Improvement in Parameters of Patch Antenna by Using "Spiral Shapes" Metamaterial Structure

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Abstract

In this work, a Rectangular microstrip patch antenna loaded with "Spiral Shaped" metamaterial structure is designed at a height 3.2 mm from the ground plane by using CST-MWS software. The resonance frequency of the designed antenna is 2.1GHz.The 10 dB impedance bandwidth of proposed antenna is 35.1 MHz the Return loss of the proposed antenna is reduced by 35 dB .This antenna is small size, cheap, compact and easy to fabricate, and achieve good radiation characteristics with higher return loss. This antenna can have wide application in a great variety of wireless communication.

Keywords: Rectangular Microstrip Patch Antenna, Metamaterials, Bandwidth, Return Loss.

1. Introduction

In high-performance aircraft, spacecraft, satellite and missile applications, where size, weight, cost, performance, ease of installation, low profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications. To meet these requirements microstrip antenna can be used. These antennas are low profile, conformal to planar and non-planar Surfaces, simple and inexpensive to manufacturer using modern printed circuit technology, mechanically robust when mounted on rigid surfaces, compatible with Monolithic Microwave Integrated Circuit (MMIC) designs.

The introduction of the so-called metamaterials [1] (MTMs), artificial materials which have engineered electromagnetic responses that are not readily available in nature, has provided an alternate design approach to obtain efficient electrically-small antenna (EESA)systems.

2. Design And Simulated Results Of RMPA And Proposed Antenna

The Rectangular microstrip patch antenna parameters are calculated from the formulas given below [2-3].

Calculation of Width (W):

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

Where,

c = free space velocity of light

εr = Dielectric constant of substrate

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

Effective dielectric constant is calculated from:

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

The actual length of the Patch (L)

L = Leff - 2Δ (3)

Where

$$\text{Leff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \quad (4)$$

Calculation of Length Extension

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

The parameters of rectangular microstrip patch antenna are specified in the Table1 and dimensional view is shown in figure 1.

Table 1: Rectangular Microstrip Patch Antenna Specifications

	Dimensions	**Unit**
Dielectric Constant (ϵr)	4.3	-
Loss Tangent (tan ∂)	0.02	-
Thickness (h)	1.6	Mm
Operating Frequency	2.1	GHz
Length (L)	34.11386	Mm
Width (W)	43.87822	Mm
Cut Width	7.4	Mm
Cut Depth	10	Mm
Path Length	38.99604	Mm
Width Of Feed	6.00	Mm

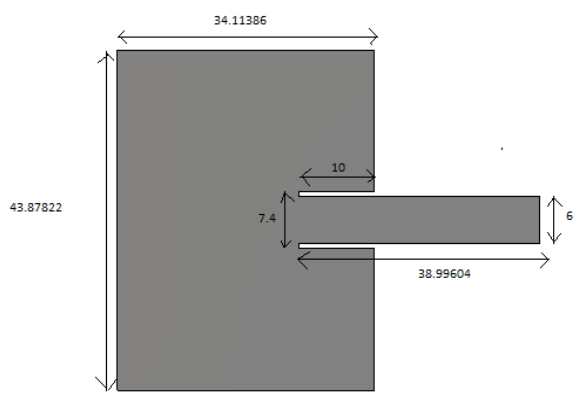

Figure 1: Rectangular patch antenna designed at 2.1GHz (All dimensions in mm).

The Simulated Results of Rectangular microstrip patch antenna is shown in figure 2 and 3.The CST-MWS (computer simulation Technology) was chosen to simulate the structures shown in the figures below.

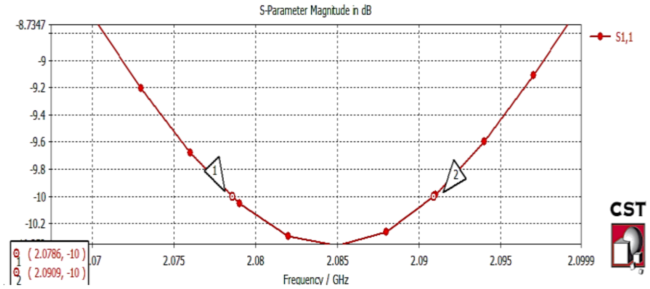

Figure 2: Simulated Result of Rectangular microstrip patch antenna showing return loss of -10.5 dB and 12.30MHz Bandwidth.

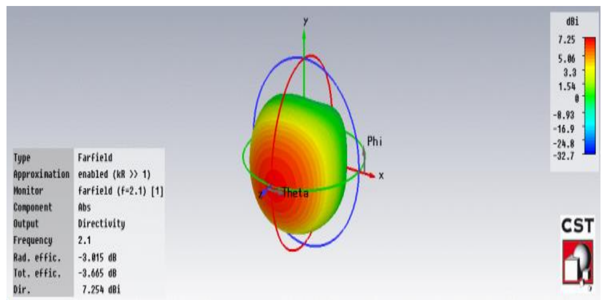
Figure 3: Radiation Pattern of Rectangular microstrip patch antenna.

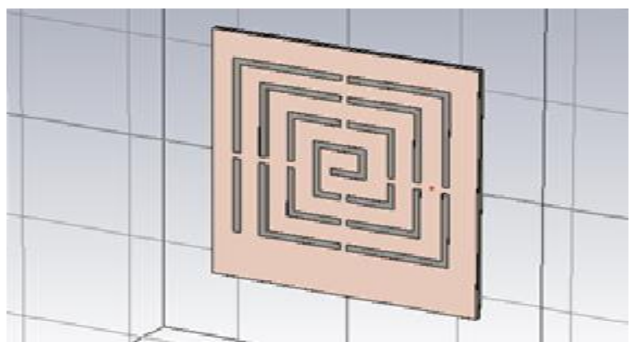
Figure 4: Proposed metamaterial Structure placed between the two Waveguide Ports at the top & bottom of Y axis.

Then, the "Spiral Shaped" metamaterial structure 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 Patch antenna alone. The required specifications of this design are shown in the figure5.

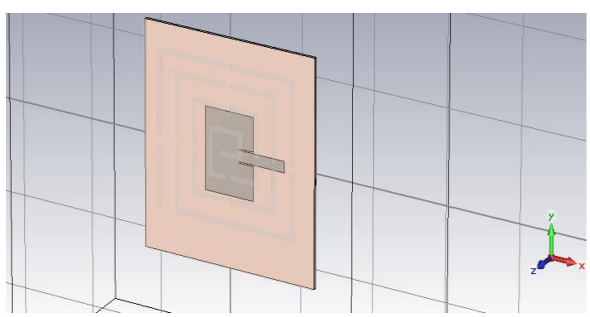
Figure 5: Rectangular microstrip patch antenna loaded with "Spiral Shaped" metamaterial Structure (All dimensions in mm).

A Research on [5-6] metamaterial was carried out to understand the fundamentals of the newly discovered substance. The simulated result of rectangular microstrip patch antenna with "Spiral

Shaped" structure is shown in figure 6. At 2.1 GHz frequency the simulated rectangular microstrip patch antenna results in Return Loss of -10.5 dB& 12.10MHz Bandwidth while when it is designed with "Spiral Shaped" metamaterial structure at 3.2mm from the ground plane, it shows Return Loss of -45 dB& 31.10MHzBandwidth which shows significant improvement of bandwidth [6] and reduction in return loss. The Return Loss of the proposed metamaterial structure is reduced by 35dB [9-10] in comparison to the RMPA alone.

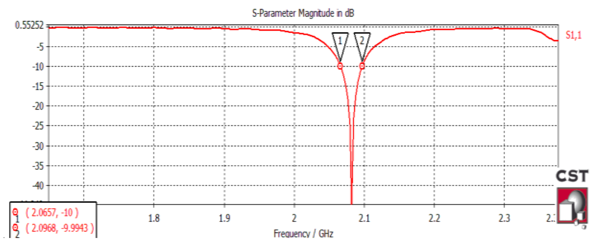

Figure 6: Simulated Return Loss of Rectangular microstrip patch antenna loaded With "Spiral Shaped" metamaterial Structure.

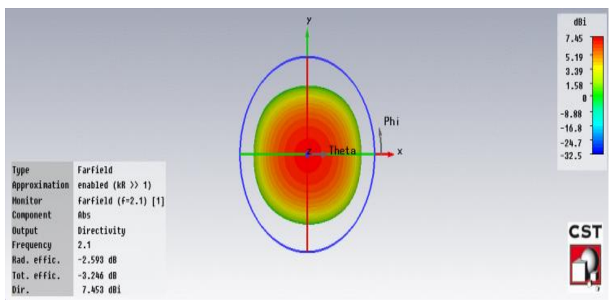

Figure 7: Radiation Pattern of Rectangular microstrip patch Antenna along With "Spiral Shaped" metamaterial Structure.

Smith Charts [6] has shown in figure 8 represents the impedance matching of antenna with coaxial cable of 50 ohm.

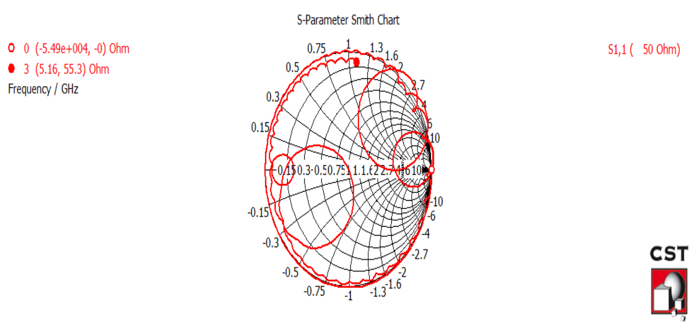

Figure 8: Smith Chart of Rectangular microstrip patch antenna loaded with "Spiral Shaped" metamaterial Structure.

3. Conclusions

The "Spiral Shapes" metamaterial structure with Rectangular antenna has been proposed in this paper. The simulated results provide high gain, wide bandwidth and directivity improvement, and increase total efficiency which encourages fabricating the structure. On making some variations in antenna parameter gain can be improved up to desired limit but some practical limitation should be taken care while fabricating the structure on CST-MWS software.

4. References

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