

Micro strip Patch Antenna for 2.4 GHz Wireless Applications

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Abstract A small Microstrip patch antenna is introduced .the antenna is designed to function in 2.4 GHz wireless radio band .it achieves return loss -38 dB by the using fr4 substrate under the patch .the antenna has many practical applications like in WLAN, WIFI, etc as illustrated in detail herein .the patch design is simulated in An Soft HFSS Vs 10 software .the result showed satisfactory performance.

Keywords— Microstrip patch antenna, wlan, Ansoft hfss

I. INTRODUCTION

Introduction

With the ever-increasing need for mobile communication and the emergence of many systems, it is important to design broadband 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. Microstrip patch antennas have found extensive application in wireless communication system owing to their advantages such as low-profile, conformability, low-cost fabrication and ease of integration with feed networks. [1]However, conventional Microstrip patch antenna suffers from very narrow Broadband Microstrip Patch Antenna 175 bandwidth, typically about 5% bandwidth with respect to the centre frequency.

There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, the use of multiple resonators, and the use of slot antenna geometry (Pozer,). However, the bandwidth and the size of an antenna are generally mutually conflicting properties, that is, improvement of one of the characteristics normally results in degradation of the other. Recently, several techniques have been proposed to enhance the bandwidth. A novel single layer wide-band rectangular patch antenna with achievable impedance bandwidth of greater than 20% has been demonstrated (Yang et al. 2001). Utilizing the shorting pins or shorting walls on the unequal arms of a U-shaped patch, U-slot patch, or L-probe feed patch antennas, wideband and dual-band impedance bandwidth have been achieved with electrically small size in (Guo et al., 2002, Chair et al., 2005). Other techniques involves employing multilayer structures with parasitic patches of various geometries such as E, V and H shapes, which excites multiple resonant modes. However,

these antennas are generally fabricated on thicker substrates (Bao & Ammann, 2007).

II. ANTENNA DESIGN

The basic structure of the proposed antenna, shown in Fig. 1, consists of 3 layers. The lower layer, which constitutes the ground plane, covers the partial rectangular shaped substrate with a side of 33×38 mm. The middle substrate, which is made of FR4 epoxy resin, has a relative dielectric constant $\epsilon_r=4.4$ and height 1.5 mm. The upper layer, which is the patch, covers the rectangular top surface. The rectangular patch has sides 33×38 mm that covers the middle portion of the substrate. Two rectangular slots are cut out from the patch near the feeding Microstrip line for impedance matching The patch is fed by a Microstrip line with 50Ω input impedance.

Simulations were performed using HFSS .Convergence was tested for a number of times. Once convergence was obtained simulations were conducted in order to obtain swept frequency response extending from 1 to 4 GHz. Initially we started with slots symmetrically positioned at the centre of the patch .however it was observed that in order to achieve proper impedance bandwidth slot position and dimensions need to be adjusted accordingly

There are many analysis methods for the design of antenna which are discussed in previous chapter. [2]From them we use transmission line analysis method for our antenna.

Step 1: Calculation of the Width (W)

The width of the Microstrip patch antenna is given as:

$$W = \frac{c}{2f_0 \sqrt{\frac{\epsilon_r + 1}{2}}}$$

Where, c is velocity of light, f_0 is Resonant Frequency & ϵ_r is Relative Dielectric Constant Of course other widths may be chosen but for widths smaller than those selected according width equation[3] , radiator efficiency is lower while for larger widths, the efficiency are greater but for higher modes may result, causing field distortion. In this work upon Substituting $c=3.0 \times 10^{11}$ mm/s, $\epsilon_r = 4.4$ and $f_0 = 2.4$ GHz, we get: **W = 37.8 mm**

Step 2: Calculating the Length (L)

Effective dielectric constant (ϵ_{eff})

Once W is known, the next step is the calculation of the length which involves several other computations; the first would be the effective dielectric constant.[3] The dielectric constant of the substrate is much greater than the unity; the effective value of ϵ_{eff} will be closer to the value of the actual dielectric constant ϵ_r of the substrate. The effective dielectric constant is also a function of frequency. As the frequency of operation increases the effective dielectric constant approaches the value of the dielectric constant of the substrate is given by:

$$\epsilon_{re} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-1}$$

In our design for the above mentioned values the effective dielectric is found to be $\epsilon_{eff} = 3.86$

Effective length (L_{eff})

The effective length is: which is found to be

$$L = \frac{c}{2 f_o \sqrt{\epsilon_{re}}}$$

$L_{eff} = 31.88 \text{ mm}$

Length Extension (ΔL)

Because of fringing effects, electrically the micro strip antenna looks larger than its actual physical dimensions.[4] For the principle E – plane (x-y plane), where the dimensions of the path along its length have been extended on each by a distance, ΔL , which is a function of the effective dielectric constant and the width-to-height ratio (W/h).The length extension is:

$$\Delta L = 0.412 h \frac{(\epsilon_{re} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{re} - 0.258) \left(\frac{W}{h} + 0.8 \right)}$$

Substituting $\epsilon_{eff} = 4.4$, $W = 37.8 \text{ mm}$ and $h = 1.5 \text{ mm}$ we get: $\Delta L = 0.661 \text{ mm}$

Calculation of actual length of patch (L)

Because of inherent narrow bandwidth of the resonant element, the length is a critical parameter and the above equations are used to obtain an accurate value for the patch length L. The actual length is obtained by:

$$L_{eff} = L + 2\Delta L$$

Substituting $L_{eff} = 31.88 \text{ mm}$ and $\Delta L = 0.661 \text{ mm}$ we get: $L = 33.20 \text{ mm}$

Feed Point Location

After selecting the patch dimensions L and W for a given substrate, the next task is to determine the feed point (x, y) so as to obtain a good impedance match between the generators Impedance and the input impedance of the patch element. It is observed that the change in feed location gives rise to a change in the input impedance and hence provides a simple method for impedance matching.

$$Z_{in} \approx jX_f + \frac{R}{1 + j2Q(f/f_0 - 1)}$$

From the equation (4.6) we see that if the feed is located at $x = xf$ and $0 \leq yf \leq W$, the input resistance at resonance for the dominant TM10 mode can be expressed as

$$R_{in} = R_r \cos^2(\pi x_f / L) \quad R_r \geq R_{in}$$

Where xf is the inset distance from the radiating edge and R_r is the radiation resistance at resonance when the patch is fed at a radiating edge[5]. The inset distance xf is selected such that R_{in} is equal to the feed line impedance, usually taken to be 50Ω . Although the feed point can be selected anywhere along the patch width, it is better to choose $yf = W/2$ if $W \geq L$ so that TM0n (n odd) modes are not excited along with the TM10 mode. Determination of the exact feed point requires an iterative solution .Below equation provides a useful guideline for the purpose. Kara has suggested an expression for xf that does not need calculation of radiation resistance. It is approximately given by

$$x_f = \frac{L}{2\sqrt{\epsilon_{re}}(L)}$$

Feed position $x_f = 7.2052 \text{ mm}$

Design of patch

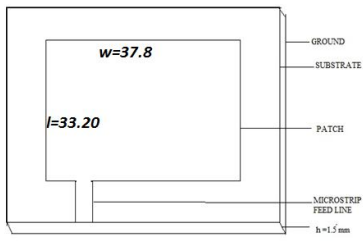


Figure 1 The proposed geometry of patch antenna

	Ground	Substrate	Patch	Microstrip
Length	42 mm	42 mm	33 mm	13 mm
Width	47 mm	47 mm	38 mm	3 mm
Height	0.2 mm	1.5 mm	0.02 mm	0.02 mm
Material	Copper	FR4 epoxy	Copper	Copper

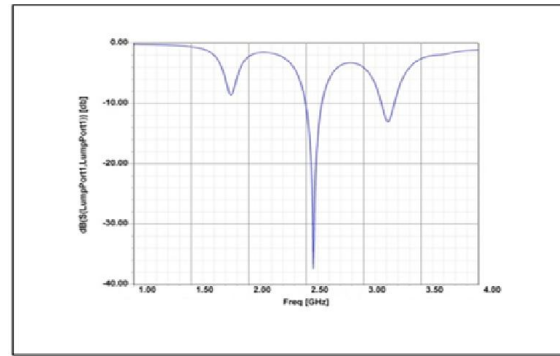


Figure 4 S₁₁ parameter Vs Frequency plot

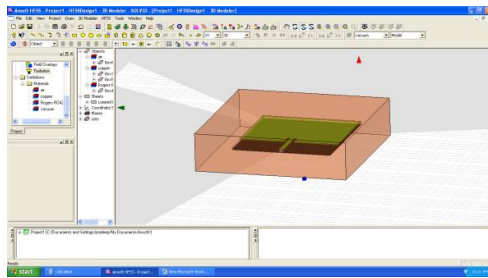


Figure 2 The proposed design of patch antenna in HFSS

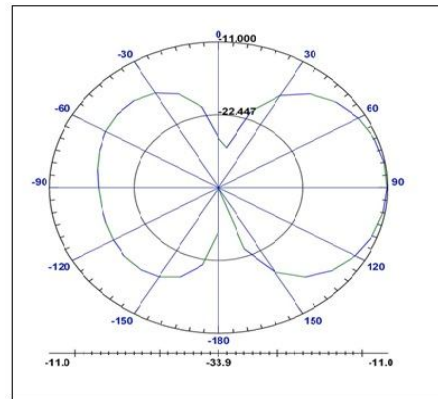


Figure 5 radiation pattern for theta = 0 degree

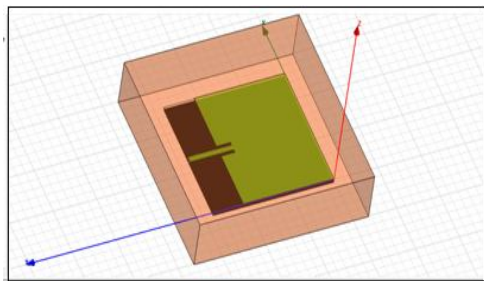


Figure 3 The proposed design of patch antenna in HFSS

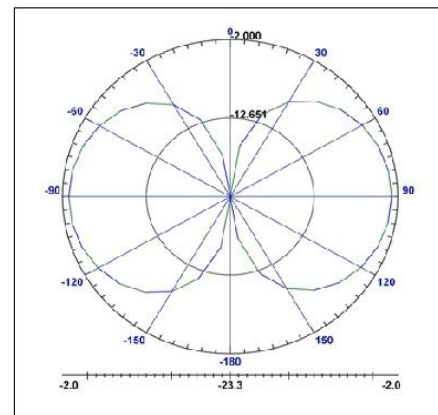


Figure 6 radiation pattern for theta = 90 degree

III. RESULTS AND DICUSSION

Conclusion:

Rectangular patch antenna at 2.4 GHz with -38 dB return loss is designed on Ansoft HFSS. Designed antenna has gain =3.954 dB and mismatch loss=-0.042 dB. Simulated results of 2D E plane, H plane patterns are shown. The calculated gain of patch antenna is 3.954 dB. The designed antenna is suitable for WLAN application.

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