Dual U-Slot Microstrip Patch Antenna with Enhanced Bandwidth

Sapna Panwar[1], Bhagwan Swaroop Sharma[2]

[1]RKDF Institute of Science & Technology, Bhopal, Madhya Pradesh, India
[2]Deptt. of Electronics & Communication, RKDF Institute of Science & Technology, Bhopal, Madhya Pradesh, India

Abstract: ***A small H-shaped microstrip patch antenna (MPA) with enhanced bandwidth is presented. The H-shaped antenna is first studied and then fully simulated by HFSS. A dual U slot H patch configuration is proposed to increase the narrow bandwidth, radiation efficiency and directivity. A novel H-shaped patch antenna suitable for wireless and satellite communications is presented. This paper presents the dual U slot H-shaped microstrip patch antenna feed by transmission line. The decrease in the prices of handheld devices and services has made available on the move internet and web services facility to the customers, small antennas requirement are increasing. In this paper H-shaped patch antenna is designed using FR4 substrate. The proposed modified H shaped antenna is designed and simulated using HFSS and caters to various wireless applications such as WiMAX, Wi-Fi, UMTS and Digital Multimedia Broadcasting (DMB) e.g. T V, etc.***

Keywords: MPA, Wimax, DMB, HFSS.

1. Introduction

A simple microstrip patch 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 as shown in figure 1[1]. Due to some of their key advantages microstrip antennas are in general preferred over conventional wire and metallic antennas, for many applications such as Global Positioning System (GPS), Direct Broadcasting Satellite (DBS) Systems, mobile communications, WiMAX, Bluetooth, Zigbee, etc. Their advantages include low profile, light weight, low cost, robustness, ease of fabrication using printed-circuit technology, integration with RF devices and conformal to mounting structures etc. However simple microstrip patch antennas often suffer low gain, bandwidth and low power-handling capability. For wireless communication system, antenna is one of the most critical components. A good design of the antenna can relax system requirements and improve overall system performance. With the available modern day services such as on the move internet browsing, e-banking, digital cable TV, etc and small handheld devices it is often require that the antenna to be achieve low profile good gain and wideband/multi-band characteristics. A number of approaches have been reported to obtain compact dual band microstrip antenna such as loading of rectangular, circular and triangular patches by shorting pins, crossed slot and the use of a rectangular ring. One of the other techniques to achieve multi-band operations is to use fractal structures.

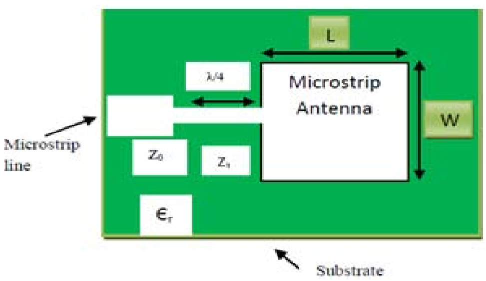

Figure 1: Structure of simple edge feed microstrip patch antenna

This paper work presents the design and analysis of H-shaped microstrip patch antenna. The designed H-shaped antennas have dual/triple band operations and provide better gain as compared to simple rectangular shaped patch antennas of same dimensions.

2. Geometry of Microstrip Patch Antenna

In an H-shaped patch antenna designing, a simple rectangular microstrip patch antenna (RMSA) is considered having different kind of feeding techniques. In the current design we have considered to use edge feeding technique as it is advantageous in small size applications [2]. The feeding is designed over the patch substrate itself.

In this design we have used an FR-4 substrate with dielectric constant (ε_r) of 4.4 & tan δ of 0.09. The substrate height is considered 62 mil. The calculation for dimension of patch is calculated according to the below mentioned formula:

Width of the patch is calculated by given equation:

$$W = \frac{C}{2fo}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where c= 3x108 m/sec
f= Solution frequency
ε_r = Dielectric constant

Length of the patch is calculated by following equation:

$$L = \frac{C}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta \qquad (2)$$

Where ε_{eff} = Effective dielectric const.
Δ = Length Extension.

Length of the ground is calculated by given equation:

$$Lg = 6h + L \qquad (3)$$

Where L= Length of Patch
h= Height of Substrate

Width of the ground is calculated by given equation:

$$Wg = 6h + W \qquad (4)$$

Where W= Width of Patch
h= Height of Substrate

Table 1: Patch Dimensions

Dielectric Substrate (FR4)	$\varepsilon_r = 4.4$; tan $\delta = 0.09$
Substrate height (h)	62 mil
$W = \frac{C}{2fo}\sqrt{\frac{2}{\varepsilon_r + 1}}$	37.26mm
$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}$	4.08
$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left[\frac{W}{h} + 0.264\right]}{(\varepsilon_{reff} + 0.258)\left[\frac{W}{h} + 0.8\right]}$	0.738mm
$L_{eff} = \frac{C}{2 f_o \sqrt{\varepsilon_{eff}}}$	28.83mm
$L = \frac{C}{2 f_o \sqrt{\varepsilon_{eff}}} - 2\Delta$	27.35mm

The table 1 above shows the mathematical calculation results to determine the dimensions. The results are for resonant frequency of 2.45 GHz. Hence the patch dimensions can be calculated and the rectangular microstrip antenna is designed with W=37mm and L=27.3 mm.

As we see electrically, the patch is a combination of R, L and C components arranged in series/Parallel combination [3]. Now, define two notches in the patch to increase the total surface area of the patch. The notches result in variation in the current distribution of microstrip patch, as a cut along the non-radiating edge, the notches added hence increases the resistance & capacitance of the layout. This happens due to increase in the length of the current path in the antenna which in result adds an extra capacitance & extra resistance in the circuit.

Now by taking up this theory, we had decided to increase the surface area of the patch by giving extra slots on the top of the patch which increases the gain and bandwidth of the patch antenna.

3. Design Parameters

Fig 2 and Fig 3 show the top view of the H-shape patch antenna designed on HFSS (High frequency Structure Simulator) software.

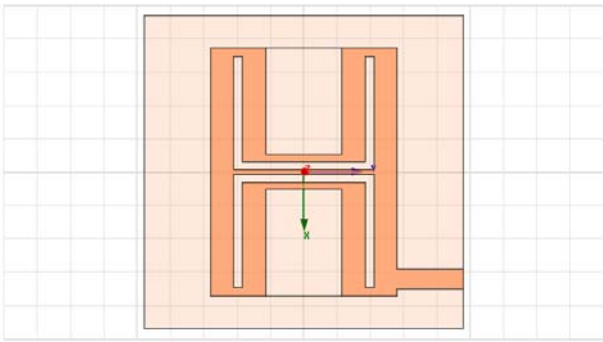

Figure 2: Top view of dual U slot H-shaped patch antenna

Edge feed is used in the design to feed the antenna. The feed location is calculated for 50Ω match and a little hit & trial is done. In an edge feed, the matching is basically achieved at the lower end of the patch [4].

Two U-shaped notches are cut in the H-Patch. The dimensions are shown in the figure below:

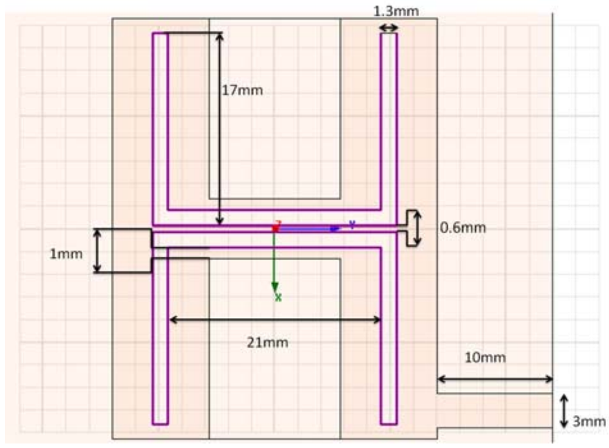

Figure 3: Dimensions of dual U slot H-shaped patch antenna

4. Simulation Results

Place The H-shaped patch antenna with double U slot in to it was achieved. The slots cause the increase in inductance on the current path of the signal. This should increase the bandwidth of the antenna as well as gain.

The figure below shows the return loss & Bandwidth of the patch antenna.

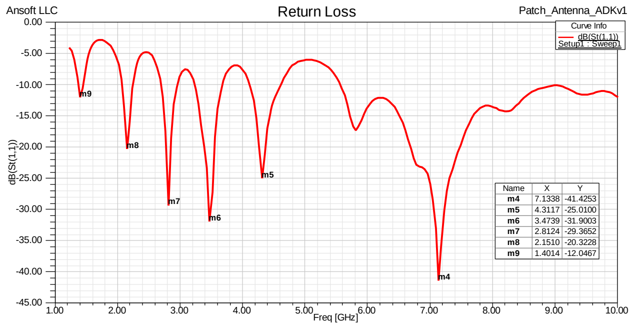

Figure 4: Return Loss

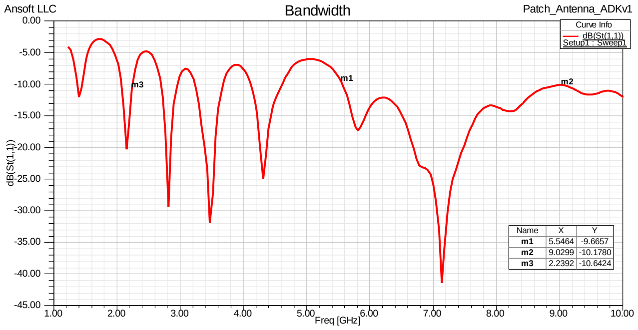

Figure 5: Bandwidth

As in the figure we can see that the return loss is -42dB. For bandwidth maximum bandwidth is achieved between frequency 5.5GHz & 9GHz. The formula for bandwidth is calculated as follows:

BW= f (high) – f (low)
= m2 – m1
= 9.0GHz – 5.5 GHz = 3.5 GHz

The Figure 6 & 7 below shows total gain of the antenna achieved at solution frequency.

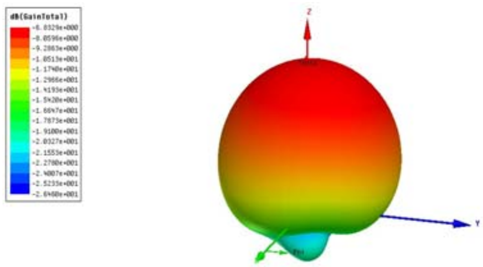

Figure 6: Total Gain (3D Polar plot)

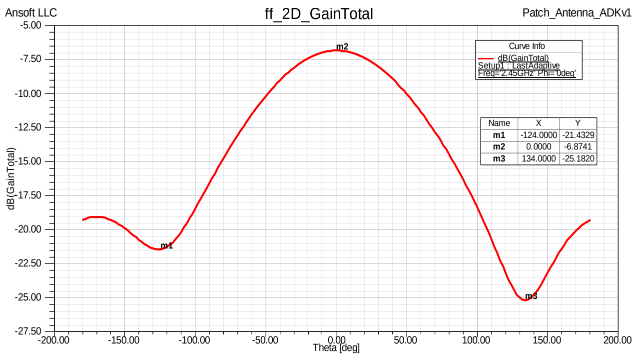

Figure 7: Total Gain (2D, Rectangular Plot)

5. Conclusion

In this paper, design and analysis of Dual U slot H-shaped patch antenna is presented. The results shown here is done by HFSS simulation. The designed antenna achieves bandwidth of 3.5 GHz and giving us high return loss, directivity and gain is also simulated by High Frequency Structure Simulator. The result also simulated that the antenna can be used for wide range of frequency. A gain of -25dB is achieved.

Thus the designed antenna can be used for various applications such as WIMAX, Wi-Fi, Digital broadcasting, geological & metrological signal, Radar navigation etc. The future works on enhancing the bandwidth can be done by increasing the surface area of the patch, but attention should be given to manage the gain as well.

References

[1] Indrasen Singh et al, Int. J. Comp. Tech. Appl., Vol 2 (5), 1595-1599, “Micro strip Patch Antenna and its Applications: a Survey” Page no-1.
[2] Constantine A. Balanis, "Antenna Theory - Analysis and Design", 2nd edition, John Wiley & Sons Inc., 1997.
[3] Rahul Batra, P.L.Zade & Dipika Sagne, "Design and analysis of modified H-shape antenna for wireless communication”, 3rd IEEE, IACC, 2013.
[4] “Broadband patch antenna with ring slot coupling” by Y. Qin, S. Gao, A. Sambell, E. Korolkiewicz and M. Elsdon ELECTRONICS LETTERS 8th January 2004 Vol. 40 No. 1
[5] J. A. Ansari, Satya Kesh Dubey, Prabhakar Singh, R. U. Khan, and Babau R. Vishvakarma, "Analysis of compact H-shaped microstrip antenna", Microwave and Optical Technology Letters / Vol. 50, No. 7, July 2008.

Author Profile

Asst. Prof. Bhagwan Swaroop Sharma is an M. Tech in Spatial Information Technology from school of Electronics DAVV Indore. He completed his M. Tech in 2011. He did his BE in Electronics & Comm. Engineering from PCST, RGPV in 2009. Since then he has been working with RKDF-IST, Bhopal as Asst. Prof. in Electronics & communication department.

Sapna Panwar is a B. Tech graduate in Electronics & Communication from SIET, Gr. Noida in 2009. She is now pursuing her M. Tech with RKDF-IST, Bhopal in Microwave & Millimeter Dept.