INVESTIGATION MAGNETIC FIELD RADIATED BY 132 kV OVERHEAD TRANSMISSION LINE

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Bachelor of Electrical Engineering (Industrial Power)
June 2013

"I hereby declare that I have read through this report entitle "Investigation Magnetic Field Radiated By 132kV Overhead Transmission Line" and found that it has comply the partial fulfilment for a awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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

Faculty of Electrical Engineering

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2013

I declare that this report entitle “Investigation Magnetic Field Radiated By 132kV Overhead Transmission Line” 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.

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To my beloved mother and father

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ABSTRACT

Magnetic field and electric field in extremely low frequency (ELF) condition on tower transmission line was expected to cause a biological effect to human health such as change in cells and hormone levels which it can be dangerous to health. However, there is no significant study to prove such illness that due to magnetic fields. Furthermore, there are many questions that need to be answered about magnetic field whether can harm human health. Moreover, it is needed to determine the limits of magnetic field exposures for the long term. The aim of this study is to analyse and compute the magnetic field strength at certain points for 132kV overhead transmission line in UTeM. Our aim is to determine the minimum requirement and safety distance right of ways (ROW) and safe area for public people near to overhead line based on magnetic field strength. To conduct this measurement, the magnetic field has measured by using the HI-3604 extreme low frequency (ELF) meter survey. The result from measurement was utilized for statistical analyses to ensure the significant result for the particular distance under the transmission line tower. The result from this project shows the public will get a minimum exposure of magnetic field at 24m from the conductors. So, the minimum safety distance of right of ways (ROW) is 24m. The exposure of the magnetic field by this 132kV transmission line shows it is within the standard and cannot harm or give effect to human health. So, this project gives a better understanding of the magnetic field exposures on the transmission line. In the future, this investigation can be done at the 275kV and 500kV overhead transmission line in Malaysia.

ABSTRAK

Medan magnet dan medan elektrik dalam kekerapan yang amat rendah (ELF) keadaan di talian penghantaran menara dijangka menyebabkan kesan biologi kepada kesihatan manusia seperti perubahan dalam sel-sel dan tahap hormon yang ia boleh membahayakan kepada kesihatan. Walau bagaimanapun, tidak ada kajian penting untuk membuktikan apa-apa penyakit yang disebabkan oleh medan magnet. Tambahan pula, terdapat banyak soalan yang perlu dijawab tentang medan magnet sama ada boleh membahayakan kesihatan manusia. Selain itu, ia diperlukan untuk menentukan had-had pendedahan medan magnet untuk jangka masa panjang. Tujuan kajian ini adalah untuk menganalisis dan mengira kekuatan medan magnet pada titik tertentu untuk talian penghantaran 132kV atas di UTeM. Matlamat kami adalah untuk menentukan keperluan minimum dan jarak keselamatan yang betul cara (ROW) dan kawasan yang selamat bagi orang-orang awam berhampiran talian atas berdasarkan kekuatan medan magnet. Untuk menjalankan ukuran ini, medan magnet telah diukur dengan menggunakan meter kaji selidik kekerapan rendah melampau (ELF) HI-3604. Hasil daripada pengukuran ini digunakan untuk analisis statistik untuk memastikan hasil yang penting bagi jarak yang tertentu di bawah menara talian penghantaran. Hasil daripada projek ini menunjukkan orang ramai akan mendapat pendedahan yang minimum medan magnet pada 24m dari konduktor. Jadi, jarak keselamatan minimum hak cara (ROW) adalah 24m. Pendedahan medan magnet oleh talian penghantaran 132kV ini menunjukkan ia berada dalam standard dan tidak boleh membahayakan atau memberi kesan kepada kesihatan manusia. Jadi, projek ini memberikan pemahaman yang lebih baik mengenai pendedahan medan magnet pada talian penghantaran. Pada masa hadapan, penyiasatan ini boleh dilakukan pada talian penghantaran overhed 275kV dan 500kV di Malaysia.

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CHAPTER 1

INTRODUCTION

1.1 Project background

The most common phenomenon happens in the transmission line is the generation of the electric field and the magnetic field. The electric field is related to the voltage. Every wire that charges will produce the electric field. It can generate even there is no current flowing. The electric field is proportional to the voltage. When the voltage increases, the electric field also increases rapidly. Normally, the electric field is reduced by the distance. The electric field exposed can easily be shielded by the any object such as a building, and trees. Thus, the electric field produced in transmission line can be effectively blocked from expose to the environment.

The magnetic field is related to the current. The motion of the current in the wire will generate the magnetic field. If there is no current flowing, the magnetic field cannot be produced. The magnetic field is proportional to the current. If the current increase, the magnetic field also will increase rapidly. Commonly, the magnetic field is reduced by the distance. If the distance is increased, the magnetic field strength will decrease. However, the magnetic field produced cannot be shielded. This means that, the magnetic field is always exposed to the environment. Both of the fields are complete unseen and soundless.

Since the magnetic field can create the biological effect on human health, the attention to this disease is increased. However, there is no scientific evidence to convince this theory. Therefore, some of the countries take a serious step to prevent the public from being exposed to magnetic fields, and electric field by developing the suitable right of way, and consider the tower design. This project is carried out because of the public concern about the effect of the magnetic field at the overhead transmission lines. This project is only focusing on the magnetic field strength of the overhead transmission line. It only focuses on the 132kV transmission line because it is commonly used in Malaysia. Hence,

this project is to compute, and analyses the magnetic field at certain points beneath the power lines based on measurement. Other than that, there is no statistical study to evaluate the magnetic field strength at a certain point under the power lines. Thus, the result from this project will be analysed using the statistical method.

This project is important because it is used to provide a safety distance and a suitable right of ways for the public near to the overhead power lines due to the magnetic field effect. Furthermore, it also helps to investigate the magnetic field nature of the power lines. Besides that, this project also can provide a better understanding of the magnetic field at the transmission line.

1.2 Motivation

The issues related to magnetic field nearby to the overhead transmission line may affect the environment and human health surround it has grown, and had to under consideration around the world. Based on some information, the magnetic field can cause harm to human health such as cancer, and the changes of hormone level. Therefore, one has to investigate the profile under the transmission line tower. It is expected a significant investigation based on the measurement under particular schedule for the magnetic field strength under the transmission line system may achieve for long run study.

1.3 Problem Statement

The magnetic field may affect human health when exposed in a long term. However, the fact as mentioned above is not clearly defined and understood. This problem highly motivated researcher to come out with an investigation on the effect of magnetic field under the transmission line system. This investigation can help the TNB to set the safe and suitable right of ways (ROW) especially in designing the new tower. Other than that, the secure area around the tower can be created to make sure public people know the exact distance that can be dangerous to them.

1.4 Objective

The objectives that need to be achieved are:

1. To determine the value of magnetic field under a transmission line through measurement and statistical analysis.
2. To investigate the factor that affects the magnetic field strength under 132kV overhead transmission line system.
3. To examine the relationship between the magnetic field strength and the distance effect under the power line.
4. To investigate either magnetic field strength under 132kV overhead transmission line is dangerous or not.
5. To propose the final result to power provider for standardizing the right of ways (ROW).

1.5 Scope

The scopes of this project are:

1. The measurement will be done under 132kV overhead line at UTeM. The location of the measurement is near to the Pembangunan office.
2. Specification of the tower design is based on Tenaga Nasional Berhad (TNB) 132kV overhead transmission line.
3. The measurements of magnetic field are using the electric and magnetic field (EMF) meter.
4. The measurement data will be collected at the normal weather condition for every day within two weeks.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In Malaysia, the electricity is transmitted and distributed from power station to load through the transmission line. Basically, the electricity from the power station is a high voltage. The transformer is used to drop the voltage from power station to a suitable voltage at the substation. Before the supply enters premises or industries, another transformer is used to step down the voltage to the suitable voltage level. Commonly, the voltage level in the power grid system is a high voltage, medium voltage and low voltage. There are two types of transmission line used in Malaysia that are overhead line, and underground cable. The commonly used transmission line in Malaysia is the overhead line.

2.2 Overhead transmission line

The overhead line is extensively used for transmission line system in Malaysia compared to underground cable. The rated voltage of overhead transmission line is commonly 132kV, 275kV and 500kV. The overhead transmission line tower design depends on the supplier company and has its own specifications, but in Malaysia mostly overhead transmission line tower is designed followed of the TNB (Tenaga Nasional Berhad) specifications and requirements. The new tower construction has increased many issues on environment, law, and physical nature related to the surroundings through which those lines will past and their construction and operation will impact on the people living nearby. [1] The tower configuration will affect the magnetic field strength. So, the design of the overhead transmission line tower should provide the minimum magnetic field levels.

In recent years, the issues of magnetic field effect that can harm people are being discussed seriously and get concern around the world. [1]

2.3 Variables that affect the magnetic field at power lines

Commonly, there are some variables that can affect the magnetic field strength under the power lines. The variables that will affect the magnetic field strength are a phase current magnitude, height of conductor, conductor configuration and lateral distance. [1]

2.3.1 Phase current magnitude

The magnetic field strength is directly proportional to the phase current magnitude under power lines. The current demand for electricity will influence the magnetic field strength. So, by determining the value of current at the power line, there is the possibility to measure magnetic field levels at a certain point nearby or under the power lines.

2.3.2 Conductor height

The height of the conductor from the ground level is influencing the magnetic field strength. If the height of the conductor is increased from the ground level, the magnetic field strength will be reduced at or close to ground level. The magnetic field strength decreases on the ground level because of the gap between the source and ground level is large. So, the magnetic field created on the ground become weak.

2.3.3 Conductor configuration

The system used in the transmission line system in Malaysia is usually three phase system. Generally, the three phase system configuration has a single or two bundled or more conductors bundled. The sum of the magnetic field at the ground

level is produced by the currents in all conductors. The total magnetic field depends on the distance between observer, and each current carrying by the power lines. The total magnetic field at the ground can be reduced by engaging all conductors at the tower as near as possible. The reduction of the magnetic field produced because of the field cancellation created between the conductors.

2.3.4 Lateral distance

By increasing the lateral distance from the magnetic field source, the magnetic field strength will decrease. This condition is approaching same to the conductor height condition. If the distance from the magnetic field sources become far, the magnetic field will be reduced.

2.4 Magnetic field theory

The magnetic field at the conductors can be determined by using the Bio-Savart law, and Maxwell equation. Besides, the magnetic field at the power lines to the certain points can be determined by using the superposition principle.

2.4.1 Bio-Savart Law

The electric charge movement is basically producing the magnetic field at the power line. The magnetic field strength is intertwined with the current flow of the line. Applying the Bio-Savart Law, the magnetic field can be calculated if the current flow is determined [2]:

$$\partial H = \frac{1}{4\pi r^2} idl \times u \qquad (2.1)$$

∂H =contribution to the magnetic field at r due to the current element idl

i =current flowing in an element dl of the conductor

r = radial distance

u =unit vector along the radial direction

From the equation above, the magnetic flux density can be found using the Maxwell equation [2]:

$$B = \mu_0 H \; in \; unit \; G(gauss) \tag{2.2}$$

μ_0 = permeability of free space

The magnitude of B-field has three components of power lines. There is X, Y, and Z components. The equation of B-field magnitude is: [2]

$$B = \sqrt{B_x^2 + B_y^2 + B_z^2} \tag{2.3}$$

So, the change of current in the conductors may influence the magnetic field strength. The unit of measure magnetic flux density is in Gauss (G), and the symbol is (B)**.** Commonly**,** the unit of magnetic flux density at the transmission lines is in miliGauss (mG) [2].

2.4.2 Superposition principle

The magnetic field is changing due to distance. Hence, the analytical calculus method is derived to calculate the magnetic field at some current point distance. [3]

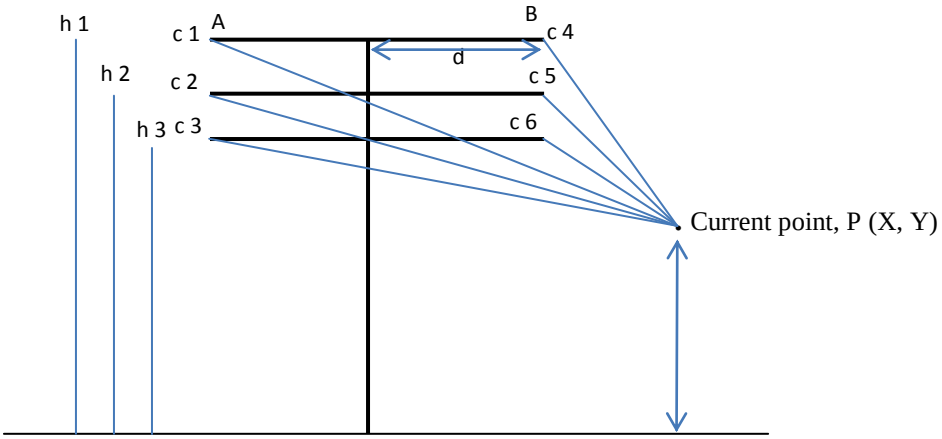

Figure 2.1: The sketch of conductors to the certain point

A = distance between the electrical image of the phase k and the current point P

B= distance between the phase k and the current point P

From figure 2.1 shows the B for each phase can be calculated using this equation:

$$For\ phase\ k = 1 : \sqrt{(X-d)^2 + (h1-Y)^2} \quad (2.4)$$

$$For\ phase\ k = 2 : \sqrt{(X-d)^2 + (h2-Y)^2} \quad (2.5)$$

$$For\ phase\ k = 3 : \sqrt{(X-d)^2 + (h3-Y)^2} \quad (2.6)$$

The A for each phase can be calculated using this equation

$$For\ phase\ k = 1 : \sqrt{(d+X)^2 + (h1-Y)^2} \quad (2.7)$$

$$For\ phase\ k = 2 : \sqrt{(d+X)^2 + (h2-Y)^2} \quad (2.8)$$

$$For\ phase\ k = 3 : \sqrt{(d+X)^2 + (h3-Y)^2} \quad (2.9)$$

The current can at the specific conductor at line can be determined using this equation:

$$I_{rms} = \frac{V_{rms}}{Z_{0,line}} \quad (2.10)$$

$$Z_{0,line} = 60 \ln \frac{2h}{r} \quad (2.11)$$

$$V_{rms} = \frac{V_{max}}{\sqrt{2}} \quad (2.12)$$

h = conductor height from the ground

V_{rms} = maximum voltage produced by power line

$Z_{0,line}$ = transmission line impedance

r = radius of conductor in meter

The magnetic flux density at each component generated by current is:

$$\mathrm{I}e^{\frac{-j2\pi}{3}} \quad (2.13)$$

The real part is:

$$\mathrm{I}\cos(\frac{-2\pi}{3}) \quad (2.14)$$

The imaginary part is:

$$\mathrm{I}\sin(\frac{-2\pi}{3}) \quad (2.15)$$

The calculation of magnetic fields around the overhead transmission line is:

$$B_{px} = -\beta \sum_{k=1}^{n} I_k \frac{Y_{pk}}{B^2} \quad (2.16)$$

$$B_{py} = \beta \sum_{k=1}^{n} I_k \frac{X_{pk}}{B^2} \quad (2.17)$$

$$B_{p} = \sqrt{(B_{px}{}^2)+(B_{py}{}^2)} \quad (2.18)$$

Where:

β = μ0/2

μ0 = $4\pi \times 10^{-7}$ H/m

B_{px}=the real part

B_{py}=the imaginary part

The equations above explained the calculation of the magnetic field on the power lines to the certain point. The magnetic field on the power lines is depending on where the coordinate of the point is located. If the point is located near to the power lines, the magnetic field produced is high.

2.5 Magnetic field effect to human

A magnetic field under the transmission line can be harmful to human health. There are several researches done by researchers to prove the magnetic field could be dangerous to human. Under the lines, there is a magnetic field effect that is causing the electric, and the magnetic induction process in the human body. Inside the human body contains the electric charges that act like a conductor, and can respond to the charges by the current on the lines. The electric induction process has made the charges at the lines to attract and subtract charges in the body. Thus, the charges within the body will move to the surfaces due to the electric force. Therefore, the power frequency electric field will motivate to create the eddy current inside the body, and charges at the surfaces.

The magnetic field is possible to create the voltage in the human body tissue, and causing the current flowed in the body due to its conductivity around them. The magnetic field might impact the tissues within the body. This impact could be beneficial or dangerous to the human depending on its nature**.** [4] There is many factors need to be counted that influence the current flow in the body based on given sources. These include the magnitude of the charges and currents in the source, the distance of the body from the source, the presence of other objects that might shield or concentrate the field, and body posture, shape, and orientation. [4]

Referring to the research, and publications by the World Health Organization (WHO) [4], the magnetic field under power line is potential to cause:

1. Short term health effect

a) Headaches

b) Fatigue

c) Insomnia

d) Burning skin

e) Muscle pain

2. Long term health effects

a) Risk of damaging DNA

b) Risk of cancer