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Design and Analysis of Metamaterial based Rectangular Patch Antenna for Satellite Communication

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Abstract: The role of communication satellite in natural and global information infrastructure is diverse. A metamaterial based rectangular patch antenna is designed for satellite communication which is cantered at 4GHz of C-band and the antenna characteristics namely return loss, VSWR, radiation pattern are analysing. The C-band communication which ranges in 4-8 GHz, are less disturbed by noises and heavy rain. Moreover the bandwidth available in C-band is cheaper. The main application of C-band is Television communication. The television applications use C- band and Ku-band of electromagnetic spectrum. The specified antenna can be used in LNB (Low Noise Block converter) of DTH (Direct To Home). Normally, DTH is used for Ku-band due to the reduced dimension of antenna. But C-band requires large dimension, hence the antenna is designed using metamaterial approach which can reduce the size of antenna up to 50% .The micro strip patch antenna is used increasable because it can be directly printed on the circuit board and is of low profile and low cost. Antennas employing metamaterial offer the possibility of overcoming restrictive efficiency bandwidth limitations for conventionally constructed, miniature antennas. The High Frequency Structure Simulator (HFSS) software is used to design this antenna which is more accurate and give faster solution. The designed frequency band and size of antenna are meeting the requirement of antenna used for the satellite communication, especially in television application

Keywords: Metamaterial, microstrip patch antenna, HFSS,C-band.

I. INTRODUCTION

The role of communication satellite in natural and global information infrastructure is diverse. A metamaterial based rectangular patch antenna is designed for satellite communication which is cantered at 4GHz of C- band and the antenna characteristics namely return loss, VSWR, radiation pattern are analysed. The C-band communication which ranges in 4-8 GHz, are less disturbed by noises and heavy rain and other factors. Moreover the bandwidth available in C-band is cheaper. The main application of C-band is Television communication and radio communication. The television applications use C- band and Ku-band of electromagnetic spectrum. The specified antenna can be used in LNB (Low Noise Block converter) of DTH (Direct To Home). Normally, DTH is used for Ku-band due to the reduced dimension of antenna. But C-band requires large dimension, hence the antenna is designed using metamaterial approach which can reduce the size of antenna up to 50% .The micro strip patch antenna is used increasable because it can be directly printed on the circuit board and is of low profile and low cost. Antennas employing metamaterial offer the possibility of overcoming restrictive efficiency bandwidth limitations for conventionally constructed, miniature antennas. The High Frequency Structure Simulator (HFSS) software is used to design this antenna which is more accurate and give faster solution. The designed frequency band and size of antenna are meeting the requirement of antenna used for the satellite communication, especially in television application.

Micro strip patch antennas are the smallest antenna that can be fabricated in printed circuit boards. It is very compact, less weighed and have light mass. Thus it makes entire antenna system less expensive. A patch antenna is fabricated on a substrate with a feed line provided. The field line is used to provide the input to the patch antenna. The feeding mechanism can be direct feeding or indirect electromagnetic coupling. There several other feeding mechanisms are available for this purpose. The main drawback associated with these antennas is excitation of surface lane waves and narrow frequency bandwidth. In this area, a reversed stacked antenna design is proposed to enhance the antenna bandwidth without producing additional plane waves in the structure. This design also allowed the antenna to operate in multiband and broadband as required by many wireless communication systems such as Bluetooth, RFID technology, satellite communication and radar communication. In order to assemble the smallness necessities, the antennas which are working on communication terminals have to be a compact antenna such as micro strip patches. These types of antennas are very popular for the communication devices such as satellite communication, radar, communication etc. The origin of Micro strip patch antennas begins with the use of planar microwave technologies such as micro strip and slotted lines. In its simple structure of a patch antenna consisting of a conducting layer on the upper plane of a dielectric substrate, and the other hand lowers the plane as figure 1.1. The size of rectangular patch antenna can be further reduced using some special metallic structures called metamaterials.

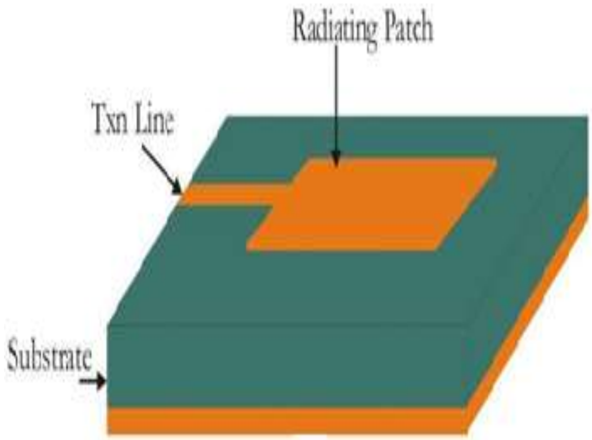

Figure 1.1 Common geometry of Rectangular patch antenna

1.1 Metamaterial Structures

A metamaterial is a kind of artificial synthetic composite material with a specific structure, which exhibits properties not found in natural materials. A metamaterial is mostly designed based on a periodic structure with respect to some electromagnetic properties like negative-permittivity or permeability, zero refractive index, and huge chirality. As in natural materials, the properties of metamaterials are decided by their components and their arrangements. In order to obtain specific properties, the components should be designed with specific patterns, yielding resonant structures. The components, sometimes called meta-atoms or metamolecules, are periodically arranged in one, two, or three dimensions. They can be coupled with each other which considerably modify the properties of the metamaterial. One of the most important applications of metamaterials is antenna design. Due to the unusual properties of metamaterials, we can achieve antennas with novel characteristics which cannot be realized with traditional materials.

1.2 Satellite communication

The role of communications satellites in the national and global information infrastructure is diverse. Communications satellites utilize electromagnetic spectrum to transmit information. The material in this project is involved in studying the application of telecommunication devices for various frequency ranges, such as L-band, C-band, Ku-band, Ka-band, etc. in implementing the emerging frequency band of Ka-band, a broadband with approximate width of 18 – 40 Giga hertz. This broadband is now becoming a big issue because the lower frequency bandwidth between 12-18 Giga hertz named Ku-band will be occupied by larger telecommunication service providers filling up the band while various factors such as rain attenuation, antenna wetting, depolarization due to rain and ice, cloud attenuation etc. still affect significantly high frequency propagation. As the traffic of the Ku-band and other lower band spectra are highly congested, regulatory organizations encounter problems in reallocating services to other frequencies. If reallocations of frequency are to be sought to certain bandwidth, it would result a loss of billions of dollars per year to previously mounted communications satellites which transport various signals. The frequency range available for satellite communications services is limited, and regulated by international agreements. For this reason, the spectrum has to be used in a highly efficient manner. Frequency assignment for different wireless services is regulated by the International Telecommunications Union (ITU), a sub-organization of the United Nations. Among them we chose c-band for satellite communication in this project. C band satellite services are technically better suited for subscribers with large bandwidth requirements. This is because it easily supports Enterprise level connectivity featuring dedicated CIR bandwidth.

2. LITERATURE SURVEY

A communication satellite system, distinguished by its global coverage, emerged by the end of World War II. Satellites have made our global world interconnected and interdependent. Today, there are approximately 150 communication satellites in orbit which are responsible for various satellite services such as GPS (Global Positioning System) satellites, satellites phones, TV network, weather satellites, military satellites, etc which continue to alter the patterns of our society. Communication between two locations separating by long distance is only achievable when signals or messages are encoded on the top of high frequency electromagnetic wave.

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This project deals with C-band communication of satellite it ranges for 4-8 GHz. Its main applications include Cable TV distribution and Satellite TV. The world's first commercial satellite systems used C-band frequency range of 3-7 GHz. Today, as there are several TV broadcast stations and telecommunication service providers, scientist are facing high technical challenges within the congested wireless communication channel of C-band. Since frequency ranges greater than 10 GHz have major drawbacks during broadcast, scientists have not been able to shift to the wider frequency bands than C-band. At higher frequencies, the size of falling droplets, rain-filled clouds, or even snow play a significant role in reducing the intensity of incoming signals from antennas mounted on satellites.

3. PROBLEM STATEMENT

An antenna is designed which is centered at 4 GHz of C-band for satellite communication with reduced dimensions. It can be solved using micro strip patch antenna. As per International Telecommunication Union (ITU), 4-8 GHz frequency band is designated as C-band. This frequency range is used for satellite communication, especially in satellite-television network. The main advantage of operating under C-band is the reduced disturbance from heavy rain. That is it can be used in tropical rainfall regions. Also it provides cheaper bandwidth for communication. The main limitation of using C-band is that it requires expensive hardware. Large antennas are necessary for the proper satellite communication. Hence an antenna with reduced dimension that operate under C- band has to be designed for very compatible satellite communication systems. The smallest antenna which is commonly available is micro strip patch antenna. If we use micro strip patch antennas for this purpose, the size of entire system becomes much compact, because patch antennas can be fabricated on printed circuit boards. Moreover there are several other advantages for micro strip patch antennas. They are low cost, easy to integrate and weightless.

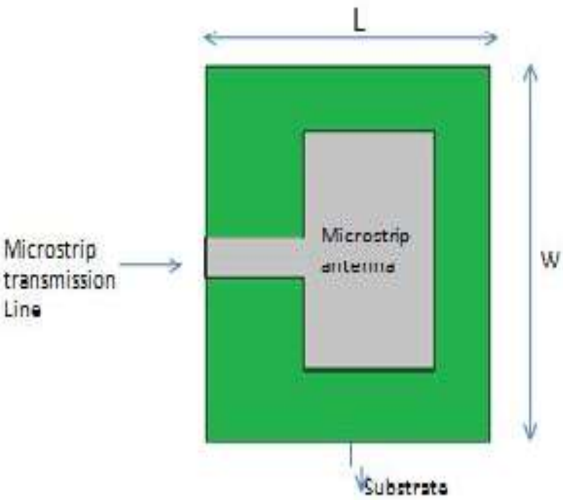

Figure 3.1 Micro strip patch antenna

The micro strip antennas are fed on the center of the substrate. The feed line is inserted into the micro strip patch. The ground and micro strip feed line are mode a high conductivity metal copper in patch antenna. L is the length and W is the width of the patch antenna. The probe can be coupled with micro strip feed to introduce the electromagnetic energy to the patch. The electric field of the patch is maximum (positive) at one side and minimum (negative) on other side, and zero at the center.

Even though the micro strip patch antennas are smaller in size we can further reduce its size by using some special metallic structures called metamaterial. A metamaterial is a kind of artificial synthetic composite material with a specific structure, which exhibits properties not found in natural materials. The metamaterial is mostly designed based on a periodic structure aiming at novel electromagnetic properties. As in natural materials, the properties of metamaterial are decided by their components and their arrangements. In order to obtain specific properties, the components should be designed with specific patterns, yielding resonant structures. The components, sometimes called meta-atoms or metamolecules, are periodically arranged in one, two, or three dimensions. They can be coupled with each other which considerably modify the properties of the metamaterial.

There are several important antenna characteristics should be considered when choosing an antenna for our application. They are mainly antenna radiation pattern, return loss and voltage standing wave ratio (VSWR). The radiation pattern

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of an antenna is a plot of relative field strength of the radio waves emitted by the antenna at different angles. Return loss is the loss of signal power resulting from the reflection caused at the discontinuity in a transmission line. VSWR is the Voltage Standing Wave Ratio defined as reflected power of the Transmission line. All these parameters have specific values for specific applications. Hence for satellite communication also there are some specific values of these parameters. The antenna design is performed using the software HFSS (High Frequency Structure Simulator). The designed antenna has to be simulated to analyze radiation pattern, return loss and VSWR for the specific application using HFSS.

4. DESIGN

Typically there are three essential parameters are required to design rectangular micro strip patch. The frequency of operation of the patch is selected by using the resonance frequency. The satellite communication in C-band uses 4-8 GHz. So the antenna must be designed to operate this frequency range. Choose 4 GHz frequency as the resonant frequency. The substrate can be made up of FR4 Epoxy with 4.4 dielectric constant. These substrate have dielectric constant it can be reduced the antenna dimension. The High Frequency Structure Simulator (HFSS) can be used to design this antenna. HFSS provides automatic, accurate, and efficient solutions to overcome challenges like reduction of antenna size, limited bandwidth and limited designing time, making it the ultimate tool of choice for antenna simulation. Basic performance characterization such as return loss, input impedance, gain, directivity and a variety of polarization characteristics can be analyzed in HFSS.

The substrate is chosen as FR4 epoxy with thickness 1.6 mm in HFSS software. The substrate length is selected as 26.9 mm whereas the substrate Width is selected as 32.4 mm. After substrate creation the patch geometry is created with patch length 17.39 mm and width 22.8mm. After the patch creation fed line is created with feed length 2.77 mm and width 17.843mm

The metamaterial can be used to design this rectangular patch antenna for better directivity and gain. It does not found in nature and it can be arranged by microscopic materials such as metals and plastics in repeating patterns. The left handed metamaterial can be used for our application.

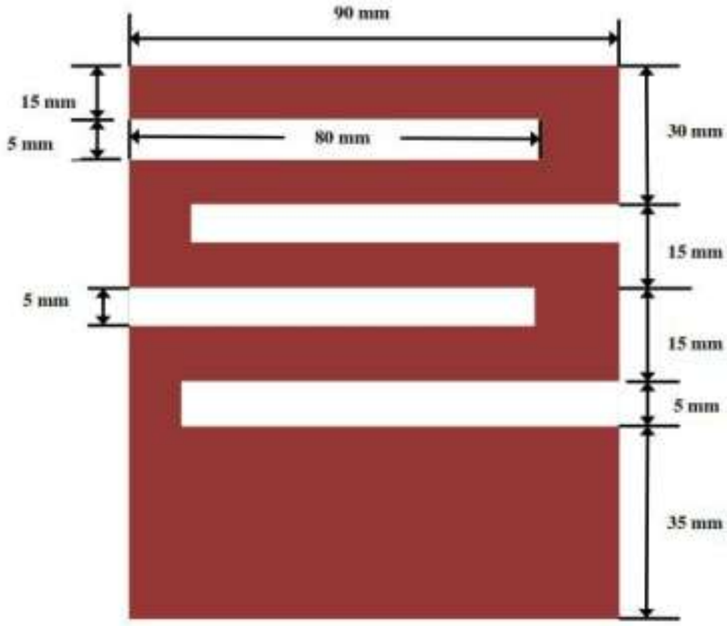

Figure 4.1 Metamaterial structure

The designed antenna has to be analyzed to obtain optimum value of return loss, radiation pattern and voltage standing wave ratio. The design is repeated with various dimensions of substrate, patch and metamaterial structure until desired values for satellite communication are obtained. The simulated results are obtained from HFSS.

After the simulation the new dimensions of the antenna were obtained ie 45 %of its original size were reduced
The entire design process can be represented as fig 4.2

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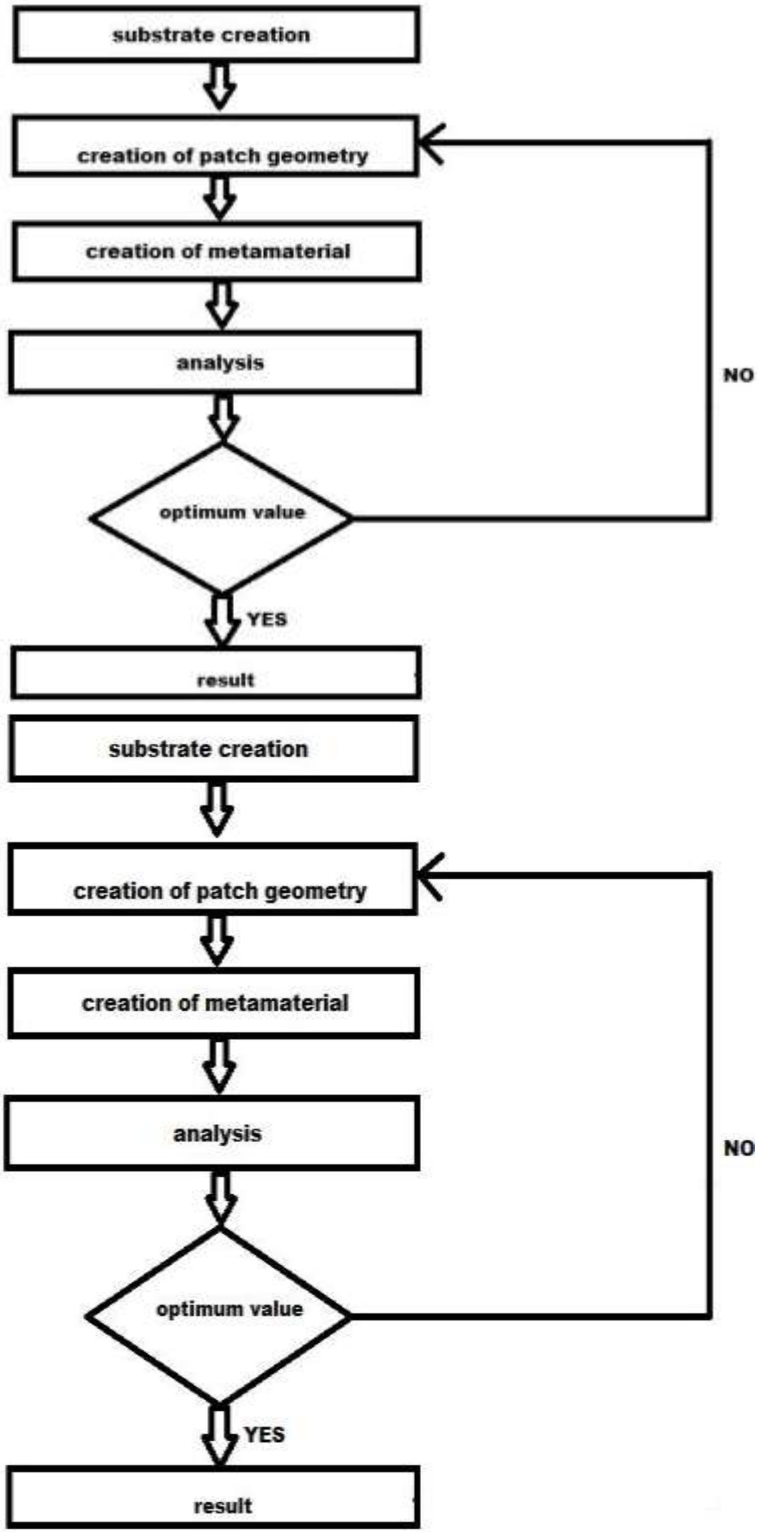

Figure 4.2 Design Flow

5. RESULTS

The designed antenna has to be analysed for specified antenna parameters. One of the most important antenna parameters specified for satellite communication is return loss. Return loss is the lost power due to the reflection of transmitted signal. The expected return loss characteristics for the above design is fig 5.1

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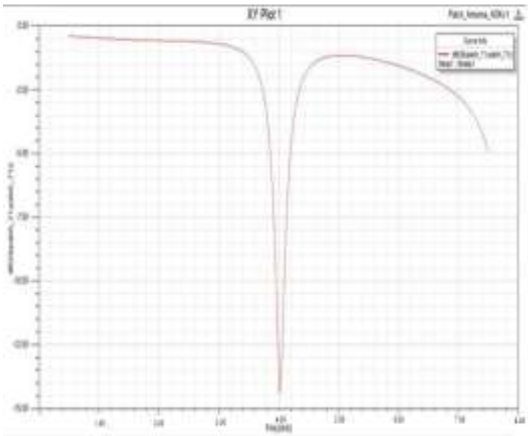

Figure 5.1 Return loss

Another antenna parameter is radiation pattern which is the plot of radiation field with respect to the different angles. Our radiation pattern for the specified application fig 5.2

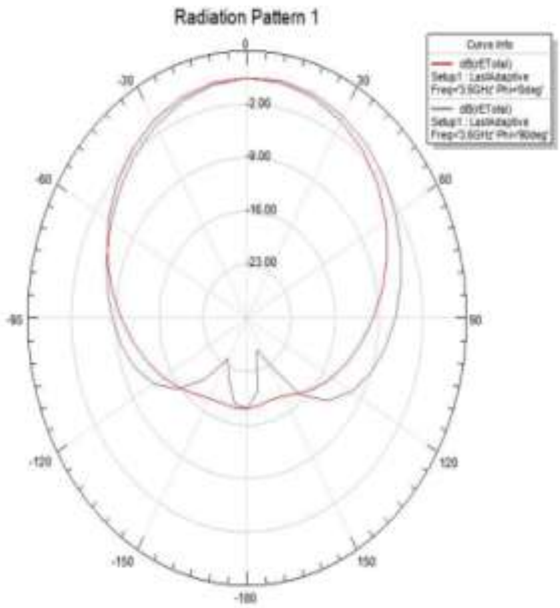

Figure 5.2 Radiation pattern

This patch antenna gives VSWR 1.55 which is sufficient for satellite communication in C-band.

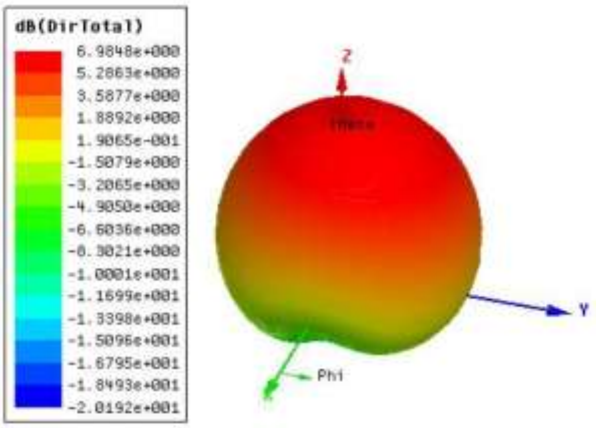

Figure 5.3 3D Radiation pattern

6. CONCLUSION

In order to overcome the limitations of satellite communication in C-band which is mainly the size of antenna, an antenna is designed with reduced dimension. Thus the metamaterial based rectangular patch antenna is analysed the parameters such as return loss, VSWR and radiation pattern in HFSS software. The VSWR and Return loss obtained are 1.55 and -14.9 at 4GHz centre frequency.

REFERENCES

[1] BoutheinaTlili, IEEE “Design of Double C-Slot Microstrip Patch Antenna for WiMax Application” Antennas and Propagation Society International Symposium (APSURSI) 2010.

[2] Slyusar V.I., Oct,.”Meta materials on antenna solutions” International Conference on Antenna Theory and Techniques, Lviv, Ukraine pp. 1924,6-9, 2009.

[3] RichardW.Ziolkowski, “An Efficient, Electrically Small Antenna Designed for VHF and UHF Applications”, IEEE Antennas WirelessPropag. Lett., vol.7, pp.217-220,2008.

[4] Dennis Roddy, “ Satellite Communications”, 3rd edition, McGraw Hill, USA, 2001,ISBN: 0-07-120240-4