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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

Micro strip patch antennas are widely used in wireless application due to great advantages .A Patch antenna is a type of low profile microstrip antenna, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. Patch antennas are simple to design and easy to modify and customize. Factors of the patch antennas can be improved by integrating metamaterial structure on it. Metamaterial is an artificial material which has negative permeability & permittivity hence named also as double negative metamaterial. It is not a practically achieved material but by using some specific designs metamaterial can be verified.

Veselago [1], a Russian physicist was the first which proposed the metamaterial theoretically in 1967. J.B. Pendry had studied further more in the metamaterial field [4]. After that in 2001, Smith made the first prototype structures of LHM [5]. The LHM is a combination of Split Ring Resonator (SRR) and thin wire (TW). Metamaterial is used because it is easy to fabricate simulate and convenient method to ameliorate the antenna parameters. All the simulation work is done on Computer Simulation Technique (CST-MWS) Software.

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)

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

Where, c = free space velocity of light
εr = Dielectric constant of substrate f_r = Relative Frequency

The actual length of the Patch (L)

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

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

Calculation of Length Extension

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

Calculation of VSWR

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

Where Γ = Reflection Co-efficent

Calculation of Return Loss

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

Calculation of Band Width (BW)

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

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

b) **Analysis of rectangular micro strip patch antenna**

TABLE I: RMPA SPECIFICATIONS

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

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 ε_r = 4.3 and height from the ground plane d= 1.6 mm.

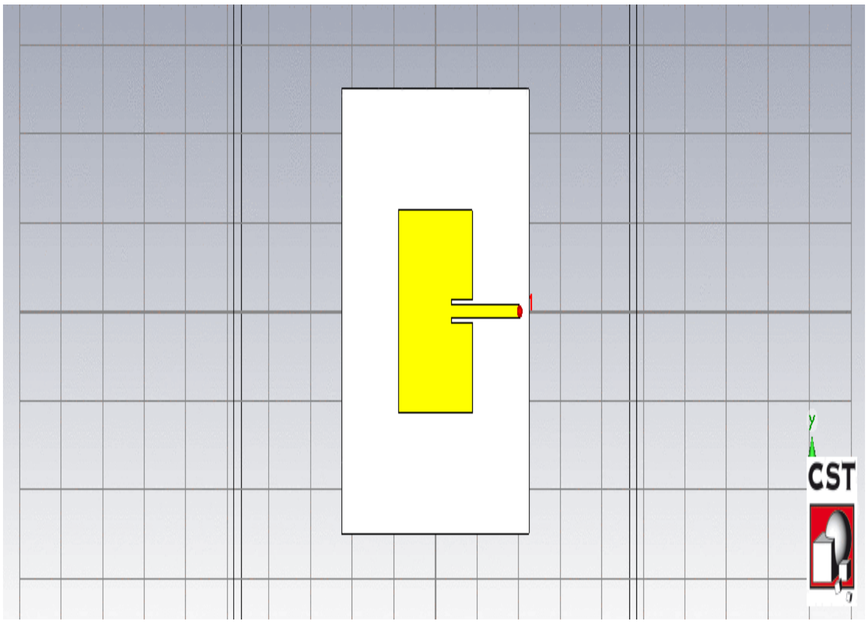

Fig1: Rectangular micro strip patch antenna at 2 GHz (all dimensions in mm).

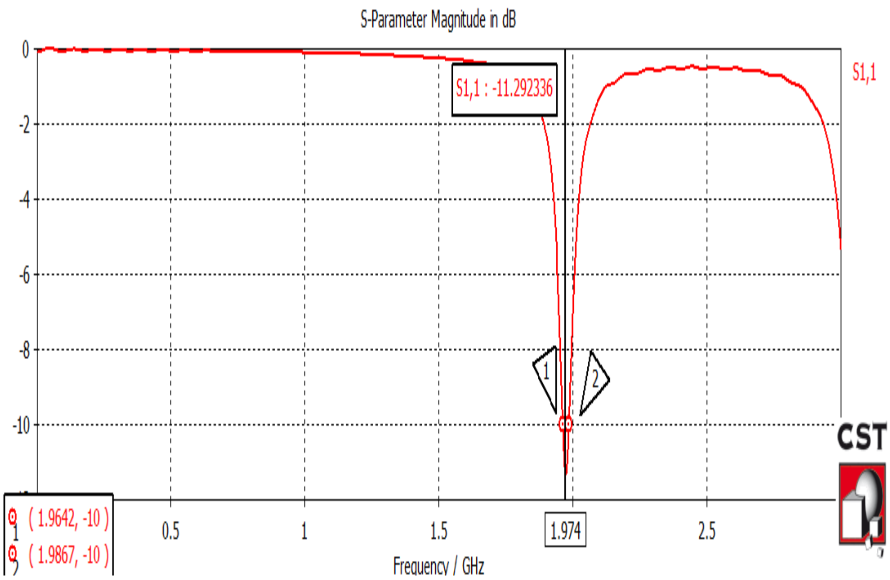

Fig2: Simulated Result of Rectangular micro strip patch antenna showing Return Loss of -11 dB and Bandwidth [6] of 22.5 MHz.

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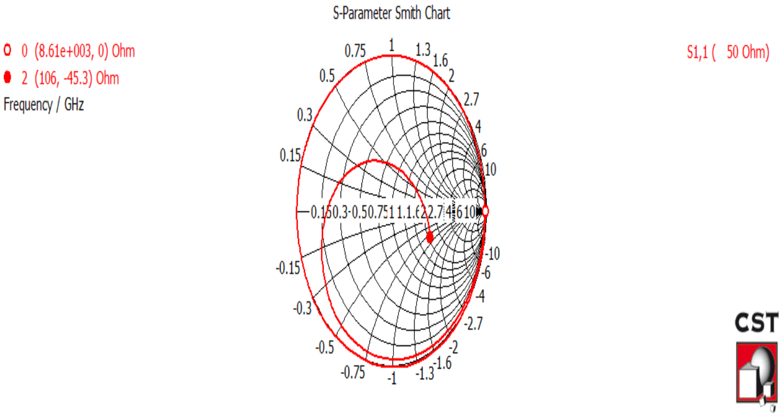

Fig3: Smith chart [7] of the rectangular micro strip patch antenna at 2 GHz

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.

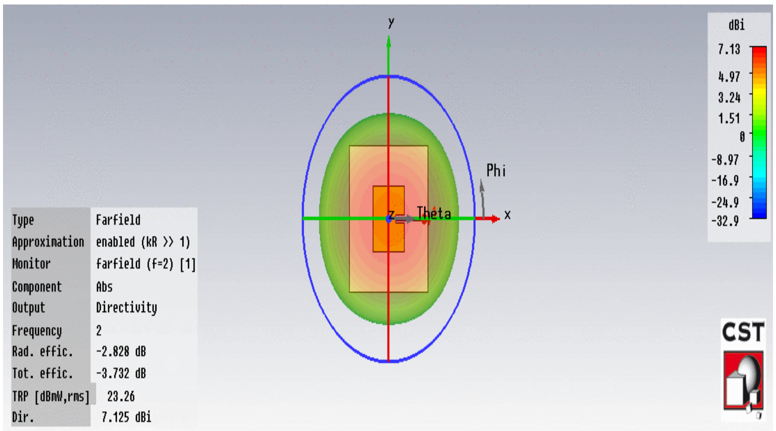

Fig4: Directivity of the rectangular micro strip patch antenna at 2 GHz

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.

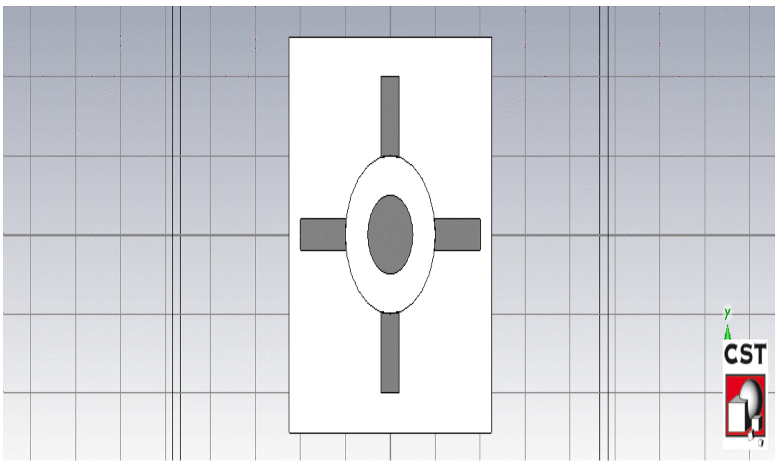

Fig5: Design of proposed metamaterial structure at the height of 3.2 mm from ground plane.

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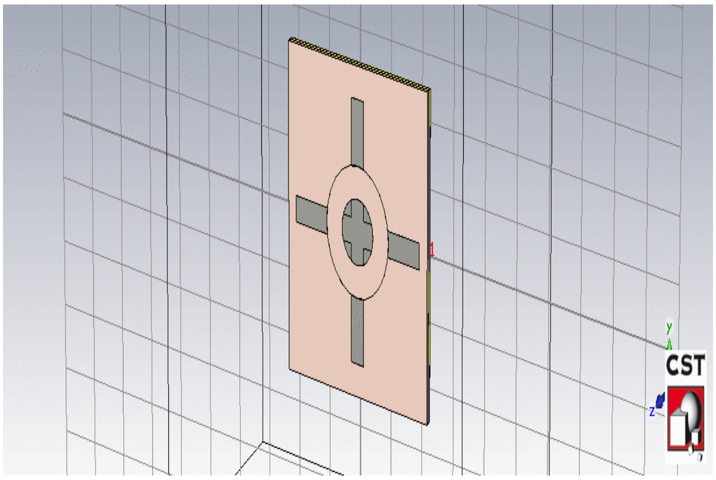

Fig6: Rectangular micro strip patch antenna with proposed Meta material structure.

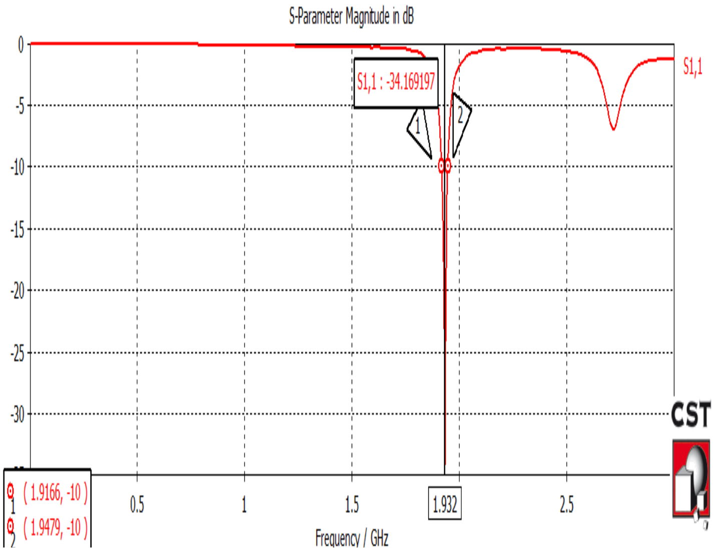

Fig7: Simulated result of the RMPA along with proposed metamaterial cover showing Return Loss of -34.16 dB & Bandwidth of 31.3 MHz. In this figure show the return loss and bandwidth of the antenna with metamaterial

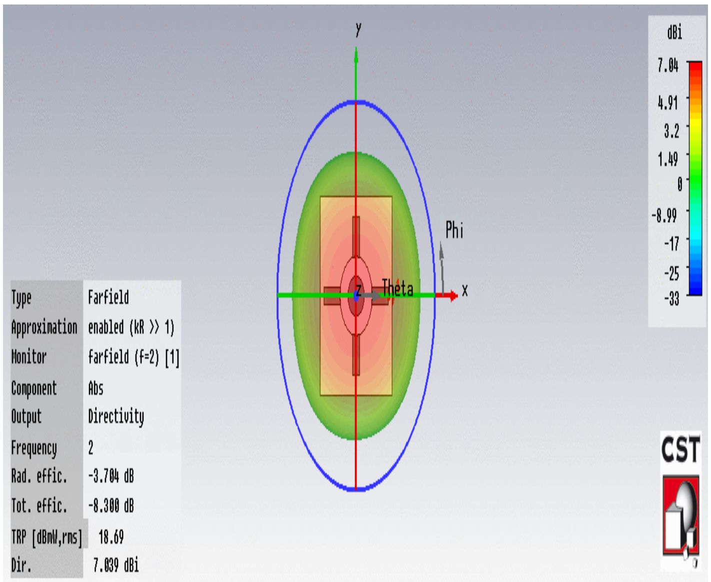

Fig 8: Radiation pattern of proposed antenna showing Directivity of 7.839 dBi.

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

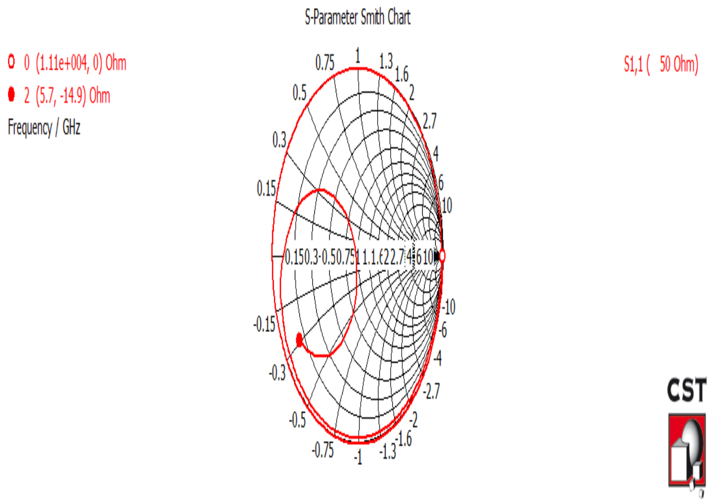

Fig9: Smith chart of RMPA with proposed meta material structure.

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.

IV. SIMULATION RESULTS AND THEIR COMPARATIVE ANALYSIS

In this section, the simulated results are presented and compare with the basic RMPA. From the 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.

TABLE II: RMPA SPECIFICATIONS with and without metamaterial

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

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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