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Zigzag Pattern Metamaterial Structure With Rectangular Patch Antenna

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Abstract

In this paper, Authors analyze a Metamaterial structure with a rectangular microstrip patch antenna. This paper presents the techniques which can be used to reduce the return loss as well as improve the gain of conventional rectangular microstrip patch antenna. The return loss of a normal patch antenna designed at the resonant frequency of 2.4 GHz has been compared with that of the same patch antenna along with an additionally stacked Metamaterial structure on to the patch antenna at a height of 3.2 mm from the ground plane. It has been measured that the return loss is improved around 5 dB.

Keywords: *Metamaterial Structure (MTM), Rectangular microstrip patch antenna, Return loss, VSWR.*

1 Introduction

The concept behind The printed radiating structure on a dielectric surface, which are thin, light weight, low cost and easier to design is known as microstrip patch antenna[3,7]. This is not too much old, but during recent years there has been enormous development in microstrip patch antenna technology[2]. There are many kinds of materials used to improve the gain of microstrip patch antenna. Among them, Metamaterial [4-6] are found most suitable. Metamaterials have opened an exciting field to realize unexpected physical properties and applications, which are not possible from naturally occurring materials. Conductive or dielectric inclusions in metamaterials can be tailored in shape and size, periodicity, and defects to produce unusual yet exciting properties. Unusual properties such as, negative permittivity and permeability, negative refraction at

the interface. Metamaterial are artificial structure that can be design to exhibit specific electromagnetic properties that doesn't found in the nature.

2 Design of Antenna

Studies shown are made towards realizing the rectangular microstrip patch antenna modeling [7]. We inserted rectangular slot cut in zigzag pattern in it and searching for reduction in return loss as well as improvement in gain. Start off by calculating basic equation of typical rectangular patch and then convert its equivalent area to a rectangular form.

Width of metallic patch (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**:**

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

Length of metallic patch(L)
$L = L_{eff} - 2\Delta L$
$Leff = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}}$
Calculation Of Length Extension

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

2.1 Design of Rectangular Microstrip Patch Antenna

The Essential parameters of rectangular microstrip patch antenna are W= 38.04mm, L=29.4148mm, Cut Width= 5.125mm, Cut Depth= 9.009mm, length of

transmission line feed= 28.029mm, with width of the feed= 3.009mm as shown in Figure 1. The Rectangular microstrip patch antenna designed on one side of glass/epoxy structure with $\varepsilon_r = 4.4$ and height from the ground plane d= 1.6mm

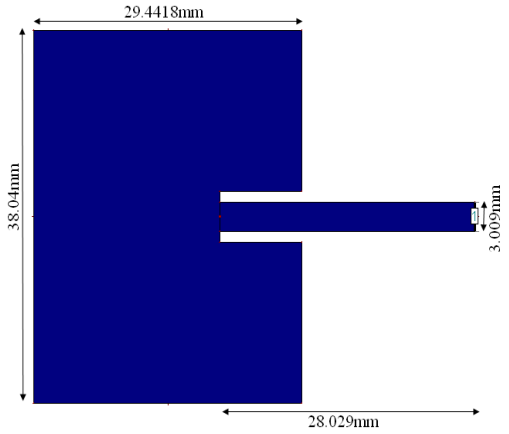

Figure 1: Rectangular Microstrip Patch Antenna at 2.4 GHz.

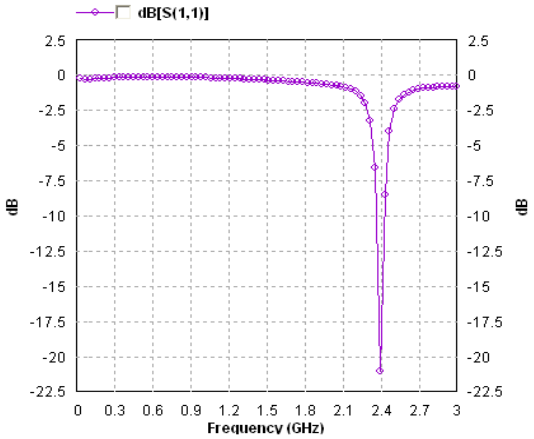

Figure 2: Simulation of Return los Rectangular Microstrip Patch Antenna at 2.4 GHz

2.2 Rectangular Microstrip Patch Antenna with "Zigzag" Structure Using Metamaterial

A research on MTM was carried out to understand the fundamentals of the newly discovered substance. Then, IE3D Software was chosen to simulate the structure shown in Figure 4. The proposed design is based on Zigzag Pattern.

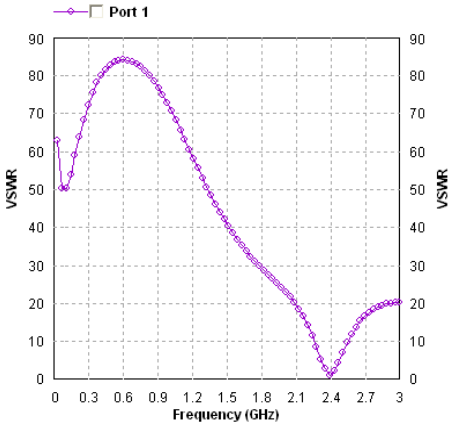

Figure 3: VSWR of Rectangular Microstrip Patch Antenna

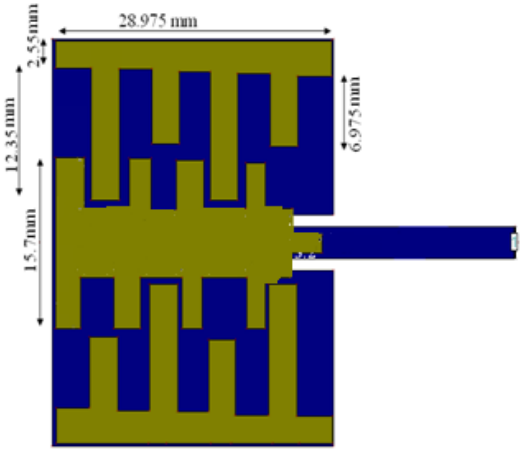

Figure 4: Rectangular Microstrip Patch Antenna with zigzag pattern.

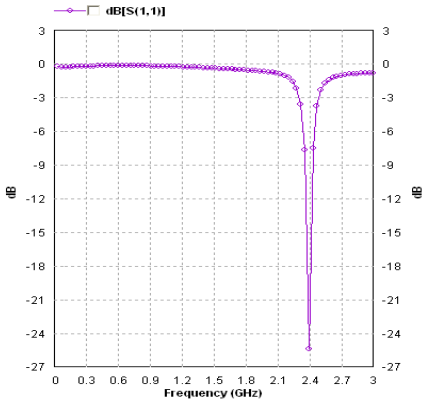

Figure 5: Simulation of Return loss of Rectangular Microstrip Patch Antenna with zigzag pattern.

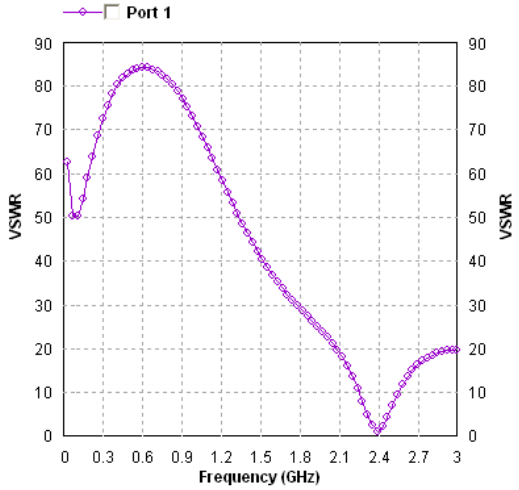

Figure 6: VSWR of Rectangular Microstrip Patch Antenna with zigzag pattern.

3 Result and Discussions

In the present paper, we have comparatively analyzed the rectangular patch antenna loaded with Metamaterial and fed with microstrip line. The simulated results of rectangular microstrip patch antenna with zigzag pattern are shown in figure 2 and 5. At 2.4 GHz frequency, simulated rectangular microstrip patch antenna exhibits alone the return loss of -21.05 dB while when it is designed with Metamaterial Structure at a height of 3.2mm it shows return loss of -26.36 dB which shows significant reduction of return loss. Which ultimately improve the directivity of patch antenna.

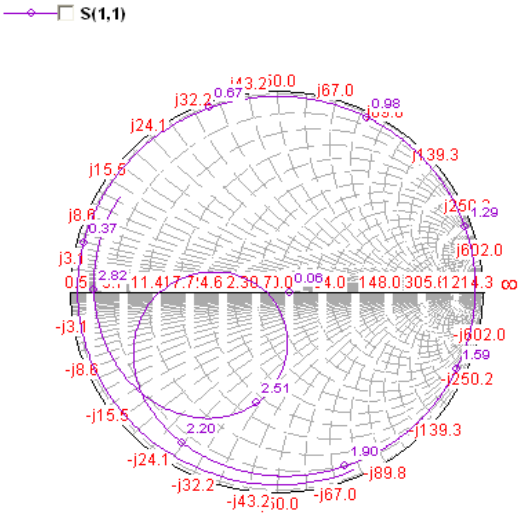

Figure 7: Smith chart of Rectangular Microstrip Patch Antenna with zigzag pattern.

4 Conclusion

In this paper the feasibility of using rectangular microstrip patch antenna with rectangular cut in zigzag pattern, to detect gain improvement has been investigated. The design and simulation were successfully done in IE3D software and all the objectives within the scope of this paper were met.

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