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A Compact Metamaterial Based Circular Polarization Antenna For Wireless Applications

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Abstract— In this paper a metamaterial based microstrip patch antenna is proposed and studied for circular polarized radiation. Today's modern satellite industry, miniaturization of antenna size is becoming a greater interest because of its low profile and high gain .By using the metamaterial property, more compactness can be realizable in overall antenna structure. The majority of metamaterial applications involve only linearly polarized antennas. The multi stacked layer model is considered to achieve dual polarization. In top layer the metamaterial rings are employed and beneath of that antenna substrate is present by a small distance. By using the transmission line model the design parameters of antenna like axial ratio, gain, bandwidth can be calculated. For the simulation process HFSS electromagnetic software has been used. At last a circular polarized antenna that can be resonated at 2.4 GHz frequency can be designed.

Keywords*- cicular polarization, single-band antenna, microstrip antenna, compact antenna.*

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I. INTRODUCTION

In today's modern communication industry, antennas are the most important components required to create a communication link. The microstrip antennas having the properties of compact size, light weight and very little amount of power consumption capability are the foremost suited in the area of space part and mobile applications. They can be designed in different types of shapes in order to obtain improved gain and bandwidth. There has been much interest in electrically small antennas. Many needs can be fulfilled if the engineers design the antenna which is electrically small, efficient, and have significant bandwidth. Metamaterials having a special electromagnetic properties, due to this these are used in tremendous applications at microwave and infrared frequencies. It is not possible to control the effective material parameters of naturally occurring materials with the degree of relative permittivity and permeability.

Miniaturization of antenna size in satellite industry helps to miniature satellites. These satellites are very affordable in cost and easy to build. Generally exterior to the satellite solar cells must cover because these are going to provide power for the whole satellite system while leaving the sufficient place to the antennas and other sensor devices [1]. Therefore, it is highly brilliant to design an antenna which is having a capability of sitting on the top layer of the solar cell of the satellite without interfering the functions of each other [1]-[2].

Here the designed antenna is having a capability of sitting directly on a solar panel of the satellite without interfering the function of each other. The antenna is designed based on the "wire mesh approach" and the whole patch of the antenna is divided into grids and 70 percent of patch area is removed to achieve transparency.

The main disadvantage of these straightforward alloys is their expense and high misfortune. Additionally, while designing of antenna by wire mesh approach they themselves are transparent making substrate also be transparent. Generally we are using plastic or quartz films to made substrate which is cost effective.

Here the designed transparent patch antenna using "wire mesh" method is implemented on a ceramic substrate instead of building on quartz or plastic films. This construction is having the two substrates with different level of thickness. After embedding the two layers of substrate the whole patch can be divided into grids and the patch can be cut through both the substrates to achieve transparency. By this construction becomes easier and inexpensive. Thus making the development easier and cheaper. We have a tendency to accomplish circular polarization [5] at two resonating frequencies by applying metamaterial ideas to only one patch, rather than utilizing more patches. A prior metamaterial-based double band circular polarization presented before is not reasonable because mounting metamaterial loading on a traditional patch does not increase transparency. So, the designed metamaterial based antenna approach yields a possibly easier and more instinctive configuration.

II. PROPOSED WORK

In this proposed work, a double band circular polarization patch using "wire-mesh" grid approach was designed and fabricated. We will accomplish circular polarized antenna at 2.4 GHz frequency by proceeding the method of metamaterial ideas to one patch instead of applying it to many patches.

A. Single band circular polarization antenna:

Truncated square patch is utilized and one of the diagonal corners truncating at an angle and fitting them together, prompting a 90 degree phase shift between the layer1's patch's TM_{01} and TM_{10} orthogonal modes. We utilize "wire network" method where a patch metal is separated into a lattice. A coaxial feed link associates with center part of the patch. The metamaterial based reception part is manufactured on a 60 ml Rogers 4003 substrate. To achieve transparency the substrates and the patch can be cut by same framework design into both the substrates. By removing the patch area, 70% of the patch has been removed.

B. Dual band circular polarization antenna:

The designed transparent patch antenna using "wire mesh" method is implemented on a ceramic substrate. On top of the patch a wire mesh is established which is having the negative refractive index property will be able to provide phase insertion at two desirable frequencies[3]-[4]. By metamaterial loading it is possible to introduce out of phase (90 degrees) between the patch orthogonal modes at two frequencies. It is occurring because of the metamaterial is having unique property containing both negative refractive index and negative permeability. The metamaterial loading consists of a series interdigitated capacitor which lies on top corner of the antenna patch and the shunt inductance linked to the ground. To obtain lowest axial ratio, the spacing between the grids is adjusted for circular polarization. The feed port is established on top left corner of the patch to provide enough space for metamaterial loading.

The 70% of the patch area is etched out to miniature the antenna size and the substrate layer is used to fit screws of antenna, So that it can directly sit on solar cell panel of the satellite without interfering the functions of each other.

III. ANTENNA DESIGN

The design system is having three layers as shown in below fig (1). The system uses two substrates with different thicknesses. Feed port is provided at one side of the transmission line and these are connecting by via passing through the antenna substrate and the matched network substrate.

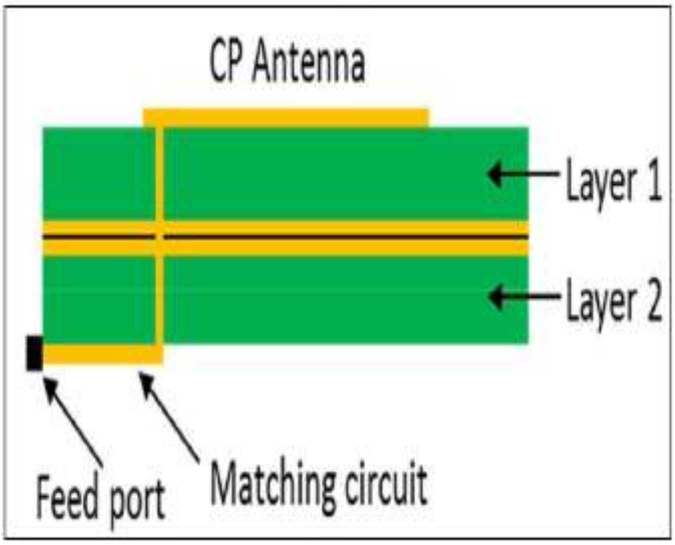

Fig (1): profile view of the entire design

A. Matched network

It is observed that for dual band circular polarization antenna adding of matching circuit is needed. Fig (1) Shows the modified matching network. It consists of two squared patches which provides shunt capacitance and via passed through substrate providing shunt inductance, simply referred as LC circuit. This network is tuned to provide resonant frequency at 2.4 GHz.

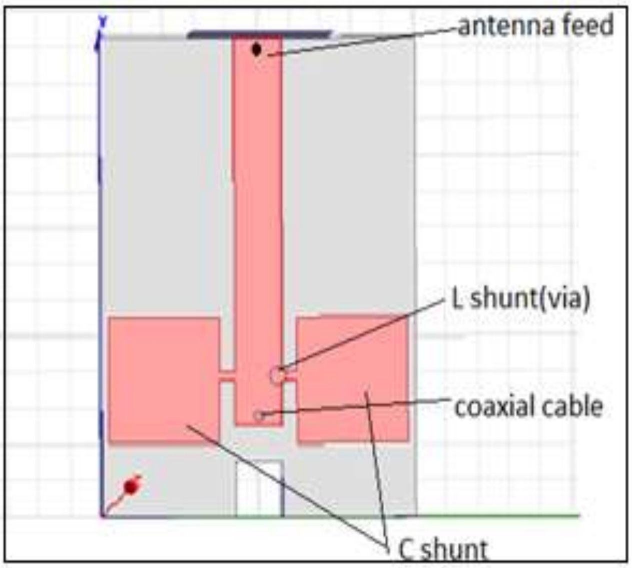

Fig (2): Designed matching network

The co-axial feed is provided at one side of the transmission line and antenna feed is provided at another side as shown in fig (2). It is tuned between two resonant frequencies and it provides the desirable inductance at high band and capacitance at low band [7]. The other end of the transmission line having via through both the antenna substrate and matching network substrate. The grid design is cut through both the antenna patch and the ground plane.

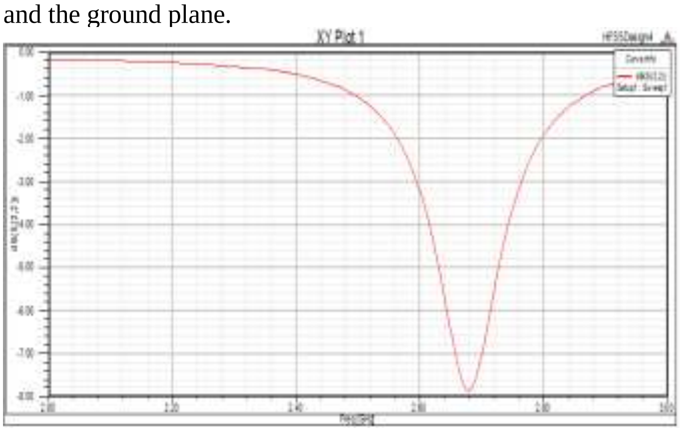

Fig (3): Simulated result of a matching network

From fig (3) we can observe that it is resonating at 2.43 GHZ. The transmission line is designed at the frequency of 2.4 GHz. The simulated result shows that it is resonating at 2.43 Ghz [9]. The transmission line lies between patch of the antenna and the matching network.

B. Dual band circular polarization antenna:

The transmission line which contains both the negative refractive index and negative resonance can give a phase difference at two difference frequencies. Now the resonant structure can provide 90 degrees phase shift between two of its modes by applying metamaterial loading. The whole system design can be viewed as in fig (4). The metamaterial loading includes an arrangement of interdigitated capacitor and a shunt inductance that is connected through ground plane by via. The lattice dividing and each capacitor and inductor mix is equipoised over betterment to catalyze about the least pivotal proportion for the circular polarize antenna[10]. To minimize

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the region required by the metamaterial loading the feeding port is shifted to the upper corner of the patch antenna. As the wire mesh occupy the top left corner of the patch, the remaining patch area is divided into grids and the 70% of the patch is removed throughout both the substrates. So that the substrate space was expanded to allow space to reinforce antenna on a solar cell of satellite system.

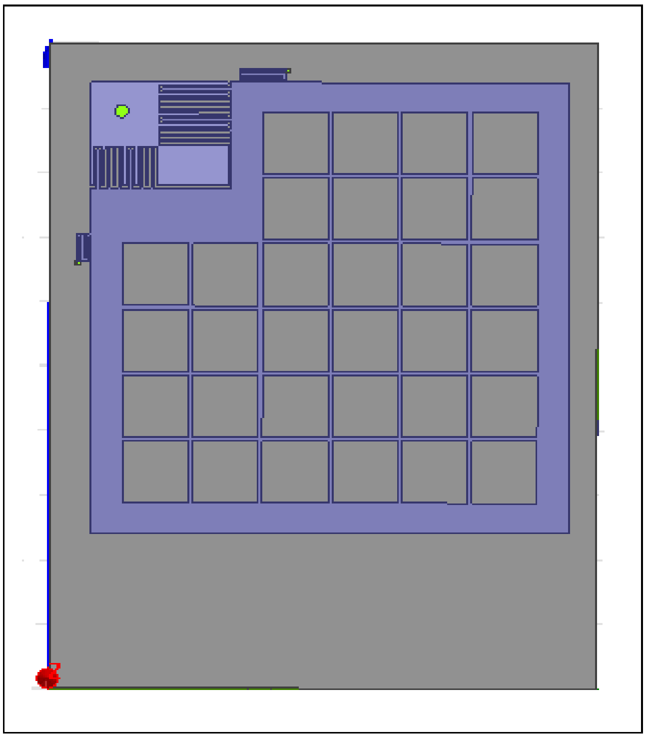

Fig (4): designed dual band CP antenna

From fig (4) it shows representation of the dual band circular polarization antenna. Fig (5) is the top left corner of the patch antenna. It is having the design of meandered lines that are splitting at opposite corners providing resonance as like metamaterial structures.

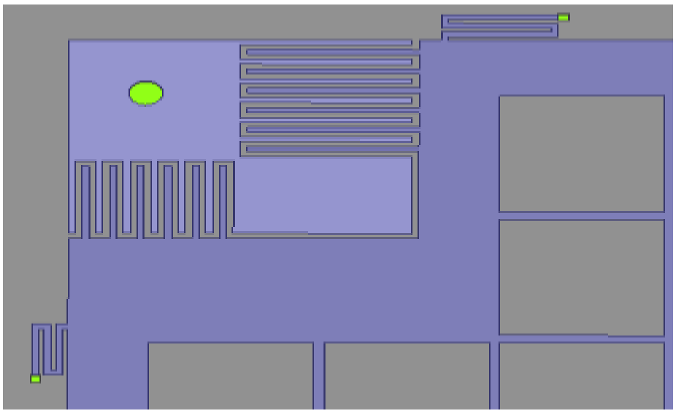

Fig (5): Top corner of the patch

Antenna feed is given at the top corner of the patch by leaving the enough space for metamaterial loading. These meandering lines provided the capacitance effect and the inductance is generated by the lines which are connected to the ground through via from layer1.

The main advantage of metamaterial loading comprises the miniaturization of the antenna. By providing the inductance and the capacitive resonating values it gives the 90 degree out of phase between the orthogonal modes of the circularly polarized antenna at two frequencies.

IV. SIMULATED RESUTS

For the simulation process HFSS 13.0 electromagnetic (EM) software has been used under driven modal. Due to many layers in the circuit design is very complicated. Fig 6(a) shows the magnitude response of s_{11} and fig 6(b) shows the magnitude response of s_{22} for the single band circular polarization antenna. We have to make sure that the electrical connection between the two grounds is correctly established.

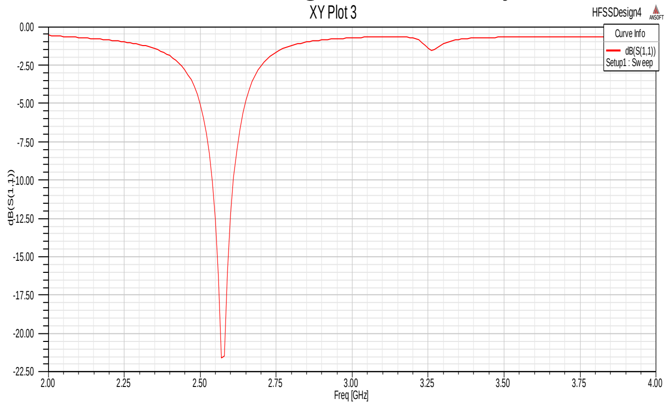

Fig 6(a): s11 of the double band circularly polarized antenna

From fig 6(a), observing that resonant frequency is very close to the desired band i.e.,2.4GHz and the and the coordinating stays underneath 10 dB.

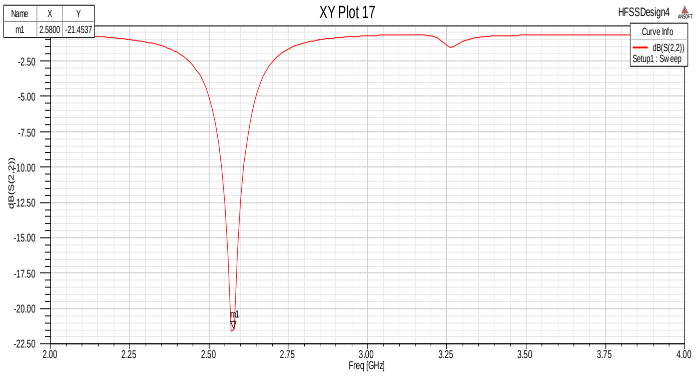

Fig 6(b):S_{22} of the dual band circular polarization antenna

Fig 6(a) & 6(b) demonstrates the deliberate and measured circularly polarized information at edgeways over the 2 desirable frequency bands. For this, at higher and lower frequencies both right hand circular polarization and left hand circular polarization was developed[11]. Generally, the deliberate top increases are 1.15 and 1.25 dB beneath the reproduced values for each of the two desirable frequency bands, considered to be sensible output which causes troubles experienced in creation.

The productivity of the double band transparent reception apparatus were resolved to be 70% at the first band. The

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proficiency at the high band is really bigger than the reproduced esteem.

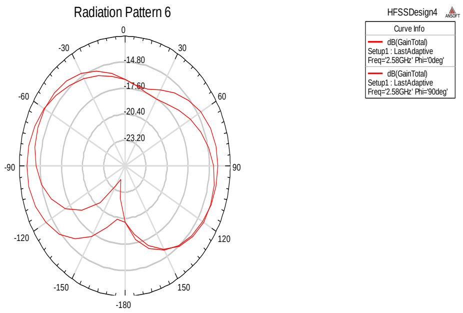

Fig 6(c): radiation pattern

This is the 3-D plot for the right hand circular polarization. The gain is expressed in dB. The axial ratio plot can give the two pivots at the two desired frequencies.

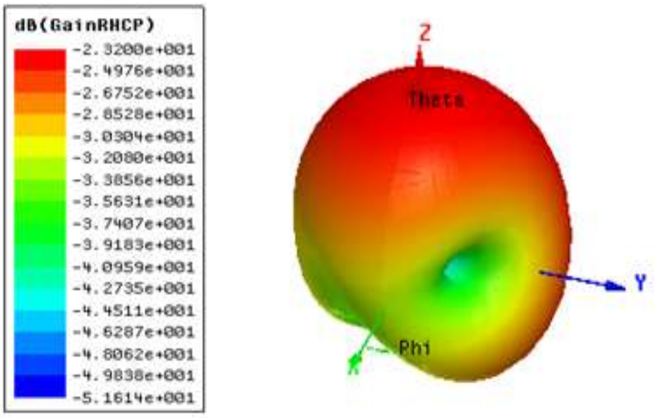

Fig (7): Simulated 3D gain pattern of RHCP at 2.5Ghz

As specified expect a solitary mode of operation, however the low pivotal proportion estimations of Fig (7) show two modes present over a wide transmission capacity, along these lines prompting little mistakes in the effectiveness. Finally designed the compact sized circularly polarized antenna.

V. CONCLUSION

The designed antenna consists of three layers. The matching network provides the matching between the source and the load through the transmission line. The designed antenna is capable operating at 2.4GHz frequency. So by using matching network we are going to tune between the resonate frequencies. This proposed work has displayed circularly energized patch antenna that utilizes the transparent lattice of the patch to enhance the transparency of the antenna.

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