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Comparison Between Circular Microstrip Patch Antenna and Metamaterial Based Cross Patch Antenna

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Abstract: Nowadays, demand for small-size devices having integrated many functions is of great interest, especially in devices that are used in daily life. To satisfy this requirement, device components must be compact for which antenna size needs to be reduced. To improve gain of antenna metamaterials-based antennas are used. Inside our paper, we are suggesting a design of an antenna using metamaterial which will not only help us in reducing antenna size but will also help us improve other antenna parameters like gain, bandwidth, etc also. The aim of this metamaterial-based paper is to design and to fabricate a metamaterial antenna and study the effect it has on various dimensions of antenna.

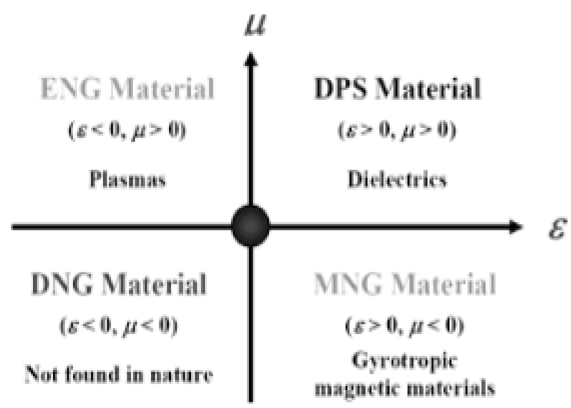
Key words: *Metamaterials, antenna, gain, bandwidth, dimensions, parameters*

1. INTRODUCTION

It is the remarkable nature of humans that we tend to create something that is unavailable in nature. Metamaterials are materials that are artificially made that allows are to create parameters with values that are not naturally occurring. Here meta refers to the resulting constructive properties whose electromagnetic feedbacks are way past of their integral materials.

In recent times, scientists have put a lot of effort into researching new artificial materials that can replace earlier used natural materials which can bring significant benefits to our life.

Metamaterials are one of those new metamaterials that are made up of an arrangement of metal structures. These materials property depends on the structure more than the components used to make it. Metamaterials are artificial in nature having properties that we don't find in materials that appear naturally. The extensive widespread property of materials is their capacity to control the propagation of EM waves. Essentially, the EM response implies what impact does the material causes on the electric and magnetic field to which it is exposed to. These artificially made materials are also cited as left-handed materials, double-negative materials, or basically metamaterials.



2. Body of Paper

2.1 Metamaterials

All metamaterials have one thing in common that is they are all developed artificially. Metamaterials are intelligent materials having a wide range of properties that differs hugely from one another. This indicates that they are artificial and not found in nature. Metamaterials are distinguished from natural materials by their extraordinary electromagnetic properties, which occurs due to their order and structure and not from their composition. Since graphite, diamond, and graphene are all composed of carbon but are distinguished on the basis of their structure, this is similar to what occurs with those materials.

1. Return loss

It refers to the power loss occured due to the signal displayed by the discontinuity in the transmission line. It is generally denoted by ratio in decibels(dB). The metamaterials have a structure that can potentially reduce the return loss and increase the working efficiency of the antenna.

2. Dimensions

The physical dimension of the antenna can be reduced by utilizing a metamaterial structure as substrate, superstrate, or any other specific arrangement.

3. Band Width (BW)

Bandwidth refers to the frequency range throughout which the antenna can accurately receive or radiate energy.

4. Gain

It is a comparative measure of an antenna's capacity to focus radio frequency energy in a specified direction. Metamaterial antenna can elevate the gain of the antenna.

2.2 ANTENNA DESIGN

Modified dual-band Jerusalem cross and patch antenna, designated by AMC1. The design of the AMC (artificial magnetic conductor) unit cells is illustrated in Fig. 1.

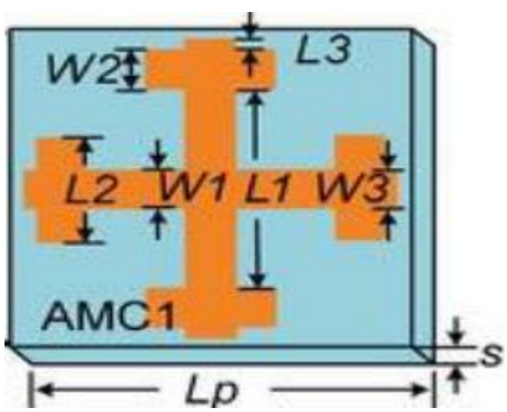


Fig. 1. Geomatry of AMC units

The above structures are symmetrical in design and hence can be utilized in double polarisations. The bottom side has a metallic ground plane installed to assure total reflection. Substrate chosen is a FR2 material having width of 3.0 mm, dielectric loss of 0.002, and relative permittivity of 2.65. All AMCs have acquired same periodicity so as to assure integer numbers of units in each of the AMC tile which comprises 5*5 unit cells. The detailed properties of FR-2 are shown in the following Table 1.

Table 1

FR-2 Substrate Properties

Properties	Values
Relative permittivity	2.65
Relative permeability	1
Loss Tangent	0.025

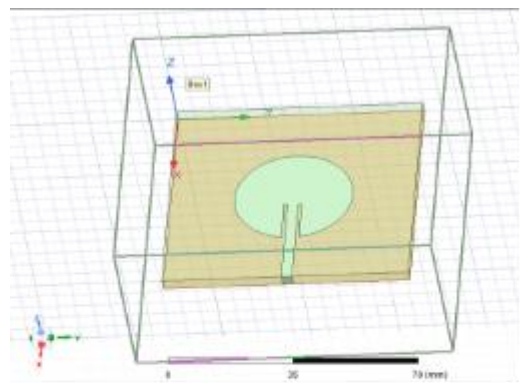
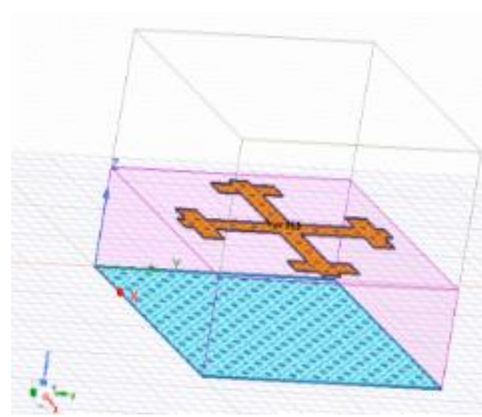


Fig. 2.a. Circular Patch Antenna



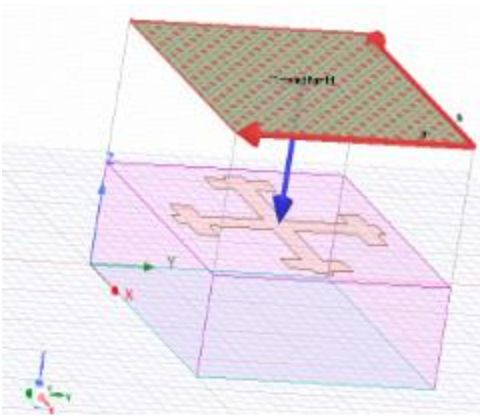


Fig. 2.b. Metamaterial-based Jerusalem cross-patch antenna

The following Table 2 represents the parameters of the circular patch antenna structure and table 3 represents the parameters of the metamaterial-based Jerusalem cross patch antenna.

Table 2

Circular Microstrip Patch Antenna Parameters

Parameter of antenna	**Dimensions(mm)**
Substrate Length	70
Substrate Width	70
Substrate Height	3.6
Radius	16.87

Table 3

Jerusalem Cross Patch Antenna Parameters

Parameter of antenna	**Dimensions(mm)**
Substrate Length	9.00
Substrate Width	9.00
Substrate Height	3.00
Cross Patch Length, L1	5.60
Cross Patch Length, L2	2.40
Cross Patch Length, L3	0.30
Cross Patch Width, W1	0.80
Cross Patch Width, W2	0.80
Cross Patch Width, W3	0.70

2.3 SIMULATION

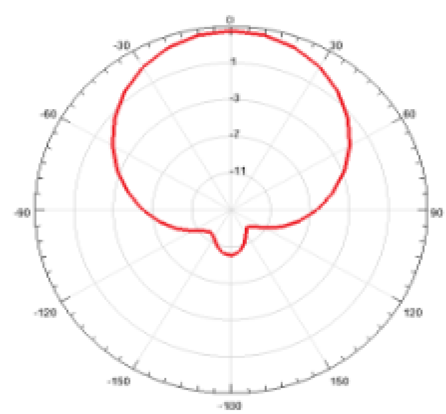


Fig. 3.a. Gain plot for circular microstrip patch antenna

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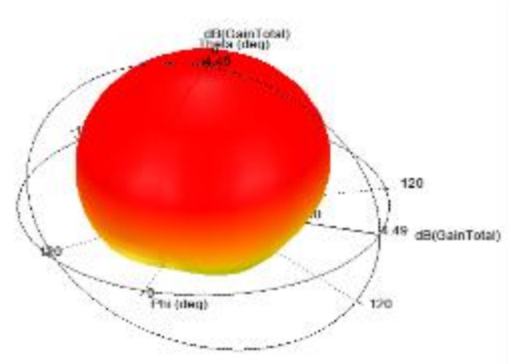

Fig. 3.b. 3D polar plot for circular microstrip patch antenna

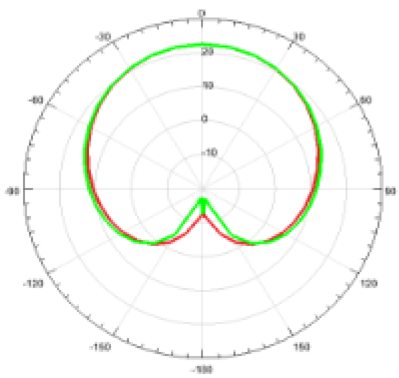

Fig. 3.c. Gain plot for jerusalem cross patch antenna

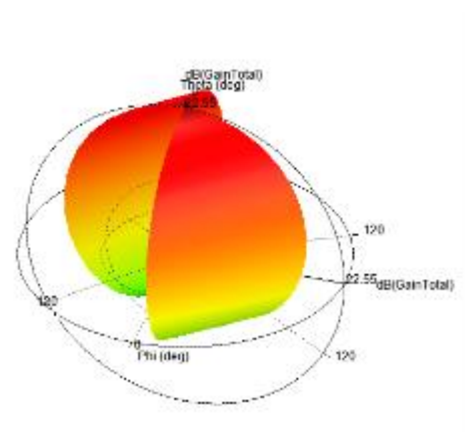

Fig. 3.d. 3D polar plot for jerusalem cross patch antenna

2.4 RESULT

The performance parameters of the circular microstrip patch antenna and metamaterial-based cross-shaped antenna are studied. The fabricated and simulated design of the prefered antenna is presented in Fig. 2.a and Fig. 2.b. The Gain plot of simulation for both antennas is represented in Fig. 3.a and Fig. 3.b. The 3D polar plot of simulated antennas are presented in Fig. 3.c and Fig. 3.d. After both types of antenna are studied, the results prove that cross-shaped metamaterial antenna provides better gain as compared to circular microstrip patch antenna.

Table 4

Comparison Table

Parameter	Circular Microstrip Patch Antenna	Metamaterial Based Cross Patch Antenna
Operating Frequency	2.4 GHz	18 GHz
Gain	4.49 db	22.55 db

3. CONCLUSION

In the following paper, a patch antenna based on Metamaterials with high performance and gain improvement has been presented. The simulated results obtained from ansoft HFSS show high performance and the high gain antenna is achieved. The measured and simulated responses depicts that gain is intensified in the complete operation band.

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