Basic Approach for Design of Dual Band Microstrip Patch Antenna for Wi-Fi Application

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Abstract- This paper presents a Dual band microstrip patch antenna for wireless communication. In its most basic form, a micro strip patch antenna consists of a Radiating patch on one side of a dielectric substrate which has a Ground plane on the other side .The patch is generally made of Conducting material such as copper and can take any Shape. A rectangular structure patch is used as the main Radiator. There are several advantages of this type of broadband Antenna, such as planar, small in size, simple in structure, low in Cost, and easy to be fabricate, thus attractive for practical applications. This rectangular micros trip patch antenna is designed for wireless communication Wi-Fi application that works at 2.4GHz.

Keywords: Bandwidth, Gain, HFSS, Length, MPA, Permittivity, Power density, Radiation Intensity, Return Loss, VSWR.

1.0 INTRODUCTION

An antenna is defined as, “A means for radiating or receiving Radio waves.” In addition to receiving or transmitting energy, an antenna is an advanced wireless system is usually required to optimize or accentuate the radiation energy in some directions and suppress it in others. Thus it serves as a directional device in addition to probing device. For wireless communication Systems an antenna is one of the most critical components. The antenna we are going to use is microstrip patch antenna [1]. This antenna consists of a metallic patch on a grounded substrate. They are most popular because of ease of analysis, fabrication, attractive, radiation characteristics, and low profile, comfortable to planar and non-planar surfaces, simple and inexpensive to fabricate using modern printed circuit technology, very versatile. The microstrip patch antenna (MSA) has many applications in aircraft, mobile phone, radio, laptop, etc. The motive behind designing this H shaped antenna is to enhance the bandwidth of the antenna for dual band frequency operation so that it can be used for WIFI applications [3]. Dual band refers to a device ability to function on two different frequency bands i.e. providing all features on both bands. In multichannel application, a small bandwidth is required over a large frequency range [1], [2].

Accordingly, a tunable antenna provides an alternative to a broadband antenna. In some applications like satellite links, cellular telephones, radio frequency, etc. dual frequency antenna is required or it is necessary that a system must work within two frequency bands that are far apart. Such requirements of certain modern wireless communication systems gave a motivation towards designing a dual band antenna [2].

The disadvantage of microstrip patch antenna is narrow bandwidth and low gain. The proposed design structure is such that a good bandwidth and gain can be obtained. Also processing cost is low. The parameters like Radiation Pattern, Returns loss, Directivity, Gain, VSWR, Bandwidth can be analyzed using HFSS software. One of type of wireless communication at 2.4 GHz is wireless Fidelity (Wi-Fi). A Wi-Fi enabled device such as a personal computer, videogame console, smart phone or digital audio player can connect to the Internet when within range of a wireless network connected to the Internet. The coverage of one or more (inter connected) access s points (hotspot) Can round up as small l as a few rooms or as large as many square mile [2], [4].

2.0 Research Methedology

Research methodology includes designing of extended rectangular shape antenna using HFSS software rectangular patch antenna and line fee feeding is used to feed the antenna [3], [5], [6]. Using HFSS software we can measure various parameters like bandwidth, gain, efficiency, radiation pattern etc.

3.0 Antenna design:

The design of antenna is shown in *Figure1* and dimensions of antenna are also given in table

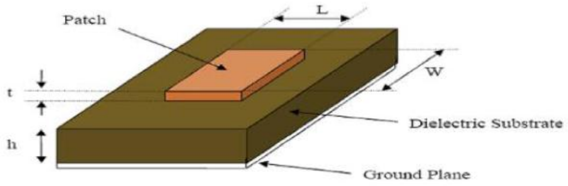

Figure1: Rectangular Microstrip patch design

4.0 Basic Geometry

basic geometry of the patch is given in figure 2.

The copper patch is in brown color, FR4 substrate is of green color, semitransparent pink represents air box and plate is attached to the feeding path for excitation.

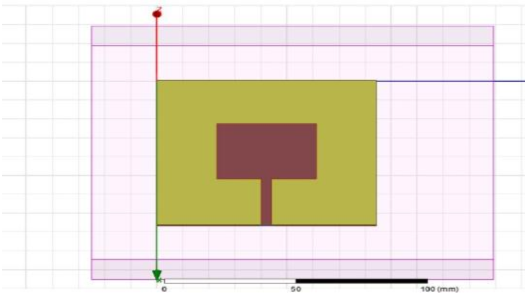

Figure 2: Structure of rectangular microstrip antenna.

4.1 Basic Parameter

(**a) Radiation Pattern:** The antenna pattern is a graphical representation in three dimensional of the radiation of the antenna as the function of direction

$W = \frac{P}{4\pi r^2}$ (1)

Then the radiation intensity for this isotropic antenna U_o can be written

$U_o = \frac{P}{4\pi}$ (2)

(b) Gain (S_{21}): It is defined as the "The ratio of the intensity in the given direction to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.

$\text{Gain}=4\pi \frac{radiation\ intensity}{total\ input\ (accepted\ )power}$ (3)

$= 4\pi \frac{U(\theta,\emptyset)}{Pin}$ (dimensionless) (4)

(c) Directivity: It is defined as the ratio of radiation intensity in a given direction from antenna to radiation intensity average overall direction.

$D = \frac{U}{Uo} = \frac{4\pi U}{Prad} = \frac{Umax}{Uo}$ (5)

The relation between directivity and gain is given as,

$G = \eta D$ (6)

(d) Bandwidth: It is defined as the range of usable frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard.

$BW\ broadband = F_h/F_l$ (7)

$(\%) = \frac{Fh-Fl}{Fc} * 100$ (8)

(e) Return loss (S_{11}): Return loss or reflection loss is the reflection of signal power from the insertion of a device in a transmission line or optical fiber.

$dB = 10\ log \frac{Pr}{Pi}$ (9)

Where i is the power supplied by the source and Pr is the power reflected.

$Rl = -20log|\text{r}|$ (10)

And the reflection coefficient r can be expressed as,

$\Gamma = Vr\ /\ Vi$ (11)

(f)VSWR: A standing wave in a transmission line is a wave in which the distribution of current, voltage or field strength is formed by the superimposition of two waves of same frequency propagating in opposite direction.

$$VSWR = \frac{Vmax}{Vmin} = \frac{1+|\Gamma|}{1-|\Gamma|} \qquad (12)$$

5.0 Design procedure for rectangular microstrip antenna:

Specify: ε_r, f_r(in Hz) and h [3]

1) Calculate width (W):

i. $$W = \frac{1}{2fr\sqrt{\varepsilon o \mu o}}\sqrt{\frac{2}{\varepsilon r+1}}$$

ii. $$W = \frac{Vo}{2\,fr}\sqrt{\frac{2}{\varepsilon r+1}}$$

2) Determine ε_{reff}:

$$\varepsilon reff = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2}$$

3) $Calculate\ \Delta L$:

$$\Delta L = 0.412h\left[\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)}\right]$$

4) For a given resonant frequency f0, the effective length is given by:

$Leff = L + 2\Delta L$.

5) Calculate actual length(L):

$$L = \frac{1}{2\,fr\sqrt{\varepsilon_{reff}}\sqrt{\varepsilon_0\mu_0}} - 2\Delta L$$

6.0 Design specifications and parameters:

Table 1: Design Specifications

Antenna parameters	Values
Resonant frequency	2.4 GHz
Dielectric constant	4.4
Substrate thickness	1.6mm
Loss tangent	0.025

Table 2: Design Parameters

Parameters	Values
Ground plane length	76.684mm
Ground plane width	84.138mm
Patch length	29.425mm
Patch width	38.046mms

6.1 Simulation Results

The microstrip antenna was designed using HFSS software. The performance of the antenna has been studied by comparing the Radiation pattern, Return loss, VSWR and Gain

(a)Radiation pattern:

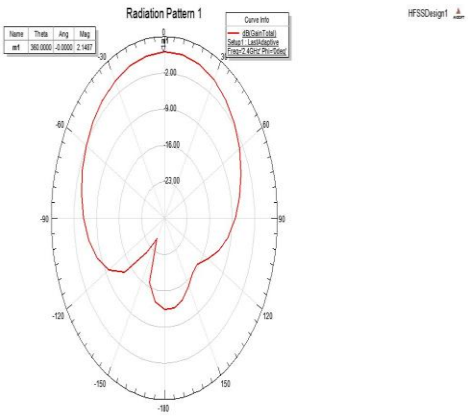

Figure 3: Radiation Pattern

In Figure3, the plot graph of 2D Radiation pattern of antenna represents radiating all power in one direction. 2D radiation pattern of antenna is shown at resonant frequency 2.4GHz and phi=0^o.

(b)Return loss:

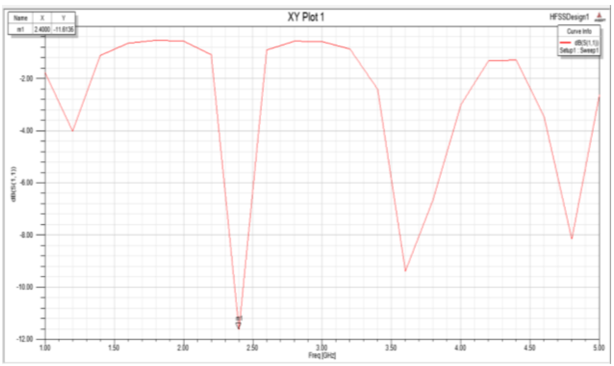

Figure 4: Frequency versus Return loss plot

In figure 4, the plot of frequency versus return loss has been presented. The standard value for return loss must be equal to or less than -10 dB. The value of simulation obtained is -11.6135dB

(c) Gain: In Figure 5, the theta versus gain plot shows the value of gain in dB. The values of gain are obtained at 0^o and 90^o.

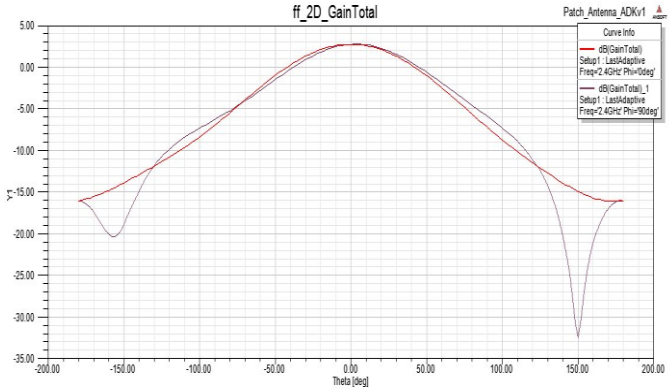

Figure 5: Theta versus Gain plot

(d) VSWR: In figure 6, the frequency versus VSWR plot shows 2.6799dB VSWR at 2.4GHz resonant frequency. The value of VSWR should be between 1 and 2 for efficient performance of an antenna.

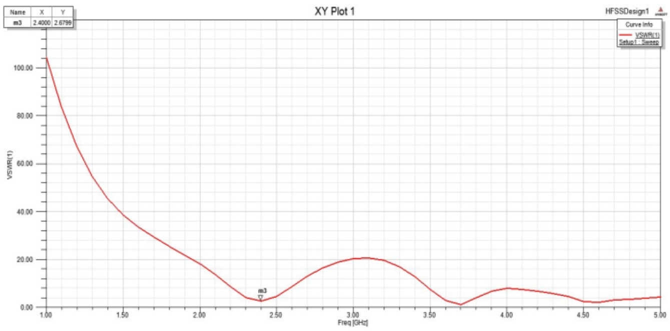

Figure 6: Frequency versus VSWR plot

7.0 ADVANTAGES OF MICROSTRIP ANTENNAS

1. They are light in weight and low profile
2. They can be made conformal to the host surface
3. Their ease of mass production using printed circuit technology leads to a low fabrication cost
4. They are easier to integrate with other micro strip circuits.
5. They support both linear polarization and circular polarization

6. They can be realized in a very compact form, desirable for personal and mobile communication hand held devices.

7. Narrow bandwidth [3].

8.0 Conclusion

The optimum dimension of rectangular microstrip patch antenna on FR4 substrate for Wi-Fi applications has been reviewed. The performance parameters can be improved by analyzing the dimensions and the design of antenna can give better result at 2.4 GHz WI-Fi frequency band.

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