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An Effective Method of Numerical Solution of a Boundary Electrodynamics Problem for Arbitrary Conducting Surfaces

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Abstract—An alternative to Packlington's and Harrington's integral equations method of numerically solving a boundary electrodynamics problem for curvilinear perfectly conducing surfaces is suggested. The essence of this method consists in a joint solution of integral equations system with respect to the unknown complex vectors of current and charge density, the use of parametric mapping technique to represent the curvilinear surface, Galerkin's method with boundary elements, "points sewing" method for Lorentz calibration. On an example of calculating the current distribution on a bicubic surface the advantages of the suggested method are demonstrated in comparison to Packlington's and Harrington's integral equations.

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PROBLEM DEFINITION

It is well-known that the analysis of radiator's characteristics may be easily performed if the amplitude-phase distribution (APD) of current on its surface is known. APD of current may be determined by solving the corresponding boundary problem. Obviously, the mathematic formulation of such a problem by means of electrodynamic potentials is perfect for researching radiators of arbitrary form. It is reduced to obtaining the integral equation.

The use of integral equations for researching radiators possesses more than 100 years of history [1]. It is well-known that for a thin conductor, which is also true for a surface, it is better to use electric field integral equation (EFIE). EFIE of Packlington and Harrington are well-known and widely used in practice for the case of linear antennas [1]. Hallen's integral equation will not be considered since it does not have electric field in its right part in the explicit form, which complicates the description of the excitation source.

However, numerical solution of the mentioned equations in the case of surface current distribution is rather difficult. So, Packlington's EFIE contains terms in its core, which are inversely proportional to the fifth degree of the distance between the point of the source and the field observation point. Due to this to achieve an acceptable precision of numerical integration rather large amount of processor time is needed. The core of Harrington's EFIE contains divergence of current vector density, which in the case of a curvilinear surface gets rather bulk and complex form. Divergence should be calculated analytically since numerical differentiation within numerical integration may lead to a divergent process and thus requires special stability research in each specific case.

The mentioned disadvantages of Packlington's and Harrington's EFIE arise due to the willingness to minimize the number of unknown variables during derivation of integral equation by excluding APD of charge density from the potential part of equation. This is accomplished either by means of Lorentz calibration or using the current continuity law. As a result, the only unknown variable in the equation is current. Such approach made sense earlier, when the computational powers of computers were insufficient for storing large arrays of data and inverting matrixes of large dimensionality. In present time there are no such limitations. However, when solving integral equation using variation-stable Galerkin's method for the surface case quad integrals should be computed and hence the computational expenses remain rather significant. That is why during the formulation of mathematic description of a boundary problem we shall shift the accent to obtaining a simpler form of integrated equations to compute.

In the present work we suggest an alternative to Packlington's and Harrington's EFIE method of numerically solving the boundary electrodynamics problem for arbitrary curvilinear conducting surfaces. The peculiarity of the method lies in formulating the boundary problem in the form of integral equations