IARJSET



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 V³, Mageswari P⁴

Assistant Professor, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology,

Chennai, India¹

Assistant Professor, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology,

Chennai, India²

Student, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology,

Chennai, India³

Student, Electronics and Communication Engineering, Sathyabama Institute of Science and Technology,

Chennai, India⁴

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 dualband 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.









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 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.

© <u>IARJSET</u> This work is licensed under a Creative Commons Attribution 4.0 International License



IARJSET



Fig 6: S Parameter of FSS

Del 20 월 월 양 연 :	1	ESULT TOOLS FARFIELD	Final-FSS Model - C	ST STUDIO SUITE			- s ×
Fix None Modeling Simulation Properties Update Uncar dB P ho Rot Properties Properties Fix Fix Fix	Rost-Processing View Ise #/Imag = Dolar Smith Chart - pt Type	10 Plot Farrield Plo 0 Auto Mis 400 Log. Ma X Axis	n: -00 Auto n: -50 Log. Y Axis	Curve Markers - Marker - Markers	X Axis: Parameter: Curve Set: 00 Result Axis	Parametric Label: No. of Parametric Label: No. of Masc 25 Show Legend Plot Legend Curve 1	Fourves
Nevigetan Tree	X Astrona share? Seal?	The Antonio altowed front	r 🖂 🔤 Doskras Had	et 🖸 🛛 🔽 Antonio model" 🖂	S Indefect of Fil		
Parameters Fercenters Fercenters Security Zenar(1) Fercestant(1) Zenar(1) Fercestant(1) Fercestantt Fercestant Fercestant Fercestant Fercestant(1)		Farfeld RCS Als (Phi=90)					
iei Sonstal, Amstal			90 90 120	150 150 theta / Degree vs. dB/m ²⁰	60 90 120 2)	Frequency = 2.4 GHz Man ibbe magnitude – Man ibbe drection = (Angular width (3 db) =	-54.8 dB(m^2) 0.0 deg. 129.5 deg.
E - Fartield (F=2.4) [Znaco(1)]	3D Schema	tic Partields//artield (f=1	2.4) [Zmm(1)] 🔣				
And Reto	Progress Antenna-phase2-tront. Se Final-FSS ModeLost Antenna modeLost Outbloc_0 V Nessages Program	est					×
Ready				R	🙉 🔶 🔛 Restore 0.5	00 Tetrahedrons=68,314 Normal	mm GHz ns Kelvin
P Type here to search	🔸 🕂 🖻	🗖 🖻 🥸	5 🔥 🔀		📜 27°C Partly	rctoudy ∧ ¶⊡ ≪ 40) 0N6	22:33 12-03-2025

Fig 7: Farfield Directivity of FSS



III. SIMULATION AND PERFORMANCE ANALYSIS

Fig 8: Design of Antenna with FSS

IARJSET



International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 $\,\,st\,$ Peer-reviewed / Refereed journal $\,\,st\,$ 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

🖹 💕 🗟 🍓 🕙 🕅 a	RESULT TO	CLS Antenna-phase2 Final	CST STUDIO SUITE	- # ×
File Home Modeling Simulation	n Post-Processing View 1D Pla	• • • • • • • • • • • • • • • • • • •		• 0
Properties Update Results	ase al/Imag = Polar Smith Chart = Mirc Max		Curve Messure Lines Parameter Markers - Multi Marker - Curve Set	Parametric Label:
Hot Properties Pr	lot type X Ao	IS T ANS	Markers UD Result Avis	Plat Legend Curve Limit Windows
Andreas Points	Anten	na-phase2 final 🔯 🛛 🔤 sample 🖸 🗖 F	inal FSS Model 🖸 🛛 🕂 Unitited_0* 🖸	
-Gg Whee -Gg Voxel Data -Gg Umensions -Gg Umped Berrents	84364	Vokage Standing V	Vave Ratio (VSWR)	
- 10 Plane Wave - 10 Fatteld Sources - 10 Faild Sources	70000	VSWR1 (Mesh Pas	is=2) : 213760.216	VSWR1 (Mesh Pass-2)
e-Ge Excitation Signals e-Ge Field Monitors	60000			
- Votage and Current Monitors - Generation Probes	50000			
Hand Mean Hand TD Results	40000			
SParameters	30000			
Balance	19266		<u></u>	
6 Brogy	1.0483 1.06	1.08 1.1 Erequen	1.12 1.14 1.16	1.1823
8- Dot Information	3D Schematic	ID Receiv/SWR/VSWRI	off one	
Adaptive Meshing Definitional	Result Navigator			× Nessages
	Y 3D Run ID	Me	sh Pass	O A C 🐱
W VSWH1	-m 2	2		successfully calculated.
B Z Nata	-н	1		Oreating parametric 1D results for Ran TO 2
H-Qat 2D/3D Results	-= 0: Current Run			Desired accuracy limit reached, mesh adaptation stopped.
isady			🗟 😡 🔶 🔛 Rater=1	.000 Meshcells=463,008 Normal mm GHz ns Kelvi
1 P Type here to search	.+i. 🕂 📵 🚍	😇 🤹 🚍 🖍	🛄 Watchlis	tideas \land 🔟 🔬 4() DNG 1820

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

■ ● ■ ● ● ● ○ ● =	Antenna chase2 Final - CST STUDIO SUITE	- # ×
File Home Modeling Simulation	Rost-Processing View 10 Plat	A (2) -
Copy View + Cipboard Settings	Storp Storp Storp Storp Math Global Properties Math Properties Math Mat	
Nevigebox Tree X	🔯 phase2 Anterna" 🗉 🛛 🔄 Anterna-phase2 Titol" 🚺 🛛 🔯 sample 🗉 🚾 Final FSS Modd 🗉 🔯 Untilda_D" 🖸	
Image: Control (Control (Contro) (Control (Control (Control (Control (Control (Control (Control (Gen (IEEE),30,Max. Value (Sold Angle) 2.8865 Gen (IEEE),30,Max. Value (Sold Angle) 	D,Mex. Value (
B- C Nets	3D Schematic	
Provide Case Provide Case	Result Report X Messages X Messages Y JD Run ID Mesn Pass 0 il 3 il	XE acculated.
C >	h IN & IN Privation 1000 Instantion 2010 Instantion	wat an Ola a Vahia
P Type here to search	an (<u>) () () () () () () () () () () () () ()</u>	ING 13-33 ING 17-03-2025

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.

■●〒号 号 号 ジ ♡ =	Antenna-chase2 5	oal - CST STLIDIO SLIITE	- 5 ×
File Home Modeling Simulation Port-Proc	Arrian View 1D Plat Farfield Plac		
Properties Update Hot Properties Protection dB Properties Protection dB	Mint Mint Mint	to Barrie Curve Barrie Curve Set Set Set Set Set Set Set Set Set Se	netric Label: Max: 25 Mex: 25 New Plot Window Unve Limit Windows
Nexigetion Tree X	sv2 Anterna* 🗉 🛛 🔤 Anterna-phase? Final* 🔯 🔤 sample 🗉	🙀 Final FSS Medid 🗉 🛛 🙀 Untitled_0* 🖸	
Alsone repeate Alsone repeate Alsone repeate Alsone repeate Alsone	90	Farfield Directivity Abs (Theta=90) 60 0 0 0 0 0 0 0 0 0 0 0 0 0	Frequency = 2.6 GHz Man lobe magntude - 0.602 dB Man bibe direction = 16.0 deg.
- to failed (=2.6)		Phi / Degree vs. dBi	Angular width (3 dB) = 132.5 deg.
No Ada Batin	D Schematic Farfields/farfield (f=2.6) (1) 🛛		
Image Result to Total Phase Y Total Phase W Total Phase W Total Phase W	rigdor Kun ID unrest Run	Men Res 2 1	X Mossings X Q: dt; 32 Secondary calculated. A Q: Decima parametric: 10 results for Ram D: Q: Decimal parametric: 10 results for Ram
Type here to search	19 💿 🚍 🛱 🐽 🖼 🖪	Construction on EVR	^ □ ≤ 40 PNG 1825

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.





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:

IARJSET



International Advanced Research Journal in Science, Engineering and Technology

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.