Advanced Research in Electrical and Electronic Engineering
p-ISSN: 2349-5804; e-ISSN: 2349-5812 Volume 3, Issue 3, April-June, 2016, pp. 223-225

http://www.krishisanskriti.org/Publication.html

Design and Analysis of Planar Antenna using Metamaterial

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Abstract—*In this present work, "Design and Analysis of planar antenna, using metamaterial (MTM) structure", we have proposed some improvements in the impedance bandwidth and reduction in return loss, hence overall improving and increasing the efficiency of planar antenna. The planar antenna mentioned is precisely rectangular micro strip patch antenna, as rectangular structure gives maximum gain and minimum loss. The Simulated and measured results indicate that the designed structure resonates at various closely spaced frequencies, lying between frequency band allocation for Wireless application and offers much improved bandwidth and return loss at resonance frequency 1.66 GHz. CST MICROWAVE STUDIO is used to design the metamaterial based planar antenna.*

Keywords*: Impedance Bandwidth, Planar Antenna, Metamaterial structure, Directivity, Return Loss, and Gain.*

1. INTRODUCTION

The devices used in the 21st century are efficient enough to meet up to the challenges. The science and technology is growing at a rapid rate and moreover we can witness the use of devices like mobile phones, headphones, laptops and many more. Similarly, there is a device, rectangular microstrip patch antenna which is used for wireless communication applications in a highly efficient manner. Rectangular Microstrip Patch Antennas (RMPA) possess certain type of drawbacks in the form of narrow bandwidth, low gain, and relatively larger size. There is always the demand of increasing the bandwidth and data rate of the wireless communications systems, for eradicating the basic problems with the device.

The simple planar antenna, more precisely Microstrip patch Antenna consists of a dielectric substrate having fixed dielectric constant. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. A communication system requires the development of low cost, minimum weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies.

Micro strip patch antennas are commonly used in the wireless devices. So, the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system. All these antennas can also be fabricated using CST simulation software and achieve sharp characteristics. Proposed RMPA can be widely used in many wireless communication systems such as for commercial and military purposes, because of their low profile and light weight.

In its most fundamental form, a Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the opposite or other side. The electric field is zero at the center of patch, maximum at one side, minimum on the opposite side. Important parameters of any type antenna are impedance bandwidth and return loss.

To improve the results, some types of ground structures are also utilized for minimizing the return loss and for increasing the bandwidth of the antenna with the introduction of METAMATERIAL structure in ground plane of patch antenna. The substrate material plays very significant role in determining the size and bandwidth of an antenna. Increasing the dielectric constant decreases the size but lowers the bandwidth and efficiency of the antenna while decreasing the dielectric constant increases the bandwidth but with an increase in size. A micro strip patch antenna using METAMATERIAL structure is simulated using CST Microwave Studio software, which is a package for the electromagnetic analysis and design.

Antenna operates at the frequency 1.66 GHZ with the value of Return Loss and Bandwidth as mentioned in the chart.

Table 1: Comparison of return loss

Return Loss	**1st Band**	**2nd Band**
Plain Patch	-10.6 dB	-24.013 dB
Metamaterial	-25 dB	-46.017 dB

Table 2: Comparison of bandwidth

Bandwidth	1st Band	2nd Band
Plain Patch	13.65 MHz	42.3 MHz
Metamaterial	29.4 MHz	108 MHz

There are two columns respectively of 1st band and 2nd band, this is because our antenna design operates at dual band frequency.

Metamaterials are made from assemblies of multiple elements fashioned from conventional materials such as metals or plastics. They are derived not from the properties of the base materials, but from their designed structure. There are two important properties that determine how a material will interact with electromagnetic radiation, these are:

1. Negative relative permittivity

2. Permeability

ANTENNA DESIGN AND RESULTS:

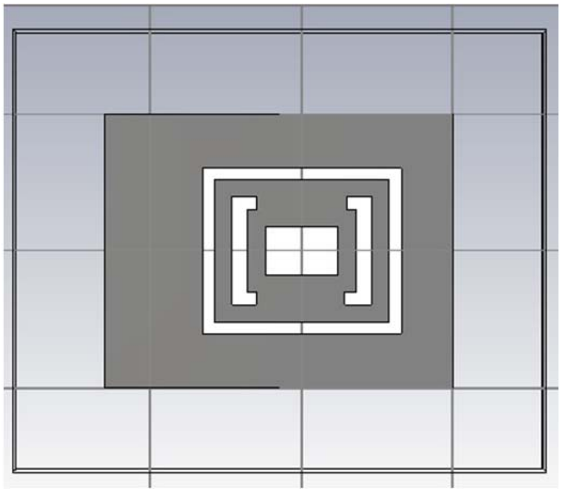

Fig. 1: Metamaterial structure.

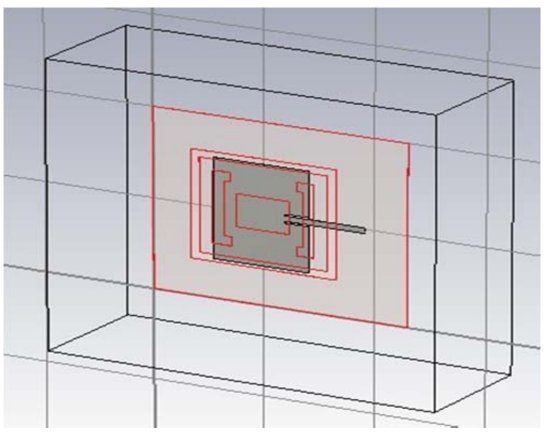

Fig. 2: Perspective View of Antenna

The Metamaterial structure shown above shows the proposed work, through which improvements are achieved,

This structure is dug out from the ground part of antenna, which is made of Perfect Electric Conductor (PEC). There can be many other Metamaterial structure that can be dug

out from the ground part, and each time the response achieved will be different from the one already present. So, we have operated at 1.66 GHz frequency and the response achieved through our dual band antenna is shown.

RESPONSE

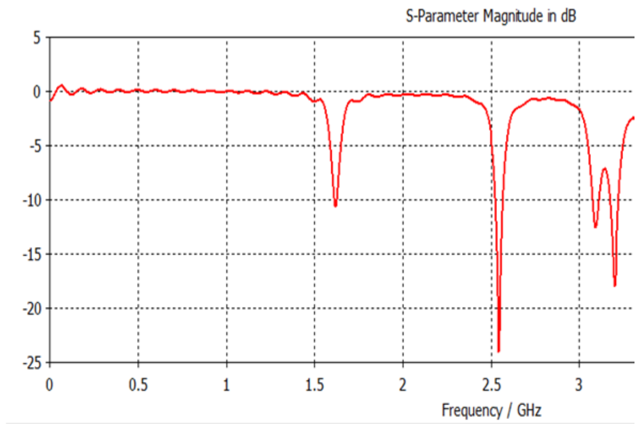

Fig. 3: Response of original plain patch

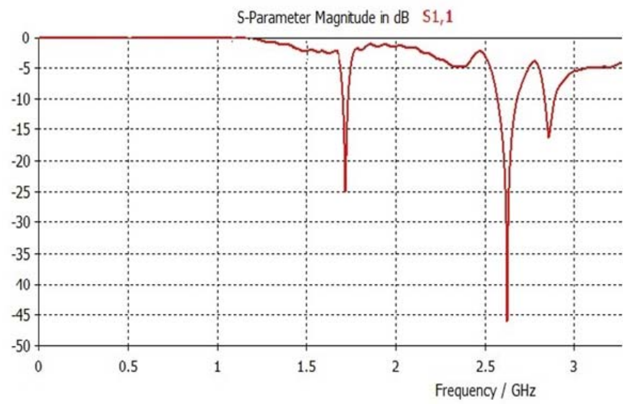

Fig. 4: Response of patch using metamaterial

SMITH CHART

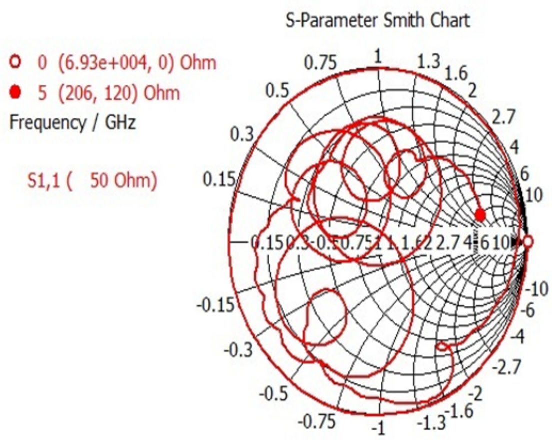

Fig. 5: Smith chart

2. SIMULATION OF PROPOSED ANTENNA:

- Length (L): The two sides are selected to be of equal length, which is 43.576 mm each.
- Width (W): The two sides are selected to be of equal width, which is 55.50 mm each.
- Frequency of operation (fo): The resonant frequency selected for our design is 1.66 GHz.
- Dielectric constant of the substrate (εr): The dielectric material selected for our design has a dielectric constant of 4.3. A substrate having high dielectric constant has been used, since it reduces the dimensions of the antenna.
- Height of dielectric substrate (h): For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not complex, bulky or large. Hence, the height of the dielectric substrate is 1.6mm.

Table 3: Parameters of patch antenna

S. NO.	PARAMETERS	VALUES
1	LENGTH	43.576 mm
2	WIDTH	55.50 mm
3	HEIGHT	1.6 mm
4	FREQUENCY	1.66 GHz
5	DIELECTRIC CONSTANT	4.3

3. CONCLUSION

The technology in today's global scenario has risen very rapidly, considering each and every big or small parameter that the device comprises. Similar case is with the antenna, the lesser the size and complexity, lesser the return loss and larger bandwidths, which as in whole increases the efficiency of the antenna. In our proposed project we have worked with the Meta-material structure that enhances and improvises the efficiency of the planar antenna.

The reduction of return loss improves gain of patch antenna which makes patch antenna more directive. The development of system such as satellite communication, highly sensitive radar, radio altimeters and missiles systems need very light weight antenna which can be easily attached with the systems and which does not make the system bulky. The simulated results provide that, the Return loss of proposed antenna is reduced by 22.004 dB.

It is clear that we can easily overcome the drawbacks of RMPA by using the properties of Metamaterial (MTM) structure.

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