Linear-to-Circular Polarization Converter Based on a Two-Dimensional Periodic Array of Inhomogenously Filled Waveguide

Hengjiang Ren, Zhongxiang Shen and Bo Li

***Abstract* — This paper presents a new linear-to-circular polarization converter based on a two-dimensional periodic array of inhomogeneously filled waveguide. Its operation principle is explained using the different propagation constants of two modes excited in the rectangular waveguide filled with a dielectric slab. An experimental prototype operating at 9 GHz is designed and constructed. Measured and simulated results are presented for the designed polarizer. It is shown that a 3dB axial ratio bandwidth of 27% is achieved.**

Index Terms — Inhomogenously filled waveguide, linear-to-circular polarization converter, polarizer.

I. Introduction

Circularly polarized waves are widely used in many communication systems, such as transmission of signals through the ionosphere or elimination of rain echoes, where the orientation of linearly polarized signal cannot be predicted. The problems of Faraday rotation by the ionosphere and unknown orientation of source can be eliminated using circularly polarized wave, instead of linearly polarized wave [1]. Circularly polarized wave can also be used to suppress interference [2] in many practical environments. The paper [4] is published resulted from the project,

II. Description Of The Proposed Polarizer

The geometry of a unit cell of our proposed polarizer is shown in Fig. 1. The rectangular waveguide has a width of $W = 23$ mm, height of $H = 20$ mm, and length of $L = 18$ mm. Substrate RO3006 with dielectric constant of $\varepsilon_r = 6.2$ is used in this design as the dielectric slab by removing the coppers on both sides. The dielectric septum is placed in the center of the rectangular waveguide, with a length of $D = 24$ mm and thickness of $S = 1.27$ mm. The length L and width W of the rectangular waveguide are so selected that the cutoff frequency of the fundamental mode in the air-filled rectangular waveguide is around 7.5 GHz.

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III. The Operating Principle

An incident plane wave of linear polarization is oriented 45° relative to the walls of the rectangular waveguide. The linearly polarized wave can be viewed as the combination of two equal orthogonal components. A thin dielectric slab is inserted in the center of the rectangular waveguide in the horizontal direction.

It is well known that the modes propagating in an inhomogenously filled waveguide for the vertical and horizontal components are LSE mode and LSM mode, respectively [3]. It is noted that the dielectric slab has more significant influence on the propagation constant of vertical component, β_v, than the horizontal counterpart, β_h. Materials with different dielectric constant may be chosen to optimize the polarization conversion performance. The length of the dielectric slab can be designed to achieve a 90° phase difference between the two orthogonal modes.

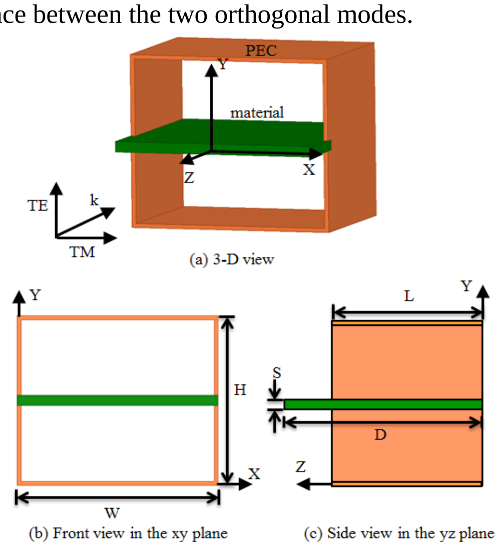

Fig.1 Structure of a unit cell of the proposed polarizer.

IV. Results And Discussion

High Frequency Structure Simulator (HFSS) is used to design and optimize the proposed linear-to-circular polarization converter. Only one unit cell is simulated by using periodic boundaries. In order to verify the design concept of the proposed polarizer, an array of 8×10 cells shown in Fig. 1 is fabricated. The prototype of the fabricated polarizer is shown in Fig. 2. The size of the array structure is around 5λ×5λ at the center frequency of 9 GHz.

Simulated and measured reflection coefficients for both TE and TM waves of the fabricated polarizer are shown in Fig. 3. It can be shown that the simulated and measured |S11| results are in good agreement. The polarizer exhibits a measured impedance bandwidth (|S11|<-10 dB) of 4.5 GHz, from 6.8 GHz to 11.7 GHz, which is approximately 50% of the center frequency 9.3 GHz.

Fig. 2 Photo of the fabricated polarizer.

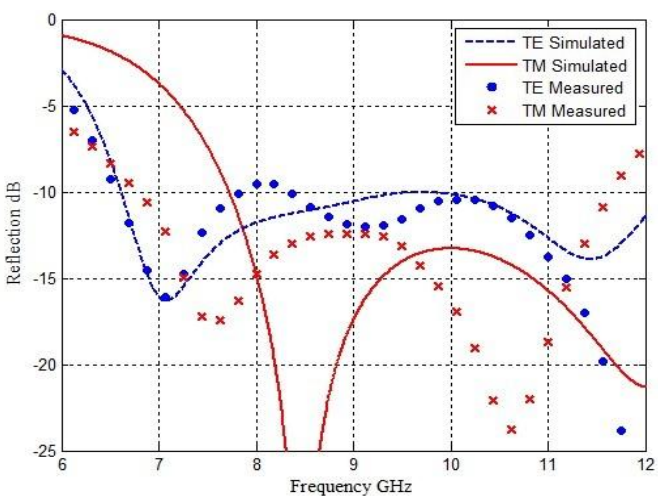

Fig. 3 Measured and simulated reflection coefficients of the proposed polarizer.

Fig. 4 shows the measured and simulated axial ratio results of the proposed polarizer. It is seen that the measured 3 dB axial ratio (AR) bandwidth of the transmitted circularly polarized wave is from 8.1 GHz to 10.6GHz, which is 27% of the center frequency 9.35 GHz. The simulated 3 dB AR bandwidth is from 7.4 GHz to 11.1 GHz, which is 37% of the center frequency 9.25 GHz.

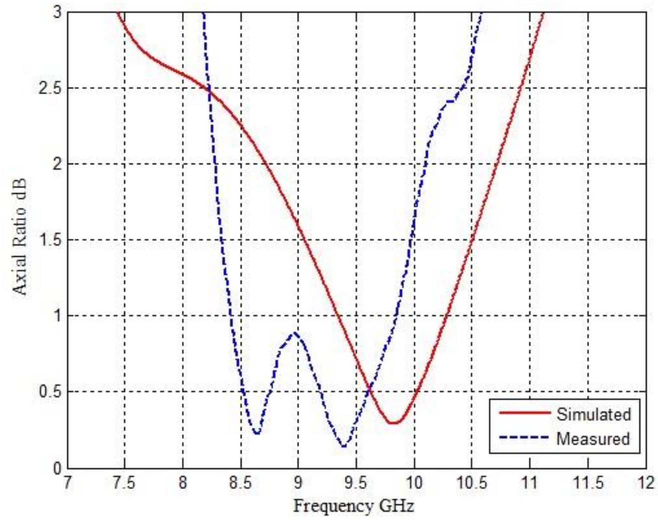

Fig. 4 Measured and simulated AR results of the proposed polarizer.

V. Conclusion

A new linear-to-circular polarization converter has been presented in this paper. It is based on a two-dimensional periodic array of rectangular waveguides inhomogeneously filled with a dielectric slab. An array polarizer of 8×10 cells has been designed, fabricated, and measured. The polarizer exhibits a bandwidth of 27% with respect to the center frequency 9.3 GHz for |S11|≤ -10 dB and AR≤ 3 dB.

VI. Career Plan

The student has attended the International Microwave Symposium 2013 hold at Seattle and received the award certification at the student award luncheon. He met other undergraduate scholars, graduate scholars and researchers in the microwave field. Due to his keen interest in the topic and discussion with the researchers in microwave field, he expects to pursue his graduate studies and a future career in Microwave and RF discipline.

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