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Truncated Microstrip Patch Antenna for CubeSat

Rachna Rajput, Alok Kumar Rastogi and Sunil Mishra

Department of Physics
Institute for Excellence in Higher Education (IEHE) Bhopal, M.P. India

Abstract

In this paper, we present the Microstrip Patch Antenna for CubeSat (Cube Satellite) application with the help of ANSYS HFSS Version15software. We have obtained the simulation results of the proposed antenna like return loss, gain, efficiency, and bandwidth. Microstrip patch antenna (MPA) has various benefits like low weight, low price and easy to fabricate that is why for the wireless communication Microstrip patch antenna is the first choice. There are also some limitations of microstrip antenna such as high return loss, low gain and minimum efficiency. In this paper, we present the design and analysis of Rectangular microstrip patch antenna with truncated corners which shows different performance parameters of patch antenna at different frequencies. The height of the material is 1.27(h) mm, and the dielectric constant is 4.4 ($\mathcal{E}r$). The proposed microstrip patch antenna has the dimensions 22 mm (Width) × 27 mm (Length). The substrate material which is utilized to structure the antenna is Rogers TMM10. To find the effect of design on antenna performance, a parametric analysis was used.

Keywords: *Microstrip patch antenna, Rectangular, Rogers TMM10, Return Loss, HFSS.*

Introduction

A CubeSat is a compact form of space mission satellite with 10x10x10 cm cubit units or in multiples of its cubic units with a mass of little more than 1 kg per unit, which is frequently used for commercial off the shelf (COTS) are expanding nowadays [1].Many developing governments, universities, and private owners employ these spacecrafts to gain expertise in satellite technology and later research projects. Because of the use of contemporary technology in the satellite's creation and its small size, the CubeSat may be planned, produced, and implemented at a cheap cost. CubeSat services can be used for complicated activities such as earth observation [2], remote sensing, seismic detection, inter-planetary and inter-satellite missions are all possible. Even as a tiny research project, the spacecraft must be able to resist the harsh space environment. As a result, the layout of every hardware component must be rigorous, which poses a significant challenge to designers.

Jordipuig-suari has designed the CubeSat, which has been functioning in LEO and is modest in size and cost to construct a satellite, and it will communicate between the link Earth and the CubeSat in antenna. This effort to deploy the picosatellite resulted in a development launcher system that was impossibly intricate and could only function for the majority of the time. Bob realises that the projects are moving slowly, so he seeks DARPA funds to complete the project and rebuild the satellite mechanism [3].

A microstrip patch antenna is extremely valuable because to its light weight, low cost, tiny size, and ease of incorporation into commercial transceiver systems. Antenna components of this type can readily radiate on the Printed Circuit Board (PCB). Microstrip patch antennas are ideal for wireless devices.

Because the patch antenna's characteristic is initiated on a dielectric substrate with some electrical and magnetic characteristics, selecting an appropriate substrate is equally critical. If the substrate change, then it will affect the overall performance of the antenna as the concerned of the output parameters. For the better performance of the antenna the thick substrate is required. But thick substrates have the dielectric constant in the lower end of the range. The reason of this is the better efficiency, larger bandwidth and loosely connected to the fields for the radiation into the space but results in large element size.

Basic Structure

As illustrated in Fig. 1, a microstrip patch antenna comprises of a radiating patch on one side of a dielectric substrate and a ground plane on the other. The patch is constructed mostly of conducting materials such as gold or copper and comes in a variety of forms [4]. The feed lines and radiating patches are photo etched on a dielectric substrate.

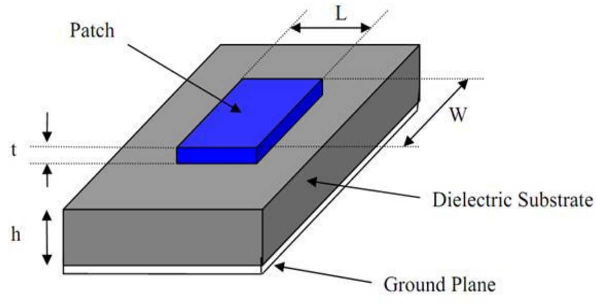


Fig 1: Basic Structure of Microstrip patch antenna

2.1 Antenna Design

To identify and verify the development of the rectangular microstrip patch antenna, we used the conventional Microstrip antenna design methodology is used [4].

Design Steps: For designing the patch of the antenna, is to utilize the following formulas in the procedures of designing.

i. Width (W)

$$W_p = \frac{c}{2f_0\sqrt{(\varepsilon_r+1)/2}} \quad (1)$$

Where:

c is the free space velocity of light, 3×108 m/s
f_0 is the frequency of operation,
ε_r is the dielectric constant.

ii. Effective Dielectric constant (Ereff)

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1 + 12\frac{W_p}{h}]^{-0.5} (2)$$

Where:

ε_r is the dielectric constant,
h is the dielectric substrate's height,
W_p is the width of patch.

iii. Effective Length (Leff)

$$Leff = \frac{c}{2fr\sqrt{\varepsilon reff}} (3)$$

Where:

c is the free space velocity of light, 3×108 m/s
*fr*is the frequency of operation,
*Ereff*is the effective dielectric constant.

iv. Patch Length Extension (ΔL)

$$\Delta L = 0.412h\frac{(\in reff+0.3)(\frac{w}{h}+0.264)}{(\in reff+0.258)(\frac{w}{h}+0.8)} (4)$$

v. Actual Length Patch (L)

$$L = Leff - 2\Delta L (5)$$

3. Antenna Modeling

In this paper, the rectangular patch has been designed on the antenna by using the ANSYS HFSS Software. Rogers TMM 10 (tm) is used as substrate materials. The patch antennas are designed for the CubeSat application. We need to give some data such as height of substrate and the dielectric constant etc. to calculate the dimensions of antenna by the conventional methodology. Modelling of patch antenna for the required frequency with the Rogers TMM 10 (tm) material has the dielectric constant of 9.2.

Table 1: Design specification of the Antenna:

Antenna Design Parameters	**Material/Values**
Dielectric Material	ROGERS TMM (tm)
Dielectric Constant	9.2
Loss Tangent	0.0022
Width (mm)	22
Length (mm)	27
Dielectric Thickness (mm)	1.27

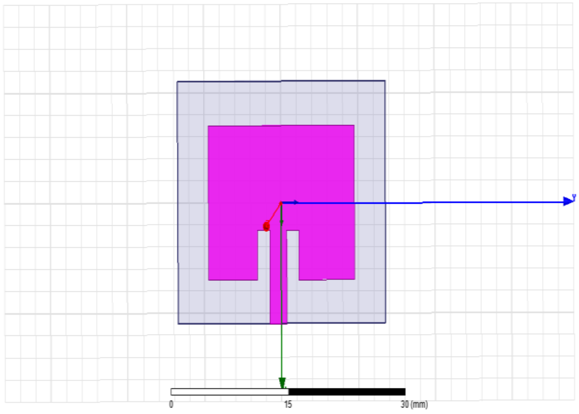


Fig 2: Rectangular Microstrip patch Antenna-1

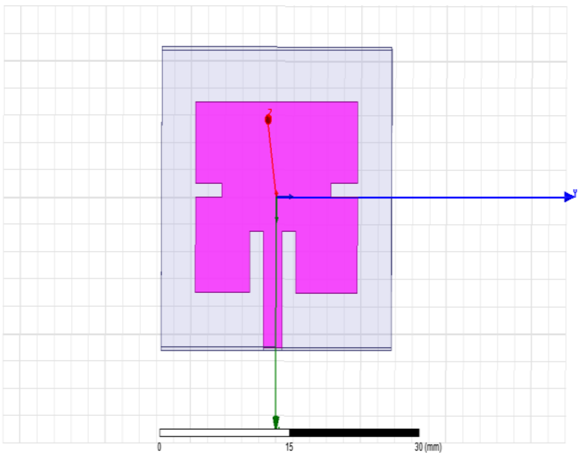


Fig 3: Rectangular Microstrip patch Antenna-2

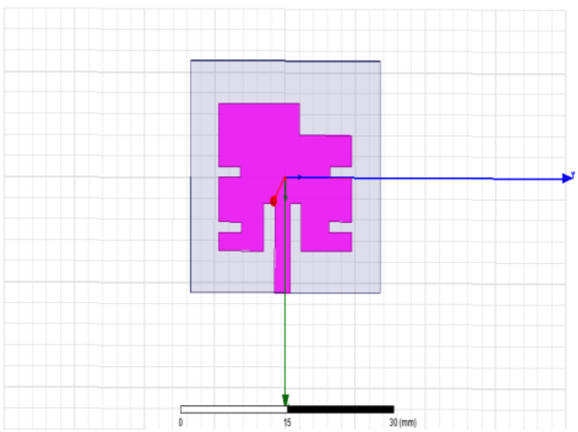


Fig 4: Rectangular Microstrip patch Antenna-3

4. Simulation Results

The designed antenna is simulated by using the ANSYS HFSS version 15, Fig. 5shows the Antenna-1, S_{11} value of the antenna which provides the S_{11} value of -37.5116 dB and -38.5322dB at 7.25 GHz and 10.58 GHz which gives the dual wideband frequency. In this study, we use an inset feeding technique to enhance the antenna return loss. In this section simulation outcomes for the S_{11}, far field radiation and current density of the designed antenna are measured and presented. From the obtained result the resonating frequency and to calculate the bandwidth of the rectangular antenna its return loss is very useful. The minimum S_{11} level of -37.5116 dB and -38.5322dB is shown in m_1 and $m_2$captions.Fig. 6shows the Antenna-2 S_{11} value of the antenna which provides the S_{11} value of -36.5522 dB and -28.8138 dB at 4.88 GHz and 9.66 GHz which gives the dual wideband frequency. Fig. 6shows the Antenna-2 S_{11} value of the antenna which provides the S11 value of -53.5518 dB and -30.4554 dB at 4.77 GHz and 9.33 GHz which gives the dual wideband frequency.

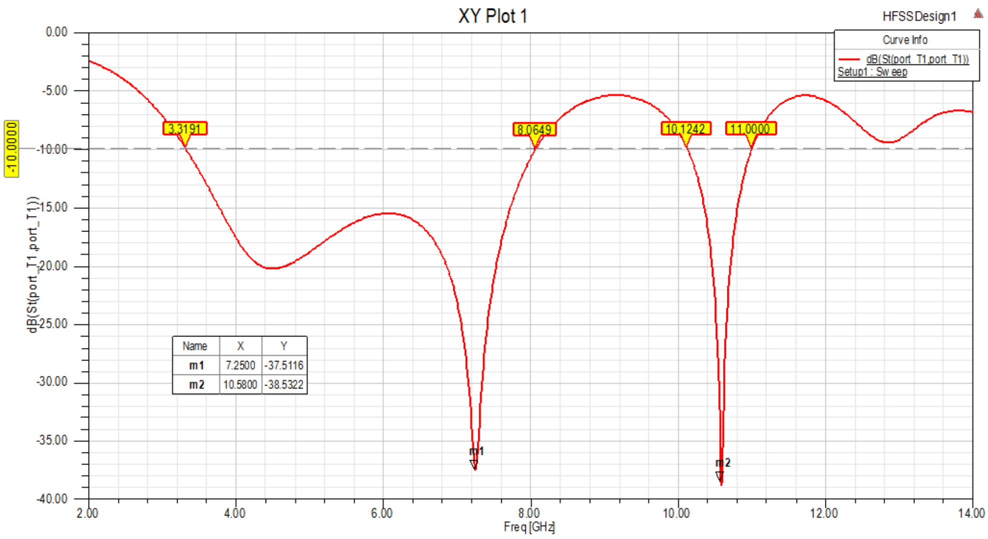


Fig 5: Returnloss of Antenna -1

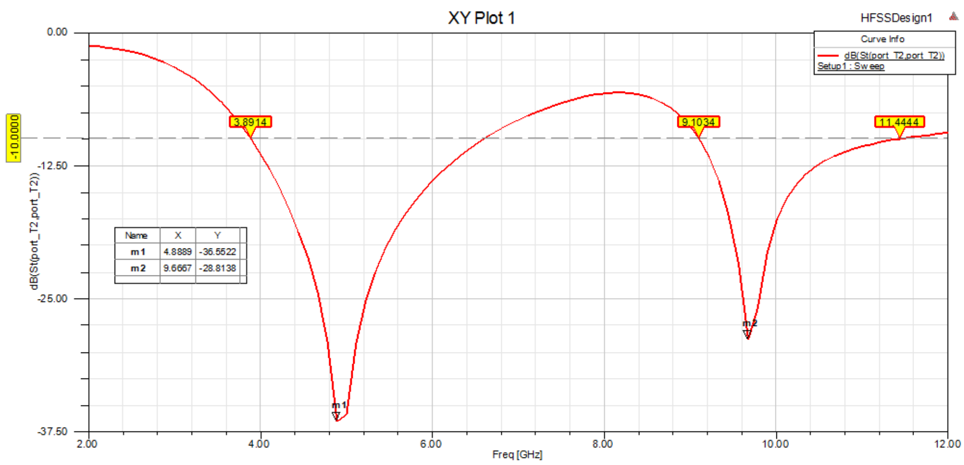


Fig 6: Returnloss of Antenna -2

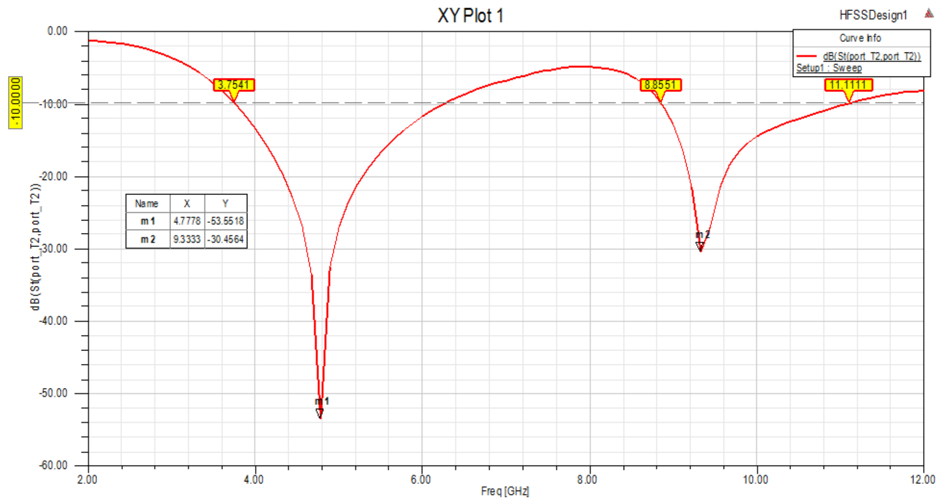
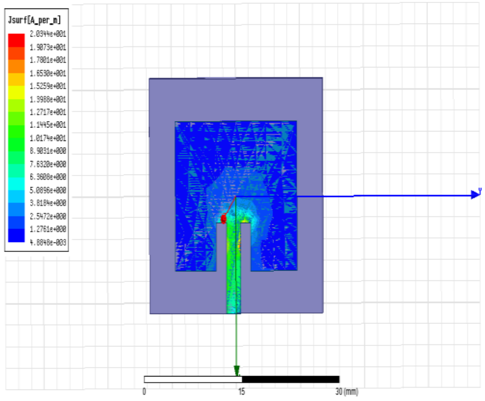
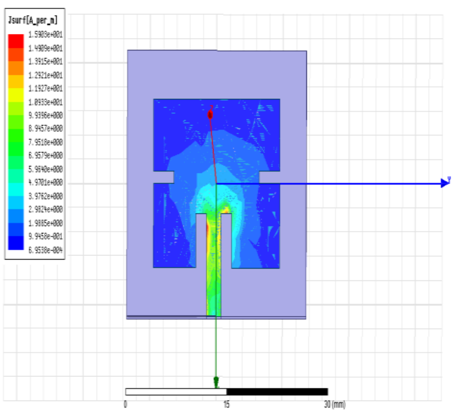


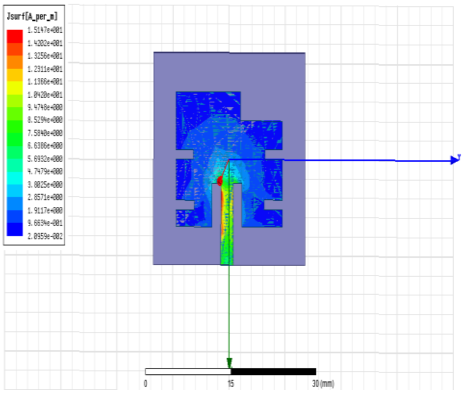
Fig 7: Returnloss of Antenna -3



(a) Antenna-1



(b) Antenna-2



(a) Antenna-3

Fig 8: Current Distribution of Rectangular Microstrip patch antenna

The current distribution of the antennas are shown in the Fig. 8.The current density distribution is a measurement of the antenna's ability to generate a beam.

5. Conclusion

In this paper, the performances analysis of Rectangular MPA we have simulated and presented with the help of ANSYS HFSS Version15 Software. The physical parameter of the antenna is studied as presented in the section of result. The goal is to compare the bandwidth of a dielectric material for rectangular shaped based MPA using the cutting material. The simulated MPA provides good return loss and gain of the antennas. A novel design technique is used for compact rectangular patch antenna. As we can see that the Rectangular Microstrip patch antenna gives the dual wideband return loss. The purpose of this paper is to simulate the design for the CubeSat application and according to the results the proposed antenna gives the promising results for the application. The rectangular MPA has good outcomes, and the proposed antenna is significant for the cube satellite application.

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