Radioelectronics and Communications Systems
Vol. 48, No. 11, pp. 4–13, 2005

Izvestiya VUZ. Radioelektronika
Vol. 48, No. 11, pp. 6–18, 2005
UDC 621.396.674.3

THE INPUT IMPEDANCE OF AN ARBITRARILY ORIENTED ELECTRIC DIPOLE LOCATED OVER A RECTANGULAR SCREEN. PART 1 — THE METHOD OF CALCULATION

N. P. Yeliseyeva

Kharkov National University, Ukraine

The paper describes a new technique for calculation of input impedance of an arbitrarily oriented electric dipole of finite dimensions arranged above a rectangular metal screen. The technique is based on the method of induced electromotive forces and on the uniform geometric theory of diffraction. The full induced impedance includes the mutual impedance between the excitation dipole and its image, and also the impedance induced in the dipole due to diffracted fields from the screen edges.

The flat metal screens, having many applications in radioelectronics, are used for redistributing the energy of electromagnetic field in the whole space. In [1–3] we applied the method of uniform geometric theory of diffraction (UGTD) to investigate the directed characteristics of radiation in the remote zone for arbitrarily oriented elementary electric dipoles located in the vicinity of flat rectangular screens. We also performed numerical calculations of radiation resistance R_Σ of a vertical and a horizontal dipole with a flat [4] and an angle reflector [5] — by the Poynting vector and by UGTD — depending on the size and ratio between the reflector sides, and on the distance from the dipole and reflector. An important parameter dictating the matching of the exciting dipole to the generator is its input impedance $\dot{Z} = \dot{U}_{\text{in}} / \dot{I}_{\text{in}}$, where $\dot{U}_{\text{in}}$ and $\dot{I}_{\text{in}}$ are the voltage across the dipole terminals and the current in it. In the general case, the input impedance is a complex quantity provided the loss is absent, i.e., $\dot{Z} = R_\Sigma + \text{j}X_\Sigma$. Based on the method of induced electromotive forces (emf) and on UGDT, in this paper we developed a technique for calculation of the active R_Σ (radiation resistance) and reactive X_Σ (reactance) parts of the input impedance of an arbitrarily oriented electric dipole of finite length, with regard for diffraction effects at screen's edges. In addition, we analyzed the impact of the dipole orientation, its distance from the screen, and the screen size and shape on the antenna input impedance.

The model for calculation of the radiating system represents an infinitely thin and ideally conducting flat rectangular screen *ABCD* with sides' dimensions *L* and *W*, and driven by an electric dipole *AB* with its arm length *l*. The center C_1 of the dipole lies on the axis *OX* of the rectangular coordinate system at distance *h* from its origin *O*, coincident with the middle of the screen. Orientation of the dipole axis is defined by the angle α of inclination towards its projection on the *XY*-plane, and by the angle ς between projection of the axis on this plane and the *X*-axis (Fig. 1). The exciting dipole and its mirror reflection are denoted in Fig. 1 as elements $i = 1$ and $i = 2$.

Within the framework of the geometric theory of diffraction [6], at $k \to \infty$ (where *k* is the wave vector), the field of the system under investigation in any observation point *P* can be represented as the sum of the falling ($i = 1$) and reflected ($i = 2$) fields, and the fields excited on each of the four edges of the screen:

$$E(P) = E_{\text{inc}}\chi + E^*_{\text{ref}}\chi^* + \sum_{n=1}^{4} E_{\text{d}_n}\chi_n + \sum_{n=1}^{4} E^*_{\text{d}_n}\chi^*_n.$$

REFERENCES

1. N. P. Yeliseyeva, Radiofizika i Radioastronomiya, Vol. 3, No. 2, pp. 217–225, 1998.
2. N. N. Gorobets and N. P. Yeliseyeva, Antenny, Iss. 2(43), pp. 57–61, 1999.
3. N. N. Gorobets and N. P. Yeliseyeva, Radiofizika i Elektronika, Vol. 7, No. 3, pp. 446–456, 2002.
4. N. P. Yeliseyeva, Radiofizika i Radioastronomiya, Vol. 3, No. 1, pp. 105–110, 1998.
5. N. P. Yeliseyeva, Izv. VUZ. Radioelektronika, Vol. 45, No. 5, pp. 65–75, 2002.
6. J. B. Keller, J. Appl. Phys., Vol. 28, No. 4, p. 426, 1957.
7. G. T. Markov and D. M. Sazonov, Antennas [in Russian], Energiya, Moscow, 1975.
8. G. Korn and T. Korn, Mathematical Handbook for Scientists and Engineers [Russian translation], Nauka, Moscow, 1970.
9. T. S. Ng and T. S. Lee, IEE Proceedings, Vol. 129, Pt. H, No. 1, pp. 11–17, 1982.

19 March 2005