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Design of Three Elements Lotus Leaf Shape Wideband Antenna for Wireless CommunicationApplications

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Abstract:

The work presents a three-elements lotus leaf-shaped wideband antenna (BIMS) designed for wireless communication applications. The antenna's size is reduced without compromising performance. The BIMS uses bio-inspired shapes like leaves, trees, animals, or insects as preference. The antenna is simulated using fiberglass laminate (FR4) as a substrate, offering maximum gain and occupying less area compared to conventional patch antennas. The work demonstrates the potential of BIMS in reducing antenna size without compromising performance.

Key Words: BIMS (Bio-inspired Micro Strip), Antenna, Size, Shape, Work

Introduction:

Since the 1990s, when the Internet first became widely available, portable terminals have grown significantly and are now crucial to the telecommunications sector. The development of digital information and communication technologies is becoming more and more crucial as the information era unfolds. Contemporary wireless applications require portable, multipurpose, aesthetically pleasing terminals that can combine several wireless services, including 4G, Wi-Fi, Bluetooth, NFC, GPS and more. Because wireless communication systems are developing so quickly, base stations and

portable terminals using antennas need to meet strict requirements such downsizing, system integration, and multiband or broadband operation. For stationary or mobile wireless applications, low-profile microstrip antennas (MSA) and arrays are a good fit.

Compact antennas that provide consistent radiation coverage throughout a wideband are becoming more and more popular for usage in contemporary wireless systems.On the other hand, electrically tiny antennas frequently result in a narrower impedance bandwidth, lower gain, and less control over the emission pattern. institutions for research such as Massachusetts Institute of Technology. In an effort to find solutions to engineering challenges in nature, Harvard University and London College have created research centers and committed resources to the field of biologically inspired engineering.

Because of their promising outcomes, recent works on bio-inspired micro strip antennas with fractal, polar, and Gielis designs have drawn attention from researchers. A bio-inspired design of directional leaf- shaped printed monopole antennas for the 4G 700 MHz band and a MIMO antenna for the broadband applications employing castor leaf-shaped as a quasi-self-complement components are examples of recent efforts.

Proposed Method:

The proposed work introduces a three-element leaf-shaped ultra-wideband antenna (BIMS) tailored for wireless communication applications, emphasizing size reduction while maintaining optimal performance. Drawing inspiration from nature, including shapes found in leaves, trees, animals, and insects, the BIMS antenna leverages bio-inspired designs to achieve compactness. Simulated on fiberglass laminate (FR4) substrate, the antenna offers maximum gain and occupies less area compared to conventional patch antennas. Through comprehensive simulations and analysis, the study showcases the potential of BIMS in significantly reducing antenna size without compromising performance, thereby opening avenues for more efficient and compact wireless communication systems.

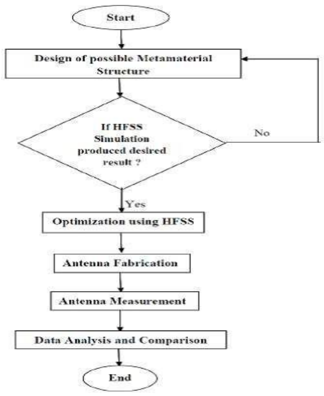
The proposed system's working can be summarized as follows:

Introduction to antenna design

Both the microstrip patch antenna and the co-planar waveguide fed rectangle co-planar antenna are constructed at their respective resonance frequencies. The frequency at the center is 6 GHz. On the examination of transmission line models, the design is based. The frequency of operation (f), the substrate's dielectric constant (h), and the height of the dielectric substrate (f) are the three key parameters that are taken into account during the design process. Three fundamental factors, namely substrate thickness, relative permittivity, and patch geometry, must be determined while designing these antennas.

Choosing the right substrate and substrate thickness is the first step. Substrate thickness increases radiation efficiency and bandwidth. Because a substrate's permittivity influences transmission efficiency, the dielectric constant or substrate permittivity mostly determines the radiation efficiency of a planar patch antenna. Low dielectric constant is consequently chosen since it provides better efficiency, lower losses, and a wider bandwidth with the antenna. Thick substrates with low dissipation factor and dielectric constant result in bigger bandwidth, higher efficiency, and loosely bound fields for radiation. However, they also have the drawback of having the antenna arrive at huge dimensions.

Figure 1. Flow Chart for Antenna Design



Since their size makes them larger than the other forms. Circular polarization can be produced with square patches. Based on the aforementioned benefit, the rectangular patch antenna used in this thesis has been chosen. They might not have provided circular polarization, though. To achieve circular polarization, a circular patch is employed in place of a rectangular patch. Since feeding is difficult with circular patches, elliptical patches can be utilized instead.

As a result, in this thesis, FR4 Epoxy Glass, which has a substrate height of 0.8 mm and a relative permittivity of 4.4, was utilized in the design process for both coplanar and microstrip patch antennas. This meets the requirements for both high substrate height and low permittivity.

Lotus leaf shaped antenna design procedure and their Results:

(HFSS design and the model description)

Design 1: Lotus leaf shaped antenna with full ground (LSA-1) Return loss curve of LAS-1

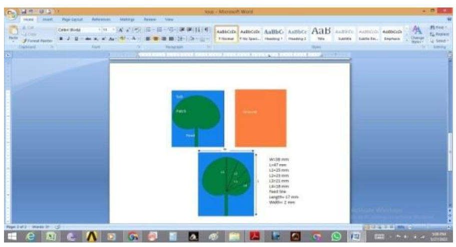


Fig: Top view and Back view of the leaf Shaped antenna

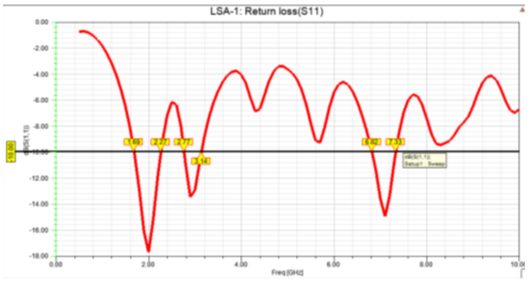


Fig: Return loss curve of LAS-1

Design 2: Lotus leaf shaped antenna with partial filled ground (LSA-2) Return loss curve of LAS-2

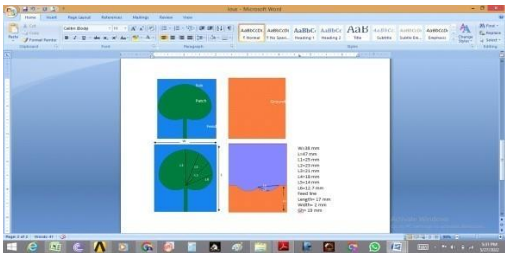


Fig: Top view and bottom view of LAS-2 and its dimensions

Fig: Return loss curve of LAS-2

Design 3: Non-uniform Lotus leaf shaped array antenna with partial filled ground (LSA3)

LSA-3: Two element array with half ground

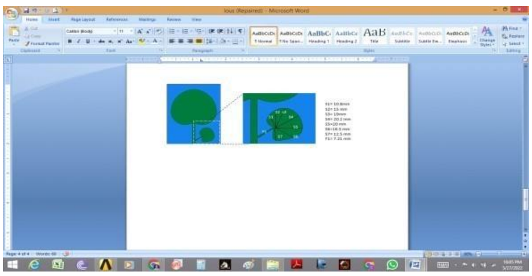


Fig. Two non-uniform element array antenna with partial ground top view and bottom view

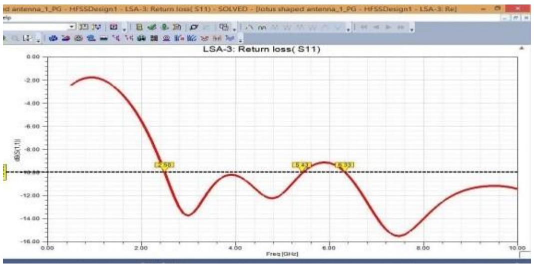


Fig: Return loss curve of LAS-3

- It shows two bands with good

LSA-4: Two element array with partial ground Return loss curve of LAS-4

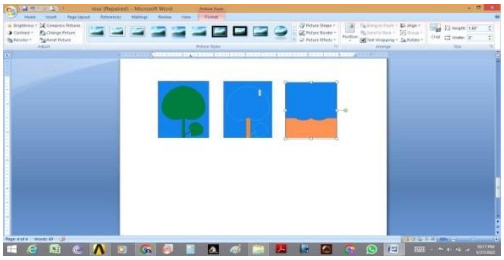


Fig. Two non-uniform element array antenna with partial ground top view and bottom view

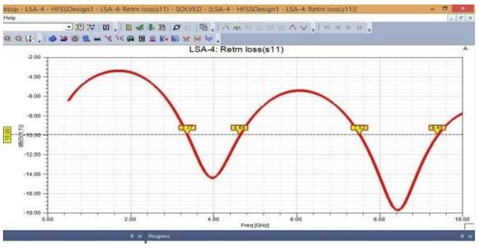


Fig: Return loss curve of LAS-4

LSA-5: Three element array with half ground

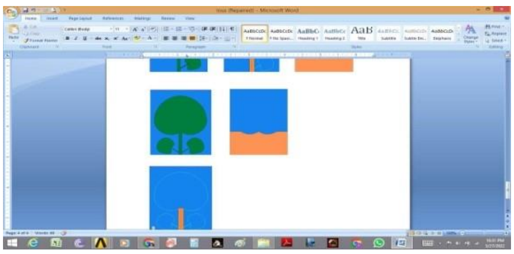


Fig. Three non-uniform element array antenna with half ground top view and bottom view

Fig: Return loss curve of LAS-5

By looking above return loss graph, the band of operations is same as the design LSA-3. Form comparing results of LSA-5,4, and 3, half ground patch is offering good result than partial ground. Form this one can say that half ground removal turns monopole into dipoles. But more removal of ground degrades the antenna performance. But we observe that the bandwidth of the designed antenna doesn’t show the bounded bandwidth, so that we further decided to add slots in the ground plane for that to attain a bounded bandwidth.

LSA-6: Three element array with four rectangular slots in half ground

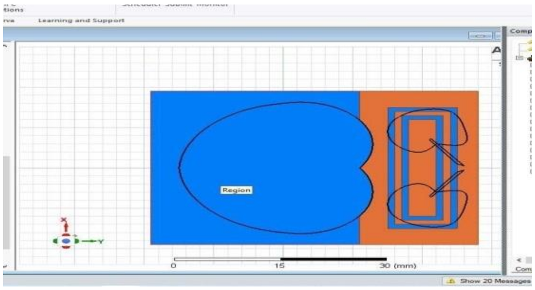


Fig: Three non-uniform element array antenna with four rectangular slots in half ground

Fig: Return loss curve of LAS-6

The above results shows the dual band , one is from 1.48Ghz to 4.89Ghz which is a wideband and the other band is from 6.8GHz to beyond 20GHz which is of a ultrawideband that cover the S and C applications. The gain is 10db high which is positive gain.

LSA-7: Fabricated Design of Three elements array with four rectangular slots in half ground

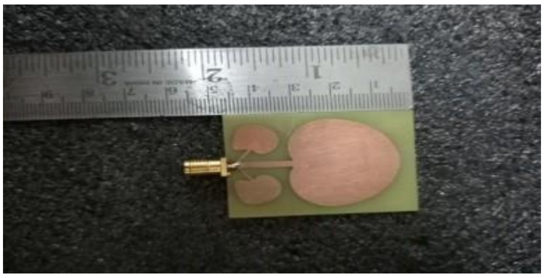


Fig: Fabricated design of Three non-uniform element array antenna with four rectangular slots in half ground(Top View)

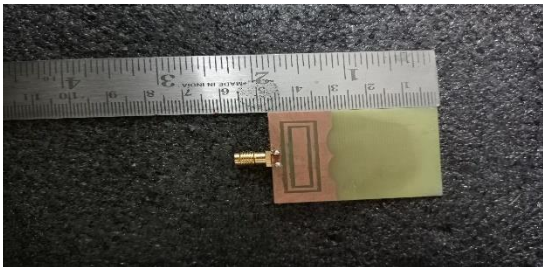
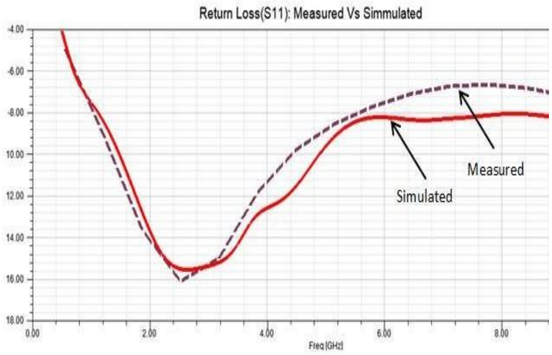


Fig: Fabricated design of Three non-uniform element array antenna with four rectangular slots in half ground(Bottom View)

Fig: Return loss curve of LAS-7

Return Loss of Measured Vs Simulated



Future Scope:

The future scope of the bio-inspired Lotus leaf shaped patch antenna (LSA) design holds significant promise across various fields of wireless communication and beyond. Its unique features, including improved return loss, expanded operating bands, and enhanced gain through ground removal, pave the way for advanced applications. Moving forward, the LSA antenna's potential lies in its adaptability and versatility. Further research could focus on refining the design for miniaturization and integration into compact devices, exploring multi-functionality for simultaneous communication and sensing tasks, and investigating adaptive and reconfigurable capabilities for dynamic environments. Additionally, its suitability for biomedical applications, environmental monitoring, and the an integration with the emerging technologies such as IoT and edge computing offers exciting avenues for exploration. Standardization efforts and experimental validation will be crucial in ensuring its widespread adoption and practical deployment in real-world scenarios. Overall the LSA antenna stands poised to catalyze innovation and advancement in wireless communication systems and beyond.

Conclusion:

In this study, a series of bio-inspired antenna designs, based on the Lotus leaf shape, are developed and simulated using a perturbation technique. Modifications to the original design include ground removal and the addition of rectangular slots in the ground plane to improve antenna parameters. Results indicate that removing ground improves return loss (S11) and gain in certain designs, while introducing rectangular slots enhances bandwidth, particularly in the case of LSA-6, which exhibits dual-band operation covering S and C bands as well as ultra-wideband frequencies beyond 20GHz.

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