EFFECT OF METAL SHIELDING THE FIBER OPTIC CABLES ON REDUCING THE NOISE PRODUCED BY ELECTRIC FIELD GENERATED AROUND HIGH VOLTAGE TRANSMISSION LINES

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ABSTRACT *: Fiber optic cables usually installed on the top of the high power line towers for control and data communication because its good resistant to weather and environmental effect. To avoid the fiber optic cables damage, the metal shielding of fiber optic cables is often used. The aim of this work is to study the effect of metal shielding on reducing the effect of electric field on the fiber optic . Based on the results obtained ,the shielding fiber optic cables can reduces the electric field strength which generates around the electrical power cables The results of this study can be used for determining the efficiency of shielding the fiber optic cables in reducing the noise in the control and data communication transmitted through these cables.*

Keywords: Shielding, fiber optic cable ,electric field ,noise reducing .

1. INTRODUCTION

High-voltage lines generate electric and magnetic fields around conductors. The source of magnetic fields is due to flow of currents in the phase conductors while the electric fields are caused by the high potential of conductors. Due to the geometry of electrical energy transmission line systems , a wide expansion of the field is obvious. However, power systems require communication network with good bandwidth for control the power systems and data communications[1].

Fiber optic cable is one medium that can be used in communications along with the high voltage transmission lines as well as with extra high voltage because of it is immunological against electromagnetic interference. Many weather effects may cause damage the ceramic Shielding of fiber optic cable installed o transmission line tower In order to be more resistant against the weather effects, the metal shielding is used[2]. In this study, we intend to know the effect of metal shielding fiber optic cables on electric field produced by transmission line conductors .Figure(1) shows the 132KV transmission line tower.

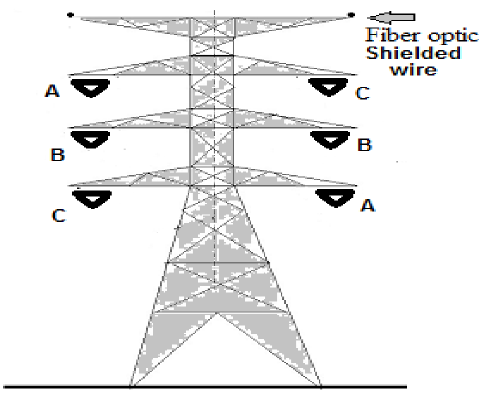

Fig. (1) : 132KV transmission line tower.

If there is a voltage difference, there is energy stored in the electric and magnetic fields. This energy cannot be ignored or dissipated instantaneously. The geometry formed by the high voltage transmission line configurations and the fiber optic cables sets up a set of capacitances that store and transfers the energy from the high voltage conductor to the fiber optic cables. In many cases the dissipation or decay of the stored energy is developed by the electric field from the high voltage line is considered to be the driving force of the induced currents causing dry-band arcing on the fiber optic cable. Electric and magnetic fields exist in high voltage networks and pose dry-band arcing problems to most nearby fiber optic cables[3]. The physical geometry of an electrical setup will considerably dictate how much dry-band arcing will be exposed or experienced by the adjacent fiber optic cable. Controlling electric fields is considered to prevent damage occur on the cable. This subject of arc control namely grounding and shielding is explained by using basic physics and cannot be approached by using circuit theory alone because the geometry of a structure is rarely treated as it appears in the physical world. We know that transmission line will cause the electric field. So, the presence of metal shielding will affect the strength of this field because it will cause capacitance between metal shielding and conductor wire., and ground [4].This study discuss the influence of shielding the fiber optic cables on the electric field resulting from 135 K`V transmission line

Back ground :

The optical fiber cable placed at position in a certain distance parallel to the conductive transmission lines. Because the fiber optics cable shielding is made of metal then there is shielding capacitance between shielding fiber optic cable and ground. Because of this capacitance, arising electric charge on the metal shielding which affect the strength of the electric field produced by the transmission line conductors[5]. The cable's outer sheath can be degraded as a result of arc current flowing along the cable’s sheath induced by the high electric field from the high voltage transmission lines . Due to the relative geometric position of the high voltage conductors and the fiber optic cable, the fiber optic cable will be coupled by capacitors between the lines and the metal shielded round. The voltage difference between the high voltage line and the fiber optic cables implies a charge distribution on the fiber optic cable [6] as illustrated in figure (2) .

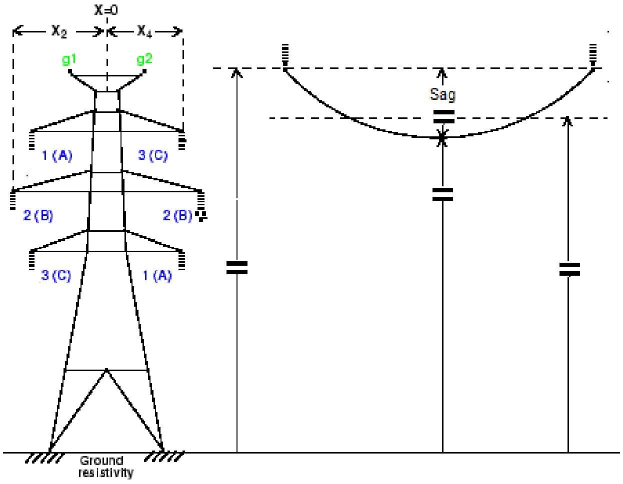

Fig. (2) : Shielding capacitance between shielding fiber optic cable ,conductor and ground.

3. Literature review

Fiber optic cables were originally developed in West Germany and the Netherlands and have been in operation on power lines of up to 110 kV successfully for a number of years of service . Attempts of installing fiber optic cable on voltage levels of 220 KV led to cable sheath failures in less than a year after installation. Examination of the damage in these early failures exhibited, what seemed to be electrical damage near the supports. Various theories ensued and tried to explain and solve the events leading to the cables dropping out of service. Dry-band arcing is now generally acknowledged to be the main cause of damage sustained by the cables strung in a high voltage environment[7].

Research at Arizona State University in joint efforts with Western Power Administration (WAPA), and Electric Power Research Institute (EPRI) has developed an experimental setup to simulate the dry-band arcing electrical damage observed on the fiber optic cables sheath. Bonneville Power Administration (BPA) also contributed to the study. [8].

The Commonwealth Associates Inc. or (CAI) conduct a lot of measurement of magnetic field under high voltage of electrical power lines. Calculations also conduct by them to study the changes in the magnetic field due to changes in the power lines. These changes include changing the structure of the line designs, switching from single-phase to three-phase distribution and using cancellation or shielding loops [9]

Another Risk Assessment Program or (RAPID) project was perform a survey to get information about the exposure to electromagnetic fields for around a thousand people, the activities that could increase or decrease the personal exposure [10].

. Methodology:

In this work, electric field strength caused by the 132 KV transmission lines with presence of metal shielded fiber optical cable and without metal shielded fiber optical cable has been calculated and practically measured. Then a comparison between two results obtained has been made. Measurement have been conduct under the transmission line level at 1 m above the ground with the following characteristics :

1(A) - The highest phase at a height of 25.25 m
2(B) - Middle phase at a height of 21.25 m
3(C) - The lowest phase at a height of 17 m

CW – Control shielded wire at a height of 27.25 m

The following parameters were taken for calculation:

- Umax = 132 KV
- L1=245,7A,
- L2=254,4A,
- L3=228,5A

The layout of conductors and control shielded wire of 132KV is shown in figure (3) .

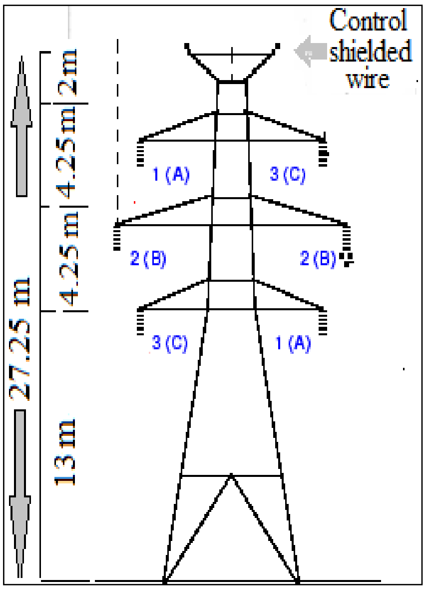

Fig.(3) : The layout of the conductors and control shielded wire of 132KV.

$$E = \frac{q_i}{2\pi . r\,\varepsilon_0} \quad ... \quad (1)$$

$$E = \frac{q_i}{2\pi . \varepsilon_0 \, (h^2+L^2)^{1/2}} \quad ... \quad (2)$$

Electric field of vertical components above ground is:

$$E \cos\theta = \frac{q_i}{2\pi . \varepsilon_0 \, (h^2+L^2)^{1/2}} \cdot \frac{h}{(h^2+L^2)^{1/2}} = \frac{q_i \, . \, h}{2\pi . \varepsilon_0 \, (h^2+L^2)} \quad ......(3)$$

Electric field of double vertical components above ground is the total field at that location and can be calculated as follows :

$$2.E = 2 \frac{q_i \, .h}{2\pi . \varepsilon_0 . \, (h^2+L^2)} = \frac{q_i \, .h}{\pi . \varepsilon_0 . \, (h^2+L^2)} \quad (4)$$

$$E = \frac{q_i \, . \, h}{2\,\pi . \, \varepsilon_0 \, (h^2+L^2)} \quad (5)$$

Where:

q_i = Load length unity (charge)(C / m)
ε_0 = Permittivity
E = Electric field (A/m)
h : height of the conductor(m)
L: distance of the conductors from midpoint (0 axes) or center of tower (m).

5 Mathematical calculations:

Calculation of electric field strength in ground surface at a certain distance from transmission line can be achieved by using the following equations [11]:

6 Practical measurement

Measurement of electric field in ground surface at a certain distance can be achieved by using the EMF-tester type (EMF 701) under the 132KV line at one meter above the ground surface as indicated in figures (4) and (5).

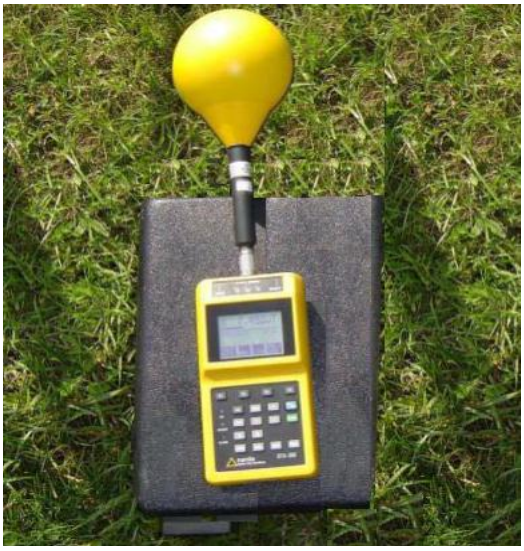

Fig.(4) Measuring instrument for electric field.

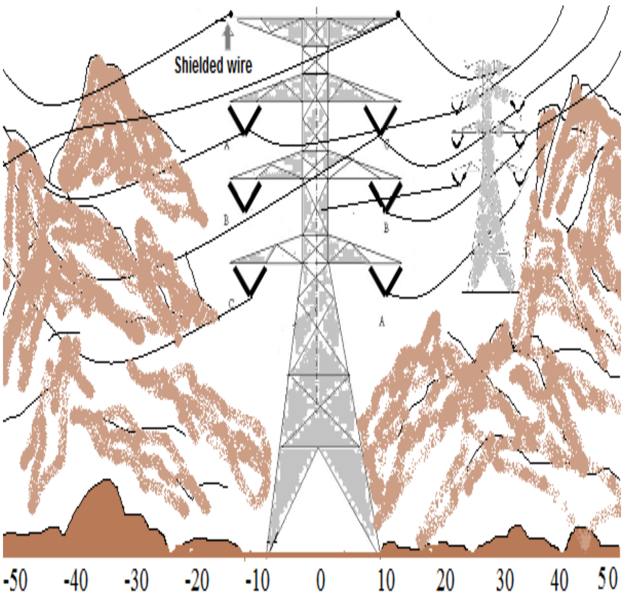

Fig.(5) : Measurement of electric field under the tower.

7 Results :

Calculation and measurement results for the 132KV configuration can be seen in tables(1)and(2) and the graph representation of results is shown in figures (6), (7), (8) ,(9) and(10).

Table(1) :Measurement of electric field (kv/m) with metal shield and without metal shield fiber optic cable for the132kv configuration in dependence of range.

Range (m)	E (KV/m) With metal shield fiber optic cable	E(KV/m) Without metal shield fiber optic cable	Range (m)	E (KV/m) with metal shield fiber optic cable	E (KV/m) without metal shield fiber optic cable
2	3.245	3.612	28	1.286	2.042
4	2.965	3.451	32	1.112	2.011
8	2.567	3.352	36	1.065	1.542
12	2.057	3.141	40	1.001	1.35
16	1.853	3.001	44	0.906	0.969
18	1.731	2.801	46	0.711	0.802
20	1.689	2.658	48	0.576	0.765
24	1.421	2.485	50	0.364	0.543

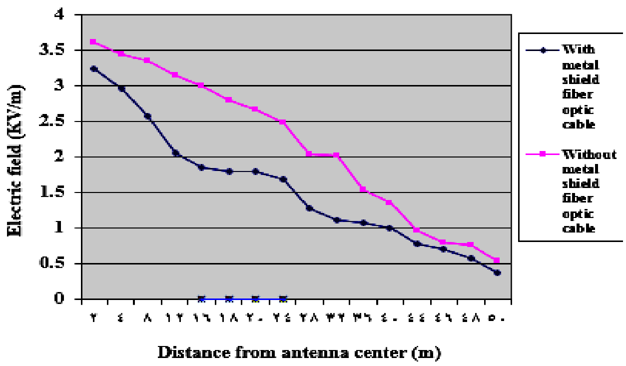

Fig.(6) :Electric field with metal shield and without metal shield fiber optic cable for the 132KV configuration in dependence of range.

Table(2) : Measurement of electric field (KV/m) with metal shield and without metal shield fiber optic cable for the 132KV configuration in dependence of range

Elevation (m)	E(KV/m) With fiber optic cable	E(KV/m) Without fiber optic cable	Elevation (m)	E(KV/m) with fiber optic cable	E(KV/m)without fiber optic cable
0.2	2.431	3.631	1.8	3.438	4.870
0.4	2.541	3.786	2	3.541	4.988
0.8	2.654	3.989	2.2	3.633	5.198
1	2.8	4.212	2.4	3.762	5.321
1.2	2.987	4.321	2.6	3.875	5.445
1.4	3.128	4.504	2.8	3.973	5.536
1.6	3.246	4.657	3	4.127	5.675

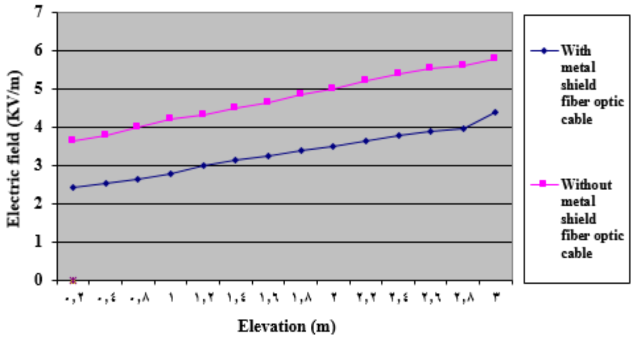

Fig.(7) :Electric field with metal shield and without metal shield fiber optic cable for the 132KV configuration in dependence of range

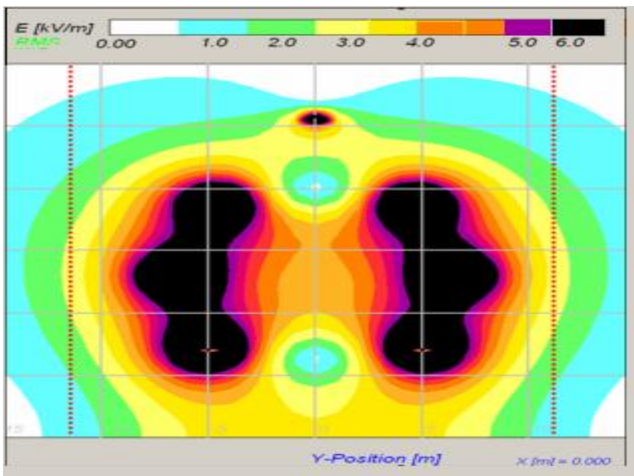

Fig. (8) : Electric field of 132 KV configuration in dependence of elevation.

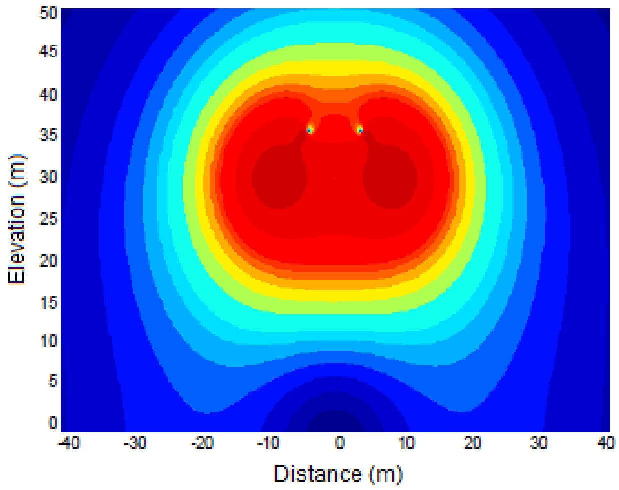

Fig. (9) : Electric field of 132 KV around the un shielded fiber optic cable

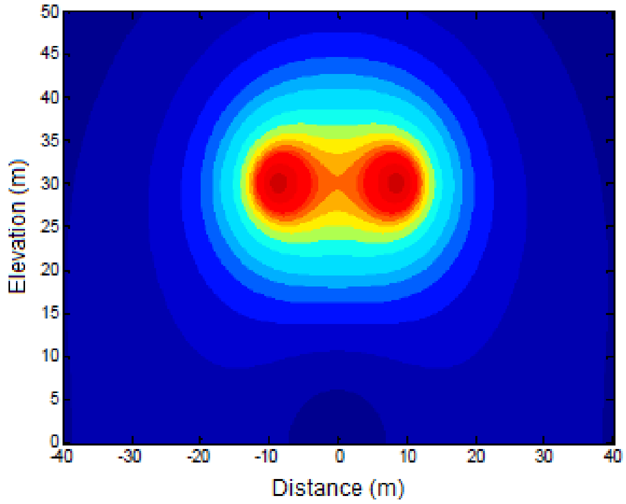

Fig. (10) : Electric field of 132 KV around the shielded fiber optic cable.

Discussion:

From results obtained we can conclude the following :

Figure (7) shows that the electric field intensity of ***132 KV*** transmission line with unshielded fiber optic cable at the midpoint transmission line is ***0.917KV/ m*** then it sharply rises until ***3.189 kV/m*** at a distance of (16m) from which is the largest electric field intensity .then it sharply declines to***5.43 kV/m*** at a distance of (16)m from the midpoint then decreases to ***1.14 kV /m*** at distance of (36) m from the midpoint and then gradually decreases until the becomes zero. While For the transmission line with shielded fiber optic cable electric field at the middle point at ***0.997KV/*****m** and then rises sharply up to **5.212KV/m** at a distance of (16m) from the midpoint which represent the highest electric field intensity then it sharply declines to ***1.01 KV/m*** at a distance of 36 m from the midpoint then it gradually decreased until become zero .This prove that the metal shielding of fiber optic cable reduce the intensity of electric field generated by power lines .

Electric field strength differences occur between transmission lines with shielded and unshielded optical fiber cables due to the presence of capacitance among shielding fiber optic cables , inductors and ground wire so that it will affect the magnitude value of total capacitance.

From all results obtained , we can conclude that the using of metal shielding on the fiber optic cables parallel with the power conductors will reduce the intensity of the electric field generated by the transmission line conductors .

CONCLUSION:

The effect of shielding the fiber optic cable on reducing the levels of electric field generated by 132KV vertical configuration with metal shielded fiber optic cables has been measured and calculated. Results indicates that the electric field generated by 132KV vertical configuration in case with shielded fiber optic cable is less than in case of unshielded fiber optic cables at a distance of (0 - 9 m) while for ranges more than 9 m fields approximately identical . The results obtained led to fact that the using of metal shielding for fiber optical cables can be reduce the electric field intensity generated by transmission line conductors which led to minimize the noise generated by high voltage transmission line .

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