Design a H shaped Patch Antenna For Wireless Communication

Sushila Gupta
E.C.E, S.R.M.S.C.E.T. Bareilly, India
E-mail: sushila.gupta784@gmail.com

Abstract – The idea used in this paper inculcates the use of H Shaped patch structure the idea of using a probe feed technique for the frequency 3.42GHz which falls in WiMAX. This paper is dedicated to simulate a H shaped rectangular patch antenna by using the software Agilent MOM based ADS 2011.10 tool. The effects of slot width, rectangular patch height, and substrate dielectric constant have been evaluated like return loss, VSWR, gain along φ, θ directions, radiation pattern in 2-D and 3-D, axial ratio, E and H Field Distributions. The compact aperture area of the antenna is 28 X 34.67 mm².

Index Terms— Agilent ADS, Gain, Microstrip antenna, Probe Feed, RT Rogers Duroid 5880.

I. INTRODUCTION

With the recent wide and rapid development of wireless communications there is a great demand in the design of low-profile antennas for mobile terminals. There are many bands for WLAN antennas which are studied and published so far. The assigned bands according to IEEE 802.11 b/a/g are 2.4 GHz (2.4–2.484 GHz) and 5.2/5.8 GHz (5.15–5.35 GHz/5.725–5.825 GHz). The bands assigned for WiMAX (Worldwide Interoperability Microwave Access) based on IEEE 802.16 are 2.5/3.5/5.5 GHz (2500–2690/3400–3690/5250–5850 MHz).

The rapid increase in communication standards has led to great demand for antennas with low real estate, low profile and size, low cost of fabrication and ease of integration with feeding network. Microstrip patch antennas are widely used because they are of light weight, compact, easy to integrate and cost effective. However, the serious problem of patch antennas is their narrow bandwidth due to surface wave losses and large size of patch for better performance.

A microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side.

- Patch: present the radiant conductive element and which can take several forms.
- Substrate: allows to isolate both conductive planes, characterized by the permittivity.
- Ground plane: conductor situated below the circuit on which is placed the substrate.

Figure 1: Microstrip antenna configuration

II. METHODOLOGY ADAPTED

Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation.

The preferred 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). The transmission
line model is the simplest of all and it gives good physical insight.

A. Method of Analysis

Transmission line 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 nonhomogeneous line of two dielectrics, typically the substrate and air.

In Figure 2, most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse electric-magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant \( (\varepsilon_{\text{reff}}) \) must be obtained in order to account for the fringing and the wave propagation in the line.

![Figure 2: Electric Field Lines](image1)

The value of \( (\varepsilon_{\text{reff}}) \) is slightly less than \( \varepsilon_r \) because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure 2 above.

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

(1)

Where,

- \( \varepsilon_{\text{reff}} \) = Effective dielectric constant
- \( \varepsilon_r \) = Dielectric constant of substrate
- \( h \) = Height of dielectric substrate
- \( W \) = Width of the patch

Consider Figure 3 below, which shows a rectangular microstrip patch antenna of length L, width W resting on a substrate of height h. The co-ordinate axis is selected such that the length is along the x direction, width is along the y direction and the height is along the z direction.

In order to operate in the fundamental TM\(_{10}\) mode, the length of the patch must be slightly less than \( \lambda/2 \) where \( \lambda \) is the wavelength in the dielectric medium and is equal to \( \lambda_0/\sqrt{\varepsilon_{\text{reff}}} \) where \( \lambda_0 \) is the free space wavelength. The TM\(_{10}\) mode implies that the field varies one \( \lambda/2 \) cycle along the length, and there is no variation along the width of the patch. In the Figure 4 shown below, the microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends. Along the width of the patch, the voltage is maximum and current is minimum due to the open ends. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.

![Figure 3: Microstrip Patch Antenna](image2)

It is seen from Figure 5 that the normal components of the electric field at the two edges along the width are in opposite directions and thus out of phase since the patch is \( \lambda/2 \) long and hence they cancel each other in the broadside direction. The tangential components (seen in Figure 5), which are in phase, means that the resulting fields combine to give maximum radiated field normal to the surface of the structure. Hence the edges along the width can be represented as two radiating slots, which are \( \lambda/2 \) apart and excited in phase and radiating in the half space above the ground plane. The fringing fields along the width can be modeled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length have now been extended on each end by a distance \( \Delta L \).
For efficient radiation, the width $W$ is

$$W = \frac{c}{2\pi f_0 \sqrt{\varepsilon_{\text{eff}}}}$$

(5)

**B. Feed Point**

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 6, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The feed co-ordinates were calculated $Y_f = W/2$ and $X_f = X_0 - \Delta L$

Where,

$$X_0 = \frac{L}{\pi} \cos^{-1} \sqrt{\frac{50}{Z_0}}$$

(6)

$$Z_0 = \sqrt{50 \times Z_m}$$

(7)

For a given resonance frequency $f_0$, the effective length is

$$f_0 = \frac{c}{\sqrt{\varepsilon_{\text{eff}}}} \left[ \left( \frac{m}{L} \right)^2 + \left( \frac{n}{W} \right)^2 \right]^{1/2}$$

(4)

Where $m$ and $n$ are modes along $L$ and $W$ respectively.
C. **Dielectric Substrate**

Considering the trade-off between the antenna dimensions and its performance, it was found suitable to select a thin dielectric substrate with low dielectric constant. Thin substrate permits to reduce the size and spurious radiation as surface wave and low dielectric constant – for higher bandwidth, better efficiency and low power loss.

### III. **ANTENNA DESIGN**

#### A. **H Slot Rectangular Patch Antenna**

In this paper, the H shaped slot is cut in microstrip patch for wide band width. H-shaped slots easily formed by cutting two slots from a rectangular patch. By cutting the slots from a patch, gain and bandwidth of microstrip antenna can be enhanced by using substrate RT Rogers Duroid 5880 of thickness 1.75 mm and the conductor is copper.

![Figure 7: Layout of H slot Patch Antenna](image)

![Figure 8: 3D view of H slot Patch Antenna](image)

The figure shows the layout and 3D view L-shaped patch antenna with appropriate length and width.

### IV. **RESULTS AND DISCUSSION**

For the Simulation of proposed antenna Agilent ADS software have been used. In this simulation we have tried to obtain optimized performance of various antenna parameters such as return loss, gain, radiation pattern, directivity etc. With the help of Agilent ADS software we can also calculate the bandwidth percentage. With the proposed antenna we have achieved a very appreciable percentage of bandwidth which could be useful for the wireless communication.

![Figure 9: Radiation intensity of the patch with time instants](image)

(a)

(b)

Figure 9: Radiation intensity of the patch with time instants
From the figure radiation intensity of slotted patch antenna at different time instants can be observed.

Figure 10: $S_{11}$ of Patch Antenna

From the plot it can be observed that return loss at frequency 3.4GHz is -0.21.

Figure 11: Smith chart of slotted Patch Antenna

The figure shows the smith chart of slotted patch antenna.

Fig. 12: Polar plots of Gain, Efficiency and effective area

The polar plot shows the directivity (7.50605 dBi), efficiency (67.194 %), gain (5.6848 dBi) and power radiated (.000415364 watts) of antenna.

Figure 13: Polarization of Patch Antenna

The polar plot represent the liner and circular polarization with axial ratio occurred by coaxial feed point.

Figure 14: E- $\theta$ Plot

The figure shows the radiation pattern of slotted patch antenna in terms of $E_0$

<table>
<thead>
<tr>
<th>S no.</th>
<th>Parameter</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Power radiated (Watts)</td>
<td>0.000415364</td>
</tr>
<tr>
<td>2.</td>
<td>Directivity(dBi)</td>
<td>7.50605</td>
</tr>
<tr>
<td>3.</td>
<td>Gain(dBi)</td>
<td>5.6848</td>
</tr>
<tr>
<td>4.</td>
<td>Maximum intensity (Watts/Steradian)</td>
<td>0.000186133</td>
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<tr>
<td>5.</td>
<td>Efficiency (%)</td>
<td>67.194</td>
</tr>
</tbody>
</table>

TABLE 1

Figure15: Parameter obtained
The table represents the various parameter of antenna.

V. CONCLUSION

In this paper, the H-slot microstrip patch antennas are designed. The parameters, gain, efficiency, power radiated, axial ratio are shown. The probe feed technique and Agilent ADS are used for simulation.

The gain and efficiency are good for these bands. The antenna is designed to be used in WiMax and WLAN.

To get this result we used the RT Rogers Duroid 5880 as the substrate. Smith Chart of the design shows the matching of the antenna at the resonant frequency. The co-polarization and cross polarization patterns are well separated and gain obtained is 5.6848dBi.

The simple design presented here can be easily implemented for coax-feed microstrip antennas to radiate in a good dual band mode. In order to increase this bandwidth for a higher extent with overall performance of the proposed antenna by varying the type of substrate its thickness, length and width of the slot the same can also be achieved.

VI. REFERENCES


