Design and Performance Analysis of Dual Band 'C' slotted Rectangular Microstrip Patch Antenna for Wide Band Applications

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Abstract

In this paper, a wide band triple 'C' slotted rectangular Microstrip patch antenna is presented. The major advantage of the approach presented here is enhanced bandwidth. It can be seen that bandwidth of rectangular Microstrip antenna is increased to a great magnitude when 'C' slots are made on the rectangular patch. Applications where wide bandwidth is required, this designed slotted patch antenna is one of the alternative solutions. The proposed antenna has frequency band (1.85-3.55 GHz) of 1.7 Ghz with fractional bandwidth of 62.96 %. The gain has been improved up to 5.52 dBi, directivity 5.65 dBi and efficiency 99.873 %. The proposed triple 'C' slotted Microstrip patch antenna is fed by 50Ω Microstrip feed line and suitable for L and S-band operations. The performance of different structures are simulated and compared by using IE3D Zealand simulation software based on method of moments.

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Keywords: Dual Band, enhance bandwidth, compact Microstrip(MS) Patch, calculated ground plane, gain, 50Ω feed line.

I. INTRODUCTION

Microstrip patch antennas have drawn the attentiveness of antenna community researchers due to its light weight, low profile, low production cost, conformability and ease of fabrication and integration with solid state devices [1]. But the major drawback of rectangular Microstrip antenna is its narrow bandwidth and lower gain. The bandwidth of Microstrip antenna may be increased using various techniques such as use of a thick or foam substrate, cutting slots or notches like W slot, E shaped, plus shaped patch antenna, introducing the parasitic elements either in coplanar or in stack configuration, defected ground plane and modifying the shape of the radiator patch by introducing the slots [2, 3, 4 and 5]. In this present work the bandwidth of Microstrip antenna is increased by cutting 'C' slots and it is obtained that the bandwidth of 'C' slotted rectangular Microstrip antenna is much greater than simple rectangular Microstrip antenna. 'C' slotted rectangular Microstrip antenna with Microstrip line feed is shown in Figure1. The width of the Microstrip line was taken as 3.8 mm and the feed length as 4.8 mm. The patch is energized electromagnetically using 50Ω Microstrip feed line [6]. The proposed antenna has been designed on glass epoxy substrate ($\xi r = 4.4$). The substrate material has large influence in determining the size and bandwidth of an antenna. Increasing the dielectric constant decreases the size but lowers the bandwidth and efficiency of the antenna while decreasing the dielectric constant increases the bandwidth but with an increase in size [7,8]. The design frequency of proposed antenna is 2.2 GHz. Different structures are simulated by using IE3D simulation software and it is obtained that rectangular patch with 'C' slots gives highest bandwidth among all the structures that are simulated.

The frequency band (1.85-3.55 GHz) of proposed antenna is suitable for broad band applications(1.605-3.381GHz) [9] such as military, wireless communication, satellite communication, global positioning system (GPS), RF devices, WLAN/WI - MAX application [10,11]. Broadband devices are mainly used in our daily lives such as mobile phone, radio, laptops and Microstrip patch antennas plays important role in these devices [12].

II. ANTENNA DESIGN

For designing a rectangular Microstrip patch antenna, the length and the width are calculated as below [11, 12 and 13].

$$w = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \qquad (1)$$

Where c is the velocity of light, ϵ_r is the dielectric constant of substrate, f_r is the antenna design frequency, W is the patch width, and the effective dielectric constant $\epsilon_{r\,eff}$ is given as [12, 13,14 and 15]

$$\epsilon_{r\,eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (2)$$

At h = 1.6 mm

The extension length ΔL is calculates as [7,12]

$$\frac{\Delta L}{h} = 0.412\frac{\left(\epsilon_{r\,eff}+0.3\right)\left(\frac{W}{h}+.264\right)}{\left(\epsilon_{r\,eff}-.258\right)\left(\frac{W}{h}+0.8\right)} \qquad (3)$$

By using the above mentioned equation we can find the value of actual length of the patch as, [8, 11 and 12]

$$L = \frac{c}{2f_r\sqrt{\epsilon_{r\,eff}}} - 2\Delta L \qquad (4)$$

The length and the width of the ground plane can be calculated as [10, 12 and 13]

$$L_g = 6\text{h} + L \qquad (5)$$

$$W_g = 6\text{h} + W \qquad (6)$$

III. ANTENNA DESIGN SPECIFICATIONS

The design of proposed antenna is shown in Figure1. The proposed antenna is designed by using glass epoxy substrate which has a dielectric constant 4.4 and the design frequency is 2.2 GHz. Height of the dielectric substrate is 1.6 mm and loss tangent *tan* δ is 0.0013. Antenna is fed through a line feed of length 3.8 mm and width 4.8 mm which is energized by 50Ω Microstrip feed line. All the specifications are given in the table1. (All lengths are in mm and frequency in GHz).

Table 1: Parameters For Antenna Design.

S.No.	Parameters	Value
1.	Design frequency fr	2.2
2.	Dielectric constant ξr	4.4
3.	Substrate height	1.6
4.	Loss tangent , *tan* δ	.0013

Table 2: Designed Structure parametrs

S.No.	Parameters	Value
1.	Ground plane width , a	41.4
2.	Ground plane length , b	30.4
3.	Patch width , c	51
4.	Patch length , d	40
5.	e	32.2
6.	f	30.2
7.	g	17
8.	h	12
9.	i	25
10.	j	7
11.	k	3.8

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IV. ANTENNA DESIGN PROCEDURE AND LAYOUT

All the dimensions of rectangular Microstrip antenna should be calculated very carefully by using the equations 1, 2, 3, 4, 5 and 6. Design frequency is 2.2 GHz taken for designing a proposed dual band triple 'C' slotted Microstrip patch antenna. Two regular 'C' slots with one inverted 'C' slot.

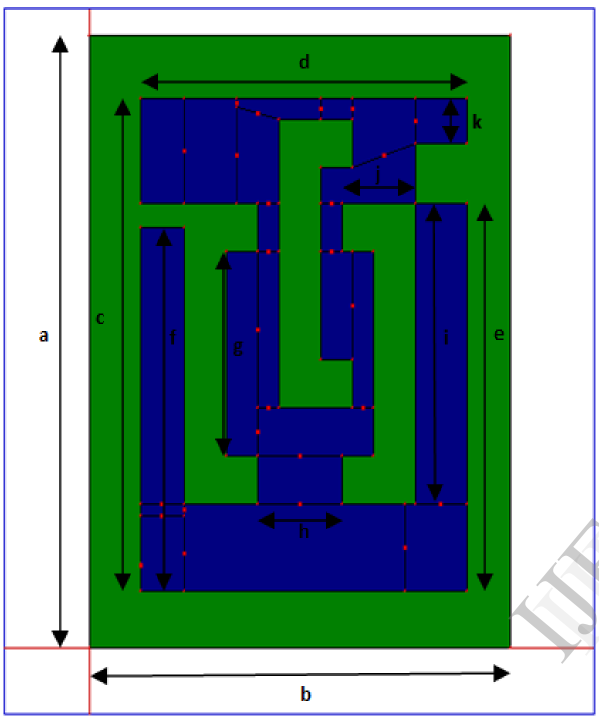

Fig.1: Geometry of proposed Microstrip antenna.

Here it should be clear that all the dimensions of simulated antennas are same as in the proposed structure and line feed should also be at the same place with same dimension.

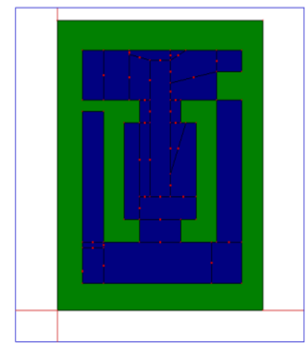

Fig. (i)

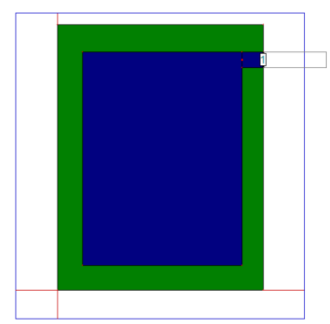

Fig. (ii)

Fig. 2: Geometry of other antennas that are simulated.

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V: PERFORMANCE ANALYSIS.

For making the proposed direct coupled 'C' slotted antenna, different structures are simulated sequentially through Zeland IE3D simulation software and their bandwidth are compared. By this computation work it is found that the bandwidth of rectangular Microstrip patch antenna with triple 'C' slot is highest among all the structures that are simulated.

Fig. 2, shows the geometry of all the structures that are simulated through Zeland IE3D simulation software.

Table 3: Antenna Geometries.

Fig.2.(i)	**Rectangular patch structure with double c slot.**
Fig.2(ii)	**Simple rectangular patch without any slot**

Table 4: Comparative analysis of bandwidth of different antenna geometries.

Structures	Frequency band	Fractional bandwidth
Triple 'C' slotted structure	1.85-3.55 4.16-4.51	62.96% 8.08%
Rectangular patch with Double 'C' slots	1.91-2.51 3.38-4.54	27.14% 29.29%
Simple rectangular patch antenna without any slot	2.04-2.34 3.62-3.89	13.69% 7.19%

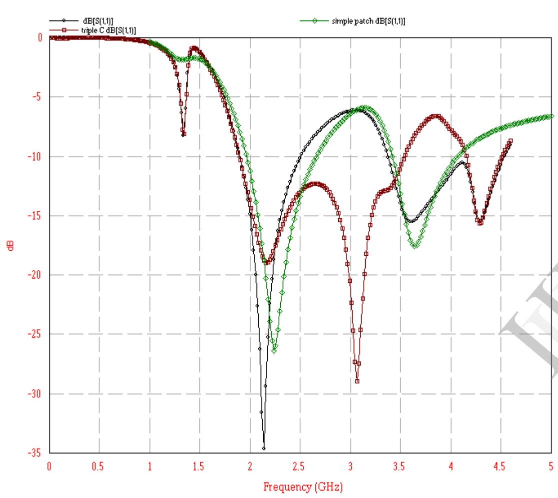

Fig.3: Comparison of return loss v/s frequency graph of different structures

Fig.3 shows Comparison of return loss v/s frequency graph of different structures. It is advent from fig that the triple c slot antenna was widest bandwidth.

VI. SIMULATION RESULT AND DISCUSSION

The narrow bandwidth of Microstrip antenna is one of the important features that restrict its wide usage**.** In the present work we are tried to increase the bandwidth of rectangular Microstrip antenna by successively cutting 'C' slots [14]. From the above available performance results it is clear that rectangular patch antenna with triple 'C' slots plies highest bandwidth among all structures that are simulated. In case of dual frequency band only highest frequency band is selected for comparison. The maximum gain of the antenna has been improved up to 5.52dBi, directivity improved up to 5.65dBi, efficiency of the antenna is found to be 99.873%, and the VSWR of the antenna is in between 1 to 2 over the entire frequency band which shows that there is a proper impedance matching. The return loss of the proposed antenna is 28.98 dBi.

The simulation performance of proposed micro strip patch antenna is analyzed by using IE3D simulation software at the selected design frequency of 2.2GHz. The performance specifications like gain, radiation pattern, smith chart etc of proposed antenna is shown in the fig 4 to 11.

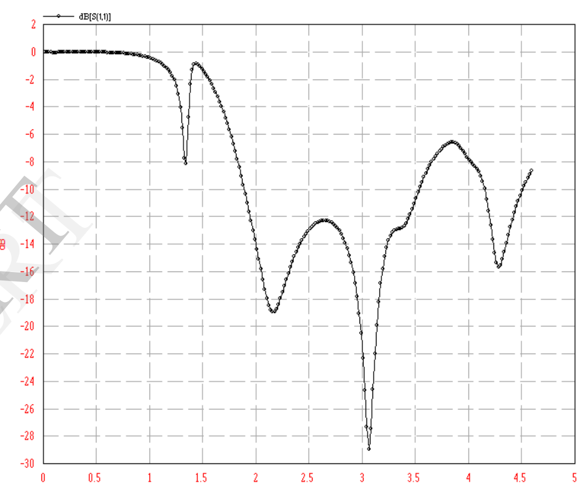

Fig.4: Return loss v/s frequency graph.

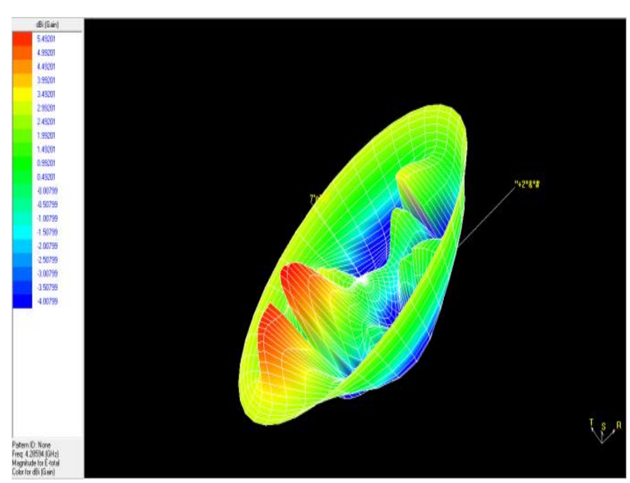

Fig.5: 3D Radiation pattern of proposed antenna.

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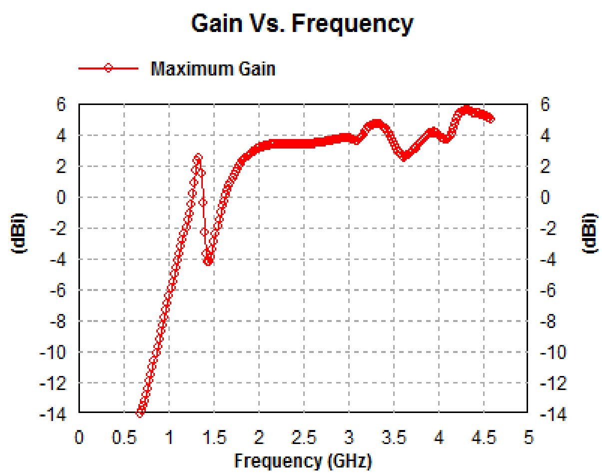

Fig.6: Gain vs. frequency plot.

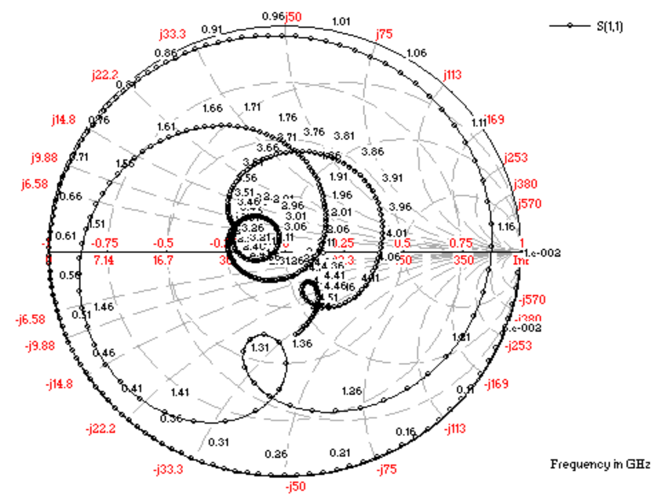

Fig.9: Smith chart

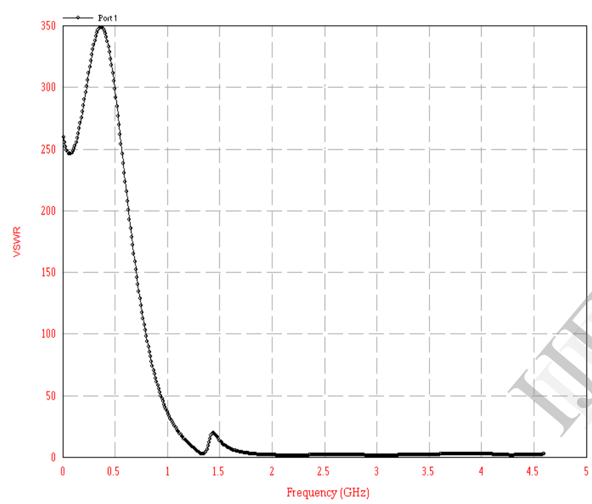

Fig7: VSWR of proposed antenna

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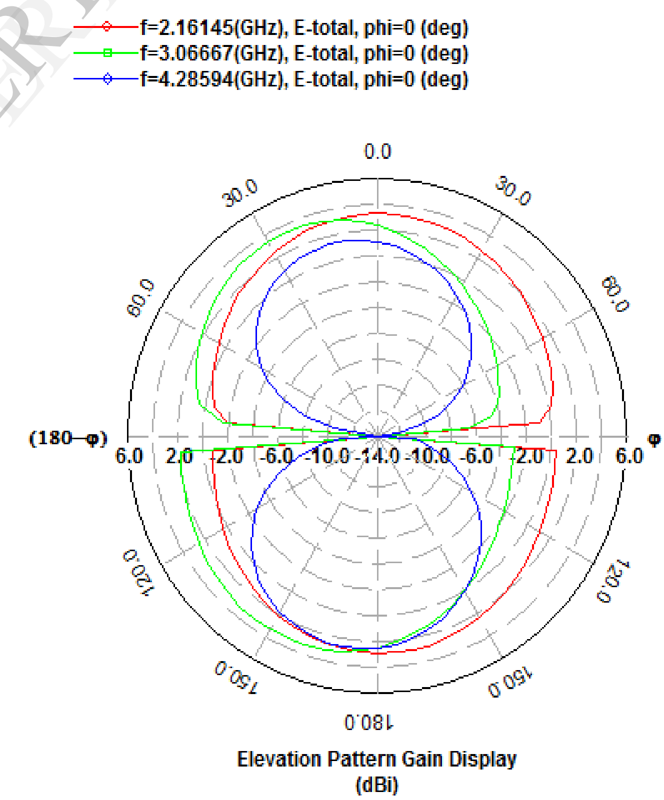

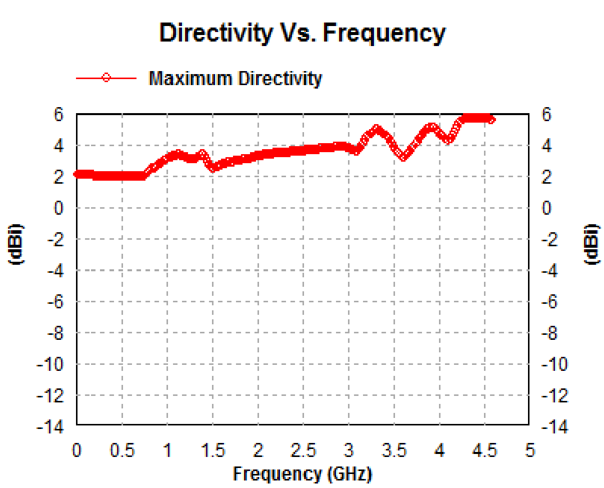

Fig.8: Directivity v/s frequency plot

Fig.10: 2D radiation pattern of antenna

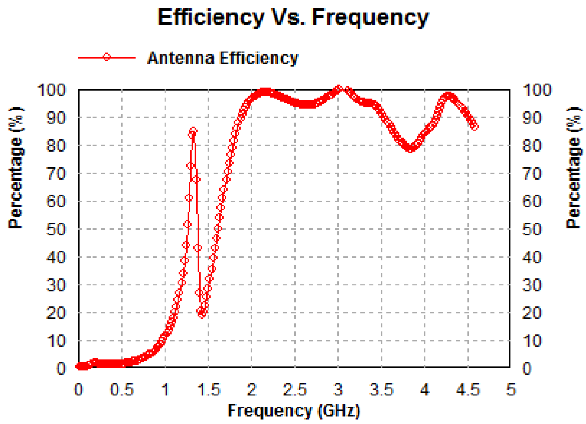

Fig.11: Efficiency graph of proposed antenna.

VII. CONCLUSION

The performance analysis and characteristics of compact triple 'C' slotted patch antenna dimensional parameters are studied through simulation results. In general, the impedance bandwidth of the traditional Microstrip antenna is only a few percent (7% -8%) [9]. Therefore, it becomes very important to develop a technique to increase the bandwidth of the Microstrip antenna. Proposed antenna provides dual frequency band with 62.96% fractional bandwidth in first band. The proposed antenna has been designed on glass epoxy substrate to give a maximum radiating efficiency of about 99.873% and high gain of about 5.52 dBi.

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