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Modified Star Patch Antenna with Enhanced Bandwidth

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Abstract: A new wideband and small size star shaped patch antenna fed capacitively by a small diamond shape patch is proposed. To enhance the impedance bandwidth, posts are incorporated under the patch antenna. HFSS high frequency simulator is employed to analyze the proposed antenna and simulated results on the return loss, the E- and H-plane radiation patterns and Gain of the proposed antenna are presented at various frequencies.The antenna is able to achieve in the range of 4-8.8 GHz an impedance bandwidth of 81% for return loss of less than -10 dB.

Key words: Bandwidth enhancement, star patch

INTRODUCTION

Conventional microstrip antennas in general have a conducting patch printed on a grounded microwave substrate, and have the attractive features of low profile, lightweight, easy fabrication, and conformability to mounting hosts. However, microstrip antennas inherently have a narrow bandwidth and bandwidth enhancement is usually demanded for practical applications. In addition, applications in present-day mobile communication systems usually require smaller antenna size in order to meet the miniaturization requirements of mobile units. Thus, bandwidth enhancement and size reduction are becoming major design considerations for practical applications of microstrip antennas (Wong, 2002). Many techniques such as meandered ground plane (Kuo and Wong, 2001), slot-loading (Eldek *et al*., 2004, Ang and Chung, 2007), stacked shorted patch (Waterhouse, 1999), feed modification (Ge *et al*., 2004), chip loading (Wong and Lin, 1998) and teardrop dipole in an open sleeve structure (Chen *et al*., 2007) have been reported to achieve wideband and to reduce the size of microstrip antennas. In addition, the bandwidth of the patch antenna can be increased by using air substrates (Ayoub, 2003). Another method of increasing the impedance bandwidth of a patch antenna is to use shorting posts between the patch and the ground plane. The performance of such structures depend on parameters such as the number of the posts used, the radius of each post and the height of the posts (the thickness of the substrate) (Mohamed, 1999). In (Mirzapour and Hassani, 2006), a star shaped microstrip patch with corners shaped and fed by a rectangular patch showed a bandwidth of around 63%.

In this study, a wideband microstrip antenna in the shape of a novel star shaped patch loaded with shorting posts and capacitive fed by a small diamond shaped patch is presented. The dimension of the patch and the parameters of the shorting posts are optimized to obtain an ancient design leading to the highest possible impedance bandwidth in the range of 4 to 8.8 GHz, i.e., 81% of the center frequency.

MATERIALS AND METHODS

This study was conducted from November 2009 to January 2010 at SRM University, Chennai, India.

Antenna geometry: Figure 1 shows the process of building the new star shaped patch antenna. The proposed antenna shape is based on a hexagonal patch in which 6 smaller hexagonal are cut from the edges. To increase the bandwidth of the antenna four shorting posts are added under the patch. The antenna is capacitive fed by a diamond shape patch that is connected to a coaxial feed. Figure 2 shows the geometry of the complete antenna.

The star-shaped patch is separated from the ground plane with an air-filled substrate. The specification of the proposed antenna is present in Table 1.

RESULTS AND DISCUSSION

The antenna performance has been investigated through simulation via a Finite Element program, HFSS. The simulated result for the return loss is shown in Fig. 3. Based on a −10 dB return loss, 81% impedance bandwidth (in the frequency range of 4 to 8.8 GHz) is obtained.

It has to be mentioned that various shapes of the feed patch were used (circular, rectangular) but through simulation it was found that the present diamond shape patch gives the best impedance bandwidth result.

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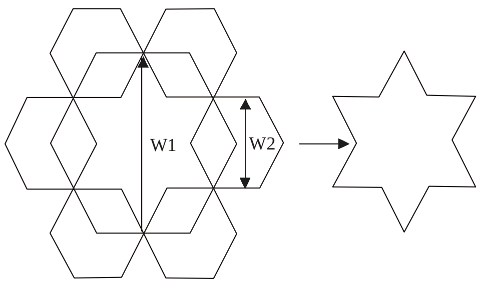


Fig. 1: Process of building the star shaped patch antenna

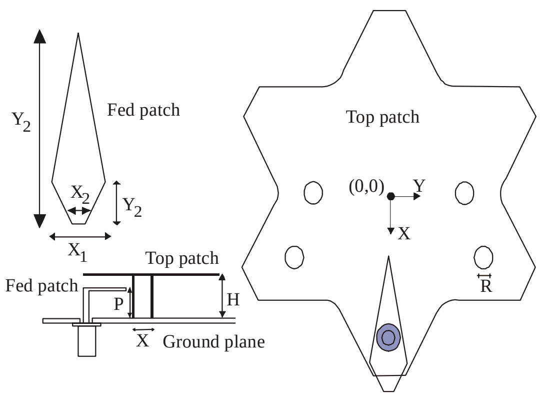


Fig. 2: Geometry of proposed antenna with the diamond shaped feed patch

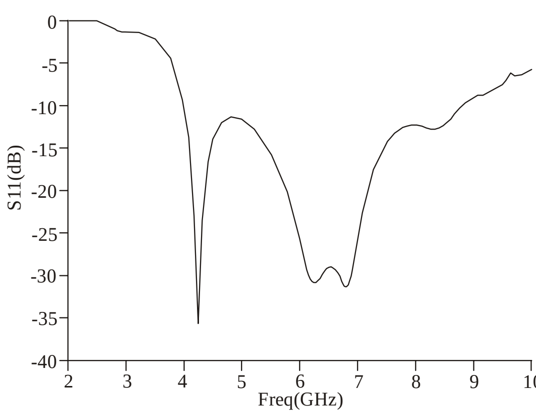


Fig. 3: Return loss of the proposed antenna. $W1 = 22$ mm, $W2 = 11.5$ mm, $P = 5$ mm, $H = 8$ mm, $X = 5.7$ mm, $X1 = 4.5$ mm, $X2 = 2$ mm, $Y1 = 4$ mm, $Y2 = 8$ mm and $R = 1.5$ mm

Table 1: Specification of the proposed antenna in mm

W1	W2	P	H	X	X1	X2	Y1	Y2	R
23.5	11.5	5	8	5.7	4.5	2	4	8	1.5

Through simulation it has been noticed that two of the most important parameters that affects the bandwidth performance of the antenna are $W1$, the star shaped patch

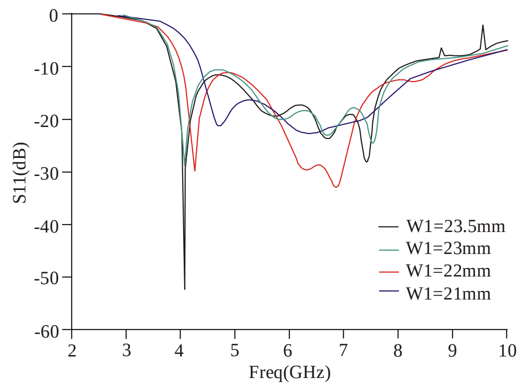


Fig. 4: The Return loss of the antenna for various values of patch diameter, $W1$. $W2 = 11.5$ mm, $P = 5$ mm, $H = 8$ mm, $X = 5.7$ mm, $X1 = 4.5$ mm, $X2 = 2$ mm, $Y1 = 4$ mm, $Y2 = 8$ mm and $R = 1.5$ mm.

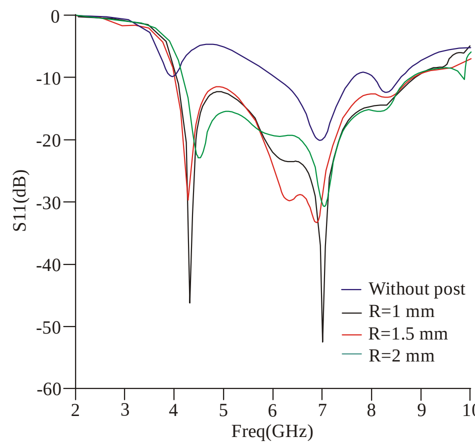


Fig. 5: Return Loss of the antenna for various diameters of the posts. $W1 = 22$ mm, $W2 = 11.5$ mm, $P = 5$ mm, $H = 8$ mm, $X = 5.7$ mm, $X1 = 4.5$ mm, $X2 = 2$ mm, $Y1 = 4$ mm, $Y2 = 8$ mm

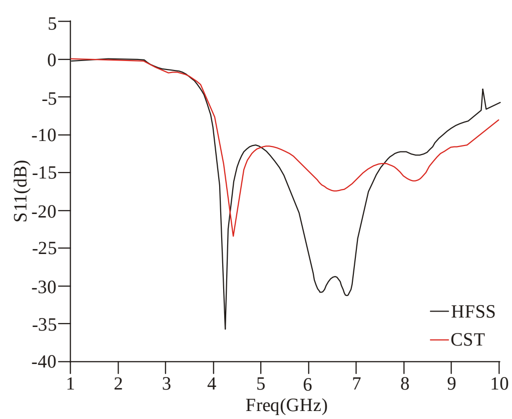
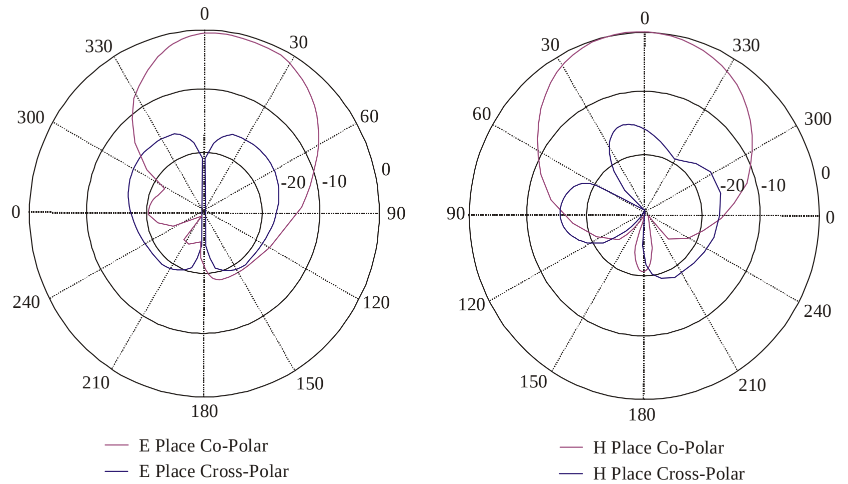
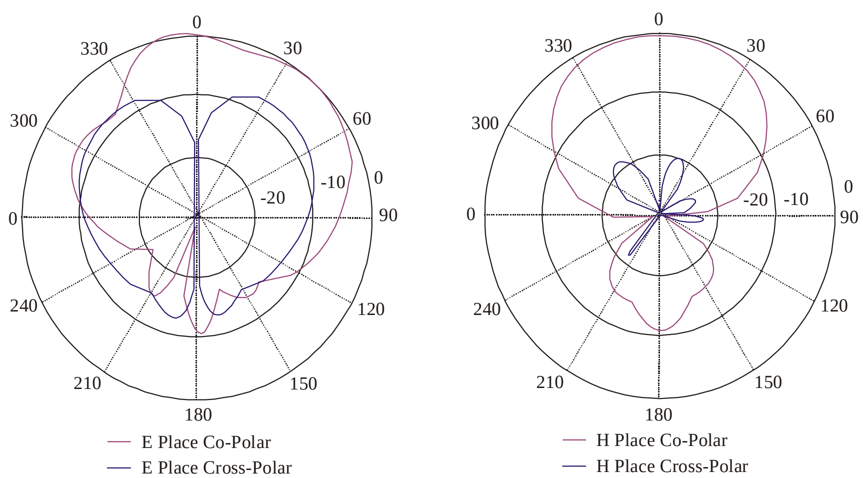


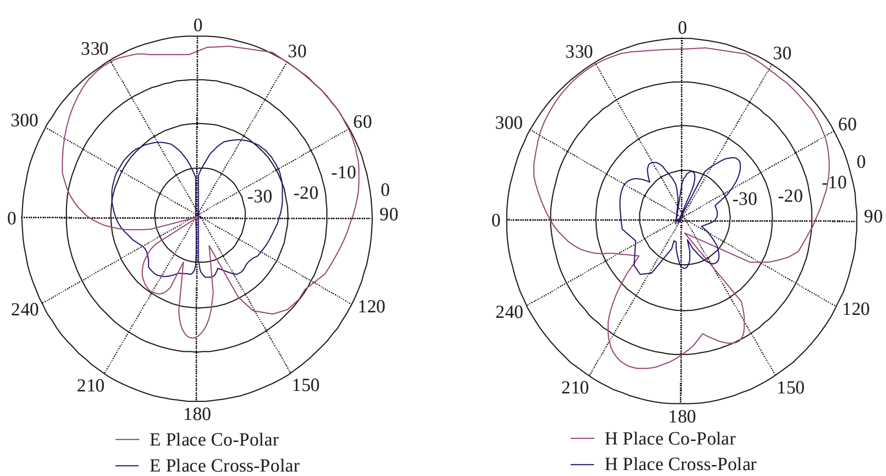
Fig. 6: Comparison of the S11 obtained through HFSS and CST. $W1 = 22$ mm, $W2 = 11.5$ mm, $P = 5$ mm, $H = 8$ mm, $X = 5.7$ mm, $X1 = 4.5$ mm, $X2 = 2$ mm, $Y1 = 4$ mm, $Y2 = 8$ mm and $R = 1.5$ mm



(A)



(B)



(C)

Fig. 7: E and H-plane radiation pattern (a) at 4 GHz, (b) at 6 GHz, (c) at 8 Ghz

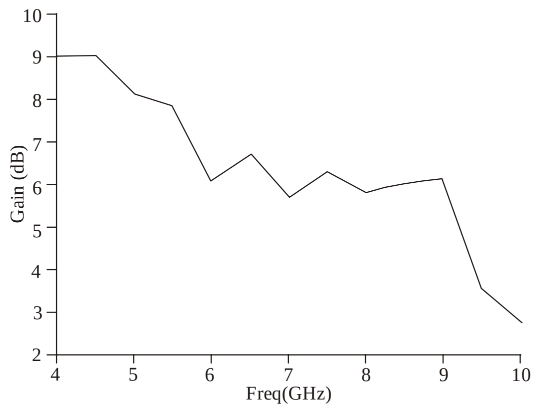


Fig. 8: Gain of the proposed antenna at various frequencies

diameter, and *R*, the diameter of the posts. Small variations on the rest of the parameters of the antenna do not significantly affect the antenna performance. Variation of return loss against slight changes on *W* 1 from 22 to 23 mm is shown in Fig. 4. It is noticed that the highest bandwidth is achievable when *W* 1 is equal to 22 mm leading to 81% impedance bandwidth.

Figure 5 shows the return loss with and without the posts. From this figure it is obvious that without posts, we have 23% of bandwidth. When the posts are added to the structure, the percentage of bandwidth increases. For diameter of the posts, *R*, equal to 1.5 mm. The bandwidth is 81%, while for diameter of 1 mm the bandwidth reduces to 73%. To confirm the simulation results of Fig. 3 where obtained through HFSS method, a second powerful computer package of CST has also been used. Figure 6 shows the comparison of S11 of this antenna with HFSS and CST.

For the structure shown in Fig. 2, the simulation of the radiation pattern over the frequency range of 4 to 8.8 GHz has also been done. Fig. 7 shows the simulated E- and H-plane patterns at 4, 6 and 8 GHz including both Co- and Cross-polarizations. Figure 8 shows the antenna gain over the entire frequency range from 4 to 10 GHz.

CONCLUSION

A novel wideband and small size star-shaped microstrip antenna including simple feed structure is presented. The proposed antenna has a 81% bandwidth over the frequencies 4-8.8 GHz. It has well cross polarization level and uniform H-plane pattern over the wireless communication band. It has more bandwidth and has a smaller surface area than similar designs reported in the literature.

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