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ANALYSIS OF TRIBAND CIRCULARLY POLARIZED ANTENNA WITH DIFFERENT FSS

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Abstract

In this paper, a triband circularly polarized (CP) microstip patch antenna is placed over a metamaterial structure known as Frequency Selective Structure (FSS) at a certain height. The FSS provides improved bandwidth and axial ratio to the triband CP antenna. When FSS with 6*6 square metallic patches are used, we obtain four frequency bands (2.4/5.3/5.8)GHz for WLAN and 3.5GHz WiMAX applications. The FSS structure designed using 6*6 circular patches was simulated to obtain ultra wide band frequency(UWB). The results are analyzed and compared with the result of triband antenna and improvement in bandwidths and axial ratio is observed.

Index Terms—Circular polarization ,microstrip patch antenna, frequency selective structure, ultra wide band frequency, axial ratio, bandwidth, radiation pattern.

I INTRODUCTION

The multi-functional antennas have become more essential for next generation communication system along with the ongoing development of various wireless applications .The most commonly used wireless applications are wireless local area network (WLAN: 2.4–2.484, 5.15–5.25, 5.25–5.35, 5.47–5.725 and 5.725–5.850 GHz) and Worldwide Interoperability for Microwave Access (WiMAX : 2.5–2.69, 3.40–3.69 and 5.25–5.85 GHz).Several countries around the world has already used both technologies to provide high speed network and internet connections .The circularly polarized antennas are used in modern wireless communication system due to their distinct advantages over linearly polarized antennas. Hence nowadays a single antenna with multi band CP characteristics has attained great attention.

Circularly polarized antennas are widely used in wireless communication systems due to advantages of immunity to polarization mismatch and resilience to multipath fading. Furthermore, in a single-layer patch employing four slots and truncated corners was used to excite dual frequency dual-sense circular polarization. However, emerging multimode systems such as wireless fidelity (WiFi) and worldwide interoperability for microwave access (WiMAX) demand circularly polarized antennas operating over more than two bands, which are widely disparate. However, some multiband antennas have been reported, such as where a linearly polarized monopole with a modified ground plane achieves triple-band operation at 2.3 GHz/3.5 GHz/5.5 GHz. But there are few reports of triple-band circularly polarized antennas with wide frequency ratios using low-profile planar structures.

Nowadays, metamaterial structures have been applied to antennas to enhance their CP radiation characteristics. In CP radiation from a patch antenna was improved by the use of a reactive impedance surface (RIS) layer. In other reports, metasurface (MS) structures were used to convert LP signals into CP signals. In previos work a quad-band CP antenna for 2.4/5.3/5.8 GHz WLAN and 3.5 GHz WiMAX applications is presented To the best of the authors' knowledge, no antenna has ever achieved quad-band CP characteristics for WLAN and/or WiMAX applications so far. So in this work quad band CP characteristic is achieved by using FSS structure and comparative study is made by introducing different frequency selective structure(FSS).

II ANTENNA DESIGN

This section describes the design process of the proposed antenna in three steps. First, a triple-band CP patch antenna similar to that in [7] is designed on a Taconic RF-5 substrate with thickness of 1.52 mm, a dielectric constant of 2.2 and a loss tangent of 0.0009. Next, a metallic FSS unit cell is implemented by investigating the reflection phase characteristics at the 5.3 GHz WLAN band. Finally, the patch antenna is suspended at a height of H above the FSS composed of 36 unit cells in a 6 × 6 layout on a Taconic RF-35 substrate with thickness of 1.52 mm, a dielectric constant of 3.5 and a loss tangent of 0.0018. The horizontal distance between the bottom edges of the antenna substrate and the FSS substrate is L. Fig. 1 shows the geometry of the antenna with the final optimized dimensions.

A. Triple-band CP patch antenna

The overall view of the triple-band CP patch antenna. The final optimized geometry was obtained through simulations with the software Ansoft HFSS 14 as reported in . Three CP modes operating at the 2.4/3.5/5.8 GHz frequency bands were achieved using an inverted-U- shaped radiator with additional I-shaped and

L-shaped strips, all rotated by 45^0around the horizontal axis. The simulated reflection coefficient (S11) and the axial ratio (AR).

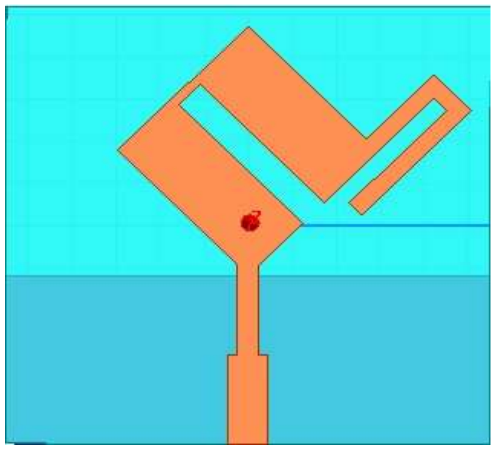

Fig 1. Triple band CP antenna

B. FSS unit cell

An important parameter in the investigation of the FSS as well as other metamaterial structures is the resonant frequency. The resonant frequency of the FSS is defined as the frequency at which the reflection phase is equal to 0o, and the bandwidth of the FSS is defined for the reflection phase between $+90^o$ and $–90^o$. To determine the reflection phase of the FSS, a FSS unit cell was optimized by placing one cell in the computational domain of HFSS. The sizes of the square metal patch and the square unit cell are denoted by a and b respectively. A waveport exciting the propagating plane wave was placed at 28.3 mm above the FSS, approximately one-half wavelength at the resonant frequency of 5.3 GHz, and de-embedded on the FSS. The desired operating frequency band was tuned between the PEC (reflection phase of 180°) and the PMC (reflection phase of 0°). After optimization, a and b were determined to be 19.6 mm and 22.2 mm respectively.

The reflection phase of the unit cell lies between +90^{o} and –90^{o} in the frequency range of 5.25–5.35 GHz, with a resonant frequency of 5.3 GHz.

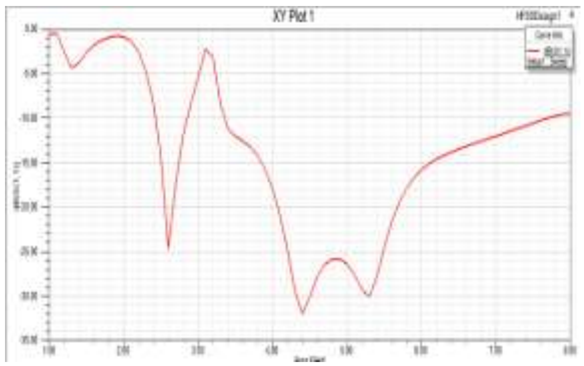

Fig 2.Reflection coefficient of triband cp antenna

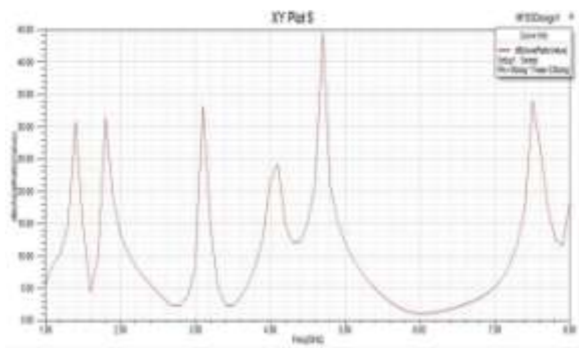

Fig 2(b). Axial ratio of triband cp antenna

C. Triple-band CP patch antenna on FSS

The triple-band CP patch antenna was first placed at a distance of 28.3 mm above the center of the FSS, and antenna characteristics for different number of unit cells were studied. As a result, a FSS structure consisting of 6 × 6 metal patches periodical along the x- and y-axis was determined to give the best results. Finally, the dimensions of the FSS and the position of the antenna relative to the FSS were further optimized to provide the best quad-band CP characteristics at the intended frequencies of 2.4/3.5/5.3/5.8 GHz. The final optimized values are shown in Fig. 1(a) and 1(b). The total size of the FSS is 133.2 × 133.2 mm2. Parametric studies are provided in Fig. 3 to Fig. 6 to investigate the effect of the design parameters on the antenna characteristics. Fig. 3 shows the influence of a, the size of the square metal patch, on the CP bands. It is observed that the reflection coefficients change only slightly, while the CP characteristics change significantly. It affects both the resonant frequency and the CP frequencies of the two upper bands near 5.3 GHz and 5.8 GHz without affecting the antenna performance at 2.4 GHz and 3.5 GHz. As a is increased, both upper CP bands tend to shift to the lower frequency region. The size of the square unit cell, b, also shows similar influence on the CP bands. The effect of the array size is investigated in,showing the best quad-band CP radiation using the 6 × 6 cell configuration. The influence of H, the vertical position of the antenna above the FSS, is investigated in Fig. 5. Large changes are observed in both the reflection coefficient and the AR characteristics. Increasing or decreasing H causes shifting of the CP bands to unintended frequencies and reduction of both the impedance and the AR bandwidth. Finally, the effect of L, the horizontal position of the antenna relative to the FSS, is investigated in Fig. 6, showing large influence on the AR characteristics at 2.4, 5.3 and 5.8 GHz. To visualize the CP operation of the antenna, the current distribution on the triple-band CP patch antenna with and without the FSS are simulated in at 5.3 GHz for t = 0 and t = T/4, where T is the period. When the antenna is placed in free space, the vector sum of the major current components at t = 0 (Jsum1) is orthogonal to

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that at t = T/4 (Jsum2), but the magnitude of Jsum1 is greater than that of Jsum2.Therefore Thus CP mode can be achieved.

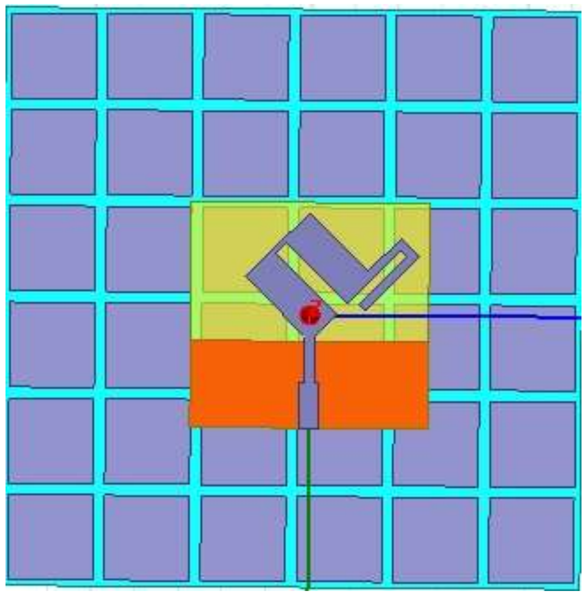

Fig.3(a) Quad band CP antenna with FSS structure.

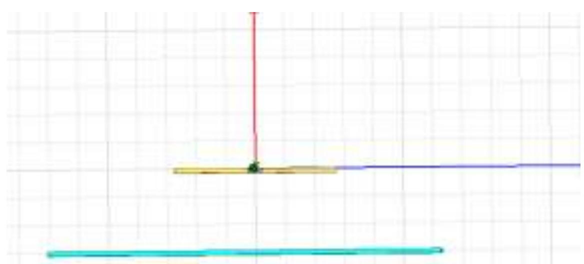

Fig.3(b)side view

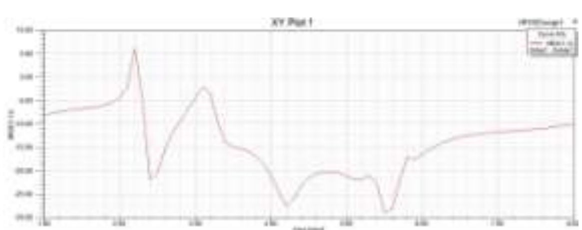

Fig.3(c) Reflection coefficient

The circular polarization can be justified,when its axial ratio is less than 3dB.If its greater than 3dB it comes under linear polarization.

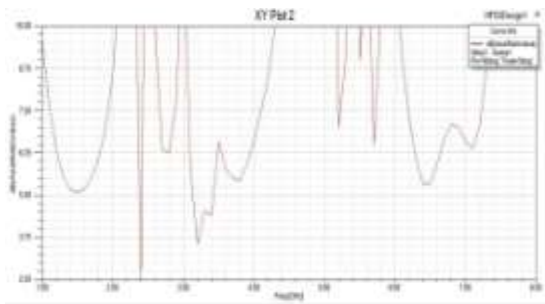

Fig.3(d) Axial ratio

D. Triband CP antenna over FSS consisting of circular patches

In previous work a quad-band CP antenna for 2.4/5.3/5.8 GHz WLAN and 3.5 GHz WiMAX application but here we are using circular metallic patches inorder to make comparative study between square and circular metallic patches from the simulated results the radius of each unit cell is 9.8mm.

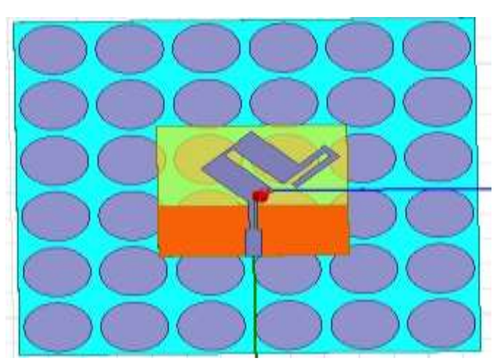

Fig.4(a).Triband over FSS consisting of 6*6 circular patches.

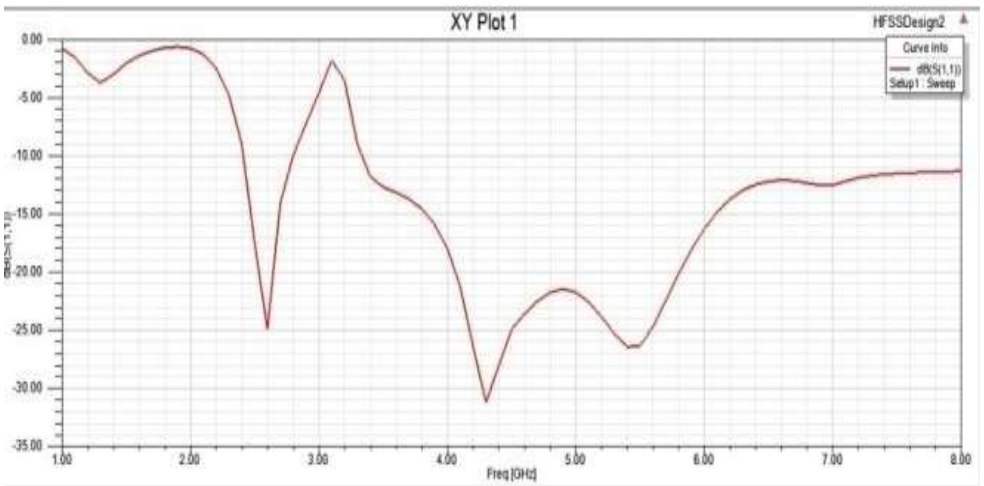

Fig.4(b) Reflection coefficient

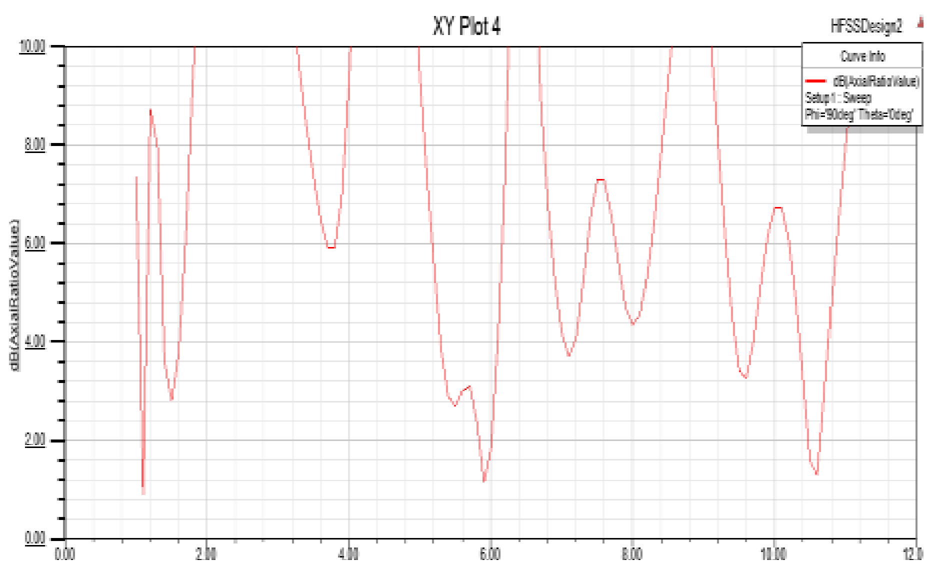

Fig.4(c) Axial ratio

III SIMULATION RESULTS

A comparative study is made based on their frequency selective surface. In this paper two types of FSS is used for quad band inorder to analyze the best result among them based on their simulated output.

Both the 6*6 metallic square and circular patches covers ultra wide band (UWB).The FSS is placed, to obtain improved bandwidth and axial ratio under circular polarization.

IV CONCLUSION

Thus for each FSS structure the bands may vary and sometimes the type of polarization also changes. Finally here the FSS consisting of circular patches covers ultra wide band application and the antenna used here behaves as a circularly polarized antenna when compared to previous researches. By using 6*6 circular patches, circular polarization is achieved and it supports ultra wide band applications such as cable television, medical imaging.

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