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A Uwb Metamaterial Based Patch Antenna For Band Notching And Mimo Application

D. Patir[1],Dipak Kr. Neog[2]
[1]*(Department of Physics, Dibrugarh University, India)*
[2]*(Dhemaji College, Dibrugarh University, India)*
Corresponding Author: D. Patir

Abstract: *In this article a ultra wide band (UWB) octagonal shaped printed patch antenna for Multiple-Input-Multiple-Output (MIMO) system is presented. The proposed octagonal patch antenna with complementary split ring resonator (CSRR) has a -10dB impedance bandwidth from 3.2 GHz to 9.2 GHz with the band notch. The designed antenna rejects the 5 GHz Wi-Fi channels (5.09-5.8) GHz by IEEE 802.11 Wi-Fi/WLAN standards. It is also shown the good MIMO performance of the proposed antenna with various configurations of array is obtained for small element spacing. The dimension of the single element patch antenna is (25×38×1.6) mm^3. The simulated and measured results show the validity of the proposed antenna design.*

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

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I. Introduction

The new generation wireless communication requires broadband and multiband devices for faster data rate with miniaturization of handheld devices. These modules of wireless communication are expected to provide good impedance matching, high gain with good radiation pattern throughout the operating frequencies. The UWB communication system (3.1-10.6 GHz) has paid a great attention and potential in wireless communication world after the Federal Communication Commission (FCC) ruling in Feb 2002. It is due to some inherent advantages such as high speed data rate, small spectral power density, highly secure environment, low cost and remote sensing application [1-3].

In UWB communication range the potential interference with other communication systems is occurred and it is desired to minimized. Therefore various UWB antenna is designed with band notch characteristics to avoid this possibility. For band rejection performance in UWB antennas different design techniques have been proposed and achieve single or more band notch function. Now a day's researchers have attempted to use a metamaterial resonator (SRR or CSRR) to reject the unwanted frequency band. The exciting fact about metamaterial with their properties of left handness or negative refractive index and ability to control and guide the electromagnetic wave propagation has drawn attention over the last few years in antenna design technology. The CSRR which is negative image of SRR are electrically small LC resonant elements used as periodic structure of metamaterial with high quality factor has attention for frequency selective structure designer [3-8]. MIMO technology as next generation wireless service depends on the use of plurality of antenna elements has attracted attention to enhance channel capacity in multipath environment. To achieve high signal capacity antenna elements must be spatially separated in MIMO configuration and mutual coupling should be low and high isolation makes uncorrelated signals among the antenna elements [7, 9-11].

In this article first, the UWB performance from 3.2-9.2 GHz with a single notch band at 5.7 GHz is obtained with microstrip feed octagonal patch and CSRR etched on the ground plane. Second the proposed antenna design with band notch characteristics has been presented for MIMO array with different configurations are analysed and which provides low mutual coupling, envelope correlation and better radiation pattern are given.

I. Antenna Design And Results

The configuration and dimension of the proposed octagonal shape patch UWB antenna design with microstrip line feed is shown in fig. 1.. This proposed antenna is constructed on FR-4 substrate with a thickness of 1.6mm and relative dielectric constant 4.4. The dimension of the patch antenna are L=38mm, W=25mm, with square shape patch p=15mm and length of the defected ground L_g=15mm.

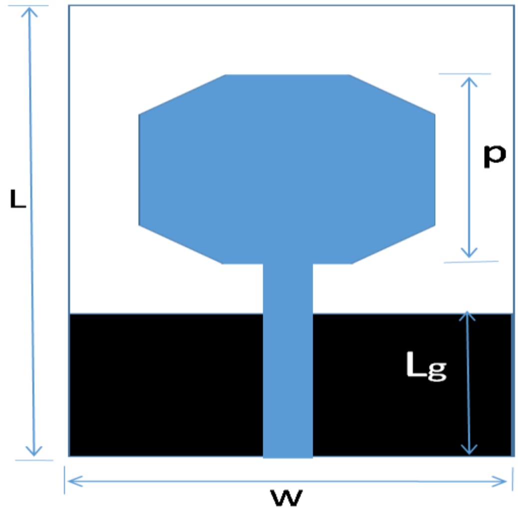


Fig1. Dimension parameters of the metamaterial based patch antenna

The designed antenna is an optimal method to obtain the UWB range through the structure parameters. Initially isoscale triangle defect is etched in corners of a square patch with the defected ground. It is worth mentioning that the characteristics of the antenna are affect with the configuration change of the ground plane. Fig.2 shows the optimal simulation return losses of the proposed patch antenna design with varying the antenna parameters.

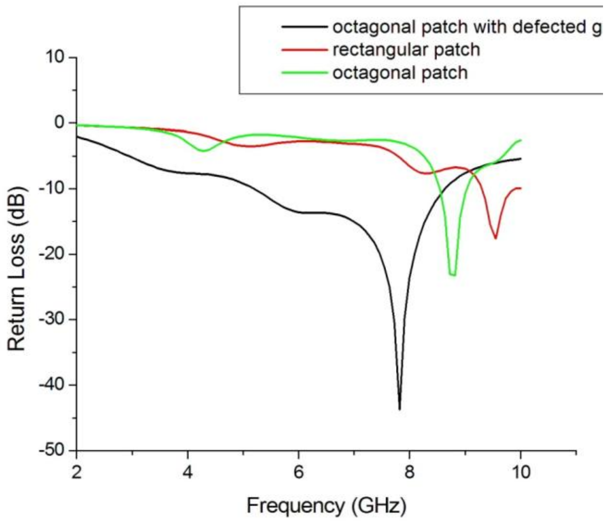


Fig.2 Optimal Reflection coefficient of the proposed antenna

We know that CSRR's are metamaterial LC resonant elements at microwave range. The CSRR periodic metamaterial structure along with a rectangular slot is etched on the ground plane of the microstrip patch antenna to achieve the excellent band rejection performance in UWB range. The proposed antenna design overall operates in UWB range from 3.2 GHz to 9.2 GHz with the single notch band of 5 GHz Wi-Fi channels (5.08-5.8 GHz). Fig. 3 shows the ground plane dimension with the CSRR parameters. The dimension of the CSRR is r=5mm, c=s=g=0.5mm and area of the rectangular slot is 5×3 mm^2.

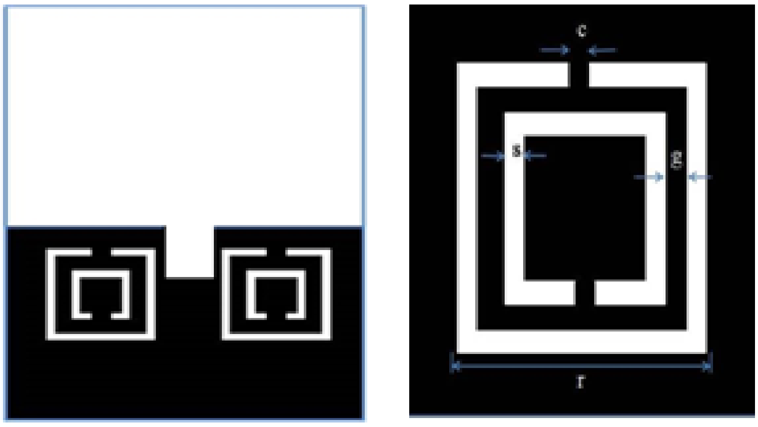


Fig. 3 Back view of the antenna design with CSRR and zoomed view of CSRR

Fig.4 (a) shows the fabricated monopole antenna and Fig 4(b) compares the simulated and measured reflection coefficients where it has been seen that the good matching of both and which validate the design accuracy. The E-plane and H-plane radiation patterns of the antenna design at 3.66, 7 and 8.2 GHz are shown in Fig. 5.

Fig. 4 (a) Fabricated monopole antenna (Front and Back view)

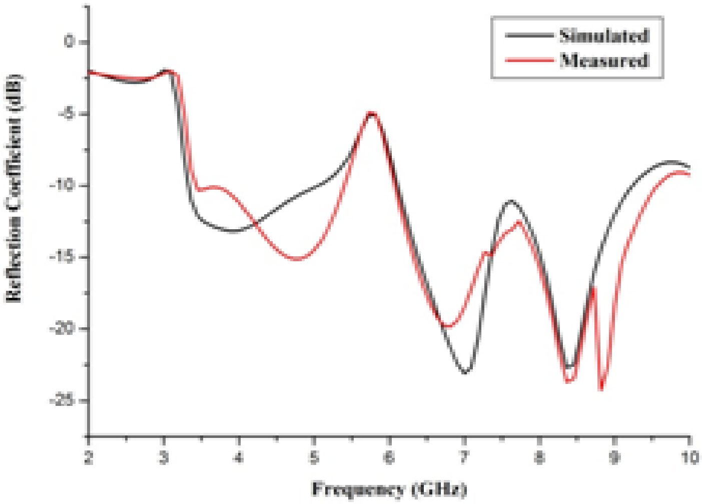
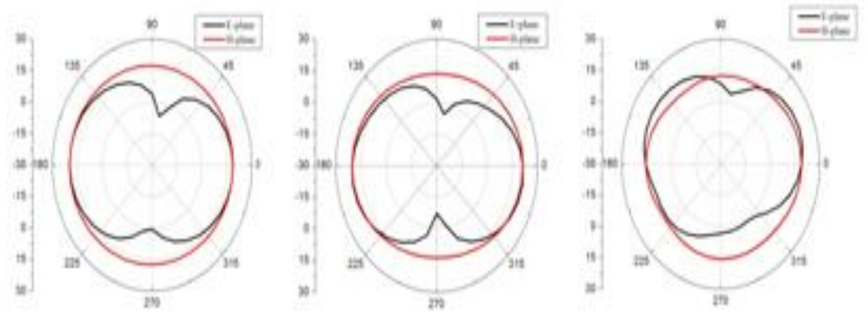


Fig. 4(b) Comparision of the simulated and measured reflection coefficients



(a) (b) (c)

Fig.5 E and H plane radiation patterns at (a) 3.66 GHz (b) 7 GHz (c) 8.2 GHz

II. Antenna Array For Mimo Application

The designed antenna result is suitable for operating from 3.2-9.2 GHz in UWB range with the band notch. This monopole antenna can also be arrayed for MIMO application. The parameters like mutual coupling, envelope correlation and radiation pattern are main dependant factors for the performance of an MIMO antenna array. Due to change in position and polarization of the antenna elements different mutual coupling is occurred. The spacing between antenna array elements in this case is set at 10mm. Fig.6 shows the simulated S-parameters with three different possible configurations. When the antenna elements are placed orthogonal and parallel to each other lower mutual coupling is occurred. Fig. 7(a) shows the fabricated MIMO antenna array and Fig. 7(b) measured S-parameters of that array structure, which shows good agreement with the simulated one.

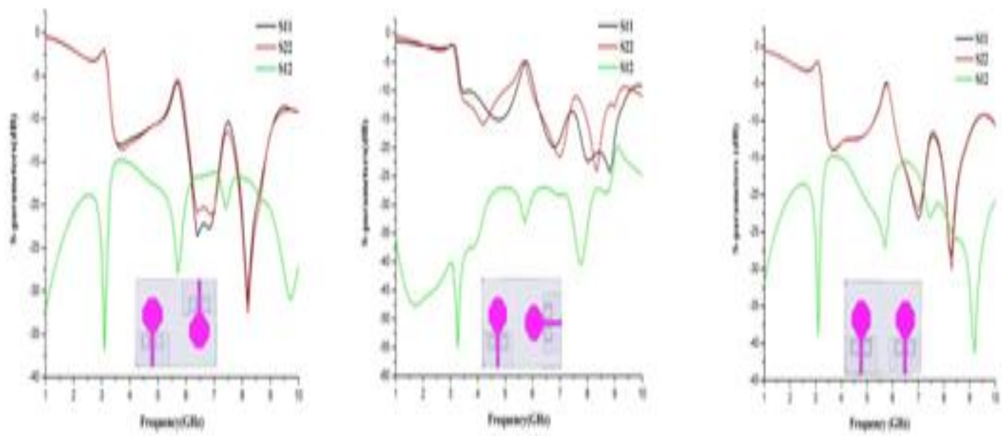


Fig. 6 Simulated S-parameters of the MIMO array Octagonal shaped antenna for different configurations

Fig. 7(a) Fabricated MIMO antenna array

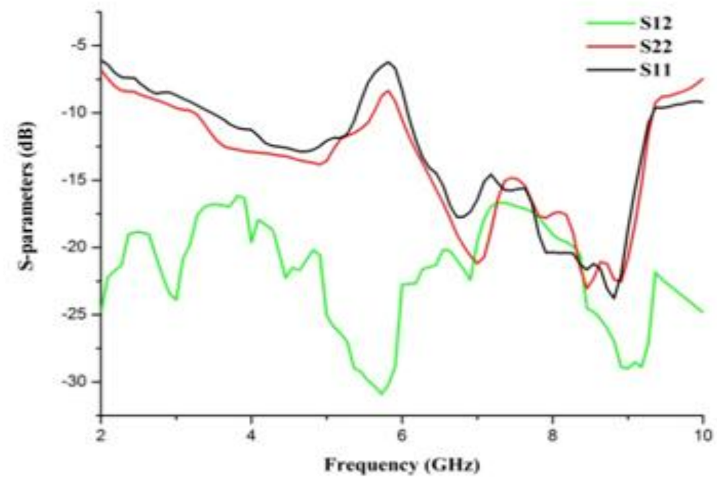


Fig. 7 (b) Measured S-parameters of that array

In order to study the system performance of the proposed antenna structures as MIMO application, the envelope correlation coefficient has been calculated. Under the assumption of uniform multipath environment, the coefficient of a two antenna system can be computed from the S-parameters is given by-

$$\rho_e = \frac{|S_{11}^* S_{21} + S_{12}^* S_{22}|^2}{|(1 - |S_{11}|^2 - |S_{21}|^2)(1 - |S_{22}|^2 - |S_{12}|^2)|}$$

The practically acceptable envelop correlation coefficient for the antenna diversity is less than 0.5. The calculated envelop correlation from the proposed metamaterial inspired antenna array is less than 0.0027. Fig. 8 shows the Envelop correlation for the proposed two element antenna array. The simulated radiation efficiency and peak gain of the proposed antenna array structure is given in Table 1. Although the array structure shown a good omnidirectional radiation pattern similar to the single element which is not shown here.

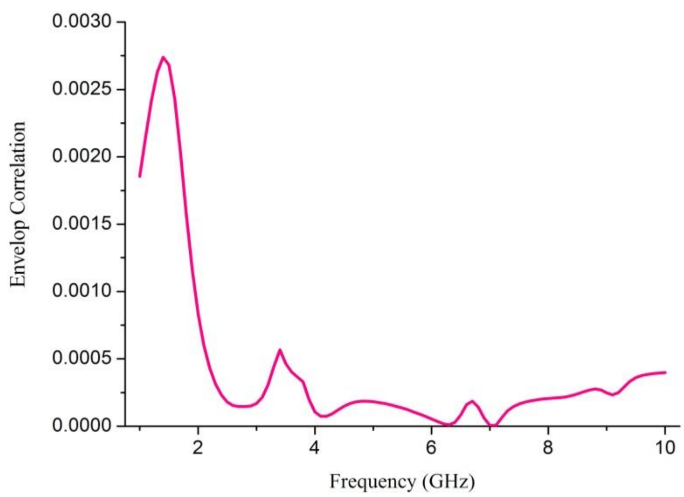


Fig. 8 Calculated envelope correlation for the MIMO array structure

Table 1. Gain and Radiation Efficiency

Frequency (GHz)	3.66 GHz	7 GHz	8.2 GHz
η(%)	88	82	81
Peak gain (dB)	2.7	3.4	4.6

III. Conclusion

A compact and novel octagonal shaped printed metamaterial based antenna with 5GHz Wi-Fi channel (5.09-5.8GHz) band notching performance for UWB application has been presented. The antenna elements are arrayed for MIMO application with various configurations. The proposed MIMO array provides -15 dB mutual coupling, envelope correlation lower than 0.0025, efficiency higher than 80% with better omnidirectional radiation pattern. These performances of MIMO array are achieved at very low element spacing.

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