# Rectangular Microstrip Patch Antenna for Wide Band Communication Application

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## ABSTRACT

Rectangular microstrip antenna is a low profile, light weighted and simple to manufacture, however it likewise have a few disadvantages like low productivity, high return loss, low directivity and so on. Right now, structure have been fused on fix recieving wire for improving the parameters of microstrip fix radio wire. Metamaterial has some properties because its negative values of permeability and permittivity. The suggested microstrip patch antenna along with metamaterial cover provides the better response in comparison to patch antenna alone. In this work, the bandwidth of directional device has become twice and the return loss reduced more than one by two times of previous one.

**KEYWORDS:** *Metamaterial (MTM), Permittivity and Permeability, Nicolson-Ross-Weir (NRW), Rectangular Microstrip Patch Antenna (RMPA).*

## INTRODUCTION

Metamaterial are artificial, manmade structures not found in nature. Its permittivity & permeability both are negative [1] so it is also called Double Negative Material (DNG). A microstrip patch antenna is also known as flat panel directional device which can be mounted on a flat surface. It consists of a flat rectangular sheet mounted over a dielectric substrate and ground. The concept of microstrip patch antenna was introduced in 1953[2] but it became popular in 1970. These antennas are having various properties like low volume, inexpensive etc. so it is used in high performance aircraft, missile application, satellite etc.

## DESIRED FORMULAE FOR CALCULATION

Width of the Patch (W):

$$W = \frac{\quad}{2 f_r} \qquad (1)$$

Effective dielectric constant:

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

Th:

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

Where,

(4)

Calculation of Length Extension:

(5)

Where,

C = Velocity of light in free space,

$\varepsilon_r$ = Dielectric constant of substrate,
$f_r$ = Resonating frequency,
$\varepsilon_{reff}$ = Effective dielectric constant,
h = Height of dielectric substrate,
W = Width of patch,
L = Length of patch and
$\Delta L$ = Effective Length

After calculation, the value of patch width is 43.67 mm and the value of patch length is 33.948 mm for operating frequency 2.058 GHz. The RMPA is fabricated on FR-4 lossy with h = 1.6 mm and $\varepsilon_r$ =4.3.

## DESIGNING AND SIMULATION

Process of simulation and designing of RMPA are performed in Computer Simulation Technology (CST) Software.

### *Designing of microstrip patch antenna*

After the calculation of patch width and length, antenna designed in this work. FR-4 lossy substrate and the area of ground are same and it is 90×60 $mm^2$. All the specifications of lone RMPA shown in figure 1 where resonating frequency is 2.058 GHz.

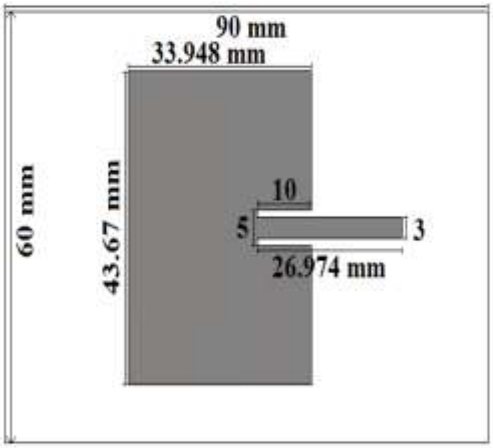


**Fig. 1: Dimensional View of RMPA at 2.058 GHz.**

### *Simulated result after designing RMPA*

In S-parameter, it indicates by $S_{11}$. In the beginning, the impedance bandwidth of the RMPA is 36.6MHz and the Return Loss is -14dB[17], as shown in figure 2.

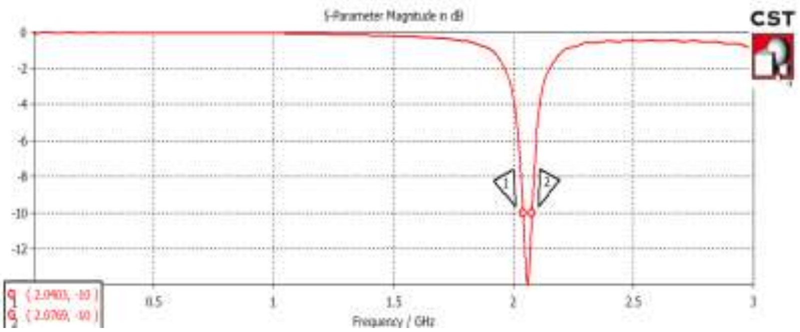


**Fig.2: Simulated Result of RMPA where Return Loss of -14 dB and BW of 36.6 MHz.**

The radiation pattern specified the power received and radiated by antenna is depending on the angular position and radical distance from the antenna. The pattern of radiation of the RMPA at operating frequency 2.058 GHz is shown in figure 3.

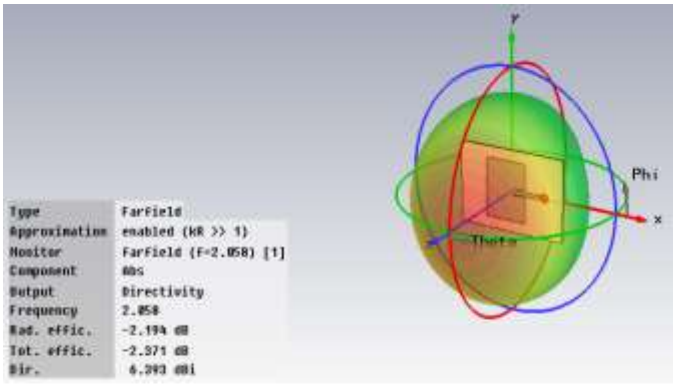


**Fig. 3: Radiation Pattern of RMPA showing 76.29% total efficiency & 6.393 dBi directivity.**

### *Designing of Metamaterial Cover on RMPA*

After simulating the lone RMPA, the suggested material cover is placed on the RMPA at a height of 1.6mm from the designed antenna. The design of material cover has two circles and one octagon as shown in figure. Suggested cover is shown in figure 4.

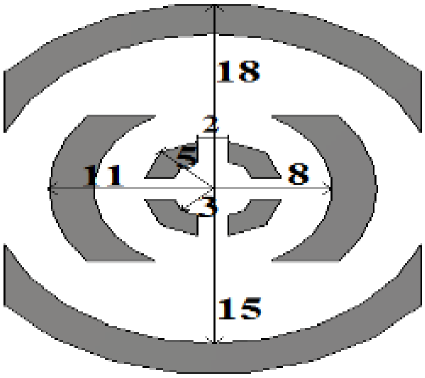


**Fig. 4: Dimensional outlook of the suggested cover**

### *Simulated result after placing suggested cover*

Proposed designed structure is incorporated with the RMPA shows the better impedance BW of 71.9MHz and reduced return loss of -35dB as in Figure 5.

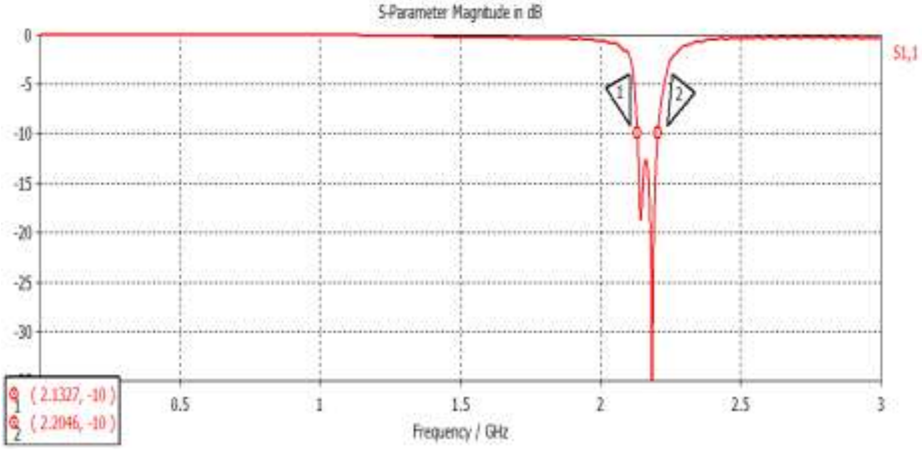


**Fig. 5: RMPA with suggested material cover has Return Loss of -35dB and BW of 71.9MHz.**

Pattern of the radiation of RMPA along with metamaterial cover at resonating frequency 2.184 and the directivity of 6.736dBi and efficiency of 75.62%.

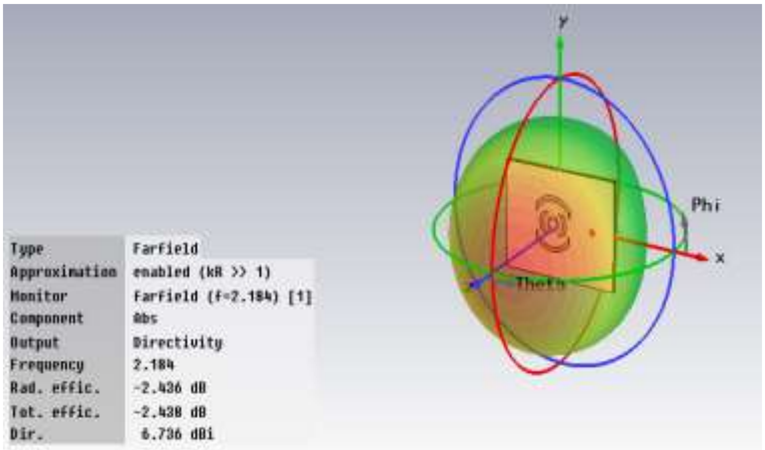


**Fig. 6: RMPA radiation pattern along with the suggested material cover showing total efficiency of 75.62% and the directivity 6.736dBi.**

***Nicolson-Ross-Weir (NRW) Approach***

NRW approach is used for proving that the suggested material shows double negative property. By this approach, determined value of permittivity & permeability and verified that these are negative in a certain range of frequency.

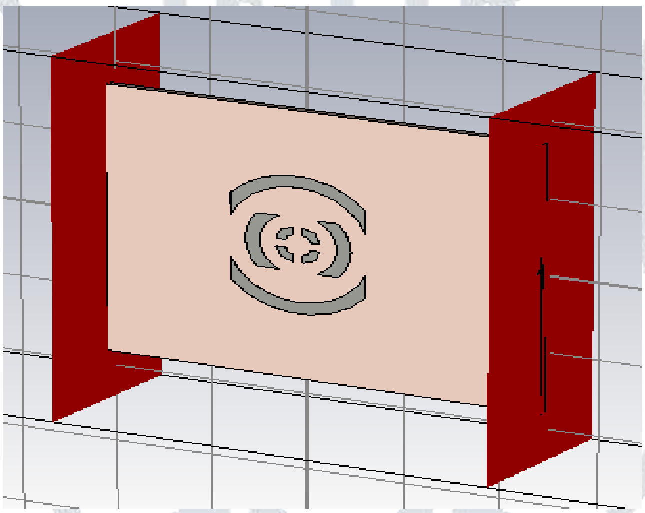

**Fig. 7: Suggested material cover placed between the two Waveguide Ports.**

Using NRW approach, the values of $S_{11}$ and $S_{21}$ parameters are in complex form for verify the double negative properties of the proposed material cover structure.
Following Formulae are used to calculate the value of permeability and permittivity using NRW approach [9][10][12]:

(6)

(7)

Where,

= +

$_2$ =

ω = Frequency in Radian,
d = Thickness of the Substrate,
C = Speed of Light,

$V_1$ = Voltage Maxima, and

$V_2$ = Voltage Minima.

The values of $\varepsilon_r$ and $\mu_r$ are calculated by using equations 6 & 7 in the simulated frequency range. Graph in figure 8 and figure 9 shows that in particular frequency range.

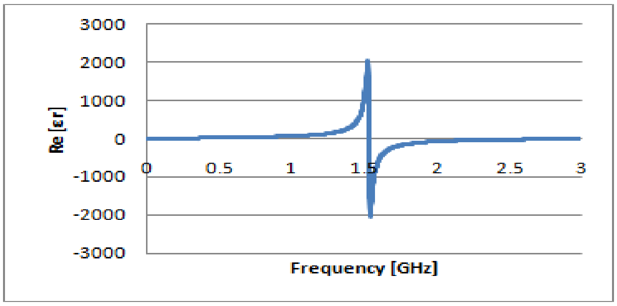


**Fig. 8: Plot between Permittivity and Frequency.**

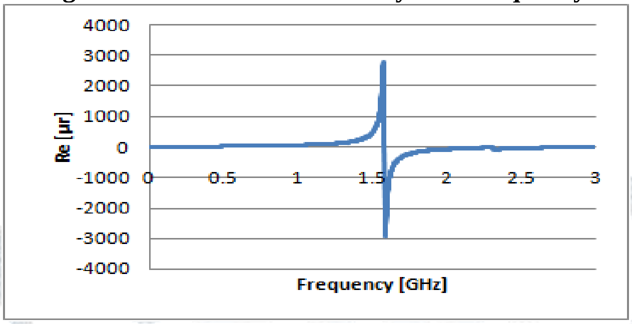


**Fig. 9: Plot between Permeability and Frequency.**

Between the frequency range 2.118 - 2.211 GHz, table 1and 2 shows the negative values of permeability and permittivity.

**Table 1: Permittivity values at frequency range 2.118 - 2.211 GHz.**

| Sample Point | Frequency(GHz) | Real value of Permittivity Re($\varepsilon_r$) |
|---|---|---|
| **710** | 2.118 | -57.109 |
| **716** | 2.1359999 | -54.868 |
| **722** | 2.1539998 | -52.593 |
| **728** | 2.1719999 | -50.115 |
| **734** | 2.1900001 | -47.686 |
| **741** | 2.211 | -45.014 |

**Table 2: Permeability values at frequency range 2.118 - 2.211 GHz.**

| Sample Point | Frequency(GHz) | Real value of Permeability Re($\mu_r$) |
|---|---|---|
| **710** | 2.118 | -54.113 |
| **716** | 2.1359999 | -50.878 |
| **722** | 2.1539998 | -46.763 |
| **728** | 2.1719999 | -42.625 |
| **734** | 2.1900001 | -39.111 |
| **741** | 2.211 | -34.319 |

*New Dimensions of RMPA*

After placing the suggested cover on the RMPA at the height of 1.6mm from the designed directional device, the dimensions of RMPA along with metamaterial are shown in table 3.

**Table 3: Dimensions of RMPA along with metamaterial**

| Parameters | Dimension of RMPA | New Dimension of Proposed RMPA | Unit |
|---|---|---|---|
| **Panel Length** | 33.948 | 31.948 | mm |
| **Panel Width** | 43.670 | 37.270 | mm |
| **Cut Depth** | 10 | 9 | mm |
| **Cut Width** | 5 | 6 | mm |
| **Feed Length** | 26.974 | 24.974 | mm |
| **Area of Ground** | 90×60 | 90×70 | $mm^2$ |
| **Width of Feed** | 3 | 3.4 | mm |

In this section, simulation results were presented. It is observed that the parameters of RMPA are improved after putting suggested cover. Figure 2 & 5 shows that the rproposed metamaterial structure has less return loss i.e 21 dB and better bandwidth which is 35.3MHz. Radiation Pattern directivity is slightly improved by 0.343 dBi. Figure 8 and figure 9 verifies double negative [11] properties of the proposed inspired metamaterial Structure.

## CONCLUSION

The intention of this work is to design a miniature size, power efficient and low cost antenna that could be used for wide band communication applications. In this work, it has been observed that the behavior of RMPA metamaterial structure at the height of 3.2mm from the ground plane is better than lone RMPA. So RMPA loaded with metamaterial can be used in more communication application comparison to lone RMPA.

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