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A Rhombus Shaped Metamaterial Inspired Antenna In The Ground Plane For X Band Applications

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Abstract: ***The objective of this paper is to present the dual band antennas that are going to work at a different set of frequencies. By using slots and rings in ground plane and top of the patch we designed dual-band antenna, works at two different set of frequencies (15.2 GHz & 23.42 GHz) with high gain which mainly covers the applications of microwave frequency Ku-band and K-band. There after we proposed metamaterial inspired antenna at X band range (25 mm to 37.5 cm).The needed -10 dB S_{11} of the antenna is obtained by analytical modeling and simulation with the help of both versions of HFSS 13.0 .***

Index terms: Metamaterial, Dual band Nature, Slots, Defected ground Structure.

I. INTRODUCTION:

Very often low-profile antennas are found in [1], [2] for dual -band applications, including satellite communications, radar and terrestrial broadband applications. Based on literature different geometrical patch structures are developed for C-band and X-band [3], [4] .In addition some papers 2.5dB to 6.76dB gain is achieved [5] at dual band with antenna dimensions 30×25×1.6 mm^3 but our proposed metamaterial antenna has compact size with dimensions 18x11x1.6mm^3 and it provides gain of 9.9 to 11.6dB. In this paper a new thought is implemented to obtain dual-band response of antenna by incorporating square shaped (SRR) metamaterials structure which include circular SRR .This paper deals with two antenna structures initial design does not contain metamaterial in ground plane and final proposed antenna contains metamaterial in ground plane .The metamaterial is a negative permeability and negative permittivity medium by using this property we can enhance the antenna parameters like Gain, band width ,Directivity. In literature so many metamaterial shapes were implemented like L shape [6], IDCLLR shape, Elliptical CSRR shape [7] in our paper we implemented combination of square SRR and Circular SRR.

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1.1 Antenna Design Parameters:

The proposed rhombus shaped slot antenna is designed using FR4 epoxy with loss tangent 0.02 and h=1.6mm. Fig 1 ,fig 2 represents geometry of initial antenna .

1.1.1 Top plane dimensions:

L1 = 18mm, *L*2 = 11mm, *L*3 = 7.8mm, *L*5 = 7.8mm, *L*5 = 1.875mm, *L*6 = 1.875mm, *L*7 = 3.31mm, *L*8 = 3.31mm, *L*9 = 1.11mm, *L10* = 1.11mm.

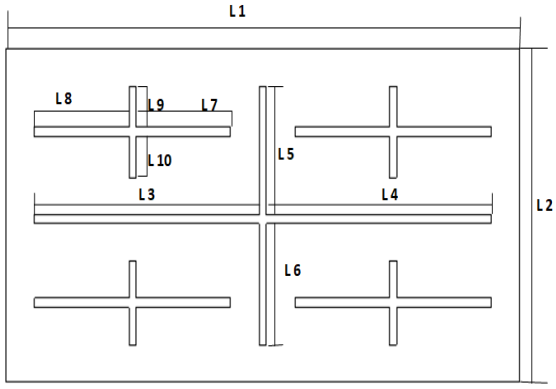

Fig 1.1 Patch of the initial antenna 1

1.1.2 Ground plane dimensions:

G1=18mm, G2=6mm, G3=0.25mm, G5=G5=G6=G7=1.875mm, G8=0.55mm, G9=0.8mm

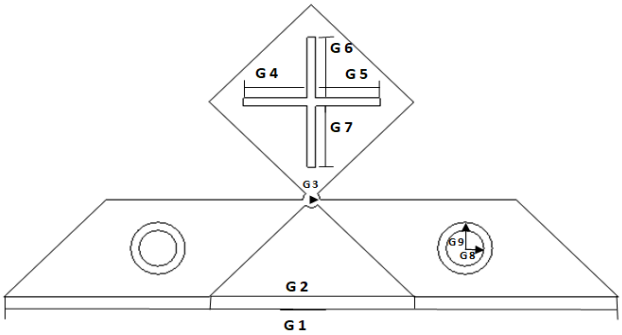

Fig 1.2 Ground plane of the initial antenna 1

The ground Plane is modeled in the form of plus and circular shape slots.

1.1.3 Antenna Geometry:

Here the patch antenna Consists of Plus Shape slots with various sizes. Top plane designs:

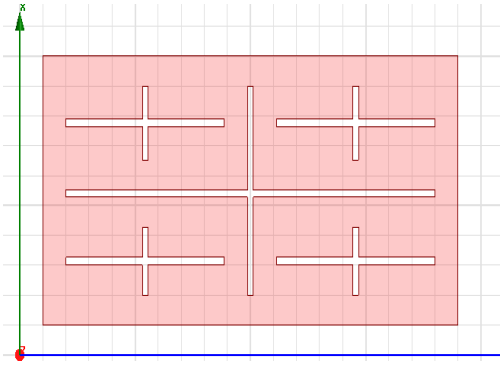

Fig 1.3 Rectangle patch with multiple slots

b) Final ground plane design:

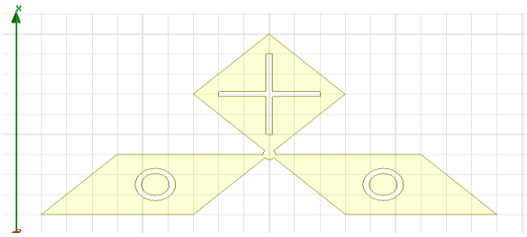

Fig 1.4 Rhombus patch with slots

Initial Proposed Antenna:

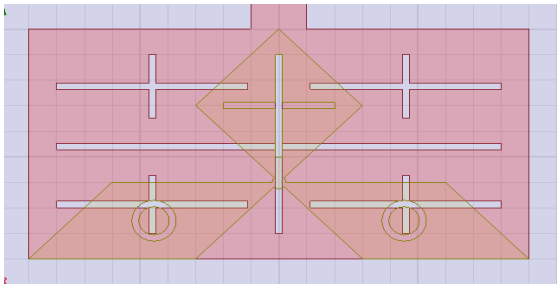

Fig 1.5 Initial Proposed antenna 1

1.2 SIMULATED RESULT OF INITIAL

1.3 PROPOSED ANTENNA 1:

The Initial designed antenna Resonates at 15.2 GHz and 23.4 GHz. For dual band operation, the slots are introduced in the conducting patch and due to these slots L_{eff} increases as a result extra inductance is introduced. This L value depends on the dimension of the slots .The above design Offers satisfactory result as shown below.

Return loss:

S-parameters S11 values are -16.3dB at 15.2 GHz and -23.1 dB at 23.4 GHz.

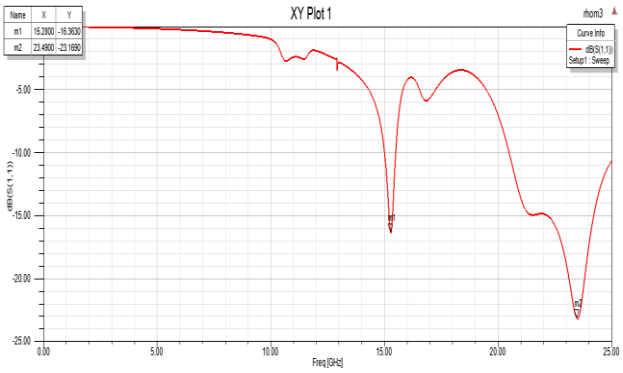

Fig 1.2.1 S11 of the Initial Proposed Antenna 1

VSWR:

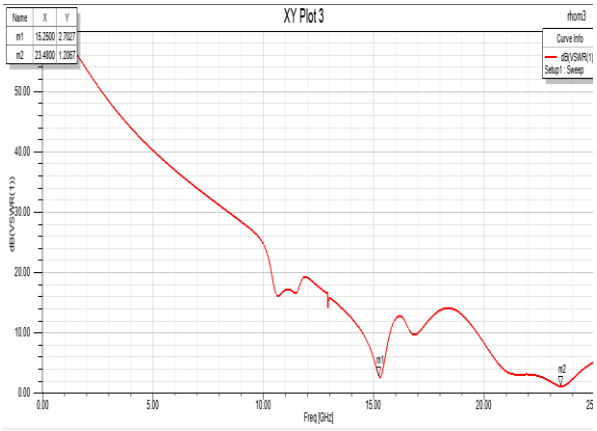

Fig 1.2.2 VSWR of the Proposed Antenna 1

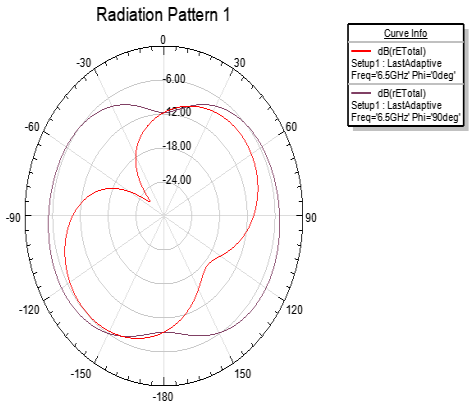

Fig 1.2.3 Radiation pattern of the Proposed Antenna 1

Gain:

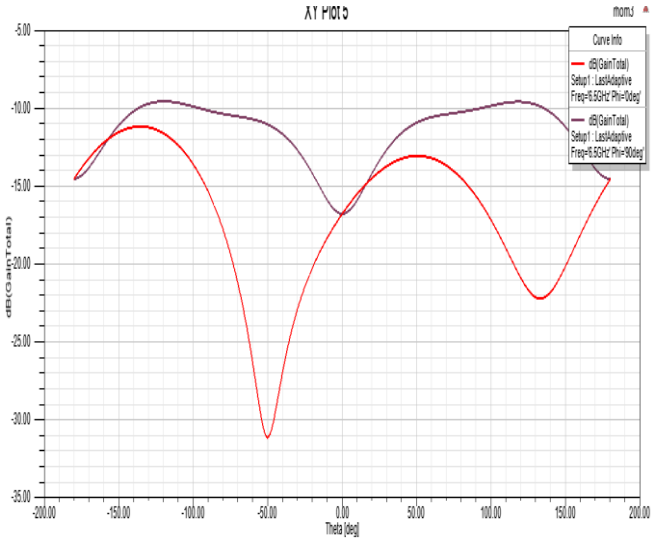

Fig 1.2.4 Gain of the Proposed Antenna 1

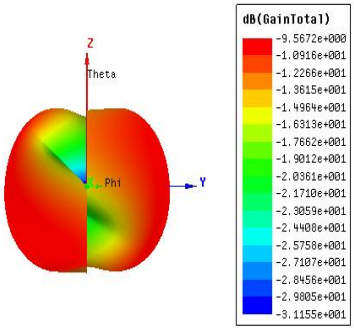

Fig 1.2.5 3D gain of the Proposed Antenna 1

1.3 Design of proposed Metamaterial Antenna:

Till now we discussed the design and its results without knowing the concept of the metamaterial. To understand the final design we have to know something about the metamaterial. Metamaterial is DNG material it belongs two 3rd quadrant as shown below fig 1.3(b) .There are several metamaterial structures in literature shown in below fig 1.3(a).which exhibits DNG nature.

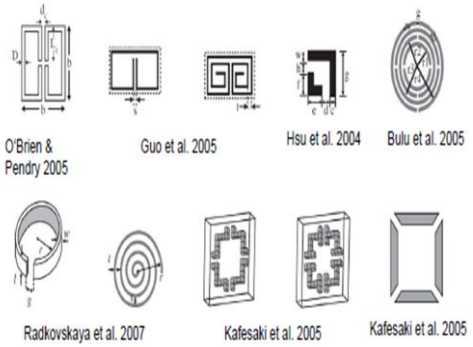

Fig 1.3(a)

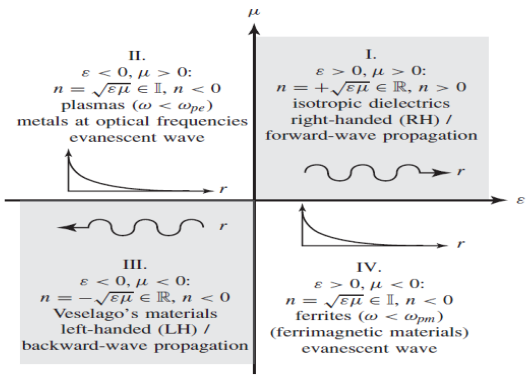

Fig 1.3(b)

1.3.1 Geometry of proposed Metamaterial Antenna:

a) Top plane Dimensions:

G1=18mm,G2=6mm,G3=0.25mm,
G5=G5=G6=G7=1.875mm,G8=0.55mm, G9=0.8mm

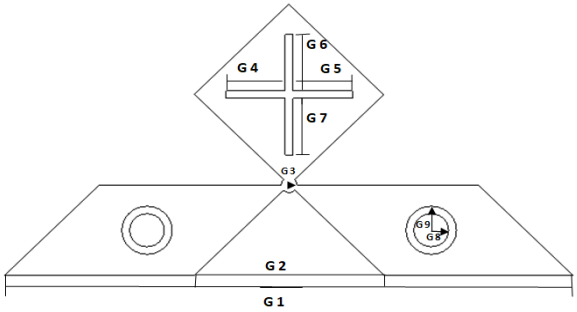

Fig 1.3.1 Patch

b) Metamaterial Design:

M1=M2=5.2 mm, M3=1.1 mm, M4=1.6 mm, M5=M6=0.8 mm, M7=0.5 mm.

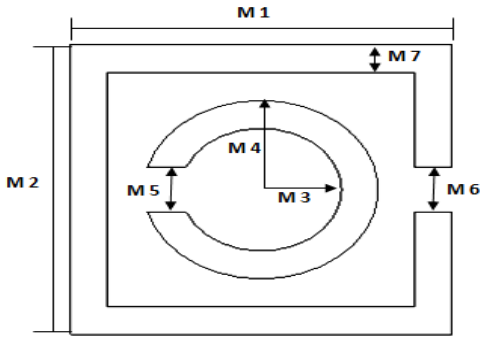

Fig 1.3.2 Metamaterial

Proposed Metamaterial Antenna:

The below figure shows the final preferred antenna. In this antenna rhombus Shaped patch and 1 x 2 array size of metamaterial is used to achieve the dual band nature in the microwave frequency band. The two frequencies are 10.42 GHz and 11.42 GHz which lie in X-band range.

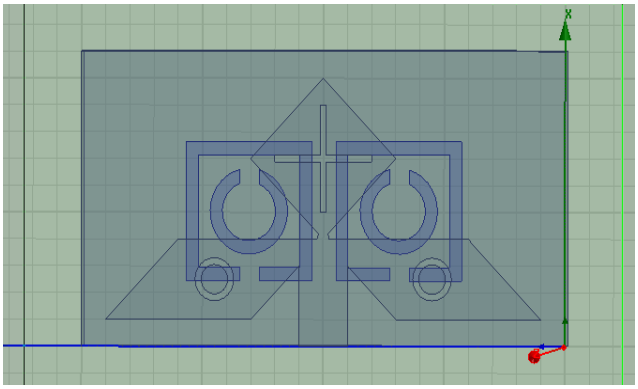

Fig 1.3.3 proposed Metamaterial Antenna

Proposed Metamaterial Antenna results:

Return loss: In the previous result of S11 we achieved more than -10dB at two frequencies in Ku band and K-band .To obtain the frequency shift, we add the 1 x 2 array size of metamaterial then we achieved the frequencies in the X-band with high gain. S11 values at 10.42GHz and 11.72GHz.

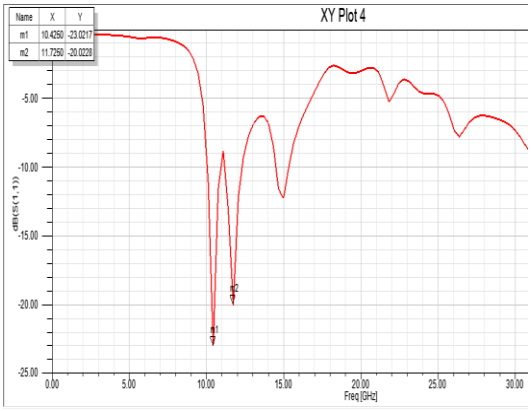

Fig 1.3.4 S_{11} for the proposed Metamaterial Antenna

VSWR:

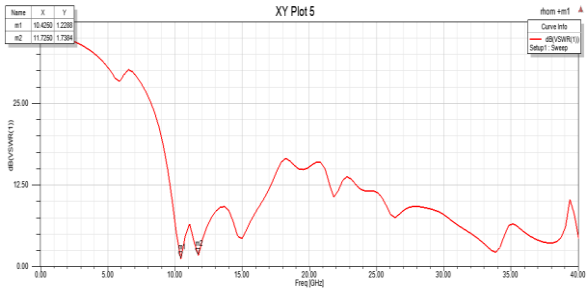

Fig 1.3.5 VSWR for the proposed metamaterial antenna

Radiation Pattern:

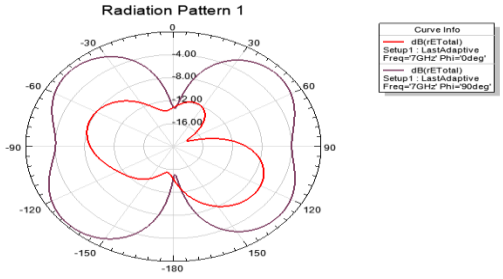

Fig 1.3.6 Radiation pattern of the proposed metamaterial antenna

Gain:

The gain values at 10.42 GHz are 9.9dB and 11.42 GHz are 11.6 dB. As shown in below Fig.

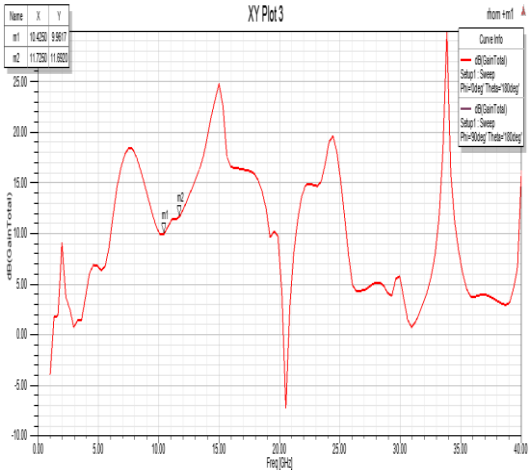

Fig 1.3.7 Gain for the proposed metamaterial antenna

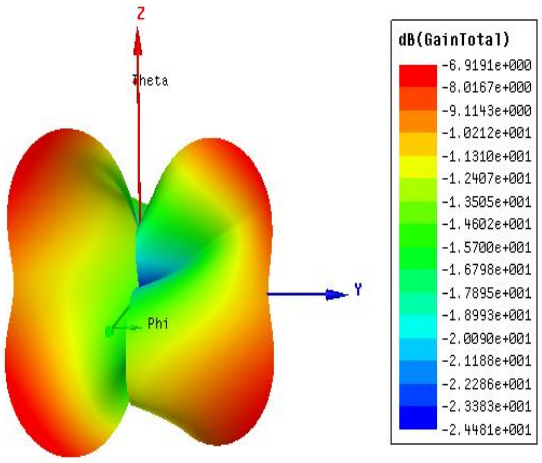

Fig 1.3.8 3D Gain for the proposed metamaterial antenna

Comparison table of initial proposed antenna and preferred metamaterial antenna.

Dual Band Antenna	Antenna without MTM(Initial design)		Antenna with MTM(Final design)	
Resonant Frequency	15.2 GHz	23.42 GHz	10.42 GHz	11.72 GHz
Return loss(dB)	-16.3	-23.1	-23.02	-20.02
Impedance Bandwidth	50MHz	478 MHz	89 MHz	112.2 MHz
Gain(dB)	1.3401	1.8032	9.9	11.6
Peak Directivity	1.8888	2.2103	1.8318	2.1984
Radiated Power	0.66879 W	0.81493 W	0.80505 W	0.8665 8 W
Accepted Power	0.94262 W	0.99891 W	0.98478 W	0.9931 7 W
Incident Power	1 W	1 W	1 W	1 W

Table No. 1

CONCLUSION

The development of a new rhombus shaped and metamaterial in the ground plane with line-feed micro strip patch antenna construction is reported. The exclusive idea and shape of the antenna mainly serves the role of enhanced result of dual nature. The simulated result shows dual band operation in X-band with enhanced bandwidth of 89 MHz and 112 MHz. The return loss values are -23.02 dB at 10.42 GHz and -20.42 dB at 11.72 GHz is achieved.

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