Radioelectronics and Communications Systems
Vol. 47, No. 8, pp. 32–36, 2004

Izvestiya VUZ. Radioelektronika
Vol. 47, No. 8, pp. 44–50, 2004
UDC 621.396.67

THE IMPACT OF POSITION OF A MAGNETIC DIPOLE WITH RESPECT TO THE OUTER BOUNDARY OF AN OPEN CYLINDRICAL VOLUME ON THE REMOTE ZONE FIELD

N. N. Gorobets, V. A. Katritch, A. A. Lyakhovskii, and Ye. V. Shepilko

Kharkov National University, Ukraine

A solution is obtained to the strictly formulated problem concerning radiation of a magnetic dipole located on the outer surface of an ideally conducting circular cylinder with an infinite longitudinal slot. It is shown that the dipole position with respect to the edge of a conductive cylindrical surface may substantially affect the radiation field distribution in the remote zone.

The electromagnetic properties of an active (radiating) slot, with regard to its position in a wall of closed volumes, have been extensively studied in [1–3]. The impact of the position of an elementary radiating slot, imitated by a magnetic dipole and located on the inner surface of an open structure in the shape of a cylindrical screen, on a field in the remote zone was considered in [4].

As distinct from [4], in this work we investigate, in the mathematically strict formulation, the problem concerned with radiation of a magnetic dipole placed at an arbitrary point of a cylindrical surface with an infinite longitudinal slot. Solution to this problem permits us to analyze the impact of position of a radiating elementary slot, with respect to the edge of a nonclosed cylindrical screen, on the field of the structure in the remote zone.

In a homogeneous and isotropic medium, with permeability μ and permittivity ε, we have an infinitely thin and ideally conducting screen in the shape of a circular cylinder with an infinite longitudinal slot whose angular width is 2δ. The axis z of the cylindrical coordinate system ρ, φ, z coincides with the axis of the cylinder of radius a (Fig. 1).

The magnetic dipole, whose moment is set equal to unity for generality, is directed in parallel with the z-axis and located in an arbitrary point $L_0(a, \varphi_0, z_0)$ on the outer part of the cylinder surface. The field of the dipole varies in time by the harmonic law $\exp(-i\omega t)$.

In order to find the full field under these conditions, the principle of superposition may be applied:

$$\vec{E}(L) = \vec{E}^0(L, L_0) - \vec{E}^1(L, L_0), \quad \vec{H}(L) = \vec{H}^0(L, L_0) - \vec{H}^1(L, L_0),$$

where $\left\{\vec{E}^1(L, L_0);\ \vec{H}^1(L, L_0)\right\}$ is the field scattered on the cylinder; $\left\{\vec{E}^0(L, L_0);\ \vec{H}^0(L, L_0)\right\}$ is the dipole field distribution in the free space, which can be represented with the aid of Hertz's magnetic vector $\vec{\Pi}_0^M$ with a single nonzero z-component Π_{0z}^M [5]:

$$\vec{E}^0(L, L_0) = ik\mu \operatorname{rot} \vec{\Pi}_0^M, \quad \vec{H}^0(L, L_0) = \operatorname{grad} \operatorname{div} \vec{\Pi}_0^M + k^2 \varepsilon\mu \vec{\Pi}_0^M.$$

Here

$$\vec{\Pi}_0^M = \vec{e}_z \Pi_{0z}^M(L, L_0) = \vec{e}_z e^{ikr\sqrt{\varepsilon\mu}} / r,$$

REFERENCES

1. Ya. N. Fel'd and S. L. Benenson, Antenna-Feeder Devices — Part 2 [in Russian], Izd-vo VVIA im. Zhukovskogo, Moscow, 1950.

2. P. Sh. Fridberg, Radiotekhnika i Elektronika, Vol. 16, No. 9, pp. 619–624, 1977.

3. F. L. Whetten and C. F. Balanis, IEEE Trans. on Ant. and Propagation, Vol. 39, No. 11, 1991.

4. N. N. Gorobets, V. A. Katritch, and Ye. V. Shepilko, Izv. VUZ. Radioelektronika, Vol. 20, No. 8, pp. 1389–1395, 2000.

5. Ye. A. Ivanov, Diffraction of Electromagnetic Waves on Two Bodies [in Russian], Nauka i Tekhnika, Minsk, 1968.

6. G. N. Watson, Theory of Bessel Functions, Part 1 [Russian translation], Inostrannaya Literatura, Moscow, 1949.

7. B. Z. Katsenelenbaum, High-Frequency Electrodynamics [in Russian], Nauka, Moscow, 1966.

8. V. P. Shestopalov, The Method of Riemann-Hilbert's Problem in the Theory of Diffraction and Propagation of Electromagnetic Waves [in Russian], Izd-vo KhGU, Kharkov, 1973.

9. L. V. Kantorovitch and V. I. Krylov, Approximate Methods of Higher Analysis [in Russian], GIFML, Moscow-Leningrad, 1962.

10. G. Z. Aizenberg, V. R. Yampol'skii, and O. N. Teryoshin, VHF Antennas, Part 1 [in Russian], Svyaz', Moscow, 1977.

21 May 2002