

**ANALYSIS OF TFR BASED ON HIGH-LOW SOIL STRUCTURE  
CONFIGURATION**

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**Bachelor of Electrical Engineering (Industrial Power)**

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**ANALYSIS OF TFR BASED ON HIGH-LOW SOIL STRUCTURE  
CONFIGURATION**

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**2015**

“I hereby declared that I have read through this report entitle “Analysis of TFR based on the high-low soil structure configuration” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering.”

Signature : .....

Supervisor's Name : .....

Date : .....

To my beloved mother and father

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I declare that this report entitle “Analysis of TFR based on the high-low soil structure configuration” is the result of my own project 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.

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## ABSTRACT

This project analysed of tower footing resistance (TFR) on high-low soil structure configuration. Soil is the mixture of many natural resources in earth crust. There are many type of soil and every type of soil has different properties. Therefore, different soil properties give a difference earth resistance. The aim of the project is determine the TFR analysis based on the soil structure, study the effect of chemical contain in the soil and identify the relationship between soil resistivity with the dissolved salt solution. This project only determines the analysis of the high-low soil structure configuration for tower footing resistance. There are some method use for determine the tower footing resistance and soil resistance. Wenner Arrangement and Fall-of-Potential Method are used in measurement in this project. MR and dissolved salt are used in this project to analyse TFR values. The result in this project is to improve transmission tower footing resistance for better grounding system. As known, good earthing can save equipment and human life.

## ABSTRAK

Projek ini menganalisa rintangan kaki menara atau tower-footing-resistance (TFR) kepada konfigurasi struktur tanah yang berjenis tinggi-rendah (High-low). Tanah merupakan campuran pelbagai sumber semulajadi yang berada di atas bumi kerak. Terdapat banyak jenis tanah di atas kerak bumi dan setiap jenis tanah mempunyai ciri-ciri yang berbeza. Oleh itu, ciri-ciri tanah yang berbeza memberikan nilai rintangan yang berbeza pada TFR. Tujuan Projek ini adalah menganalisa TFR berdasarkan struktur tanah, mengkaji kesan bahan kimia yang terkandung di dalam tanah kepada TFR dan mengenalpasti hubungan antara kerintangan tanah dengan larutan garam. Projek ini hanya terhad kepada analisa konfigurasi struktur tanah tinggi-rendah untuk TFR. Terdapat beberapa kaedah yang digunakan untuk menentukan nilai TFR dan rintangan tanah. Wenner Arrangement dan Fall-of-Potential Method adalah teknik yang digunakan untuk pengukuran dalam projek ini. Micro-Reservoir (MR) dan garam terlarut adalah bahan yang digunakan dalam projek ini untuk menganalisa nilai-nilai TFR. Hasil projek ini adalah untuk menambahbaik nilai TFR untuk reka bentuk sebuah sistem pbumian yang lebih baik. Seperti yang diketahui, pbumian yang baik boleh menyelamatkan peralatan dan juga dapat menyelamatkan nyawa.



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**LIST OF SYMBOL**

A	-	Ampere
a	-	Distance between two Electrode
°C	-	Celsius
CaCl <sub>2</sub>	-	Calcium Chloride
CuSO <sub>4</sub>	-	Copper(II) Sulphate
d, D	-	Diameter
FOP	-	Fall-of-Potential
FYP	-	Final Year Project
I	-	Current
<i>l</i>	-	Length
LRM	-	Low Resistance Material
m	-	Meter
MgSO <sub>4</sub>	-	Magnesium Sulphate
MR	-	Moisture Reservoir
NaCl	-	Sodium Chloride
Pcs	-	Pieces
R	-	Resistance
SV	-	Supervisor



TFR	-	Tower Footing Resistance
V	-	Volt
$\pi$	-	Pi
$\rho$	-	Soil Resistivity
$\Omega$	-	Ohm

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Motivation

Soil is the mixture of many natural resources like mineral, organic matter, gases and organism in earth crust. These soils have been mapped on swampy terrain, level, undulating, rolling, hilly and mountainous. It is occurring depend at high and low attitudes. Other than that, every place has a different value of soil structure and properties. Nowadays, grounding system or known as earthing system is very importance to protect the equipment and prevent electrical shock. Especially during lightning or fault occurs. Soil structure configuration has relationship with the grounding system in electrical. The soil structure configuration and soil resistivity affects the grounding system efficiency. Lower ground resistance give higher grounding protection. High chemical contain in the soil effect the ground resistance. Adding more chemical contain such as NaCl to the soil will decrease ground resistance. Good grounding system can be achieved when soil resistance value are lower.

## 1.2 Problem Statement

As known, every place has a difference type of soil configuration. Malaysia has variety type of soils. Every soil configuration have they own properties. In electrical system, grounding system need to be connected into the circuit for safety precaution. There are some specifications that must be fulfilled to design good grounding system. Soil structure configuration indirectly involved to design good grounding system. From the previous research, the TFR value quite higher. TFR must achieve below  $10 \Omega$  for tower grounding resistance. Therefore, this project will help to analysed Tower Footing Resistance (TFR) based on the high-low soil structure configuration. Other than that, this project will help to identify the effect of salt to the soil resistivity.

## 1.3 Objective

The main objective of this project is:

- i. To determine the analysis of Tower Footing Resistance (TFR) based on the analysis based on the high- low soil structure configuration.
- ii. To study the effect of moisture to the soil resistivity.
- iii. To study the relationship of soil resistivity to salt dissolved soil configuration.

## 1.4 Scope

This project only covers the analysis of TFR based on high-low soil structure configuration only. The other types of soil structure configuration are not involved. Other than that, this project will be carried out nearby Block F, Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka. This project will determine the relationship of soil

resistivity to the salt dissolved into soil configuration. Only circular pit salt installation method is used to install the salt. Result of soil configuration model for two set of TFR will be use as result comparison. Both set of TFR will applied with Micro Reservoir but only Set 1 will applied with salt dissolved. For this project, Micro Reservoir is applied to maintain the moisture in the soil to prevent random error caused by rain. The parameter used in this project is Potential Difference, Volt (V), Current, I (Ampere), Resistance, R ( $\Omega$ ), Distance, d (m) and Resistivity ( $\Omega\text{m}$ ). Wenner 4 Pin Method is used to measure soil resistivity and Fall-of-Potential Method is used to measure TFR value.

## 1.5 Thesis Outline

This project has 5 chapters. Introduction is the first chapter which contain motivation, problem statement, project objective and scope of the project. In first chapter describe what the issues of the problem arise; the objective and scope will guide the researcher from off topic. In Chapter 2, Literature Review contains a lot of paper, journal, conference, previous research and technical manual that related to the project. There are several topics that related to this project which are grounding testing method, designing TFR, factors that affect soil resistivity and TFR, differences of high-low and low-high soil structure configuration and standard guidelines. Methodology is in Chapter 3. Methodology describes the flow of the project and analysis parts are proceeding. The list of equipment and project setup procedure is parts of methodology. In this project, there are two testing method to measure parameter. Another part of methodology is discussing the testing procedure, measurement parameter and analysis part. Result and Discussion are in Chapter 4. All of measured data are recorded and data are analysed. The value of soil resistivity and TFR are analysed. Result will be presented in form table, graph, calculation or simulation. The effect of salt dissolved to TFR and soil resistivity will discuss in this chapter. The last chapter is Chapter 5. This chapter is Conclusion and Recommendation. This chapter will state the significant conclusion and give some recommendation to improve the project for further project.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

Tower footing resistance (TFR) usually measured at TNB transmission tower. Tower footing resistance help to reducing back flashover occurrence. Lower value of earthing resistance is needed for each TNB transmission tower. The value of earthing resistance depends on the value of transmission voltage. For 132 kV and 275 kV transmission towers must be lower than 10  $\Omega$  and 500 kV transmission tower must have lower than 5  $\Omega$  of tower footing resistance. TNB standard tower design use stranded galvanised-iron conductor rod as the earthing electrode. Four tower footings will connect to this conductor rod together and 1.2 m cooper-clad steel rod installed in the center [1, 2].

#### 2.2 Review of previous related works

Before this project start, there are some previous works that related to this project. One of the project discuss about TFR in a journal titled as A Practical Evaluation of surge Arrester Placement for Transmission Line Lightning Protection [1]. The authors explain briefly about the TFR calculation and the important of TFR in transmission line. Other than that, in other journal titled as Grounding Resistance Measurement using Fall-of-

Potential Probe Located in Opposite Direction to Current Probe discuss about the effect in measurement if some of the probe are located in different angles [2]. In that paper state that some of the angle in measuring using Fall-of-Potential method will give inaccurate value of ground resistance. Besides that, in conference paper titled Effects of Salt Content on Measurement of Soil Resistivity discuss the effect of salt to soil resistance [3]. In that paper also discuss about the chemical reaction in the soil structure between copper rod and salt solution. Other than that, from that project, it proves the salt absolutely suitable used in grounding. Other than that, in journal titled Analysis of Earth Resistance of Electrodes and Soil Resistivity at Different Environments discuss analysed the value of soil resistivity in different type of soil [4]. Therefore, all of this paper related to this project for TFR and soil resistivity analysis.

### **2.2.1 Previous Work 1: A Practical Evaluation of surge Arrester Placement for Transmission Line Lightning Protection [1]**

In this paper, lightning protection design was evaluated. Other than that, 115 kV transmission line is used by researcher. Tower Footing Resistance is very importance equipment for lightning protection. This paper explain briefly how to get the value of changing resistance by analysis of TFR , lightning current and limitation current. This paper explain briefly the effect of soil ionization gradient and soil resistivity to limitation current that can be initiate soil ionization.

### **2.2.2 Previous Work 2: Grounding Resistance Measurement using Fall-of-Potential Probe Located in Opposite Direction to Current Probe [2]**

In this paper, Fall-of-Potential have some error in measure grounding resistance. This paper briefly explained measurement error can be occurred. Based on paper analysis,

the best probe arrangement is in a straight line. However, the potential probe usually could not be located in straight line. This is because the building, roadblock or metallic pipe at that position. Because of that, the potential probe needs to be located at opposite side of earth electrode and current probe. In other ways, potential probe needs to be located in range from  $90^\circ$  to  $270^\circ$ .

### **2.2.3 Previous Work 3: Effects of Salt Content on Measurement of Soil Resistivity [3]**

In this paper, soil resistivity is the important factor that could be considered in choosing suitable grounding area. The experiment was carried out on the grounding zone of the University Technology MARA. Soils that have high moisture and salt content and also exposed to high temperature can influence the soil resistivity. Ground resisting is a technique used to identify the effectivity of the certain ground for building. This paper explains briefly about chemical reactions of NaCl with copper rod in ionization process. As the result, the resistivity value will decrease when salt are added into the soil.

### **2.2.4 Previous Work 4: Analysis of Earth Resistance of Electrodes and Soil Resistivity at Different Environments [4]**

In this paper, the values of soil resistivity are much related to the environment. This project shows the relationship of type of soil and soil resistivity. There are 5 different locations in this project and every location has a different value of soil resistivity. It shows that the lower resistivity happened at lowland and wet soil. The higher soil resistivity is at barrel land and hill. As the result, the type of soil or environment one factor that related that affected the soil resistivity value.