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Enhancement of Bandwidth and Return Loss in Microstrip Patch Antenna for Tri Band Applications

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***Abstract**: This paper presents the design of a modifiedrectangular Microstrip Patch Antenna for Tri band applications specially for X-band, Ku-band and K-band applications. Simulated using ADS Method of Moment (MoM) and its various parameters such as bandwidth, return loss, gain, and directivitywere analysed.Compare to the existing Microstrip Antenna the proposed Rectangular Microstrip Patch antenna design gives more bandwidth and return loss also operate in multiband. The resultshows that the return loss of -28.9.70 dB is achieved at the first resonant frequency of 11.3 GHz, -20.05 dB at the second resonant frequency of 14.4 GHz, -25 dB at the third resonant frequency of 16.3 GHz, -18.5 dB at the fourth resonant frequency of 17.59 GHz and -17 dB at the fifth resonant frequency of 18.5GHz.*

***Keywords–** Antenna Design, BW Enhancement, Microstrip Patch Antenna, Rectangular Microstrip Patch Antenna, Return loss.*

I. Introduction

patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible thus we can enhance the bandwidth.[1-2].

Some patch antennas do not use a dielectric substrate and instead made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radiocommunications devices, Satellite communication purpose.

In this study, a simplecompact design of microstrippatch element with microstrip feed line is proposed for five different frequencies operation in Tri band (X-band, Ku-band and Kband) applications. The principal applications of X-band, Ku-band and K-band are radar, aircraft, spacecraft and mobile or satellite based communication system.

II. Antenna Design and Geometry

A. Design of Microstrip Patch Antenna

The geometry of the existing antenna and the current distribution has been shown in Fig. 1. The antenna comprises of circular and rectangular slots both on the radiating patch and ground plane. The design process begins with the radiating patch with substrate, ground plane and a feed line. It is printed on a 1.6 mm height FR4 substrate that contains dielectric loss tangent 0.02, permittivity 2.2.

The length and width of the microstrip patch antenna can be calculated in accordance with the operating frequency using the following equations which is stated by the specified approximation [3].

i) To calculate width:

$$w = \frac{1}{2f\sqrt{\mu_0 \varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

ii) To calculate Length:

$$L = \frac{c}{2 f_o \sqrt{\varepsilon_r}} - 2l$$

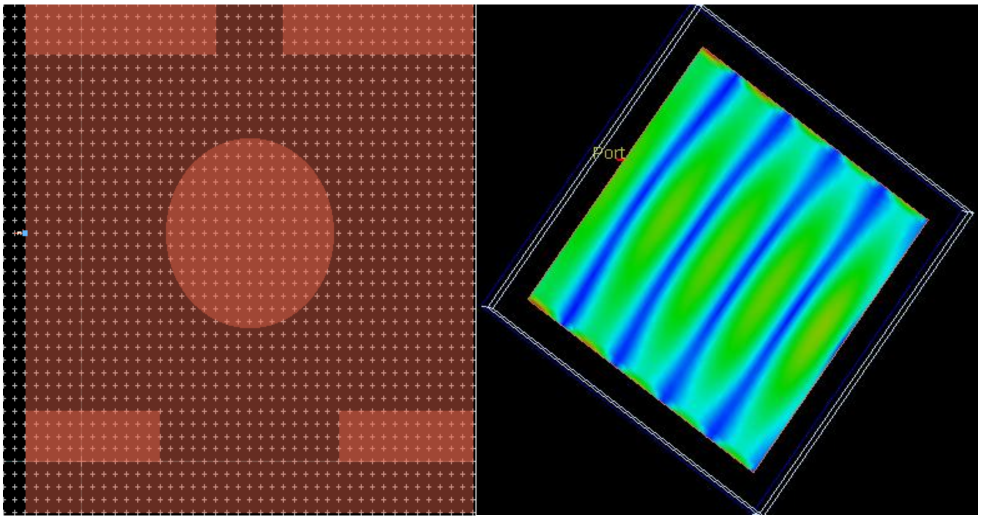
$$l = 0.412h \frac{(\varepsilon_e + 0.3)[\frac{w}{h} + 0.8]}{(\varepsilon_e - 0.258)[\frac{w}{h} + 0.8]}$$

Where, W is the width of the patch, L is the length of the patch, $f_0$is the operating resonance, *c* is for to measure light speed in a vacuum. The effective dielectric constant is obtained by following equation:

$$\varepsilon_e = \frac{1}{2}(\varepsilon_r + 1) + \frac{1}{2}(\varepsilon_r - 1)\ (1 + \frac{10h}{W})$$

ε_r=dielectric constant of the substrate
h=height of the substrate

The elementary geometry of the proposed microstrip antenna was designed using the equations from thetransmission line model (TEM) approximation in which the radiating patch is shown with no transverse field variations as a transmission line resonator.The first two dimension of rectangular slit L=17mm, W=4mm and the last two rectangular dimension L=12mm, W=4mm and the radius is 7.5mm. The dimension of the antenna was 40 ×40 mm^2



(a) (b)

Fig.1.a) Existing Microstrip Patch Antenna and b) current distribution

B. Design of Proposed Rectangular Microstrip Patch antenna

The geometry of the proposed antenna has been shown in Fig. 2. Basically, microstrip patch antenna consists of three layers: a metallic layer with antenna element pattern, dielectric substrate and another metallic layer as the ground plane[4-5]. The antenna is designed by using FR-4 with permittivity ε_r =2.2 and height, h=1.588 mm. The antenna has a simple structure fed by 50Ω microstrip line.

i) To calculate Width

$$w = \frac{1}{2f_r \sqrt{\mu_0 \varepsilon_0}} \cdot \sqrt{\frac{2}{\varepsilon_r + 1}}$$

ii) To calculate Length

$$L = \frac{1}{2fr\sqrt{\varepsilon_{eff}}\sqrt{\varepsilon 0 \mu 0}} - 2\ L$$

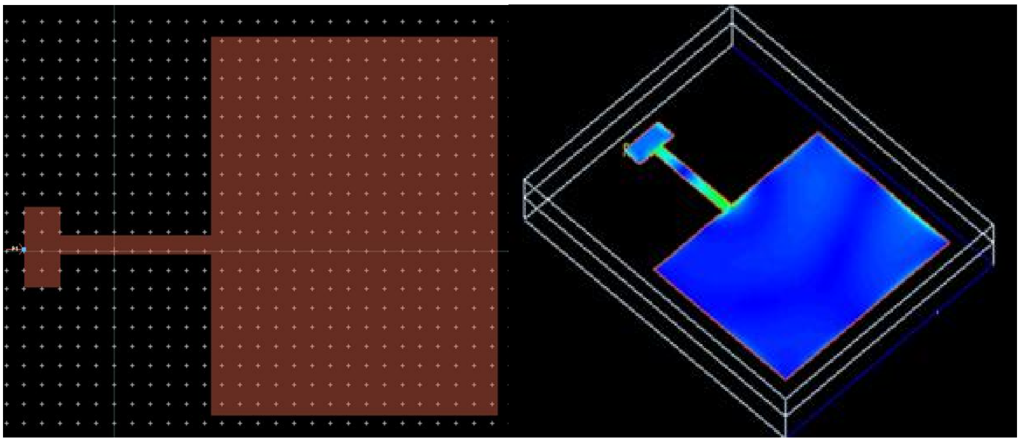
Where,

$$L = 0.41h \frac{\varepsilon_{eff} + 0.3}{\varepsilon_{eff} - 0.258} * \frac{\frac{w}{h} + 0.264}{\frac{w}{h} + 0.8}$$

And

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\frac{h}{w}}}$$

Where, λ is the wave length, f_r (in GHz) is the resonant frequency, L indicates the length and W indicatesthe width of the patch element and ε_r is the relative dielectric constant. Based on the calculation the path Length is L=19.88 mm and the Width is w=15.99 mm. Transmission line width is W= 1mm and Length is =8.4 mm.



(a) (b)

Fig.2. a) Proposed Antenna Design and b) Current distribution

III. Result and Discussion

It become easy to simulate the design through computer before real time implementation. The ADS software helps us to determine bandwidth, return loss, gain and directivity.This toolalso helps to reduce the fabrication cost because only the antenna with the best performance can be fabricated.The simulated results of existing antenna and the proposed antenna design shown in figure 3 and figure 4.

A.Return Loss and Bandwidth:

Figure 3 shows that the return loss of -20.05 dB is achieved at the first resonant frequency of 8.75GHz, -16.60 dB at the second resonant frequency of 10.45 GHz. Both the frequencies are used for satellite communication operate at X-band.

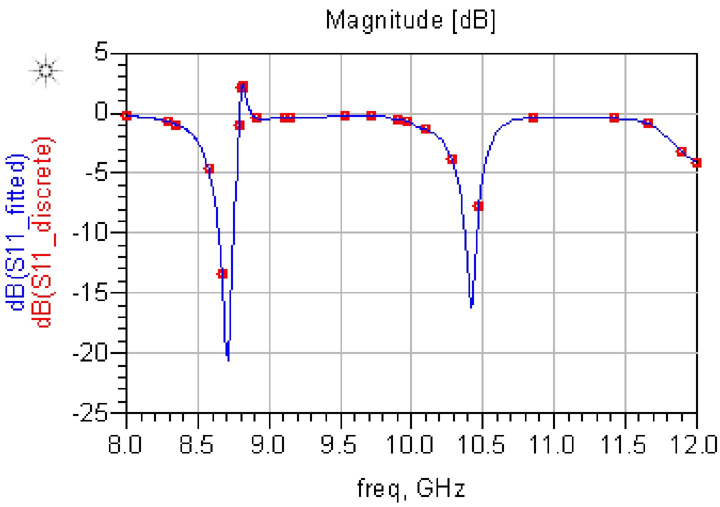


Fig.3. Return loss result for Microstrip Patch Antenna

Figure 4 shows proposed antenna return loss as -28.9 dB is achieved at the first resonant frequency of 11.3 GHz used in X-band application. -20.05 dB at the second resonant frequency of 14.4 GHz, -25 dB at the third resonant frequency of 16.3 GHz, and -18.5 dB at the fourth resonant frequency of 17.5 GHz used in Ku-band application and -17dB at the fifth resonant frequency of 18.5GHz**.**

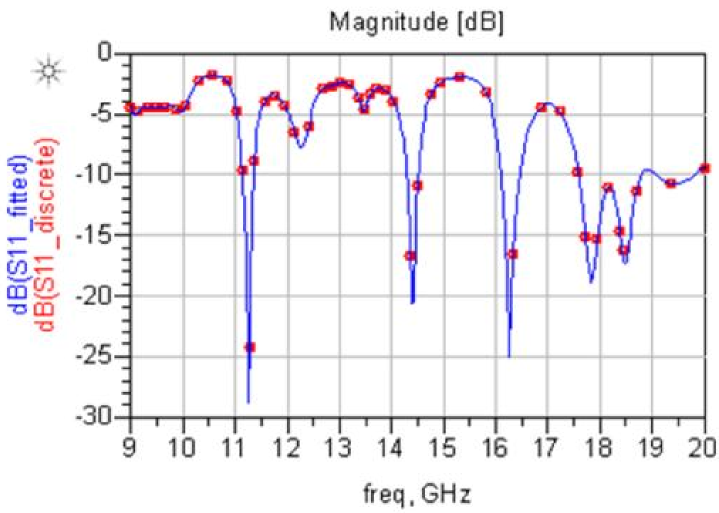
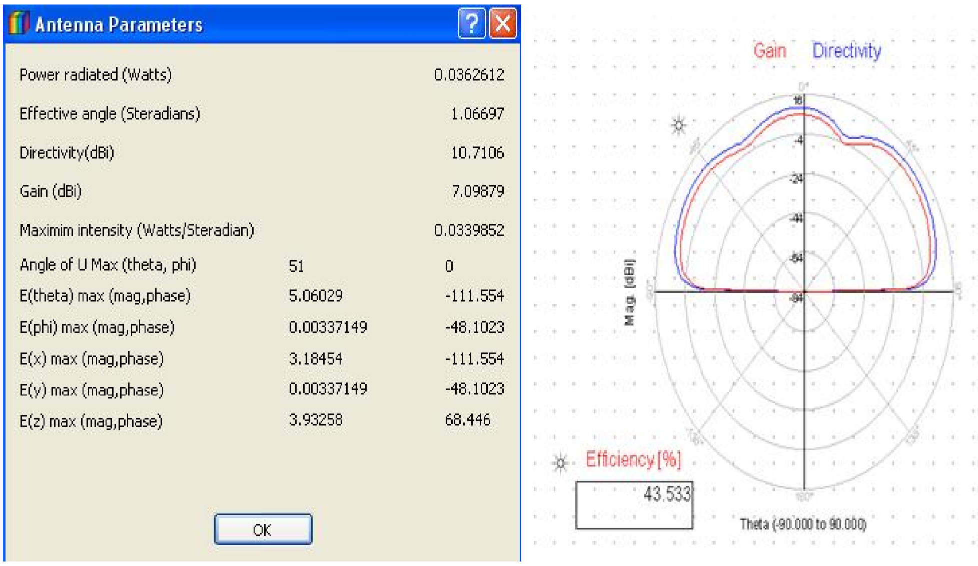


Fig.4. Return loss result for Proposed Antenna

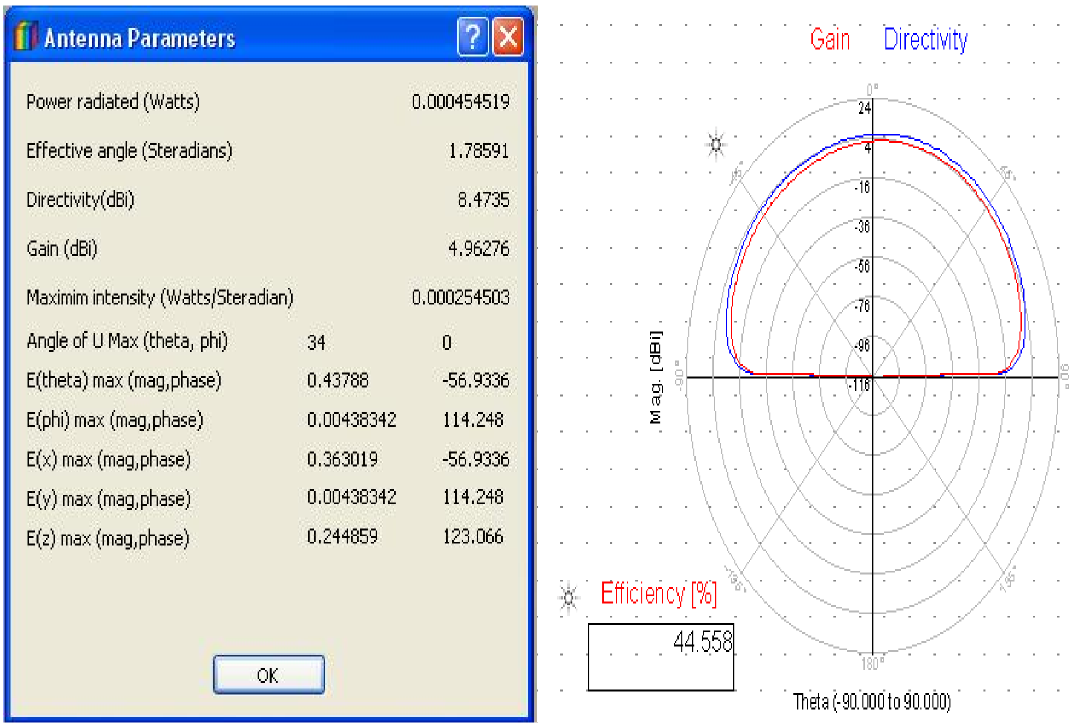
B. Directivity and Gain

Figure 5(a) and (b) shows the result of gain and directivity where the existing antenna has gain as 7.09879 dBand directivity as 10.7106 dB.Figure 6(a) and (b) shows the proposed antenna has gain value as 4.96276 dB and directivity as 8.4735dB.Compare toMicrostrip, Rectangular patch antenna has less gain and directivity because the proposed antenna works as MIMO based application.



(a) (b)

Fig.5. Antenna Parameter of Microstrip Patch Antenna



(a) (b)

Fig.6. Antenna Parameter for Proposed Antenna

IV.Conclusion

Antenna plays a vital role in communication whether it an ISM band, C band, X-band, Ku-band or K-band. The proposed antenna delivers high return loss and bandwidth where a single antenna can used for multiple application. The efficiency of the proposed antenna have higher result than existing antenna. Thus, Rectangular Microstrip Patch Antenna has much better result for satellite communication.

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