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Unified Grounding Systems for Future Projects to Ensure Public Safety and Improve Performance

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Abstract:- This study provides a comprehensive analysis of earthing systems as defined by international standards. It involves the calculation of fault currents and contact voltages, the selection of suitable electrical protection for each system type, and an evaluation of the currently implemented systems. The research highlights the distinctions in system performance, focusing on supply continuity and the corresponding protection mechanisms. It also addresses methods for defining neutral points in both high and low voltage networks. Furthermore, the study examines the effectiveness of protective devices during ground faults, including the implications of unearthed neutral systems. Both existing and proposed methods of protection are discussed, with particular emphasis on the utilization of derivatives of transient waves for safeguarding against atmospheric disturbances. The role of earthing in ensuring public safety during work on electrical equipment is explored, addressing the prevention of direct and indirect contact, protection against overcurrent and overvoltage, mitigation of electric shock risks, and safeguarding of both personnel and equipment from electrical discharges. This research incorporates international standards and measurements, applying them to grounding systems used globally. The findings lead to scientific, economic, and safety-related conclusions, culminating in recommendations for the optimal use of grounding devices across various settings.

Keywords:- *Electrical Safety, Earthing System, Grounding, Protection, Neutral Point.*

I. INTRODUCTION

The topic of earthing appears at first sight to be one of the simple topics in the field of distribution and use of electrical power, but in fact it is one of the most complex topics on which research and experiments are still being conducted in order to reach the best solutions that ensure public safety during the normal use of electrical equipment [1-2]. Electrical grounding systems are a fundamental component of power distribution networks, serving to provide a low-impedance path for the flow of fault currents, ensure the proper functioning of protective devices, and safeguard personnel and equipment from the hazards of electrical faults and transient overvoltages [3-4]. These systems play a critical role in maintaining the safety and reliability of infrastructure, and their importance has only increased with the growing complexity and interconnectedness of modern power systems [5]. The choice of grounding system is heavily influenced by factors such as the system voltage, the type of power generation (e.g., isolated, solidly grounded, or impedance grounded), and the specific safety and reliability requirements of the application [6]. Common grounding system configurations include the TN, TT, and IT systems, each with its own unique characteristics and applications [7]. Proper design and implementation of grounding systems requires a thorough understanding of the fault current and touch voltage calculations, as well as the selection of appropriate electrical protection devices [8]. Inadequate grounding can lead to dangerous touch voltages, the risk of electric shock, and the potential for equipment damage during faults. In addition to the technical considerations, the economic and operational implications of grounding system selection must also be taken into account [9-10]. Factors such as installation costs, maintenance requirements, and the impact on power quality and reliability can all influence the choice of grounding system [11]. The basic principle behind grounding is to ensure that any unintended electrical currents, caused by faults such as short circuits or lightning strikes, are safely transferred to the earth. By creating a low-resistance path to the ground, grounding systems help maintain the safety of electrical systems and protect both equipment and personnel from potentially hazardous overvoltages [12]. There are various types of grounding systems, each designed to meet specific needs. The most common types include the solid grounding system, which directly connects the electrical system to the ground without any resistance, and the resistance grounding system, which incorporates resistors to limit the fault current. Solid grounding is often used in low-voltage systems, where it provides an effective means of fault protection and system stability [13]. In contrast, resistance grounding is typically applied in medium- and high-voltage systems, where it reduces the risk of equipment damage and minimizes the potential for arc flash incidents [14]. Grounding systems are vital for the safe and efficient operation of electrical installations by providing a controlled path for electrical currents to reach the earth, grounding systems mitigate the risks associated with electrical faults and enhance system reliability. Understanding the different types of grounding systems and their applications is essential for anyone involved in the design, installation, or maintenance of electrical systems [15]. Experiments also show that permanent electric earth electrodes presented resistivity values greater than for new electrodes. These resistivity values can be up to twenty times greater for a third or fourth grounding line or for an expansion of the ground electrode [16]. The aim of the research is to study the earthing system

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and its applications and methods of defining the neutral point for the proper use of electricity through global measurements and standardisation for all future projects in order to maintain the safety of human resources, devices, equipment and production away from confusion, accidents and disasters that may occur due to the effects of the effects.

II. GROUNDING SYSTEMS

Grounding systems are electrical systems that connect various conductive parts of an electrical installation to the earth or ground. The grounding system is symbolized by two letters:

- *First Letter: Means the Relationship of the Power Distribution System to the Ground as Follows:*

- T: The direct connection of a single point to the ground.
- I: All sections carrying the voltage are isolated from the ground or a single point is connected to the ground by an impedance.
- Second letter: Means the relationship of the metal bodies of the foundations to the ground as follows:
- T: The direct connection of the metal bodies to the ground independent of the ground of the foundation.
- N: The direct connection of the metal objects to the system's grounding point, i.e. “neutral”.
- Subsequent letters: The relationship between the neutral and grounding wires is as follows:
- S: The neutral wire is separate from the grounding wire.
- C: A common wire for both neutral and ground.
- The international standard states that there are three main types of system grounding:

A. TT- Earthed System

The protection is realized in the direct grounding of the system by having the neutral directly connected to the ground. Also, the exposed metal bodies of electrical devices are connected with a special ground rod through the ground block to the neutral ground of the transformer, and in the hope that the loop impedance is low, the ground current is sufficient to melt the fuse and cut off the current. If a phase (neutral) is interrupted between the body of the equipment or machine, the fault current (IF) will pass through the circuit, as shown in Fig. 1.

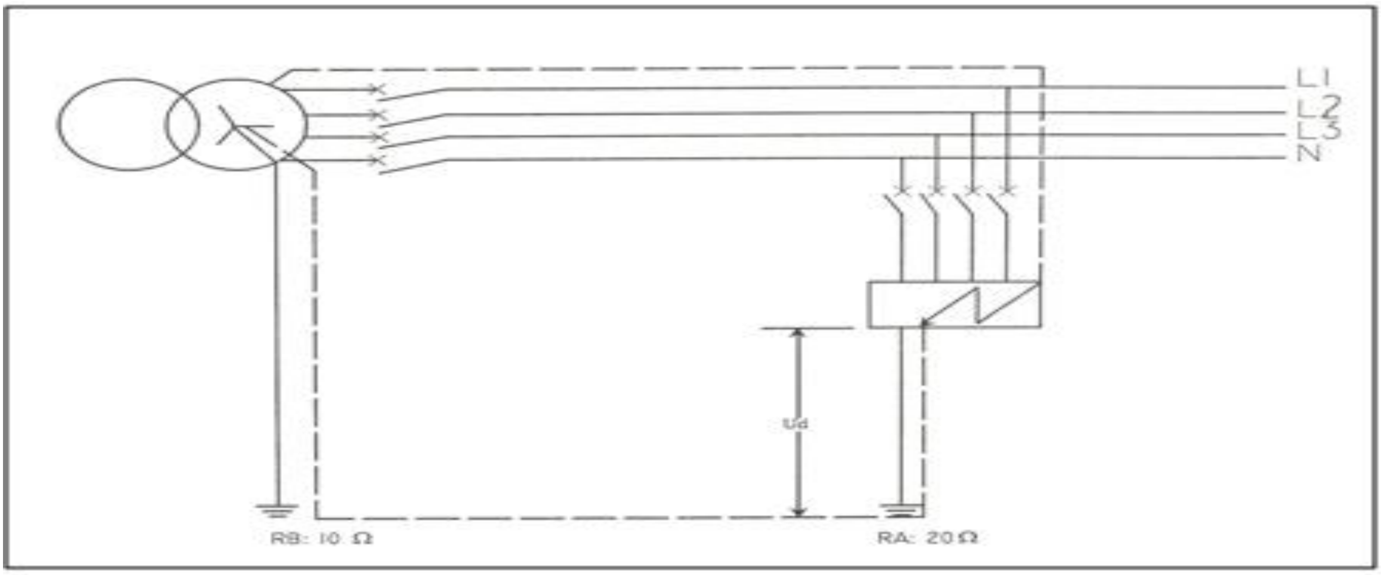

Fig 1: Directly Earthed Neutral (TT) System

- Flawed phase (negligible resistance) R=0
- Same flaw (resistor RF)
- Resistance of the ground connected to the equipment body (Resistance RA)
- The ground connected to the transformer neutral (RB)

If we assume
RA = 20
RB = 10
IF = U0 / RF + RA + RB
IF = 220 / 30 = 7.3 A

The contact voltage generated by the fault is:
UC = IF * Ra
UC = 7.3 * 20 = 142V

These voltages are dangerous to people, and protective devices must disconnect the faulty circuit in less than (200 µS). This current is insufficient to power the protective devices against O/L and S.C.

To ensure protection in this system, it has become necessary to use electrical protection, which includes disconnecting a breaker on such currents, called an (RCD). (Residual current device) it is a breaker that senses small currents (ground leakage) The main circuit breaker in case the current (ground leakage) reaches a certain value, the working principle of the (RCD) consists of (Toriod) placed around all conducting wires, including the neutral wire (but not the ground) will collect the currents passing through it (if the sum of the currents passing through it is zero, then the total current generated by these currents will be zero, so there will be no

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current in the secondary coil (Toriod). Therefore, the (Toriod) senses fault currents, so during a fault, the current is sent to the (RCD), which in turn sends a Tripping signal. The (Toriod) senses fault currents, so during a fault, the current is sent to the (RCD), which in turn sends a disconnect signal to the (Tripping). Sometimes the (RCD) needs a secondary supply and sometimes a self-feeding supply. The sensitivity of the RCD is called the (IΔn), which is the value that if the fault current is exceeded, the (RCD) will send a disconnect signal to the disconnect switch. In fact, we can't actually determine the value of the fault current, we can only determine the threshold for its presence. (RCD) High sensitivity 30 mA and currently operates without time delay, (RCD) Medium sensitivity 30 mA to 3A, (RCD) Wattage sensitivity higher than 3A, the operation of the medium and low (RCD) can be delayed in time. Fig. 2, shows how the compounds distribute the phase and neutral currents and how to connect (Toriod) the phase and neutral currents.

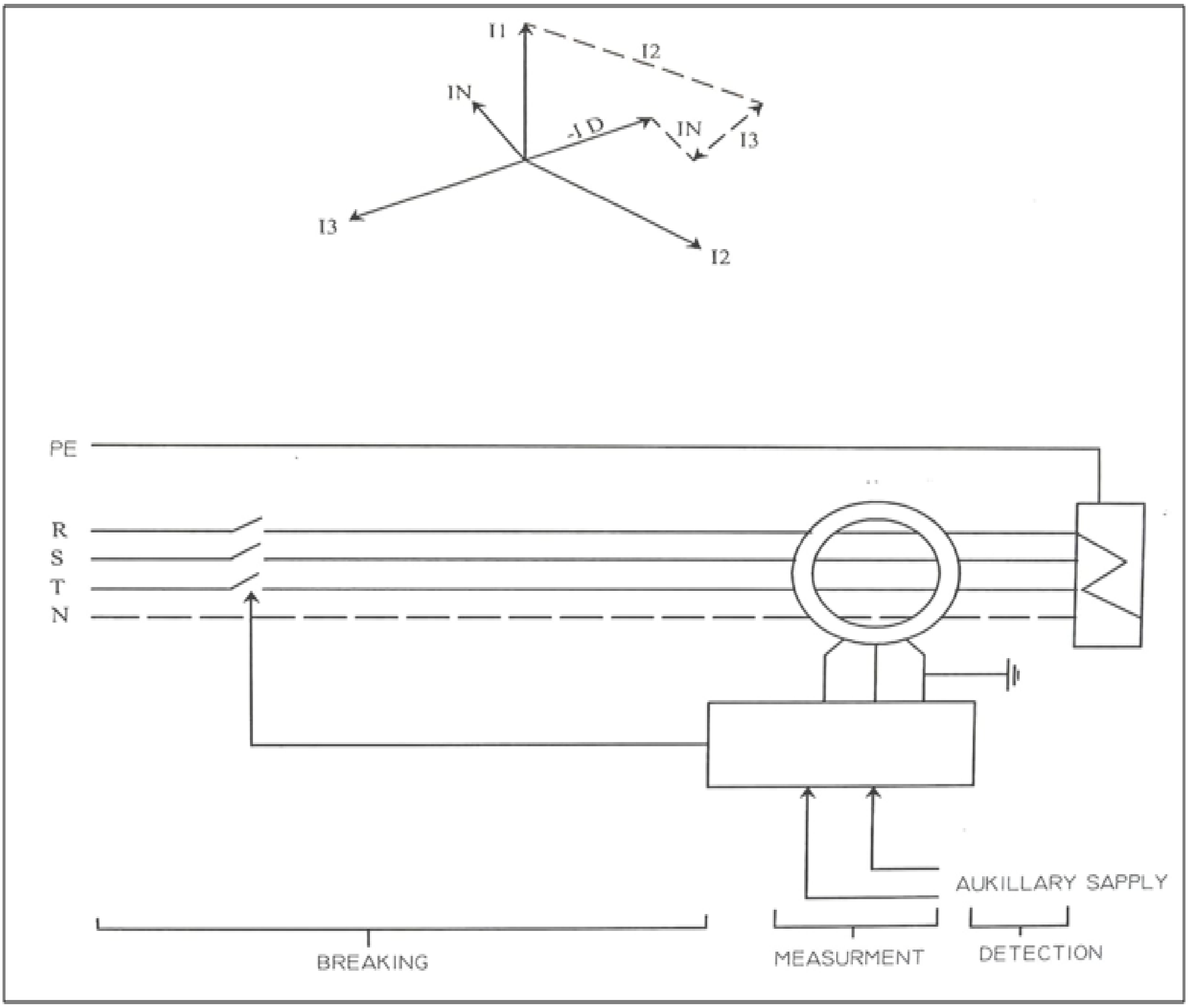

Fig 2: How the Compounds Distribute the Phase and Neutral Currents and How to Connect (Toriod) the Phase and Neutral Currents

B. TN-Earthed System

➢ *This System Can Actually be Divided into Two Systems:*

(TNC, TNS), sometimes called (TNA, TNB) and sometimes (TN-5 Wire, TN-4 Wire).

- The letter (C) is (Common) for common usage.
- The letter (S) is (Separated) for common usage, Sometimes the two systems coexist in the same network, as shows in Fig. 3.

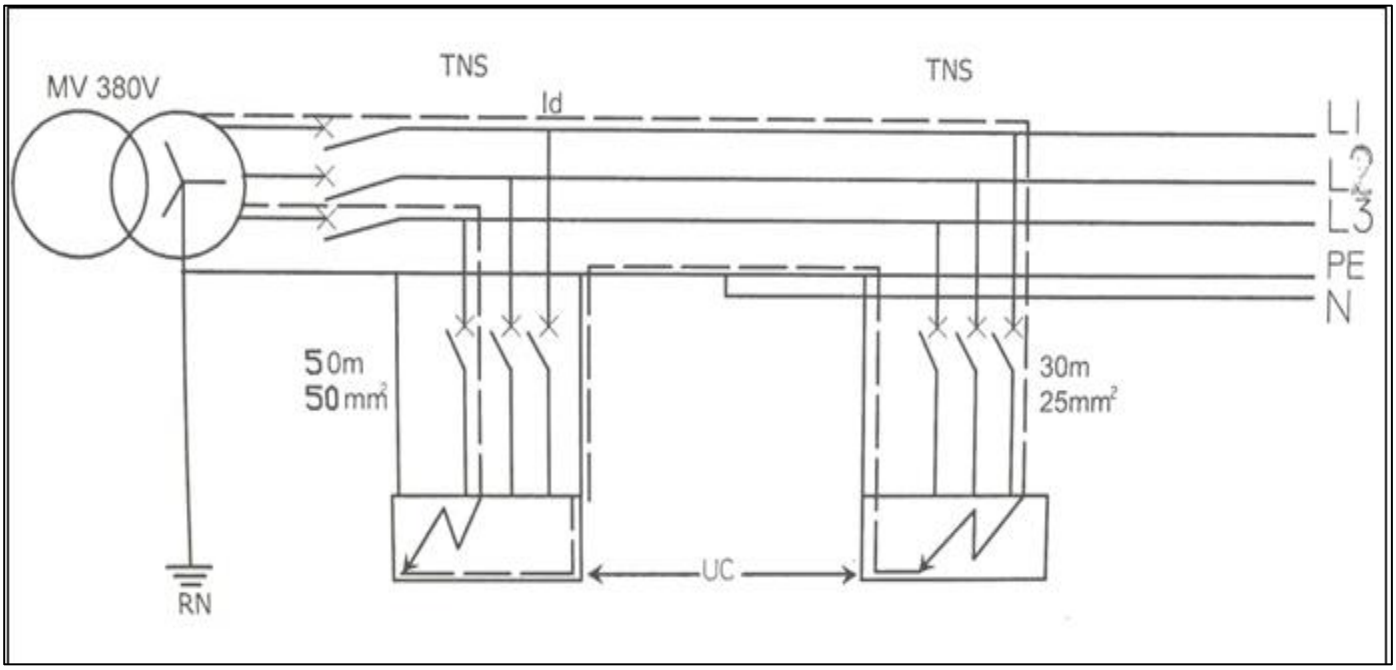

Fig 3: Ungrounded Neutral (TN) System

The benefit of the (TNC) system is that it requires fewer wires and fewer electrodes for the devices, but the rules for using the grounding system are very restrictive and follow the following:

- The TNS system (5-wire system) must be used for cables greater than or equal to the size of (6mm^2) copper or (10mm^2) aluminum.
- The protection wire (PEN or PE) must take the same path as it is for the phases (in fact, it is subordinate to them).
- When using this system, the main protection wire must be grounded at different points of the foundations, i.e. at least at each transformer or generator and at the entrance of each building.
- While working on the TNS system, it is not possible to switch to the TNC system. In the event of a fault in this system between the body and the ground, it is equivalent to a phase and neutral fault (Short Cct), so the protective devices will operate against (O/C), i.e. either the fuse is melted or the circuit breakers are disconnected. It must be ensured that the fault current is high enough to operate the protective devices by measurement or calculation. If we consider that the circuit protected by the circuit breaker is magnetically disconnected and calibrated to (IM) is less than (IF) fault current. If the location is far from the source, the voltage loss (20%) at the moment of the short circuit between the phases and the protection wire (PEN) must be taken into consideration.

- Contact voltage = half of 0.8 * 220/2 = 88V
- IM < 0.8 Vo / Rpen + Rph

(RCD) can be used for circuits (pallet and suitcase), but as is known, the (TNC) system cannot be used because (Toriod) must pass all live conductors through it except for the ground, that is the protection wire, and here in this system cannot be realized, as the neutral wire is the same as the protection wire.

C. IT-Earthed System

In this system, there is no direct connection between the neutral point and the ground, so the entire system (Insulated) only the bodies of the equipment, sockets and current-conducting parts are lent, and since the system (Floating System) is sensitive and exposed to the voltages (Voltage Source) that come from the high pressure side, especially in high Voltage Source cases, and to prevent the occurrence of faulty foundations and insulator collapse, an insulating weak point will be placed between phase and ground, its high resistance will drop to a very small value in the case of flashing voltages on high-pressure roads.

➢ *To Find the Fault Current in this System, the System Cannot Actually be Considered Completely Isolated from Ground Because:*

- Cable insulation resistance = approximately (10MΩ/KM).
- The capacitance to ground of the cable itself is approximately (0.3µF/KM).
- Thus, the impedance between the neutral and the ground is about (3.5KΩ/KM).

IF = Uo / Zet = 220 / 3500 = 62 mA ,

This value is too small to cause a fire.

➢ *If we Visualize a Resistance Between Two Points (A.B) (As Shows In Fig. 4) Equal to (2Ω), then the Voltage of Copper is:*

UC = RA.B * IF
UC = 2 * 0.062 = 0.124V

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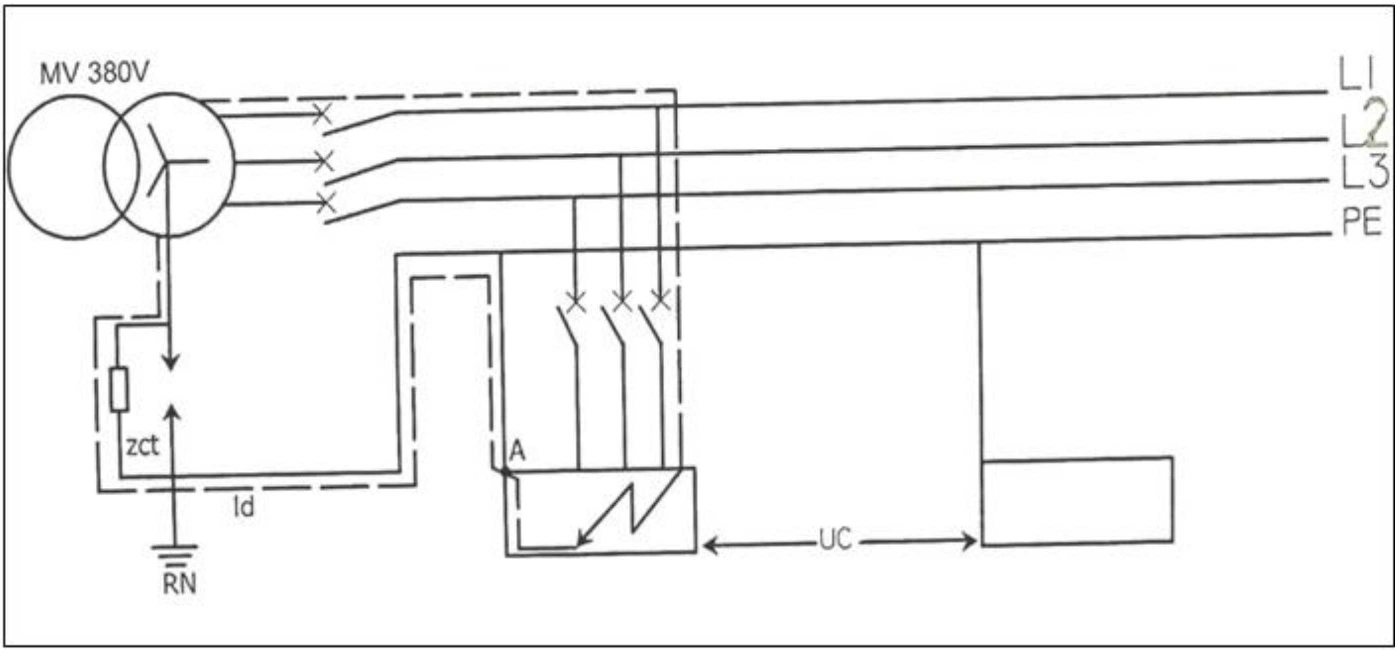

Fig 4: Ungrounded Neutral (TN) System

These voltages are completely harmless, so it is not possible to disconnect the breaker in the event of a first insulator malfunction using this system because the voltage on the body is non-hazardous. The occurrence of two faults is equivalent to a phase-to-phase fault, i.e. a short circuit, which is dangerous for people, goods and equipment. As in the TN system, short-circuit faults can be eliminated by high-current protection devices (O/C) such as fuses or magnetic relays for circuit breakers, the disconnections must be checked by calculations taking into account the area of the phase section, protection wire, magnetic relay calibration, and the specific resistance of copper and aluminum.

In this system, the recommendation not to distribute the neutral must be observed as it may lead to binary faults if it is distributed as follows:

- At one end between the neutral and the body.
- At another end between the body and the phase.

As a result, it leads to a short error between the phase and neutral, so we minimize the size of the plane phases of the cables, which are poor protection for people as in the TN system, which are:

- The clip area must be maximized.
- Minimize the magnetic relay parameters.
- Add additional grounding connections.
- Use (RCD).

We have seen from this system that the first error is not dangerous to people, but it is important in order to alert and send a warning signal about its occurrence and for the purpose of addressing it. The main idea of this system is to maintain the continuity of the feed when the first error occurs, not like the (TN.TT) system, which disconnects the network immediately when an error occurs.

III. GROUNDING THE NEUTRAL POINT

Dealing with the issue of neutral point grounding, it is necessary to take great care of the ground connection itself, that is, the device buried in the ground or another place for the purpose of obtaining a point at or near a ground voltage, and if there is no attention to the grounding system itself, construction and maintenance may be dangerous to human life under conditions of failure.

➢ *The Main Points That Must Be Considered When Constructing Grounding Devices:*

- The total cross-sectional area should be sufficient to carry the maximum fault current and depending on the temperature rise of 450°C and the short circuit current during a period of 30 seconds as shows in Table 1. The relationship between (short circuit current) and section area.

Table 1: The Relationship between Short Circuit Current and Section Area

Short Circuit Current	Size of Standard Copper Tape
Up to 14 KA	1 inch * 1/8 inch (Minimum size for Mechanical strength.
Up to 22 KA	1 inch * 3/10 inch
Up to 30 KA	1(1/2) inch * 3/16 inch
Up to 44 KA	2 inch * 1/4 inch

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- To have a very low resistance in order to maintain a safe low value of the voltage gradient in the ground surrounding the plates under fault conditions, the value of the ground resistance can be found by the following law:

Value of resistance = 0.367P/L, Log10 (42/d)

Where
P = soil resistivity in ohm /cm;
L = Length of electrode . cm;
d = diameter of electrode . cm;

Since most of the resistance of the grounding system is in the immediate vicinity of the plates, the voltage drop in the ground under fault conditions is similarly distributed in nature, and in order to keep this value does not pose a danger to life, the current in the ground facility must be maintained at a number either by using several plates in parallel or buried to a great depth and connected to an insulated cable as shown in Fig. 5, The relationship between electrode length and resistance.

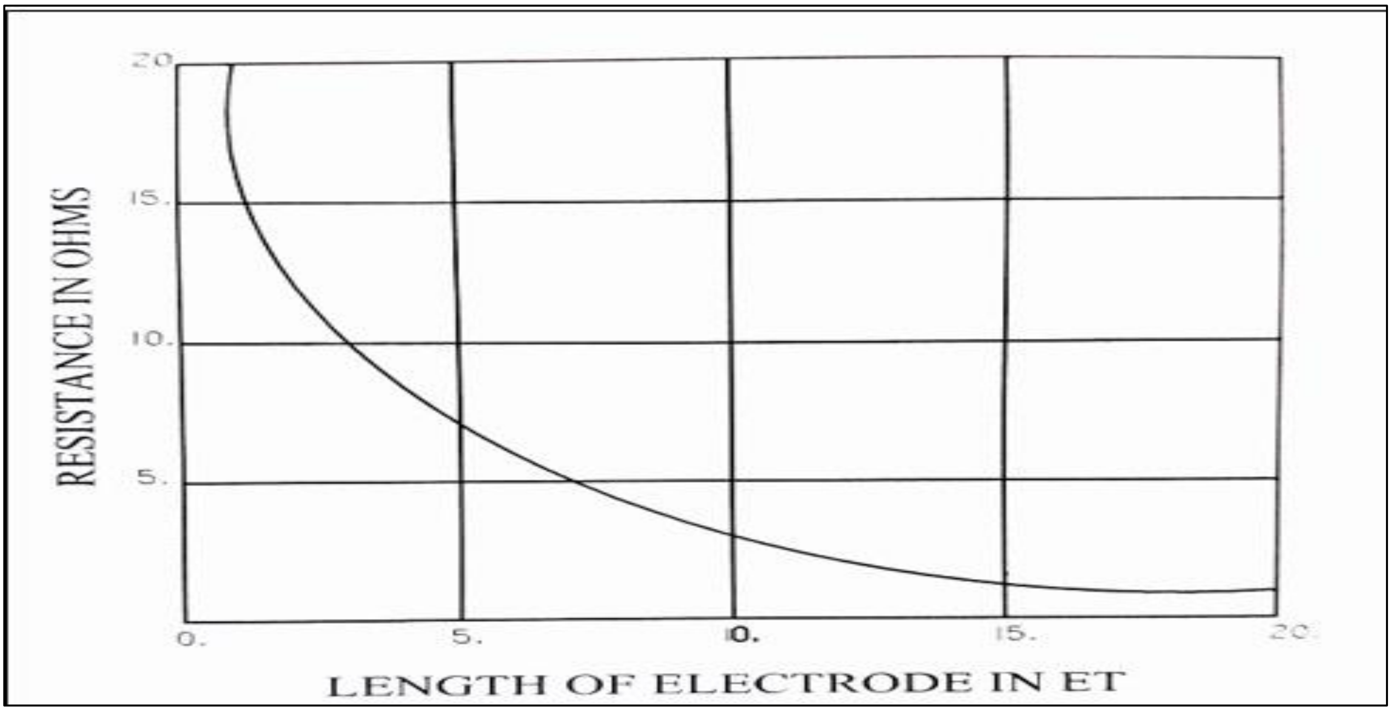

Fig 5: Relationship between Electrode Length and Resistance

If a naturally moist area can be utilized, the soil is likely to have a lower resistance as shown in Table 2, the relationship between soil type and specific resistance, however, moisture conservation should be avoided by passing water as shown in Fig. 6, the effect of moisture on specific resistance.

Table 2: Relationship between Soil Type and Specific Resistance

Soil type	**Resistivity ohm - cm**
Marshy Ground	200 - 270
Loam and clay	400 - 15000
Chalk	6.000 - 40000
Sand	9.000 - 800.000
Peat	20.000 up wards
Sand gravel	30.000 - 50.000
Rock	100.000 up wards

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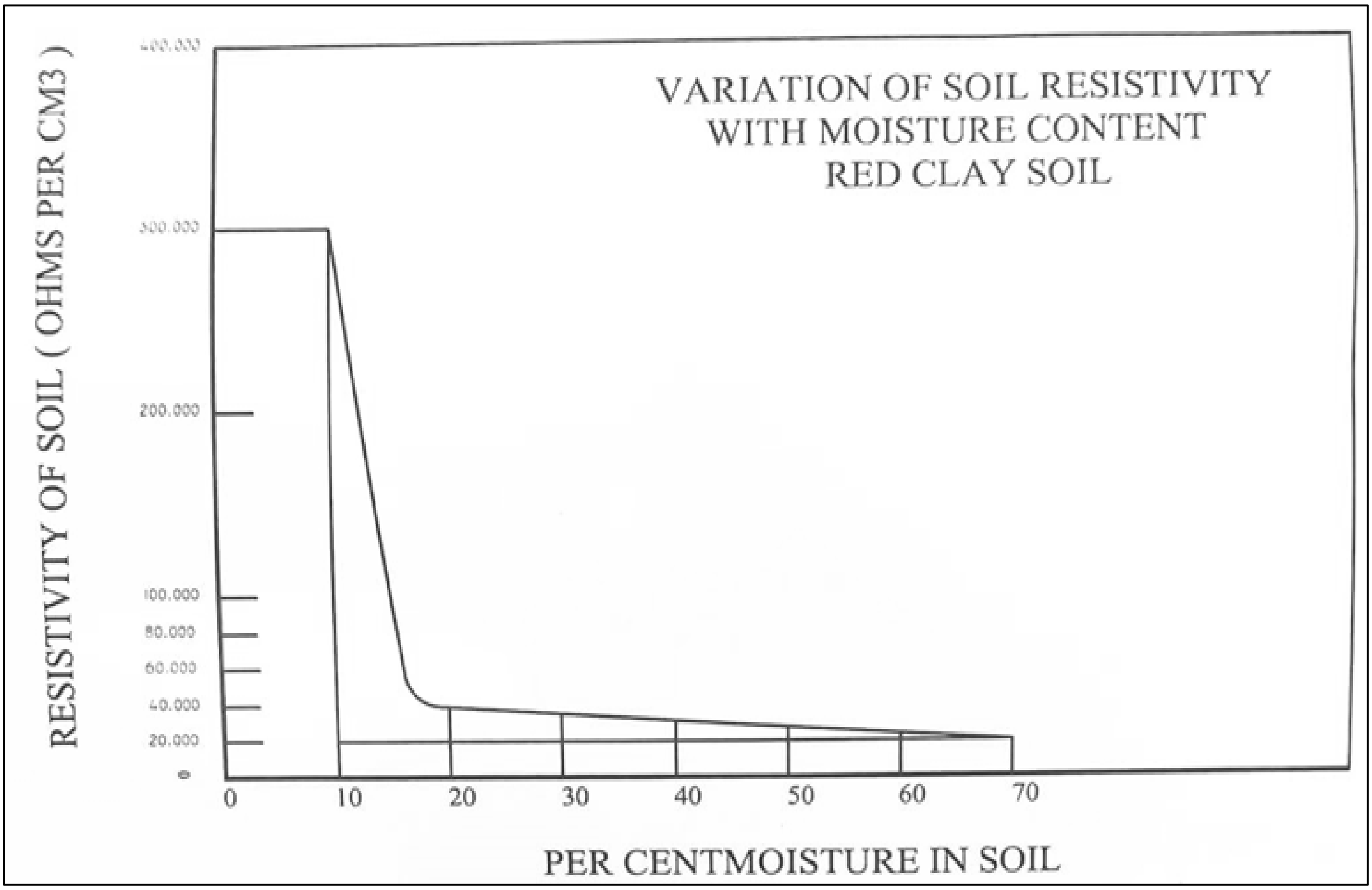

Fig 6: Effect of Moisture on Specific Resistance

The conductivity can be improved by chemically treating the soil, as shown in Table 3, the effect of salt on the specific resistance of the soil.

Table 3: Effect of Salt on the Specific Resistance of the Soil

Added salt percent by weight of moisture	Resistivity ohm-cm
0	10.700
0.1	1.800
1.0	460
5	190
10	130
20	100

Connections from the neutral or equipment to the grounding facility itself should be of a wide cut so that there is plenty of room for the greater fault current and there is no unusual drop along these connections.

A. Grounding for High Pressure Neutrality

The grounding of high-pressure neutral is the maximum effectiveness of self-protection devices as soon as it occurs with the ground in the system, and most line faults in high-pressure networks occur with the ground, especially when such systems consist of buried cables, and in the system that uses isolated neutral, these faults take the form of an arc with the ground in general, which in the case of multi-core cables leads to a severe short circuit between the phases, while grounded neutral with self-protection devices causes the isolation of the faulty part at the initial stages of the fault. The elimination of continuous ground communication turns a ground fault into a short circuit between the line and the neutral, and that the high voltage fluctuation that often occurred in isolated neutral systems, which caused significant damage to such systems, has been minimized and the safety factor of the system against ground faults has increased accordingly. When a stable ground fault occurs on an isolated system line, the voltage of the two healthy lines rises to the full line voltage above ground, which remains as long as the fault remains, and all devices connected to the lines are exposed to this high voltage, and although they withstand the first few shocks, they eventually fail as a result of the increasing vulnerability. The voltage of two healthy lines may reach a value close to twice the normal line voltage at the first moment of the fault, in systems with very high voltage due to stable capacitors, or if an additional double charge occurs when a pure capacitor is introduced into the circuit, the insulation of the system will be affected accordingly. The voltage between any line and the ground in an ungrounded system may take any value up to the breakdown voltage of the insulator with the ground, as this situation may easily appear during the process of stable electrical induction in systems that use air lines, because these are exposed to stable charges generated by charged clouds, dust, snow, fog or rain, or a change in the height of the lines of these generated charges. Dust, dust, snow, fog, rain, or changing the height of the lines of these generated charges, gradual accumulation will occur and the line and the devices connected to it may

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reach a high voltage (floating) above the ground until the unusual circumstance ends with the collapse of the insulator of the line and the place with the ground. However, if we ground the neutral point directly or through a current limiting device, the generated stable charges are discharged to ground whenever they appear and all hazards against the line insulators and devices are eliminated, so that no part of the system can reach a grounded part with a voltage above ground greater than the ground voltage between the line and the neutral.

B. Neutral Grounding Methods:

The choice of a suitable device to be inserted into the neutral connection for the purpose of determining ground fault currents depends partly on the voltage of the system to be grounded, whether it is high pressure or low pressure, and partly on the output of the system. In the case of high pressure systems, the neutral point may be grounded in the following ways:

- Soild.
- Resistance.
- Reactance.
- Arc Supperession.

If the neutral point is solidly grounded, the voltage of any conductor cannot exceed the voltage between the line and the neutral, and as the voltage of the neutral point under these conditions is zero, it is possible to reduce the insulation with ground for cables and aerial lines, thus saving cost, and according to the measurement (BS), the insulation of the neutral end is listed for system voltages greater than (66 kV).

If the fault current of a single short circuit is within the current necessary to operate the protection relays or if the fault current flow produces electromagnetic tension in the system equipment to a degree that can be easily overcome, this method can be used, While the introduction of some type of current limiting device is restrictive in minimizing fault currents, it must be remembered that healthy lines may be exposed for a short period of time to voltages higher than the normal phase voltage. However, if the protective devices operate quickly enough, the effects of such voltage increases are not serious. In small systems up to 11,000 volts, these may take the form of molded or pressurized grids, while in large systems where high fault currents are often used liquid resistors and resistors are generally designed to operate for 30 seconds with a fault current equal to the full rated load current of the transformer. The required resistance between the neutral point and the ground can be found by the following law:

$R = V2 / \sqrt{3}\, I$

R: Resistance in ohm.

V2: Line voltage in volt.

I: Full load current of largest machine of transformer in amp.

However, if the transformers are connected in a triangular shape, the grounding of the neutral point in such a case must be achieved by inserting a secondary device specially designed for this purpose, which is usually in the form of an overlapping star or a star/triangle attempt and is called a neutralization attempt.

The two methods mentioned above are two of the currently used grounding methods, as an alternative to these methods, the connection between the neutral point and the ground can be made during the suppression coil as shown in Fig. 7. The bonding method, and this form of ground connection reduces the number of times the source is cut off under fault conditions between the line and the ground because the fault is self-terminating, but if the fault is intermittent and does not self-terminate, the coil allows the system to operate by grounding one of its lines for a relatively short time until the fault is identified and repaired. In the event of a ground fault on a system with an isolated neutral and using overhead lines, the electrical capacitance stabilized with the ground of the two undamaged lines does not normally produce a capacitance current sufficient to operate the protection relays, but it helps to maintain an electric arc across the faulted insulators. As a result, the undamaged lines are exposed to abnormal voltages above the ground. Therefore, a variable reactance (arc suppression coil) is connected between the system neutral and the ground. It can be tuned so that the current passing through it at a power factor of approximately zero backward is equal to the current of a complete fault with the ground at a power factor of approximately zero forward. The small residual ground current is sufficient to maintain the arc. Since it is completely in phase with the voltage of the faulted conductor, both pass through zero at the same moment, and the probability of arc formation again is reduced. The advantages of this method are the slow appearance of the system voltage after the arc has ended, and it also reduces neutral and ground faults by 20%. It is usually used with diagonal lines and at a lower cost. The benefit of the switch (By pass) is that it allows the fault current to pass for a while and makes the protection switch work and isolates the faulty line from the circuit.

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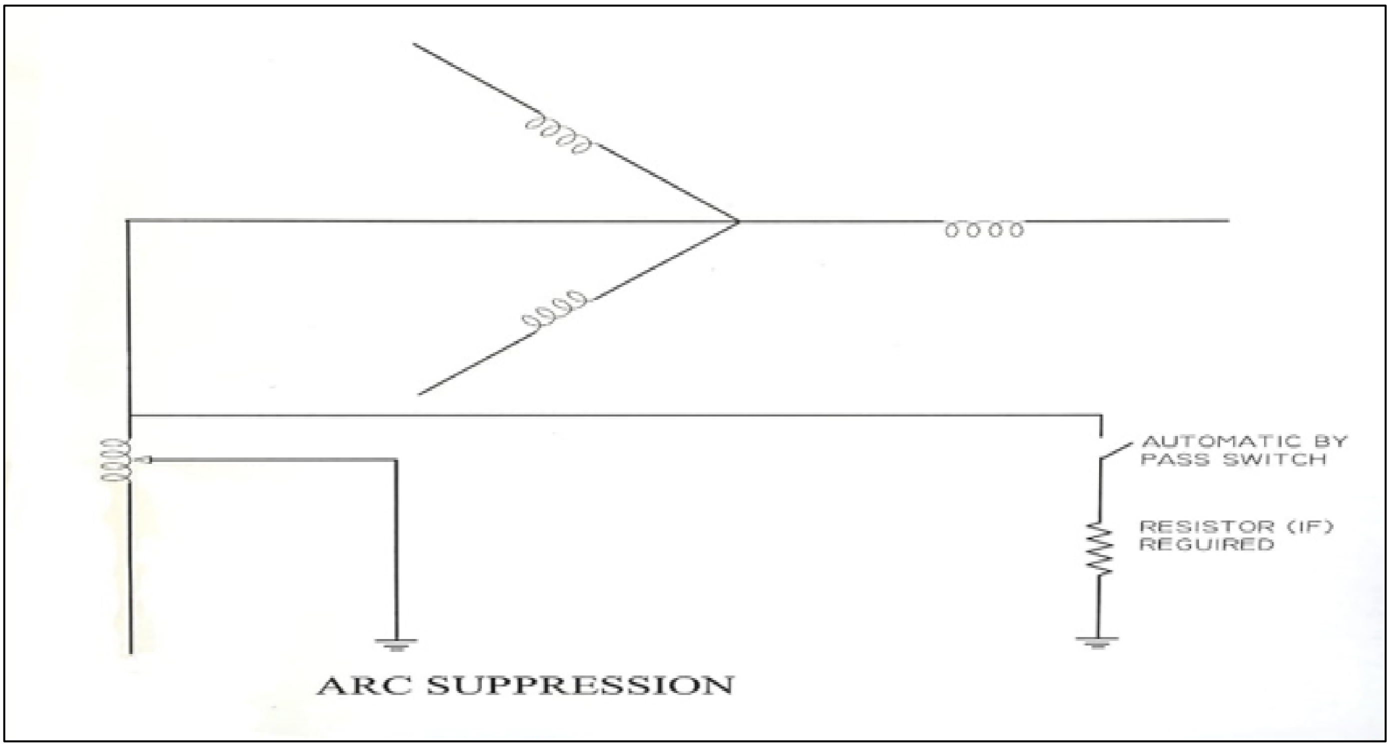

Fig 7: Connection between the Neutral Point and the Ground

C. *Low-Pressure Neutral Grounding*

The grounding of low-pressure neutral points is done in many ways directly in some cases without the use of secondary devices, and in other cases through a resistor or through a fuse in parallel with a current meter. The current meter is used to know the amount of current leaking to earth periodically, while the fuse opens the neutral connection automatically in the event of a severe ground fault, indicating the existence of such a fault. The benefit of direct grounding is that no higher than normal phase voltages can occur in the low-pressure circuit, thus minimizing the risk of electrocution. High voltages may exist in the low-pressure coil if the low-pressure neutral is not grounded, when a breakdown occurs between the high-pressure and low-pressure coils, under certain high-pressure circuit fault conditions, and at certain ratios of different static capacitances.

IV. TURBULENT WAVE DISPERSION

Turbulent changes with high voltage or high frequency can occur in the system due to the electrical arc with the earth if the equalization point is isolated due to the opening and closing of switches or due to the effect of atmospheric interference, and these interferences initially take the form of traveling waves with high values and a steep wave front and often follow the turbulent waves. Turbulent waves with their high values and frequencies may reach the transformer windings and break the insulation between their windings, especially the windings near the ends of the line. All spike wave scatterers give similar results, i.e. splitting the spike waves from the lines to ground to prevent them from reaching the transformer, and basically the different types of spike wave scatterers use several spark waves in series with non-linear resistors connecting the scatterers from each line to the line. All precautions to protect the surge protector may fail if adequate attention is not given to grounding because the surge voltage resulting from the lightning strike transmitted to the transformer is regulated by the voltage drop through the non-linear resistance of the dispersers if there is no resistance in series with the dispersers, but in practice there is the resistance of the connections from the ends of the disperser to ground, the resistance of the ground plate or rods, and the resistance of the ground itself, but in practice there is the resistance of the connections from the ends of the disperser to the ground. Since the sink current passes through additional resistors, its voltage drop must be added to the resistance of the sink to obtain the total voltage traveling to the transformer, and since the sink current is in the range of several thousand amperes, the earth path resistance, which is a few ohms, can be added to the voltage passing through the sink and to improve the networks. The ideal organization in this case is to pass a copper conductor with a suitable section from the end of the ground sink directly to the ground and to a depth of about a meter and then parallel to the transmission lines and the ground wire, ending with the transformer structure, and this identification conductor must be connected to a system of plates or ground rods, and the same degree of grounding can be obtained from the rods for each less than the plates.

V. THE ROLE OF GROUNDING IN ENSURING PUBLIC SAFETY

➢ *Ensuring Public Safety When Working On and Using Electrical Appliances has Multiple Aspects:*

- Protection against direct or indirect touch.
- Protection against overcurrent and ground currents and protection against overvoltage.

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The first purpose of grounding is to facilitate the interruption of current in the event of a fault that leads to contact between the electrical conductor carrying the current and the metal body of the electrical device, before the voltage on this body reaches a dangerous level and before the current reaches an amount that may lead to an electrical fire. The second goal is what happens when the current is not interrupted as a result of the high impedance value in the case of direct grounding, then electric shock can be avoided because grounding reduces the voltage difference between the metal body of the faulty device and the conductive objects to earth. In fact, there are peaceful ways to use electricity organized through high measurements, and international standards stipulate that protection devices must cut off the power to the devices when there is a malfunction so that the touch voltages cannot continue with a value higher than the maximum limit, which is:

- (50 volts) for fixtures that feed devices that do not contain exposed metal objects.
- (25 volts) for foundations that feed devices that contain exposed objects that can be touched by hand.

A. The Effect of Electric Current on People

Electricity, when passing through the human body, affects the respiratory system, blood circulation and the nervous system (brain) and causes internal and external hazards and burns, and the heart is the sensitive element in the body with electrical currents, because it is based on repeated timing and heart contractions depend mainly on currents similar to the electrical currents that are generated inside it. Therefore, any external current alters the regularity of the heartbeat and thus produces a difference in the pumping of blood to the body parts. Here are the electrical effects across the body of a person of average weight and age, taking into account the current for a contact time of (one second):

- (1 mA) Initiation of electrical sensation
- (5 mA) Accept maximum tolerance
- (10 mA) Most people are sensitized to it and the body stiffens (muscle contraction)
- (20 - 30) mA Muscle contraction reaches the respiratory system
- (100 - 200) mA High blood pressure and respiratory muscle spasm
- (0.3 - 1) A Heart failure, paralysis and death.

In fact, we should be talking in terms of voltages as well, not just currents.

B. Causes of Electric Shock

- Wiring robe Electrical appliances that are within reach of hands, as it causes when the human body is in direct contact with the electric current due to the exposure of some of its parts to the outside.
- Leakage current, the source of this current is localized due to the type of insulation used inside electrical devices or the generation of charges and their stability on the device due to the presence of residual magnetism between the coils and wires, and this happens when the electrical device is rotating, knowing that the use of the ground wire is the successful scientific treatment for this issue.

Human resistance depends on many factors (age, gender) that may be affected by the weather condition (degree of humidity) that affects contact resistance. The highest non-hazardous voltage (Limit Voltage VL) in normal lengths is (50 volts), (VL) may drop to (25 volts) in humid atmospheres and may drop to (12 volts) in wet atmospheres. In fact, the risk of electrocution comes from personal contact with the wire or a conductive part (incorrectly and habitually connected to dangerous voltages).

C. Direct Contact and Indirect Contact:

- Direct: A person comes into contact with a hot part of the foundation or part of the electrical equipment.
- Indirect: A person comes into contact with equipment that is wrongly plugged into an outlet.

The only known protection against direct and indirect contacts is the use of properly sourced voltages (properly transformed) and following useful safety rules.

➢ *Protection Against Direct Contact*

It can be accomplished by:

- Isolating the live part.
- Protection by placing barriers or wrapping them with boxes (enclosure) and to ensure good protection against direct contact, the protection level (protection level) of the enclosed box or barrier must be (Ip2x) and the barrier or box must be equipped with screws or special keys to open them to avoid accidents or to be opened after cutting the circuit breaker.
- Prevention by placing network obstacles (obstacles).
- Isolation by placing the hot parts in an inaccessible place (out of reach).
- Protection using (residual current devices)

The use of high sensitivities (≤= 30 mA) for this type of devices, this protection is considered as efficient as what was mentioned above in cases of direct contact.

➢ *Protection Against Indirect Contact*

- *Protection Without Disconnecting the Switch and can be Achieved as Follows:*

✓ Using equipment that is not normally disturbed and is insulated and does not have to be grounded
✓ Protection by (Non earthed equipotential link).
✓ Protection by electrical separation, and this is done by using special separation transformers with a screen barrier between the primary and secondary coils that feed the transformer with some important points or only one point.

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- *Protection by Disconnecting the Power Supply is a Very Common Way of Protecting People Against Electrocution and is Done by Following the Following Rules:*

- ✓ All current conducting parts must be connected to a single wire called ground
- ✓ The parts connected to the different equipment are connected to the same ground point, preferably through two paths, in case one of them breaks, the other remains.
- ✓ A protective device (electrical disconnection) must isolate electricity at the foundations when any dangerous electrical fault appears in them, and the fault is considered dangerous when the voltage of the metal parts conducting the current reaches the voltage (VL) previously mentioned, the voltage on the metal surface must not exceed this limit.
- ✓ The disconnection time for total protective devices should not exceed what is stated and shown in Fig. 8, and in the Table 4 below:

Table 4: Disconnection Time for Total Protective Devices

Contact voltage (v)	Total opening time (s)
< 50	∞
50	5
75	0.5
90	0.2
110	0.1
150	0.05
220	0.03

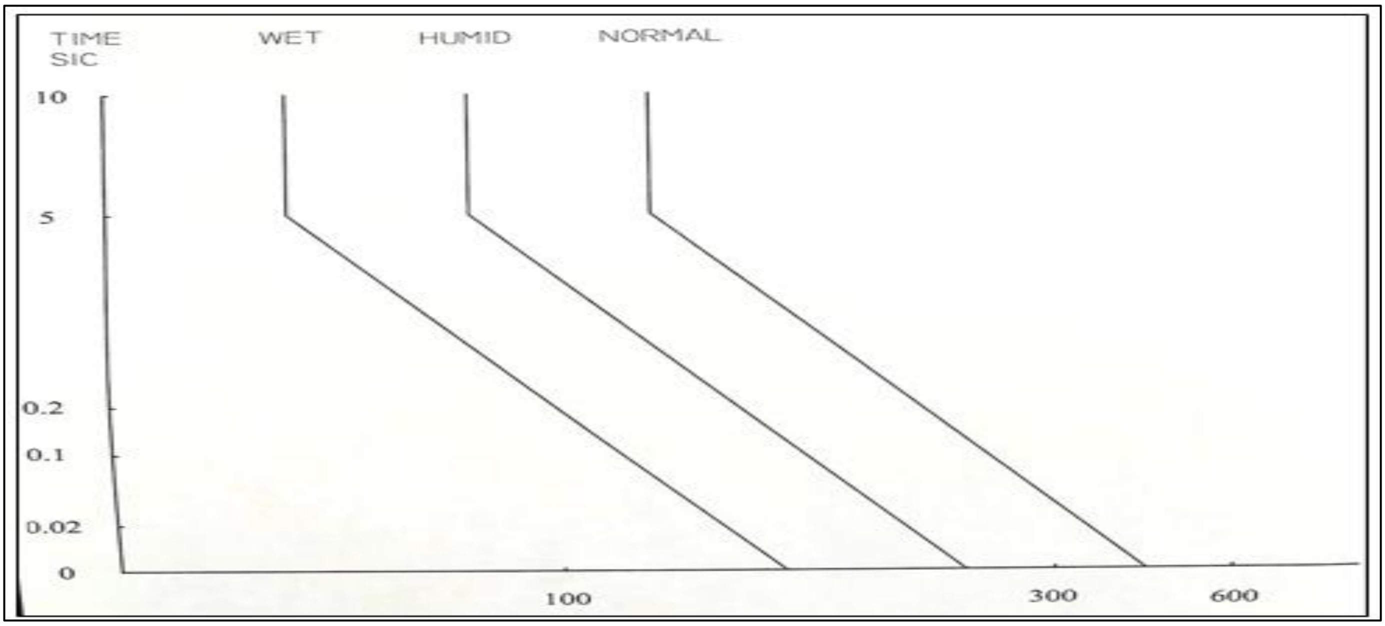

Fig 8: Contact Voltage (v).

The curves shown in Figure 8 are very important as they are the basis for every human being against electrocution by contact and it is important to consider its applications

VI. PROTECTING PEOPLE AND EQUIPMENT FROM ELECTROSTATIC DISCHARGE

The grounding of the high pressure neutral point protects the electrical system and the equipment itself, especially in systems that use air lines, because these are exposed to stable charges generated by neighboring charged clouds, current, snow, snow, fog and rain, or changing the height of the lines from these generated charges, gradual accumulation will occur and the line and devices connected to it may reach a high voltage (floating) above the ground until the unusual circumstance ends with the collapse of the line or machine insulation with the ground or the flash jumps to the stepping stools. However, if the neutral point is grounded either directly or through a current limiting device, the generated stable charges are discharged to ground whenever they appear and all hazards against the line insulators and devices are eliminated, so that no part of a grounded system can reach a voltage above ground greater than the normal voltage between the line and the neutral. Low-voltage neutral grounding prevents the presence of any voltage higher than that shown on the low-voltage circuit, thereby minimizing the potential risk to human life, eliminating the possibility of a false arc with earth and the risk of fire, and at the same time ensuring the rapid disconnection of the faulty device from the system as well as minimizing the potential risk to human life in case of accidental contact with any voltage-carrying wire.

VII. CONCLUSION

In the context of electrical system design and safety, it is crucial to rely on global standard systems and evaluate them within the standards of common grounding systems. According to the global specification, the protection devices must be designed to operate and cut off power to the devices when a fault occurs. Grounding the neutral point is necessary to discharge the generated stable charges, eliminate dangers, and protect equipment from high pressure. This grounding also reduces the risk to human life and eliminates the

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possibility of false arcs with the ground and the outbreak of fires in the event of low pressure. Grounded neutrality with self-protection devices ensures that the faulty part is isolated in the initial stages of a fault. The method of grounding the suppression coil has been found to reduce the number of times of disconnection and ground neutral errors by 20%. Finally, the surge voltage resulting from lightning strikes transmitted to the transformer can be controlled through the use of diffusers with resistance in series and a conductor with a suitable cross-section from the end of the diffuser to the ground. Overall, this comprehensive approach to electrical system design and safety, which incorporates global standards, grounding system evaluation, protection device sensitivity, and targeted grounding techniques, helps to ensure the reliable and safe operation of electrical systems.

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