A Compact Ultra Wideband Metamaterial Based Octagonal Shape Patch Antenna for Band Notch Performance

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Abstract—*In this paper, a novel configuration of microstrip line fed ultra wideband (UWB) antenna with band notch characteristic and reasonable gain is proposed. The proposed antenna design is an octagonal patch with defected ground plane consisting with complementary split ring resonator (CSRR) which is inserted for rejecting 6.6 GHz (Synchronous Transport Module level-1) and 7.5 GHz (Downlink of X-band satellite communication system). The octagonal patch with defected ground have a -10 dB impedance bandwidth from3.8GHz to 9GHz with the band notch. The dimension of the patch antenna is 25x38x1.6 mm^3 and simulated in Ansoft HFSS with FR4 substrate of ε_r=4.4.*

Keywords*: Ultra wide band (UWB), Metamaterial, Complementary Split Ring Resonator (CSRR), Band notched antenna, HFSS.*

1. INTRODUCTION

Extensive research and development of microstrip patch antenna (MPA) and arrays containing the advantages such as light weight, low volume, low cost, plannar configuration have led to various applications within the broad field of microwave antennas. The primary goal of researchers in the field of designing antennas is to increase the gain and also the impedance bandwidth. Now a day's ultra wideband (UWB) antennas has been continuingly paid a great attention and potential for radio interference by other system that have the UWB bands (3.1-10.6 GHz) or have neighbouring Radio frequency system bands [1-3]. UWB technology has been received attention because of its characteristics such as low cost, extremely high data rates, low complexity, and small size. However the frequency band of UWB range causes interference with other communication system. To minimize the potential interference of different bands it is desired to design an antenna with band notch characteristic.

Recently various potential monopole antennas with a single or more band notch function have been presented where different methods have been used to achieve the band notching [2-6]. Over the last few years electromagnetic metamaterial has drawn considerable attention due to their left handness or negative refractive index. Now various researchers used CSRR as a band notched element in the broadband antenna because it is more suitable to be mounted on the plannar structure than SRR. This CSRR structure provides enough space on the conventional wide band antenna to embed the band rejection elements due to the subwavelength resonant structure of CSRR [5, 7].

In this paper a compact (25x38x1.6 mm^3) and a 50Ω microstrip line feed octagonal shape patch antenna with UWB performance is proposed. Two CSRR are etched on the ground plane to reject the 6.6GHz and 7.5 GHz band with changing the no. of split rings.

2. ANTENNA DESIGN AND SIMULATION RESULTS

The geometry of the octagonal patch shape antenna with microstrip line feed and defected ground is shown in figure1. FR4 substrate with thickness 1.6 mm and ε_r=4.4 is used to design the antenna.

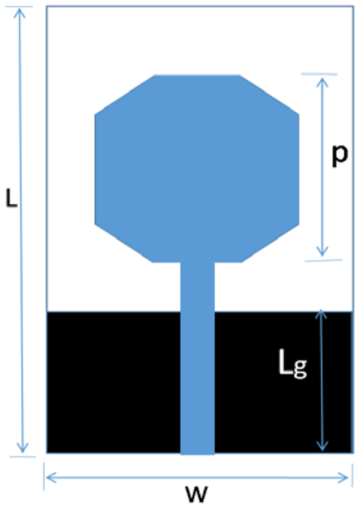


Fig. 1: Geometry of the proposed antenna

The dimension of the patch antenna are L=38mm, W=25mm, with square length of the patch p=15mm and length of the defected ground L_g=15mm.This is an optimal method to obtain an improved bandwidth through the parameters. The proposed antenna design starts with consist of a square rectangular patch and a ground plane gives one resonant frequency of 9.5GHz with bandwidth from 9.3-9.9 GHz. Then an isoscales triangle defect is etched in corners of the square patch and seen that the resonant frequency shifts to lower one to 8.8 GHz with bandwidth from 8.5-9 GHz.

It is worth mentioning that the configuration of the ground plane also affects the characteristics of the antenna. So the proposed antenna design with defected ground plane under 50Ω microstrip feed line is consider to achieve good impedance matching and made the band wider which is operating from 5 GHz to 8.8 GHz.

Fig. 2 shows the simulated return losses of the corresponding patch antenna.

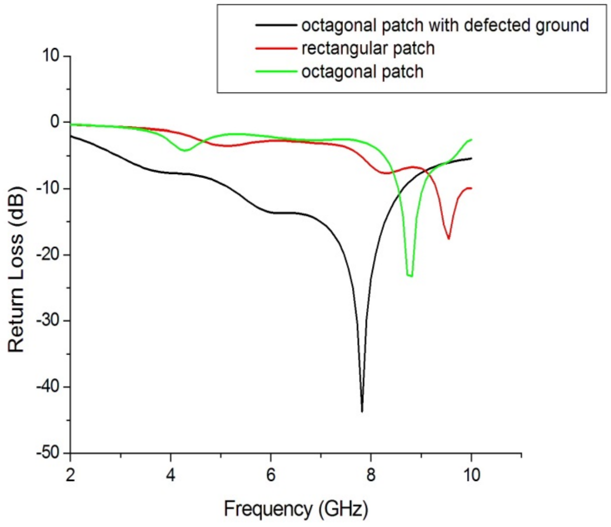
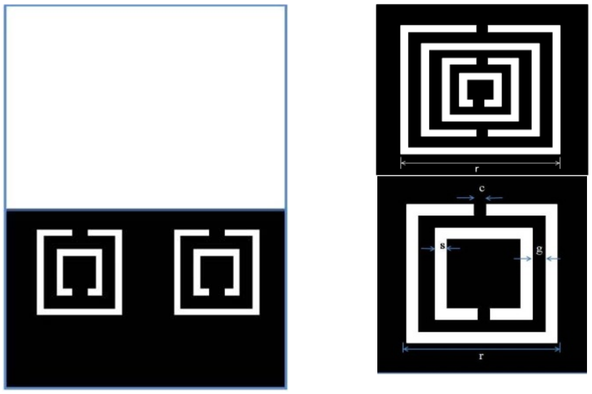


Fig. 2: Return loss of the proposed antenna.



(a) **(b)**

Fig. 3: Back view of the proposed antenna with CSRR and zoomed view of CSRR, for no. of split ring n=2 and n=4

We know that CSRR's are LC resonant elements at microwave range and used as periodic structure of metamaterial. This structure has a LC parallel resonator acts as a band stop filter. Fig. 3.a. shows the prototype back view of the proposed antenna, when CSRR is loaded in the ground plane. The dimension of the CSRR (Fig. 3.b) is r=5mm, c=s=g=0.2mm.

Fig. 4 shows the return losses of the proposed antenna with two different cases. The overall antenna operates in UWB range from 3.8GHz to 9GHz except the notch band.

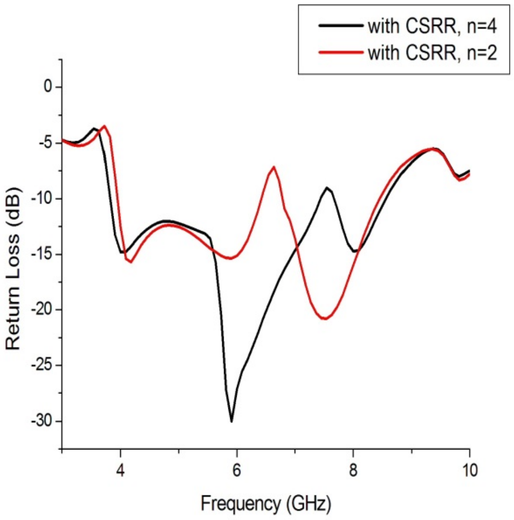


Fig. 4: Simulated return loss of the antenna with CSRR

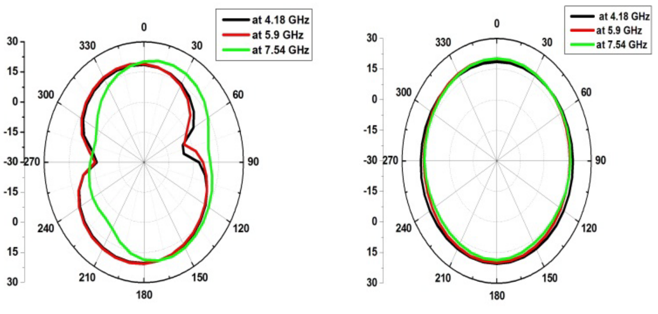
In one case the no. of split rings n=2 and which achieve the band rejection function at 6.6 GHz (6.4 GHz- 6.7 GHz). The second case is for CSRR with no. of split rings n=4 where in this case it achieves band rejection function at 7.5 GHz (7.4 GHz- 7.62 GHz).

Table 1: Comparison of simulated peak gains at the resonant frequency.

Antenna	Resonant frequency	Peak Gain
With CSRR, n=2	4.18 GHz 5.9 GHZ 7.54 GHz	2.8 dBi 3.5 dBi 3.57 dBi
With CSRR, n=4	4 GHz 5.9 GHz 8.09 GHz	2.44 dBi 3.21 dBi 4.22 dBi

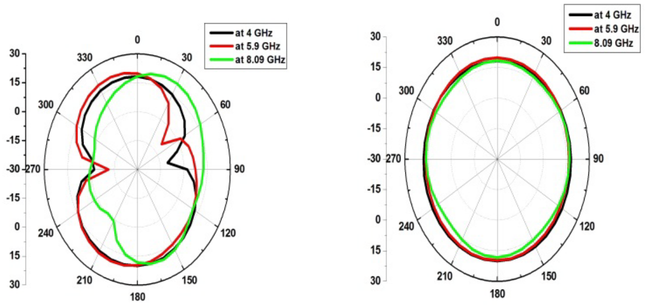
Table 1 shows the simulated peak gain at the three resonant frequencies for both the cases for n=2 and n=4.

The simulated radiation patterns of the antenna for both n=2 and n=4 in the E-plane and H-plane are shown in Fig. 5 and Fig. 6. It is observed that the radiation patterns are almost omnidirectional.



(a) **(b)**

Fig. 5: Radiation patterns for the antenna with n=2 (a) E-plane (yz-plane) (b) H-plane (xz-plane)



(a) **(b)**

Fig. 6: Radiation patterns for the antenna with n=4 (a) E-plane (yz-plane) (b) H-plane (xz-plane)

3. CONCLUSION

In this compact antenna design the CSRR structure has been loaded on the ground plane as a bandstop filter for rejection of the unwanted frequency band such as wireless application of STM link-1 and Downlink of X-band satellite communication system by varying the CSRR’s number of split rings. The simulation results shows that this proposed antenna has band notched function over the UWB operation band in a hostile radio environment caused by various radio interference and with good radiation pattern and gain.

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