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Design and Analysis of RMPA with Metamaterial

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ABSTRACT: A Rectangular microstrip patch antenna is designed with a hybrid shaped metamaterial structure at a height 3.2 mm from the ground plane. This paper show comparison between Rectangular microstrip patch antenna alone and Rectangular microstrip patch loaded with hybrid shaped metamaterial which results in enhancement in gain, bandwidth, Directivity and Return loss at same resonant frequency. The resonance frequency of the designed antenna is 2.1GHz.The 10 dB impedance bandwidth of the designed antenna is 31.10 MHz. The return loss of the antenna is reduced by 35 dB .This antenna is small size, cheap, compact and easy to fabricate, and achieve good radiation characteristics with higher return loss. This antenna can have wide application in a great variety of wireless communication.

KEYWORDS: Rectangular Microstrip Patch Antenna (RMPA), Metamaterials, Bandwidth, Return Loss, NRW.

I. INTRODUCTION

In the recent years the development in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies. The future development of the personal communication devices will aim to provide image, speech and data communications at any time, and anywhere around the world.

This indicates that the future communication terminal antennas must meet the requirements of multiband or wideband operations to sufficiently cover the possible operating bands. The performance of the fabricated antenna was measured and compared with simulation results [1]. Moreover, we have also indicated the appropriate choice of particular metamaterial for different specific purposes like antenna size reduction and other mode modification-related applications [2]. The performance of a rectangular patch antenna array on a metamaterial substrate was studied relative to a similar array constructed on a conventional FR4 substrate [3].In modern wireless communication systems, the microstrip patch antennas are commonly used in the wireless devices. The demand in commercial and military wireless systems is due to capabilities of proposed antenna such as low weight, low profile, low cost, easily combined with design and technology, and relatively simple fabrication.

All these antennas can also fabricate using CST simulation software and get very sharp characteristics. Proposed RMPA can be largely used in many wireless communication systems because of their low profile and light weight Microstrip antennas are largely used in many wireless communication systems because of their low profile and light weight [5]. Metamaterial based rectangular microstrip patch antenna improves the bandwidth and return loss in significant way. CST MICROWAVE STUDIO is a software package for the electromagnetic analysis and design, use to design the metamaterial based rectangular microstrip patch antenna.

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II. LITERATURE SURVEY

In early 1970's when the conformal antennas became necessity for missiles then Micro strip antennas are introduced in practical application. Microstrip antennas are more useful due to their conformability, low cost, and light weight. Microstrip antennas can integrate with the printed strip-line feed networks and the active devices. Recently Microstrip antennas are used in revolution in the electronic circuit miniaturization. Microstrip antennas are based on photolithographic techniques so they have small size and low cost as compared to costly and bulky conventional antennas. This makes a relative new generation of the antenna engineering. Now a days Microstrip patch antennas have more and more importance. Microstrip antennas are versatile in terms of the possible geometries so they are applicable for different situations. Microstrip antennas have more applications in field of the telecommunications.

They have low volume, low profile, low cost, light weight, ease of fabrication and conformity and small dimension. So recently they made great progress. Microstrip patch antennas have better prospects and many advantages as compared to the conventional antennas. Microstrip patch antennas are more popular in area of wireless applications because of their low-profile. So Microstrip antennas are much compatible for the embedded antennas in the handheld wireless devices like pagers, cellular phones etc. Microstrip antennas are small in size and thin so they can be used as telemetry and communication antennas on the missiles.

Garg, Agrawal & Sharma, proposed a reduced size RMPA incorporated with interconnected framed shaped metamaterial structure which best suited for wireless LAN applications and evaluated satisfactory results.

Gangwar, Das & Yadava proposed a technique for reduction of mutual coupling in metamaterial based microstrip antennas. This work presents a novel defected ground structure. The performance of microstrip antennas and their array can be enhanced by introducing the defects in the ground plane with metamaterial structures.

III. EVALUATE DESIGN PARAMETERS OF A SINGLE MSA

The basic parameters of an RMPA must be calculated before design and analysis. The RMPA parameters are calculated from the formulas given below [6-7]. The three essential parameters for the design of a RMPA are:

For an efficient radiation, the width of the RMPA can be written as:

$$W = \frac{c}{2 f_r \sqrt{\frac{\varepsilon_r + 1}{2}}}$$

The length of the antenna is given by

$$L = L_{eff} - 2\Delta L$$

Where, The effective length is given by

$$L_{eff} = \frac{c}{2 f_o \sqrt{\varepsilon_{ref}}}$$

The length extension is:

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

And the effective dielectric constant is given as:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-1/2}$$

Inset length of the patch for inserting microstrip feed line

$$Y_o = 10^{-4}[0.001699\varepsilon_r^{\ 7} + 0.13761\varepsilon_r^{\ 6} - 6.1783\varepsilon_r^{\ 5} + 93.187\varepsilon_r^{\ 4} - 682.69\varepsilon_r^{\ 3} + 2561.9\varepsilon_r^{\ 2} - 4043\varepsilon_r^{\ 1} + 6697]\frac{L}{2}$$

After optimization, the parameters of rectangular microstrip patch antenna are specified in the Table1 and dimensional view is shown in figure 1.

Table 1: RMPA Specifications

PARAMETERS	DIMENSIONS
Thickness (h)	1.6 mm
Length (l)	34.11386 mm
Width (w)	43.87822 mm
Cut Width	7.4 mm
Cut Depth	10 mm
Path Length	38.99604 mm
Feed Width	6.0 mm
Operating Frequency	2.1 Ghz
Dielectric Constant (ε_r)	4.3
Loss Tangent (tan ∂)	0.002

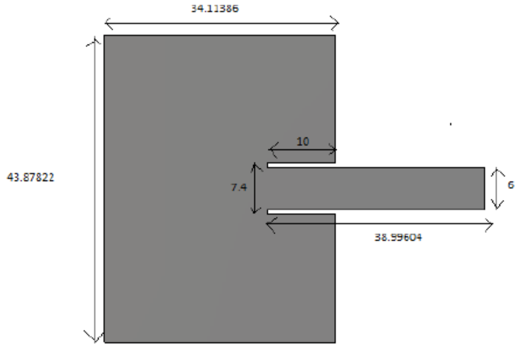

Figure 1: RMPA designed for 2.1Ghz.

The Simulated Results of RMPA is shown in figure 2. The CST-MWS (computer simulation Technology) was chosen to simulate the structures shown in the figures below.

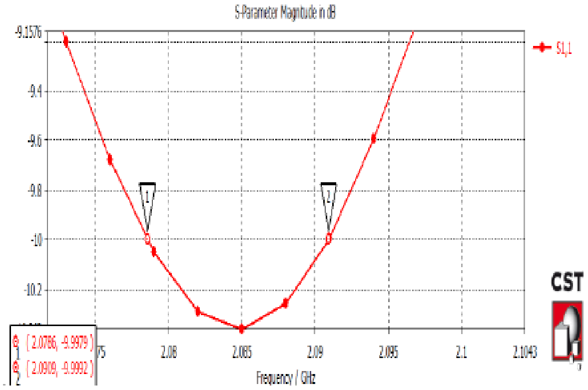

Figure 2: Simulated Result of RMPA.

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IV. ANALYSIS OF RMPA WITH METAMATERIAL STRUCTURE

The former designed RMPA is than loaded with a hybrid shaped metamaterial structure and it 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. The required specifications of this design are shown in the figure 3.

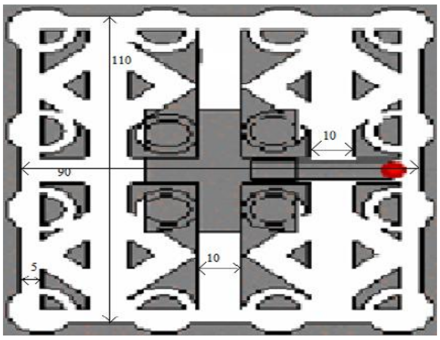

Figure 3: RMPA with a metamaterial structure.

V. SIMULATION RESULTS

A Research on [8-9] metamaterial was carried out to understand the fundamentals of the newly discovered substance. The simulated result of RMPA with hybrid shaped structure is shown in figure 4, 5 & 6. At 2.1 Ghz frequency the simulated rectangular microstrip patch antenna results in Return Loss of -10.5dB & 12.1 MHz Bandwidth while when it is designed with hybrid shaped metamaterial structure at 3.2mm from the ground plane, it shows Return Loss of -45 dB & 31.10 Mhz Bandwidth which shows significant improvement of bandwidth [12] and reduction in return loss. The Return Loss of the proposed metamaterial structure is reduced by 35dB [10-11] in comparison to the RMPA alone. The response of the proposed metamaterial when tested with the help of spectrum analyzer shows the return loss of -42db & 29.5 Mhz band width which is slightly less than the simulated response due to the practical conditions & limitations.

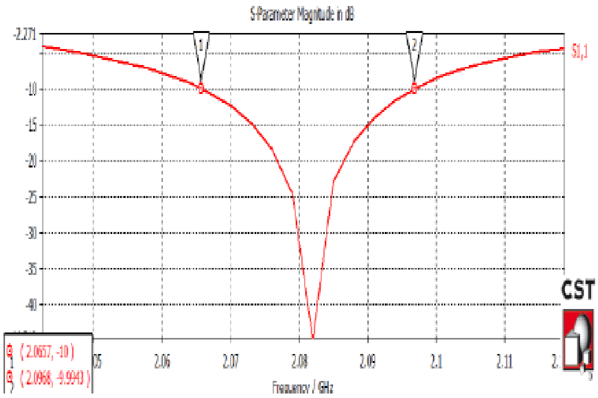

Figure 4: Simulated result of RMPA With hybrid shaped metamaterial Structure.

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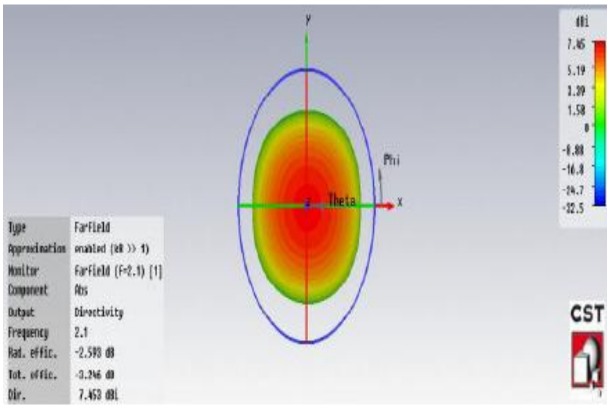

Figure 5: Radiation Pattern of RMPA With a metamaterial Structure.

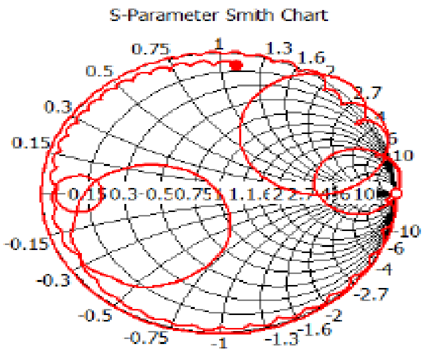

Figure 6: Smith Chart of RMPA with hybrid shaped metamaterial Structure.

Smith Charts [13] shown in figure 6 represents the impedance matching of antenna with coaxial cable of 50 ohm.

VI. TEST OF FABRICATED RMPA WITH METAMATERIAL

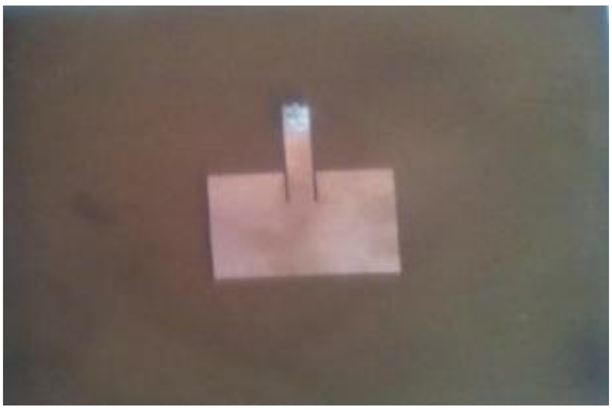

Figure 7: Rectangular microstrip patch antenna.

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Figure 8: RMPA wth hybrid metamaterial.

Figure 9: Analysis of RMPA with hybrid shaped metamaterial structure.

VII. CONCLUSION

The above simulated results show that the hybrid shaped metamaterial structure with RMPA performs well as compared to the single RMPA design. The simulated results provide high gain, increase total efficiency, and directivity improvement and wide bandwidth and this leads us to fabricate the structure. After making some variations in antenna parameter we can increase the gain up to desired level but there are some practical limitation which should be taken care while fabricating such structures.

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