ANALYSIS AND COMPUTATION OF ELECTROMAGNETIC FIELDS IN VARIOUS CONFIGURATIONS

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Abstract— **This article discusses the electromagnetic field in a various configuration in measuring flux. The flux pattern has not remain same for the electrode, and it's depend on the shape and geometry. Depend on the various configuration, flux pattern are observed and analysed. In a conductors, charges can easily move around. The insulation is act as barrier for the flow of current. If any conductive material is placed between the dielectric medium, there is a distortion of magnetic flux. Higher the amount of magnetic flux will leads to more electric strength. Based on the graph, electrical field is zero inside the conductor. At the surface of the conductor, electric field is higher. The more number of lines of flux will strengthen the flux and vice versa.**

Keywords -- Electromagnetic fields, flux, electrode ,conductor, cable, simulation

I. Introduction

Every material have positive and negative electric charges. Though an electric field is applied to a dielectric medium, there is no net electric current. Because the charges cannot move separately from each other
However, the field does drive the tiny bit of positive charges in the direction of E, while the negative charges are drive in the opposite directions. Consequently, the dielectric containing the atoms and the molecules acquire tiny electric dipole moments.

The net effect of all these dipole moments are stated that all the positive charges into a large uniform charge density +ρ and likewise all the negative charges into uniform charge density −ρ. Without the electric field, these densities overlap each other and the net charge density cancels out. But when the electric field is applied, the positive density and the negative density moves in the opposite direction.

As the result, the bulk of the dielectric remains electrically neutral. But the surface layer on the left and right side of the dielectric have positive and negative charges. Altogether, the surface charges develops in the dielectric material.

The signs of the surface charges induced by the electric field is given as below. The positive external electrode have negative surface charge, while on the side of the negative external electrode, it is positive. Accordingly, the induced surface charges reduce the electric field in the dielectric.

Since, electric field is a vector quantity, we conclude that the electric field vector direction is in the same direction with the force exerted on a positive test charge which is located at the point of interest[2].

The properties of electric field lines is that the electric field vector is tangent to the field line. and no two field lines can intersect. The strength of the electric field is the number of field lines passing through a units surface is proportional to the strength of the electric field generated at that location.

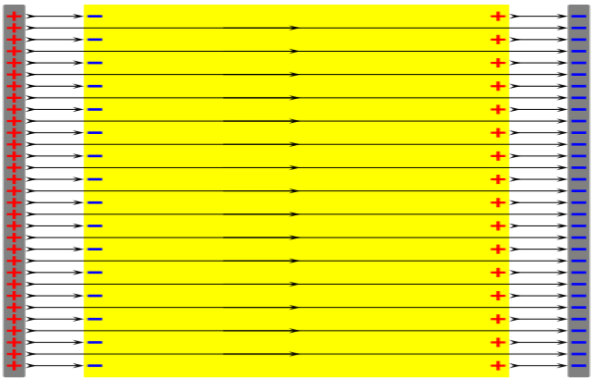

Fig.1. Electric field lines

The black lines indicate electric field line and in the dielectric are shown in Fig.1.

II. ELECTROMAGNETIC FIELDS

Electric field E is defined as the force per unit charge. A line of force or electric field line is the path a charge would follow if it were allowed to move along in exactly the direction of the force acting on it. The intelligence of E is the direction of the force on a positive test charge.

The rules for field and equipotential lines are

1. Field lines start and end on conductors.
2. Field lines never cross other field lines.
3. Conductors are equipotential surfaces.
4. Equipotential lines surround conductors.
5. Equipotential lines never cross other equipotential lines.
6. Field lines intersect equipotential lines and conducting surfaces at right angles

There is no work done acts if a test charge is moved in a direction perpendicular to E.Therefore, there is no change in electric potential. Such a path is an equipotential surface. Since there is a potential and electric field value at every point in space, there is no limit to the number of field lines and equipotential surfaces[3].

We can use superposition to work out the electric field within a small cavity that is hollowed out inside a block of dielectric. We'll take the electric field within the dielectric to be Eo (which need not be constant), and the polarization to be P (again, not necessarily constant). The displacement is then Do=εoEo+P. In the small region of interest, we'll

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take P pointing upwards, so that the field it induces points downwards.[1]

The polarization in the empty space must be zero, so we can simulate the situation by superimposing a sphere with equal and opposite polarization -P on top of the dielectric. The polarization field within a uniformly polarized sphere is given as

$E_s=(1/3\varepsilon_0)P$ ---(1)

Thus the net field within a spherical cavity is

$E=E_o+E_s =E_o+(1/3\varepsilon_0)P$ ---------------------------------------(2)

Since the net polarization within the cavity is zero, the displacement is

$D= \varepsilon_0 E_O +(1/3)P =D_0 -2/3P$ -----------------------------------(3)

III. CLASSIFICATION OF FIELDS

The main classification of field is uniform and non-uniform field. The uniform electric field is observed between two parallel charged plates separated by dielectric medium. These acts as capacitor too. It is needed to know about the field pattern in various electrodes configuration.

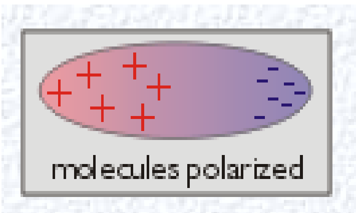

Fig.2. Structure of molecules polarized

The characteristics of uniform field can be analysed in a pair of flat, parallel metal plates which are oppositely charged.

A charged body will move parallel to the direction of the field, toward the plate which carries opposite charge. A neutral body is not migrated in any direction. The fig.2 shows the structure of molecules polarization.

Even though it appears to ignore the field, however, the neutral body is not completely unaffected. It acquires, in effect, a negative charge on the side facing the positive electrode and a positive charge on the side facing the negative electrode. The reason for this polarization, as it is called, is that the atoms composing the neutral body are made up of separate electric charges - positive nuclei and negative electrons. Under the influence of the outside field the electrons and nuclei are pulled in opposite directions, so that the center of negative charge no longer coincides with the center of positive charge. The amount of separation produced by a given electric force (the 'polarizability') varies widely for different materials, but all are influenced to some degree[4].

The net effect is an excess of positive charge on one half of the body and an equal excess of negative charge on the other. Therefore the two sides of the gross body are also pulled in opposite directions by the field. Since the charges are equal and the field is the same on both sides, the opposing forces exactly cancel. If, however, the field is made stronger on one side than the other, the forces are no longer in balance, and the body is pulled in the direction of the stronger field. The effect can be demonstrated with electrodes in the form of a pair of concentric cylinders. In running from the larger to the smaller electrode the lines of electric force converge. This means that the field grows stronger from the outside in. An uncharged body suspended in the space between is seen to move toward the inner electrode.

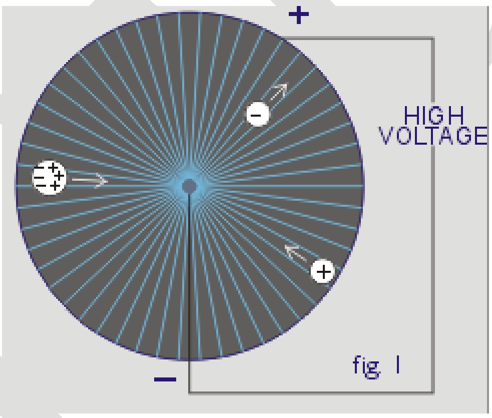

Fig.3. Non uniform field acts on both neutral and polarised particles.

Note that it travels the same way no matter which electrode is positive and which is negative. The polarity of the field makes no difference; the only thing that matters is how its strength varies. Thus an alternating voltage applied to the electrodes produces the same result as a direct voltage. This is because the polarization induced in the body switches with the field. Each half is always charged oppositely to the electrode it faces, and the pull of the inner electrode is always greater than that of the outer one[5]. The motion of electrically polarized matter in nonuniform fields is called DIELECTROPHORESIS [attraction to the strongest part of electric flux]. Compared to the movement of charged particles (ELECTROPHORESIS) [attraction to opposite polarity electrode], it is a mild effect, which is why it has been so long neglected.

IV. DISCUSSIONS

4.1 DIFFERENT ELECTRODE CONFIGURATIONS

The analysis of electrostatic field in various configuration such as parallel plane and rod rod are modelled and their flux distribution is shown in fig.4,fig. 5,fig. 6 and fig.7. The flux have higher value in the high potential electrode. The flux strength and the pattern of lines are shown in the figure below. The sharp point's needle has higher flux intensity. The parallel

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planes have uniform field and rod rod electrode have non uniform fields in the dielectric medium.

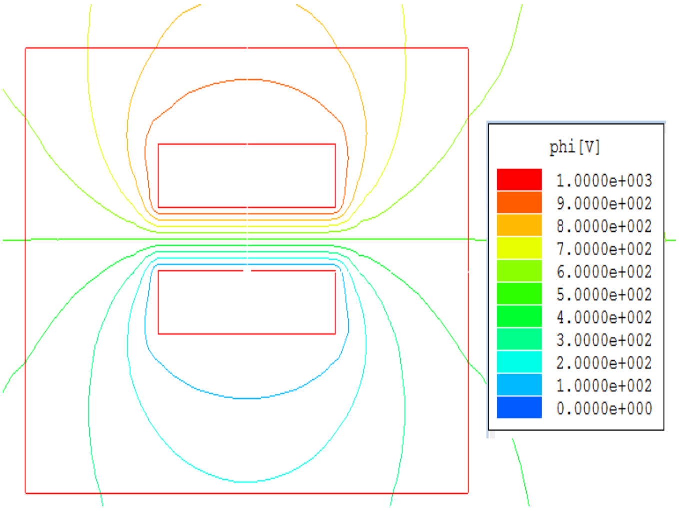

Figure 4. Parallel plane configuration- Flux plot

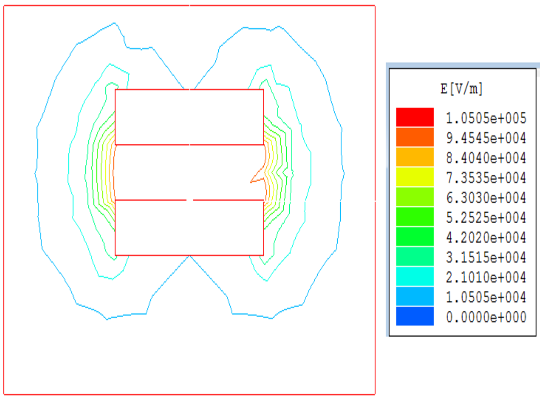

Figure 5. Parallel plane configuration- Electric field plot

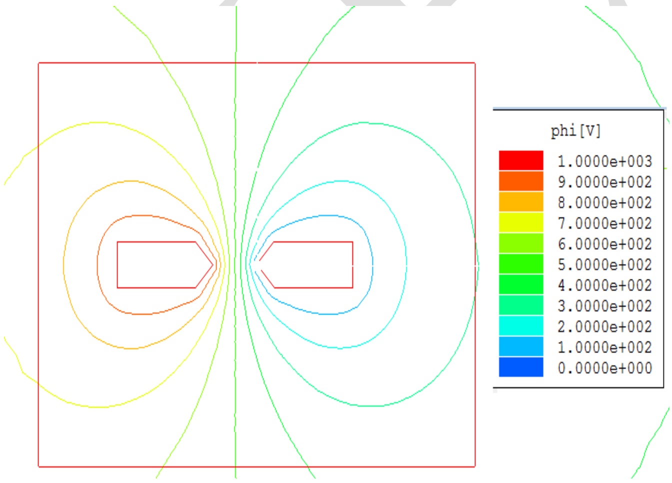

Figure 6. Rod rod configuration- Flux plot

The sharp needle shaped electrode has high electric field intensity which causes earlier breakdown compared to other electrode configuration. These electrodes are used in the testing of dielectric oil. Depend on the applied voltage and insulation strength of the dielectric medium, air bubbles are formed which are responsible for the breakdown mechanisms. Once the breakdown occurred inside the medium, it loses its dielectric strength.

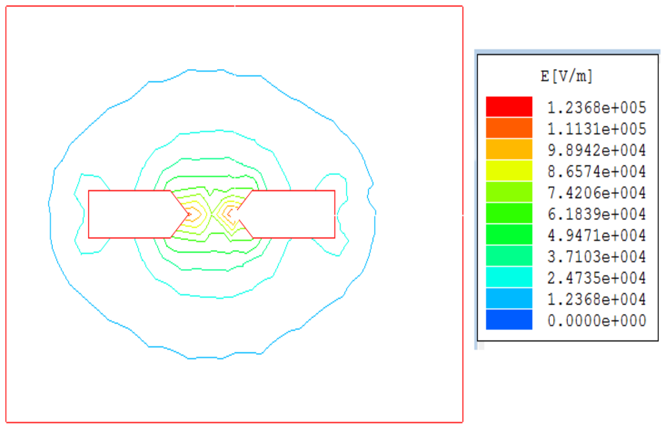

Figure 7. Rod rod configuration- Electric field plot

The flux distribution plot for the curved shaped electrode at the edge is shown in fig 8 and fig.9 and it has uniform shaped flux pattern.

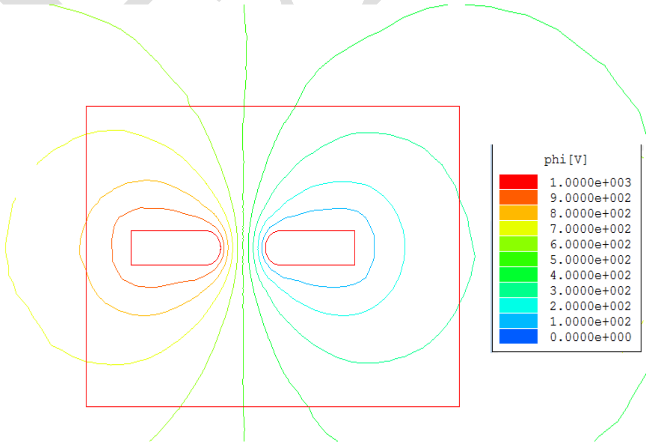

Figure 8. Curved shaped configuration- Flux plot

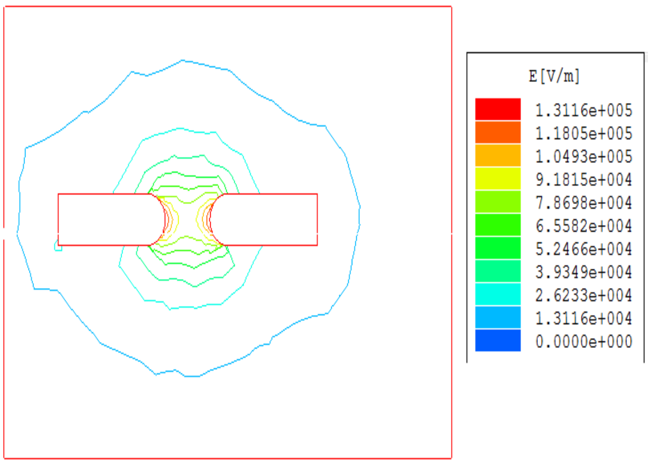

Figure 9. Curved shaped configuration- Electric field plot

The flux distribution plot and electric field plot for the spherical shaped electrode at the edge is shown in fig 10 and fig.11 and it has uniform shaped flux pattern

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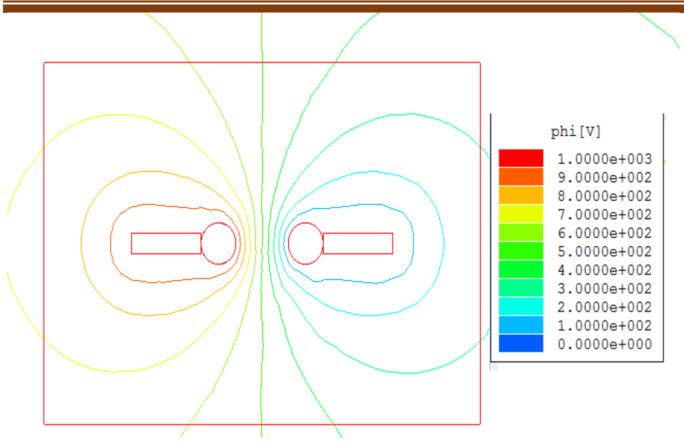

Figure 10. Spherical shaped electrode – Flux plot

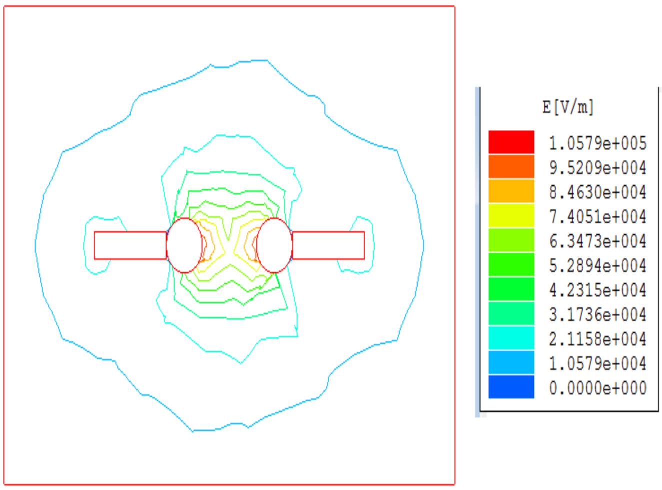

Figure 11. Spherical shaped electrode - Electric field plot

4.2 SINGLE CORE CABLE, THREE CORE CABLE AND MULTISTRNADS CONDUCTOR CONFIGURATION

The analysis of electrostatic field in single core cable, three core and multi strands conductor are modelled and their flux distribution is shown in fig 12,fig 13 and fig 14 below. The flux is uniform inside the dielectric medium. The potential value is higher nearer to the conductor surface and electric field is zero inside the conductor.

The electric field of a charged solid spherical distribution is shown in fig.15 and fig.16.

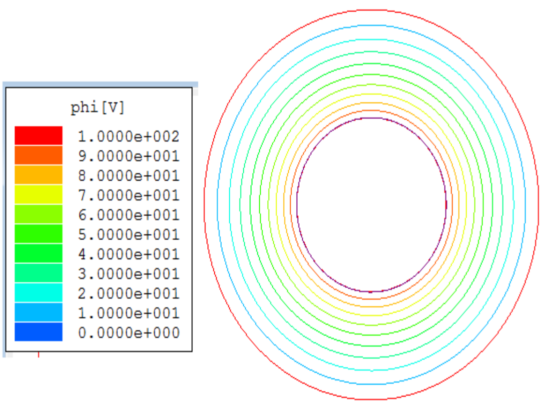

Figure 12. Single core cable equipotential plot

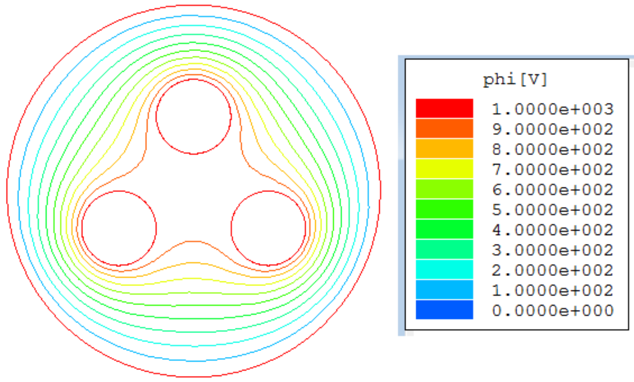

Figure 13. Three core cable equipotential plot

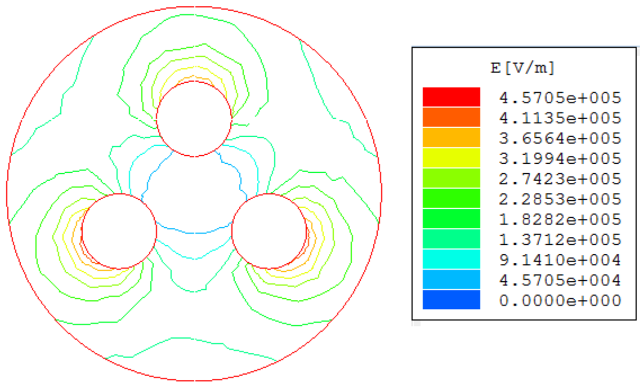

Figure 14. Multistrands conductor Flux plot

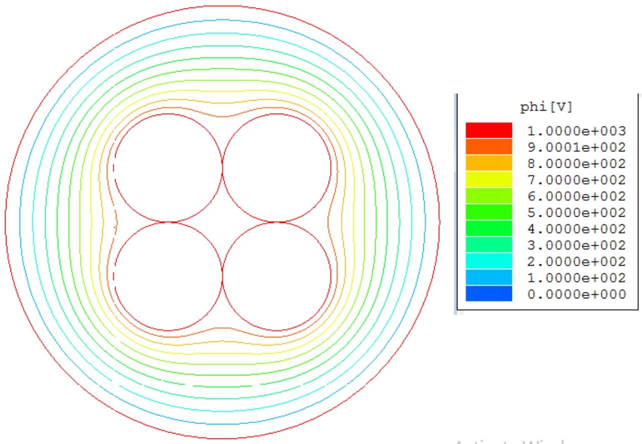

Figure 15. Multistrands conductor Flux plot

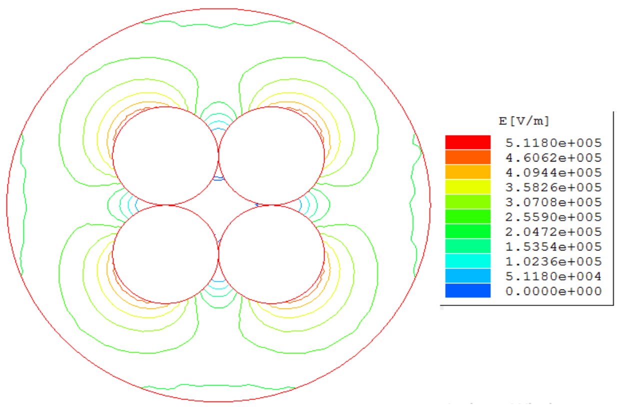

Figure 16. Multistrands conductor Field plot

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4.3 DISTRIBUTION OF FLUX IN CONDUCTOR

The two conductors is modelled and the distribution of flux in a current carrying conductor is shown in fig 10 and fig.11 below. The analysis shows that force of attraction is taking place between the same directions of current carrying conductors whereas the force of repulsion of flux is occurred between the conductors with opposite direction of current.

The magnitude of these forces for both of these two cases will be the same and their directions are going to be, depending upon how the current is flowing through these wires, whether it is in the same direction or in opposite direction, then we will end up with either attractive or repulsive forces.

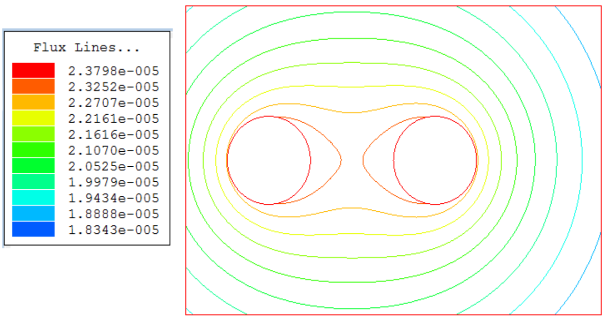

Figure 17 Flux plot for conductors carrying current in same direction

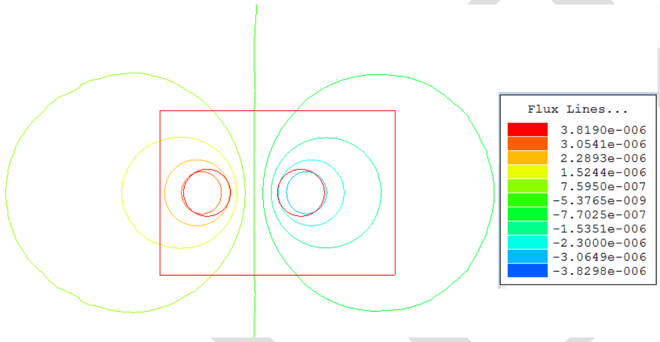

Figure 18. Flux plot for conductors carrying current in opposite direction

V. CONCLUSIONS

Our study gives the analysis about the field in different shaped electrodes and cables. The illustrations showed different shapes of the electrodes and cables are modelled for the comparative analysis.

Based on the simulation results, the following conclusions are drawn.

1. The field pattern is not identical for the electrodes. It depends on the shape, size and gap distance between the electrodes.
2. For the same voltage, same gap distance maintained between the electrode, the electric field intensity is not same for all the electrodes.
3. From the simulations results, the electric field is increased gradually from parallel shaped, sphere shaped, rod rod and curved shaped electrode
4. Zero electric field inside the conductor for the single and multistrands cables.
5. For the cables, the electric field is increased gradually from single core, three core and mutistrands cables.
6. If a current carries in a two conductors are in same direction, there is a force of attraction of flux between the conductors and vice versa.

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