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Algorithm for Transforming Antenna Electromagnetic Near-Field Measured on Spherical Surface into Far-Field Based on Direct Calculation of Stratton and Chu Formulas

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Abstract—This study examines the possibility of direct calculation of vector forms of Kirchhoff's integral in algorithms of electromagnetic near-field to far-field transformation of antenna harmonic radiation. A simple algorithm based on the integral derived from the Stratton and Chu formulas is proposed for the spherical scanning scheme of electromagnetic near-field. Method errors of the proposed algorithm stipulated by the assumptions made in the process of its derivation are investigated by mathematical simulation. The total error is estimated in experiments on reconstruction of antenna amplitude radiation patterns. For comparison, the results of the classical algorithm performance based on electric field expansion in terms of spherical modes are presented in all experiments. It has been shown that the accuracy of the proposed algorithm in comparison with the classical algorithm is not inferior, the programming complexity is lower, while the execution speed is higher on condition of the reconstruction of radiation pattern only in principal sections.

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INTRODUCTION

The direct measurements of antenna radiation patterns (RP) involve the need of using the measuring complexes that ensure the conditions equivalent to far-field (FF) for radiated electromagnetic waves. As the electric size of tested antennas increases, the minimum distance corresponding to FF conditions also increases that results in the rise of and cost of the measuring complex. For such conditions, the antenna near-field (NF) measuring complexes have got widespread use, the size of which are determined primarily by the dimensions of tested antennas. The antenna pattern functions in such complexes are measured indirectly using the algorithms of electromagnetic NF to FF transformation (NF-FF algorithms).

All the well-known NF-FF algorithms are based on different forms of Kirchhoff's integral that represents an expression for the electromagnetic field in free space in terms of its known values over an arbitrary closed surface S_m that covers all sources. A variety of equivalent representations of the Kirchhoff integral in scalar and vector forms exist, however, for simplifying the subsequent analysis, we shall use the most obvious form represented by the Stratton-Chu formulas in the symmetric system of units [1]:

$$\vec{E}(\vec{r}) = -\frac{1}{4\pi}\oint_{S_m}\Big(\mathrm{i}k\big[\vec{n}(\vec{r}\,'),\vec{H}(\vec{r}\,')\big]G(\vec{r},\vec{r}\,')$$

$$+\Big[\big[\vec{n}(\vec{r}\,'),\vec{E}(\vec{r}\,')\big],\vec{\nabla}G(\vec{r},\vec{r}\,')\Big]-\big(\vec{n}(\vec{r}\,'),\vec{E}(\vec{r}\,')\big)\vec{\nabla}G(\vec{r},\vec{r}\,')\Big)\mathrm{d}S', \quad (1)$$

$$\vec{H}(\vec{r}) = -\frac{1}{4\pi}\oint_{S_m}\Big(\mathrm{i}k\big[\vec{n}(\vec{r}\,'),\vec{E}(\vec{r}\,')\big]G(\vec{r},\vec{r}\,')$$

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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