A Comparative Study of Compact Slotted Rectangular and Circular Microstrip Patch Antenna for C-Band Application

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***Abstract*— In this paper we present the design of a compact size, single feed, single layer, dual frequency Rectangular and Circular microstrip patch antenna for C Band applications. For the design and simulation we have used method of moment based EM Simulation software I3ED.With the introduction of slots at the edges of the rectangular and circular patch the size of the antenna has been reduced to 48% and 37%. We have also calculated Gain, antenna efficiency and radiation efficiency of the proposed antenna structures. The radiation patterns of the proposed compact rectangular and circular microstrip patch antenna are also studied.**

Keywords- Compact, Rectangular, Circular, C- Band

I. INTRODUCTION

In satellite and wireless mobile communication applications, microstrip antennas have attracted much interest due to their small size, light weight, low cost on mass production, low profile and easy integration with other components [1-3]. The most common patch structures are rectangular, circular and triangular. This paper describes the design of compact slotted rectangular and circular microstrip antenna. The size of the antenna may be effectively reduced by cutting rectangular slots on printed antennas. With the recent advancements in mobile and wireless communication systems particularly for data communication, the demand for broad band, multi frequency and multi band patch antenna was realized. These requirements forced workers for modification in patch antenna geometries. A large number of microstrip patches to be used in wireless applications have been developed [4-6].

II. ANTENNA DESIGN

A. Rectangular patch Antenna Design

The Width (W) and length (L) of Antenna1 are calculated from Conventional equations [7].

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

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

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

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

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

Where L_{eff}=Effective length of the patch, $\Delta L/h$=Normalized extension of the patch, ε_{reff}=Effective dielectric constant. The length and Width of the Rectangular microstrip patch antenna operating in frequency 5.8GHz are 11.74mm and 15.73mm respectively with substrate thickness h=1.6mm and dielectric constant (FR-4).

B. Circular Patch Antenna Design

The radius of the circular microstrip patch antenna operating at frequency 5.8GHz is calculated from conventional formula [5]

Radius,
$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}}$$

$$F = \frac{8.791\times 10^9}{f_r\sqrt{\varepsilon_r}}$$

The radius of the circular microstrip patch antenna operating at frequency 5.8GHz is 6.83mm.

III. RESULT AND DISCUSSION

Simulated (using IE3D[8]) results of return loss of conventional and slotted rectangular and circular Microstrip antenna are shown in Figure1-5.A significant improvement of frequency reduction is achieved in slotted rectangular and circular microstrip antenna with respect to the conventional antenna structure. In the conventional rectangular microstrip antenna return loss of about -29.56dB is obtained at 5.547GHz. Due to the presence of slots in antenna the first resonant frequency is obtained at 4.225GHz with return loss of about -16.62dB. The second resonant frequency is obtained at 6.70GHz at -13.0dB .In the conventional circular microstrip antenna return loss of about -25.34dB is obtained at 5.776GHz.Due to the presence of slots in antenna the first resonant frequency is obtained at 4.821GHz with return loss of about -34.20dB.The second resonant frequency is obtained at 6.87GHz at -15.70dB. The antenna efficiency of the proposed compact slotted rectangular microstrip antenna at the frequencies 4.22GHz and 6.70GHz are 74.25% and 46.87% respectively. The antenna efficiency of the proposed compact slotted circular microstrip antenna at the frequencies 4.821GHz and 6.87GHz are 42.53% and 60% respectively. The radiation efficiency of the proposed compact slotted rectangular microstrip antenna at the frequencies 4.22GHz and 6.70GHz are 78.49% and 53% respectively.The Radiation efficiency of the proposed compact slotted circular microstrip antenna at the frequencies 4.821GHz and 6.87GHz are 68.13% and 64.27% respectively.

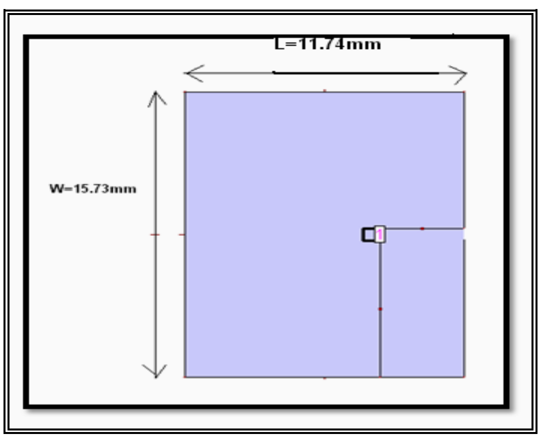

Figure1:Structure of Rectangular Microstrip patch Antenna(without slot)

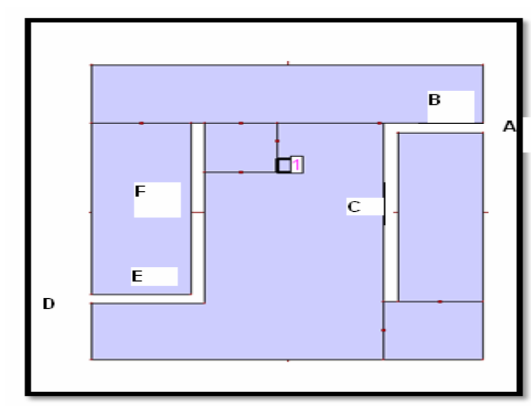

Figure2: Structure of slotted rectangular microstrip patch Antenna

A=D=Cut Width=0.5mm, B=Cut Depth=3.5mm
C=Cut Depth=9.5mm, E=Cut Depth=4mm
F=Cut Depth=9.125mm
Location of Probe= (0.375mm, 2.5mm)

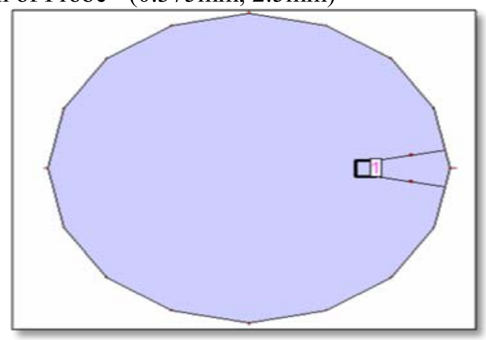

Figure3: Conventional circular microstrip patch antenna

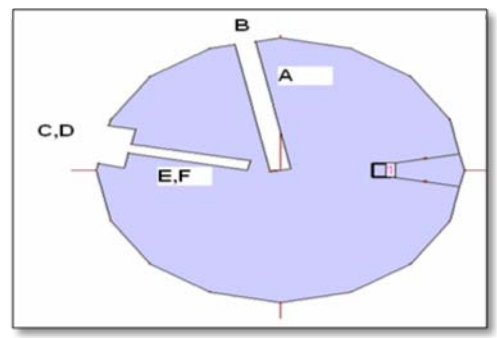

Figure4: Slotted circular microstrip patch antenna with dimensions

A=Cut Depth=6.6987mm, B=Cut Width=0.75mm
C=Cut Depth=1mm, D=Cut Width=2mm
E=Cut Depth=4.5mm, F=Cut Width=0.5mm
Location of Probe= (3.75mm, 0mm)

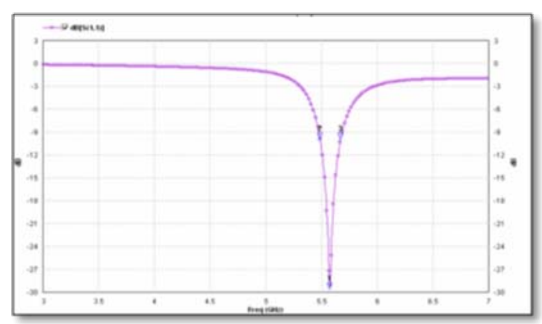

Figure5: Return loss of conventional rectangular Microstrip Patch Antenna (without slot)

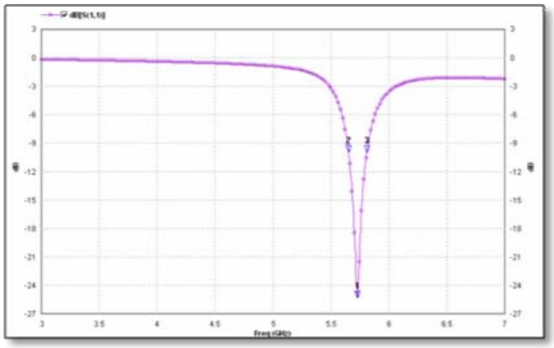

Figure6: Return loss of conventional Circular Microstrip Patch Antenna (without slot)

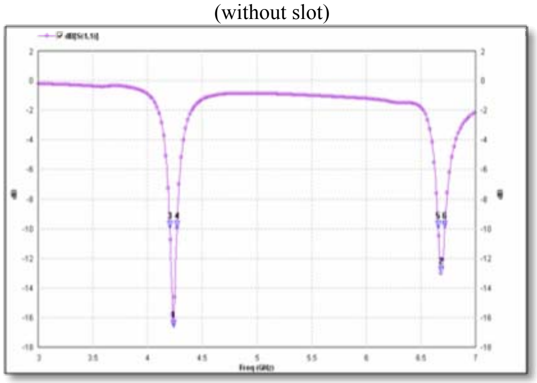

Figure7: Return loss of Slotted Rectangular Microstrip Patch Antenna

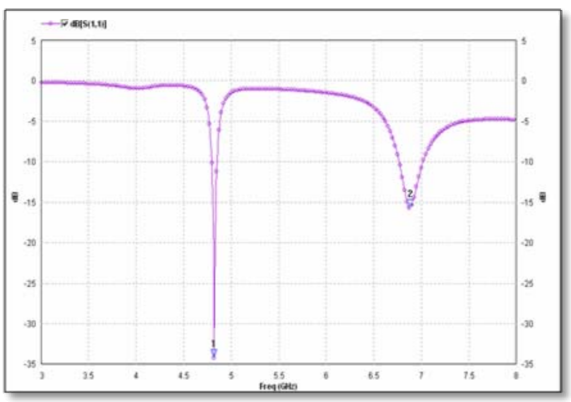

Figure8: Return loss of Slotted Circular Microstrip Patch Antenna

The radiation pattern of E-TOTAL at phi=0^0 and phi=90^0 are shown in figure9-14

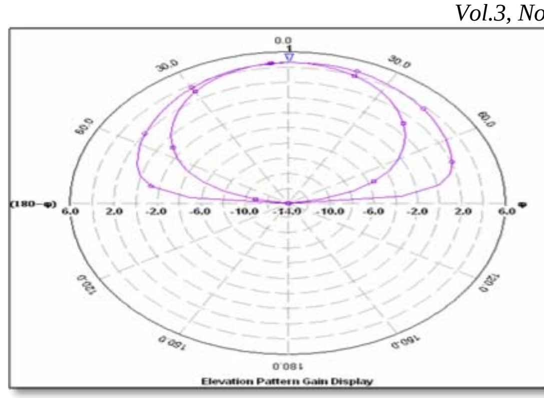

Figure09: Radiation Pattern of Conventional rectangular microstrip antenna (5.547GHz)

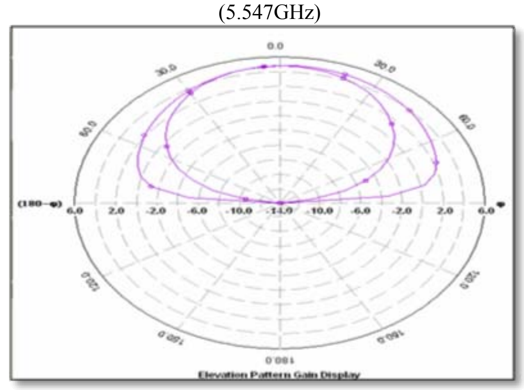

Figure10: Radiation Pattern of slotted Circular microstrip antenna (5.726GHz)

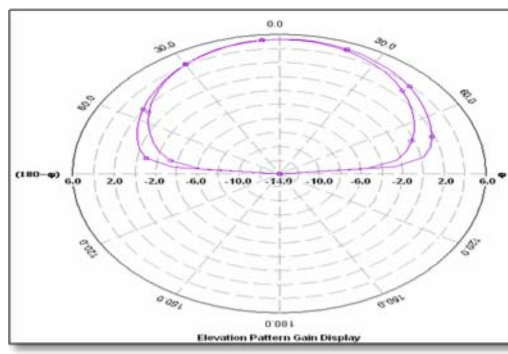

Figure11: Radiation Pattern of slotted rectangular microstrip antenna (4.225GHz)

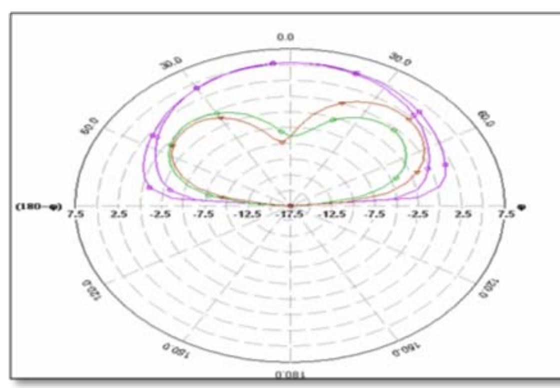

Figure12: Radiation Pattern of slotted rectangular microstrip antenna (6.70GHz)

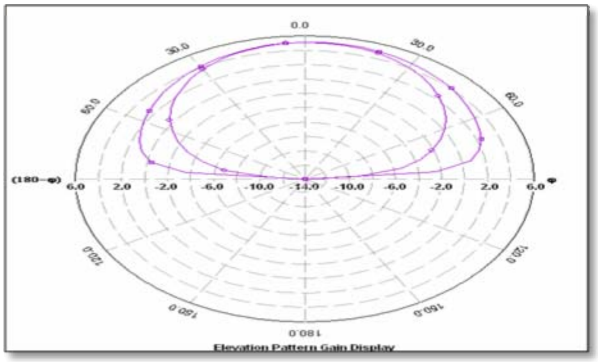

Figure13: Radiation Pattern of slotted circular microstrip antenna (4.821GHz)

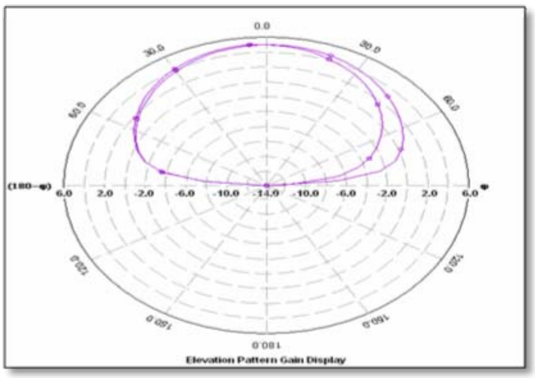

Figure14: Radiation Pattern of slotted circular microstrip antenna (6.87GHz)

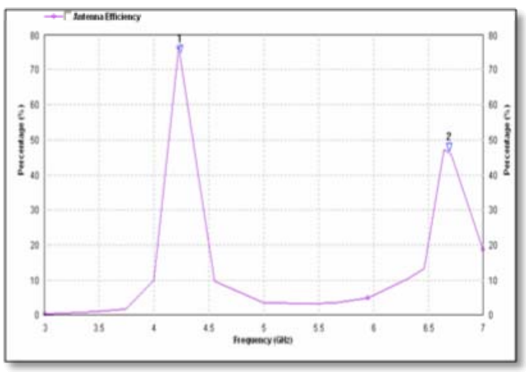

Figure15:Antenna efficiency of the slotted rectangular microstrip patch antenna

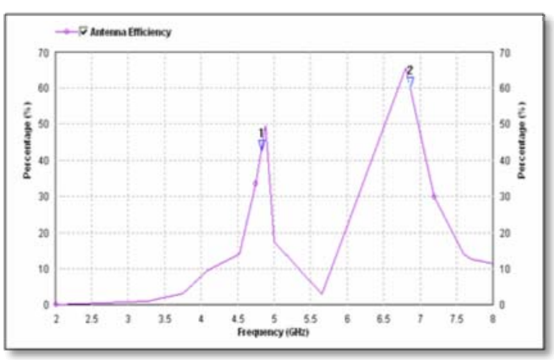

Figure16: Antenna efficiency of the slotted circular microstrip patch antenna

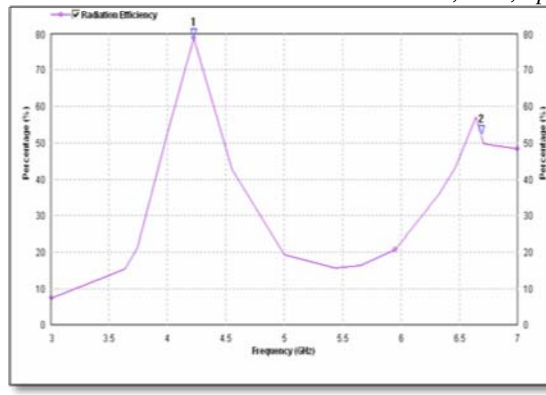

Figure17: Radiation efficiency of the slotted rectangular microstrip patch antenna

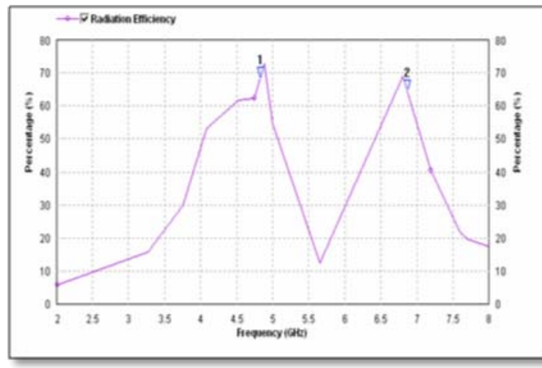

Figure18: Radiation efficiency of the slotted circular microstrip patch antenna

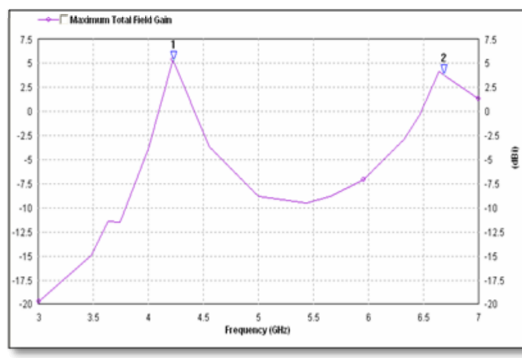

Figure19: Maximum total field gain of slotted rectangular microstrip patch antenna

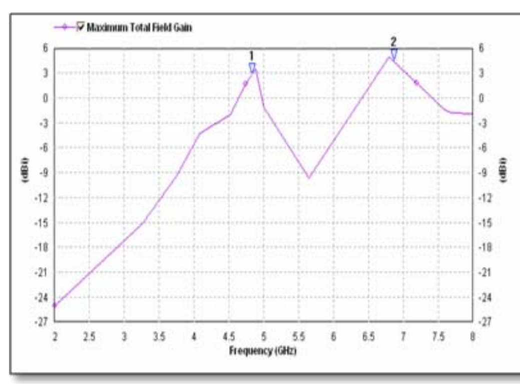

Figure20: Maximum total field gain of slotted circular microstrip patch antenna

Table-1: Simulated Results For Antenna1,2,3 and4

Antenna Structures	**Resonant frequency(GHz)**	**Return loss(dB)**	**10dBBandwidth (MHz)**	**Gain (dBi)**
1	5.547	-29.56	183	5.3
2	5.726	-25.34	156	5.2
3	4.225	-16.62	64	5.15
	6.70	-13.08	60	3.71
4	4.82	-34.20	54	2.74
	6.87	-15.70	244	4.43

IV. CONCLUSION

Theoretical investigations of a single layer single feed microstrip patch antennas have been carried out using Method of Moment based software IE3D.Introducing slots at the edges of the Rectangular patch a size reduction of about 48% has been achieved and with the introduction of slots at the edges of the circular patch a size reduction of about 37% has been achieved. The both proposed antenna structures in this paper can be used for Microwave C-Band applications.

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