International Journal of Wireless Networks and Communications.
ISSN 0975-6507 Volume 8, Number 1 (2016), pp. 7-14

http://www.irphouse.com

Design And Analysis Of Compact U Slot Microstrip Patch Antenna For Wireless Applications

Hrucha R. Kharat, Madhuri D. Khetmalis, Shruti H. Pimpalgaonkar and Prof. Rameez Shamalik

Dept. of E&TC, BVCOEW, Pune, India

Abstract

In this paper, the slot antenna concept has been used in patch antenna designed to reduce antenna size. There is a reduction of resonance frequency from 2. 44GHz to 2. 10GHz i. e. around 15 % with the proposed antenna compared to the square patch of the same size. The antenna operating frequency range is 2. 41GHz -2. 47GHz with VSWR less than 2. It exhibits remarkable gain which corresponds to the gain of 5. 32dB. It has wireless applications which require more bandwidth such as for covering wireless applications of WLAN. The radiation pattern, beamwidth, directivity, return loss, VSWR and Bandwidth of the proposed antenna are described and simulated using HFSS software package.

Index Terms: Rectangular micro strip, U -slot, WLAN

INTRODUCTION

Recently, in high performance applications where size, weight, cost, ease of installation are constrains. Namely an application such as aircraft, spacecraft, and satellite and missile applications requires low profile antennas. As U slot micro strip antenna is best for its wideband characteristics.

Such antennas are operating at a higher order TM02 mode for stationary terminals of various indoor wireless communication networks [1]. Because of advantages of micro strip antenna, such as low cost, simple configuration, ease of fabrication, mechanically rugged and compatibility with integrated circuits, so that now -a -days micro strip patch antenna becomes the contender for antenna designer [2].

From the military interest research areas most of the groundbreaking technologies have emerged. Military environments are mostly hostile where the general antenna may show fatigue [3]. In many wireless communication applications such as telemetry and communications, aviation, naval communications, automatic guidance of intelligent weaponry, radar, GPS systems, micro strip antennas are used because of its advantages and also make them popular. This structure of an antenna is simple to manufacture and versatile in nature and also it is proposed to perform functions which include circular polarization as well as dual and triple band operations with wide and small frequency ratios. The primary advantage of this approach is the case of fabrication as the design does not require alignment between multiple layers of metal and dielectrics. The antenna has enough freedom to control the dual design frequencies. It covers the applications such as WCDMA 3G [4].

It is derive that the resonant frequency is inversely proportional to the slot length and feed point and at the same time as it increases with increasing the coaxial probe feed radius and slot width [5]. In recent years, some papers were reported for Dual/triple band operation by using single/double U slot in the microstrip antenna. It is seen that the applications which require dual frequency operation with small frequency ratio were designed by using the U slot in a wideband micro strip antenna [6].

Micro strip antennas are suffer from low impedance bandwidth characteristics to increase wideband applications. To avoid this suffering of antennas, there have been various bandwidth enhancement techniques like coplanar parasitic patches, stacked patches, or novel shapes patches such as the U and H -shaped patches. Here in this design one method is used, called as special feed networks or feeding techniques, to compensate for the natural impedance variation of the patch. To avoid the use of coplanar or stacked parasitic patches we can do the etching process on the patch with U -slot, which increases either the lateral size or the thickness of the antenna. So, sometimes with enhancing the impedance bandwidth, changing the current distribution on the micro strip patch more than one resonant frequency is obtained. In 1995, two scientists named as Huynh and Lee was presented a broad band single layer probe fed patch antenna with a U -shaped slot on the surface of the rectangular patch [7].

In this paper, we design a rectangular micro -strip patch antenna in which U shaped slots are cut in micro -strip patch to enhance its bandwidth and frequency response.

MICRO STRIP ANTENNA DESIGN

Micro strip antenna in rectangular shape is the easiest geometry for designing and implementation. The basic U -slot loaded rectangular micro strip patch antenna design is seen in below Figure. 1. Here, L is the patch length, W is the patch width, F is the feed point, Ls is the vertical slot length, Ws is the horizontal slot length, tL and tW are slot widths in the vertical and horizontal, respectively.

A simple rectangular linear polarized micro strip

Patch antenna is designed to operate at 2. 47GHz. To develop a light weight antenna, FR4_epoxy is used as the substrate material as it is light in weight and also have good mechanical strength, which is having the thickness of 1. 6mm and permittivity εr =4. 4. The length and width of the patch are 39mm and 28. 2mm respectively. The feed point is 7. 5mm from the centre of the patch.

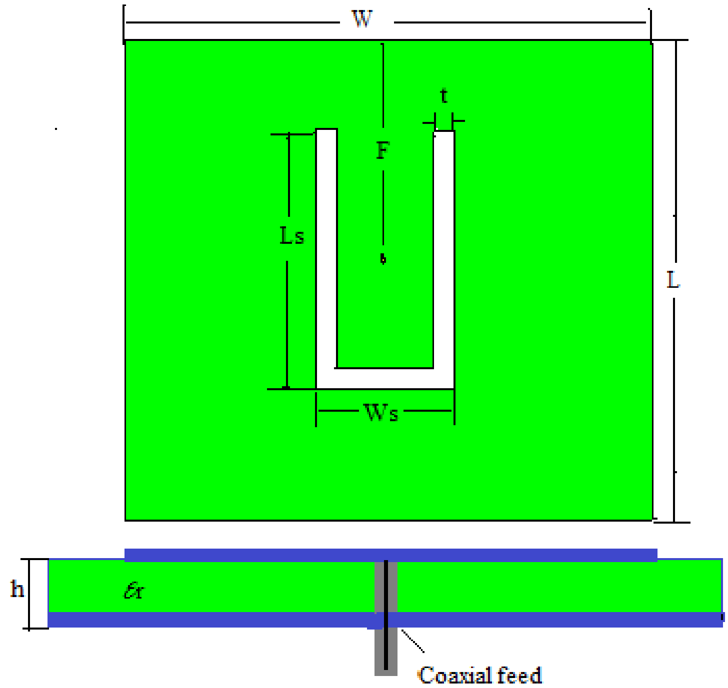

Figure 1: U -Slot loaded rectangular micro strip antenna

These properties make FR4_epoxy very attractive to be used as substrates for the fabrication of antennas in applications requiring light weight, low loss, reduced bill of materials, preserving the electromagnetic performance.

METHODOLOGY

The formulas for calculating the length, width and value of air gap are taken from [8]. The value of resonant frequency (Fr) is 2. 44 GHz and dielectric constant of the substrate (εr) is 4. 4 and Height of dielectric substrate (h) is 1. 6mm.
Next step is to calculate the other parameters like length and width of micro strip patch is given as follows:

Step 1:
Width of micro strip patch is given below:

$$w = \frac{c}{2fo\sqrt{\frac{\varepsilon_r + 1}{2}}} \tag{1}$$

Step 2:
Length of micro strip patch is given below:

$$\Delta L = (0.412 * h) \times \frac{(\varepsilon_{reff} + 0.3) \times \left(\frac{w}{h} + 0.264 \right)}{(\varepsilon_{reff} - 0.258) \times \left(\frac{w}{h} + 0.813 \right)} \quad (2)$$

Step 3:
The resonant frequency for any mode is given by:

$$fo = \frac{c}{2\sqrt{\varepsilon_{reff}}} \left[\left(\frac{m}{l} \right)^2 + \left(\frac{n}{m} \right)^2 \right]^{1/2} \quad (3)$$

RESULTS AND ANALYSIS
Simulation of this antenna has been carried out in HFSS. The simulation results are given in the following section:

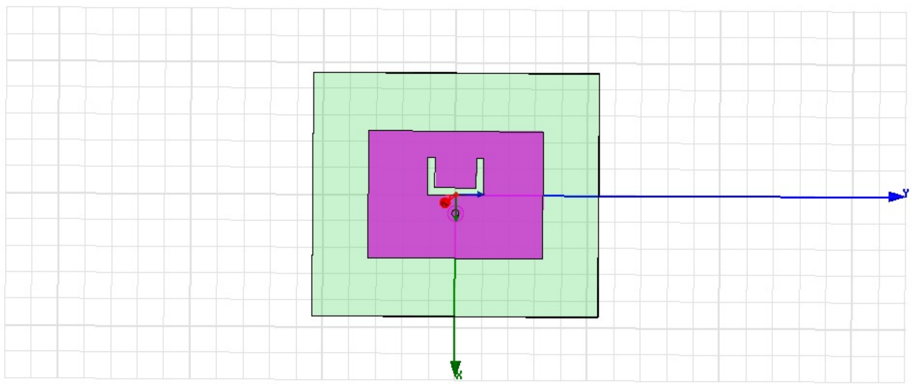

Figure2: U slot on patch

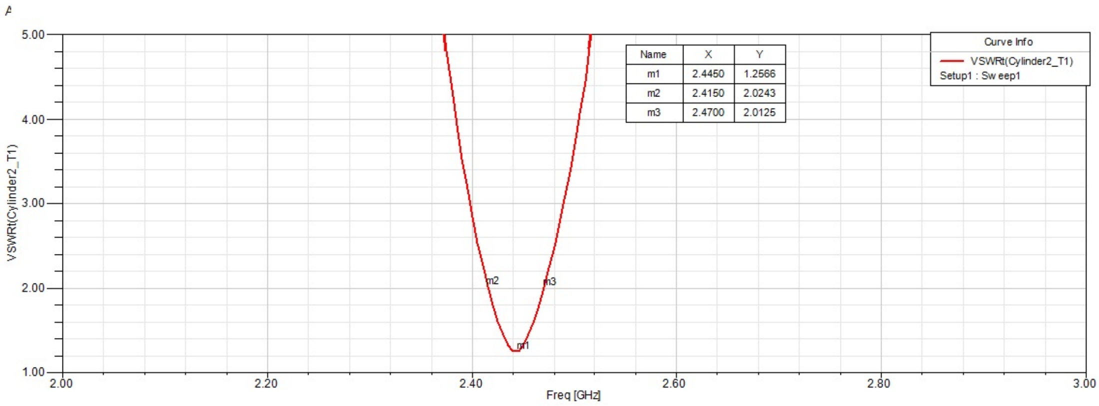

Figure3: VSWR

The Voltage Standing Wave Ratio or VSWR is defined as the relation between the maximum voltage and the minimum voltage all along the transmission line. Further definition of the VSWR can be derived from the level of forward and reflected waves, it is also a sign of how capably or intimately an antenna's terminal input impedance is matched to the characteristic impedance of the transmission line. Also, VSWR and mismatch between the transmission line and antenna are directly proportional to each other that are when there is an increase in VSWR indicates an increase in the mismatch between the transmission line and antenna. As shown in figure: 3 the value of VSWR is 1. 25.

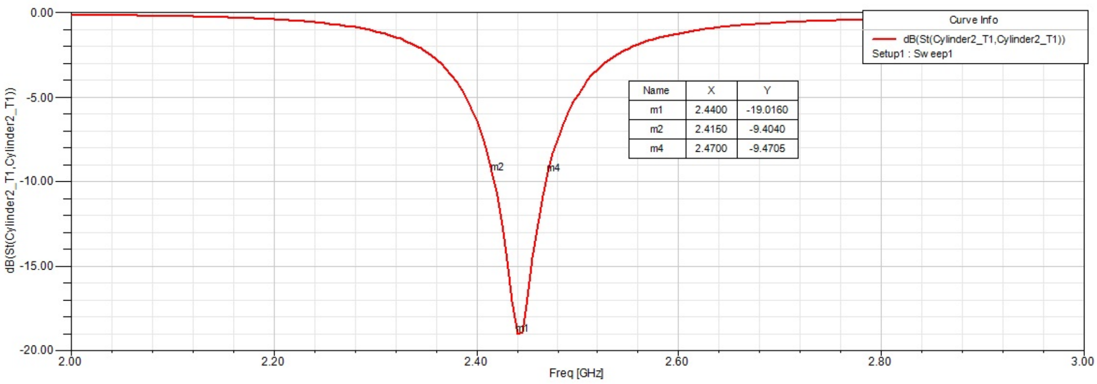

Figure4: Return loss

Return loss is used to indicate the amount of power that is lost to load, and the lost power does not return as reflection. Return loss is an aspect similar to VSWR to be a sign of how well the matching between transmitter and antenna has taken place. Ideal value of return loss is approximately -13dB which corresponds to VSWR of less than 2. As shown in figure: 4 the value of Return loss is -19. 01dB.

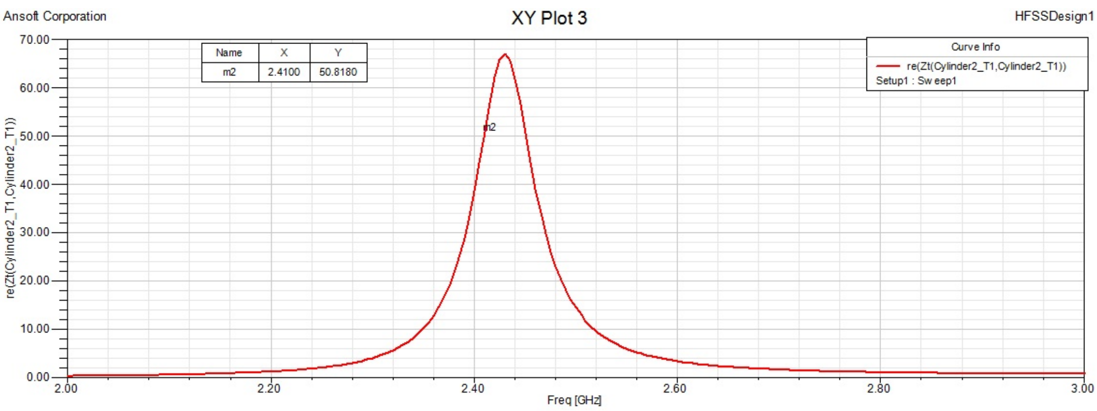

Figure5: Impedance

The VSWR provides an indication of how closely the impedance of an antenna matches the impedance of the connecting transmission line. a reflected wave will be created towards the energy source if an impedance mismatch exists,. This reflected wave responsible for reducing the level of forward energy transferred from the transmission line to the antenna. This effectively reduces the total level of energy available for radiation thus reducing the effective gain of the antenna. As shown in figure: 5 the value of Impedance is 50. 81.

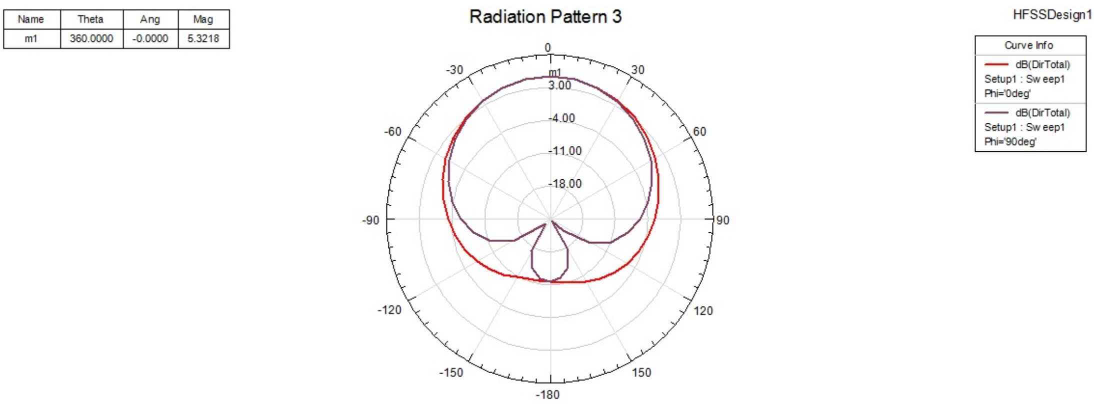

Figure 6: E & H Plane

In many cases, the protocol of an H -plane and E -plane pattern or sweep is used in the presentation of antenna pattern data. The H -plane is the plane that contains the antenna's radiated magnetic field potential while the E -plane is the plane that contains the antenna's radiated electric field potential. These planes are always orthogonal. These quantitative aspects generally include the 3 dB beam width (1/2 power level), directivity, side lobe level and front to back ratio. The 3 dB beam width of antenna is simply a measure of the angular width of the -3 dB points on the antenna pattern relative to the pattern maximum.

Figure7: Radiation Pattern

The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. As stated earlier, an antenna cannot radiate more total energy than is delivered to its input terminals. Antenna radiation patterns are typically presented in the form of a polar plot for a 360 degree angular pattern in one of two sweep planes. As shown in figure: 7 the value of Directivity is 5. 32dB.

ANALOGY

Type of Antenna	Freq (GHZ)	Return Loss (dB)	VSWR	Bandwidth (MHZ)	Directivity (dB)	Size (mm)
Without U -slot	2. 43	-16. 21	1. 38	68	5. 0	60*70mm
With U -Slot	2. 44	-19. 01	1. 25	51	5. 3	46*56mm

The work started with basic rectangle antenna with resonant frequency 2. 43GHz and bandwidth of 68MHZ, then the same antenna was converted to U -slot patch antenna which resulted into lower shift in frequency of operation at 2. 10GHz. This result shows an area reduction of antenna. The size of this slot antenna is lower than that of rectangular antenna. To improve the compact size of this antenna, modified U -slot technique is introduced. As seen from the table U -slot antenna with dimension of only 46mm*56mm.

CONCLUSION

In this paper, compact micro strip antenna with U -shaped slot is designed and has been simulated using HFSS software. The simulated results showed very good with ideal and practical values. The proposed antenna have some favorable characteristics such as; compact size, almost symmetrical radiation pattern, higher gain, satisfactory return loss and acceptable bandwidth in desired frequency. Analysis of this antenna has been carried out on the basis of type of antenna that is with u -slot and without u -slot. Overall simulated parameters of proposed antenna are suitable for the wireless communication.

REFERENCES

[1] P. Vetriselvi, Sathiyamoorthy Murugan Dr. V. Rajamani. International Journal of Innovative Research in Science, *Engineering and Technology. Volume* 3, Special Issue 3, March 2014

[2] C. A. Balanis, "Antenna Theory, Analysis and Design, " John Wiley & Sons, Inc, New York 1997.

[3] Rameez Shamalik, Sushama Shelke / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248 -9622, www. ijera. com Vol. 2, Issue 3, May -Jun 2012, pp. 2168 -2170.
[4] Koen W. A. van Dongen, Peter M. van den Berg, and Ioan. Nicolaescu, ``Subsurface imaging using measured near -field antenna Footprints'', Near Surface Geophysics, February 2004, Vol. 2, Number 1, Pp. 31 -37, ISSN: 1569 -4445.
[5] S. Murugan, E. Sathish kumar, and V. Rajamani, — Design and Analysis of Double U Slot Loaded Dual Frequency Microstrip Antenna Progress in Electromagnetic Research C, Vol. 45, 101 -112, 2013.
[6] A. Anssari and A. Mishra. —Half u -slot loaded semicircular disk patch Antenna for GSM Mobile phone and optical communications, Progress in Electromagnetic Research c, vol. 18, 31 -45, 2011.
[7] Lee, K. F., K. M. Luk, K. M. Mak, and S. L. S. Yang, —On the use of U Slots in the design of dual -and triple -band patch antennas, IEEE Antennas And Propagation Magazine, Vol. 53, No. 3, 60 -73, 2011.
[8] Yang, S. -L. S., A. A. Kishk, and K. -F. Lee, — Frequency reconfigurable U - slot micro strip patch antenna, IEEE Antennas and Wireless Propagation Letters, Vol. 7, 127 -129, 2008.