Journal of Nano- and Electronic Physics
Vol. **18** No 5, 05030(5pp) (2026)

Журнал нано- та електронної фізики
Том **18** № 5, 05030(5cc) (2026)

OPEN ACCESS

REGULAR ARTICLE

A Compact Octagonal Shaped Antenna for ISM Band Applications

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(Received 05 June 2026; revised manuscript received 18 October 2026; published online 28 October 2026)

This article discusses how wireless communication systems use small, effective antennas to send and receive signals. Because of their small size, low profile and ease of fabrication, micro strip feed line patch antennas have become more and more common. They have been successfully constructed with partial ground plane for ISM band applications. The antenna is built on FR4 substrate with relative permittivity of 4.3 and thickness of 1.6mm. Its dimensions are 50 mm × 50 mm × 1.6 mm. An inset feed line, which offers a small and effective feeding mechanism, feeds the antenna. The performance of antenna has been evaluated using the HFSS 21.0 version. The planned antenna achieved – 10 dB impedance bandwidth of 1 GHz, stretching from 2.4 GHz to 5.8 GHz, with a return loss of – 18 dB at 2.4 GHz and – 34 dB at 5.8 GHz. It also shows improvements of 14 and 11 dB peak gain at 2.4 GHz and 5.8 GHz respectively with about 93 % radiation efficiency. Numerous wireless communication standards are compatible with the antenna.

Keywords: Patch antenna, Frequency, ISM band applications, Octagonal tree mode.

DOI: 10.21272/jnep.18(5).05030 PACS number: 84.40.Ba

1. INTRODUCTION

In 1888, the German physicist Heinrich Hertz invented the Antenna. An antenna is a transducer that allows wireless transmission and reception across open space by transforming electrical impulses into electromagnetic waves that propagate [1]. "In wireless communication technologies, antennas perform a critical function, making them integral to any system that enables wireless signal transmission. Among their numerous applications, micro strip patch antennas hold significant importance in satellite communication" [2]. "A wide variety of antenna configurations are available to meet diverse functional needs. As modern electronic and communication systems move toward increasing miniaturization, compact antennas have become essential. Micro strip patch antennas are widely adopted because they provide reduced size, low mass, simple manufacturing processes, and seamless integration with other components." "A diverse range of antenna structures can be employed in embedded systems, including wire antennas [3], aperture-type antennas [4], meta surface-based reflectors [5], and micro strip patch antennas [6, 7]. Among these, micro strip patch antennas commonly known as printed antennas have attracted consistent research interest for several decades [8]. These antennas are typically described by parameters such as their physical dimensions (length and width), gain, and radiation characteristics" [9]. There are several patch feeding methods. The most widely used are the micro strip feeder, line feeder, and co-axial feeder. Different types of antennas are available, but the researchers are mainly focused on planar or printed antennas because of easy fabrication, low profile comfort, and low cost. The micro strip patch antennas (MSA) are also printed antennas because they are fabricated using micro strip techniques on a PCB (Printed Circuit Board). In MSA, the patches are constitutive elements in an array. The features of MSA comprise: 1. Patch Layer (Thin, flat metallic region); 2. Substrate Layer; 3. Ground Layer (Comparatively larger than patch dimension); 4. Excitation Layer (Antenna Feed).

It is appropriate for a variety of applications, including mobile communications, networking systems, radar, GPS, and Internet of things-based devices, because to its structural simplicity and functional advantages.[10] MPAs developed for embedded and wireless systems frequently operate in the ISM band and utilize WLAN communication in accordance with the IEEE 802.11b [11]. As a result, extensive research efforts have focused on developing compact, efficient, and robust antenna architectures for ISM-band operation [12-15]. This project aims to refine the antenna's geometry, substrate properties, and feeding approach in order to achieve optimal radiation performance while ensuring adaptability for the intended use cases [16]. Additionally, both bands are essential since small, portable systems are needed [17]. The primary components of the micro strip antenna are a substrate, ground plane and radiating element, also known as a patch. These are wired radiating elements, or monopole patch antennas [18] and large-radiating-surface micro strip antennas [19-21]. El Ansari et al. [22] designed and validated a wideband directional dual-beam antenna using a hybrid coupler.

This paper proposes a novel octagonal shaped antenna for ISM band applications. The work is significant because it demonstrates a compact and low-cost dual-

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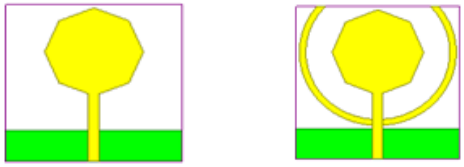
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Cite this article as: B. Gayathri, et al., *J. Nano- Electron. Phys.* 18 No 5, 05030 (2026) https://doi.org/10.21272/jnep.18(5).05030

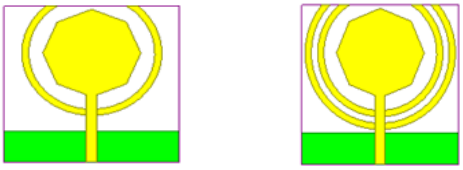
band antenna that provides wide bandwidth, high gain, and high efficiency at 2.4 GHz and 5.8 GHz which are key frequencies for ISM-band systems. Its simple planar structure and strong performance make it well suited for practical wireless, IoT and WLAN applications.

2. ANTENNA GEOMETRY

The dimensions of the suggested model are ($L \times W \times H$) 50 mm × 50 mm × 1.6 mm, with thickness of H = 1.6 mm and loss tangent of 0.025 with relative permittivity of ε_r = 4.3, we have chosen the FR-4 (lossy) substrate. It has been shown that the ground plane's dimensions are 10 mm × 50 mm. The designed simulation model of step-by-step iterations as shown in below figures.

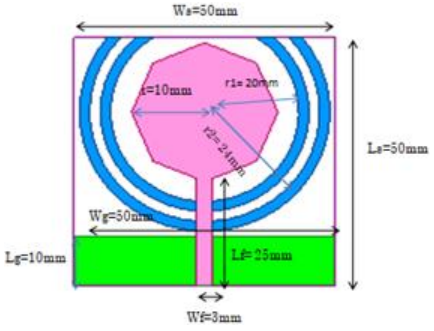


(a) Iteration1 (b) Iteration2



(c) Iteration3 (d) Iteration4

Fig. 1 – The designed simulation model of step-by-step Proposed antenna: (a) Iteration1, (b) Iteration2, (c) Iteration3, (d) Iteration4



(a) Simulated model in HFSS



(b) Front view (c) Rare view

Fig. 2 – The designed simulation model and fabricated model

"The paper introduces a micro strip antenna based on an *Octagonal Tree Model with Concentric Rings Shaped* Antenna Structure Configuration, optimized for Industrial, Scientific, and Medical (ISM) band usage in constrained environments. A 50-ohm feed port is employed for excitation. Antenna performance is improved through strategic slit insertion on the radiating patch, while ground-plane deformation contributes to wavelength reduction and enhanced compactness."

2.1 Antenna Design Details

A conductive patch, a dielectric substrate, and a ground plane are the three main components of a conventional micro strip patch antenna. Patches can have a variety of shapes, including rectangular, circular, and ring geometries.The presented design targets ISM-band operation, with its construction details depicted in Figure 1. HFSS 21.0 was utilized for the antenna design and simulation due to its accuracy and broad acceptance in the research community."

Table 1 – Proposed antenna dimensions in mm

Parameter	Value(mm)
Ls	50
Ws	50
Lf	25
Wf	3
Lg	10
Wg	50
Octagonal Radius	10
Radius1	20
Radius2	24

3. RESULTS AND DISCUSSION

A monopole rectangular strip patch antenna with an octagonal shape is taken into consideration in the first design process (Ant1). Ant-1 exhibits no resonances. Ant-2 is created by giving Ant-1 a circular form. The antenna resonates at 2 GHz in this step, with a ref-lection coefficient of – 11 dB. In order to improve performance, Ant-3 is also constructed with an additional circular shape and octagonal ring holes. This step involves the antenna resonating at a frequency of 2 GHz with a reflection coefficient of – 22 dB. Ant-4 operates in two bands at 2.4 GHz and 5.8 GHz frequencies with reflection coefficients of – 25 dB and – 34 dB. It is constructed with an octagonal slot on the ground plane. It is discovered that bandwidth and antenna impedance matching around the two ISM core frequencies have improved.

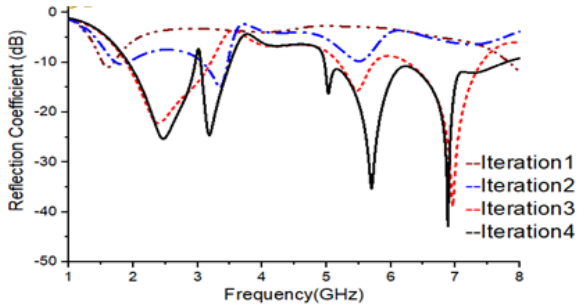


Fig. 3 – Simulated antenna reflection coefficient iterations at four design graphs

Its operating performance is described by impedance bandwidth, VSWR, gain, directivity, radiation efficiency and radiation patterns.

3.1 Impedance Bandwidth

Throughout the operating band, the observed return loss (S_{11}) is consistently less than − 10 dB, with values as low as − 18 dB and − 34 dB at particular frequencies. These results demonstrate excellent impedance matching to the standard 50 Ω load [19, 20].

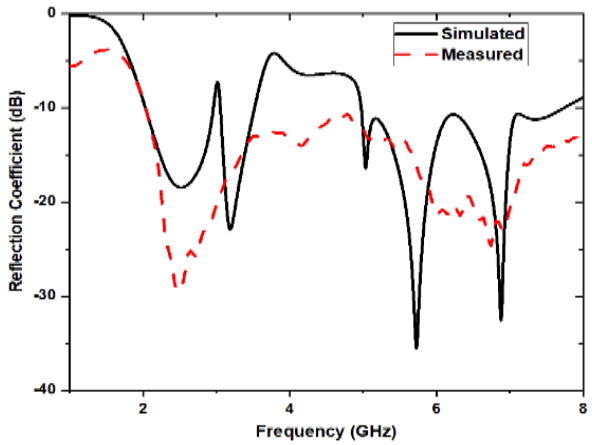


Fig. 4 – The proposed simulated and measured antenna of reflection coefficient

3.2 VSWR

The VSWR should be between close to 1 and 2 for optimal performance. It depends on the reflection coefficient, which is a positive, actual value. 1.1 is the simulated VSWR value. It is a unit less dimension.

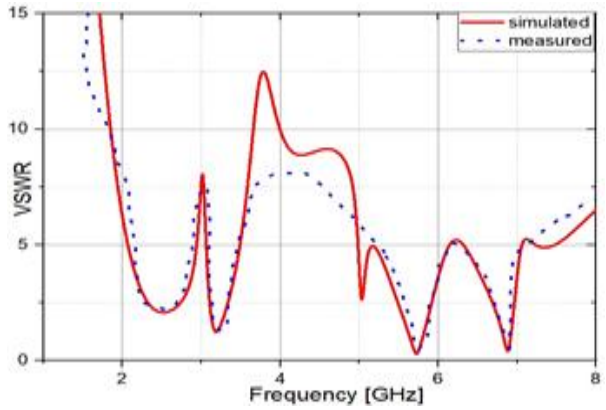


Fig. 5 – The proposed antenna of simulated and measured VSWR

3.3 Gain

At 2.4 GHz, the gain value is achieved 14 dB and at 5.8 GHz, the gain value is achieved at 11 dB on FR4 substrate as shown in Figures 6a and 6b.

3.4 Radiation Efficiency

High-performance antennas need to have high antenna efficiency. It shows the radiation efficiency of the recommended antenna. At resonance frequencies of 2.4 GHz and 5.8 GHz, the radiation efficiency is determined to be 93 %.

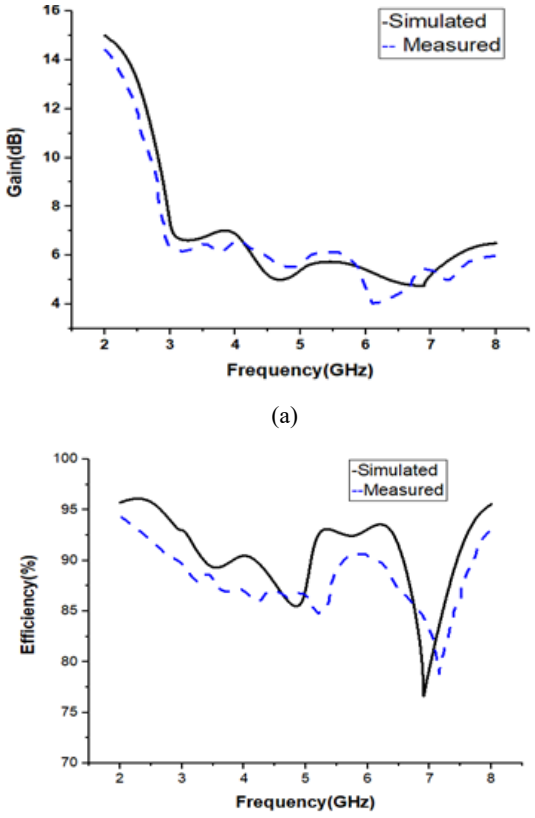


Fig. 6 – The proposed simulated and measured antenna: (a) Gain characteristics, (b) Radiation efficiency characteristics

3.5 Radiation Pattern

A radiation pattern is a graphic representation of an antenna's radiated power as a function of direction. It may be depicted in two-dimensional or three-dimensional form to characterize the angular distribution of radiation. At two different frequencies, 2.4 GHz and 5.8 GHz, its radiation characteristics are displayed in *E*-plane and *H*-plane. *H*-plane shows an omnidirectional pattern. The radiation patterns for antennas constructed on FR4 substrates are displayed in Figures 8a and 8b.

3.6 3D Gain Plot

The directional efficiency of the antenna is represented by the gain plot, which displays the amount of power radiated in particular directions. It illustrates the antenna's gain in dBi across different angles, highlighting the maximum radiation direction. For the proposed micro strip feed line patch antenna, the gain plot demonstrates a high peak gain, indicating strong directivity and efficient power transmission, suitable for 2.4 GHz and 5.8 GHz for ISM applications. The gain value on the FR4 substrate is 14 dB at 2.4 GHz and 11 dB at 5.8 GHz as shown in Figures 9a and 9b.

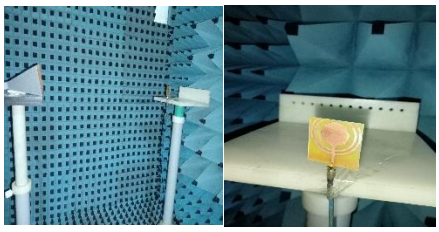
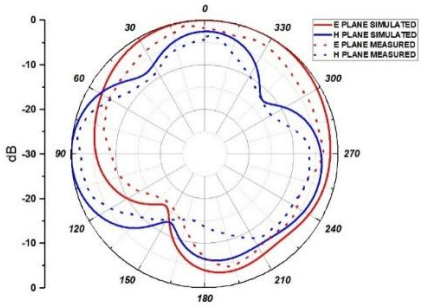
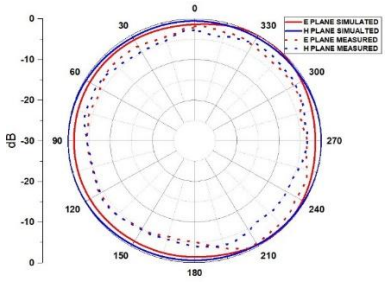


Fig. 7 – Measurement setup of anechoic chamber

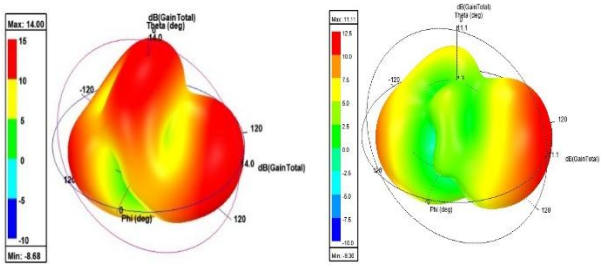


(a)



(b)

Fig. 8 – Radiation pattern of proposed antenna with simulated (a) at 2.4GHz (b) at 5.8GHz



(a) (b)

Fig. 9 – Gain of the proposed antenna: (a) 3D view at 2.4 GHz (b) 3D view at 5.8 GHz

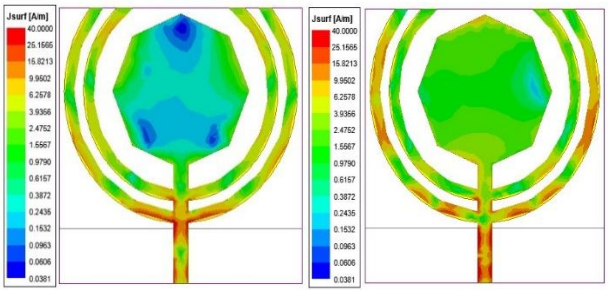
4. PERFORMANCE COMPARISON WITH STATE OF THE ART

Table 2 – Comparison of present work with existing research

Ref.	Antenna Size (mm)	Resonant frequency (GHz)	Substrate	Bandwidth (MHz)	Gain (dB)
[17]	–	2.4 5.8	PDMS	84 247	4.16 4.34
[18]	62 × 62 × 3.6	2.4 5.8	PDMS/PF4-foam	200 300	4.90 3.5
[19]	45 × 45 × 1.524	2.4 5.8	Rogers RO4350B	320 3730	3.5 6.2
This work	50 × 50 × 1.6	2.4 5.8	FR4	1GHz	11.11 14

5. SURFACE CURRENT DISTRIBUTION

The surface current distribution for the proposed antenna is shown in Figure 6. Demonstrates how current propagates across the antenna surface and correlates with its radiation and efficiency. The distribution remains symmetrical due to the geometric symmetry of the antenna. At 2.4 GHz and 5.8 GHz, a continuous increase in magnitude and consistent current behavior are seen, with a peak current density of 40 A/m as shown in below Figures 10a and 10b.



(a) (b)

Fig. 10 – Surface current distribution of the proposed antenna: (a) at 2.4 GHz and (b) at 5.8 GHz

6. CONCLUSION

HFSS 21.0 is used in the design and simulation of the micro strip feed line patch antenna. The Suggested antenna achieves a – 10 dB impedance bandwidth of 1 GHz, stretching from 2.4 GHz to 5.8 GHz, with return losses of – 18 dB and – 34 dB. It also displays a gain of 14 dB at 2.4 GHz and 11 dB at 5.8 GHz, along with an efficiency of 93 %. The antenna will resonate at two bands of frequencies for ISM Band applications: 5.8 GHz and 2.4 GHz, which is the frequency of our research.

REFERENCES

1. John D Kraus, *Antennas, 2nd Edition* (Tata McGraw Hill Company Limited: 1997).
2. R. Samson Daniel, *Multiband antenna design for wireless applications*, 96 (2014).
3. S. Muhammad, J.J. Tiang, S.K. Wong, A. Smida, R. Ghayoula, A. Iqbal, *IEEE Access* **9**, 99944 (2021) https://doi.org/10.1109/ACCESS.2021.3096834.
4. F.S.M. Noor, Z. Zakaria, H. Lago, Said, *Proceedings of the IEEE PES* (Kota Kinabalu, Malaysia: 2018).
5. B.R. Behera, S.K. Mishra, M.H. Alsharif, A. Jahid, *Electronics* **12**, 2723 (2023) https://doi.org/10.3390/electronics12122723.
6. N. Singh, B.K. Kanaujia, T.B. Mainuddin, S. Kumar, T. Khan, *AEU – Int. J. Electron. Commun.* **93**, 123 (2018)

https://doi.org/10.1016/j.aeue.2018.06.020.
7. J.-H. Chen, C.-Y. Cheng, C.-M. Chien, C. Yuangyai, et al., *Sensors* **23**, 4278 (2023) https://doi.org/10.3390/s23094278.
8. D. Guhaand, Y.M.M. Antar, *Micro strip* (John Wiley and Sons: New York, NY, USA: 2011).
9. S. Sreenath Kashyap, Vedvyas Dwivedi, *Stacked Swastik shaped micro strip patch antenna for Terahertz application,* (SVNIT Surat: 2014).
10. Constantine A. Balanis, *Antenna Theory: Analysis and Design*, *4th Edition* (John Wiley & Sons: 2016).
11. David M. Pozar, *Microwave Engineering* (John Wiley & Sons: 2011).
12. Yong Liu et al., *MSP* **2012** (2012).
13. Custódio Peixeiro, *Microstrip Patch Antennas*, 684 (2011).
14. Nusrat Jahan Shimu, Anis Ahmed, 1062 (2016).
15. Shera Prabjyot Singh et al., *IOSR Journal* **1** No 1, 1 (2016).
16. Mohammed Y. Aalsalem, Wazir Zada Khan, Wajeb Gharibi, Nasrullah Armi, *International Conference on Radar, Antenna, Microwave, Electronics, and Telecommunications (ICRAMET)*, (2017).
17. R.B. Simorangkir, Y. Yang, L. Matekovits, K.P. Esselle, **16**, 677 (2017).
18. P.B. Samal, S.J. Chen, C. Fumeaux, *IEEE Trans. Antennas Propag.* **72**, 1286 (2024)
19. X. Deng, P. Yang, S. Chen, W. Ren, *Electronics* **12**, 2645 (2023) https://doi.org/10.3390/electronics12122645.
20. A. El Ansari, T. Islam, S.V.R. Rao, A. Saravanan, S. Das, N.E.A.E. Idrissi, *J. Nano-Electron. Phys.* **15** No 3, 03003 (2023) https://doi.org/10.21272/jnep.15(3).03003.
21. P.B. Samal, S.J. Chen, C. Fumeaux, *IEEE Trans. Antennas Propag.* **72**, 1286 (2024) https://doi.org/10.1109/TAP.2023.3332432.
22. A. El Ansari, S.K. Khandare, N.E.A.E. Idrissi, A. Bendali, S. Das, F. Younis, H.K. Abduljaleel, A.J.A. Al-Gburi, *Progress Electromagn. Res. M* **132**, 39 (2025) http://dx.doi.org/10.2528/PIERM24112304.

Компактна антена восьмикутної форми для застосувань у діапазоні ISM

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У статті розглядається, як системи бездротового зв'язку використовують компактні та ефективні антени для передавання й приймання сигналів. Завдяки своїм малим розмірам, низькому профілю та простоті виготовлення, мікросмужкові антени з живленням через мікросмужкову лінію набувають дедалі більшого поширення. Були успішно розроблені конструкції таких антен із частковим екраном (земляною площиною) для застосування в діапазоні ISM. Антена виконана на підкладці з матеріалу FR4 з відносною діелектричною проникністю 4,3 і товщиною 1,6 мм; її габаритні розміри становлять 50 мм × 50 мм × 1,6 мм. Живлення антени здійснюється за допомогою врізної мікросмужкової лінії, що є компактним та ефективним механізмом підведення сигналу. Характеристики антени було оцінено за допомогою програмного забезпечення HFSS (версія 21.0). Розроблена антена забезпечує смугу пропускання за рівнем – 10 дБ (за імпедансом) шириною 1 ГГц – у діапазоні від 2,4 ГГц до 5,8 ГГц, при цьому зворотні втрати становлять – 18 дБ на частоті 2,4 ГГц та – 34 дБ на частоті 5,8 ГГц. Також досягнуто пікового коефіцієнта підсилення 14 дБі на частоті 2,4 ГГц і 11 дБі на частоті 5,8 ГГц, а ефективність випромінювання становить близько 93%. Ця антена сумісна з багатьма стандартами бездротового зв'язку.

Ключові слова: Мікросмужкова антена, Частота, Застосування в діапазоні ISM, Режим «восьмикутне дерево».