IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 15, Issue 2, Ser. I (Mar-Apr 2020), PP 18-24
www.iosrjournals.org

Design and Simulation of Substrate Integrated waveguide and Substrate Integrated Waveguide Antennas

[1.] Dipika Sharma, [2.] Sudarshan Kumar, [3.] Sonu kumar
[1]*M-Tech Scholar, ABSS Institute of Technology, Meerut.*
[2]*Assistant Professor, ECE Department, MAIT, New Delhi.*
[3]*Assistant Professor, ECE Department, ABSS Institute of Technology, Meerut*

Abstract: *In this article a substrate integrated waveguide and substrate integrated waveguide antennas is first designed and simulated. The structure is designed and simulated using the HFSS electromagnetic solver. The different parameters of the waveguide, such as propagation constant and the different parameters of antennas such as return loss, radiation pattern of antenna is investigated and discussed. Two types of SIW antennas one SIW slotted and another is SIW leaky wave antenna is designed. The designed structure is simulated from the frequency range of 2 GHz to 10 GHz.*

Key Words: *SIW, Leaky, Slotted*

Date of Submission: 25-03-2020 Date of Acceptance: 14-04-2020

I. Introduction

The rapid development of complex microwave and MM-wave circuits and components requires integration of passive components, active devices, transmission lines, and antennas. In most cases, various components of a system are designed and manufactured separately, and different fabrication technologies are required to implement each component at the best. A number of different fabrication technologies are available for the implementation of microwave and millimeter-wave components. Printed planar technologies, such as those based on microstrip line and coplanar waveguide, represent the ideal choice for manufacturing a variety of passive components interconnects, and antennas, operating in the microwave frequency range. These technologies lead to compact, low-profile, and light-weight components, which can be manufactured by adopting inexpensive fabrication processes. Nevertheless, printed components often exhibit significant losses, especially at MM-wave frequency; moreover, they are subject to radiation leakage and undesired coupling between adjacent elements, and exhibit limited power-handling capability. In this dissertation Substrate Integrated waveguide (SIW) is designed and simulated.SIW antennas are also designed simulated. Both Types of antennas such as SIW slotted antenna and SIW leaky wave antennas are simulated. The Simulation software HFSS version 12 is used, and the dielectric material used is FR4/Glass epoxy of relative dielectric constant of 4.4, and the height of the substrate taken is 1.6 mm.

II. SIW And SIW Antenna Design

The SIW is designed on the substrate FR4/glass epoxy of dielectric constant 4.4 and the loss tangent of 0.02. The FR4 is lossy material, so SIW is not designed on this material. But we have used this material and get the optimum result. The SIW is basically the rectangular waveguide designed on the dielectric substrate. In the SIW the top and bottom wall of the wave guide is replaced by two ground planes and the two side walls is replaced by metallic vias. The cut off frequency and the other parameters of SIW is same as the rectangular waveguide. The cut off frequency for the rectangular waveguide is given by the formula.

$$f_c = \frac{c}{2\sqrt{\varepsilon_r}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2} \qquad 1$$

The pitch is taken as 1.5 mm and the diameter of the vias is 1 mm. Then the designed SIW is as shown in figure 1.

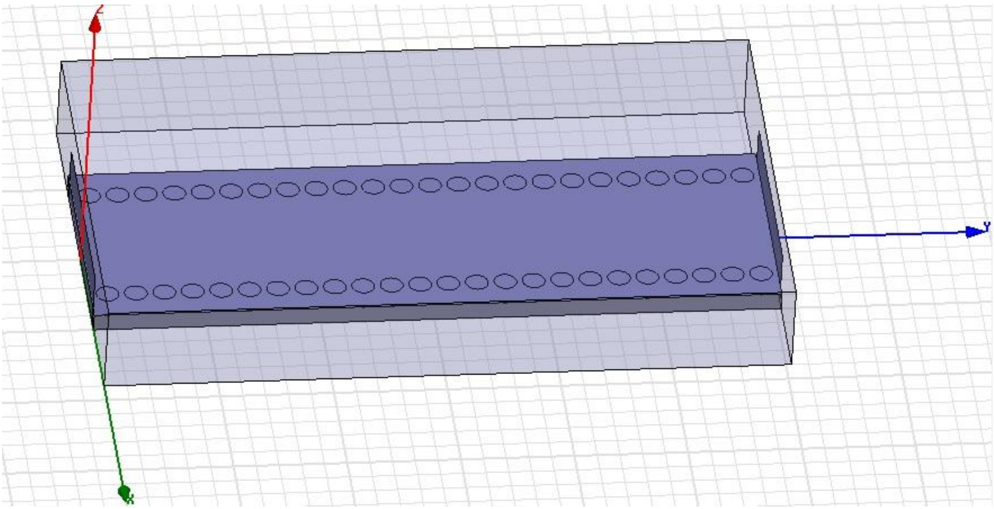


Fig.1 Designed SIW

The height of substrate is 1.6 mm. The port used in the designing is wave port. The distance between the two rows of the cylinders is 14mm, that is the width of the corresponding rectangular waveguide. The slotted SIW antenna is made from the designed SIW. The Slots are made in the upper metallization plate of the SIW. The slots are arranged symmetrically on either side of the symmetric plane. The slots are 7 by 2 mm. The length is half guide wavelength. The SIW slotted antenna is resonates at near 5 GHz, that is the cut off frequency of the corresponding SIW. The port 2 in SIW is also removed and cover by similar vias. The antenna also has a good radiation pattern. The fig.2 shows the SIW slotted antenna.

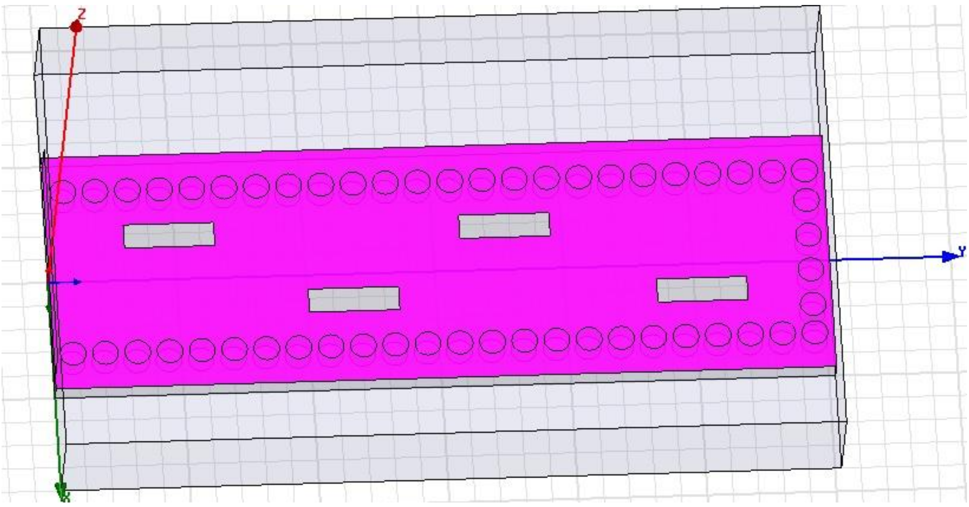


Fig. 2 SIW slotted Antenna

The concept behind the SIW Leaky wave antenna is concerned by radiation loss of substrate integrated waveguide. If the spacing in the between the metallic vias is increased. As the spacing between the vias is negligible small then the electromagnetic energy is totally confined in the structure. If the spacing between the vias is increased then the electromagnetic energy is leak out from the spacing between the vias. Or another concept of leaky wave antenna is by the excitation of TM modes in the SIW. In the TM mode configuration the current has the longitudinal component so the current cut the gap between the metallic vias. So the only mode supported by the SIW is the TE_{n0} mode here n=0, 1, 2, 3, 4……, no TEM and TM mode is supported by SIW. So in this thesis SIW leaky wave antenna is designed by increasing the gap among the vias on one side of the SIW. The separation in the SIW vias is made 5 mm (the distance between center to center). The designed SIW leaky wave antenna is shown in fig.3

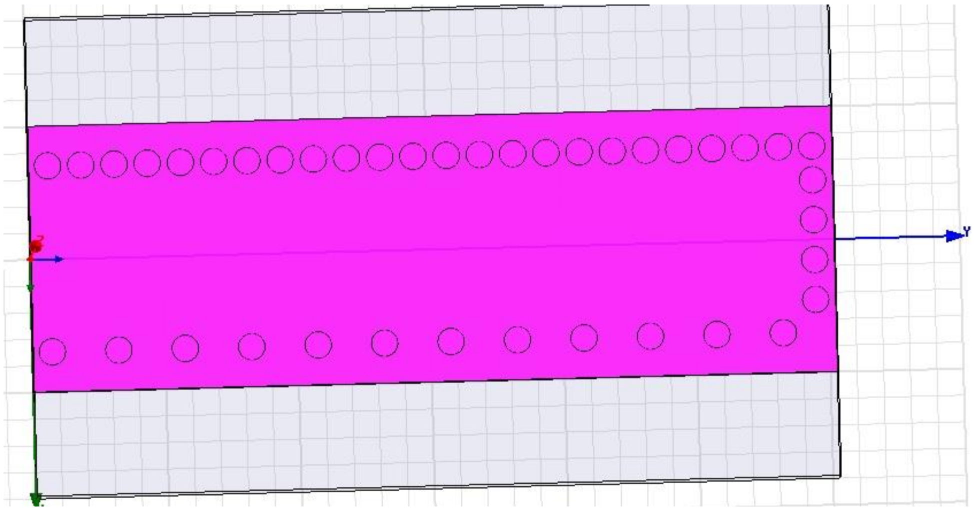


Fig.3 SIW leaky Wave antenna

In this configuration of the designed SIW leaky wave antenna the distance among the one sided vias is increased at their present location and the result is investigated. The another SIW leaky wave antenna is made by shifting the increased pitch side vias towards the edge of the dielectric and the result is investigated. In this configuration of the designed SIW leaky wave antenna the width of the SIW is maintained (means the other side's vias are also shifted. Fig.4 shows the SIW Leaky wave antenna with the radiating side on the edge of the dielectric.

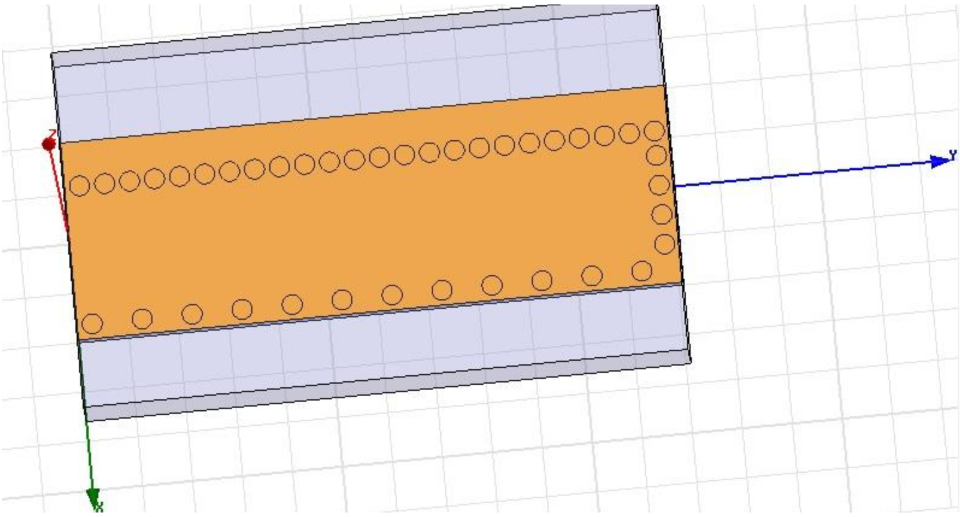


Fig.4 SIW leaky Wave antenna with radiating slot towards the edge

III. Results And Discussions

Fig 5 shows S_{11} Vs frequency curve shows return loss is less than -10 dB after the cut off frequency of 5 GHz of the substrate integrated waveguide. This shows the waveguide acts like a high pass filter. The S_{21} Vs frequency curve shows that transmitted energy from 2 ports to 1 port which is less than around -125 dB means very less.

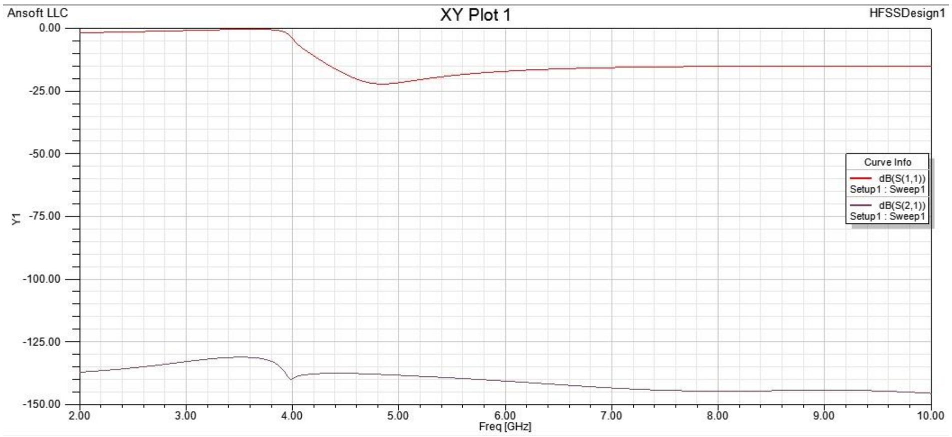


Fig.5 S_{11} and S_{12} Vs Frequency curve

Fig .6 show the phase constant β of the designed SIW is positive at the cut off frequency of the antenna this show that at the cut off frequency wave is guiding the EM wave properly

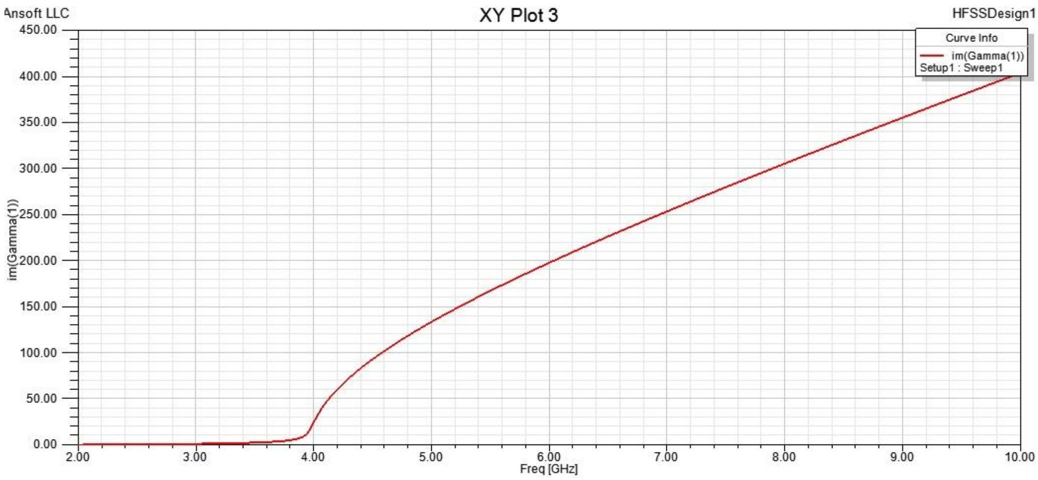


Fig. 6 Phase Constant of Designed SIW

Fig. 7 shows the return loss curve of the slotted SIW antenna. The Return loss is around -22 dB at the resonating frequency of the antenna, and also has the value less than -10 dB upto 10 GHz. This SIW antenna shows the wide band behavior.

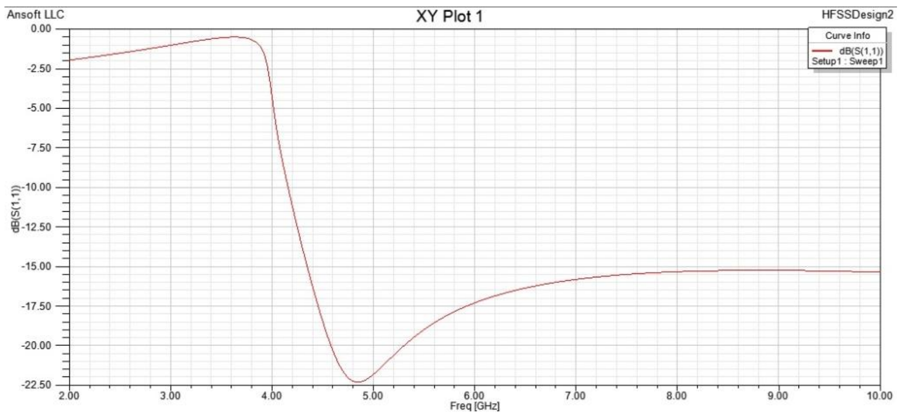


Fig. 7 S_{11} Vs Frequency curve of the SIW slotted Antenna

Fig. 8 shows the return loss curve of the SIW leaky wave antenna. This SIW leaky wave antenna consists of the vias position similar to as in the designed SIW and the spacing is increased in one side vias. This SIW leaky wave antenna shows the multiband behavior at different resonating frequency

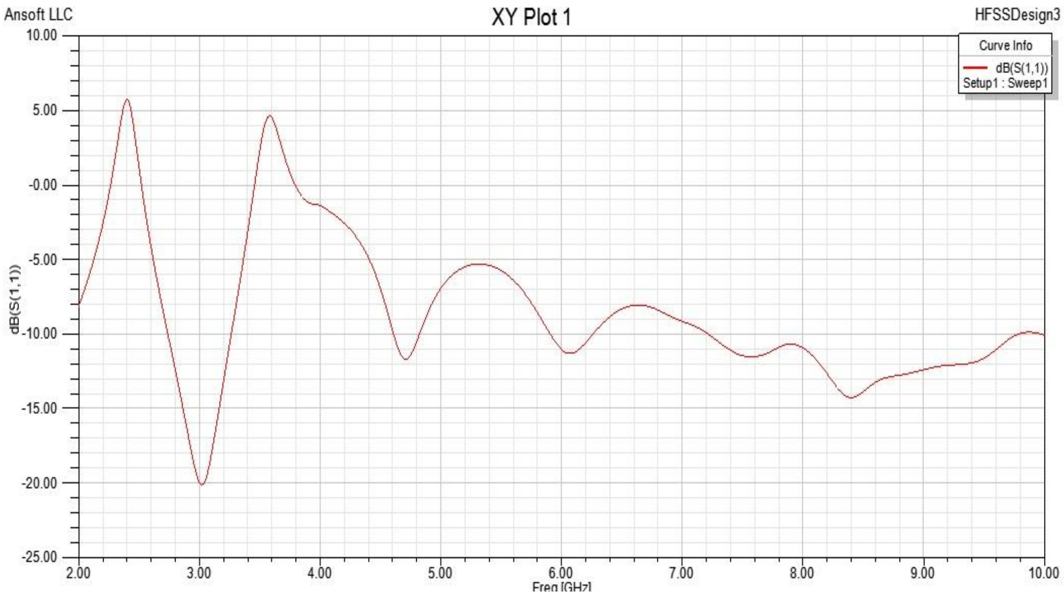


Fig. 8 S_{11} Vs Frequency curve of the SIW Leaky Wave Antenna

Fig 9.shows the return loss curves of the SIW leaky wave antenna. This SIW leaky wave antenna vias is shifted so that the leakage energy is less traveled in the dielectric as surface wave. This SIW leaky wave antenna shows the multiband behavior at different resonating frequency. This shows the difference between the behaviors of the SIW slotted antenna and leaky wave antenna.

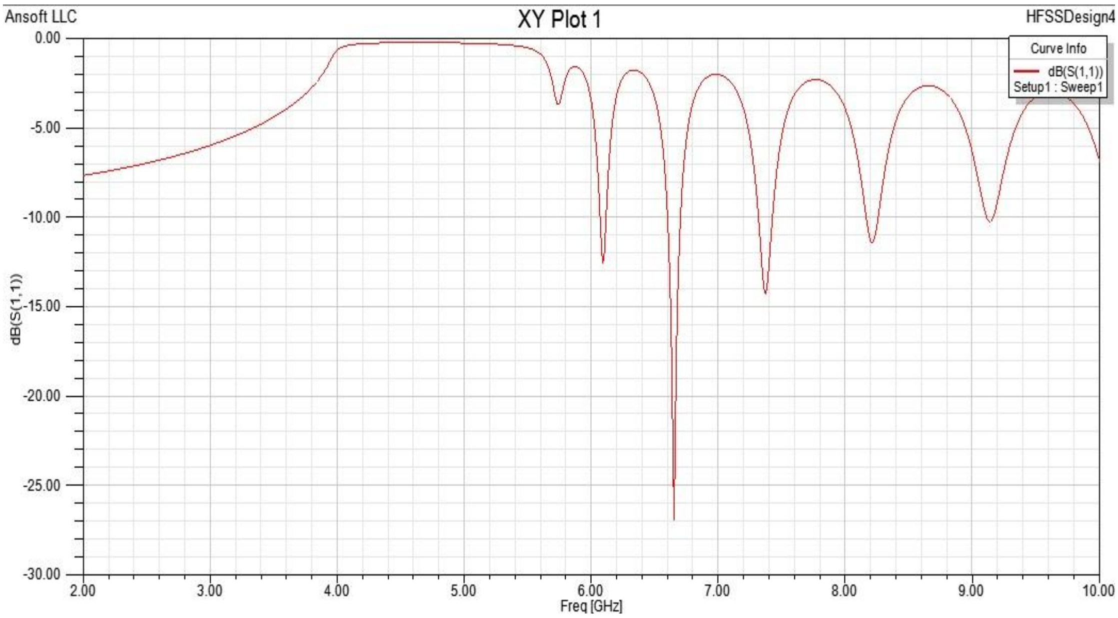
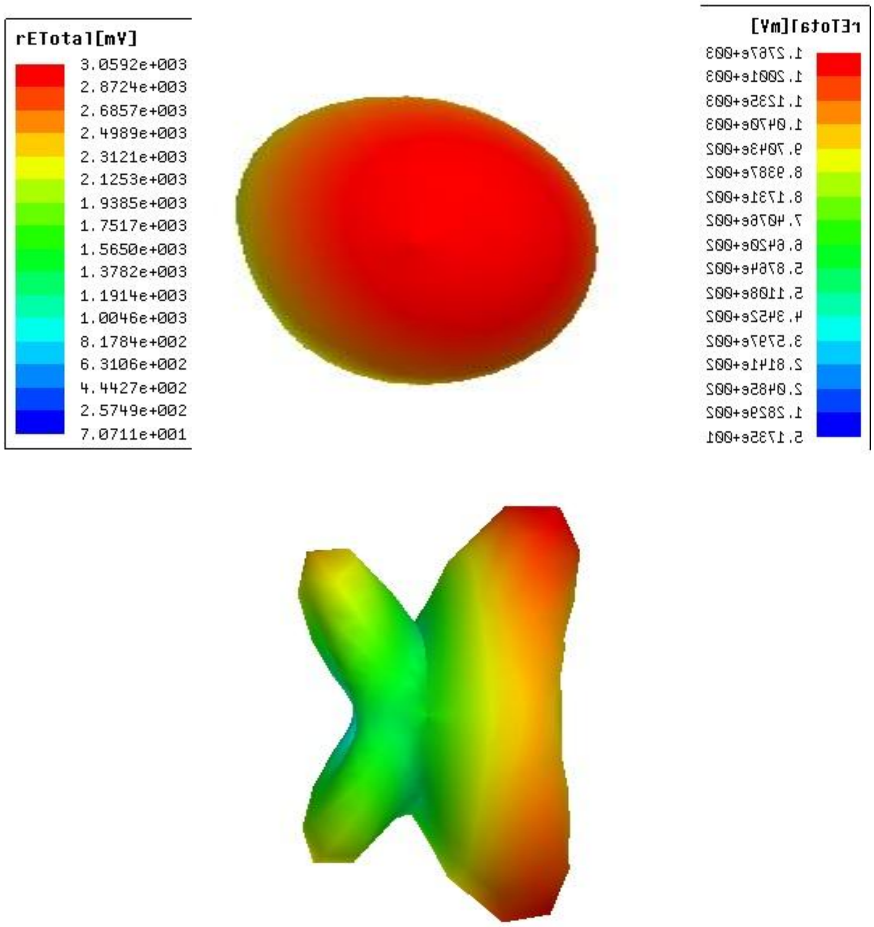
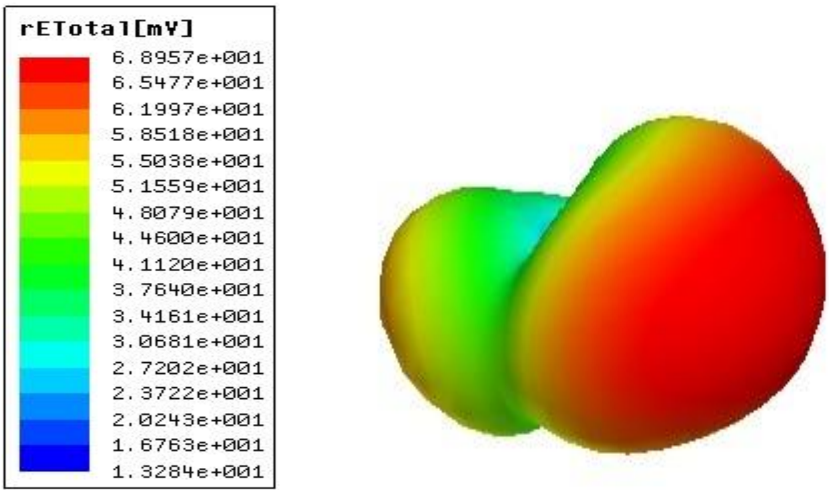


Fig. 9 S_{11} Vs Frequency curve of the SIW Leaky Wave Antenna

Fig .10 a, shows the 3 dimensional radiation pattern of the SIW slotted antenna. This shows the result in terms of induced voltage. The pattern shows the omnidirectional pattern. This shows the pattern circular in a plane



(a) **(b)**



(c)

Fig.10 a,b,c Radiation Pattern Of SIW Antennas

Fig. 10 b and c shows the 3 dimensional radiation pattern of the SIW leaky wave antenna with vias shifted. The vias shifted towards the edge along the leaky side maintaining the width of the SIW. This shows the result in terms of induced voltage. The pattern shows the end fire radiation pattern. This antenna radiation pattern is good in comparison to SIW slotted antenna and SIW leaky wave antenna in which the position of the slot is not changed.

References

[1]. Chen, P., et al., "A Substrate Integrated Waveguide Circular Polarized Slot Radiator and Its Linear Array," IEEE Antennas Wireless Propagation Lett., Vol. 8, No. 1, 2009, pp.120–123.
[2]. Stephens, D., P. R. Young, and I. D. Robertson, "W-band substrate integrated waveguide slot antenna," Electron. Lett., Vol. 41, No. 4, 2005, pp. 165–167.
[3]. Yan, L., et al. "Simulation and Experiment on SIW Slot Array Antennas," IEEE Microwave Wireless Comp. Lett., Vol. 14, No. 9, 2004, pp. 446–448.
[4]. Feng Xu and Ke Wu, "Guided-Wave and Leakage Characteristics of Substrate Integrated Waveguide" IEEE Transactions On Microwave Theory And Techniques, Vol. 53, No. 1, January 2005.
[5]. Deslandes, D., and K. Wu, "Substrate Integrated Waveguide Leaky-Wave Antenna: Concept and Design Considerations," Proc. Asia-Pacific Microwave Conference 2005, Suzhou, China, December 4–7, 2005, pp. 346–349.
[6]. Xu, F., K. Wu, and X. Zhang, "Periodic Leaky-Wave Antenna for Millimeter Wave Applications Based on Substrate Integrated Waveguide," IEEE Trans. Antennas Propagat., Vol. 58, No. 2, 2010, pp. 340–347.
[7]. Nikolaos Grigoropoulos, Benito Sanz- quierdo, and Paul R. Young, "Substrate Integrated Folded Waveguides (SIFW) and Filters" IEEE Microwave And Wireless Components Letters, Vol. 15, No. 12, December 2005.
[8]. Amiya Kumar Mallick And Gitindra S, Sanyal, "Electromagnetic Wave Propagation in a Rectangular Waveguide with Sinusoidally Varying Width" IEEE Transactions On Microwave Thbory And Techniques, Vol. MTT-26, No. 4, April 1978.
[9]. Feng Xu and Ke Wu, "Numerical Multimode Calibration Technique for Extraction of Complex Propagation Constants of Substrate Integrated Waveguide " 0-7803-8331-IEEE MTT-S Digest-2004.
[10]. Cheng, Y. J. , W. Hong, and K. Wu, "Design of a Monopulse Antenna Using a Dual V Type Linearly Tapered Slot Antenna (DVLTSA)," IEEE Transact. Antennas Propagat., Vol. 56, No. 9, 2008, pp. 2903–2909.
[11]. Juan R. Sánchez , Carmen Bachiller , María Juliá, Vicente Nova, Héctor Esteban , and Vicente E. Boria, "Microwave Filter Based on Substrate Integrated Waveguide With Alternating Dielectric Line Sections" IEEE Microwave And Wireless Components Letters, Vol. 28, No. 11, November 2018.
[12]. M. Bozzi A. Georgiadis, K. Wu, "Review of substrate-integrated waveguide circuits and antennas'' IET Microw. Antennas Propag., 2011, Vol. 5, Iss. 8, pp. 909–920.
[13]. R. B. Hwang and C. W, " A Band-pass Filter Consisting Of Two Substrate Integrated Waveguide Cavities Coupled By An Aperture On Their Common Side Wall " Microwave And Optical Technology Letters / Vol. 49, No. 8, August 2007
[14]. Chen, P., et al., "A Multibeam Antenna Based on Substrate Integrated Waveguide Technology for MIMO Wireless Communications," IEEE Trans. Antennas Propagat., Vol. 57, No. 6, 2009, pp. 1813–1821.
[15]. Tarek Djerafi, Ali Doghri and Ke , "Substrate Integrated Waveguide Antennas" Handbook of Antenna Technologies Springer Science+Business Media Singapore 2015

Dipika Sharma,etal. "Design and Simulation of Substrate Integrated waveguide and Substrate Integrated Waveguide Antennas." *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)* 15(2), (2020): 18-24.