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Simulation of Plasma Antenna Parameters

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Abstract

In this paper a simulation study of a short plasma antenna is presented which is based on electromagnetic software. Using the model, different antenna parameters such as S-Parameter, radiation pattern, directivity, gain and return loss of the plasma antenna are calculated. Results suggests that plasma antenna have four resonance frequencies ranging from 1 MHz to 2 GHz. At different resonance frequencies, different radiation pattern are obtained.

1. Introduction

An antenna according to Webster's dictionary define as "a conducting metallic device for transmitting and receiving radio signals" here by replacing the conducting metallic material with the plasma to work as an antenna is called plasma antenna. As plasma has charged particles ions and electrons so it has conductivity[1]. Previous studies proved that it is possible to use plasma element as a antenna to transmit and receive radio signals is known as plasma antenna[2]. Plasma antenna is a device that has various advantages in the field of communication, the main advantage of plasma antenna is that it can be switched off and on electrically which change the antenna appearance just by switch on and off the electrical power[3]. It has been investigated that by changing operating parameters e.g. working pressure, driven frequency, input power, radius of glass tube, length of plasma column and argon gas, single plasma antenna can be transformed to array plasma antenna, helical antenna and spiral antenna which shows Reconfigurability of plasma antenna[4, 5]. Plasma density and plasma conductivity change the plasma frequency so it is possible to retune the same plasma antenna for different frequency. A smart plasma antenna can steer the radiation pattern in different directions electronically[6]. So on the basis of above advantages plasma antenna now become an intrusting topic for research.

Most of the work on plasma antennas deals with experimental approach and lack of discussion about the resonance frequency and radiation pattern dependency. Therefore present study is devoted to understand the relation between resonance frequencies with the radiation pattern which gives us almost all the antenna parameters of the plasma antenna using High Frequency Structure Simulator (HFSS).

2. Theory and Plasma parameters

For the weakly ionized plasma in which the collision frequency is higher than the wave frequency($v_m \gg \omega$) the conductivity can be calculated by the formula is written blow[7].

$$\sigma = \frac{e^2 n_e}{m_e v_m} \qquad (1)$$

Here e is the electronic charge, n_e is the electron density, m_e is the mass of electron and v_m is the collision frequency.

Plasma in terms of electromagnetic properties is a non-homogeneous, non-linear and dispersive environment. Permeability (μ), conductivity (σ) and permittivity (ε) in plasma can be varied in terms of frequency and other parameters and make plasma a special environment. As a result, for any frequency of the incident wave and in any density of ionization, one particular response occurs. Radiated electromagnetic waves on plasma will absorb, scatter or pass through. We can choose to absorb, scatter or pass through with changing the basic parameters like electron density and collision frequency. The relative permittivity of plasma is defined by [8]:

$$\varepsilon_r = \varepsilon_r^{'} - j\varepsilon_r^{''} = 1 - \frac{\omega_p^2}{\omega(\omega - jv)} \qquad (2)$$