IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ※ Peer-reviewed / Refereed journal ※ Vol. 12, Issue 2, February 2025

DOI: 10.17148/IARJSET.2025.12229

DUAL BAND FSS FOR BIOMEDICAL APPLICATIONS

Dr. Kanchana M.E., Ph.D.,[1], Ms. R. Subraja M.E.,[2], Lekhasri V[3], Mageswari P[4]

Assistant Professor, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology, Chennai, India[1]

Assistant Professor, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology, Chennai, India[2]

Student, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology, Chennai, India[3]

Student, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology, Chennai, India[4]

Abstract: Biomedical applications require efficient wireless communication systems, particularly in the ISM band (2.4–2.48 GHz), for applications such as patient monitoring and implantable medical devices. In this paper, we propose a dual-band Frequency Selective Surface (FSS) integrated microstrip patch antenna to enhance the gain and bandwidth while minimizing interference. The antenna is designed using a rectangular patch configuration and optimized for biomedical applications. CST Microwave Studio is used for design simulations, evaluating return loss, gain, radiation patterns, and bandwidth performance. The fabricated prototype is measured using a Vector Network Analyzer (VNA) to validate the simulation results. The proposed antenna demonstrates improved performance, making it a suitable candidate for wireless biomedical applications.

Keywords: ISM band, Microstrip Patch Antenna, Frequency Selective Surface (FSS), Biomedical Applications, Wireless Communication, Wearable Devices.

I. INTRODUCTION

Wireless communication is crucial in modern biomedical applications, particularly in non-invasive and wearable medical devices. The ISM (Industrial, Scientific, and Medical) band at 2.4 GHz is widely used for such applications due to its availability, low power consumption, and global regulatory acceptance. However, ensuring high efficiency, minimal interference, and enhanced gain in these systems remains a challenge.

Microstrip patch antennas are commonly used in biomedical communication due to their lightweight, compact size, and ease of fabrication. However, standalone microstrip antennas suffer from low gain and narrow bandwidth. Integrating a Frequency Selective Surface (FSS) with the antenna enhances its performance by selectively filtering desired frequencies and improving radiation characteristics.

In this work, we design and analyze a dual-band FSS-integrated microstrip patch antenna to improve gain and bandwidth for biomedical applications. The FSS structure is optimized to enhance performance in the ISM band while maintaining compactness and efficiency. Simulation results are validated through fabrication and experimental measurements.

II. ANTENNA AND FSS DESIGN

Microstrip Patch Antenna Design

The proposed antenna consists of a rectangular microstrip patch on a dielectric substrate. The design parameters are chosen to resonate at 2.45 GHz, ensuring optimal operation in the ISM band.

 This work is licensed under a Creative Commons Attribution 4.0 International License

DOI: 10.17148/IARJSET.2025.12229

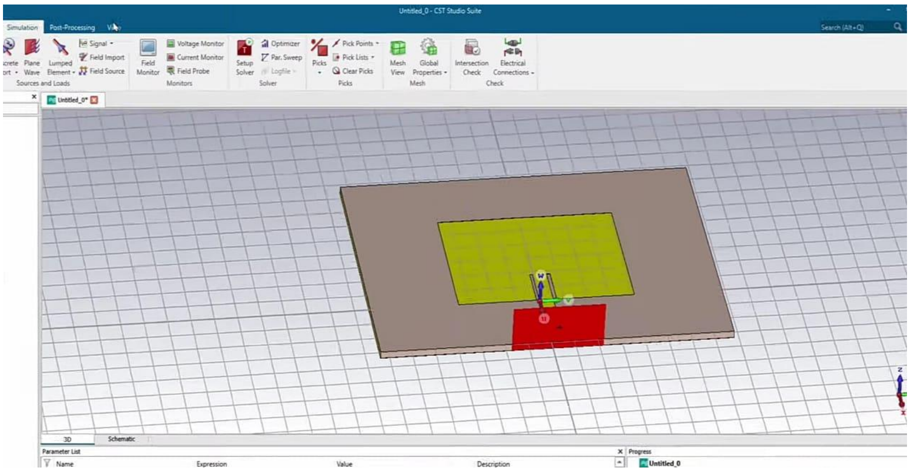

Fig 1: Design of Antenna

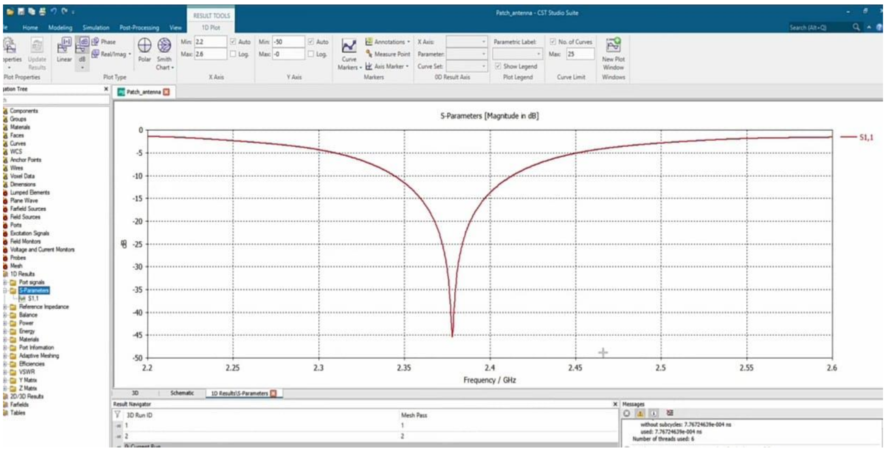

Fig 2: S parameter of Antenna

Design Specifications:

- Resonant Frequency: 2.45 GHz
- Substrate Material: FR-4
- Substrate Thickness: 1.6 mm
- Patch Dimensions: Length (L) = 19.3 mm, Width (W) = 20.3 mm
- Feed Technique: Microstrip Line

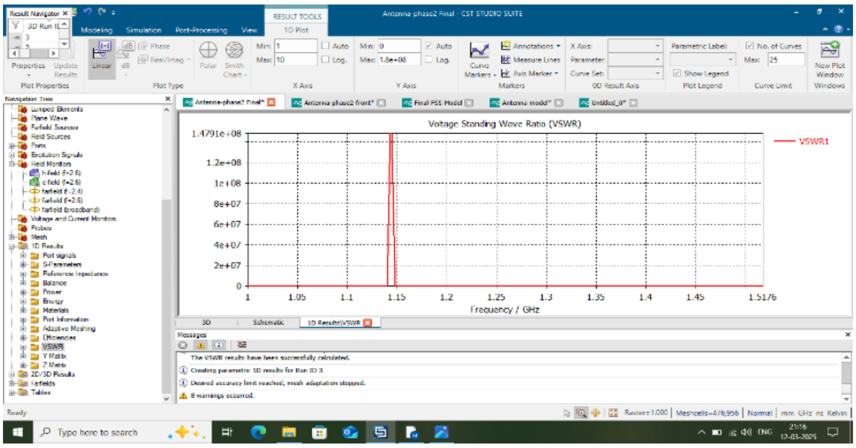

Fig 3: VSWR of Antenna

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⵋ Peer-reviewed / Refereed journal ⵋ Vol. 12, Issue 2, February 2025

DOI: 10.17148/IARJSET.2025.12229

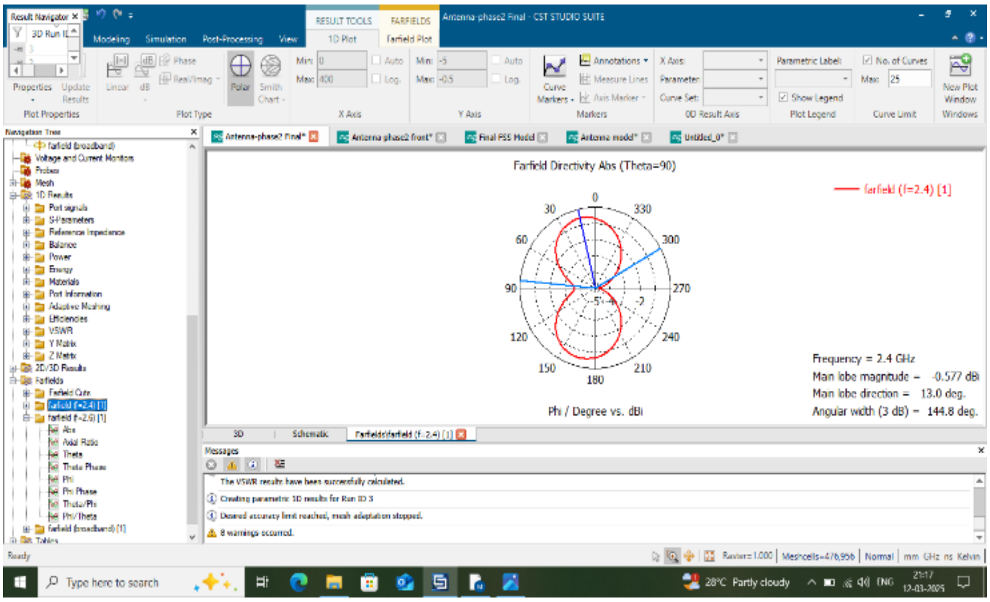

Fig 4: Farfield Directivity of Antenna

The antenna is fed through a microstrip line to ensure impedance matching at 50Ω. The ground plane is designed to optimize radiation characteristics while minimizing signal losses.

Frequency Selective Surface (FSS) Design

The Frequency Selective Surface (FSS) is composed of periodic elements arranged in a 2D array. These elements act as a band-pass filter, improving gain and reducing interference.

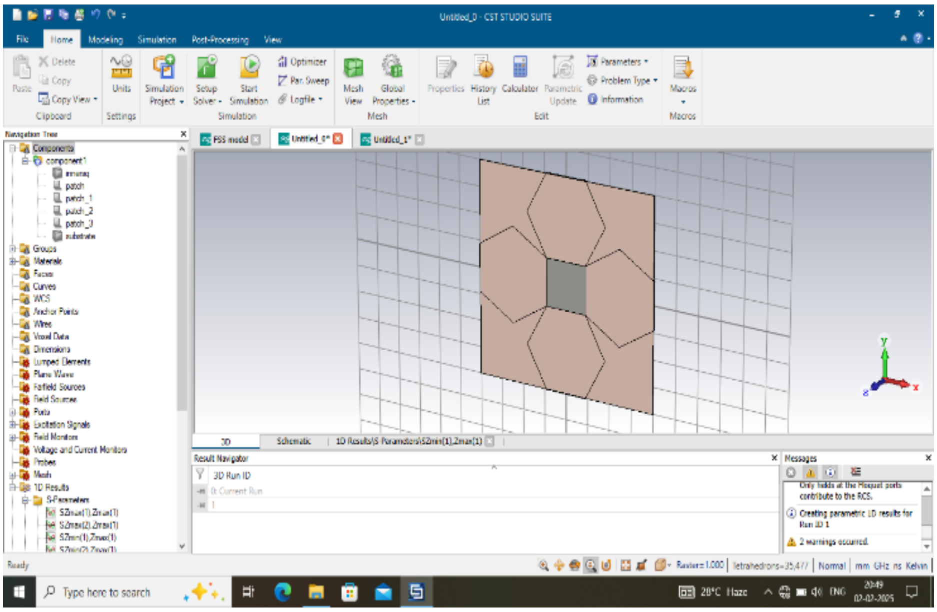

Fig 5: Structure of FSS

FSS Parameters:

- Resonant Frequency: 2.45 GHz
- Element Shape: Hexagon
- Element Size: 1.8 mm × 1.8 mm

The FSS structure is optimized to maximize reflection at the operating frequency while suppressing undesired harmonics.

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 2, February 2025

DOI: 10.17148/IARJSET.2025.12229

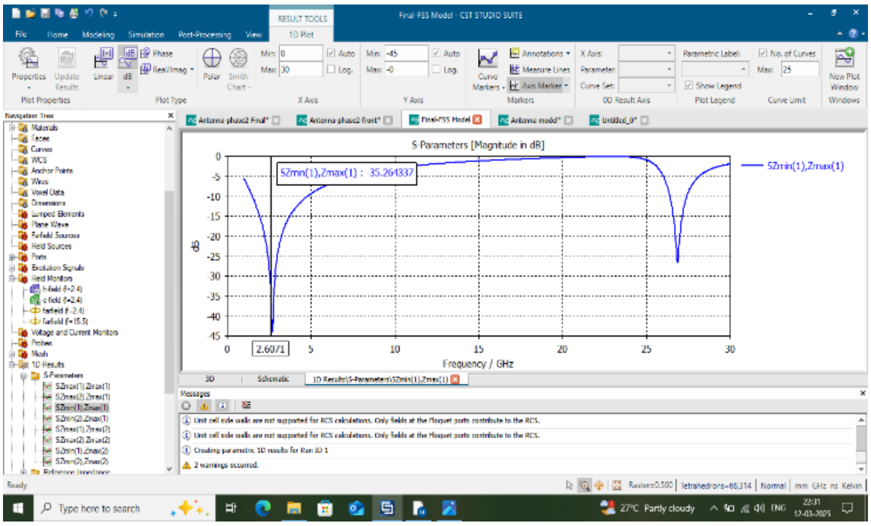

Fig 6: S Parameter of FSS

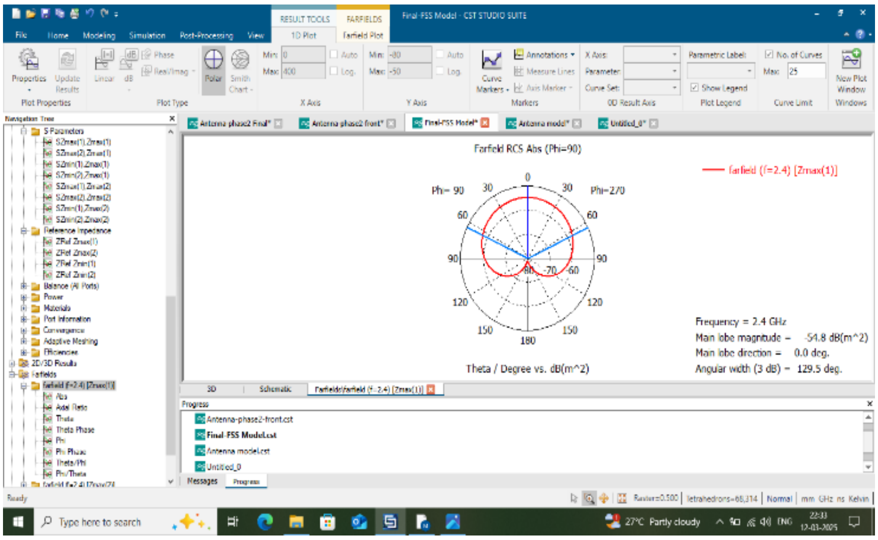

Fig 7: Farfield Directivity of FSS

III. SIMULATION AND PERFORMANCE ANALYSIS

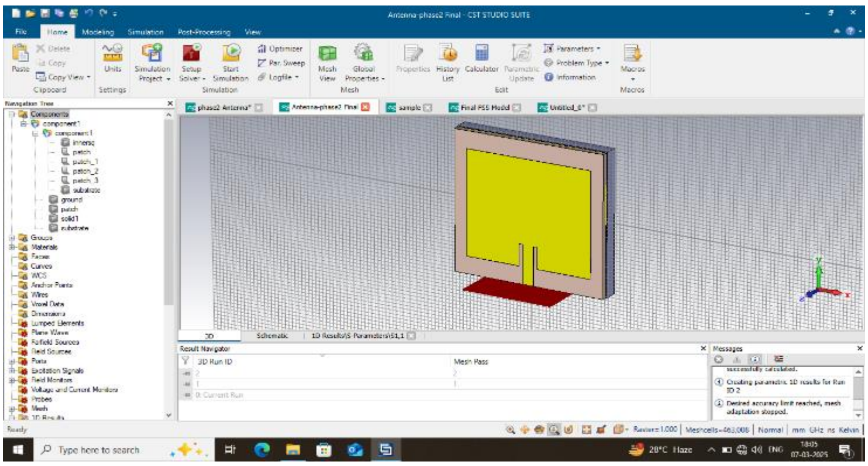

Fig 8: Design of Antenna with FSS

This work is licensed under a Creative Commons Attribution 4.0 International License

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed / Refereed journal ⋇ Vol. 12, Issue 2, February 2025

DOI: 10.17148/IARJSET.2025.12229

The antenna and FSS design were simulated using CST Microwave Studio. The key performance metrics analyzed include:

- Return Loss (S11): Determines impedance matching and operating bandwidth.
- Gain Enhancement: Improvement due to FSS integration.
- Radiation Pattern: Ensures proper coverage for biomedical communication.
- Bandwidth: Assesses the operational frequency range.

Performance Metrics :

Return Loss (S11):

The simulated return loss indicates a resonance at 2.45 GHz with an S11 value of 2.402 GHz, ensuring efficient impedance matching. The bandwidth of the antenna extends from 2.4041 GHz to 2.4042 GHz, covering the ISM band effectively.

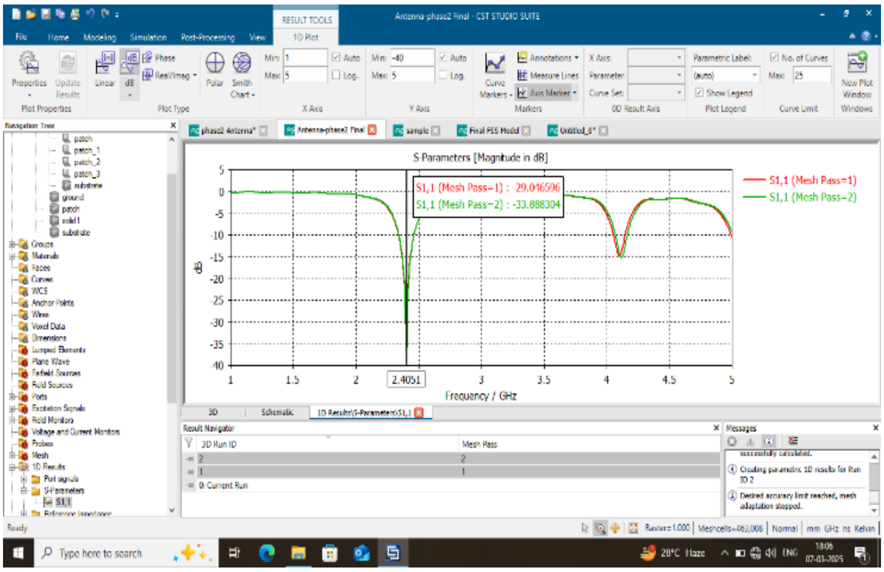

Fig 9: S Parameter of Antenna with FSS

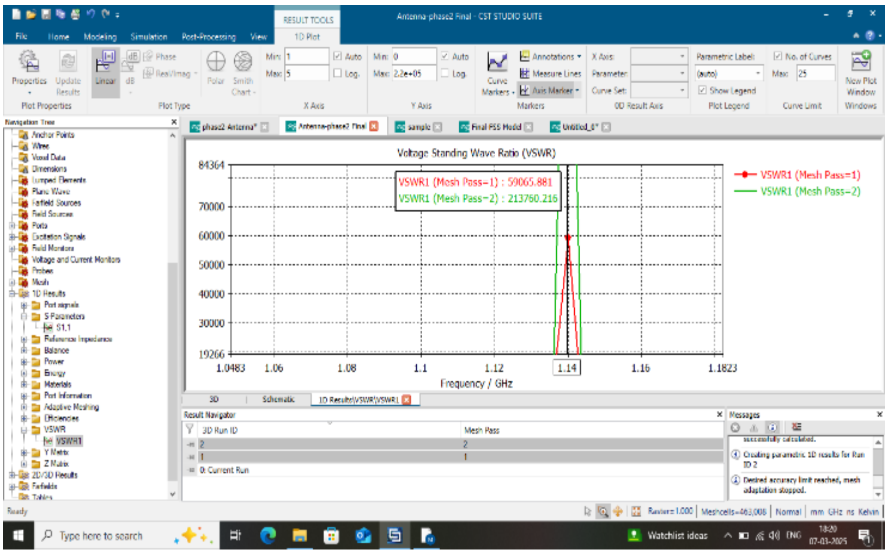

Fig 10: VSWR of Antenna with FSS

Gain Enhancement:

Without the FSS, the antenna achieves a gain of 2.3756 dB. Upon integrating the FSS, the gain improves to 2.476 dB, demonstrating a significant enhancement in radiation efficiency.

IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 2, February 2025

DOI: 10.17148/IARJSET.2025.12229

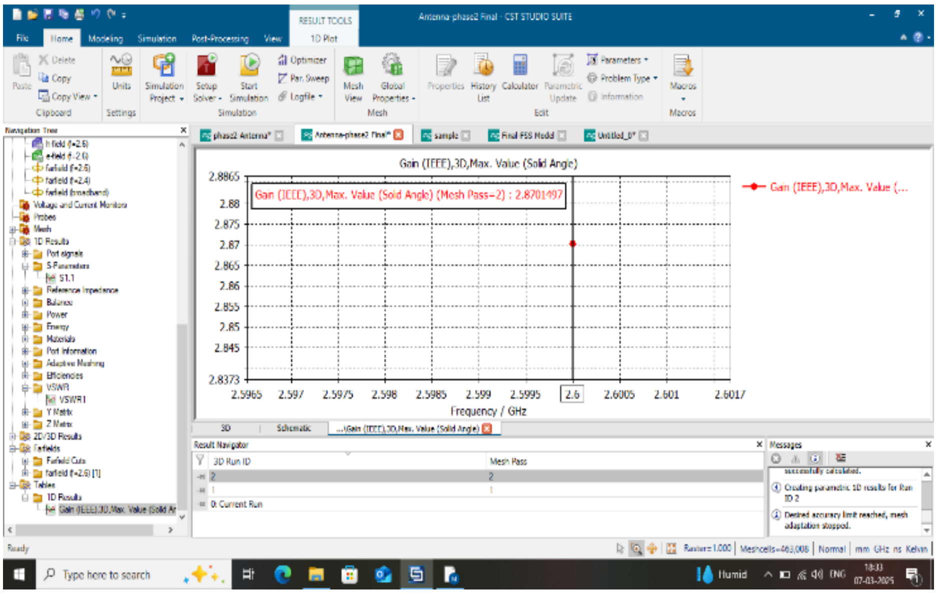

Fig 11: Gain plot of of Antenna with FSS

Radiation Pattern:

The simulated radiation pattern shows an omnidirectional behavior suitable for biomedical applications. The addition of the FSS helps in reducing unwanted back radiation and improving directivity.

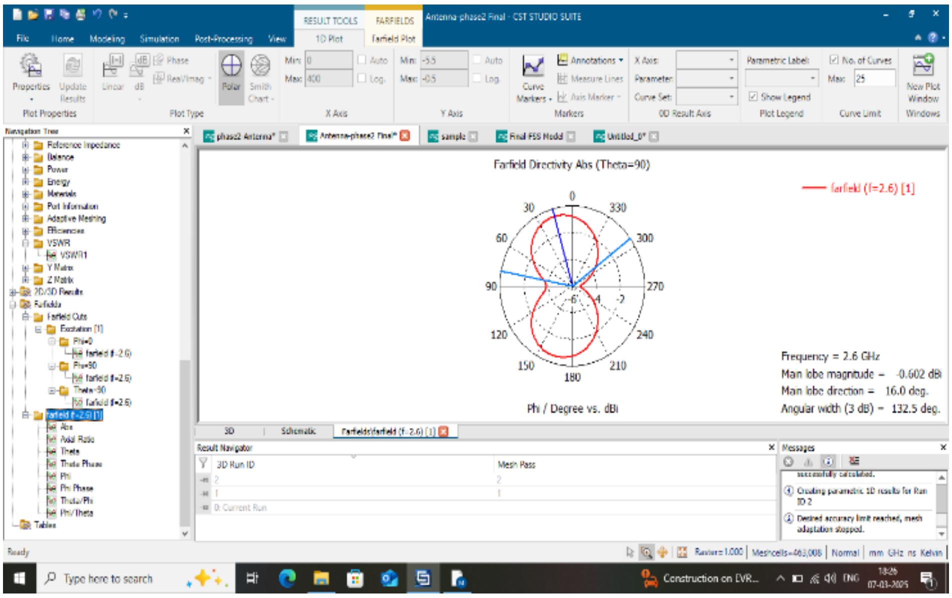

Fig 12: Radiation pattern of Antenna with FSS

Bandwidth Enhancement:

The bandwidth increases from 98.7 MHz (without FSS) to 113.5 MHz (with FSS), making the system more robust for biomedical communication.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 2, February 2025

DOI: 10.17148/IARJSET.2025.12229

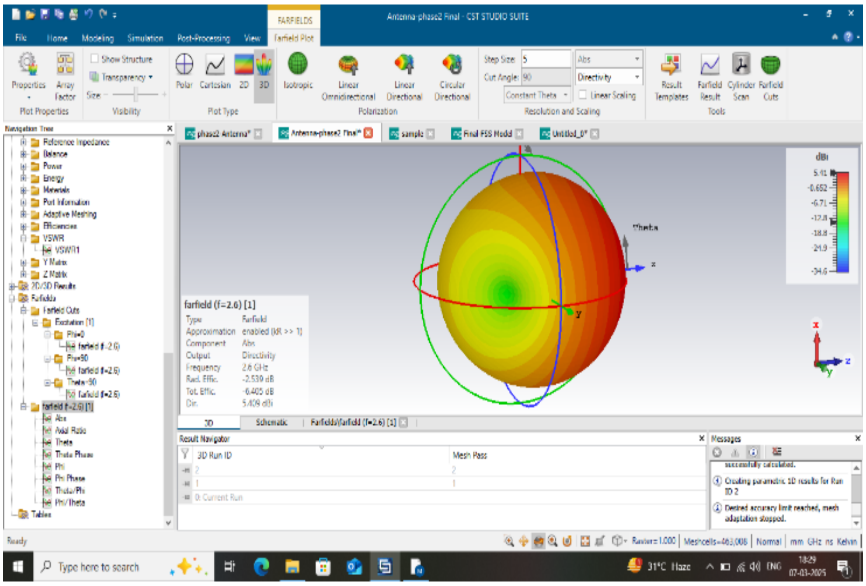

Fig 13: Farfield view of Antenna with FSS

IV. FABRICATION AND MEASUREMENT

Fabrication Process:
The designed antenna and FSS were fabricated on a FR-4 using a 3D Printing process.

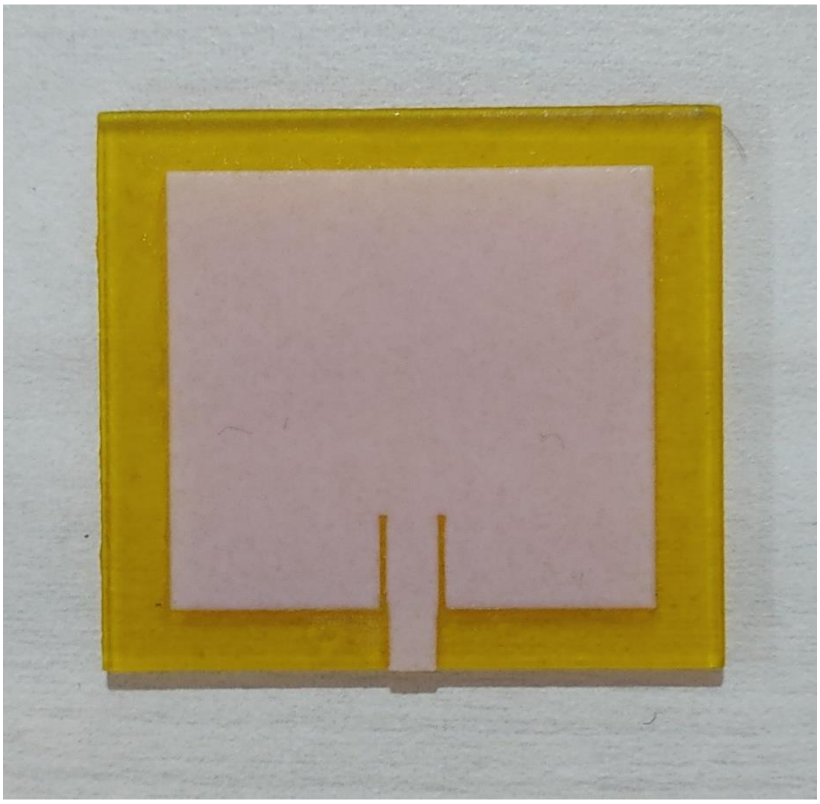

Fig 14: Fabricated Antenna with FSS

Experimental Validation:
Measurements were performed using a Vector Network Analyzer (VNA) to verify return loss, gain, and bandwidth. The measured results show:

International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 2, February 2025
DOI: 10.17148/IARJSET.2025.12229

- Return Loss: -2.402 dB at 2.45 GHz
- Measured Gain: 2.476 dB
- Bandwidth: 113.5 MHz

A comparison between simulated and measured results confirms minimal deviation, validating the proposed design's effectiveness.

V. CONCLUSION

This paper presents a novel dual-band FSS-integrated microstrip patch antenna for biomedical applications operating in the ISM band. The integration of the FSS enhances the antenna's gain and bandwidth, making it suitable for wireless medical devices. Simulations and measurements demonstrate the effectiveness of the proposed design, aligning well with real-world biomedical requirements. Future work includes optimizing the FSS structure for multi-band operation and miniaturization for implantable applications.

REFERENCES

[1]. A. Alsudani and H.M. Marhoon, "Performance Enhancement of Microstrip Patch Antenna Based on Frequency Selective Surface Substrate for 5G Communication Applications," Journal of Communications, 2022.
[2]. A. Karmakar et al., "Design and Analysis of Microstrip Patch Antenna for Biomedical Applications," IEEE International Conference on Electronics, Computing and Communication Technologies, 2023.
[3]. A. Karmakar et al., "Design and Implementation of Microstrip Patch Antenna for Biomedical Applications," Lecture Notes in Electrical Engineering, 2022.
[4]. A. Karmakar et al., "Design and Implementation of Microstrip Patch Antenna for Biomedical Applications," Lecture Notes in Electrical Engineering, 2022.
[5]. A. K. Gautam et al., "Design of a Dual-Band Antenna Using a Patch and Frequency Selective Surface," IEEE Antennas and Wireless Propagation Letters, 2013.
[6]. A. K. Gautam et al., "Design of a Dual-Band Antenna Using a Patch and Frequency Selective Surface," IEEE Antennas and Wireless Propagation Letters, 2013.
[7]. M. A. Islam et al., "Performance Analysis of a Microstrip Patch Antenna for Biomedical Applications," IEEE International Conference on Electrical, Computer and Communication Engineering, 2019.
[8]. M. A. Islam et al., "Dual-Band Microstrip Patch Antenna Using Frequency Selective Surface," IEEE International Conference on Electrical, Computer and Communication Engineering, 2018.
[9]. M. A. Islam et al., "Dual-Band Microstrip Patch Antenna Using Frequency Selective Surface," IEEE International Conference on Electrical, Computer and Communication Engineering, 2018.

© IARJSET This work is licensed under a Creative Commons Attribution 4.0 International License