors and protection relays
- Effective testing techniques
- New street-lighting mechanism

13. PROPOSED EARTHING SYSTEM FOR INDIA

We have included some provisions for a new model of earthing system keeping in mind the following objectives:

- Provide a low impedance earth fault return path to clear the earth fault and to achieve protection.
- Limit the touch and step voltages on the accessible equipment and surfaces both during normal operation and during transients to safe levels.
- Minimize electrical noise interference in control and instrumentation systems.
- Minimize the effect of lightning strikes on personnel, equipment and structures.
- To ensure protection and smooth functioning of PLCC.
- To overcome the problems related to street-lighting systems.
- Replace the potentially most dangerous earthing system (The Virtual TN-C).

I. MULTIPLE EARTH:-

First requirement is a multiple earthed system. Multiple earth provides measurement scheme between two poles easily. This helps in finding fault and correcting it effectively and efficiently. This is similar to the PEM/ MEN system which is used in UK or Australia. But here, we are actually having a small drawback. If there is a problem of faulty pole insulator, the resulting leakage current would mix with the neutral current, thereby making it impossible to trace and eliminate such a fault. The neutral currents would also find a parallel path through the earth at each pole. These currents will deteriorate the earthing system .These can be overcome using multiple earth scheme, though it has a set back of frequent check and control.

II. SEPERATE PE WIRE:-

Multiple earth is very important but it comes with a drawback as seen in previous section. This can be overcome by using a separate PE wire .We have already studied the significance and advantages of a separate protective earth (PE).Best suited for the dangerous overhead distribution

systems. Each of the poles can be connected with separate PE wire and not neutral. This system therefore now requires a very little maintenance .The separate PE wire can be extended to consumer premises. Now the system is a complete loop network with multiple solid earthing system, with an effective resistance which is very low. Such a network is called TN-S-ME, where- ME- Multiple Earthed , S- Separate , T- Terra

II. SEPERATING SL FEED FROM THE TN-S-ME:-

Separating SL feed will prevent the injection of currents into the earth network. A separate feeder to be provided in every transformer zone for street-lighting. Neutral path can be same as distribution sector. The issue of current injection into local earth thus gets circumvented .Unwanted lighting/ flickering of lighting can be prevented by using signaling techniques without the interference of earth loop currents.

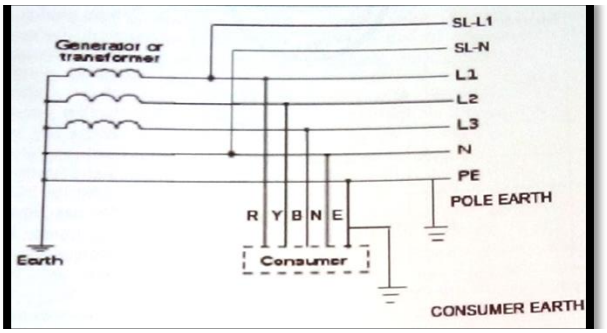

Fig. 2: TN-S-ME with separate SL Feed

15. COST ANALYSIS

Total no. of conductors used in this proposed earthing system is six. A separate (independent) street-light feeder is no doubt an expensive proposition. But it is a one-time investment. There will be no need of frequent maintenance and repairs because of separate PE wire. In a broader sense, an incremented capital is required. And in later stage, the accidents and repair cost are compensated. Talking about underground systems, this proposition is much more cost-effective.

16. CONCLUSION

If implemented, this model will ensure safety more effectively.60% of the accidents can be prevented effectively. Remaining 40% can be accounted for periodic checks. The TN-S-ME earth network coupled with separation of streetlamp feeder that is proposed here overcomes all the disadvantages of current system.

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