MITIGATION OF 150 kV ELECTROMAGNETICS FIELDS EXPOSURE AT RESIDENSIAL AREA

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Abstract: The effects of electromagnetic fields (i.e. electric fields and magnetic fields) to the human health have become a big environmental problem to the Electric Company. The electric field strength threshold and magnetic field of 150 kV on the transmission system through the Riau Province is needed to be studied, to check whether it has been fill up the recommendations of IRPA/INIRC, WHO 1990. C.95-2000. This report provided information about magnetic field condition, base on the measurement and calculation of the electric field with the impedance characteristic equation, and then, it were compared with the recommendation of IRPA/INIRC, WHO 1990. The highest magnetic field of 0,00009 Tesla and this value is shown lower than recommended magnetic field of 0,0001 Tesla (standard value), however the electric field of 70 V/m, it is shown lower than standard (5 kV/m). Base on standard; the electromagnetic field of 150 kV overhead power lines in Riau province is safe for human healthy. Magnetic field mitigation efforts are still needed for the consideration of psychological factors and the height building structure is exposed by overhead transmission lines. It is recommended that the addition of a wire loop under the transmission lines, installation of the wire loop can reduce the magnetic field up to 30%.

Keywords: electromagnetic field, recommendations of IRPA/INIRC,WHO 1990, mitigation magnetic filed.

1. Introduction

150 kV Overhead lines (OL) pass through residential areas, agriculture (rice fields, gardens), forest and scrub. The existence of this OL will be negative impacts on the environment, such as social impact, public unrest (psychology) and also influence to the electronic equipment. In addition, the negative impact can also lead to electrical shock, which could be possibly derived from plants that touch on the OL. The tendency of the negative effects is caused by the effects of electromagnetic field. The electromagnetic fields exposures cause the symptoms of stress, due to shocks from electrostatic discharge or by contact with electrically charged objects. So, this affects on the psychological aspects (fear, etc.) and environmental comfort. Primarily, it is a very big influence on the people who have less knowledge about electricity.

2. Related Works/Literature Review

Recommendations of IRPA/INIRC,WHO 1990, SNI 04-6950-2003 and IEEE std. C95.6-2000 suggest the electromagnetics exposure for human healthy at level of magnetic field and electric field of 0,0001 Tesla and 5 kV/m, respectively[4,7-9].

However, long-term exposures of magnetic field of 10 mG (1.0 micro.T) and it are higher than 10 mG exposures indicating the psychology effect or stress response. [1,2]. The safety issue of electromagnetics field exposure should be a reasonable cost with the good reliability [5]. However, many people live under overhead lines. It is needed the technology to reducing the electromagnetic field exposure to the human body. In this paper, it will describe how to reduce the electromagnetic field exposure under overhead lines.

3. Material & Methodology

3.1. Data

This study was conducted to investigate the measurement of electromagnetic field as much as 67 points with FH 51 Gauss (Teslameter) with height of 1 meter from the ground, and also presented about some reviews which are related to the mitigation of the electromagnetic field. Thus far, a number of literatures have been taking based on the standards and recommendations issued by the IRPA / INIRC and WHO.

3.2. The Electromagnetic fields threshold

Recommendations from IRPA / INIRC to the exposure limit of the electromagnetic field on the controlled environment and also public for the frequency 50/60 hz as depicted in Table 1 [4,7].

Table 1. IRPA / INIRC recommendations

Clasification	Electric field (kV_{rms}/m)	Magnetic Flux (T_{rms})
• Controlled environment	10	$0,5 \times 10^{-3}$
1. Whole day	30 [a)]	5×10^{-3} [b)]
2. Short time	-	25×10^{-3}
3. Human body	5	$0,1 \times 10^{-3}$
• General:	10	1×10^{-3}

Notes

a) Exposure time for the electric field strength of 10-30 kV / m can be calculated using the formula: $t \leq 80 / E$ where t = exposure time (hours) and E = electric field strength (kV / m)

b) Maximum exposure time for each day is 2 hours

c) Applicable for the open space such as recreation places, ground, etc

d) Exposure limits may exceed for a few minutes per day depend on the prevention condition.

Base on IRPA guidelines, it require the electric field strength and magnetic field density of 5 kV /m and 0.1 mT, respectively, for the residential areas.

3.3 WHO recommendation

On 1990 WHO give a recommendation for the electromagnetic fields [4], it was presented in Table 2.

Table 2. Threshold value for the electric field

Electric Field Density (kV/m)	Exposure Time (minutes)
5	Unlimited
10	180
15	90
20	10
25	5

For general public WHO 1990 recommended the maximum exposure level of 100 μT for magnetic field and 5 kV/m for the electric field.

3.4 Calculation of magnetic field without mitigation [3,11]

Ampere's law can be applied to determine magnetic flux density at the point (xj, yj), it was generated by the wire with unlimited length. The formula is presented as follow:

$$\overline{B}_{ij} = \frac{\mu I_i}{2\pi r_{ij}} \overline{\varphi}_{ij} \text{ Tesla} \quad (1)$$

Magnetic field without mitigation is the initial field generated by each phase wire on the OL without the influence of wire mitigation which produced by current flowing in each phase wire. In the case of three-phase systems as in figure 4 with a magnetic flux density with no mitigation is the total flux density of each phase wire,

$$\overline{B}_{ij} = \sum_{i=1}^{n} \frac{\mu I_i}{2\pi} \left[\frac{(x_i - x_j)\overline{a}_y - (y_i - y_j)\overline{a}_x}{(x_i - x_j)^2 + (y_i - y_j)^2} \right] \quad (2)$$

$$B_x(x_j) = \frac{\mu}{2\pi} \sum_{i}^{n} I_i \frac{(y_i - y_j)}{(x_i - x_j)^2 + (y_i - y_j)^2} \quad (3)$$

$$B_y(x_j) = \frac{\mu}{2\pi} \sum_{i}^{n} I_i \frac{(x_i - x_j)}{(x_i - x_j)^2 + (y_i - y_j)^2} \quad (4)$$

where; n = total wires, $\overline{a}_x$ = vector at x axis, $\overline{a}_y$ = vector at y axis. The total magnetic flux density in vector;

$$\overline{B} = B_x \overline{a}_x + B_y \overline{a}_y \quad (5)$$

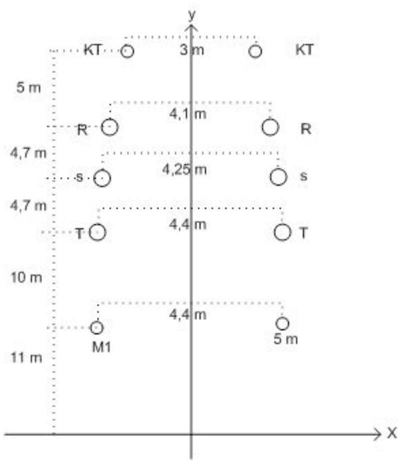

Figure 1. Overhead transmission lines of 150 kV with loop wires under phase wires

3.5 Calculation of mitigation magnetic field [3]

Induced current in the wire loop mitigation is very affecting to the magntetic field mitigation. With mitigation wire placement in the coordinates ($x_{m1}y_{m1}$) and ($x_{m2}y_{m2}$) as presented on Figure 2, then the amount of flux that penetrates the field of wire loop mitigation are presented as:

$$\phi = l \ x \int_{x_1}^{x_2} B_n \ dx$$

$$= \frac{-\mu I l}{4\pi} \sum_{i=1}^{n} \ln \frac{(x_{m2} - x_i)^2 + (y_{m2} - y_i)^2}{(x_{m1} - x_i)^2 + (y_{m1} - y_i)^2} \qquad (6)$$

Where B_n is magnetic field density and μ is the permeability in a medium. The induction current I_{mit} leads to magnetic field density $\boldsymbol{B}_m$ at the coordinat points,

$$\overline{B}_m = B_{mx} \overline{a}_x + B_{my} \overline{a}_y \qquad (7)$$

$$B_{mx} = \frac{\mu I_{mit}}{2\pi} \left[\frac{(y_{m1} - y_j)}{(x_{m1} - x_j)^2 + (y_{m1} - y_j)^2} - \frac{(y_{m2} - y_j)}{(x_{m2} - x_j)^2 + (y_{m2} - y_j)^2} \right] \qquad (8)$$

$$B_{my} = \frac{-\mu I_{mit}}{2\pi} \left[\frac{(x_{m1} - x_j)}{(x_{m1} - x_j)^2 + (y_{m1} - y_j)^2} - \frac{(x_{m2} - x_j)}{(x_{m2} - x_j)^2 + (y_{m2} - y_j)^2} \right] \qquad (9)$$

The magnetic field is the opposite of the original magnetic field mitigation. The most important thing is the magnetic field caused by the wire mitigation is a quantity vector and always changing with the time, as well as the original magnetic field which is a quantity vector and also change with the time. So, the magnetic field results of mitigation can be defined as follows,

$$\overline{B}_t = \overline{B} + \overline{B}_m \qquad (10)$$

4. Results and Discussion

From the magnetic field strength measurement by using the tool FH 51 Gauss / Teslameter and calculation of the electric field strength on the OL of 150 kV by using impedance characteristic equation for transmission lines [6] (where: h = 17 m and a cross-section area ACSR = 150mm2) as depicted as follow [10].

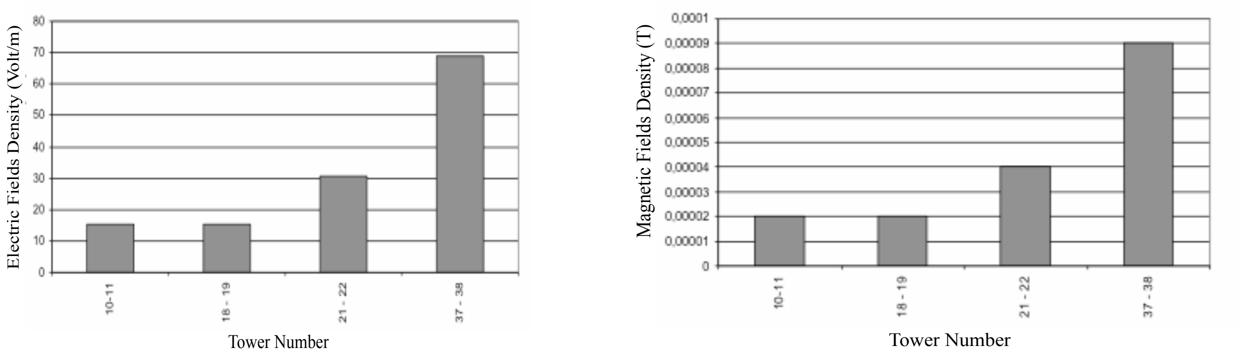

Figure 2. Electric and magnetic fields at GI PLTA Koto Panjang - GI Bangkinang

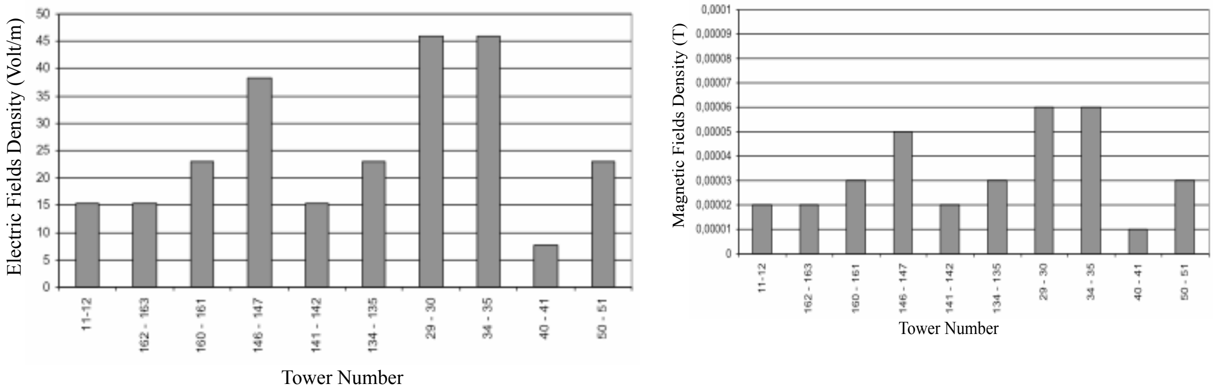

Figure 3. Electric and magnetic fields at GI Duri - GI Dumai

Base on figure 2, the graph of density magnetic field to GI PLTA Koto Panjang - GI Bangkinang between 37-38 tower with the highest density is 0.00009 Tesla, and it is still below the threshold recommended by the IRPA / INIRC, WHO1990 is 0.0001 Tesla. According to figure 2 also the graph of the electric field strength to GI PLTA Koto Panjang - GI Bangkinang is between 37-38 tower with the highest electric field strength of 70 V / m, below the threshold recommended by IRPA / INIRC, WHO1990 is 5kV / m. Base on both of the graph (i.e. magnetic field density and electric field strength), the weather (drizzle) can enhances the value of a electric field strength and magnetic field density. Figure 3 is presented the electric and magnetic fields at GI Duri - GI Dumai with the values are lower than at figure 2.

By using equation 1-10, from the measurement as presented in Figure 4 for configuration as like as Figure 1.

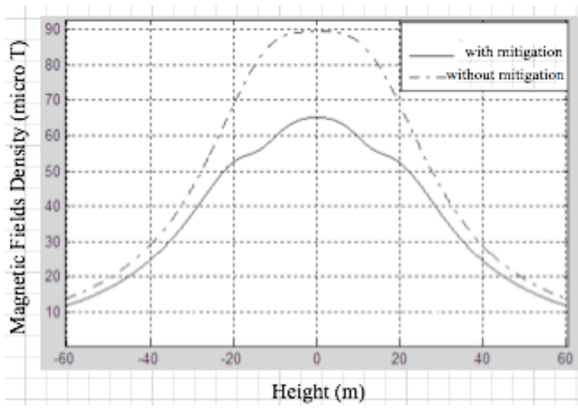

Figure 4. Magnetic field distribution on OL

With the wire loop instlallation can reduce the magnetic fields up to 30%. To get a better security due to exposure to a magnetic field, metal materials such as zinc roof and fence should be grounded to avoid the induced residual stress such as the residual voltage. The grounding system value should be lower or base on standard.

5. Conclusion

From the measurement and calculation of the magnetic field and electric field in the OL at Riau, it is still below the threshold of 0.0001 Tesla, the highest value of the magnetic field is under the OL of 0.00009 Tesla, while the electric field is also still below the threshold of 5 kV / m, and the highest value of the electric field is under the OL of 70 V / m.

Environmental was affected to the increasing of the electric field strength and magnetic field density. Based on measurements and calculations, the OL at Riau is safe based on a recommendation of IRPA / INIRC, WHO 1990.

Wire loop installation can reduce the magnetic fields of up to 30%. Metals such as zinc and fences must be grounded to avoid the residual stress of the voltage.

Acknowledgement. -

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Patent

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Appendix

Appendixes, if needed, appear after Reference.