STUDY OF ELECTROMAGNETIC FIELD EXPOSURE UNDER TRANSMISSION LINE BY USING FINITE ELEMENT METHOD

LEE ZHER YE

FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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LEE ZHER YE

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DECLARATION

I declare that this thesis entitled " STUDY OF ELECTROMAGNETIC FIELD EXPOSURE UNDER TRANSMISSION LINE BY USING FINITE ELEMENT METHOD" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : LEE ZHER YE

Date : 4/7/2021

APPROVAL

I hereby declare that I have checked this report entitled "STUDY OF ELECTOMAGNETIC FIELD EXPOSURE UNDER TRANSMISSION LINE BY USING FINITE ELEMENT METHOD" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours.

Signature : .....

Supervisor Name : IR. DR. SHARIN BIN AB. GHANI
PENSYARAH KANAN
Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

Date : 5/7/2021

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Due to the evolution of the technology and industry, electricity has become more vital in human's daily life. To fulfil the demand of electricity supply to residential and industry area, more and more transmission line have been built to transmit electrical energy from generating station to distribution units. However, studies have shown that transmission line emits electromagnetic radiation that bring negative impacts to human. Therefore, this report is aimed to study on electromagnetic field generated by transmission line at human height level. In order to study on the electric field, Comsol Multiphysics, a finite element based software has been used to simulate the electric field and magnetic field generated by transmission line. Finite element based simulation method is used in this project because analytical method is difficult to handle complex geometry engineering problem and practical measurement is time consuming and is more dangerous. The electric and magnetic field generated by transmission line is first computed and validated by comparing to previous studies. After the validation process, some parameters of transmission line including voltage of conductor, current carried by conductor, radius of conductor and horizontal phase spacing. The results shows that the electric field intensity increase while voltage of conductor increase, radius of conductor increase and horizontal phase spacing increase. Besides, magnetic field intensity increase when current in conductor increase and decrease while horizontal phase spacing increase. Radius of conductor has no impact on magnetic field intensity. For the generated transmission line model, voltage of 700kV above will exceed safety limit established by ICNIRP which is 50kV/m for residential exposure. Hence, a safety distance needed to be considered when planing the ROW of the transmission line.

ABSTRAK

Disebabkan evolusi teknologi dan industri, tenaga elektrik telah menjadi semakin penting dalam kehidupan harian manusia. Untuk memenuhi keperluan tenaga elektrik di kawasan perumahan dan industri, ramai talian penghantaran elektrik telah dibina untuk dijadikan saluran dari stesen janakuasa ke unit pengedaran. Namun, banyak kajian telah menunjukkan bahawa talian penghantaran elektrik ini memancarkan radiasi elektromagnetik yang membawa kesan negatif kepada manusia. Oleh itu, tujuan laporan in adalah untuk mengkaji kesan medan elektomagnetik yang dihasilkan oleh talian penghantaran elektrik terhadap manusia. Untuk pengkajian ini, satu software yang menggunakan kaedah unsur berhingga bernama "Comsol Multiphysics" telah digunakan untuk mensimulasikan medan elektrik dan medan magnetik yang dihasilkan oleh talian penghantaran elektrik. Kaedah unsur terhingga telah digunakan dalam projek ini atas sebab kaedah analisis agak sukar untuk menyelasaikan masalah kejuruteraan yang kompleks dan pengukuran praktikal tidak berefisen dan mempunyai risiko yang tinggi. Medan elektrik dan medan magnetik yang dihasilkan oleh talian penghantaran elektrik telah dikirakan dan divalidasikan dengan kajian lepas. Seterusnya, parameter merangkumi voltan konduktor, arus konduktor, jejari konduktor dan jarak antara fasa telah diubah untuk dianalisis. Hasil telah menunjukkan bahawa medan elektrik meningkat bila voltan konduktor, jejari konduktor dan jarak antara fasa meningkat. Manakala, medan magnetik meningkat bila arus konduktor meningkat dan menurun bila jarak antara fasa menurun. Jejari konduktor tidak akan memberi kesan kepada medan magnetik. Bagi standard ICNIRP, voltan konduktor yang melebihi 700kV bagi model talian penghantaran yang disimulasi telah melebihi had limit keselamatan medan elektrik di kediaman iaitu 50kV/m. Oleh itu, jarak yang sesuai harus dicadangkan untuk ROW supaya keselamatan penduduk dapat dijaminkan.

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LISTS OF SYMBOLS AND ABBREVIATIONS

TL	-	Transmission Line
EMF	-	Electromagnetic Field
ACSR	-	Aluminium conductor steel reinforced
σ	-	Electrical conductivity
ε	-	permittivity
$\vec{E}$	-	Electric Field Vector
ROW	-	Right of Way
$\vec{V}$	-	Electrostatic potential vector
$\vec{\nabla}$	-	Divergence
J	-	Current density
FEM	-	Finite Element Method
CSM	-	Charge Simulation Method
FDM	-	Finite Difference Method
MCM	-	Method of Conditional Moments

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CHAPTER 1

INTRODUCTION

1.1 Motivation/ Background

In this globalization of era, electricity has become more and more important for people lives as it can be converted into various type of energy, such as heat, light and mechanical work. Its application are general for facilitate and let human being to have a more comfortable and easy life. Based on a 2019 report by the Energy Commission of Malaysia, domestic user used a 23% of total electricity usage [1]. This report shows that the modern lifestyle of new generation has become more dependent on electricity. The rising number in population and technological evolution have led to more electrical usage. National Grid in Malaysia is in charge of distributing the electricity to consumers; it has coordinated the value of 132kV, 275kV and 500kV. Transmission line, which act as a key link between the electricity generation and consumer, plays a vital role in the power network. These days, the location of transmission line is much nearer to urban and working environment resulting in the increase of electromagnetic field level in urban and working area. [2][3] The radiation of these waves can bring negative effect to human as it can cause the cancer and leukemia [4] [5]. Besides, there are many electrical workers working in the power network sector. Some of them are in charge of maintenance job of transmission line in order to let the community have an uninterrupted power supply. Hence, the workers are directly exposed to the electromagnetic field generated by the high voltage transmission line.

The intensity of electric field is proportional with the voltage. Hence, the higher the voltage of the transmission line, the higher the electric field generated by the transmission line. The electric field will exist when there is no flow of current. However, the generation of magnetic field is directly related to the current. This means that the magnetic field will be generated when there is flow of current in the power line[6]. However, studies show that the maximum body current induced by electric field from a transmission line is much larger than the body current or current density induced by the magnetic field [8].

The World Health Organization (WHO) has offered a maximum time of being under electromagnetic field in order to avoid health hazard [7]. Hence to prevent human from health hazard, the solution is to do a research to analyze on the electric field of transmission line. To calculate the electrostatic field, Laplace's partial differential equation with boundary conditions prescribed over the boundary has to be solved [8]. This involved in complex geometries, such as high voltage engineering design and applications and the solution is to use a numerical analysis. There are several numerical analysis used to simulate non-uniform electric field such as finite element method (FEM), charge simulation method (CSM), charge density method (CDM), Monte-Carlo method (MCM), finite-difference method (FDM) [2]. Hence, finite element method is applied to calculate electric field distribution under the transmission line using Comsol Multiphysics software.

Comsol Multiphysics software is a finite element analysis-based software that can aid to solve complex geometry problem. The calculated results can be compared with national and international safety guideline. Each country has its own criterion for electric field based on standard recommended by organizations like the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [8]. The ICNIRP has recommended a constant electric field exposure limit of 5 kV/m for common public and 10kV/m for occupational exposure at a frequency of 50 Hz [8][9][10]. This indicates that the electric field of the transmission line may cause hazard to human beings if it exceeds the exposure limit. The results obtained from simulation can help to protect our general public in determination of boundaries of areas where the electric field exceeds the limit and restrict the public access to the area. Besides, appropriate sign and notice can be placed to inform work personnel in high voltage region to prevent them from health hazard.

1.2 Problem Statement

Summarization of the problems mentioned, the evolution of industry has led to the electricity power has become more important in daily life than before. The rapid growth of population meaning more residential area and industrial area will be developed. Besides, to fulfil the rising demand of the electricity power, the amount of power station and transmission line have to be increased. The former in charge of electricity power generation while the latter in charge of transmitting the current and voltage to distribution unit. Although the existence of transmission line benefits the entire community a lot, it also brings negative impact which is the emission of electromagnetic field. The exposure to electromagnetic field may be dangerous and cause health hazard if it exceeds the exposure limits. This situation concerns the public as the transmission line is built much nearer to residential area these days. Therefore, a research has to be carried out to study the effect of electromagnetic field generated by transmission line towards human. The studies will be conducted through finite element analysis-based software, Comsol Multiphysics.

1.3 Objectives

The aim of this project is to:

i. Analyze the electric field distribution at human height level beneath an overhead transmission line using FEM based Comsol Multiphysics.

Ii. Examine the magnetic field distribution at human height level beneath an overhead transmission line using FEM based Comsol Multiphysics

1.4 Scope

i. Develop a transmission line model in FEM based Comsol Multiphysics. The transmission line is developed in two-dimensional.

ii. The electric field distribution intensity at human height level is analyzed. The parameters of the transmission line including voltage,radius and gap distance of the line is adjusted to analyze the electric field distribution.

iii. The magnetic field distribution intensity at human height level is analyzed.The parameters of the transmission line including current,radius and gap distance of the line is adjusted to analyze the magnetic field distribution

iv. The electric field and magnetic field intensity is compared to ICNIRP standard

1.5 Thesis Outline

This thesis consists of five chapters which are introduction, literature review, methodology, result & analysis and conclusion & recommendation.

In Chapter 1, it will discuss the brief introduction of this project which include the project background, problem statement, objectives, scope and thesis outlines. These chapter will mainly discuss about the phenomena of the transmission line increasing and the reason to do the study on its electric field emission.

In Chapter 2, it will discuss about the literature review of this project. This includes transmission line, the theories of electrostatic and magnetic field field, the studies related to the research topic such as the method used to evaluate the electromagnetic field, the negative impact of electromagnetic field towards human and comparison of electric field and magnetic field. For completing this project, all the journals and books that related to this project are used as a references.

In Chapter 3, it will discuss about the methodology of the project. The project activity is to describe the flow of the whole project which stated in the project flowchart. All the method and procedure used in completing the project is explained in this chapter.

In Chapter 4, it will discuss about the results and discussions of the project. The data of the simulation including 2D plot graph and 1D line graph will be stated and analyzed in this chapter.

In Chapter 5, it will discuss about the conclusion and recommendation of the project. It will summarize all the topics in previous chapter. Besides that, it will list out the future study of the project.