

# Design and Simulation of Compact Microstrip Patch Antenna by Using Metamaterial for WLAN

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## Abstract

In this paper development and design of microstrip patch antenna with SRRs (Split Ring Resonators) and Rods are introduced. To enhance better performance of microstrip patch antenna SRRs and rods are used. Metamaterial technique is used for designing. Substrate FR-4 is used which has dielectric constant 4.9. The results of return loss and VSWR are far much better. The return loss of microstrip patch antenna at operating frequency 4.864 GHz is -25.688 dBi and VSWR is 1.109. The simulated and measured results of the proposed antenna are obtained by using CST Software.

## Keywords

Microstrip Patch Antenna, Metamaterial, SRRs (Split Ring Resonators), Rods, Permeability, Permittivity, Return Loss

## I. Introduction

Nowadays, Wireless communication systems have grown drastically. The microstrip patch antennas are commonly used as the wireless devices. As according to that multifunction antennas have been designed for multipurpose operation over different wireless services. Also user demands exhibits the need for compact, reliable and efficient, wireless systems, integrating whole transmitter and receiver system on a single chip. So, the compactness of patch antenna is important issue nowadays. Different design methods used for reducing size of patch antennas are inserting slots, the corrugation structure, iris structure and the shorting pin. But these antennas designing methods having complex structures and have low performance. Recently designed methods used for reduction of size of patch antenna are to introducing SRR and CSRR on patch antennas which having simple structures and better performance also [1-2]. In other words achievements of size reduction of antenna with SRR and CSRR has a special meaning [3]. Metamaterials investigated theoretically to represents the normalized frequency effects on electromagnetic wave propagation. The Left handed materials are widely used. The properties of normal guided modes of Metamaterials waveguide are totally different than the conventional waveguide because of no cut-off thickness for the first mode of metamaterial wave-guide. And this gives solution to the problem of energy transmission below the diffraction limits [4]. In this paper, for patch antenna SRR and rods are introduced and substrate FR-4 is used. The proposed antenna takes an advantage over the previous published miniaturized of patch antenna research.

## II. Design and Methodology:

The proposed microstrip patch antenna with the FR-4 substrate dielectric material which has relative permittivity ( $\epsilon_r$ ) 4.9 having height ~1mm are used by introducing SRR between the two layers of substrate. The dimensions  $l$  and  $w$  radiating patches which excited by 50  $\Omega$  microstrip feed, by using quarter wave length transformer having dimensions  $l_i$  and  $w_i$ ,  $l_j$  and  $w_j$  for the impedance matching. The ground patch antenna dimensions are

$l_t$  and  $w_t$ . The results shown here are by introducing SRRs and rods structure in Antenna. Antenna operating frequency is 4.864 GHz. The model of the antenna simulated and optimized by using popular software CST. The metamaterial resonator having the negative permeability which is SRR, was proposed by Pendry in 1999 [5]. The SRR, Rods and Microstrip patch antenna geometry shown in figures below:

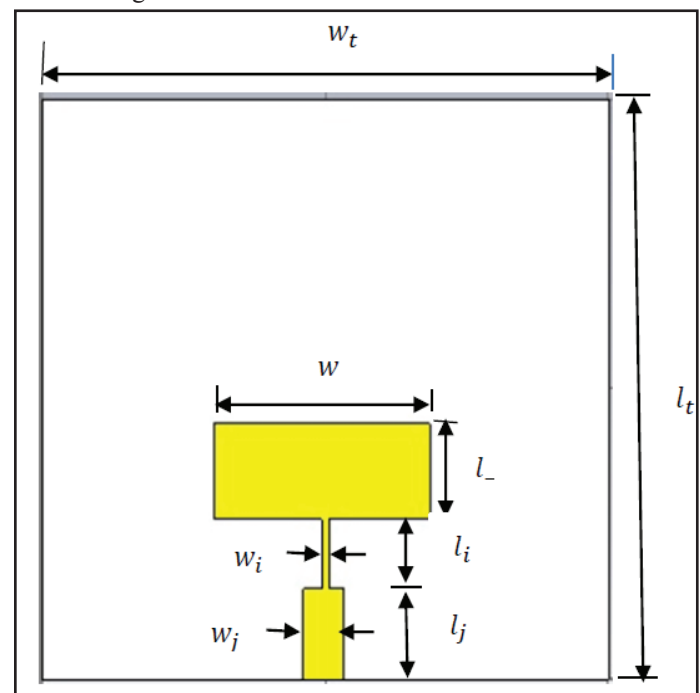


Fig. 1: Front View of Proposed Antenna

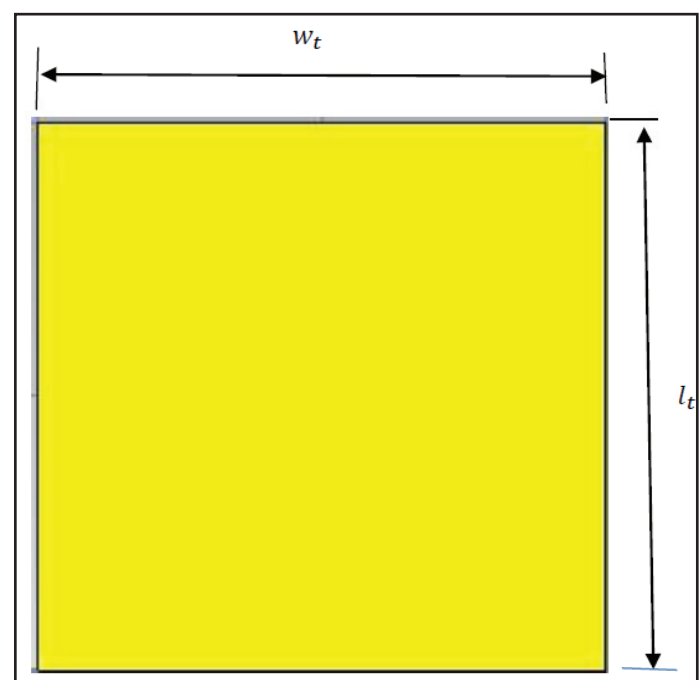


Fig. 2: Back View of Proposed Antenna

Parametric representation of the patch antenna is given in Table 1 below:

Table 1: Parameters of Proposed Antenna

| Parameters | Dimensions (mm) |
|------------|-----------------|
| $l_t$      | 40              |
| $w_t$      | 40              |
| $l$        | 11.35           |
| $w$        | 15.25           |
| $l_i$      | 4.90            |
| $w_i$      | 0.50            |
| $l_j$      | 6.15            |
| $w_j$      | 3.5             |

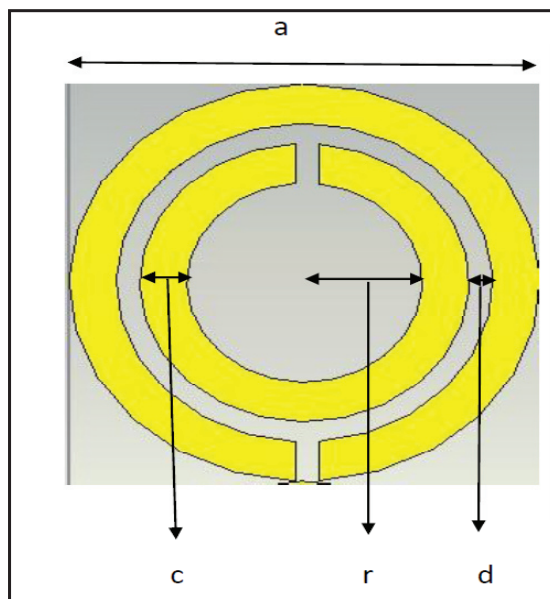


Fig. 3: Split Ring Resonator (SRR)

Parametric representation of Split Ring Resonator is given in Table 2 below:

Table 2: Parameters of Split Ring Resonator

| Parameters | Dimensions (mm) |
|------------|-----------------|
| $a$        | 10              |
| $c$        | 1               |
| $d$        | 0.5             |
| $r$        | 2.5             |

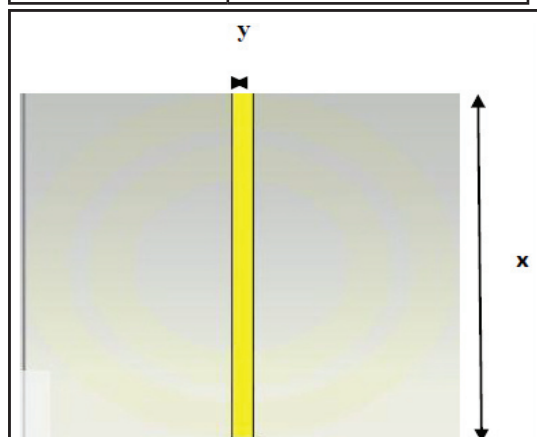


Fig. 4: Rod

Table 3: Parameters of Rod

| Parameters | Dimensions (mm) |
|------------|-----------------|
| $x$        | 10              |
| $y$        | 0.5             |

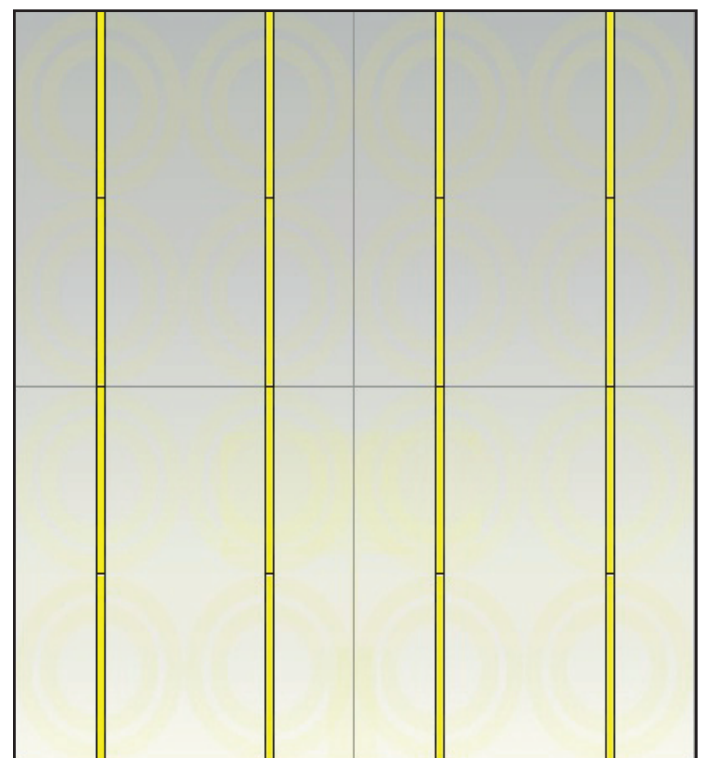
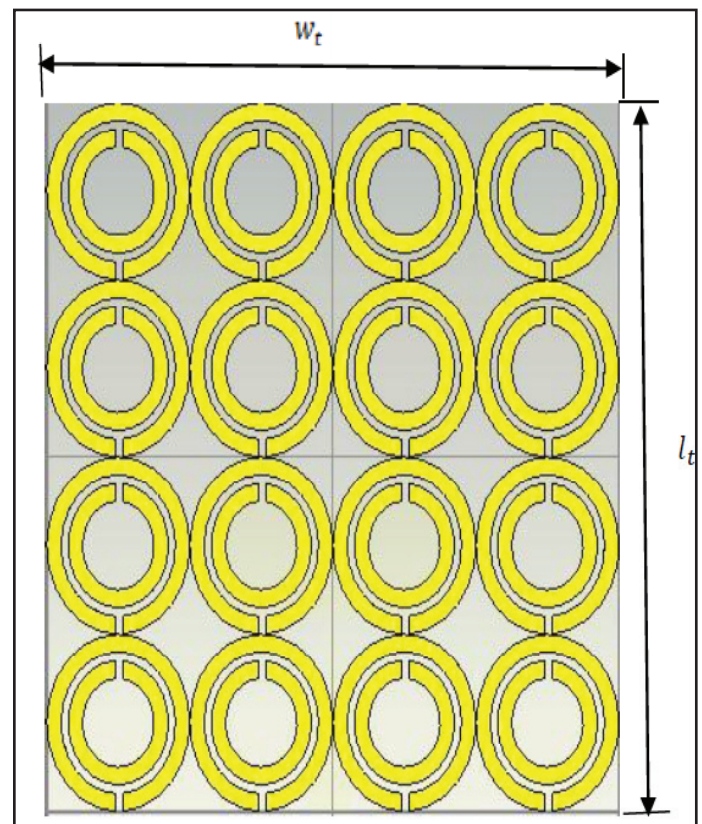


Fig. 5: Introducing SRR and Rods in Proposed Antenna

The above fig. represented that arrays of SRR and rods are introduced in such a way in the proposed antenna.

**Return loss:-** Return loss is the loss of power in the signal returned/ reflected by a discontinuity in transmission line or optical fiber. It is usually expressed as the ratio in decibels (dB),

$$RL \text{ (dB)} = 20 \log_{10} \frac{SWR}{SWR-1}$$

Where RL (dB) is return loss in dB, and SWR is Standing Wave Ratio.

By using the equation,  $BW = \left[ \frac{f_2 - f_1}{f_c} \right] \times 100\%$ , Impedance [5].

Bandwidth over return loss less than -10dB can be calculated, where  $f_1$  is lower cut off frequency,  $f_2$  is upper cut off Frequency of Band and  $f_c$  is center frequency of  $f_2$  and  $f_1$  [5]. The simulated return loss characteristics of proposed antenna is -25.688 dB at 4.864 GHz which is less than the -2.688 dB.

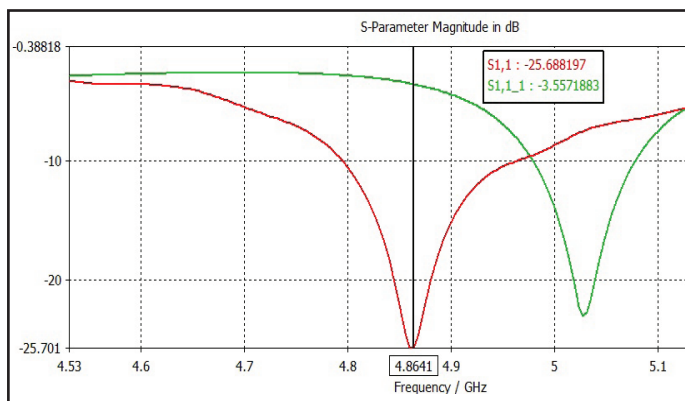


Fig. 6: Return Loss vs Frequency

### A. VSWR

VSWR is stand for Voltage Standing Wave Ratio, and also related to as Standing Wave Ratio. VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna [6]. VSWR is defined as,

$$VSWR = \frac{V_{max}}{V_{min}}$$

In this paper, the VSWR of the proposed antenna is 1.109 at 4.864 GHz. The results VSWR is given:

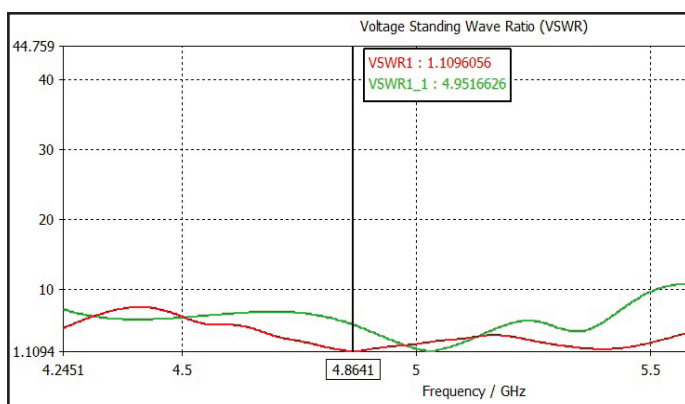


Fig. 7: VSWR vs Frequency

### B. Directivity

Directivity of an antenna is the maximum value of its directive gain. It measures the power density the antenna radiations in the direction of its strong emission.

The Directivity of the proposed antenna at 4.864 GHz. The simulated results of Directivity is given below:

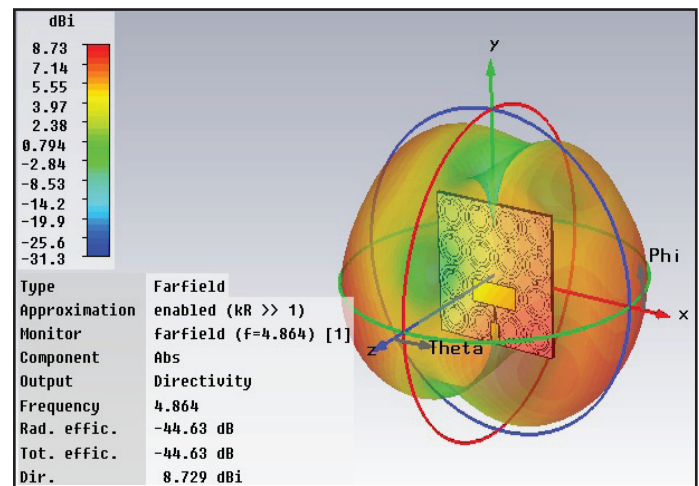


Fig. 8: Directivity 8.729 dBi at 4.864 GHz

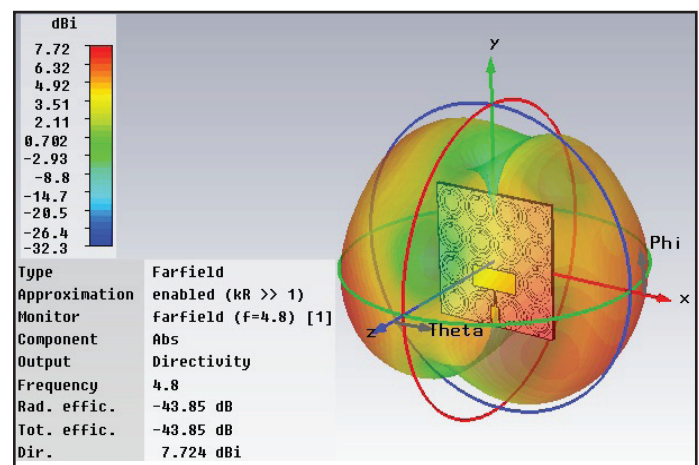


Fig. 9: Directivity 7.724 dBi at 4.8 GHz

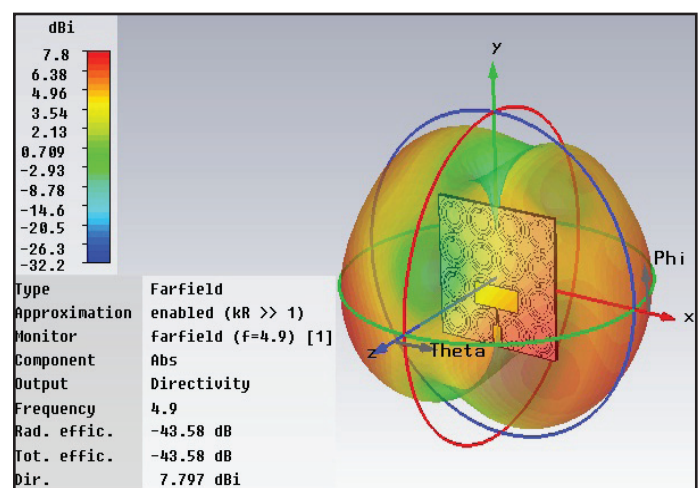


Fig. 10: Directivity 7.797 dBi at 4.9 GHz

### C. Radiation Pattern

Radiation pattern refers to the directional dependence of the strength of the radio waves from the antenna or other sources. Antenna radiation patterns are taken as one frequency, one polarization and one plane cut. The pattern are usually presented in the polar or rectilinear form with a dB strength scale.



The results of radiation pattern are given below at 4.864 GHz is given:

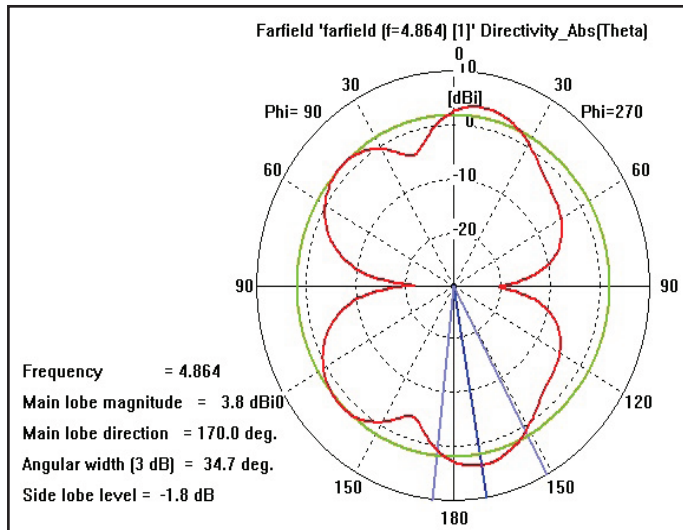


Fig. 11: Farfield Radiation Pattern at 4.864 GHz



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### III. Conclusion

In this paper, the proposed antenna is simulated and measured for WLAN. The results of the radiation pattern, return loss and VSWR are shown in this paper by introducing the Metamaterial in the proposed antenna and due to which its performance become better than the previous paper. The operating frequency of the antenna is 4.864 GHz. The return loss of the antenna with the SRRs is -23.00 dB and with SRRs and rod is -25.688 dB, the bandwidth for return loss better than 10 dB and the VSWR of the antenna is the 1.109 in the range of 4.5-5 GHz. The results are better as compare with the Return loss and VSWR.

### References

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