ISSN 2229-5518

Rectangular Microstrip Patch Antenna for Wireless Communications at 6.5 GHz

Ms. Neha Patel[1], Prof.Jaikaran singh[2], Prof.Mukesh Tiwari[3]

Abstract—Due to the existence of growth in development of low cost, less weight, highly reliable, minimal profile antennas for wireless devices, it poses a new challenge for the design of antenna in wireless communications. This paper presents design and simulation of a rectangular microstrip patch antenna at 6.5 GHz for wireless communications. This antenna has 140 MHZ bandwidth, Return loss at centre frequency has less than -16.70dB. The beauty of this antenna is the use of single patch which make it easy to fabricate consequently cost of antenna becomes cheaper. The rectangular microstrip patch antenna is analyzed using High Frequency Structure simulator (HFSS) v 11.

Keywords: Rectangular Microstrip Patch Antenna, Return Loss, VSWR, Bandwidth, High Frequency Structure simulator (HFSS) v 11, Wireless communication.

1. Introduction

Microstrip patch antennas have drawn the attention of researchers over the past few decades. However, the antennas inherent narrow bandwidth and low gain is one of their major drawbacks [1, 2]. This is one of the problems that researchers around the world have been trying to overcome. Throughout the years, authors have dedicated their investigations to creating new designs or variations to the original antenna that, to some extent, produce wider bandwidths.

The patch antenna has been rapidly used in various fields like space technology, aircrafts, missiles, mobile communication, GPS system, and broadcasting. Patch antennas are light in weight, small size, low cost, simplicity of manufacture and easy integration to circuits. More important is these can be made out into various shapes like rectangular, triangular, circular, square etc [1].

Many techniques have been suggested for achieving the high bandwidth. These techniques includes: using parasitic elements either in same or other layer [7], utilization of thick substrates with low dielectric constant [4], and slotted patch [5]. We have used a thick dielectric substrate having a low dielectric constant which provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size. In order to design a compact Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance.

2. Microstrip Patch Antenna

Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1.

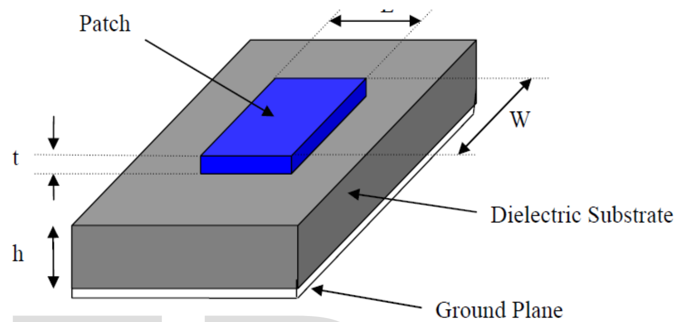

Figure1. Microstrip Patch Antenna

The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate [1, 3]. The patch is selected to be very thin such that $t << \lambda o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda o \leq h \leq 0.05\lambda o$. The dielectric constant of the substrate (εr) is typically in the range $2.2 \leq \varepsilon r \leq 12$ r. Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in hand-held wireless devices such as cellular phones, pagers etc. The telemetry and communication antennas on missiles need to be thin and conformal and are often Microstrip patch antennas. Another area where they have been used successfully is in Satellite communication.

3. Feed Technique

Microstrip patch antennas can be fed by a variety of methods [1, 2]. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a Microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are the Microstrip line (fig.2), coaxial probe (fig.3) (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).This paper uses microstrip line feeding technique.

- *Ms .Neha Patel: M.Tech Scholar (Digital Comm.), SSSIST, Sehore (M.P) India*
- *Prof.Jaikaran singh, Prof.Mukesh Tiwari: Assoc. Professor, ECE, SSSIST, Sehore (M.P)*

ISSN 2229-5518

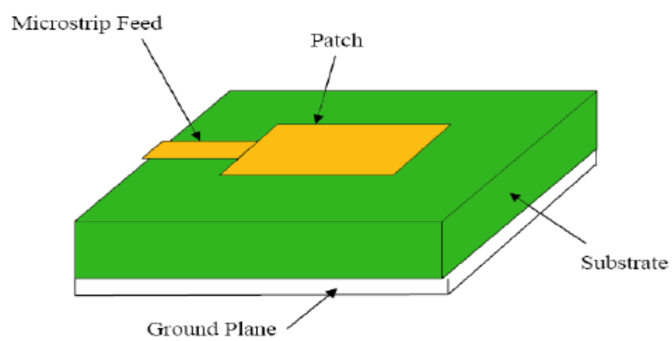

Figure 2. Microstrip Line Feed

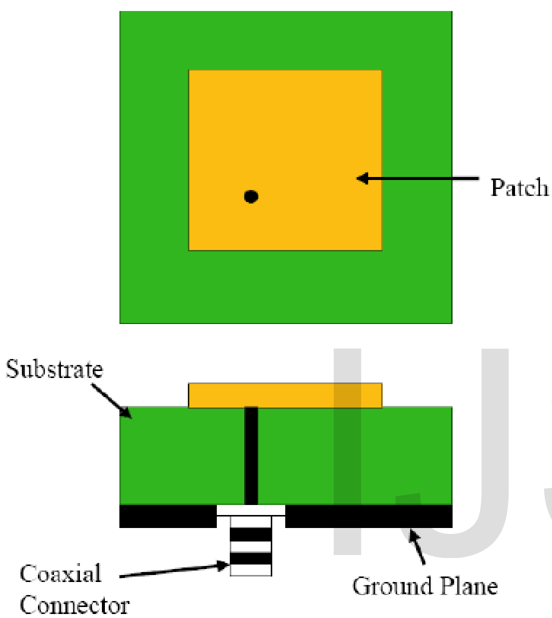

Figure3. Coaxial Feed

4. Method Of Analysis

The most popular models for the analysis of Microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method) [1,3]. The transmission line model is the simplest of all and it gives good physical insight, but it is less accurate. The cavity model is more accurate and gives good physical insight but is complex in nature. The full wave models are extremely accurate, versatile and can treat single elements, finite and infinite arrays, stacked elements, arbitrary shaped elements and coupling. These give less insight as compared to the two models mentioned above and are far more complex in nature. In this paper Transmission line model is used for designing the patch antenna.

4.1 Transmission Line Model

This model represents the microstrip antenna by two slots of width W and height h separated by a transmission line of length L. The microstrip is essentially a non homogeneous line of two dielectrics, typically the substrate and air. The formulas used in this model for calculation of the dimensions are discussed in next section.

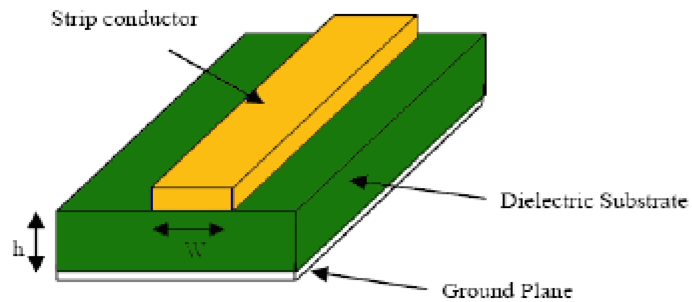

Figure4. Microstrip Line

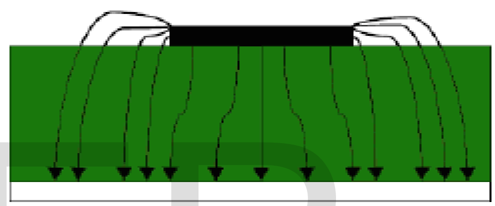

Figure5. Electric Field Lines

5. Microstrip Rectangular Patch Antenna Design

Design of microstrip patch antenna depends mainly upon three parameters, namely substrate and its dielectric constant, height of the substrate and resonant frequency. In this paper, selected three parameters are: Resonant Frequency (fr) = 6.5 GHz, Dielectric constant (εr) = 4.5, Height of the dielectric substrate (h) = 1.50 mm.

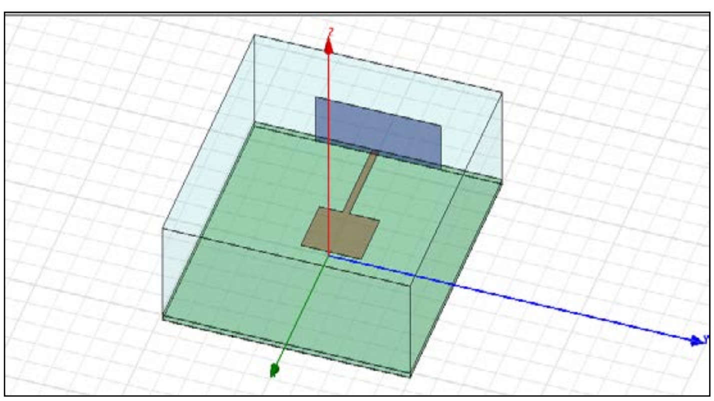

Figure6. Represent design of Microstrip Rectangular Patch antenna.

ISSN 2229-5518

5.1 Calculation of the width (W):

The width of the Microstrip patch antenna is given by equation (1) [1, 2]:

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

5.2 Calculation of Effective dielectric constant (Ɛeff):

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

5.3 Calculation of the Effective length (Leff):

$$L_{eff} = c/2f_0\sqrt{\xi_{reff}}$$

5.4 Calculation of the Length Extension (ΔL):

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

5.5 Calculation of the resonant length of patch (L):

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

Table 1: Dimensions of patch antenna

Resonating frequency fr	**6.5GHZ**
Patch Width W	24mm
Patch Length L	22mm
Branch line length qw	24.05mm
Substrate height H	1.50mm
Relative permittivity Ɛr	4.4
Feed line length	15mm
Feed line width	2.75mm

6. SOFTWARE TOOL

The software used to model and simulate the microstrip patch antenna is HFSS. HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields [6].

7. SIMULATION RESULTS

The Microstrip Rectangular patch antenna is simulated using Ansoft HFSS. The parameters evaluated were Return loss, VSWR, Radiation pattern, Directivity, Gain, 3D polar plot.

Figure7.1 Return loss for Rectangular patch antenna

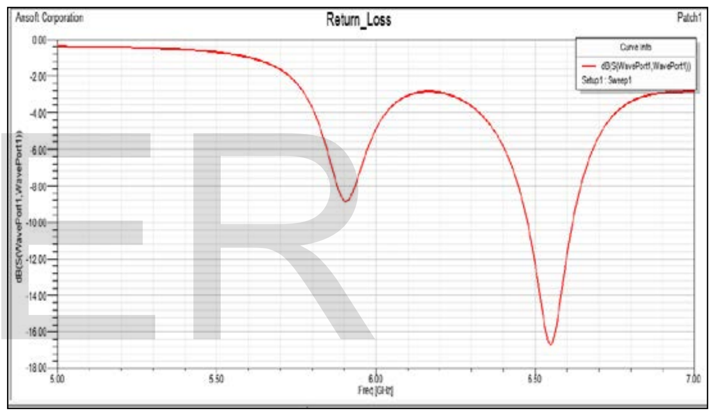

Figure7.2 VSWR for Rectangular patch antenna

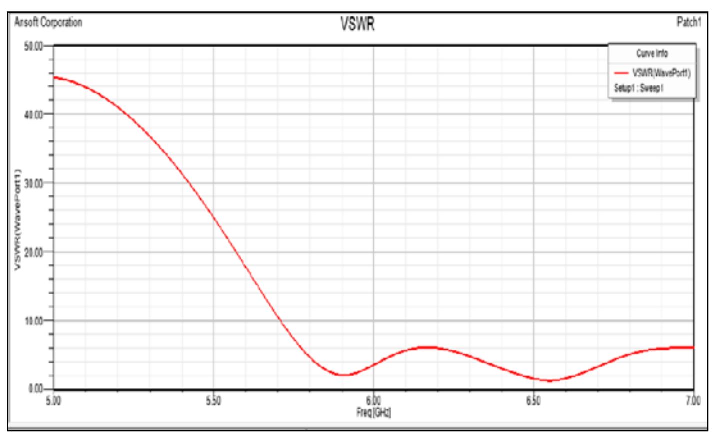

Figure7.3 Radiation Pattern for Rectangular patch antenna

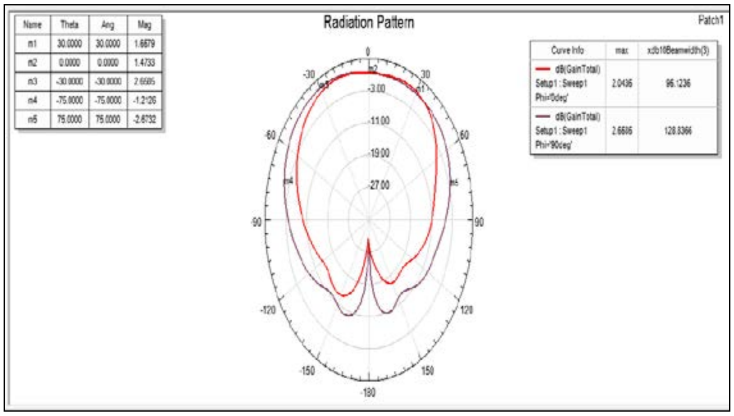

Figure7.4 Directivity for Rectangular patch antenna

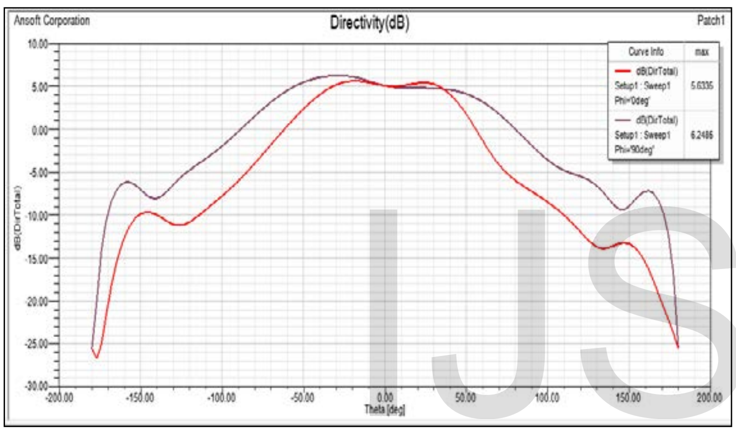

Figure7.5 Gain for Rectangular patch antenna

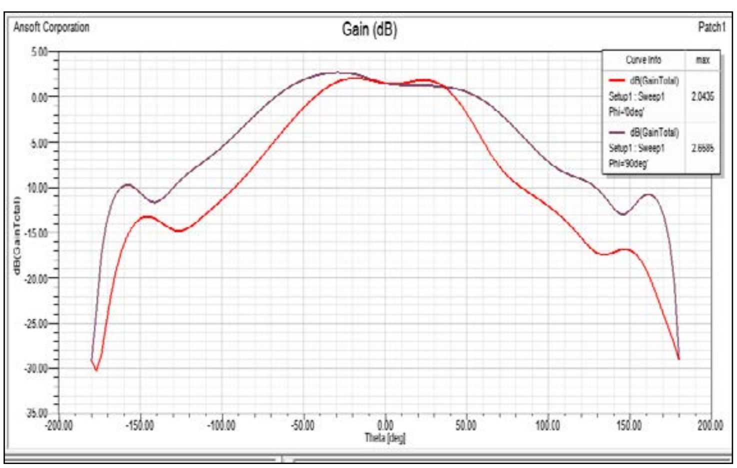

Figure7.6 3D polar plot for Rectangular patch antenna

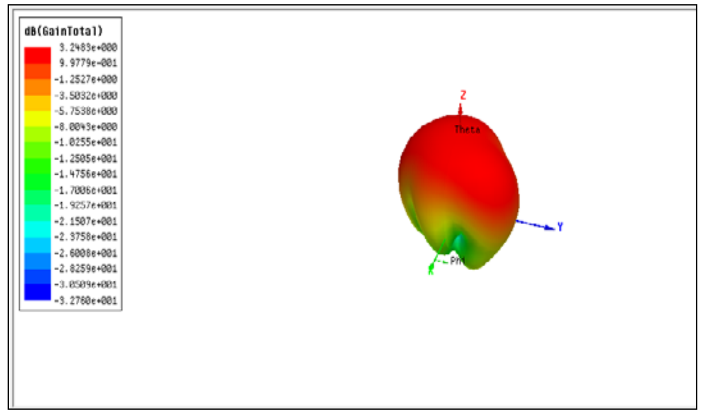

Table 2: The results of Microstrip rectangular patch antenna

Parameters	Rectangular patch
Resonant frequency	6.5GHz
Bandwidth	140MHz
Return loss(dB)	-16.70
VSWR	1.34
Gain(dB)	2.65
Directivity(dB)	6.24

8. Conclusion and Future Scope

Thus the design and simulation of Microstrip rectangular patch antenna was successfully designed and analyzed using Ansoft HFSS. The performance parameters were achieved with Return loss -16.70dB, gain 2.65 dB and bandwidth 140 MHz for rectangular patch antenna. The use of slotted patch reduces the size of antenna and higher bandwidth, which is the area that can be improved with the proposed design.

9. References

[1] J Constantine A. Balanis; Antenna Theory, Analysis and Design, John Wiley & Sons Inc. 2nd edition. 1997.
[2] Garg, R and Ittipiboon, A; "Micro strip Antenna Design Handbook", Artech House, 2001.
[3] D.M. Pozar, —Microstrip Antennas, Proc.IEEE, vol.80, No.1, January 1992.
[4] Neeraj Rao, Gain and Bandwidth Enhancement of a Microstrip Antenna using Partial substrate removal in multiple layer dielectric substrate, PIER proceedings, Suzhou, China, Sept.12-16, 2011.
[5] Isha Puri, Bandwidth and Gain increment of microstrip patch Antenna with Shifted elliptical", IJRST, vol.3No.7, July, 2011.
[6] www.AnsoftHFSS.com
[7] Wood.C, Improved Bandwidth of Microstrip Antenna using parasitic elements, IEEE vol.127, Issue4, 11Nov, 2008, pp.-231-234