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Tri-band Microstrip Patch Antenna for Satellite Communication

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ABSTRACT

A compact and high gain micro strip patch antenna is proposed for satellite communication. The antenna covers the frequency of C-band, X-band and Ku-band. The proposed antenna having the maximum reflection coefficient of -28.076 at 13.13GHz. This antenna achieves high gain and directivity. Four circular slots are inserted into the rectangular patch of the antenna. Low cost FR4 dielectric is used as a substrate material. The antenna provides the bandwidth of 14GHz. The gain achieved by the antenna is 3.04dBi at 4GHz, 4.90dBi at 8GHz, 1.88dBi at 12GHz and 8.29dBi at 18GHz. The design and simulation of the Microstrip antenna is done by Advanced Design System(ADS) software 2016 version.

KEYWORDS: *Microstrip, triband, ADS*

I. INTRODUCTION

Antenna is a very essential component in various wireless communications systems [1]. Nowadays Satellite technology is growing fast and the applications for satellite technology are increasing all the time. Micro strip patch antennas are becoming widely useful because of their characteristics of printed directly onto a circuit board, low cost, have a low profile and are easily fabricated. In Micro strip antenna complexity of design is very less. Wide band micro strip antenna can be used in the applications of Satellite Space craft, Air craft, Missile, Radar Communication. Antenna is an electronic device which is used for both transmission and reception.

Triband encapsulates X-band, C-band and Ku-band. A band is a small section of spectrum. As per the IEEE standards, the frequency covered by C-band is 4 – 8 GHz. The frequency of X-band is from 8.0 – 12.0 GHz and the frequency of Ku-band is from 12.0-18.0 GHz. Research shows that cutting slots in radiating patch and the operating frequency is shifted by a small ground plane and resonating frequencies are raised [2]. Antennae are the ones which have a very large bandwidth and hence they can be used for many applications [3][4].

During the last decade, the cost of the micro strip antenna has reduced, because of the advancement of its technology and increasing investment in this sector commercially [5]. Nowadays multi frequencies and multiband antennas are becoming very much popular because of their operation. Using single antenna different resonant frequencies are achieved.

II. Designing formulas:

Selecting the resonant frequency and a dielectric medium for designing of micro strip patch antenna.

A. *Width (W):*

The width of the patch is computed using the following equation, [6][7][8]

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

Where,

W=Width of the patch

C_0=Speed of light

ε_r=Value of the dielectric substrate

B.Effective refractive index:

The radiating wave is travelling from the patch in the direction of ground plane pass through air and some pass through substrate. The amount of the effective dielectric constant (ε_{reff}) is computed using the following equation [6][7][8]:

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

C. *Length:*

Calculating the actual rise in length (ΔL) of the patch using the successive equation [6][7][8]

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

Where 'h'=height of the substrate

The length (L) of the patch is instantly be computed using the below equation [6][7][8]

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

D. Length(Lg) and Width (Wg) of Ground Plane:

$$L_g=6h+L$$

$$W_g=6h+W$$

The length and width of a substrate is same as the length and width of the ground plane.

III. Antenna Design:

Fig.1 shows the design of micro strip patch antenna. FR4 substrate is used as a substrate which is having the relative permittivity ε_r of 4.6 and the loss tangent of 0.01. The substrate thickness is 1.6 mm. The proposed antenna resonates at 4 GHz. 50 ohms of input impedance is given through the port of the antenna. The rectangular patch which is having the four circular slots with the radius of 2 mm. The length and width of the patch is 22.4 mm and 17.01 mm as in accordingly and the length and width of the substrate is 32 mm and 26.61 mm respectively.

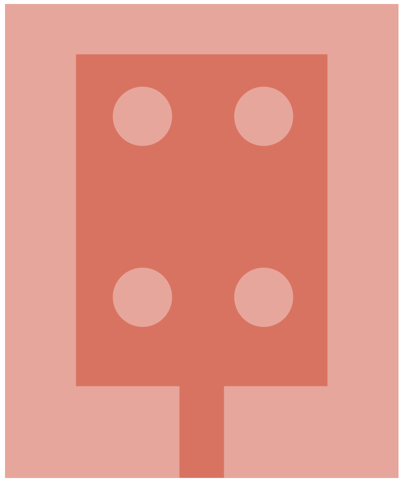

Fig.1 Design of triband antenna

IV. Result analysis and Calculation:

The micro strip patch antenna was simulated and results were analyzed using ADS.

A. Reflection Coefficient:

The variation of reflection coefficient in accordance with frequency is illustrated in Fig.2. From Fig.2 the maximum reflection coefficient achieved is -28.076 dB at 13.13 GHz. The bandwidth of the antenna is 14 GHz. The resonant frequency is 13.13 GHz.

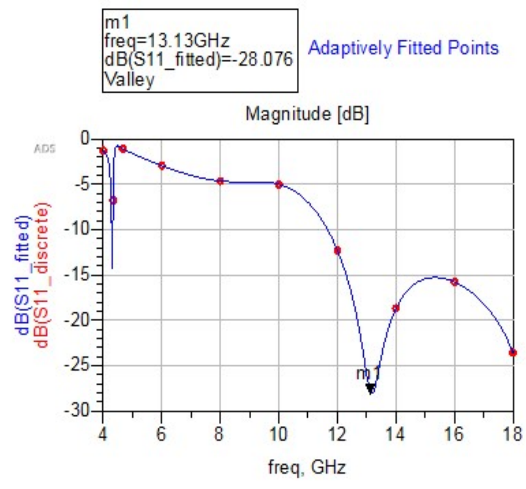

Fig.2 Reflection Coefficient of Proposed antenna

B. Gain and Directivity:

The simulated gain of proposed antenna with respect to frequency is revealed in Fig.3. Gain is varied from 0.86 dBi to 8.29 dBi at the frequency of 4GHz to 8 GHz. The gain is varied in accordance with frequency.

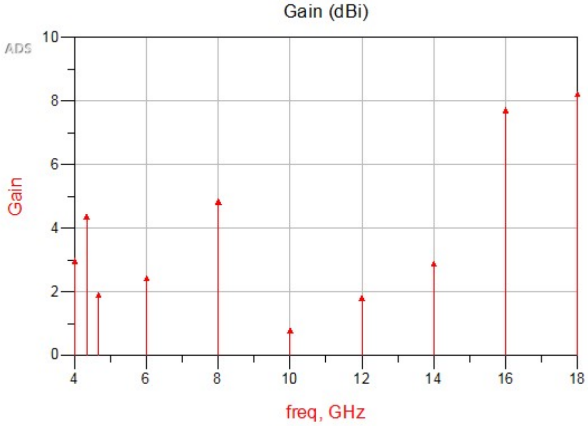

Fig.3 Simulated gain Vs frequency plot

Directivity is overall range of of how directional the radiation pattern is. The simulation directivity of antenna in accordance with frequency is depicted from Fig.4.

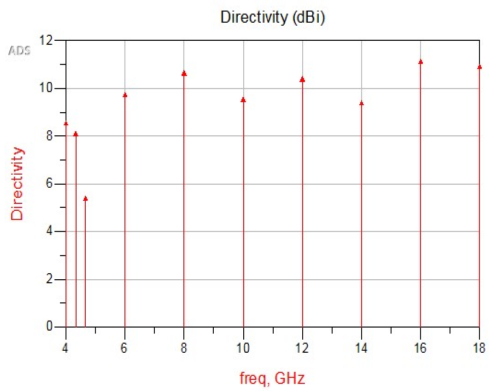

Fig.4 Simulated directivity Vs frequency plot

The directivity and gain of the antenna for different frequencies are presented in Table.1.

TABLE.1 PARAMETERS OF PROPOSED ANTENNA

Frequency (GHz)	Gain (dBi)	Directivity (dBi)
4	3.04	8.63
6	2.49	9.83
8	4.90	10.74
10	0.86	9.64
12	1.88	10.48
14	2.96	9.48
16	7.79	11.20
18	8.29	11.01

C. Radiation efficiency:

Fig.5 shows the radiation efficiency of the designed antenna.

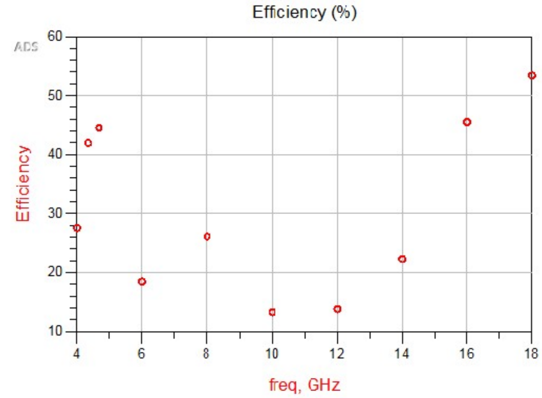

Fig.5 Radiation efficiency of antenna

The radiation efficiency can be derived using the radiated power and the input power accepted by the antenna.

D. Radiation Pattern:

Fig.6 displays the radiation pattern of the proposed antenna at 4 GHz and Fig.7 shows the radiation pattern of antenna at 18 GHz. A radiation pattern describes the variation of the power radiated by an antenna as a function of the direction away from the antenna.

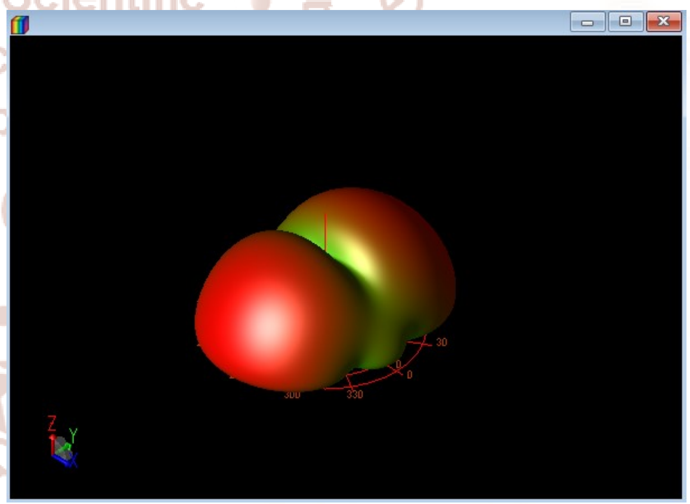

Fig.6 Radiation pattern of antenna at 4 GHz

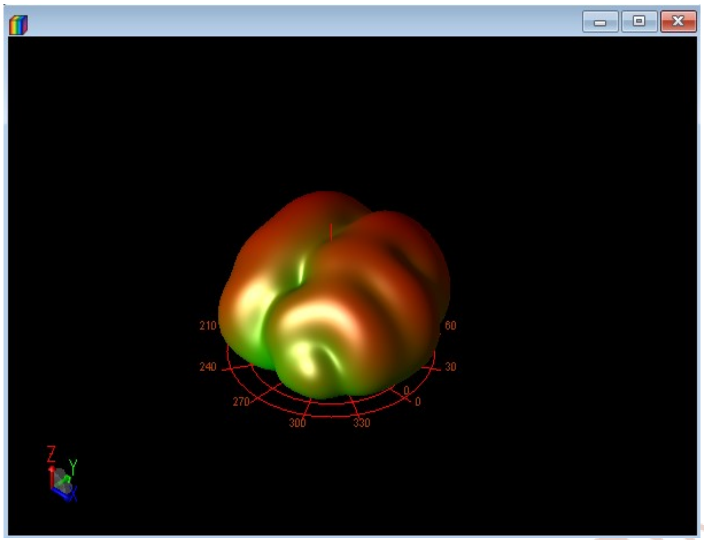

Fig.7 Radiation pattern of antenna at 18 GHz

V. Conclusion:

A simple design of microstrip patch antenna with slots is proposed in this paper. The designed antenna is radiated from 4 GHz to 18 GHz of triband frequencies. In this paper the antenna achieves high gain upto 8.29 dBi and high directivity. The simulation result shows the antenna reaches high reflection coefficient of -28.076. The performance of the antenna is improved.

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