UNIVERSITI TEKNIKAL MALAYSIA MELAKA

GROUNDING MONITORING SYSTEM FOR RETAINING THE PROPERTY OF GROUNDING PROTECTION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electrical Engineering Technology (Department of Electrical Engineering Technology) (BETI)

by

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DECLARATION

I hereby, declared this report entitled "Grounding Monitoring System for Retaining the Property of Grounding Protection" is the result of my own research except as cited in references.

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Date : 4 JANUARY 2016

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Department of Electrical Engineering Technology) (BETI). The member of the supervisory is as follow:

……………………………………………

(DR. ZIKRI ABADI BIN BAHARUDIN)

ABSTRAK

Projek ini adalah untuk memantau sistem pembumian untuk mengekalkan ciri-ciri perlindungan pembumian di mana tumpuan kepada pengukuran potensi pembumian yang dihasilkan oleh kilat. Sistem pembumian adalah litar yang menghubungkan bahagian litar elektrik dengan tanah. Pengukuran pembumian yang dihasilkan oleh kilat dikesan menggunakan antena yang bertindak sebagai pengesan. Dua kotak pembumian disambungkan kepada litar penyepadu aktif dengan menggunakan THS4631D. Keluaran litar penyepadu aktif disambungkan dengan osiloskop berkelajuan tinggi. Projek ini menggunakan perisian OrCAD untuk mereka bentuk litar PCB. Bentuk gelombang dianalisa menggunakan osiloskop storan digital (DSO), Teledyne LeCroy HDO4024. Sepanjang projek ini, beberapa parameter dari profil gelombang asas yang dihasilkan oleh kilat boleh ditentukan. Oleh itu adalah penting untuk mempunyai satu sistem untuk memantau prestasi pembumian dengan memantau voltan keupayaan antara dua kotak elektrod pembumian. Tujuan utama pemantauan sistem pembumian adalah untuk melindungi orang, binatang dan semua peralatan dalam bangunan daripada rosak selepas ia telah melanda dengan kilat. Kesimpulannya, keseluruhan objektif berjaya dicapai tetapi penambahbaikan perlu dilakukan untuk meningkatkan tahap ketepatan data yang akan diperoleh pada masa hadapan.

Kata Kunci : **Sistem Pembumian, Potensi Voltan, Perlindungan Pembumian, Osiloskop Storan Digital, Panahan Kilat, OrCAD**

ABSTRACT

This project was to monitor grounding system for retaining the property of grounding protection where focus on measurement of potential of grounding generated by lightning strike. Grounding system is circuitry which connects parts of the electric circuit with the ground. The measurement of grounding produced by lightning detected using an antenna that act as a sensor. Two grounding chamber act as input is connected to the active integrator circuit by using THS4631D. Output of the active integrator circuit is connected to the high-speed oscilloscope. This project used OrCAD software to design the PCB circuit. The waveform was observed using the Teledyne LeCroy HDO4024 digital storage oscilloscope (DSO). Throughout this project, the several parameter from the profile of grounding waveform generated by lightning strike can be determined. Therefore it is important to have a system to monitor the grounding performance by monitoring the potential voltage between two electrode grounding chamber. The main purpose of grounding monitoring system is to protect people, animals and all of the equipment in a building from being damaged after it had been struck with lightning. In conclusion, the objectives are successfully achieved and further research need to be done to increase the result accuracy of this project.

Keyword : **Grounding System, Potential Voltage, Grounding Protection, Digital Storage Oscilloscope, Lightning Strike, OrCAD**

DEDICATIONS

To my beloved family and friends

Appreciation for their supports and understanding.

ACKNOWLEDGEMENT

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

In the Name of Allah, the Most Beneficent, the Most Merciful

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A special appreciation to UTeM, especially the Faculty of Engineering Technology for giving me the chance to participate in this project paper. This project has really helped me understand the basic of monitoring grounding system. I really hope that this knowledge will help me for my future work. Finally, I would also like to acknowledge the assistance of my colleagues and other persons involved in the completion of this research and preparation of this report writing.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Ω	-	Ohm
FYP	-	Final Year Project
UTeM	-	Universiti Teknikal Malaysia Melaka
TNB	-	Tenaga Nasional Berhad
ST	-	Suruhanjaya Tenaga
ELCB	-	Earth Leakage Circuit Breaker
US	-	United States
DC	-	Direct Current
NEC	-	National Electrical Code
NEV	-	Neutral-to-Earth Voltage
IEEE	-	Institute of Electrical and Electronics Engineers
UK	-	United Kingdom
RMB	-	Renminbi
IC	-	Intra-cloud
CC	-	Cloud-to-cloud
CG	-	Cloud-to-ground
BNC	-	Bayonet Neill–Concelman
DSO	-	Digital Storage Oscilloscope
MSIEC	-	Malaysian Standard International Electrotechnical Commission

CHAPTER 1

INTRODUCTION

1.0 Introduction

This beginning chapter will explain about project background, problem statement, scope, and objective regarding to this project.

1.1 Background

As required by various authority such as Jabatan Bekalan Elektrik & Gas Malaysia, which is now known as Suruhanjaya Tenaga (ST) and Tenaga Nasional Berhad (TNB), it is essential to ascertain the grounding arrangement at the source of supply of an installation and the type of path intended for earth fault current to flow in order to select the appropriate protective measures to be used for the protection against electric shock. The electrical engineers and researchers always doing the studies about the grounding monitoring.

Grounding system is circuitry which connects parts of the electric circuit with the ground. The electrical resistivity of soil is significantly important because it can influenced by shape of the particle of soil, presence of moisture in soil, chemical properties of soil and presence of organic materials in soil. Usually, some contractors did not concerned about soil property after commissioning test. The ageing process can cause changes property of soil which can lead the changes of resistivity and thus reduce the performance of grounding protection. Therefore it is important to have a system to monitor the grounding performance by monitoring the soil property.

In other words, the soil is a direct electrical connection to the earth, a connection to a certain point in the electrical circuit or an indirect connection that operates as a result of capacitance between wireless equipment and the earth or a large mass of conductive material. Electrical grounding system is important because it provides the reference voltage level is called zero potential or ground potential of all other voltage in the system established and measured. As we know, an effective grounding is also effective to reduce interference with the equipment. In addition, it also aims to reduce the risk of equipment damage caused by lightning. It can eliminate electrostatic formation which can damage the components of the system and help protect workers who are repairing and servicing electrical systems.

Electrical connection to the earth was made for two reasons. First, for the safety of users from the dangers of electrical shock, fire and damage to property. In the early stages, this protection use a fuse element but is now more modern circuit breakers are used. The circuit breaker will be tripped if it detects any electrical leakage in the circuit. Second, as we know, the electricity supply needs multiplier live and neutral to complete the electrical circuit. If the neutral conductor is grounded, it was saving up to 50% cost routing through the neutral conductor to complete a circuit.

1.2 Problem Statement

Normally, during the commissioning test, it indicates the assessment is successful where it found the value of resistance at the chamber shows less than 2 ohms. After the grounding system operates for several years, there are some cases that shows the performance of grounding system slowly deteriorate, it means the resistance become higher than acceptable range. Therefore, the effect from this will lead to resistance grounding system is not balanced. This effect is very significant if lightning strike between 1km-10km which will cause the possibility of stray voltage between the two chambers or some chambers. The impact of stray voltage would cause the firing of Earth Leakage Circuit Breaker (ELCB) will trip and disturbing the electricity flow in building systems.

1.3 Objectives

The main objective is to investigate the profile between two grounding chamber during lightning strike. Then, regarding to this main objective, we can see the aim of this project are as follow :

1) To describe the relationship between the lightning strike distance and grounding chamber.
2) Simultaneously, we are able to monitor the potential between two chamber during lightning strike.
3) Able to determine the profile of the grounding system when the lightning strike.
4) To design a suitable sensor and design all the instrumentation layout for detecting stray voltage.

1.4 Scope of Project

In order to achieve the objective, some scope was determined in this study. The scope of our study will involve between two chambers. This is because we want to measure the potential between the two chambers. Then, this project used a high-speed oscilloscope to record the data. We have choose UTeMASA Room as a control room. Then, we will use the two grounding chambers in front of UTeMASA room. In addition, this study focus on natural cloud to ground lightning strike in the range of 1km-10km. Based on the investigation that has been done by lightning protection investigators. This distance is sufficient to effect the property of electrical system. Besides, we just want to measure stray voltage. This stray voltage is depend on the distance of the lightning strike.

1.5 Report Outline

In this report, there are three chapters altogether. Chapter 1 gives some introduction, objective and scope of this project. Literature review of this project is included in Chapter 2. This chapter reviews the related work that been done by other people as well as the existing project. Chapter 3 reveals the methodology of completing this project. For Chapter 4 is about result data review and discussion based on result. Chapter 5 will be conclusion for the project.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This subtopic reviews about the past research that relevance with this paper. The content is taken from various reports, journal, and articles. The purpose of this chapter is to understand more regarding the research of the project. In this chapter, it will consists all the theory and implementation of the components regarding the project to achieve the project objective. All the journal or article that has been taken is about the protection system, the property of soil, the tripping of protection device and the method on how to measure the stray voltage from the previous research.

2.1 Grounding Theory

Regarding to the Electrical Grounding book, Third Edition by Ronald P.O'Riley, in Chapter 1, Article 250, grounding means a conducting connection, whether it is intentional or accidental, between an electrical circuit or equipment or to conducting body that serves in place of the earth. Electrical grounding system is one part of the electric power system whose function is to provide security and protection to the user and the system. Some people think that the grounding system is easy and only had electrodes planted in the ground. Actually, this grounding system depends on several factors, including the type of soil conditions and the type of installation of the grounding system. This grounding system uses one or more electrodes that are implanted under the soil surface and depth required is between 0.75 meters to 1 meter depend on the soil resistivity (Anggoro 2012). There are several types of soil needed to install the grounding system and the best soil type is the moist soil because it has a good resistivity.

Besides that, there are several methods available in the installation of this system including vertical rods, horizontal rods, grid, plate and combination of certain types. The grounding grid substation is very important for maintaining the power system stability and safety of workers. Based on a survey conducted in China, a fundamental error that occurs was due to the basic grid substation corrosion and suffered a loss in economic terms because every mistake has reached several million. Therefore, one of the best techniques to prevent this from happening is to install a monitoring system in the place to identify the status of grounding conductor corrosion.

In China, to carry out the information about corrosion, they used method by digging around the grounding conductor and checked one by one. Substation operation needs to stop for a while for measurement and if the operation was not stopped, it would be costly (Cong-li 2007). Underground corrosion had an extensive network and uncertain because the soil resistivity can be as low as 200Ω per cubic centimeter or high 50000Ω. Besides, the concentration of electrolyte ions in the soil varies because each type of soil had differences in terms of particles, moisture, chemical properties and organic material in soil (Escalante 1981).

Corrosion of grounding system usually occurs within five up to ten years after installation and ten percent of affected depending on the type or resistivity of soil. In the United States (US), the most affected areas are in the western region of Mississippi because the land is quite dry. So, an effective coating for copper will prevent from occurring corrosion problem in substations, generation stations and other large electrical capacity installations (Escalante 1981).

2.2 How Corrosion Occurs

Corrosion was caused by inequality metal surface and exposed environment (Escalante 1981). As we know, the properties of soil is corrosive and metal are corrodible and one of the ways to detect different metals are in terms of DC voltage potential of the metal in the ground. Table 2.2.1 below shows the typical values recorded.

Table 2.2.1 Typical Potentials of Metals in Soil Measured (Escalante 1981).

TABLE 1 TYPICAL POTENTIALS OF METALS IN SOIL MEASURED FROM A COPPER-COPPER SULFATE REFERENCE ELECTRODE	
Metal	**Potential (Volts)**
Magnesium	-2.5
Aluminium	-1.3
Zinc	-1.1
Iron	-0.7
Copper	-0.2

Regarding to the Table 2.2.1 above, the metal had more negative value current would tend to discharge current and corroded. While the metal having a low negative value will collect current and protected. This means that copper has a negative value is lower and it is the best to use to install the grounding system.

2.3 Concept and Theory of Stray Voltage

Stray voltage is an unexpected voltage present between two conductive surfaces that can be simultaneously contacted by a human or animal (Xu et al. 2015). In other words, stray voltage occurs when the electrical potential between the two objects are ideal and do not need to have any voltage difference between them. Therefore, due to normal current flow in the power system, a small voltage will exist between two objects based on a separate location. Based on this project, stray voltage usually occurs when there is an electric potential between the two chamber grounding.

It is a phenomenon that has been well documented in the industry and is the voltage from neutral to earth on multi-grounded distribution system. It is usually found between 0.2 volts and 4.0 volts (Williams & Member n.d.). This voltage can appear in various locations on customer equipment. Based from the previous research, there have complaints from humans usually involves a wet area because of the resistance of the skin is low and the level of the perception of the current generated by stray voltage is low.

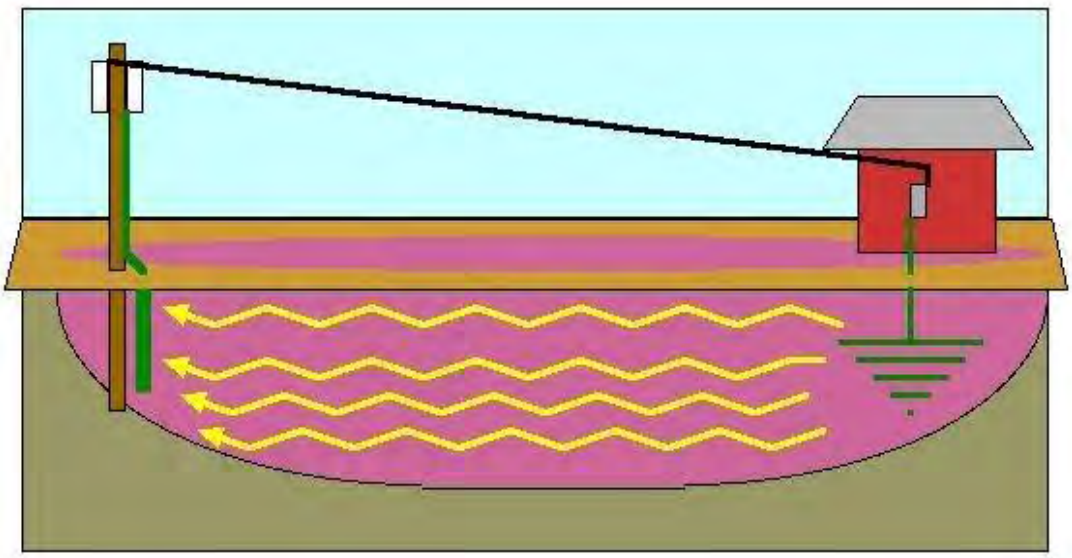

Figure 2.3.1 Cross section of a pole-supplied building with a grounding electrode system (source: http://forums.mikeholt.com/showthread.php?t=82041)

As we can see from the figure 2.3.1, the pole is supplied with a ground rod, as would be required by the NEC standards. The brown shaded has no detectable voltage. Then, the pink area of the earth is affected by stray voltage, and will have a certain amount of potential on it. As the neutral path overhead begins to deteriorate, current begins to make more use of the grounding electrodes to move the neutral current that not balanced. Figure 2.3.2 below shows the stray voltage in power transmission. A conductor who fell from power transmission lines to force the flow through the earth. The resistance of the earth will produces a voltage difference between the point of contact and distant earth. If the rate of change in voltage at a great distance there will be a potential danger of someone walking in the area.

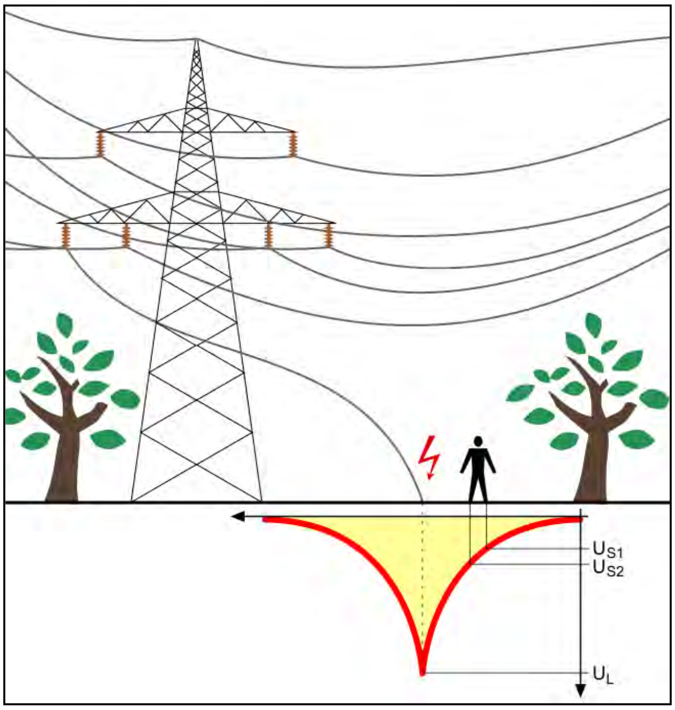

Figure 2.3.2 Stray voltage in power transmission

(Source: https://en.wikipedia.org/wiki/Stray_voltage)