RADIATION CHARACTERISTICS OF A NOVEL "RING-IN-CONE" ANTENNA

Dubrovka F. F. and Bankowsky V. L.

National Technical University of Ukraine "Kyiv Polytechnic Institute",
Department of Theoretical Foundations of Radio Engineering, Kyiv, Ukraine
E-mail: fedor.dubrovka@gmail.com
E-mail: vbankowsky@gmail.com

Abstract

Results of numerical investigations of radiation characteristics of the finite "ring-on-rod" antenna and a novel combined "ring-in-cone" antenna are presented.

Keywords: "ring-on-rod" antenna, combined "ring-in-cone" antenna, crosspolar radiation.

1. INTRODUCTION

One of the most important requirements to modern onboard and ground reflector antennas for satellite communication systems and terrestrial station consists in providing low level of crosspolar radiation which allows realizing polarization division multiple access (PDMA) and, therefore, doubling the information capacity of such systems. Since in most cases a feed is the main source of crosspolar radiation of reflector antenna, there is a necessity for using feeds with low level of cross-polar radiation. This problem is solved by creating impedance boundary conditions, for example, by introducing corrugation [1], partial filling with dielectric, etc. But in the case of transition to the Ka-band, technological difficulties arise which are caused by difficulties of manufacturing high precision corrugated surfaces. Therefore it makes sense to search and investigate feeds constructed on the basis of metal-dielectric structures in which the technology of dielectric's surface metallization can be used. An antenna consisting of a dielectric rod with metal rings periodically placed along its length belongs to such structures. In [2] the mathematical model of "ring-on-rod" antenna is created and numerical research of its dispersive characteristics and characteristics of radiation in approximation of periodic structure are carried out. In this work we present the results of numerical research of radiation characteristics of the "ring-on-rod" antenna with finite electric length and a novel combined "ring-in-cone" antenna. The main attention is paid to cross polarization characteristics and side lobe levels.

2. RESULTS

A general view of "ring-on-rod" antenna which is excited by a circular waveguide is shown in Fig.1. Numerical research is performed using CST Microwave Studio environment which implements the finite difference time domain (FDTD) method.

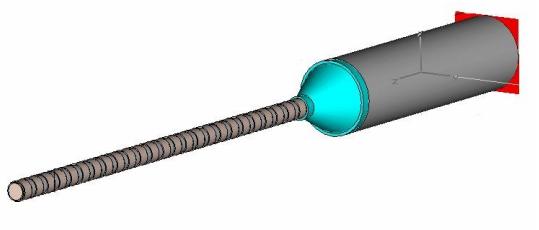
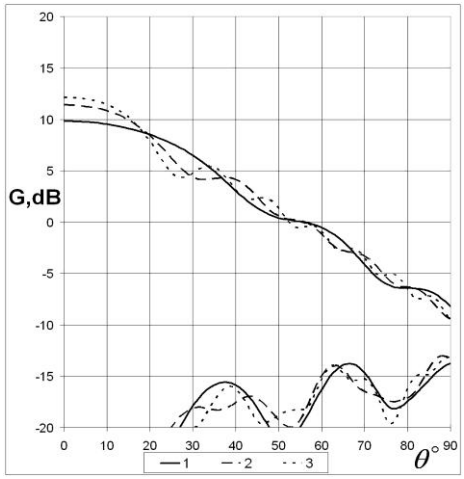


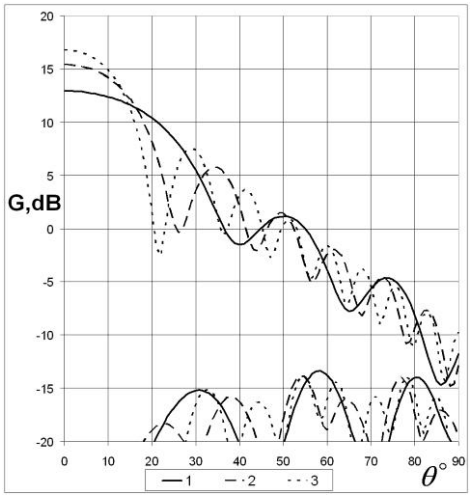
Fig. 1. The "ring-on-rod" antenna.

Teflon (permittivity ε = 2,08) is used for dielectric rod. To match "ring-on-rod" antenna with a circular waveguide a polystyrene foam element been used. Placing of the port (Fig.1) used to excite electromagnetic field in the structure is determined experimentally.

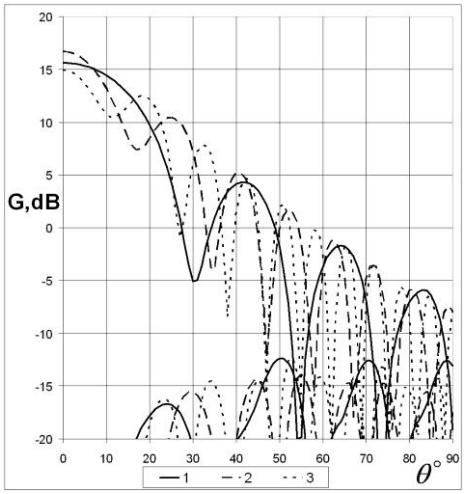
Results of radiation characteristics calculations of "ring-on-rod" antenna for the main polarization and cross polarization at three fixed frequencies for three lengths: $L = 3\lambda_0$ $L = 6\lambda_0$ $L = 9\lambda_0$, where λ_0 - length of a wave on frequency of 6 GHz, are presented in Fig.2. Frequency dependences of maximum cross polarization level of "ring-on-rod" antenna for three lengths ($L = 3\lambda_0$ $L = 6\lambda_0$ $L = 9\lambda_0$) in the frequency range 5,0 - 7,0 GHz are presented in Fig.3.



a)



b)



c)

Fig. 2. Radiation characteristics of "ring-on-rod" antenna for main polarization and cross polarization at frequencies: a) 5 GHz, b) 6 GHz, c) 7 GHz at its length: 1) $L = 3\lambda_0$, 2) $L = 6\lambda_0$, 3) $L = 9\lambda_0$

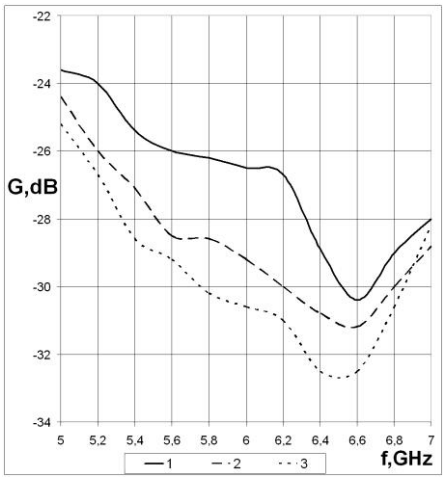


Fig. 3. Frequencies dependences of maximum cross polarization level of "ring-on-rod" antenna for three lengths: 1) $L = 3\lambda_0$, 2) $L = 6\lambda_0$, 3) $L = 9\lambda_0$.

The plots in Fig. 2 and Fig. 3 prove that the "ring-on-rod" antenna has low level of cross polarization radiation, but has significant side lobe levels, especially at lengths $L > 6\lambda_0$. In order to reduce side lobe levels the "ring-on-rod" antenna was axially aligned in a cone. The design of the combined "ring-in-cone" antenna is shown in Fig. 4. The geometry of the cone (aperture diameter is 160 mm, length is $L = 3\lambda_0$) has been optimized in order to achieve the necessary radiation characteristics.

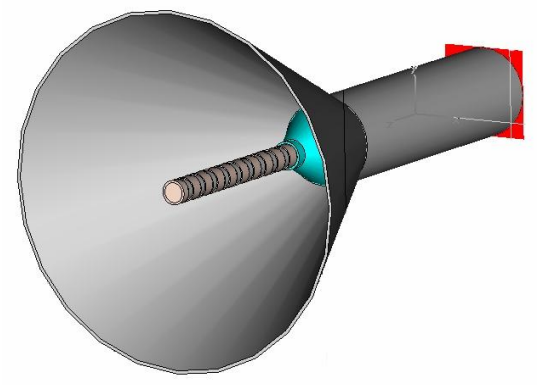


Fig. 4. The "ring-in-cone" antenna.

Radiation characteristics for the main polarization and cross polarization of the "ring-in-cone" antenna on three frequencies (f = 5 GHz, f = 6 GHz, f = 7 GHz.) are depicted in Fig.5. As follow from the plots, the maximum level of cross-polar radiation decreases with increasing frequency.

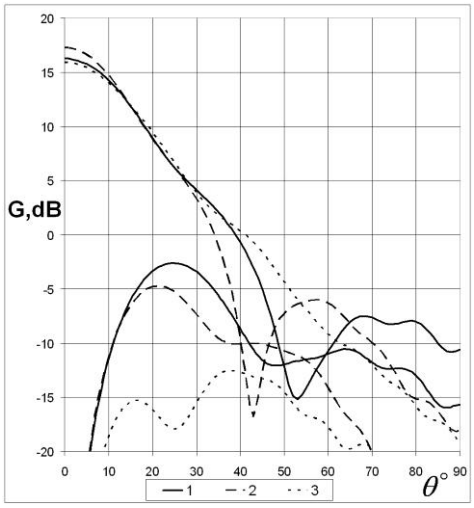
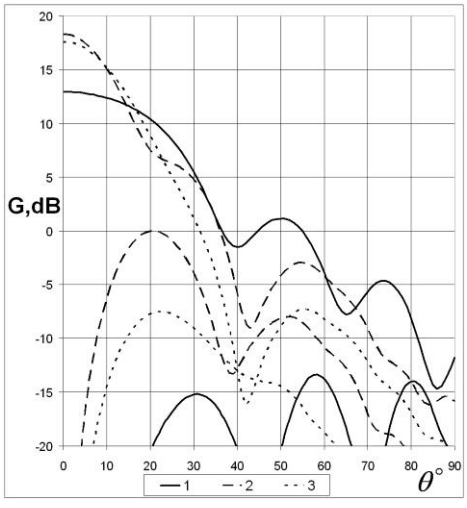
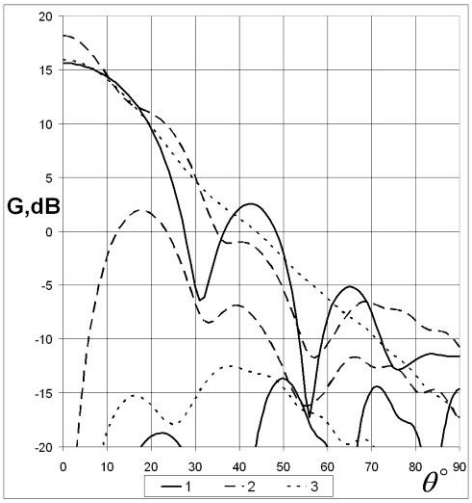


Fig. 5. Radiation characteristics for main polarization and cross polarization for the combined "ring-in-cone" antenna with length $L = 3\lambda_0$ at frequencies: 1) f = 5 GHz; 2) f = 6 GHz; 3) f = 7 GHz.

Radiation characteristics for the main polarization and cross polarization of the "ring-on-rod" antenna, the cone and the "ring-in-cone" antenna are compared in Fig. 6. As one can see, in Fig. 6 the "ring-on-rod" antenna and the cone antenna have the minimal and the maximal levels of crosspolar radiation respectively. The combined "ring-in-cone" antenna is a little worse than the "ring-on-rod" antenna in the level of crosspolar radiation, but has considerably lower side lobe levels and greater gain.



a)



b)

Fig. 6. Radiation characteristics for main polarization and cross polarization at frequency a) f = 6 GHz, b) f = 7 GHz at $L = 3\lambda_0$ for: 1) "ring-on-rod" antenna, 2) cone antenna, 3) combined "ring-in-cone" antenna.

3. CONCLUSIONS

As a result of the performed numerical research of radiation characteristics of the "ring-on-rod" and the novel "ring-in-cone" antennas we can conclude: increasing the length of the "ring-on-rod" antenna leeds to crosspolar radiation decreasing, but side lobes increase; in the case of axial alignment of the “ring-on-rod” structure in the cone the crosspolar radiation level insignificantly increases while gain increases and side lobes drastically decrease.

REFERENCES

1. P.J.B. Clarricoats, A.D. Olver. Corrugated horns for microwave antennas. London, Peter Peregrinus Ltd., 1984, 231 p.
2. Dubrovka F. F. Pantov V. S. Radiation of electromagnetic waves by cylindrical ring antennas // Radioelectronics and communications systems. - 1991. - volume 34. - №5. - pp. 44 - 49.