MAGNETIC FIELD CALCULATION OF 63KV TRANSMISSION LINES

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ABSTRACT

Magnetic fields are produced by electric currents, which can be macroscopic currents in wires, or microscopic currents associated with electrons in atomic orbits. So, magnetic fields are produced wherever electricity or electrical equipment is in use. Magnetic fields are very widely used throughout modern technology, particularly in electrical engineering and electro mechanics. But, magnetic fields of power transmission lines cause electrical currents inside the body. So, some people are concerned that daily exposure to magnetic fields may cause health problems. Transmission lines are considered one of the major sources of magnetic field. As a contribution to the assessment of expected biological risk from exposure to power line magnetic fields, in this paper magnetic field distributions under 63kV power lines are investigated. This paper is directed to measure magnetic field on existing lines (63kV transmission lines) in Marvdasht. This measurement has been done using the prepared software package. This simulation software package is developed in MATLAB. According the previous studies maximum allowable magnetic field is 0.04 μT for small animals and about (4-100) μT for humans. By using prepared software package and based on maximum allowable magnetic field, safe margin around the transmission line has been detected.

Keywords: *Magnetic field, Transmission line, Software package, MATLAB, Safe distance*

1. INTRODUCTION

The interaction between the power frequency (50 Hz) magnetic fields of transmission lines and the living organisms still draw worldwide attention because of the results of many of studies which indicated possible harmful effects due to the exposure to these fields. According the previous studies maximum allowable magnetic field is 0.04 μT [1]. Many researches addressed the evaluation of the magnetically-induced currents in living organisms [1-2]. Transmissions lines are considered one of the major sources of magnetic field [3]. Nowadays power lines generally assume to be harmless. However, this assumption has never been adequately tested. Low-level harmful effects could be missed, yet they might be important for the population as a whole since electric lines are ubiquitous. Many studies have been carried out to evaluate the magnetic fields beneath different power lines which are considered as major sources of induction [4]. Transmission of the electric power is accompanied with generation of low-frequency electromagnetic fields. Nowadays of special concern is the possibility of detrimental environmental effects arising from the magnetic fields formed adjacent to the overhead transmission lines. These fields may affect both operation of near electric and electronic devices and appliances and also various living organisms [5]. Electric power transmission and distribution systems are becoming increasingly prevalent in the environment. This has raised public health concerns and accelerated research to identify possible biological effects associated with exposure to power-frequency magnetic fields [6]. The environmental effects of magnetic fields have not been studied completely. In recent years great public concern has arisen because of reports on adverse health effects due to Magnetic fields. Many 63kV transmission lines passes through Marvdasht and About 500000 peoples are living at the city. So, the goal of this paper is magnetic field measurement under 63kV transmission lines. Accurate magnetic field measurement is very important for safe margin detection around the line. A new software package is proposed to detect the magnetic field around the transmission line. According the previous studies maximum allowable magnetic field is 0.04 μT for small animals and about (4-100) μT for humans, and it will depend on the percentage area of the human body with respect to the animal's body area and also on the value of the line current[1]. By using prepared software package and based on maximum allowable magnetic field, safe margin around the transmission line has been detected.

2. MAGNETIC FIELD

Magnetic fields are created only when there is an electric current, the motion of electric charges (electrons) in a conductor, such as a wire [7-8]. The magnitude of a magnetic field is proportional to the current flow through an electric line, not the voltage. As the current increases, so does the magnetic field.

There is no relationship between magnetic field strength and voltage. In the world of electric transmission lines, it is not uncommon for a 63 3 (kV) electric line to have a higher magnetic field than a 115 kV line. High voltage 400 kV lines can carry large currents and as a result may produce relatively high magnetic fields, but primary distribution lines with voltages less than 63 kV can produce fields similar to those measured around a transmission line if they are carrying enough current. Magnetic fields become weaker rapidly with distance from the source. However, they do pass through most non-metallic materials and are therefore more difficult to shield. In the literature, magnetic field data are presented in either units of Gauss (G) or Tesla (T). A milligauss (mG) is equal to one-thousandth of a Gauss (G). One Tesla is equal to 10,000 Gauss. A micro tesla (μT) is equal to one-millionth of a Tesla or 10 mG.

2.1. Ampere's Law

A useful law that relates the magnetic field along a closed loop to the electric current passing through the loop is Ampere's Law that first discovered by André-Marie Ampere in 1826. Ampere's Law is used to find the magnetic field generated by currents in highly symmetric geometries like the infinitely long wire and the solenoid. This law express that the integral of B around any closed mathematical path equals μ_0 times the current intercepted by the area spanning the path. Equation (1) could describe the content of this concept[7-8].

$$\oint B.dl = \mu_0 I \qquad (1)$$

Where, the line integral is over any arbitrary loop , I is the current enclosed by that loop and r is the distance from the center of the wire.

The magnetic field of an infinitely long straight wire can be obtained by applying Ampere's law. The magnetic field generated by a single wire is equal to the following equation.

$$\vec{B} = \frac{\mu_0 I}{2\pi r}\vec{a}_\varphi \qquad (2)$$

In Cartesian coordinate system, $\overrightarrow{a_\varphi}$ and r can be rewritten as follows:

$$a_\varphi = -\frac{y - y_n}{R}\vec{a}_x + \frac{x - x_n}{R}\vec{a}_y \qquad (3)$$

$$r = \left[(x_n - x)^2 + (y_n - y)^2\right]^{\frac{1}{2}} \qquad (4)$$

So, equation (2) can be rewritten as follows:

$$B = B_x.\vec{a}_x + B_y.\vec{a}_y \qquad (5)$$

$$B_x = \frac{\mu_0 I}{2\pi r}\left(-\frac{y - y_n}{r}\right) \quad \& \quad H_y = \frac{\mu_0 I}{2\pi r}\left(\frac{x - x_n}{r}\right) \qquad (6)$$

$$|B| = (B_x^2 + B_y^2)^{\frac{1}{2}} \quad , \quad \theta = Arc\tan\left(\frac{B_y}{B_x}\right) \qquad (7)$$

Finally,

$$B = |B|\angle\theta \qquad (8)$$

2.2. Magnetic field of power transmission line

Based on Ampere's Law Magnetic field of power transmission line in any point can be calculated as following equations [7]:

$$B_{xa} = \frac{-\mu_0(I_{ra} + j\,I_{ia})(y_a - y_n)}{2\pi}\left[\frac{1}{(x_n - x_a)^2 + (y_n - y_a)^2}\right] \qquad (9)$$

$$B_{ya} = \frac{\mu_0 (I_{ra} + j\, I_{ia})\,(x_a - x_n)}{2\pi}\left[\frac{1}{(x_n - x_a)^2 + (y_n - y_a)^2}\right] \quad (10)$$

Equations (9) and (10) can be rewritten as follows:

$$B_{xa} = B_{rxa} + j\, B_{ixa} \quad (11)$$

$$B_{ya} = B_{rya} + j\, B_{iya} \quad (12)$$

So,

$$B_{rx} = B_{rxa} + B_{rxb} + \cdots \quad (13)$$

$$B_{ix} = B_{ixa} + B_{ixb} + \cdots \quad (14)$$

$$B_{ry} = B_{rya} + B_{ryb} + \cdots \quad (15)$$

$$B_{iy} = B_{iya} + B_{iyb} + \cdots \quad (16)$$

Then, the real and imaginary values of the magnetic field can be calculated.

$$B_x = B_{rx} + j\, B_{ix} \quad (17)$$

$$B_y = B_{ry} + j\, B_{iy} \quad (18)$$

And finally, the amplitude of magnetic field can be calculated as follows:

$$\begin{aligned} |B| &= \left(|B_x|^2 + |B_y|^2\right)^{\frac{1}{2}} \\ |B_x| &= \left(|B_{rx}|^2 + |B_{ix}|^2\right)^{\frac{1}{2}} \\ |B_y| &= \left(|B_{ry}|^2 + |B_{iy}|^2\right)^{\frac{1}{2}} \end{aligned} \quad (19)$$

2.3. Magnetic field of three-phase transmission lines

Three-phase electric power is a common method of alternating-current electric power generation, transmission, and distribution. It is a type of poly phase system and is the most common method used by electrical grids worldwide to transfer power. Three-phase systems can produce a magnetic field that rotates in a specified direction. In a three-phase system, three circuit conductors carry three alternating currents (of the same frequency) which reach their instantaneous peak values at one third of a cycle from each other. Current of phases in these systems can be expressed as follows [8]:

$$\begin{aligned} I_a &= I_m \cos(\omega t + \varphi_a) \\ I_b &= I_m \cos(\omega t + \varphi_b) \\ I_c &= I_m \cos(\omega t + \varphi_c) \\ \varphi_b &= \varphi_a - 120 \\ \varphi_c &= \varphi_a + 120 \end{aligned} \quad (20)$$

The effective values of currents can be calculated using following equations.

$$\begin{aligned} I_{ra} &= \frac{I_m}{\sqrt{2}}\cos(\varphi_a) \qquad I_{ia} = \frac{I_m}{\sqrt{2}}\sin(\varphi_a) \\ I_{rb} &= \frac{I_m}{\sqrt{2}}\cos(\varphi_b) \qquad I_{ib} = \frac{I_m}{\sqrt{2}}\sin(\varphi_b) \end{aligned} \quad (21)$$

$$I_{rc} = \frac{I_m}{\sqrt{2}} \cos(\varphi_c) \qquad I_{ic} = \frac{I_m}{\sqrt{2}} \sin(\varphi_c)$$

According the equations (9) and (10), magnetic field induced using phases a, b and c at an arbitrary point $N(x_n, y_n)$ can be calculated using following equations.

$$H_x = H_{xa} + H_{xb} + H_{xc} \tag{22}$$

$$H_y = H_{ya} + H_{yb} + H_{yc} \tag{23}$$

Where

$$|H_x| = \left[(H_{rxa} + H_{rxb} + H_{rxc})^2 + (H_{ixa} + H_{ixb} + H_{ixc})^2\right]^{\frac{1}{2}} \tag{24}$$

$$|H_y| = \left[(H_{rya} + H_{ryb} + H_{ryc})^2 + (H_{iya} + H_{iyb} + H_{iyc})^2\right]^{\frac{1}{2}} \tag{25}$$

And finally

$$|H_n| = \left(|H_x|^2 + |H_y|^2\right)^{\frac{1}{2}}, \quad \theta = \mathrm{Arctg}\left(\frac{|H_y|}{|H_x|}\right), \quad H_n = |H| \angle \theta \tag{26}$$

3. SOFTWARE PACKAGE

MATLAB is currently available on popular computer for engineering applications. Magnetic fields around three phase's systems have been calculated by using software package developed in MATLAB. Several parameters such as current of wires, height of transmission towers, diameter of wires and position of the phases in transition tower are input data of software package. By using input data and based on equation (26) magnetic field around three phases systems at a constant height from the ground or in a fixed-width of the transmission tower can be calculated .

4. CALCULATION OF MAGNETIC FIELD AROUND 63KV TRANSMISSION LINES

In Iran, several line configurations are installed for 63kV voltage level.

The design, shown in Figure 1 is typical Lattice-type structure for most of 63kV lines that are used in Iran. These figures present the line conductor configurations and dimensions of the employed 63 kV lines.

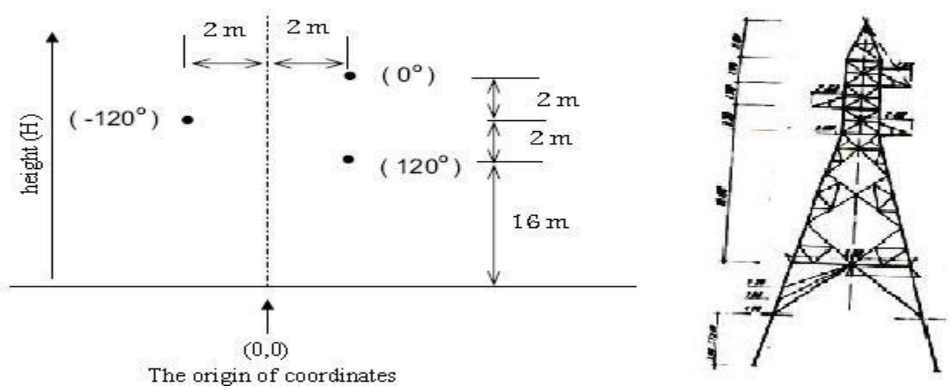

Figure 1: Line conductor configuration of 63 kV lines

The data for these cases are listed in table 1.

Table1: The data for 63kV cases

Maximum current	2000 A
Diameter of wires	28.14 mm

According data of table1 and figure1 and by using prepared package software, magnetic field around 63kV lines can be calculated easily.

The curves of magnetic field in several constant heights (H) are shown in Figures 2-4.

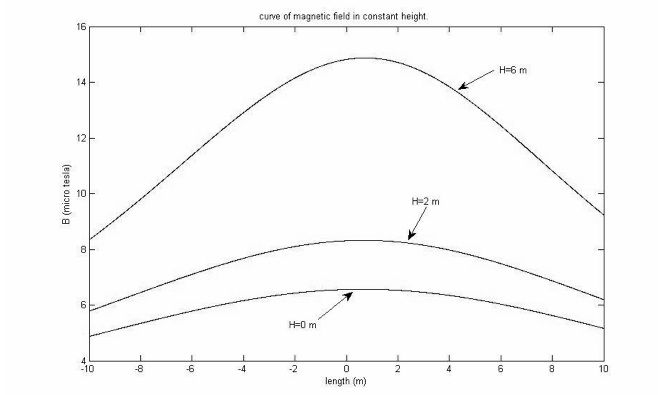

Figure 2: The curves of magnetic field in constant heights (H=0, 2&6 m)

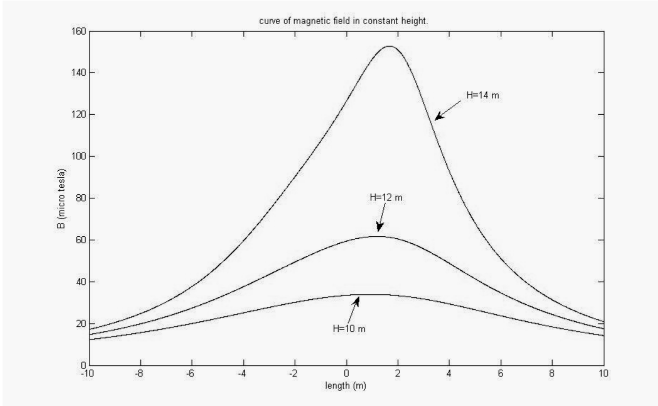

Figure 3: The curves of magnetic field in constant heights (H=10, 12&14 m)

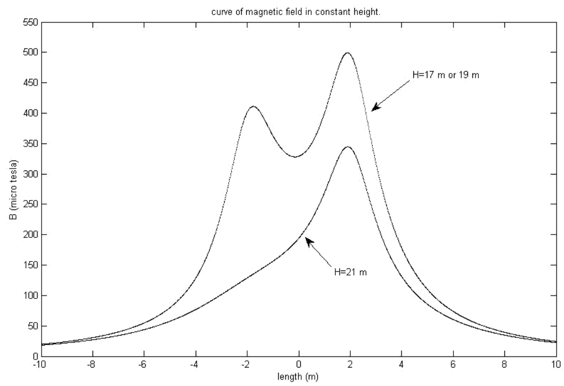

Figure 4: The curves of magnetic field in constant heights (H=17, 19&21 m)

The curves of magnetic field in several constant lengths (X) are shown in Figures 5-7.

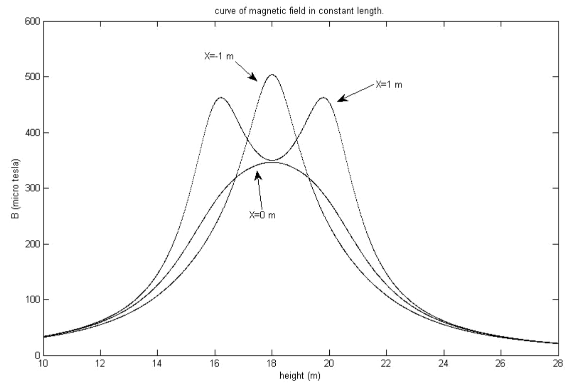

Figure 5: The curves of magnetic field in constant lengths (X=-1, 0&1 m)

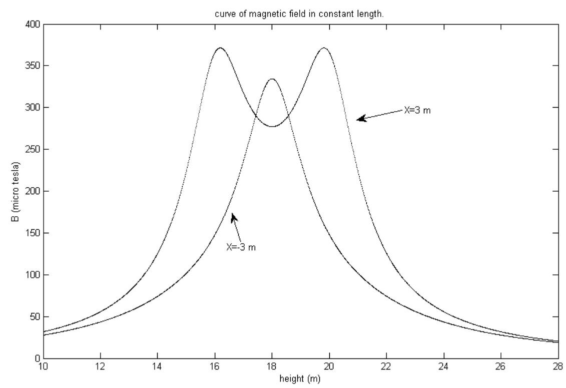

Figure 6: The curves of magnetic field in constant lengths (X=-3&3 m)

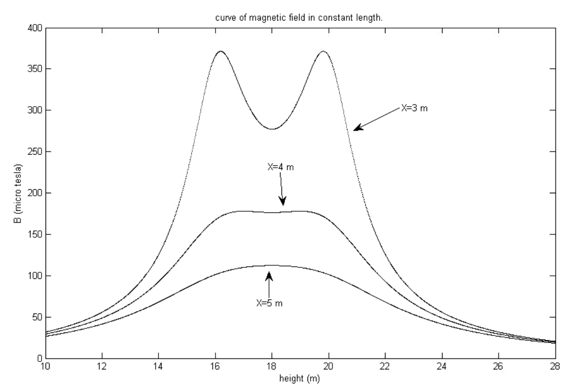

Figure 7: The curves of magnetic field in constant lengths (X=3, 4&5 m)

The obtained data on changes in the immune and various systems indicated the fact that a value of 0.04 μT magnetic flux density during 4 h daily exposure induces adverse health on the experimental animals [1]. This value of magnetic flux density (0.04 μT) is for small animals, but for humans, it will be likely more (higher), and it will depend on the percentage area of the human body with respect to the animals body area and also on the value of the line current [1].

In this section, the magnetic fields are obtained for tower configuration shown in Fig. 1, in the two directions. The results of the magnetic field (in μT) obtained from the different cases of study. From these figures we can conclude that:

- Magnetic fields under or near power transmission lines have adverse health effects if the field value is higher than the minimum safe value.

- Using these figures, the safe distance around the towers can be determined easily.
- Magnetic field rapidly decreases when the distance from the center of the wire increases.
- The biological effects of magnetic fields depend on the exposure intensity and duration time.
- The results of this study confirm the environmental pollution of the magnetic field produced near transmission lines.

5. CONCLUSIONS

Magnetic fields are invisible lines of force that produced by anything with electric current flowing through it. The magnetic fields may have adverse health effects on any live type near the source of magnetic field, since there will be an induced current in any conducting particles, like the human body. In this paper one of the major sources of magnetic field, which is the three phase transmission lines, has been considered. A new magnetic field simulation package has been prepared and used to quantify the field values resulting from the transmission lines. Using this software magnetic field for 63kV existing configurations in Marvdasht has been calculated. The results of this study confirm the environmental pollution of the magnetic field produced near transmission lines. By using the curves of magnetic field around the 63kV transmission lines obtained from software, the safe distance around the towers can be determined easily.

6. REFERENCES

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