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Analysis of Horn Radiators Having the Complex Form Cross-Section and Aperture

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Abstract—An approach to the calculation of radiation patterns and matching characteristics with free space of waveguide-horn radiators having the cross-section and aperture of complex form has been proposed. Solutions were obtained for rectangular and circular ridged radiators with due regard for the proper numbers of equivalent ridged waveguides in the known expressions for the reflection coefficient and radiation patterns of open ends of waveguides having the simple (rectangular and circular) form. The possibility of using the obtained solutions for the practical calculations with the required accuracy at a much smaller computational complexity as compared with similar solutions has been shown.

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STATEMENT OF THE PROBLEM

The ever increasing requirements to different radio-TV complexes necessitate the search for ways of improving the characteristics of their constituents, in particular antenna systems and channeling devices. In many cases the waveguide and horn radiators featuring such useful properties as simple design, sufficient bandness, and operational reliability are applied as elements of antenna systems. The expansion of their working frequency band, while maintaining the initial shape of radiation pattern (RP), the required level of side lobes, and matching with free space can be achieved by using the waveguide structures having the cross-section of complex form [1, 2]. The waveguide-horn radiators built on the basis of waveguides with two- and four-ridge sections are of large practical interest. Figure 1 presents the structure of the above waveguides and the employed system of size designations.

A sufficiently large number of studies (and among them papers [1–6]) were devoted to investigations of waveguide devices, including horn antennas based on waveguides having the cross-section of complex form. In this case, the majority of studies dealt with ridged waveguide-horn radiators having the simple-form aperture (due to the special design the ridges disappear in the aperture plane).

The main attention is paid to the issues of solving internal problems, while for the analysis of external characteristics, in the majority of cases, the solutions for the open end of circular or rectangular waveguides [7, 8] and also for simple horns [9] are used.

At the same time the horn radiators having the complex-form aperture become reasonably popular and among them the ridged ones. Unfortunately the above solutions [7, 8] are invalid for such radiators. The form of aperture of the radiators in question is similar to the form of cross-section (Fig. 1) of basic waveguide with sufficiently complex field structure [2] that determine the complexity of the analysis of external characteristics. Thus far no solutions of external problems are available in closed form for the radiators having the forms presented in Fig. 1. The results of numerical solution obtained by splitting the radiating surface into elemental areas with subsequent superposition of partial diagrams [6] have major disadvantages, namely: high computational complexity and applicability only for the front half-sphere of space.

Thus, the existing approaches toward the analysis of waveguide-horn radiators with the complex-form aperture have significant disadvantages that limit the efficiency of their subsequent practical application and necessitate the search for new more relevant solutions. In this case, the development of appropriate methods for the analysis of external characteristics of waveguide-horn radiators with complex-form cross-section and aperture is an urgent issue of the modern theory and technology of antennas.