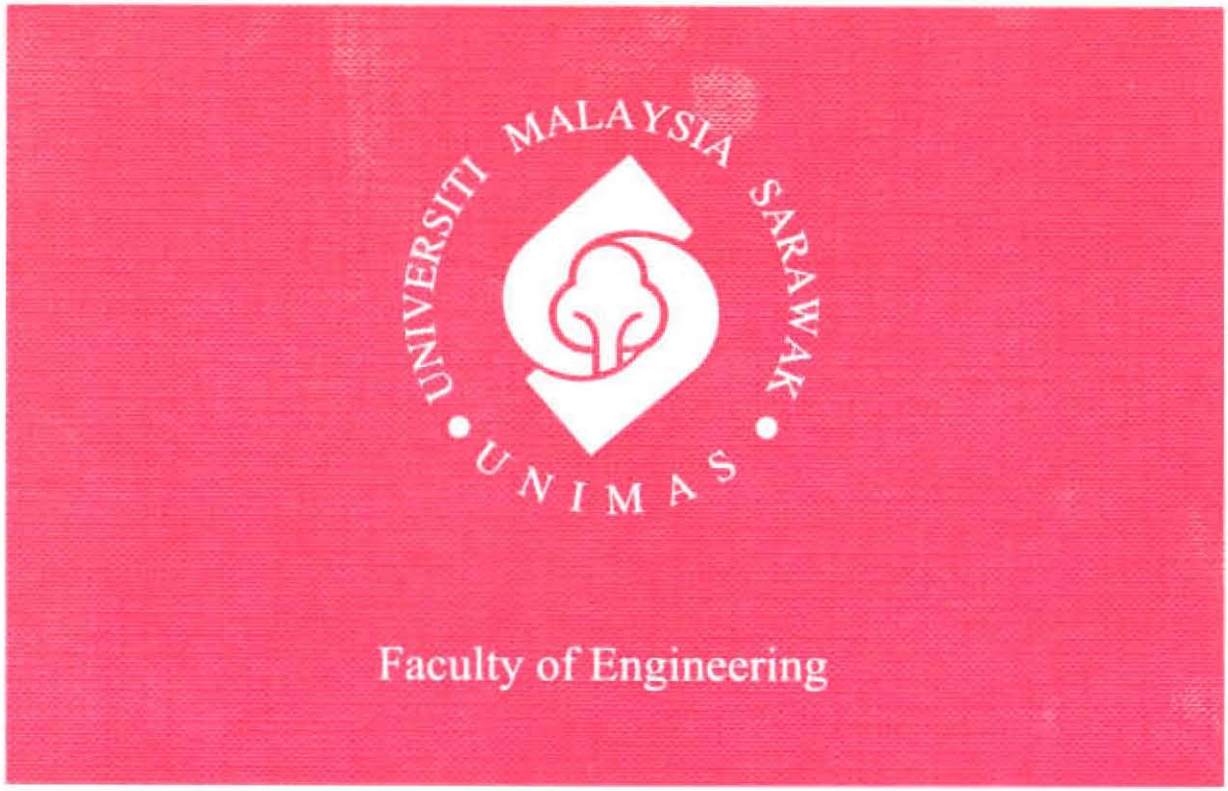

EXPERIMENTAL STUDY BETWEEN GALVANIZED IRON AND COPPER AS JOINING CABLE IN EARTHING SYSTEM

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Bachelor of Engineering (Hons) in Electronics (Computer)
2017

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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Final Year Project Report ☑

Masters ☐

PhD ☐

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This declaration is made on the 14 day of JULY 2017.

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EXPERIMENTAL STUDY BETWEEN GALVANIZED IRON AND COPPER AS JOINING CABLE IN EARTHING SYSTEM

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A dissertation submitted in partial fulfillment of
the requirement for the degree of
Bachelor of Engineering (Hons)
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Dedicated to my beloved family and
in memory of Reverend David Banta, Sinken Buli and Layah Suka.

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ABSTRACT

Earthing system refers to buried electrodes to ground as a path of electrons from electrical appliances to flow back to the earth and bonding system refers to connection or cable joined from transmission tower to building and from building to earthing rods. Copper has been extensively used in both earthing and bonding system. However, constant increase of copper price has caused doubt regarding the continuing usage of copper in electrical system in the long run. The increase of copper price has lead to illegal and dangerous activity such as copper rod and cable theft. This study is conducted to find the alternative metal to replace copper for the bonding system. Galvanized iron is selected for this study as it is cheap and widely available. The experiment consists of two set which each set consists of four electrodes and are bonded with copper wire and galvanized iron respectively. The data monitoring had been conducted for 30 days at an open space in Kota Samarahan under varying weather condition and it results that galvanized iron (GI) shows significance difference in earth resistance with difference soil resistivity. Wenner Arrangement method is used to measure the soil resistivity of the setup. To conclude, galvanized iron (GI) wire has a capability to replace copper only if more copper electrode is buried to stabilize the resistance with copper resistance. Besides that, the corrosion rate must be control in the usage of galvanized iron in earthing and bonding system as it affects the resistivity of both system.

ABSTRAK

Sistem pembumian merujuk kepada elektrod dikebumikan ke tanah sebagai jalan elektron dari perkakas elektrik mengalir kembali kepada sistem bumi dan sistem ikatan merujuk kepada sambungan atau kabel dari menara penghantaran ke bangunan dan dari bangunan ke rod pembumian. Tembaga telah digunakan secara meluas di dalam sistem pembumian dan sistem ikatan. Walau bagaimanapun, peningkatan harga tembaga yang berterusan telah menimbulkan keraguan mengenai penggunaan tembaga dalam sistem penghantaran elektrik dalam jangka masa panjang . Peningkatan harga tembaga telah membawa kepada aktiviti haram dan berbahaya seperti kecurian rod tembaga dan kabel. Kajian ini dijalankan untuk mencari logam alternatif untuk menggantikan tembaga untuk sistem ikatan. Besi bergalvani telah dipilih untuk kajian ini kerana ia adalah murah dan boleh didapati secara meluas. Percubaan terdiri dari dua set yang mana setiap set terdiri daripada empat elektrod dan terikat masing-masing dengan dawai tembaga dan besi tergalvani. Pemantauan data telah dijalankan selama 30 hari di kawasan lapang di Kota Samarahan dengan keadaan cuaca yang berbeza-beza dan ia menunjukkan bahawa besi bergalvani (GI) menunjukkan perbezaan yang signifikan dalam rintangan bumi dengan kerintangan perbezaan tanah. Wenner Arrangement telah digunakan untuk mengukur kerintangan tanah persediaan. Kesimpulan daripada eksperimen ini, besi bergalvani (GI) wayar mempunyai keupayaan untuk menggantikan tembaga jika lebih banyak tembaga elektrod dikebumikan untuk menstabilkan rintangan dengan rintangan tembaga. Selain itu juga, tahap kekakisan harus diatasi di dalam penggunaan sepenuhnya besi bergalvani dalam sistem pembumian dan ikatan kerana tahap kekasisan berkait rapat dengan nilai rintangan sistem-sistem tersebut.

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LIST OF SYMBOLS

Ω	-	Ohm
Ω-m	-	Ohm per meter
d	-	Diameter of driven rod
l	-	Length of rod into the ground
R	-	Resistance measured by the machine
ln	-	Natural logarithm
π	-	Pi
V	-	Voltage
I	-	Current
a	-	Distance between each probe
L	-	Distance from the outer probe to the center
l	-	Distance from the inner probe to the center
R_{impulse}	-	Impulse resistance
V	-	Volume of soil *(Sphere of Influence*)

LIST OF ABBREVIATIONS

AC	-	Alternate current
Al	-	Gold
C	-	Celsius
F	-	Fahrenheit
FEM	-	Finite element method
GEM	-	Ground enhancement method
GI	-	Galvanized iron
GPR	-	Ground potential rise
IEEE	-	Institute of Electrical and Electronics Engineers
LEA	-	Local Electrical Authority
NEC	-	National Electrical Code
SEB	-	Sarawak Energy Berhad
TNB	-	Tenaga Nasional Berhad

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter discusses on the background of the study. It provides the statement of the problem, motivation of the study, proposed solution of the study, study objectives, scope of the experiment and summary of the report. It also gives detail on metal that is used in earthing system currently and the alternative metal that is possible to replace the current metal.

1.1 Earthing System and Bonding System

Earthing system (grounding system) is essential part in every electrical appliances for safety purposes towards sensitive appliances and human being. Earthing system refers to electrical connection to the ground [1]. Earthing and bonding are systems that are related to one another. Grounding and earthing differ only due to terms referred by the American and British. Earthing refers the flow back of the electrical current to earth while bonding refers to the connection between earthing system to the grid.

Earthing system is part of electric power system that are vital in generation, transmission and distributing electricity in order to provide a safe and proper operation of any electrical installation. Earthing system is referring to the installation of earthing electrodes into the ground to ensure the electrons from the electrical appliances flows back to the earth. The electrode functions as a point and it is vital to be install to the earth to avoid electrons flows into human. Basically, earthing system refers to the attachment of earth with electrical appliances as earth is a good conductor to electrical current in order to results zero voltage point and avoid danger to human and environment.

Bonding system refers to two electrical conductors joined together by wire or pipe. Bonding purpose is to set up an operative path for fault current that in return facilitates the operation of the over current protective device [2]. Without bonding system, it is impossible for the electric current to flow from the substation to buildings surrounding. Hence, it will disrupt the daily activity and all electrical appliances will unable to function. By bonding system, electrical current from the house or building will flow to the grounding electrode then will flow back to the earth and cycle will keep on repeating.. The cycle of electric current is considered complete when there is no intrusion in the cycle.

1.2 Background of the study

Buildings that consists of sensitive equipment must have a high quality standards of design in aspect of wiring and earthing to ensure the system does not create unwanted incidents such as explosion and fire. It is necessary to design a system properly and maintain the wiring and earthing systems to ensure the safety aspect and protection for both personnel and environment. Besides that, it is to avoid instrumentation error and bias in electric and electronic system.

Efficient earthing system in electrical environment results low level of electrical noise and ensure a safe performance of sensitive electronic equipment. A building earthing system consists of earth-grounding system and equipment-grounding system. It also consists of lightning-protection system and signal-reference system that is necessary for protection and performance of a system. The faulty in power and grounding of sensitive equipment emerge a concern for most industrial companies and telecommunication companies. The resistance of earthing system varies with the type of building and equipment such as:

Table 1.1 Range of resistance for buildings and equipment

Type of building or equipment	Resistance, Ω
Domestic dwellings and factories	100
Switch gear	10
Substations and power station	1

Electrical fatality or accidents happen mostly due to improper grounding and bonding. Earth potential when power system earth is at fault might put people surrounding the earthing system at risk. Hence, earthing system design is vital and a concern in terms of safety and control in power system. The earth electrode resistance are preserved to be low value so the current will spread at the ground smoothly. Safety of human, conductivity and permeability of the metal used for earthing system must be considered in earthing system.

Earthing is essential especially for AC power system as it functions in three way [3]. First, limiting the voltages generate from any accidental contact with high voltage conductors or by lightning. Lightning strike is one of the deadliest attack as no human is able to withstand strike of million kilowatt of current. Hence, earthing system functions as a secure path for current to return back to earth and reduce both damage and fatality. Secondly, it is to stabilize voltage under normal conditions. Voltage has a variable figure and it is hard to determine the exact voltage flow. Thus in order to ensure the electrical appliances and building to have almost similar voltage to the various voltage source, grounding system functions to fix the variable voltages. Lastly, to facilitate the operation of over current devices underground-fault conditions. This is the main reason of earthing system as over-current might harm both human and environment.

National Electrical Code Articles 250.4 (A) emphasizes on codes regarding earthing and bonding system that needed to be considered by electrical personnel in conducting and handling both earthing and bonding system [4]. However in Sarawak particularly, Local Electricity Authority (LEA) have set a rule that 35 mm^2 bare copper cables must be used to join ground rods to another rod and from the rod to the switch gear. Currently, copper is used for both grounding and bonding system due to its conductivity and permeability level. In this experimental study, galvanized iron is selected as it has the nearest compatibility to copper metal in aspect of resistance and conductivity.

1.3 Project Motivation

This project is conducted to find the suitable metal grounding rod to replace the bonding system. Copper is used as a standard metal for electrical cable. As a replacement, galvanized iron is chosen as it has the nearest compatibility with copper. Aspect to be consider in this study are the resistance level between each rod and also the temperature and weather surrounding the setup. Galvanized iron compared to copper is

cheaper in price but it has high corrosion level than copper. With the current increase of copper theft which does not only happen in Malaysia but in other developed and undeveloped countries and also with the increase of market value of copper are the motivation for this study to be conducted.

1.4 Problem Statement

Copper compared to any other metal is the best metal to be used in earthing system due to its low resistance and low corrosion level. Therefore, any big electrical company, consultants and engineers prefers to use copper as their standard material for earthing system. Sarawak Energy Berhad (SEB) alongside with Shorefield (second largest electric installation company after SEB) are also using copper as the main metal for both earthing and bonding system..

Unfortunately, in Malaysia, like any other countries face the same issue regarding the earthing and bonding system which is copper theft. The increase of copper price around the world is the biggest contribution to this crime. Copper is an industrial-used metal and become the main attraction of theft as the price of copper increase corresponding to the demand and become biggest threats to electrical system [8]. In electrical industry, this crime contributes not only power lost and high expansion to restore the damage but also the safety of personal and people surrounding. According Utusan Malaysia on 9th July 2013 [5], Tenaga Nasional Berhad Malaysia (TNB) had recorded a total loss of RM180mil due to copper cable theft at its substations in the peninsula for the 10 years. Sarawak Energy Berhad (SEB) particularly had recorded 383 cases of stolen cable since 2015 and has spent more than RM2 million for restoration of the destructed equipment for past two years [6].

Copper theft in electrical field is commonly heard nowadays however less are aware the risk of these illegal activity. One of the concern regarding these activities is the level of electric shock one might faced. The electric shock one might experienced from the illegal activity are not a common shock most had experienced in daily life but it involved thousand volts, which is almost similar to lightning strike and it may lead to death. In West Yorkshire (2011), James Sorby aged 22 suffered burns after being hit by 22000 volts when attempt to steal copper cable [7]. Malaysia had recorded few cases of stealing copper cable but recorded no fatal cases due to electric shock from the attempt yet.

There were few cases recorded related to copper cable theft in past ten years. On 1st May 2008, a power transmission tower had collapsed in Sabah due to missing of structural component of the tower which lead to a massive blackout throughout the state and caused death to one personnel from Tenaga Nasional Berhad (TNB) and injury to four other personnel during the emergency repair of the collapsed tower few weeks later [5]. Early 2017, Sarawak Energy Berhad (SEB) had recorded four cases related to copper cable theft in consecutive two days and resulted to power outages and damaged equipment in several premises at Kuching and Bintulu areas [6].

1.5 Project Proposed Solution

There are few ways to overcome issue related to copper theft in earthing system which are by using a low value of scrap metal as material, increasing the difficulty of metal theft, building the grounding system based on design and apply extreme penalties on copper theft and industries that accept the transaction of stolen materials [10]. In aspect of market price, galvanized iron wire is more cheaper than copper thus it may results to less attraction to theft.

Thus, the proposed solution for this matter in Malaysia is to replace the 35 mm^2 bare copper wire with galvanized iron (GI) wire as galvanized iron has a slight potential as an alternative replacement of copper wire. The installation cost can be reduced by using galvanized iron as the bonding metal. In this experiment, 8 copper rod and 4 mm^2 copper wire and galvanized iron wire respectively is used and each set consists of 4 copper rod and one set is bond with copper wire and another set is bond with galvanized iron (GI) wire.

In the beginning of the experiment, the resistance value of one copper rod is determined before it is installed to the ground. Besides that, the type of soil where the copper rod is buried is determined as it is an important factor that will affect the resistance of all the copper rod buried. Another factor to be considered in this experiment is weather. In this experiment, the data will be collected in the same weather to avoid bias in data measurement.

1.6 Problem Objective

Specifically, the study is to fulfill the following objectives:

1. To analyze the potential of galvanized iron to replace copper as joining cable.
2. To determine the resistance value of galvanized iron and copper under one type of soil resistivity at an open space.
3. To study the correlation of galvanized iron and copper with environmental factors in Kota Samarahan.

1.7 Scope of project

In order to achieve the objective of this experiment, there are several scopes that needed to be reckon which are:

1. This experiment focuses on the resistance value between galvanized iron wire and copper wire.
2. The experiment is to determine which metal is suitable to generate low resistance level for earthing and bonding system.
3. This experiment begin on 1st March 2017 and data are collected for consecutive 30 days.
4. The experiment is conducted at the same place and same weather (if the particular time is raining, data will be only collected after it)
5. Data is taken twice a day, in the morning and in the evening.
6. This experiment consist of two set (Set A is for copper wire and Set B is for galvanized iron wire)
7. For each set, 4 copper rod is buried in straight line and respective wire is attached to each rod.
8. The resistance value for each joining of the set is taken three times and the mean of the three data is the final value of the resistance.
9. The final value of the resistance is recorded in table and the data is analyzed in graph form.

1.8 Report Summary

The final year project report consists of five chapters. The main chapters of this report are introduction, literature review, methodology, results and interpretation and lastly conclusion and recommendation.

Chapter 1 is the introduction of this research which consists of introduction of the study. It also summarized the background and scope of this experiment. In addition, it consists of the objective of the study based on the problem faced in real world and proposed solution as well as the expected outcome of the experimental study.

Chapter 2 describe the international code applied on the grounding and bonding system and the theory of grounding and bonding system. This chapter discuss the methods to measure soil resistivity and criterion of soil suitable for grounding and bonding system. At the end of this chapter discuss about the outcome of the previous work regarding grounding system, bonding system, soil resistivity and earth resistance.

Chapter 3 discuss the methodology of this experiment and procedures of the experiment execution. This chapter is vital for reference in conducting the experiment and to ensure the objective of this study is achieved. In addition, this chapter is the guideline for the experimental study to avoid out of the project scope.

Chapter 4 cover the results of the experiment and analysis obtained based on the results. Calculation based on the results are included in this chapter.

Chapter 5 is the conclusion based on the data that had been gathered. Type of wire and soil resistivity value that are suitable for the bonding system will be discuss in this chapter. This chapter consists of recommendations for the future work and the management of the experiment.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will discusses on four main ideas of the experimental study which are earthing system, bonding system, soil resistivity and earth resistance measurement. Besides that, this chapter consists of previous works or study that had been conducted regarding the four main ideas of this experimental study.

2.1 National Electrical Code (NEC) Article 250

Earthing system is vital in generating electric current from substation to buildings and flow back from buildings to ground. Earthing system consists of horizontal buried conductors known as earth rod and the main metal used as earth rod is copper. According to 2005 edition of National Electrical Code (NEC) Article 250 [4], earthing must be intentionally low impedance for faulty current path and also defined as capacity to carry ground faulty current. Every electrical and sensitive electronic system must be grounded to limit the high voltage level to the earth under normal circumstances. Earthing is necessary for operation of protection devices, therefore reduces voltages stern of electrical insulators. Limiting the imposed voltage is to be considered as earthing electrode conductors affect the system.