Performance Enhancement using circular cut shape Rectangular Microstrip Patch antenna

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Abstract— In this paper, we designed a circular cut shape microstrip patch antenna for the performance comparison with the normal microstrip patch antenna using the spectrum analyzer. The return loss of circular cut shape microstrip patch antenna designed at the resonant frequency of 2.42 GHz has been compared with the normal microstrip patch antenna at a substrate height of 1.6 mm. We get improvement in return loss. This paper shows the faithful return loss means we get dual band operation for the circular cut shape on the patch side and a very good practically value of VSWR obtain at the 2.42 GHz resonant frequency. The circular cut is of 3mm at the center. Gain as well as Directivity is also improves in this paper. These structures are simulated using IE3D version 12.29 Electromagnetic simulator of Zeland software incorporation.

Index Terms - Circular cut shape RMPA, Return Loss, VSWR, Gain, Directivity.

I. INTRODUCTION

At the present time of wireless communication systems, RMPA plays a very important role. In modern wireless communication systems, the microstrip patch antennas are commonly used in the wireless devices. Therefore, the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system [1].To meet these requirements, microstrip antennas can be used. Microstrip antennas are largely used in many wireless communication systems because of their low profile and light weight [2]. In spite of having a lot of advantages (low profile, low cost and Omni directional radiation patterns etc.), it has some drawbacks like narrow bandwidth and low gain [9].

These antennas is conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible designs, and when the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency. The currently popular antenna designs suitable for the applications of wireless local area network and world-wide interoperability for microwave access [3].

II. DESIGN SPECIFICATIONS

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Fig.1 the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane [10].

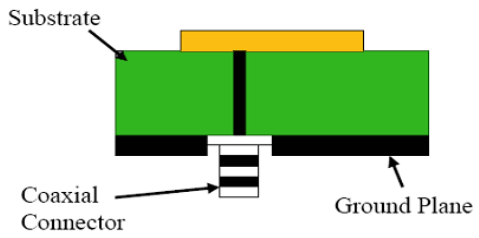

Fig.1 Coaxial probe feed via. SMA connector

The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. The Rectangular microstrip patch antenna parameters are calculated from the following formulas. Desired Parametric Analysis [4] [5].

Step 1: Calculation of the Width (W):

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

Step 2: Calculation of Effective dielectric constant (ε_{reff}):

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

Step 3: Calculation of the Effective length (L_{eff}):

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

Step 4: Calculation of the length extension (ΔL):

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

Step 5: Calculation of actual length of patch (L):

$$L = L_{eff} - 2\Delta L$$

Where, ε_r = relative permittivity
c = speed of light
W = width of antenna patch
h = height of antenna patch
f_o = resonant frequency of antenna

III. DESIGN & SIMULATION

The length and width of patch, the ground plane has been rounded off to the following values: L = 29 mm, W = 37 mm. Rectangular Microstrip Patch Antenna is etched on FR4 (Lossy) substrate of thickness h = 1.6mm and dielectric constant ε_r = 4.4 by using PEC [6] (Perfect Electric conductor) as the conducting plane. Hence, the essential parameters for the design are resonant frequency f_o = 2.42 GHz, dielectric constant of the substrate ε_r = 4.4 & height of dielectric substrate h = 1.6 mm.

Case 1: In normal RMPA Feed point is obtained by probe feed and feed point location (X_f, Y_f) is X_f = 8.5 mm and Y_f = 19 mm by the simulation through IE3D software and the result of return loss & VSWR given in the below table:

S. no.	Parameter	Normal rectangular patch
1	Return loss	-16.65 dB at 2.42 GHz
2	VSWR	1.37 at 2.42 GHz

Table 1: Shows return loss & VSWR for the normal RMPA

Case 2: In Circular cut shape Feed point in the figure is represent by probe feed and feed point location (X_f, Y_f). X_f = 10 mm and Y_f = 15 mm by the simulation through IE3D software shown in figure 2.

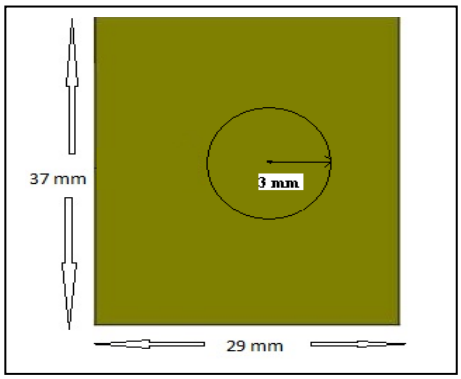

Fig.2. Circular cut shape of RMPA

After simulation of circular cut shape rectangular microstrip patch antenna return loss is -14.59 dB at 1.91GHz & -21.12 dB 2.42 GHz is obtained. The return loss graph at corresponding frequency is shown by the Fig.3.

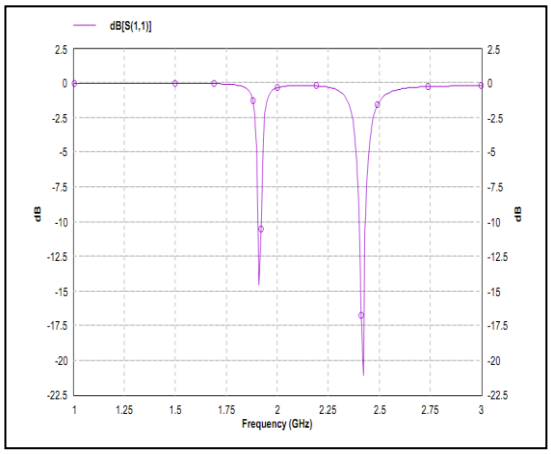

Fig.3. Return loss vs. frequency graph of Circular cut shape of rectangular microstrip patch antenna

After simulation of circular cut shape rectangular microstrip patch antenna voltage standing wave ratio (VSWR) is 1.458 at 1.91GHz & 1.399 at 2.42 GHz is obtained. This is practically good. The VSWR graph at corresponding frequency is shown by the Fig.4.

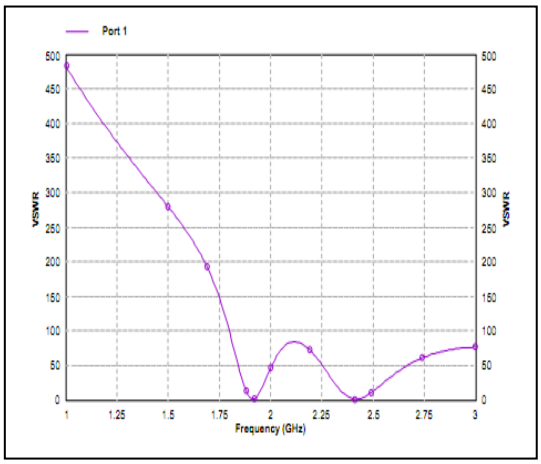

Fig.4. VSWR vs. frequency graph of Circular cut shape
of rectangular microstrip patch antenna

By the simulation of circular cut shape rectangular microstrip patch antenna gain is 4.82 at 1.91GHz & 5.3 at 2.42 GHz is obtained. The Gain graph at corresponding frequency is shown by the Fig.5

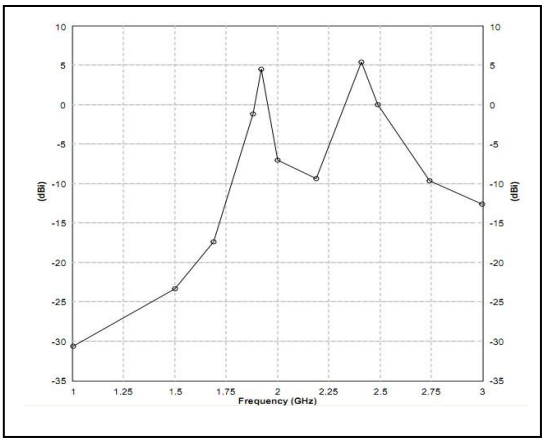

Fig.5. VSWR vs. frequency graph of Circular cut shape
of rectangular microstrip patch antenna

By the simulation of circular cut shape rectangular microstrip patch antenna directivity is 6.3 at 1.91GHz & 6.49 at 2.42 GHz is obtained.which show the very good result using circular cut of 3 mm on patch side. The directivity graph at corresponding frequency is shown by the Fig.6

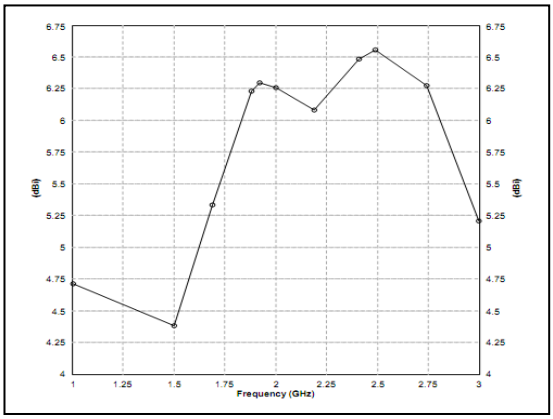

Fig.6. Directivity vs. frequency graph of Circular cut shape of rectangular microstrip patch antenna

In Fig.7 2D-Radiation pattern shows the impedance variation within the simulated frequency range and on the basis of smith chart information about impedance matching can be easily obtained at 2.42 GHz.

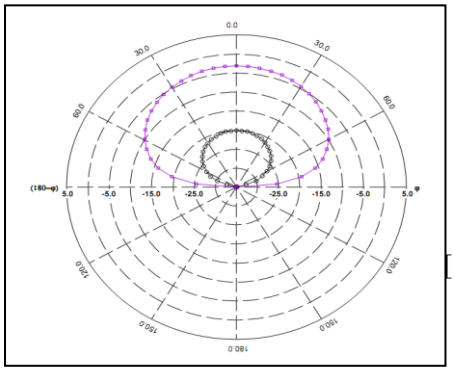

Fig.7. 2D Radiation pattern of Circular cut shape of rectangular microstrip patch antenna at freq. 2.42 GHz.

IV. Results & Discussion

After the fabrication of proposed antenna the antenna parameters like return loss and Voltage standing wave ratio are measured on the spectrum analyzer. Dual band operation of the proposed antenna can be verified from the Graph given in Fig.2, 3, 4, 5, 6, & 7.This graph has been plotted within the operating frequency range obtained from the Frequency analyzer.

V. Conclusion

We compare Circular cut shape rectangular microstrip patch antenna to normal rectangular microstrip patch antenna at an operating frequency 2.42 GHz. The circular cut shape RMPA provide dual band operation at 2.42 GHz. At 2.42 GHz the values of Return loss are -14.59 dB at 1.91 GHz & -21.12 db at 2.42 GHz.we know that the dual band operating frequency improves the gain of antenna. Hence here Circular cut shape rectangular microstrip patch antenna has been designed at frequency 2.42 GHz for Aircraft & mobile communication. The simulated results provide better gain & return loss as well as good VSWR. The value of return loss 1.458 at a frequency 1.91 GHz & 1.3999 at a frequency 2.42GHz. That encourages fabricating the structure. On making some variations in antenna parameter gain can be improved up to desired limit but some practical limitation should be taken care while fabricating the structure on IE3D education software.

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