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# Plasma-Dielectric Traveling Wave Antenna

**A. N. Artemenko[1], V. D. Karlov[2*], Yu. V. Kirichenko[3**], and Yu. F. Lonin[3***]**

[1]*Ministry of Defence of Ukraine, Kyiv, Ukraine*
[2]*Kharkiv Air Force University, Kharkiv, Ukraine*
[3]*National Science Center "Kharkiv Institute of Physics and Technology", Kharkiv, Ukraine*
**email: karlov@ukr.net*
***email: kiryuv51@ukr.net*
****email: Lonin@kipt.kharkov.ua*

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**Abstract**—The paper investigates the efficiency of transformation of traveling wave into radiation in longitudinally inhomogeneous plasma cylinder. The plasma is limited by a dielectric shell of finite thickness. The investigation involves the use of the method of spectral field expansion in terms of a set of functions including the surface and spatial waves of plasma cylinder with dielectric shell. A system of integro-differential equations for expansion coefficients has been obtained. These coefficients determine the amplitudes of transmitted, reflected, and scattered waves and also radiation patterns (RP). The system of equations is solved for the case of strong longitudinal variation of plasma density. The relationships of the transformation coefficients of surface wave energy as a function of the plasma density gradient, electrical length of section of plasma inhomogeneity, the electric radius of plasma cylinder, dielectric permittivity, and the thickness of dielectric were calculated. The fraction of surface wave energy that is transformed into radiation at acute angles can amount to 35%. The resultant narrow-beam RPs have only one lobe. The radiation maximum fits into an angle of several degrees with respect to the direction of surface wave propagation. With an increase of plasma density gradient, the lobe width is reduced, while its position shifts to 0°. The impact of dielectric properties on radiation characteristics has been also investigated.

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## INTRODUCTION

As was shown in experiments in [1, 2], a cylindrical column of low-temperature plasma can function as a transmit antenna. In experiments described in these papers, the energy of surface wave in gas-filled dielectric waveguide is partially spent on creation of plasma and partially is converted into radiation. In this case, the plasma density decreases as we move away from the waveguide end face. It is due to this inhomogeneity that the radiation of such antenna emerges.

Longitudinal irregularities in plasma dielectric waveguides are always present in real conditions of experiments. Therefore, the correct understanding of the radiation process in cylindrical plasma antennas and their designing involve the need of investigating the relationship of the coefficients of surface wave energy transformation into radiation as a function of the degree of inhomogeneity of plasma density. The account of this inhomogeneity is of crucial significance, since it affects the operation efficiency of any plasma traveling wave antenna, including the cylindrical one. Plasma traveling wave antennas were also explored in [3, 4].

The present paper investigates the transformation of axially symmetric surface wave in plasma antenna. The latter represents a cylindrical column of isotropic cold plasma limited by dielectric. The plasma density varies in the longitudinal direction. The rate of plasma density variation in the longitudinal direction can be arbitrary, inter alia high one. The last circumstance necessitated the use of numerical methods.

The method making it possible to solve such problems was developed by V. V. Shevchenko and reported in [5]. According to this method, the total field is expanded in terms of the complete set of functions of plasma cylinder including the surface and spatial waves of open systems. The coefficients of such expansion in the presence of inhomogeneities depend on the longitudinal coordinate. They satisfy the system of integro-differential equations.

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