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Performance Characterization of Monopole Antenna Loaded with Metamaterial

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ABSTRACT: In this paper, a simple monopole antenna loaded with metamaterial provides suitable wireless applications especially for wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX) applications. At the frequency range of operation, the return loss remains <-10dB. The monopole antenna alone provides a wide band around 3.1-5.3GHz. When the modified H-shaped metamaterial is inserted infront of the antenna, the beam of the antenna is tilted upto ±4°.After the loading of the metamaterial, an increase in gain occurs than the antenna without metamaterial.

KEYWORDS : WLAN/WiMAX applications, metamaterial, monopole antenna.

I.INTRODUCTION

In today's world with increase in the development of the mobile communication, there is a necessity to provide the wireless applications with low cost, compact size and multiband operation are needed.

Compact monopole antenna with inverted L–shaped slot cut [1] ,coplanar waveguide monopole antenna with L–shaped etch [2] , Meander line, fractal geometries, various shape slots, wide band, dual band, pentaband [3-6] or embedding chip inductors in the monopole antennas [7, 8] were the several techniques used in the development of WLAN/WiMAX/WiFi applications. In this communication,a new technique is put forward to provide a new solution of beam tilting mechanism along with the increase in gain for the proposed design. There will not be any changes occur in the antenna like gain drop, impedence matching due to the metamaterial loaded onto it. This metamaterial provides essential refractive index to re-direct the beam.

The metamaterials are classified based on the permeability and permittivity, such as right handed material,Epsilon negative material,Mu negative materials and Double negative materials.Double negative materials are the effects on Snell's law. There are various unitcell structures.First of all, Metamaterial is the periodic arrangement of unitcells.

In the following sections,first we define about the metamaterial unitcell which is a modified version of the H-shaped resonator which is explained in [9]. The proposed structure is chosen because of easy integration onto the antenna.Here, the antenna alone provides a particular gain with good return loss on a specific angle,but when the metamaterial is loaded onto it, it tilt the main beam upto ±4° at the frequency of 3.5- 5.5 GHz ,but the insertion does not affect the gain,return loss and the antenna matching.The metamaterial here is known as Integrated Metamaterial Loading (IML),because of easy integration into the substrate infront of the antenna.

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II.METAMATERIAL UNITCELL

Metamaterial can also be used as antenna, absorber, superlens, cloaks, sensors and phase compensator. The proposed metamaterial structure has to be fabricated onto the FR-4 (lossy) substrate,in which the dimensions are given below.The dimensions of the unit cell are L1=1.8mm, L2=1mm, L3=0.8mm, L4=1.1mm, L5=0.6mm, L6=0.8mm and g=0.2mm is shown in Fig.1.The Substrate with the height and width of 70 mm and 40 mm.

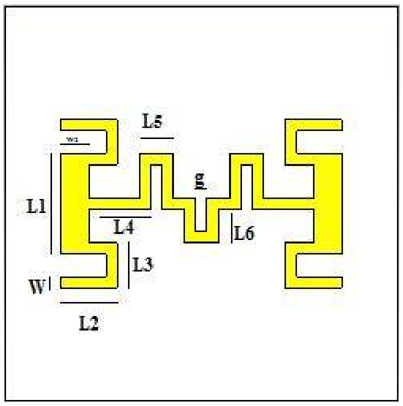

Fig.1 Metamaterial Unitcell

The unitcell was simulated using HFSS with PEC and PMC boundary conditions,the unit cell alone is characterized with the dimensions mentioned above. The return loss was obtained with <-10dB.Two ports are given hence the transmission coefficient S_{12} and return loss S_{11} both are obtained.

III. ANTENNA DESIGN

Intially, the monopole antenna was designed to show the variation between with and without metamaterial.The material used for the substrate is FR-4 with the height of 30 mm, thickness of 1.6 mm, width of 20 mm.The ground with the height of 15 mm,width of 20mm and thickness of 0.035mm.The patch parameters are structured as follows,

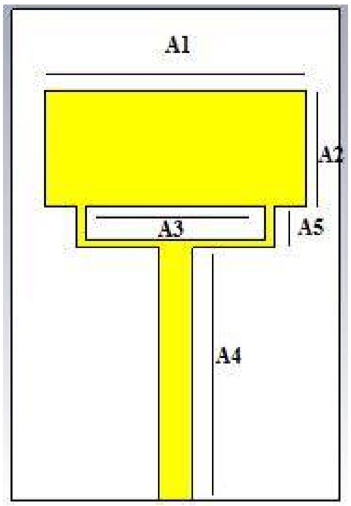

Fig.2 Front view

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The dimensions of the antenna are A1= 16mm ,A2 = 5mm, A3= 12mm,A4 = 15mm, A5= 3mm. Fig.2 gives the parameters of the antenna . Fig.2 and Fig.3 shows the front and back view with the substrate along with the ground plane in the back view. Here,the FR-4 substrate is used with perfect electric and magnetic boundary conditions.

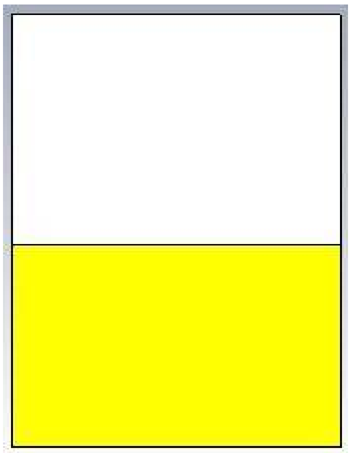

Fig.3 Back view

With the insertion of the metamaterial it provides a beam deflection on the radiation emitted by the antenna.Fig.4 and Fig.5 shows the whole structure of the antenna with the metamaterial. The metamaterial was structured with 2×4,3×5 arrays to show a difference in the tilt angle,gain,return loss and the radiation pattern.Intially the metamaterial alone is characterized for obtaining the transmission coefficient and return loss.

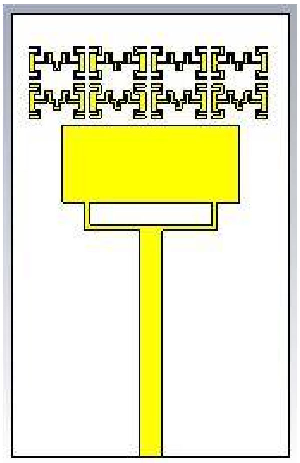

Fig.4 Antenna with 2×4 array

The waveguide port is used for the simulation. The metamaterial alone is designed with two ports to provide the transmission coefficient and return loss. The metamaterial used here is the modified version of the H-shaped resonator,that provides a wide band throughout the frequency upto 10GHz.The individual unitcell provides a good return loss and transmission coefficient.

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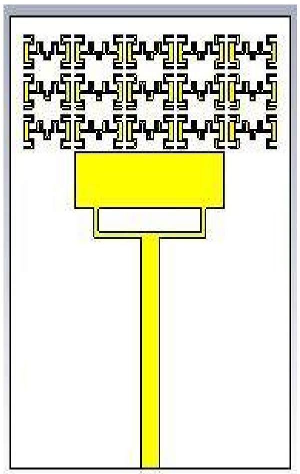

Fig.5 Antenna with 3×5 array

The periodic array structures for various matrices like 2×4,3×4,3×5 are checked for the better tilting angle to be obtained.The results and the comparision table are given in the following sections.

IV.RESULTS AND DISCUSSION

Fig.6 Shows the return loss and transmission coefficient for the IML unit cell alone. It is the simulation for the design shown in Fig.1.

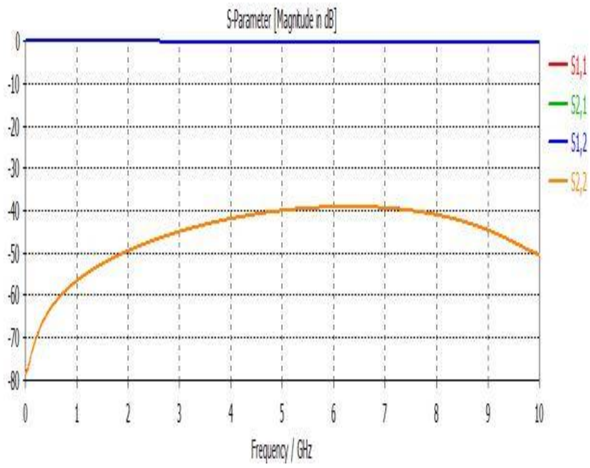

Fig.6 Simulation Results for unitcell alone

The results for the antenna with the return loss is given in Fig.7. It provides a maximum result around the frequency of 3.1-5.5 GHz with a wide band. After the design has made,the design is fixed with the boundary conditions and port is given at the bottom of the patch,it supplies the power to the antenna that is to be radiated.

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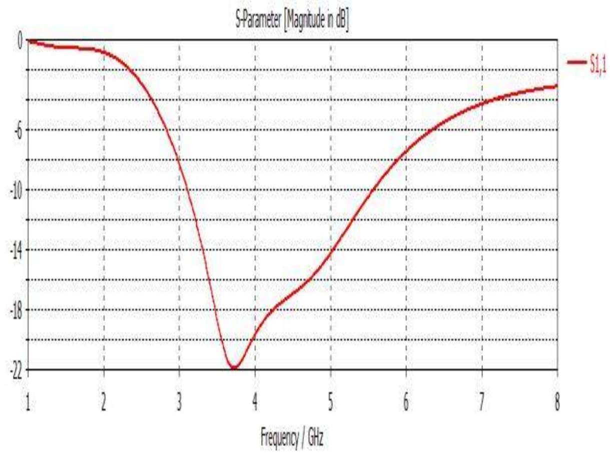

Fig.7 Return loss for the antenna alone

After the verification of the return loss in Fig.7,the farfield parameter is checked for the results of directivity and gain.Fig.8 shows the maximum tilting of the main lobe direction. Initially the main lobe of the antenna alone is at the angle 160◦ is faced.It is clearly shown using the Polar plot.

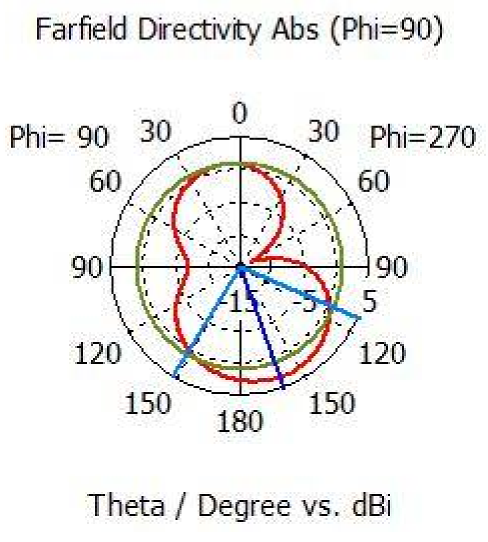

Fig.8 Polar plot for the antenna

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The antenna is radiated maximum at the theta direction,which shows clearly in the above polar plot.

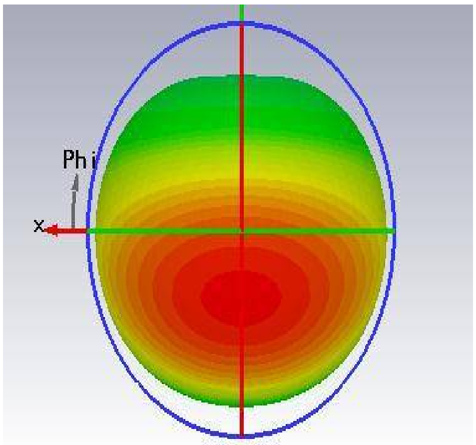

Fig.9 Three dimensional view without IML

The metamaterial loding is to enhance the gain and also to redirect the beam.Fig.9 shows the 3D view of the monopole antenna and also the radiation is maximum at the theta direction.

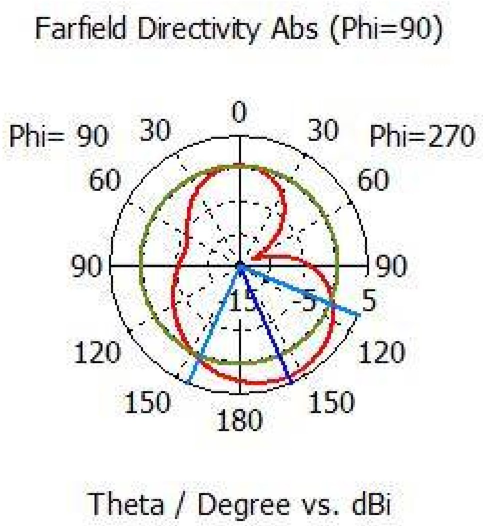

Fig.10 Polar plot with metamaterial

The gain for the antenna with and without the metamaterial is shown in Fig.11 and 12.The gain is enhanced upto 1dB with the use of metamaterial.

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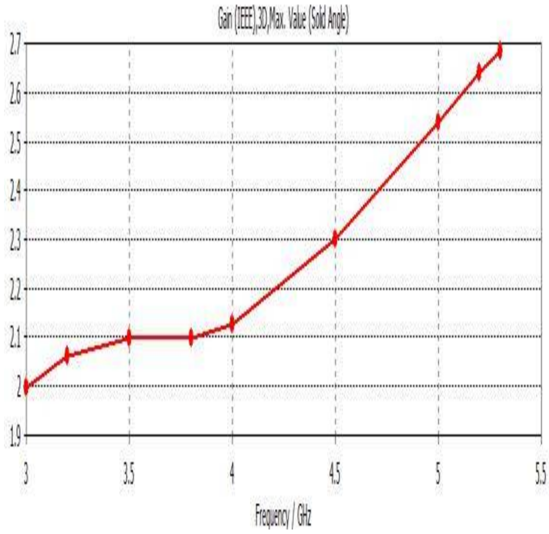

Fig.11 Gain for the antenna

Gain has improved while modified H-shaped antenna is inserted infront of the antenna.It is clearly shown from the results in Fig.11 and 12.

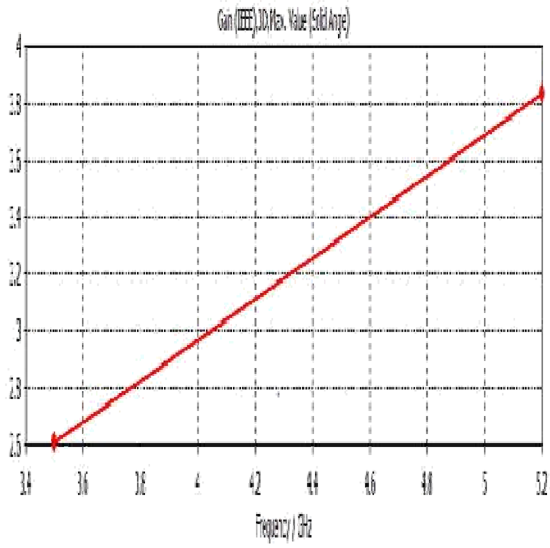

Fig.12 Gain using metamaterial

The above results are shown using only 2×4 arrays of IML into the antenna. For the various matrices section,that does not provide with the better gain and directivity though good return loss is obtained.

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No. of Unit-cell columns in IML	2×4	3×4	3×5
Return loss (dB)	-19	-14	-11
TiltAngle (Degrees)	5	2	5
Gain (dBi)	3.8	2.5	2

Table.1 Comparision of IML arrays

The variation between the various metamaterial unitcell columns is shown in Table.1.

V.CONCLUSION

The method is presented with a simple monopole antenna provides a wide band around 3.1-5.3 GHz with wireless applications especially for wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX) applications.

Along with the use of the metamaterial,that is integrated onto the antenna,which provides an gain enhancement along with the beam tilt of ±4° over the main lobe direction. . The main mechanism of using the metamaterial to provide a higher refractive index that makes the deflection. The metamaterial alone is characterized and then integrated in front of the antenna.The metamaterial unit-cell of 2×4 array is designed and simulated.The other metamaterials arrays were also designed. In future,we are going to work in gain enhancement and also to increase the tilt angle which is better than the proposed work.

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