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Design and Simulation of Substrate Integrated Waveguide Antenna for Millimeter Wave Applications

[1]Navneet Yadav, M.Tech Scholar
Email : lavayyadav@gmail.com
[2]Nishant Singh, Assistant Professor
Email: nishantsingh2490@gmail.com
[3]Umesh Singh,Assistant Professor
Email: umeshsinghiet@gmail.com
[123]Institute of Engineering and Technology, Dr. Ram ManoharLohiaAvadh University, Ayodhya (India)

Abstract*: This study describes the design and simulation of a compact antenna based on a substrate integrated waveguide (SIW) utilizing the slot section technique. Using a full wave electromagnetic simulation tool HFSS based on Finite elements methods. The antenna is meant to operate in the millimeter wave (mm-wave) frequency bands. The radiating patch is printed on a 7.5 x 30 x 0.254 mm^3 Rogers's RT 5880 substrate with a relative permittivity of 2.2 and a loss tangent of 0.0009. The antenna shows the multiband behaviour at the frequencies of 26 GHz, 28 GHz,30.7 GHz, and 32GHz. The various parameters of the proposed antenna such as return loss, VSWR and radiation pattern, gain and radiation efficiency etc. are investigated and analyzed.*

Key Words*: Multiband, SIW, Slotted*

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I. Introduction

In recent years, the microwave community has grown more interested in substrate integrated waveguide (SIW) technology due to its versatility in the construction of microwave circuits[1].SIWs have propagation and dispersion properties that are extremely comparable to rectangular waveguides, allowing hollow waveguide expertise to be applied to SIWs. Many waveguide devices, in fact, can be easy to manufacture with substrate integrated waveguides. SIW devices are also created using regular printed circuit board (PCB) techniques, making them easier to construct, lighter, and less expensive than waveguide devices made using a typical process like milling. Because SIW devices are constructed on a dielectric substrate, they are simple to integrate[2-5].

The employment of SIW technology in the production of low-profile, light, and low-cost antennas promises to be very promising. High gain, multi band, and very wide band SIW antennas, on the other hand, might be difficult to design. There are a few ways to accomplish this, such as using slot arrays or cavity-backed patches[6-8].

SIW antennas have lesser performance than their rectangular waveguide equivalents in the majority of applications [9]. Substrate integrated waveguides, on the other hand, are gaining popularity for their ability to fabricate low-profile and low-cost antennas for 5G applications [10, 11], where traditional waveguides are impractical. The antenna gain, in particular, is a trade-off because it increases linearly with the antenna area while decreasing exponentially with the length of the transmission lines due to losses. In this opinion, making very large antennas for a particular substrate is not practical because the gain actual decreases beyond a certain size[12, 13].

In this work a SIW antenna is designed by making two rectangular slotsin the upper ground plane. The proposed antenna resonates at different frequency band in the millimeter band.

II. SIW ANTENNA DESIGN AND RESULT ANALYSIS

The proposed antenna is designed on a dielectric substrate RT duroid 5880 of relative dielectric constant of 2.2. The thickness of the substrate is 0.254 mm. Two rectangular slots of dimensions 6.5 x 0.7 mm^2 and 4.2 x 0.17mm^2.For the impedance matching a taper transition and a microstrip feed line is designed the analysis of the feed line is shown in [14]. The diameters of the vias are taken as 0.5 mm and the spacing between the viasare taken as 1 mm. Fig. 1 shows the proposed SIW antenna.

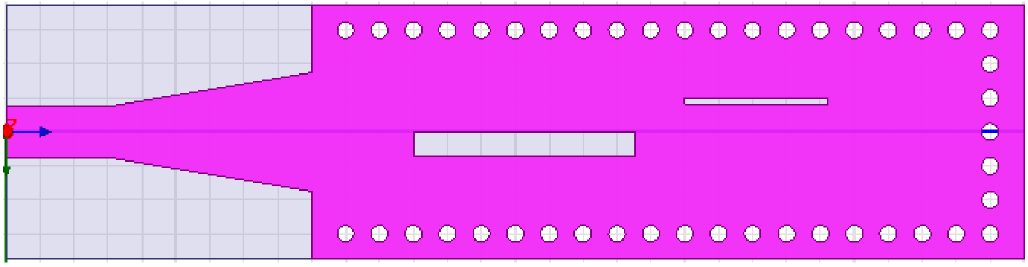

Figure 1 Proposed SIW antenna

The slots are off set to each other so the proposed SIW antenna shows the multiband behaviour in the range of 25 GHz to 40 GHz. Figure 2 shows the return loss curve of the proposed antenna. The Return loss at 26 GHz is -16 dB,28 GHz is -13.5 dB, 30.7 GHz is -20 dB and at 32 GHz is -17 dB.

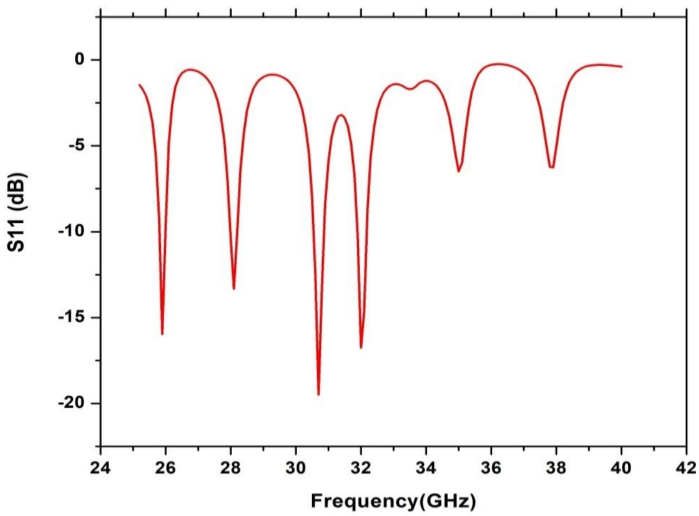

Figure 2. Return loss curve of SIW antenna

The VSWR curve of the proposed antenna is shown in Fig 3 it is seen from the cuve that the resonating frequencies the value of the VSWR is lies between 1 and 2, this shows the good impedance at these resonating frequencies. The **E** plane and the **H**plane radiation pattern of the proposed antenna at the 28 GHz is shown in Fig 3. The main application of 28 GHz is the 5 G wireless communication systems.

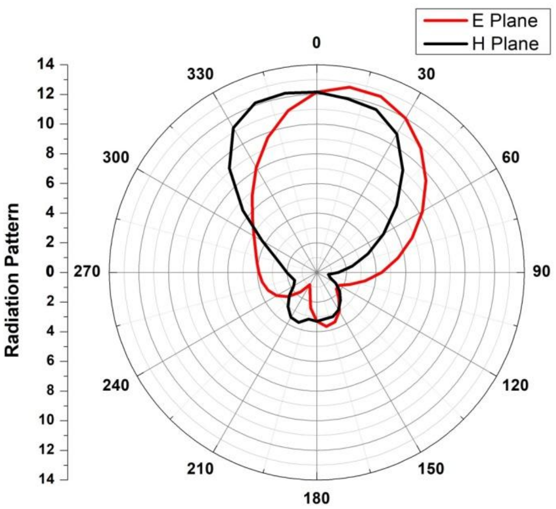

Figure 3. E and H Plane Radiation Pattern at 28 GHz

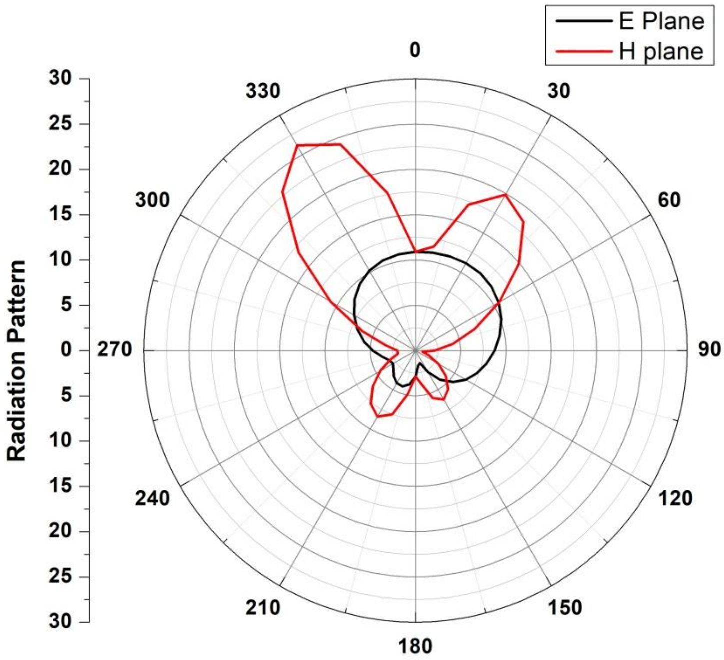

Figure 4. E and H Plane Radiation Pattern at 26 GHz

Both the radiation pattern indicates that the antenna has half broadside radiation pattern at 28 GHz. The gain of the proposed antenna is also analyzed. The gain curve is shown in Fig. 5

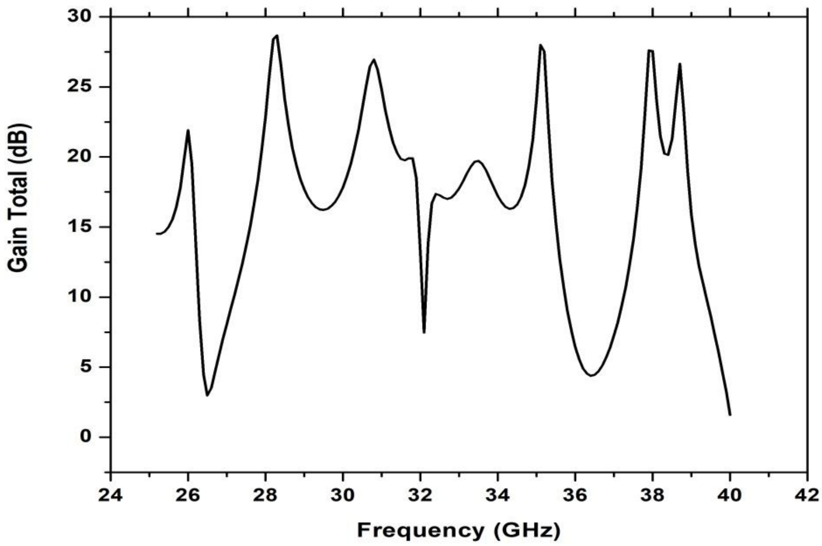

Figure 5 Gain Curve of proposed antenna

The total gain of the antenna at 26 GHz is 15 dB, at 28 GHz 19 dB, at 30.7GHz is 19 dB and at 32 GHz is 8 dB.The Radiation efficiency of the proposed antenna is shown in Fig. 6

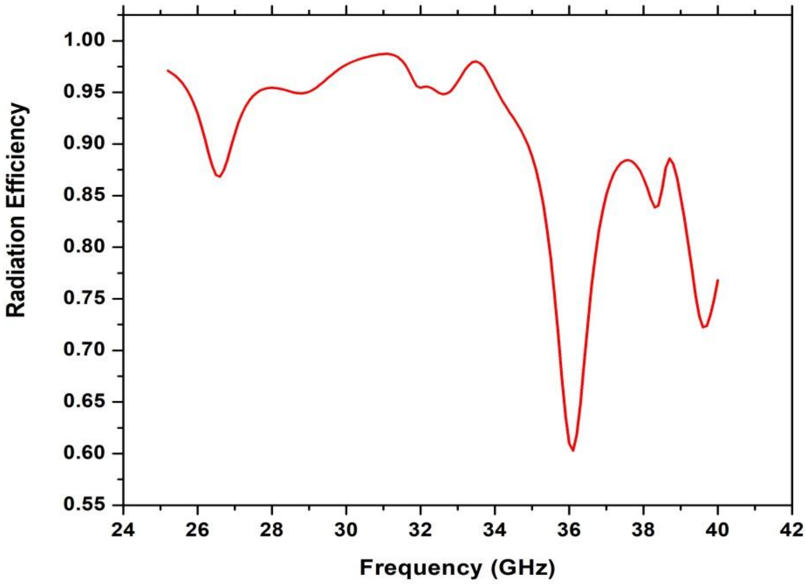

Figure 5 Radiation Efficiency Curve of proposed antenna

The Radiation efficiency of the proposed antenna is more than 90% at all the resonating frequencies.

III. Conclusions

The proposed SIW antenna is applicable for future 5G wireless communication systems for the frequencies of 26 GHz and 28 GHz. At 31 GHz, point-to-point microwave radio applications. The Proposed antenna shows a high gain and high efficiencies so the suggested SIW slotted antenna is a good contender for future millimeter wave communication systems based on these findings.

References

[1]. Giuseppe Venanzoni , DavideMencarelli , Antonio Morini, Marco Farina and Francesco Prudenzano, "Review of Substrate Integrated Waveguide Circuits for Beam-Forming Networks Working in X-Band", Appl. Sci. 2019, 9, 1003;

[2]. Deslandes, D.; Wu, K. Single-substrate integration technique for planar circuits and waveguide filters.IEEE Trans. Microw. Theory Tech. 2003, 51, 593–596.

[3]. Deslandes, D.; Wu, K. Accurate modelling, wave mechanism and design considerations of a substrateintegrated waveguide. IEEE Trans. Microw. Theory Tech. 2006, 54, 2516–2526.

[4]. Bozzi, M.; Georgiadis, A.; Wu, K. Review of substrate-integrated waveguide circuits and antennas.IETMicrow. Antennas Propag. 2011, 5, 909–920

[5]. Kumar S and De A, "Design and analysis of sinusoidally modulated substrate integrated waveguide and filters" Int. J of RF microwcomput Aided Eng.2022, 32(e), 22912,

[6]. Wan, L.; Hong,W.; Hua, C.; Chen, J.;Wu, K. Simulation and experiment on siw slot array antennas. IEEEMicrow. Wirel. Compon. Lett. 2004, 14, 446–448.

[7]. Awida, M.H.; Fathy, A.E. Substrate-integrated waveguide Ku-band cavity-backed microstrip patch arrayantenna. IEEE Antennas Wirel. Propag. Lett. 2009, 8, 1054–1056.

[8]. Losito, O.; Mescia, L.; Mencarelli, D.; Venanzoni, G.; Prudenzano, F. SIW Cavity-Backed Patch Antenna for Ku Band Applications. In Proceedings of the 7th European Conference on Antennas and Propagation(EUCAP 2013), Gothenburg, Sweden, 8–12 April 2013; pp. 3095–3098.

[9]. Jin, L.; Lee, R.M.; Robertson, I.D. Design and performance of log-periodic substrate integrated waveguideslot antennas. In Proceedings of the IEEE MTT-S International Microwave Symposium Digest, Montreal, QC,Canada, 17–22 June 2012.

[10]. Li, Y.; Luk, K.M. Low-Cost High-Gain and Broadband Substrate-Integrated-Waveguide-Fed Patch AntennaArray for 60-GHz Band. IEEE Trans. Antennas Propag. 2014, 62, 5531–5538.

[11]. Zhu, Q.; Ng, K.B.; Chan, C.H.; Luk, K.M. Substrate-Integrated-Waveguide-Fed Array Antenna Covering57–71 GHz Band for 5G Applications. IEEE Trans. Antennas Propag. 2017, 65, 6298–6306.

[12]. Josefsson, L. Analysis of longitudinal slots in rectangular waveguides. IEEE Trans. Antenna Propag. 1987,AP-35, 1351–1357.

[13]. Rengarajan, S.R.; Steinbeck, M. Longitudinal slots in dielectric filled rectangular waveguides. In Proceedings of the Antennas and Propagation Society Symposium 1991 Digest, London, ON, Canada, 24–28 June1991;Volume 2, pp. 1276–1279.

[14]. Morini, A.; Farina, M.; Cellini, C.; Rozzi, T.; Venanzoni, G. Design of low-cost non-radiative SMA-SIWLaunchers. In Proceedings of the European Microwave Conference, Manchester, UK, 10–15 September 2006.