IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 15, Issue 3, March 2025, ||Series -1|| PP 25-31

Design of Hexagonal Multi Input Multi Output Antenna for Ultra-Wide Band Applications

P. ANUSHA[1], B. PRASANNA[2], K. N. DEEPTHI[3] N. VIKRAM[4], Dr. M.RAGHUNATH[5]

[1,2,3,4] *B.Tech Scholars, Department of ECE,*

[5]*Professor, Department of ECE, Aditya College of Engineering and Technology, Surampalem, Kakinada, AP, India.*

ABSTRACT

The project theme is to develop a "DESIGN OF HEXAGONAL MULTI INPUT MULTI OUTPUT ANTENNA FOR ULTRA-WIDE BAND APPLICATIONS." MIMO technology is widely used in wireless communication systems due to its ability to enhance data rates and system reliability. In this project, we design a hexagonal multi-input multi-output (MIMO) antenna for ultra-wideband (UWB) applications. The proposed antenna structure ensures compactness while maintaining excellent impedance matching and stable radiation characteristics. The antenna supports high-speed wireless communication by providing a broad impedance bandwidth and consistent gain performance. The design and simulation results validate its efficiency, making it a suitable choice for modern wireless communication applications.

I. Introduction

What is the origin of the antenna?

Early devices like compasses and Franklin's kite experiment weren't true antennas, as they detected static fields or direct currents rather than electromagnetic waves. Even the human eye, though it receives light, acts more as a sensor since it doesn't transmit. The first real step toward understanding electromagnetism came in the 1830s with Faraday's experiment. By moving a magnet near a wire coil, he created a changing magnetic field, which induced an electric current.

This setup functioned like a simple antenna. The coil responded to the changing magnetic field, producing a current detected by a galvanometer. Though electromagnetic waves were unknown, the experiment hinted at the deep connection between electricity and magnetism—an early glimpse into wireless communication.

Fig - 1

A painting of Michael Faraday. Being a great experimentalist, he naturally dabbled in chemistry, shown here.

Heinrich Hertz developed a wireless communication system in which he forced an electrical spark to occur in the gap of a dipole antenna. He used a loop antenna as a receiver, and observed a similar disturbance. This was 1886. By 1901, Marconi was sending information across the Atlantic. For a transmit antenna, he used several vertical wires attached to the ground. Across the Atlantic Ocean, the receive antenna was a 200 meter wire held up by a kite.

II. Related work

Paper - 1 - "Triple Band Rejection Capability-Based UWB MIMO Antenna for Wireless Applications" (2023)

This paper presents a hexagonal UWB MIMO antenna with triple band-notched characteristics, operating over 3.1–13.7 GHz. It uses inverted L-shaped and modified Gshaped slots with EBG structures to notch WiMAX, WLAN, and X-band frequencies. A Tshaped strip on the substrate enhances isolation between radiators. The design ensures high isolation and effective notch control for wireless applications.

Drawback: The complex design, involving multiple slots and EBG structures, may pose challenges in fabrication and precise tuning.

Paper - 2 - "Hexagonal Microstrip Patch Antenna Design for UWB Application" (2022)

This study introduces a hexagonal-shaped microstrip patch antenna tailored for UWB applications. The antenna achieves a gain of approximately 5.32 dB and an efficiency of 90.88%, indicating its viability for high-frequency communication systems. The design emphasizes compactness and wideband performance, catering to modern wireless communication demands.

Drawback: The paper lacks detailed information on mutual coupling and isolation between multiple antenna elements, which are critical factors in MIMO configurations.

Paper - 3 - "UWB MIMO Antenna Implemented with Orthogonal Quasi-Circular Slot Dipole Radiators" (2019)

This research presents a low-profile, two-port UWB MIMO antenna with orthogonal quasi-circular slot dipole radiators. Operating from 2 to 10 GHz, it maintains performance across varying input signal phases. The design improves bandwidth and isolation compared to previous slot configurations.

Drawback: The use of coaxial feeding and slot dipole radiators may complicate the integration process into planar circuit boards.

Paper - 4 - "A Novel Hexagonal Microstrip Antenna for UWB Applications" (2020)

This study proposes a compact hexagonal microstrip patch antenna with a slotted ground plane for UWB applications. The design focuses on achieving a wide impedance bandwidth and improved radiation characteristics.

Drawback: The slotted ground plane may introduce fabrication complexities and affect the structural integrity of the antenna.

Paper - 5 - "Designing and Analysis of MIMO Antenna for UWB Applications" (2018)

This paper focuses on the implementation of a monopole structure UWB MIMO antenna with a microstrip patch. The design aims to achieve wideband performance suitable for various applications, with an overall system dimension of 32 x 32 x 1.6 mm^3. The antenna demonstrates promising results in terms of bandwidth and efficiency.

Drawback: The study does not provide comprehensive details on isolation between antenna elements, which is crucial for MIMO system performance.

III. Methodology

DESIGNING STEPS OF A HEXAGONAL MIMO ANTENNA SYSTEM FOR UWB APPLICATIONSANTENNA IN HFSS SOFTWARE

1. Open HFSS V13.0.

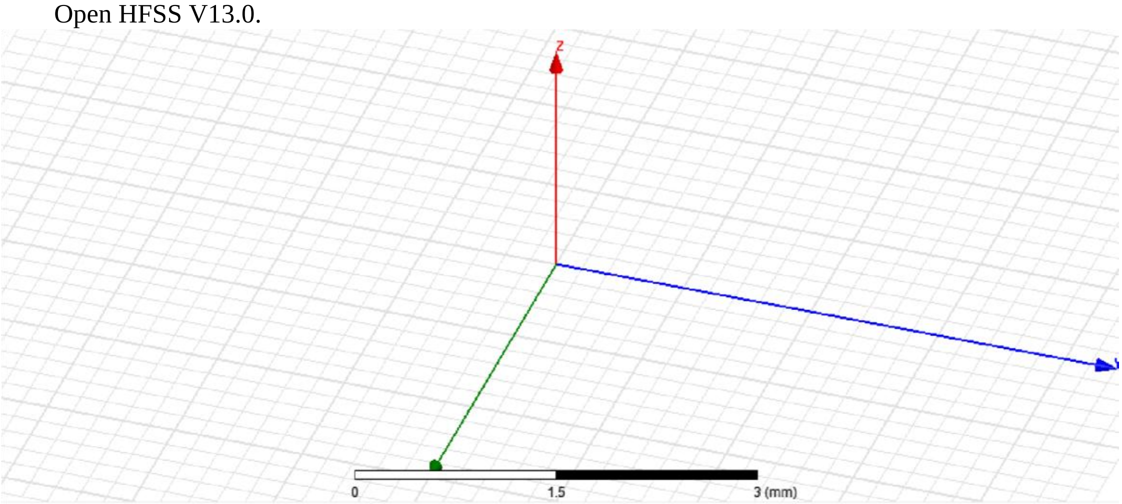

Fig - 33

2. Draw a Rectangular 3D box, name it as substrate and assign the measurements to the box.
3. Zoom the box out.
4. Create a rectangle1 inside the substrate and another rectangle2 opposite to it and assign the values.

5. Create a new rectangle named Patch1 next to Rectangle1, similar to how Patch2 is positioned beside Rectangle2, and adjust the values accordingly for proper alignment.
6. Now, create a Rectangle3 (Patch1) next to Rectangle1, just like Rectangle4 (Patch2) beside Rectangle2, and adjust the values accordingly.

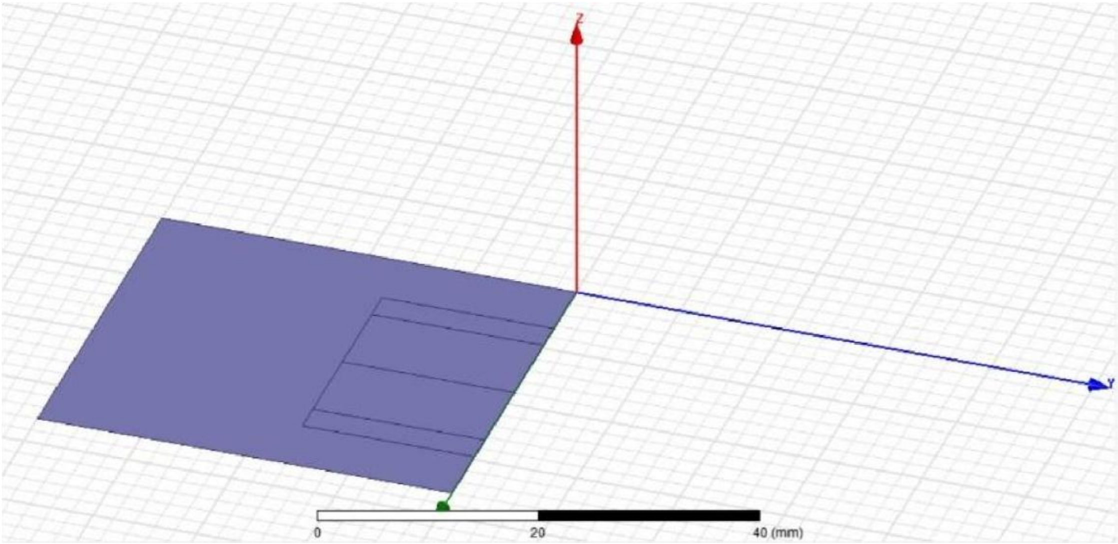

Fig - 34

7. Create rectangles on top of Rectangle3 to align Hexagon1, then use the move tool to properly position them on Rectangle3.

By using duplicate along line align another hexagon2, subtract the rectangles inside the hex1 with the hex1 same again to the hex2.

IV. Proposed System

This paper presents a hexagonal ultra-wideband (UWB) MIMO antenna designed to enhance isolation, minimize mutual coupling, and simplify fabrication challenges observed in previous works. The proposed design operates over a wide frequency range while incorporating an optimized slot structure and modified ground plane to achieve better notch control and radiation efficiency. Unlike previous studies that relied on complex structures such as EBG elements, coaxial feeding, or multiple slot configurations, our approach maintains a balance between performance and practical manufacturability. By integrating an innovative isolation mechanism, such as a well-placed T-shaped strip or orthogonal radiator arrangement, the proposed system ensures reliable operation in modern wireless communication environments.

Additionally, our design addresses key limitations found in existing research, including fabrication complexity, integration issues, and insufficient isolation in MIMO configurations. By refining the antenna geometry and carefully selecting notch frequencies, we enhance its ability to mitigate interference from WiMAX, WLAN, and X-band frequencies. The proposed antenna demonstrates improved gain, efficiency, and impedance bandwidth compared to previous designs while maintaining a compact and low-profile structure. This makes it an ideal candidate for high-speed wireless applications where robust performance, minimal interference, and ease of implementation are critical.

V. Results

5.1. Return Losses:

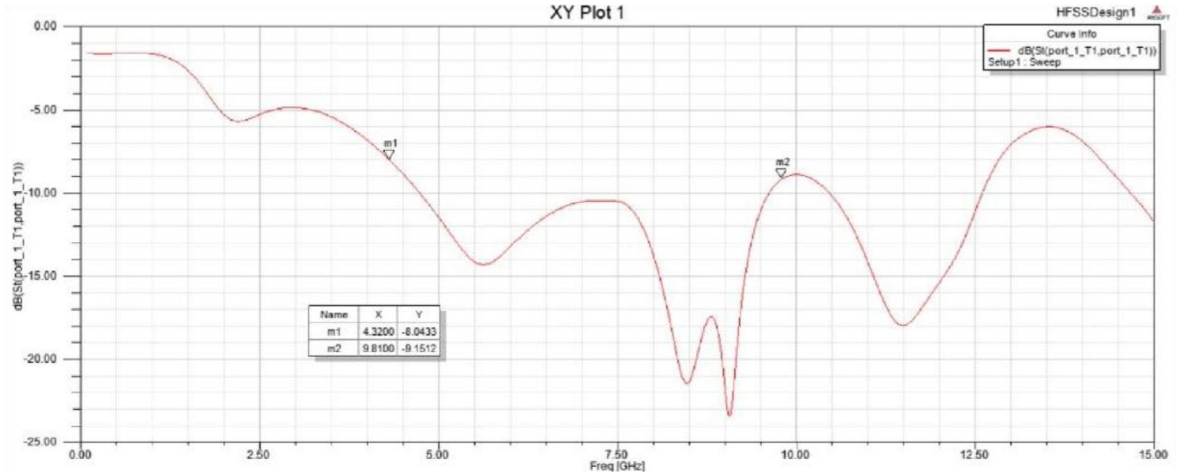

Fig - 41

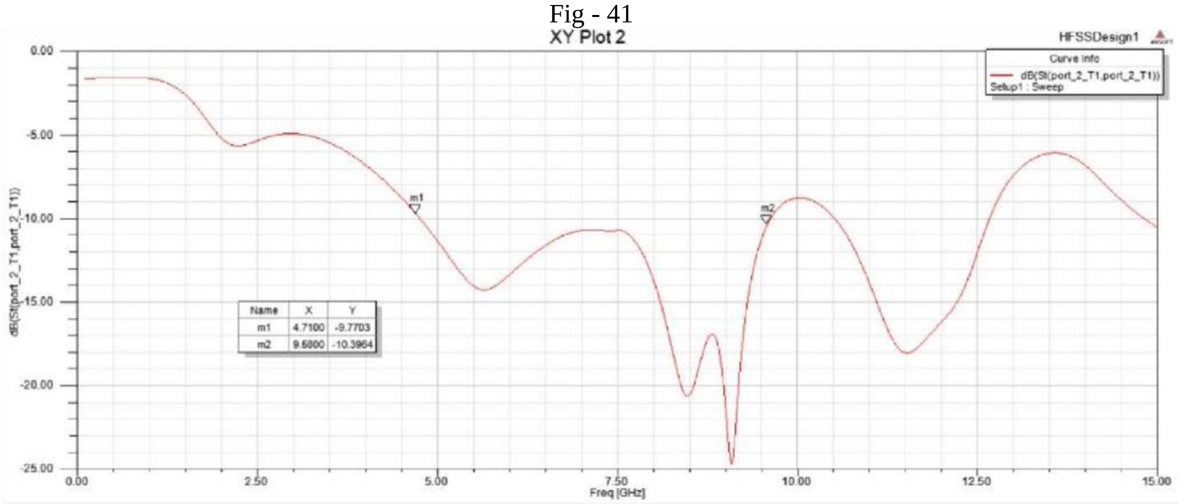

Fig - 42

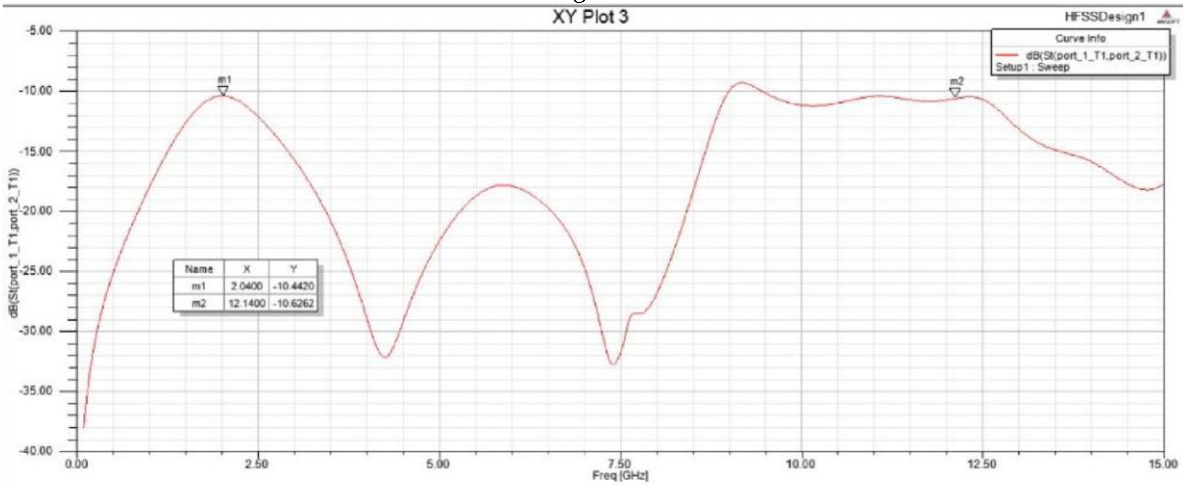

Fig - 43

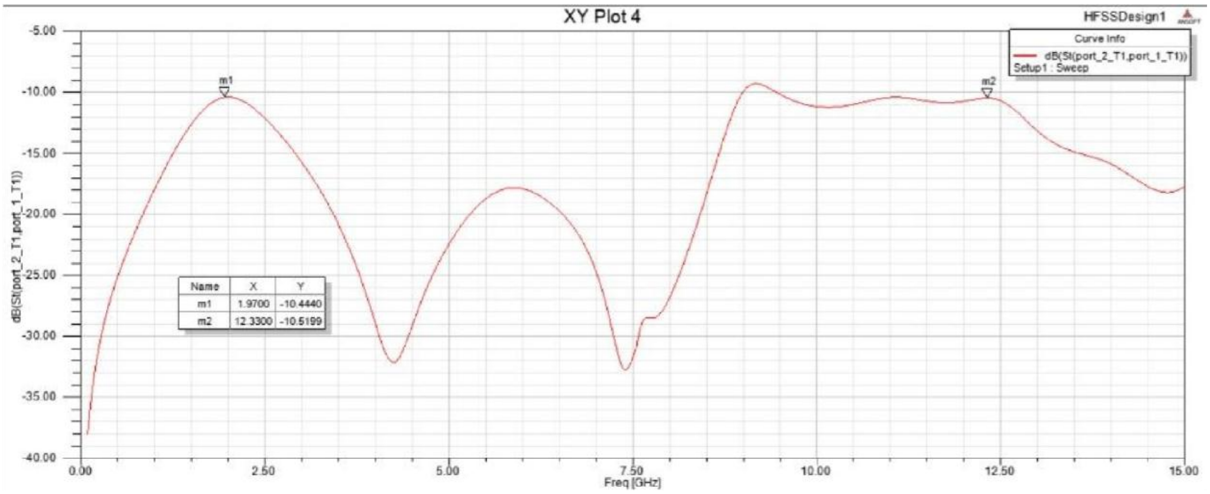

Fig - 44 **5.2 Radiation Pattern:**

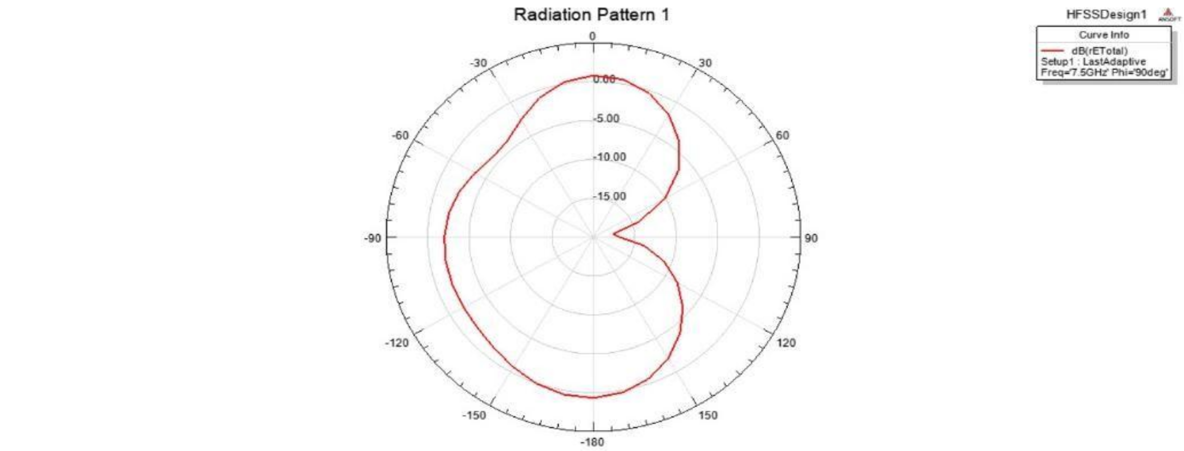

Fig - 45

5.3 3D plot :

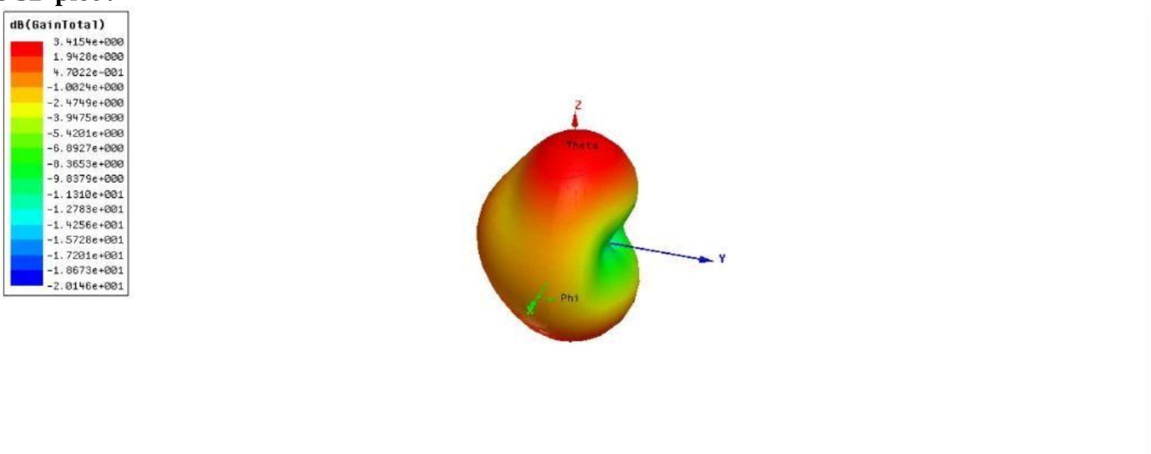

Fig - 46

5.4 E-field vectors from the patch:

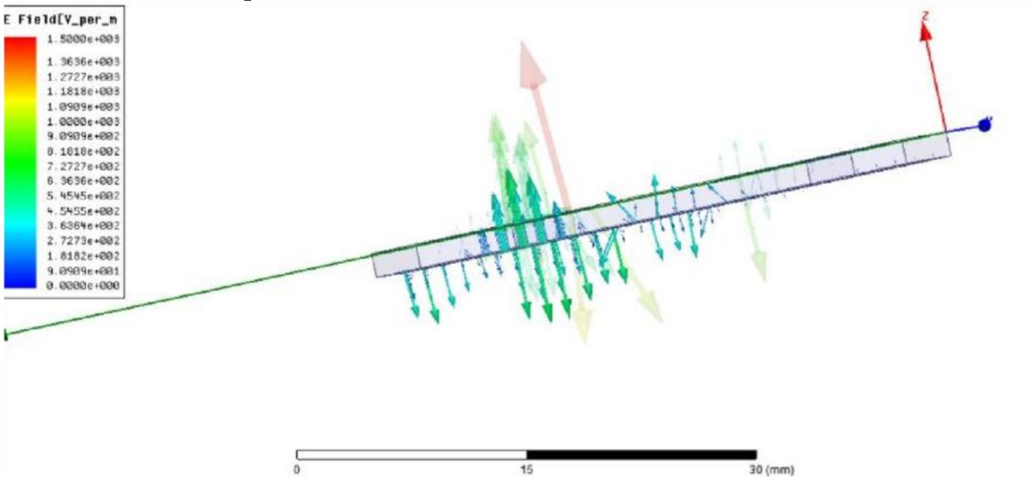

Fig - 47

5.5 vector H:

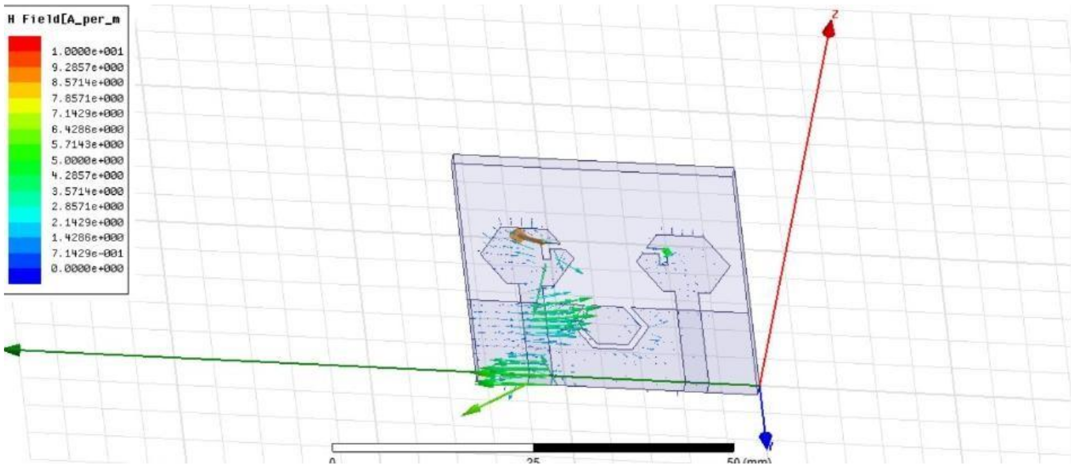

Fig - 48

5.6 Radiation from the Patch:

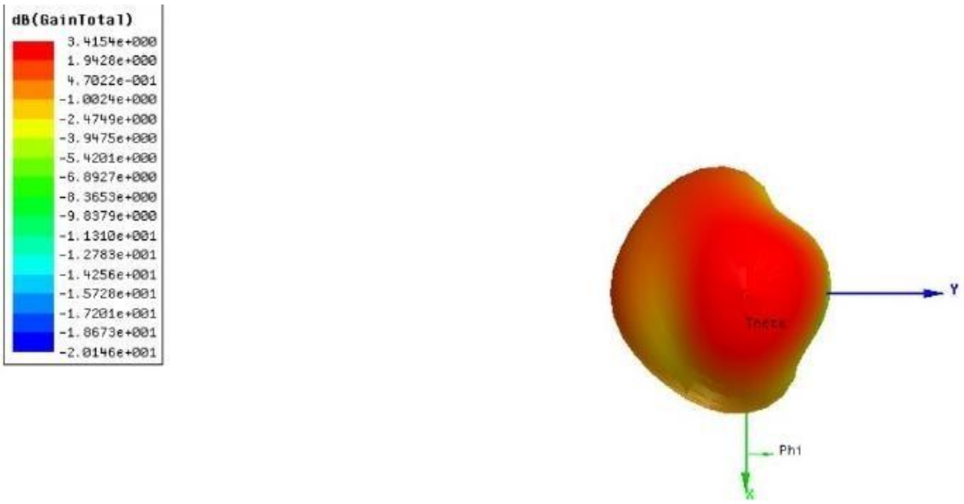

Fig - 49

CONCLUSION:

Hence, we designed a Hexagonal MIMO Antenna for Ultra-Wide-Band Applications successfully and analyzed using Ansoft HFSS. And the performance parameters are achieved.

FUTURE SCOPE:

The Hexagonal MIMO Antenna has great potential for the future. It can be improved with better materials, reconfigurable elements, and AI-based optimization to boost performance. Smaller designs and multi-band support will make it perfect for IoT, 6G, radar, and satellite communications, helping in next-generation wireless technology.

REFERNCES:

[1]. M.S. Sharawi, A.B. Numan, M.U. khan and D.N. aloi, "A dual element dual band MIMO antenna system with enhanced isolation for mobile terminals", IEEE antenna wireless propg. Let., vol. 11, pp. 1006-1009, 2012

[2]. Mc.Hbal, Aicha et al. "Spatial and Polarization Diversity Performance Analysis of a Compact MIMO Antenna." Procedia Manufacturing. Vol. 32. Elsevier B.V., 2019. 647– 652. Procedia Manufacturing

[3]. S.K Mishra, R.K Gupta, A. Vaidya & J. Mhukerjee "A compact deal band fork shaped monopole antenna for Bluetooth and UWB Applications ", IEEE antenna wireless propag Let. Vol.10, pp 627-630, 2011.

[4]. M. K. Mandal and S. Sanyal, "A novel defected ground structure for planar circuits", IEEE Microwave Compon. Lett., vol. 16, no. 2, pp. 9395, 2006.

[5]. S. Chouhan, M. Gupta and D. K. Panda, "Dual band compact antenna with series of hexagonal cut and coupling structure for isolation enhancement," 2017 7th International Conference on Cloud Computing, Data Science & Engineering - Confluence, 2017, pp. 750-7