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Metamaterial Based Multiple Frequency Antenna

Piyush Moghe[1], P. K. Singhal[2]

Research Scholar, Electronics & Communication Department, Madhav Institute of Technology & Science, Gwalior, India [1]

Professor, Electronics & Communication Department, Madhav Institute of Technology & Science, Gwalior, India [2]

Abstract: Antennas that are electrically small, efficient and have significant bandwidth would fill many needs of new generation communications systems if antenna engineers could reconcile these usually contradictory requirements. The introduction of the so-called metamaterials (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. A micro strip antenna based on metamaterial is proposed in this paper. The purpose of this work is to investigate the response of a small antenna enclosed in metamaterial. The new structure is useful in designing small antennas. Return loss less than -50 dB has been achieved at 2.426 GHz. Antenna also radiates at 1.24 GHz, 2.51 GHz and 2.95GHz effectively.

Keywords: Microstrip Antenna, Metamaterial based Antenna

I. INTRODUCTION

Conventionally and historically, the function or behaviour of materials can be altered through their chemistry. For example, colour or hardness of glass can be changed by adding lead . However, at the end of the 20th century this description expanded [1].

In 1967, V. Victor produced an often cited, seminal work on a theoretical material that could produce extraordinary effects that are difficult or impossible to produce in nature. At that time he proposed that a reversal of Snell's law, an extraordinary lens, and other exceptional phenomena can occur within the law of physics. This theory lay dormant for a few decades. There were no materials available in nature, or otherwise, that could physically realize Veselago's analysis [2][3][4]. Not until thirty-three years later did the properties of this material, a metamaterial, became a sub discipline of engineering and physics. How ever, there were certain observations, demonstrations, and implementations that closely preceded this work. Permittivity of metals, with values that could be stretched from the positive, to the negative domain, had been studied extensively. In other words, negative permittivity was a known phenomena by the time the first metamaterial was produced. The ancient Greek prefix, meta (means "beyond"), has been used to describe materials with unique features not readily available in nature. Depending on the exhibited electromagnetic properties, various names have been introduced in the literature such as Double negative (DNG) materials, Left-handed (LH) materials, Negative refractive index (NRI) materials, Magneto materials, Soft and hard Surfaces, High impedance surfaces, Artificial magnetic conductors (AMC), etc, as shown in Fig.1[5].

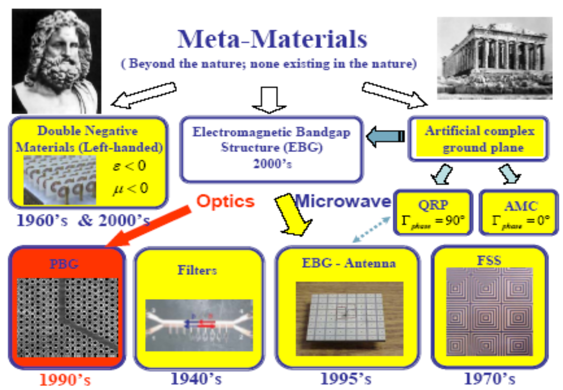

Fig.1. Metamaterials and their representative applications

II. RESENT DEVELOPMENTS

In the year 2000 a team of USCD researchers produced and demonstrated metamaterials, which exhibited unusual physical properties that were never before produced in nature. These materials obey the law of physics, but behave differently from normal materials. In essence these *negative index metamaterials* were noted for having the ability to reverse many of the physical properties that govern the behaviour of ordinary optical materials. One of those unusual properties is the capability to reverse, for the first time, the Snell's law of reflection. Until this year 2000 demonstration by the UCSD team, the material was unavailable. Advances during the 1990s in fabrication and computation capabilities allowed these first metamaterials to be constructed. Thus, testing the "new" metamaterial began for the effects described by V. Victor 30 years earlier, but only at first in the microwave frequencies domain. Reversal of group velocity was explicitly announced in the related published paper[6][7]. In 2006 , Wang, S., Feresidis, A.P., Goussetis, G. & Vardaxoglou, J.C proposed a resonant cavity antenna based on metamaterial ground plane. Metamaterial ground planes with negative reflection phase values have been applied for the first time to a high-gain resonant cavity antenna configuration. A ray analysis was employed to predict the effect of the Metamaterial Ground Plane (MGP) to the antenna profile and directivity. It was derived theoretically that subwavelength cavity antennas can be achieved by incorporating ground planes with negative reflection phase response. MGPs with negative reflection phase have been designed that yielded a maximum gain of 19.2 dBi [8].

III. PROPOSED DESIGN

All paragraphs must be indented. All paragraphs must The proposed design consists of a metallic patch sandwiched between two layers of dielectric material. Top view of layer-1 is shown in figure 1. Figure 2 shows the top view of antenna when Layer2, deposited on layer1. To energize the antenna, single probe feed is applied to the patch. Position of feed is also shown in figure 1. By increasing the antenna height, resonant coupling of printed antenna can be enhanced [6].

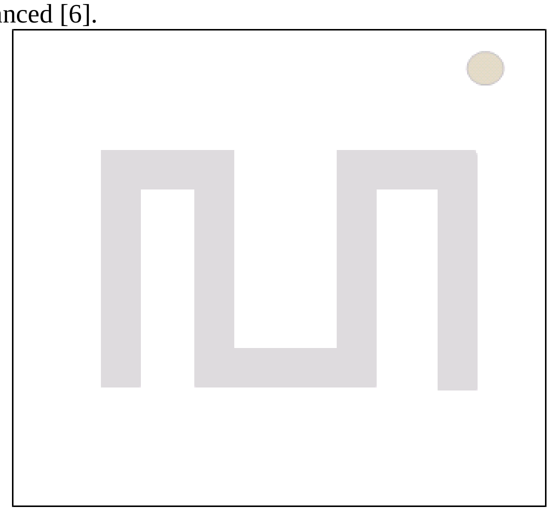

Fig.2 Front View & Feed Point of Layer 1

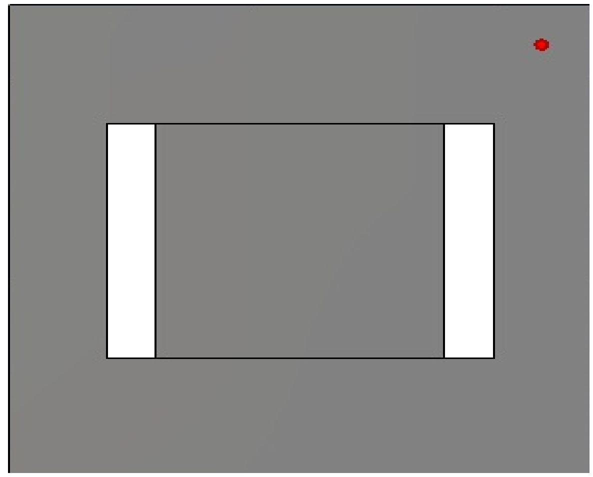

Fig.3 Front View both layers

Table I
PARAMETERS & DIMENSIONS

Layer	Material	Dimension
1	Metallic Ground	120 X 120 X 0.005
1	Substrate	120 X 120 X 1.6
1	Metallic Patch	120 X 120 X 0.005
2	Substrate	120 X 120 X 1.6
2	Metallic Patch	120 X 120 X 0.005

IV. RESULTS & DISCUSSIONS

The proposed antenna has been simulated by using the CST MICROWAVE STUDIO 5.0 simulation package. Figure 3 shows the setup used to evaluate the performance of the proposed design. Figure 4 shows the simulation results for the variations of S11 with Frequency while Figure 5 shows the simulation results for the variation of VSWR with frequency for the proposed antenna. Laboratory results shown in figure 6 suggest some frequency shift from simulation results but confirm that the proposed antenna radiates at 1.28 GHz, 1.45 GHz & 2.49 GHz.

Fig.4 Setup used to evaluate the antenna

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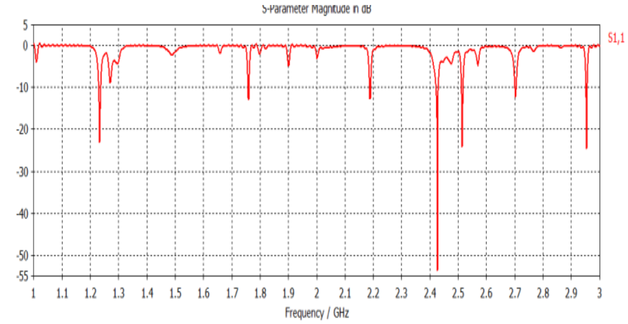

Fig.5 S_{11} Vs Frequency graph

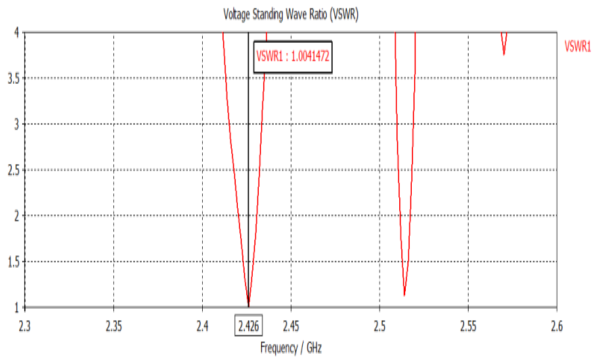

Fig.6 VSWR Vs Frequency graph

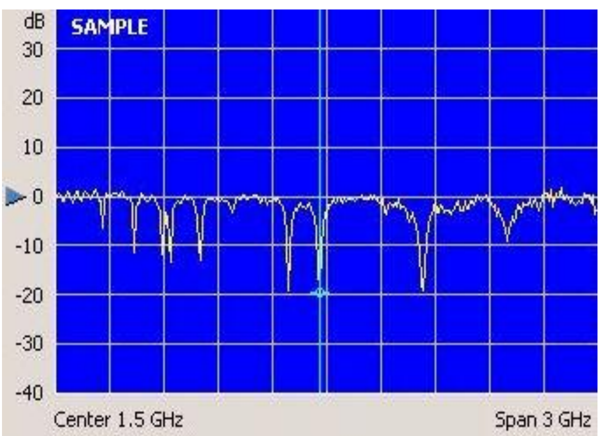

Fig.7 Measured results of S_{11}

V CONCLUSION

In this paper, we have presented an electrically small, multiple frequency antenna which exhibits characteristics of metamaterial.

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