S-Band Deployable Rectangular Microstrip Patch Antenna for Cubesat Applications

Shaik Thasleem Bhanu, Amrish Afsal S R , Avinash T, Sathya.R

Abstract*: *This paper presents the designand simulation of a RMSA with pentagon fractal slot which is operated in S-band at two bands 2.4 GHz & 3.88GHz. The measurements taken from the simulated and fabricated antenna show good results for the operating frequencies and enhanced performance in gain, bandwidth and VSWR parameters. The antenna was fabricated on a 1.6 mm thick FR-4 substrate. To obtain themultiband characteristics DGS (Defected Ground Structure technique) and fractal geometry has been used.DGS is used to increase the bandwidth, Fractal slots to obtain multi bands and corporate feed 2x1 array structure has been used to increase overall Gain. The simulation is conducted with HFSS (High Frequency Structure Simulator).From the proposed design parameters like return loss and gain are obtained. Being a compact antenna, it has a size, geometry and characteristics that match with the CubeSat's structure standards.

Index Terms*:*RMSA, 2.4 GHz, 3.88GHz, FR-4 Epoxy, DGS, HFSS, CubeSat..

I. INTRODUCTION

The researchers are seeking out other methodology for designing planar low profile, multi-band antenna with higher bandwidth [1-3] to meet their requirements.

CubeSat space missions have increased over the last decade, in such a way that it finds applications in weather monitoring system, e-learning, Earthquake detection and many other useful purposes.

The development of CubeSat standards and orbital parameters are a great challenge to be faced for implementing subsystems, which is basic necessity to ensure good communication with earth stations. To achieve higher bit-rates we go for S-band (2-4 GHz) antennas are being developed. Designing microstrip antenna on a FR-4 substrate is convenient for low-budget implementations. It also reduces the size of an antenna and used to maintain a wide bandwidth. Cubesat simulation work with a passive magnetic stabilization system. So antenna should be designed with an Omni directional radiation pattern to increase the accuracy. The dimensions of the CubeSat faces are given in terms of the number of units (1U, 2U, 3U). 1U denotes that each face must have a 10cm * 10 cm * 10 cm area. It is represented in terms of cubic units so called as CubeSats. CubeSats are primarily used for solar panels so that the area available for antenna is thus restricted.

A RMSA is a narrowband antenna with high beam width. It is manufacturing by etching the antenna element to the dielectric substrate such as FR4, Air, foam etc. The opposite side of the substrate is known as a ground plane. There are many different types of shapes of microstrip antennas such as rectangular, square, circular and elliptical. DGS technique can be used to obtain wideband and multiband characteristics and also used to increase the bandwidth. Different Rectangular antenna is mainly used to reduce the harmonic radiation and increasing the conversion efficiency. We have implemented the technique of H-shaped DGS to reduce the higher order harmonics in microstrip antenna.

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II. SINGLE RMSA DESIGN

The principal formulae for design of rectangular microstrip patch antenna re

$$W = \frac{C_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}, W/_h > 1$$

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

$$L = \frac{C_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

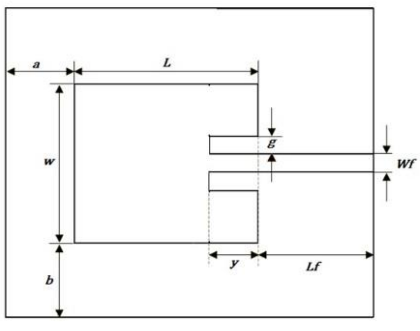

Fig.1 Line fed single RMSA

The rectangular microstrip

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antenna is designed by keeping geometrical limitations in mind. The microstrip antenna uses FR-4 substrate which has a relative permittivity ε = 4.4 and Dieletric loss tangent tan δ = 0.002.The substrate height is chosen to be as h = 1.6 mm. The overall dimension have been determined as width of the substrate Ws= 37.26 mm and length of the substrate Ls= 28.829 mm, which is equal to the width (Wg) and length(Lg) of the ground. The generation of hexagon-shaped fractal slot at different stages in RMSA is shown in following Fig.2

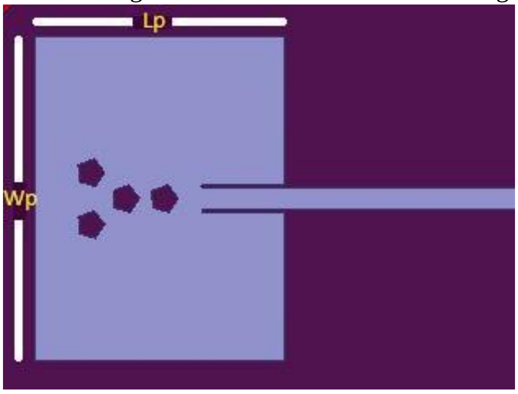

Fig.2 RMSA patch with pentagon slots

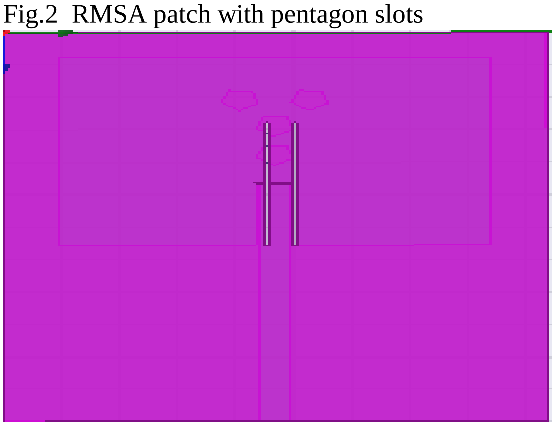

Fig. 3 Ground plane of RMSA with H-shaped DGS

Symbol	Description	Values (mm)
Wp	Width of the patch	37.26
Lp	Length of the patch	28.829
h	Substrate height	1.6
g	Gap between feed line and patch	0.3
Lf	Line Feed length	27.15
c	Inset Depth	9.572
Wf	Line Feed width	2.56
a,b	Effective length and Width	4,4.8

Table 1. Parameters of single patch RMSA with FR4 substrate

2X1 RMSA array DESIGN

In order to increase the gain of the S-band deployable antenna for cubesat, we have designed 2x1 array of single RMSA with pentagon slots by using corporate feed method. The following data is given for 2x1 array of RMSA.

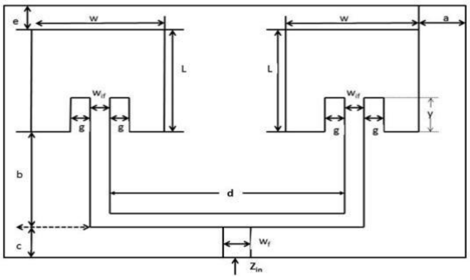

Fig. 4 Basic structure of 2x1RMSA array with corporate feed

Symbol	Quantity	Values (mm)
	Dielectric constant	4.4
Wp	Width of the patch of RMSA	37.26
Lp	Length of the patch of RMSA	28.829
h	Height of the substrate	1.6
g	Gap between the line feeder and patch	0.3
b	Length of the feed	27.15
c	Inset depth_50Ohms	10.094
wf	Width of the main feed	2.56
Wif	Width of the feed	0.446
y	Depth_100Ohms	9.04
d (λ/2)	Distance between two RMSA	18
a,e	Effective length and width	4.8,4

Table 2. Parameters of 2x1 RMSA array with FR4 substrate

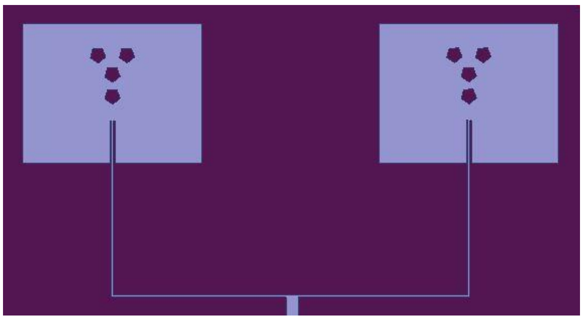

Fig. 5 Top view of 2x1 RMSA array with pentagon slots

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Fig. 6 Bottom view of 2x1 RMSA array with H-shaped DGS

III. RESULTS AND DISCUSSIONS

The gain and return loss of single RMSA with pentagon slots using FR4 as a substrate is tabulated. The gain of single RMSA with pentagon slots and H-shaped DGS is 3.12dB and return loss of -14.06dB at 2.41GHz, for FR4 substrate and similarly the return loss of 2x1 RMSA array is -17.22dB at 2.37GHz and -9.2dB at 3.88GHz.

The gain of single RMSA is 3.12dB and 2x1 RMSA array is 5.18dB .The gain and return loss of 2x1 RMSA array is more than that of single RMSA.

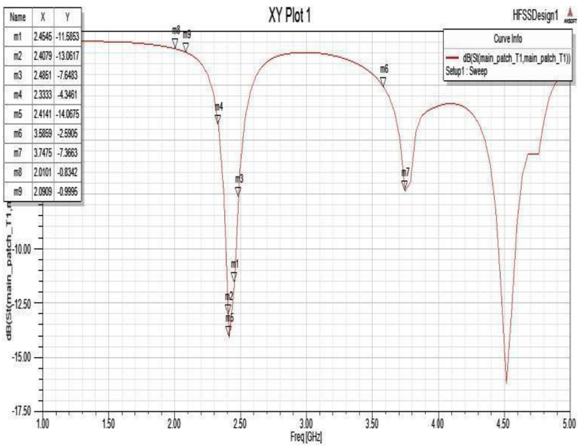

Fig.7 Return loss of single RMSA using FR4 substrate

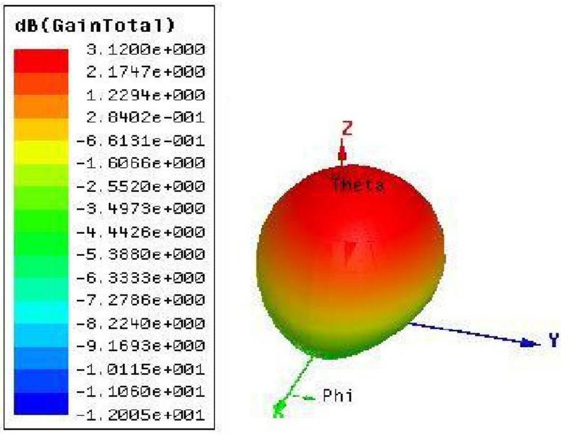

Fig. 8 Gain of single RMSA using FR4 substrate

The fabricated 2x1 RMSA with pentagon slot and H-shaped defected ground has been shown in Fig 9 &10.

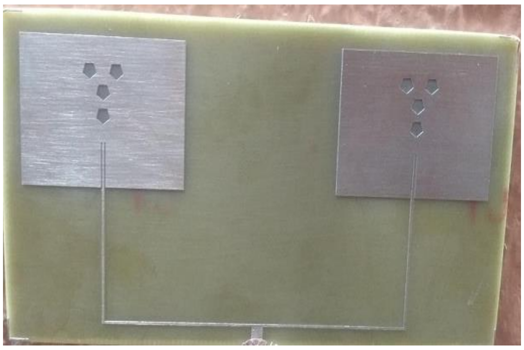

Fig.9 Top view of 2x1 RMSA array with pentagon slots

Fig.10 Bottom view of 2x1 RMSA array with H-shaped DGS

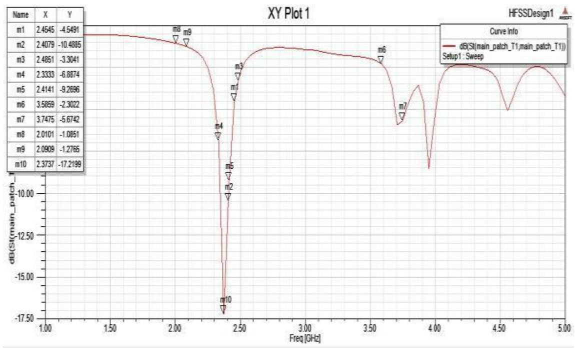

Fig.11 Return loss of 2x1 RMS Aarray using FR4 substrate

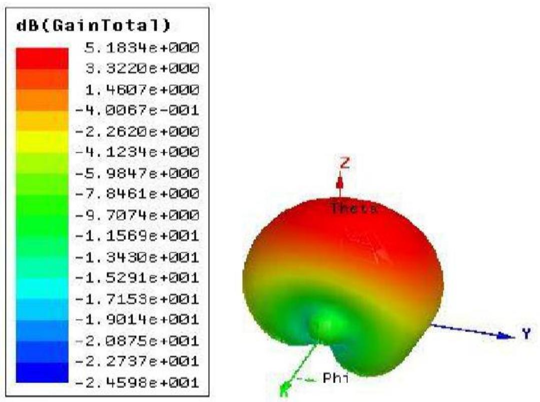

Fig.12 Gain of 2x1 RMSA array using FR4 substrate

IV. CONCLUSION

A novel planar 2x1 RMSA

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array with pentagon slots with H-shaped DGS antenna structure with FR4 substrate has been presented. The proposed structure is less copmlex for implementation. This optimized RMSA design is suitable for applications in CUBE Satellites. Not only this it can find applications in Bluetooth, WiFi, baby monitors, keyless vehicle monitors.

The researchers are seeking out other methodology for designing planar low profile, multi-band antenna with higher bandwidth [1-3] to meet their requirements.

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