MODIFICATION OF COPPER ROD TO REDUCE GROUND RESISTANCE

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BEKP
MAY 2010

"I hereby declare that I have read through this report entitle "Modification of copper rod to improve ground resistance" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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Date : 22th MARCH 2010

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This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree Bachelor In Electrical Engineering Industry Power

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

October 2010

I declare that this report entitle "*Modification of copper rod to improve ground resistance*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : SAIFUL NIZAM BIN SA'ARI

Date : 22th MARCH 2010

To my beloved mother

ACKNOWLEDGEMENT

First of all, I would like to express my thankfulness and gratitude to Allah S.W.T who has given me all the strength that I needed to complete this report.

Secondly, I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) for funding and providing the necessary infrastructure that enables the completion of this report.

Besides that, I would like to express my thankfulness to my final year project supervisor En Farhan Bin Hanaffi for providing continuous guidance and untiring supervision throughout the duration of the project and during the writing of this paper.

In addition to this, I would like to express gratitude to my family and relatives for their unwavering support, guidance and motivation to assist me in the completion of this paper. Also, I would like to extend my sincere thanks towards my fellow friends and housemates, whom have contributed a lot of needed ideas, support and encouragement towards the completion of this paper.

ABSTRACT

Grounding of electrical installation is primarily concerned with ensuring safety. In power networks the grounding system helps to maintain the voltage of any part of network with a predetermined range with respect to earth under steady state and fault condition. This approach has been in practice for many years but it is not perfect solution because the conventional grounding rod is typically less efficient for residential used. In order to determine a good rod, an experiment has been conducted on five types of copper rods which are solid rod or conventional rod, hollow rod, hollow rods with NaCl and the remaining two are hollow rods with NaCl but difference size of leach holes. The distance of the leach holes also must be careful designed because it may affect the material strength of the earth electrodes. The leach holes size also must be suitable to the size of NaCl because it can less maintenance of the earth electrode besides improving efficiency. In observation during eight weeks the conventional rod gives a large rate in increasing resistance from time to time. As follow grounding standards evolved to require lower resistance levels, better electrodes are needed. In this project, chemical rods were used as a solution for this problem. The chemical rods which are used NaCl as an electrolytic salt to help in increasing the soil's conductivity. Furthermore, the chemical rods can function proper to carry unwanted current flows to earth without exceeding any operation, protecting equipments and ensuring a person or livestock is not exposed to danger of critical electric shock. All the earth electrodes have been located at the same placed and the same type of soil. In testing process, Megger Digital Earth Tester has been used to measure the resistance of the earth electrodes by using Fall Of Potential Method. This testing process has been conducted during eight weeks and all the data were recorded. The performance of each earth electrode has been analyzed after plotting graphs through the data obtained. Ideally, to maintain a reference potential for instrument safety, protect against static electricity and limit the system to frame voltage operator safety an earth electrode resistance should be zero ohm. In reality, after literature review and experiment has been done the value cannot be obtained.

ABSTRAK

Pemasangan sistem pembumian berkait rapat dengan ciri-ciri keselamatan. Sistem pembumian membantu untuk mengekalkan voltan sistem elektrik dalam keadaan stabil dan juga keadaan gagal. Usaha untuk mempraktiskan kepentingan sistem pembumian telah bertahun-tahun lamanya tetapi penyelesaian yang baik masih belum diperolehi kerana kendalian rod konvensional yang digunakan kurang efektif. Bagi mendapatkan rod yang baik, satu ujikaji telah dijalankan ke atas lima rod yang berlainan iaitu rod tembaga padat, rod tembaga berongga, rod berongga berisi NaCl dan selebihnya rod berongga berisi NaCl dan mempunyai lubang resapan yang berlainan saiz di sepanjang elektrod. Jarak lubang resapan juga harus bersesuaian kerana ia boleh menjejaskan kekuatan bahan elektrod. Saiz lubang resapan juga harus bersesuaian dengan saiz NaCl yang digunakan kerana ia dapat mengurangkan proses penyelenggaraan ke atas rod itu disamping dapat meningkatkan kecekapan. Pemerhatian selama lapan minggu didapati rod konvensional memberikan kadar peningkatan yang besar dari semasa ke semasa. Mengikut piawaian 142 yang telah ditetapkan menyatakan bahawa untuk mencapai tahap rintangan rendah bagi sistem pembumian, elektrod bumi yang baik diperlukan. Dalam projek ini, elektrod kimia telah digunakan sebagai jalan penyelesaian bagi mengatasi masalah ini. Elektrod kimia ini menggunakan NaCl sebagai garam elektrolitik untuk meningkatkan konduktiviti tanah. Oleh itu, elektrod kimia dapat berfungsi dengan baik untuk membawa arus yang tidak dikehendaki tanpa menganggu operasi lain disamping melindungi peralatan dan memastikan manusia dan juga haiwan tidak terdedah kepada renjatan elektrik. Semua elektrod ditanam di dalam tanah yang sama jenis untuk proses pengujian. Dalam proses pengujian 'Megger Digital Earth Tester' telah digunakan untuk mengukur nilai rintangan elektrod dengan menggunakan kaedah 'Fall Of Potential'. Proses pengujian ini dijalankan selama lapan bulan dan semua data yang diperolehi direkod. Prestasi setiap elektrod dianalisis dengan menggunakan graf. Idealnya, untuk menjamin keselamatan peralatan dan melindungi daripada kebocoran arus, nilai rintangan elektrod bumi harus sifar. Secara realitinya, untuk mendapatkan rintangan electrod bumi sifar adalah mustahil.

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NaCl	-	Natrium Chloride
MCB	-	Miniature Circuit Breaker
RCCB	-	Residual Current Circuit Breaker
TT Network	-	Supply and exposed conductive part are directly earth
E.M.F	-	Electromagnetic field

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter explains the introduction of this project that consists of project background, projects objectives, project scopes and problem statements. In addition, this chapter includes thesis outline that is describe roughly about all the chapters in this thesis.

1.2 Project Background

The purpose of the grounding is to provide safe, reliable and efficient power distribution. These are the goals of the grounding from a power distribution viewpoint where electrical noise interference is not a consideration. In electrical engineering, ground or earth is a huge conductor which can be considered to be at reference or zero potential. Human beings are normally in, more or less, direct contact with this ground. Any metal parts which become charged with respect to ground may cause a hazard or electrical shock if touched by human body [1]. The purpose of grounding is to link together all metalwork, and carry the unwanted current to ground. Normally for residential grounding system used solid single copper rod as an easy path to allow the unwanted current flow to ground. However, the conventional copper rod has some witness, for example it cannot maintain the resistivity [2]. The copper rod plays importantly in order to ensure the grounding system can work properly. For the TT grounding system, the maximum resistance of the copper rod must not exceed 500 Ω.

Grounding of electrical installation is primarily concerned with ensuring safety. Generally, each house used miniature circuit breaker (MCB) as a protection. MCB is as switch designed to protect an electrical circuit from damage caused by overload and short

circuit [1]. The MCB will operate when the current reached 100mA and it cannot detect the leakage current. Human body can touched the maximum current is only 50mA while the MCB will operate at 100mA. This problem will exposed humans and livestock to electric shock. However, TT system required residual current circuit breaker (RCCB) as an addition to detect the leakage current [1]. This device connected to the electrode placed in the earth. No doubt, the electrode needed to operate properly to carry the unwanted current flows to the earth. This project will do an experiment by using chemical rod as a preventive action to overcome the problems. Besides that, soil conductivity also may affect the resistivity of the rod. The soil resistivity varies with the dept from the surface, type of soil, the moisture content and the soil temperature [3]. Thus, the chemical rod used Natrium Chloride to maintain the moisture and soil resistivity. In order to measure the value of resistance, the used of Megger digital earth tester is required.

1.3 Problems Statement

Nowadays, the conventional earth electrode has a few problems due to electrode and soil resistivity. These problems will cause an equipment failure or damage and exposed humans and livestock to electrical shock if they touch the equipment. Mostly people did not know the problems exist due to grounding system failure. The performance of conventional rod usually decreased from time to time. Thus, finding a better earth electrode is important in order to replace the conventional rod.

In this project have been discovered a better earth electrode compare to conventional rod which is chemical rod. The chemical rod has been designed with hollow copper rod that used Natrium Chloride as an electrolytic salt to improve the earth resistance and soil conductivity. Besides that, the performance of the chemical rod is better and economical for residential used. The most important thing of the earth electrode is to maintain the lowest resistance in changing condition of soil, temperature and moisture content in the soil. Thus, the performance of grounding system is very important in order to avoid electrical shock hazard and equipments damage.

1.4 Project Objectives

In this project there are four objectives need to be achieved in order to complete this project with successfully which are:

i. To get the lowest resistance of the earth electrode that is less than 500Ω.
ii. To test the presence of NaCl can decreased the resistance value of earth electrode.
iii. To evaluate and analysis the performance between chemical rod and conventional rod.
iv. To study the relationship between leach holes size and ground resistance.

1.5 Project Scopes

In order to achieve the objectives of this project, there are several scopes have been specified. The scope of this project includes:

i. This project is to determine the performance of conventional rod and chemical rod.
ii. This project is to test the performance of five rods with different design but these earth electrodes are located in the same place and same type of soil.
iii. In this project used Natrium Chloride, NaCl as an electrolytic salt in order to improve the resistance of earth electrode.
iv. Megger Digital Earth Testert is used to measure the resistance value of earth electrodes.
v. Testing process of these five electrodes is conducted during eight weeks and all the data are recorded.
vi. The performance of each earth electrode is determined by analyzing the graph that has been plotted due to data obtained.

1.6 Thesis Outline

Chapter 1 briefly summarizes the project background and problem statements as well as elaborates the objectives and scope of the project. All these are important the way to start any project because it helps in understanding more about the project and know the steps should be taken to ensure this project successful.

In the Chapter 2 describe about literature review that involve in order to completing this project. Firstly, this chapter introduce about grounding system and grounding arrangement. Secondly is explanation about TT network system that is mostly used for residential in Malaysia. Then, this chapter also discuss about the function of residual current circuit breaker which is a device that can detect current leakage to ground or equipments. Besides, it is important to understand the earth electrode resistance and it's characteristic. In this chapter also describe about chemical rod and its performance compare to conventional rod. The resistivity of soil also will influence the earth electrode resistance depending on concentration of soluble chemicals in the soil, the moisture content and the soil temperature. In addition the brief elaboration on the using Megger Digital Earth Tester is elaborated.

Chapter 3 introduces the methodology that used in order to completing this project successful. The methodology which is the most important part that describes the flow of this project is also discussed in detail in this chapter. Usually, project methodology defines the planning process flow and principles that is essential guide to produce a proper planning project. This is important to ensure this project follow the methodology because project methodology is a planning of a project in order to achieve the objectives of this project.

Chapter 4 is detail on the results of this project. All the data are recorded in table and graphs are plotted from the data obtain. In this chapter also describe the analysis of this project results by comparing the performance of each earth electrode in eight weeks.

In Chapter 5 describes the analysis due to data obtained during eight weeks. In addition this chapter will explained more and discussed the performance of all earth

electrodes. Besides that, the difference resistance of each earth electrode also has been described in this chapter.

Lastly, the Chapter 5 elaborates about conclusion of this project and necessary recommendations are stated clearly. This chapter will determine that the objectives of this project have been achieved or not.

CHAPTER 2

GROUNDING SYSTEM

2.1 Overview

Basically for residential application grounding system is play important to ensure safety of the residents. However, not many people aware and know the purpose of the grounding system in our home. In grounding system there are several challenges to be faced there are rod material selection, soil resistance and earth electrodes designed. This chapter describes the resources that have been referred to ensure that this project is progressing well.

2.2 Introduction

Generally, the definition of grounding system is the reference point in an electrical circuit from which other voltages are measured, or a common return path for electric current, or a direct physical connection to the earth [1]. In this project there are two factors to concern that affect the operation of grounding system which are resistivity of copper rod and soil conductivity. In low voltage system grounding, IEE regulation defines an electrical system consisting of a single source of supply [1]. There are five types of grounding systems classified by combination of two to four letters namely as TT, TN-S, TN-C, TN-C-S and IT isolated network. This grounding network arrangement is shown in Figure 2.1. However, in Malaysia mostly for residential application used TT network system. The TT network system is a system with independent earth which is used earth electrode that installed at the house. This project is study about the grounding system base on TT network, basic operation of Residual Current Circuit Breaker (RCCB), earth electrode resistance, chemical rod design, soil resistivity and method of measuring electrode resistivity by using Megger Digital Earth Tester.

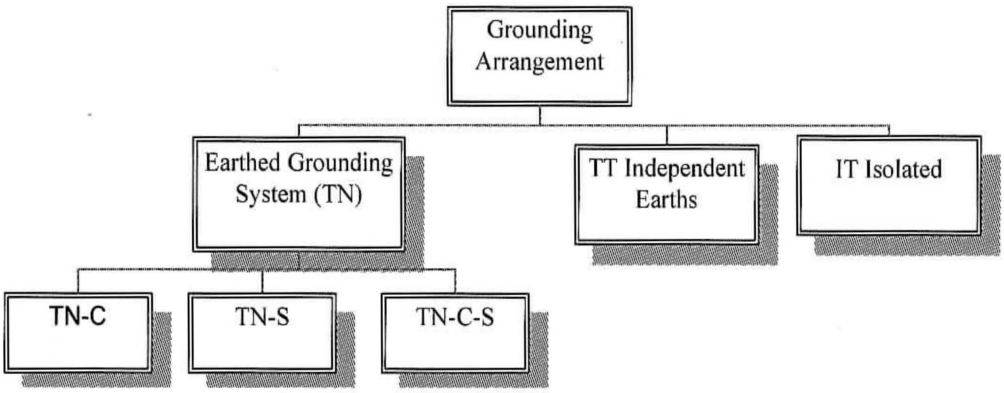

Figure 2.1: Grounding Arrangement

2.3 Earthing or Grounding System.

Grounding of electrical systems, services and equipment is done primarily for reason of safety. In the event of an electrical shock circuit between an energized supply conductor and any of metallic components, the hazard of electrocution must be minimized. In addition short circuit to ground may produce an excessive amount of arcing at the point of fault, resulting the arcing may cause fire or damage of property and possibly loss of life. Besides that, lightning induce surge must also be discharged to the earth ground to prevent dangerous overvoltage from occurring in various equipment and on equipment enclosures.

Normally, electricity required a complete path or circuit to continuously flow. Thus, without two contact points on the body to current enter and exit there is no possibility hazard of shock [1,2,3]. Therefore, that is why bird can safely rest on high voltage power line without getting any shocked. This no possibility hazard of shock is shown in Figure 2.2.

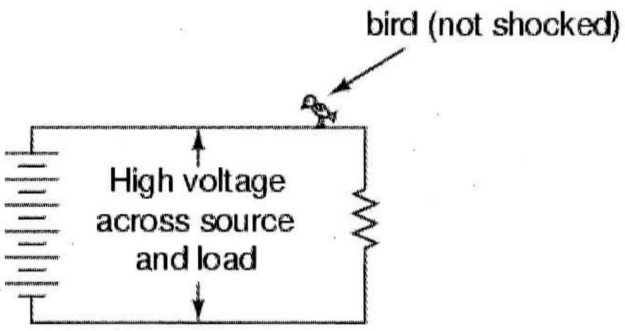

Figure 2.2: No possibility hazard of shock

In order for current to flow through the conductor, there must be a voltage present to allow the current to flow. Voltage is always between two points, there is no such thing as voltage at only one point in the circuit [3], so the bird contacting a single point in the above figure and voltage applied across its body allow current flow through it.

However, this situation is different with human life because people are usually standing on the ground. Thus, for a person touching a single wire can make contact between two points which are live wire and ground. Unfortunately, this also means that persons or livestock in contact with live part and earth at risk of electric shock. This shocked current flow is shown in Figure 2.3.

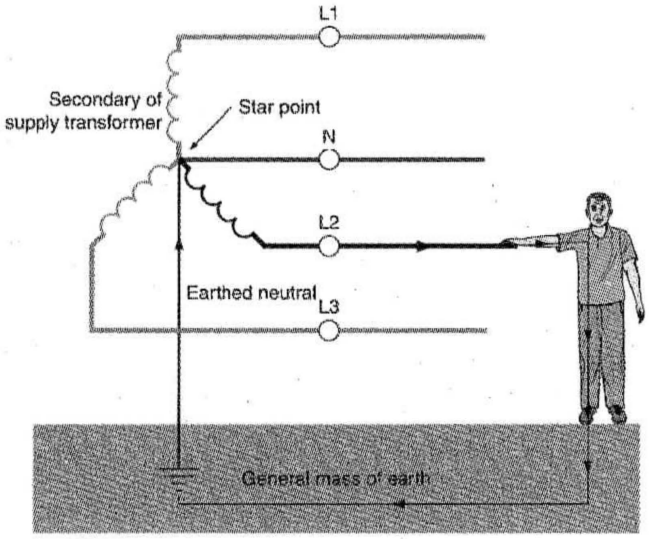

Figure 2.3: Shock current flows through person

In this way, the star point is maintained at or about 0V. This also means that person in contact with live part and earth is at risk of electric shock. The definition of earth is therefore the conductive mass of earth, whose electric potential at any point is conventionally taken as zero [4]. Hence, by connecting a voltmeter between a live part and earth, the voltmeter may read 240V because the earth provides a path to complete the circuit. This connection is shown in Figure 2.4.

According that, a person in an installation touching a live part while the person standing on the earth would take the place of the voltmeter shown in Figure 2.4 and could suffer a critical electric shocked. Normally the accepted current level of shock current

passing through a person is only 50mA or 1/20A [5]. If the person touched live part with current more than 50mA the person will die.

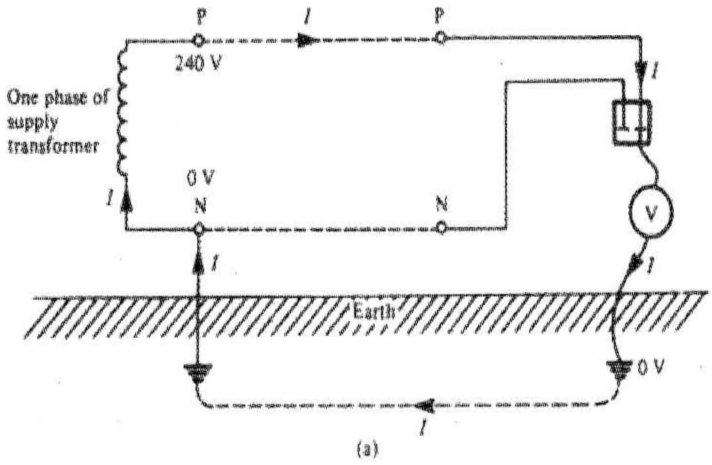

Figure 2.4: Connection live part to earth

However, by connecting the positive 12V terminal of a car battery and earth, the voltmeter will measured nothing because in this case the battery itself no part of earth to complete the circuit. Thus the current cannot exist in open circuit. Figure 2.5 has shown the connection between earth and battery.

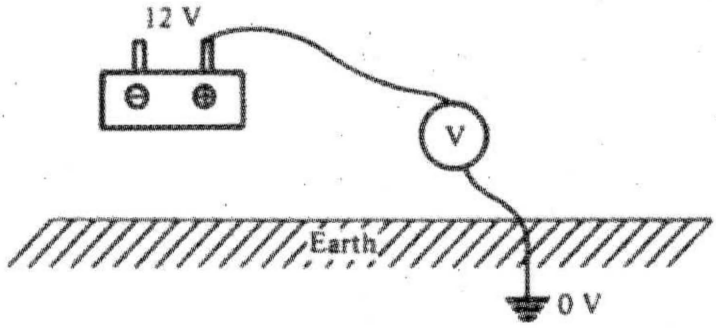

Figure 2.5: Connection battery to earth

The primary variable to determine the severity of electric shock is electric current which passes through the body. This current is of course depending on voltage and the resistance of the path it follows through body. An approximate general framework for shock effect is as follow in Figure 2.6 above. The figure shows that, when a person touching 1mA to 2mA the person will get barely perceptible and no harmful effects. Then, for a person touching 5mA to 10mA will cause throw off or painful sensation. By touching