Research Article *ISSN: 2319-507X*
Rajas Khokle, IJPRET, 2013; Volume 1(8): 203-209 *IJPRET*

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

HORIZONTALLY POLARIZED STEPPED SLOT ULTRA WIDEBAND ANTENNA

RAJAS KHOKLE[1], RAJ KUMAR[3], R.V.S. RAM KRISHNA[2]

1. M. Tech. Student, LEOC-21, Department of Applied Physics, DIAT (Deemed University), Girinagar, Pune.
2. Research scholar, Department of Electronics Engineering, DIAT (Deemed University), Girinagar, Pune.
3. Armament Research and Development Establishment, Pashan, Pune.

Accepted Date:

27/02/2013

Publish Date:

01/04/2013

Keywords

Stepped slot Antenna,

Horizontal polarization,

Ultra wideband Antenna

Corresponding Author

Mr. Rajas Khokle

Abstract

A Horizontally polarized UWB slot antenna with a novel L shaped feed is proposed in this paper. First a stepped slot structure is fed by L shaped feed to achieve multiple resonances. Later a parasitic slot is introduced in a ground plane which improves impedance bandwidth. The -10 dB impedance bandwidth of 4 GHz from 5.1 GHz to 9.1 GHz is reported. The design has been carried out using the Finite Element Method and Finite Integration Technique and results are compared. The radiation pattern and gain is also reported.

INTRODUCTION

Since the proposal of UWB (3.6-10.1 GHZ) by FCC in 2002, many new microstrip antenna designs were proposed till date. However, most of the patch antennas are vertically polarized. This will lead to unwanted interference between the signals. Hence there is need to reduce Electromagnetic Interference .It is well known that interference can be substantially reduced by employing different orthogonality to the carrier. Also, it has been predicted in [1] & [2] that use of Horizontal polarization instead of vertical will result in 10dB more power. Hence, there is growing need of developing horizontally polarized UWB antenna.

In order to achieve omnidirectional horizontal radiation pattern, very less designs are found which include alford loop antenna [3], a dipole array [4], segmented loop antenna [5], Periodical capacitive loaded loop antenna [6], printed arc dipole [7].In this respect microstrip slot antenna may be a good choice as it can be made compact, low profile and can be integrated with MMIC. In this paper, a horizontally polarized stepped slot antenna with a chamfered L shaped microstrip feed is proposed. For achieving wider bandwidth, the technique of generating multiple resonances and matching them is used. To generate multiple resonances, a stepped slot configuration in ground plane is designed and it is excited by a chamfered L shaped feed. Chamfering the feed provides perturbation in current path which leads to additional resonant frequencies, thereby increasing the bandwidth. This provides two bands of operation such that -10 dB Bandwidth of first band is 0.8 GHz from 5.2 GHz to 6 GHz and Bandwidth of second band is 2.2 GHz from 6.8 GHz to 9 GHz. In order to get a continuous band from 5 GHz to 9 GHz a parasitic slot is cut in ground plane adjacent to the feed as a further modification.

GEOMETRY & DESIGN

The antenna is designed on commercially available FR4 glass epoxy substrate with ε_r=4.4 and thickness 1.58mm. In order to match the 50 Ω SMA connector to microstrip line the width of microstrip is calculated to be 3 mm using equation 1[8].

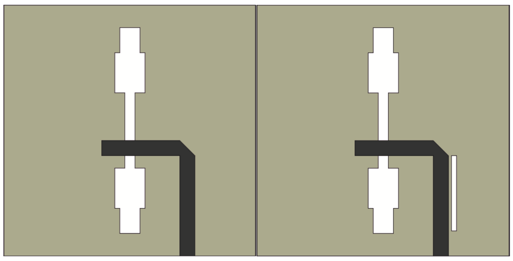


Figure 1 (a) Stepped slot Antenna (b) Stepped Slot Antenna with parasitic slot

$$\frac{W}{d} = \frac{8e^{A}}{e^{2A}-2} \quad (1)$$

Where $A = \frac{z_0}{60}\sqrt{\frac{\epsilon_r+1}{2}} + \frac{(\epsilon_r-1)}{(\epsilon_r+1)}\left(0.23 + \frac{0.11}{\epsilon_r}\right)$ (2)

The slot antenna (Figure 1a) consists of a ground plane printed on one side of the substrate. A stepped slot is etched on the ground plane and fed by a 50 ohm L Shaped microstrip feed line printed on the other side. This feed is then chamfered at 45^0 at L bend to reduce capacitive effect of bend. The antenna has overall dimensions of 50 x 50 mm. To improve the impedance bandwidth as explained in the introduction a parasitic slot has been added near the vertical arm of feed (Figure 1b). This parasitic slot gets excited by electromagnetic coupling from vertical arm of feed. The length, width and position of slot are optimized such that it provides resonance at 6.5GHz. The geometry of the final optimized antenna with parasitic slot is as shown in Figure 2 and the antenna dimensions are indicated in Table 1. As seen from figure the slot dimensions are symmetric along length and width of antenna. Hence L1=L7 and L2=L6. Also the widths of upper and lower slot steps are same. The parameters 'D1' and 'D3' are optimization parameters for matching impedances to get a wider bandwidth.

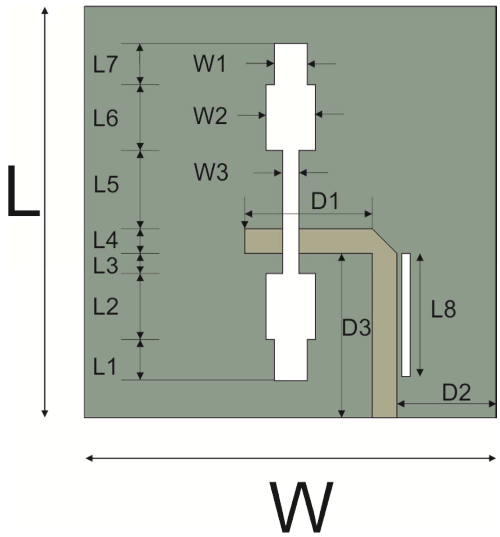


Figure 2 Sketch map of Antenna

Table 1. Proposed Antenna Optimized Parameters

Parameter	L1	L2	L3	L4	L5	L8
Value	5	8	3	3	9	15
Parameter	w1	w2	w3	D1	D2	D3
Value	4	6	2	15.5	12	20.5

SIMULATION RESULTS

The antenna without parasitic slot and the antenna with parasitic slot are designed and simulated in Ansoft HFSS with FEM solver and CST Microwave Studio with transient solver (FIT method). Results of both numerical full wave analyses are in excellent agreement with each other. The S_{11} magnitude plot as simulated by both the software are shown in Figure 3.

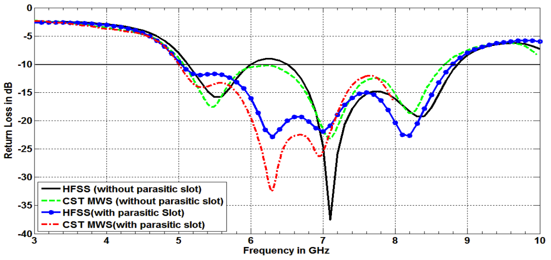


Figure 3 Return Loss of antenna without parasitic slot and with parasitic slot.

From the S_{11} Plot it is seen that both the antennas show multiple resonances from 5 to 9 GHz. The resonances of both the antenna are indicated in Table 2 below. It clearly shows that addition of a parasitic slot in ground plane has very little or no effect on other resonances.

Table 2. Antenna Designs and observed resonances.

Antenna	Resonances (in GHz)
Antenna without Parasitic Slot	5.4, 7.1 ,8.2, 8.6
Antenna with Parasitic Slot	5.3, 6.4, 7.0, 8.1, 8.6

The resonances shown in the above table are governed by effective wavelengths inside the substrate calculated by using equation 3. $\lambda_{eff} = \frac{\lambda}{\sqrt{\epsilon_{r_{eff}}}}$, $\& \epsilon_{reff} \approx \frac{\varepsilon r+1}{2}$

(3)

Where λ is free space wavelength. In order to verify the role of the parasitic slot the plot of the surface currents on ground plane (magnitude plot) and E-fields inside slot (Vector Plot) at 6.4 GHz for both the designs, is shown in figure 4.

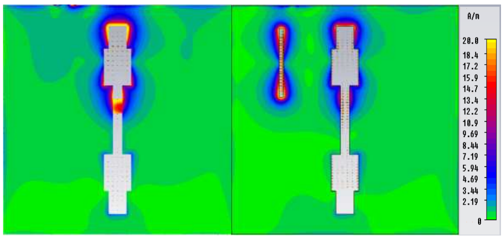


Figure 4 Current distributions on ground conductor and E –field distribution inside slot at resonant frequencies.

This clearly validates the premise that addition of parasitic slot of proper length has contributed to an extra resonant peak which ultimately led to the enhancement of bandwidth.

Horizontal polarization

In order to study the polarization characteristics of antenna with parasitic slot a plot of the ratio of horizontal (E_ϕ) and vertical (E_θ) component (E_ϕ (dB) -E_θ (dB)) in bore sight along with S_{11} curve is shown in Figure 5. When this ratio curve crosses 0 dB, from that frequency the vertical component dominates horizontal component. The band over which the antenna will have good impedance matching as well as good polarization purity at bore sight is from 5.1 to 7.4 GHz i.e. 2.4 GHz bandwidth. As frequency increases, the difference between horizontal and vertical polarization decreases. The least cross polarization obtained is -40dB around 5 GHz. Thus it can be effectively used in 5 GHz Wireless Local Area Network (WLAN), HIPERLAN/2 and Worldwide Interoperability for Microwave Access (WiMAX) bands (5.15 - 5.85 GHZ).

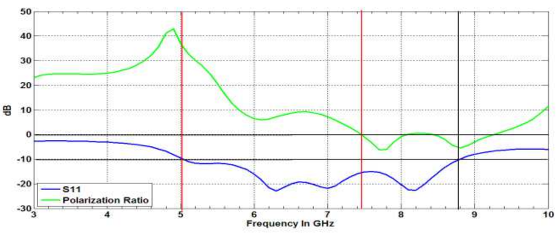
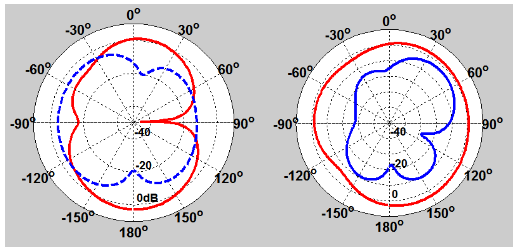


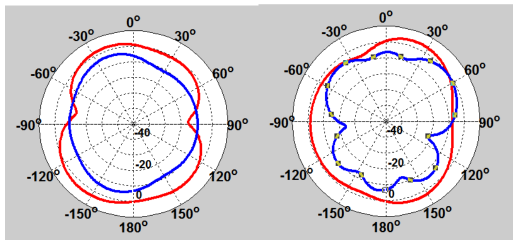
Figure 5 Plot of polarization ratio over frequency at boresight.

Radiation patterns

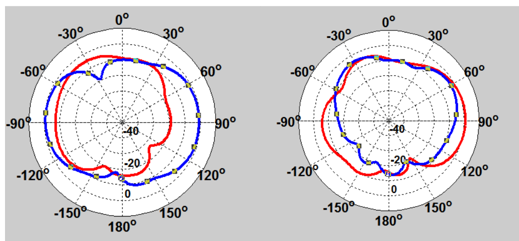
The simulated radiation pattern in E Plane and H plane at 5 GHz, 7 GHz and 8 GHz for antenna with parasitic slot is shown in Figure 6. From H plane it can be seen that Horizontal polarization is almost omnidirectional. In H plane pattern, we find that cross-polarization level is more from θ= 0 to -180. This is due the presence of vertical feed on reverse side. Also, the cross-polarization levels in azimuthal plane are about -15 dB up to 7GHz. As frequency increases the cross polarization also increases specially in bore sight. This can be attributed to the offset feed configuration.



(a) (b)



(c) (d)



(e) (f)

Figure 6 Simulated Radiation Patterns for antenna with parasitic slot, (a & b) 5 GHz

(E & H Plane). (c & d) 7 GHz E & H Plane).(e & f)-8.0 GHz (E & H plane).

Gain and radiation efficiency

The peak gain and radiation Efficiency as a function of frequency, for both the antenna, are plotted in Figure 7 and Figure 8 respectively. The Radiation efficiency decreases with increase in frequency beyond 7.2 GHz. As such there is no appreciable change in gain or radiation efficiency by adding the parasitic slot (except at 6 GHZ) and hence it can be concluded that addition of parasitic slot improves the return loss without influencing other frequencies.

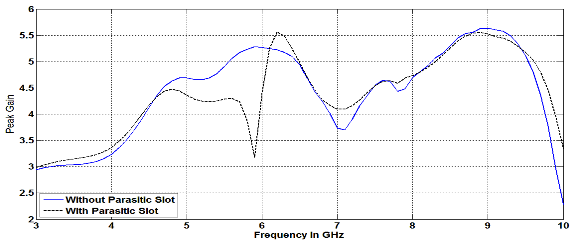


Figure 7 Peak gains of both antennas as a function of Frequency

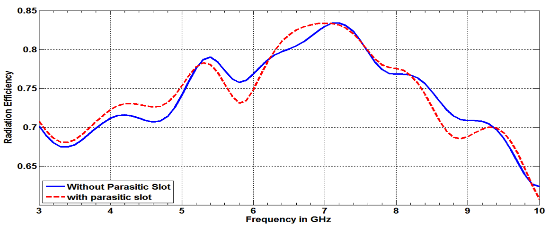


Figure 8 Radiation Efficiency of both antennas as a function of Frequency

CONCLUSION

In this paper a design for horizontally polarized ultra wideband antenna has been proposed and simulated using commercial software. An impedance bandwidth from 5.1 to 9.0 GHz has been achieved by combination of stepped slot configuration; L shaped chamfered feed and introduction of parasitic slot. The polarization bandwidth is 2.4 GHz and cross polarization levels are below -15 dB in this band. The antenna shows fairly omnidirectional pattern, appreciable gain and radiation efficiency in operating frequency band.

ACKNOWLEDGEMENT

The first author is an M. Tech student at Defence Institute of Advanced Technology, Pune, India and acknowledges the financial support and facilities extended for carrying out the research work.

REFERENCES

1. Soras C, Karaboikis M, Tsachtsiris G, and Makios V, Analysis and design of an inverted - F antenna printed on a PCMCIA card for the 2.4 GHz ISM band, IEEE

Antennas Propagation. Magzine, 2002; Vol. 44(1): 37–44.

2. Chizhik D, Ling J, and Valenzuela R A, The effect of electric field polarization on indoor propagation, Proceedings IEEE International Conference Universal Personal Communications, 1998; vol. 1: 459–462.

3. Lin C C , Kuo L C, and Chuang H R, A Horizontally Polarized Omnidirectional Printed Antenna for WLAN Applications, IEEE Transactions on Antennas and Propagation, 2006; 54(11):3551-3556.

4. Wu D, Zhao M, Fan Y, and Zhang Y, A wideband 8-element omnidirectional array for wireless system, Microwave and Optical Tech. Letters, 2007; 49 (2944-2946).

5. Xianming Qing; ZhiNing Chen , Horizontally polarized omnidirectional segmented loop antenna, 6th European Conference on Antennas and Propagation (EUCAP), 2012 ; 2904-2907.

6. Kunpeng Wei, Zhijun Zhang, Senior Member, IEEE, and ZhengheFeng, Fellow, IEEE, Design of a Wideband Horizontally Polarized Omnidirectional Printed Loop Antenna, IEEE Antennas And Wireless Propagation Letters, 2012; 11(49-52)

7. Quan X L, Li R L, Wang J Y and Cui Y H, Development of a broadband horizontally polarized omnidirectional planar antenna and its array for base stations, Progress In Electromagnetics Research, 2012; 128: 441-456.

8. D. M. Pozar, Microwave Engineering, John Wiley & Sons Inc., Fourth Edition, 2011.