SIMULATION OF POWER TRANSMISSION LINE ELECTRIC AND MAGNETIC FIELD EXPOSURE

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Bachelor of Electrical Engineering (Industrial Power)

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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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I hereby declare that I have read through this report entitle “Simulation of Power Transmission Line Electric and Magnetic Field Exposure” and found that has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power).

Signature	:	………………………..
Supervisor’s name	:	………………………..
Date	:	………………………..

I declare that this report entitle "*Simulation of Power Transmission Line Electric and Magnetic Field Exposure*" 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 submitted in candidature of any other degree.

Signature : ....

Name : MOHD HAFIZUDDIN BIN SAMSUDIN

Date : 2/7/2012

To my beloved mother and father

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Abstrak

Sistem utiliti penghantaran dan pengagihan masih menyiasat cara-cara yang dapat mengurangkan ketakutan masyarakat terhadap tahap kesihatan yang tidak diingini kesan daripada pendedahan kepada medan magnet. Kajian selama 30 tahun telah dijalankan bagi mengenal pasti sama ada medan electromagnet dapat membawa kemudaratan pada kesihatan manusia. Walau bagaimanapun, para saintis masih belum dapat membuat kesimpulan muktamad sama ada medan electromagnet dapat memberi kesan kepada kesihatan manusia atau tidak. Kaedah yang paling mudah untuk mengurangkan pendedahan kepada medan magnet adalah untuk meningkatkan jarak dari sumber.Walau bagaimanapun, kawasan perumahan kini semakin hampir dengan sistem penghantaran dan pengagihan. Kaedah simulasi menggunakan perisian FIELDS dan berdasarkan teori formula Biot-Savart Law's telah diguna pakai bagi mengira medan electromagnet yang dihasilkan di pencawang penghantaran. Pencawang penghantaran 275kV litar berkembar telah dipilih untuk simulasi ini.Semua spesifikasi diperolehi dari Tenaga Nasional Berhad Transmission (TNBT). Pengaturan atau penyusunan fasa akan dilakukan untuk mencari EMF terendah yang terhasil menggunakan Perisian FIELDS.

Abstract

Transmission and distribution utilities are still investigating ways in which they can decrease resident fear of undesirable health effects from exposure to magnetic field. Electromagnetic field (EMF) health matter has been traced to be developed for the past 30 years and score of studies have been carried out to find the relationship between EMF and health harms. However, scientists are still far from making a conclusion on whether EMF does effect to human health. The easiest method to reduce exposure to magnetic fields is to raise the distance from the source. However, residential areas are now closer to transmission and distribution system. Field simulation method and Biot-Savart law have respectively been adopted to calculate the EMF produced of the transmission line tower modeling. 275kV double circuit transmission tower have been selected for this simulation. All specification will be obtained from Tenaga Nasional Berhad Transmission (TNBT). Phase arrangement will be done to find the lowest EMF produce using the FIELDS Software.

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CHAPTER 1

INTRODUCTION

1.0 General Background

Electric and magnetic fields existed each time electricity is generated, transmitted or used. Power frequency magnetic fields are receiving growing attention in recent years due to concerns that exposure to magnetic fields might cause health effects [1]. At the late 1970s, Wertheimer and Leeper showed that the children living near electric wiring configurations have increased risk of cancer [2]. Therefore, many researchers have made a study to assess whether the exposure to extremely low frequency (ELF) electric and magnetic field (EMF) can adversely affect human health.

Electric and magnetic field (EMF) are unseen lines of force that encircle any electrical device that is plugged in and turned on. EMF is made up of waves of electric and magnetic energy moving together (radiating) through space. Electric fields are produced by electric charges and magnetic fields are produced by the flow of current through wires or electrical devices. EMF is usually related with power lines. Lot of people is concerned about potential adverse health effects. Most of the research about power lines and potential health effects are not convincing. In spite of more than two decades of research to determine whether elevated EMF exposure, principally to magnetic field, is related to an increased risk of childhood leukemia, there is still no final answer.

The objective of the study is based on journal written by Ismail Said from EMF Research Group UNITEN, says ”studies are currently being undertaken to find other tower configuration, phase arrangements, loading assignment etc. that can provide lower magnetic field at the edge of right-of-way without incurring considerable cost for the utilities"[3]. The FIELD software is used to determine the strength of ELF EMF present from the various type of phase arrangement of the transmission line.

1.1 Problem Statement

As the economy in industrialized countries has maintained rapid growth, the requirement of electric power is increasing. The voltage and current of power transmission lines have been improved to meet this development, many large substations and ultra high voltage (UHV) power transmission lines have been constructed in many countries[4]. Speedy enlargement in the present cause the space between the transmission lines and the public area become closer. From the research magnetic field can be risky to human but the correct effect to health is still no definitive answer[5].

1.2 Project Objectives

There are three objectives that need to be achieved to complete this project which are:

1) To determine a specification of TNB's 275 kV transmission line.
2) To analyze the EMF produced from TNB's 275 kV transmission line by using FIELDS simulation.
3) To identify the suitable phase arrangement with lowest EMF producing of TNB's 275 kV transmission line based on FIELDS simulation result.

1.3 Project Scopes

In this paper, it only focuses on transmission line 275 kV double circuits to analysis. Considering magnitude of phase current according to the journal by Ismail Said on his journal regarding at power frequency, the magnetic field is proportional to magnitude of the phase current. The current on a line varies with the demand for electricity. Hence it is not possible to define a single magnetic field level associated with a given point near a transmission line unless the current carried by the line is known or given[3].

The scopes of this project are:

a) Analysis is on the transmission line 275kV double circuits.
b) The specification of tower 275 kV is taken from Tenaga Nasional Berhad Transmission, Malaysia.
c) All data is incorporated into the software to get the value of EMF produced from the tower.
d) The different EMF produced can be seen based on phase arrangement of cables.
e) Models for the different phase cable arrangement of 275kV transmission line configuration were constructed using the FIELDS software.

CHAPTER 2

LITERATURE REVIEWS

2.0 Introduction

Double circuit overhead transmission lines in Malaysia have been in operation for several years. Rapid infrastructure development incited the utility company to raise electrical transmission capacity to ensure acceptable and consistent supply to the consumers. Due to this some towers had been built close to another tower. In certain places, under different circumstances it could consists of six towers energized within the same land reserve. It is estimated that 80% from the total number of transmission line towers in Malaysia are of the double circuit type while the rest are designed for quadruple circuit type[3]. There is a requirement to study and evaluate the impact of EMF exposure levels for these multiple towers[3]. This paper present the results of magnetic field measurement based on double circuit 275 kV transmission line configuration in Malaysia. Using the real dimensions of the 275 kV transmission lines, models were constructed and substantiated.

2.1 Extremely Low-Frequency (ELF) Electric and Magnetic Fields (EMF)

An electromagnetic field (also EMF or EM field) is a physical field produced by movement electrically charged substance. It affects the actions of charged objects in the surrounding area of the field. The electromagnetic field extends for an indefinite period throughout space and describes the electromagnetic interaction. It is one of the four fundamental forces of nature (the others are gravitation, the weak interaction, and the strong interaction).

The field can be viewed as the combination of an electric field and a magnetic field. The electric field is produced by stationary charges, and the magnetic field by moving charges (currents); these two are regularly described as the sources of the field. The means in which charges and currents relate with the electromagnetic field is described by Maxwell's equations and the Lorentz force law.

Magnetic fields are formed by moving charges and as a result are relative to electric currents in a classification, irrespective of the voltage used. From Biot-Savart law show that the short element of current produce the magnetic flux density shown in equation (2.0) and (2.1)[2].

$$\mathbf{B} = \int \frac{\mu_0}{4\pi} \frac{IdI \times \hat{r}}{|r|^2} \tag{2.0}$$

Or, equivalently,

$$\mathbf{B} = \int \frac{\mu_0}{4\pi} \frac{IdI \times r}{|r|^3} \tag{2.1}$$

Where:

$\boldsymbol{I}$ = current

$\boldsymbol{d}$ **l** = vector, whose magnitude is the length of the differential element of the wire, and whose direction is the direction of usual current

B = magnetic field,

$\boldsymbol{\mu_0}$ = magnetic constant,

$\hat{\mathbf{r}}$ = displacement unit vector in the direction pointing from the wire element towards the point at which the field is being computed

$\mathbf{r} = r\,\hat{\mathbf{r}}$ is the full displacement vector from the wire element to the point at which the field is being computed

A flowing current in any conductor, no matter how complex form of the conductor, can be broke down into a series of infinitesimally segments, joined end-to-end. So the following equation of basic form can be used for calculate the magnetic flux density of a conductor which is fixed length. Fig. 2.0 shows the relationship of each parameter and equation (2.2) shows the formula.

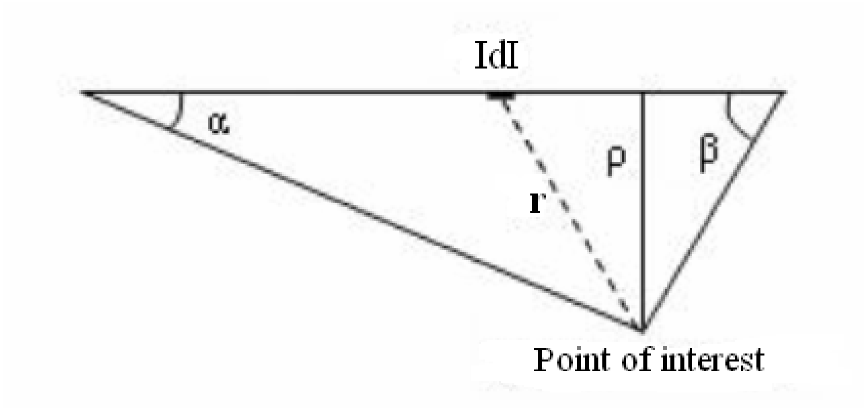

Figure 2.0: Calculation of Magnetic Field

$$\mathbf{B} = \int \frac{\mu_o I}{4\pi\rho}(\sin\alpha - \sin\beta) \quad (2.2)$$

Where:

ρ = vertical distance between the conductor and point of interest.

$\boldsymbol{\alpha}$ = angle between ***I*****dl** and **r** when ***I*****dl** at the left end of the conductor.

$\boldsymbol{\beta}$ = angle between ***I*****dl** and **R** when ***I*****dl** at the right end of the conductor [2]

2.2 Magnetic Field Limitation Exposure

This simulation presents an exposure assessment study for magnetic field at the edge of ROW double circuit transmission line 275 kV. Lot of studies over the years in determining the safe exposure levels to people especially at the residential area[3]-[6]. For permissible exposure levels, several organizations have developed guidelines and standards. Institute of Electronic and Electrical Engineers (IEEE) as the most important organizations have contributed to the establishment of these standards and guidelines [9], and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [10]. By refer the standards and guidelines from ICNIRP, the World Health Organization (WHO/182 1998), International Labour Organization (ILO) and the European Committee on Electrotechnical Standardization (CENELEC 1995) that use in this countries the occupational and public exposure limit for electric and magnetic fields of ELF EMF are 10,000 V/m and 5,000 V/m, and 5000mGauss and 1000mGauss respectively.

2.3 Transmission Line Specification

About 420 transmission substations in the Peninsular are connected together by approximately 11,000 km of transmission lines operating at 132, 275 and 500 kilovolts (kV). The 500 kV transmission systems is the single major transmission system to be ever developed in Malaysia. Beginning in 1995, Phase 1 implicated the design and construction of the 500kV overhead transmission lines from Gurun, Kedah in the North along the west coast to Kapar, in the central region and from Pasir Gudang to Yong Peng in the south of Peninsular Malaysia[6].

The total distance enclosed for the 500 kV transmission lines is 522 km and the 275 kV portion is 73 km. Of the lines constructed, only the Bukit Tarek to Kapar sections had been energized at 500 kV. The residual lines are presently energized at 275 kV. Later, in order to provide for the additional power transmission requirements from the 2,100 megawatt (MW) Manjung Power Station, the 500 kV systems was extended from Bukit Tarek to Air Tawar and from Air Tawar to Manjung Power Station. In 2006, the 500 kV lines between Bukit Batu and Tanjung Bin were made to order to carry the power generated by the 2,100 MW Tanjung Bin Power Station[7].

A project linking laying a 730 km high-voltage direct current transmission line and a 670 km undersea cable for the 2,400-megawatt Bakun hydroelectric dam has been considered. This may connect all three of Malaysia's electric service companies with state grids: Tenaga Nasional Berhad (TNB), Sarawak Electricity Supply Corporation (SESCO) and Sabah Electricity Sdn Bhd (SESB). Many of Sabah and Sarawak's generation plants are still not interconnected to a grid.

In this research project, 275 kV transmission line is chosen with specification of the tower gained from Tenaga Nasional Berhad (TNB) Transmission. Figure 2.1 and 2.2 show the example transmission line tower data sheet and example of 275 kV double circuit transmission line that use in Malaysia while figure 2.3 shows the danger sign at transmission line area. The specification that already obtained is:

1. Maximum and minimum height
2. Maximum shortest distance between pylons to another pylon
3. Phase arrangement (red yellow blue) on 275kv double circuit transmission line.
4. Cable size for 275kv double circuit transmission line.
5. Electromagnetic flux produces by the 275kv double circuit transmission line

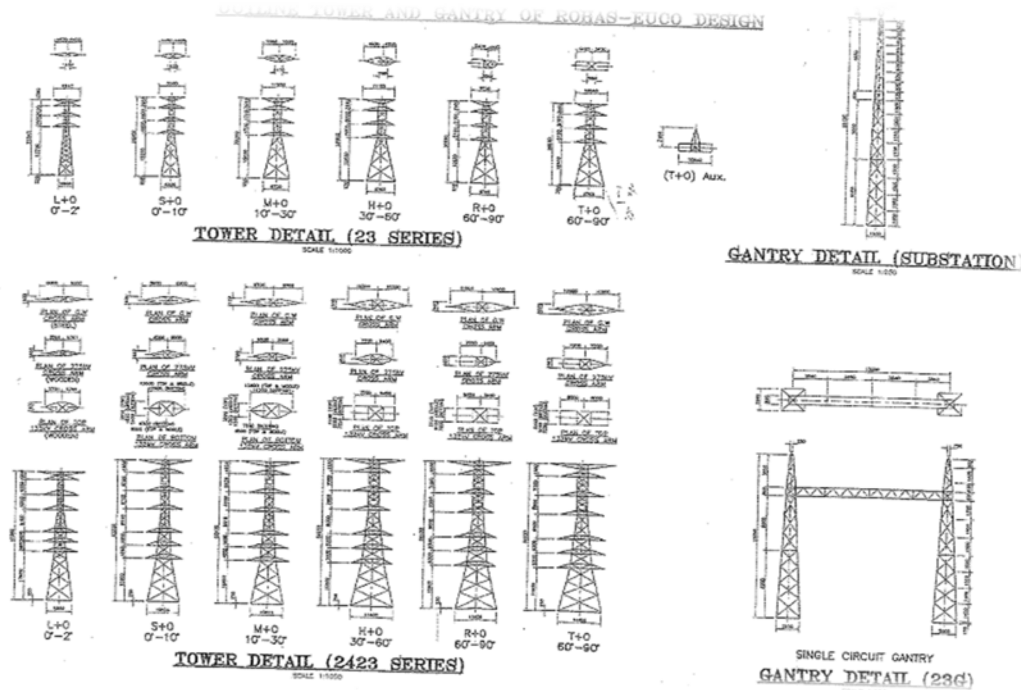

Figure 2.1: Example transmission line tower data sheet

Figure 2.2: Example 275 kV double circuit transmission line

Figure 2.3: Danger sign at transmission line area.