A Compact Rectangular Microstrip Antenna For Wlan And Wi-Max Application Working in 2.4 Ghz

Pon. Keerthana,
ME- Communication systems, (SIET),
Sri Shakthi Institute of Engineering and technology,
Coimbatore, India,

***Abstract*— A compact rectangular patch antenna is designed to function in 2.4 GHz wireless radio band. The proposed antenna is useful for wireless applications like WLAN and WIFI. The antenna is printed on 42×47 mm^2 FR4 epoxy substrate of thickness of 1.6mm, with dielectric constant of ε_r=4.4mm. The upper layer of substrate is 33×38 mm^2 patch of thickness 0.02mm made up of copper material. The antenna is fed using edge feed technique by a Microstrip line with 50Ω input impedance. Then to prove the validation of the design, a prototype is simulated using HFSS 13.0 Antenna design software. The simulated results shows that the antenna can provide wider bandwidth when centred at 2.4 GHz and the proposed design is useful for WLAN and WI-MAX applications. In addition, the radiation pattern of the proposed antenna shows that it is omnidirectional in 2.4 GHz frequency with low cross polarization level with stable antenna gain across the operating bands.**

I INTRODUCTION

Nowadays there is a vast usage of mobile communication, to support our wide usage new system emerges. In other hand, it is important to design broadband antennas to cover a wide frequency range. The major challenge for current trend is to design an efficient wide band small size antenna for recent wireless application. Microstrip patch antenna is widely used in wireless application because of their advantages like low profile, conformability, low cost fabrication and ease of integration with feed network. But microstrip patch antenna suffer from narrow bandwidth, there are numerous and well known methods to increase the bandwidth of antenna they are, increase of substrate thickness, the use of low dielectric substrate, the use of low dielectric substrate, the use of various impedance matching and feeding techniques, the use of multiple resonators and the use of slot antenna geometry. However bandwidth and size of the antenna are inversely proportional properties, that is, improvement of one of the characteristics normally result in degradation of other. A novel single layer wide-band rectangular patch antenna with achievable impedance bandwidth of greater than 20% has been demonstrated already using the shorting pins or shorting on the unequal arms of a U-shaped patch, U-slot patch, or L-probe feed patch antenna wideband and dual band impedance bandwidth have been achieved with electrically small size. But these antennas are generally fabricated I thicker substrate. To overcome all drawbacks, the antenna is proposed to work in 2.4 GHz of wider bandwidth in tin substrate of 1.6mm thickness using FR4 epoxy material.

RECTANGULAR MICROSTRIPANTENNA

A rectangular microstrip (also known as patch antenna) antenna is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet of "patch" of metal, mounted over a large sheet of metal called a ground plane. The assembly is usually contained inside a plastic cover, which protects the antenna structure from damage. The patch antennas are simple to fabricate and easy to modify and customize. The two metal sheets together form a resonant piece of microstrip transmission line with a length of approximately one-half wavelength of radio waves. The radiation mechanism arises from discontinuities at each truncated edge of the microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used. A patch antenna is usually constructed on dielectric substrate using the same materials and lithography processes used to make printed circuit boards.

FEEDING TECHNIQUE –MICROSTRIP LINE FEED

In this type of fed technique a conducting strip is connected directly to the edge of the microstrip patch antenna. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modelling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. Figure 1 shows the microstrip line feed in rectangular patch antenna.

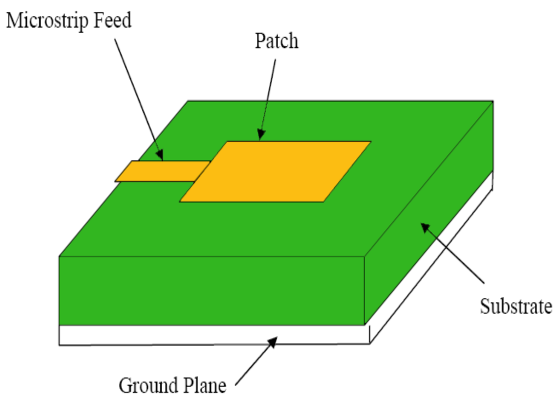


Figure 1- Microstrip line feed in rectangular patch antenna

Proposed Antenna Design

The basic structure of proposed antenna is shown in Figure 2. It consist of 3 layers. The lower layer constitutes the ground plane, covers the rectangular shaped substrate, which is made of FR4 epoxy resin material. It has relative dielectric constant $\varepsilon_r = 4.4mm$ and height of 1.6mm, the upper layer of the proposed antenna is patch coers the rectangular top surface. The rectangular patch has $33\times38\ mm^2$sides that covers the middle portion of the substrate. Two rectangular slots are cut down from the patch near the feeding microstrip line for impedance matching. The patch is fed by microstrip line with 50Ω input impedance. Simulations were performed using HFSS. Convergence was tested for a number of times. Once convergence is obtained simulations were conducted in order to obtain swept frequency extending from 1 to 4 GHz. In order to achieve proper impedance it is needed to adjust bandwidth, slot position and dimensions accordingly. There are many analysis methods for the design of antenna. For the proposed antenna design transmission line analysis method is used.

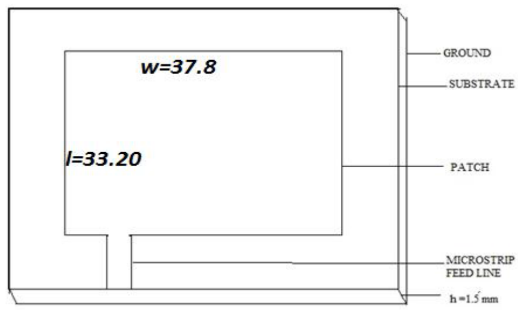


Figure 2- Proposed antenna design

Transmission Line Model Analysis

In order to achieve proper impedance and efficient gain for the proposed antenna design it is needed to adjust all dimensions, slot position and bandwidth accordingly. For this purpose we use transmission line model analysis for the proposed antenna.

Transmission line model analysis for antenna is very simple and needs only less mathematical computations and provides sufficient engineering accuracy. Transmission line model treats the rectangular patch radiator as a strip line resonator with no transverse field variation and assumes the radiation to occur from the two transverse open edges. It is well known that dominant mode of propagation in a strip line is the TEM or quasi TEM mode having negligible variation of fields in the transverse direction. As it is the parallel plate type of TEM mode, when properly exited only the two open edges normal to the direction of propagation take part in radiation.By using transmission line analysis model the parameters needed for the proposed antenna design is calculated, they are width of the patch antenna, length, dielectric constant, effective length, length extension, actual length of the patch, feed point location.

ANTENNA DESIGN ANALYSIS

(I) CALCULATION OF WIDTH (W)

The width of microstrip patch antenna is given as

$$w = \frac{c}{2f\sqrt{\frac{(\varepsilon r+1)}{2}}}$$

Where, c is velocity of light,f is resonant frequency, ε is relative dielectric constant

If the width becomes smaller than the selected width radiator efficiency will be lower, while for larger width, efficiency is greater and it cause field distortion. For our calculation we use the values for parameters as $c=3\times10^{11}$ mm/s, $\varepsilon_r=4.4$, f=2.4GHz. By using these values we obtain the width as w=38mm.

(ii) CALCULATION OF LENGTH (L)

(a)TO FIND EFFECTIVE DIELECTRIC CONSTANT (ε_{eff})

To know length we should first find other parameters like effective dielectric constant, the dielectric constant of substrate is much greater than the unity, the effective value of ε_{eff} will be closer to the value of actual dielectric constant ε_r of the substrate. As the frequency of the operation increases, the effective dielectric constant approaches the value of dielectric constant of the substrate, it is given as

$$\varepsilon_{eff} = \frac{\varepsilon r=1}{2} + \frac{\varepsilon r-1}{2}[1 + 12\frac{h}{w}]^{-1/2}$$

In proposed design, for the above mentioned values, the effective dielectric is found to be ε_{eff}=4.1.

(b)TO FIND EFFECTIVE LENGTH (L_{eff})

Then we find the value for effective length (L_{eff}). It is very important parameter that is determines the effective length of the patch. The effective length of the resonating patch is important which determines the radiation behaviour of the antenna. It is found using the formula,

$$Leff = \frac{c}{2f\sqrt{\varepsilon eff}}$$

By this formula we find the value of L_{eff} is 32mm.

(c)TO FIND LENGTH EXTENSION (ΔL)

As the antenna has fringing effects, electrically the microstrip antenna looks larger than its actual physical dimensions 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,

$$\Delta L = \frac{0.412h(\varepsilon eff + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon eff - 0.258)(\frac{w}{h} + 0.8)}$$

By substituting ε_{eff}=4.4, w=38mm and h=1.6mm we get, $\Delta L = 0.672mm$

(iii)CALCULATION OF ACTUAL LENGTH OF PATCH (L)

The length is critical parameter as the resonant element has narrow bandwidth. The actual length is obtained as

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

We know the values of L_{eff}=32mm, $\Delta L = o.672mm$, now the value of actual length is L=33.312mm.

(iv)FEED POINT LOCATION

After selecting the patch dimensions like L,W for a substrate next task is to determine the feed point (x,y) so as to obtain a impedance match between the generator impedance and input impedance of the patch element. The feed line impedance is found to be about 50Ω. To find the approximate feed point we use a equation as

$$X_f = \frac{L}{2\sqrt{\varepsilon_{eff}(L)}}$$

The value of X_f =7.253mm.

ANTENNA GEOMETRY

From the above analysis the geometry of the proposed antenna design is framed which makes the antenna to work efficiently in wider bandwidth. This tabular column provides the geometry of the proposed antenna design. Table 1 provides the length, width, height, material of the ground, substrate, patch, microstrip used for the design of the proposed antenna.

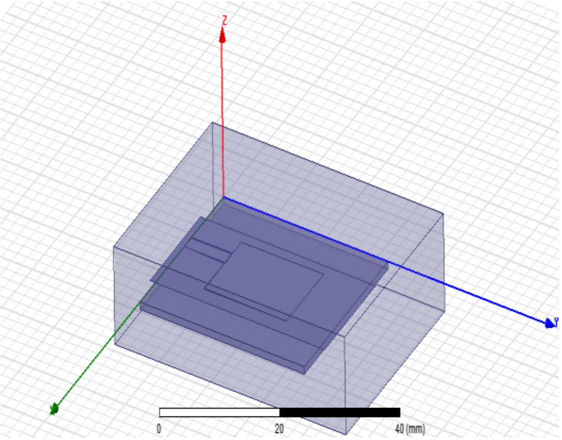
	Ground	Substrate	Patch	Microstrip
L	42mm	42mm	33mm	13mm
W	47mm	47mm	38mm	3mm
H	0.2mm	1.6mm	0.02mm	0.02mm
material	copper	FR4 epoxy	copper	Copper

Table 1- Antenna geometry for the proposed design

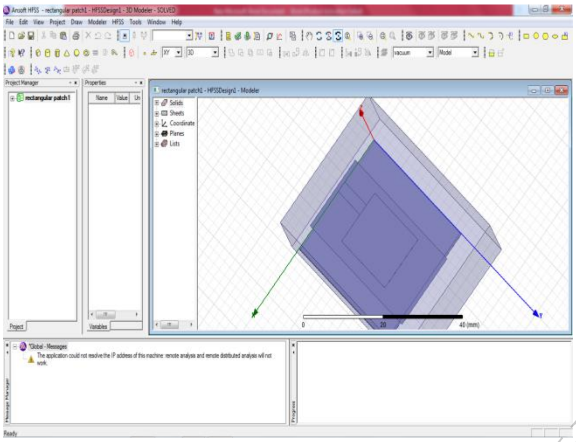
RESULTS

Results obtained from the simulation made using HFSS 13.0 antenna design software are shown. Figure 4 shows the radiation pattern of the antenna in xy plot, Figure 5 shows the 3D radiation pattern of the proposed antenna and Figure 6 shows the return loss of the proposed antenna.

THE PROPOSED ANTENNA DESIGN USING HFSS 13.0



3(a)



3(b) Figure 3(a),(b)- The proposed design of rectangular microstrip antenna in HFSS

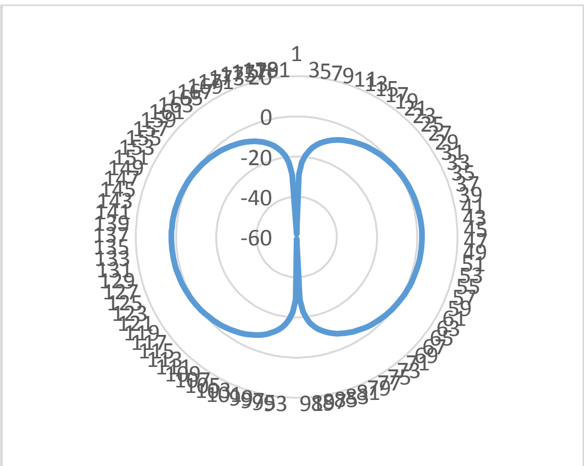


Figure 4- radiation pattern of proposed rectangular microstrip antenna

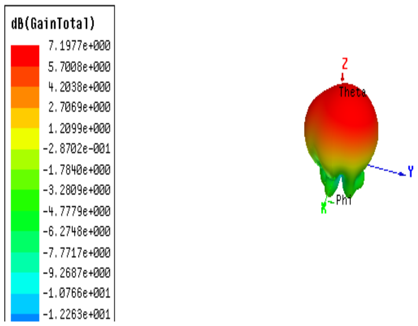


Figure 5- 3D radiation pattern of the rectangular microstrip antenna.

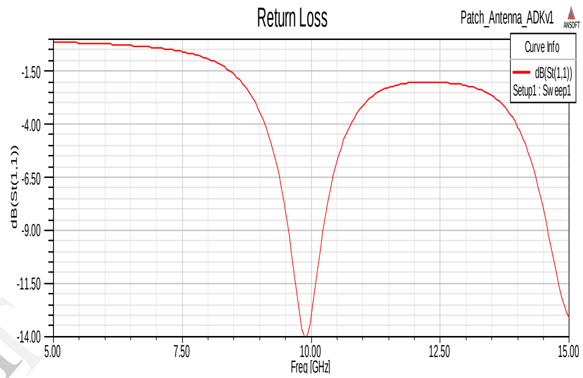


Figure 6- return loss of the rectangular microstrip antenna

CONCLUSION

Thus a compact rectangular microstrip antenna is designed to work in 2.4 GHz with return loss of 38dB using Ansoft HFSS 13.0 antenna design software. The designed antenna provide gain of about 3.842 dB and mismatch loss of -0.04dB. Thus the designed antenna is suitable for wide band wireless application such as WLAN and WI-MAX

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