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Design of Slotted Square Microstrip Patch Antenna Connected with Rectangular Shaped Meta Material Structure to Enhance Parameters at 2.6GHz

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Abstract

In this work, Rectangular Micro strip Patch Antenna (RMPA) along with Meta material which has design of "Slotted Square Connected with Rectangular shaped cover structure" is proposed at height of 3.2 mm from the ground plane. The RMPA with proposed Meta material structure is designed to resonate at 2.6 GHz frequency. This work is mainly focused on increasing the potential parameters of micro strip patch antenna. Proposed Meta material structure is significantly reduced the return loss and increased the bandwidth and directivity of the antenna with compare to RMPA alone. The bandwidth is increased up to 22MHz in comparison to RMPA alone. The return loss of proposed antenna is reduced by 41.88dB by incorporating the proposed Meta material structure. For simulation purpose CST-MWS Software has been used.

***Keywords**: (RMPA), Double Negative, Left-Handed Meta material, Bandwidth, Slotted Square, Return Loss*

1. Introduction

Left-handed Meta material is a substance with simultaneously negative values of permittivity and permeability. In year 1968 Victor Vesalgo [1] had given the concept of Meta material. This artificial has several special properties that doesn't find in the natural material, for example propagation of wave in opposite to that of the flow of energy and the focusing effect inside it slab. Vesalgo concluded that materials with negative refractive index might be synthesized by using the materials having positive refractive index and found in nature. But after a long time in 1996 Pendry and his colleagues [2] and in year 2001 smith fabricate a structure which is a composition of split ring resonator and thin wire. It is combined known as LHM [3]. In fact many researches were done to increase the response of micro strip antenna as this type of antenna is desired for its low cost properties but compromises in gain and directivity. In micro strip patch antenna, using split ring resonator and wired based structure we can improve its bandwidth and gain[4-7]. Simulation of this LHM geometry is targeted to operate at 2.6 GHz where it shows the negative permittivity and negative permeability. Micro strip patch antennas have several advantages compared to convention Microwave antennas, and therefore many applications cover the broad frequency range from 100MHz to 100GHz.

2. Desired Parametric Analysis

Calculation of Width (W)

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

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Where,
c = free space velocity of light
ε_r = Dielectric constant of substrate

The effective dielectric constant of the Microstrip antenna to account for fringing field. [14]

Effective dielectric constant is calculated from**:**

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

The actual length of the Patch (L)

$$L = L_{eff} - 2\Delta L \tag{3}$$

where

$$Leff = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \tag{4}$$

Calculation of Length Extension

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

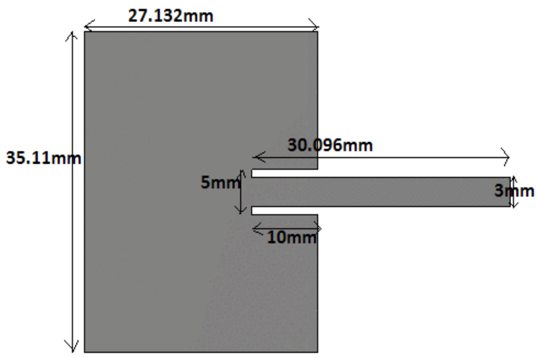

Figure 1. The Rectangular Micro Strip Patch Antenna is Shown in Figure

Essential parameters of the design are shown in Table 1.

Table 1. Rectangular Micro strip Patch Antenna Specifications

Parameters	Magnitude	Unit
Dielectric Constant	4.3	-
Loss Tangent	0.02	-
Thickness (h)	1.6	mm
Operating Frequency	2.6	GHz
Length (L)	27.132	mm
Width (W)	35.1104	mm
Cut Width	5	mm
Cut Depth	10	mm
Path Length	30.196	mm
Width of Feed	3.0	mm

Then, the Slotted Square connected with Rectangular Meta Material Structure Micro Strip Patch Antenna At 2.6GHz 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 antenna alone.

3. Design and Analysis of RMPA with Meta Material Structure

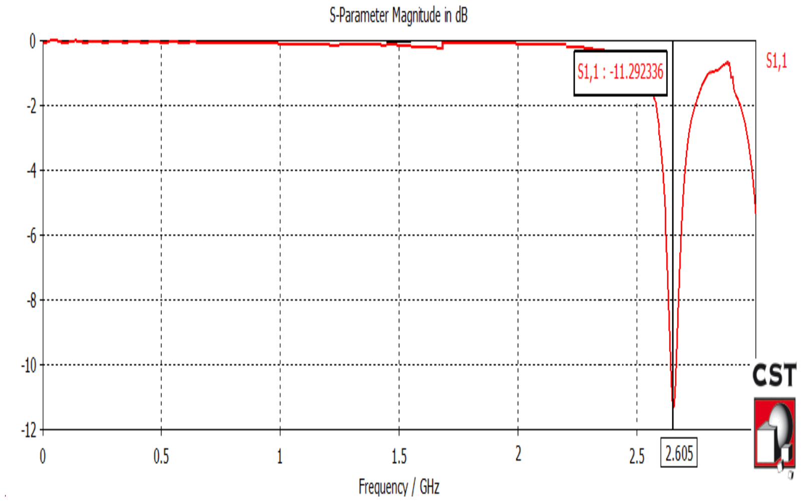

Figure 2. Rectangular Micro Strip Patch Antenna at 2.6 GHz

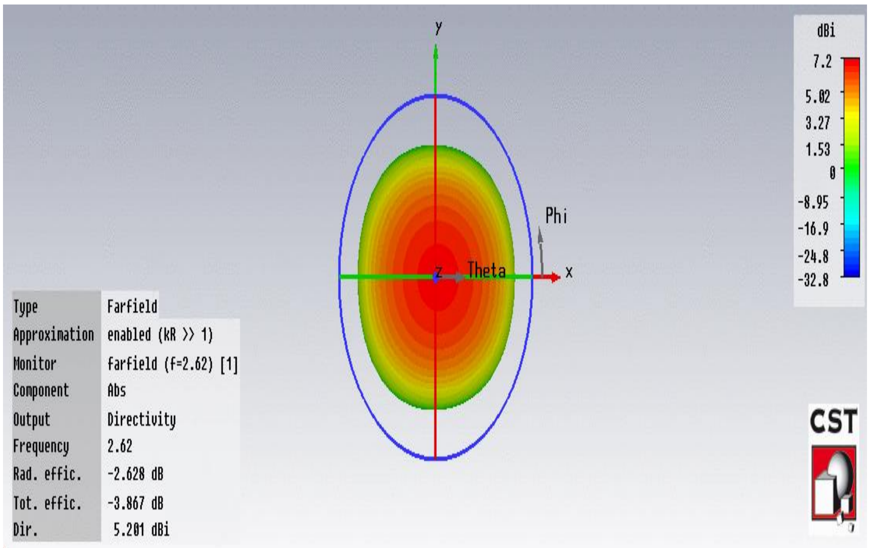

Figure 3. Radiation Pattern of RMPA Showing Directivity of 5.201dBi

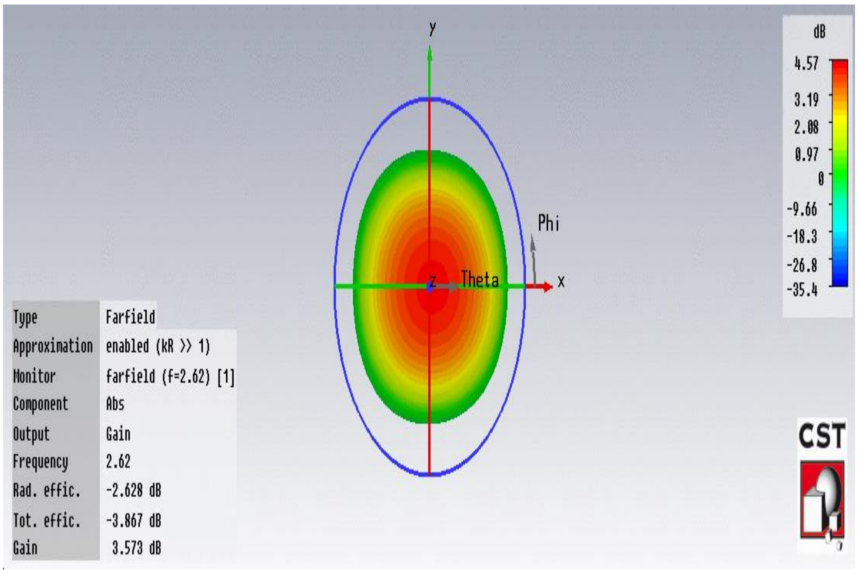

Figure 4. Radiation Pattern of RMPA Showing Gain of 3.573dB

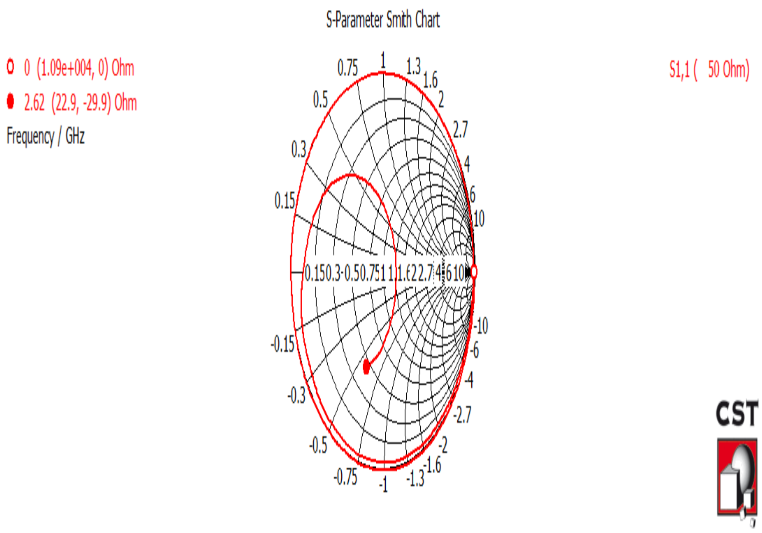

Figure 5. Smith Chart of RMPA at the 2.62GHz

4. Designing and Simulation of Slotted Square Microstrip Patch Antenna Connected with Rectangular shaped Meta Material Structure

When the proposed structure is incorporated with the RMPA, it shows the improved impedance bandwidth [9] of 22MHz & Return Loss of -41.88Db.

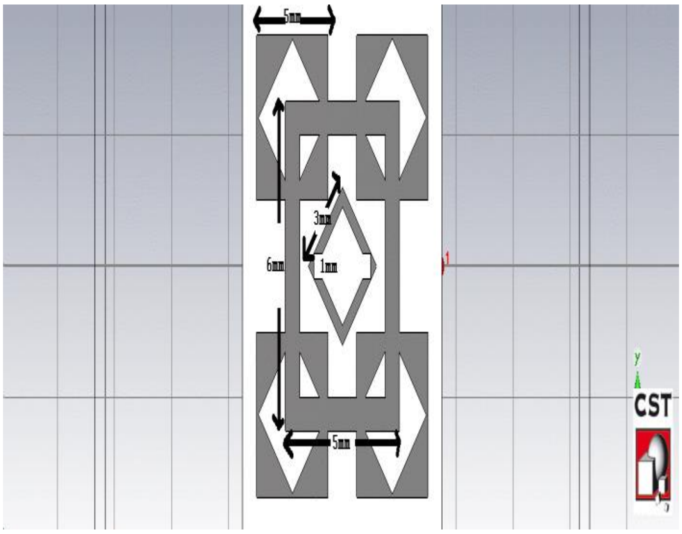

Figure 6. Rectangular Micro strip Patch Antenna loaded with "Square Connected with Rectangular" Shaped Meta Material Structure. (All Dimensions in mm)

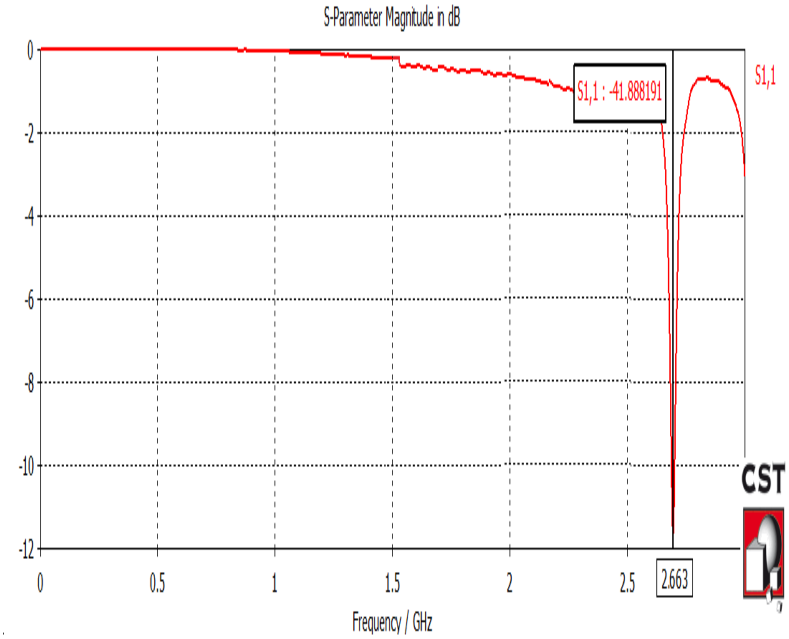

Figure 7. Simulated Result of Proposed Meta Material Structure Showing Return Loss of -41.88dB and Bandwidth of 22 MHz

Simulation result of Return loss Rectangular micro strip patch antenna loaded with Meta material structure is shown in Figure 7.

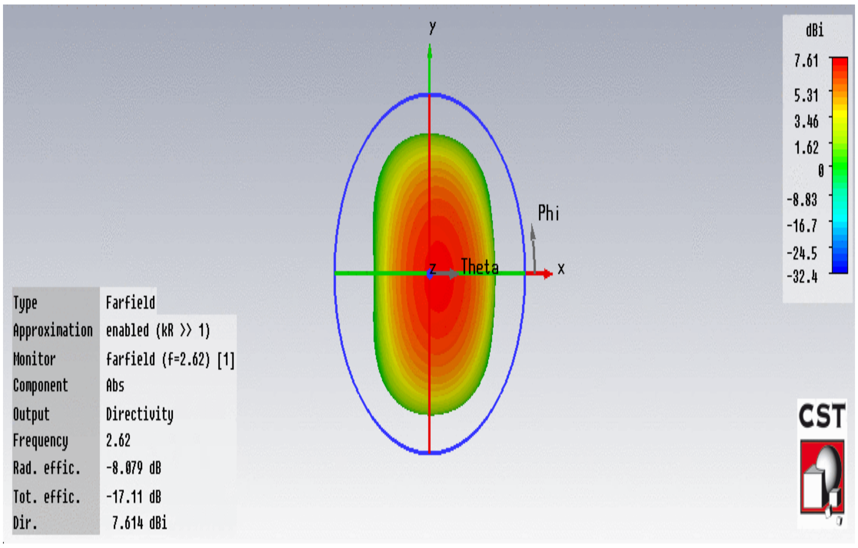

Figure 8. Shows the Improved Directivity [12-13] in Z Direction with Respect to the Proposed Meta Material Antenna

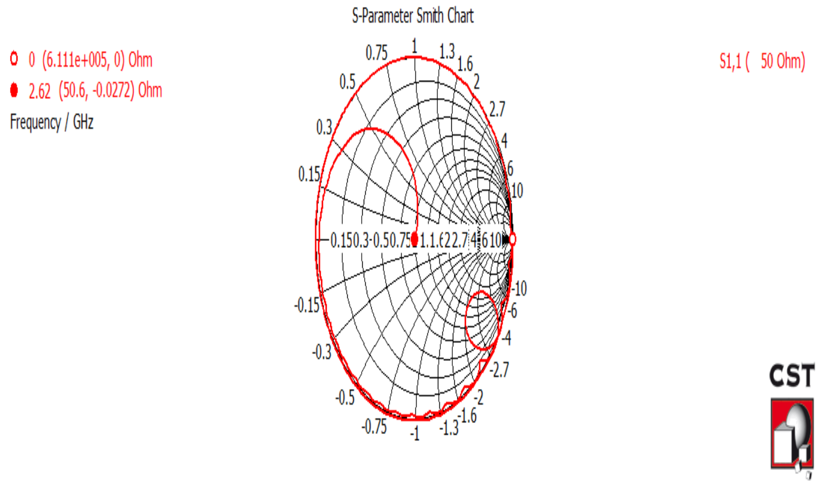

Figure 9. Smith Chart of the Proposed Meta Material Structure at 2.62GHz

The smith chart is very useful when solving transmission problems. The real utility of the Smith chart, it can be used to convert from reflection coefficients to normalized impedances (or admittances), and vice versa.

5. Conclusion

In this work, the behavior of a Rectangular Micro strip Patch Antenna loaded with "Square Connected with Rectangular" shaped double negative Meta material structure at a height of 3.2mm from the ground plane is examined. It is revealed that integrating the proposed Meta material structure with the patch antenna at a height of 3.2mm from the ground plane, significantly improves the potential characteristics of the antenna. The proposed "Square Connected with Rectangular" Meta material structure is electrically small and suitable to handle easily. The proposed antenna could be used in several microwave applications that requires improved bandwidth & reduced return loss at the operating frequency. The simulated results provide that, improvement in the bandwidth is 22 MHz and the Return loss of proposed antenna is reduced by -41.88 db. It is clear that we can easily overcome the drawbacks of RMPA by using the properties of Meta material (MTM).

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