CROSS-POLAR RADIATION OF A DUAL-BAND COAXIAL FEED HORN WITH PARTIAL DIELECTRIC LOADING

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Abstract

Cross-polar radiation of a novel dual-band coaxial hybrid-mode feed horn with partial dielectric loading for single and dual reflector antennas has been investigated. In comparison to dual-band corrugated horns this horn has higher crosspolar level, but provides larger band separation (e.g., 6.6:1 in the paper) and rather good electrical performances over a wide frequency range (20% and more) within each operational frequency band. Furthermore, the main concept of the coaxial feed system can be easily extended for multi-band cost-effective applications.

Keywords: Coaxial feed system, dielectric loaded horn, dual-band feed horn.

1. INTRODUCTION

Growing traffic requirements in modern communication systems demand improved performance of antenna systems. As a result, considerable attention is currently being paid to single and dual reflector antennas operating in several frequency bands simultaneously. One of the key elements of such antennas is a feed horn. Properly designed and manufactured horn antennas are crucial for overall performance of reflector antennas. Furthermore, in the most cases a wide bandwidth within each operational frequency bands is required. Hence, a novel feeds should be proposed to comply with modern demands.

The dual-band dielectric loaded feed horn for S/X frequency bands [1] requires a complicated matching system. An overview of existing solutions for dual and multi-band feeds had been recently presented in [2]. One of possible solutions is a Pottern's type horn. However, as it was shown previously, such a horn has narrow operating bandwidth (5...7%).

We propose another way to build multi-band hybrid-mode feed horns for satellite communications [3-5]. The essence of the idea is a partial dielectric loading of a coaxial horn in such a way that there are air gaps between metallic walls of coaxial horn and dielectric body. Compared to the corrugated horns, the new feed system can simultaneously and independently operate in a few wide frequency bands with significant separation between each operating frequency band.

2. DESIGN

A novel dual-band coaxial feed horn with a partial dielectric loading (Fig. 1) to meet strict requirements of advanced dual-band telecommunication systems has been designed in collaboration between National Technical University of Ukraine "KPI" (UA) and Queen Mary University of London (UK). It consists of two smooth-wall profiled horns partially filled with a dielectric material. Hybrid modes in a lower frequency coaxial horn are excited and supported by a dielectric body that partially fills the coaxial horn, forming air gaps V_1 and V_2 between metal surfaces and the dielectric core. It has been found that radiating characteristics of the horn depend on the air gap widths, core dielectric permittivity and outer-to-inner horn diameter ratio.

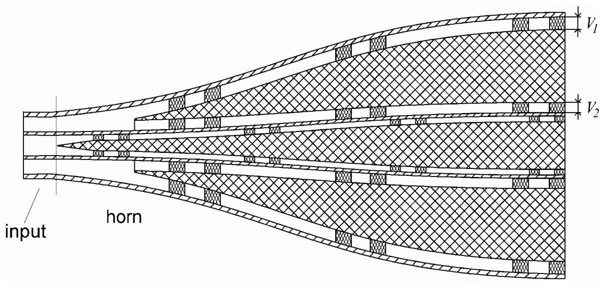


Fig. 1 Dual-band coaxial feed horn with a partial dielectric loading and air gaps V_1 and V_2

For the high frequency (HF) band a dielectric material with significant permittivity partly fills common conical or shaped horn. It is well known [6] that the dielectric loaded horn provides well pattern symmetry and low cross-polar radiation in the wide frequency range. Air gap between metal surface and dielectric creates special boundary conditions for the operating H11 mode in the circular waveguide (horn) and excites hybrid modes in such structure. The hybrid HE11 mode provides low cross-polar level and equal main beamwidth in cardinal planes. In our case, HF-horn is mounted inside the low-frequency horn (LF). Obviously, in such structure we should create the same boundary conditions for the H11 coaxial mode near the both metal surfaces (inner and outer conductors of the coaxial horn) in order to excite coaxial hybrid HE11 mode.

3. RESULTS

Numerical investigations have been performed by CST Microwave Studio code. The software utilizes finite difference time domain (FDTD) method, hence, consume large amount of computer resources. However, it has been proved that the results for horns are usually in a good agreement with measurements. To prove the concept, the large amount of simulations has been undertaken. As a result of previous investigations [4] it has been shown that better electrical performances of the dual-band horn can be achieved using high dielectric permittivity materials, such as low loss polystyrene ($\varepsilon = 2.5$) or Teflon ($\varepsilon = 2.05$).

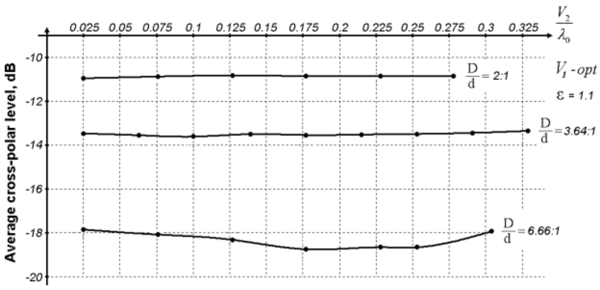
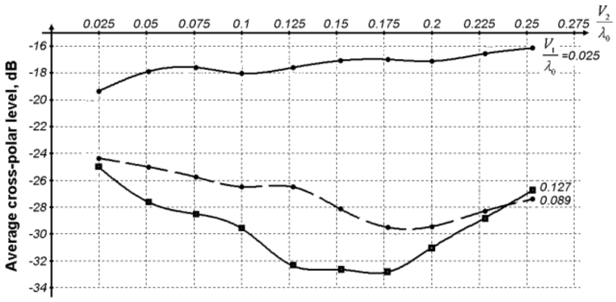


Fig. 2. Crosspolarization level versus dielectric constant of the filling material (ε = 1.05). Parameter: outer-to-inner conductor diameter ratio.

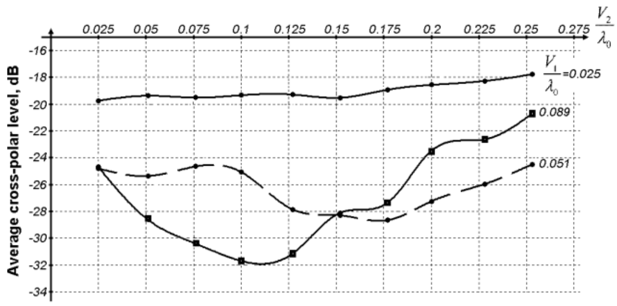
Fig. 2 shows that materials with low dielectric constant (ε = 1.05) do not provide low level of cross-polar radiation of the coaxial horn with partial dielectric loading. Moreover, it has also been proved that a single air gap in the dielectric loaded coaxial horn is not sufficient to decrease crosspolar radiation to the required low level. Fig. 3 demonstrates that only dual air gap dielectric loaded coaxial horn provides required low cross-polar radiation level. Besides, one can see in Fig. 3 that the larger outer-to-inner diameter ratio (6.6:1 in this case) the better polarization purity of the horn. Finally, it is to be noted that a larger frequency band separation yields a better radiation performance. As a proof of the concept, in [6] radiation patterns and matching over C/Ku operational frequency bands were demonstrated for the horn with outer-to-inner diameter ratio 3.6:1.

4. CONCLUSION

Crosspolar radiation of novel dual-band coaxial feed horn with a partial dielectric loading and air gaps between metallic surfaces and dielectric body has been presented. This horn is characterised by a simple design, low cost and good electrical performances over a wide frequency range within each operational frequency band, namely, a symmetrical radiation pattern,



a)



b)

Fig. 3. Crosspolarization level versus gap widths for the 6.6:1 outer-to-inner conductor diameter ratio with different filling material: a) teflon; b) polystyrene.

an appropriate levels of crosspolar radiation and return loss without additional matching and almost constant phase centre in both frequency bands.

A full mathematical model, based on mode-matching technique, of the horn is in the process of completion. It includes multilayer and multi-band structures and will be published soon.

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