Design of optimal chamfered bends in Rectangular Substrate Integrated Waveguide

Rahali Bochra[1], Feham Mohammed[1], Junwu TAO[2]

[1] STIC laboratory, University of Tlemcen, Algeria

[2] Laplace Laboratory, INP ENSEEIHT Toulouse, France

Abstract

Recently, has emerged a n ew technology, substrate integrated waveguide (SIW) [1] [2], it has been applied successfully to the conception of planar compact components for the microwave and millimeter waves applications [3] [4]. Our study concerns the analysis of right bends of rectangular waveguides under SIW technology by the HFSS code, in order to simulate different chamfrain positions, through the analysis of the transmission coefficient S21. In order to reduce losses of the performance, it is usual to chamfrain the external wall of the waveguide. Thus, through this modeling, we have confirmed the optimal position [5] of the chamfrain. A good agreement between HFSS simulations and reference results has been obtained.

Keywords: *Wave Guide, Substrate Integrated Waveguide, Bend, Chamfered, Optimal.*

1. Introduction

A large range of SIW components, such as filters, antennas, transitions, couplers, power dividers have been proposed and studied at low cost, high quality, relatively high power and integration with other microwave components in the same dielectric substrate [1] [2].The SIW structures such as rectangular waveguides are fabricated using two rows of periodic metallic posts witch connect two higher and lower planes mass of dielectric substrate. If the distance between two posts and their diameter are chosen properly [3], the energy leaking between consecutive posts is negligible. Also these structures preserve the majority of the metallic rectangular waveguide advantages; effectively the distribution of the electric field in a rectangular waveguide SIW (RSIW) is similar to that of the classical rectangular waveguide [1] [4]. The bends of waveguides are frequently used in many telecommunication systems such as wave transformers, radar and satellite. As shown in figure1, the RSIW is composed of two parallel rows of metallic posts inserted in a plated substrate. In this study the rectangular waveguide [6], of length value L=92.36mm is conceived in the Ku band [12-18 GHz], with a substrate Fr4 of permittivity value εr=4.4, of height value H=0.508mm and copper posts such as a=2.54mm, d=1.524mm and Wg=7.016mm; a, d and Wg are respectively the distance between two posts, the diameter of the post and the distance between two rows of posts.

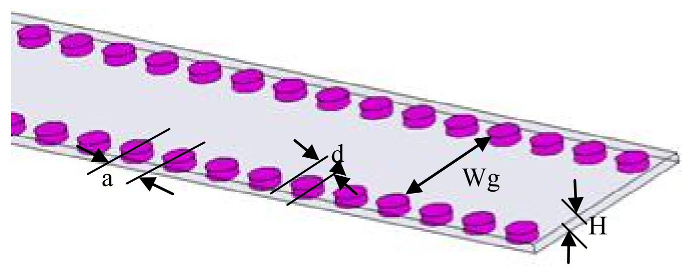

Fig. 1 SIW Rectangular waveguide.

2. The conception of chamfrain

The propagation direction is not always straight, to change this direction stiffness waveguides requires the use of bends, and they are essentials in microwave systems such as radars, diplexers and multiplexers. The common method to compensate the discontinuity of right bend in waveguide is to chamfrain [2] [5] its corner in order to reduce the reflection. Through this paper, we are interested in the design of SIW chamfered bends in the millimeter band. Thus, we have analyzed the effect of position of the chamfrain on the transmission coefficient bends. In this study, we have analyzed many structures with HFSS tool, such as the rectangular waveguide (Fig.1), a right bend (Fig.2) and a rectangular chamfered bend with a chamfrain angle of 45 degrees (Fig.3) such that Aopt =0.7W, Aopt (Fig.4) is the distance between the middle of the chamfrain and the inner corner of the right bend and W is the width of the rectangular waveguide.

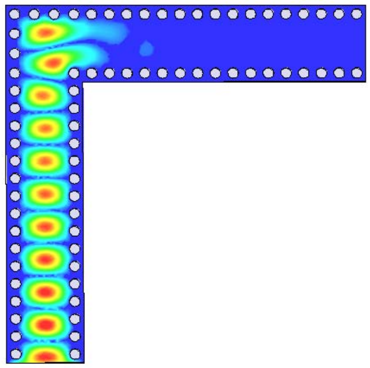

Fig. 2 Simulation of the TE10 electric field magnitude of a right bend at f=18 GHz.

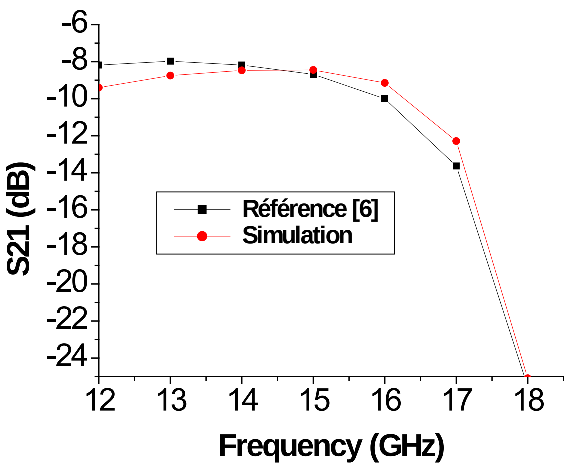

Fig. 3 Transmission coefficient S21 for the right bend.

It is observed from the figure 3, that we have reproduced, by using the SIW technology, the same transmission coefficient S21 of a rectangular waveguide right bend [6] in the Ku band [12-18] GHz.

The chamfrain is useful to reduce the losses at the right bend corner, and the position of the chamfrain depicted by Aopt (Fig.4), introduces modification of the response of the bend following their inclination. Some investigations were done to find the optimal position of the chamfrain. For example, figure 5 and figure 6 represent respectively the magnitude of the TE10 electric field in a right bend chamfered at Aopt=0,7W and Aopt=W.

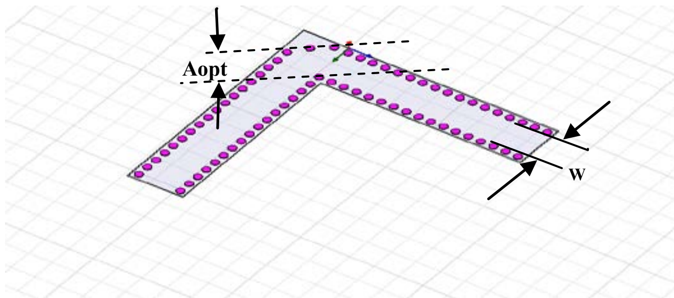

Fig. 4 Chamfered bend at Aopt position.

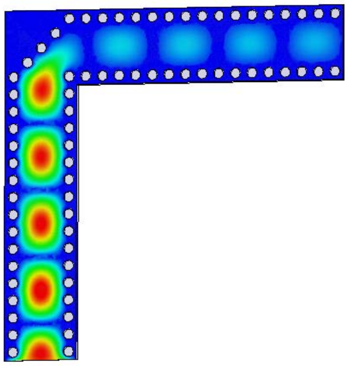

Fig. 5 Simulation of TE10 electric field magnitude for a Rectangular SIW chamfered bend 45°, Aopt=0.7W.

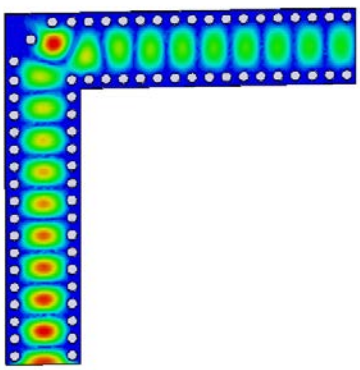

Fig. 6 Plot of the TE10 electric field magnitude of a SIW chamfered bend Aopt=W.

Figure 7 shows the transmission coefficients S21 in the Ku band, of a right bend , a chamfered r ight bend at Aopt=O,7W corresponding to 45 degrees of inclination, a chamfered bend at Aopt=W and an uniform rectangular waveguide. This comparison demonstrates that t he response of a chamfered bend with Aopt=W is identical to that due to an uniform rectangular waveguide.
Also, the figure 8 presents the effect of the position of the chamfrain translated by different value of Aopt. As shown, the optimal position of the chamfrain is such that Aopt=W.

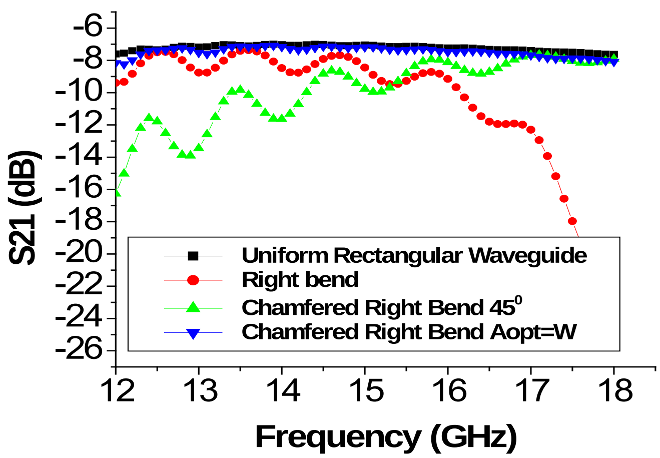

Fig. 7 Transmission coefficient S21.

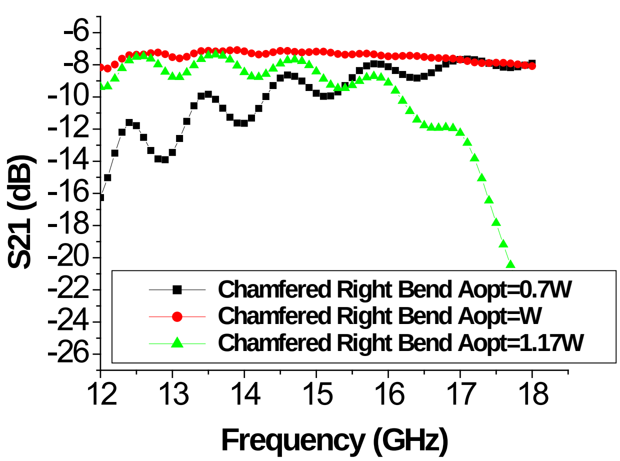

Fig. 8 Transmission coefficient S21 for different values Aopt.

Other manipulations which effect losses can be done on a SIW structure[1], [2],[4], [5], such as the bend (A) where a metallic post is added at the right angle of the left sidewall in order to reduce the width (Fig. 9), the bend (B) is a chamfered bend in which a metallic post is removed from the right angle corner of the right sidewall (Fig.10) and the circular bend (C) with a rounded corner (Fig.11). These figures show also the magnitude of the TE10 electric field in the suggested compensated bend structures.

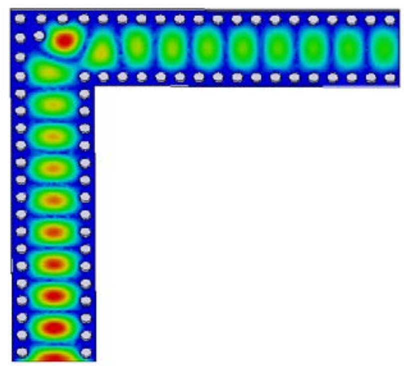

Fig. 9 (A) Right bend with a metallic post added at the right angle corner.

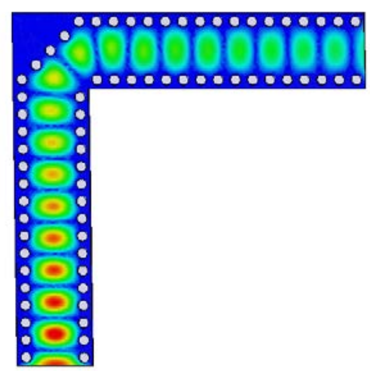

Fig. 10 (B) Rectangular S without metallic post in the right corner SIW chamfered bend 45°.

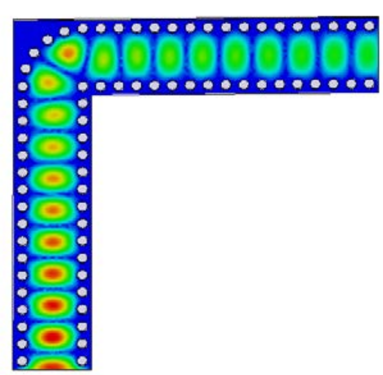

Fig. 11 (C) SIW Circular bend.

The transmission coefficient simulation presented in figure 12 reveals that the three chamfered bends A, B, C and the uniform rectangular waveguide have comparable coefficients S21.
Then, from the curves presented in figure 13, it is observed that the waveguide bends A, B, C and the chamfered bend at Aopt =W, have coherent results of transmission coefficient S21.
These results confirm that these differently chamfered bends are very effective to transmit signal with low losses.

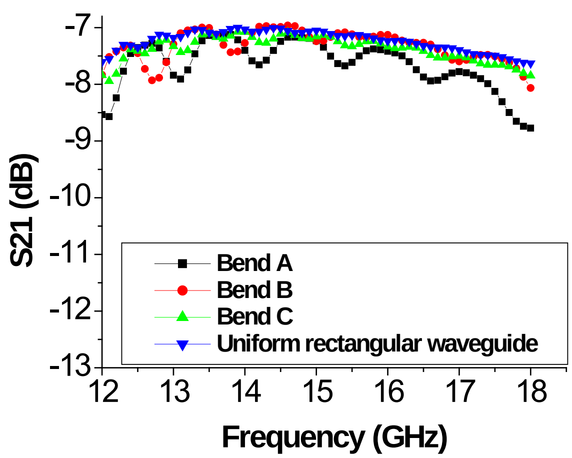

Fig. 12 Transmission coefficient S21.

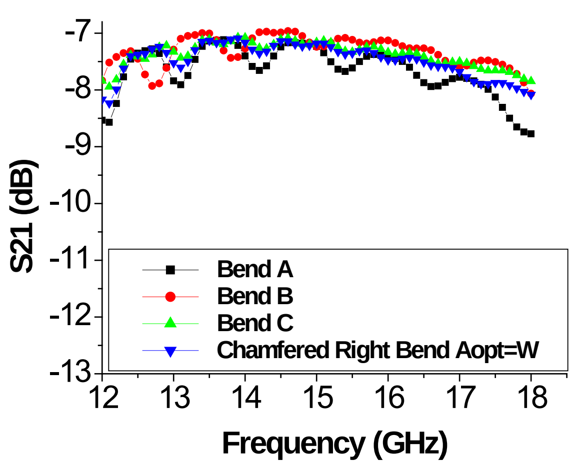

Fig. 13 Comparing coefficient S21.

3. Conclusion

In this paper, we have investigated the influence of the geometry of the chamfered bends in SIW technology, also we have determined the transmission coefficients S21 and we have plot the electric field magnitude of the TE10 mode. The analysis of the compensation of the discontinuity of a right bend in SIW rectangular waveguide, shows that the ideal and optimal position of the chamfrain is obtained with Aopt =W, where W is the width of the rectangular waveguide. It is found that is very important to maintain a uniform width W along the bend to obtain efficient signal transmission.
All these structures offer similar performances, thus, the ultimate choice of the design depends on the ease of fabrication. The choice of method for compensating the discontinuity of the right bend of the rectangular waveguide depends in final on manufacturing constraints.

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