International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 03, March 2017
www.ijates.com
ijates
ISSN 2348 - 7550

BANDWIDTH-ENHANCED MIMO ANTENNA USING OCTAGON METAMATERIAL STRUCTURE FOR WLAN APPLICATION

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ABSTRACT

In this paper bandwidth enhanced metamaterial Multiple Input Multiple Output (MIMO) antenna is presented, using octagon split ring metamaterial structure. The proposed MIMO antenna consists of four ports rectangular patch and electrically small size 62.8x60x1.6mm3, with inexpensive FR4 substrate of a dielectric constant of 4.4. This work study the uses octagon complementary split ring resonator (OCSRR) loaded on its ground plane and inset slot on the patch antenna. The designed antenna resonate at 5.9GHz frequency and its isolation -17.9dB, with overall bandwidth 416MHz.It supported data rate of 9.071Gbps with maximum envelope correlation coefficient is less than 0.03 and VSWR is 1.31. The result of this small size MIMO antenna system shows a good isolation, bandwidth and high data rate with low envelope correlation coefficient which is promising for WLAN application systems.

Keywords:Wireless Local Area Network (WLAN), Microstrip Antenna, Octagonssplit resonator, MIMO,Metamaterial;

I INTRODUCTION

The rapid changes in the wireless communication technology poses several challenges to academics and industries such as high data rate, small size, high capacity, low correlation coefficients, without degrading the performance and capabilities. Giga bits per second (Gbps) represents a significant increase in the peak rate, which is ten times or more than the 150 Mbps peak rate, currently provided by 4G. Today's 4G networks can support high definition (HD) video and audio, web browsing, social media, and similar services. However, it won’t be long before higher peak rates are required to support 2K/4K video, virtual reality, enhanced reality, telemedicine, and other new services. For example, virtual reality requires 1Gbps to ensure user experience, which can only be available on a 4.5G network [2-4].

Gbps is implemented through MIMO system, and antenna is the largest part of the communication system. To design MIMO antenna by considering miniaturization, mutual coupling reduction and enhanced bandwidth for compact wireless technology. These challenges are answered by introducing metamaterial concept in MIMO antenna design.

The metamaterial is used to enhance the bandwidth, mutual coupling reduction and good isolation of the MIMO antenna without compromising the device performance. This metamaterial structure is having artificially negative permeability and permittivity are generally made by split ring resonator (SRR) is introduced by pandry [6-8]. Hence thismetamaterial structure effectively coupled with MIMO antennas and it allows for mutual coupling reduction bandwidth enhancement with good isolation [9-11].

In this work we proposed novel four element MIMO antennas using octagon split ring resonator metamaterial structure to resonate at 5.9GHz. The smallest edge-to-edge separation of the four symmetrical patch antennas is $\lambda/4$ (where λ is the free space wavelength).The proposed antenna is compact and exhibiting the wide bandwidth of 416MHz with supporting data rate 9.071Gps. The results included scattering parameters, peak gain, VSWR, correlation coefficient and diversity gain to indicate that the proposed MIMO antenna using octagon spit ring resonator metamaterial structure can provide better diversity to increase data rate for WLAN application.

II DESIGN PROCESS

A. Geometry of the octagon split ring resonators (OCSRR)

An attractive properties of metamaterial is that plane wave propagating in the media would there phase velocity antiparallel with group velocity so that media would support backward waves.In this paper we proposed a periodic octagon split ring resonator structure; a unit cell is depicted in figure l.

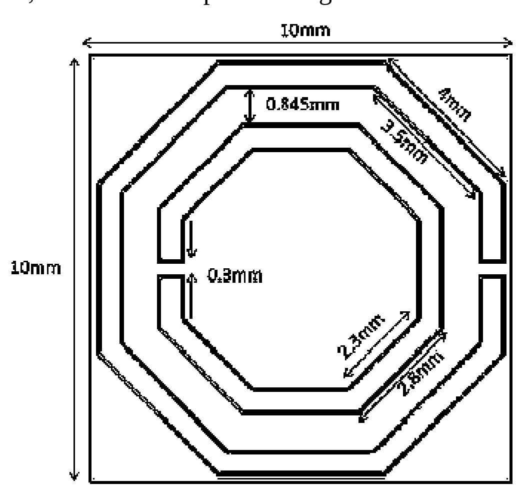

Figure1: The unit cell structure

This metamaterial octagon split ring unit cell is composed of two nested spilt rings, which are etched on a FR4 substrate of a dielectric constant of 4.4. The dimension of the unit cell is shown in table 1.The resonance frequency of this octagon split ring unit cell structure depends on the gap dimension (*g*). By increasing the gap, the capacitance in LC circuit model of the unit cell decreases. The decrement of the capacitance, results the increment of the resonance frequency of the structure.

Parameters	Dimensions(mm)
Length of Substrate *'Ls'*	10
Width of Substrate *'Ws'*	10
Thickness of substrate 't'	1.6
Sides of octagon S1, S2, S3,S4	4, 3.5, 2.8,2.3
Gap 'g'	0.3
Distance between octagon	0.845

Table1: Dimension of unit cell structure

B. MIMO Antenna design

The conventional MIMO antennas consist of a four patch element with FR-4 substrate and its dielectric constant is 4.4. Distance between the four patch antenna element considered as quarter wavelength of the resonating frequency of the simulated conventional MIMO antenna is shown in figure 2 and dimension of the conventional MIMO antenna are depicted in table 2.

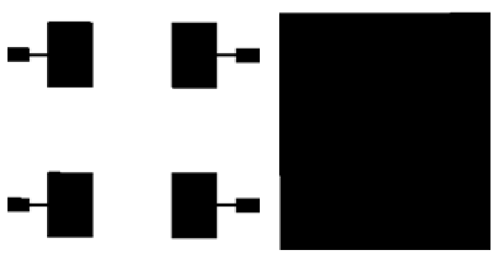

Figure2: Conventional MIMO Antenna top and bottom view

Parameter	Dimensions (mm)
Length of substrate	62.8
Width of substrate	60
Thickness of substrate	1.6
Length of patch	15.25
Width of patch	11,35

Table2: Dimension of conventional MIMO Antenna

Figure 3.a shows the simple patch MIMO antenna with octagon split ring metamaterial structure on ground plane and Figure3.b shows MIMO patch antenna with H shaped octagon split ring metamaterial structure on ground plane and Figure3.c shows MIMO patch antenna with inset slot on the patch and H shaped octagon split ring metamaterial structure on ground plane.

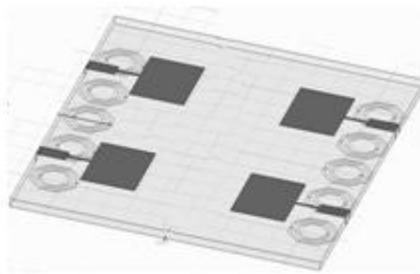

Figure 3.a Simple MIMO antenna with octagon split ring metamaterial structure

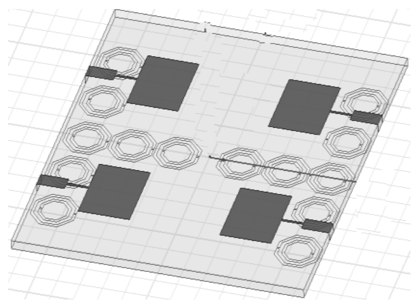

Figure 3.bMIMO antenna with H shape octagon split ring metamaterial structure

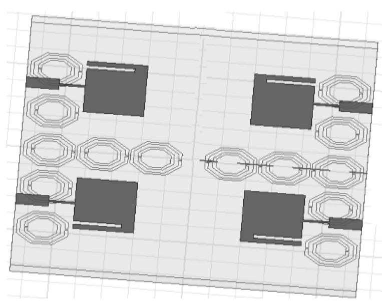

Figure 3.cMIMO antenna with inset slot and H shape octagon split ring metamaterial structure

III RESULTS AND DISCUSSION

A. Reflection Coefficients

The simulated reflection coefficients of conventional MIMO antenna and MIMO antenna with octagon split ring metamaterial are shown in figure 4 and are summarized in table 3.

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www.ijates.com
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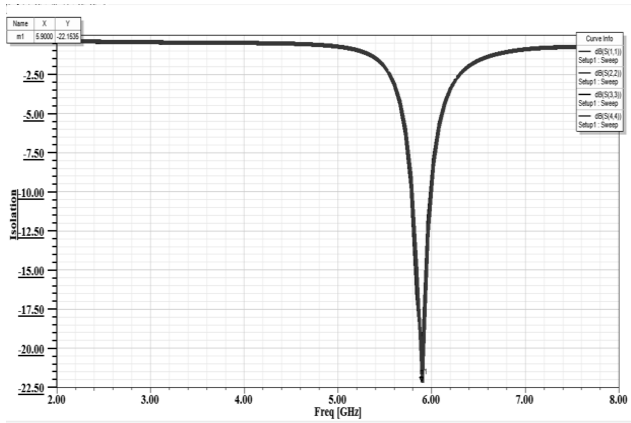

Figure 4.aReflection coefficient of conventional MIMO Antennas

Antenna Type	Reflection Coefficient	Bandwidth
Figure 4.a	-22.15dB	200MHz
Figure 4.b	-19.49dB	357MHz
Figure 4.c	-17.8db	369MHz
Figure 4.d	-20.15dB	416MHz

Table 3: Summarised reflection coefficient with bandwidth of MIMO antennas

Observing table 3 results, MIMO antenna with inset slot and H shape octagon split ring metamaterial gives improved bandwidth with good isolation.

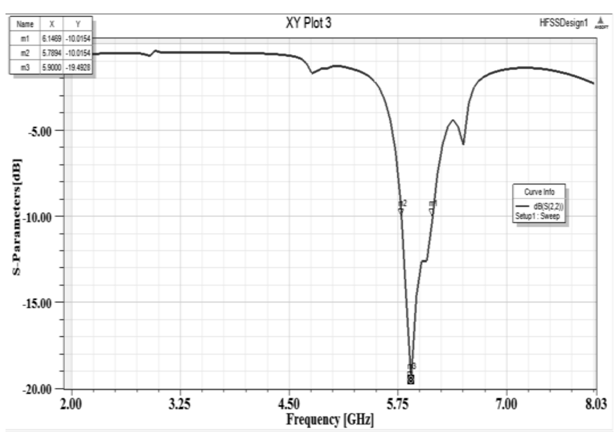

Figure 4.bReflection coefficient of Simple MIMO antennas with octagon split ring metamaterial structure

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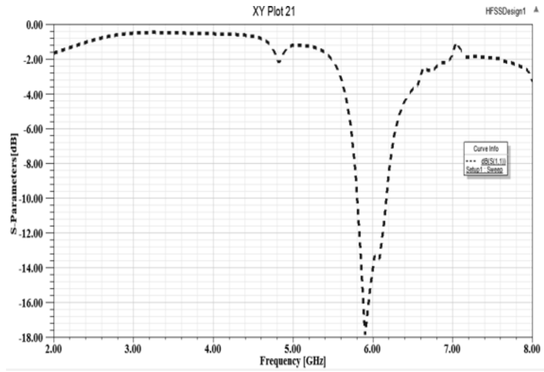

Figure 4.c Reflection coefficient of MIMO antenna with H shape octagon split ring metamaterial structure

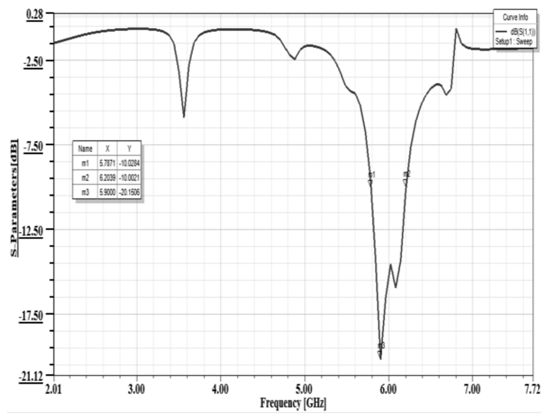

Figure 4.dReflection coefficient of MIMO antenna with inset slot and H shape octagon split ring metamaterial structure

B. Peak Gain

Peak gain of finalized MIMO antenna with inset slot and H shape octagon split ring metamaterial structure gives 4.44dBi as depicted in Figure 5

C. Mutual Coupling

The mutual coupling of finalized MIMO antenna with inset slot and H shape octagon split ring metamaterial structure gives very low i.e. -25.6dB as depicted in Figure 6.

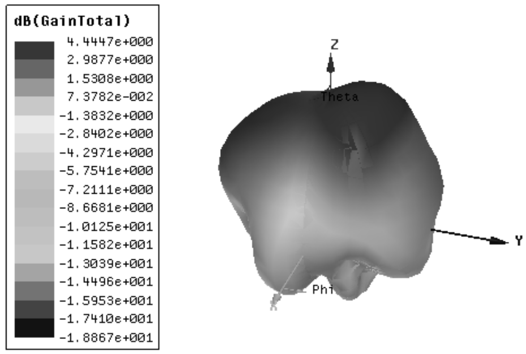

Figure5. Peak Gain of MIMO antenna with H shape octagon split ring metamaterial structure

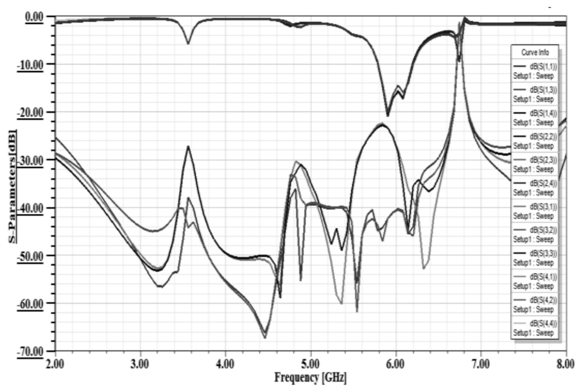

Figure 6. Mutual coupling of MIMO antenna with H shape octagon split ring metamaterial structure

D. VSWR

Normally in antenna application the VSWR value is in between 1 to 2. HenceMIMO antenna with inset slot andH shapedoctagon split ring resonators, it gives VSWR is 1.22, at the resonance frequency of 5.9GHz. Hence it concluded that if VSWR ≤ 2 then 89% of power transfer along the antenna, if VSWR < 1.7then 93% of power transfer along the antenna, if VSWR < 1.5 then 96% of power transfer. So that our designed antenna VSWR value is less than 1.5 hence good amount of power transfer along the antenna shown in figure 7.

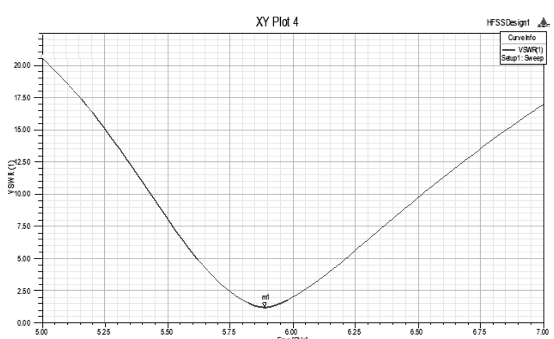

Figure 7.VSWR of MIMO antennas with inset slot and H shape octagon split ring metamaterial structure

D. Envelope Correlation Coefficient

The envelope correlation coefficient is the important parameter in MIMO system that can significantly influence the capacity of a MIMO system. This enveloped correlation coefficient between signals received by the antennas of the array can be computed through the S-parameters with the assumption that the incoming signals are uniformly distributed, i.e. the direction of arrival of each multipath component has equal probability. The correlation coefficient between any two elements of the array is given as.

$$\rho_{i,j} = \frac{\left|S_{ii}^{*}S_{ij}+S_{ji}^{*}S_{jj}\right|}{(1-|S_{ii}|^{2}-|S_{ji}|^{2})(1-|S_{jj}|^{2}-|S_{ij}|^{2}}$$

From Figure 7, it is clear that the envelope correlation coefficient (ECC) is very low over the whole triple band which indicates very good isolation between the four antennas. The maximum ECC is less than 0.03.

Envelope correlation coefficient gives a measure of how much the antennas are correlated with each other in MIMO antenna system. Achieving good Diversity Gain (DG) envelope correlation coefficient should be zero or very low and mean SNR of each branch should be similar. The key principle behind antenna diversity is the desire to have the fading at each antenna by independent of the other antennas to minimize the likelihood of all signals fading identically. Diversity gain given as

$$DG = 10*\sqrt{(1-(0.99*ECC)^{2})}$$

From our designed metamaterial MIMO antenna having ECC is 0.03 hence diversity gain it become 9.4dB. It indicates that designed metamaterial MIMO antenna having good reliability.

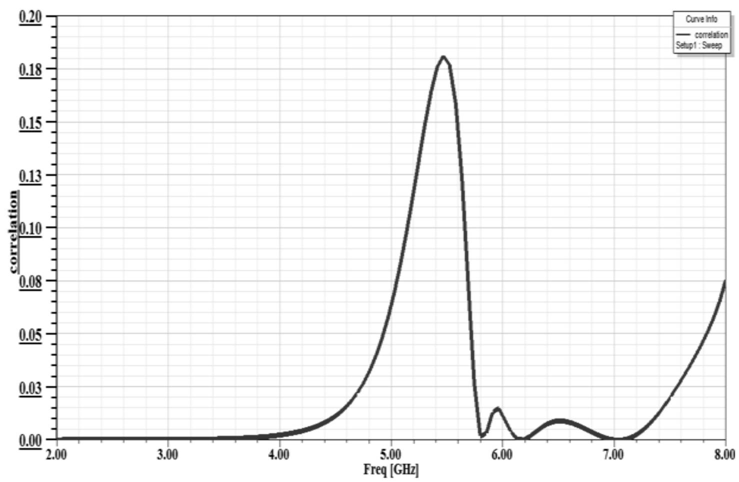

Figure 8.Envelope correlation coefficients of MIMO antennas with inset slot and H shape octagon split ring metamaterial structure

IV CONCLUSION

A compact four element MIMO antenna with improved bandwidth and reduction in mutual coupling is proposed and designed. A good bandwidth is achieved by MIMOantennawith insetslot and H shape metamaterial structure. The designed antenna has small size with simple geometry which makes it highly suitable for integration in to system circuits. The characteristics obtained shows that the proposed antenna is fit for WLAN application.

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