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Compact Patch Antenna Parameters Integrating Using Left Handed Meta Material at 2.41GHz

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Abstract
This paper propose a new generation of antenna design that applies Meta material properties at the height of 3.2mm above from the ground Plane. Paper also analyzed the performance of Ractangular Micro strip Patch Antenna with and without using the Meta material structure. All antenna parameters such as Return Loss, Gain, Directivity and Band width were measured. The main focus of this paper was to improve Return loss so that Patch antenna used for wide band applications. The additional features were its compact size and used in multiband operation.

Keywords
RMPA (Rectangular Micro strip Patch Antenna), CST (Computer Simulation Technique), Bandwidth, Return loss.

1. INTRODUCTION

A. Rectangular Microstrip Patch Antenna

Micro strip antennas are largely used in many wireless communication systems because of their low profile and light weight. The substrates of dielectric constant are usually in the range of 2.2 to 12. Meta materials (MTMs) denote artificially constructed materials having electromagnetic properties not generally found in nature. Examples include photonic band gap structures [2, 9] and double negative (DNG) media [1][3][8], i.e., MTMs having negative permittivity and negative permeability. In RMPA having a lot of advantages (low profile, low cost and omnidirectional radiation patterns etc.), it has some drawbacks like narrow bandwidth and low gain [10]. Several researches have been done to overcome their drawbacks. In this context Victor Vesalago [11, 12] introduced the theoretical concept of meta material in 1967. According to the theory of Vesalago, these materials are generally artificial materials used to provide properties which are not found in readily available materials in nature [13, 14]. Later on J.B. Pendry and his colleagues, [15] added more information into the theory of meta material [16].

In this paper, Rectangular Microstrip patch antenna with Height of 1.6mm & 4.3 dielectric constant. FR4 Substrate whose dielectric constant is 4.3 are used for investigate the better result. This design is operated at 2.41GHz frequency. In RMPA having a advantages (low profile, low cost and

omnidirectional radiation patterns etc.), it has some drawbacks like narrow bandwidth and low gain. To overcome this problem we use meta material with double negative property of veselago media at a height of 3.2mm with the ground plane.

2. FORMULA SECTION WITH DESIGN METHODOLOGY & SIMULATED RESULTS

Formula Used For Designing of RMPA [17, 18]
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
ε_r = Dielectric constant of substrate

The effective dielectric constant of the RMPA

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right) \quad (2)$$

The actual length of the Patch (L)

$$L = L_{eff} - 2\Delta L \quad (3)$$

Where

$$Leff = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}} \quad (4)$$

Calculation of Length Extension

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)} \quad (5)$$

Table I. shows the dimensions of the RMPA (rectangular micro strip patch antenna), also the simulated results are shown in fig2&fig3. After designing & simulating the RMPA, the proposed Meta material Structure is taken into analysis as shown in fig5.

Table1. RMPA Specifications

PARAMETER	DIMENSION	UNIT
Dielectric Constant	4.3	-
Loss Tangent	0.02	-
Thickness	1.6	mm
Operating Frequency	2.41	GHz
Length (L)	28.56	mm
Width (W)	36.85	mm
Cut Width	5	mm
Cut Depth	10	mm
Path Length	28.4288	mm
Feed Width	3	mm

In this paper, a rectangular micro strip patch antenna are designed. The width, length and height for ground plane are 36.85mm, 28.56mm and 1.6mm.The substrate height is 1.6mm with dielectric constant is 4.3 are taken to design the antennas. The operating frequency is 2.41GHz. The more parameters are define in above table1.

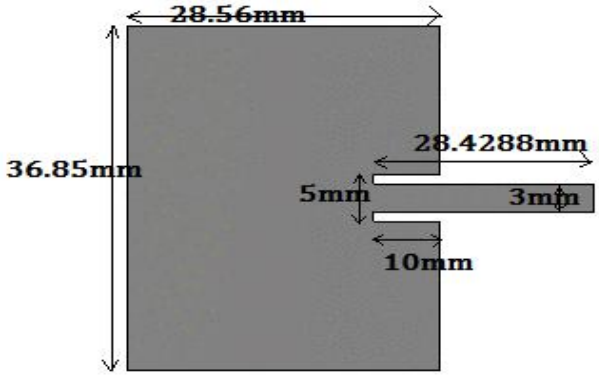

Fig 1: Rectangular micro strip patch antenna at 2.41 GHz (all dimensions in mm).

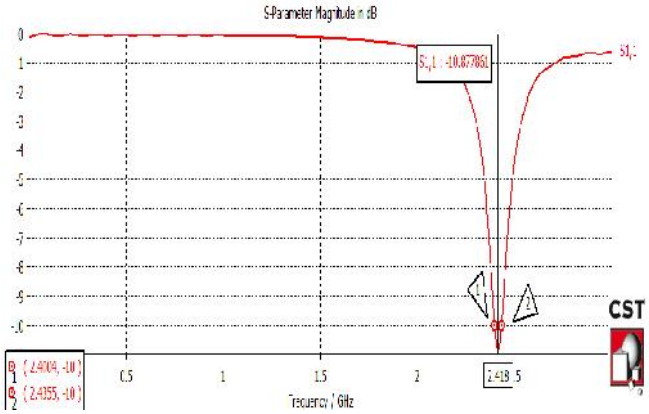

Fig2: Simulated Result of Rectangular micro strip Patch antenna showing Return Loss of -10.87 dB & bandwidth of 35.1 MHz.

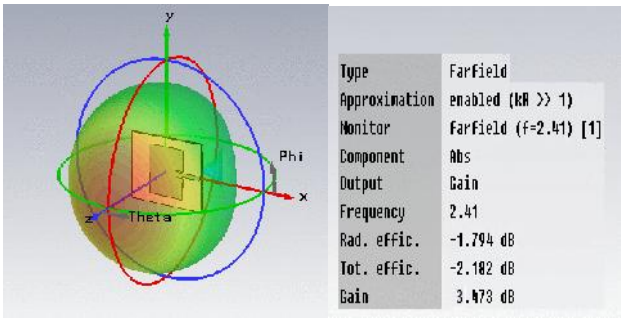

Fig3: Radiation Pattern of Rectangular micro strip patch antenna showing Gain of 3.473 dB.

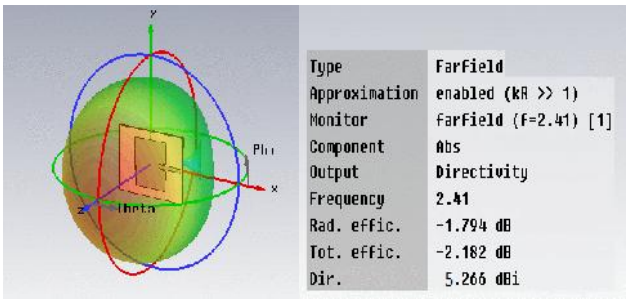

Fig4: Radiation Pattern of Rectangular micro strip patch antenna showing Directivity of 5.266 dBi.

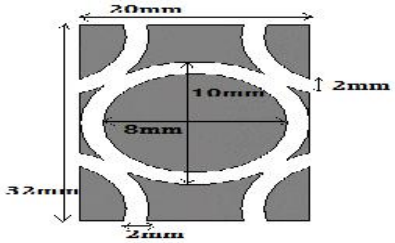

Fig5: Rectangular micro strip patch antenna loaded with "Slotted Circular Ring with Rectangular" Meta material Structure (All dimensions in mm).

Then, the "Slotted Circular Ring with Rectangular" meta material structure is placed above the patch antenna at a height of 3.2 mm from ground plane in order to study its influence, and the results are compared with those of the Patch antenna alone.

3. RESULT

A Research on [19, 20] meta material was carried out to understand the fundamentals of the newly discovered substance. The simulated result of rectangular micro strip patch antenna with "Slotted Circular Ring with Rectangular" The results of structure is shown in figure 2&7. At 2.41GHz frequency the simulated rectangular micro strip patch antenna results in Return Loss of -10.87dB & 35.1MHz Bandwidth while when it is designed with "Slotted Circular Ring with Rectangular" meta material structure at 3.2mm from the ground plane, it shows Return Loss of -37.02dB& 53.0MHz Bandwidth which shows improvement of bandwidth and significant reduction in return loss.

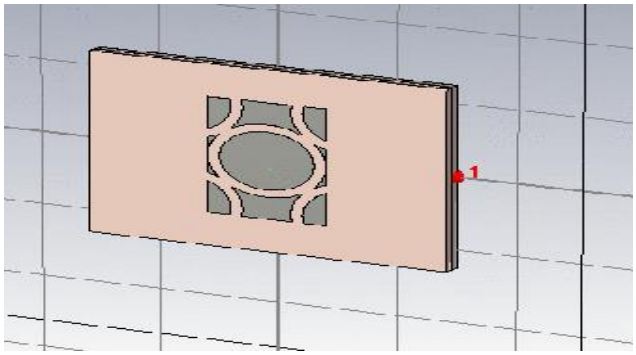

Fig6: Rectangular micro strip patch antenna with proposed meta material structure.

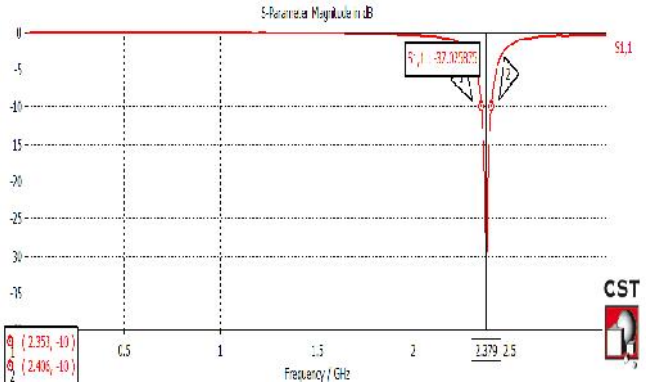

Fig7: Simulated Return Loss of Rectangular micro strip patch antenna loaded With "Slotted Circular Ring with Rectangular" meta material Structure.

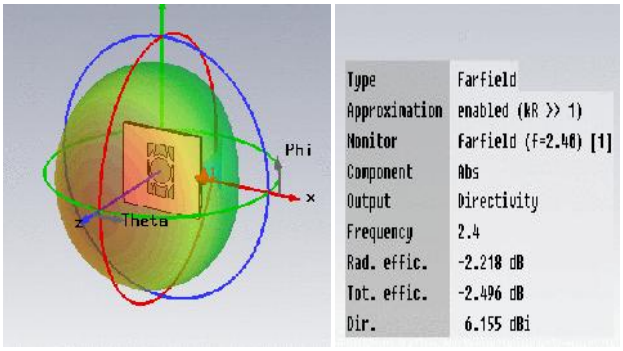

Fig8: Radiation Pattern of the RMPA along with proposed meta material cover showing Directivity of 6.155dBi.

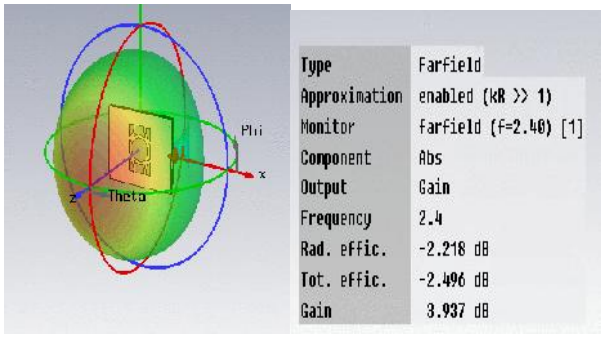

Fig9: Radiation Pattern of the RMPA along with proposed meta material cover showing gain of 3.937dB.

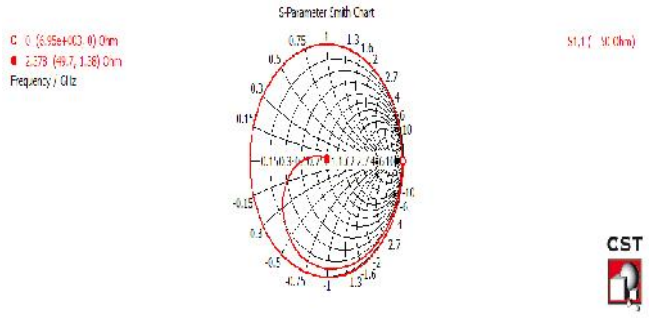

Fig10: Smith chart of the RMPA along with proposed meta material cover at 2.41GHz.

Fig9 shows the smith chart [21] of the RMPA along with proposed metamaterial cover, it is clear from the figure that the impedance of the antenna is matched with the coaxial cable i.e., 50Ω.

4. CONCLUSION

The "Slotted Circular Ring with Rectangular" meta material structure with RMPA antenna has been proposed in this paper. This antenna gives high gain due to huge reduction in return-loss. By using CST simulation software we can easily analyze that there is an amendment in to the bandwidth (34 MHz), gain and return loss is improved upto 0.464dB & -26.15 dB. The Compare result of patch antenna & meta material at 2.41GHz operating frequency in given below Table II.

Table II. Comparison Result of Designed Antenna

Parameters	Patch result	Metamaterial result
Return loss	-10.87dB	-37.02dB
Bandwidth	35.1MHz	53.0MHz
Gain	3.473dB	3.937dB
Directivity	5.266dBi	6.155dBi
Impedance	41.5ohms	49.7ohm

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