International Journal of Electronic and Electrical Engineering.
ISSN 0974-2174 Volume 6, Number 1 (2013), pp. 13-20

http://www.irphouse.com

Design of U Slot Wideband Antenna

Mr. Kadam Sudhir A.[*] and Prof. Desai K. R.[**]

[*]*department of Electronics,*
Bharati Vidyapeeth's College of Engineering
Morewadi, Kolhapur, Maharashtra, India.
[**]*department of Electronics,*
Bharati Vidyapeeth's College of Engineering
Morewadi, Kolhapur, Maharashtra, India.

Abstract

The U-slot patch antenna was originally developed as a single-layer, single-patch wideband antenna. It has recently been shown that it can also be designed to perform a number of other functions. In this paper, a comprehensive account is given on the development of this antenna. Emphasis is placed on experimental and simulation results for various U-slot topologies. U-slot Microstrip patch antennas were originally developed for bandwidth broadening applications.

Keywords:- Microstrip, multi frequency and U-slot antennas, circular polarization, wideband system.

1. INTRODUCTION

The basic geometry of the U-slot antenna is shown in Figure 1.This antenna was introduced in 1995 as a single layer, single patch linearly polarized wideband patch antenna. It was firmly established that the U-slot patch antenna can provide impedance bandwidths in excess of 30% for an air-substrate thickness of about 0.08 λo, and in excess of 20% for material substrates of similar thickness. There has recently been a renewed interest in this antenna. The recent studies showed that the U-slot patch antenna can be designed not only for wideband applications, but also for dual-band and triple-band applications, as well as for circular polarization operation.

The purpose of this article is to present a comprehensive account of this versatile antenna, with emphasis on the recent developments. In recent years, the demand for broad-band antennas has increased for use in high-frequency and high-speed data communication. Printed antennas are economical and easily hidden inside packages, making them well suited for consumer applications. Unfortunately, a "classical" Microstrip patch antenna has a very narrow frequency bandwidth that precludes its use in typical communication systems. However, if the frequency bandwidth could be widened, a broad-band Microstrip antenna would prove very useful in commercial applications such as 2.5 G and 3 G.

Wireless systems, wireless local area networks (WLAN), and Bluetooth persona. In this paper, we present a set of simple design procedures for the rectangular U-slot Microstrip patch antenna on microwave substrates. These procedures provide antenna engineers with approximate rules that result in a good first-pass design with prescribed characteristics that requires only minimal tuning. Additionally, the accompanying parametric studies give direction for the selection and variation of the proper geometric and material parameters to achieve desired antenna behavior.

2. A WIDEBAND LINEARLY POLARIZED ANTENNA

While the antenna is known to provide more than 30% impedance bandwidth when an air substrate thickness of about 0.08λo is used, less well known is that a thinner antenna will also provide sufficient bandwidth for several applications. For example, in Advanced Mobile Phone Service (AMPS), about 8.1% bandwidth is sufficient. Likewise, in Global System for Mobile Communications (GSM), only 8.7% bandwidth is needed. While such bandwidths cannot be realized by the traditional patch antenna, we shall show that it can be realized by the U-slot
patch antenna of only 0.03λo thick, which has 10.6% bandwidth.

3. BASIC CHARACTERISTICS: MATERIAL SUBSTRATE

Although the first investigations of the U-slot patch antenna used an air or foam substrate, subsequent investigations have confirmed that this wideband design can also be implemented with material substrates. As expected, the bandwidth of an antenna on a material substrate is smaller than an antenna on an air or foam substrate. Tong et al presented both experimental and FDTD analysis of two antennas on a substrate with relative permittivity εr= 2.33.

4. WIDEBAND DESIGNS

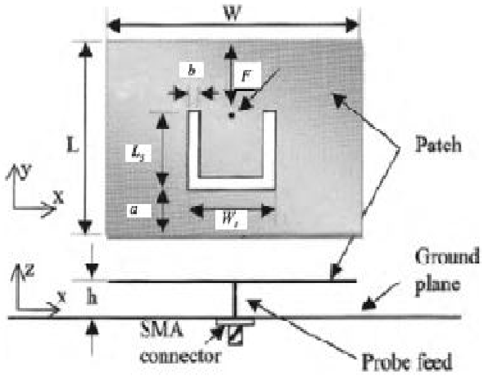

Figure 1. The geometry of the U-slot patch antenna.

In the original study of Huynh and Lee, the wide bandwidth characteristic of the antenna was demonstrated experimentally. It was pointed out in their paper that the factors contributing to the wideband behavior were the air substrate; a relative thick substrate (- 0.08 λo); the capacitance introduced by the U slot, which cancelled out the feed inductance; and the additional resonance introduced by the U-slot, which combined with the patch resonance to produce a broadband response. Representative results for the VSWR response, S parameter and radiation patterns are shown in Figures 2, 3 and 4. The gain of the antenna was around 7.2 dB, about 2 dB higher than the traditional Microstrip antenna. Although the first investigations of the U-slot patch antenna used an air or foam substrate, subsequent investigations have confirmed that this wideband design can also be implemented with material substrates. As expected, the bandwidth of an antenna on a material substrate is smaller than an antenna on an air or foam substrate. We have performed simulation and experimental studies on a U-slot antenna with an air substrate as a function of thickness. The dimensions of the antennas are listed in Table 1.

The Radiation pattern of the U-slot patch antenna is as shown in figure 4 and the calculated gain is 7.23

Table 1: Dimensions of the antenna

Antenna	εr	W	L	Ws	Ls	a	h	b	F
1	2.3	36	26	14	18	4	6.4	2	13

In the literature, wideband U-slot patch antennas are usually designed on foam or air substrates, resulting in patches with a resonant length of 0.5λ 'fo' decrease the resonant length, simulation results of these patch antennas on three types of microwave substrate were obtained, as shown in Figure 1 .

An inset feed microstrip antennas is designed to resonate at 10.1 GHz frequency with dielectric constant (εr) = 2.2, substrate thickness h=1.588 mm, L=6 mm, W=8.88 mm on a ground plane. All dimensions of the antenna are in mm. The length and the width of the patch are calculated initially by the relationships (1)-(6) given in

$$W = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

Where υ0 is the free space velocity of the light.

$$L = \frac{v_o}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \tag{2}$$

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \tag{3}$$

where ¢ L is extension in length due to fringing effects

The effective dielectric constant is given by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \tag{4}$$

The ground plane dimensions would b e given as

Lg=6(h) +L= 6(1.588) +6= 15.528 mm (5)

Wg=6(h) +W= 6(1.588) +8.886= 18.40 mm (6)

Figure 2 show the geometry of inset feed microstrip antenna with two slots in the patch. The patch is energized electromagnetically using 50 ohm microstrip feed line. The length of the current path is increased due to the slot which leads to additional inductance in series. Hence wide bandwidth is generated as the resonant circuits become coupled. The slots aggregate the currents, which give additional inductance controlled by the patch width. HFSS software has been used to calculate the return loss (S 11) & hence the cut off frequencies f 1 and f 2 of the antenna. Firstly the example antenna is designed without slots with patch dimensions L = 6, W = 8.88 for resonating frequency of 10.1 GHz. The bandwidth for the antenna is around 820 MHz.

5. SIMULATION RESULTS

The present work signifies that by introduction of two slots in the same design, the bandwidth gets enhanced about 25%-45%, i.e., from 700 MHz to 800 MHz. The same antenna is designed for different co-ordinate values of both the slots X and Y keeping patch dimensions, slot dimensions, εr and h constant and the corresponding cut off frequencies are recorded. Figure 3 and Figure 4 show the return loss (S11) vs. frequency curve for the proposed inset feed microstrip patch antenna without slot and with two slots of same physical patch dimensions. The positions of the slots were varied to see the effect on the microstrip antenna bandwidth. It was observed that antenna performance could be controlled by introducing slots to a large extent in terms of increased bandwidth, As the slots move in Y direction the bandwidth gets increases for the proposed design. From the present work it can b e inferred that as the slots are moving along the Y axis in both the directions, of course in specified range the bandwidth and other performance parameters are also improving significantly.

The VSWR vs. Frequency plot is shown in figure 2. The simulated VSWR is 1.31.

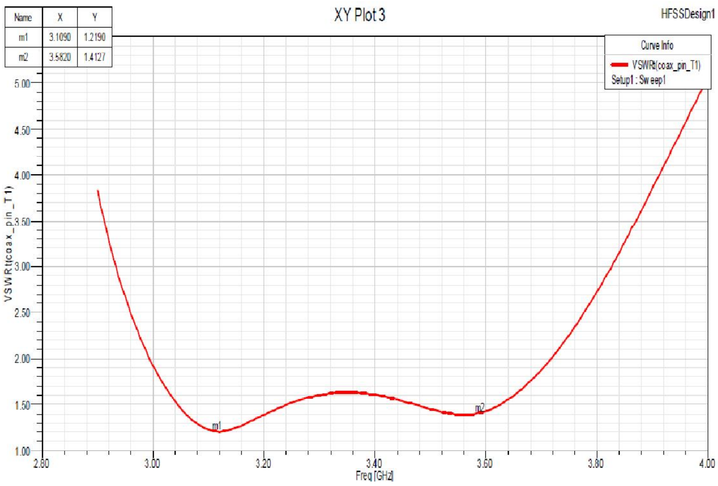

Figure 2. The VSWR of the U-slot patch antenna.

The s parameter ou u slot patch antenna is shown in figure 3 and simulated return loss is -17.28 and calculated

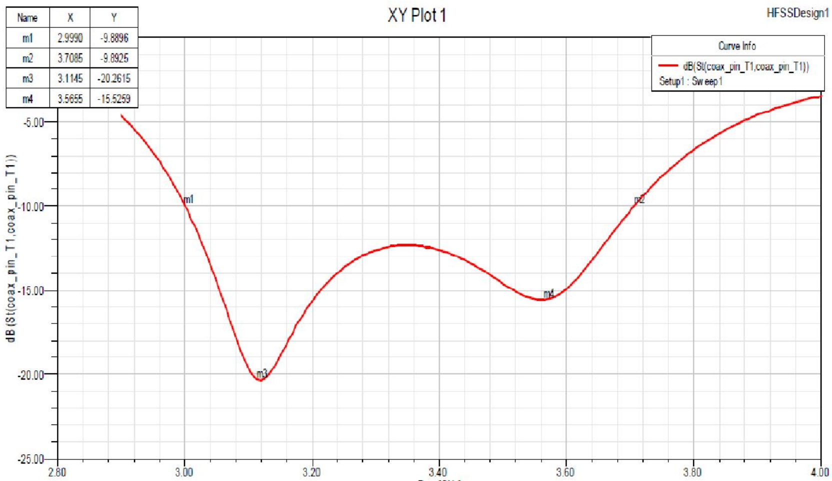

Figure3. The S parameter of the U-slot patch antenna.

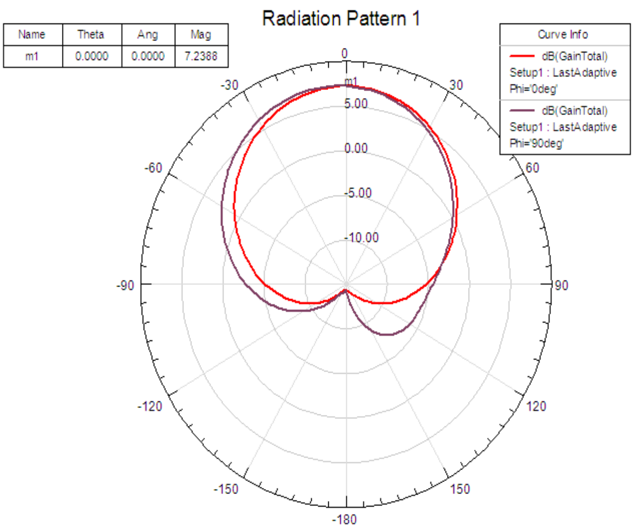

Figure 4. The Radiation pattern of the U-slot patch antenna.

6. CONCLUSION AND FUTURE OUTLOOK

This paper presents a new design procedure for the U-slot rectangular patch antenna based on previous literature and theoretical and parametric analyses. The origins of the structure's multiple resonant frequencies, which can be combined to produce a broad-band frequency response, are analyzed and discussed. Results of parametric studies are provided to aid in the fine-tuning of preliminary designs. Several new antennas are designed using the outlined procedure and evaluated with simulations and measurements. While the design rules presented here are approximate and may not work in all situations, they do provide an excellent starting point for antenna designers that give better and more timely results than simple guesses or cut-and-try techniques.

Further study is necessary in several areas to arrive at a more complete picture of this antenna's capabilities. Clearly, the substrate thickness and the feed point position remain important factors in achieving broad-band frequency operation and further parametric studies on these variables, as well as U-slot position and coaxial probe radius, are required. Second, these additional studies need to be coupled with the present paper and more detailed theoretical examinations to determine if some geometric factors can be used to compensate mismatches caused by prespecified substrate heights and probe radii. Finally, this paper can be used as a basis to derive design techniques for similar structures that result in multiband rather than broad-band operation.

7. REFERENCES

[1] T. Huynh and K. F. Lee, *"Single-Layer Single-Patch Wideband Microstrip Antenna,"* Electronics Letters, 31, 16, 1995, pp. 13101312.

[2] K. F. Lee, K. M. Luk, K. F. Tong, S. M. Shum, T. Huynh and R. Q. Lee, *"Experimental and Simulation Studies of the CoaxiallyFed Ll- Slot Rectangular Patch Antenna,"* lEE Proceedings Microwave Antennas and Propagation, 144, 5, 1997, pp. 354-358.

[3] K. F. Tong, K. M. Luk, K. F. Lee, and R. Q. Lee, *"A Broadband V-Slot Rectangular Patch Antenna on a Microwave Substrate,"* IEEE Transactions on Antennas and Propagation, AP-48, 6, 2000, pp. 954-960.

[4] M. Clenet and L. Shafai, *"Multiple Resonances and Polarization of Ll-Slot Patch Antenna,"* Electronics Letters, 35, 2, 1999, pp. 101-102.

[5] S. Weigand, G. H. Huff, K. H. Pan, and J. T. Bernhard, *"Analysis and Design of Broad-Band Single-Layer Rectangular If-Slot Microstrip Patch Antenna,"* IEEE Transactions on Antennas and Propagation, AP-51, 3, 2003, pp. 457-468.

[6] D. H. Schaubert, D. M. Pozar and A. Adrian, *"Effect of Microstrip Antenna Substrate Thickness and Permittivity: Comparison of Theories and Experiment,"* IEEE Transactions on Antennas and Propagation, AP-37, 6, June 1989, pp. 6.

Authors

Kadam Sudhir A. has received B.E .in Electronics & Telecommunication in 2011 from PVPIT Budhagaon , Sangli . and M.E. from the BVCOE Kolhapur, under the guidance of Prof. Desai K.R in year 2012-2013.Currently he is working as a Assit.Prof. in BVCOE, Kolhapur (India). Email-sudhir.kadam2009@gmail.com Ph.No-+919561043104

Prof. Desai K.R. has received M.E .in Electronics in 2006 from TKITE Warananagar , Kolhapur . and PhD from the Shivaji University Kolhapur, under the guidance of Dr. R.H.Chile ,Currently he is working as a Associate..Prof. in BVCOE, Kolhapur (India). Email-kr_desai@indiamail.com Ph.No-+919823390330