RESEARCH ARTICLE OPEN

Microstrip Patch Antenna: Analysis of Surface Area for Bandwidth Improvement

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Abstract
A rectangular Microstrip patch antenna with edge feeding technique is presented in this paper. The H-shape patch antenna has wide bandwidth and high Gain. The surface area plays a major role in bandwidth of any antenna. This paper describes the comparison of the increase in the bandwidth with the increase in the surface area of the patch. 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.

I. Introduction

A simple Microstrip patch antenna consists of a metal strip on a dielectric substrate covered by a ground plane on the other side as shown in figure 1[1].

Microstrip antennas are planar resonant cavities that leak from their edges and radiate. We can utilize printed circuit techniques to etch the antennas on soft substrates to produce low-cost and repeatable antennas in a low profile. As electronic devices continue to shrink in size, the antenna design is pushed to reduce the antenna size as well. Bandwidths widen with increased circuit losses (material losses) or by efficient use of the restricted volume. Decreasing the volume increases the Q (Quality Factor) value of each mode and a sum, weighted by the energy in each mode, determines the overall Q value. Thicker substrates develop greater bandwidths, but they increase the possibility of higher-order mode excitation and surface-wave losses. The dielectric substrate retains most of the power because the shielding ground plane is spaced a few substrate thicknesses away. Removing the shield in antenna applications allows radiation from resonant cavities. We also discover feeding circuits etched on the substrate radiate to some extent, but their radiation is comparatively small.

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. A number of approaches have been reported to obtain compact multiple 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.

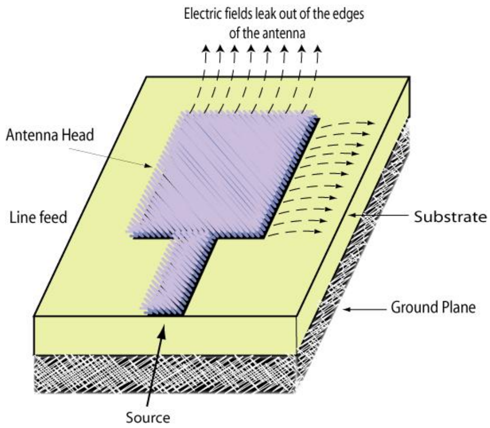

Figure 1: Structure of simple edge feed microstrip patch antenna

This paper work presents the analysis of rectangular Microstrip patch antenna with varying surface areas. 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.

II. Antenna Design Parameters

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 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.

Table 1: Patch Dimensions

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

The rectangular Microstrip patch antenna has radiating edges. To increase the radiating area, we can provide the slots at the patch. We did the same exercise on the patch and reached to a conclusion to analyze the effect of surface area on the Gain & Bandwidth of Antenna.

To start with, simple rectangular patch antenna with the above mentioned size was taken. The antenna is designed with edge feeding technique. HFSS is used for simulation of the design. Then the feed location of edge feed probe for 50Ω is calculated. With the same patch, we designed normal H-shaped antenna, H-shaped skeleton antenna and finally Dual U-slot H-shaped Microstrip patch antenna. The simulated results are taken and compared.

III. Simulation Results

The Rectangular patch antenna designed, is simulated.

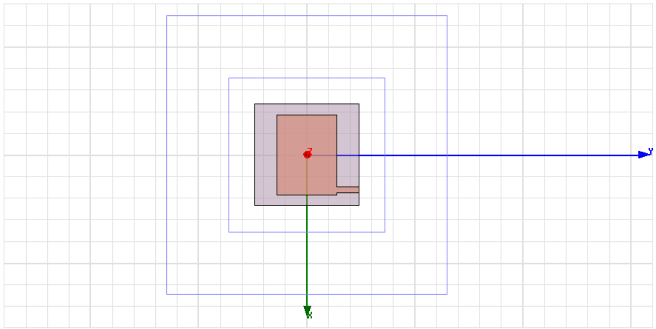

Figure 2: Top view of Rectangular patch antenna

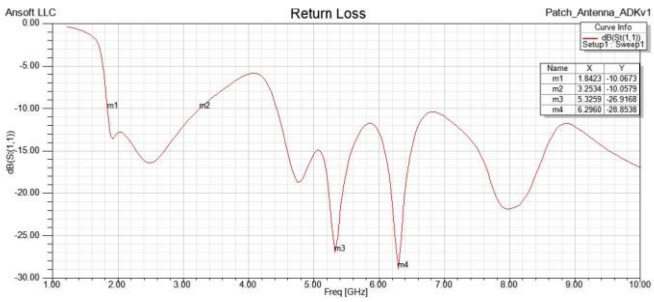

Figure 3: Return Loss & Bandwidth

The simulated result gives a bandwidth of 1.4 GHz. 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. The H-patch is also split by a H-skeleton on the patch. The simulated result is shown below.

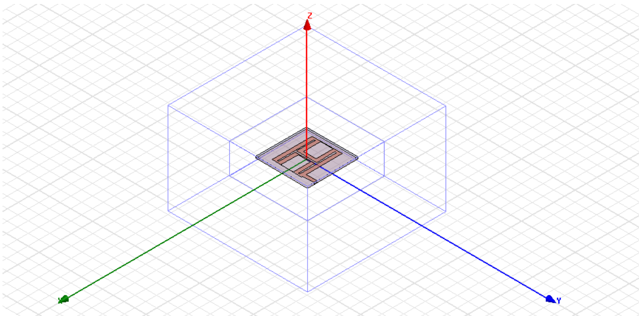

Figure 4: Top view of dual H-shaped patch antenna with H-shaped skeleton

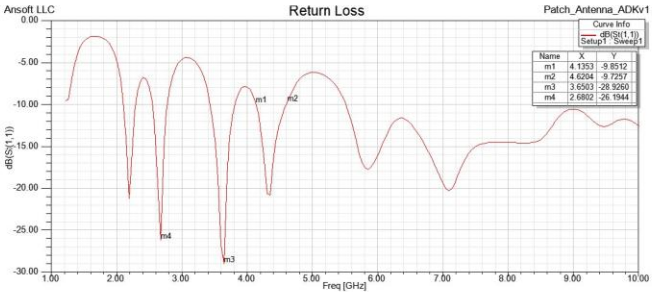

Figure 5: Return Loss and Bandwidth

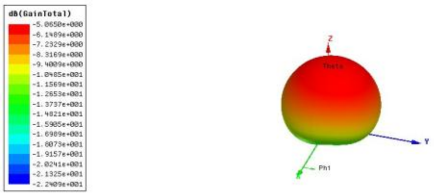

Figure 6: 3D Gain

The result shows a bandwidth of 3.4GHz and gain of -5dB.

To improve further we replaced the H-skeleton [3] from Dual U-slot. The simulation result is shown below.

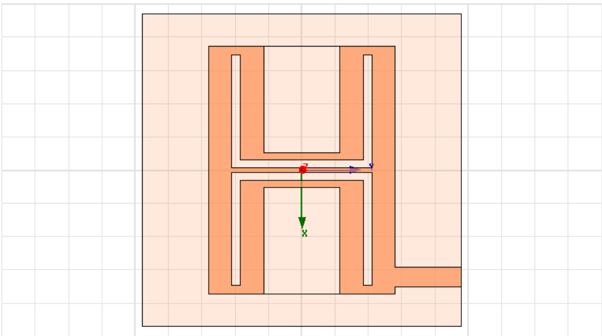

Figure 7: Top view of dual U slot H-shaped patch antenna

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:

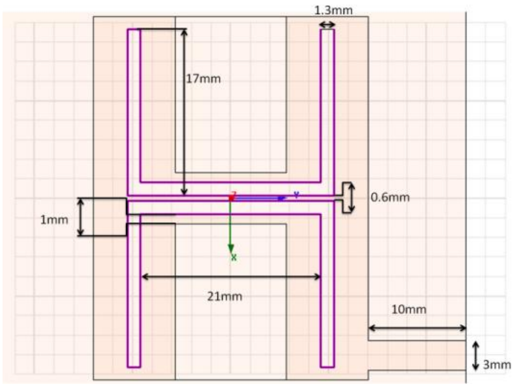

Figure 8: Dimensions of dual U slot H-shaped patch antenna

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.

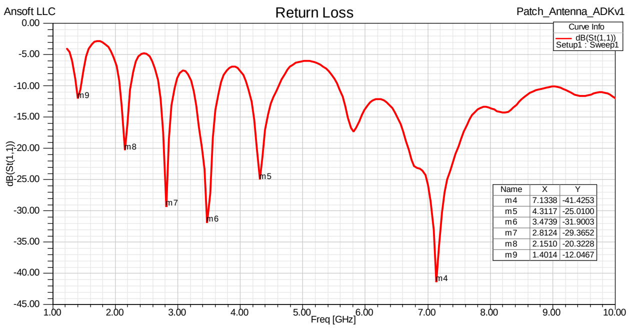

Figure 9: Return Loss

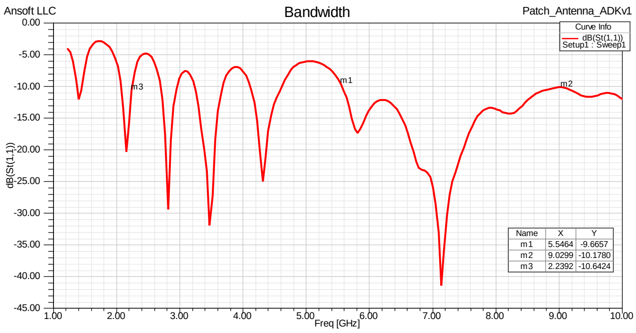

Figure 10: Bandwidth

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.

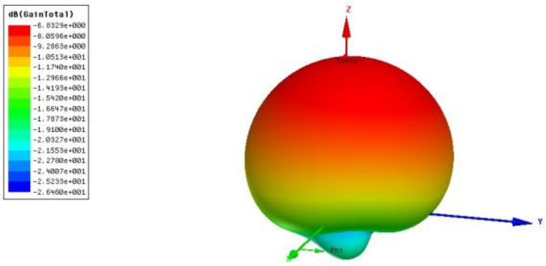

Figure 11: Total Gain (3D Polar plot)

IV. Conclusion

In this paper, design and analysis of surface area was studied. The rectangular patch antenna is presented with H-shape and several slits and slots to increase the surface area. 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. The result also simulated that the antenna can be used for wide range of frequency. It was simulated that with the increase in the surface area, the Bandwidth of the same patch increased from 1 GHz to 3.5GHz and Gain increased from -1dB to -6.5dB.

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.

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