B.TECH ELECTRONICS AND COMMUNICATION DEPARTMENT
PROJECT-1

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PROJECT GUIDE

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TITLE OF THE PROJECT

DESIGN AND DEVELOPMENT OF WEARABLE ANTENNA FOR BIO-MEDICAL APPLICATIONS

Developed a wearable antenna optimized for biomedical applications, focusing on performance parameters such as gain, efficiency, and S11. Future development includes RFID antennas for further enhancement in biomedical solutions.

BROAD AREA OF PROJECT

INTRODUCTION TO WEARABLE ANTENNAS

- ✓ Wearable antennas are antennas designed to be **integrated into or worn on the body**, typically as part of wearable technology such as **smart clothing, fitness trackers,** or **other wearable devices.**
- ✓ These antennas are designed to be **flexible, lightweight,** and **comfortable**, making them suitable for a variety of applications.

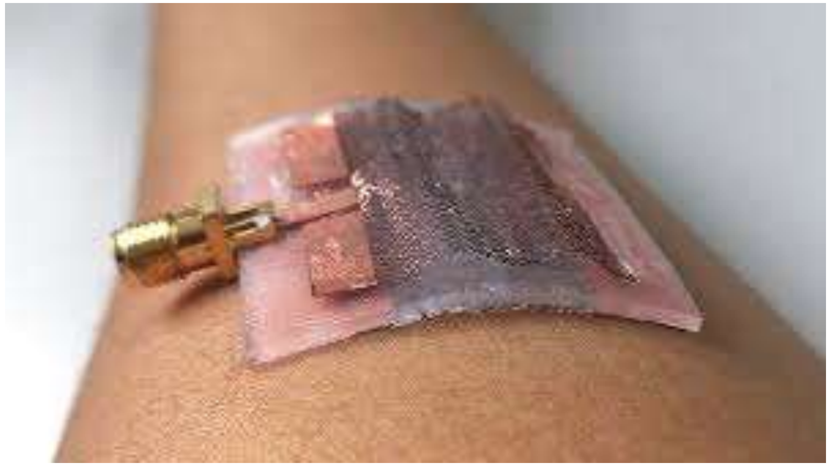


Fig.1. Wearable Antenna

WHY WEARABLE ANTENNA IS USED?

- ✓ Integration with textiles
- ✓ Compact size, Flexible and Conformable
- ✓ Performance Efficiency
- ✓ Application-specific design
- ✓ Durability and Adaptability
- ✓ Electromagnetic Compatibility (EMC)

CHALLENGES AND DESIGN CONSIDERATIONS

MINIATURISATION

- Fitting antennas into small, compact wearable devices

FLEXIBILITY AND DURABILITY

- Must withstand bending and stretching without compromising performance

PERFORMANCE NEAR THE HUMAN BODY

- Ensuring the antennas performance near the human body is not significantly degraded affecting the radiation pattern and efficiency

INTEGRATION

- Seamlessly embedding antennas into clothing without compromising aesthetic or functional aspects

INTERFERENCE AND NOISE

- Mitigating Electromagnetic Interference (EMI) from surrounding electronics or the wearer's body

COMFORT

- Should be lightweight, non-intrusive and comfortable for the wearer

CURRENT STATUS AND MOTIVATION-

Numerous studies have focused on designing antennas for biomedical applications, particularly for wireless communication in implantable devices, body area networks (BANs), and health monitoring systems.

Most antennas are designed to operate at specific frequencies (e.g., ISM bands), aiming for optimal performance with minimal body interference.

Many existing designs lack the flexibility needed for dynamic biomedical environments, where the antenna may need to adapt to different operating conditions or frequencies (e.g., bending or proximity to human tissue).

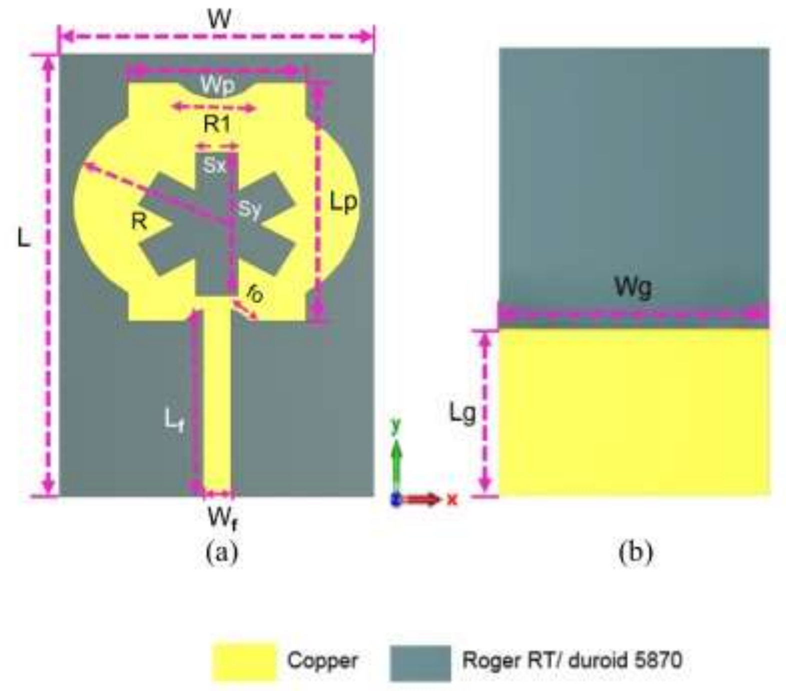
Efficiency and gain often degrade when these antennas are subjected to real-world biomedical conditions, like body bending or tissue absorption.

The motivation behind this project is to address the gap in current antenna designs by developing a **flexible, high-gain, efficient variable antenna** specifically tailored for biomedical applications.

LITERATURE REVIEW

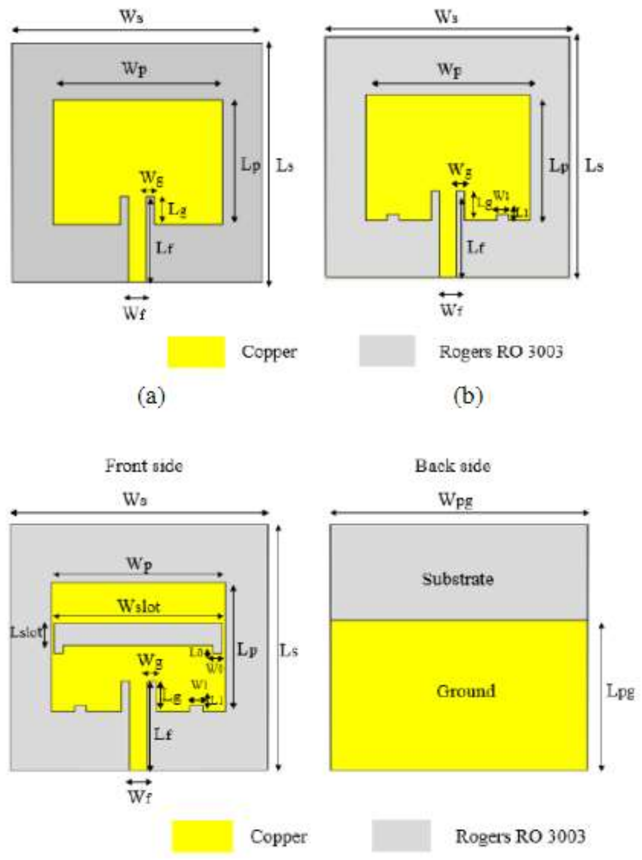
1. A Comprehensive Analysis of Low-Profile Dual Band Flexible Omnidirectional Wearable Antenna for WBAN Applications

Author, Journal Name and year	M. A. Khan et al., in IEEE Access, vol. 12, 2024
Antenna Size (mm^2)	47 x 30
Substrate Material	Rogers
Substrate Type	Semi Flexible
Frequency Range (GHz)	2.45 / 5.2
Gain (dBi)	2.50 / 4.63
Bandwidth (%)	57 / 38.5
SAR (W/kg)	0.45 / 0.29 (1g) 0.17/ 0.46 (10g)
Efficiency (%)	98.5 (fs), 20 (ob) 95.0 (fs), 60 (ob)



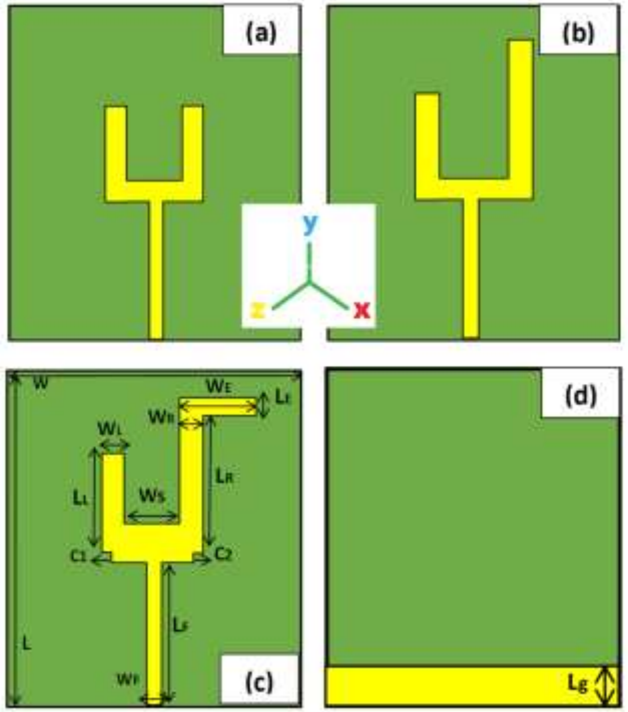
2. Design and Analysis of a Compact Dual-Band Wearable Antenna for WBAN Applications

Author, Journal Name and year	U. Musa, S. M. Shah, H. A. Majid, I. A. Mahadi, M. K. A. Rahim, M. S. Yahya, and Z. Z. Abidin, IEEE Access, vol. 11, 2023.
Antenna Size (mm^2)	41 x 44
Substrate Material	Rogers
Substrate Type	Semi Flexible
Frequency Range (GHz)	2.4 / 5.8
Gain (dBi)	3.74/5.13
Bandwidth (%)	3.8/5.2
SAR (W/kg)	0.45 / 0.29 (1g) 0.17/ 0.46 (10g)
Efficiency (%)	98.5 (fs), 20 (ob) 95.0 (fs), 60 (ob)



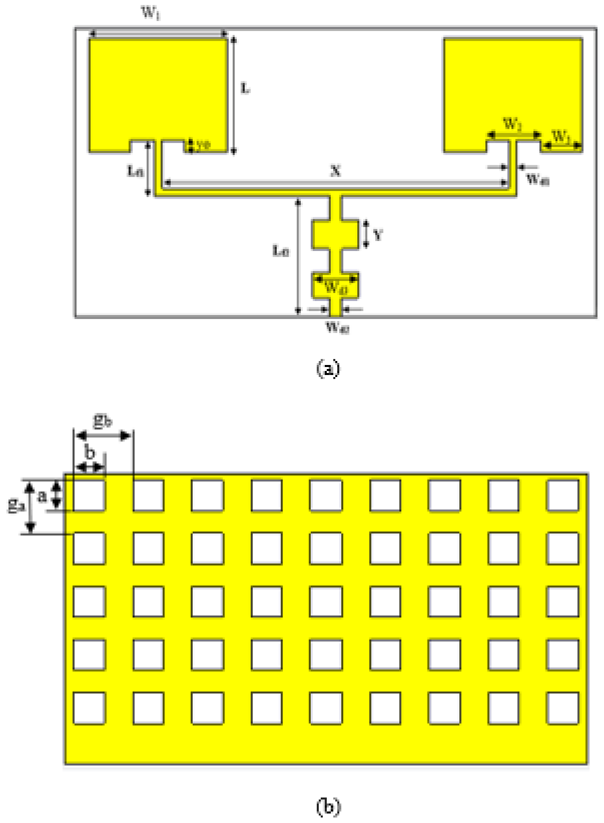
3. A Simulation Study of Triband Low SAR Wearable Antenna

Author, Journal Name and year	M. A. Khan et al., in IEEE Access, vol. 12, 2024
Antenna Size (mm^2)	52 x 40
Substrate Material	Kapton Polyimide
Substrate Type	Flexible
Frequency Range (GHz)	2.45 / 5.8 / 8.0
Gain (dBi)	0.36 / 4.82 / 6.57
Bandwidth (%)	NA
SAR (W/kg)	0.34 / 1.45 / 1.57
Efficiency (%)	65.8(fs), 83.8(fs), 76.4(fs)



4. Design of a compact dual-band textile antenna based on metasurface

Author, Journal Name and year	K. Zhang, P. J. Soh, and S. Yan., IEEE Trans. Biomed. Circuits Syst., vol. 16, 2022
Antenna Size (mm^2)	44.1 x 44.1
Substrate Material	Felt
Substrate Type	Flexible
Frequency Range (GHz)	2.45 / 5.5
Gain (dBi)	-0.69 / 7.4
Bandwidth (%)	10.2 / 22.5
SAR (W/kg)	0.476 / 0.024
Efficiency (%)	34 (fs), 18 (ob) 42 (fs), 40 (ob)



5. A compact dual-band semi-flexible antenna at 2.45 GHz and 5.8 GHz for wearable applications

Author, Journal Name and year	S. M. Shah., Bull. Electr. Eng. Informat., vol. 10, 2021
Antenna Size (mm^2)	30 x 38
Substrate Material	Rogers
Substrate Type	Semi Flexible
Frequency Range (GHz)	2.4/ 5.8
Gain (dBi)	NA
Bandwidth (%)	NA
SAR (W/kg)	0.271 / 0.202
Efficiency (%)	NA

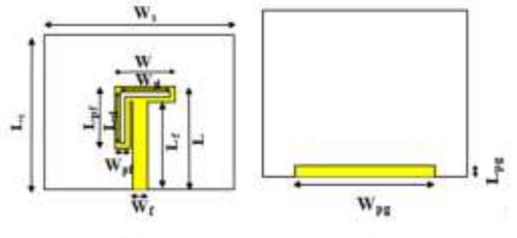


Figure 1. The proposed dual-band semi-flexible antenna at 2.45 GHz and 5.8 GHz, (a) Top view, (b) Bottom view

SOFTWARE USED

CST Studio Suite:

- CST (Computer Simulation Technology) Studio Suite was used for the design and simulation of the variable antenna.
- It allowed us to model the antenna, simulate its performance characteristics, and optimize parameters like S11 ,far-field, gain, efficiency, bending analysis and current distribution.

OBJECTIVE

- The primary objective of this project is to design and develop a wearable antenna optimized for biomedical applications, focusing on key performance parameters such as gain, efficiency, and S11.
- The antenna is intended to provide reliable communication in dynamic biomedical environments, with future plans to incorporate RFID technology for enhanced patient monitoring and healthcare solutions.

METHODOLOGY

- A compact, breathable, flexible and cost effective wearable antennas for biomedical applications will be designed and miniaturized.
- The design frequency will be 2.8 GHz.
- Performed Bending analysis for wearable applications.
- Axial Ratio and SAR evaluation will be carried out to ensure robustness.
- Wearable antennas based on body monitoring system will also be designed and analysed.

PROPOSED DESIGN

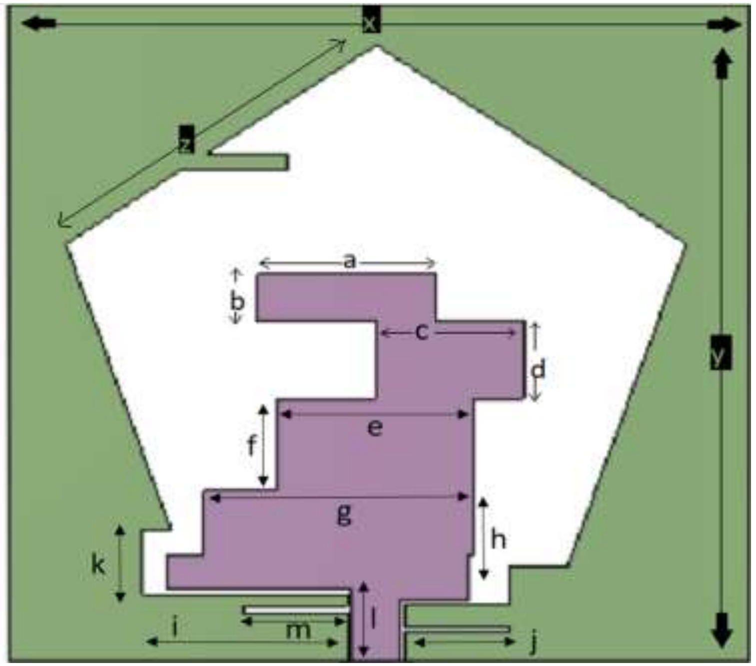


Fig.1. Front View

Ground (PEC)

Feed line (PEC)

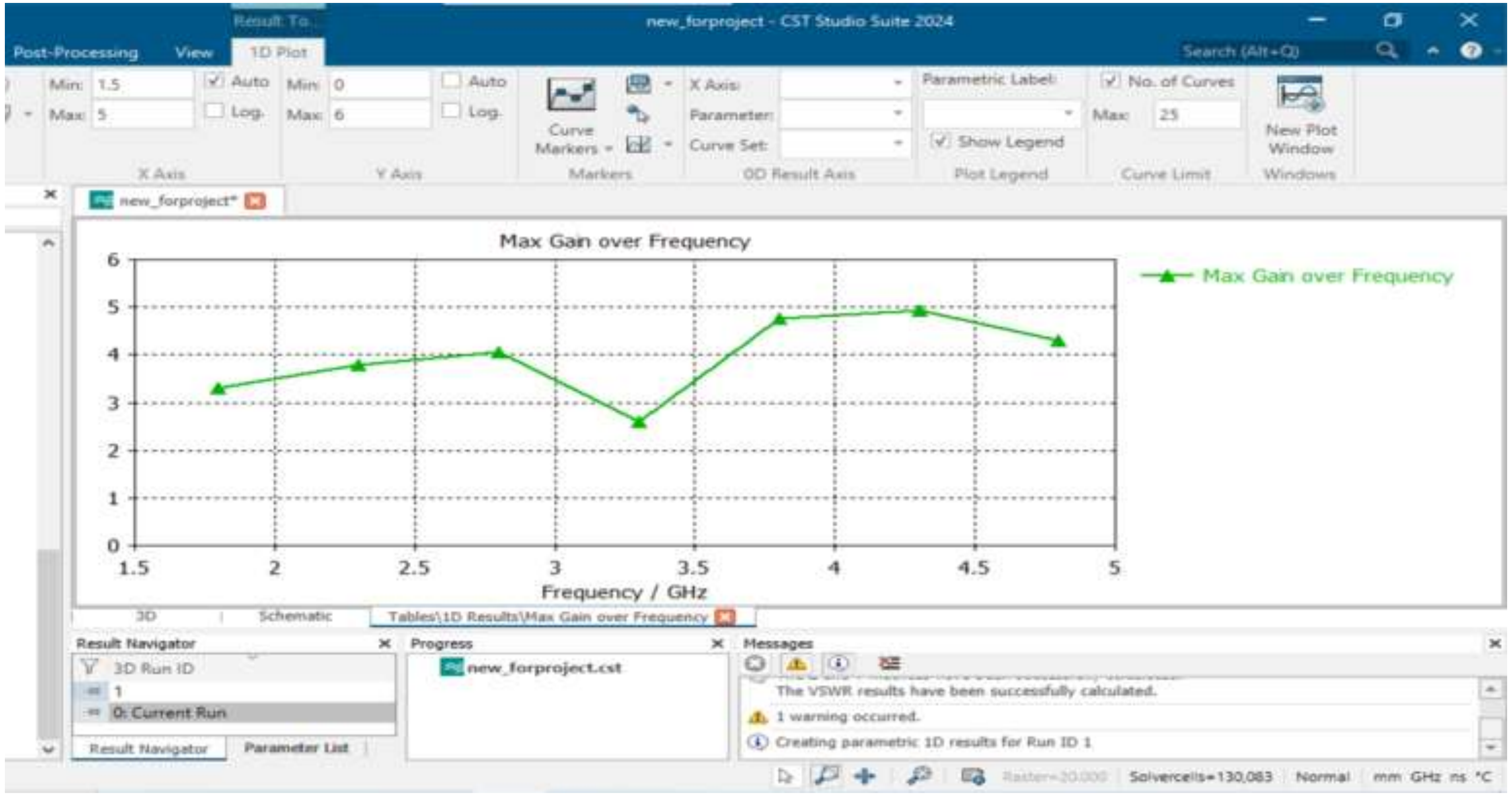
Substrate (Rogers RT Duroid)

a	b	c	d	e	f	j
12	3.5	10	6	13.2	6	7
l	k	m	n	g	h	i
7	5	7	5	18.2	5	18

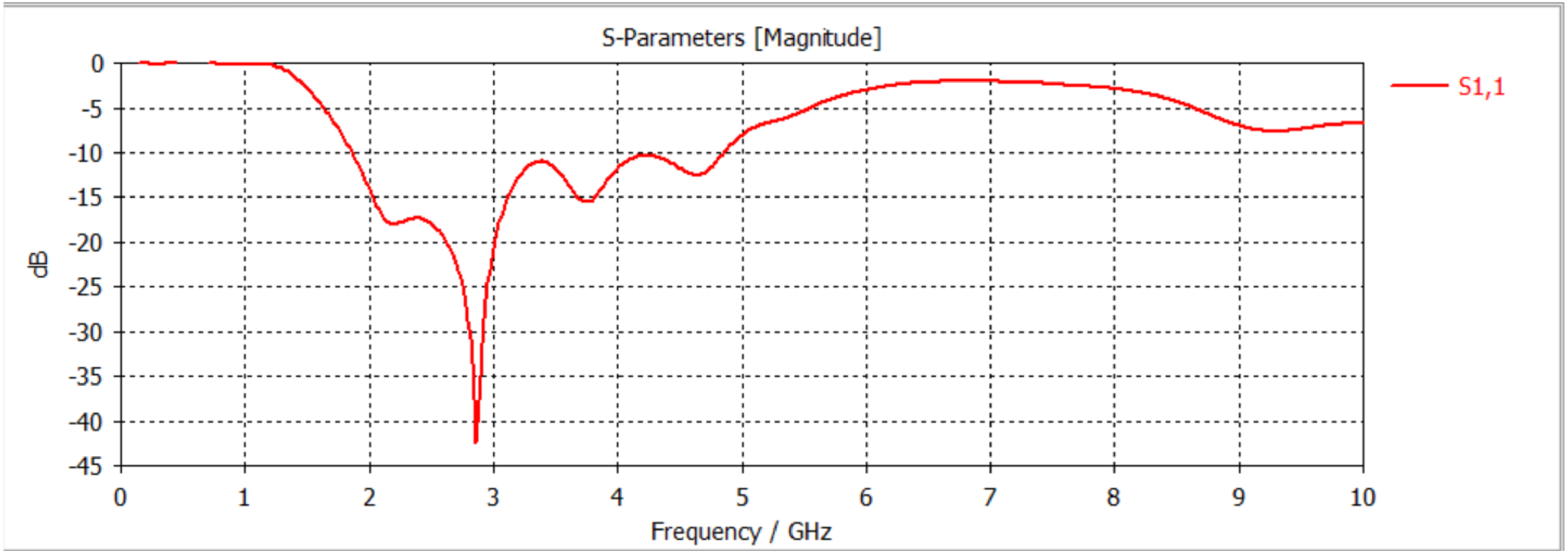
Table 1. Design Parameters

RESULTS-

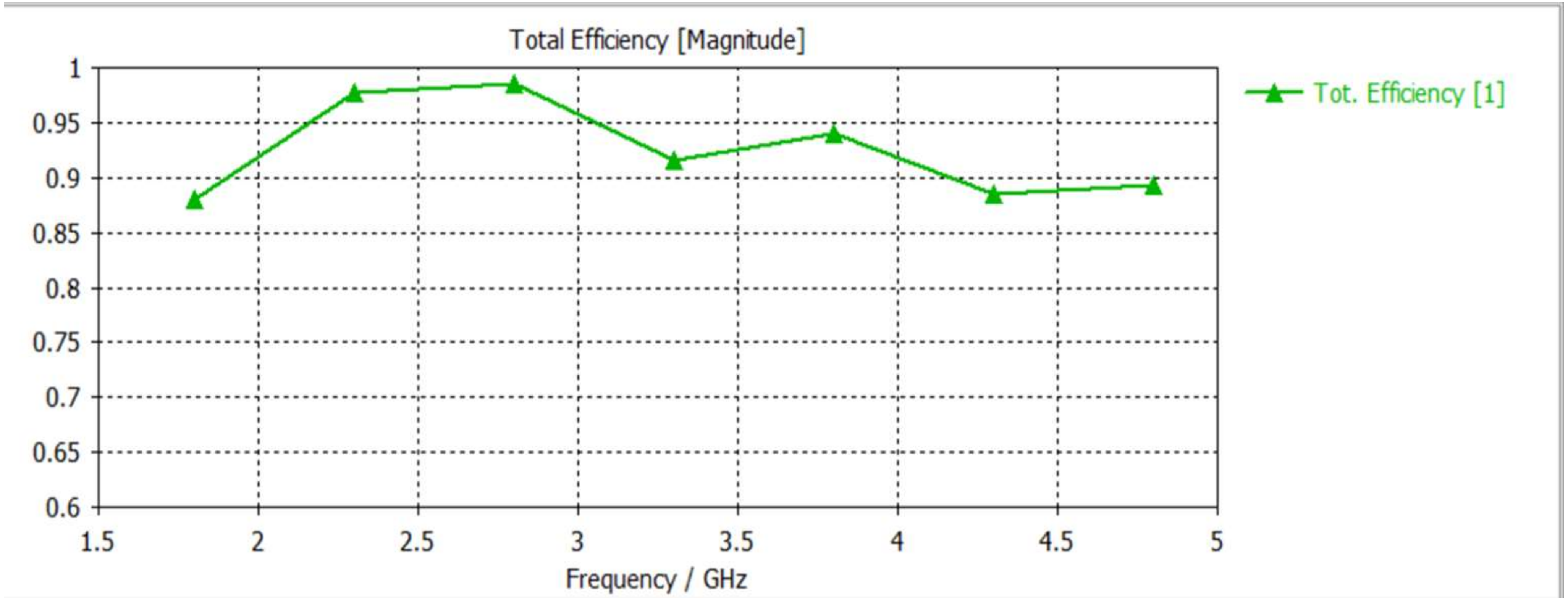
GAIN-



S PARAMETER


S-Parameters [Magnitude]
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
dB
0
1
2
3
4
5
6
7
8
9
10
Frequency / GHz
S1,1

EFFICIENCY-

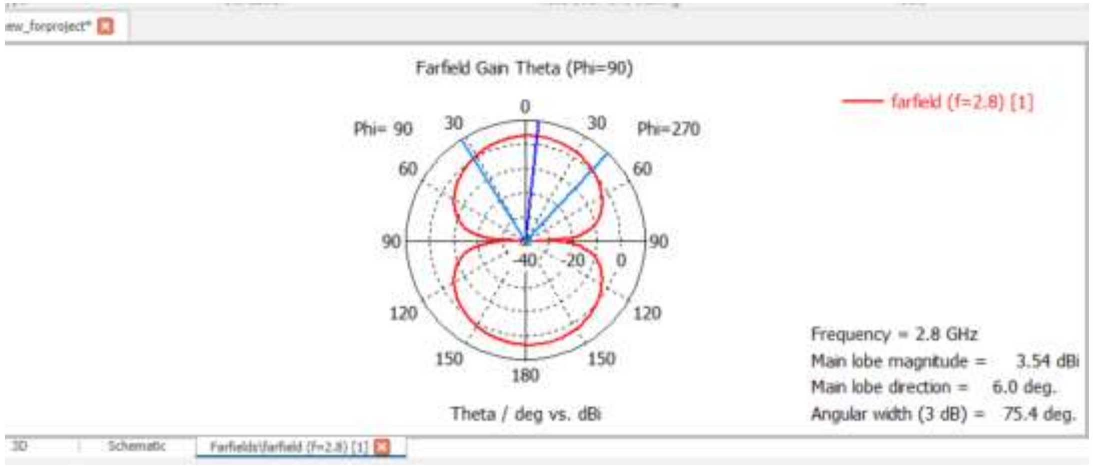


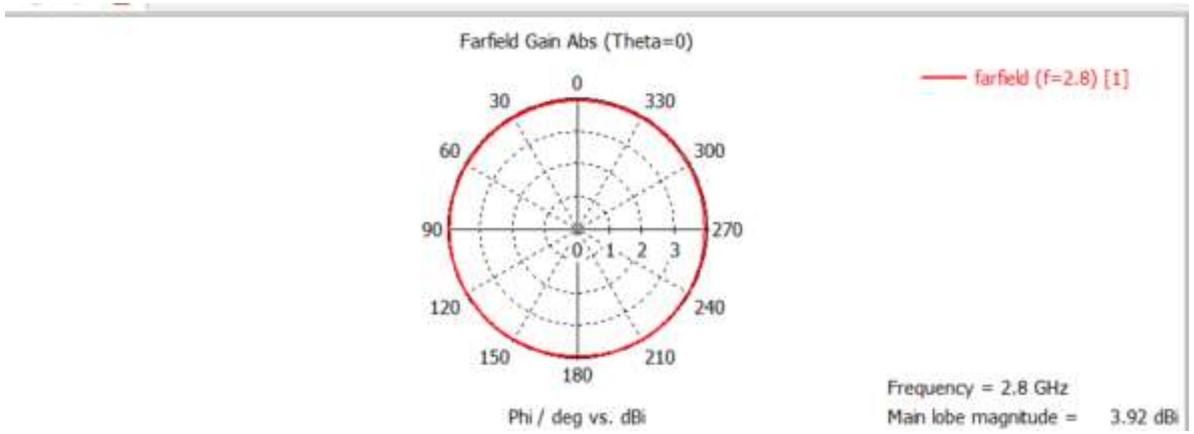
Total Efficiency [Magnitude]
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
1.5
2
2.5
3
3.5
4
4.5
5
Frequency / GHz
Tot. Efficiency [1]

FARFIELD PARAMETERS

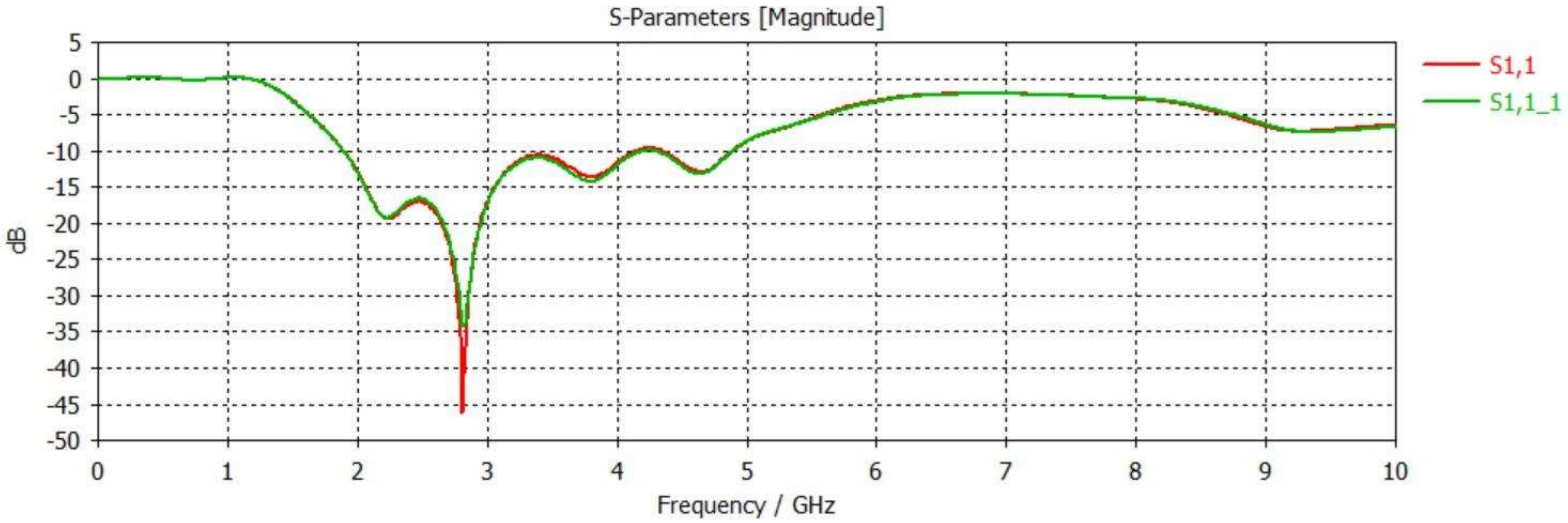
Far-field Gain Theta (Phi=90)

Far-field Gain Abs (Theta=0)





BENDING ANALYSIS AT (10 AND 15 DEGREES)



Conclusion

1. The stubs create a partial ground plane which increases the bandwidth and efficiency of the antenna.
2. The current design of the antenna is linearly polarized and the future aim is to achieve circular polarization.
3. The simulated antenna is designed to resonate at a frequency of 2.8 GHz.
4. The antenna has a bandwidth of 1.8 GHz to 4.8 GHz.
5. The antenna gives a Fractional bandwidth of 90.9%.
6. The efficiency plot shows an efficiency greater than 85% throughout the Bandwidth.
7. The resultant gain of the antenna is between 3-5 dB
8. The bending analysis does not show any significant change in the S11 parameters.

NOVELTY

1. **Cost Effective:**

   We have used only composite materials in our design (fr4 and Rogers RT duroid 5880) unlike the literature available in the space which used metamaterials. Composite materials are materials made up of multiple components, while metamaterials are artificial materials with properties that don't exist in nature.While both composite materials and metamaterials offer unique properties, the primary benefit of using a composite material over a metamaterial is its wider range of practical applications due to generally better manufacturing feasibility, cost-effectiveness, and established design techniques, while still achieving high strength-to-weight ratios and tailored properties, whereas metamaterials often require complex microstructures for achieving specialised functionalities, making them more challenging to produce at scale and potentially more expensive.

1. **Flexibility:**

   The design is also semi flexible (bending results are nearly the same)

1. **Miniaturisation**:

   It is miniaturised despite being composed of composite materials (22x22 mm)

SOCIAL IMPACT

Wireless communication:

Wearable antennas allow wireless communication between medical devices, such as heart monitors and implants, and other bio-telemetry equipment.

Real-time data transmission:

Wearable antennas can transmit vital health data, such as heart rate, body temperature, and blood pressure, to medical professionals or monitoring systems in real time. This allows for timely interventions and improved healthcare quality.

Medical systems:

Wearable antennas are used in medical systems such as body area networks, remote health monitoring, and microwave imaging systems.

Implantable sensors:

Wearable antenna sensors are used in implantable devices such as heart pacemakers, cochlear implants, and intraocular implants.

SUSTAINABLE DEVELOPMENT GOALS

1. SDG 3: Good Health and Well-being

Objective: Ensure healthy lives and promote well-being for all at all ages.

Application: Wearable antennas for biomedical applications can improve healthcare by enabling continuous monitoring of vital signs, disease tracking, and early diagnosis. This technology can enhance telemedicine, improving access to healthcare, especially in remote or underserved areas.

Design Consideration: Ensure that the device is user-friendly, comfortable, and effective in providing reliable health data.

2. SDG 9: Industry, Innovation, and Infrastructure

Objective: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

Application: Wearable antennas represent an innovation in healthcare technology. These devices can help create advanced healthcare infrastructure by supporting remote monitoring and health data transmission.

Design Consideration: Prioritize innovation that improves the functionality and accuracy of wearable antennas, while maintaining cost-efficiency for broader market access.

TIMELINE

AUGUST → Literature Survey

SEPTEMBER → Antenna Design

OCTOBER → Axial Ratio ,SAR evaluation, circular polarization

NOVEMBER → Fabrication ,final documentation and planning to file a patent

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THANK YOU