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Design of a 'Helicop' Shaped Dual-Band Patch Antenna for 5G mm-Wave Wireless Communication Applications

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ABSTRACT

This paper introduces a Helicop shaped dual -band patch antenna designed for the applications of 28/38 GHz 5G mm-wave wireless communication. The proposed antenna is made on Rogers RT5880 material and has dimensions of 7 mm x6 mm x 0.8 mm. The antenna employs rectangular Slots and Stubs positioned identically within the patch, along with the slots in the ground, The 28 GHz and 38 GHz frequencies are where the antenna is most suited to resonate. At these frequencies, it shows excellent performance, with return losses of -20.1 dB at 28 GHz and -19 dB at 38 GHz, while maintaining a VSWR of below 2 for the 28 GHz and 38 GHz bands. A dual-band patch antenna was modelled and analyzed through CST software.

Keywords: return loss, 5G antenna, mm-wave, and wireless communication.

1. INTRODUCTION

The millimeter wave (mm-Wave) frequency band, ranging from 20 to 50 GHz, has been designated for use in fifth-generation (5G) communication systems [1]. This band offers significant advantages, including higher data rates, increased capacity, and reduced latency, which are anticipated to meet the growing demands of end users in the near future [2]. Frequencies such as 2 8 GHz, 38 GHz, and 48 GHz are currently under consideration for mobile network deployments due to their suitability for high-speed data transmission [3]. Recent studies have presented antenna designs operating at 28 GHz and 38 GHz, specifically developed to enhance gain performance [4]. These designs often incorporate features such as elliptical slots and stubs are employed on patch, and defected ground structures to improve return loss [5]. The development of compact antennas capable of operating in the mm-Wave band is essential for modern wireless communication systems [6]. In particular, the 28 GHz frequency band has emerged as a promising candidate for implementing dense 5G small-cell networks in urban environments, where high user density demands robust and efficient connectivity. [7]. The newest wireless communication technology for mobile networks is called 5G. It marks a significant advancement over 4G by providing features that were previously unavailable [8]. Notably, 5G enables ultra-fast data speeds, extremely low latency, highly reliable connections, and supports a vast number of connected devices simultaneously [9]. This study's multi-band antenna design operates in several fundamental modes, each of which is connected to a distinct circular slot [10]. This makes the antenna attractive, as it achieves higher gain and efficiency for each dominant mode [11]. This work presents an innovative approach to antenna design for 5G access points, featuring the use of concentric elliptical and rectangular stubs and slots operating at millimeter-wave frequencies [12]. A helicop shaped patch antenna design is proposed for use in 5G mobile terminals operating in the mm-wave frequency ranges [13]. To develop a millimeter-wave antenna, it's essential to increase the bandwidth in order to support multiband applications [14]. Antenna design was carried out to support dual-band operation, specifically targeting the 28 GHz and 38 GHz frequency bands [15].

This paper introduces a novel compact of helicop shaped dual band structure for 28 GHz and 38 GHz wireless communication applications. The dimensions of the suggested antenna simulation are 7 mm x 6 mm by 0.8 mm. The dielectric constant of the Rogers RT5880 substrate material used in this technology is 2.2. and a loss tangent of 0. 0009. To Enhance return loss of single elements, an elliptical, rectangle and square slot and Stubs is placed at patch. The design exhibits better return loss at both 28 and frequencies of 38GHz.The next parts discuss the antenna design analysis, findings, and conclusion.

2. ANTENNA DESIGN AND GEOMETRY

A dual -band helicop shaped patch antenna has been developed for operation at 28 GHz and 38GHz, elliptical and rectangular Slots are etched on the patch. Consequently, the resulting antenna operates at frequencies of 28 GHz and 38GHz.The dimensions of propose antenna is 7 mm x 6 mm, possesses a relative permittivity of 2.2. Table 1 lists the antenna's dimensions.

ANTENNA DESIGN

2.1 Patch Antenna

Initially, as presented in Fig.1(a), a basic patch antenna with an elliptical-shaped main body and a feed line was designed for resonant frequencies at 28 GHz and 38 GHz. However, the antenna exhibited an operational frequency range from 41.2 GHz to 46.2 GHz, centered at 43.2 GHz. But we didn't get our required resonance frequency band. The outcomes of the simulation are depicted in Fig.1(a), indicating a return loss of -16 dB at 43.2 GHz.

2.2 Patch Antenna with Stubs and Slots

The designed basic antenna is further upgraded to create for accurate resonance at 28 GHz and 38 GHz millimetre-wave frequency. For this purpose, an elliptical shaped patch with stubs and slots is done for desired resonates. then we got the operational frequency range from 41.8 GHz to 47.7 GHz Centered at 44.2 GHz. But we didn't get our required resonance frequency band. The outcomes of the simulation are depicted in Fig .1(b), indicating a return loss of -22.8 dB at 44.2 GHz.

2.3 Patch Antenna with Middle Square Slot

In next stage we added, a Square Slot referred as in the middle of the Patch. This modification expanded the operational frequency ranges from 38.6 GHz to 45.1 GHz, with a centered frequency at 42.4GHz. This work presents an innovative approach to antenna design for 5G access points, featuring the use of concentric elliptical and rectangular stubs and slots operating at millimeter-wave frequencies. But we didn't get our required resonance frequency band. The outcomes of the simulation are depicted in Fig.1(c), indicating a return loss of -26.2 dB at 42.4 GHz.

2.4 Ground Without Slots2.4 Ground Without Slots

A dual-band helicop shaped patch antenna has been designed to operate at 28 GHz and 38 GHz. The proposed antenna, featuring a full ground plane, has dimensions of 7 mm * 6 mm.

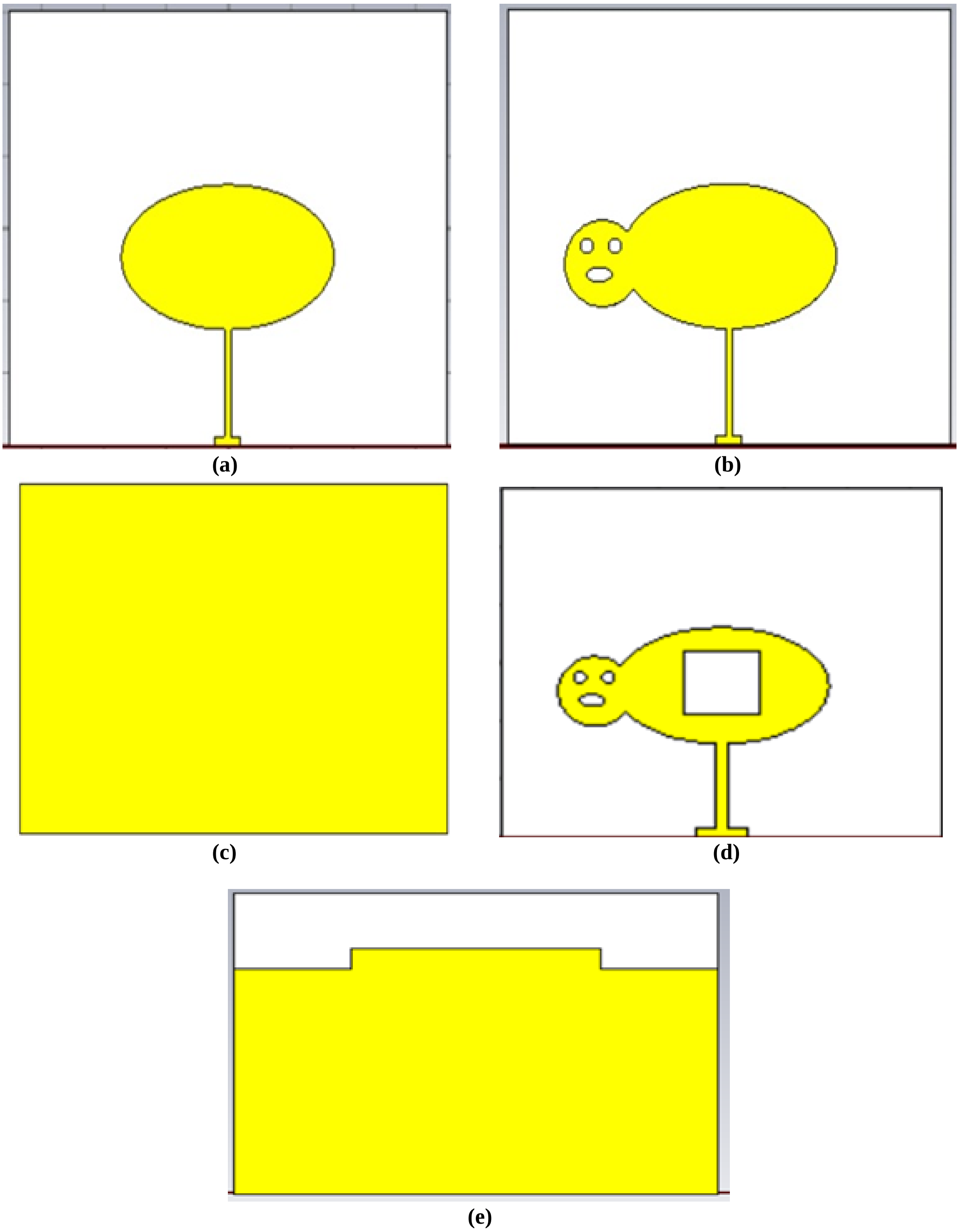
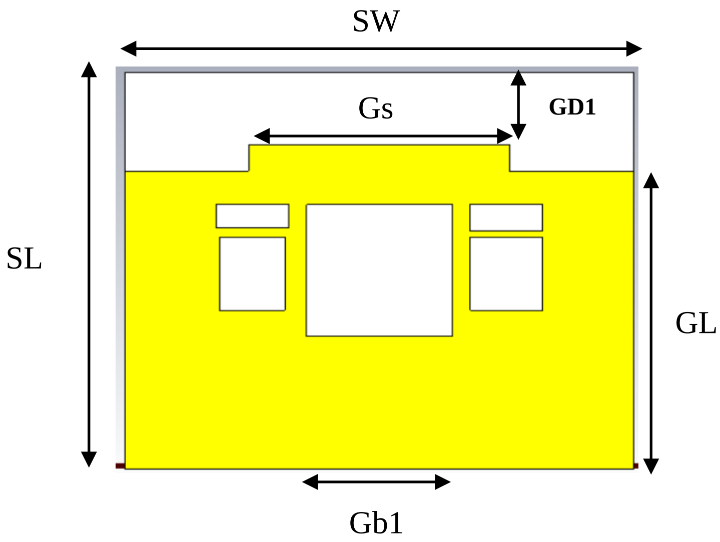


Fig 1(a)Patch.1(b): Patch with Stubs and Slots.1(c): Ground and.1(d): Patch with Middle Square Slot.1(e): Partial Ground with Stub.

2.5 Ground with Square Slots and Rectangular Slots

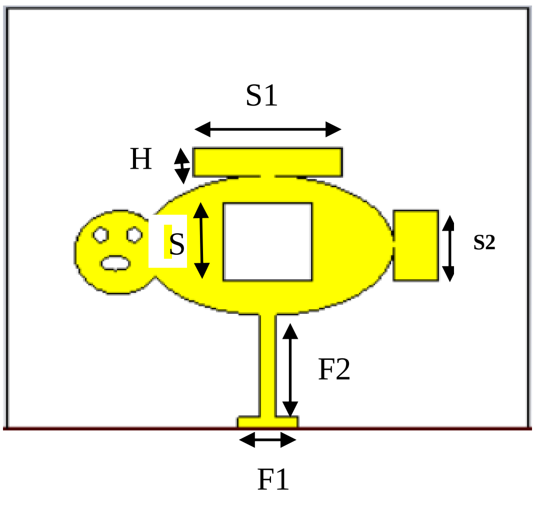
In the second stage, to improve the resonance characteristics, a Square Slots and Rectangular Slots incorporated into the design at Ground. the designed antenna achieves the dual-band functionality, to achieve perfect bands at 28 GHz and 38 GHz.



(a)

2.6 Patch Antenna with Elliptical Slots and Square Slot

In the third stage, to improve the resonance characteristics, an Elliptical Slot and Square Slot referred to as the "Head and Back" was incorporated into the design. This modification expanded the operational frequency ranges from 27.1 GHz to 28.5 GHz, with a centered frequency at 27.8 GHz and similarly, the frequency ranges from 36.6 GHz to 40.1 GHz centered at 38.2 GHz. then we got our required resonance frequencies. The outcomes of the simulation are depicted in Fig 3(d), indicating a return loss of -20.1 dB at 27.8 GHz and -19 dB at 38.2 GHz.



(b)

Fig 2: (a)Ground with Square Slots and Rectangular Slots.2(b) Patch antenna with Elliptical Slots and Square Slots.

2.7 PARAMETERS:

Parameters	**SW**	**SL**	**GL**	**GD**	**Gb1**	**GD1**
Values	7	6	2.5	4.5	2	4.9
Parameters	F1	F2	S1	S2	S	H
Values	0.4	1.95	2	1	1.1	0.482

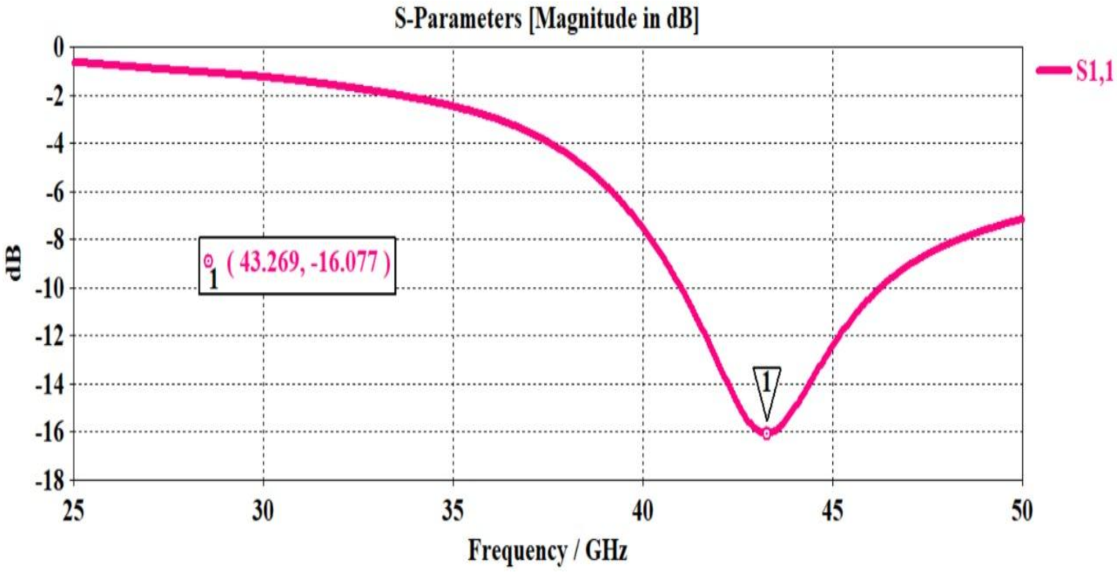
TABLE 1. The proposed helicop shaped dual-band antenna parameters and their values (unit: mm)

3. RESULTS AND DISCUSSIONS

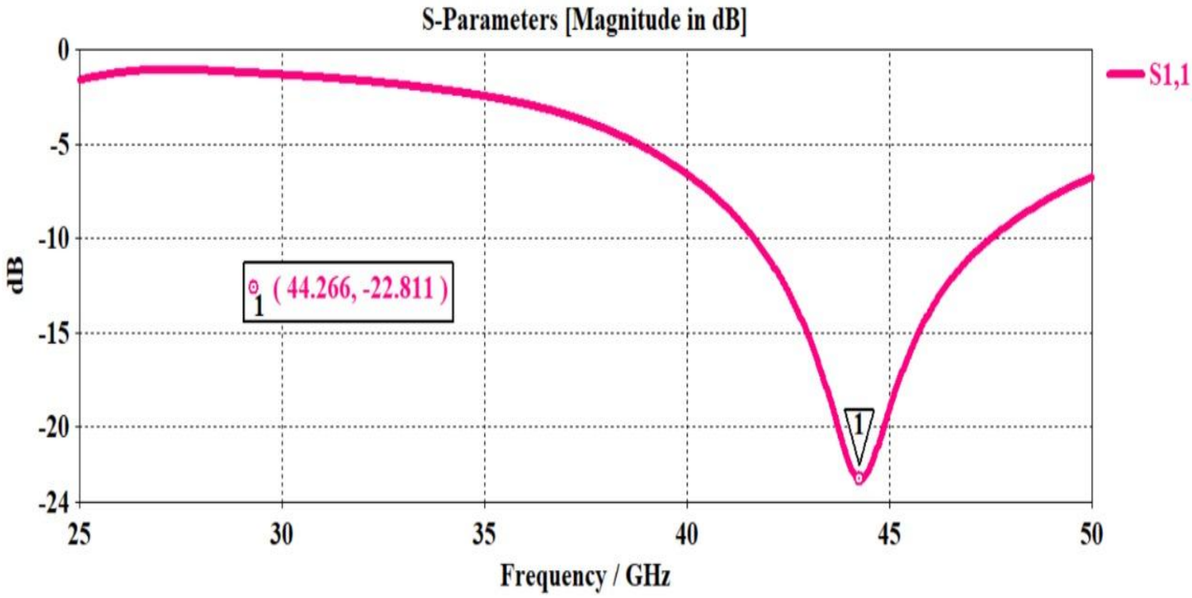
An analysis of the dual-band helicop shaped patch antenna's performance is carried out by examining its S-parameters, VSWR, surface current distribution, and radiation pattern.

3.1. S-Parameters

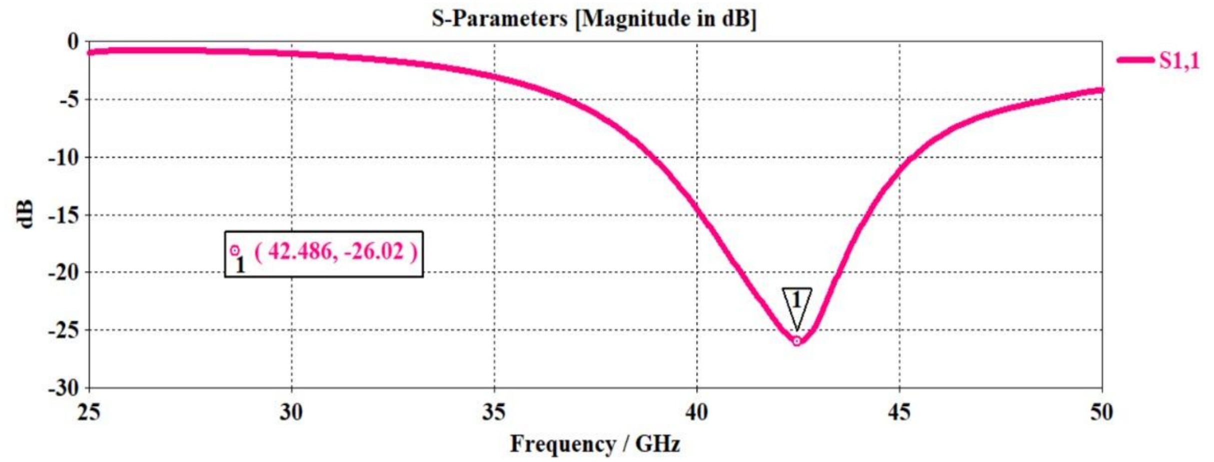
Figure 3(d) displays the S-parameters of dual-band helicop shaped patch antenna with slots and Stubs. However, introducing slots in patch and ground creates an additional resonance at 38 GHz. The proposed design provides return loss of -20.1dB at 28GHz and -19 dB at 38 GHz. Introducing slots modifies the current distribution on the antenna surface, resulting in multi-frequency resonance characteristics.



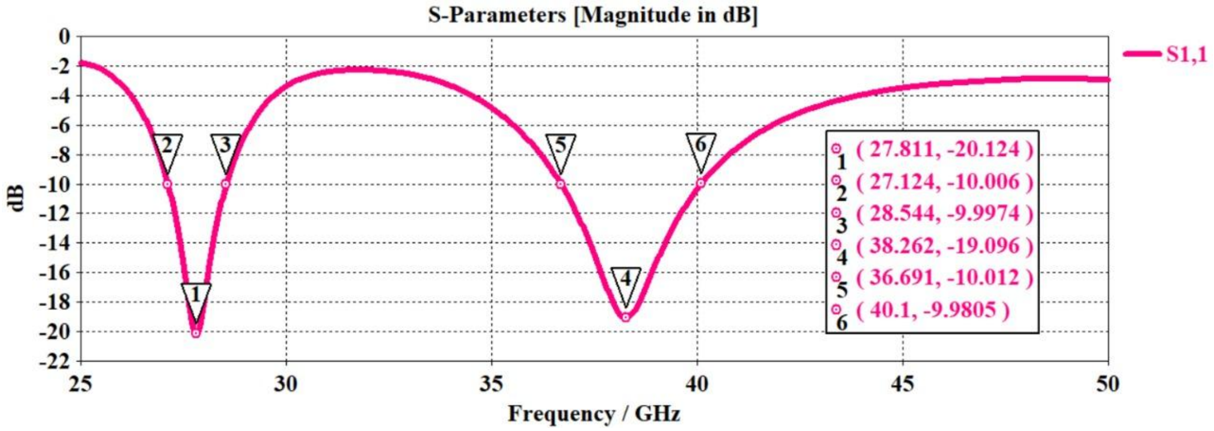
(a)



(b)



(c)



(d)

Fig 3:(a) band occurred at 43.2 GHz. 3(b): band occurred at 44.2 GHz.3(c)band occurred at 42.4 GHz.3(d)got the required frequency band at 28 GHz and 38 GHz.

3.2. VSWR (VOLTAGE STANDING WAVE RATIO)

In Fig. 4, the VSWR plot of the proposed antenna design featuring elliptical-shaped slots is shown, with the resonant frequency observed to be below 2.

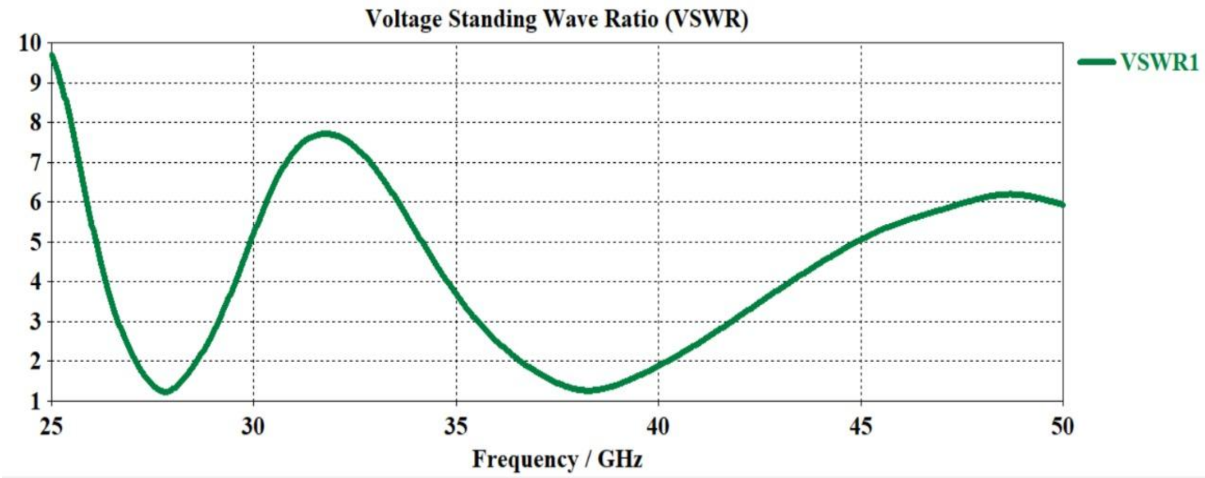
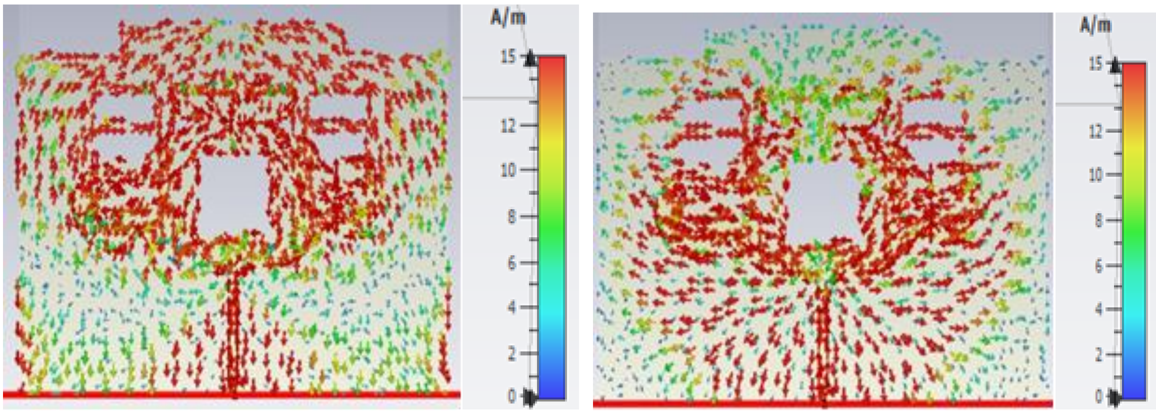


Fig 4: VSWR Plot below 2 at 28 GHz and 38 GHz

3.3. Surface Current Distributions



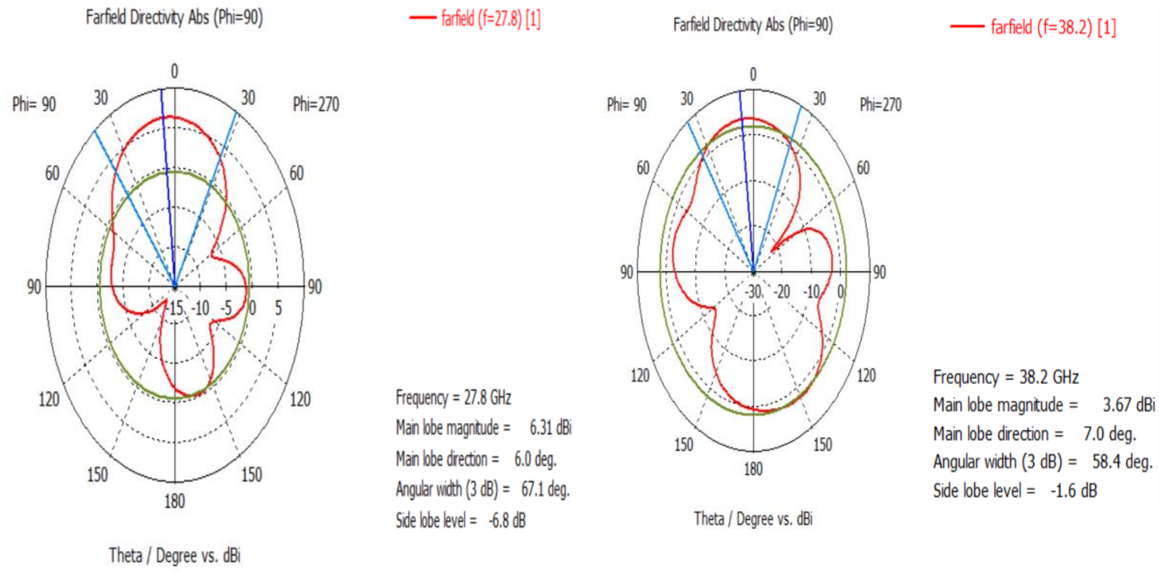
(a) **(b)**

Fig 5: Surface Current Distributions of port at (a)28GHz and 5(b) at 38GHz

From Fig 5 show the surface current distributions on the antenna. At 28 GHz, strong current concentration is seen around the central and lower slot regions, indicating active resonance there. Similarly, at 38 GHz the current spreads differently, especially around the outer slots, suggesting that distinct parts of the antenna structure resonate at each frequency.

4. Radiation Patterns

4.1 2-D Radiation Patterns at 28 GHz

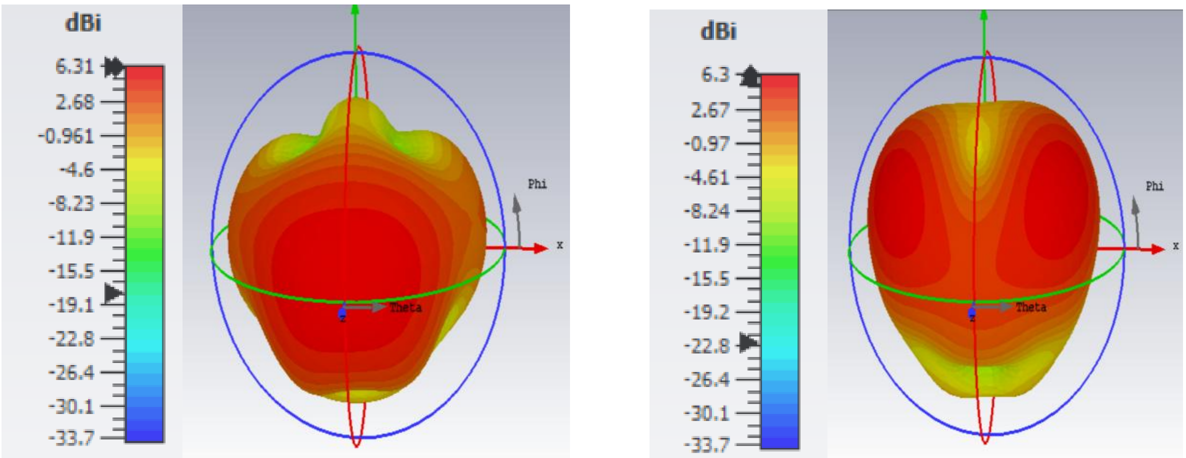


(a) **(b)**

Fig-6: 2-D Radiation Pattern at(a) 28GHZ and (b) 38GHz

This 2-D radiation pattern shows the far-field directivity of an antenna at 27.8 GHz with Phi = 90°.The main lobe has a peak gain of 6.31 dBi in the 6.0° direction, with a 3 dB angular width of 67.1°. The side lobe level is -6.8 dB, indicating good directionality and low side lobe interference. And similarly, for 38 GHZ 2-D radiation pattern shows the far-field directivity of an antenna at 38.2 GHz with Phi = 90°.The main lobe has a peak gain of 3.67 dBi in the 7.0° direction, with a 3 dB angular width of 58.4°. The side lobe level is -1.6 dB, indicating good directionality and low side lobe interference.

4.2 3-D Polar Plot



(a) **(b)**

Fig 7: 3-D Radiation Pattern at(a) 28 GHZ and (b) 38 GHz

The image illustrates the 3D radiation patterns of a 5G millimeter-wave (mm-wave) antenna operating at two key frequencies at 28 GHz and 38 GHz. These frequencies are widely used in 5G New Radio (5G NR) technology to provide high-speed data transmission and low latency, particularly in dense urban environments. The radiation pattern at 28 GHz (Figure 4) shows a relatively omnidirectional gain distribution, suggesting it is well-suited for broader area coverage, such as in small cells. In contrast, the 38 GHz pattern (Figure 4(b)) exhibits more pronounced directional lobes, which are indicative of beamforming capability allowing the antenna to focus energy in specific directions for improved signal strength and capacity. The gain values, measured in dBi, are color-coded, with red areas representing higher gain and blue indicating lower gain. Such characteristics are essential in 5G systems where antenna design must balance coverage, directionality, and signal strength to meet the high data demands and dense connectivity of modern networks.

CONCLUSION

A Dual-band helicop shaped Patch Antenna for 5G mm-Wave applications was designed and tested. The antenna works well at 28 GHz and 38 GHz showing a return loss of -21.2 dB and -19 dB which means very little signal is lost. The Elliptical shape helped make the antenna small and improved its performance. Overall, the design is a good choice for compact and efficient 5G systems and can be further improved for future wireless technologies.The proposed antenna comprises two radiating elements with ground slots on the substrate's bottom side and elliptical stubs on the top and back side. Elliptical slots are inserted on patch antenna element to enhance return loss. The 5G mm-wave helicop shaped dual-band patch antenna holds great promise for future wireless technologies. Its compact size, ease of integration, and potential for smart reconfigurability make it a strong candidate for next-generation applications. From chip-level integration in mobile and IoT devices to use in drones, satellites, and smart sensing systems, these antennas will play a key role in enabling faster, smarter.

Declaration by Authors

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Conflict of Interest: None declared.

REFERENCES

1. Zhang, D. Wu, K.L. Yeung, L. Jiang, and R. Murch, "Decoupling and matching network for binary-band MIMO antennas, " IEEE Trans. Antennas Propag., vol. 70, no. 3, pp. 1764-1775, Mar. 2022.
2. Yang, R.; Xi, S.; Cai, Q.; Chen, Z.; Wang, X.; Liu, G. A Compact Planar Dual- Band Multiple- Input and Multiple- Affair Antenna with High insulation for 5G and

4G operations. Micromachines 2021,12,544. doi10.3390/mi12050544.
3. H. M. Marzouk, M. I. Ahmed, and A. A. Shaalan, “Novel dual-band 28/38 GHz MIMO antennas for 5g mobile applications,” Prog. Electromagn. Res. C, vol. 93, pp. 103–117, 2019.
4. M. Aboualalaa et al., “Independent Matching Dual-Band Compact Quarter-Wave Half-Slot Antenna for Millimeter-Wave Applications,” IEEE Access, vol. 7, pp. 130782–130790, 2019.
5. D. T. T. Tu, N. T. B. Phuong, P. D. Son, and V. Van Yem, “Improving characteristics of 28/38GHz MIMO antenna for 5G applications by using double-side EBG structure,” J. Commun., vol. 14, no. 1, pp. 1–8, 2019.
6. P. Talebbeydokhti, S. Dalmia, T. Thai, R. Sover and S. Tal, "Ultra Large Area SIPs and Integrated mm-WaveAntenna Array Module for 5G mm-Wave Outdoor Applications," 2019 IEEE 69th Electronic Components and Technology Conference (ECTC), pp. 294-299, 2019.
7. M. N. Naik and H. A. Virani, "High Gain 16 Ports MIMO Antenna at 60 GHz for Millimeter Wave Applications," 2019 IEEE Indian Conference on Antennas and Propogation (In CAP), pp. 1-3, 2019.
8. R. Singh, G. K. Soni, R. Jain, A. Sharma and N. V. Tawania, "PAPR Reduction for OFDM Communication
9. System Based on ZCT-Pre-coding Scheme," IEEE Second International Conference on Electronics and Sustainable Communication Systems (ICESC), pp. 555-558, 2021.
10. Chang, L.; Yu, Y.; Wei, K.; Wang, H. Orthogonally Polarized Dual Antenna Pair with High Isolation and Balanced High Performance for 5G MIMO Smartphone. IEEE Trans. Antennas Propag. 2020, 68, 3487–3495.
11. Li, M.-Y.; Ban, Y.-L.; Xu, Z.-Q.; Wu, G.; Sim, C.-Y.-D.; Kang, K.; Yu, Z.-F. Eight-Port Orthogonally Dual-Polarized Antenna Array for 5G Smartphone Applications. IEEE Trans. Antennas Propag. 2016, 64, 3820–3830. [CrossRef]
12. Chen, Q.; Lin, H.; Wang, J.; Ge, L.; Li, Y.; Pei, T.; Sim, C.-Y.-D. Single Ring Slot-Based Antennas for Metal-Rimmed 4G/5GSmartphones. IEEE Trans. Antennas Propag. 2018, 67, 1476–1487. [CrossRef].
13. 12.X. Wang, Y. Wu, W. Wang, and A. A. Kishk, “A simple multi-broadband planar antenna for LTE/GSM/UMTS and WLAN/WiMAX mobile handset applications,” IEEE Access, vol. 6, pp. 74453-74461, 2018.
14. C. Deng, Y. Li, Z. Zhang, and Z. Feng, “Planar printed multi-resonant antenna for octa-band WWAN/LTE mobile handset,” IEEE Antennas Wireless Propag. Lett., vol. 14, pp. 1734-1737, 2015.
15. 14.R. Tang and Z. Du, “Wideband monopole without lumped elements for octa-band narrow-frame LTE smartphone,” IEEE Antennas Wireless Propag. Lett., vol. 16, pp. 720-723, 2017.
16. 15. Nachabe, N., Luxey, C., Titz, D., Costa, J. R., Matos, S. A., Gianesello, F., & Fernandes, C. A. (2017, July).
17. Low-cost 60 GHz 3D printed lens fed by a planar source with WR15 transition integrated on FR4 PCB. In
18. Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2017 IEEE International Symposium on (pp. 2671-2672). IEEE.

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