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Tri Band CP Slot Antenna Backed with Dual FSS Reflector

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Abstract: A tri band, Multi layer circularly Polarized (CP) slot antenna backed with dual frequency Selective surface with incremental feed-line is designed and fabricated. The design consists of two crescent shaped slots with incremental feed line and two reflectors. The half moon shaped structure employs circular polarization with beam tiled problem can be overcome by dual slot structure backed with FSS, a high gain is obtained. The measured results offer an 11.84 %(4.21 GHz–4.74 GHz), 11.83 %(5.9-6.7 GHz), 5.9 %(7.9-8.4 GHz) CP bandwidth. By introducing the dual FSS reflector, 11.1 dBi of peak gain is also obtained at 6 GHz which is greatly enhanced when compared with the antenna without FSS. A high gain is obtained with simple structure for CP bandwidth is simulated and measured.

Keywords:Frequency selective surface (FSS), Crescent shapes, Circularly Polarized (CP).

I. INTRODUCTION

As day by day the technology is advancing to have latest wireless communication systems which require CP antennas in recent years. weather radars require CP rather than Linear polarized antennas. CP receiving antennas have an excellent performance over linearly polarized (LP) structures in cellular, radio and in climate radar. Because of low cost and easy fabrication one side fed antennas are widely used for wireless communication. To generate CP for single-encouraged receiving wires, the structure has to undergo perturbations which were done in [1, 2]. To get wide bandwidth and narrow CP bandwidth patch antennas is used.

Different planar structures of simple profile, less weight, broadband bandwidth, simple impedance matching and good radiation efficiency printed CP antennas are utilized in various applications, [3-5]. In any case, the CP antenna structures are largely bidirectional and have constrained use. CP antennas of Unidirectional are normally required for long distance and point-to-point correspondence framework. To accomplish directional patterns in one way, a supported cavity [6] or reflector [7] can more often be presented. But, the CP of unidirectional of space radio antennas with backed cavity or reflector can reduce the AR and impedance Bandwidth. It in turn will affect the system performance for wideband applications.

Lately, intermittent structures, for example, In [8–11] electromagnetic band gap (EBG), artificial magnetic conductor (AMC) and high-impedance surface (HIS) are being utilized as a reflector to enhance the gain as well as bandwidth. In [8], an EBG reflector with circular antenna was. In spite of the fact that the impedance bandwidth and AR are improved significantly, the 3 dB AR BW was just 17%. But, inserting a via of EBG structure is a tough task as cost of fabrication will increase in turn, to overcome the above periodic antennas without keeping via is required for fabrication. Though, reflector type AMC or HIS are introduced to increase the performance of an antenna.. In [9], the HIS reflector is used to increase the unidirectional radiation pattern in addition to acquire wide impedance bandwidth and also great AR. Both AMC and HIS plane are same, which is used as a wall to reflect the EM waves which will improve antenna performance [10, 11]. The antenna performances in [8– 11] aren extraordinarily upgraded, but the BW is less than 50% in which it cannot be used for some broadband. Another self symmetry structure, such as frequency selective surfaces (FSSs) isused in addition shown to improve the characteristics LP antenna [12, 13].However, FSS was utilized likewise as a reflector in coplanar waveguide-sustained CP antenna [14].However, the radiation patterns of the antenna backed with FSS CP, where beam tilted problem is more lead to heavy problem in the entire band leads to pattern stability. Finally an antenna with good pattern stability with high gain and wide band with circular polarization is required.

In this paper, two half moon shaped slots with incremental feed line are incorporated to achieve circular polarization with high gain and multiband. The geometry of the slot antenna is shown in Fig.1 .It is fabricated and simulated on (FR4) dielectric substrate (ε_r=4.4 and $\tan\delta$=0.02).The size of the antenna is $65 \times 70 \times 15$ mm^3.Here two slots are etched on a ground plane and two FSS reflectors are used to increase the gain by 11.1dBi.

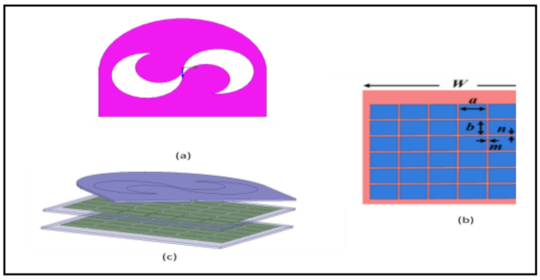

Fig.1. Geometry of the proposed antenna (a)Top View (b) reflector array (c) 3D-view m = 0.7, n = 0.9, a = 10, b = 8; unit: millimeters.

The paper is described as follows. Section II describes the operating principle and structure description and results. Section III describes the comparative analysis of the proposed structure with the previous designs. Section IV includes conclusion and future scope.

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II. STRUCTURE DESCRIPTION, OPERATING PRINCIPLE

Single slot antennas even though achieve CP radiation and broadbandwidth has drawbacks and limitaions and in practical usage.In Single slot antenna as frequency is increased the beam is tilted at the peak in *xoz* and mainly in *yoz* planes,this is because of asymmetric slots shape of crescent type.In order to overcome the beam tilted problem at the peak we will go for Dual slot Anenna backed with FSS.

The single slot image is created and rotataed at 180 degress in phase generating dual slot.by adjusting the feed line properly multiband CP radiation is achieved in our structure.In previous work dual slot have radiated in wideband of incremental feed of L shape[15]. But to achieve multi band in C-band range some notches are created at different bands to operte the struture in some Satelite Communication range.

A. Description of the Structure

The substrate used is FR4 eproxy of 4.4 with loss tagent of 0.02 with thick ness of 1.58 mm.the crescent shaped slot is obtained by subtracting smaller circle from the larger circle and their dimensions are shown in table.1.The feed is a L shaped incremetal length to match impedance of 50 ohms.The FSS reflector designed is made up of 6*6 array of metal sheets with dimensions a,b,n,m shown in the figure.1.

Table-I: Dimensions of the Proposed Structure.

Dimensions of the structure	In mm	Dimensions of the structure	In mm
L	65	h	1
d_3	2.5	W	70
W_f_3	1	R_1	15
L_f_2	11	S	7.4
d_f	30	R_2	10
L_f_1	12	R_3	15
d_2	3.5	Offset_circle_x	0.1
W_f_2	1.3	R_4	10
d_1	5.7	h_fss	14
W_f	2.6		

B. Integration of antenna with FSS

Even though single slot anteanna are unidirection which is used for long distance communications such as point to point ,to reduce the backside radiation and to increase the gain of the struture a reflector is kept below the slot structure.The designed structure is a dual slot antenna radiated bi directional and circularly polarized .To increase the gain and reduce the wastage of power in back side an array of 6*6 mettalic plate is introdued to completely reflect the power in forward direction thus increasing the overall gain of the Antenna fabricated setup shown in fig.2(a,b).

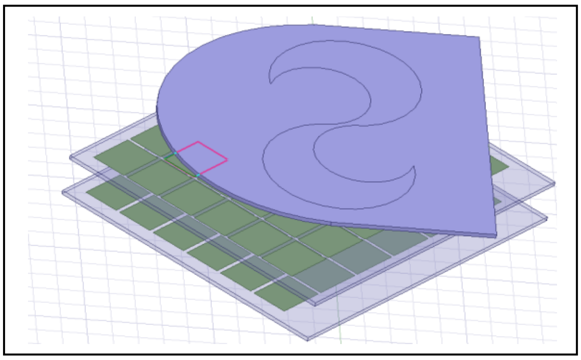

Fig.2.Antenna with Integration Over Dual FSS in sumulation.

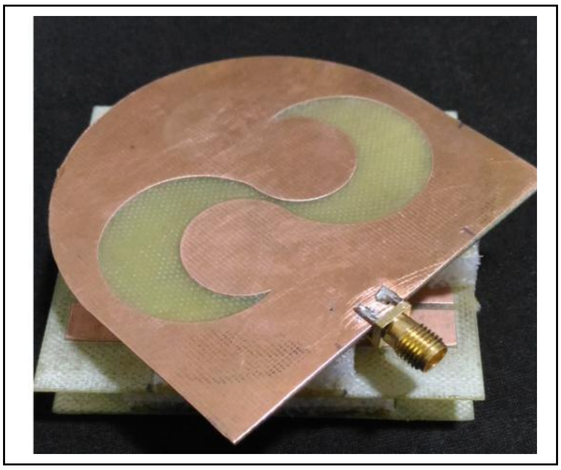

Fig.3.Fabricated Antenna with Integration Over Dual FSS.

C.Design Principle of FSS Surface

By introducing the FSS below dual slot antenna the gain and bandwidth is improved.the operation includes as first the waves from the backside of the structure incident on FSS relector and reflects back towards the forward direction in phase as like Perfect magnetic conductor.Thus reflected and radiated contributes to higher gain.But to achieve circular polariztion the forward and reflected waves should have 90 degress phase difference it is achieved by proper choice of FSS dimensions to acieve CP band width.

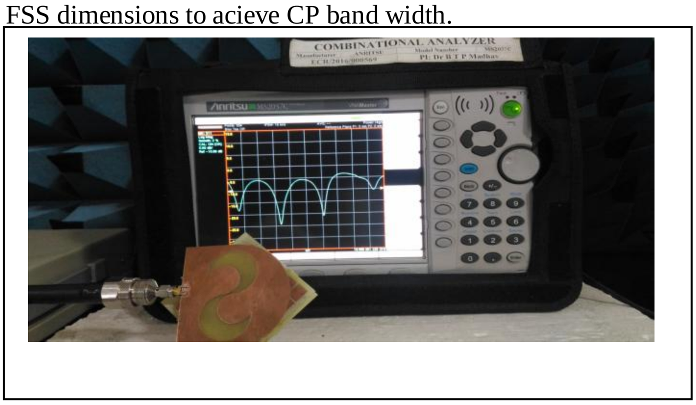

Fig.4. Fabricated Setup and Simulation Using CA.

D. Results

The Simulated and fabricated structures results almost close to each other with tri band resonating at 4.4 GHz, 5.5 GHz and 8.2 GHz shown in Fig.4. The bandwidths are 534 MHz at resonant frequency of 4.4 GHZ, 750 MHz at resonant frequency of 5.5 GHZ and 494 MHz at resonant frequency of 8.2 GHz. But the 10 dB fractional Bandwidths are 11.84%, 11.83%, 5.9% respectively.

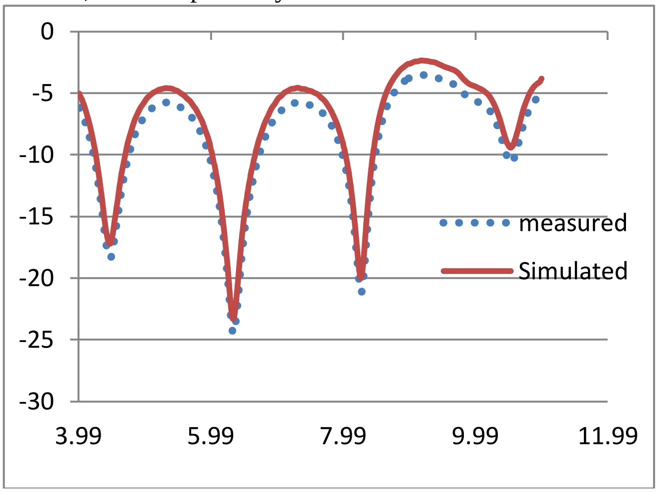

Fig.5. Simulated Results of S11

The main advantage of this structure is enhancement in gain of 11.5dB at 6.0 GHz due to dual FSS shown in Fig.5.

FREQUENCY	GAIN
4	4.44
4.5	4.32
5	6.8
5.5	7.6
6	11.3
6.5	9.25
7	8.11
7.5	7.2
8	4.9
8.5	4.84
9	4.94
9.5	4.68
10	3.9

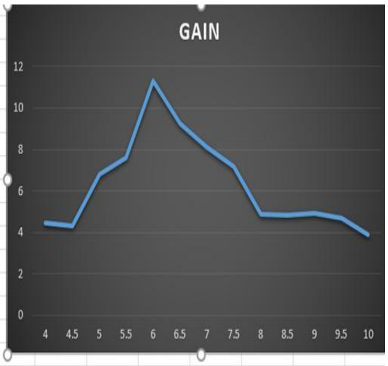

Fig.6. Gain at 6GHz and at different frequencies.

The Axial Ratios at different frequencies between 3 to 10 GHZ show in fig.6. But at around 3.8 to 4.19 GHz it is crossing above 3dB at remaining frequencies it is radiating in circular polarization.

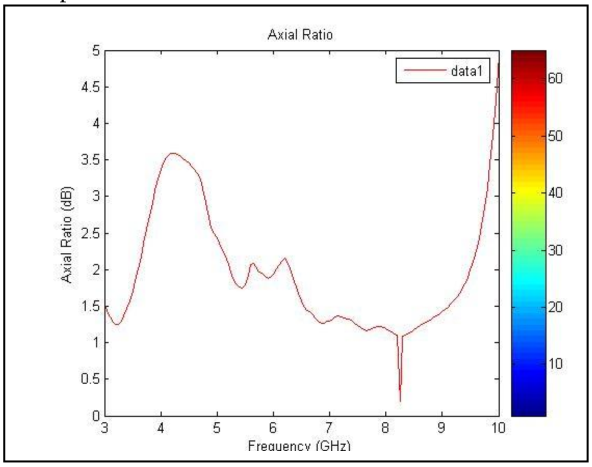

Fig.7.Axial Ratios at Different Frequencies.

When coming to the point of radiation patterns at three resonating frequencies beam tilted problem is reduced as shown in fig.7.

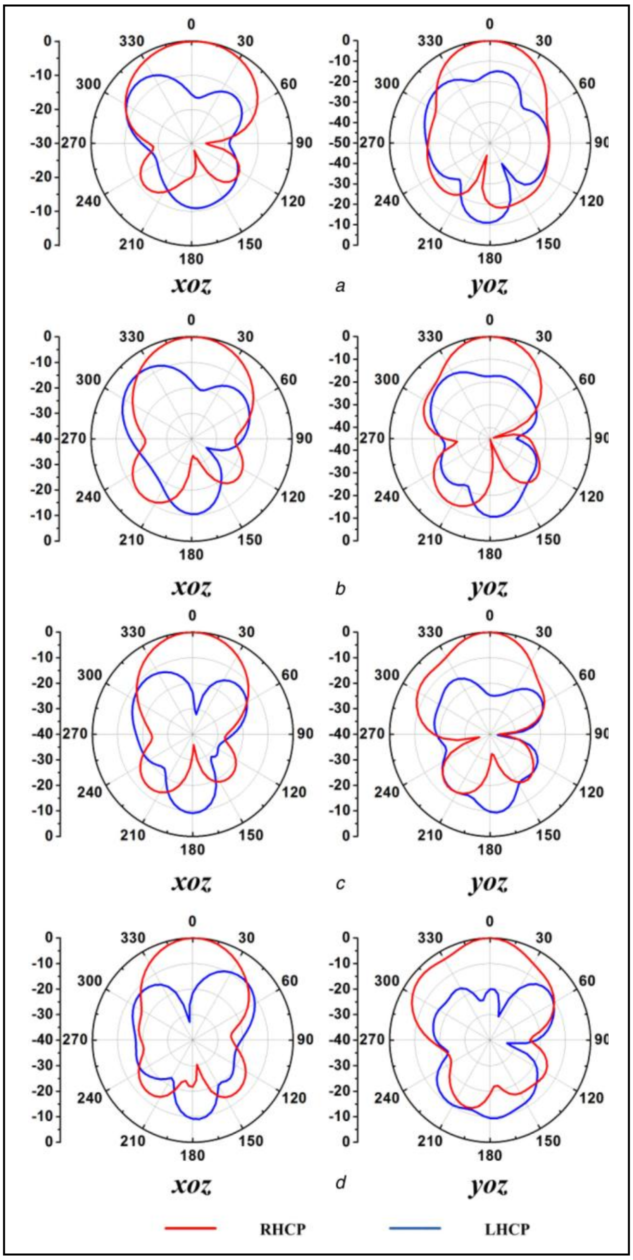

Fig.8. Radiation patterns measured in two principal planes at **(a)** 4.4 GHz, **(b)** 5.5 GHz, **(c)** 6.3 GHz, **(d)** 8.2 GHz.

III. COMPARATIVE ANALYSIS

With references to many structures of different reflectors the proposed design is having highest gain of 11.1 dB, but the fractional bandwidth is more in compare with HIS reflector, pattern stability is good in compare with EBG, AMC, and FSS. The Axial ratio bandwidth is high among all the reflectors and the area is almost close to the remaining references.

Table-II: Comparative Analysis

Ref	Type of Reflector	10 dBi S_{11}%	3 dB AR BW,%	Gain (dB)	Pattern stability	Antenna size, mm^3
[6]	Cavity	20	22	9	good	62×36 × 12
[7]	PEC	57	34.4	7.6	good	100×100×57
[8]	EBG	27.5	17	8.2	bad	40×40× 6.6
[9]	HIS	3.2	3.1	8	good	150×150× 18
[10]	AMC	36.2	33.2	6.9	bad	30× 36× 9.5
[14]	FSS	109	55.7	7.3	bad	110×110× 20
[15] Present Work	FSS Dual FSS	84.6	56 68	10 11.1	good good	65×70 × 16 65 ×70 × 14

IV. CONCLUSION

A multiband band slot antenna of CP backed with dual FSS reflector has been proposed. The beam-tilted problem using dual slot crescent-shaped design. Introducing dual slot with dual FSS reflector can improve CP performance as well as gain. The impedance bandwidth measured is of 10 dB can quite less because of narrow band; The 3dB axial Ratio bandwidth is 68.04%.The peak gain measured is of 11.1 dBi at 6 GHz. The antenna having FSS are useful for CP application over the 4.8–9.75 GHz with band notches at different frequency spectrum in vehicular radar and ground infiltrating radar where high increase execution and UW data transmission are requested.

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