International Journal of Engineering Research and Science & Technology

IJERST

ISSN : 2319-5991



www.ijerst.com

Email: editor@ijerst.com or editor.ijerst@gmail.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 21, Issue 2, 2025

DESIGN AND ANALYSIS OF MICROWAVE ANTENNA FOR ISM BAND APPLICATIONS

Dr AKHILA JOHN. DAVULURI [1],
PARABATHINA ANUHYA [2], (Graduate Student),
CHEVURI VASU [3] (Graduate Student),
DEVARAKONDA POOJANLAVYA [4] (Graduate Student).

[1]Department of Electronics and communication Engineering, Assistant professor, *ANUCET*
[2] Department of Electronics and communication Engineering, *ANUCET,*
[SS3] Department of Electronics and communication Engineering, *ANUCET,*
[4] Department of Electronics and communication Engineering, *ANUCET.*

UNIVERSITY COLLEGE OF ENGINEERING & TECHNOLOGY, Nagarjuna nagar, Guntur.Dist, A.P-522510

A B S T R A C T

This paper presents the design and optimization of a compact antenna operating in the ISM band, specifically aimed at medical applications such as wireless patient monitoring, implantable and wearable health devices. With the growing demand for real-time data transmission in healthcare, the proposed antenna offers a reliable and efficient solution for short-range wireless communication. The design emphasizes a low-profile, biocompatible structure with stable radiation performance and minimized Specific Absorption Rate (SAR) to ensure patient safety. Simulations and analysis were conducted to evaluate key parameters including return loss, VSWR, gain, and radiation pattern, ensuring compatibility with medical-grade wireless standards. The results confirm that the antenna provides robust connectivity and is well-suited for integration into medical telemetry systems, remote diagnostics, and body sensor networks. Further, the results are expected to contribute to the development of AI-assisted medical diagnostics, improving early detection and treatment planning.

Keywords**: ISM Band Frequencies, Bowtie antenna, wearable devices, SAR, Medical applications.**

I. INTRODUCTION

The monitoring and diagnosis of diseases in the biomedical sector have been made significantly easier by microwave-based technology, which has been successful in achieving this goal [1]. The ISM band, especially the 2.45 GHz frequency, has gained popularity for medical telemetry applications due to its global license-free status and reliable performance [2]. Conventional imaging techniques such as MRI and CT, although widely used, are expensive and expose patients to risks related to ionizing radiation or magnetic fields [3]. Microwave imaging, on the other hand, is based on non-ionizing EM radiation, making it a safer option for repetitive diagnostic procedures [4].

Microwave systems use antennas to transmit and receive EM waves, which interact with tissues having different dielectric properties. These interactions allow detection of abnormalities such as tumors and hemorrhages. The use of bowtie and UWB antennas, especially those fabricated using textile or flexible substrates, has been extensively explored for wearable biomedical applications. Recent studies have integrated these microwave imaging techniques with AI algorithms to classify and localize internal anomalies such as brain hemorrhages with high accuracy. Therefore, the combination of compact microwave antennas and intelligent processing platforms presents a promising direction for real-time, non-invasive healthcare systems. and the detection of a variety of other abnormalities, the work using this technology has shed new light in being a future role model in medical and deformity affecting the brain's primary cells, is currently one of the greatest concerns. It is a severe medical illness that occurs when a blood vessel gets ruptured, resulting in the build-up of blood in

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

various parts of the brain. The brain is enclosed by multiple layers of protection, including the skin, fat, bone, and three layers of brain tissue: the dura mater, arachnoid, and pia mater. The ventricles of the brain contain cerebrospinal fluid (CSF) that safeguards the brain from potential damage caused by accidents, brain tumors, strokes, or high blood pressure. Factors like age, blood thinners, and alcohol increase the risk of brain hemorrhage which can result in unconsciousness or even death. The suggested research focuses on two locations of Brain Hemorrhage that are prevalent in the majority of instances. Bleeding can occur within the brain's interior areas as well as between its protective layers, suggesting a similar prototype of a spherical anomaly in the mentioned places.

II. MATERIALS & METHODS

Design Approach

The designed antenna operates at a resonant frequency of 2.45 GHz, targeting the ISM band used in applications like WLAN, Bluetooth, and RFID. Two feeding techniques are explored: Coplanar Waveguide (CPW) and coaxial feed, each [5] influencing antenna performance such as impedance bandwidth, radiation pattern, and fabrication complexity.

The antenna uses FR-4 [6] as the substrate due to its widespread use in low-cost PCB fabrication. The parameters of the substrate are:

- Dielectric constant (εr) = 4.4
- Loss tangent (tanδ) = 0.002
- Thickness (h) = 1.6 mm

Antenna Structure

Two configurations of bowtie antennas are constructed:

1.CPW-Fed Bowtie Antenna:

A bowtie antenna is a type of planar antenna characterized by its triangular radiating elements, resembling a bowtie. It is a modified form of a dipole antenna and is widely appreciated for its broadband characteristics, simple geometry, and ease of fabrication, especially on printed circuit boards (PCBs). The bowtie antenna supports wide bandwidth due to its tapered shape, which facilitates better impedance matching across a wide frequency range [6].

2.Coaxial-Fed-BowtieAntenna:

This design uses a ground plane beneath the substrate with a central probe to feed the antenna. The coaxial feed provides strong coupling and is suitable for wideband performance [7] When a signal is fed through the coaxial cable, the **inner conductor** energizes one triangular arm of the bowtie, and the **outer shield** is typically connected to the ground plane or the second arm. This creates a strong electric field across the feed gap, leading to radiation [8].

Table 1: Initial Dimensions of the coaxial Fed bowtie Antenna

(L X W)	Θ (deg)	S11(dB)	VSWR	G (dB)	A.R(dB)
60 X 41.7	71.46	-9.57	5.99	5.9	59.22
77.7 X 41.87	101.11	-21.33	1.49	3.0	27.25
76 X 43	82.93	-26.72	0.80	2.8	6.18
77.72 X 41.86	85.74	-12.01	4.45	3.0	2.50

Table 2: Initial Dimensions of the CPW Fed bowtie Antenna

(L X W)	Θ (deg)	S11(dB)	VSWR	G (dB)	A.R(dB)
60 X 30	90	-31.90	0.44	4.9	60.28
60 X 20	112.6	-27.30	0.74	5.4	42.69

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

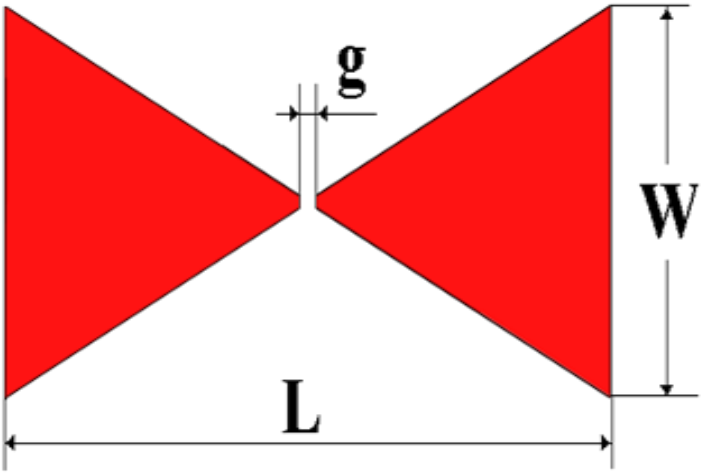


FIG 1: Bowtie Antenna

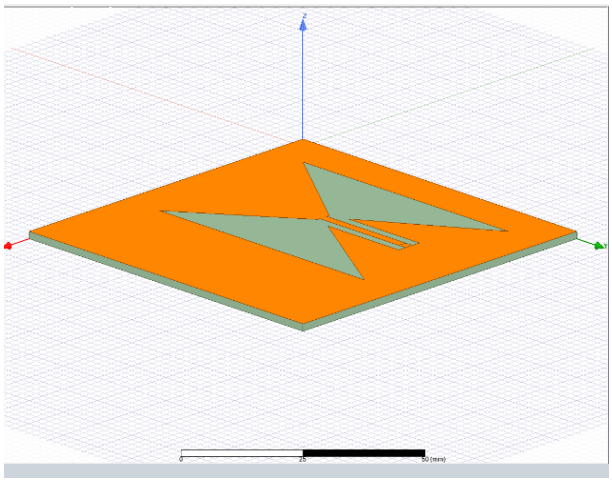


FIG 2: CPW Fed Antenna

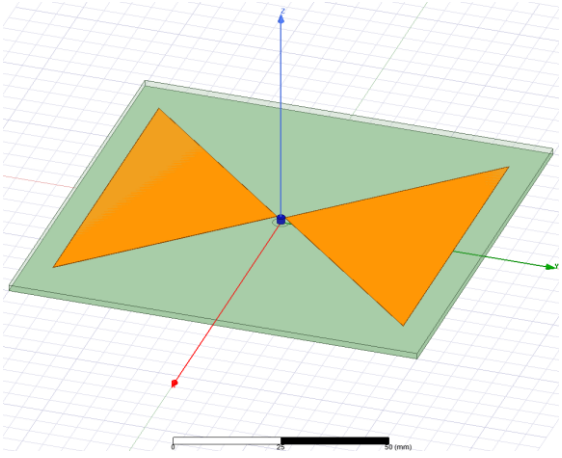


FIG 3: Coaxial Fed Bowtie Antenna

Table3:

(L X W)	Θ(deg)	S11(dB)	VSWR	G(dB)	A.R(dB)
77.72 x 41.86	85.74	-12.01	4.45	3.0	2.502

RESULTS AND DISCUSSION:

Simulation Results:
The proposed Coaxial fed bowtie antenna was designed and evaluated using full-wave electromagnetic simulation software such as ANSYS HFSS. The simulation focused on analyzing the antenna's reflection coefficient, impedance matching, gain, bandwidth, axial ratio and radiation characteristics across the ISM frequency 2.45GHz[9]. The simulation was carried out assuming Perfect Electric Conductor (PEC) surfaces for the patch and ground plane, and an FR-4 substrate with a dielectric constant of εr = 4.4 and thickness h = 1.6 mm.

Return Loss (S11)

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com

Vol. 21, Issue 2, 2025

The antenna achieved a minimum return loss of –21 dB at the resonant frequencyof 2.44GHz, indicating excellent impedance matching and minimal reflection of incident power. Typically, a return loss below –10 dB is considered acceptable for antenna performance, and the achieved value signifies strong coupling between the feed and radiating elements. This suggests that nearly all the input power is radiated, and very little is reflected back to the source[10]. Return loss showed in FIG 4.

Return Loss (dB)=−20log10|S11|

where

- S_{11} is the reflection coefficient at Port 1.
- A lower value of |S11|| | (closer to 0) indicates **better matching** and **less reflection**.

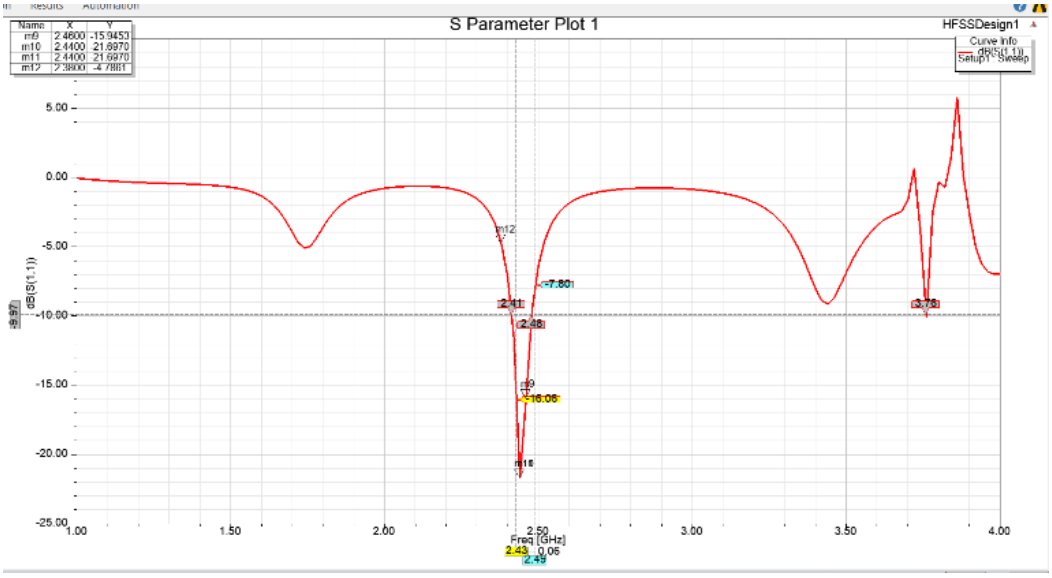


FIG 4: S Parameter Plot

Voltage Standing Wave Ratio (VSWR):

At the resonant frequency. A VSWR value below 2 is generally acceptable for practical antennas, while values close to 1 imply near-perfect impedance matching. This ensures maximum power transfer between the antenna and the transmission line. VSWR showed in FIG 5.

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 21, Issue 2, 2025

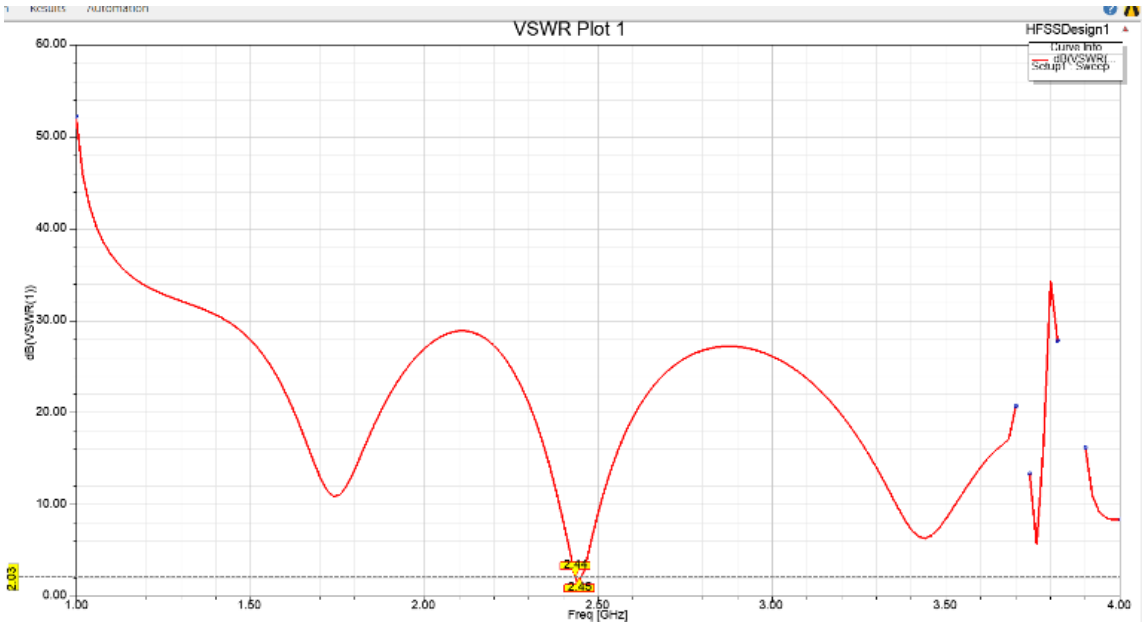


FIG 5: VSWR Plot

Gain:

The simulated realized gain of the antenna was found to be -3 dB at 2.45 GHz. This level of gain is considered suitable for ISM band applications FIG 6.

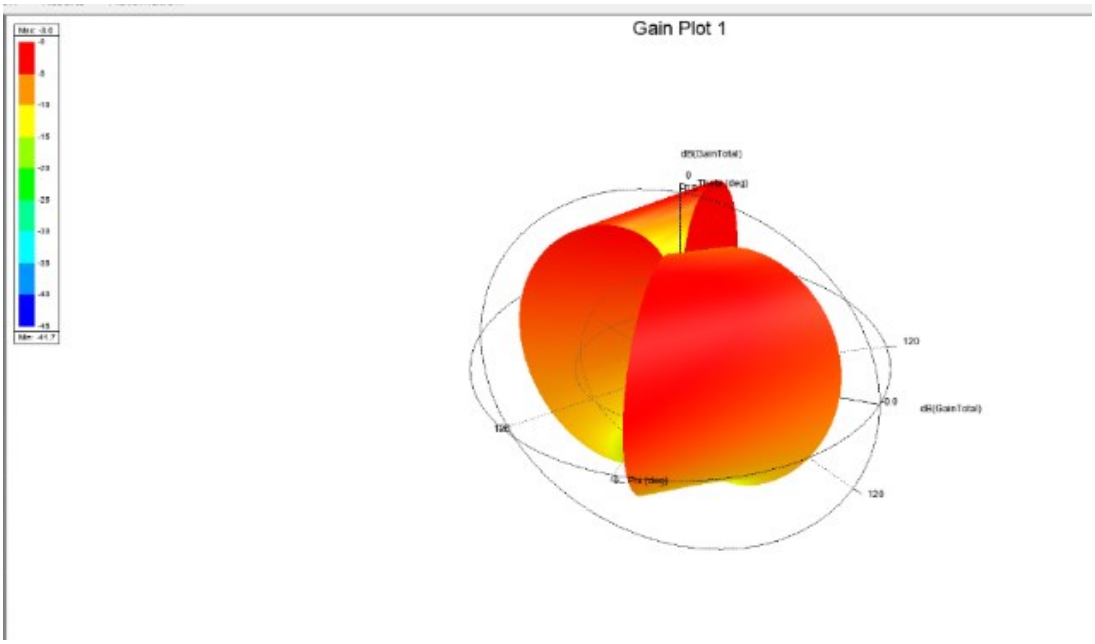


FIG 7: 3D Gain Plot

Axial ratio:

Axial ratio (AR)[11] is a critical parameter used to quantify the polarization purity of a circularly polarized (CP) antenna. It is defined as the ratio of the major axis to the minor axis of the polarization ellipse described by the electric field vector.

Axial ratio is the **ratio of the major axis to the minor axis** of the polarization ellipse formed by the electric field vector of the radiated wave.

- **AR = 1 (or 0 dB)** ⇒ Perfect circular polarization.

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 21, Issue 2, 2025

- **AR > 1 (or > 0 dB)** ⇒ Elliptical polarization.
- **AR** → ∞ ⇒ Linear polarization.

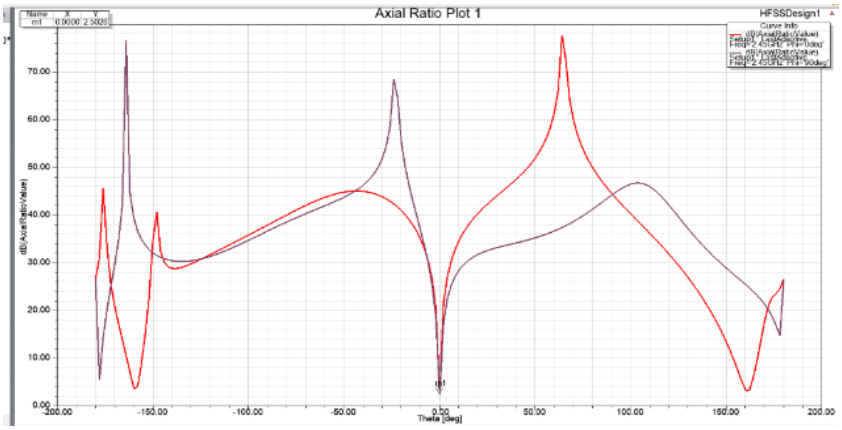


FIG 8: Axial Ratio Plot

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 21, Issue 2, 2025

Table 3: comparison of 2.45GHz bowtie antennas

Reference	Area	S11 Operating frequency (GHz)	Axial ratio	Gain(dB)	Planner and printable
[12]	55 x 55	1.99 – 3.22	27	6.8	NO
[13]	210 x 57	2.38 – 2.61	29.20	7.5	NO
[14]	140 x 24	2.31- 4.00	49.40	7.83	NO
[15]	60 x 60	2.36 – 2.64	2.86	4.68	YES
This work	77.72x41.86	2.41-2.46	2.50	3.0	YES

ACKNOWLEDMENT:

We would like to express our heartfelt gratitude to **Dr. Akhila John Davuluri**, Coordinator of the Department of Electronics and Communication Engineering, DR.Y.S.R. ANUCET, for her invaluable guidance, encouragement, and constant support throughout this project. We also extend our sincere thanks to the faculty and staff of the ECE department for providing us with the necessary resources and environment to carry out this research. Finally, we are grateful to our families and friends for their patience and unwavering moral support.

REFERENCES:

[1]. Theodoros N. Kapetanakis, Martin Pavec, Malina P. Toamidou, 2021: Embroidered Bow-Tie Wearable Antenna for the 868 and 915 MHz ISM Band. 2021.
[2]. N. Othman, N.A. Samsuri, M.K.A Rahim, K. Kamardin, Thariq Majid: Meander Bowtie Antenna for Wearable Applications. 2018.
[3]. Zheng Gong, Yahui Ding, Yifan Chen, Michael J. Cree: Wearable Microwave Medical Sensing for Stroke Classification and Localization: A Space-Division-Based Decision Tree Learning Method. 2023.
[4].Farzad Khajeh-Khalili, Parisa Shirvan, Mohammad H. Neshati: Textile-Based High-GainBow-Tie Antenna using Metamaterials for Medical Applications. 2020.
[5] Anton Venovil, Matthieu Egels, Mohammed Benwadih, Philippe Pannier: Design Guidance of a Circularly Polarized Bowtie Antenna for ISM Bands. 2023
[6]. Ognodon Assofoa, Arnaud Brossard, Yvan Duroc. "A new low cost compact antenna for the 2.45 and 5.8GHz ISM bands." 2021.
[7]. Nur Syahirah Hamdan, Mas Haslinda Mohamed, Adiwati Sali. "Sensing and analysis of spectrum holes in ISM band using USRP test bed." 2021.
[8]. Neha Minhas, Dr. Ashok Kumar. "Performance analysis of ISM band antenna." 2018.
[9]. Bo Yin, Ming Ye, Youhai Yu. "A novel compact wearable antenna design for ISM band." 2021.

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 21, Issue 2, 2025

[10]. Dalia N. Elsheakh et al., 'Textile Antennas for Breast Cancer Detection,' IEEE Biomedical Circuits, 2023.
[11]. Anton Venouil et al., 'Circularly Polarized Bowtie Antenna Design,' 2023.
[12]. He Y, He W, Wong H. A wideband circularly polarized cross dipole antenna. IEEE Antennas Wireless Propag Lett. 2014;13: 67-70. doi:10.1109/lawp.2013.2296324.
[13]. Liu W, Zhang Z, Feng Z, Liu H. A bidirectional circular polarized array with the same rotation using a special substrate. In: 2013 IEEE Antennas and Propagation Society International Symposium (APSURSI). IEEE; 2013.
[14]. Li M, Cheung SW, Wang B, Yuk TI. A wideband endfire CP antenna using magnetic dipole. In: 2017 11th European Conference on Antennas and Propagation (EUCAP). IEEE; 2017.
[15]. Li JY, Zhao X. Circularly polarized wearable antenna based on NinjaFlex-embedded conductive fabric. Int J Antennas Propag. 2019;2019:1-8.