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LOW LOSS SUBSTRATE INTEGRATED WAVEGUIDE SLOT ANTENNA FOR 5G APPLICATIONS

Naveen kumar G[1], Avanigadda Naga Sai Nithin[2], Balaji Chintala [3], Dasi Raghava[4], Damaravarapu Lakshmi Naga Vamsi kiran[5]

[1]Assoc Professor, [2,3,4,5]UG Student, Department of Electronics and Communications Engineering, Vasireddy Venkatadri Institute of Technology, Namburu(V), Guntur(Dt), Andhra Pradesh, India

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Abstract - Substrate integrated waveguides are the best choice for micro-wave and millimeter-wave applications. The SIW structure suffers from three kinds of losses, radiation losses, dielectric loss and conductor loss. In this paper our aim is to minimize the radiation losses, dielectric loss and conductor loss by optimizing SIW slot antenna structure. Hence, by this optimization we can improve the antenna parameters like Quality factor, gain.

Key words: substrate integrated waveguide; losses; Q-factor; gain.

1. INTRODUCTION

Indeed, a variety of communication tools such as internet, computers of high performance radar and satellite systems have become necessary both for entertainment and for business use. To follow the market demands imposed by technological advancement, the researchers were interested in high frequency circuits that are used in all devices mentioned earlier.

Rectangular waveguides (RW) are the most popular waveguides in microwave applications [1] [2]. Thanks to their high quality factor and low loss. The problem with (RW) is their low density of integration and their cost. Planar wave guides such as micro-strip lines and coplanar wave guides came to solve these problems, they can be integrated with planar components on the same substrate, but losses are the problem of these waveguides. Substrate integrated waveguides (SIW) came to fill these problems [3] [7] [8].

Substrate Integrated Waveguide(SIW)

In high frequency applications, microstrip devices are not efficient, and because wavelength at high frequencies are small, microstrip device manufacturing requires very tight tolerances. At high frequencies waveguide devices are preferred, however their manufacturing process is difficult. So a new concept emerged: substrate integrated waveguide. SIW is a transition between microstrip and dielectric-filled waveguide (DFW). Dielectric filled waveguide is converted to substrate integrated waveguide (SIW) by the help of vias for the side walls of the waveguide.

1.1 BLOCK DIAGRAM

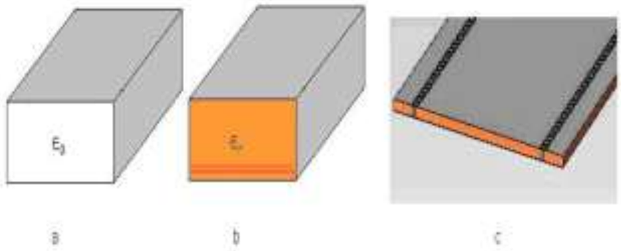

Fig1: Evolution of Substrate Integrated Waveguide(SIW)

Where (a)is the Air filled waveguide, (b) dielectric filled waveguide, (c) substrate integrated waveguide

IDEA OF THE PROJECT

The idea of this structure is to build a substrate integrated waveguide just as the name suggests. With a substrate (which may be a printed circuit board with a conductive ground plane), two rows of metal holes, a conductive patch, and within a few laws of design, we can obtain a high performance waveguide

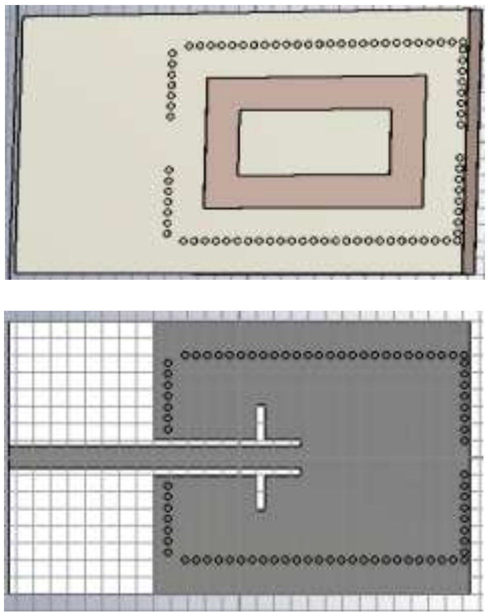

Fig 2: Top and Bottom views of Proposed Antenna

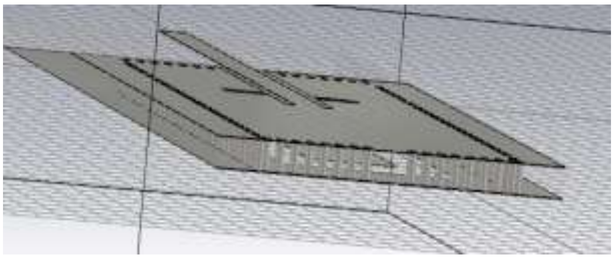

Fig 3: Side View of the Proposed Antenna

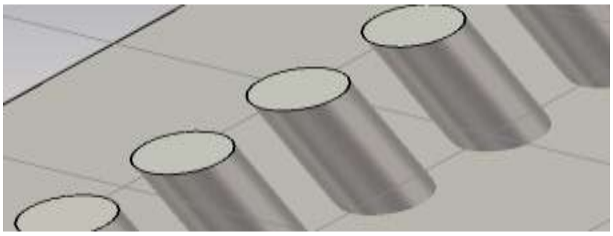

Fig 4: Allignment of Vias

Table 1: Optimized parameters of the proposed design

Parameters	Value(mm)
SIW width, W	12
Substrate thickness, B	1
Substrate length, L	26.5
Via diameter D	0.4
Via Holes Spacing, p	0.65
Metal thickness	0.017

In this study, we will discuss the limitations of this technology namely losses. We will study its different types and impacts of changes in the parameters of the SIW structure on these losses

A. Radiation loss

The radiation attenuation constant α_r is due to wave leakage through the gaps between the metalized via holes [4]. These losses can be minimized if the cylinders have a large diameter and are closely space

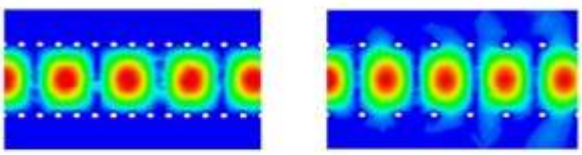

Fig. 5: the wave leakage through gaps between the holes

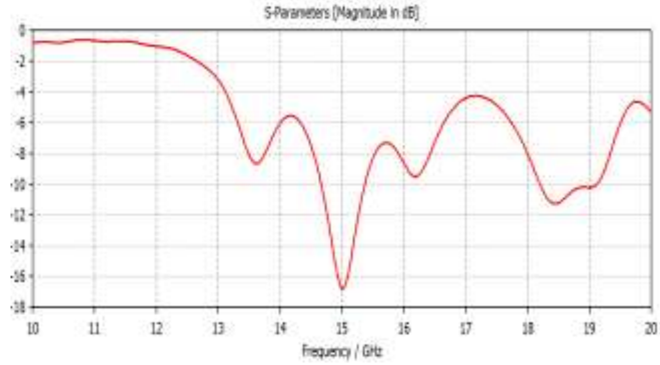

Fig 6: S-Parameters of Proposed Antenna

B. Conductor loss

The conductor losses are related to the conductivity of the used metal, according to [5] the expression of constant conductivity attenuation is:

$$\alpha_c(f) = \frac{\sqrt{\pi f \varepsilon_0 \varepsilon_r}}{h\sqrt{\sigma_c}} \frac{1+2(f_0/f)^2 h/a}{\sqrt{1-(f_0/f)^2}}$$

Where 'a' is the width of an equivalent rectangular waveguide, and σ_c is the conductivity of the used metal. The thickness h of the dielectric plays a very important role in reducing ohmic losses. From equation (6) if we increase 'h' the conductor attenuation constant decreases. The increase of h (while keeping unchanged the other dimensions) causes a significant reduction in the conductor losses.

C. Dielectric loss

The dielectric substrate is the support on which the two metal planes arise. The choice of substrate material is not arbitrary. To minimize the dielectric losses which are due to the dissipation caused by this material. We must study the parameters that characterize the substrate such as the dielectric permittivity 'ε_r', the substrate's thickness 'h' and

$$\alpha_d = \frac{\pi f\sqrt{\varepsilon_r}}{c\sqrt{1-(f0/f)^2}}\tan\delta$$

the tangent loss.

According to [10] dielectric losses are the main source of loss, and they are particularly more important than radiation losses and conductor losses. Of course, this classification could be changed when changing the dielectric properties of the substrate and the operating frequency. We can obtain the expression of the dielectric constant of attenuation by the following relationship.

RESULTS

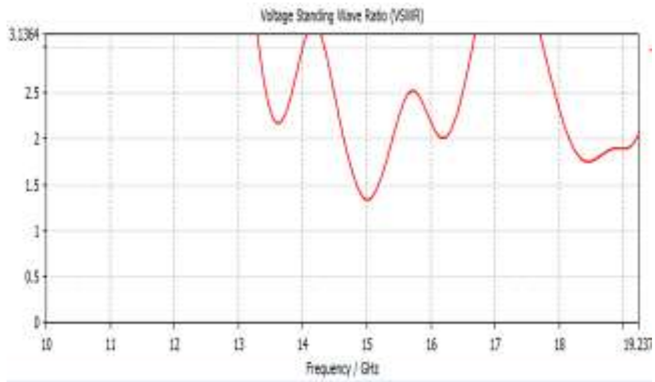

Fig 7: Voltage Sianding wave Ratio of the Proposed Antenna

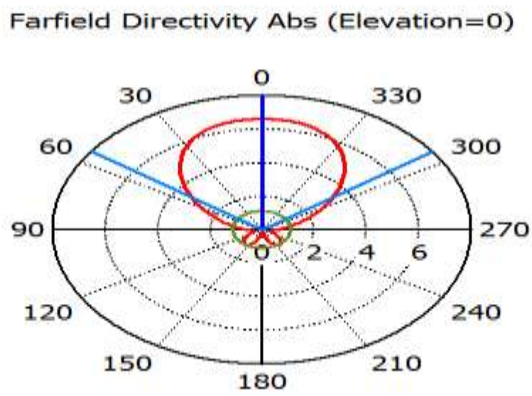

Fig 8: Radiation Pattern of the Proposed Antenna

CONCLUSION

This paper has studied all types of losses in the substrate integrated waveguides, namely radiation, conductor and dielectric losses. It results that the substrate of the waveguide, with all its parameters such as thickness and permittivity have a significant impact on the losses. We also improved a SIW slot antenna structure with minimizing dielectric losses, which are the largest source of losses by applying changings on the geometry of the substrate.

REFERENCES

[1] Tore N.Anderson, "Rectangular and Ridge Waveguide" IRE Transactions on Microwave Theory and Techniques, vol. 1, pp. 201-209, 1956.
[2] Q. Zhang, C. Yuan, and L. Liu, "Theoretical Design and Analysis for Rectangular Waveguide Mode Converters," IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, vol. 60, no. 4, pp. 1018–1026, 2012.
[3] Y. Cassivi, L. Perregrini, P. Arcioni, M. Bressan, K. Wu, and G. Conciauro, "Dispersion Characteristics of Substrate Integrated Rectangular Waveguide," IEEE Microwave and Wireless Coponents, vol. 12, no. 9, pp. 333–335, 2002.
[4] F. Xu and K. Wu, "Guided-Wave and Leakage Characteristics of Substrate Integrated Waveguide," IEEE Transactions on Microwave Theory and Techniques, vol. 53, no. 1, pp. 66–73, 2005.
[5] M. Bozzi, M. Pasian, L. Perregrini, and K. Wu, "On the Losses in Substrate Integrated Waveguides," Proceedings of the 37th European Microwave Conference, no. October, pp. 384–387, 2007.
[6] M. Pasian, M. Bozzi, S. Member, L. Perregrini, and S. Member, "A Formula for Radiation Loss in Substrate Integrated Waveguide," IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, vol. 62, no. 10, pp. 2205–2213, 2014.
[7] M. A. Rabah, M. Abri, J. W. Tao, and T. Vuong, "Substrate Integrated Waveguide Design Using the Two Dimentionnal Finite Element Method," Progress in Electromagnetics Research, vol. 35, pp. 21–30, 2014.
[8] Y.J. Cheng, W. Hong, and K. Wu. "Design of a substrate integrated waveguide modified R- KR lens for millimetre-wave application," IET Microwave Antennas and Propagation, vol. 4, pp. 484–491, 2010.
[9] M. Bozzi, L. Perregrini, K. Wu, and P. Arcioni, "Current and Future Research Trends in Substrate Integrated Waveguide Technology," RADIOENGINEERING, vol. 18, no. 2, pp. 201–209, 2009.
[10] N. Ranjkesh and M. Shahabadi, "Loss Mechanisms in Siw and Msiw," Prog. Electromagn. Res. B, vol. 4, pp. 299–309, 2008