Sigma J Eng & Nat Sci 38 (1), 2020, 305-310

Sigma Journal of Engineering and Natural Sciences
Sigma Mühendislik ve Fen Bilimleri Dergisi

Research Article

DESIGN AND REALIZATION OF DUAL BAND MICROSTRIP SIW ANTENNA

Aysu BELEN*[1], Filiz GÜNEŞ[2]

[1] *Yıldız Technical University, Electronics and Communications Engineering Department, Esenler-ISTANBUL;* ORCID: 0000-0002-0949-3687
[2] *Yıldız Technical University, Electronics and Communications Engineering Department, Esenler-ISTANBUL;* ORCID: 0000-0001-5038-424X

Received: 31.05.2019 Revised: 08.11.2019 Accepted: 10.12.2019

ABSTRACT

Herein, realization of a high performance dual band microstrip antenna via the use of Substrate Integrated Waveguide technology (SIW) has been studied. Firstly, a 3D Electromagnetic based SIW antenna design has been modeled in CST Microwave Studio. The proposed dual band antenna is aimed to operate at 10 & 24 GHz frequency. After obtaining an optimal simulated model, the proposed antenna is fabricated on Rogers's 4350 high performance substrate. The simulation and measurement results of the proposed SIW antenna are compared. As it can be seen from the measurement results the proposed antenna achieves a measured gain characteristic of 6 and 7.2 dB at 10 & 22 GHz frequency with a S_{11} level of less than -10 dB.
Keywords: Microstrip antenna, X band, K band, substrate integrated wavequide, SIW, radar.

1. INTRODUCTION

The need of antenna design with low-cost, low-profile, broadband or multi band specs has become a very important research topic for microwave engineers [1-3]. One of the most commonly used antenna model for antenna design with the mentioned specs, is microstirp patch antennas. For the last few decades there had been many studies on design and realization of dual band micrsotirp patch antennas [4-12]. However the traditionally microstirp patch antenna design also suffers from the disadvantages such as narrow operation band, low directivity or waveguide loss. Substrate-Integrated Waveguide (SIW) is a novel and efficient solution counterpart of the traditionally waveguide designs [13–14]. Since a SIW structure can easily realized on a planar substrate, its integration with other planar microwave systems is possible. Also compare to a traditionally microstrip resonator, the SIW resonator can achieve a higher Q factor [15].

Recently, Antenna designs with SIW technology are becoming a trending topic for novel, high performance antenna design [16-20]. Antennas designed with SIW technology have excellent performance due to the ability of suppressing surface wave propagation, wider operation band, decreased end-fire radiation and cross-polarization radiation. High performance antenna designs have a very wide application range such as satellite communication, and radar. In this

[*] Corresponding Author: e-mail: aysu.yldrm07@gmail.com, tel: (212) 383 58 81

work, SIW technology is applied to design a dual-band antenna for X and K Band Radar applications. Firstly, a novel SIW antenna is designed in CST Microwave Studio for 10 & 24GHz band application and prototyped on Rogers 4350. The simulated and measured performance results of the design is compared. As a result, it can be concluded that, the proposed model is a sufficient and low-cost solution for X and K band radar applications.

2. DESIGN PROCEDURE OF SIW ANTENNA

In SIW design by using rows of metallized via's through the dielectric substrate material it is possible to form walls for confining both electric and magnetic waves. Moreover the conductive layers both in top and ground layer of the microstrip substrate would provide two additional waveguide walls.

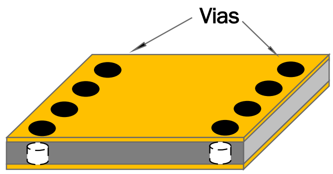


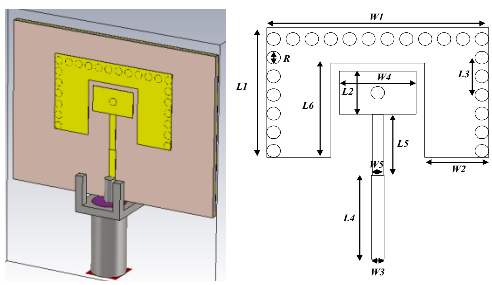
Figure 1. Schematic of a SIW structure.

In the procedure of SIW design there are important parameters that their values should determine wisely such as, (i) Dielectric constant of the substrate: effects the radiation efficiency and the bandwidth of the operation frequency of the design. For achievement of wide impedance bandwidth a low dielectric constant is required. (ii) Metallized via arrays, the total number of via's and their gaps are plays an important role for building the side- walls of SIW structures.

In the next section by using the SIW technology, the design procedure and schematic of a high performance dual band antenna has been presented.

3. STUDY CASE

The proposed dual band SIW antenna model is given in Fig. 2 alongside of its parametric design layout and optimally selected parameters value in Table 1. The values of parameters given in Table 1, are obtained via trial and error alongside of local optimization process of CST studio Environment to achieve high performance for both X and K band applications. The proposed antenna is modelled and fabricated (Fig. 3) on Rogers's 4350 high performance substrate the simulation and measurement results of the proposed SIW antenna are given in the next section Figs. 4-6 and Table 2.



(a) (b)

Figure 2. (a) Antenna geometry, (b) Parametric layout of SIW antenna.

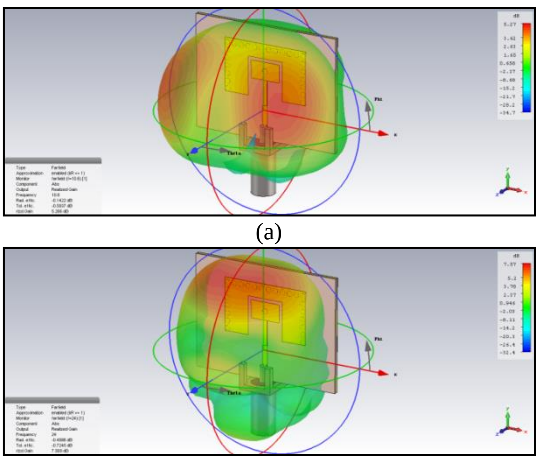
Table 1. Parameter List in (mm)

W_1	16.4	**W_5**	0.8	**L_4**	6.5
W_2	4.8	**L_1**	10.0	**L_5**	4.75
W_3	1	**L_2**	3.35	**L_6**	7.35
W_4	5.6	**L_3**	3	**R**	0.8

The measurement results are obtained using the measurement setup given in Fig. 3. The antennas given in [21] are used for measurements at 1-18 GHz and 18-30 GHz respectively. As it can be seen from the measurement results, the proposed SIW antenna achieves a return loss characteristics of less than -15 dB at 10 & 22 GHz and a gain level of almost 6 & 7.2 dBi. Although, there is a frequency shift at the secondary band due to the manufacturing errors, antenna still achieves a high performance. A detailed performance measurement of the prototyped antenna compared to counterpart designs with and without SIW structure has been given in Table 2. Furthermore, a comparison of the proposed antenna with counterpart design in literature had been presented in Table 3.

(a) (b)

Figure 3. (a) Fabricated antenna (b) Measurement setup [22].



(b)

Figure 4. Simulated Gain Patterns (a) @10GHz, (b) @24GHz

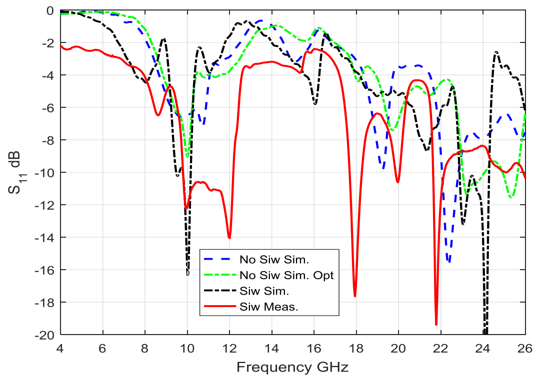
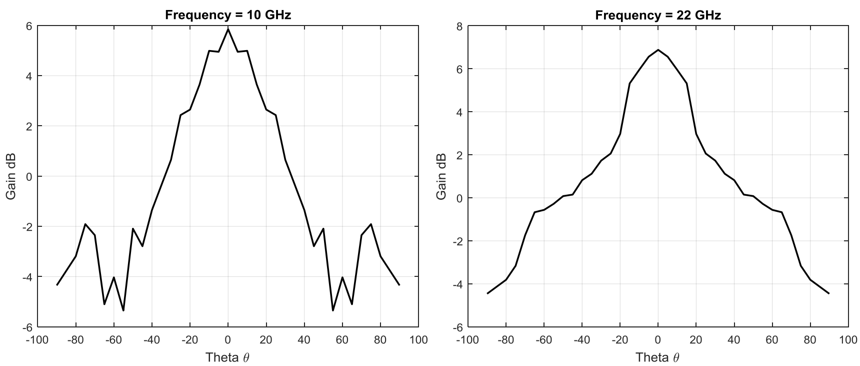


Figure 5. Simulated and measured return loss



(a) (b)

Figure 6. Gain measurement (a) 10GHz (b) 22GHz.

Table 2. Comparison of Realized Gain

Model	Realized Gain dB		Die Size (mm)
	10GHz	22GHz	
Siw Meas	6	7.2	28 x22.5
Siw Sim	6.2	7.6	28.14x22.45
No Siw	2.82	6.46	28.14x22.45
No Siw Opt	3.58	7.5	26.4x22.45

Table 3. Comparison of Antenna with literature

Models	*f* *(GHz)*	S_{11} (dB)	Realized Gain dB	Substrate	Die Size (mm)
This Work	10 / 22	-10 / -20	6 / 7.2	Roger 4350	28 x22.5
[18]	10	-25	9.8		30x30
[23]	15	-15	7.5	---	30x30
[24]	25	-20	---	Arlon 25N	15x27
[25]	10 / 12	-30 /-30	8 / 9	Taconic TLY	40x56
[26]	18.2-23.8	<-15	9.5	Roger-Droid 5880	20x25

4. CONCLUSION

In this paper, a novel high-gain planar SIW antenna had been proposed for X and K band applications. By using, SIW technology on microstrip patch antenna an easy and cost-effective fabrication is achieved. As it can be seen from simulation and measurement results, the proposed novel high-gain planar SIW antenna for X and Ka band applications is a suitable candidate for RADAR application that require an enhanced-gain performance. The performance of the proposed antenna design had been verified with its simulation and measurement results.

Acknowledgment

We would like to express our special thanks of gratitude to the Aktif Neser Elektronik, for providing researcher license of CST, Microwave and Antenna Laboratory of Yıldız Technical University. This work was supported by 100/2000 YÖK and TÜBİTAK-BİDEB 2011/A International PhD Fellowship Programme.

REFERENCES

[1] A.K Bhattacharjee., S.R Bhadra., D.R. Pooddar and S.K. Chowdhury, "Equivalence of impedance and radiation properties of square and circular microstrip patch antennas," IEE Proc. vol.136, pp338-342, 1989.

[2] L. I.Basilio, M. A. Khayat, J. T.Williams, and S. A. Long, "The dependence of the input impedance on feed position of probe and microstrip line-fed patch antennas," IEEE Trans. Antennas Propagat., vol. 49, no. 1, pp 45-47, 2001.

[3] 1. J.S. Roy, N. Chattoraj, and N. Swain, Short-circuited microstrip antennas for multiband wireless communications, Microwave Opt Technol Lett 48 (2006), 2372–2374

[4] L. Hong, H. Zhixiang and S. Dengzhi, "Design of a dual-band microstrip antenna," 2016 11th International Symposium on Antennas, Propagation and EM Theory (ISAPE), Guilin, 2016, pp. 156-158. doi: 10.1109/ISAPE.2016.7833907

[5] A. Mounsef, I. Tabakh, M. E. Bakkali, Y. E. Gholb and N. El Amrani El Idrissi, "Design and simulation of a dual band microstrip patch antenna for an emergency medical service system," 2017 International Conference on Wireless Networks and Mobile Communications (WINCOM), Rabat, 2017, pp. 1-4. doi: 10.1109/WINCOM.2017.8238175

[6] Belen MA, Mahouti P., 2018.Design and realization of quasi Yagi antenna for indoor application with 3D printing technology. Microwave and Optical Technology Letters, 60:2177–2181. https://doi.org/10.1002/mop.31319.

[7] A. A. Deshmukh, V. Pandita, R. Colaco and R. Doshi, "Dual band dual polarized modified circular microstrip antenna," 2014 International Conference on Circuits, Systems, Communication and Information Technology Applications (CSCITA), Mumbai, 2014, pp. 347-352.

[8] X. Dai, T. Zhou and G. Cui, "Dual-Band Microstrip Circular Patch Antenna With Monopolar Radiation Pattern," in IEEE Antennas and Wireless Propagation Letters, vol. 15, pp. 1004-1007, 2016.

[9] P. Mahouti, F. Güneş, M. A. Belen, A. Çalışkan, and S. Demirel, 2016. Design and Realization of Dual Band Microstrip Monopole Antenna", MIKON 2016 - 21st International Conference on Microwaves, Radar and Wireless Communications, May 9-11, Krakow POLAND.

[10] A. Caliskan, M. A. Belen, P. Mahouti, S. Demirel, F. Günes, 2015. "Design of a Multiband Microstrip Patch Antenna with Defected Ground Structures", European Microwave Week EUMW 2015, Paris, France.

[11] B. Yan, L. Wang, Z. Luo, D. Deng, L. Feng and H. Zheng, "Dual-band microstrip antenna fed by coaxial probe," 2016 11th International Symposium on Antennas, Propagation and EM Theory (ISAPE), Guilin, 2016, pp. 228-230.

[12] O. Ayop, M. K. A. Rahim and T. Masri, "A dual band gap slotted patch electromagnetic band gap for dual band microstrip antenna," 2008 IEEE International RF and Microwave Conference, Kuala Lumpur, 2008, pp. 322-325.

[13] G.Q. Luo et al., (2008) "Planar Slot Antenna Backed by Substrate Integrated Waveguide Cavity," IEEE Antennas Wireless Propag. Lett., 7(1), 236–239.

[14] G.Q. Luo et al,(2009) "Development of Low Profile Cavity Backed Crossed Slot Antennas for Planar Integration," IEEE Trans.Antennas Propag., 57(10)2972–2979

[15] W. Tan et al., (2005),"A Gain–Enhanced Microstrip–Fed Cavity-Backed Slot Antenna," Process. Asia-Pacific Microw. Conf., Suzhou, China, 2, 4–7.

[16] M. Esquius-Morote, B.Fuchs, J.-f. Zürcher, and J.R. Mosig,(2013) "Novel thin and compact H-plane SIW horn antenna", IEEE Transactions on Antennas and Propagation, 61(6)

[17] J. Lacik , (2012) "Circularly polarized SIW square ring-slot antenna for X-bandapplications", Microw. Opt. Technol. Lett., 54: 2590–2594.

[18] Mehmet A. Belen, Filiz Güneş, Alper Çalışkan, Peyman Mahouti, Salih Demirel and Aysu Yıldırım, (2016), "Microstrip SIW Patch Antenna Design for X Band Application", MIKON 2016 - 21st International Conference on Microwaves, Radar and Wireless Communications, May 9-11, Krakow POLAND

[19] Mehmet A. Belen, P.Mahouti, A. Çalışkan, A. Belen, (2017), "Modeling and Realization of Cavity-Backed Dual Band SIW Antenna" Applied Computational Electromagnetics Society Journal, Vol. 32, No. 11, November 2017, 974-978

[20] Mahouti, P, Belen, MA, Güneş, F. Performance enhancement of a microstrip patch antenna using substrate integrated waveguide frequency selective surface for ISM band applications. Microw Opt Technol Lett. 2018; 60: 1160– 1164. https://doi.org/10.1002/mop.31124

[21] A-info, LB8180, (2015), 0.8-18 GHz Broadband Horn Antenna, Available at: http://www.ainfoinc.com/en/p_ant_h_brd.asp, Accessed on November 9.

[22] Belen, M. A., Güneş, F., Mahouti, P., & Belen, A. (2018). UWB Gain Enhancement of Horn Antennas Using Miniaturized Frequency Selective Surface. Applied Computational Electromagnetics Society Journal, 33(9).

[23] M. Esquius-Morote, B.Fuchs, J.-f. Zürcher, and J.R. Mosig, "Novel thin and compact h-plane siw horn antenna", IEEE Transactions on Antennas and Propagation, June 2013, vol. 61, no. 6.

[24] A. Collado and A. Georgiadis, "24 GHz substrate integrated waveguide (SIW) rectenna for energy harvesting and wireless power transmission," 2013 IEEE MTT-S International Microwave Symposium Digest (MTT), Seattle, WA, 2013, pp. 1-3. doi: 10.1109/MWSYM.2013.6697772

[25] L. Sabri, N. Amiri and K. Forooraghi, "Dual-Band and Dual-Polarized SIW-Fed Microstrip Patch Antenna," in IEEE Antennas and Wireless Propagation Letters, vol. 13, pp. 1605-1608, 2014. doi: 10.1109/LAWP.2014.2339363

[26] T. Cheng, W. Jiang, S. Gong and Y. Yu, "Broadband SIW Cavity-Backed Modified Dumbbell-Shaped Slot Antenna," in IEEE Antennas and Wireless Propagation Letters, vol. 18, no. 5, pp. 936-940, May 2019. doi: 10.1109/LAWP.2019.2906119