Reduction the electric field effect generated by high voltage on fiber optic cables using metal shielding

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Article Info	ABSTRACT
	Because of the fiber optic cables have perfect resistant to weather and environmental effects they can be installed on or with transmission line towers for the power supply control and data communication. To avoid the damages of fiber optic cables, it is used shielded fiber optic cables. Due to the using of this shielding, the electric field that produced from transmission line will be effected. In this paper is studied and compared the influence of metal shielding of fiber-optic cable in the strong electric field which produced by a high voltage transmission line for various types of channel configuration. Based on the results obtained, the metal shielding of fiber optic cables will reduce the electric field strength that lead to good efficiency of communication through the optical cable.

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1. INTRODUCTION

Due to the geometry of electrical energy transmission line systems, a wide expansion of the field is clear in the high-voltage lines create magnetic and electric fields in their neighborhood. The magnetic fields are caused by the currents in the phase conductors while the electric fields are generated by the high potential of conductors. However [1] Power systems require telecommunication network with a good bandwidth for control the power systems and data communications [2]. Fiber optic cable is one medium that can be used in telecommunications networks along with high voltage transmission lines as well as with extra high voltage because of it is immunological against electromagnetic interference. Varied Effects of weather often caused damaging the ceramic (Shielding) of fiber optic cable contained in transmission line. So to be more resistant against the influence of weather and environment, the shielding that made of materials in optical fiber cable is used [3]. So, we must know the effects of shielding fiber optic cables on electric field produced by transmission line conductors [4].

There is energy in the electric and magnetic fields if there is voltage difference and this energy cannot be ignored easily [5]. The high voltage transmission line configurations and the fiber optic cables generate a shaped area that sets up a group of capacitances that able to store and then transfers the energy from the high voltage conductor to the fiber optic cables. In several cases the dispersion of the energy is caused by the electrical field from the high voltage line is taken into account to be the driving force of the currents causing dry-band arcing on the fiber optic cable. Dry-band arcing problems to nearby fiber optic cables cause by high voltage networks due to electric and magnetic fields exist in it [6-7]. The amount

of dry-band arcing that will be viewed by the adjacent fiber optic cable is limited by the geometry of electrical lines [8]. To prevent damage occur on the cable, electric fields should be controlled. This subject of arc control named shielding and grounding is studied by the physics theory and cannot be solved by using only circuit theory 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 [9]. The presence of metal shielding will affect the strength of this field because it will cause capacitance between metal shielding Conductor wire, and ground [10].

In the alternating current transmission system there are single-phase and three-phase systems. Three-phase system has some advantages compared with the single-phase system because power is distributed over large instantaneous value. Configuration of transmission line can be divided in the single and double transmission line channels [11-12]. Single circuit transmission line has several configurations, namely horizontal configuration, vertical configuration and equilateral triangle configuration. In the horizontal configuration [13]. The three phases are in the same height and with the same inter-conductor separation distance while in the vertical configuration, the three phases arranged vertically with the same separation distance between the conductors as shown in Figure 1. While in the double circuit transmission line, there are several configurations, namely: vertical configuration, triangular configuration, and hexagonal configuration [14].
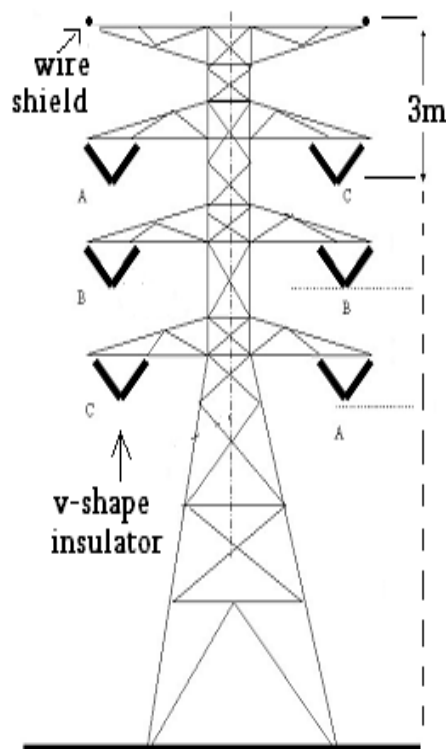

Figure 1. 132KV double circuit configuration transmission line

The optical fiber cable placed at position in a certain distance parallel to the conductive transmission lines. Because the fiber cable optics shielding is made of metal then there is shielding capacitance between shielding fiber optic cable and ground. Because of this capacitance [15] arising electric charge on the metal shielding which affect the strength of the electric field produced by the transmission line conductors. The cable's outer sheathing can be degraded mod as a result of arch current flowing along the cable's sheathing created by the (HEF) high electric voltage from the (HTL) high voltage transmission lines in hat location. Due to the relative geometric location of the (HVC) high voltage conductors and certainly the (FOC) fiber optic cable [16]. The fiber optic cable will be coupled by based capacitors between the (HTL) and the metal shielded roundabout. The voltage difference between the (HVL) and the (FOC) implies a charge distribution on the groups of (FOC) [17].

Perhaps levels of 220 KV or higher led to cable sheathing failures in less than a year or two years after installation and application of course [18]. Examination of the damage in these early failures presented, what may be electrical damage near the supports. Some theories really ensued tried to explain and maybe solve the events leading to the cables dropping out of service [19]. Dry-band arcing is now almost acknowledged to be the major cause of damage strengthen by the cables tension in a high voltage climate. Research at Universityof Arizona State in joint efforts with (WPA) Western Power Administration, and (EPRI) Electric Power Research Institute has developed an experimental setup to imitate the dry-band arcing electrical damageobserved on the (FOC) sheathing (BPA) Bonneville Power Administration alsocontributed to the modern study [20].

2. RESEARCH METHOD

We will calculate and measure the electric field strength caused by the transmission line network with presence of metal shielded fiber optical cable and without metal shielded fiber optical cable [21]. Then we will make a comparison between two results obtained from these calculations. So [22] electric and magnetic fields in the substation has been performed by measurements of electric field (KV/m) with and without fiber optic cable for or the double circuit configuration in accordance to the range and measurements of electric field (kv/m) with and without fiber optic cable for double circuit configuration in accordance to the elevationand comparison the results [23].

2.1. Mathematical calculations

Calculation of electric field strength in soil surface at a certain distance from transmission line can be done using the following equation [24, 25]:

$$E = \frac{q_i}{2\pi.r.\varepsilon 0} \tag{1}$$

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

Electric field of vertical components above ground is:

$$E \cos\theta = \frac{q_i}{2\pi\varepsilon_0 (h^2+L^2)^{1/2}} x \frac{h}{(h^2+L^2)^{1/2}} = \frac{q_i}{2\pi\varepsilon_0(h^2+L^2)} \tag{3}$$

Where; h=height of the conductor
L=distance of the conductors from midpoint (0 axes) or center of tower

3. RESULTS AND DISCUSSION

Calculation results for the double circuit configuration can be seen in Table 1 and Table 2. In the Figure 2 it can be seen that the electric field with and without fiber optical cable which sharply decreases to almost close to zero, then slightly rise and slowly back down until a strong electric field becomes zero. This caused by the configuration channel. This is a vertically configuration in which vertically Conductor arranged from top to bottom with a particular distance. In this configuration there's a largest value of electric field strength at the midpoint of transmission line. In Figure 3 for transmission line without optical fiber cable the greatest strength field located at the midpoint of the transmission line is equal to (0.65683 kV/m) and then sharply fell until it reaches (0.007793 kV/m) at a distance of 14 m from the middle point of the transmission line and then rise and becomes (0.02968 kV/m) at a distance of (22) m and thereafter gradually decreased until electric field strength became zero. For the transmission line with a fiber optical cable is located the largest field strength at the midpoint of the transmission line is amounted to 0.451042 kV/m and then sharply decreased until it reaches (0.011539) kV/m at a distance of 14 m from the midpoint of transmission line and then rise to (0.036033 kV/m) at a distance of (22) m and after it gradually fell to a zero. At a distance of (0 up to 12) m electric field generated by transmission line without fiber optical cable greater compared with the transmission line with fiber optical cable. While for the distance (14 up to 50) meter the case is inverse. This is caused by capacitance and the configuration of the transmission line. In the figure above the electric field at the midpoint of the transmission line increases with increasing the height of the surface.

Table 1. Measurements of electric field (kV/m) with and without fiber optic cable

range (m)	electric field (kV/m) with fiber optic cable	electric field (kV/m)without fiber optic cable	range (m)	electric field (kV/m) with fiber optic cable	electric field (kV/m) without fiber optic cable
2	2.345	3.412	28	2.786	2.742
4	2.965	3.551	32	2.112	2.211
8	4.567	3.952	36	1.565	1.542
12	5.657	5.341	40	1.221	1.995
16	5.453	5.301	44	0.976	0.969
18	5.231	5.101	46	0.811	0.802
20	4.789	4.658	48	0.776	0.765
24	3.721	3.685	50	0.564	0.543

Table 2. Measurements of electric field (kV/m) with and without fiber optic cable for double circuit configuration in accordance to the elevation

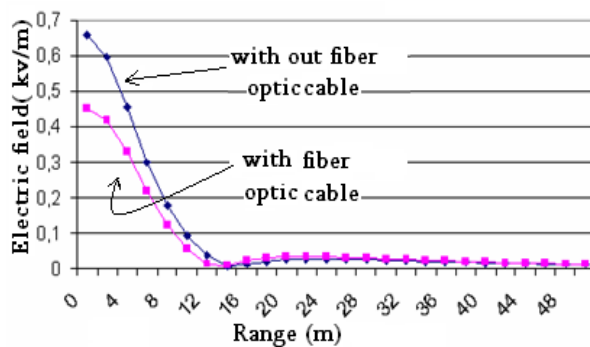| Elevation (m)	Electric Field (kV/m) with fiber optic cable	Electric Field(kV/m) without fiber optic cable	Elevation (m)	Electric Field (kV/m) with fiber optic cable	Electric Field (kV/m)without fiber optic cable
0.2	2.431	3.631	1.8	3.438	4.870
0.4	2.541	3.786	2	3.541	4.988
0.8	2.654	3.989	2.2	3.653	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

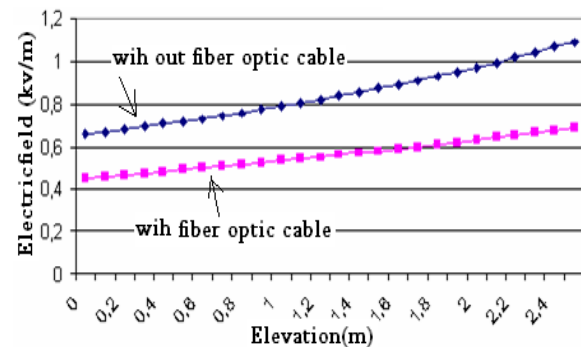Figure 2. Electric field for double vertical configuration

Figure 3. Electric field of double vertical configuration according to land surface

4. CONCLUSION

In the transmission line double vertical configuration Circuit with fiber optics cable, the generated electric field at a distance of 0 to 10 m is less than the transmission line without fiber optic wires, while for distances greater than 10 m state in reverse. In this configuration, the largest electric field strength is at a distance of 14m from the midpoint of the transmission line. In transmission line double vertical configuration circuit with fiber optic cable, the generated electric field at a distance of (4) m is less than the transmission line circuit without optical fiber wires, while for distances greater than (12) m state in reverse. In this configuration, the largest electric field strength is at the midpoint transmission line or at a distance of (0) m. In this configuration, electric field strength caused by transmission line with fiber optic cables in generally less than the transmission line without optical fiber cable. The results obtained can be used for determining the free distance of transmission line installation, if shielding optical fiber cable done by using metal shielding.

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