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Design And Study of The Effect of Stub At The Tip Of Simple, Stacked Triangular Patch With And Without Air Gap

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Abstract *- The design of three antennas of triangular microstrip patch with a stub at the tip for circular polarization is presented in this article. These antennas are designed for maximum axial ratio bandwidth, and the whole axial ratio bandwidth lies within the impedance bandwidth. The axial ratio bandwidth of the proposed three antennas is 1.43% for 1st, 1.48% for 2nd, and 2.22% for 3rd antenna structure. The return loss bandwidths of the three proposed antenna structures are achieved as 5.6% for the first, 5% for the second, and 5% for the third antenna structure. The realized gain, efficiency, and radiation patterns were also studied. A detailed study of all three antenna structures is given in this paper.*

Keywords — *Triangular patch antenna, Stub, Circularly polarization, Probe feed, and parasitic elements.*

I. INTRODUCTION

In satellite communication systems application, circular polarization plays a vital role because of its insensitive to the transmitter and receiver orientation [1-10]. Polarization diversity is used to mitigate the detrimental fading loss caused by multipath effects [10-15]. Circular polarization modulation is used as a modulation scheme in microwave tagging systems [16]. Antennas with switchable polarization have become the focus of research. To obtain the polarization diversity function between left and right-hand circular polarization (LHCP/RHCP), varactor diodes and PIN diodes are used. This technique is useful for wideband antennas [17-27].

II. DESIGN CONFIGURATION

A. First antenna structure

The geometry of a single-layer patch for circular polarization is shown in Figure 1. The resonant frequency is 2.305 GHz. Stub in the patch is used to improve the axial ratio of the antenna, and the band of operation shifts to the lower side because the effective electrical length increased.

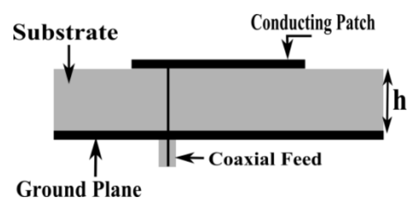


Fig.1.a Side view of 1st antenna structure.

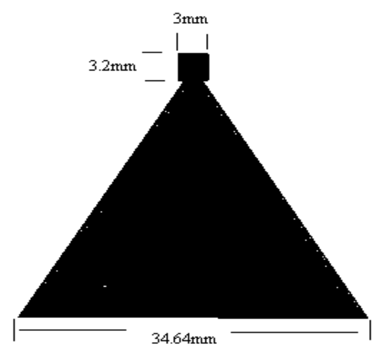


Fig.1.b Top view of 1st antenna structure.

B. Second antenna structure

In this, the structure contains two patches stacked vertically with no air gap. The side length of feed patch with stub is 34.64 mm and stub of length 2.2mm & width of 3mm as shown in Figure 2b. The side length of the parasitic patch with stub is 33.77mm and stub length of 3.1mm & width of 2.9mm, as shown in Figure 2c. The center frequency of the antenna is 2.185GHz with reduced return loss bandwidth.

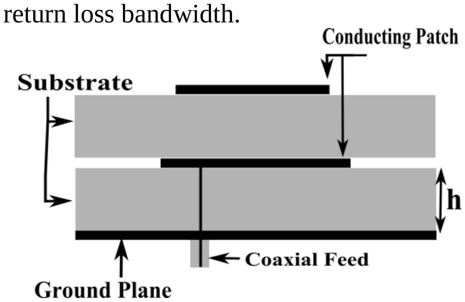


Fig.2.a Side view of 2nd antenna structure.

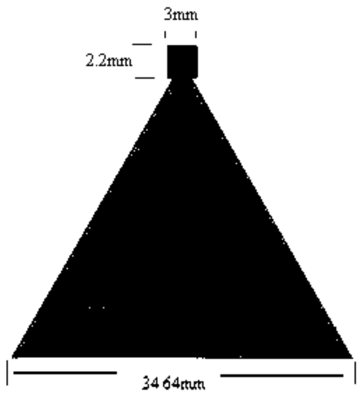


Fig.2.b Top view of the driven patch.

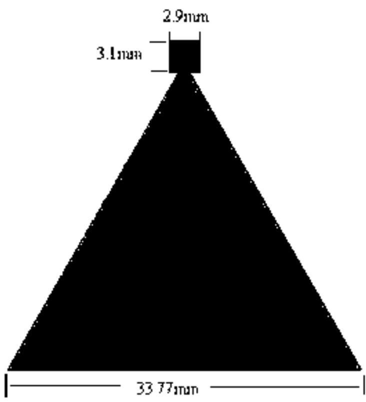


Fig.2.c Top view of the parasitic patch.

C. Third antenna structure

The side view of the third antenna structure with an air gap is shown in Figure 3a. The resonant frequency is 2.325GHz. The air gap between the driven patch and parasitic patch has been taken 0.78 mm. It is observed that resonant frequency can be tuned by adjusting the air gap. The combination of air-gap thickness, feed position, stub length, and width is optimized for best impedance matching.

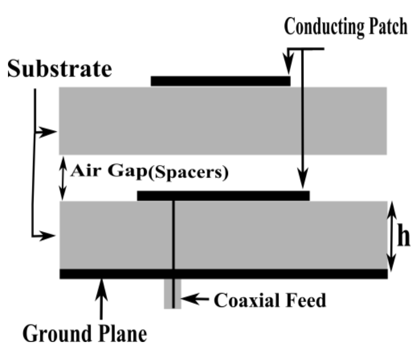


Fig.3.a Side view of 3rd antenna structure.

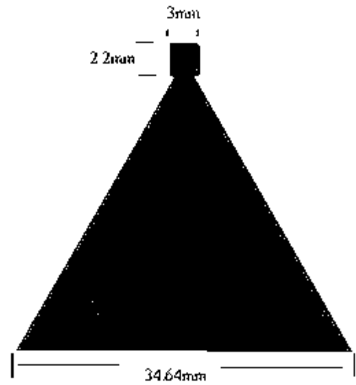


Fig.3.b Top view of the driven patch.

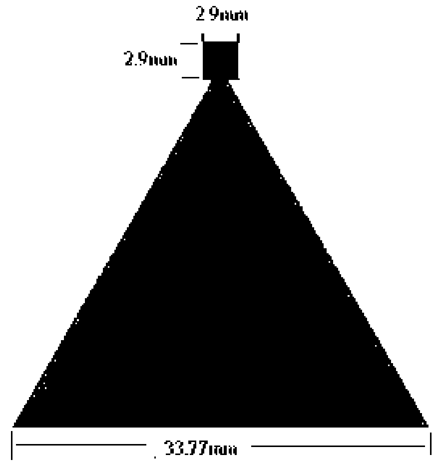


Fig.3.c Top view of the parasitic patch.

III. RESULT AND DISCUSSION

All three designs have the same impedance bandwidth and central frequency shifts towards the lower frequency side for the second structure in comparison to the simple patch antenna, as shown in Figure 4. The optimized dimensions and performance of all three antenna structures are summarized in Tables -1 & 2.

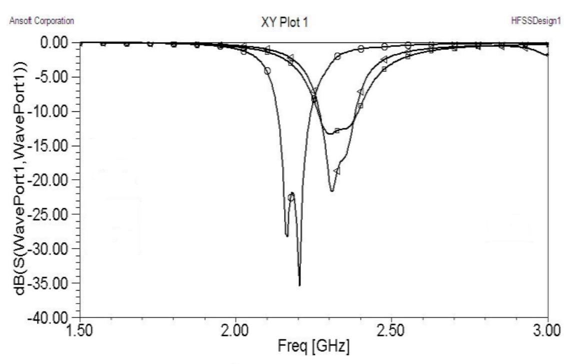


Fig.4 Simulated return loss(dB) of all antenna Structures

S No	Types of patch	Side Length(mm)	Stub Length & Width (mm)	Resonant freq. fo(GHz)
1	Simple Patch	Feeding Patch-34.64mm	Feeding Patch-3.2mm &3mm	2.305GHz
2	Dual Patch	Feeding Patch-34.64mm Parasitic Patch-33.77mm	Feeding Patch-2.2mm & 3mm Parasitic Patch-3.1mm & 2.9mm	2.185GHz
3	Dual Patch with Air Gap	Feeding Patch-34.64mm Parasitic Patch-33.77mm	Feeding Patch-2.2mm & 3mm Parasitic Patch-2.9mm & 2.9mm	2.325GHz

Table 1; Optimum dimension & resonant frequency of simple triangular microstrip patch, stacked without & with the airgap.

S No	Return Loss Bandwidth (MHz)	Axial Ratio Bandwidth (MHz)	Average Gain(dB)	Efficiency η (%)
1	130.4MHz	33MHz	2.34dB	34.15%
2	108MHz	32.38MHz	3.3dB	41.26%
3	116.3MHz	51.5MHz	4.66dB	53.23%

Table 2;shows Returnloss bandwidth(MHz), Axial Ratio bandwidth(MHz), Average Gain(dB) & Efficiency(%)

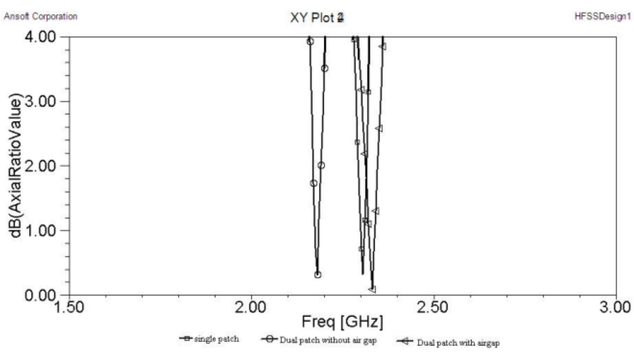


Fig. 5. Simulated axial Ratio(AR) bandwidth of simple, dual patchs with and without airgap.

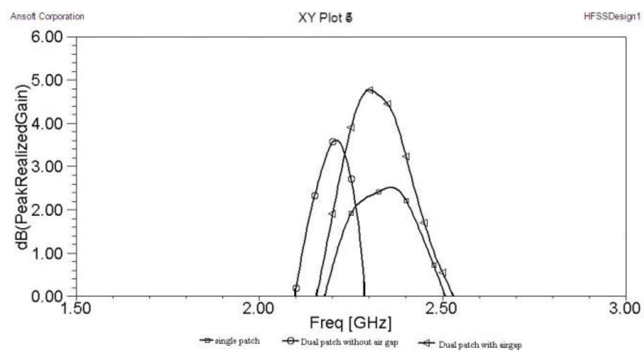


Fig. 6. Simulated average gain(dB) of simple, dual patchs with and without airgap.

The axial ratio bandwidth is highest for the third antenna structure, as shown in figure 5. The peak realized gain for all three antenna structures also shown in Figure 6. The radiation efficiency is also shown in Figure 7. The radiation patterns of the simple triangular patch with stub are simulated in E-plane and H-plane at frequency 2.305 GHz. The simulated radiation pattern is shown in Figure 8.a. It is observed that the half-power beamwidth in E-plane is better than in H-plane. Second, the back lobe in E-plane seems to be more than H-plane. The radiation patterns of the triangular patch with the parasitic triangular patch are simulated in E-plane and H-plane at frequency 2.185GHz. The simulated radiation pattern is shown in Figure 8.b. It is observed that the half-power beamwidth in E-plane is better than in H-plane. Second, the back lobe in E-plane seems to be more than H-plane.

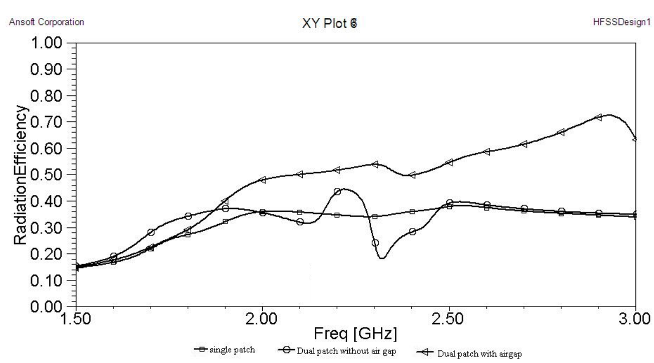
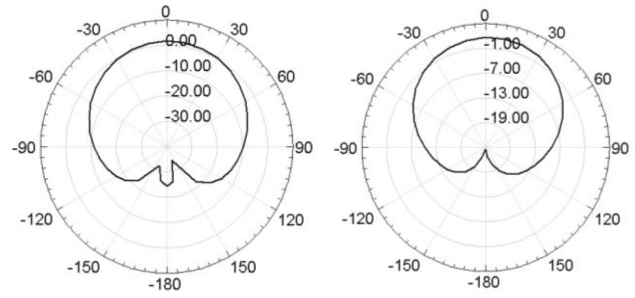
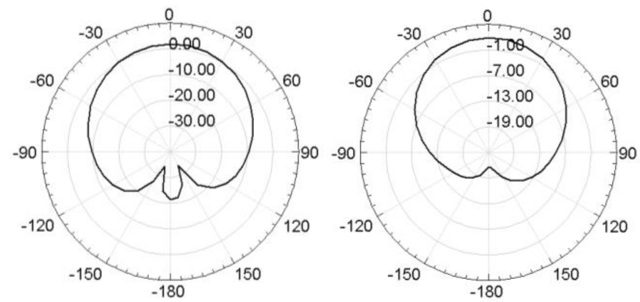


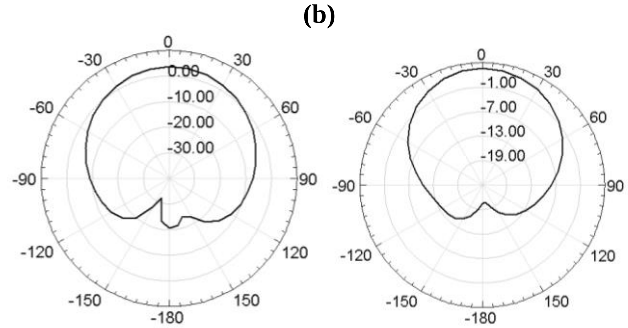
Fig. 7. The simulated radiation efficiency of simple, dual patchs with and without air gap.



(a)



(b)



(c)

Fig.8. Simulated radiation patterns in E and H-plane of (a) Simple triangular patch with the stub, (b) Stacked patch without air gap, and (c) Stacked patch with an air gap.

But half-power beamwidth and back lobe are slightly more in comparison to simple truncated tip triangular patch. The radiation patterns of the triangular patch with a parasitic triangular patch with an air-gap of 0.78 mm are simulated in E-plane and H-plane at frequency 3.59 GHz. The simulated radiation pattern is shown in Figure 8.c. It is observed that the half-power beamwidth in E-plane is better than in H-plane. Second, the back lobe in E-plane seems to be more than H-plane.

IV. CONCLUSION

In this paper, a comparative study of three antenna structures is presented. The simple triangular patch antenna with stub is vertically stacked with a parasitic patch with & without air gap. All designed & analyzed with respect to the bandwidth, axial ratio, circular polarization, average gain & efficiency. The impedance bandwidth of a multilayer triangular patch is achieved almost the same as a simple triangular patch with stub & with parasitic element without air gap. It is observed the design of antenna for circular polarization, stacked with spaced is offer the better performance in term of Bandwidth, purity of circular polarization and average gain & efficiency. These antennae are simple in structure and easy to fabricate, and easily integrated with MIC/MMIC systems. These antennas can be used for the wireless communication system.

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