Journal of Theoretical and Applied Information Technology
30th June 2025. Vol.103. No.12

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

SIW CAVITY LOADED WITH DUMBBELL SHAPED SLOT ANTENNA FOR WIDEBAND APPLICATIONS

[1]K. VIDYA SAGAR, [2]RAMPRASAD RAVULA, [3]SATTI SUDHA MOHAN REDDY, [4] PANGULURI VINODH BABU, [5]KADIYALA SUDHAKAR, [6]GUNTI SURENDRA, [7]SURYA PRASADA RAO BORRA

[1]Department of EIE, VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad
[2]Department of ECE, Sri Vasavi Engineering College, Tadepalligudem, India
[3]Department of ECE, SRKR Engineering College, Bhimavaram, AP., India
[4]Department of ECE, Bapatla Engineering College, Bapatla, India.
[5]Department of ECE, RVR & JC College of Engineering, Guntur, India
[6]Department of CSE, Koneru Lakshmaiah Education Foundation, Vaddeswaram AP, India
[7]Department of ECE, PVP Siddhartha Institute of Technology, Vijayawada, India
Corresponding Author: suryaborra1679@gmail.com

ABSTRACT

Substrate Integrated Waveguide (SIW) technology is significant in the design and development of modern communication systems, telecommunications, aerospace, automotive healthcare, radar and in sensing technologies owing to its unique combination of performance, integration capabilities and cost-effectiveness. This paper is designed a microstrip patch antenna with applied SIW on dumbbell shaped antenna is focused to obtain high bandwidth and high gain and directivity with minimum reflection coefficient value. The dimensions 38mm*28mm*1.575mm (L×W×t) of the proposed antenna, excited with micro strip line feeding technique. The antenna is resonated at 15.27GHz and 15.47GHz frequencies. The VSWR values are 1.06 and 1.08 which represents the antenna is a good matching with the ideal value of 1.0. The low VSWR represents efficiency is increased significantly in the transmission line and reflected energy values are negligible. The bandwidth achieved is 1.38GHz. The gain achieved with the proposed antenna is 4.4dB. Directivity, electric field distribution and current distribution parameters are also considered to evaluate the performance of the antenna. The results extracted with the proposed antenna is compared with other existing slot antennas shows superior results. This antenna can be used for wide band communication applications specifically in the domain of aerospace and medical era.

Keywords: *Bandwidth, Current Distribution, Micro Strip Patch Antenna, Gain, Reflection Coefficient, Substrate Integrated Waveguide, VSWR And Voltage Distribution.*

1. INTRODUCTION

When Micro strip patch antenna using SIW (Substrate Integrated waveguide) technology is having wide significance in wireless communication applications. The microwave community has given this SIW technology a lot of attention in recent years in an effort to mitigate these negative impacts [1-2]. For decades, numerous authors have been discussed various investigations related to the construction of broadband antennas [3] and compact multi-band [4-5]. Using millimetre-wave and microwave components, this technique has shown promise in forming traditional metallic waveguide structures in a flat substrate [6]. The integration of metal cavities with arbitrarily curved surfaces has led to a lot of research in the literature in recent years about the advantages, gain, compactness and wideband with a large volume of cavity-backed slot antennas (CBSA's) [7-11].

Furthermore, the employment of two competing technologies printed circuit boards (PCB's) and metallic waveguides make the construction process of CBSA's extremely complicated. This discourages the use of such antennas in modern, small wireless networks. The development of planar slot antennas with low-profile, unidirectional radiation properties, large impedance bandwidth [Specific range of frequencies the dumbbell shaped with applied SIW antenna is radiating], and significant gain is a well-known technique for combining numerous communication systems in the millimetre and microwave range [12].

The SIW-backed planar antennas have a unidirectional radiation pattern and low back-lobe

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

radiation, just like traditional metallic CBSA's. In addition, it has exceptional advantages over standard CBSA's, including lower manufacturing costs, a smaller profile, more weight and compactness. The first SIW cavity-based planar slot antenna is demonstrated in [13]. Several waveguide-based antennas can be easily made with this cutting-edge technology. This makes it possible to integrate other planar circuits at great densities. SIW structures can be produced by printed circuit board, which lowers the cost of production [14].

By eliminating the substrate beneath the slot, the quality factor (Q) of the cavity and slot is decreased. In [15], SIW CBSA's bandwidth is increased. Although it is challenging, detaching the substrate during production produces more complex and costly designs. Another method for expanding the bandwidth in [16] was to place a single shorting via (via-hole) above the I-shaped slot to produce a second resonance nearer the resonance. The SIW circular cavity has been fitted with both butterfly-shaped feed lines and ellipse-shaped slots to enhance the bandwidth to approximately 9% by combining three resonant frequencies [17]. By appropriately integrating the cavity's two hybrid-modes, a total bandwidth of 9.4% was achieved in a dual resonance SIW based bowtie-shaped slot antenna that was revealed [18]. Three distinct connected modes are activated within the frequency range when two long bowtie-shaped slots in [19] are filled separately and adjacent to one another. The bandwidth of the antenna is increased by more than 15% as a result. Nonetheless, the antenna's size is increased by the two chambers.

The dimension of the patch is influences on the characteristics of the antenna i.e. reflection coefficient [Reflection coefficient is also labelled as return losses and S11], gain, bandwidth, radiation pattern, current and voltage distribution. Cylindrical metallic array vias are drilled around the patch, substrate and ground treated as cavity accordingly waves are guiding into the substrate using an artificial channel. A dumbbell shaped patch is designed with applied SIW technology by using FR4 glass epoxy material is used as a dielectric substrate. The proposed dumbbell shaped slot is excited with micro strip line feed technique. With line feed technique, the generated total energy is transferred to the dumbbell antenna. The dimension of the antenna is optimally tuned to minimize the surface waves and false feed radiation. To achieve better resonating frequency, the feed point is considered at various distinct locations longitudinal to the centre axis of the dumbbell shaped patch.

2. PROPOSED ANTENNA DESIGN STEPS AND CONFIGURATION

Fig. 1 illustrates the three iterations of wideband antenna construction processes. The wideband antenna is built entirely on a single dielectric substrate FR4 with a thickness of h which improves the electric breakdown strength of the proposed dumbbell antenna and allows high current to flow through the antenna. The first iteration, shown in Fig. 1(a), creates a SIW cavity resonator by uniformly placing metal vias along the antenna's edges on the same substrate around four sides to form a cavity. To minimize energy leakage losses through the cavity's sidewalls and prepare SIW cavity on par with a standard metallic cavity, the cylinder diameter (d) and the distance (pitch) between two adjacent vias (p') are carefully chosen based on the requirements ($p' < 2d$ and $d \leq 0.1\lambda_0$). The starting size of the planar cavity can be found using the resonant frequency formula, which is given in Eq. (1) [21].

$$f_{mnp'} = \frac{1}{2\sqrt{\mu_0 \varepsilon_0 \varepsilon_r}} \sqrt{\left(\frac{m}{L_{eff}}\right)^2 + \left(\frac{n}{W_{eff}}\right)^2 + \left(\frac{p'}{h}\right)^2} \qquad \text{...Eq.1}$$

Where m, n, p' = 0 are integers; ε_r - relative permittivity of the substrate;
Via diameter is represented with'd'
The pitch distance is represented with's'
Substrate thickness is represented 'h'
The effective width and length of the SIW structure is estimated using following expressions.
Effective width of the cavity is estimated using Eq.2

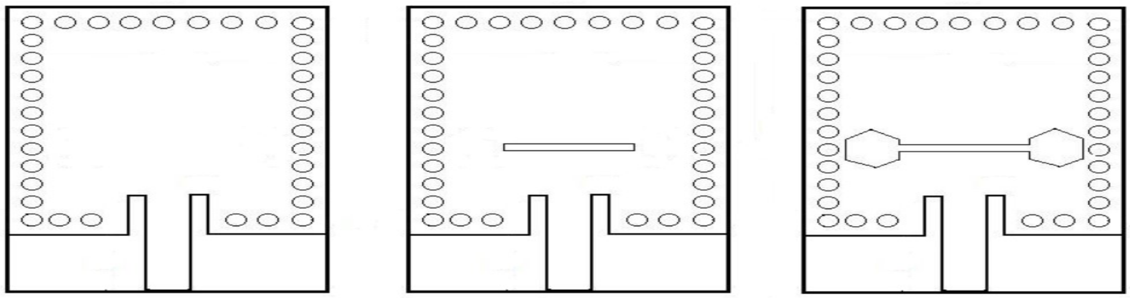
$$W_{eff} = W - \frac{d^2}{0.95 * s} \qquad \text{... Eq.2}$$

Effective length of the cavity is estimated using Eq.3

$$L_{eff} = L - \frac{d^2}{0.95 * s} \qquad \text{... Eq.3}$$

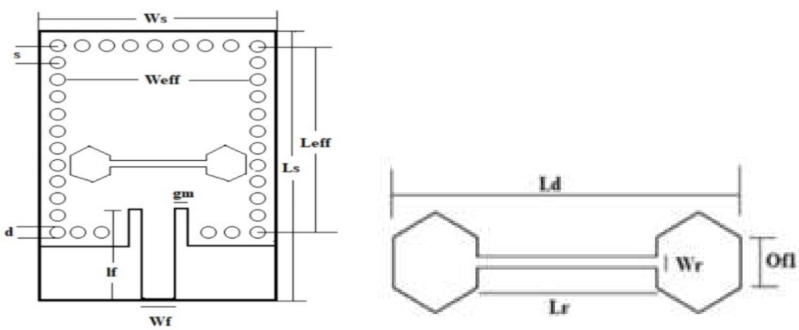
In iteration-2, a rectangular slot is used to disturb the cavity's conventional modes. Fig. 1(b) shows an embodiment of the rectangular slot. The slot's dimensions are (W_r) 0.6 mm and (L_r) 11.74 mm.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195



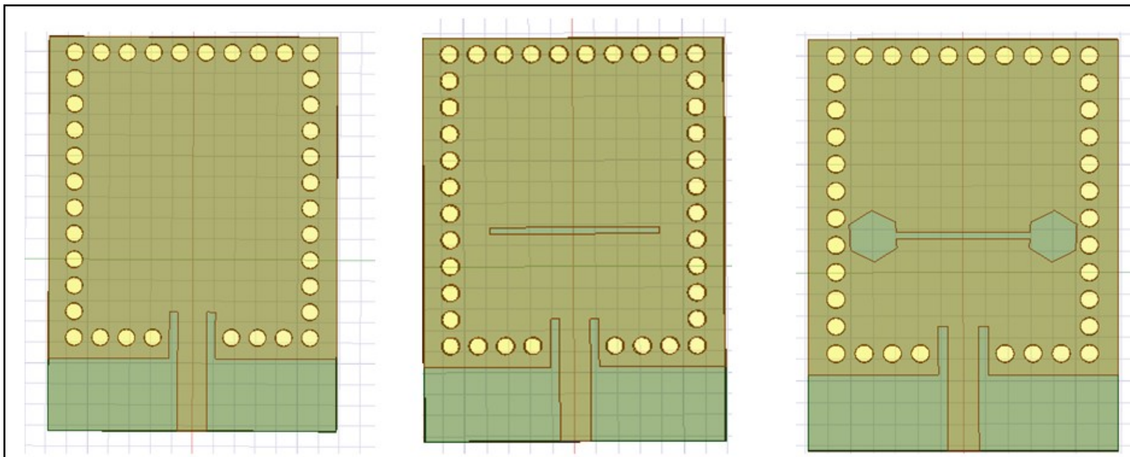
(a) (b) (c)

Fig. 1. Iteration stages: (a) SIW cavity (Iteration-1)
(b) Rectangular slot antenna (Iteration-2)
(c) Dumbbell-shaped slot antenna (Iteration-3)



(a) (b)

Fig. 2. Geometry of the proposed antenna [Ws = 28, Ls = 38, Weff = 20.9, Leff = 27.5, Wf = 2.8, lf = 11.5, gm = 0.8, Of1=2.38, lr = 11.74, ld = 20.12, wr = 0.6, p = 2.5, d = 1] (Units: mm).



(a) (b) (c)

Fig. 3. Evaluation of the SIW cavity-based dumbbell shaped slot antenna

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

As seen in Fig. 1(c), iteration-3 is intended to achieve wide bandwidth. It includes a rectangular slit that has been cut out of it, with two hexagons at each end of the slot and hexagonal head diameter of 2.38 mm.

The radiator's hexagonal dumbbell-shaped slot is printed on the top metal lamination of the substrate with height of 1.575mm. As illustrated in Fig. 2, the hexagonal dumbbell slot is the result of a transformation process that involves joining a small rectangle shaped slot at one end of two hexagonal slots to modify the basic dumbbell-shaped slot. It is noteworthy that there is an offset between the hexagonal dumbbell-shaped slot and the rectangular slot to enhance the bandwidth. The evaluation of SIW cavity-based dumbbell shaped slot structures shown in Fig.3

The design parameter of proposed dumbbell-Shaped slot antenna is presented in table.1.

Table 1: Design Parameters Of The Proposed Antenna

Design Parameters	Dimensions (in mm)
L_s	38
W_s	28
H	1.575
L_{eff}	27.5
W_{eff}	20.9
L_f	11.5
W_f	2.8
g_m	0.8
S	2.5
D	1
L_d	20.12
L_r	11.74
W_r	0.6
Of1	2.38

3. WORKING OF THE ANTENNA

3.1 Antenna without Dumbbell slot

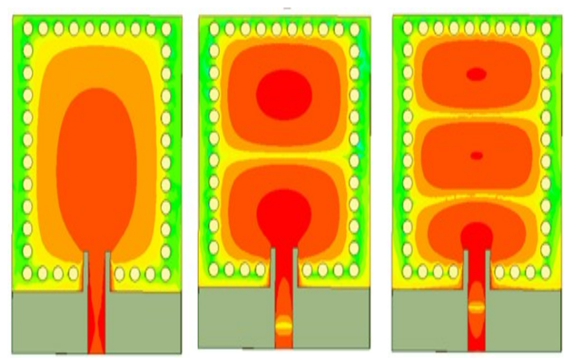
When the SIW cavity called Iteration-1 is not loaded with a dumbbell slot, three cavity modes called TE_{110}, TE_{210} and TE_{310} are generated at 4.2GHz, 6GHz and 8.5GHz respectively.

By looking at the field distributions, one can plainly understand how the modes are generated. The cavity mode's electric field distribution is significantly disrupted.

Consequently, the cavity's fundamental mode TE_{110}, operates at 4GHz. Similarly, the TE_{210} mode radiates at 6GHz and is divided into two modes. The electric field distributions of the corresponding modes, as shown in Fig. 4, can be used to examine the same. Additionally, there is some perturbation in the loaded cavity's TE_{310} mode. But this mode isn't used to increase bandwidth.

3.2 Antenna loaded with Dumbbell slot

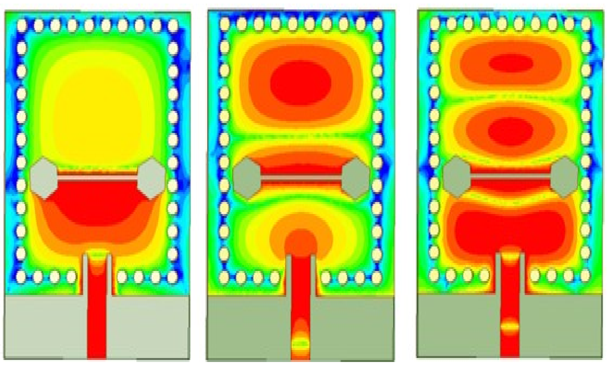
The proposed dumbbell shaped MSPA dimensions are 38mm×28mm (Ls× Ws). The height of the substrate is 1.575mm. To achieve high gain value the ratio of width and length are tuned to 38mm×28mm. The effective length of the antenna (Leff) is 27.5mm. The effective length is tuned to intensify the radiating energy level and subsequently, the reflection coefficient value is diminished to a low value. The effective width is deliberated to increase the bandwidth of the proposed dumbbell shaped patch. With optimum tuning (Weff) is 20. 9mm.The bandwidth is marginally enhanced, but the resonant frequency remains constant. The length of the feed (lf) is leverages on the reflection coefficient (S11). The patch size is influencing on the centre frequency, and the length of the feed is changing the reflection coefficient value (S11) significantly. The performance of the SIW applied dumbbell antenna is improved significantly with optimized length of the feed. The feed line impedance is also deliberated in this study. The feed point is considered between the edges and centre of the patch. 50Ω feed line is considered.



(a) 4.2GHz (b) 6GHz (c) 8.5GHz

The width of the patch is optimized to curtail the coupling between the proposed antenna and micro strip. Length of the patch is tuned to half the wavelength so that gain of the antenna is increased and return losses are significantly reduced. The length of the dumbbell (Ld) is 20.12mm, length of the slot (Lr) is 11.74mm and the face dimensions of the hexagonal head (of1) is 2.38mm and the width of the slot (Wr) is 0.6mm. The simulation study is done by tuning the Ld value, Lr value, 'of1' value and Wr value. Reducing the Ld and Lr value impact on the return losses which are significantly increased, and the performance of the proposed dumbbell shaped antenna is challenging.

The operation of the SIW cavity-based dumbbell-shaped slot (Iteration 3) is easily understood thanks to the electric field distribution. The parallel inductance raises the series capacitance when the dumbbell-shaped slot is utilized.



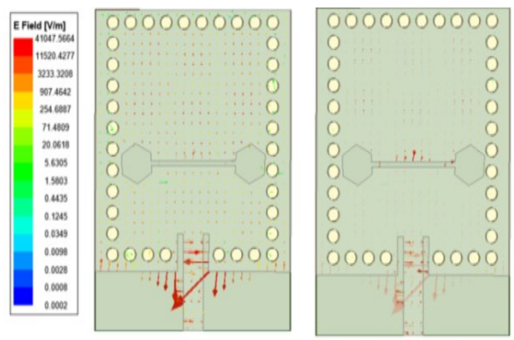
a. 4.8GHz (b) 7GHz (c)10.2GHz

The fundamental mode (TE_{110}) is tuned toward the top side between 4.8GHz and 10.2GHz as a result of the parallel inductance lowering. Further the radiation properties of the proposed dumbbell-shaped slot, Figure 5 shows the electric field distribution on the antenna's top metallic surface at 4.8 GHz, 7 GHz and 10.2GHz.

More impedance matching is achieved between 14GHz and 17GHz. Within the operational band (14GHz to 17GHz), the suggested design (Iteration 3) achieves two resonances at 15.27GHz and 15.47GHz. It is shown that the corresponding return losses are -28.2dB and -30.2dB. The placement of the slot (Iteration-2) makes it evident that the electric field distributions at 15.2GHz and 16.4GHz are almost the same as those of Iteration-3.

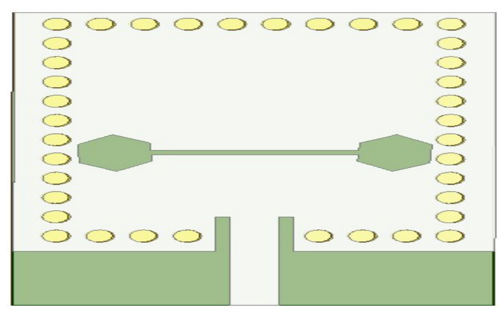
In Fig.5, the area above the centre rectangle slot has the strongest electric field, while the area below the slot has the weakest electric field strength. The superposition of odd TE_{210} and half TE_{110} is the mode that is obtained at this frequency.

The slot can send electromagnetic waves into free space because, the electric field magnitudes on either side of it are out of phase at this frequency. The strongest field is found at the bottom of the slot. It is found that the two hexagon-shaped slots and the central rectangular slot emit more radiation at 15.47GHz. The electric field vector representations at 15.27GHz and 15.47GHz are displayed in Fig.6. Furthermore, there are differences in the strength of the electric field at this resonance on either side of the slot, which could lead to the slot radiating into space. It is evident that the inclusion of a dumbbell-shaped slot affects the electric distribution at both resonances.

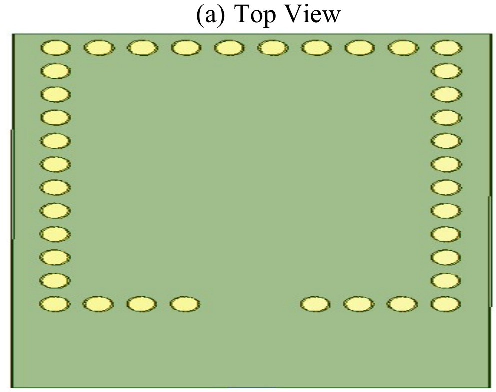


(a) 15.27GHz (b) 15.47GHz

Fig. 6. Current distribution of SIW cavity dumbbell shaped slot Antenna



(a) Top View



(b) Bottom View

Fig. 7.Proposed Antenna

permittivity value

4. RESULTS AND DISCUSSION

The simulated designs with top and bottom views have been shown in below Fig. 7.
The reflection coefficient (S11) characteristics of the simulated antenna Iteration-1, Iteration 2 and Iteration-3 represented in figure 8. This paper is focused to achieve minimum return losses, high gain value. Iteration-1 is simulated with SIW cavity structure. In Iteration-2, horizontal slot and the performance of the antenna is examined. In Iteration-3, dumbbell heads are added to the slot. This Patch with applied SIW structure is excited with line feed.

In Iteration-1 antenna is resonating at 14.85GHz and the corresponding reflection coefficient (S11) value is -18.80dB, feeding power is reflected owing to transmission line and feed point miss match. To minimize the radiation losses, the dumbbell supporting rod slot is applied in Iteration-2. The antenna is resonating at dual frequencies. The return losses -20.85dB at 15.17GHz and -20.21dB at 16.20GHz are observed. The return loss with Iteration 3 is -30.50dB at resonance frequency of 15.27GHz and -28.34dB at 15.47GHz resonance frequency. The proposed SIW applied dumbbell shaped slot antenna is resonating at 15.27GHz and 15.47GHz frequencies. The return losses are significantly reduced.

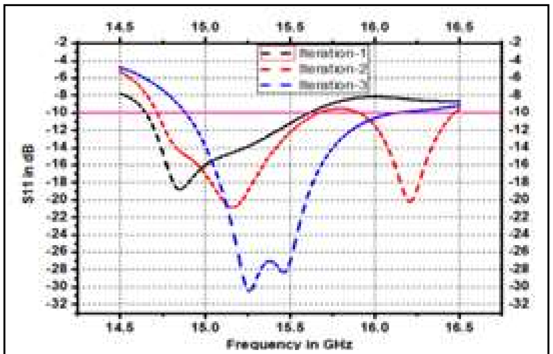


Fig. 8. Reflection Co-efficient

In Iteration-1, it is observed that VSWR value is 1.26 at 14.85GHz resonating frequency. In Iteration-2 the VSWR value 1.20 is observed at 15.17GHz and 1.22 at 16.20GHz respectively. The VSWR values for iteration 1 and 2 are lies within the limit of 1.2 and 1.5. Accordingly in Iteration-3, VSWR values are 1.06 and 1.08 at respective resonating frequencies 15.27GHz and 15.47GHz. It represents the Iteration3 (proposed antenna) exhibits no reflected energy and the antenna is a good match with the transmission line
Fig. 10 Gain in 3D plot represents the gain performances of the antenna design structures Iteration-1, 2 and 3.

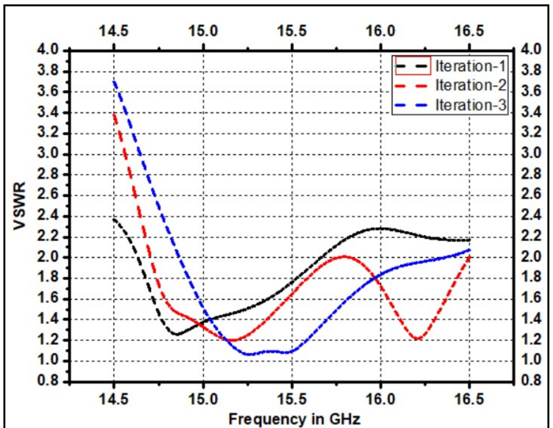
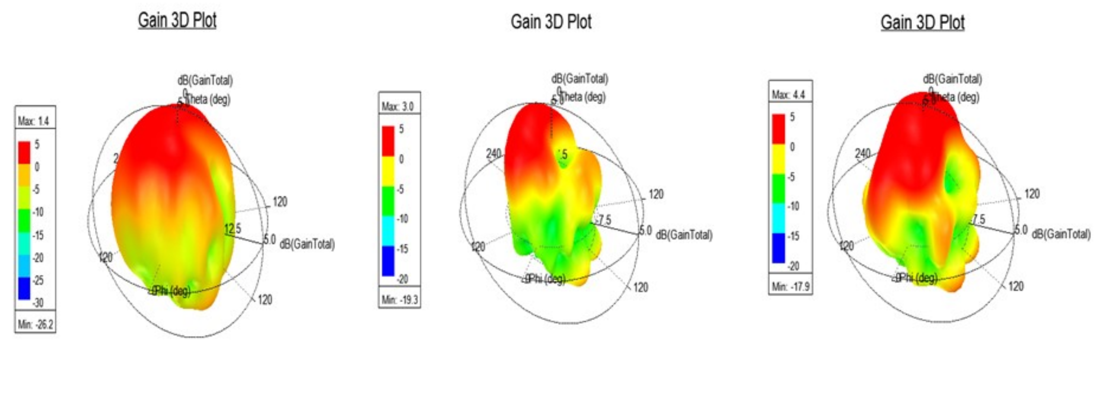


Fig. 9. Voltage Standing Wave Ratio

that peak gain is 3dB. Accordingly proposed SIW based dumbbell shaped slot antenna produce peak gain of 4.4dB. By the comparison of all design Iterations, proposed antenna having maximum gain.
The bandwidth at -10dB is measured from the Fig.9 As per Iteration-1 design structure explore the f1 frequency is 14.65GHz and f2 frequency is 15.60GHz. The resultant bandwidth is 0.96 GHz. In Iteration-2 design the antenna is operating in between 14.72GHz and 15.65GHz the resultant bandwidth is 0.93GHz.
At the second frequency band range between 16.65GHz and 15.92GHz with operational bandwidth is 0.27GHz

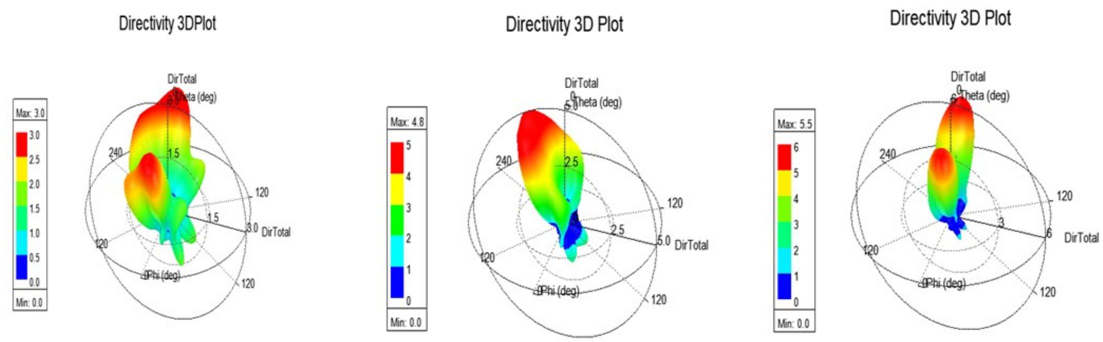
Journal of Theoretical and Applied Information Technology
30th June 2025. Vol.103. No.12

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195



(a) Iteration-1 (b) Iteration-2 (c) Iteration-3

Fig. 10. Gain plot



(a) Iteration-1 (b) Iteration-2 (c) Iteration-3

Fig. 12. Directivity

Table.2 Comparative parametric analysis of design Iterations

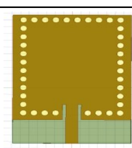
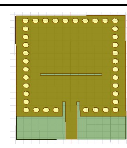
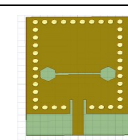
Parameter	Iteration-1	Iteration-2	Iteration-3
Design structure			
Resonating Frequency (GHz)	14.85	15.17 & 16.20	**15.27 & 15.47**
S11(dB)	-18.80	-20.85 & -20.21	**-30.50 & -28.34**
VSWR	1.26	1.20 & 1.22	**1.06 & 1.08**
Gain(dB)	1.4	3	**4.4**
Directivity	3	4.8	**5.5**
Bandwidth (GHz)	0.96	0.93 & 0.54	**1.38**

Table.3 Proposed antenna with existing reported SIW-Cavity based antennas (CBA's).

References [Year]	Dimensions in mm (LxW)	ϵ_r	Height (h) (mm)	Design (Radiator)	Feed	Resonating Frequency (fr) (GHz)	Peak Gain (dB)	BW
22[2015]	36x26	2.2	0.787	Dumbbell-shaped slot	MSL	9.5 & 13.85	4.3	200MHz
23[2016]	32x22	2.2	0.787	Bow-tie shaped slot	MSL	11.5 & 12.02	5.2	900MHz
24[2017]	23.2x18.8	2.2	1	Slot & shorting vias	MSL	9.32,9.97,10.70 & 11.12	7.3	65MHz
25[2018]	44x24.5	3.55	1.524	Semi hexagonal slot	MSL	5.8	5	70MHz
26[2019]	26x22	2.2	1	Slot & unbalanced vias	MSL	8.8 & 10.7	4.9	1.9GHz
27[2020]	29.5x23.5	2.2	1.57	Dumbbell-shaped slot	MSL	10	6.2	1.4GHz
28[2021]	96.87x45	4.4	1.6	Dual Dumbbell & Rectangular Slot	Tapered MSL	2.45	2.5	0.3GHz
29[2022]	36x24	2.2	1.57	I-shaped slot	MSL	9.75 & 10.6	5.6	1.56GHz
31[2024]	40x60	4.4	1.6	Split Ring Resonator	MSL	5.8	11.15	0.4GHz
Proposed work	**38x28**	**4.4**	**1.57**	**Dumbbell-shaped slot**	**MSL**	**15.27 & 15.47**	**4.4**	**1.38GHz**

ϵ_r –di electric constant of the substrate, MSL-Micro strip Line

5. CONCLUSION

This work discusses the results of a wideband antenna based on a SIW cavity loaded with a hexagonal dumbbell-shaped slot. For planar integration, a micro strip line feed is applied to replicate the SIW cavity. Because of the loading of the hexagonal dumbbell-shaped slot, which is positioned almost in the center of the SIW cavity, the lowest mode's individual bandwidth is shifted upward and linked with higher-order resonances, which increases the antenna's bandwidth to 1.38GHz. The gain achieved with the proposed antenna is 4.4 db.

By the comparison of all design Iterations, proposed antenna having maximum gain. From the comparative analysis, it is clearly observed that Iteration-3 dumbbell shaped slot SIW cavity antenna exhibits better parametric as compared with reaming Iterations.

Table 3 displays a performance comparison of suggested design with the currently reported antennas in order to demonstrate its merit. It is evident that the suggested SIW-based hexagonal dumbbell-shaped slot antenna design provides a respectable gain and bandwidth. The suggested antenna satisfies the wideband response in comparison to the other antennas mentioned in [21-31]

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Highest gain 7.3db is achieved with reference 24 but the band width is dropped to a lowest value. High gain 5.6db and bandwidth 1.56GHz is achieved with ref.29 but the antenna is resonating at 9.75 and 10.6 GHz frequency only. This antenna is not recommended at operating points. The proposed antenna is resonating at 15.27 GHz and 15.47 GHz frequencies. The gain achieved is 4.4db and the bandwidth is 1.38GHz. This antenna cis best fit for a wide band communication application specifically in the domain of aerospace and medical era.

REFERENCES:

[1] Deslandes D, Wu K. "Integrated microstrip and rectangular waveguide in planar form", IEEE Microwave Wireless Components Lett 2001;11(2):68–70. https://doi. org/10.1109/7260.914305.

[2] Hong W, WU K, Tang H, Chen J, Chen P, Cheng Y et al. "SIW-like guided wave structures and applications", IEICE Trans Electron. 2009.

[3] Kunwar A, Gautam AK, Rambabu K. "Design of a compact U-shaped slot triple band antenna for WLAN/WiMAX applications", AEU-Int J Electron Commun 2017;71: 82–8.

[4] Chen SY, Hsu P. "Broad-band radial slot antenna fed by coplanar waveguide for dual-frequency operation", IEEE Trans Antennas Propag 2005;53(11):3448–52.

[5] Lin JF, Chu QX. "Increasing bandwidth of slot antennas with combined characteristic modes", IEEE Trans Antennas Propag 2018;66(6):3148–53. https:// doi.org/10.1109/ TAP.2018. 2811846.

[6] Bozzi M, Geordiadis A, Wu K. "Review of substrate-integrated waveguide circuits and antennas", IET Microwaves Antennas Propag 2011;5(8):909–20. https://doi. org/10.1049/iet-map.2010.0463.

[7] Harikowa J, Arai H, Goto N. "Cavity-backed wide slot antenna", IEE proceedings H - Microwaves, Antennas Propagat 1989;136(1):29–33.

[8] Chen Z, Shen Z. "A conformal cavity-backed supergain slot antenna", In: IEEE Antennas and Propagation Society International Symposium (APSURSI); 2014. pp. 1288–9.

[9] Liu Y, Chen S, Ren Y, Cheng J, Liu QH. "A broadband proximity-coupled dualpolarized microstrip antenna with L-shape backed cavity for X-band applications", AEU-Int J Electron Commun 2015;69(9):1226–32..

[10] Basit MA, Wen G, Rasool N, Xiaolin X. "A wide-band cavity-backed slot antenna for end-fire radiation", Microwave Opt Technol Lett 2016;58(1):193–6. https://doi. org/10.1002/mop.29524.

[11]. Zarifi D, Ahmadi A. "A broadband slant polarized cavity backed microstrip-fed wide-slot antenna array", e22164 Int J RF Microwave Comput Aided Eng 2020.

[12] Yoshimura Y. "A micro strip slot antenna", IEEE Trans Microw Theory Tech 1972;20 (11):760–2.

[13] Luo GQ, Hu ZF, Dong LX, Sun LL. "Planar slot antenna backed by substrate integrated waveguide cavity", IEEE Antenna Wireless Propagat Lett 2008;7:236–9.

[14] Kumar A, Saini G, Singh S. "A review on future planar transmission line", Cogent Eng 2016;3(1):1–12.

[15] Yun S, Kim DY, Nam S. "Bandwidth and efficiency enhancement of cavity-backed slot antenna using a substrate removal", IEEE Antenna Wireless Propagat Lett 2012; 11:1458–61.

[16] Yun S, Kim DY, Nam S. "Bandwidth enhancement of cavity backed slot antenna using a via-hole above the slot", IEEE Antenna Wireless Propagat Lett 2012;11: 1092–5.

[17] Feng C, Yang J, Yan L, Zhang Y, Geng Y, Zhang W. "Broadband substrate-integrated waveguide slot antenna", Electromagnetics 2012;32(5):294–304. https://doi.org/ 10.1080/ 02726343.2012.686844.

[18] Mukherjee S, Biswas A, Srivastava KV. "Broadband substrate integrated waveguide cavity-backed bow-tie slot antenna", IEEE Antenna Wireless Propagat Lett 2014;13: 1152–5.

[19] Mukherjee S, Biswas A. "Design of SIW cavity backed slot antenna for wideband application", In: Asia-Pacific Microwave Conference (APMC) New Delhi; 2016. p. 1–4;

[20] Yang W, Zhou J. "Wideband low profile substrate integrated waveguide cavity backed E-shaped patch antenna", IEEE Antennas Wirel Propag Lett 2013;12:143–6.

[21] Xu et.al, "Guided wave and leakage characteri stics of substrate integrated waveguide", IEEE Transactions. Microwave Theory Technology, vol. 53, no. 1, pp. 66-73, 2005.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[22] S mukerjee et.al, "Substrate Integrated Waveguide Cavity Backed Dumbbell Shaped Slot Antenna for dual frequency applications", IEEE Antennas and Wireless Propagation Letters,2015.
[23] Sourav Nandi and Akhilesh Mohan "Bowtie Slotted Dual-Band Siw Antenna", Microwave and Optical Technology Letters, Vol. 58, No. 10, October 2016.
[24] Shi Y et.al, "Wideband triple- and quad-resonance substrate integrated waveguide cavity-backed slot antennas with shorting vias", IEEE Transaction Antennas Propagation, vol.65, no. 11, pp. 5768–5775, 2017.
[25] Divya Chaturvedi & S. Raghavan "A Half-Mode SIW Cavity-Backed Semi-Hexagonal Slot Antenna for WBAN Application", IETE Journal of Research, 2018.
[26] Wu Q, Yin J, Yu C, Wang H, Hong W. "Broadband planar SIW cavity-backed slot antennas aided by unbalanced shorting vias". IEEE Antennas Wireless Propag Lett 2019;18(2):363–7.
[27] Lokeshwar Bollavathi et.al, "Wideband planar substrate integrated waveguide cavity-backed amended dumbbell–shaped slot antenna", International Journal of Electronics and Communications, pp.1-9, October2020.
[28] Mekaladevi Velusamy et.al, "Design and Analysis of Dual Dumbbell and Rectangular Slots SIW Cavity-Backed Antenna at 2.45 GHz", Serbian Journal Of Electrical Engineering, Vol. 18, No. 2, pp. 211-224,June 2021,
[29] Anil Kumar Katta and Praveen Babu Choppala "Development of a Low Profile Wideband SIW Cavity-Backed I-Shaped Slot Antenna", Progress In Electromagnetics Research C, Vol. 123, 227–236, 2022.
[30] Shankaragouda M.et.al,"Bandwidth enhancement of substrate integrated waveguide cavity-backed half bow-tie complementary-ring slot antenna for Ku-band applications", Alexandria Engineering Journal, pp.46 54, September 2023,
[31] Dhara M Patel and Falguni Raval, "Gain improvement of HMSIW Antenna with SRRs", December 2024.