ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 2, Issue 7, July 2014

Design of patch antenna based on metamaterial

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: Many needs of new generation communication system would be filled by electrically small, efficient antennas having significant bandwidth, if we reconcile these contradictory requirements. The introduction of metamaterials has provided an alternate design approach to obtain efficient electrically small antennas. These are the artificial materials which have engineered electromagnetic responses that are not readily available in nature. A micro-strip antenna based on metamaterial is proposed in this paper is to investigate the response of an antenna enclosed in metamaterial. With this design the return loss of -43dB has been achieved at the frequency of 1.6142 GHz.

Keywords: Microstrip antenna, Metamaterial based antenna

I. INTRODUCTION

The behavior or function of material 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.

However, 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 figure 1[5].

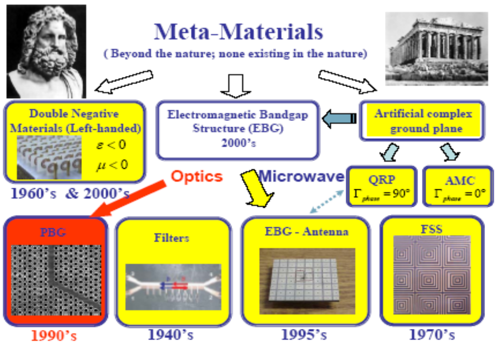

Fig.1. Metamaterials and their representative applications

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 sub-wavelength 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

The proposed design consists of a metallic patch sandwiched between two layers of dielectric material. Top view antenna shown in figure 2. Value of ‘a’ & ‘b’ shown in figure 2 is 15mm and 10mm respectively. Figure 3 shows the top view of ground plane. To energize the antenna, single probe feed is applied to the patch. Position of feed is also shown in figure both figures by a small circle. By increasing the antenna height, resonant coupling of printed antenna can be enhanced [6].

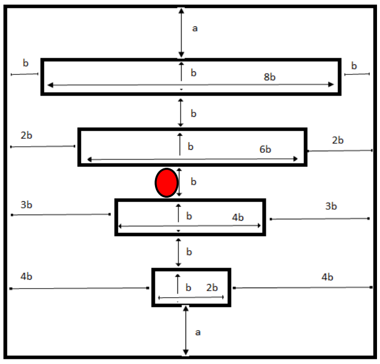

Fig. 2 Top view of upper layer with feed point

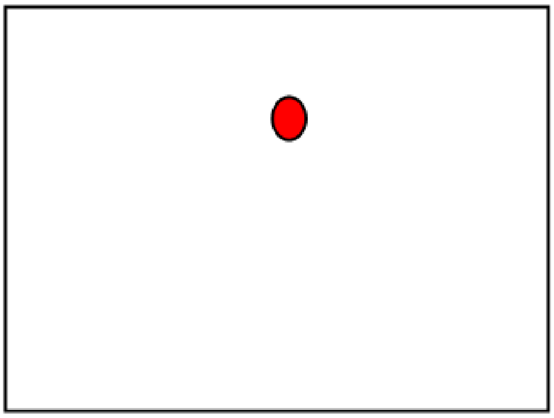

Fig.3 Top view of Bottom layer with feed point

Table 1: Parameters & Dimensions

Material	Dimension (millimeter) Length x width x thickness
Metallic Ground	100x100x0.005
Substrate	100x100x1.6
Metallic Patch	100x100x0.005

IV. RESULTS & DICSUSSIONS

The proposed geometry of the antenna has been simulated by using the **CST MICROWAVE STUDIO 5.0** simulation package. Figure 4 shows the implemented antenna while Figure 5 shows the simulation result for the variation of S_{11} with frequency and figure 6 shows the simulation results for the variation of VSWR with frequency for the proposed antenna. Laboratory result shown in figure 7, suggested a frequency shifh of about 12%.

Fig.4 Implemented Antenna

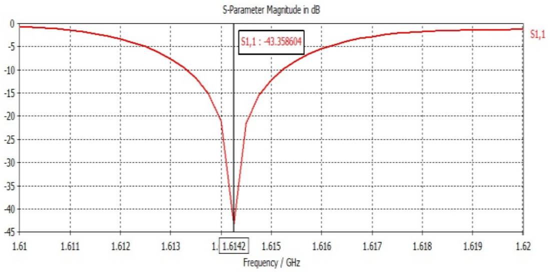

Fig.5 Variation of S_{11} with Frequency

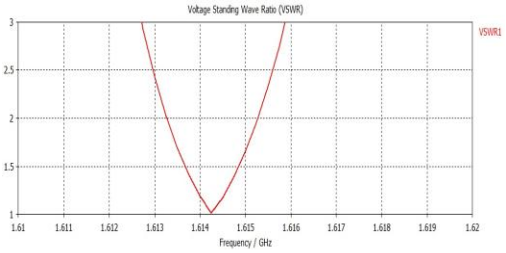

Fig.6 Variation of VSWR with Frequency

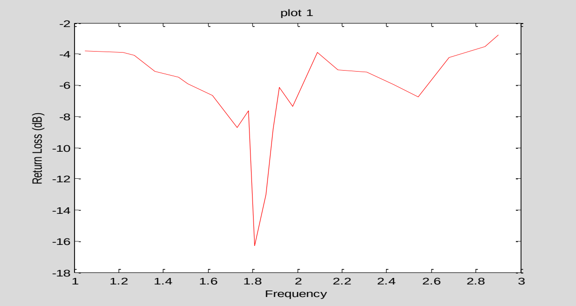

Fig.7 Variation of VSWR with Frequency

REFERENCES

[1] Hapgood, Fred; Grant, Andrew (From the April 2009 issue; published online 2009-03-10). “Metamaterial Revolution: The New Science of making Anything Disappear”. Discover (magazine): pp. 4 pages. Retrieved 2010-03.

[2] “Professor David R. Smith, Publications”. The electromagnetic properties of artificially structured materials. Duke University - Meta Group. July 13, 2009. Retrieved February 28, 2011.

[3] Pendry, J.B. et al. "Extremely Low Frequency Plasmons in Metallic Microstructures". Phys. Rev. Lett. 76, 4773 (1996)

[4] Pendry, John B.; AJ Holden, DJ Robbins, and WJ Stewart (1999-02-03. Actually published in 1999-11). “Magnetism

from conductors, and Enhanced Non Linear Phenomena" IEEE Trans. Microwave Theory Tech **47** (11): 2075–2084.
[5] Rahmat-Samii, Y.; Antennas and Propagation, 2007.The Second European Conference Page(s): 1 - 5 IET Conferences.
[6] Veselgo, V. G. (1968). "The electrodynamics of substances with simultaneously negative values of [permittivity] and [permeability]". Soviet Physics Uspekhi **10** (4): 509–514.
[7] Ward, David W.; Nelson, Keith A and Webb, Kevin J (2005). "On the physical origins of the negative index of refraction". New Journal of Physics **7** (213): 213.
[8] Piyush Moghe, P.K. Singhal " Metamaterial Based Multiple Frequency Antenna" International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 1, April 2013