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Designing of Rectangular Microstrip Patch Antenna for C-Band Application

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***Abstract**: Microstrip patch antenna becoming very popular day by day because of its ease of analysis, fabrication, low cast, light weight easy to feed and their attractive radiation characteristics. In this paper we proposed the designed of rectangular microstrip patch antenna to operate at frequency range 5-6 GHz. The simulation is carried out using high frequency simulation structure (HFSS) program. The antenna is based on the modified epoxy substrate with dielectric constant of approximate 4.4. After simulation rectangular microstrip antenna performs characteristics such as VSWR & return loss smith chart.*

***Keywords:** Rectangular microstrip patch antenna, microsrtip feed line, HFSS, FR- epoxy (4.4) .*

I. INTRODUCTION

The enhancing bandwidth and size reduction mechanism can be improved by performance of rectangular micro strip patch antenna. A micro strip rectangular patch antenna has the advantage of low cast, light weight, and low profile planner configuration [4]. They suffer from drawbacks such as narrow bandwidth, low gain and excitation of surface wave etc. In the early 1980 the rectangular micro strip patch antenna element and Array ware well established in the term of designing and application. In the last 10 years the micro strip patch antenna has been studied to their advantage over the other radiating system which includes low cast, reduced weight and the ease of integrating with active device [5]. 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. 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 [6]. 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 noncontacting. The RF power is fed directly to the radiating patch using a contacting element such as a microstrip this is called contacting method. In non contacting method the electromagnetic field coupling is done to transfer power between the microstrip 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 5-6 GHz. We have proposed an antenna with dielectric material of FR_4 epoxy (4.4) which gives performance characteristics like return loss, VSWR smith plot etc.

II. STRUCTURE OF MICROSTRIP RECTANGULAR PATCH ANTENNA

Antennas play a very important role in the field of communications some of them are parabolic reflectors, patch antennas, slot antennas, and folded dipole antennas with each type having their own properties and uses. It is perfect to classify antennas as the backbone and the driving force behind the recent advances in Communication technology [8]

In proposed structure of microstrip 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 22.18 mm x 26.38 mm. the patch dimension is 12.58 mm x 16.78 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 microstrip patch antenna .thickness of & relative permittivity [1].

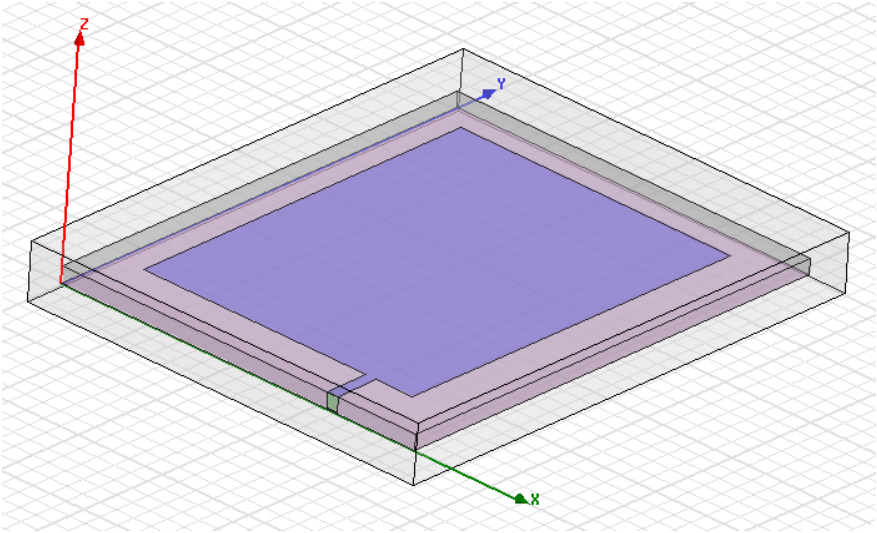


Figure (1): Rectangular microstrip patch antenna

III. ANTENNA DESIGNE CONSIDERATION

Substrate Selection- In the designing of rectangular microstrip patch antenna used the dielectric material of the substrate (εr) is FR-4 epoxy .the dielectric constant of this material is 4.4 and this is very important parameter for designing of the antenna .We are using the low dielectric constant for designing of the microstrip patch antenna because of better efficiency, higher bandwidth and increased radiated power. In this antenna the patch is important part of dielectric constant. [2]

Resonant Frequency – The resonant frequency is also very important parameter of designing of antenna .The frequency range used is 5-6 GHz and the proposed antenna must operate within the frequency range of 5-6 GHz.

Substrate Thickness- This is also an important parameter .The thickness of the dielectric substrate of the of microstrip patch antenna with microstrip feed line is used in "c" band frequency range. The height of dielectric substrate of proposed antenna is 1.6 mm.

IV. Designing Parameter of Rectangular Microstrip Patch Antenna

By the transmission line method [6] the parameter of antenna can be calculated as

Step 1: Calculation of the Width (W):

The width of the Micro strip patch antenna is given by:

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

Substituting c = 3 x10^8 m/s, $\boldsymbol{\varepsilon}_r$ = 4.4 and $\boldsymbol{f}_o$ = 5.44 GHz,

Step 2: Calculation of Effective dielectric constant (ε_{reff}):

The effective dielectric constant is given as:

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

Substituting ε_r = 4.4, W = 16.78 mm and h = 1.6 mm

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

The effective length is given as:

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

Substituting $\boldsymbol{\varepsilon}_{reff} = 3.86$, $c = 3 \times 10^8$ m/s and
$f_o = 5.44$GHz we get:

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

The length extension is calculated as:

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

Substituting $\varepsilon_{reff} = 3.86$, $W = 16.78$ mm and $h = 1.6$ mm we get:

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

The actual length is obtained by -

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

Substituting $L_{eff} = 14.034$ mm and $\Delta L = 0.725$ mm we get

Step 6: Calculation of the ground plane dimensions (L_g and W_g):

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$L_g = 6h + L = 6(1.6) + 12.58 = 22.18 \text{ mm}$$

$$W_g = 6h + W = 6(1.6) + 16.78 = 26.38 \text{ mm}$$

Step 7: Feed point location:

A micro strip line type feed is to be used in this design. 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.

IV. TABLES

Length	12.58 mm
Width	16.78 mm
Feed(X)	01.19 mm
Feed (Y)	04.8 mm
Ground Length (Lg)	22.18 mm
Ground Width (Wg)	26.38 mm
Port Length (X)	01.19 mm
Port Width (Y)	01.6 mm

V. Simulation Setup

The software used to model and simulate the micro strip patch antenna is HFSS software. 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.

VI. Results and Discussion

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 -22.26db is minimum.

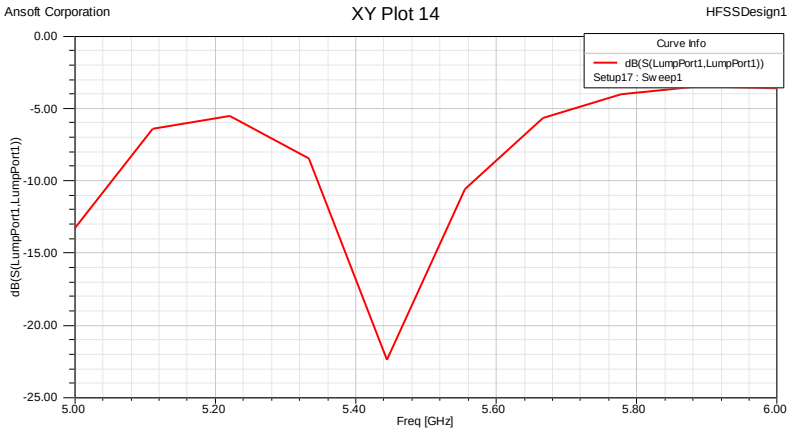


Figure (2): Return loss vs. frequency plot

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 1.1 which ia shown in figure3. The Impedance bandwidth is 2.78GHz and the percentage bandwidth is 27% of the antenna for the feed point location calculated.

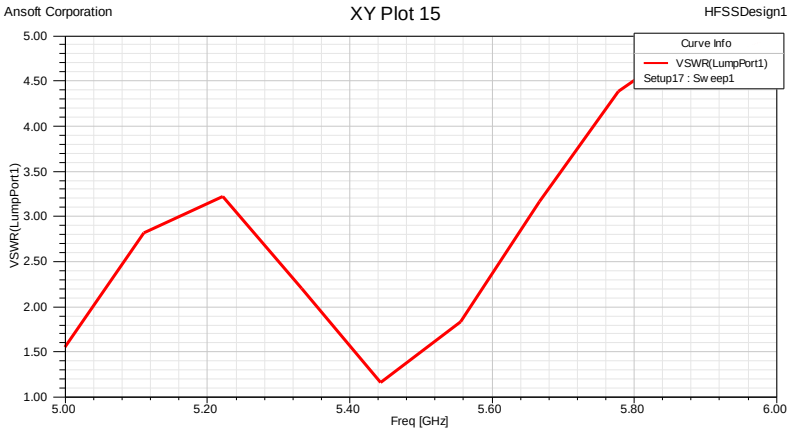
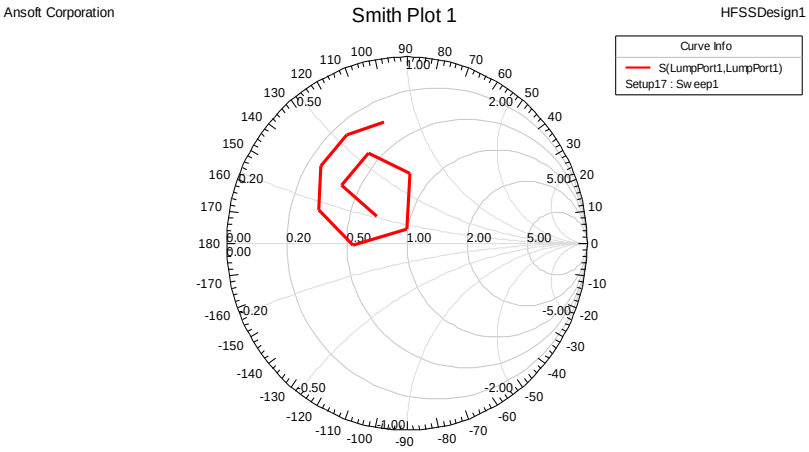


Figure (3). VSWR Vs Frequency



Figure(4): Scattering parameter S_{11} versus frequency on the Smith chart

VI. Conclusion

In this paper we have presented the design of microstrip rectangular patch antenna which covers the spectrum of 5-6 GHz frequency range. The design antenna exhibits a good impedance matching of approximate 50 ohms at the center frequency. This antenna can be easily fabricated on substrate material due to its small size and thickness.

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