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The Effect of Changing the Conductors Layout on the Magnetic Field Level Generated Around Conductors of 132kv High Tension Transmission Lines Extended In Kirkuk City

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ABSTRACT

In this research, the magnetic flux density generated by the 132 kV double vertical line circuit configuration has been studied using shadow method and the results were compared with measured values. The behavior of different geometric configurations of power lines had been simulates to determine which of them produce less "magnetic. Obtained results indicate that the strength of magnetic field is still below the threshold defined by the International Commission for Protection Against Ionizing Radiation Protection (ICNIRP). Results indicate that the Changing of the Standard dual vertical channel configuration into a dual vertical configuration of the modified phase layout reduce the magnetic flux density on the ground surface in mid- channel (X = 0), of about (65. %).

Keywords: Transmission lines, channel configuration changing, magnetic field.

List of abbreviations

EMF : electromagnetic field
IRPA : International Radiation Protection Association
ROW : right-of-way
WHO **:** World health organization

INTRODUCTION

To distribute electrical power from the power plant to the load center it will be required a network starting from the transmission line until the consumer, so that in the vicinity of the transmission line and distribution network it will be a strong electromagnetic field caused by currents that are drawn by their Conductors. The using of air transmission line with extra high voltage has some advantages. For example, by using high voltage the greater the power supplied obtained and power transmission line losses can be suppressed. But in addition to advantages , there are also disadvantages caused by the extra high voltage network. So, With the increasing of the applications of EHV transmission lines, electromagnetic pollutions caused by power lines attract more people's attention [1]

Some laboratory experiments have found that, under certain conditions, and in some animals models, magnetic fields can have Biological effects. The recommendation of the European Union, July 12 1999, sets the limit of tolerability in 100 µT, which taken into account the precautionary principle. This recommendation is endorsed by many agencies, institutions, scientific reports, doctors, etc.. such as: The International Association for the Protection Radiation (IRPA) and The National Institute of State Regulations USA (ANSI). In recent years, different studies have been published in which we study the magnetic field produced by transmission lines of electricity [2,3] and Ways to reduce stress [4,5]

Objective:

The goal of this research is to calculate the magnetic field emitted by the 132KV high-voltage transmission lines extended in Kirkuk city using the imaging method emitted and compare the results obtained with experimental measurements made in line. The second objective is to study and analyze the distribution of the magnetic flux density as a function of geometric configuration of the conductors of the line phase sequence and the current mismatch between circuits in order to determine which configurations produce less "magnetic pollution."

Researching on the electromagnetic field at operating frequency of EHV transmission lines is very meaningful for the EHV transmission lines' design and the measurement of the surrounding electromagnetic environment.. An injurious influence to the health of human beings caused by the direct effect of technical low frequency electromagnetic fields (50Hz) is scientifically not proven yet. Since ca. 25 years research efforts to find a correlation mechanism between the field quantities and their effect to the human beings are going on but without significant success. In this situation, the electric and magnetic field quantities of high-voltage lines have to be examined in order to avoid EMC problems with the environment close to the power transmission line while planning high voltage lines[6].

Theoretical Part

Electric and magnetic fields are fields of force created by electric voltage and current. Such fields occur in nature, High-voltage lines generate electric and magnetic fields in their neighborhood. The source of the magnetic fields are the currents in the phase conductors. The electric field is caused by the high potential of the conductors. Due to the geometry of electrical energy transmission lines a wide expansion of the field is obvious .The electromagnetic environment typically consists of two components, an electric field and a magnetic field. In general for time-varying fields, these two fields are coupled but in the limit of unchanging fields, they become independent. Computation of the fields produced by overhead power lines is important for studying the possible effects of extremely low frequency electric and magnetic field on a human health. For evaluation the influence of the energy line, it is not sufficient to calculate the coupling impedances or capacitances of the line. It is necessary to analyze the generated fields itself. The IRPA(International Radiation Protection Association) standards supply maximum values for the duration of the stay of human beings exposed to electromagnetic fields of frequencies below 10 kHz.

There, for the general public the permanently allowed effective value of magnetic field strength with 50Hz (for the field of professional exposure (8 hours per day) magnetic field density (B = 100 µT) and for the exposure (24 hours per day) magnetic field density (B = 40 µT)[7] The simulation of the line during planning has the advantage to know about possible risks and disturbing influences. One of them is the magnetic field generated by Conductors. One Way among others ways to minimize the magnet field strength, is by elevating transmission network or changing the channel configuration. Usually the extra high voltage overhead lines flows through three or six transmission cables. In six transmission cable system there are three opposing Conductor forming double circuit. the greater the Power supplied allow the emergence of a large magnetic field. This prompted to analyze about the strength of the field that will happen and how to reduce it. [8] The magnetic field produced from the transmission lines is our main concern and will be considered in this work. Designers of power lines are searching for technically and economically acceptable right-of-way (R.O.W.).

LITERATURE REVIEW

The measurement of the magnetic field and implementation of the new techniques that enhance the reduction of the exposure to this field induced by the power lines have been the concern of many engineers for the past years; this lead to the publication of many studies and development research in this area, such as the Commonwealth Associates Inc or(CAI),. These associates work on the measurement of the magnetic field under high voltage and distribution power lines. Calculations are also done by them to observe the changes in the magnetic field due to changes in the power lines and the substations .These changes, include the rearrangement of the phases in the power lines, provide an equilibrium in the phase and circuit loadings, changing the structure of the line designs, switching from single-phase to three-phase distribution, increasing the voltages and finally using cancellation or shielding loops. After studying all the parameters that could determine whether the particular magnetic field reduction technique can be implemented or not, the (CAI) also performs a cost analysis to check for the feasibility of the EMF reduction technique due to cost considerations. [9]

Another (RAPID) Risk Assessment Program project was to conduct a survey that gathers information about the personal exposure to electromagnetic fields around a thousand people, the activities that could increase or decrease the personal exposure (work and going to bed respectively), gender and age differences as well as sizes and mobility of residences differences [10].

Fei Wang, Weijie Wang , Zhichao Jiang, Xuezeng Zhao were studied some helpful conclusions on the reduction of electromagnetic field intensity of EHV transmission lines and the estimation of the EHV transmission lines' status according to the distributions of electric field by Analyzing of the Line-Frequency Electric Field Intensity around EHV Transmission line[11]. Guangwen Pan and Jilin Tan analyzed the radiation effect of micro strip transmission line [8].While Floderus et al. (1993) investigated sets of electromagnetic field measurements made at 1015 different workplaces. This study covered 169 different job categories, and participants wore the dosimeters for a mean duration of (6-8 h).The most common measurement was (0.05 µT) and measurements above (1µT) were rare [9].

ELECTRIC POWER TRANSMISSION LINE CONFIGURATION

Overhead three-phase power transmission lines consist of pylons that carry three or multiples of three conductors. The conductor layout depends on environment and voltage provided .There are 3 kinds of channel configuration of transmission line:

1. Single horizontal configuration (400 kV),
2. Single delta configuration (400 kV),
3. Double vertical Configuration(132 kV), as shown in figure (1)
4. Equilateral triangle configuration . [12]

In the horizontal configuration, the three phases are in the same height and with The same inter-conductor separation distance as shown in Figure (1), while in the vertical configuration, the three phases arranged vertically with the same separation distance between the conductors as shown in Figure (2).[13]. .

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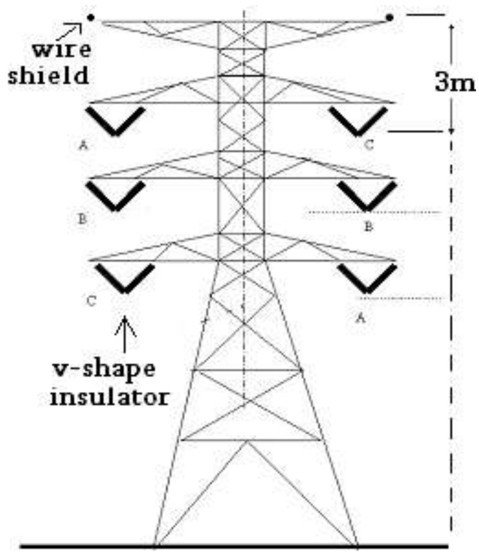

Fig. (1) Double circuit configuration Transmission line

PRACTICAL PART

Measurement of the Magnetic Field Density under Transmission Lines

The magnitude of the field is the highest under the power lines and decrease rapidly with the increasing of distance from the lines. From the point of view of human exposure the most critical points are those within or close to the right of way of the lines. So, magnetic field density is calculated at ground level under the High Voltage Channel (transmission lines).

The measurements should be done on open area to eliminate shielding and at equal distance from pylons to eliminate distortion due to influence of sag [14].Transmission line configuration type used is a type of a dual vertical configuration. For simplify the calculations made for various assumptions as follows [15]:

- The system is analyzed at a normal state of operation and assumed a state balanced in the burden. voltages and currents at each channel point are the same.

- In the calculation, conductors regarded as load lines parallel to each other between the conductor-conductor and between the conductive earth surface.

- Effect of ground wire can be neglected because it is located above the transmission line, so that it has no influence on the magnetic field density above the ground level.

The magnetic field around a three-phase line can be calculated by superimposing the individual contribution of the current of each phase conductor and taking into account the return currents through the earth .Magnetic field intensity can be evaluated using image and shadow method. So, the quasi-static magnetic field of a line source in free space above earth is equivalent to the magnetic field of the line source plus a “complex image” in free-space [16] The magnetic field intensity at the point ***P*** is obtained by considering the contribution of all conductors, assuming parallel lines over a flat earth A line conductor is located at (*xi; yi*) with electric current of ***Ii***. The intensity of the magnetic field due to a very long single conductor can be calculated as follows: [17]

$$H = \frac{I}{2\pi r} \quad (A / m) \qquad (1)$$

With
H :is the magnetic field intensity (A / m)
I : is current flowing through the Conductor (A)
r : is the radial distance to the destination point (m).

In this work is used the help of the shadow method to determine the intensity of the magnetic field. Shadow method which states that if a conductor on the earth's surface electrified, then the magnet field will be resurrected conductor around it. In this work be assumed an imaginary conductor as identical to the original conductor and has a distance that the same as the original conductor above the ground But the location of this imaginary conductor is opposite to the location of the original conductor. So for calculation of magnetic field density around a transmission line, the earth can be replaced by the imaginary conductor which has charge opposite to the original conductor.[18]

In Figure (1) there is a conductor which replaced by imaginary earth conductor. distance between the original conductor and the earth surface is ***Yi***, so, if there is a point **P** that is Located at the ground surface, then the magnetic field intensity at this point is the total magnetic field intensity generated by each current in native. So ,If current in the original conductor is **I*i***, then the magnetic field intensity at point (**P**)due to the linearity, can be computed and superposed by the BIOT' SAVART law. In this case each segment of the infinitesimally-thin filament carries a current i(t). The generated flux density of this part of the conductor is given by

$$|d\mathbf{B}| = \frac{\mu_0}{4\pi r^2} \cdot i(t) \cdot dl \cdot \sin\alpha$$

After integrating (4), the flux density in a point inside the system (x~,~,~ x y z) is calculated with

$$B = \mu_0 \frac{I}{2\pi r} \left[\frac{2Yi}{X^2 i + Y^2 i}\right] \qquad (2)$$

Where
i = name of the Conductor : A, B, C
Y = height Conductor above the grownd surface (m)
X = distance between the conductor and the reference point (m)
μ_o = permeability constant = $4\pi x10^{-7}$ (T.m / A)

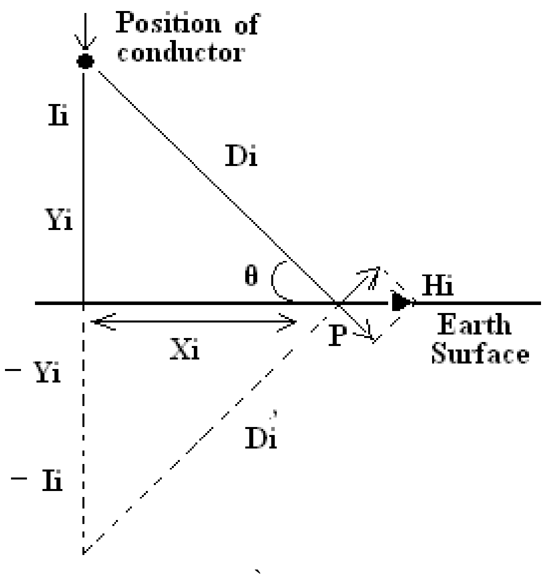

Fig. (1). The magnetic field generated by current I*i* and his shadow

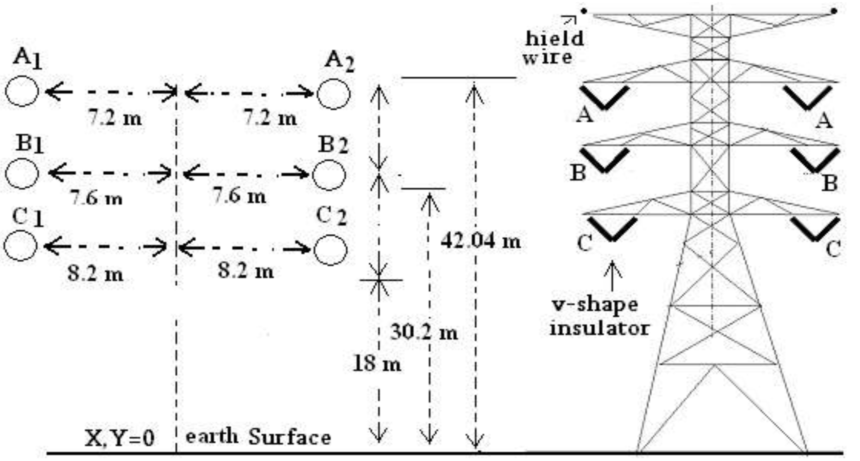

Fig. (2). Transmission line with double vertical configuration

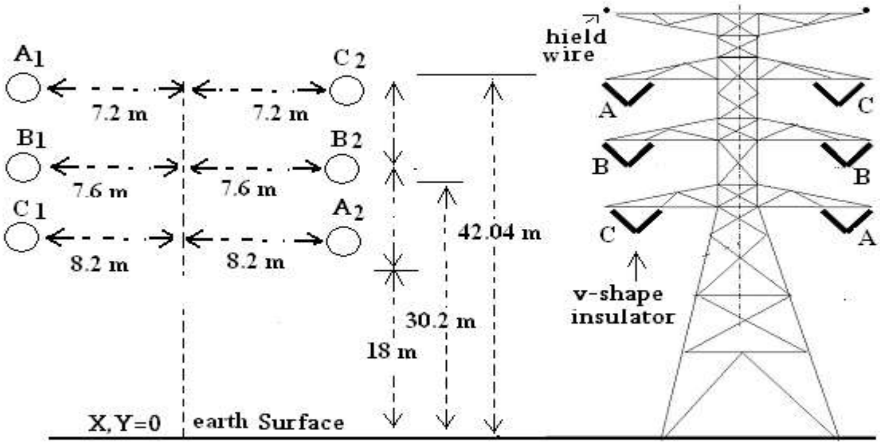

Fig. (3). Dual vertical transmission line Configuring after phases layout changing

Based on the drawing 2-5, the transmission channel spacing data shown in table (1) and table (2). Given that the flowing current of (730) A is a three-phase current. So, the currents flowing on each phase are as follows:

I_A = 720 (1 + j0) = 720A
I_B = 720 (-0.5 + j0, 865) A
I_C = 720 (-0.5 - j0, 859) A

RESULTS

The data transmission channel that listed table (2) is then inserted into equation (2) and (3) so that obtained the magnetic fields which is listed in table (3).

Table(2). Transmission line data for double vertical Configuration

Phase	double vertical Configuration distance (m)
A1	24
B1	20.3
C1	16.5

Table (3). result of calculation the magnetic field flux density (B)

Transmission Line configuration type	Magnetic flux density (B) (μT)
double vertical (132k)	6.872
dual vertical transmission line Configuring after phases layout changing(132kv)	4.534

Table (4). Practical measurement of magnetic field flux density (B)

Transmission Line configuration type	Magnetic flux density (B) (μT)
double vertical (132k)	6.752
dual vertical transmission line Configuring after phases layout changing(132kv)	3.534

PRACTICAL MEASUREMENT OF MAGNETIC FIELD

Practical measurement of the magnetic field cannot be accurately specified because of the impossibility to predict the currents flowing through the conductors at a given moment.

Table (5). result of practical measurement of the magnetic field flux density (B)

Transmission Line configuration type	Magnetic flux density (B) (μT)
double vertical (132k)	6.120
dual vertical transmission line Configuring after phases layout changing(132kv)	3.972

The measurements of the magnetic field strength is based on the electromotive force induced in a coil. Therefore the probe of the field meter (EMF –TESTER) model EMF-872, Only the effective value of the space component perpendicular to the plane of the probe is measured. The field quantities below the overhead transmission lines are measured at a height of 1 m above the ground level. All computations and measurements are performed at the place of the highest slack and at 1 m above the ground level. Because the transmission line is situated in a non-hilly area in Iraq, the assumption of the ground level to be even holds. Figure (4) show the x- component of the effective value of the magnetic field. The calculations and the measurement show good agreement.

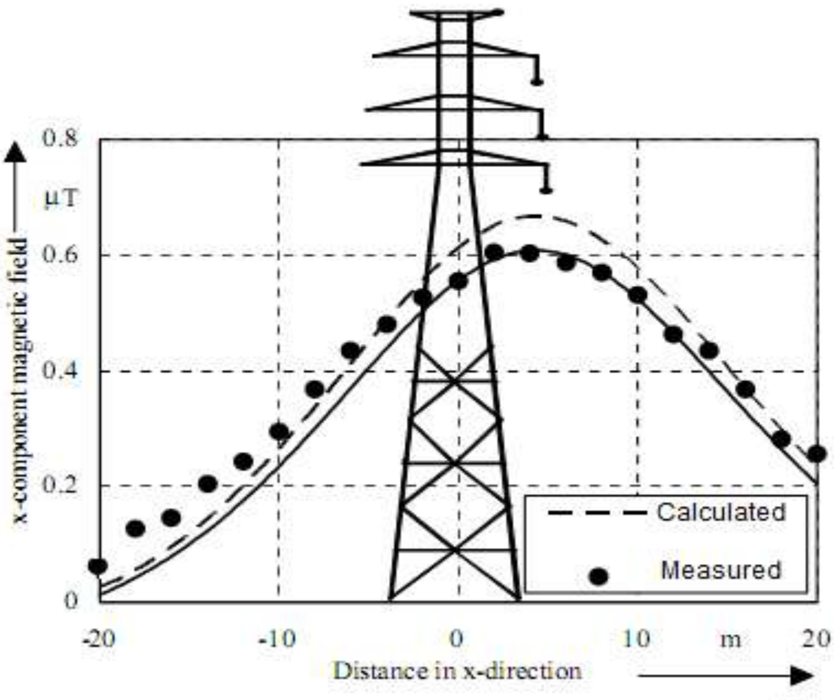

Figure (4) the effective value of the magnetic field.

DISCUSSION

The results for (132 KV) double channel configuration without changing the layout phase (standard) flux density obtained in the earth surface level at mid-channel with the distance of (18) m above the earth surface amounted (6.120) µT. Whereas by changing the layout phase configuration the calculation obtained of about (3.972) µT. This is because, with phase change the layout means there is a change in conductor distance closest to the ground surface. Originally Conductors closest to the ground surface is C1 and C2. By changing the layout phase Conductor C2 located in the top position and Conductor position A_2 located at the bottom closest to the surface soil. So the position closest Conductor to ground surface are conductive C_1 and A_2. On the other side three-phase currents flowing through each Conductor phase unchanged. Consequently Conductor who originally had the closest distance to the ground (C_2) will generate smaller magnetic field intensity, because it is far above the ground surface. The results of this calculation can be reduce means that the change of phase lies in the dual configuration can be reduce the magnetic flux density on the ground surface in mid- channel (X = 0), of about (64. %).used as one way to reduce the magnetic field intensity above ground.

When compare the results ,we can see that the calculated results are approximately equal to the practical measurement . The difference between the practices measured values of field with those obtained by calculation, may be mainly due to the real currents in the measurement period, were slightly lower than calculated by the histogram of powers provided by the supply company and also the accuracy measuring instrument. Finally ,According to the above results of the measurements , it is found that the magnetic field produced by this transmission line configuration is below tolerability limit set by the international recommendation for exposure Limits .

CONCLUSION

There is a need and obligation according to WHO to calculate and measure the magnetic fields because of the negative health effects of these fields. In this research a different arrangements of phase conductors were analyzed to find the best solution for minimizing the magnet field intensity and a mathematical model and practical measurements of magnetic field density (B) in a high voltage power transmission line 132kv has been conducted. According to the results of the measurements in situ, it is found that the magnetic field produced by (132kV) transmission line network are below tolerability limit set by the international recommendations. With proper redistribution of the phases is achieved an important way to reduce the value of the field. However in the design of a line to be considered other factors such as the capacities between conductors, corona losses, the cost of line, etc.

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