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Design and Analysis of ISM Band Leaf shaped Antenna

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Abstract — In this paper, we propose the design of a leaf shaped Micro strip Patch Antenna with one of the commonly used Rogers RT Duroid 5880 substrate for application in the ISM band using the simulation and design software called Computer Simulation Technology (CST) studio. Currently, Micro strip patch antennas are not very popular for developing RFID and medical devices, but research is being made to implement them in these fields. Thus, the aim of the paper is to develop microstrip patch antenna for the discussed field of applications. By this, light weighted and low-cost devices can be developed. The industrial, scientific, and medical radio band (ISM band) is a group of internationally reserved frequency bands in the radio spectrum for medical, industrial and scientific researches and applications predominantly. The proposed antenna is designed to operate in this frequency making it suitable for specific applications like in wearable antennas, wildlife monitoring by RFID and military tracking. The design and the performance parameters of this antenna are analysed through simulation to bring out application suitable outcomes. A frequency-domain analysis is carried out to obtain the parametric results.

Keywords — Antenna, CST software, ISM Band, Frequency domain, Microstrip Patch, RT Duroid 5880.

I. INTRODUCTION

The field of telecommunication is showing rapid growth in recent years. Its areas of application are expanding such that wireless technology is now playing an important role in the medical and environmental science s also in global sensing, animal monitoring, biomedical imaging, telemetry etc. [1]. Thus, it becomes important in developing efficient and application suited antennas.

The Micro Strip Patch Antenna is now becoming popular for its small size, low fabrication cost, the high frequency range of operation and support of dual polarization. The antenna basically consists of a ground plane, substrate layer, and the patch. The patch can take any shape which is dependent on the parameters that are required for the application for which it is intended.

The substrate material (Dielectric material) selection plays a crucial role in deciding the antenna performance parameters. The substrate selection has a direct effect on the gain, return loss and radiation pattern. The substrate material also contributes towards mechanical strength to the antenna.

The patch is another main component of the antenna. The dimensions of the patch decide the bandwidth of operation. The feeding position to the patch plays a role in impedance matching.

Thus, we put forth this proposal of leaf shaped patch antenna built of the copper annealed ground plane and patch material and Rogers RT Duroid 5880 substrate material [4],[10].

As the antenna is in the shape of a leaf, it can be camouflaged in trees and plants and to help monitor birds and animals with the help of RFID tags. The use of Rogers RT Duroid 5880 substrate in the design is due to its properties like lowest electrical loss and moisture. Moreover, it is isotropic in nature with uniform electrical properties over the frequency range and also, the antenna efficiency is improvised as the substrate Rogers RT Duroid 5880 has low permittivity (ε_r=2.2) [5].

The performance parameters such as the Return Loss, VSWR, and Efficiency are shown below.

II. SIMULATION RESULTS

The results obtained during simulation of the designed antenna under frequency domain analysis are as follows.

A. Antenna Design

The ground plane and the substrate have the same template length and width dimensions of 60mm length and 40mm width. The thickness of the ground plane is 2.3mm and that of the substrate material is 1mm. The ground plane is selected to be copper annealed and the substrate to be of Rogers Duroid 5880 (lossy) material in CST software. The leaf shaped patch is designed in copper annealed material

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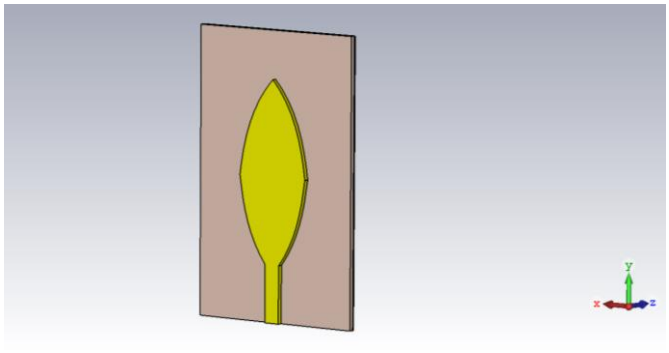
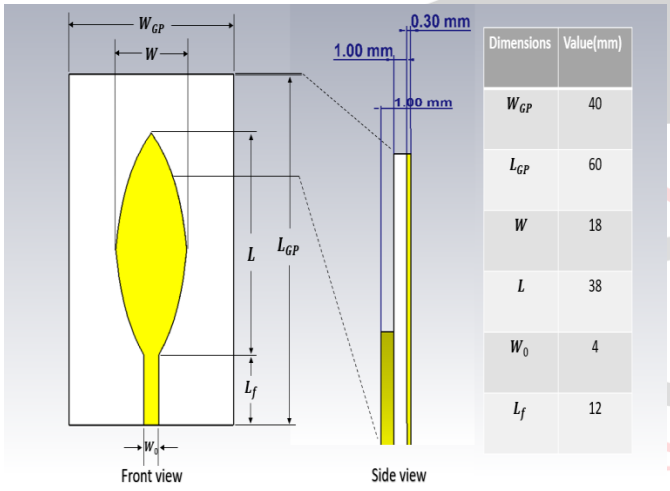
and has a maximum width and length of 18mm and 38mm respectively. This thickness of the patch is made 1mm. the patch antenna is fed by a corner feed with feed line of dimensions 12mm x 4mm x 1mm. the parameters are as follows.



The above figure shows the overall antenna structure. The substrate material Rogers RT Duroid 5880 (Lossy) exhibits a dielectric constant of 2.2



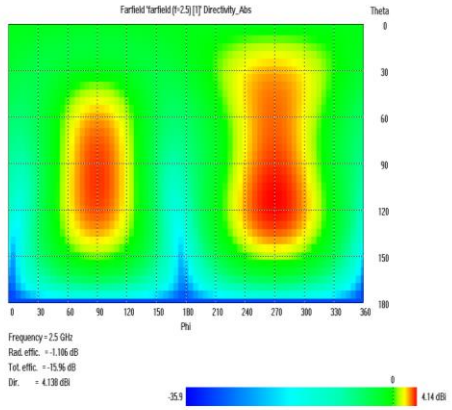
Dimensions	Value(mm)
W_{GP}	40
L_{GP}	60
W	18
L	38
W_0	4
L_f	12

This figure is a pictorial representation of the dimensions of the antenna.

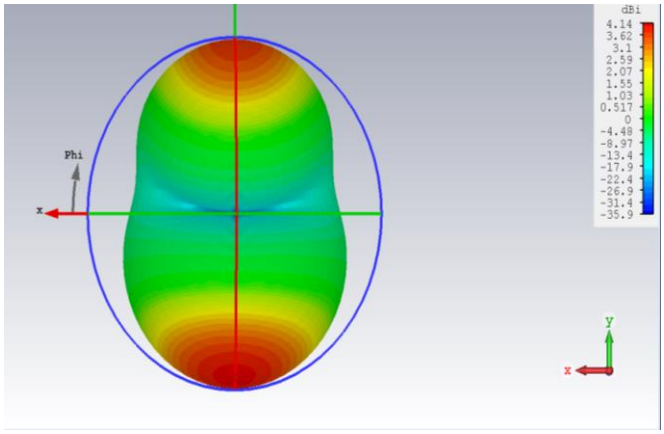
B. Far-Field radiation (f = 2.5)

The far-field directive radiation at a frequency of 2.5GHz is 4.14 dBi. (a) Shows the far-field pattern in 2D and (b) shows the far-field pattern in 3D.

(a)



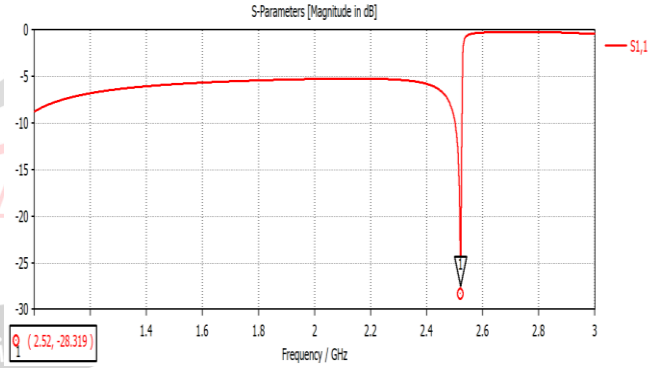
(b)



C. S-Parameter (Return Loss S_{11})

S parameter at the antenna and transmission line junction is observed using a network analyser to give S_{11}. The S_{11} measures the amount of power that is reflected from the antenna port due to impedance mismatch. This value helps determine the amount of loss that is happening at the port and a low S_{11} value indicated low loss and high energy delivery to the antenna. This parameter is measured in decibels and is given on the negative scale.

The return loss plot for the frequency range of 1GHz to 3GHz is shown below:



The plot shows a steep fall of about -28.319 dB around 2.52GHz. It reaches back to 0dB around 3GHz. From the plot, it can be found that the cut off frequency of the antenna to be 2.52GHz.

D. Efficiency

The ratio of power fed to the antenna to the power radiated from the antenna gives the efficiency of the antenna. Antenna with high efficiency indicated a greater proportion of radiated power to absorbed power. A high efficiency antenna is usually desirable as it indicated a minimum loss. In a low efficiency antenna, most of the input power is absorbed and only some are radiated. Improper impedance matching can also contribute to the poor efficiency of the antenna.

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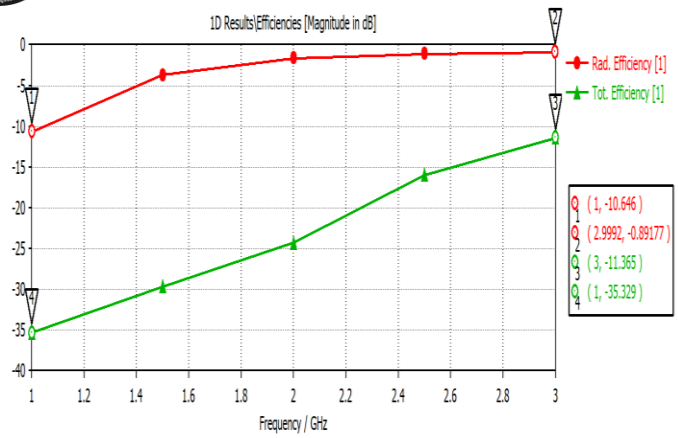

The above plot indicates a total efficiency of -35.329dB at 1GHz and -11.365dB at 3GHz and radiation efficiency of -10.646dB at 1GHz and -0.89177dB at 3GHz.

III. APPLICATION

The nature of this design adapts to applications like wildlife monitoring without any intrusion to the nature's cycle, RFID applications [8], Medical bio imagining and diagnosis, development of wearable antennas, implantable devices, medical implants [6],[7], military application in various platforms of tracking and monitoring [9], Bluetooth devices and in Wireless communication. Since this is leaf shaped design, it can be well merged with the natural environment in which it is being used. The frequency range in which it is developed to operate serves as the basis for all the above-mentioned application.

IV. CONCLUSION

To conclude, this paper gives the design and simulation results of the performance parameters of the proposed new design leaf shaped antenna designed using the Computer Simulation Tool (CST) Studio. The frequency of operation is observed to be 2.52GHz showing a return loss of -28.319dB at that point. The use of Roger's substrate has produced this output for the given dimensions. Increasing the substrate thickness or changing the dielectric material can bring about significant changes in the antenna performance [2]. Changing the feed point also can affect the performance metrics. On an overall basis, this design proposed shows low return loss and good efficiency making it suitable for wireless applications. This antenna can be used for animal monitoring using RFID [3], communication, Bio-Imaging etc. making the best use of the ISM band in which it operates.

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