FIELD COMPUTATIONS AT HV CONDUCTORS

A Thesis Presented to
The Faculty of Engineering
Ain Shams University

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B.Sc. Electrical Engineering, 1972

for

The M.Sc. Degree in Electrical Engineering

1976

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ACKNOWLEDGMENT

God enjoined man to think and have an insight in the infinite natural phenomena at his disposal.

It is through God's grace that the present trial to search about one of the complex natural phenomena facing high-voltage engineers was possible. It was carried out under the supervision of Prof. Dr. A. El-Arabaty, Dr. E. Mansour, at the Electrical Department, Ain-Shams University and Dr. M. Abdel Salam at the Electrical Department, Assiut University, to whom the author is deeply indebted for their valuable discussions and constant encouragement during the progress of this work.

Particular thanks are due to Dr. S. El-Debeiky for his interest.

The author would like to acknowledge Miss N. Mahdy, the Programmer in the IBM 1130 Computer Center, Ain-Shams University, for the facilities made available to the author.

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ABSTRACT

Knowledge of the electric field distribution in the vicinity of a transmission line conductors is necessary for estimating corona threshold and radio interference levels. The computations of such field values are based on the so-called charge simulation technique commonly known for solving electrostatic field problems.

In the charge simulation technique, line charges are assumed to represent the electric charge on the conductor's surface. These line charges have different unknown charges per unit length. The values of these unknowns are determined by satisfying carefully chosen boundary conditions; from which the potential and electric field are directly evaluated anywhere. The method is applied for calculating the field in the vicinity of a single and boundle of two, three and four subconductors. In a previous attempt, the boundary equations were written to relate the unknown line charges with the potential and its derivatives along the subconductors surface. It is observed that the computed line charges yield potentials satisfying the boundary conditions only at the selected points, while the potential at the other points on the subconductor's periphery deviate from the applied voltage. Also it is observed that the system of equations obtained are only solvable for

particular choice of the number of line charges and their relative locations. When this attempt was tried for bundles more than two subconductors, higher derivatives of the potential got involved and solution of the equations became extremely difficult to achieve.

In the present thesis, the simulation technique is modified by formulating a number of equations greater than the assumed line charges, thus fulfilling the potential at a large number of points on the subconductors surface . Thus, the boundary equations are simply formulated without using the higher derivatives of potential. The solution of the set of simultaneous equations is achieved by using the linear least-square technique. This yielded equipotential surfaces which almost coincided on the subconductor surfaces with a considerable improvement over the previous attempt as regards the accuracy and the computational time. No restrictions are imposed on the present method as regards the bundle number per pole either with smooth or stranded subconductors. The method as applied to bipolar dc lines, showed its validity to ac lines.

To check the calculated field values obtained by the proposed method, corona threshold levels were computed using the calculated field values for a laboratory model of a bipolar transmission line with smooth subconductors. The corona threshold levels were measured for the laboratory model with two, three and four subconductors per pole. The corona threshold level as depending upon the pole spacing, the subconductor diameter and spacing as well as the bundle height is studied.

The criteria used for computing the corona threshold levels were reported previously for monopolar lines. On a bipolar dc transmission line, it is well known that the corona discharge starts at one of the poles at a voltage smaller than the level for the corona to occur at both poles. Some ions travel from the pole in corona to the other pole. As a result, ions of opposite polarity penetrate into the ionization zone of the conductor free from corona and enhance the field at the latter's surface. Therefore, corona starts at the latter pole at a voltage lower than if the former pole was absent. This phenomena is evaluated here-for the first time-to estimate the corona onset voltage on bipolar lines as different from monopolar lines.

For a practical bipolar dc transmission line, corona takes place on the positive pole first. The effect of the positive ions into the cathode zone was found to depend upon the line geometry and the difference between the onset levels on both poles. It vanishes for extremely long spacings between poles. This corroborates experimental findings.

On the contrary for a laboratory model, the effect of penetration is so small that it can be neglected. The agreement between the computed threshold levels with those measured experimentally for the laboratory model under investigation is satisfactory. This reflects itself in a fact that the present method offers easy means to predict experimental corona results.

LIST OF PRINCIPAL SYMBOLS

B(K,J)	Angle defining the location of line charge J on the K^{th} subconductor.
C(K,I)	Angle defining the location of boundary point I on the K^{th} subconductor.
D	Subconductor spacing
E	Applied electric field
E_R	Component of E in the R-direction
E_Z	Component of E in the Z-direction
E'	Electric field with space charge
E_{max}	Maximum surface field
H	Pole height above ground plane
K_{NS}	Coefficient of Bundling
N	Number of unknown line charges per subconductor.
NN	Total number of line charges
NS	Number of subconductors per pole
$N_e(x) - 1$	Number of positive ions in the avalanche at a distance x from its starting point.
M	Number of boundary points per subconductor
MM	Total number of boundary equations.
Q(K,J)	Magnitude of line charge J on the k^{th} subconductor

RS	Outer radius of subconductor either smooth or stranded
RF	Fictitious radius
S	Pole spacing
V	Applied voltage
V_{on}, V_{op}, V'_{on}	Corona threshold levels introduced.
ϵ	Deviation of the computed potential from the applied value.
α	Townsend first ionization coefficient
η	Attachment coefficient
ρ	Space charge density
ϕ	Electric potential
ξ	Scalar point function.

LIST OF FIGURES