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Design and Simulation of Plastic free antenna using chitosan substrate

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***Abstract*:** The majority of wearable and flexible 5G and 6G devices are widely used plastic substrates, which are harmful to the environment. Therefore. The enhancement of sustainability and plastic-free radio frequency (RF) devices becomes a crucial issue. In this regard, we present a fully biocompatible Planar Inverted-F Antenna (PIFA), simulated on a 55 μm-thick chitosan substrate. Chitosan has a relative dielectric constant of 5. This antenna is working at 4.5 GHz in the sub 3-6 GHz band of the 5G spectrum. Chitosan, Sourced from chitin, an organic biopolymer found in the outer shells of crustaceans and insects, has emerged Has arisen as a strong alternative due to its biodegradable, non- toxic, and renewable nature.

Keywords: Plastic-free antennas, sustainable devices, biocompatible chitosan substrate, sub 3-6GHz band

I. INTRODUCTION

The 5G and new 6G communication networks are opening interesting perspectives for wearable and wireless sensor nodes and are Offer great prospects for advancing sensor capabilities [1], [2]. New conceptions of sensing systems imply very compact footprints and connection capabilities to: minimize the impact of the devices, allow the sharing of data.

Recently, there has been a growing interest in the enhancement of environmentally friendly and sustainable technologies across various industries, including electronics and telecommunications. One such area of innovation is the structuring and formation of antennas, essential components in radio communication systems. Traditional antenna manufacturing processes typically involve the adoption of non- biodegradable materials such as plastics, which contribute to environmental pollution. As a response to this, researchers and engineers are exploring the adoption of sustainable materials to minimize the ecological footprint of antenna production.

The design strategy will encompass a thoughtful analysis of the antenna's electrical properties, such as impedance matching, bandwidth, and radiation efficiency, to ensure that the chitosan substrate provides a viable alternative to conventional plastic-based designs. Additionally, the fabrication process will be optimized to minimize environmental impact, focusing on Approaches that work well with sustainable practices

The growing need for sustainable and eco-friendly technologies has spurred to the exploration of renewable materials in various Sectors of engineering and science. One such area is the creation and evolution of antennas, which are essential components in communication systems, satellite technology, wireless networks, and many other applications. Traditionally, antennas are

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constructed using plastic-based materials or composites, which, despite their functional efficiency, contribute significantly to environmental pollution, particularly regarding waste and non-biodegradability. This has prompted researchers to explore substitute materials capable of provide the required mechanical properties, electrical performance, and environmental compatibility without compromising functionality. Among these sustainable alternatives, chitosan – A biodegradable biopolymer extracted from chitin, present in crustacean shells – has gained considerable attention. Chitosan is recognized for its biodegradability, non- toxicity, and ability be transformed into different formats, including films, fibers, and coatings. These properties make chitosan A desirable material for replacing plastic components in numerous applications, including electronics and antennas. Chitosan's eco-friendly nature is a compelling factor, particularly in the design of plastic-free antennas, which aim to minimize the ecological footprint of traditional electronic components. The idea of developing a plastic-free antenna on a sustainable chitosan substrate merges the functionality of high-performance communication systems with the necessity of sustainability in design and materials. Recently, there has been a surge in research focused on using biopolymers like chitosan to construct antenna substrates, as they offer an ideal balance of mechanical integrity, flexibility, and environmental benefits. The utilization of chitosan in antenna design Goes beyond solving environmental matters while additionally holds The ability to revolutionize industries by reducing dependency on petroleum-based materials.

Moreover, chitosan-based antennas can be engineered to operate efficiently A broad spectrum of frequencies, allowing them to be used for wireless communication applications, Internet of Things (IoT) devices, and wearable technologies. They also provide unique benefits, such as light weight, easy fabrication, along with the capability to support both 2D and 3D configurations, , which play a crucial role in contemporary communication systems.

The design and simulation of a plastic-free antenna on a sustainable chitosan substrate will be explored, focusing on the material properties, performance characteristics, and the environmental benefits of such a design. The integration of sustainable materials in antenna systems is crucial for the evolution of more eco-conscious communication technologies that can reduce ecological footprint impact without sacrificing performance. The design process will consider factors like material conductivity, dielectric properties, and the overall mechanical robustness of the chitosan substrate to ensure that the antenna meets or exceeds the necessary operational standards for modern communication systems.

II PLANAR INVERTED F-ANTENNA DESIGN

The implementation of a Planer inverted F-antenna design involves putting the theoretical concepts into practice by building and deploying the antenna. The antenna is intended to operate at a frequency of 4.5 GHz, with a width 3mm and length 5mm . The dielectric constant 5 Simulations indicate that the antenna attains a gain of 1.49 dB, and the Radiative distribution is also presented with s parameter results.

Chitosan is a natural polymer extracted from chitin, which is a natural polymer located in the outer coverings of crustaceans, including such as shrimp, crabs, and lobsters. Chitosan is the second most naturally occurring polysaccharide, subordinate to cellulose and is Widely recognized for its multiple biological, chemical, and physical properties. Due to these characteristics, it finds extensive applications in a range of fields, including medicine, agriculture, food, cosmetics, and environmental science. Chitosan substrate is designed at Frequency of resonance 4.5Hz ,

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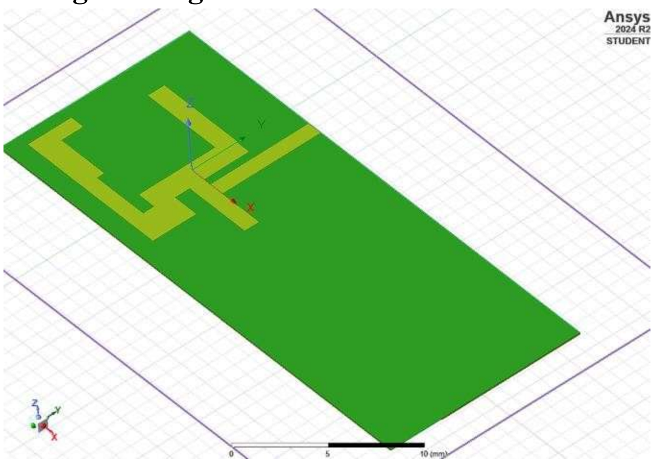
Dielectric height 1.6mm, Dielectric constant 5 and at thickness of 0.055mm.

Fig: 1 Design of Planar inverted F-antenna



The fig:1 results the design of Planer inverted F-antenna with L shape patch placed at the center of the radiation pattern.

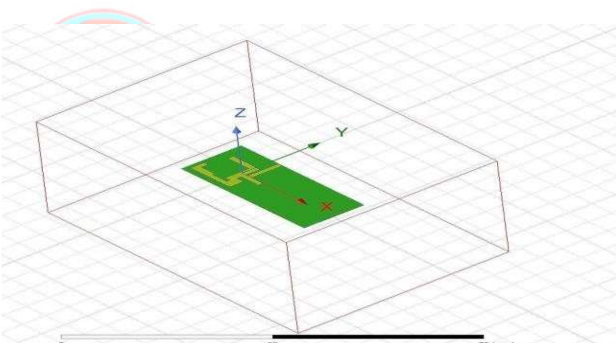


Fig:2 Radiation boundary of planer inverted F-antenna

TABLE I DESIGN RESULTS

Parameter	Specification Elements	Elements
S Parameter	4.5 GHz	4.57 GHz
Gain	1.38	1.49

III. SIMULATION & RESULT ANALYSIS

The planar inverted F-antenna utilized a Chitosan substrate, In fig.3. shows the reflected power loss for 4.5 GHz obtained at -1.84 dB.

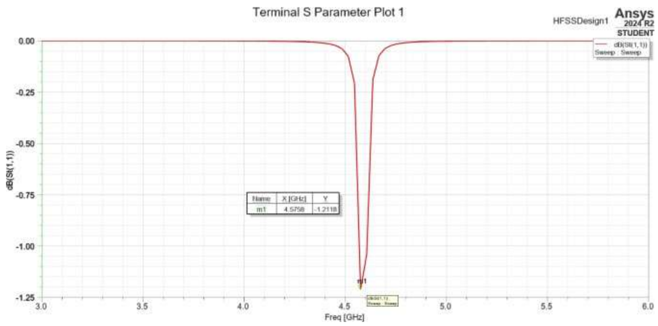


Fig. 3. Return loss of Planar inverted F Waveguide.

VSWR and reflected power are alternative metrics for assessing the same parameter as shown in Fig.4. Voltage Standing Wave Ratio (VSWR) is a measure of 4.5GHz

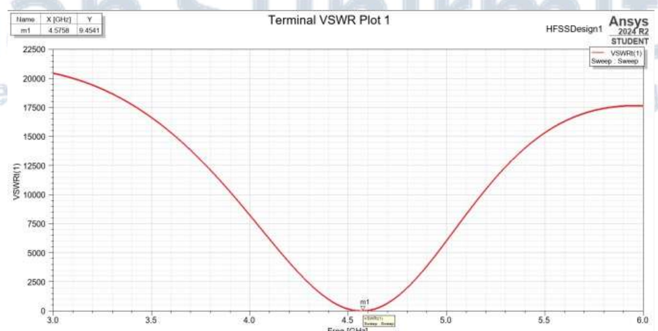


Fig.4. VSWR Plot of Planar inverted F Antenna Antenna.

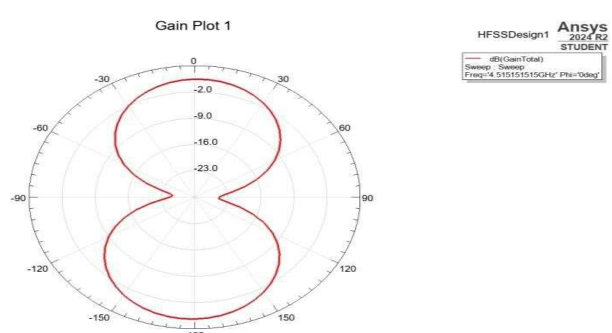


Fig. 5. Radiation Pattern of a planar inverted F-antenna at Phi 0

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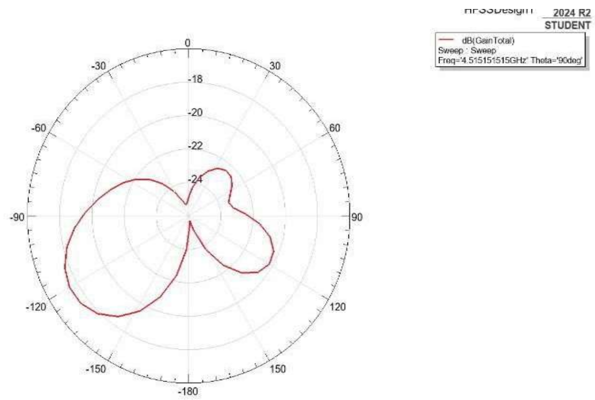

Fig. 6. Radiation Pattern of a planar inverted F-antenna at Theta 90

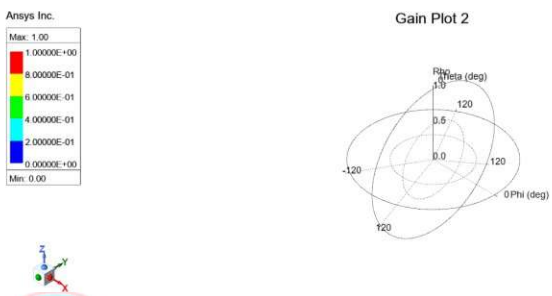

Fig 7: 3D plot of Radiation pattern of lanar inverted F- antenna

Radiating pattern is the concept that measures how effectively an antenna transforms input energy into radiated electromagnetic waves in a specific direction. It quantifies the directionality and efficiency of an antenna in transmitting or receiving signals. In essence, it evaluates how well an antenna focuses its energy in a desired direction compared to an radiator, which radiates energy equally in all orientations. Gain helps in optimizing antenna Effectiveness across multiple applications, including, telecommunications, radar, and broadcasting.

For a linearly polarized antenna, performance is often described in terms of its Principal E and H-plane patterns. The E-plane is defined as "the plane containing the electric-field Vector and the direction of the maximum radiation." As shown in the above fig.5 and fig:6. The H- plane as "the plane containing the magnetic field vector and the direction of the maximum radiation. "The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as it varies with the spatial co- ordinates which are specified by the elevation angle (θ) and the azimuth angle (φ).

IV CONCLUSION

The design and simulation of plastic-free antennas using chitosan substrates demonstrate a significant step towards Eco-conscious and renewable wireless communication technologies. Through comprehensive simulations, analysis reveals that antennas using chitosan substrates achieve efficient performance in terms of impedance matching, radiation patterns, and gain, making them viable for a range of applications.

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