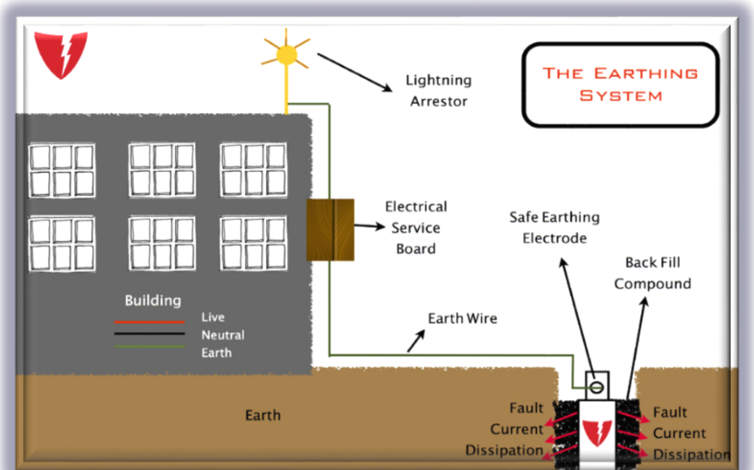
Earthing System

(PART-3)



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COGS GLOBAL

Authored by: Shubham Gupta

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Earthing System

INTRODUCTION

CEAR namely **Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010** are regulations framed by the Central Electricity Authority of India under the Indian Electricity Act, 2003, to regulate measures relating to safety and electric supply in India.

CEAR came into effect on 20 September 2010, in place of The Indian Electricity Rules, 1956.

The Electricity Act, 2003, was formulated combining the Indian Electricity Act 1910 and the Indian Electricity (Supply) Act 1948.

Central Electricity Authority

Formation: 1951

Headquarter: New Delhi, India

Owner: Government of India

Purpose: Construction of electrical plants, electrical lines and connectivity to the rid, installation and operation of meters, grid standards and safety

Under CEAR, rule 41, there is a specific provision of earthing neutral wire of a 3-phase, 4-wire system and the additional third wire of a 2- phase, 3-wire system. Earthing is to be done with two separate connections. The grounding system also to have a minimum of two or more earth pits (electrode) such that proper grounding takes place. As per rule 42, installation with load above 5 kW exceeding 250 V shall have suitable Earth leakage protective device to isolate the load in case of earth fault or leakage.

Neutral and earth run separately on overhead lines/cables. Separate conductor for overhead lines and armoring of cables are used for earth connection. Additional earth electrodes/pits are installed at user ends for proper earth.

All-metal casing or metallic coverings of electric supply line or apparatus to be connected with the earth and all such earthling points shall be so joined to make a good mechanical and electrical connection incomplete system.

Under the Electricity Act 2003, CEA prescribes the standards on matters such as the construction of electrical plants, electric lines, and connectivity to the grid, installation, and operation of meters and safety and grid standards. The CEA is also responsible for the concurrence of hydropower development schemes of central, state and private sectors taking into consideration the factors which will result in the efficient development of the river and its tributaries for power generation, consistent with the requirement of drinking water, irrigation, navigation, and flood control.

Contents

Part 01

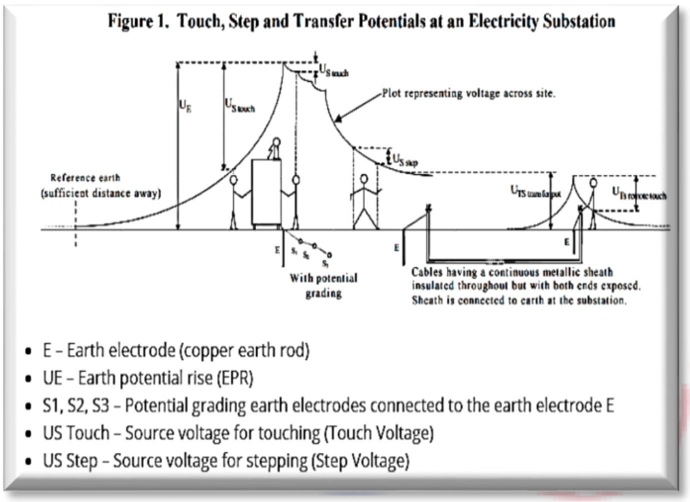
Part 02

Part 03

Part 04

HIGH-VOLTAGE SYSTEMS

In high-voltage networks (above 850 volts), which are far less accessible to the general public, the focus of earthing system design is less on safety and more on the reliability of supply, reliability of protection, and impact on the equipment in presence of a short circuit. Only the magnitude of phase-to-ground short circuits, which are the most common, is significantly affected by the choice of earthing system, as the current path is mostly closed through the earth. Three-phase HV/MV power transformers, located in distribution substations, are the most common source of supply for distribution networks, and the type of grounding of their neutral determines the earthing system.



There are five types of neutral earthing:

- **Solid-earthed neutral**
- **Unearthed neutral**
- **Resistance-earthed neutral**
  - **Low-resistance earthing**
  - **High-resistance earthing**
- **Reactance-earthed neutral**
- **Using earthing transformers (such as the Zigzag transformer)**

Solid-earthed neutral

In *solid* or *directly* earthed neutral, the transformer's star point is directly connected to the ground. In this solution, a low-impedance path is provided for the ground fault current to close and, as a result, their magnitudes are comparable with three-phase fault currents. Since the neutral remains at the potential close to the ground, voltages in unaffected phases remain at levels similar to the pre-fault ones; for that reason, this system is regularly used in high-voltage transmission networks, where insulation costs are high.

Resistance-earthed neutral

To limit short circuit earth fault an additional neutral earthing resistor (NER) is added between the neutral of the transformer's star point and earth.

Low-resistance earthing

With a low resistance fault, the current limit is relatively high. In India, it is restricted for 50 A for open cast mines according to Central Electricity Authority Regulations, CEAR, 2010, rule 100.

High-resistance earthing

High resistance grounding system grounds the neutral through a resistance which limits the ground-fault current to a value equal to or slightly greater than the capacitive charging current of that system

Unearthed neutral

In *unearthed*, *isolated*, or *floating neutral* systems, as in the IT system, there is no direct connection of the star point (or any other point in the network) and the ground. As a result, ground fault currents have no path to be closed and thus have negligible magnitudes. However, in practice, the fault current will not be equal to zero: conductors in the circuit — particularly underground cables — have an inherent capacitance towards the earth, which provides a path of relatively high impedance.

Systems with isolated neutral may continue operation and provide uninterrupted supply even in the presence of a ground fault. However, while the fault is present, the potential of the other two phases relative to the ground reaches of the normal operating voltage, creating additional stress for the insulation; insulation failures may inflict additional ground faults in the system, now with much higher currents.

The presence of uninterrupted ground fault may pose a significant safety risk: if the current exceeds 4 A – 5 A an electric arc develops, which may be sustained even after the fault is cleared. For that reason, they are chiefly limited to underground and submarine networks, and industrial applications, where the reliability need is high and the probability of human contact relatively low. In urban distribution networks with multiple underground feeders, the capacitive current may reach several tens of amperes, posing a significant risk for the equipment.

The benefit of low fault current and continued system operation thereafter is offset by the inherent drawback that the fault location is hard to detect.

Terminology:-

Substations- A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions. Between the generating station and consumer, electric power may flow through several substations at different voltage levels. A substation may include a transformer to change voltage levels between high transmission voltages and lower distribution voltages, or at the interconnection of two different transmission voltages.

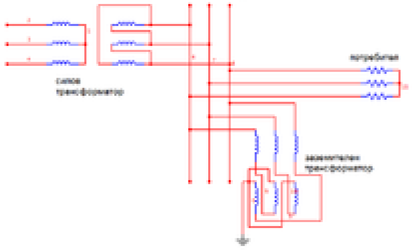
Transmission substations connect two or more transmission lines. The simplest case is where all transmission lines have the same voltage. In such cases, substation contains high-voltage switches that allow lines to be connected or isolated for fault clearance or maintenance. A transmission station may have transformers to convert between two transmission voltages, voltage control/power factor correction devices such as capacitors, reactors, or static VAR compensators and equipment such as phase-shifting transformers to control power flow between two adjacent power systems.
A distribution substation transfers power from the transmission system to the distribution system of an area. It is uneconomical to directly connect electricity consumers to the main transmission network, unless they use large amounts of power, so the distribution station reduces the voltage to a level suitable for local distribution.

Distribution substations in distributed generation projects such as a wind farm or Photovoltaic power station, a collector substation may be required. It resembles a distribution substation although power flow is in the opposite direction, from many wind turbines or inverters up into the transmission grid.

Converter substations may be associated with HVDC converter plants, traction current, or interconnected non-synchronous networks. These stations contain power electronic devices to change the frequency of the current, or else convert from alternating to direct current or the reverse. Formerly rotary converters changed frequency to interconnect two systems; nowadays such substations are rare.

Earthing Transformer - A grounding transformer or earthing transformer is a type of auxiliary transformer used in three-phase electric power systems to provide a ground path to either an ungrounded wye or a delta-connected system. Grounding transformers are part of an earthing system of the network. They let three-phase (delta connected) systems accommodate phase-to-neutral loads by providing a return path for current to a neutral.

Earthing transformer with a zig-zag



Grounding transformers are typically used to:

- Provide a relatively low-impedance path to ground, thereby maintaining the system neutral at or near ground potential.
- Limit the magnitude of transient overvoltages when restriking ground faults occur.
- Provide a source of ground-fault current during line-to-ground faults.
- Permit the connection of phase-to-neutral loads when desired.