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Improving the Performance of Ground Systems in Electric Distribution Network

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Abstract

The grounding systems in electric network are presented and classified compare to the IEC and NEC standard systems. In this research, shows the effect of ground systems on improving the protection and performance of electric networks. Various types of grounding are studied and list in this research. Depending on the different types and methods that are studied, the best grounding system for different cases will be investigated and recommending improving the reduction of the earth fault current.

Keywords: International Electric Code (IEC), National Electric Code (NEC), Ground systems, Electric networks, Electrical systems

INTRODUCTION

Due to the importance of the electrical power which it represents an important part of our life need and according to the lots equipment that are used within the electrical networks, there are a lot of riskiness that are caused by the usage of the electric power, sometimes these risks are because of the environmental conditions or by the big and sudden changes in the voltage surges of the electrical systems [1]. A high voltage is generated by different factors such as faults that occurs by touching the circuit connectors with higher effort connectors or by the thunderstorms [2]. To reduce the losses that may be happens by these problems and to provide higher safety, it's important to investigate a protection system. One of these protection systems is the grounding [3].

According to British standard (BS) and International Electrical Code (IEC), the grounding system named by earthing while the American National Electric Code (NEC) named it by ground. They briefly express the difference between the earth and ground where the grounding means that any mass that has reference voltage which is measured per the other efforts of the body which is not necessary to be the earth. For example, the grounding in the car is connecting the to the body of the car; same thing happens with satellite and motorbikes. Now we can define the grounding depending on American references as the mass that electrical current can go through by connecting to its body with effort equal to zero for the rest of the system. The world earth is representing the plant earth only [4].

The rest of this paper will be organized as following: section II is the electrical ground systems. Section III is the types of grounding systems. Section IV will be the results and discussions. Finally, Section V is the conclusion.

ELECTRICAL GROUNDING SYSTEMS

The electrical grounding systems means finding the point of neutrality that joint the connectors of the power systems that are carrying the current to the earth. To know more about the grounding systems, we should study the ungrounded systems first and compare between them.

A. Ungrounded Systems

While there is a capacitive value between the power transporter lines and the earth and because of various efforts, these kinds of systems are connected to the ground by capacitors as shown in Fig. 1.

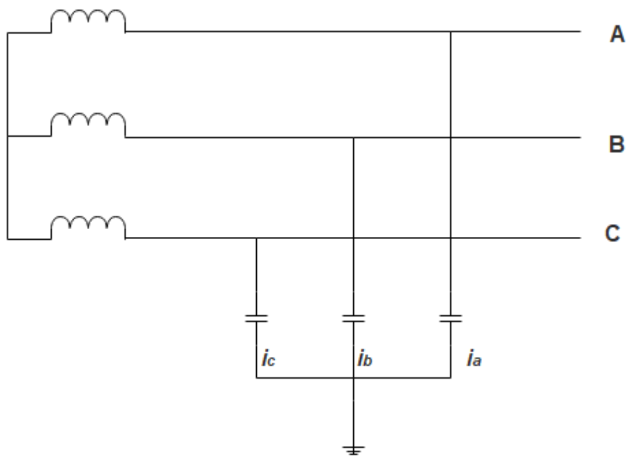

Figure 1. Ungrounded system

When there is no fault, the biasing of the system will be under balance load and the biasing voltage is close to zero. From Figure 1 it can be notice that there are three currents (i_a, i_b and i_c) which are equal to V/X_c where V is the voltage phase and X_c is the capacitive phase compare to the ground. Because of these currents are balanced to each other, there will not be a current at the ground. These currents are followed by the voltage by 90 degrees [5].

In case a fault occurs in one line for example A as shown in Figure 2

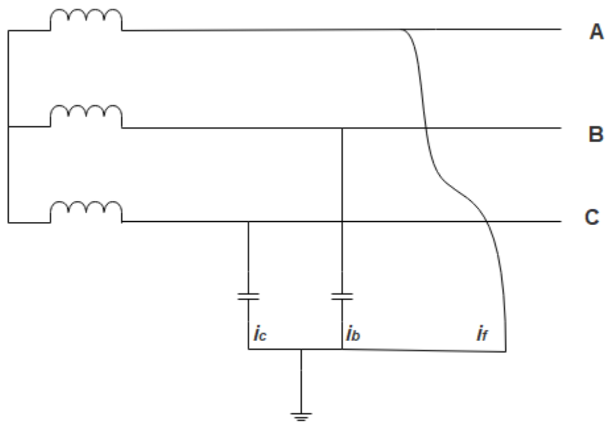

Figure 2. Fault in ungrounded system

The currents that are passing (I_b and I_c) through the capacitors then reaching the fault are generating two voltage (V_b and V_c) that are following the currents by 90 degrees of phase as a capacitive impedance [9].

$$I_b = \frac{V_b}{X_c} = \frac{\sqrt{3}V}{X_c} \quad (1)$$

$$I_c = \frac{V_c}{X_c} = \frac{\sqrt{3}V}{X_c} \quad (2)$$

The short circuit will be the summation of the current's phases.

$$I_{s.c} = \sqrt{3} \times \sqrt{3} \times \frac{V}{X_c} = \frac{3V}{X_c} \quad (3)$$

The effects of faulting on ungrounded systems will be:

- The voltage of the two remaining lines will increases by 1.73% compare to the identical situation.
- The capacitive charging increases by √3.
- The current is faulting line increases by triple compare to normal case.
- Generating an electrical field because of the sum of currents which will affect the nearby communication stations.

B. Grounded systems

When the short circuit happens in such kinds of systems, the current goes to ground then to the biasing point N which has same voltage of the ground. This will help to handle the following issues:

- Improve the performance of security devices and makes its usage easier.
- Eliminate the ground arch that's effecting on the grounding and minimize the communication interference.
- The voltage of the Non-shorted phases will not increase because of the biasing point which connected to the ground.

GROUNDING SYSTEM TYPES

According to the international standards, there are three types of grounding systems [8]. Each system is defined by two letters. These systems are:

A. IT system

The letter I is from isolated which means that there is no connection point between the power source and the ground while the letter T is came from Terre which a French word means that there is a direct connection between the earth and consumer point. This system is used in the airplane and ships which has a high resistance only. The reason of using this system in such examples because of there is on earth to connect the grounding to it. This system contains an isolated device that's monitoring the isolation and if its reaches the threshold it will gives an alarm. This system can be used in surgery rooms also [6, 7].

B. TT system

Every T means Terre but the first T means that there is a connection between the power source and the earth, the second T like the IT system means that there is a connection between the earth and consumer point. In this system, the grounding in consumer side works no matter what is happening in the source side. The major advantage of this system is that there is no interference between the high and low frequencies that are occurs from the different devices that are connected to the system. In addition to that is avoid the problems of cutting the N point with the ground. For these advantages, this system is used by the special wire and wireless communication systems [6, 7].

C. TN system

In this system, the power source is connected to the ground and usually the star connection is used to connect to the N point where that means that there is a direct connection between the consumer and neutral point which is also connected to the ground. There are three types of this system [6, 7].

- TN – S: Where S means separate. In this connection, the two connecters PE and N are separated from each other. This system is used by many countries around the world.
- TN – C: Where C means combined. This system works by combining the two connectors PE and N in one connector named PEN. This connection is used to connect the main line between the source power and the consumer while the end branches for consumer devices are separated.
- TN – C – S: This system is combination of the previous systems where its combined in main lines of the network and separated in the end points of transformers. This system is used in USA and UK electrical network systems.
  Table 1 shows a comparison between the grounding systems in terms of cost, safety, interference and risks.

Table 1. Comparison between the Grounding Systems

	IT	**TT**	**TN - S**	**TN - C**	**TN – S - C**
Needs of grounding rod	Need	Need	No need	No need	No need
Impedance of short circuit	High	Moderate	Low	Low	Low
PE cost	Low	Low	Very high	Very low	High
Risks of N cut	Do not have	Do not have	Do not have	Very big	Big
Safety	Low	Safe	Very safe	Moderate	Safe
Interference	Very low	Very low	Low	High	Low
Risks	In high voltage	When the grounding impedance increasing	PE cut	N cut	N cut

METHOD AND PROCEDURE

To study the grounding system of electrical network and show its performance and safety in the electrical network the following stems are implemented.

A- Grounding system classification

To classify the grounding system, several stations are selected with different amount of load. These stations are:

- Station A with 60 M.V.A
- Station B with 64 M.V.A
- Station C with 33 M.V.A
- Station D with 20 M.V.A
- Station E with 30 M.V.A

After that a brief study is done on these stations starting from the moderate received voltage which is around 33 kv all way to the distributer with 11 kv. The grounding system for these stations is studied starting from the local transformers until the consumer's units. 50 points are selected to be the subjects of this research to present the performance grounding system that is used in both the consumer and provider sides which it is in this case the electrical network.

B- Measuring the grounding resistance

The identical grounding resistance is zero, but it's impossible to reach the identical situation because of many parameters that are affecting it. According to the international standards IEC and NEC, the accepted grounding resistance should be 1 Ω or lower. There is more than one way to measure the grounding resistance. Fall of potential method was used in this research. This method works by adding copper coating steel to one of the original grounding rods. Figure 3 Shows the connection of fall potential method to measure the grounding.

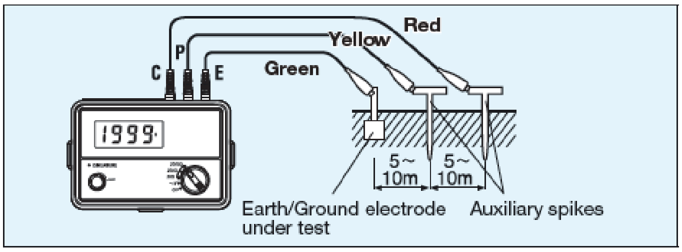

Figure 3. Measurement process

RESULTS AND DISCUSSION

By applying the process in the method section, we get the following results. The grounding system that is used in the secondary stations is a coper network underground the station. The grounding network is connected in Parallel with the concrete mesh of the ground. The main network is using a standard coper conductor with 120mm length. The secondary stations or branches are using same conductor but with 95mm length. Two steps are done to make the stations safer, these are all the stations are grounded to eliminate the danger of the touch and step voltage and the second step is adding a lightning rod to the roof of the buildings. The neutral point of the transformers is linked to a 21 Ω resistance to reduce the feedback current.

One the other hand, all transformers is connected to two isolated copper silks with 50 mm^2 diameter and 1.5 m length underground. The reason of isolating the two silks is to do not allow the voltage of the transformer body to go high if one of the phases shorted. The weakness point is in the consumer side where there is not grounding or circuits. Table 2 shows the grounding resistance that are measured for the selected stations in this research.

Table 2. Grounding Resistance for Measured Stations

Station	Resistance in Rod 1Ω	Resistance in Rod 2Ω	Resistance in Rod 3Ω	The average resistance Ω	Error
A	0.11	0.11	0.12	0.11	0.0011 %
B	0.21	0.15	0.11	0.16	0.0016 %
C	0.16	0.21	0.22	0.20	0.0020 %
D	0.12	0.48	0.31	0.30	0.0030 %
E	0.13	0.16	0.14	0.14	0.0014 %

The table shows that station A has the lowest grounding resistance because of the wet ground. While the highest resistance recorded at station D because of the properties of the station ground are dry and sandy. That means different ground needs different kinds of grounding because of the properties of grounding system in both stations A and D were the same but different ground gives different results. From table 2 we can see that the all stations have very close to identical grounding resistance according to international standards.

CONCLUSION

From this research, we can conclude that the grounding system of the selected network is not IT because they are using three phase networks without biasing. If the consumer introduces a grounding to all his electrical devices, then we can say this network have a grounding system that is matches with TT system. The network cloud be count as TN system if they used a reputation biasing for fixed distance between each one of them.

Every grounding system has its advantages. Depending on the advantages of each system we should select it to match with needs of the building or the region. For example, TI system is the best grounding system for surgery halls. There are no disadvantages in the grounding systems but there is extra cost or if its suitable or not. Depending on them the system should be selected.

The tested stations showed that the grounding resistance was in range of international standards which means that the grounding can protect the people from high voltage if its occurs, the network can stay in working position even if one of the phases got a problem like voltage surges and finally, the interference of the nearby communication remains under control.

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