Differential Phase Shifter for Satellite Antennas

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Abstract — *This article presents the design and characteristics of new wideband differential phase shifter based on a square waveguide with diaphragms. Matching and polarization characteristics of the differential phase shifter have been simulated and optimized. Frequency dependences of the simulated characteristics are presented. Developed differential phase shifter can be applied in modern satellite antennas.*

Keywords: microwave engineering, telecommunication systems, differential phase shifter, polarizer, circular polarization, differential phase shift, crosspolar isolation, axial ratio, satellite information systems, satellite antennas.

INTRODUCTION

Nowadays, new extended frequency bands are widely applied in modern satellite information systems, terrestrial communications and radio astronomy [1–6]. In this regard the development and simulation of new designs of waveguide differential phase shifters is a relevant problem [7–18]. Differential phase shifters are an essential part of the feeds of satellite reflector antennas. The application of differential phase shifters allows to operate at two orthogonal circular polarizations. Consequently, the volumes of transmitted information in the telecommunication system increase in two times.

DESIGN OF THE DEVELOPED DIFFERENTIAL PHASE SHIFTER

A waveguide differential phase shifter is a microwave device, which performs the conversion of the electromagnetic waves with orthogonal circular polarizations into electromagnetic waves with linear polarizations. This operation is performed by the introduction of an additional differential phase shift of 90° between the modes of a waveguide with orthogonal polarizations.

Typically, differential phase shifters and orthomode transducers are based on circular and coaxial waveguides [19], and square waveguides [20–32]. The main advantage of the iris differential phase shifter is its most wideband operation compared to other designs. Besides, it provides efficient electromagnetic characteristics and good matching of a structure. The main disadvantage is the increase of the differential phase shifter's length for the wide and ultra wide operating bands. Differential phase shifters based on guides with irises are technological devices and they are easily fabricated by milling.

Inner structure of typical structure of the waveguide iris differential phase shifter is shown in Fig. 1. The differential phase shifter is based on the square waveguide and several diaphragms.

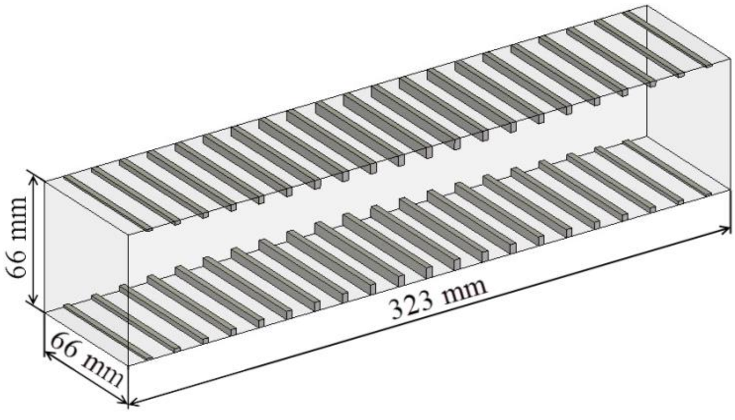

Fig. 1. The structure of a differential phase shifter based on the square waveguide with irises

ELECTROMAGNETIC CHARACTERISTICS OF DEVICE

The sizes of the waveguide and irises were varied for the optimization. The most important parameter of a differential phase shifter is differential phase shift. Optimized differential phase shift of the differential phase shifter is demonstrated in Fig. 2. The introduced differential phase shift is 90°±3° in the operating satellite band 3.4–4.8 GHz. The crosspolar isolation of the differential phase shifter is higher than 31 dB. Fig. 3 presents the frequency dependences of VSWR. The solid curve correspond to the vertical polarization. The dashed curve corresponds to the horizontal polarization. As one can see, VSWR is less than 1.1 for both polarizations of waveguide modes.

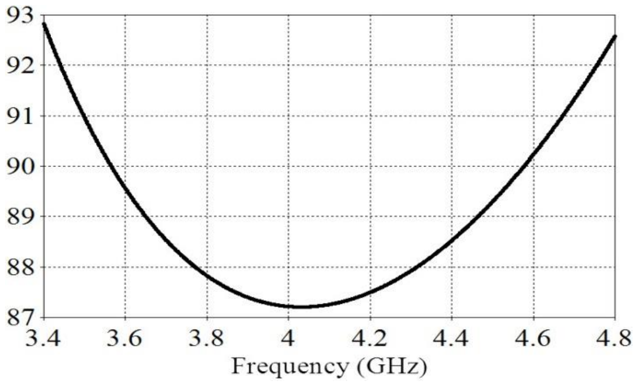

Fig. 2. Differential phase shift of a differential phase shifter in the extended satellite C-band

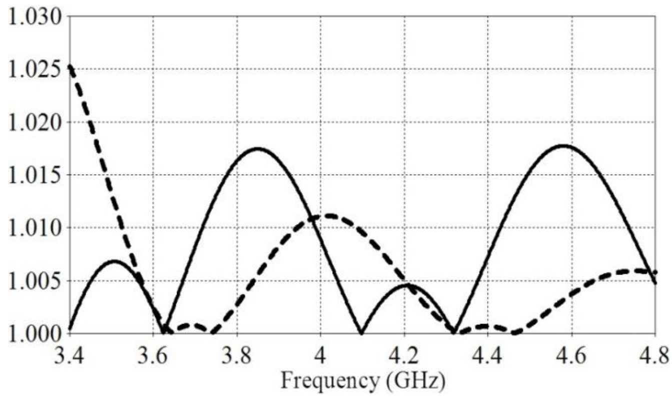

Fig. 3. VSWRs of a differential phase shifter in the extended satellite C-band for both polarizations

CONCLUSIONS

Therefore, a new differential phase shifter has been developed and optimized in the article. The structure consists of a square waveguide with metal irises in it. Developed differential phase shifter provides efficient phase characteristic and good matching with low VSWR level. Developed differential phase shifter can be widely applied in modern satellite antenna systems.

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