A SIMPLE APPROACH FOR BLACK-OUT PROBLEM

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Antennas surrounding by the plasma medium does not radiate for all the frequencies but only for those which are greater than the plasma frequency. Here we have proposed a cylindrical (axially magnetized) antenna system which radiates for all frequencies irrespective of plasma frequency and this is the solution for the black-out situation which occurs for certain frequencies.

The interaction of electromagnetic waves with the ionised gases in the ionospheric plasma is a very important field of research for the communication engineers. The information carried by a modulated electromagnetic wave may be absorbed or even completely destroyed (black-out), when the wave travels through a plasma media. Radiation leaving an antenna on earth need not travel very far before it encounters the natural plasma in ionosphere. Various authors [1—4] have proposed the electronically scannable plasma antenna system in which the direction of the radiation peak is scannable by the plasma density. However in these studies, the radiation is not obtained for all frequencies. In this paper, we have proposed in antenna system which radiates for all frequencies and hence black-out can be removed.

To overcome the problem of the black-out, we have proposed an antenna system which contains an axially magnetized cylindrical, one component semiconductor plasma consisting only of electrons (e.g. *n-In Sb*), of radius situated such that its longitudinal axis corresponds to the z-axis of the cylindrical co-ordinates. The plasma column is surrounded by the dielectric (permittivity ϵ) cylinder of radius c. The magnetic ring source[3] of radius $a (b < a < c)$ is located at $z = 0$ plane. Since a semi-conductor plasma when immersed in the magnetic field can not support independent TE and TM modes, therefore the mixmode analysis is used. The radiation field is obtained from the asymptotic evaluation of the integral by saddle point integration. It was found that the structure radiates for all the frequencies and there is no black-out in the radiation pattern.

ANALYSIS

Assuming the variation $e^{j(Kz - \omega t)}$ for the fields, Maxwell's equations can be combined to give the following equation for H_ϕ (Appendix A).

where

$$\frac{\partial^2 H_\phi}{\partial \rho^2} + \frac{1}{\rho}\frac{\partial H_\phi}{\partial \rho} + \left(V_1^2 - \frac{1}{\rho^2} \right) H_\phi = - j\omega\epsilon_0 \epsilon_3 \, \delta(\rho - a)\delta(Z) \tag{1}$$

where

$$V_1^2 = \left[K_0^2 - K^2/(\epsilon_1 + \epsilon_2 \alpha) \right] \epsilon_3$$

$$\alpha = K_0^2 \epsilon / (K^2 - K_0^2 \epsilon_1), \; K_0 = \omega (\mu_0 \epsilon_0)^{\frac{1}{2}}$$

ϵ_1, ϵ_2 and ϵ_3 are the components of the relative dielectric tensor[5], and ω is the frequency of the source. In arriving at (1) we have assumed

$$\left| \frac{\partial H_z}{\partial \rho} \right| << \left| j K H_\rho \right| \tag{2}$$

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which is well satisfied in high density semi-conductor plasmas. The radiation field in spherical co-ordinates (r, θ, ϕ) can be written in the form[6] (Appendix B)

$$H_{\phi}(r, \theta) = \frac{j \omega \epsilon_0 \epsilon a}{2\pi} \; F(\theta) \; \frac{e^{jK_0 r}}{r}$$

where

$$f(\theta) = \frac{[Y_1(V_2 a) - (X_2/X_1) J_1(V_2 a)]}{V_2 a \, a_{22} [Y_0(V_2 a) J_1(V_2 a) - Y_1(V_2 a) J_0(V_2 a)]}$$

$$a_2 = (X_3/X_4) \left[\frac{Y_1(V_2 a)}{J_1(V_2 a)} \; \frac{X_2}{X_1} \right] + \frac{H_1(V_0 c)}{J_1(V_2 c)}$$

$$X_4 = V_2 c \, [J_0(V_2 c) \, Y_1(V_2 c) - J_1(V_2 c) \, Y_0(V_2 c)]$$

$$X_3 = V_0 c \, H_0(V_0 c) \, J_1(V_2 c) - V_2 c \, J_0(V_2 c) \, H_1(V_0 c)$$

$$X_2 = a_{11} \, Y_0(V_2 b) - V_1 b \, J_0(V_1 b) \, V_1(V_2 b)$$

$$X_1 = a_{11} \, J_0(V_2 b) - V_1 b \, J_0(V_1 b) \, J_1(V_2 b)$$

$$a_{11} = (\epsilon_3/\epsilon) \, V_2 b \, J_1(V_2 b), \; V_0 = K_0 \cos\theta,$$

$$V_2 = K_0 (\epsilon - \sin^2\theta)^{\frac{1}{2}}$$

$$V_1 = K_0 \left[\epsilon_3 \left\{ 1 - \frac{\sin^2\theta (\sin^2\theta - \epsilon_1)}{\epsilon_1 \sin^2\theta + (\epsilon_2^2 - \epsilon_1^2)} \right\} \right]^{\frac{1}{2}}$$

J_n, Y_n, H_n are the Bessel functions of first kind, second kind and Hankel function of first kind and of nth order respectively.

RESULTS AND DISCUSSION

The radiation patterns (variation of $F(\theta)$, with θ) have been computed with the help of IBM-1130 computer. It is pointed out that the angle at which the radiation peak is observed gets shifted to the higher degrees as ϵ increases from 0·1 to 0·7 but the further increase in ϵ reduces the amplitude of the peaks. If ϵ takes the negative values, which may be the case if one assumes that the dielectric is nothing but the gaseous plasma such that the plasma frequency (say ω_p) is greater than ω, the source frequency, the radiation peaks or still observed. If, however, the semi-conductor plasma is not there then, for $\omega < \omega_p$ no radiation is observed. This is what we called the black-out situation. The half power beam width of the peaks observed is of the order of 0·1 degrees. The diameters of the semi-conductor plasma column and that of the dielectric medium affect both the amplitude and the direction of the radiation peaks while the diameter of the ring source changes only the amplitude of the radiations. The direction of the radiation peaks remains unchanged with the magnetic field, the semi-conductor plasma frequency and the collision frequency but the amplitude changes with them.

CONCLUSIONS

It may be pointed out that in the geometry which we have proposed, there is no black-out of the radiation. Based upon the results of this paper, one can design an antenna system which will be very useful for the space flight problems.

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