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MINIATURISED METAMATERIAL ANTENNA FOR WLAN AND WiMAX APPLICATIONS USING MULTICELLS

Divyareddy.A[1], Priyanka.M [2] , Vineela.K[3] , Kalyani.R [4]

[1,2,3,4] *Dept. of Electronics & Communication Sphoorthy Engineering College Hyderabad India 501510*

ABSTRACT

In this work rectangular microstrip patch antenna using circular spilt ring metamaterial unit cell is designed, simulated and analyzed. The circular split ring metamaterial unit cell and conventional rectangular microstrip patch antenna are designed using FR-4 substrate with dielectric constant 4.4. The overall dimensions of conventional rectangular microstrip patch antenna and circular split ring metamaterial unit cell are 40X40X1.6mm^3, 30X30X1.6mm3 respectively. Then designed metamaterial unit cell is loaded on the ground plane of conventional rectangular microstrip patch antenna is resonated at 3.73GHz to 6.33GHz with overall bandwidth 269.4MHz.Simulated results include bandwidth gain VSWR and radiation pattern. The proposed rectangular patch antenna is compared with conventional rectangular patch antenna, which shows the significant miniaturization as compared to conventional rectangular patch antenna hence the proposed antenna shows good results and it well suited for WLAN and WiMAX (Wireless interoperability for Microwave Access) applications.

Keywords:Wireless Local Area Network (WLAN), WiMAX,Microstrip Antenna, Circularsplit resonator, Metamaterial;

I INTRODUCTION

Now a days the demand for wireless and portable devices are going to increase for the wireless applications like WLAN, WiMAX, and Wi-Fi etc. Antennas play a very important role in the field of wireless communications. During the recent years, microstrip antennas have attracted an important interest in modern communication systems because of their significant characteristics of small size, light weight, low cost on mass production and thin profile. They are also compatible with wireless communication integrated circuitry due to their simple feed methods, especially microstrip-line and coplanar waveguide feeds. However, their capability to operate at a single frequency, narrow bandwidth and low gain when comparing it with other microwave antennas restrict their practical applications.

Metamaterials are artificial materials engineered to provide properties which “may not be readily available in nature”. These materials usually gain their properties from structure rather than composition, using the inclusion of small inhomogeneities to enact effective macroscopic behavior. The metamaterials have entered into the main stream of electromagnetics. The essential property in metamaterials is their unusual and desired qualities that appear due to their particular design & structure. In particular composite media electromagnetic waves interact with the inclusions which produce electric & magnetic moments, which in turn affect the macroscopic effective permittivity & permeability of the bulk composite medium. Since metamaterials can be synthesized by embedding artificially fabricated inclusions in a specified host medium. This provides the designer with a large collection of independent parameters such as properties of host materials, size, shape, and compositions of inclusions. All these design parameters can play a major role in getting the final result. In these the shape of the inclusions is one that provides a new possibility for metamaterial processing. In electromagnetism, electric permittivity (e), and magnetic permeability (μ) are the two fundamental parameters characterizing the EM property of a medium. By understanding this metamaterial theoretical concept here we proposed metamaterial rectangular microstrip patch antenna for WLAN applications by using FR4 substrate with 4.4 dielectric constant. The proposed antenna it gives an dual band characteristics frequency around 3.73GHz to 6.33GHz,which supported 269.4MHz bandwidth so, that our proposed antenna result shows that it is well suited for WLAN and WiMAX applications.

II GEOMETRY OF THE CIRCULARSPLIT RING METAMATERIAL STRUCTURE (CSRM)

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 circular split ring resonator structure (CRSM) a unit cell is depicted in figure 1. This metamaterial CRSM 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 rectangular 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.

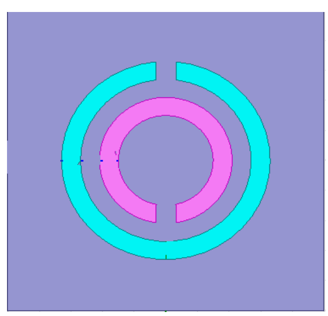

Figure1: The CSRM unit cell structure

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 the substrate	30
Width of the substrate	30
Length of rectangle split ring , L	20
Width of rectangle split ring, W	20
Thickness, d	0.03
Gap, G	0.2
Distance between the split ring	0.2

Table1: Dimension of CSRM unit cell structure

In all of the previous work, slot loaded miniaturized patch antennas were used in WLAN applications. Such patch antennas were never extended and analyzed by metamaterial structure. Hence here we designed circular split ring metamaterial structure and it loaded on ground plane of the conventional rectangular microstrip antenna so that we achieved 75% of size reduction and good amount of bandwidth and gain for WLAN and WiMAX applications.

III ANTENNA DESIGN

A. Conventional Rectangular Microstrip Patch Antenna

In this paper we proposed a rectangular microstrip patch antenna having Fr-4 substrate with 4.4 dielectric constant and having thickness of the substrate 1.6mm .The overall dimension of the rectangular microstrip patch antenna are shown in table 2.and conventional rectangular microstrip patch antenna as shown in figure 2 .

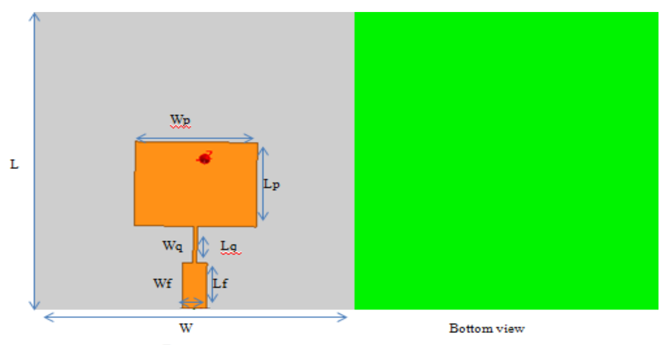

Figure2: Conventional Rectangular Microstrip Patch Antenna top view

B. Metamaterial Microstrip Patch Antenna

In this work designed circular split ring metamaterial structure loaded on the ground plane of the conventional rectangular micro strip patch antenna so that we etched the CSRM structure on the ground plane of the conventional rectangular microstrip patch antenna, so that CSRM structure is actively coupled with conventional rectangular microstrip patch antenna hence it shows that the antenna miniaturized to 75% of size reduction as compared to conventional rectangular microstrip patch antenna, and it supported 269.4MHz bandwidth as well as 4.7dB gain more than conventional microstip patch antenna bandwidth and gain was 200MHz, 4.8dB respectively.

Parameter	Dimensions(mm)
Length of the substrate (L)	40
Width of the substrate (W)	40
Quarter wavelength of the feed line(Lq)	4.9
Quarter wavelength of the feed line (Wq)	0.5
Length of feed line (Lf)	6.15
Width of feed line (Wf)	3.05
Thickness of the substrate	1.6
Length of the patch (Lp)	11.35
Width of the patch (Wp)	15.25

Table2: Dimensions of the Conventional Rectangular Microstrip Patch Antenna

The designed metamaterial rectangular microstrip patch antenna is shown in figure 3.after that by varying the width and gap of the metamaterial structure parametric studies was done for the better improvement of bandwidth and gain and efficiency for WLAN applications, so that here we simulated and compared conventional microstrip antenna result with proposed metamaterial microstrip patch antenna.

Microstrip patch antenna size can be reduced by using metamaterial structure. In addition, a wide bandwidth also can be obtained by reducing the ground plane of the antenna. The bandwidth of a single patch antenna can be raised by placing a number of metamaterial unit cells. Here we are placed 25 metamaterial cells on a microstrip patch antenna. So that here we got a miniaturized antenna with high bandwidth of 269.4MHz.We can also increase the metamaterial unit cells for better bandwidth and gain.

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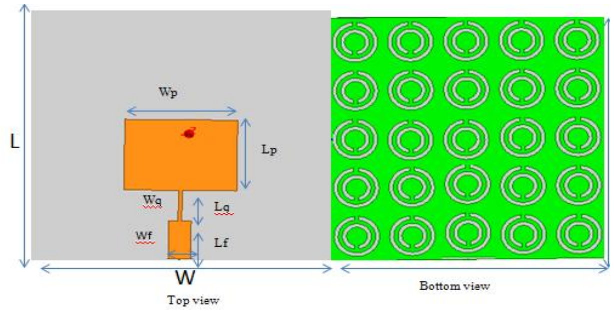

Figure3: Metamaterial Rectangular Microstrip Patch Antenna top and bottom view

IV RESULTS AND DISCUSSION

In this section we are presenting the design and simulated results for the conventional rectangular microstrip patch antenna as well as metamateial microstrip patch antenna , in the following section first we presented all the conventional antenna results like scattering parameter, bandwidth, gain, VSWR, radiation pattern after that we presented our proposed metamaterial microstrip patch antenna for the same parameter like scattering parameter, bandwidth, gain, VSWR, radiation pattern, then we summarized the result in table 3

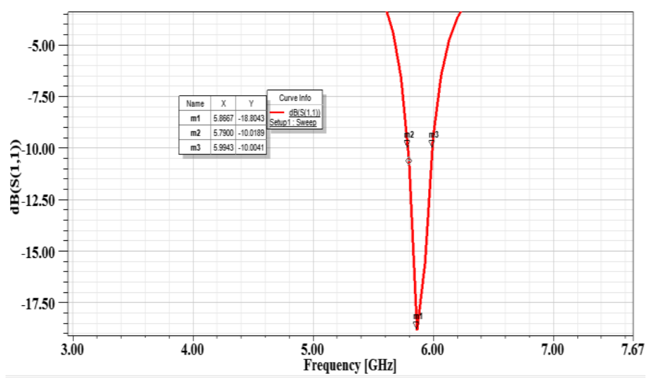

Figure 4: Reflection coefficient of conventional rectangular microstrip patch antenna

Figure 4 shows the reflection coefficient conventional rectangular microstrip patch antenna is that -22.51dB at 5.9GHz and it supported bandwidth 200MHz.

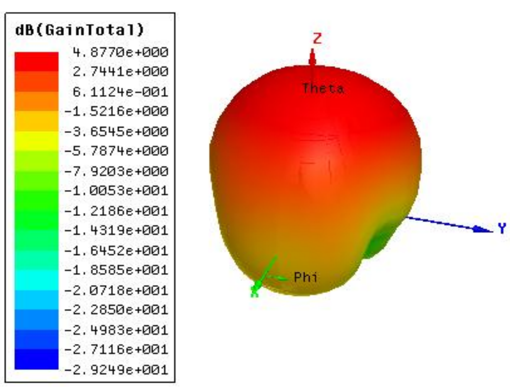

Figure 5: 3D gain pattern of conventional microstrip patch antenna

Figure 5 show that conventional microstrip patch antenna supported gain is about 4.8dB, and figure 6 show the VSWR of conventional microstrip patch antenna is 1.2.

The radiation pattern and current distribution pattern of conventional rectangular microstrip patch antenna are shown in figure 7 and figure8 respectively. And figure 9 shows the proposed metamaterial rectangular microstrip patch antenna reflection coefficient bandwidth here the proposed antenna resonate a dual band frequencies are 3.73GHz and 6.33GHz with supported 269.4MHz bandwidth, so that as compare with conventional microstrip patch antenna We achieved 75% of size reduction as well as increased in bandwidth and it resonate at dual frequencies. Figure 10 show the gain parameter of the proposed antenna is 4.7dB hence proposed antenna gain reduced slightly because of more number of metamaterial unit cell etched on ground plane of the conventional micro strip patch antenna.

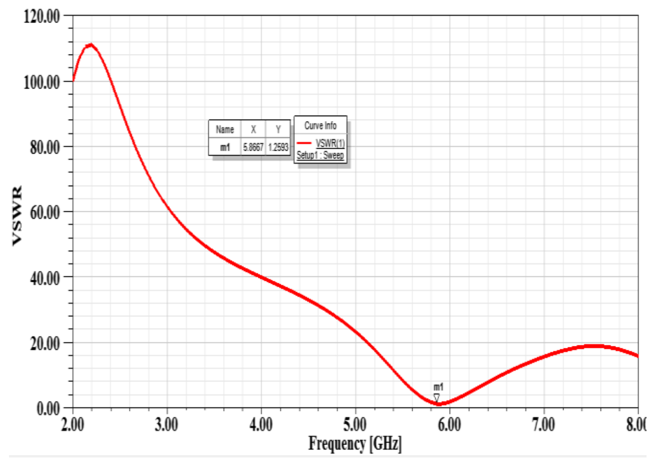

Figure6: VSWR of conventional microstrip patch antenna

Figure 11 and figure 12 shows the VSWR and radiation pattern of the proposed metamaterial rectangular microstrip patch antenna.

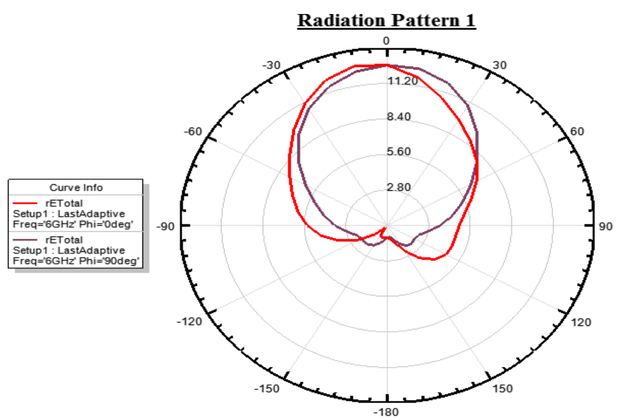

Figure 7: Radiation pattern of conventional microstrip patch antenna

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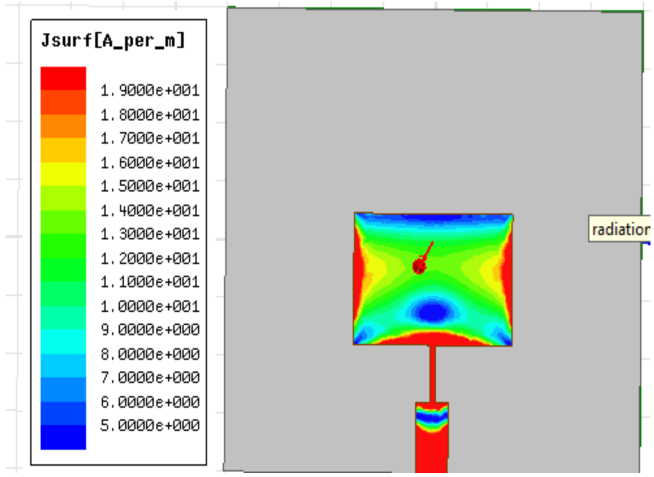

Figure 8: Current distribution of conventional rectangular microstrip patch antenna

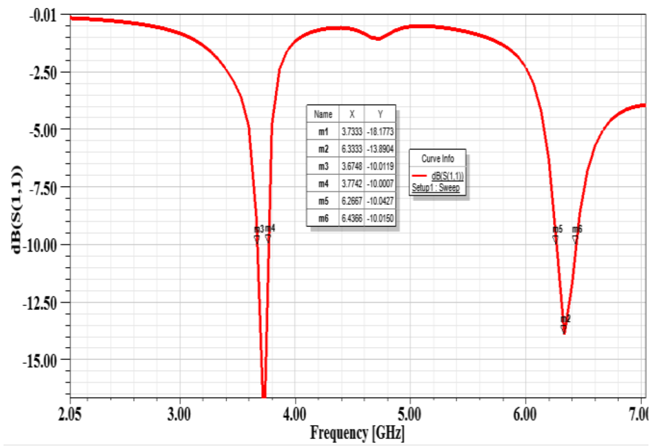

Figure 9: Reflection Coefficient of Metamaterial microstrip patch antenna

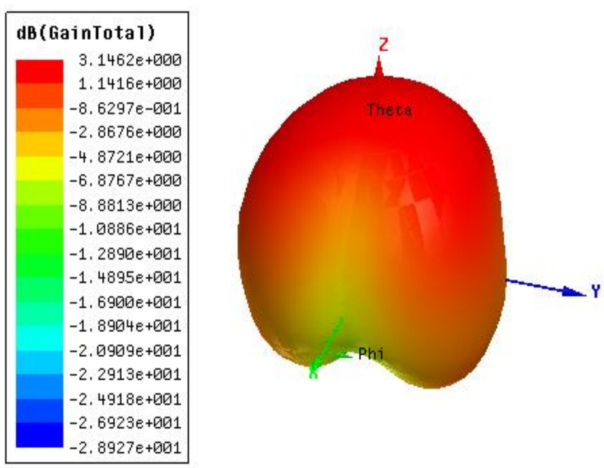

Figure 10: 3D gain pattern of metamaterial microstrip patch antenna

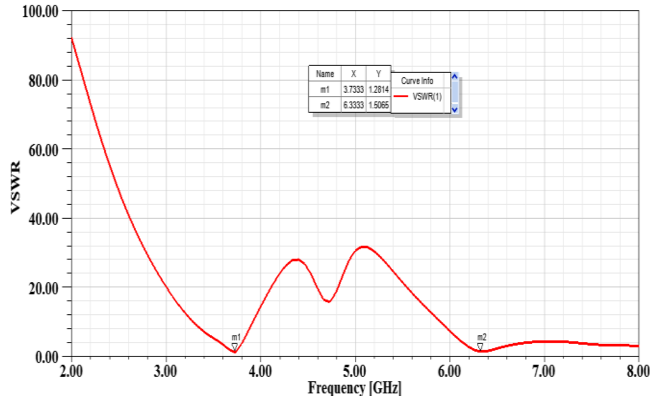

Figure 11: VSWR of Metamaterial microstrip patch antenna

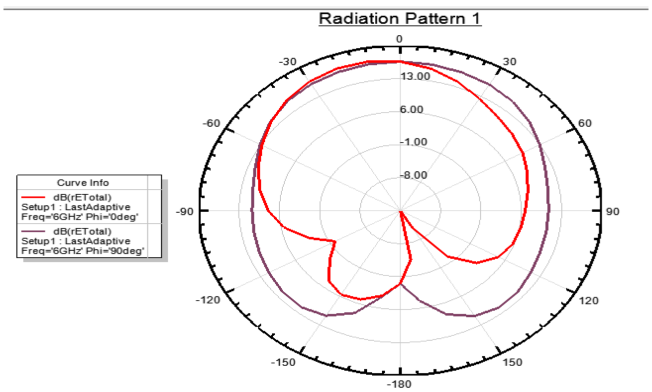

Figure 12: Radiation pattern of metamaterial microstrip patch antenna

Parameters	Conventional Antenna	Proposed Antenna
Resonating Frequency	5.9GHz	3.73GHz ,6.33GHz
Reflection Coefficients	-18.31dB	-17.20dB, -13dB
Bandwidth	200MHz	269.4MHz
Gain	4.8dB	4.7dB
VSWR	1.2	1.2

Table 3: Compression of conventional and proposed metamaterial microstrip patch antenna

V CONCLUSION

A new antenna has been designed and simulated using rmetamaterial at the frequency range of 3.73GHz to 6.33GHz. Bandwidth of 269.4MHz .The proposed rectangular microstrip patchantenna with metamaterial gives a dual band operation compared to conventional rectangular microstrip patch antenna.By analyzing the simulation result, it is found that the bandwidth is increased by using metamaterial structure. Further the size of antenna is also reduced. Such a compact dual band rectangular metamaterial microstrip antenna is well suited for WLAN and WiMAX applications.

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Biography

Divyareddy.A Currently she is pursuing her B.Tech in the department of Electronics& Communication, Sphoorthy Engineering College Hyderabad.Her research area interest includes metamaterial antenna, and Signal Processing system design.

Priyanka.M Currently she is pursuing her B.Tech in the department of Electronics& Communication, Sphoorthy Engineering College Hyderabad.Her research area interest includes metamaterial microstrip antenna, and Signal Processing.

Vineela.K Currently she is pursuing her B.Tech in the department of Electronics& Communication, Sphoorthy Engineering College Hyderabad.Her research area interest includes metamaterial microstrip antenna, and Microwave Engineering.

Kalyani.R Currently she is pursuing her B.Tech in the department of Electronics& Communication, Sphoorthy Engineering College Hyderabad.Her research area interest includes metamaterial microstrip antenna, Microwave Engineering Signal Processing.

Siddanagouda.F.B received his BE and M.Tech from PES College of Engineering Mandya and IIT Kharagpur in the year 2009 and 2012 respectively. Currently he is pursuing his Ph.D. in the field of Microwave Antennas at Gulbarga University