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Design and Performance Analysis of Dual band Circularly Polarized C-Slot Patch Antenna

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Abstract— In this paper dual band aperture coupled Circularly Polarized (CP) C-Slotted antenna with a small frequency ratio exited through a single feed is proposed for GPS application. The optimized design of C- Slot antenna has been validated using IE3D Electro-magnetic wave simulator. The C-slot is asymmetrical about the centre of the antenna. The antenna parameters can be optimized by changing the physical parameters like as length of the slot , permittivity of the dielectric etc.The measured 10-dB return loss bandwidth of the optimized slot are 44.91% & 6.8%for the lower and upper band respectively. The measured Axial Ratio is 0.14 at 1.29 GHz. The overall antenna gain is more than 5.5 dBic and efficiency is 80%.A dual frequency aperture coupled patch antenna may provide a sub-stitute to large bandwidth planner antenna.
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Index Terms— Microstrip antenna, dual band antenna, patch antenna, Circular polarization, circularly polarized antenna, GPS antenna

1 INTRODUCTION

Microstrip antennas are very popular due to their compact size, low cost, simple in manufacturing and conformability. Most interesting feature of the aperture coupled microstrip antenna is that these are reconfigurable. Depend upon the type of feeding, shape and size of the slot, patch antenna has a lot of application in Radar, Mobile and Satellite Communication.

A variation of the aperture coupled patch antenna enhances the various parameters. By changing the physical parameters of the antenna are investigated, wideband operation can be achieved [1]. In [2], Kai-Ping Yang et al had proposed a design for dual band circularly polarized (CP) square patch antenna.Thedesigned is achieved by four T slits at patch edges. They reduced 36 % size of the slot in their design. Circularly Polarized rectangular bent slot antenna baked by rectangular cavity to achieve input impedance, axial ratio and radiation pattern [3]. Rashid A Sayeed et al had designed aperture coupled feed microstrip antenna for WLAN.Circular Polarization is the resultant of two signals having same amplitude and 90 degree out of phase. Circular polarization can be achieved if two orthogonal modes are excited with a 90^{o} time phase difference between them. Regardless of the receiver orientation CP will able receiving a component of the transmitted signal. It is only possible due to the wave having the angular variation.

This can be accomplished by adjusting the physical dimensions of the patch and using either single, two or more feeds [4].The microstrip antenna with an annular - ring patch excited by L-Slot is proposed by Cai et al. Dual band CP is occur to magnetic circulating currents flowing in the opposite direction along the ring with two different specified frequencies [5].In [6], Bao et al optimized circularly polarized patch antenna with small frequency ratio and compact in size. The size of the slot is reduced up to 53 % and angular frequency ratio of resonant modes is tunable and suitable for wireless communication. Using E-Shaped structure the antenna is designed for Wide band operation about 31.6- 40 GHz. It is suitable for millimeter wave application [7].Gh. Z. Rafi et al suggested a low profile integrated patch antenna for GPS-DSRC application. Antenna operates at L1 GPS frequency of 1.575 GHz with circularly Polarized and 5.88 GHz with vertical linear polarization [8]. Nasimuddin , Zhi Ning et al proposed s-Shaped Circularly Polarized patch antenna with small frequency ratio for GPs application.Asymmetrical S-shaped slot cut at center which provides 16% upper band and 12.5 % lower band 10-dB return loss Bandwidth respectively and the Axial ratio 6.9% for lower band and 0.6% for upper band [9].

Three Wilkinson power combiners have been used to combine the signals from the four feed-lines at the slots with same amplitudes and 90^{o} phase difference.

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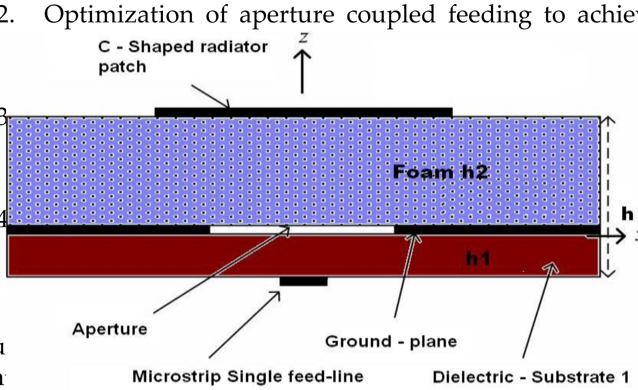
2 DESIGN OF DUAL-FREQUENCY CP-SLOTTED PATCH ANTENNA

The antenna structure comprising two substrates, the lower substrate material is FR4, relative permittivity 4.4 (Loss tangent 0.02) – and the upper substrate is foam which has a relative permittivity of 1.06 (Loss tangent 0.0). A 50 Ohm coaxial probe feeds the top radiating patch through a via hole in the bottom layer; the ground plane size is 90 mmX90 mm.

The designed shape of the antenna is shown in figure 2.The radiating patch is feed through an aperture coupled 50 ohm single feed microstip line under the ground plane.The frequency range for which single feed line is matched is defined Bandwidth , in other way frequency range for which antenna performed and give satisfied results. In aperture coupled feed, RF energy coupled from single feed line to the radiating patch [4].Following steps are sequentially used to design the antenna [1]-[9].

1. First we have to determine initial dimensions of the radiating C- slot for the lower band and the constraint is size of antenna.

2. Optimization of aperture coupled feeding to achieve



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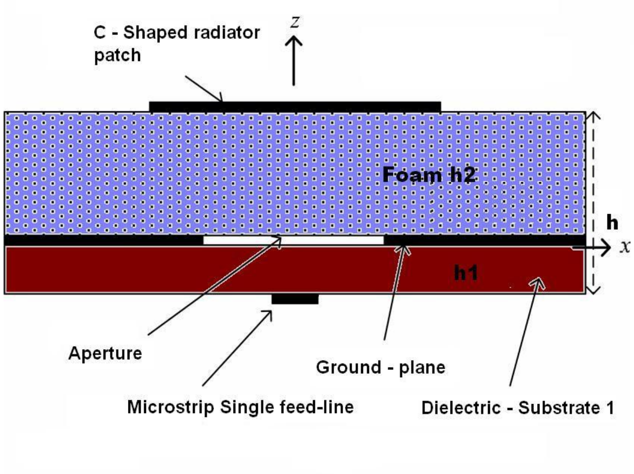


Fig.1: Cross sectional view of antenna [9]

Table-Dimensions of the patch

No	Parameter	mm	No	Paremeter	mm

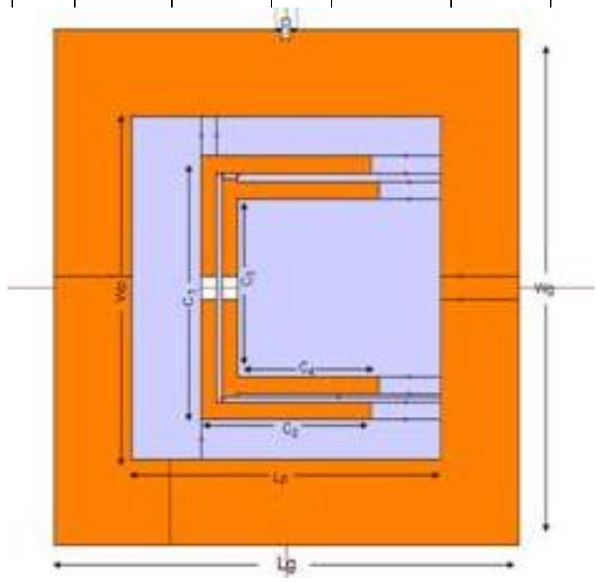


Fig.2: Designed C-Slot Antenna

3 SIMULATION RESULTS

After the simulation of above design on Zeland_IE3D_v14.10 we get the following results. These all results are plotted against frequency.

A. Return Loss

The input reflection coefficient obtained from IE3D ver. 14.0[10] for the dual band Circularly Polarized high gain microstrip antenna is shown in Fig.3.For the proposed structure shown in Fig.3, the measured 10 dB return loss is -30.2 at 1.15 GHz and -17.8 at 1.89 GHz.

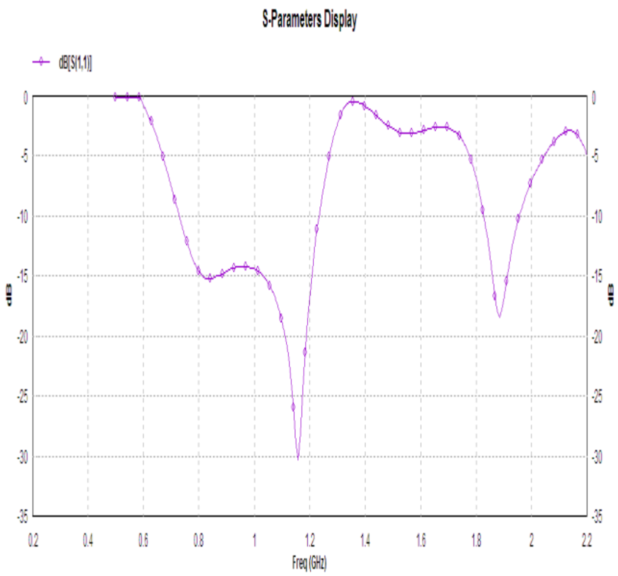
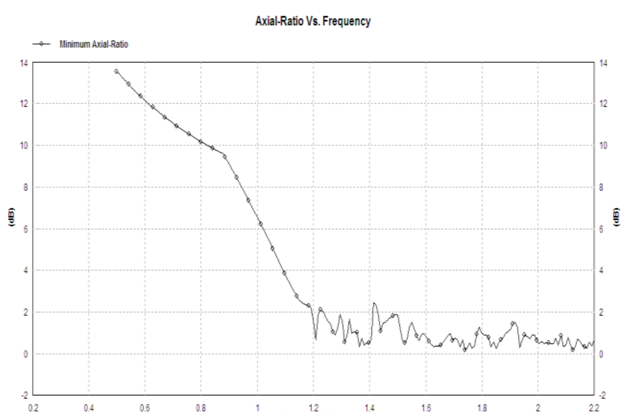


Fig.3: Return loss Vs Frequency

B. *Axial Ratio*

The value of axial ratio for Circularly Polarized antenna should be low. Simulation result for the Axial Ratio is shown in Fig.4.In the designed structure the axial ratio is 0.14 at 1.29



GHz.

Fig.4: Axial Ratio Vs Frequency

C. *Total Field Gain*

Simulated result obtained for the above proposed design is shown in Fig.5. At the lower resonant frequency gain is 3.34 .On comparing the gain of C- slot antenna with the conventional antenna [9], it is improved. The maximum achievable gain is 5.5 dBi

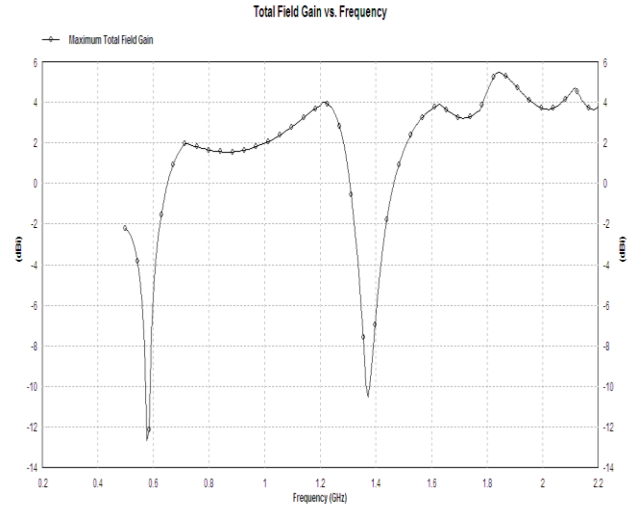
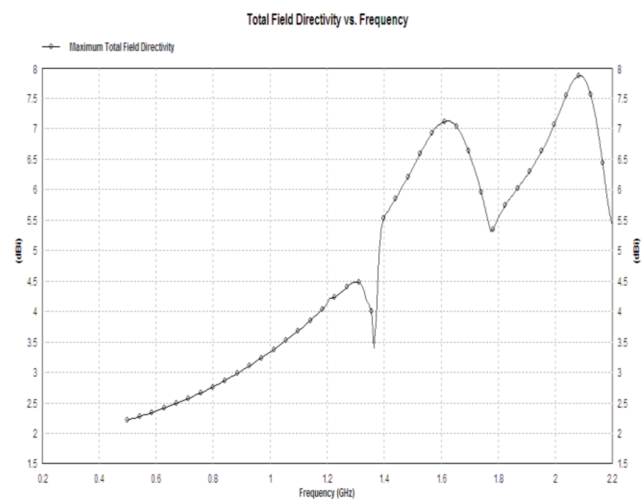


Fig.5: Total Field Gain Vs Frequency

D. *Total Directivity*

The directivity for the propose design is 4.01at 1.15GHz.The simulated result is shown in Fig.6. The range of



Directivity is 4-8 dBi in between 1.45 - 2.2 GHz.

Fig.6: Total directivity Vs Frequency

E. *Antenna Efficiency*

The simulated result of the C-Patch antenna efficiency is shown in Fig.7 .The measured Antenna Efficiency is 81% at 1.15 GHz.

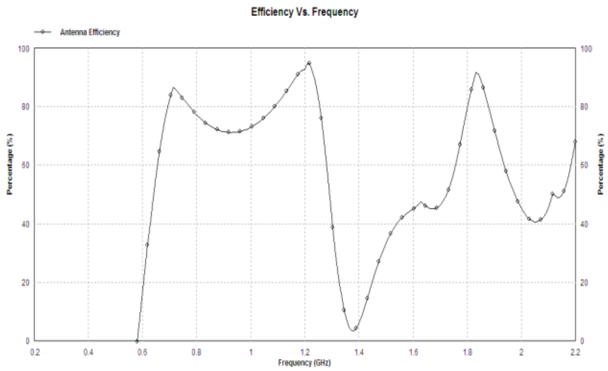


Fig.7: Antenna Efficiency Vs Frequency

F. Radiation Efficiency

It is the very important performance parameter of antenna specification. Radiation Efficiency result is shown in Fig.8. Radiation Efficiency is 83% at 1.15 GHz.

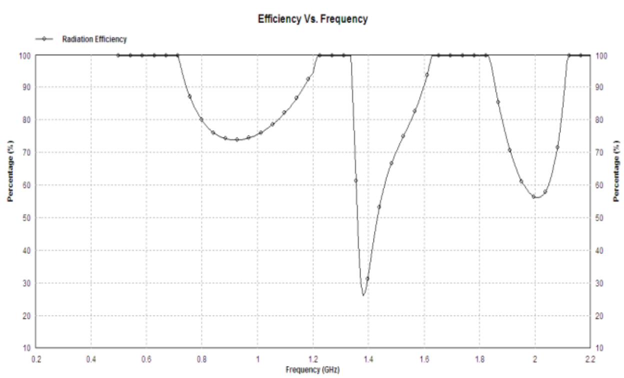


Fig.8: RadiationEfficiency Vs Frequency

G. Current Distribution

The current distribution for the designed slot is shown in Fig.9.

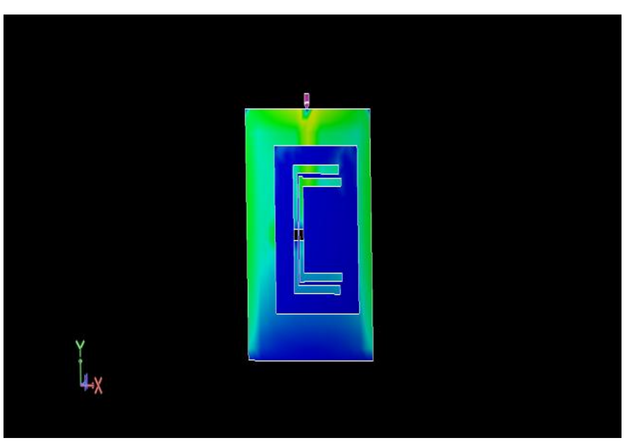


Fig.9: Current Distribution

H. Radiation Pattern

Radiation pattern describes the efficiency of antenna.. For proposed structure the radiation pattern shown in Fig.10 .

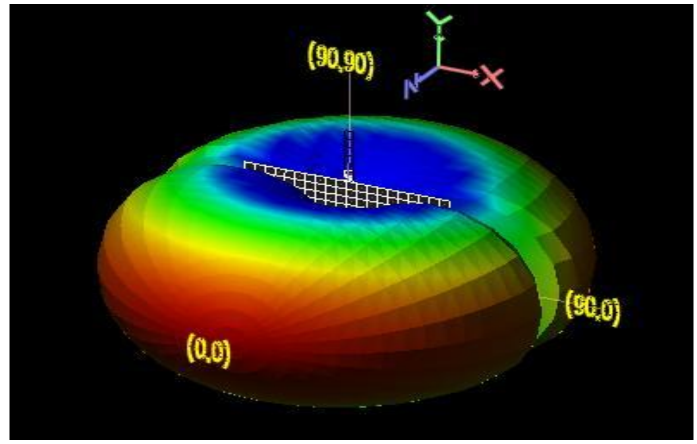


Fig.10: Radiation Pattern

4. CONCLUSION

In This paper we proposed a single feed circularly polarized dual band antenna with a small frequency ratio .In C-slot patch design the lower band width is 44.91 % and also a suitable small axial ratio is 0.14.The main interesting point in this simulated design is Return Loss which is -30.2dB.Total field directivity is 4-8 dBi.from the simulated result this C-Slot Shape is very much appropriate for designing the antenna array to achieve high performance for the GPS applications.

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