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Performance Enhancement of RMPA Parameters Using Circular shaped Split Ring Resonator with Rectangular Cross Strips Metamaterial Structure at 2 GHz

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ABSTRACT: In this paper, Rectangular Microstrip Patch Antenna (RMPA) along with metamaterial which has circular Split Ring Resonator and Horizontal & Vertical Rectangular Strips structure is proposed at height of 3.2 mm from the ground plane. The RMPA with proposed metamaterial structure is designed to resonate at 2 GHz frequency. Here in this paper we mainly focused on increasing the potential parameters of microstrip patch antenna. Proposed metamaterial structure is significantly reduced the return loss and increased the bandwidth and directivity of the antenna with compare to RMPA alone. These improvements are due to the Double-Negative (DNG) properties of metamaterial structure that acts as a lens when placed in front of the RMPA. All the simulation work is done by using CST-MWS Software.

KEYWORDS: Rectangular Micro strip Patch Antenna, Metamaterial, Bandwidth, and Return Loss.

I.INTRODUCTION

A Microstrip or Patch Antenna [1][2] is a low profile Antenna that has a number of advantages over other antennas it is lightweight, inexpensive, and easy to integrate with accompanying electronics. While the antenna can be 3D in structure (wrapped around an object, for example), the elements are usually flat, hence their other name, Planner Antennas. A Planner Antenna is not always a patch antenna [3]. But use of Rectangular Microstrip Patch Antenna alone is very difficult because of its low gain and narrow bandwidth. So to overcome these problems an artificial material called Metamaterial [4] is incorporates. Metamaterial [5] are an artificial material engineered to provide properties which are not readily available in nature. We have utilized the Metamaterial Structure on the Rectangular Microstrip Patch Antenna to improve its performance.

Earlier, John Pendry [4] published his investigations on two types of periodic arrays of metallic elements called split-ring resonators (SRRs). Zhang [9] demonstrated on spherical shells of homogenous, isotropic negative permittivity (ENG) material are designed to create electrically small resonant systems for several antenna. Majid [12] proposed a UWB antenna operating from 2.45 GHz to 11.6 GHz. To reduce the total size of proposed antenna, compact metamaterial based antenna is employed as the basic radiating elements. R. Pandeeswari [14] presented a frequency reconfigurable antenna based on metamaterial. It is composed of a coplanar-fed straight-line monopole with two double split-ring resonators (DSRRs) of different size disposed at its proximity.

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II. DESIGN SPECIFICATION

a) FORMULA USED TO DESIGNING RMPA

The Rectangular micro strip patch antenna parameters are calculated from the formulas given below:

Calculation of Width (W)

$$w = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where, c = free space velocity of light

εr = Dielectric constant of substrate f_r = Relative Frequency

The actual length of the Patch (L)

$$L = L_{eff} - 2\Delta L \qquad (2)$$

Where $Leff = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}}$ & $\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right)$

Calculation of Length Extension

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)} \qquad (3)$$

Calculation of VSWR

$$VSWR = S = \frac{1+|\Gamma|}{1-|\Gamma|} \qquad (4)$$

Where Γ = Reflection Co-efficent

Calculation of Return Loss

$$\text{Return Loss} = 20\log|\Gamma| \qquad (5)$$

Calculation of Band Width (BW)

The BW of the MSA is inversely proportional to its quality factor Q and is given by [8]

$$\text{Bandwidth} = \frac{VSWR-1}{Q\sqrt{VSWR}} \qquad (6)$$

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b) ANALYSIS OF RECTANGULAR MICRO STRIP PATCH ANTENNA

Parameter	**Dimension**	**Unit**
Dielectric Constant	4.3	-
Loss Tangent	0.02	-
Thickness	1.6	mm
Operating Frequency	2	GHz
Length	35.44	mm
Width	45.64	mm
Cut Width	5	mm
Cut Depth	10	mm
Path Length	35.99	mm
Feed Width	3	mm

TABLE I: RMPA SPECIFICATIONS

The physical parameters of rectangular micro strip patch antenna are W=45.64 mm, L=35.44 mm, length of transmission line feed= 35.99 mm, with width of the feed= 3 mm. The rectangular micro strip patch antenna designed on one side of glass/epoxy structure with $\varepsilon_r = 4.3$ and height from the ground plane d= 1.6 mm.

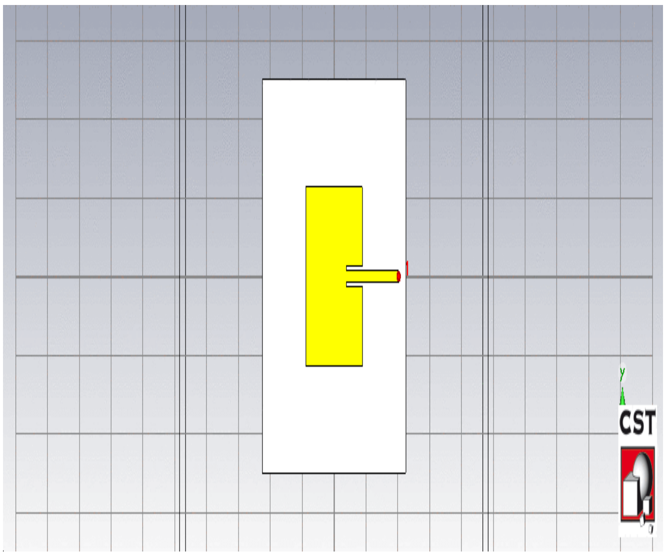

Fig1: Rectangular micro strip patch antenna at 2 GHz (all dimensions in mm).

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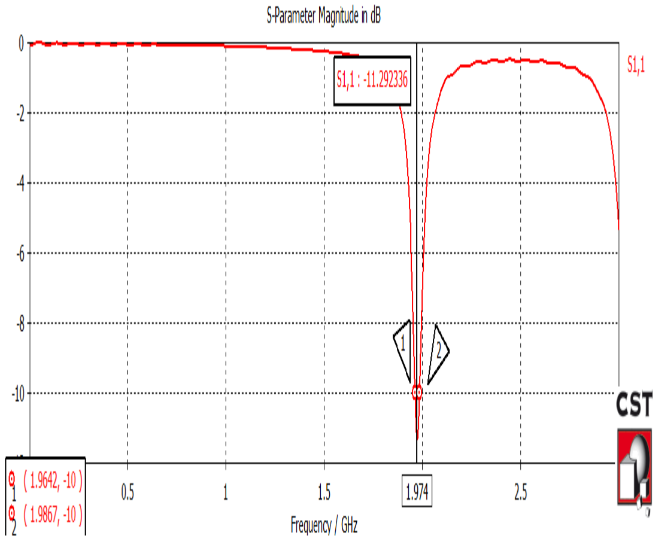

Fig2: Simulated Result of Rectangular micro strip patch antenna showing Return Loss of -11 dB and Bandwidth [6] of 22.5 MHz

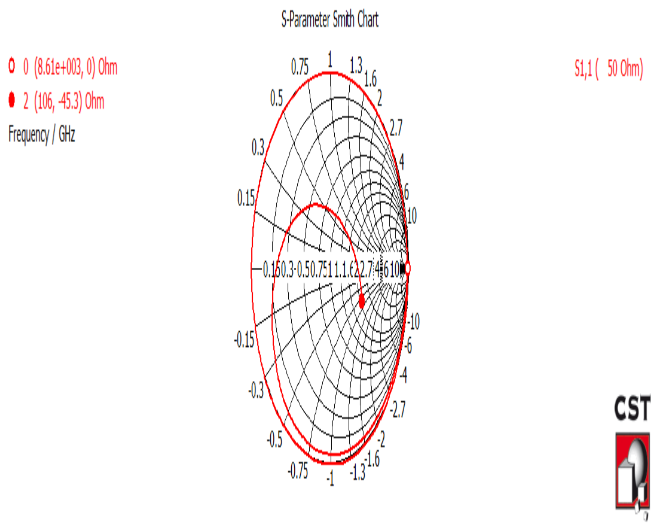

Fig3: Smith chart [7] of the rectangular micro strip patch antenna at 2 GHz

The Simulated result of RMPA along without Metamaterial cover are shown in figure 2 & 4, it has been found that the potential parameter like return loss, bandwidth and directivity.

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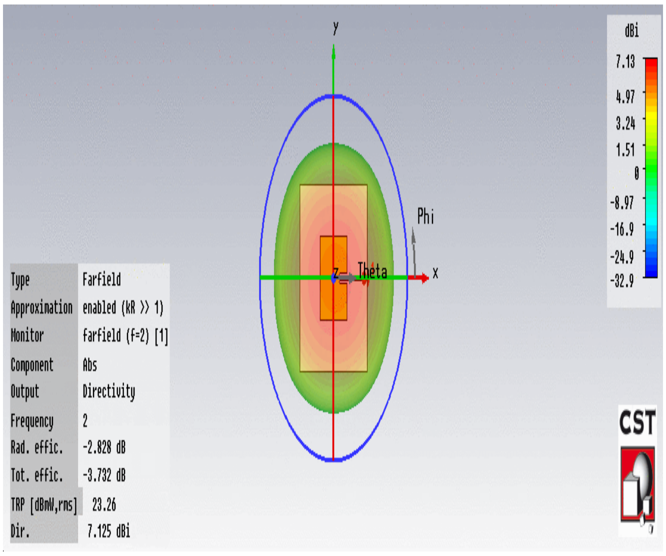

Fig4: Directivity of the rectangular micro strip patch antenna at 2 GHz

III. PROPOSED STRUCTURE OF CIRCULAR SHAPED SPLIT RING RESONATOR WITH RECTANGULAR CROSS STRIPS USING METAMATERIAL.

Metamaterial is an artificial or manmade material which gains its Properties, negative permeability and permittivity from its structure rather than directly from its composition. In this Meta material design, are loaded on the patch antenna. This Meta material Structure is distributed equally with each other and cut vertically with 2 mm width. This design gives the better improvement in impedance bandwidth and reduction in return loss.

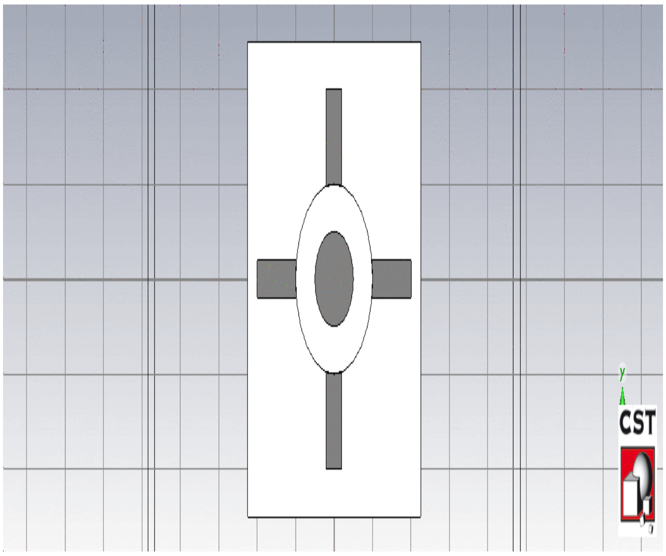

Fig5: Design of proposed metamaterial structure at the height of 3.2 mm from ground plane.

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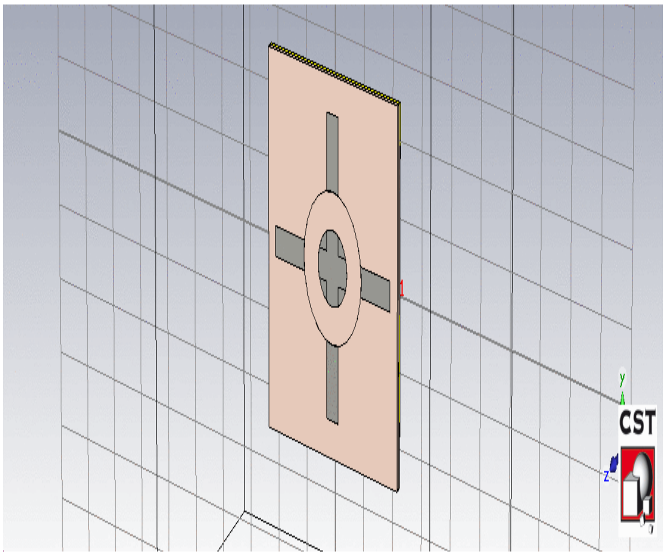

Fig6: Rectangular micro strip patch antenna with proposed Meta material structure.

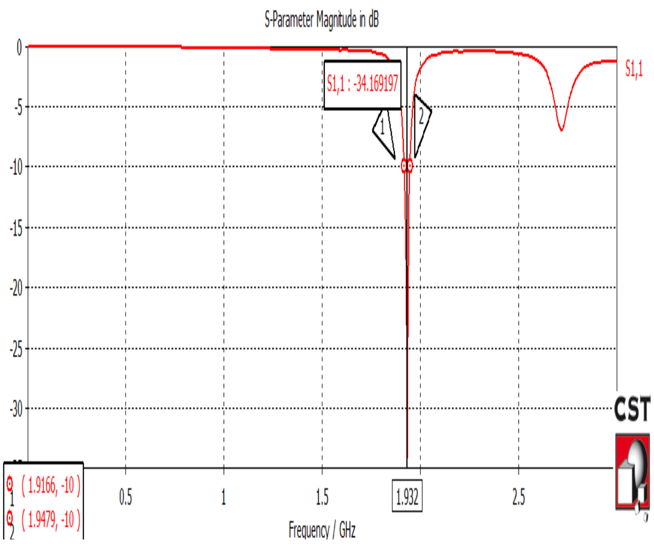

Fig7: Simulated result of the RMPA along with proposed metamaterial cover showing Return Loss of -34.16 dB & Bandwidth of 31.3 MHz In this figure show the return loss and bandwidth of the antenna with metamaterial

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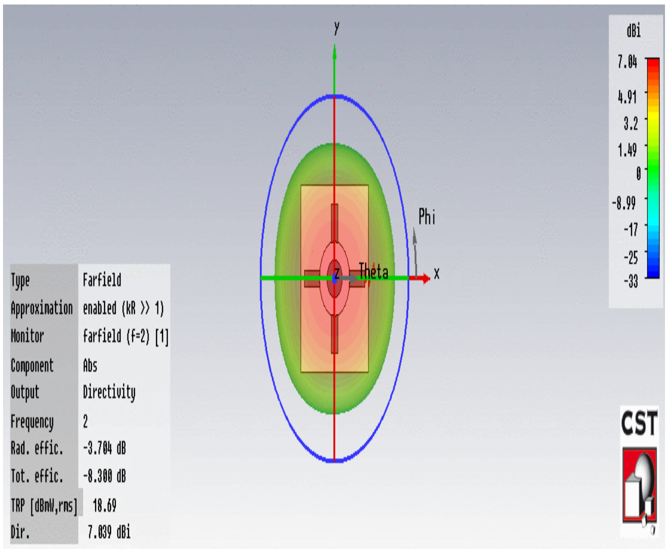

Fig 8: Radiation pattern of proposed antenna showing Directivity of 7.839 dBi.

Directivity is the figure of merits from an antenna it measure the power density the antenna radiate in that direction.

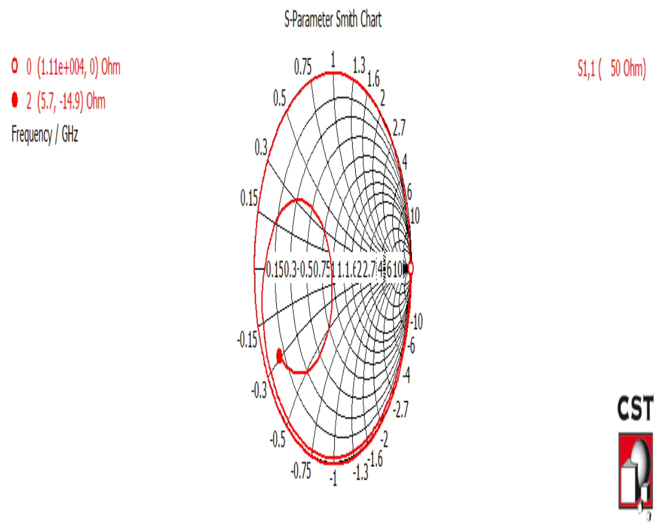

Fig9: Smith chart of RMPA with proposed meta material structure.

The simulated results of the RMPA along with proposed meta material cover are shown in figure 7 & 8, it has been found that the potential parameters like [8][9] (Total efficiency, & directivity) of the proposed antenna increases significantly in comparison to RMPA alone. The return loss of the RMPA along with proposed Meta material cover is reduced by -34.16 dB.

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IV. SIMULATION RESULTS AND THEIR COMPARATIVE ANALYSIS

In this section, the simulated results are presented and compare with the basic RMPA. From the simulated results we can easily say that the proposed design gives better results in term of antenna parameters like return loss, bandwidth, directivity and gain as shown below in the table II.

Parameter	**Without Metamaterial**	**With Metamaterial**
Return Loss	-11.29 dB	-34.169 dB
Bandwidth	22.5 MHz	31.3 MHz
Directivity	7.125 dBi	7.839 dBi
Gain	2.297 dB	3.335 dB

TABLE II: RMPA SPECIFICATIONS with and without metamaterial

From the simulated results of the RMPA along with proposed Meta material cover we found that the potential parameters of the proposed antenna increases significantly in comparison to RMPA alone. The return loss of the RMPA along with proposed Meta material cover is reduced by -34.16 dB.

V. CONCLUSION

The microstrip antenna is simple to fabricate, easy to replacement, low profile and highly efficient. The use of this type of antenna is highly preferred into satellite communication and wireless communication. This antenna gives high gain due to huge reduction in return-loss. The use of Metamaterial provides a large advancement into the parameters of RMPA. In this proposed work we present the advancements into the antenna parameters after the use of meta-material structure at a height of 3.2 mm. The proposed work shows that integration of meta-material design over rectangular patch antenna gives amelioration to the antenna factors like directivity, bandwidth and return loss. These antennas are highly used in mobile and wireless communication the simulated rectangular micro strip patch antenna results in Return Loss of -11.29 dB & 22.5 MHz Bandwidth while when it is designed with Meta material structure at 3.2 mm from the ground plane, it shows Return Loss of -34 .16dB & 31.3 MHz Bandwidth which shows improvement of bandwidth and significant reduction in return loss.

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