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Enhancing Performance of Rectangular Patch Antenna Using "SYMMETERICAL CIRCUITOUS SQAURES" Loaded with Metamaterial Structure

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Abstract—
In this Research work, a Rectangular microstrip patch antenna loaded with rectangular patch antenna using Symmetrical Circuitous Structure Loaded with metamaterial structure is designed at a height 3.2 mm from the ground plane by using CST-MWS software. This material is said to have **simultaneous negative parameters or double negative parameters (DNG Parameters) of the permittivity and permeability. It improves gain due to its negative refractive property the resonance frequency that we have used here is 2GHz. There are many parameters those are associated with antenna here in this paper we have considered return loss, directivity , VSWR and bandwidth of antenna The Return loss of the proposed antenna is reduced by 14.28dB. Voltage Standing Wave Ratio has also reduced from 1.63 to 1.09 bandwidth and directivity of proposed antenna have also showed significant improvement. upto a significant of this antenna has also increased upto 27MHZ that shows improvement in antenna property by proposed design. This antenna can has many applications in communication at L-band.**
For simulating our proposed antenna we have used CST-2010 simulator. CST is a tool that provides 3D view of the simulated antenna so directivity can be understands in a easy way. In this view it provides different colors for different region so when directivity is high it can be easily indicated by this tool polar plot of directivity can also get.

Keywords - Rectangular Microstrip Patch Antenna, Metamaterials, Bandwidth, Return Loss, VSWR, Direcitvity.

I. INTRODUCTION

An antenna is an electrical device which converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves)[1]. In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals, that is applied to a receiver to be amplified.

Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, television,receivers, radar, cell phones, and as well as other devices wireless, Bluetooth enabled and RFID tags on merchandise Antennas play a very important role in the field of wireless communications. Some of them are Parabolic Reflectors, Patch Antennas, Slot Antennas, and Folded Dipole Antennas. We can say antennas are the base and crucial in the wireless communication without which the world could have not reached at this age of technology. Antennas may also contain reflective or directive elements or surfaces not connected to the transmitter or receiver, such as elements, parabolic or horns, which serve to direct the radio waves into a beam or other desired radiation pattern. Antennas can be designed to transmit or receive radio waves in all directions equally, or transmit them in a beam in a particular direction, and receive from that one direction only (directional or high gain antennas).

A patch antenna (also known as a rectangular micro strip antenna) is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. The assembly is usually contained inside a plastic radome, which protects the antenna structure from damage. Patch antennas are simple to fabricate and easy to modify and customize [2, 3]. They are the original type of microstrip antenna described by Howell; the two metal sheets together form a resonant piece of microstrip transmission line with a length of approximately one-half wavelength of the radio waves. The radiation mechanism arises from discontinuities at each truncated edge of the microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used. A patch antenna is usually constructed on a dielectric substrate, using the same materials and lithography processes used to make printed circuit boards.

Metamaterials are artificial materials engineered to have properties that may not be found in nature. They are assemblies of multiple individual elements fashioned from conventional microscopic materials such as metals or plastics, but the materials are usually arranged in periodic patterns [6, 7]. Metamaterials gain their properties not from their composition, but from their exactingly-designed structures. Their precise shape, geometry, size, orientation and arrangement can affect the waves of light or sound in an unconventional manner, creating material properties which are unachievable with conventional materials. These metamaterials achieve desired effects by incorporating structural elements of sub-wavelength sizes, i.e. features that are actually smaller than the wavelength of the waves they affect.

2. ANTENNA PERFORMANCE METRICES

The Rectangular microstrip patch antenna parameters are calculated from the formulas given below [8, 9].

Resonance Frequency

$$f_0 = \frac{c}{2Le\sqrt{\varepsilon_r}}$$

Calculation Of Width (W)

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

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.
Effective dielectric constant is calculated from**:**

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

The Avtual Length of The Patch (L)

$L = L_{eff} - 2\Delta L$,
where
$$\text{Leff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}}$$

Calculation of Length Extension

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

Calculation of VSWR

$$\text{VSWR=S=}\frac{1+|\Gamma|}{1-|\Gamma|}$$
Where Γ = Reflection Co-efficient

Calculation of Return Loss

Return Loss=$20\log|\Gamma|$

TABLE 1: RECTANGULAR MICROSTRIPPATCH ANTENNA SPECIFICATIONS

	Dimensions	Unit
Dielectric cons (εr)	4.3	-
Loss tangent (tan	0.02	-
Thickness (h)	1.6	Mm
Operating Frequency	2	GHz
Length (L)	35.84	Mm
Width (W)	45.54	Mm
Cut Width	5	Mm
Cut Depth	10	Mm
Path Length	40.54	Mm
Width Of Feed	3.009	Mm

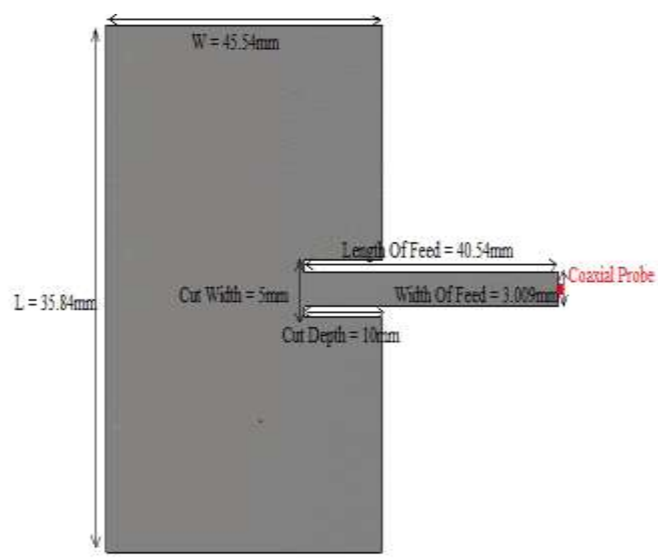

Figure 1: Rectangular patch antenna designed at 2 GHz (All dimensions in mm).

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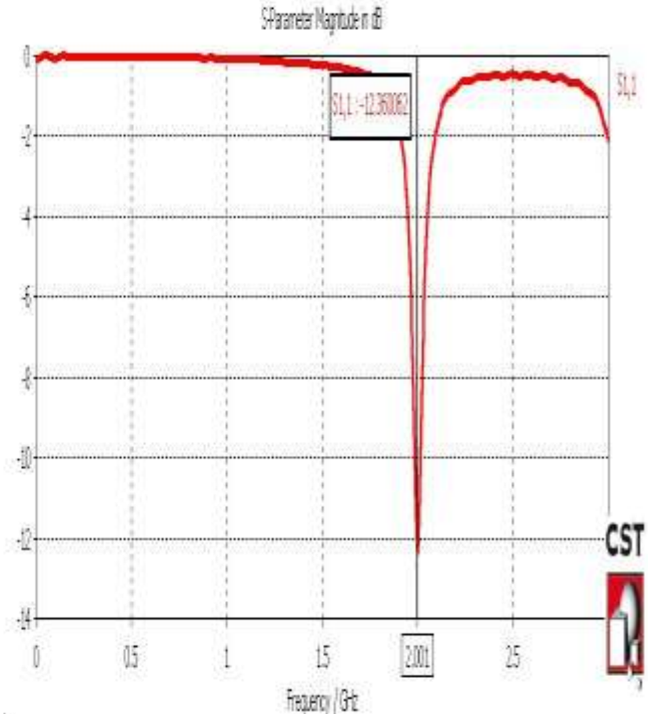


Figure 2: Simulated Result of Rectangular microstrip patch antenna showing return loss of -12.36 dB.

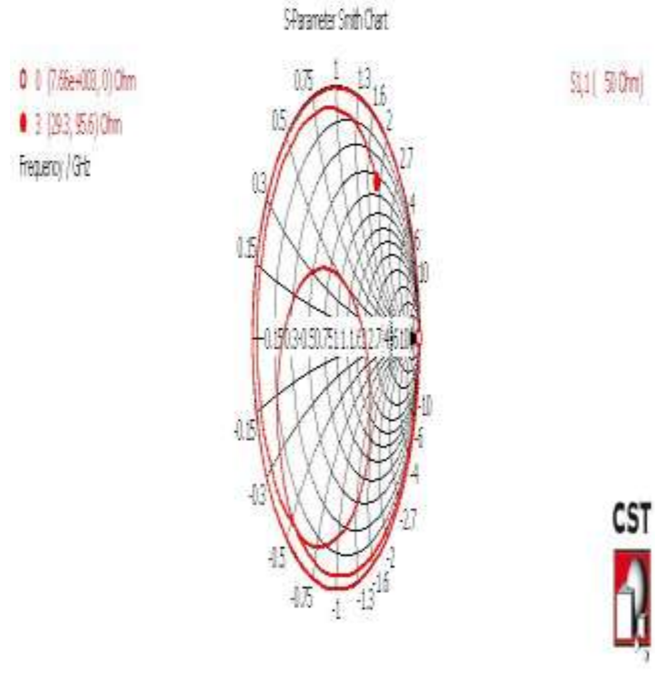


Figure 4: Smith chart of Rectangular microstrip patch antenna at 2 GHZ

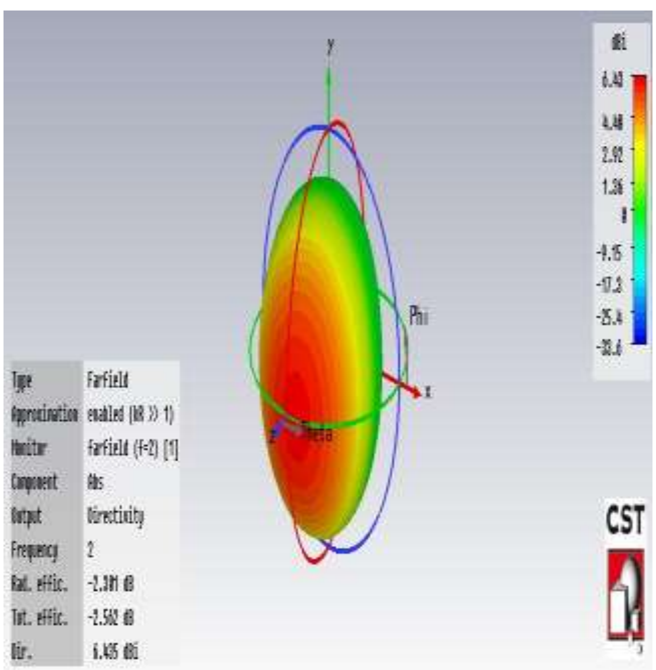


Figure 3: Radiation Pattern of Rectangular microstrip patch antenna with directivity 6.425dBi.

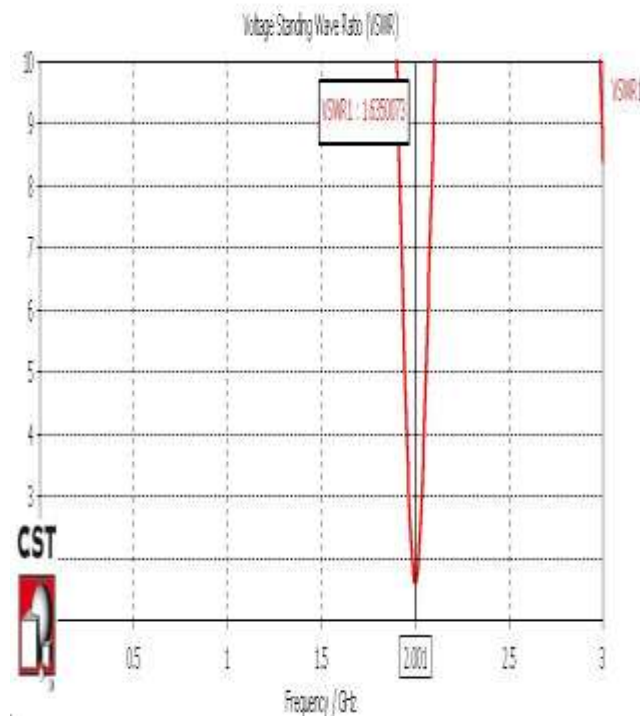
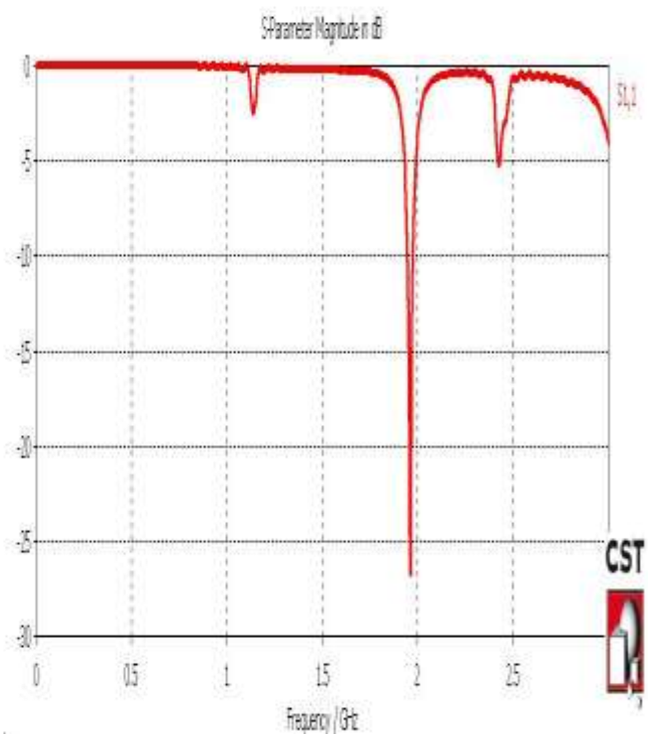


Figure 5: VSWR 1.65 of Simulated RMPA at 2 GHz.



3. SIMULATED PROPOSED DESIGN

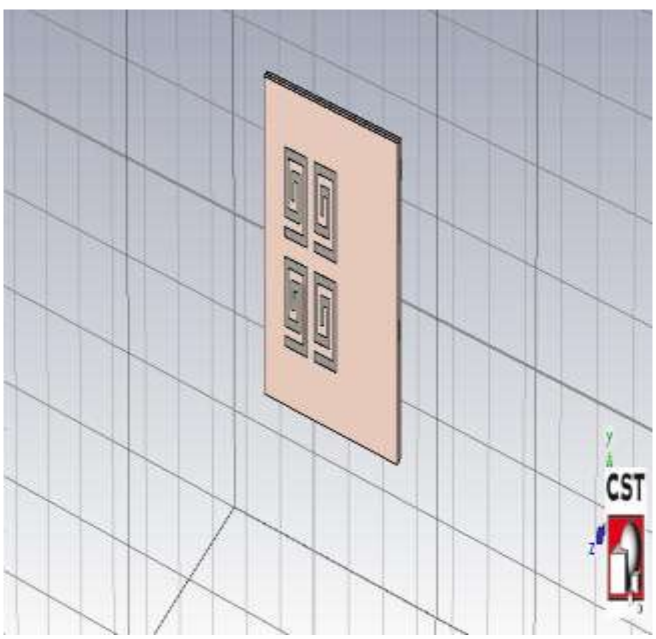


Figure 6: Proposed Symmetrical Square Structure

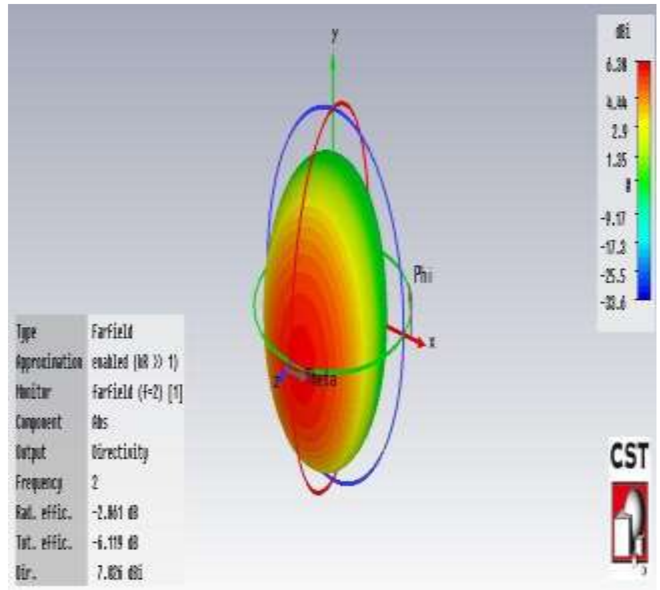


Figure 9: Radiation Pattern of proposed antenna showing 7.026dBi directivity.

Figure 8: Showing return loss -26.33 db of proposed structure

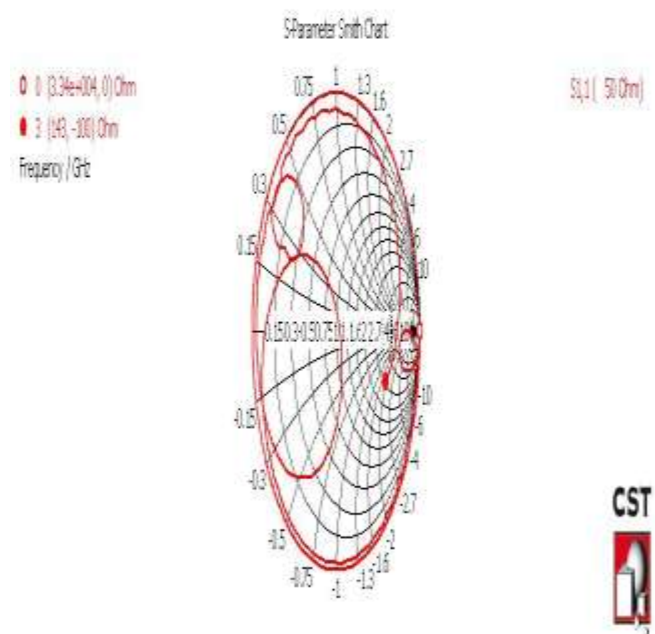


Figure 10: Smith Chart of proposed Structure at 2 GHz

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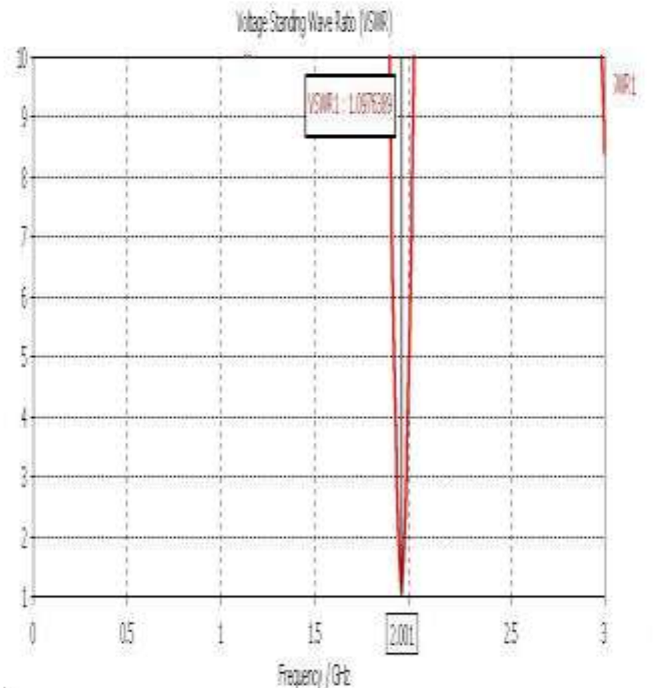

Figure 11: Improved VSWR 1.09 of proposed Metamaterial Structure

4. RESULTS AND DISCUSSIONS

The simulated results of rectangular microstrip patch antenna with “Symmetrical circuitous Square” shaped structure are shown in the simulated figures. The CST-MWS simulation software was chosed to simulate the antenna. By simulating the proposed metamaterial structure with the rectangular microstrip antenna shows improvement of 14.28dB in return loss & also improvement in bandwidth while the directivity also got improved. At 2 GHz frequency the simulated rectangular microstrip patch antenna shows (Figure 2) return loss of -12.36dB. While the same when designed with “Proposed structure at 3.2 mm from the ground plane shows (Figure 4.10) Return loss of -31.54 dB & (Figure 8). Respective smith chart of RMPA and proposed designed also shown in Figure 4 and Figure 10. Here normalized impedance has been taken. We have also analyzed directivity of RMPA (Figure 3) and RMPA with loaded proposed metamaterial structure (Figure 9) and by analyzing these radiation patterns we can comment that when we introduced proposed metamaterial structure directivity of designed antenna can get improved. VSWR that is the main factor in antenna designing we have shown improvement in VSWR it has reduced from 1.65 to 1.09 in our proposed metamaterial structure.

5. CONCLUSION & FUTURE WORK

In this research work a method of designating, enhancing, measurement and result analysis of rectangular microstrip patch antenna with and without proposed metamaterial structure is discussed. The design and simulation has done with equations those have mentioned in this thesis. There are many applications like Satellite communication, Radar we always want antenna with light weight and improved directivity, gain and bandwidth. Rectangular Microstrip Patch Antenna can provide printed radiating structure, which are electrically thin, lightweight and low cost. That’s why now a day’s Microstrip antenna can easily installed patch. Microstrip patch antenna can provide these features easily and at low fabrication cost. And patch antennas can also provide improved gain, bandwidth and directivity by using metamaterial structure properties of antenna can be improved further. Some time it happens that t is not possible for single patch antenna to provide a desired radiation pattern in that case, left-handed metamaterial provides great opportunity. Metamaterial can provide unrealistic value of permittivity and permeability, which cannot be achieved by any material in the nature.

The rectangular patch antenna using array of hexagonal rings double negative” metamaterial structure with Rectangular microstrip patch antenna has been proposed in this paper. The simulated results provide gain, bandwidth and directivity improvement, can be further improved by using some variation these variation can be in length, width, frequency and material. But some practical limitation should be taken care while fabricating the structure on CST-MWS software.

Further works can be performed in order to obtain a good Metamaterial properties working in the higher frequency range. Varies other dimensions may also be used to see how the properties of metamaterial will react and how the frequency band will be behave under these circumstances.

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