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Analysis the Magnetic Field Emissions Under Transmission Line 132kV and 275kV Using ANSYS Maxwell Software

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ABSTRACT

This research deal with simulation of magnetic field emissions under the transmission line. The research around transmission lines is very important because of the potential effects to human and the environment due to the magnetic field distribution. The of this project are to analysis the magnetic field emission for 132kV and 275kV transmission line by using simulation. This project will be simulated by using ANSYS Maxwell Software specifically Finite Element Method (FEM) that provided can illustrate the magnetic field. Based on the result, the highest magnetic field for 132kV is 1.43uT and 275kV is 3.78uT.

Key words: magnetic field emission, ANSYS Maxwell, transmission line,

1. INTRODUCTION

Today, electrical has been essential part in our lives, it is quite hard to survive in the future without electrical energy. Malaysia has introduced a system and it used until today, it called the national grid to ensure the smooth distribution of electricity to consumers. Power lines or transmission lines carry a high voltage electric current flow from one location to another. When current flows through a cable, electromagnetic will be produced. a magnetic field and an electric field are produced around it. These are the two components of the electromagnetic field. The transmission line also produces a magnetic field and high power below the tower. From the previous research, the electric field can be blocked easily by solid objects such as trees, wall, and buildings. However, the magnetic field cannot be blocked. This means, the environment is exposed to the magnetic field. Other than that, this field also gives health and environmental effect. However, both fields are silent and invisible. Electric and magnetic field can be reduced with distance from source. Therefore, this project take measure under transmission line and makes simulation studies to carry out the simulation. This research will be focuses on transmission line that is typically used in

Malaysia 132kV and 275kV. The transmission lines model is based on specification gained from past researcher. This project has adopted simulation by Ansys Maxwell's software. EMDEX II will be used to measure under transmission line was comparing with the simulation.

In [1] describe the electric field strength propagating of 132 kV overhead power lines. The author objectives are to define the suitable method for enabling calculating the electric field strength underneath the 132 kV line. Author use method such as Excel and Visio to calculate the conductor distances, conductor sag, and conductor clearance for each level. The research will be compared the results with the EMF exposure standards exposure limits. In paper [2] describe EMF radiation affect people health. Authors conduct a research by using some method such as measurement, questionnaires, and interview. The authors also explain that the higher the voltage level of the transmission line the higher the EMF emission. In paper [3] describes the method of analysis for the calculation of magnetic field emissions, caused by overhead power lines. The results obtained are verified with measurements and numerical calculations using the finite element method. The author will compare the results obtained with the proposed method of analysis with the calculation results in which the conductor sagging. The authors say this method is suitable for use in optimization procedures where computation time can play an important role. In paper [4] describes in the development of scaled down Six Phase Transmission Line (SPTL) model developed in the IVAT laboratory to serve the purpose of study of the steady state and transient behaviour of high phase system. The author uses Finite Element Method (FEM) in ANSYS Maxwell software to simulate the project. In paper [5] describe the measure and analyse the magnetic field from different configurations of 132kV power lines. The measurement was conduct by using EMDEX II meter. Author also developed some equations and MATLAB Graphic User Interface for double circuit 132kV vertical configuration based on Bio-Savart's law and Maxwell's equations to make researchers easy to calculate the magnetic field.

2. MATERIAL AND METHOD

This part discusses the theory of transmission lines, electromagnetic, and the software and equipment used in the project. Electric current flow in the wire or equipment produced electric and magnetic field. The field will decrease due to the increasing distance from the source.

2.1 Transmission Line

Transmission lines are used to transfer electrical power between designated locations over long distances, usually starting from the central generating station to the various distribution unit. For the more, it also used for electric power transmission from one central station to another for distribute electricity. With transmission lines, the voltage will be stepped up at generation station, then transmitted through the transmission grid to the load center, there it will be stepped down for distribution. High voltage transmission lines mainly consist of tower, conductor, and insulator. Depending on the type of line and country, the tower for transmission lines takes a variety of shapes. Conductor is a material which usually uses copper type as a medium to electric charge flow [6]. Since the power losses on transmission lines are proportional to the square of the load current in equation (1):

$$P_{loss} = I^2 R \quad (1)$$

to reduce the loss high voltages are used. Thus, as high voltage
at the transmission line, the losses to transfer voltage can be reduced. High voltage transmission line power can be classified by the range of voltages in Table 1 [6].

Table 1: Overhead transmission lines classification [1]

Voltage classes	Voltage range (kV)	User
High voltage (HV)	33kV-230kV	Sub-transmission and transmission
Extra high voltage (EHV)	230kV-800kV	Long distance and very high power transfer
Ultra high voltage (UHV)	800kV-1600kV	

2.2 Magnetic Field

Electromagnetic field has two components which are, magnetic field and electric field. Usually, both magnetic and electric field are present, so we can use term EMF to mean either the magnetic field from the transmission line can vary widely because current in flow in the conductor depend on the amount of power demand. On the other hand, electric field from transmission line varies very little because the voltage essentially remains constant. Magnetic and electric fields are also different in the way they interact to the surroundings. Electric filed can be block while magnetic field will penetrate anything. Usually, the electric fields near the transmission lines are greater than those found in the house because they have a higher voltage than residential sources or appliances. Electromagnetic fields will be decrease dramatically with distance from the source, EMF emission from power lines is significantly decreased by the distance from the wires-including the height of the towers or poles supporting overhead transmission and distribution lines. Magnetic fields from transmission lines, cannot be blocked by any solid object, so that they are further penetrate inside homes and buildings. The method by which charges and currents relate to electromagnetic fields are explained by Maxwell's equations and Lorentz-style laws [7].

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) and (3)[7].

$$\mathbf{B} = \int \frac{u_0}{4\pi} \frac{I d\boldsymbol{I} \times \hat{\boldsymbol{r}}}{\|r\|^2} \quad (2)$$

Or, equivalently,

$$\mathbf{B} = \int \frac{u_0}{4\pi} \frac{I d\boldsymbol{I} \times \boldsymbol{r}}{\|r\|^3} \quad (3)$$

Where:

$\boldsymbol{I}$ = current
$d\boldsymbol{I}$ = vector, whose magnitude is the length of the differential element of the wire, and whose direction is the direction of usual current
$\mathbf{B}$ = magnetic field
u_0 = magnetic constant
$\hat{\boldsymbol{r}}$ = displacement unit vector in the direction pointing from the wire element towards the point at which the field is being computed
$\boldsymbol{r} = \boldsymbol{\gamma}\hat{\boldsymbol{r}}$ is the full displacement vector from the wire element to the point at which the field is bieng 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 calculating the magnetic flux density of a conductor which is fixed length.

Figure 1 shows the relationship of each parameter and equation (4) shows the formula.

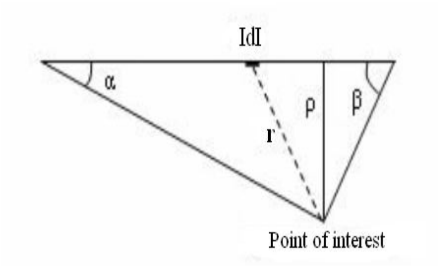

Figure 1: Calculation of Magnetic Field

$$\mathbf{B} = \int \frac{\mu_0}{4\pi}(\sin\alpha - \sin\beta) \qquad (4)$$

Where:

$\rho =$ vertical distance between the conductor and pont of interest.
$\alpha =$ angle between *l*dI and **r** when *l*dI at the left end of the conductor.
$\beta =$ angle between *l*dI and **R** when *l*dI at the left end of the conductor.[7]

2.3 Tower Characteristics

Table 2 tabulates the details of voltage level, current capacity and sizing used in 132kV and 275kV transmission line

Table 2: Data of the Tower

Voltage level	132kV	275kV
Conductor (mm)	Single Batang ($300mm^2$)	Twin Zebra ($400mm^2$)
Current each Conductor (A)	15	40

The dimension of the 132kV and 275kV transmission line tower shows in Figure 1 and Figure 2. Finite Element Method (FEM) transmission line model will be made based on information given.

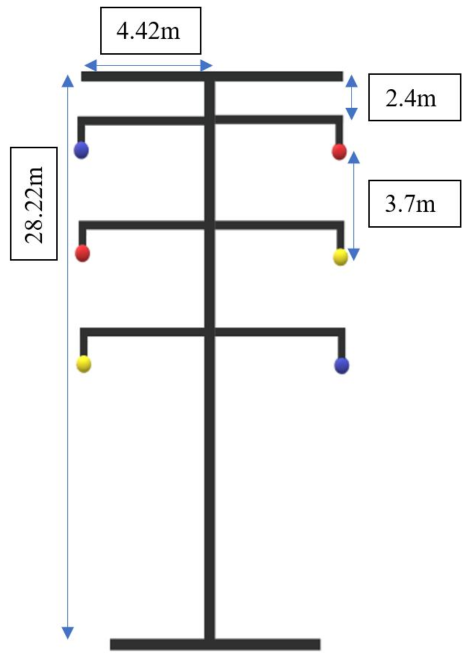

Figure 2: The tower design with dimensions for 132kV. [4]

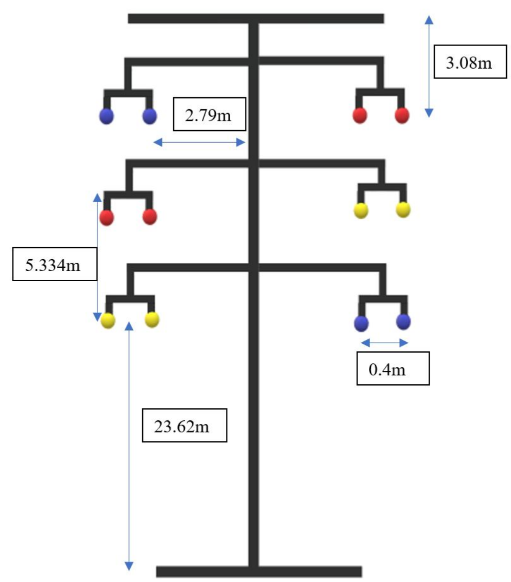

Figure 3 : The tower design with dimensions for 275kV. [4]

2.4 ANSYS Electronics Desktop

ANSYS Electronics Desktop is the premier, unified platform for system simulation, circuit, and electromagnetic. Without retriction tools like ANSYS HFSS, Maxwell, Q3D Extractor, and Simplorer are built natively in the Electronics Desktop, which serves as a universal Pre/Post processor for these tools. With ANSYS Electronic Desktop, it can integrate rigorous circuit simulations and system analysis electromagnetic in a comprehensive and easy-to-use design platform. Figure 3 shows general process of simulation, where the learning process to simulate the design of a transmission line [8].

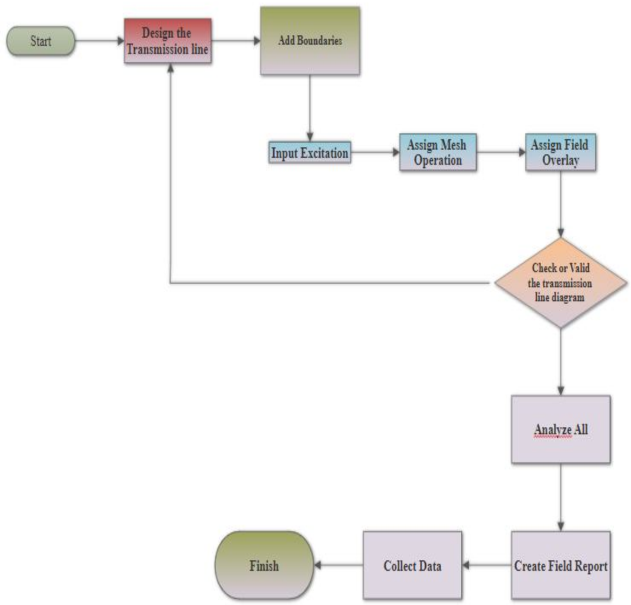

Figure 4 : Flow chart of ANSYS Software

The development of the appropriate model structure can be visualized by using a material software designer [9].

(I) Design the Transmission Line
For this design, there have six cables and the length is 300m aluminum conductor. The line in the middle indicate the level above the ground to generate the image of electromagnetic field that occur along the tower to tower.

(II) Excitation
The part to set the input current by using excitation interface as shown in Figure 5.

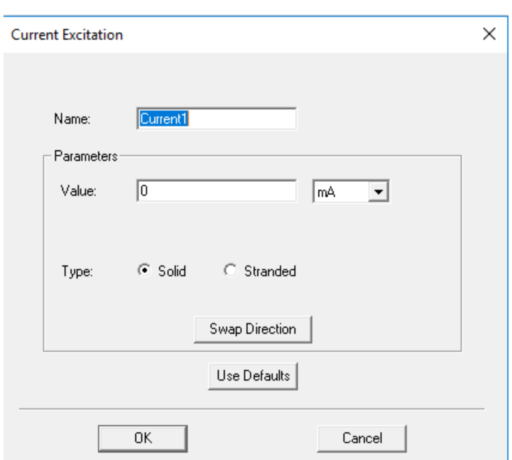

Figure 5: Input Excitation

To set a current excitation:

i. Select the section of the the conductor on which wan to apply the excitation normally a face or other 2D object.

ii. Click ***Maxwell>Excitations>Assign>Current.*** The Current Excitation window appears.

iii. Enter a name for the excitation in the Name box, or accept the default.

iv. In the Parameters section, specify the following options:

a. Enter a value for the current given.

b. Select stranded as the Type of conductor. For a stranded conductor, a uniformly distributed current density is assumed.

c. Click Swap Direction to change the direction of the current flow.

(III) Mesh Operation
The Mesh operations are optional mesh refinement settings that provide Maxwell with mesh construction guidance as shown in Figure 6. This technique of guiding Maxwell's mesh construction is referred to as "seeding" the mesh. Seeding is performed using the Mesh Operations commands on the Maxwell3D. When defining a mesh, normally assign the mesh operations first using the ***Maxwell 3D> Mesh Operations> On Election> Length Base*** and then input Maximum Length of Elements to 0.5meter.

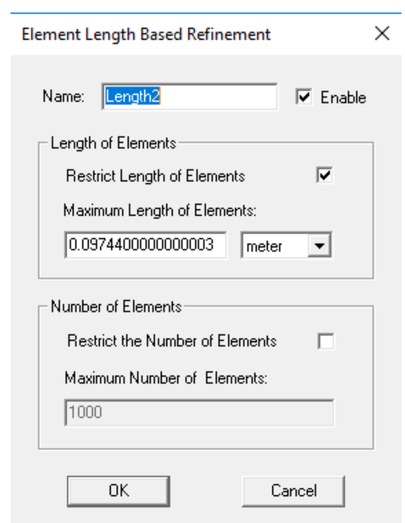

Figure 6: Assign Mesh

(IV) Field Overlay
The information the image magnetic field in by create a Field Overlay such as in Figure 7. Then choose Mag_B for the Quantity section and then done.

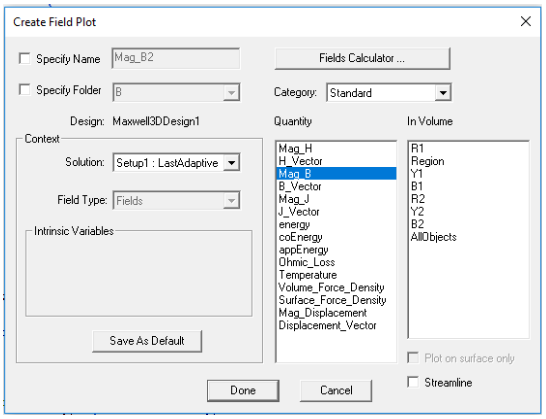

Figure 7: Field Overlay

(V) Validate

After create Field Overlay; then Validate the transmission circuit diagram such as in Figure 8. If there is an error check at the message manager what the error and repeat the step above. If there is no error the next step is click the analyze all the run the design.

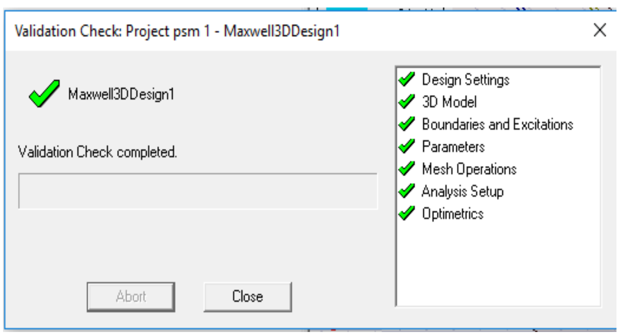

Figure 8 : Validation Check

(VI) Magnetic Field

It shows that the magnetic field nearest the conductor is more intense. After that we plot a graph by select at the project manager ***Results>Create Field Report>Rectangular Plot.*** From the category, select Calculator Expression and Mag_B. at the geometry select the line from the diagram that need to be plot. The magnetic field is measured from Ground level to 5m.

3. RESULTS AND ANALYSIS

This part will explain the data and results collected from simulations. All data and results were taken to produce a graph and table to magnetic field below the 132kv and 275kV transmission lines.

3.1 132kV Transmission Line

Figure 9 shows a simulation design of a 132kV transmission channel using Ansys Electronic Desktop. The distance from tower to tower has been determined from the ground 0 m to 5 m. Each distance of 1 m indicates a magnetic field has been detected after conducting the simulation. The color indicates the intensity of the magnetic field release. The color blue indicates the lowest magnetic field and for the highest is red. This show that the center of the transmission line has the highest magnetic field.

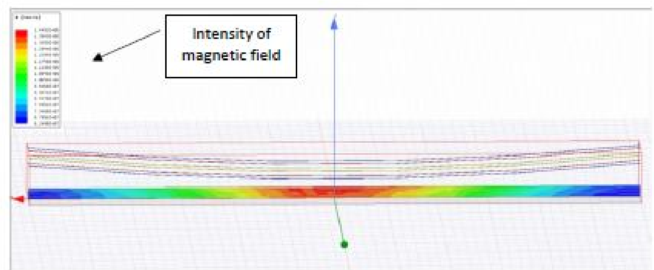

Figure 9: Magnetic Field Under 132kV Transmission Line with 300m Distance

Figure 10 shows the intensity of magnetic field along the 300m transmission line. There six colour of the line indicates the level of magnetic field emission from ground level to 5m. The lowest magnetic field is at distance 0m and 300m and the highest is at 150m in the middle of the path.

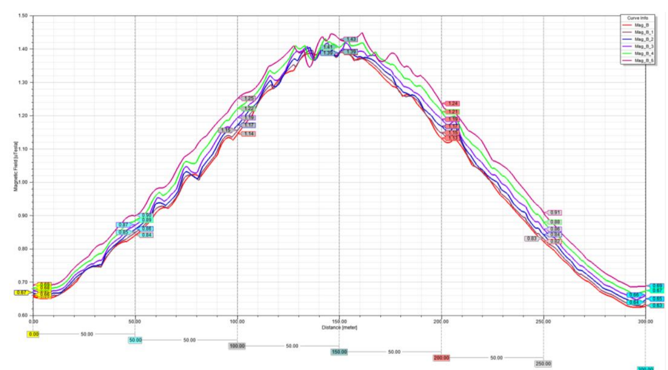

Figure 10: Graph of Magnetic Field (uT)vs Distance (m) along the 300m under transmission line

According to the Table 3, the intensity of magnetic field in the middle is the highest. The highest magnetic field is in the middle of transmission line 1.43uT. The lowest is at the start 0.69uT and at the end 0.69u magnetic field a highest towards the center of the span where the sag of the conductor brings them closest to the ground 150m and decreases by the end of the transmission channel span at 0m and 300m.

Table 3: Intensity of magnetic field along the 132kV transmission line

Distance above the ground (m)	Magnetic Field along the 300m under the transmission line (uT)				
0	0m	100m	150m	250m	300m
1	0.66	1.14	1.39	0.82	0.63
2	0.66	1.15	1.39	0.83	0.64
3	0.67	1.17	1.39	0.84	0.65
4	0.68	1.19	1.39	0.86	0.66
5	0.69	1.22	1.41	0.88	0.67

Max value

3.2 275kV Transmission Line

Figure 11 shows a simulated design of a 275kV transmission channel using ANSYS Electronic Desktop. The distance from tower to tower has been determined from the ground 0 m to 5 m. Each distance of 1 m indicates a magnetic field has been detected after conducting the simulation. The color indicates the intensity of the magnetic field release. The color blue indicates the lowest magnetic field and for the highest is red. This indicates that the center of the transmission line has the highest magnetic field. This happen due to the sag nearest to the ground.

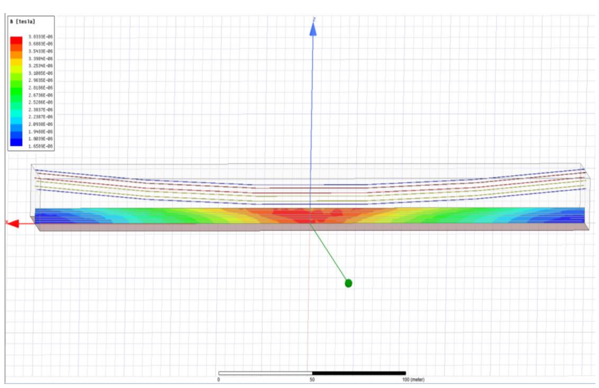

Figure 11: Magnetic Field under 275kV transmission line distance; 300m.

Figure 12 shows the intensity of magnetic field along the 300m transmission line. There are eight color of the line indicates the level of magnetic field emission from ground level to 5m. The lowest magnetic field is at distance 0m and 300m and the highest is at 150m in the middle of the path.

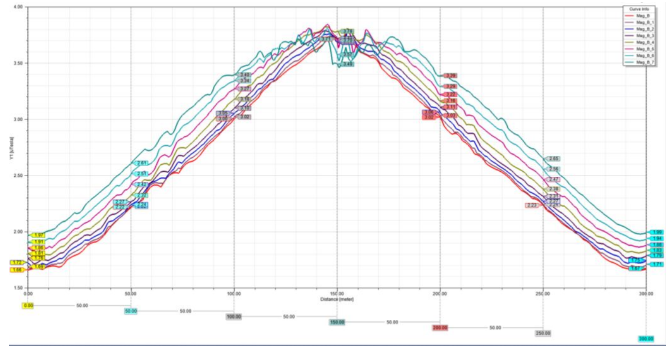

Figure 12 : Magnetic Field along the 300m under 275kV transmission line

According to the Table 4, the intensity of magnetic field in the middle is the highest. The highest magnetic field is $3.78uT$. The lowest is at the start $1.66uT$ and at the end $1.67uT$. Magnetic field in the center of transmission line above is decreasing 5m is $3.70uT$. This happen due to the collision of magnetic flux between two cables.

Table 4: Intensity of magnetic field along the transmission line

Distance above the ground (m)	Magnetic Field along the 300m under the transmission line (uT)				
	0m	100m	150m	250m	300m
0	1.66	3.00	3.71	2.23	1.67
1	1.69	3.02	3.68	2.24	1.71
2	1.72	3.05	3.69	2.27	1.75
3	1.76	3.10	3.72	2.31	1.79
4	1.81	3.18	3.78	2.38	1.83
5	1.86	3.27	3.70	2.47	1.88

Max value

5. CONCLUSION

The objectives of this research are through of this simulation studies, the 132kV and 275kV transmission line can be model by using Finite Element Method (FEM) by ANSYS Maxwell software. The model based on specification from the best knowledge of the personal concern by Transmission Division. This research is to determine magnetic field produced from transmission line model. From the simulation, the magnetic field is higher at distance 150m which in the middle of a conductor. The highest magnetic field for 132kV is 1.43uT and 275kV is 3.78uT. The transmission line modelled using Finite Element Method (FEM) are neglecting environmental factor and power demands. In overall, the results are below than 100uTesla from ROW.

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