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3dB Directional Couplers on Image Dielectric Waveguides of 80–110 GHz Frequency Band

B. Yemelyanenkov and O. Turieieva

National Technical University of Ukraine "Kyiv Polytechnic Institute" (NTUU KPI), Kyiv, Ukraine

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Abstract—The effective dielectric permittivity method is applied, generalized and modified to determine image guide dielectric rods configurations for directional couplers with maximum bandwidth in 3-mm wavelengths range. Optimization problem of directional coupling, splitting and summing signals in image guide directional couplers with distributed coupling in the 80–110 GHz frequency range was solved using CST Microwave Studio software. Optimization results were been experimentally confirmed

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1. INTRODUCTION

One efficient way of designing radio engineering systems in the short-wave segment of the millimeter frequency range (SWSMFR) [1] consists in applying the monopulse reception method [2] for spatial signals processing. In monopulse systems sum-difference converters (SDC) are used for generating sum and difference signals. 3dB directional coupler (DC) is an essential component of SDC. In [3] it is proven that in order to design SDC with high identity of partial channels the loss of power in DC should not exceed 0.5 dB and transient attenuation should lie within (–0.2…+0.4) dB, while directivity should equal to at least 22.5 dB. In SWSMFR it is reasonable to use image dielectric waveguide (IDW) with low losses [4] as a basis for designing radio engineering devices, hence modeling and optimization of 3dB DC on IDW in this frequency range is of great interest.

There are several modeling and optimization methods for DCs on dielectric waveguides (DW) [4–6]. In [4] analysis of DC on IWD was conducted using the effective dielectric permittivity method (EDP). In order to achieve correspondence of calculated and experimental results on 8.5 GHz the authors used phase correction of DC's scattering matrix components. In [5] the transversal decomposition method was used for analyzing a DC on two inset dielectric guides (IDG) in the low-frequency range (6–12 GHz). Deviation of calculation results for DC's dispersion characteristics from experimental results on 12 GHz amounted to 15%. In [6] the FDTD method was applied for analyzing DC on layered DW in the 350–550 GHz frequency range and a sufficient degree of correspondence between the obtained experimental results and the calculated characteristics of a perfect coupler is determined (without conducting an experiment).

In the present article the EDP method [7] is generalized and modified for determining a configuration of rods in IDW for DC with maximum operating bandwidth in the 3-mm wavelength range. Optimization of directional coupling, division and summation of signals in DC on IDW with distributed coupling in the 80–110 GHz frequency range is conducted in CST Microwave Studio (CST MWS) [8] software. Optimization results are experimentally confirmed and a possibility of designing a 3dB DC on IDW for SDC with high identity of partial channels in the 80–110 GHz frequency range is demonstrated.

2. MODELING OF DC ON IDW IN THE 80–110 GHz FREQUENCY RANGE

Modeling of DC on IDW in the 80–110 GHz frequency range aims to determine configuration and dimensions of IDW, suitable for practical use in SDC structures according to the criterion of maximum operating bandwidth, in which transient attenuation of (3 ± 0.2) dB, width of coupling slot and minimum dimensions are achieved. The EDP method [7] is chosen for this purpose. The EDP method is applied to the DC model containing a system of two IDW with coupling in *H*-plane (Fig. 1). During analysis of interaction between waves E^y_{mn} in such a system the fact that the dominant component of electric field E_y is perpendicular to the metal substrate is taken into consideration.