Magnetic Fields Generate by High Voltage 400 KV. Electrical Overhead Lines

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ABSTRACT

In this paper the magnetic field around a 400kv. power line had been measured and simulated. The measurement results and simulated results had been compared, and had the same variation. The results agreed with the international standards. Measurements of magnetic field intensity at one meter above the ground level carried out for an existing high voltage 400KV. overhead lines extending between Zawia generating station (step up station) and Tripoli-west substation, show that the emissions of magnetic fields around overhead line within the right of way (ROW) could be high, and a solution should be considered like increasing the right of way (ROW) distance, or lowering the current.

One of the main finding is that the transmission corridor(ROW) is not forced and people are living and still building houses under the transmission lines. The health risk due to field generated from high voltage lines are still under consideration from research groups in developed countries. Probable risk of leukemia, breast cancer neuropsychological disorders and reproductive outcomes had been reported due to this exposure. Especially when exposed for a long time.

Keywords Electromagnetic, High voltage lines ,fields , health

1.Introduction

High voltage overhead lines have electric and magnetic fields around them, these fields increase with the increase in loading (current). In Libya the 400 KV overhead lines are the highest voltage in use and started few years back (2009). People who are living very close to the lines had a health risk .

In this paper we will present the measured magnetic field , design a computer program for simulation based actual data (The line used that extended from Zawia to Tripoli-West stations) will be compared with the measured results. Many papers have been written about the distribution of electromagnetic fields under high voltage transmission lines. Daniel Greenan (from Ireland) found that overhead lines have a negative visual impact and health implications.[1] Dib Djalel and Mordjaoui Mourad (from Algeria) Confirmed the non-standards compliance to the limits of human exposure to ELF fields in the case of the town of Tebessa and approved the aggression on human health.[2] Adel Z. Eldein had discussed a paper about the studied of magnetic field under Egyptian 500kv overhead Transmission line. [4]

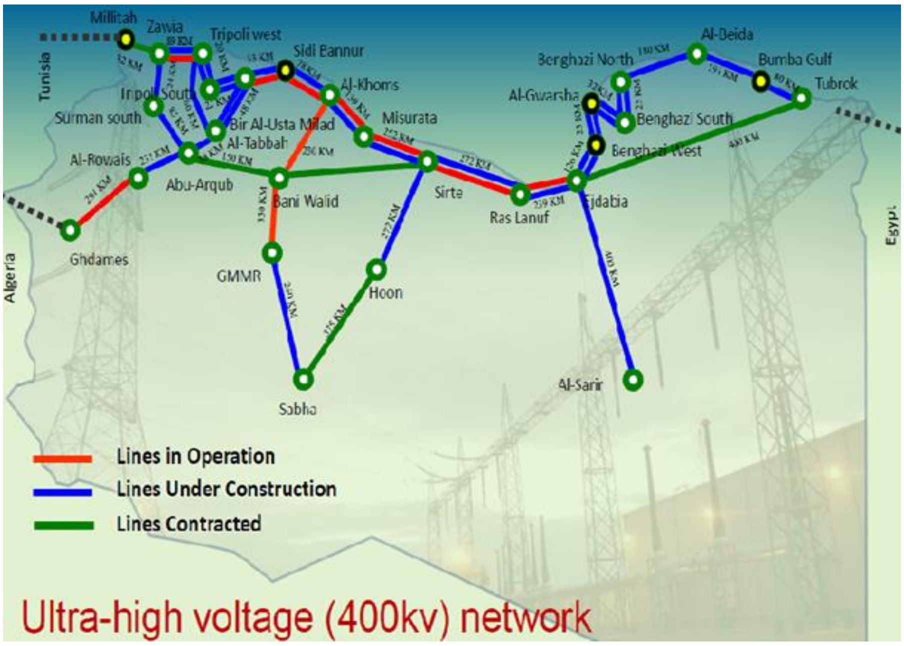
These papers have explained only the lateral profile of the electromagnetic field distribution on the ground. Increasing demand on transmission systems to deliver hundreds and thousands of megawatts will increase in future. Space and land are at a premium. A huge quantity of conducting wires and steel supports as well as insulators are required to make and tie up the transmission system. As the transmission voltage increases, more space and insulation are needed. Transmission Voltages less than 300KV are categorized as a high voltages, those between 300KV and 765KV are termed as Extra High Voltages(EHV), and those greater than 765KV are classified as Ultra High Voltages(UHV).

In this paper, if it's not otherwise specified, a high voltage means any of the categories just defined. The structure of a single circuit 3-phase transmission line system is different from that of a double or a multi-circuit transmission line system. The arrangements of the conductors as well as the supporting towers are different. In the case of double circuit systems, larger towers have to be used to ensure a safe spacing between the two circuits while phase arrangements can take different configurations.

2.The Libyan Electricity Network

General Electric Company Of Libya (GECOL) is a state-owned power utility responsible for generation, transmission and distribution of electric power throughout Libya and it is the only supplier of electricity in the country .

The data related to the peak generation and distribution circuits lengths as listed in GECOL Site. The 400kv power lines, network extended through Libyan land for more than 2,823km .The next map figure (1) shows the 400KV. lines which are in operation (red color) and which under Construction (blue color).



Figure(1) Libyan high voltage coverage

3.Types of transmission lines.

3.1 Single Circuit 3-Phase Transmission Lines.

In single circuit transmission line system, electrical power is transmitted over a group of conductors constituting the 3-phase sequence of the total or part of the power generated. Two, three, and four bundled conductor per phase are widely used in one way or another as shown in Figure (2). In the case of single circuit transmission line systems, the phases are usually configured horizontally or in a triangular configuration.

Another wire, sometimes two, is used for earthing with the single circuit transmission system. A single circuit transmission line system is usually used in case of extra high voltages where large insulation spacing between phases is required as well as between conductors and the support structures.

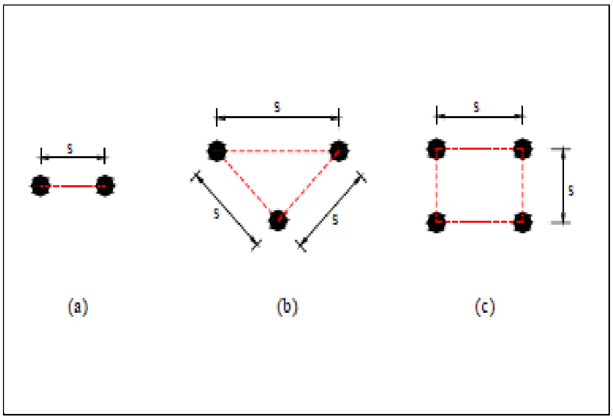


Figure 2: Bundled conductors, (a) two bundled conductors,
(b) three bundled conductors, (c) Four bundled conductors.[5]

A 400KV. single circuit 3-phase typical line configuration constructed in Libya is shown in Figure(3), with the phasing arrangement confirmed from the substation side.[5]

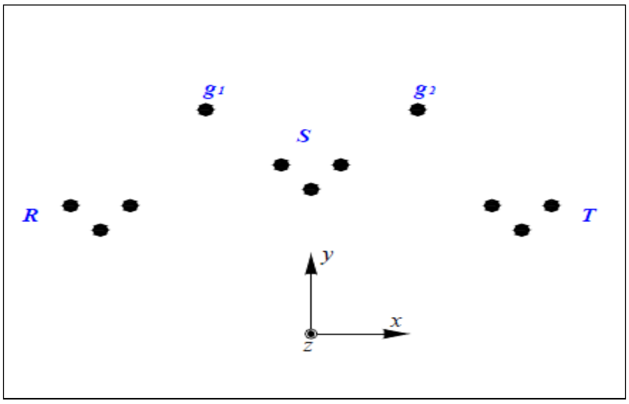


Figure 3:Typical 400kv single circuit line configuration using bundled conductors
and two earth wires (cross-sectional view).[5]

3.2 Double Circuit 3-Phase Transmission Lines.

For larger amounts of power or in case of a part load centers, double circuits can be used to transmit power instead of single circuit system. Two single circuits on each side of a transmission tower can be supported with enough spacing between them. A common earthing wire can be used for protection. The two single circuits supported by the single tower are called double circuits. The two circuits may supply the same load center or at some point they may separate to supply different load centers. The line configuration of the two circuits is usually vertical on either tower sides. A 400KV. typical line configuration for double circuit system is shown in Figure (4). [5]

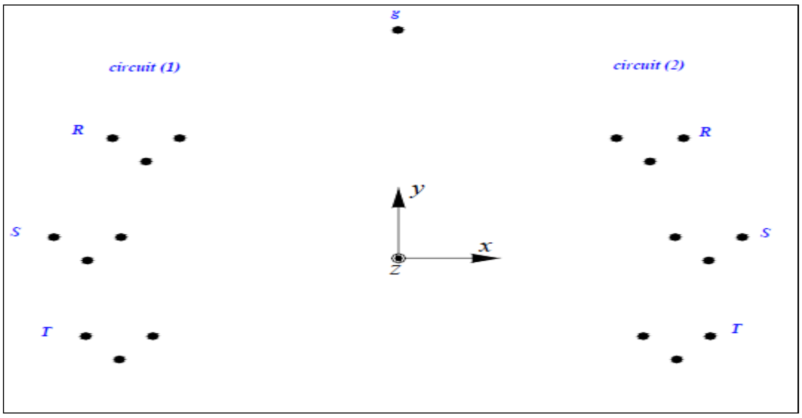


Figure 4:Typical 400kv double circuit line configuration using triangular bundled conductors and single earth wire (cross-sectional view).[5]

The magnetic field analysis will be discussed later for the single and double circuits described above.

3.3 Multi-Circuits 3-PhaseTransmission Lines.

In multi-circuit systems, the span is constituted from more than two circuits that may be charged with the same voltage or may have different voltages. The line configuration of these circuits and the spacing between them is a design issue that has to take into consideration the line voltages and the maximum load for each circuit. such system is not used by GECOL.[5]

4. Magnetic Field Analysis for Single and Double Circuit.

$$\overline{\boldsymbol{B}} = \frac{\mu_0}{4\pi} \int_{-\infty}^{\infty} \frac{\overline{I} \times \overline{a}R}{R^2} \overline{dl} \quad .... (1)$$

when , $\overline{I}$= i(t_0) $\overline{a}z$, and $\overline{dl}$ = dż , equation (1) becomes:

$$\overline{B} = \frac{\mu_0}{4\pi} \int_{-\infty}^{\infty} \frac{i(t_0)\, \overline{az} \times \overline{aR}}{R^2} d\dot{z} \quad ....(2)$$

The following equations are used to calculate the magnetic field. The results of Equations (3) and (4) depends on the number of conductors on the line and the distance of all the conductors from a given point along the one meter height.

$$B_x = \sum_{j=1}^{n} \frac{\mu_0 * I_j * y_j}{2\pi(x_j{}^2 + y_j{}^2)} \quad ....(3)$$

$$B_y = \sum_{j=1}^{n} \frac{\mu_0 * I_j * x_j}{2\pi(x_j{}^2 + y_j{}^2)} \quad .... (4)$$

The magnitude of magnetic field :

$$|\, B \,| = [B^2{}_x + B^2{}_y]^{\frac{1}{2}} \quad .... (5)$$

, [B = μ_0 . H] , where: ($\mu_0 = 4\,\pi . 10^{-7}$)

Considering the system as a balanced one the line currents are equal in magnitude and 120° a part so:

$$I_1 = I\ e^{-j0}\ ,\ I_2 = I\ .\ e^{-j120} \text{ and } I_3 = I\ .\ e^{-j240} \quad .... (6)$$

The above equations will be used to compute the magnetic flux density.

5. Measurement and Simulation of Magnetic field.

Low frequency magnetic fields induce circulating eddy currents with their intensity depends on the field level which depends on voltage, current and distance from the line. The circuit used in this study starts

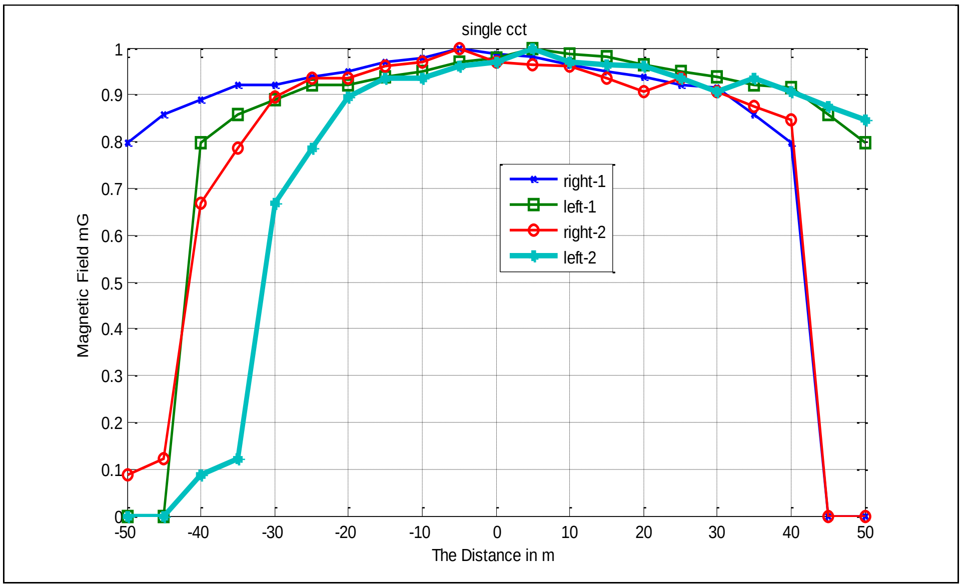
with double circuits on the same
tower then for an explainable reasons the two circuits are split into two parallel paths each tower group carries one circuit and this increases (ROW) .
The first step was to take measurements of magnetic field near the high voltage power line and on several points at different distances. The measuring instrument used is the model: Electromagnetic radiation detector (DT-1130), 50-2000MHz. which is highly sensitive and measures the magnetic fields.

5.1 Measurement Results.

The measurements were taken ± 50 meters on each side of the line center with the normalized meter′s reading and computer program for plotting are given in Appendix-2. These measurements were taken at points half way between the towers where the lines are at the closest distance to the ground. Practical measurements are conducted in both sides of the transmission line in a step of 5 m from the center line.

5.1.1 Measurement of Magnetic Field for Single Line Circuit.

When the magnetic field under the single circuits overhead line was measured, the two lines found very near to each other, so there is a big interference between fields.(i.e. the field produced by circuit-1 reach the area of field produced by circuit-2,overlap).The measurements are made between the towers and on both sides of them, this makes the magnetic field in the region between the circuits almost constant and decay outside them, a phenomena do not exist for double circuit case figures(7-8). To make the comparison with the computer simulation normalized the two to the same peak-1.

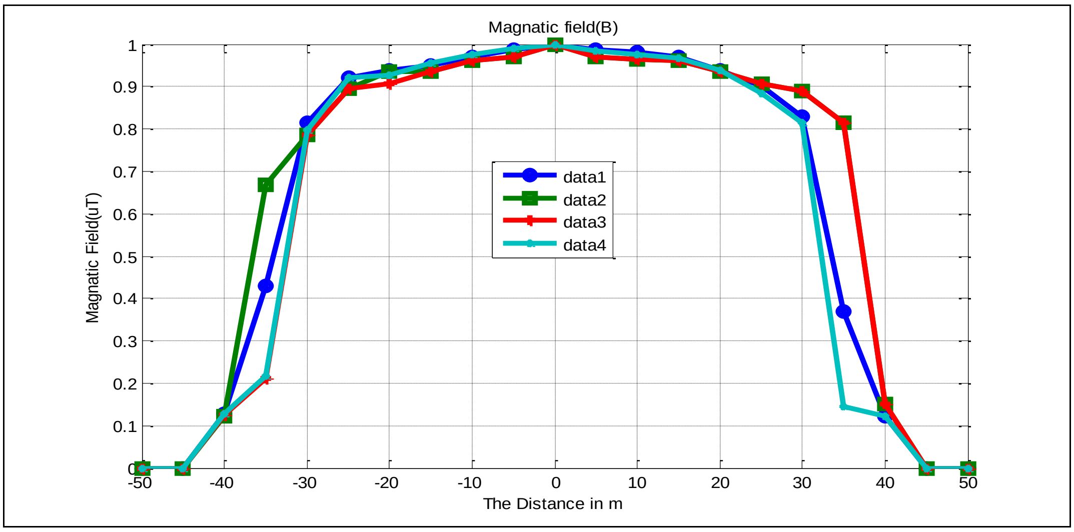


Figure(7): Normalized Magnetic field of 400kv single circuit.

Where: Right-1 means the measurement reading taken of circuit-1which is on the right side.
Left-1 means the measurement reading taken of circuit-2 which is on the left side.
Right-2 means the measurement reading taken of circuit-1 at different place and time.
Left-2 means the measurement reading taken of circuit-2 at different place and time.

5.1.2 Measurement of Magnetic Field for Double Circuit Line

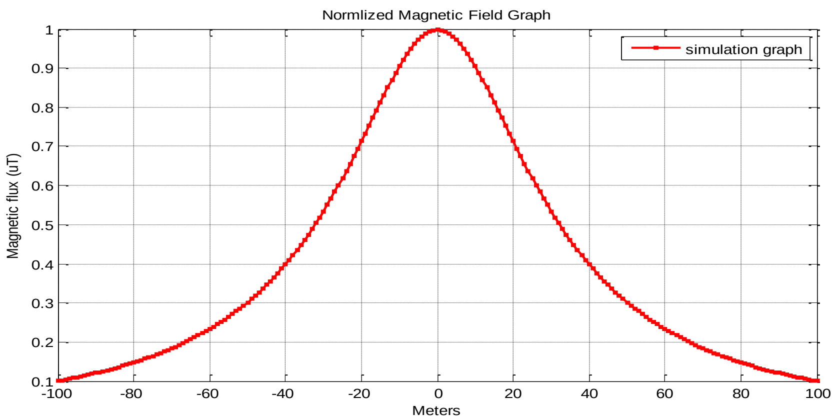
The results of measured magnetic field of double circuit 400 KV overhead lines are listed in table-2 in appendix-2, with the plotting given in figure(8).



figure(8): Normalized measurement of magnetic field of 400kv double circuit

5.2 Simulation Result

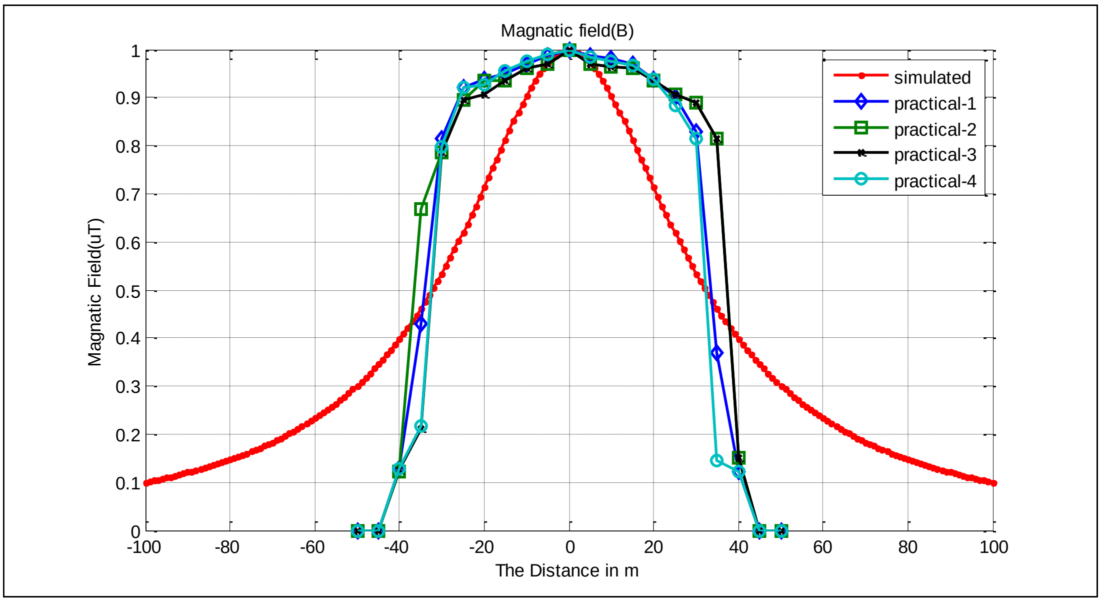
The MATLAB computer programs (M-files) used to simulate the magnetic field at different distances. The equations (3), (4), (5), and (6) are used for magnetic flux density field simulation, with the current having a magnitudes of 204Ampers,
(which is a maximum current as given by GECOL). The physical and geometrical data needed for the computations were taken from GECOL. The results obtained have been compared to those already measured on site. Simulation result is showing in the figure (9) .



figure(9):Normalized magnetic flux density

5-3 Comparison Between Measured and Simulation Results

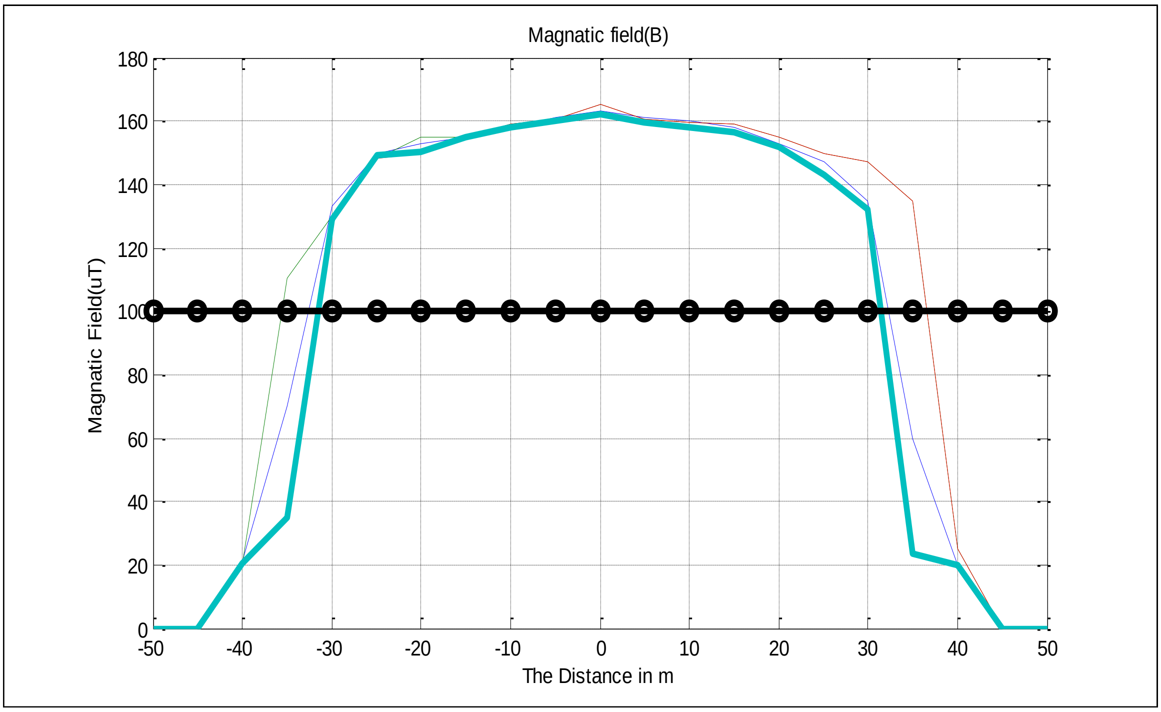
Figure (10) shows the real measurements and simulated results. The practical measurements are higher than the simulation results. But both almost follow the same distribution.



Figure(10): Measurement and simulation magnetic field.

7. Result discussion

Comparison between measured results and simulated result could be seen clearly in figure (13) . The variations of the magnetic field with the lateral distance is shown in Figure(7)and figure(8). At 1m above ground level, it can very clearly be seen that for lateral distances near ±30m and away from the center line, the magnetic flux density is smaller than the reference magnetic flux density set by the ICNIRP (100µT) and (500µT)for all the assumed line current. For the line current,204A, and 20m as a minimum clearance, the maximum magnetic flux densities associated with current at the right of way(ROW) edge (±30m) is 165 µT. In the area bounded by the ROW edges which is assumed to be the occupational area (transmission corridor area between ±30m), the maximum magnetic flux density ranges between 120 µT and 165 µT. Although, these maximum field values occurs just under the high voltage transmission Lines, they are high compared to the reference field level (100µT). Metallic building(object) under the transmission lines should be avoided to reduce the eddy current generated with the “minimum clearance of 20meter for 400kv lines.



Figure(13)

If we consider the (100µT) as the maximum permissible level for exposure then figure(13) shows that + or – 35 meter from the line center should be closed zone, No farming and No living in should be allowed

Recommendation

- It is necessary to force the ROW distance not to allow people to build in.
- Medical follow up over long period to those who are living close to the ROW.
- Effect on farming the ROW distance should be studied.

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References

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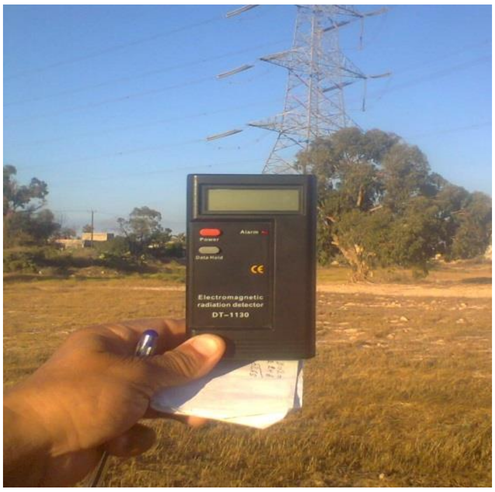
Appendix-1

Measurement Device Description:



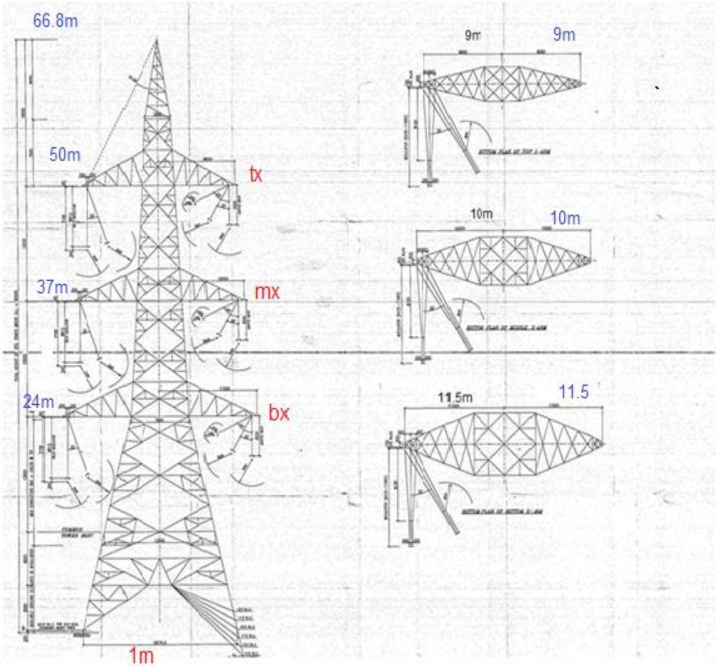
Features:
- Model: DT-1130.
-Color: Black
- Shell material: durable ABS plastic.
- 100% brand new and high quality electromagnetic radiation detector.
- Designed to meet CE industrial standard.
- Great for the environmental electromagnetic radiation,testing: bedroom, office, computer room, control room, cable, power lines, monitors, transmitters and other sources of measurement.
- Can be used in home electrical equipment, measurement of electromagnetic radiation:
mobile phone, computers, televisions, copiers, fax machines, air conditioners and other power sourcesof test analysis.
- Wide range of detectable frequency.
- Come with a built-in stand for convenient to put in on the table or other smooth surfaces.
- Portable design, light weight, easy to use and convenient to carry.

Specifications

- Frequency range: 50Hz~2000MHz.
- Reacting time: 0.4 seconds
- Operating voltage: 9V.
- Battery model: 6F22 9V (included).
- The device measures electromagnetic fields in Mille Gauss (mG) .

Appendex-2

The towers in the measurement area are of the type shown in figure below. These dimensions have given by **GECOL.**



Dimensions of the 400kv tower.

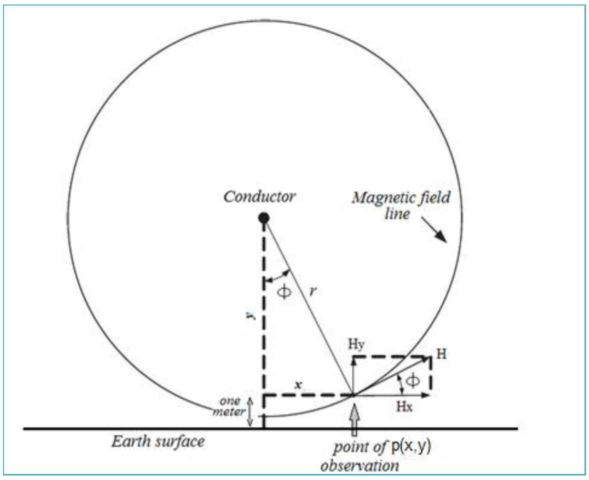
The dimentions of the 400kv tower are:

1-The height of the first phase from the ground is 24 meter.

2-The height of the second phase from the ground is 37 meter.

3- The height of the third phase from the ground is 50 meter.

4- The width of wings from the tower center are 11.5, 10,and 9 meter respectively. Note:(mx),(bx) and (tx) are the labels assigned to the conductors in MatLab program.



Geometry to find the magnetic field at the point p(x , y) due to the phase conductor

Single and double circuit

Table-1:The measured magnetic flux density (B) in micro Tesla at (1 m) under 400KV. single circuit.

Distance from the line center(m)	Measured values of B (μT)	Distance from the line center(m)	Measured values of B (μT)
-50	0	50	0
-45	14.5	45	140
-40	20	40	145
-35	110	35	150
-30	130	30	150
-25	148	25	155
-20	155	20	159
-15	155	15	159.4
-10	159	10	160
-5	160	5	160.5
0	165.5	0	165.5

Table.2: The measured magnetic flux density (B) in micro Tesla and at (1 m) under 400 kv Double Circuit.

Distance from the line center(m)	Measured values of B (μT)	Distance from the line center(m)	Measured values of B (μT)
-50	0	50	0
-45	0	45	0
-40	20.8	40	20
-35	70.0	35	60
-30	133	30	135
-25	150	25	147
-20	153	20	153
-15	155	15	158
-10	158	10	160
-5	161	5	161
0	165	0	165