DESIGN AND DEVELOPMENT OF COMPACT MICROSTRIP MEANDERED SLOT ANTENNA

L.Ashok Kumar [1], J.Navarajan [2], A.Nandheeni [3], M.Priyanka [4], V.Subhasree [5]

[1]*Assistant Professor, Electronics and communication, Panimalar Institute of Technology, Tamilnadu, India*
[2]*Assistant Professor, Electronics and communication, Panimalar Institute of Technology, Tamilnadu, India*
[3]*UG Scholar, Electronics and communication, Panimalar Institute of Technology, Tamilnadu, India*
[4]*UG Scholar, Electronics and communication, Panimalar Institute of Technology, Tamilnadu, India*
[5]*UG Scholar, Electronics and communication, Panimalar Institute of Technology, Tamilnadu, India*

ABSTRACT

Microstrip patch antenna is a lightweight, inexpensive antenna which is used for various applications such as Bluetooth, WLAN, satellite communication, biomedical applications and telemedicine due to its Compact size. This work aims at reducing the size of the antenna using meander slot. In this work we explored reduction, which makes it appropriate to apply for more applications. In this paper, a compact microstrip meandered slot antenna is designed by selecting a suitable offset feed position, it is feasible to provide 50 ohm characteristic impedance and thus making better impedance matching. The slot antenna is designed in meandered shape, so we get the advantages of both meandered shape and slot antenna. The proposed antenna has to be fabricated with FR4 substrate and dimensions of (19 x 22 x 1.6) mm. An extensive analysis of the return loss, radiation pattern and efficiency of the proposed antenna is shown in this paper. Finally, a prototype antenna operating at 4.2 GHz which is C band frequency is designed and fabricated. The permittivity of the substrate is 4.4. There is a good agreement between the measurement and simulation results.

Keyword: *- FR4 substrate, Gain, Microstrip patch antenna, Meander Slot, Return Loss, Size reduction.*

---

1. INTRODUCTION

In modern communication and radar systems, the microstrip patch antenna is much popular since it can be easily integrated with many other active and passive circuits such as filters, amplifiers, oscillators, and mixers. Recently, due to rapid changes in wireless communication technologies, there is rapid increase in data rate and at the same time reduction in antenna size and weight is require. To provide the high mobility for a wireless communication device, a small and light weight antenna is likely to be preferred. For this purpose, compact Microstrip antenna is preferred as one of the most suitable device. When compared to conventional microwave antenna, microstrip antennas have several advantages so they are widely used in many practical applications. They can be designed to have many geometrical shapes and dimensions. Cutting slot in proper position on the microstrip patch is one of the effective technique to reduce the size of the antenna. There are so many antennas which are used to reduce the size of the antenna. Reducing the size of the antenna drastically reduced the resonant frequency of slotted antenna as compared to conventional antenna. The size of the antenna may effectively reduced by cutting rectangular slots on printed antennas. Here, compact microstrip antenna is designed by cutting rectangular slots which has a resonant frequency much lower than the resonant frequency of the conventional antenna with the same patch area. It also increases the return loss and gain-bandwidth performance of the antenna. To reduce the size of the antenna, substrates are chosen with higher value of dielectric constant. The meandered slot antenna performance depends on various factors like the position of meander slots and number of turns on the meander slots. Recently, due to rapid changes in wireless communication technologies, there is rapid increase in data rate and at the same time reduction in antenna size and weight is require. To improve the bandwidth of antenna, antenna developers have provided number of techniques like defected ground structure, metamaterial loading and fractal antennas etc. The bandwidth of antenna can also be improved by decreasing the dielectric constant and by increasing the height of substrate, but these trends are limited by an inductive impedance offset that increase with thickness. In order to accomplish wide-band operation, it becomes necessary to reduce the antenna dimensions. The meander line is preferred over all other techniques due to low-profile, ease of printing and low-cost.

2. ANTENNA DESIGN

A meandered slot microstrip antenna is designed. The slot antenna is designed in meandered shape, so we get the advantages of both meandered shape and slot antenna. This antenna is fabricated with FR4 substrate material and dimensions of antenna is (19 x 22 x 1.6) mm.The operating frequency range for this antenna is 4.2GHz which is C band frequency. The permittivity of the substrate is 4.4. As the permittivity increases, the size of the antenna decreases. The shape and size of the antenna as well as the frequency determines the radiation pattern. Slot antennas are often used at microwave frequencies. The advantages of meandered slot antenna are its size, design, simplicity and convenient adaptation to mass production using either waveguide or PC board technology. The C band (4 to 8 GHz) has various applications such as satellite downlink, radar system, Wi-Fi etc. The polarization of antenna depends on radiations from the bend, the spacing between two bends is very vital, cross coupling is more if bend are close to each other, which affects the polarization purity of the resultant radiation pattern. In other case the spacing is limited due to the available array grid space and also the polarization of the radiated field will vary with the spacing between the bends, and the spacing between the microstrip.

The number of flat and vertical lines helps to increase the efficiency and transmission capacity of the antenna. 'W' shows the width, 'L' presents the length, 'h' depicts the height and 'g' mentions the gap between meander lines as shown in the fig 1.

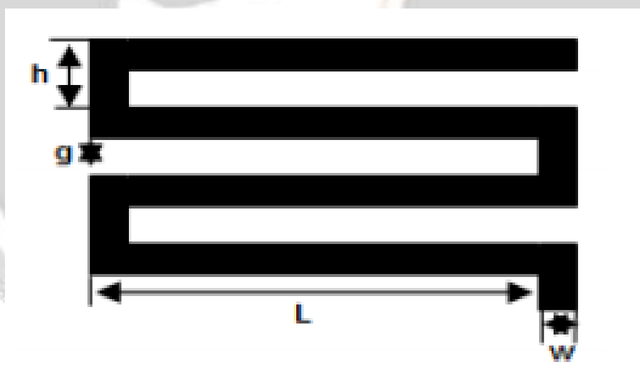

Fig -1: Meandered shape with dimensions

The meandered slot is used to reduce the size of microstrip patch antenna. The application is WLAN. It is applied to different applications such as Bluetooth, WLAN, satellite communication, biomedical applications, and telemedicine and so on due to its Compact size. This work aims at reducing the size of the antenna using meander slot. Reduction in size makes it appropriate to apply for more applications. Meander slot follows an asymmetrical path which increases the path for current flow.

The conducting element of meandered slot antenna is bent back and forth, so the performance of meandered slot depends on its parameters. The gain of the antenna and size is reduced by placing the long conducting material as a meander slot. Based on bobbinet's principle every slot in the antenna acts as a source element and how the slot antenna reradiates the power. Meander slot, defective ground structure and edge -truncation with the conducting patch bandwidth enhancement and size reduction is made possible. To achieve lower resonant frequency (MICS band), meander type slot antenna are used. This will increase the efficiency of antenna by reducing dissipation.

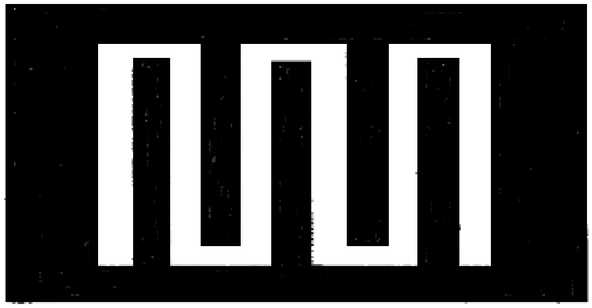

Fig -2: Meandered slot antenna

2.1 Design of Meandered Slot Antenna

Microstrip patch antenna with meandered slot is designed. The reduction in size of the antenna depends on suitable slots. The design of meandered slot antenna is a set of horizontal and vertical lines. Combination of horizontal and vertical slot forms turns. Number of turns increases efficiency increases. In case of meander slot if meander spacing is increase, resonant frequency decreases. A meander antenna is an extension of the basic folded antenna. Meandered slot antenna with 2 resonant and 4 resonant for vertical and horizontal shape is designed and analyzed.

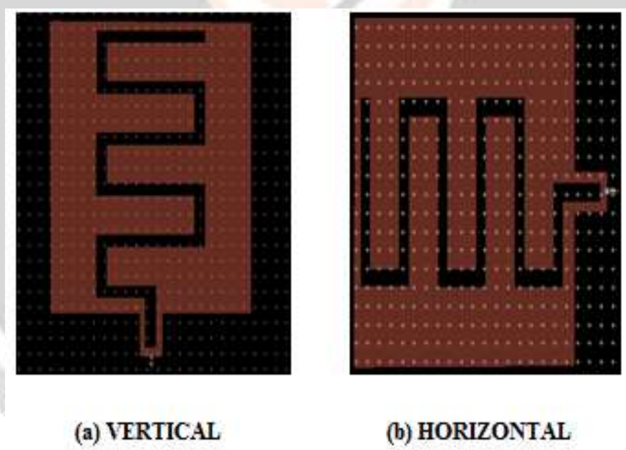

Fig -3: Two resonant slot antenna

The width and length of the designed vertical 2 resonant meandered slot antenna are 19mm and 22mm. Initially a rectangular patch with above mentioned dimension is drawn. The horizontal and vertical slots combined to form the meandered slot. Dimensions of horizontal slot are 10.1mm and 0.8mm and for vertical slot 0.9mm and 4.1mm. In Fig 3(a), 5 horizontal and 5 vertical slots are combined. Feed is placed at the center of the bottom edge. Feed used in the designed antenna is microstrip feed. The width and length of the designed horizontal 2 resonant meandered slot antenna are 22mm and 19mm. Initially a rectangular patch with above mentioned dimension is drawn. The horizontal and vertical slots combined to form the meandered slot. Dimensions of vertical slot are 10.1mm and 0.8mm and for horizontal slot 0.9mm and 4.1mm. In Fig 3(b), 5 horizontal and 5 vertical slots are combined. Feed is placed at the center of the right edge.

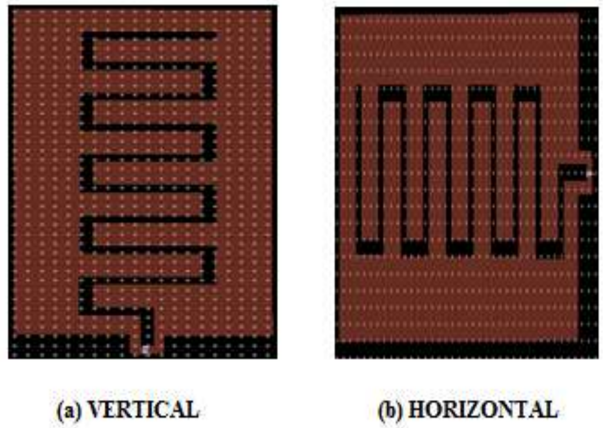

Fig -4: Four resonant slot antenna

The width and length of the designed vertical 4 resonant meandered slot antenna are 20mm and 37mm. Initially a rectangular patch with above mentioned dimension is drawn. The horizontal and vertical slots combined to form the meandered slot. . Dimensions of horizontal slot are 10.1mm and 0.8mm and for vertical slot 0.9mm and 4.1mm.In Fig 4(a), 9 horizontal and 9 vertical slots are combined. Feed is placed at the center of the bottom edge. The width and length of the designed horizontal 4 resonant meandered slot antenna is 37mm and 20mm. Initially a rectangular patch with above mentioned dimension is drawn. The horizontal and vertical slots combined to form the meandered slot. Dimensions of vertical slot are 10.1mm and 0.8mm and for horizontal slot 0.9mm and 4.1mm. In Fig 4(b), 9 horizontal and 9 vertical slots are combined. Feed is placed at the center of the right edge.

2.2 Design of Meandered Patch Antenna

The meandered patch antenna is also called meandered line antenna. The meander line antenna was for reducing the resonant length. Meandering the patch increases the patch over which the surface current flows and that eventually results in lowering of the resonant frequency than the straight wire antenna of same dimensions. The meander line element consists of vertical and horizontal line so it formed a series of sets of right angle bends. The number of flat and vertical lines helps to increase the efficiency and transmission capacity of the antenna. In this design, as the meander spacing and separation increases, resonant frequency decreases. Meandered patch antenna with 2 resonant and 4 resonant for vertical and horizontal shape is designed and analyzed.

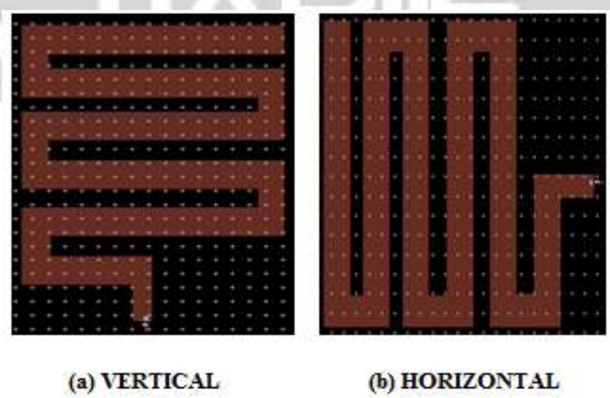

Fig -5: Two resonant patch antenna

The width and length of the designed vertical 2 resonant meandered patch antenna are 15.7mm and 21.2mm. The horizontal and vertical patch combined to form the meandered patch. Dimensions of horizontal patch are 15.7mm and 2.1mm and for vertical patch 1.6mm and 5mm. In Fig 5(a), 5 horizontal and 5 vertical patch are combined. Feed is placed at the center of the bottom edge. Feed used in the designed antenna is microstrip feed. The width and length of the designed horizontal 2 resonant meandered patch antenna are 21.2mm and 15.7mm. The horizontal and vertical patch combined to form the meandered patch. . Dimensions of vertical patch are 15.7mm and 2.1mm and for horizontal patch 1.6mm and 5mm. In Fig 5(b), 5 horizontal and 5 vertical patch are combined. Feed is placed at the center of the right edge.

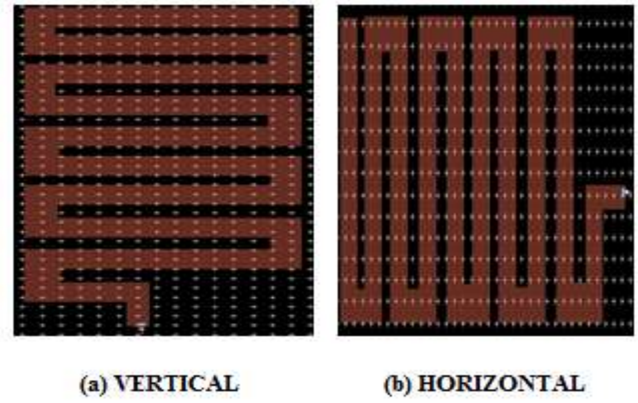

Fig -6: Four resonant patch antenna

The width and length of the designed vertical 4 resonant meandered patch antenna are 14.4mm and 34.1mm. The horizontal and vertical patch combined to form the meandered patch. Dimensions of horizontal patch are 14.4mm and 2.1mm and for vertical patch 1.6mm and 5mm. In Fig 6(a), 9 horizontal and 9 vertical patch are combined. Feed is placed at the center of the bottom edge. The width and length of the designed horizontal 4 resonant meandered patch antenna are 34.1mm and 14.4mm. The horizontal and vertical patch combined to form the meandered patch. . Dimensions of vertical patch are 14.4mm and 2.1mm and for horizontal patch 1.6mm and 5mm. In Fig 6(b), 9 horizontal and 9 vertical patch are combined. Feed is placed at the center of the right edge.

3. DESIGN EQUATION

For designing of the antenna the width and length are calculated using the formulas

$$\text{Width} = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$$

$$\text{Length}=\frac{c}{2f_0\sqrt{\varepsilon_{eff}}} 0.824h\left\{\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)}\right\}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+12\left(\frac{h}{w}\right)}}\right)$$

Where,

f_0 =resonant frequency = 4.2GHz

C= velocity of light = 3x10^8 m/s

ε_r=relative permittivity = 4.6

w =width of the antenna = 19mm

h=thickness of dielectric substrate = 1.6mm

4. SIMULATION RESULTS

4.1 Slot Antenna

A slot antenna consists of a metal surface, a flat plate, with a hole or slot cut out. When the metal surface is driven as an antenna by a driving frequency, the slot radiates electromagnetic waves similar to a dipole antenna. The shape and size of the slot, as well as the driving frequency, determine the gain, directivity, return loss as well as other parameters. Often the radio waves are provided by a waveguide, and the antenna consists of slots in the waveguide. Slot antennas are used at UHF and microwave frequencies when greater control of the radiation pattern is required.

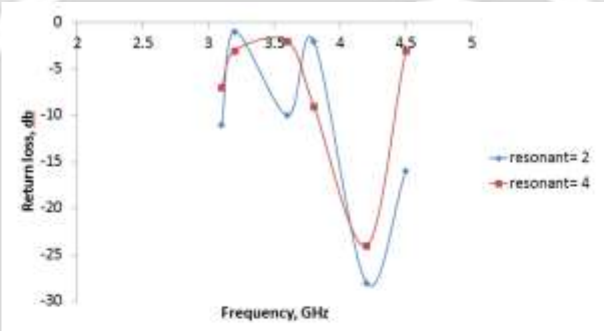

Fig -7: Vertical slot antenna

A vertical slot antenna of size 16mm x 21mm with 2 resonant is simulated. Its return loss and gain is obtained as -27db and 4.03db. Return loss and gain of vertical slot antenna of size 19mm x 37mm with 4 resonant are -24db and 3.9db.

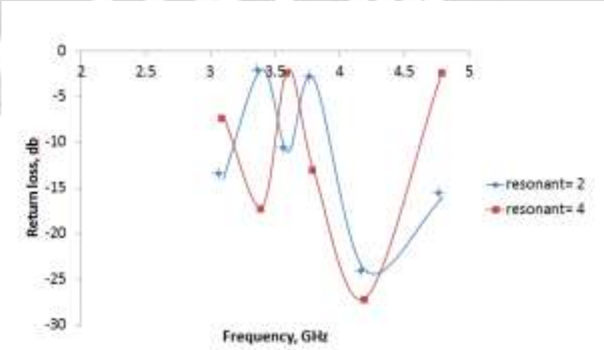

Fig -8: Horizontal slot antenna

Horizontal slot antenna of size 21mm x 16mm with 2 resonant is simulated. Its return loss and gain is obtained as -24db and 3.36db.Return loss and gain of horizontal slot antenna of size 37mm x 19mm with 4 resonant are -27db and 4.02db.

4.1 Patch Antenna

A patch antenna is a type of microstrip antenna consists of vertical and horizontal line so it formed a series of sets of right angle bends. The idea is to fold the conductors back and forth to make the overall antenna shorter.

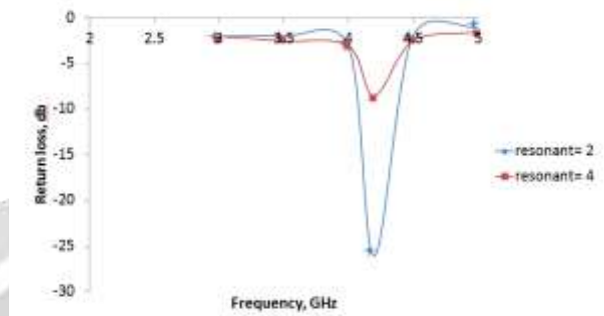

Fig -9: Vertical patch antenna

Vertical patch of size 16mm x 21mm with 2 resonant is simulated and obtained results as return loss is equal to -26db and gain is 3.6db. Return loss and gain of vertical patch antenna of size 14mm x 34mm with 4 resonant are -8.5db and 1.26db.

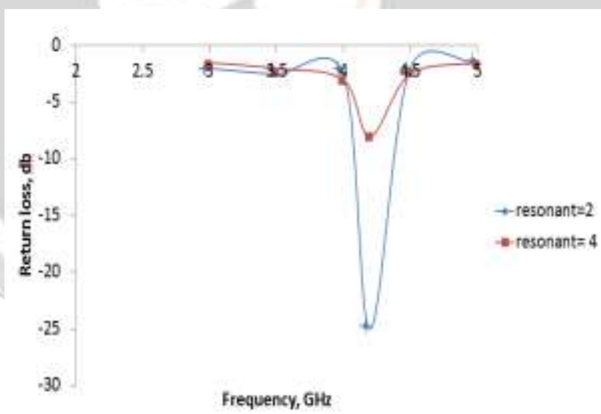

Fig -10: Horizontal patch antenna

Horizontal patch antenna of size 21mm x 16mm with 2 resonant is simulated. Its return loss and gain is obtained as -24db and 3.5db.Return loss and gain of horizontal patch antenna of size 34mm x 14mm with 4 resonant are -8db and 1.2db.

Table -1: Comparison of meandered slot antenna

PARAMETER	MEANDERED SLOT			
	VERTICAL		HORIZONTAL	
	2 RESO	4 RESO	2 RESO	4 RESO
FREQ	**4.2**	4.2	4.2	4.2
RL	**-27**	-24	-24	-27
GAIN	**4.03**	3.9	3.36	4
EFFI	**56.24**	45.3	49.09	47.20

Table -2: Comparison of meandered patch antenna

PARAMETER	MEANDERED PATCH			
	VERTICAL		HORIZONTAL	
	2 RESO	4 RESO	2 RESO	4 RESO
FREQ	4.2	4.2	4.2	4.2
RL	-26	-8.5	-25	-8
GAIN	3.6	1.2	3.6	1.2
EFFI	51.4	35.3	51	35.1

From the observation, it is clear that 2 resonant vertical slot antenna has higher return loss, gain, efficiency at the operating frequency of 4.2 GHz.

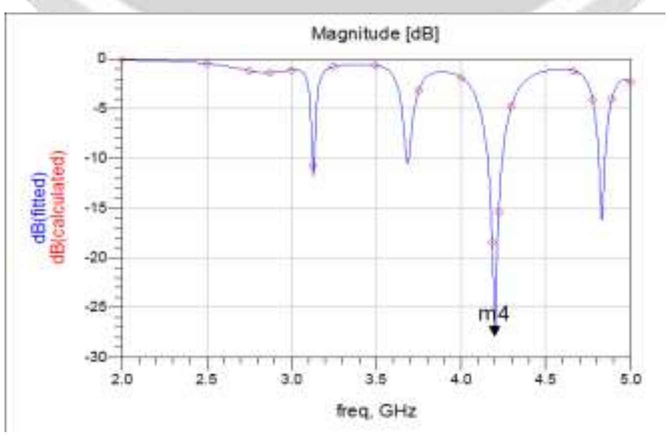

Fig -11: Return loss graph for 2 resonant slot antenna

5. FABRICATED ANTENNA

A two resonant vertical slot antenna is fabricated among 8 designs because of its higher performance as shown in Fig 12

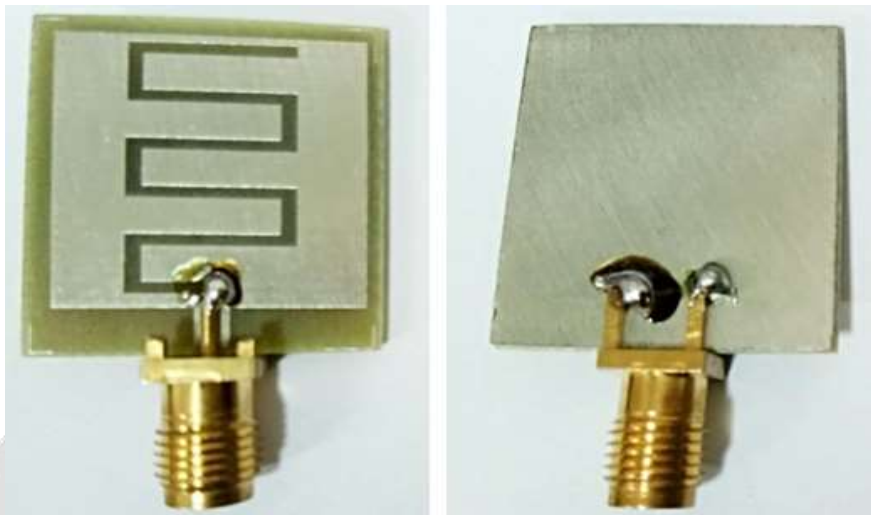

Fig -12: Fabrication of 2 resonant slot antenna

6. CONCLUSION

In this paper, meandered slot and patch antennas are designed and simulated. Out of eight models simulated, meandered vertical slot antenna with two resonant has better results as gain=4.03db and return loss= -27db at the resonant frequency 4.2 GHz. From the observations it is clear that the size of slot determines the gain of antenna. To validate design method, antenna operating at **4.2GHz** is designed using ADS2011 software. The good performance of designed antenna is demonstrated by comparison table (Table 1, 2).The frequency 4.2 GHz is under **C- band.** The Institute of Electrical and Electronics Engineers (IEEE) designate the C-band. The C band (4 to 8 GHz) has various applications such as satellite downlink, radar system, Wi-Fi etc. The commercial telecommunications via satellites was first done by C-band frequency. The same frequencies were in use for terrestrial microwave radio relay chains. The C-Band is mainly used in satellite communication between Ground station and satellite. Frequencies from 5.925 to 6.425 GHz are used for uplink direction and frequencies from 3.7 to 4.2 GHz are used for downlink direction. Uplink refers to ground station to satellite and downlink refers to satellite to ground station.

7. REFERENCES

[1]. R. Nagendra, T. Venkateswarulu, “Design and development of compact microstrip Patch dual band antenna for wireless applications”, Alexandria Engineering Journal, 24 September 2017.

[2]. Sharada N. Ohatkar , Nikita G. Amlani , Amruta P. Dange , Diksha D. Kadam “probe and edge fed miniaturized meander slot antenna using IE3d, IJLTEMAS , ISSN 2278 – 2540.Volume V, Issue IV, April 2016.

[3]. Mohammad M. Fakharian, Pejman Rezaei, and Ali A. Orouji, “A Novel Slot Antenna with Reconfigurable Meander-Slot DGS for CognitiveRadio Applications” ACES JOURNAL, Vol. 30, No. 7, July 2015.

[4]. N. A. Zainuddin1, Z. Zakaria, M. Z. A. Abd Aziz, M. N. Husain, M. A. Mutalib “Investigation of Meander Slots To Microstrip Patch antenna”,IEEE International conference on RFID technologies and applications, ,johor bahru , Malaysia, 4-5 september,2013.

[5]. Nassrin Ibrahim Mohamed Elamin, Tharek Abd Rahman, and Amuda Yusuf Abdulrahman, “New Adjustable Slot Meander Patch Antenna for 4G Handheld Devices”, IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 12, 2013.

[6]. Yuandan Dong, Senior Member, IEEE, Jun Choi, Member, IEEE, and Tatsuo Itoh, Life Fellow, IEEE, “Folded Strip/Slot Antenna with Extended Bandwidth for WLAN Application”, IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 16, 2017.

[7]. R.Brinda, S. Sara Preethy, “Miniaturized Antenna with Combination of Meander and Square Spiral Slots for Biomedical Applications”, International Journal of Computer Applications (0975 – 8887) Volume 85 – No 4, January 2014.

[8]. Yuan Yao, Senior Member, IEEE, Caixia Cui, Junsheng Yu, and Xiaodong Chen, Fellow, IEEE“A Meander Line UHF RFID Reader Antenna for Near-field Applications”, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 65, NO. 1, JANUARY 2017.

[9]. V. L. Naga Sudheer, M.Tech student, VRSEC, Dr. A. Jhansi Rani,Professor, VRSEC, “Frequency Reconfigurable Meander Slot Antenna for Cognitive Radio Applications”, International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Volume 5, Issue 10, October 2016.

[10]. Jia-Qi Zhu, Yong-Ling Ban, Chow-Yen-Desmond Sim, Senior Member, IEEE, and Gang Wu, Member, IEEE “NFC Antenna With Nonuniform Meandering Line and Partial Coverage Ferrite Sheet for Metal Cover Smartphone Applications”, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 65, NO. 6, JUNE 2017.

[11]. B.Mazumdar, U.Chakraborty, A.Bhowmik, S.K.Chowdhury & A.K.Bhattacharjee, “A Compact Microstrip Patch Antenna for Wireless Communication” Global Journal of researches in engineering Electrical and electronics engineering, Volume 12, Issue 5, Version 1.0, April 2012.

[12]. Jin-Dong Zhang, Member, IEEE, Lei Zhu, Fellow, IEEE, Qiong-Sen Wu, Student Member, IEEE, Neng-Wu Liu, Student Member, IEEE, and Wen Wu, Senior Member, IEEE “A Compact Microstrip-Fed Patch Antenna with Enhanced Bandwidth and Harmonic Suppression”, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 64, NO. 12, DECEMBER 2016.