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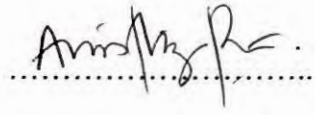
Signature	:	
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RESISTIVITY ANALYSIS IN LAYERED SOILS

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A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Industrial Power)

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JULY 2012

I declare that this report entitle "Resistivity Analysis in Layered Soils" 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 in candidature of any other degree.

Signature : .....

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Date : 02 July 2012

Specially dedicated to my beloved mother and father, my brother, my sister and all my friend. Thank you for all of the support and encouragement during my journey to gain knowledge.

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ABSTRACT

All electrical or electronic equipment must have a grounding system to protect and maintain the life cycle expectancy of device. Ground or earth is defined as a conductive mass of earth in which its electrical capacity at any point is usually taken as zero. Besides that, a grounding grid built using conductive materials buried underground horizontally to make a ground electrode, supported is typically by a number of vertical rods connected to the grid to provide low impedance current path. The purpose of grounding is to protect an electrical system and equipment when fault happen and minimize the ground potential rise during fault. In addition, there are some factors that affect grounding such as resistance, moisture, mineral salt contained in soil and weather. Furthermore, electrode grounding systems are buried in the soil and the resistance depend on the soil characteristics so, this experiment is carried out to analyze the effect of different types of soil to the performance of a grounding system. The main purpose is to construct an experiment for different type of soil using a scaled-down model. There are three types of soils that have been used in this experiment which are uniform, second layer and multi layer soils. This will include investigation of ground resistance for different types of soil, soil structure and suitable method to examine the resistivity of soil. The significant of this project is to identify the differences types of soil make on the resistivity and conclude on which type of soil gives better performance in terms of low value resistivity. Factor affecting the soil resistivity are the condition of the soil, moisture, weather, and minerals contained in the soil. In conclusion, three layer soils provide the best reading than other types of soil.

ABSTRAK

Semua peralatan elektrik atau elektronik mesti mempunyai sistem pembumian untuk melindungi dan memanjangkan jangka hayat sesuatu peranti. Tanah atau bumi ditakrifkan sebagai jisim konduktif bumi di mana kapasiti elektrik pada mana-mana titik biasanya diambil sebagai sifar. Selain itu, grid secara asasnya dibina menggunakan bahan konduktif yang ditanam di dalam tanah secara melintang untuk membuat elektrod bumi, biasanya disokong oleh beberapa rod menegak yang disambungkan ke grid untuk memberikan laluan arus semasa pada galangan yang rendah. Tujuan pembumian adalah untuk melindungi sistem elektrik dan peralatan apabila kegagalan berlaku dan meminimumkan "*ground potential rise"*. Di samping itu, terdapat beberapa faktor yang mempengaruhi nilai rintangan pembumian seperti kerintangan tanah, kelembapan, garam mineral yang terkandung di dalam tanah dan cuaca. Tambahan pula, sistem elektrod bumi telah ditanam di dalam tanah dan rintangan bergantung kepada ciri-ciri tanah, eksperimen ini dijalankan untuk menganalisis jenis tanah yang berbeza dan kesan kepada prestasi sistem pembumian. Tujuan utama adalah untuk membina satu eksperimen bagi menguji rintangan tanah yang berbeza dengan menggunakan model berskala. Selain itu, terdapat tiga jenis tanah yang telah digunakan dalam eksperimen ini iaitu tanah seragam, tanah dua lapis dan tanah tiga lapis. Kajian yang dilakukan termasuk rintangan tanah untuk setiap jenis tanah, struktur tanah dan kaedah yang sesuai untuk menguji rintangan tanah. Kepentingan projek ini adalah untuk mengenal pasti jenis tanah yang memberi prestasi yang baik melalui bacaan rintangan tanah. Faktor yang mempengaruhi kerintangan tanah adalah keadaan tanah, kelembapan, cuaca, dan mineral yang terkandung di dalam tanah. Kesimpulannya, tanah tiga lapis memberikan bacaan terbaik berbanding jenis tanah yang lain.

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LIST OF ABBREVIATIONS

UTeM	-	Universiti Teknikal Malaysia Melaka
BS	-	British Standard
IEC	-	International Electrotechnical Commission
IEEE	-	Institute of Electric and Electronic Engineers
ST	-	Suruhanjaya Tenaga
TNBD	-	Tenaga Nasional Berhad Distribution
GPR	-	Ground Potential Rise

LIST OF SYMBOLS

Ω	-	Ohm
A	-	Ampere
V	-	Volt
K	-	kilo
Cm	-	centimeters
m	-	meter
mm	-	millimeter

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CHAPTER 1

INTRODUCTION

This chapter will discuss about the definition and function of grounding system. The importance of grounding for electrical system and safety consideration in grounding. In addition, problem statement, objective and scope will be discussed in this chapter.

1.1 Grounding System

Grounding in the electricity supply system is defined as a continuity of the flow of a circuit or electrical equipment connected to the mass of earth. This connection is made to establish and maintain the earth potential in an electrical circuit connection. The connection must be installed correctly so that the resistance for the grounding circuit can be smaller than the load or electrical equipment. Refer to [1], grounding means that all electrical circuits should be connected to earth so that, the grounding can protects the electrical circuit.

Grounding system is actually the system that has ground electrodes which is a form of meshes electrodes that is constructed as a grid place horizontally at shallow depth, added by some of vertical rods connected to the grid. In addition, grounded system also means a system that has at least one point of purposely grounded conductor, whether solidly or through impedance. If the soil has a mesh grid buried with good conductivity, grounding system will be improved and current can flow properly. Grounding system plays a very important role in order to protect an electrical system and surrounding when fault

happens. It is also an effort to increase the reliability of the electrical supply and achieve the stability of voltage conditions. Besides that, the grounding system helps to prevent the over voltage peaks during fault and provides a measures of protection against lightning. Grounding system has been designed to minimize the unsafe situations and the subnormal property and integrity of the electrical system [2].

1.2 Problem Statement

The resistance of earth electrode is influenced by several parameters. The primary characteristic that needs to be justified is the resistivity of the soil. Different soil types and composition will result in varying resistivity values and this will affect the design of grounding system. Therefore a study on the correlation between soil types and its resistivity will improve the quality of the grounding system design.

Soil resistivity may also be affected by elements such as humidity and the salt mineral contained in the soil itself. Thus, the impacts of these elements to the soil resistivity require experimental investigation to determine it is significant effect on the soils resistivity.

1.3 Objective

They are three main objectives for this final year project. The objectives to be accomplished are:

a) To construct an experiment for different types of soil using scaled-down model.
b) To determine the suitable method to examine soil resistivity, collect data and compare the value of resistance and resistivity for different types of soil.
c) To measure soil resistance for the different types of soils and calculate soil resistivity of each type of soil.
d) To improve value soil resistivity with treatment the soil.

1.4 Project Scope

The scopes for this project are:

(a) Location of the experiment to be conducted.

i. The project being done at laboratory Centre of Excellent, Research and Innovative (CERIA) Universiti Teknikal Malaysia Melaka (UTeM).

(b) Electrolytic tank as scale model used for examine and analyze the grounding performances.

(c) Soil structure used for this experiment

i. Uniform
   - Peat

ii. Two layer
   - First layer: Peat soil
   - Second layer: Loam and clay add with sand

iii. Multi-layer
   - First layer: Peat soil
   - Second layer: Loam and clay added with sand
   - Third layer: Rock

(d) Method to test grounding system

i. Electrode test

(e) Apparatus that are used in this experiment

i. Earthing tester
ii. Fluke Hygrometer
iii. Multimeter
iv. DC power supply
v. Copper rod and wire
vi. Binding post

(f) Standard used for testing

i. BS 6651: Practice for Protection of Structures Against Lightning
ii. BS 7430: Practice of Earthing
iii. BS 1377-3: Determination electrochemical and corrosivity properties of soil and water samples.
iv. IEC 60364-1: Electrical Installation of Building
v. IEEE std 80-1986 Guide for Safety in AC Substation Grounding

(g) Malaysian Standard regulation

i. Suruhanjaya Tenaga Malaysia
ii. Electricity Regulation 1994, Act 447
iii. Electrical Safety Rules TNBD

CHAPTER 2

LITERATURE REVIEW

This chapter briefly explains the grounding system in term of different soil layers and the effects to the soil resistivity. This can be referred from literature reviews from journal published. In addition, this chapter will present terms including, soil resistivity, grounding impedances, earth potential and method that can be used to examine the soil resistivity.

2.1 Definition

Grounding is important to protect human, equipment and circuit from short circuit and lightning strike. There are several parts in grounding which are ground, grounding conductor, grounding electrode and bonding. Ground means a conducting connection between an electrical circuit or equipment and the earth or others conducting body. Meanwhile, grounding conductor is a conductor used to connect equipment to ground but for grounding electrode refer to metal component such as water pipe connected to ground. Besides, bonding means the joining of metal components to form a conductive path. In other hand, the grounding system can be known as the electrical potential of the electrical equipment that interfaces to the earth surface. When deciding to choose any type of grounding, the safety and electromagnetic compatibility of the power supply need to be considered. In grounding systems there are many regulation standards for grounding system and each country have their own standard.

Here is the example of a national standard that applies by the British, United States (U.S.) and Malaysia:

i. BS 7430: Practice of Earthing (BS 7430: 1998)
BS 7430 states grounding is to install earthing system in correctly to make sure the equipment and people in safe condition [22].

ii. IEC 60364-1: Electrical Installation of Building
The IEC electrical grounding system is divided into three main families using two letter code of TN, TT, and IT.

iii. IEEE Guide for Safety in Substation Grounding, New York, NY (ANSI/IEEE Std. 80)
Refer to [18], electric circuit or equipment link to earth or body as a conductor whether intentional or unintentional must functional and properly grounded.

iv. Suruhanjaya Tenaga Malaysia (Malaysian Standard)
Refer to ST standard grounding is a system which made up the connection among metals in electrical wiring with earth. They have two earthing system which is grounding the equipment and grounding the system [1].

v. Electricity Regulation 1994, Act 447 regulation No 34(1) (Malaysian Standard)
This regulation states all metal sheath, cover, and handle, joint box except of class ii (whole wood) construction which indirect contact or double insulated equipment shall be grounded. System TNC and IT for grounding are not permitted by this regulation except have special approved obtained from the Director General.

2.2 Fundamentals of Grounding

Short circuit and transient phenomena (lightning and switching operation) occurred at any time and grounding safety practice has two main objectives which are to protect system (personnel safety) from fault and equipment protection. Besides, the main consideration when designing the grounding system [2]:

i. To prevent any danger to the person, the grid must work to reduce the voltage between two points. Step voltage, touch voltage and mesh potential are important criteria need to consider.

ii. When fault occur, maximum fault current flow at grid and the grid should be able to withstand.

iii. The grid design needs to minimize the Ground Potential Rise (GPR) so that current flows pass through that electrode impedance easily.

2.3 Grounding Medium

Soils consists of three main component which are mineral that come from organic matter, mineral that come from rocks below and the living organisms that reside in the soil. In grounding system, soils are a main part that behaves as conductor with resistance and as dielectric. It also can be represented by a pure resistance.