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Multiband Frequency Compact Patch Antenna for 5G Applications

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Abstract:- The design of a multi-band microstrip patch antenna, with a focus on the frequencies of 27.4GHz, 46GHz, and 58.2GHz, is described in this work. The antenna arrangement consists of a rectangular patch with an incorporated 0.088mm x 2mm rectangular slit. The antenna is based on a 3.285mm×7.235mm Roger RT/duroid 5880(tm) substrate with a dielectric constant of 4.4. It is fed via a 3.4mm×4.1mm microstrip-fed rectangular patch. The antenna operates in multi-band mode, as demonstrated by the simulation results, which show that it can reach respective bandwidths of 19 GHz and 12 GHz. At 27.4 GHz, 46 GHz, and 58.3 GHz, the return loss values are roughly -35.5 dB, -13.35 Db, and -26.9 dB. The measured gains at 27.4GHz, 46GHz, and 56.6GHz are 6.04dB, 3.55dB, and 10.04dB, respectively. The outcomes produced by this suggested antenna should meet the requirements for 5G wireless communication applications and automotive radar systems.

Keywords:- *HFSS.*

I. INTRODUCTION

Our effort to design a multiband microstrip patch antenna in order to redefine wireless connectivity is evidence of our dedication to innovation and advancement in the field of communication technology. This ambitious research offers a ground-breaking solution that goes beyond the bounds of frequency limits, departing beyond the limitations of conventional single-band antennas.

Fundamentally, our multiband antenna signifies a fundamental change in the way we view wireless communication. Through its smooth transition between several frequency bands, it opens up a new dimension of flexibility and variety in antenna design. This adaptability is crucial for minimizing spectrum usage and improving overall network efficiency in addition to satisfying the constantly increasing need for seamless connectivity and high-speed data transmission.

But there are a lot of obstacles in the way of realizing a multiband antenna's flawless operation. Every component necessitates painstaking attention to detail and rigorous design optimization, from impedance matching to radiation pattern control and minimizing cross-coupling between bands.

However, these difficulties also present a wealth of chances for creativity and progress.

Multiband antennas have the potential to be used in a multitude of industries and sectors, including telecommunications, aerospace, healthcare, and the Internet of Things (IoT). We are able to access previously unreachable functionalities and capabilities with single-band designs by utilizing the power of multiband operation. This propels progress and innovation forward by creating exciting opportunities for game-changing breakthroughs in a variety of disciplines.

Additionally, the significance of multiband antennas increases with the introduction of 5G technology. The global deployment of 5G networks is driving up demand for antennas that can handle a wide range of frequency bands and cutting-edge features. Multiband antennas present a strong option in this situation, giving 5G networks the adaptability and scalability needed to provide high-speed access to a variety of devices and applications.

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II. RELATED WORKS

[1] The possible use of the underutilized spectrum in millimeter-wave frequency bands for next-generation cellular systems, including 5G networks, is discussed in this study. In addition to presenting contemporary channel measurement results from the United States and Korea, as well as free space propagation measurements, it draws attention to previous concerns over short-range and non-line-of-sight coverage issues. In order to demonstrate the viability of mmWave bands for cellular usage, the article also presents a novel hybrid beamforming method and its simulation findings, along with mmWave prototype efforts and indoor/outdoor test results.

[2] The fifth generation of wireless communication, or 5G, is being created to keep up with technological advancements and consumer demands. These days, this technology is a hot topic, with most research and development focused on it. The design of a reconfigurable microstrip antenna capable of operating on the various frequencies used by 5G technology is presented in this research. HFSS simulation software will be used to simulate this antenna. With a 3.4 mm x 4.2 mm dimension, a radiation patch, a feed line, and a substrate, the developed microstrip 5G antenna operates at a frequency of 28 GHz. The simulated S11, S21, and VSWR demonstrate the antenna's reconfigurability, demonstrate its ability to function in 5G frequencies, and demonstrate their suitability for implementation.

[3] This paper describes how the number of wireless devices being used for voice and data transmission has surpassed five billion, which has resulted in a notable rise in the use of mobile data. It emphasizes how crucial multiple input multiple output (MIMO) technology is to achieving high data rates and spectrum efficiency. The emphasis is on using HFSS software to create small microstrip patch antennas for MIMO systems. In order to satisfy the demands of contemporary wireless communication, these antennas provide increased bandwidth and data speeds by operating in the mmWave frequency region.

[4] This paper presents the microstrip antennas working at 28GHz for 5G applications. There are three suggested microstrip antenna variants with distinct slot configurations. It is thought that the 28GHz operating frequency is appropriate for 5G antenna design. The design makes use of a low-cost FR4 substrate with a dielectric constant of 4.4, thickness of 0.8 mm, and loss tangent of 0.02. An analysis and comparison are conducted on the antennas' performance with respect to return loss, bandwidth, efficiency, gain, and directivity. Slot arrangements decrease the effective area while increasing bandwidth. The bandwidth is improved over the current design by adding more slots to the layout. A high-frequency structure simulator is used to mimic the suggested designs, and the antennas are small in size with 7×7mm.

III. PROPOSED ANTENNA

A multi-band microstrip patch antenna with a specific focus on 58.2GHz, 46GHz, and 27.4GHz frequencies has been constructed. The antenna configuration consists of a rectangular patch with a 0.088mm x 2mm rectangular slit built right into the patch structure. Fabrication is performed on a 6.285mm x 7.235mm Roger RT/duroid 5880TM substrate with a dielectric constant of 4.4. The antenna uses a 3.4 mm by 4.1 mm rectangular patch that is fed by a microstrip. Figure 1 shows the arrangement of the antenna.

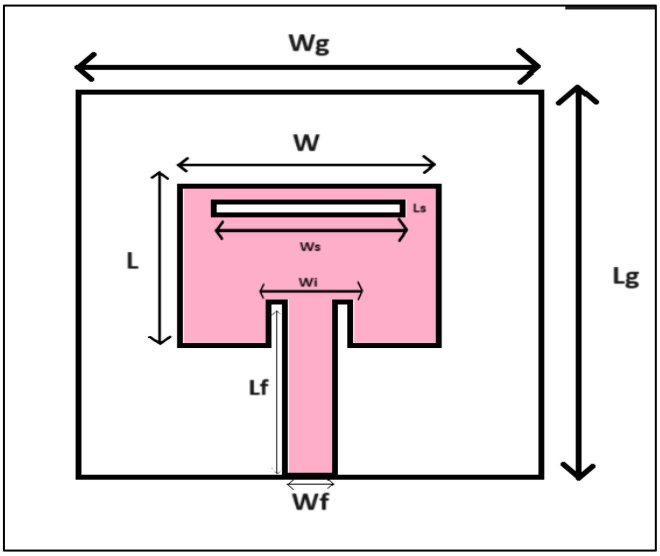

Fig 1 Structure of Microstrip Patch Antenna

➢ *The Geometry Pertaining by the Proposed Microstrip Patch Antenna is as Follows:*

Table 1 Dimensions of Proposed Design

Paramters	Value(mm)
Ground plane length, Lg.	6.285
Ground plane width, Wg.	7.235
Length of patch, W.	3.4
Length of width, W.	4.1
Height of substrate, h.	0.5
Width of feedline, Wf.	1.25
Feedline insertion, Fi.	1.25
Ground thickness, t.	0.035
Slot length, Ls.	2
Slot width, Ws.	0.088

ANSYS HFSS software is employed in the multi-band microstrip patch antenna design process. The substrate in this design is drawn first, measuring 7.235 mm in length, 6.285 mm in width, and 0.5 mm in thickness. A Roger RT/duroid 5880(tm) substrate with a dielectric constant of 4.4 is used to create the antenna. The ground plane gives the antenna current a return path and acts as a reference point for the radiation from the antenna. By reflecting and guiding the radiation in the correct direction, it also aids in lowering back radiation and increasing antenna efficiency. Next, a rectangular patch with dimensions of 2 mm in width and 0.088 mm in length is placed on top of the substrate. The electrical connection required for signal transmission and reception is provided by a feedline. As seen in the figure, boundaries are given to patch and ground, or patch pec and ground pec.

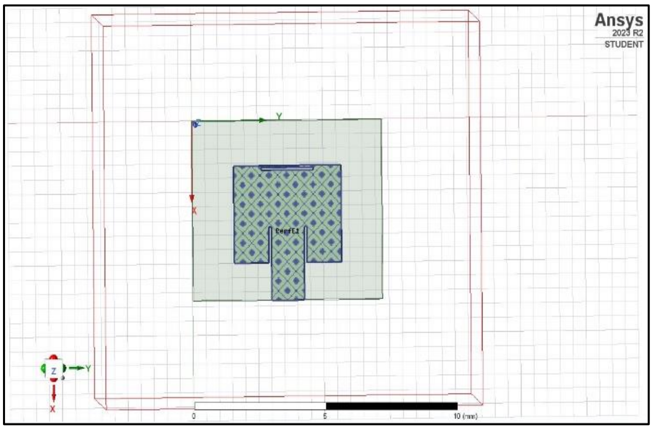

Fig 2 Boundary Patch Pec with Slot

- *Parameter Analysis*

To improve port-to-port isolation, we adjusted the antenna design's specifications. The setting as it was matched by simulations. We discovered that 3.4mm length and 4mm width yielded the best results when we changed the substrate width from 4mm to 4.5mm. Key frequencies (27.74GHz, 46.96GHz, and 57.52GHz) that are essential for satellite, radar, and wireless communication were obtained as a result.

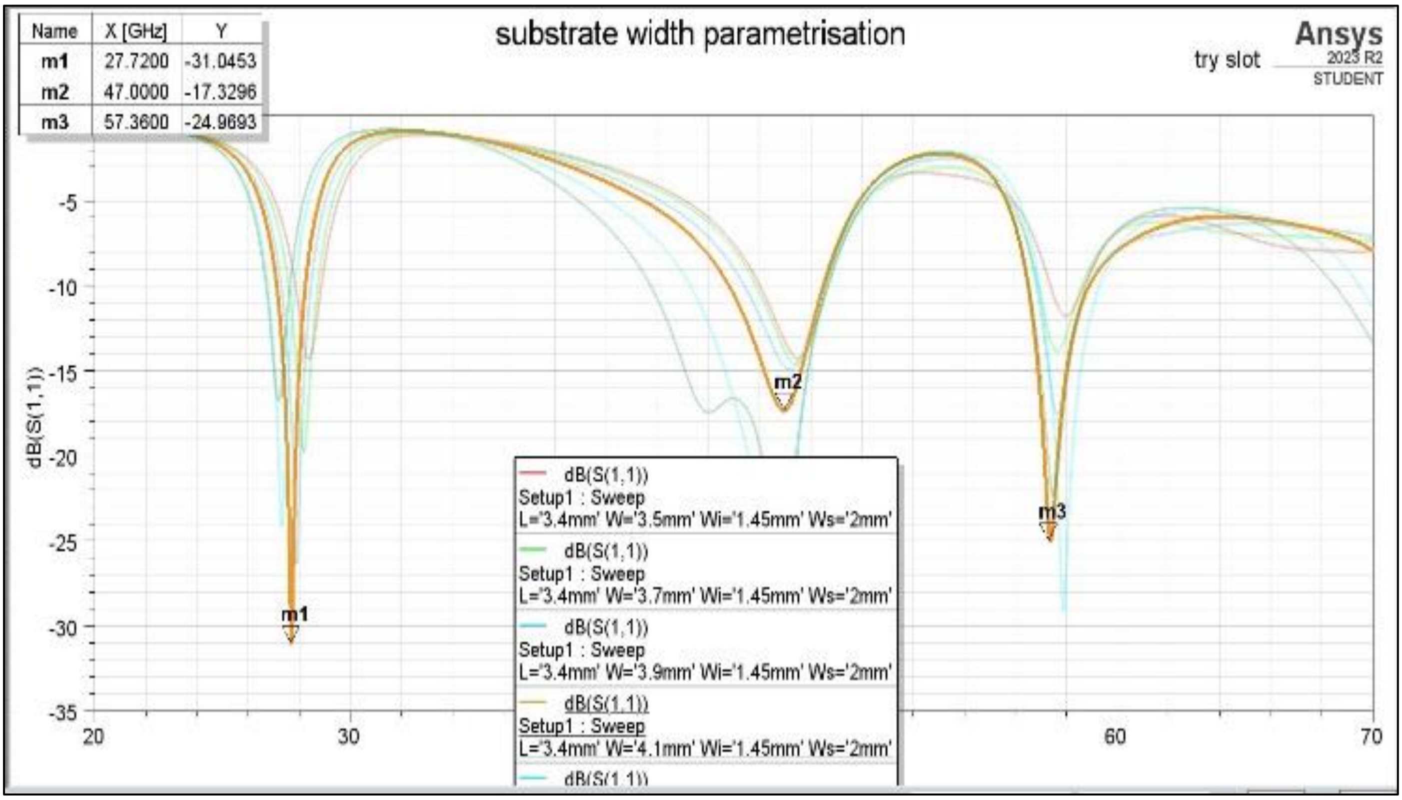

Fig 3 S Parameter Plot with Variable Substrate Width

Variations in substrate length (3 mm to 4 mm width) were examined. The longest drop in performance was observed at 3 mm, which is important for small antennas. This length allowed for the acquisition of frequencies of 30.8GHz, 46.38GHz, and 59.38GHz, which are essential for the dependable operation of sensing and communication systems.

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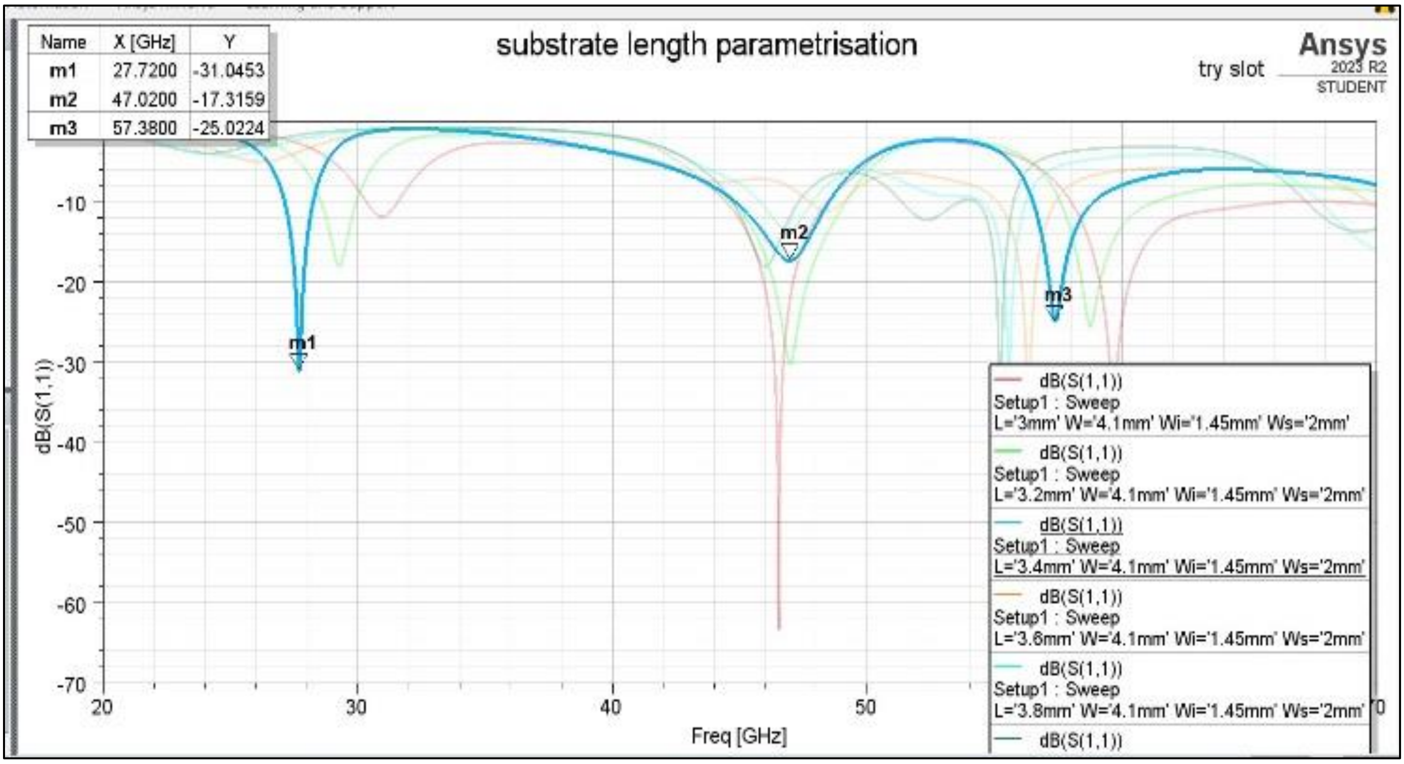

Fig 4 S Parameter Plot with Variable Substrate Length

Next, while maintaining the inset width constant, we parametrized the inset length at the following values: 1mm, 1.2mm, 1.4mm, 1.6mm, 1.8mm, and 2mm. On the s parameter plot, a maximum dip of 1.2 mm was noted.

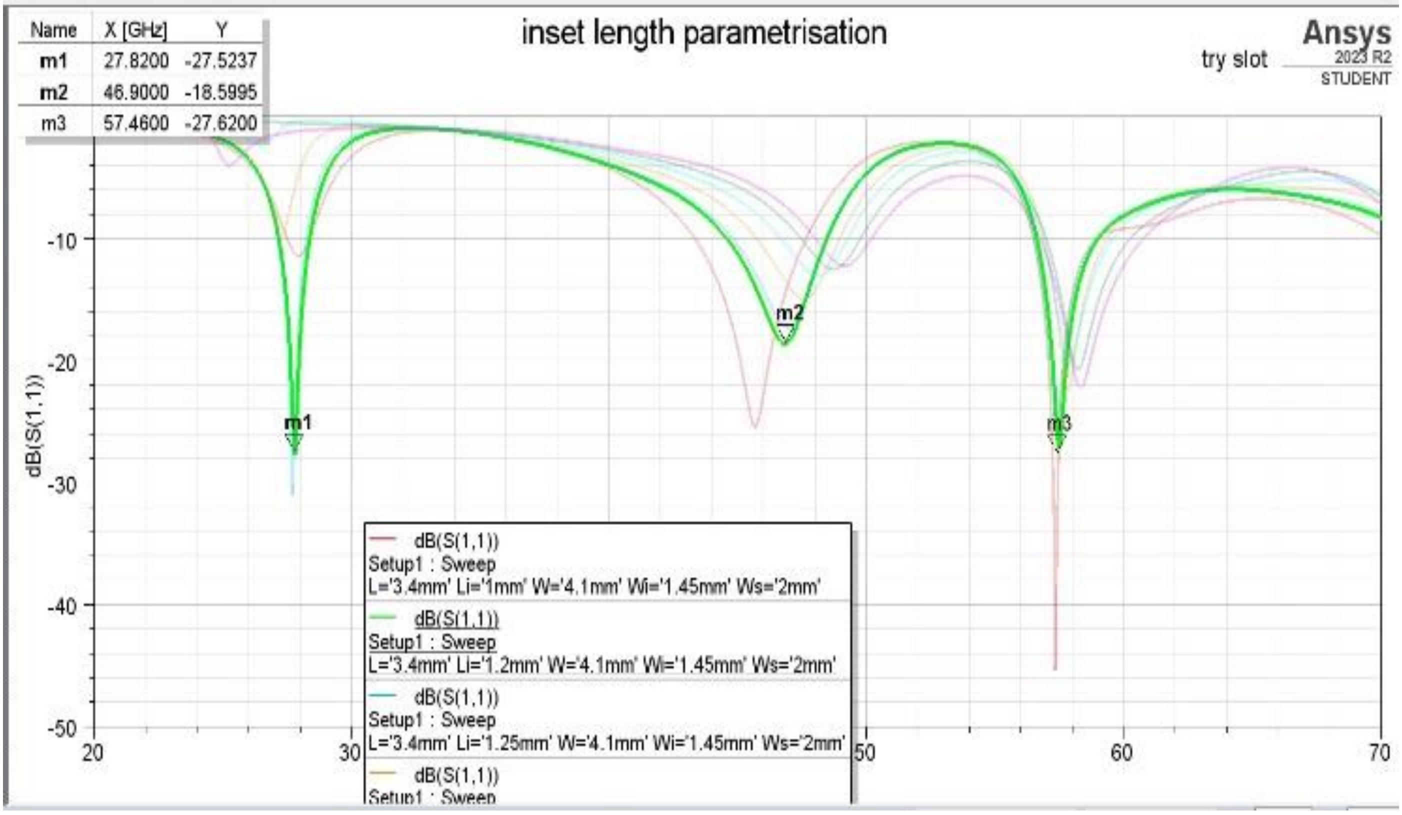

Fig 5 S Parameter Plot with Variable Inset Length

Next, while maintaining a constant inset length, we parametrized the inset width at the following values: 1mm, 1.2mm, 1.4mm, 1.6mm, 1.8mm, and 2mm. On the S parameter plot, the largest dip was measured at 1.45 mm.

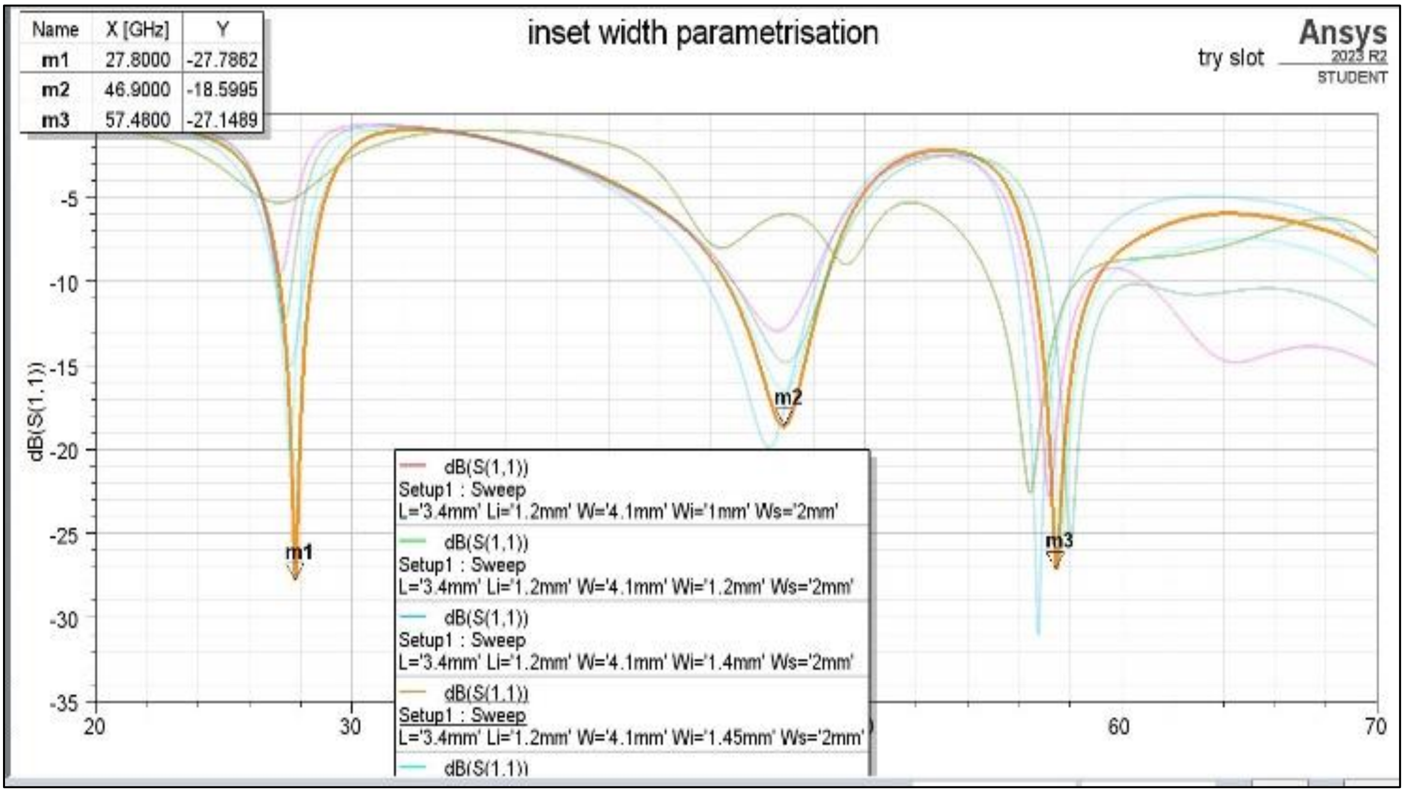

Fig 6 S Parameter Plot with Variable Inset Width

Next, while maintaining a constant slot width, we parametrized the slot length at the following values: 0.01mm, 0.02mm, 0.04mm, 0.06mm, 0.08mm, and 0.1. On the S parameter plot, the largest dip was noted at 0.03 mm.

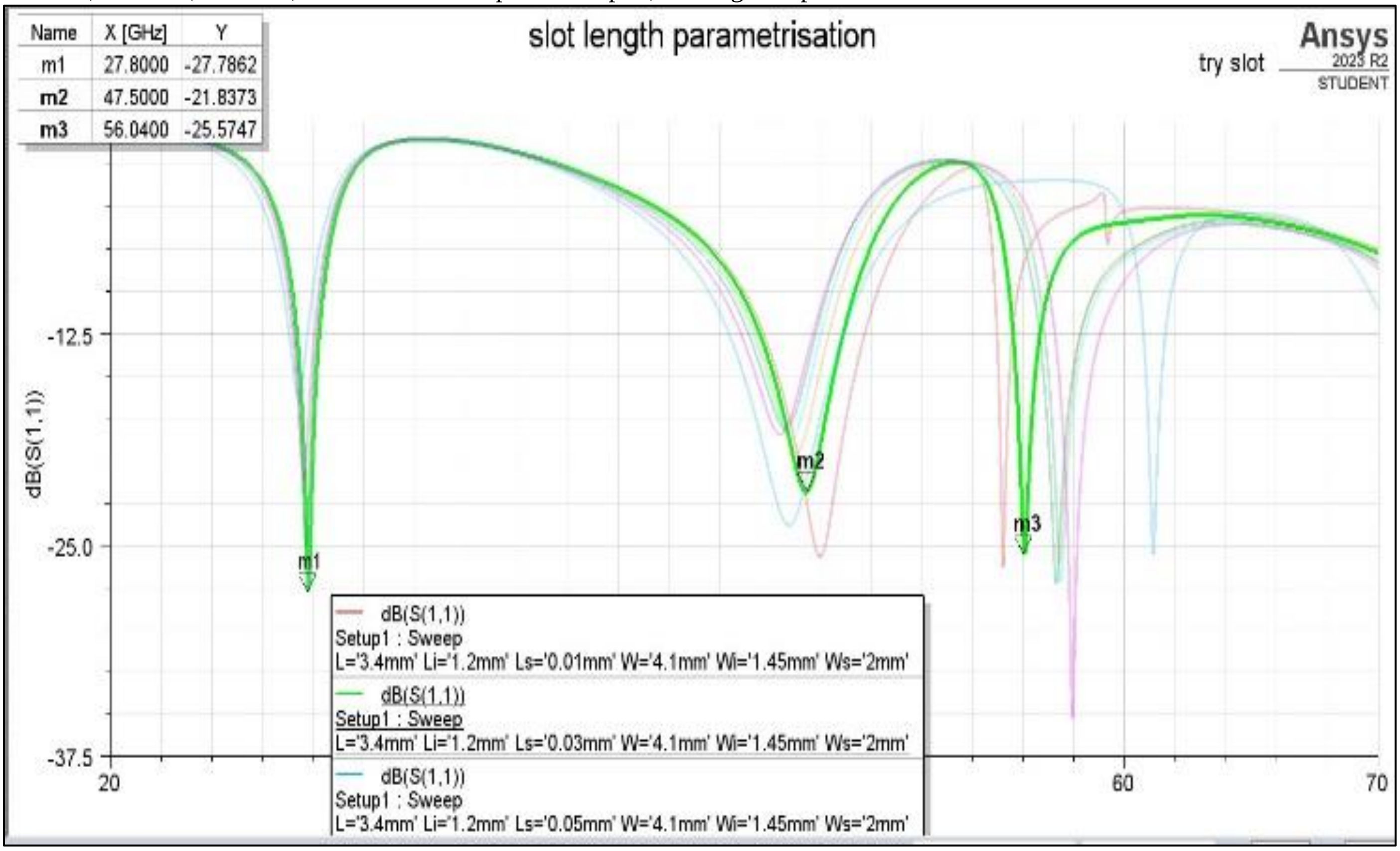

Fig 7 S Parameter Plot with Variable Slot Length

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Next, while maintaining a constant inset length, we parametrized the slot width at the following values: 2mm, 2.2mm, 2.4mm, 2.6mm, 2.8mm, and 3mm. On the s parameter plot, a maximum dip of 2 mm was noted.

Fig 8 S Parameter Plot with Variable Slot Width

IV. EXPERIMENTATION RESULTS

Our original design has been refined into a new one. The suggested tiny slotted patch antenna for ultrahigh frequency is designed using the ANSYS HFSS software. We have improved the outcomes by simulating this design.

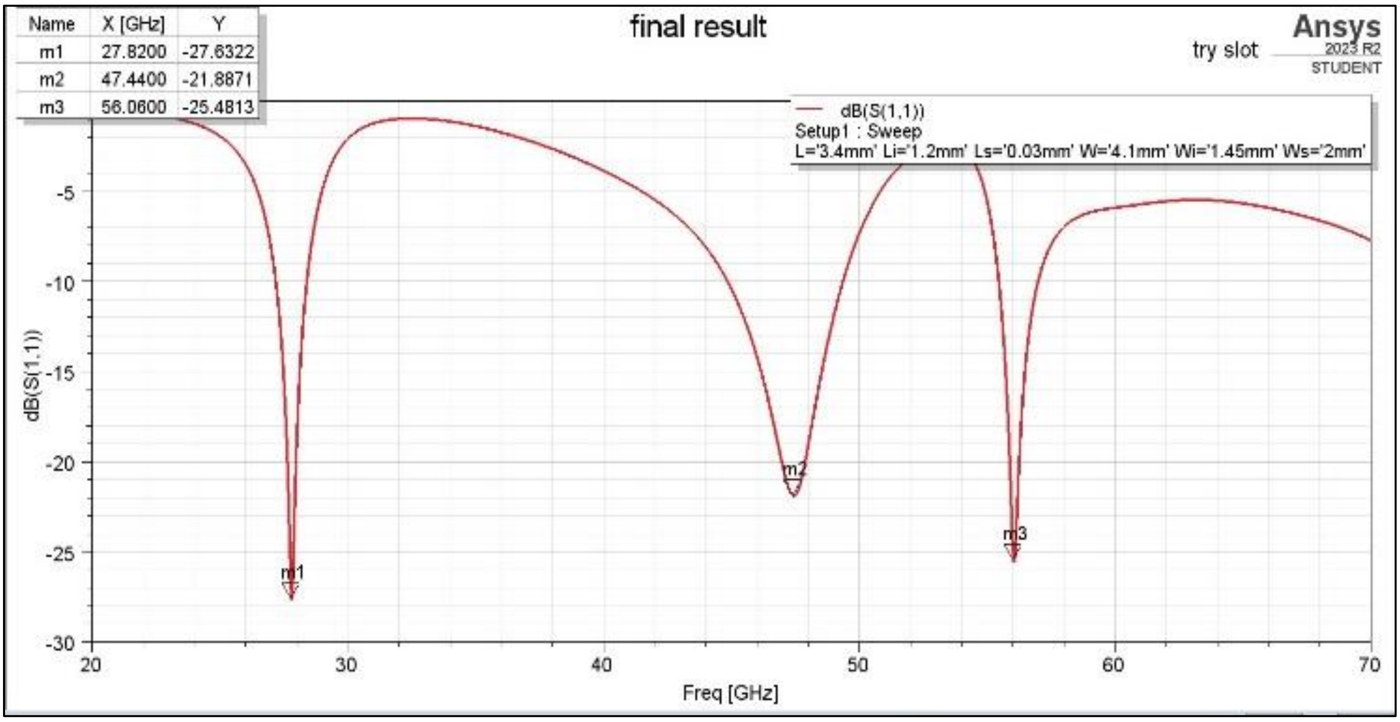

Fig 9 S Parameter Plot

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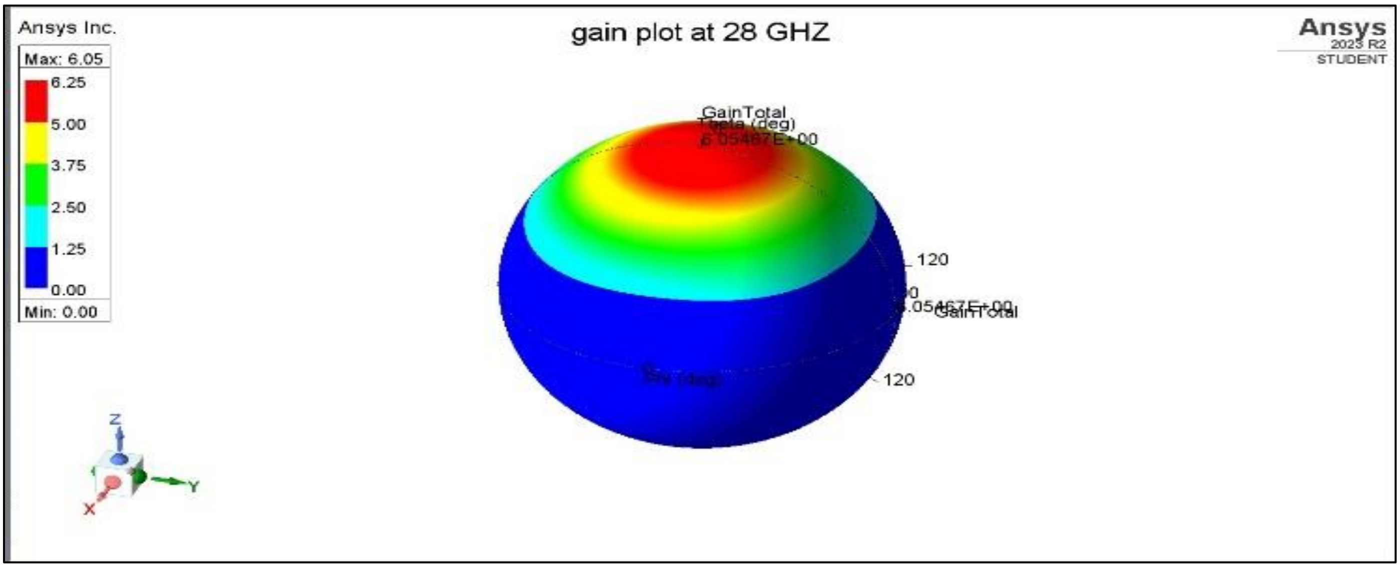

Fig 10 Gain Plot at 28GHz

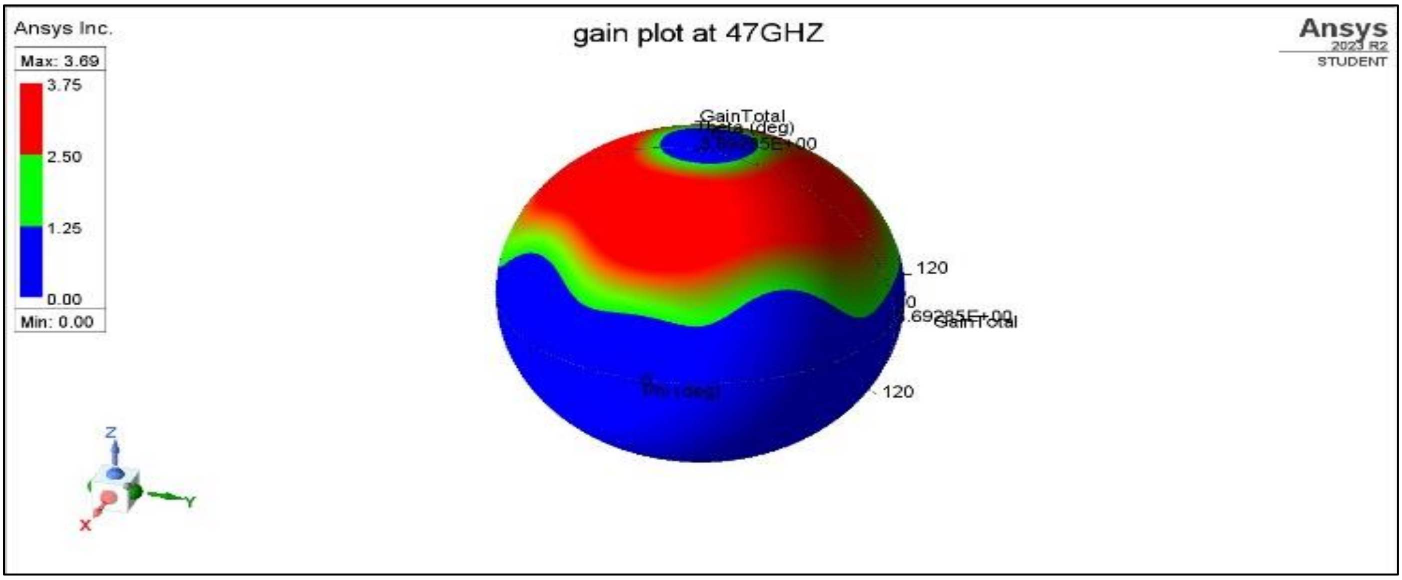

Fig 11 Gain Plot at 47GHz

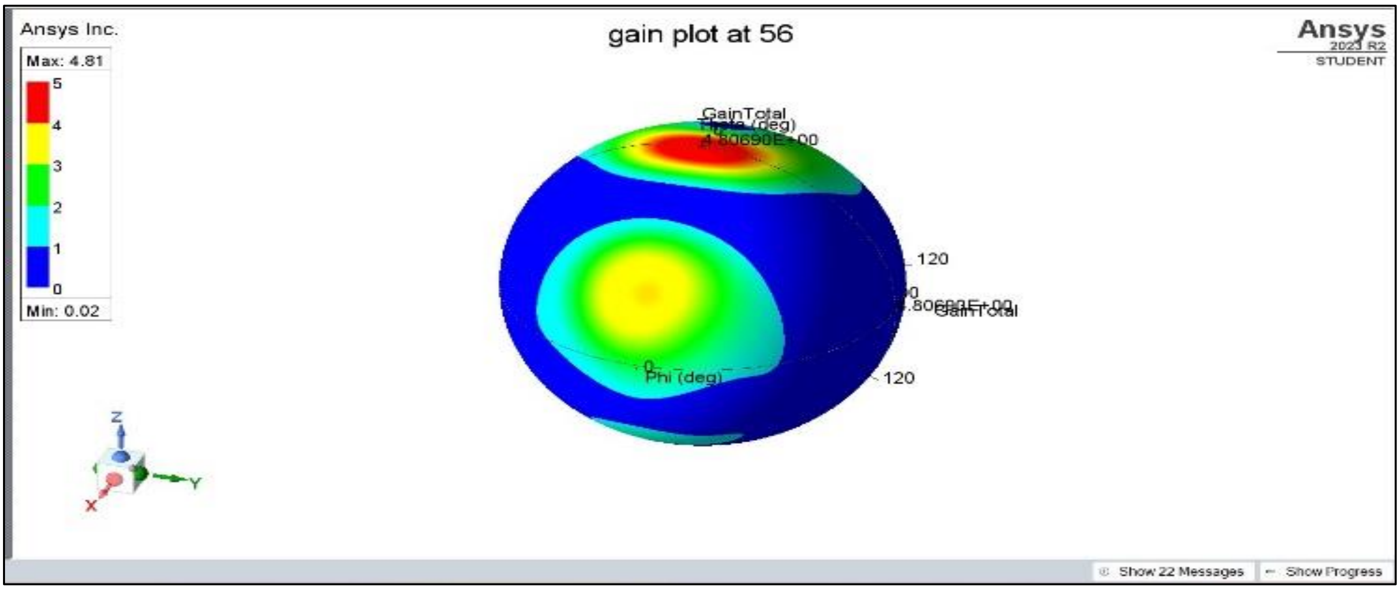

Fig 12 Gain Plot at 56GHz

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V. CONCLUSION

We have demonstrated a multi-band microstrip patch antenna that can be used for satellite communication at 47GHz and 57GHz, vehicle radar systems, and 5G communication at 28GHz. The optimization of the antenna's physical dimensions, such as length and width, to maximize gain and directivity and achieve resonance at the required frequencies was included in the parametric analysis. Through the use of sophisticated simulation methods made possible by HFSS software, the antenna was put through a rigorous evaluation process to verify its functionality. The analysis of the S parameter gave important information about the impedance matching properties of the antenna and its effectiveness in transferring power to and from the feeding network. The success of the antenna design was further validated by the surface current distribution, which showed a homogeneous and concentrated distribution with sections of full blue indicating excellent current flow and minimal energy losses. The outcomes show that the developed antenna is a reconfigurable microstrip patch antenna, with applications in satellite communication, automotive radar systems, and 5G communication systems, among other domains. The success of the antenna design was further validated by the surface current distribution, which showed a homogeneous and concentrated distribution with sections of full blue indicating excellent current flow and minimal energy losses. The outcomes show that the developed antenna is a reconfigurable microstrip patch antenna, with applications in satellite communication, automotive radar systems, and 5G communication systems, among other domains.

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