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Design and Simulation of Metamaterial in Compact Broadband Microstrip Patch Antenna for Wireless Router

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***Abstract* – A microstrip patch antenna using Metamaterial is introduced. A negative refractive index or Metamaterial eliminates the specious harmonics associated with the original structure. The simulated results represents that the return loss and VSWR are less than -40 dB and 1.008 in range of 2.5 ~ 3 GHz respectively. The frequency band from 2.5 ~ 3 GHz presented and measured. Its simple configuration and low profile makes it more attractive. The dimension of the antenna is 50×90 mm and CSRRs introduced in it having unitcell whose length is 10 mm. The CST-MWS software is used for designing and simulation.**

***Index Terms* — Microstrip Patch Antenna, Metamaterial, Complementary Split Ring Resonators (CSRRs), Patch antenna.**

I. Introduction

It is important to design broadband antennas to cover a wide frequency range with the development of wireless communication technology and the evolution of many communications systems. Recently, many researches have been introduced microstrip antenna to improve bandwidth and gain performance, about the various shapes and techniques of the microstrip antennas [1].

Microstrip patch antenna size depends on the wavelength crossponding to its resonant frequency. They have narrow bandwidth, to improve the bandwidth of the patch antenna there are different methods such as change of the substrate thickness, low dielectric substrate, various impedance matching, feeding techniques, multiple resonators slot structures, and multilayer structures etc.[2]. The realizability of material with –ve refractive index, predicted in 1986 by Veselgo. After that features of electromagnetics with +ve and –ve constitutive parameters analyzed by many researchers. Metamaterials are artificial structures that can be designed to exhibit specific electromagnetic properties which does not physically available in the nature. Presently, In Metamaterial environment for negative and positive index regime. 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 [3]. Wireless devices mostly used microstrip patch antennas for wireless communication systems. Commonly by utilizing high permittivity dielectric substrate, the microstrip patch antenna size can be reduced. But these antenna has many drawbacks like these are expensive, narrow bandwidth and have less radiation efficiency. So, design methods are used for the good performance and the miniaturized patch antenna. These methods included SRR or CSRR [4]. In this paper, Complementary Split ring resonators are designed. The return loss and VSWR are -47.94dB and 1.008 respectively in the range 2.5 to 3 GHz.

II. Antenna Configuration

The proposed antenna consists of radiating element copper (red colour) and substrate Teflon (white colour) between the radiating element and ground plane. The CSRRs are designed on the Ground Plane. Figure1 shows the radiated patch. Figure2 shows the geometry of CSRRs and of the patch antenna.

The results shown here are by introducing CSRRs structure in Antenna. Antenna operating frequency is 2.88 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 [4]. The radiating patch parameters and complementary split ring resonator of proposed antenna are represented:

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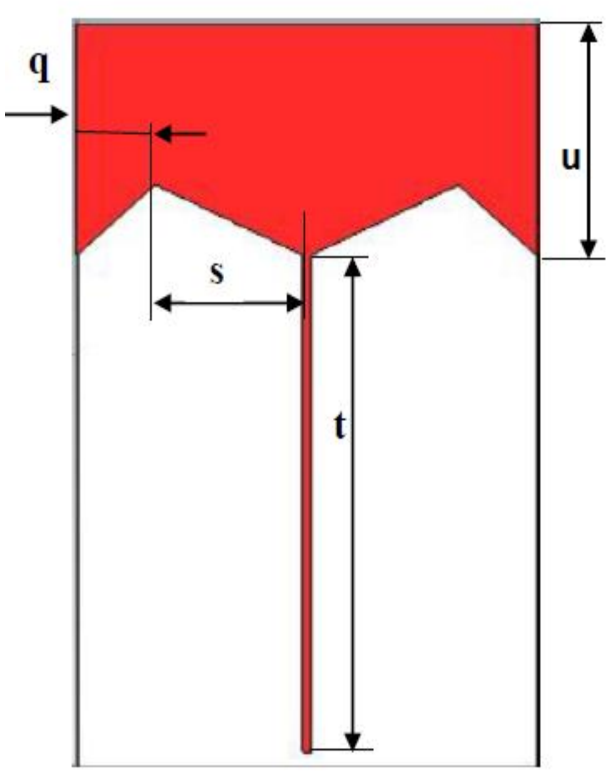

Figure 1: Microstrip Patch Antenna

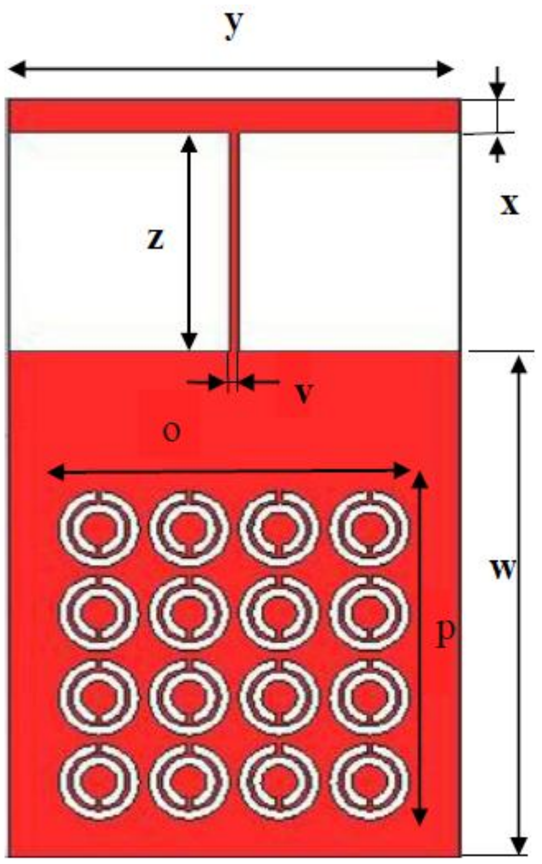

Figure2: Back Ground of antenna with CSRRs

Parametric representation of the patch antenna is given in Table no.1 below:

Parameters	Dimensions (mm)
o	40
p	40
q	8.5
s	16
t	60.2
u	28
v	1
w	60
x	4
y	50
z	26

Table no.1: Parameters of proposed antenna

The Metamaterial resonators having the negative permeability due to SRRs. The CSRR is the negative image of SRR based on the Babinet principle and the duality concept. The basic mechanism of SRR and CSRR is same except for excited the axial electric field. Due to these resonators, the resonant frequency can be easily turned to the desired value [4].

To obtain complementary of split ring resonator structure, replace the copper parts with substrate material and the substrate material with copper parts [5]. Here the unit length (a) is 10mm, radius (r) is 1.98mm, width (c) is 0.5mm and space between two co-centric circles (d) is 0.5mm.

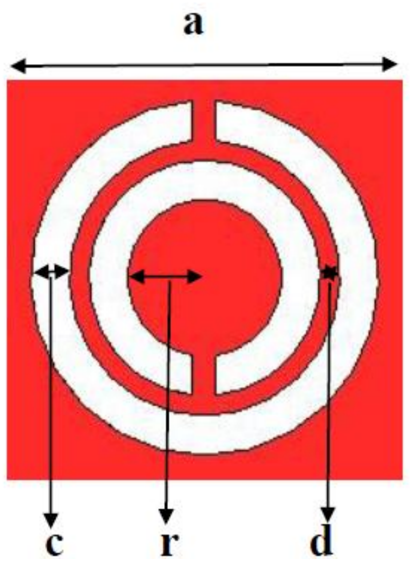

Figure 3: Complementary Split Ring Resonator (CSRR)

To create an effective negative permittivity (ε) medium and inhibit signal propagation at resonance, the CSRRs behaves as an electric dipole excited by an axial electric field [6].

Parametric representation of Complementary Split Ring

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Resonator is given in Table no.2 below:

Parameters	Dimensions (mm)
a	10
c	0.5
d	0.5
r	1.98

Table no.2: Parameters of Complementary Split Ring Resonator

III. SIMULATION AND MEASUREMENT

A. *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),

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

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

By using the equation, BW = $\left[\frac{f2-f1}{fc}\right] \times 100\%$, Impedance Bandwidth over return loss less than -10dB can be calculated, where $f1$ is lower cut off frequency, $f2$ is upper cut off Frequency of Band and fc is center frequency of $f2$ and $f1$ [6]. The simulated return loss characteristics of proposed antenna is -47.94dB at 2.88 GHz which is less than the -19.59dB.

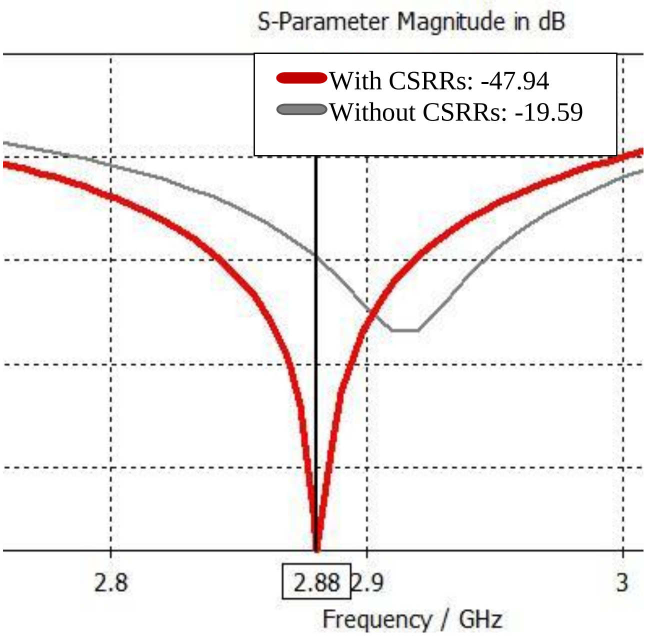

Figure 4: At 2.88 GHz, Return loss vs Frequency

B. *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. VSWR is defined as,

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

In this paper, the VSWR of the proposed antenna is 1.008 at 2.88GHz. The results VSWR is given below:

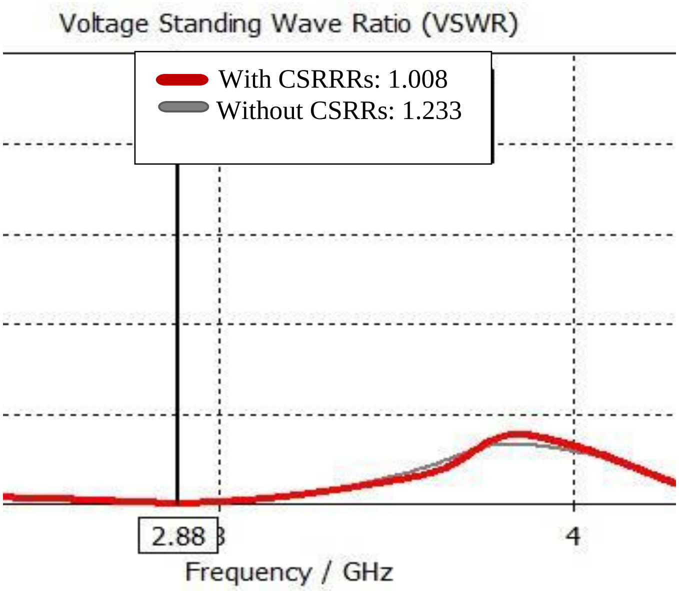

Figure 5: At 2.88 GHz, VSWR vs Frequency

C. *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 2.88 GHz, 2.89 GHz and 3.00GHz are 4.104dBi, 4.093dBi and 3.979dBi respectively. The simulated results of Directivity is given below:

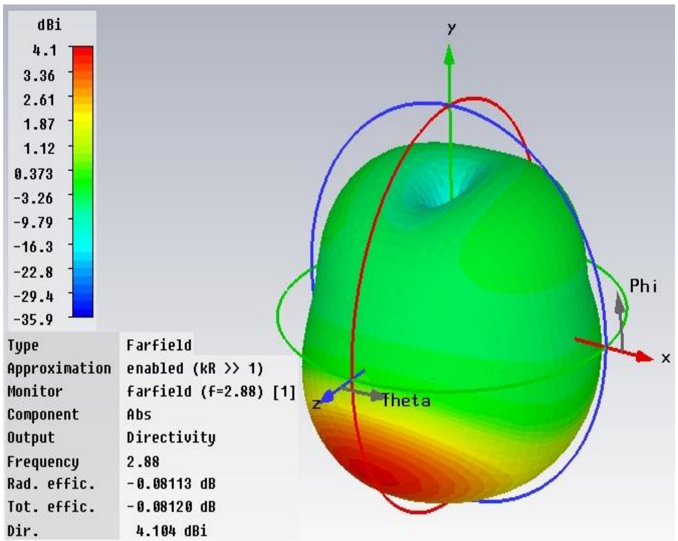

Figure 6: Directivity 4.104 dBi at 2.88GHz

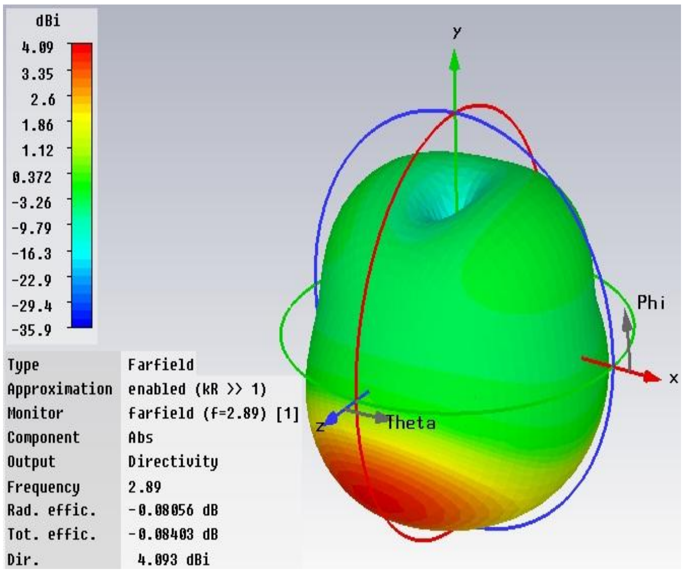

Figure 7: Directivity 4.093 dBi at 2.89 GHz

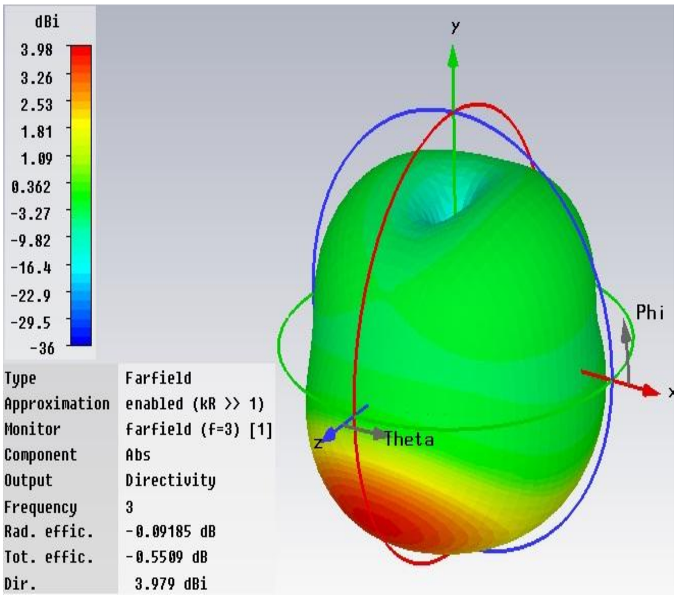

Figure 8: Directivity 3.979dBi at 3.00 GHz

D. 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 2.88 GHz, 2.89 GHz and 3.00 GHz:

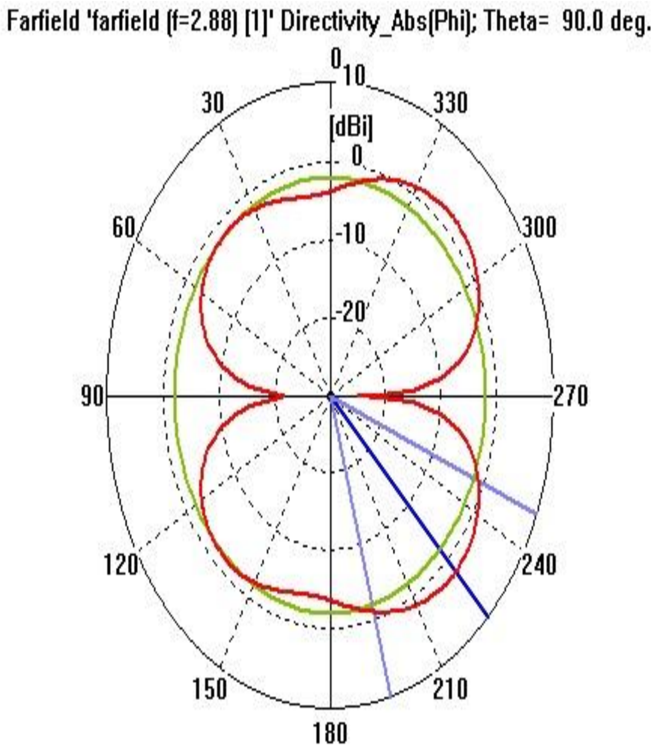

Figure 9: Farfield Radiation pattern at 2.88GHz.

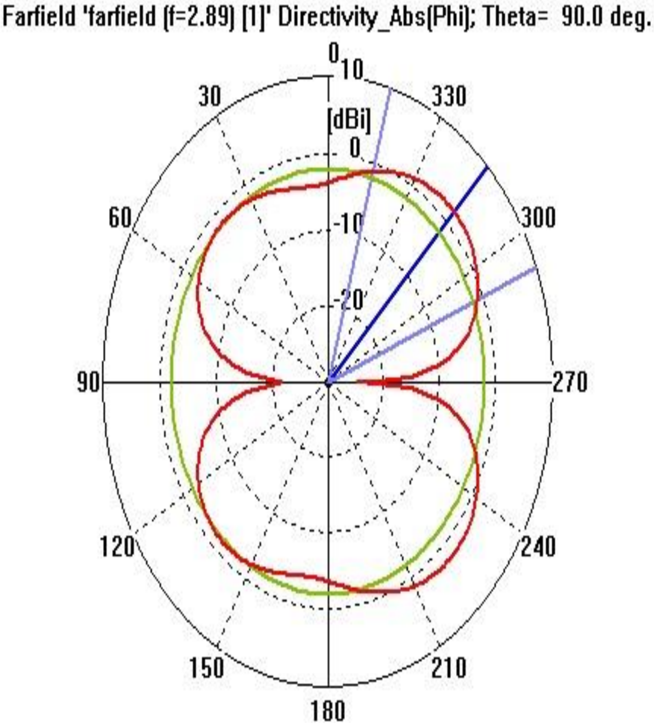

Figure 10: Farfield Radiation pattern at 2.89 GHz.

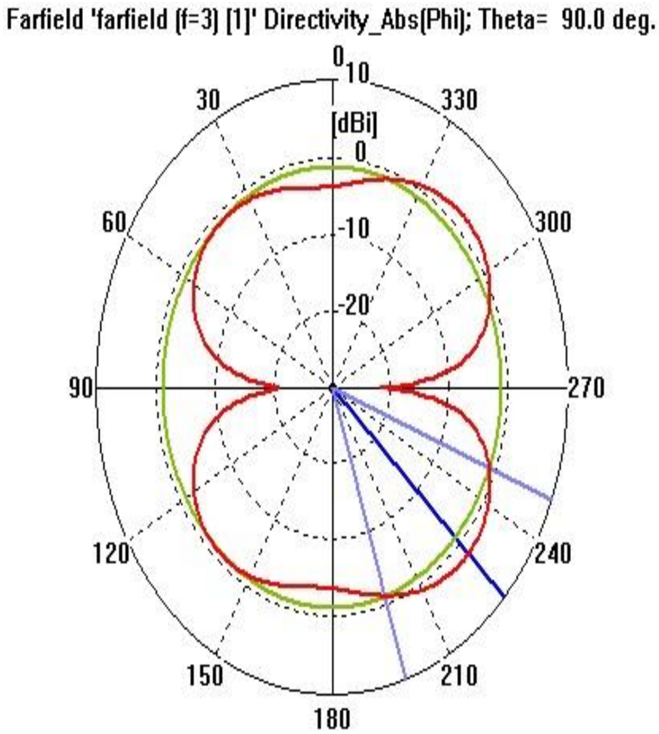

Figure 11: Farfield Radiation pattern at 3.00GHz

IV. CONCLUSION

In this paper, the proposed antenna is simulated and measured for wireless routers. The results of the radiation pattern, return loss and VSWR are shown in this paper. The return loss of the antenna with the CSRRs is -47.94 dB, the bandwidth for return loss better than 10 dB and the VSWR of the antenna is the 1.008 in the range of 2.5-3 GHz. The results are better as compare with the Return loss and VSWR.

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