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Design and Improved Performance of Rectangular Micro strip Patch Antenna for C Band Application

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ABSTRACT
In the resent year the development in communication system requires the development of low cast, minimum weight and low profile antennas that are capable of maintaining high performance over wide spectrum of frequency. This technological trend has focused much effort into the design of micro strip patch antenna. The object of this paper is to design an micro strip line fed rectangular micro strip patch antenna which operate in C-band at 5.33 GHz the antenna design is based on high frequency structure simulation (HFSS) software which is infinite element method based. This proposed antenna is design at height of 1.5 mm from the ground plane at frequency of 5.33GHz. The HFSS software has become the most versatile, easy to used, efficient and accurate simulation tool. After the simulation the performance characteristics such as input impedance, return loss, and VSWR are obtained

Keywords **-**Rectangular micro strip patch antenna, micro strip feed line, FR- epoxy (4.4) substrate, return loss, an soft HFSS

I. INTRODUCTION

Micro strip patch antenna has been studies over the past many years because of its low profile, light weight, low cost and easy fabrication [9]. These low profile antennas are also useful in aircraft, satellites and missile application where size, weight, cost, and easy of installation and aerodynamic profile are strict constraints. But micro strip patch antenna suffers from drawbacks like narrow bandwidth and low gain [4]. While using micro strip patch antenna the other problem which will occur are high loss and surface waves. In the substrate layer as the losses will always occur in radiation as the antenna in transmitting the signal. Due to the surface wave excitation losses occur that will cause decrease in the antenna efficiency, gain and the bandwidth

Antenna play a very important role in the field of wireless communication some of them are parabolic reflector ,patch antenna ,slot antenna and folded dipole antenna with each type of having own properties .it is perfect to classify antenna as the backbone and the driving force behind the recent advantage in wireless communication technology[5]. By the early 1980 the basic rectangular micro strip patch antenna element and Array ware well established in the term of designing and application. In the last decades the micro strip patch antenna has been largely studied due to their advantage over the other radiating system which includes low cast, reduced weight and the ease of integrating with active device (pozar 1995). Rectangular micro strip patch antenna consists of radiating patch on top of the dielectric substrate and at the bottom of the dielectric substrate it consists of ground plane[6]. The other side of dielectric substrate is using contacting material such as copper and gold for making of the radiating patch. The micro strip feed line and radiating patch is generally photo etched on the dielectric substrate (balanis 2005). In between patch edge and ground plane the fringing field is generated by the radiation of micro strip patch antenna .the rectangular micro strip antenna can be fed by a verity of methods. These methods can be classified into two categories, contacting and non contacting.

The RF power is fed directly to the radiating patch using a contacting element such as a micro strip this is called contacting method. In non contacting method the electromagnetic field coupling is done to transfer power between the micro strip line and the radiating patch which include proximity Feeding and aperture feeding. In the characteristic of micro strip patch antenna many no. of physical parameters are introduced compare to conventional microwave antenna. In this paper the operating frequency for the design of micro strip feed line antenna by using the high frequency structure simulation program is in the operating frequency range of 5.33 GHz. We have proposed an antenna with dielectric material of FR_4 epoxy (4.4) which gives performance characteristics like return loss, VSWR and smith chart, etc.

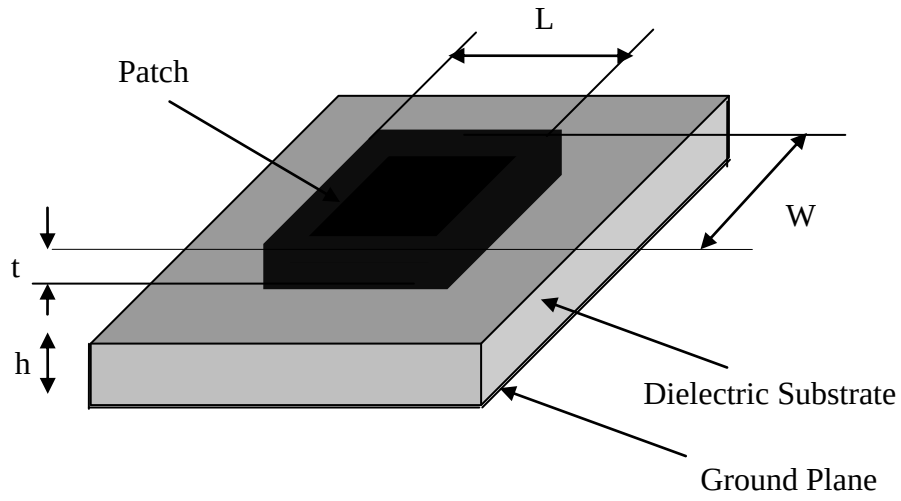


Figure (1): Basic features of a patch antenna

II. FOUNDATION FOR MICROSTRIP PATCH ANTENNA DESIGN

A micro strip patch antenna is a radiating patch on one side of a dielectric substrate, which has ground plane on the underside. The EM wave fringe off the top patch into the substrate, reflecting off the ground plane and radiates out into the air radiation occur mostly. Due to fringing field between the patch and ground. The radiating efficiency of the patch antenna depends largely on the permittivity of the dielectric. The advantage of micro strip patch antenna is that they are low cost, conformable, light weight and low profile.

In proposed structure of micro strip rectangular patch antenna the patch length "L" is usually $0.3333\lambda<L<0.5\lambda$, Where λ is the wavelength of free space, the patch is selected to be very thin such that $t << \lambda$ (Where t is patch thickness), the height "h"of dielectric substrate is usually $0.003\ \lambda<h<0.05\ \lambda$ [6]. The ground plane dimension is 22.90 mm x 26.76 mm.

the patch dimension is 13.30 mm x 17.16 mm. The feed dimension is 1.19 mm x 4.8 mm.the port dimension is 1.19 mm x 1.6 mm. We are used the substrate of FR_4 epoxy (4.4) for designing the micro strip patch antenna .thickness of & relative permittivity [1].

III. ANTENNA DESIGN CONSIDERATION

The three essential parameters for the design of a Rectangular Micro strip Patch Antenna are:

Dielectric constant of the substrate (ε_r) : The dielectric material selected for the design is FR_ epoxy which has a dielectric constant of 4.4 . A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

Frequency of operation (f_o) : The resonant frequency of the antenna must be selected appropriately. The wireless Communication System uses the frequency range of microwave frequency e. g GHz. Hence the antenna designed must be able to operate in this frequency range.in this proposed antenna we are used frequency in 5.33 GHz

Height of dielectric substrate (*h*): For the micro strip patch antenna to be used in wireless communication, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.5 mm

TABLE I: ANTENNA PARAMETER

Frequencyof operation(f_o)	5.33 GHz
Height of substrate (h)	1.5mm
Dielectric constant(ε_r)	4.4

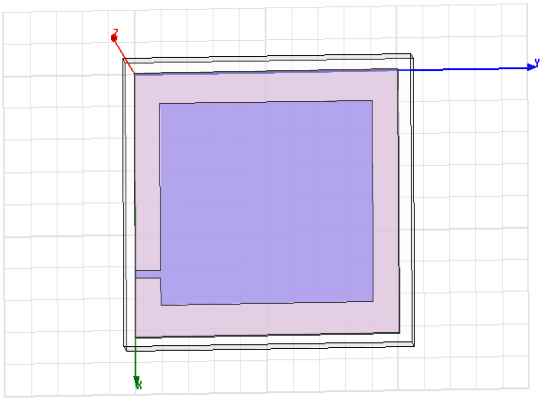


Figure (2): Rectangular micro strip patch antenna top view

IV. DESINING AND MODELING PARAMETER OF RECTANGULAR MICROSTRIP PATCH ANTENNA-

BY the transmission line method (balanis,2005) the parameter of antenna can be calculated as

Step 1: Calculation of the Width (W): The width is critical in the term of power efficiency, antenna impedance and bandwidth. It is largely dependent on the operating frequency and substrate dielectric constant. The equation below was used to workout the width of the patch

$$W = \frac{C}{2f_0\sqrt{(\varepsilon_r + 1)/2}}$$

Substituting
c = 3 x10^8 m/s,
ε_r = 4.4
f_o = 5.33 GHz,

Step2:Calculation of Effective dielectric constant (ε_{reff}):

The calculation of the effective dielectric constant by the equation of given below

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}}$$

Substituting
ε_r = 4.4,
W = 17.16 mm
h = 1.5 mm

The effective dielectric constant is less than εr, because of fringing field around the periphery of the patch is not to the dielectric speared in the air.

Step 3: Calculation of the Effective length (L_{eff}):

Calculation of the effective length is calculated by the equation is given below

$$L_{eff} = c/2f_o\sqrt{\varepsilon_{r}}\text{eff}$$

Substituting
ε_{reff} = 3.86
c = 3 x10^8 m/s
f_o = 5.33GHz

The transmission line method is applicable to in infinite ground plane only. However for practical consideration it is essential to have a finite ground plane it has been show by that similar result for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimension by approximately six time the substrate thickness all ground the periphery .

Step 4: Calculation of the length extension (ΔL):

Calculation of the length extension is calculated by the equation is given below

$$\Delta L = 0.42h\,\frac{(\varepsilon reff+0.3)\ (\frac{W}{h}+0.264)}{(\varepsilon reff-0.258)\ (\frac{W}{h}+0.8)}$$

Substituting
ε_{reff} = 3.86,
W = 17.16 mm
h = 1.5 mm

Step 5: Calculation of actual length of patch (L):

The actual length of patch is obtained by the equation of given below

$$L = L_{eff} - 2\,\Delta L$$

Substituting
L_{eff} = 14.034 mm
ΔL = 0.725 mm

Step6:Calculationof the ground plane dimensions (L_g and W_g):

Calculation of the ground plane dimension is obtained by the equation of given below (huang, 1983)

L_g = 6h + L = 6(1.6) + 12.58 = 22.90 mm

W_g=6h +W = 6(1.6) + 16.78 = 26.76 mm

The rectangular shape is most commonly used configuration for the patch antenna because of easy to analysis using transmission line method.

Step 7:Determination of feed point location (f_x,f_y)

A coaxial probe type feed is to be used in this design. As shown in Figure 6.1, the center of the patch is taken as the origin and the feed point location is given by the co-ordinates (f_x , f_y) from the origin. The feed point must be located at that point on the patch, where the input impedance is 50 ohms for the resonant frequency. Hence, a trial and error method is used to locate the feed point. For different locations of the feed point, the return loss (R.L) is compared and that feed point is selected where the R.L is most negative. There exists a point along the length of the patch where the R.L is minimum.

Hence in this design co-ordinates (*f x, f y*) from the origin is (10.937, 11.437).

V ANTENNA MODEL

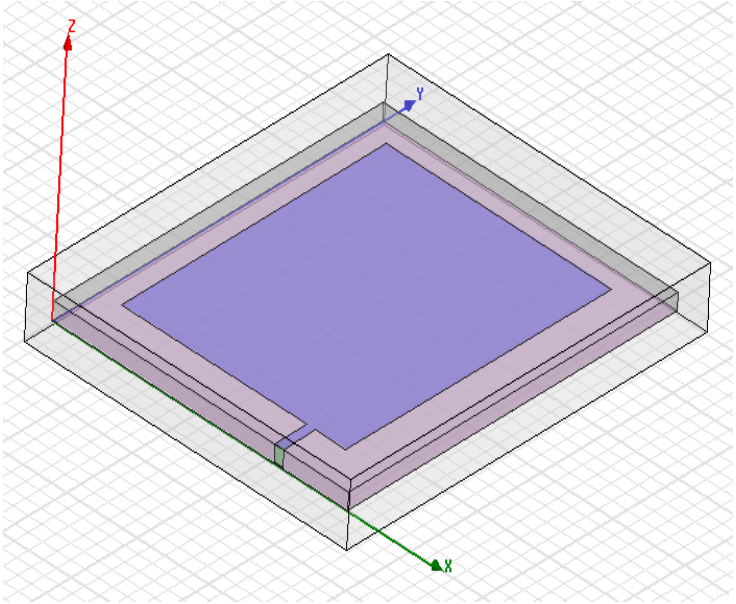


Figure (3): construction Rectangular micro strip patch antenna

VI SIMULATION SETUP

For designing of micro strip patch antenna we are used software of HFSS. HFSS software is a full-wave electromagnetic simulator based on the finite element method. It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF/wireless antennas. It can be used to calculate and plot the S parameters, VSWR, return loss as well as the radiation patterns.

VII SIMULATED RESULT

Return loss is important parameter for calculating the bandwidth of the antenna. The center frequency is selected as the one at which the return loss -14.16db is minimum.

The bandwidth can be calculated from the return loss (RL) plot. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -10 dB (-10 dB corresponds to a VSWR of 1.2 which is shown in figure3. The Impedance bandwidth is 5.33GHz and the percentage bandwidth is 27% of the antenna for the feed point location calculated.

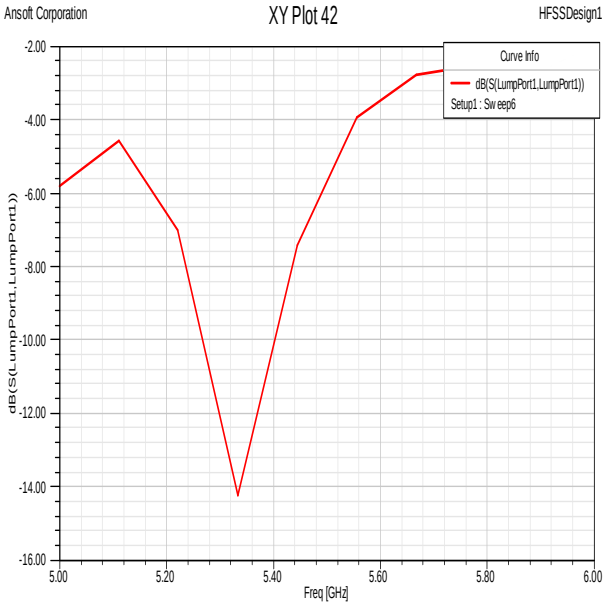


Figure (4): Return loss vs. frequency plot

The parameter VSWR is a measure that numerically describe how well the antenna impedance match to the transmission line it is connected to. VSWR stand for voltage standing wave ratio and it is function of reflection coefficient in this paper the VSWR lie in the range of 1.2.

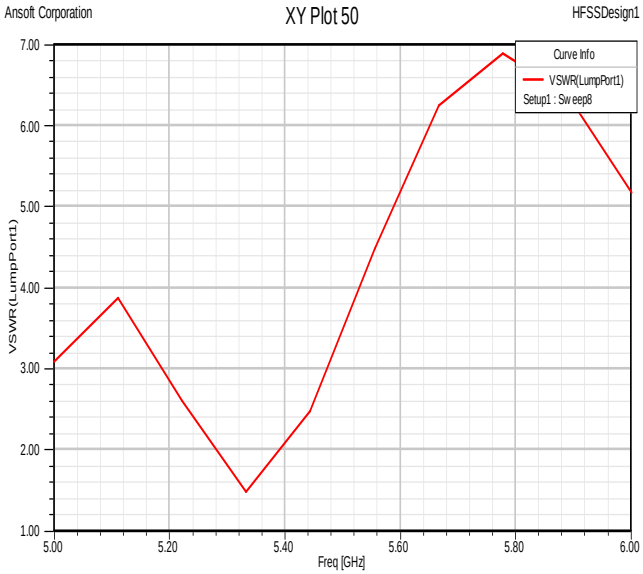
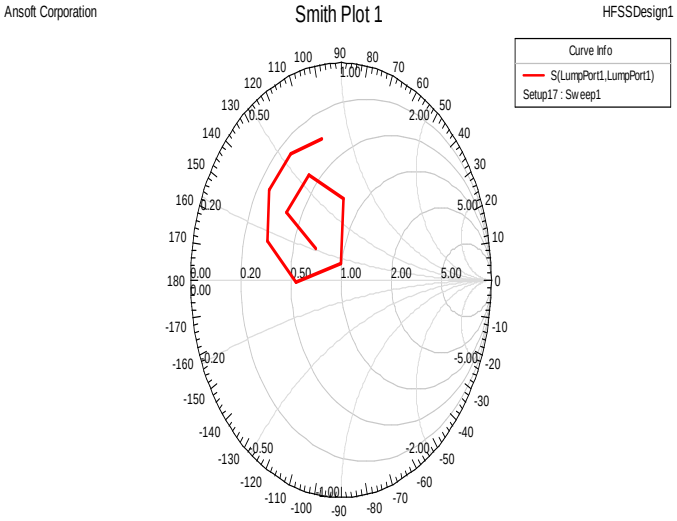


Figure (5). VSWR Vs Frequency.



Figure(6): Scattering parameter S_{11} versus frequency on the Smith chart

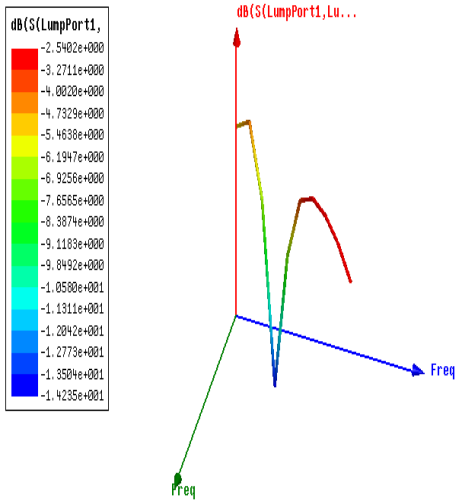


Figure (7): 3 D plot Return loss vs. frequency plot

TABLE I: ANTENNA DESIGNING PARAMETER

Length	13.30 mm
Width	17.16 mm
Feed (X)	01.19 mm
Feed (Y)	04.8 mm
Ground Length	22.90 mm
Ground width	26.76 mm

VIII CONCLUSION

It is show that the simulation result obtained by HFSS simulator show good agreement. The proposed rectangular patch antenna can be good candidate for C band application due to its miniature size and it good performance. The frequency range of this antenna is 5.33GHz and impedance matching approximate 50 ohms at the canter frequency.

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