A COMPACT TRIPLE BAND MEANDERED LINE ANTENNA FOR 2.4/3.6/5 GHZ WIFI-SAT.COM APPLICATIONS

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Abstract - *Number of users of wireless communication systems is increasing day by day. This in turn induces an increased demand for cellular capacity. Recently different types of antennas were developed which are of dual band antennas for WIFI Applications. Most of the antennas currently work in 2.4/5 GHz WLAN applications. With the dual band antennas cannot satisfy demand for all the users and causes interferences. This paper presents a triple band antenna which will operate on three frequencies 2.4/3.6/5 GHz for WIFI Applications. Also proposed antenna can be used for SAT.COM applications. It can be well used in mobile hotspots for increasing capacity. It can be used in portable laptops and WIFI dongles. The antenna dimension is 20×35×0.8 mm and it is fabricated on FR-4 epoxy substrate. Since substrate thickness is 0.8 mm, it is reliable for using in mobile phones. Multiple meandered lines are used for designing the antenna. 50- Ohm microstrip feed line is used for the antenna. All the simulations are carried out in Ansoft's HFSS version 13.0.*

***Key Words*: Cellular capacity, WIFI, WLAN, FR-4 epoxy, SAT.COM**

1. INTRODUCTION

Demand for wireless communication systems are increasing due to advances in the field of information technology and internet speeding. So there is a need in increasing cellular capacity by improving number of communication bands. So have to design multiband antennas with low cost and compact structures. Therefore microstrip patch antennas can be considered with low profile, light weight and easy to manufacture. Many designers are focused on the design of antennas with characteristics of compact size, multiband, sufficient impedance bandwidth, omnidirectional pattern, etc. In addition to the outstanding features, it should include the simple configuration of a single metallic layer. Wi-Fi (Wireless Fidelity) is a technology used for wireless local area networking with devices based on the IEEE 802.11 standards. Wi-Fi technology uses in the devices like

Personal computers, phones and tablets, digital cameras, smart TVs, digital audio players and modern printers. Wi-Fi compatible devices can connect to the Internet through a WLAN and a wireless access point. Wi-Fi wireless networking sends radio transmissions on specific frequencies where receiver devices can receive them. The radio transmitters and receivers are built into Wi-Fi enabled equipment like routers, laptops, and mobile phones. Antennas picking up incoming signals and radiating outgoing Wi-Fi signal.

Satellite communication technology is progressed fast, and the applications of satellite technology are increasing in each year. Satellite systems for communications and broadcast and briefly alludes to the significant scientific space programs which act as a technology driver for the industry. The proposed antennas can be used for C band satellite applications.

In recent years so many microstrip patch antennas are emerged for WLAN Applications. Among that 2.4/5 GHz application antennas are enormous [1]. The most popular WLAN protocols used widely are IEEE 802.11b/g and IEEE 802.11a utilizing the 2.4 GHz ISM band (2.4–2.485GHz) and the 5 GHz U-NII band and ISM band (5.15–5.825 GHz) respectively. IEEE 802.11yutilizing3.6 GHz (3.65-3.69) [2-5]. In addition to 2.4,5 GHz proposed antenna covers 3.6 GHz operating frequency.

There are so many antennas raised as dual and multiband antennas. In many of them bandwidth is very less in upper frequencies. Also recent multiband antennas provide good impedance characteristics, but complicated in structure. They are larger in size and complex in nature. The dipole structures for these frequencies are of insufficient bandwidth for the two bands in each structure [6]. ACS-fed antennas do not provide satisfactory operation for single or dual band applications. Other antennas also do not provide satisfactory operation [7-9].

HFSS 13.0 version is used as simulation software. Substrate used is FR4 epoxy. Conventional microstrip antennas have considered substrate, with increased thickness for the patch antennas. But here thickness of the substrate is considered as about 0.8 mm and it provides better size reductions. It consists of three groups of meandered lines. One group is designed for 2.4 GHz, next for 3.6 GHz and the other for 5 GHz. Resonance frequencies can be controlled by adjusting the dimensions of the meandered monopole radiation elements. Resonant frequency increases with decrease in length of the meandered lines. Easily be excited by a 50 Ω microstrip line and can provide good impedance matching for these operating frequencies [10]. Thickness of the substrate is considered to 0.8 mm for reduce the return loss. The antenna covers 2.4 GHz (2.3 – 2.5 GHz), 3.6 (3.65 – 3.69) GHz (3.4 – 3.7 GHz) and 5 GHz (4.8 – 7 GHz). Removal in ground structure helps to increase the bandwidth in both lower and upper bands. Triangular and rectangular slots are introduces in the ground structure for reducing return loss in the obtained band.

2. ANTENNA DESIGN

The proposed antenna is simulated in HFSS version 13.0. The proposed antenna has been fabricated on FR-4 epoxy substrate with relative dielectric constant of Ɛr = 4.4 which is cost effective and easily available. Here tan ξ = 0.02 and thickness T= 0.8 mm. Figure 2 shows the radiating side of proposed antenna and Figure 1 shows the ground plane side. The antenna substrate has 20*35*0.8 mm dimensions. 50 –ohm microstrip feed line is used for good impedance matching and width of the feed line is fixed as 1.4 mm. Each meandered group is designed by λ/2 design process. Inverted L strips are employed, which provides good impedance matching.

Meandered lines and ground structure is designed by the following equations [11].

2.1 Design of Meandered Lines

The dimensions of substrate is W=20 mm, L= 35mm, h=0.8 mm. relative permittivity Ɛr = 4.4, height of the antenna is given by the equation.

$$h \le \frac{0.3 * c}{2 * \pi * fr \sqrt{\varepsilon r}} \quad \text{.......................(1)}$$

Width of the substrate calculated from

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \quad \text{....................... (2)}$$

Effective dielectric constant is

$$Leff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left(1 - 12\frac{h}{w}\right)^{\frac{-1}{2}} \quad \text{.......................(3)}$$

$$\frac{\Delta L}{h} = 0.412 \frac{(\varepsilon eff+0.3)\ \left(\frac{W}{h}+0.264\right)}{(\varepsilon eff-0.3)\ \left(\frac{W}{h}+0.8\right)} \quad \text{.......................(4)}$$

Length of the substrate is given by the equation is

$$L = \frac{c}{2fr\sqrt{\varepsilon eff}} - 2\Delta L \quad \text{.............................(5)}$$

Effective length and effective width can be obtained from the equations (5) and (6)

$$L_{eff} = L + 2\Delta L \quad \text{...............................(6)}$$

$$W_{eff} = W + 2\Delta W \quad \text{...............................(7)}$$

Signal is radiated through the meandered lines. The length of the meandered line can be obtained from the guided wavelength. The guided wavelength is

$$\lambda = \frac{c}{fr\sqrt{\varepsilon eff}} \quad \text{.............................. (8)}$$

And the length of meandered line is λ/2.

Design of ground structure

Length of ground structure is, Lg = 6h + L .... (9)

Width of ground structure is, Wg = 6h + W .... (10)

In the ground structure parameter F is removed on the two sides in order to provide improvement in return loss. For further improvement two rectangular slots are introduced into it. The removal of the parameter in the ground structure increases the bandwidth. The gap between the meandered lines improves the return loss.

Two iterations are employed. First iteration is for a dual band antenna, which works on 2.4 GHz and 5GHz frequencies is implemented by two meandered groups. Second iteration is for a triple band antenna, which works on 2.4, 5 and 3.6 GHz frequencies. For 3.6 GHz another set of meandered group is implemented.

2.2 Iteration 1

In first iteration, an antenna is designed for 2.4 GHz and 5 GHz applications. The lower frequency corresponds to longer set of meandered lines. The higher frequency corresponds to shorter set of meandered lines.

Triangular slot of parameter F is removed in the ground structure. Each sides of the triangular shape are 4 mm. The triangular shape is removed on both sides of the ground structure. The slots are made away from the microstrip line. The removal reduces the return loss for the antenna.

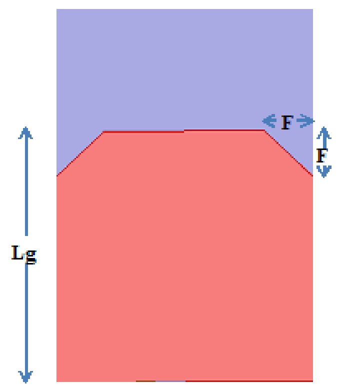

Fig - 1: Ground structure of antenna

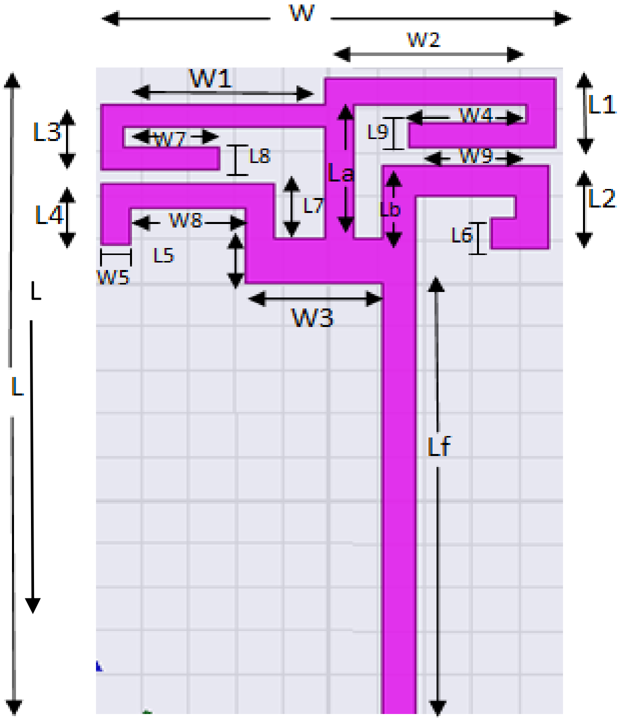

Fig - 2: Radiating side of antenna

2.2 Iteration 2

In second iteration, an antenna is designed for 2.4 GHz, 5GHz and 3.6 GHz applications. An additional meandered group is employed for 3.6 GHz by considering length of meandered lines as λ/2.

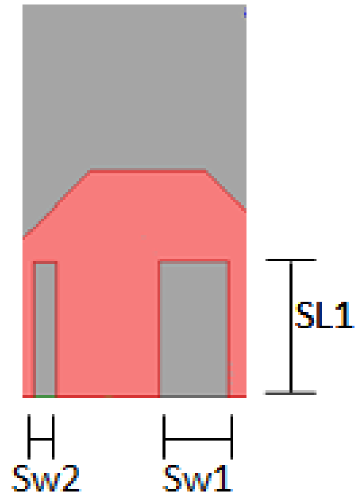

Fig - 3: Ground structure of antenna

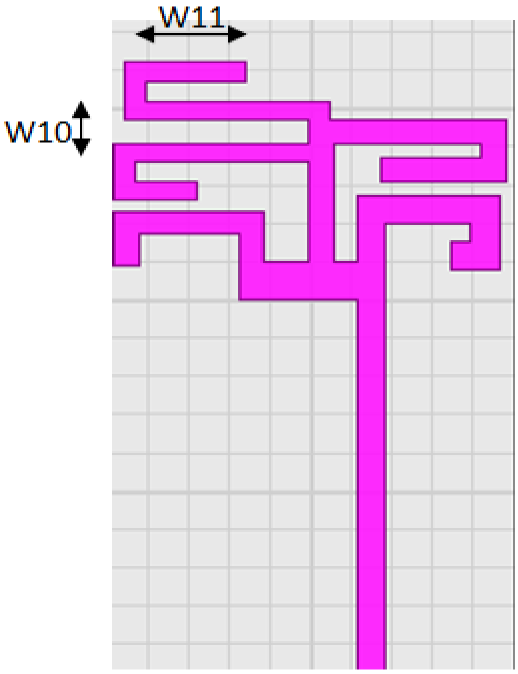

Fig – 4: Radiating side of antenna

For second iteration length of substrate is considered as 35 mm. One more set of meandered lines are added corresponding to 3.6 GHz.

Ground structure is of width and length 20 mm. Two triangles of length 4 mm and 6 mm are removed from both sides of the antenna. Rectangular slots introduced in the ground are of width 2mm and 6mm and a length of 12 mm. These slots are introduced away from the microstrip [12].

Table -1: Dimensions of Antenna Parameters

Parameter	Value(mm)	Parameter	Value(mm)
L	35	L2	3.8
W	20	L3	3.0
Lf	20	L4	2.8
Wf	1.4	L5	2.0
W1	8.5	L6	1.4
W2	8.5	L7	2.6
W3	5.8	L8	1.0
W4	5.0	L9	1.2
W5	1.2	La	6.0
W6	2.4	Lb	3.4
W7	4.0	Lg	20
W8	4.9	Sw1	2
W9	4.2	Sw2	6
W10	8	SL1	12
W11	6	F1	6
L1	3.2	F2	4

3. RESULTS AND DISCUSSIONS

Antenna is designed using Ansoft's High frequency structure simulator version 13 was used to for analysis. Antenna is simulated and find out the return loss versus frequency plot. It is a compact triple band meandered line antenna for 2.4/3.6/5 GHz WIFI and SAT.COM Applications for 2.4 GHz, 3.6 GHz and 5GHz of resonant frequencies. Triple bands are obtained for the antenna. The antenna completely covers IEEE Standards 2.4,5 and 3.6 GHz frequencies which can be used for WIFI applications. Also provides resonant frequency in 5GHz at which a wider band width is obtained which covers 4.8 – 6.5 GHz.

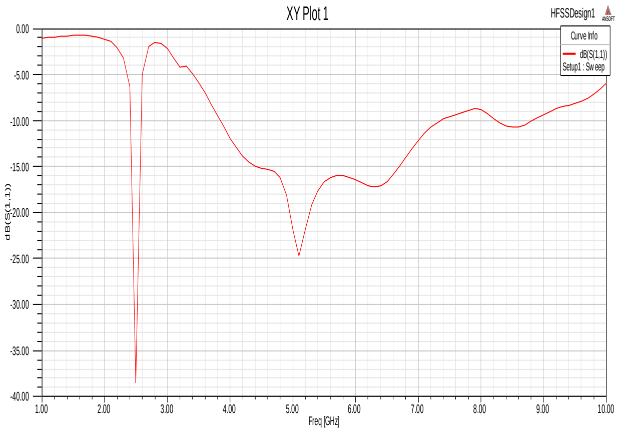

Chart -1: Return loss versus frequency plot (Iteration 1)

Return loss versus frequency plot of iteration1 provides resonant frequencies at 2.4 GHz and 5GHz. At 2.4 GHz it provides a band with return loss of -38 dB. The resonant frequency in 5GHz provides a return loss of -24 db. The antenna covers 2.3– 2.5 GHz for 2.4 GHz frequency and covers 4.8-5 GHz for the resonant frequency of 5 GHz. Inverted L shaped meandered lines provides satisfactory bandwidths.

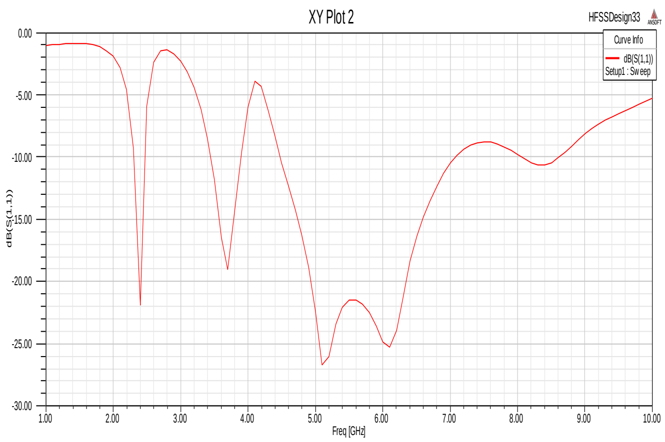

Chart -2: Return loss versus frequency plot (Iteration 2)

It is return loss versus frequency plot of iteration 2.When new set of meandered lines are employed 5 GHz resonant frequency provides a return loss of -27 dB. There is return loss reduced from -24 to -30 dB. Return loss at 2.4 GHz is of about -22 dB which shows good impedance match.3.6 GHz which shows a return loss of -19 dB. In the ground structure a triangular shaped parameter of length F is removed from two sides of antenna. This parameter depends on and varies the return loss of the antenna. Rectangular slots in the ground structure improve the return loss.

For SAT.COM application, the proposed antenna covers 4.8 – 7 GHz frequencies. Return loss is less than -10 dB for these frequencies. At 5.9 – 6.4 GHz it provides a wide band width. Also return loss is around -20 dB. Return loss can be improved by removing parameter F in the ground structure and the rectangular slots in the ground provides the wideband which can be used for SAT.COM applications.

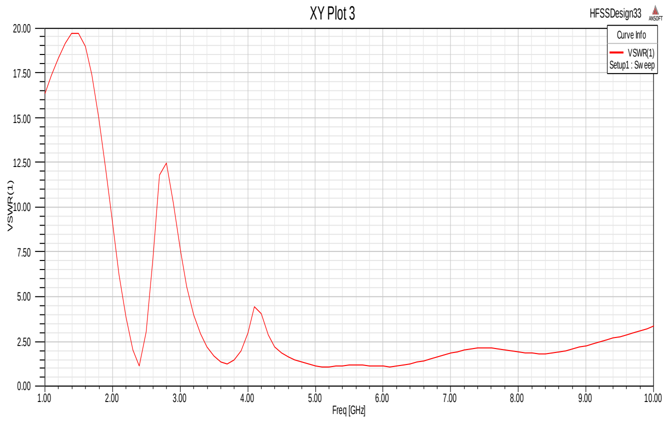

Chart -3: Frequency versus VSWR plot (Iteration 2)

The frequency versus VSWR plot provides good radiating characteristics. VSWR is voltage standing wave ratio and it is the measure of how effectively the radio frequency is radiating through a transmission line. The proposed antenna operates in the frequencies 2.4, 3.6 and 5 GHz. The antenna provides satisfactory operation for less than VSWR value 2. For this in 2.4 and 3.6 GHz frequencies VSWR is less than 2. That is it provides good radiating characteristics. In 5GHz proposed antenna provides a wide band. Also VSWR is less than 2 for this wide band of frequency.

2.4 GHz frequency has become standard and all Wi-Fi enabled devices can utilize this network. 2.4 GHz radio waves are able to penetrate in objects (such as walls and floors) much better and provide better result for WIFI applications. 5 GHz has a much higher bandwidth [12]. This network is not used by common wireless devices such as cordless phones; therefore, there will be no or very little interference to cause a reduction in bandwidth for WIFI application. In 3.6 GHz interference is very less. As lower the frequency typically further it will propagate if trade of distance for bandwidth. Since this antenna is used for WIFI applications range is important and these lower frequencies will provide higher distance range. For two signals of equal strength and different frequencies lower frequencies travel further than higher ones.

The simulation results indicates that the proposed antenna completely covers IEEE standards IEEE 802.11b/g at 2.4 GHz (2.4–2.485GHz), IEEE 802.11a at 5 GHz (5.15–5.825 GHz) and IEEE 802.11y at 3.6 GHz (3.65-3.69).

4. CONCLUSION

This paper presents A Compact Triple Band Antenna for 2.4/3.6/5 GHz WIFI and SAT.COM Applications. The proposed antenna completely covers IEEE standards IEEE 802.11b/g at 2.4 GHz, IEEE 802.11a at 5 GHz (5.15–5.825 GHz) and IEEE 802.11y at 3.6 GHz. L shaped meandered line strips are used for the antenna designing. Since it is a triple band antenna cellular capacity of the communication system can be increased in mobile phones and portable devices. Various characteristics are considered for the antenna. Simulated results of the proposed antenna shows good impedance match, stable gain and improved return loss. Also the antenna provides satisfactory bandwidth so can be used for WIFI Applications. The proposed antenna can be used for mobile phones and portable devices. The proposed antenna can be well used in C band satellite communication systems.

Communications Authority (CA) is actively contemplating the case of re-allocating the lower part of the C-Band (i.e. the 3.4 - 3.7 GHz band) from FSS to mobile service. It will be a promotion for the proposed antenna.

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