Design of Slotted Back to Back E-Shaped Microstrip Patch Antenna for Wi-Fi Applications

[1]S. Shirley Helen Judith , [2] M. Priyanga, [3]M. Preethika, [4] Dr. S. Maheswari, [5] Dr. S. Hemajothi
[1,2,3] PG student, [4,5]Professor, Department of Electronics & Communication Engineering
[1,2,3,4]Panimalar Engineering College, [5]Prathyusha Engineering College,Chennai,India

***Abstract*—Micro strip patch antennas are widely used in wireless applications in recent years. The C-band frequencies of 5.4 GHz band [5.15 to 5.35 GHz, 5.47 to 5.725 GHz, or 5.725 to 5.875 GHz, depending on the region of the world] are used for IEEE 802.11a Wi-Fi and cordless telephone applications, leading to occasional interference with some weather radars that are also allocated to the C-band. The proposed slotted back to back E-shaped antenna designed for 29.4*29.4mm operates at a frequency of 5.4GHZ for C band application such as Wi-Fi. The substrate material of the antenna is Flame Retardant (FR-4), dielectric constant 4.4 and thickness 1.6mm. The basic theory and design are analyzed, and simulated using Advanced Design System Software ADS. The main objective of the work is to improve gain, return loss and radiation.**

Keywords— Slotted back to back E shape microstrip patch antenna, Wi-Fi, ADS, FR4

I. INTRODUCTION

In modern wireless communication systems, high data rate is required over band-limited channels. For the explosive growth of wireless system and booming demand for a variety of new wireless application, it is important to design broad band antennas to cover a wide frequency range. The design of an efficient wide band small size antenna, for recent wireless applications, is a major challenge. Micro strip patch antenna have found extensive application in wireless communication system wowing to their advantages, low – cost fabrication and ease of integration with feed networks. In this project, the design and development of slotted back to back E shaped patch antenna is fabricated for 5.4GHz frequency, reduction in return loss and increased gain for Wi-Fi application. Currently 5.4GHz has less traffic through use and it can handle more traffic more efficiently as the frequency gains in popularity, with the clear signal, more non over lapping channels and can offer higher speeds. However, narrow bandwidth is the major disadvantage for this type of antenna. The double back to back E shaped micro strip patch antenna is to optimize higher bandwidth. The list of WLAN channels is the set of legally wireless local area network channels using IEEE 802.11protocols.They have a five distinct frequency ranges; 2.4GHZ, 3.6GHZ, 4.9GHZ, 5GHZ bands. The IEEE802.16 WiMAX standard allows data transmission using multiple broadband frequency ranges. The original 802.16a standard specified transmission range 10-66GHZ, but 802.16d allowed lower frequencies in the range 2 to 11GHZ. Patch of the Microstrip antenna is made up of copper or gold and it can be of any shapes. It has radiating patch on one side of a dielectric substrate and ground plane on the other side as shown in fig.1

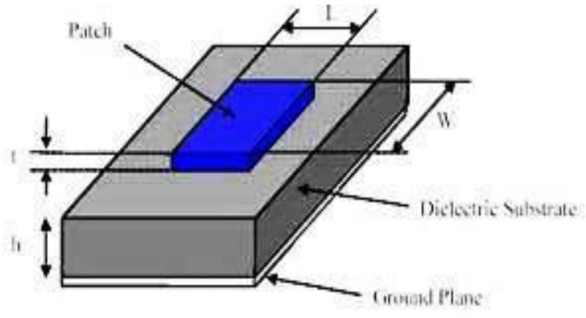

Figure 1. Structure of Microstrip Patch Antenna

Micro-Strip Patch Antenna is used as it has many advantages like its low-profile structure, less fabrication cost, supporting both linear and circular polarization. Thick substrate is used to increase the bandwidth of patch antennas.

Micro-strip patch antenna feeding is classified into two categories- contacting and non-contacting. The four most popular feed techniques used are the Micro-strip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

The feed used here is the coaxial feed. It is also called as the probe feed which is one of the most common techniques used for feeding microstrip patch antennas. As seen from figure 2, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

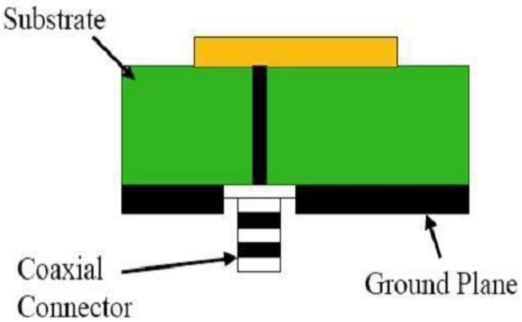

Figure 2. Microstrip Coaxial Feed

The main advantage of this type of feeding scheme is that the feed can be placed at any desired position inside the patch in order to obtain impedance matching. This feed method is easy to fabricate and has low spurious radiation effects.

II. EXISTING SYSTEM

In the existing system, the designed antenna structure of 45*35mm with substrate thickness of 10.6mm and dielectric constant 1.07mm operating at 2.62 GHz is used for Bluetooth applications. The major drawback of the existing system is large size of the antenna, huge substrate thickness, less dielectric constant, increase in radiation losses, moderate gain and directivity. a microstrip line fed single frequency Microstrip patch antenna has been designed and simulated using HFSS 13.0 Antenna simulation software. This is operating in the frequency of 5.4GHZ Wi-Fi communication in the IEEE 802.11 standard. The simulated corresponding value of return loss as -16.7269dB which is small enough and frequency is closed enough to the specified frequency band feasible for Wi-Fi application. Cutting inclined slots on the patch, the size of the microstrip antenna may be reduced; also the bandwidth may be enhanced[1].A novel wideband probe fed inverted slotted microstrip patch antenna. The design adopts contemporary techniques; coaxial probe feeding, inverted patch structure and slotted patch. The composite effect of integrating these techniques and by introducing the proposed patch, offer a low profile, broadband, high gain, and low cross-polarization level. The results for the VSWR, gain and co-and cross polarization patterns are presented. The antenna operating the band of 1.80-2.36GHz shows an impedance bandwidth (2:1 VSWR) of 27% and a gain of 10.18dB with a gain variation of 1.12 dB. Good radiation characteristics, including a cross-polarization level in *xz*-plane less than -42 dB, have been obtained[2]. Multiband star shaped slotted antenna helps us to get the better radiation with proper gain and return loss, here number of band increases the radiation effect[3].A star shape multiband micro strip patch antennas is simulated. The antennas have slotted geometry. It is found that the as the number of slots are increased, the operational frequency band also increases[4]. A new concept of a wearable antenna is easily integrated into clothing. A novel eagle shaped microstrip antenna was presented[5].The proposed system eliminates the above mentioned drawback.

III. OVERVIEW OF THE PROPOSED SYSTEM

A microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight, low profile planar configuration, low fabrication costs and capability to integrate with microwave Integrated circuits technology, the microstrip patch antenna is very well suited for applications such as wireless communications system , cellular phones, pagers, radar systems, and satellite communications systems.

In this proposed system, a Back to Back E-shaped slotted patch antenna has been designed with over all dimensions 29.4 mm x 29.4 mm and substrate thickness of 1.6mm. Different types of antennas have been analyzed. Among these, microstrip patch antennas are best choice for wireless applications. The range for C-band is 4GHZ-8GHZ . C-band frequency of 5.4GHz antenna is chosen for IEEE 802.11a Wi-Fi and Cordless Telephone applications. Back to Back E shaped microstrip patch antenna is designed and simulated using ADS software. The parameters such as S11, gain, directivity, radiation pattern etc are analyzed to study the antenna performance. Finally, the simulated output was tested using Network analyzer.

IV. DESIGN AND IMPLEMENTATION

A. Proposed Antenna Design

Design considerations

Operating frequency (f_0) =5.4GHZ.

Velocity of light(c) =3x10^8m/sec.

Substrate Flame Retardant 4 with relative permittivity (εr)=4.4

Substrate thickness(h)=1.6mm

B. Calculation For Operating Frequency 5.4ghz

Calculation of Width (W):

$$W = \frac{c}{2f_0}\sqrt{\frac{2}{\epsilon_r + 1}} \qquad \ldots\ldots\ldots\ldots(1)$$

$$W = \frac{3*10^8}{2*5.4*10^9}\sqrt{\frac{2}{4.4+1}}$$

$$W \approx 1.69m$$

Calculation of Effective dielectric constant:

$$\in_{reff} = \frac{\in_r + 1}{2} + \frac{\in_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \ldots\ldots(2)$$

$$\in_{reff} = \frac{4.4+1}{2} + \frac{4.4-1}{2}\left[1 + 12\frac{1.6}{3.8}\right]^{-1/2}$$

$$\in_{reff} \approx 3.39$$

Calculation of effective length(Leff):

$$L_{eff} = \frac{c}{2f_0\sqrt{\in_{reff}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$L_{eff} = \frac{3*10^8}{2(29.4*10^9)\sqrt{3.39}}$$

$$L_{eff} = 2.77m$$

Calculation of the Extension Length ΔL:

$$\Delta L = 0.412h\left[\frac{(\in_{reff}+0.3)+(\frac{w}{h}+0.264)}{(\in_{reff}-0.258)(\frac{w}{h}+0.8)}\right] \ldots\ldots\ldots\ldots\ldots(4)$$

$$\Delta L \approx 0.6455m$$

Calculation of actual length of patch(L):

$$L = L_{eff} - 2\Delta L \ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

$$L = 2.77 - 2(0.644)$$

$$L \approx 1.479m$$

V. SIMULATION RESULTS

The antenna with optimized dimensions are simulated using ADS software as shown in Fig. 3 and fabricated as shown in Fig. 4. It is modeled on a FR4 substrate of dielectric constant ∈r = 4.4 and thickness h =1.6mm with tangent 0.001. The resulting antenna resonates at 5.4 GHz. From the simulation and experimental studies, it is found that the dimensions of the patch is optimized with optimum gain (value is 3.1dB). The fabricated output gives the return loss

as -26.829dB with the resonance frequency of 5.4 GHz as shown in Fig. 5.

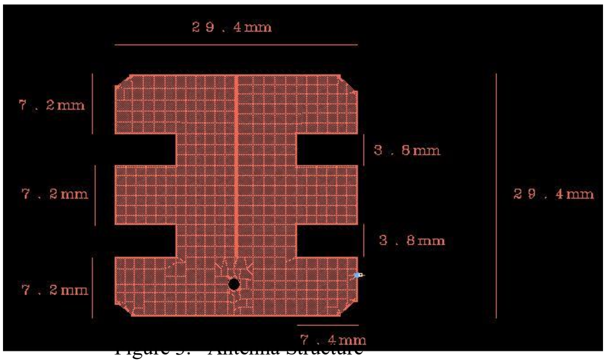

Figure 3. Antenna Structure

Figure 4. Fabricated Design

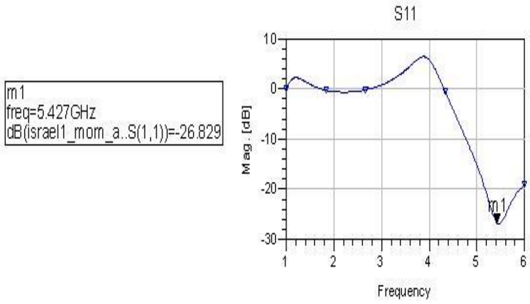

Figure 5. Simulation of return loss characteristics

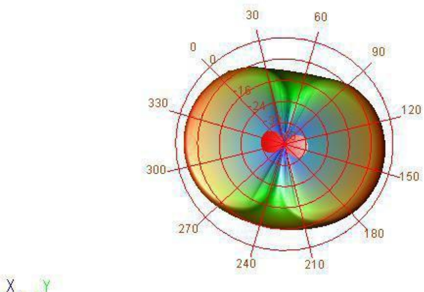

Figure 6. Simulated radiation pattern

3D radiation pattern for the proposed antenna is shown in Fig. 6. Antenna Parameters such as Power radiated (watts), Directivity(dB), Gain(dB) etc., obtained are shown in Fig. 7.

TABLE I. ANTENNA PARAMETERS

Power radiated(watts)		3.92372e-05
Effective angle(steradians)		3.21178
Directivity(dB)		5.92464
Gain(dB)		3.10073
Maximum intensity(watts/steradians)		1.22167e-05
Angle of Umax(theta,phi)	0	0
E(theta)max(mag,phase)	0.0949953	-91.8603
E(phi)max(mag,phase)	0.0134414	-91.8885
E(X)max(mag,phase)	0.0766763	-91.8638
E(Y)max(mag,phase)	0.576673	88.1444
E(Z)max(mag,phase)	0	0

Various parameters such as Return loss, SWR, bandwidth, Impedance matching and Phase for the proposed antenna are measured using Network analyzer at 5.4GHzare shown in Fig. 8,9,10,11 and 12.

Figure 7. Measured return loss by Network Analyzer at 5.4GHz

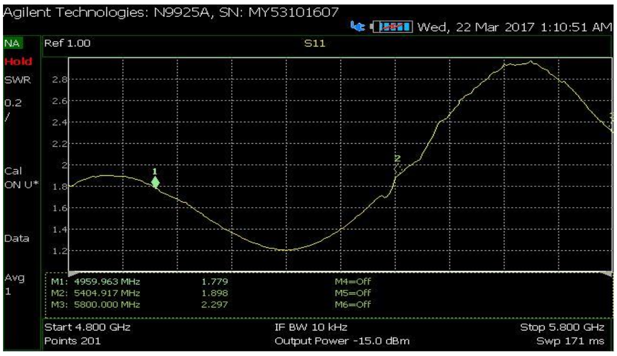

Figure 8. Measured SWR by Network Analyzer at 5.4GHz

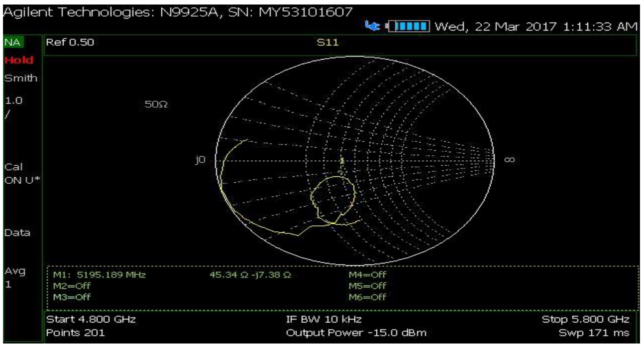

Figure 9. Measured Bandwidth by Network Analyzer at 5.4GHz

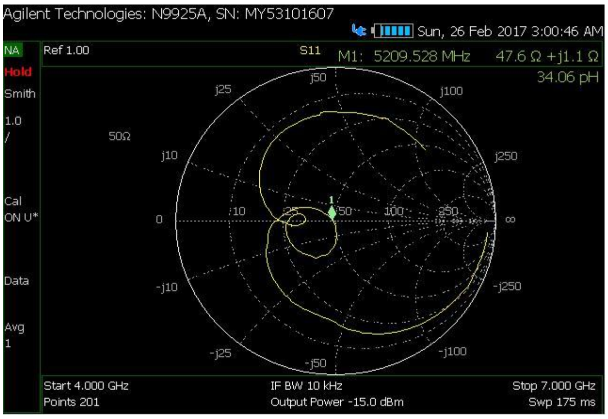

Figure 10. Impedance matching Measurement

Figure 11. Phase Measurement

VI. CONCLUSION

In this paper, a Back to Back slotted E-shaped microstrip patch antenna is proposed, to achieve miniaturization, proper impedance match, gain and bandwidth. A Slotted E-shaped microstrip patch antenna was designed at 5.4GHZ and simulation and fabrication results are obtained. The return loss achieved for this antenna is -26.829 dB , gain is 3.1dB and directivity is 5.9dB. The fabricated output attains the return loss -26dB with the resonance frequency of 5.4GHz are chosen for Wi-Fi applications.

TABLE II. THE COMPARISON OF EXISTING AND PROPOSED SYSTEM

PARAMETERS	EXISTING	PROPOSED
ANTENNA SIZE	45*35MM	29.4*29.4MM
THICKNESS	10.6MM	1.6MM
RESONANCE FREQUENCY	2.62GHZ	5.4GHZ
RETURN LOSS	-16DB	-26.829DB
GAIN	2.8DB	3.1DB
DIRECTIVITY	4.3	5.9

As a future enhancement, size and number of the slots and thickness of the substrate can be increased in order to improve the gain, return loss and directivity.

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