Microstrip Line-Fed-Slotted UWB Antenna With Truncated Ground Plane

[1] Niranjana Devi K, [2] Priya M, [3] Shobana Sree R
[1] *M.E. Communication System,* [2,3] *Asst. Professor, E.C.E. Department*

Abstract

In this paper, the concept of strip lined truncated ground plane with Inset Fed slotted Microstrip Patch Antenna is used. And a slot of 0.85 x 0.07 cm^2 is cut within the radiating patch at a distance of 0.12cm from the end of the patch, on either sides, due to which return loss decreases below -50 dB at 10.5GHz. The developed antenna operates at an UWB frequency of 9.25GHz - 14.2GHz with a bandwidth of 4950MHz or 47.14% at the center frequency of 10.5GHz and has a VSWR of less than 2 over the entire operating band. A maximum gain of 5.2dB is obtained with almost a complete Omni-directional radiation pattern and does not require additional impedance matching circuitry. The results show that the reference antenna (without slot) has a return loss of -34 dB and the proposed antenna (with slots on either sides of patch) has a return loss of -50 dB at 10.5 GHz. The design and simulation of the antenna structure is carried out in HFSS ver 13.

Keywords: Inset feed, truncated ground plane, Slotted patch and UWB Antenna.

1. Introduction

Modern wireless communication technology demands compact and wideband antennas. Microstrip antennas can be classified into two basic types by structure, namely microstrip patch antenna and microstrip slot antenna. The slot antennas can be fed by microstrip line, slot line and CPW.

In this work we present the design and optimization of a microstrip inset fed patch antenna with reduced ground plane by including slots in the patch which is a modification in the design of previously available antenna design technique[1], to obtain low return loss and high gain conserving broad bandwidth, and proper impedance matching with reduced ground plane effects without the need for impedance matching circuitry as in [2].

It has been found that by choosing suitable combinations of feeding structure and slot shape, an optimum impedance bandwidth can be obtained, which includes use of thick substrate, cutting a resonant slot inside the patch, use of a low dielectric substrate. For enhancing the bandwidth, various slot shapes, that is, square [3], triangle [4] and circular/ellipse [5], have been utilised with a suitable feeding stub. Various stub shapes, that is, forklike, triangular, bow-tie, arc shape and L-shape [6], are used. For some cases, rotation of the wide slot is used for larger bandwidth [7].

Ultra-wideband (UWB) is also known as ultraband. UWB is a technology for transmitting information spread over a large bandwidth (>500 MHz). Ultra wideband was formerly known as "pulse radio", but the FCC (Federal Communication Commission) and the ITU-R(International Telecommunication Union Radio communication) Sector currently defined UWB in terms of a transmission from an antenna for which the emitted signal bandwidth exceeds the lesser of 500 MHz or 20% of the center frequency and has a fractional bandwidth (FBW) greater than 0.25 [8].

2. Antenna Configuration

Fig. 1 shows the geometry and dimensions of the reference Strip Lined Truncated Ground Plane on Inset Fed Slotted Microstrip UWB Antenna[1].

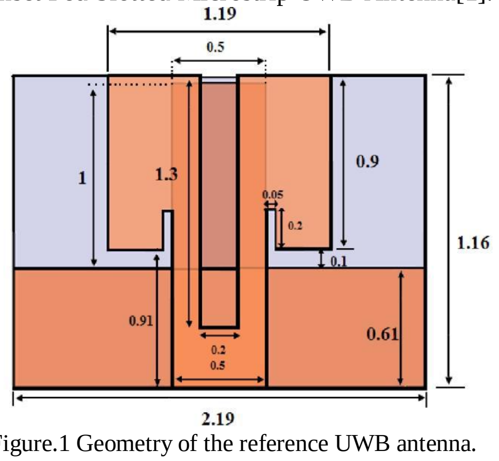


Figure.1 Geometry of the reference UWB antenna.

The antenna dimensions length L, width W are calculated using the patch antenna design equations [9] given below:

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}} \quad \text{------------------ (1)}$$

$$\Delta L = 0.412h\left[\frac{(\epsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\epsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}\right] \quad \text{--------------- (2)}$$

$$L = L_{eff} - 2\Delta L \quad \text{----------------- (3)}$$

$$L_{eff} = \frac{c}{2f_r\sqrt{\epsilon_{reff}}} \quad \text{---------------- (4)}$$

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad \text{----------------- (5)}$$

Where,

εreff --- Effective dielectric constant
Leff --- Effective Length
ΔL --- Length Extension

The ground plane dimensions are calculated as:

$$W_g = 6h + W \quad \text{----------------- (6)}$$

$$L_g = 6h + L \quad \text{------------------ (7)}$$

Where, W_g and L_g are the length and width of ground plane respectively.

Fig. 2 and table 1 gives the geometry and dimensions of the proposed antenna structure respectively.

The proposed antenna is fabricated on commercially available FR4 dielectric substrate with a permittivity of 4.4 and a thickness of 62mil and a slot of of 0.85 x 0.07 cm^2 is cut within the radiating patch at a distance of 0.12cm from the end of the patch on either sides.

Table 1: Dimensions of proposed antenna structure

DESCRIPTION	DIMENSIONS (cm)
Ground plane	Truncated Ground plane L=2.19 ,W=0.61 Patch (at center) L=1.0 , W=0.5
On top metal	Patch with line feed and a slot in the radiating patch (i) Patch L=1.19, W = 0.9 (ii) Feed Inset distance=0.91 Inset Gap=0.05 W= 0.5 (iii) Slot *at center* L=1.3 , W= 0.2 *On either sides* L= 0.85, W=0.07
Substrate	FR 4, εr =4.4, h=1.6 mil

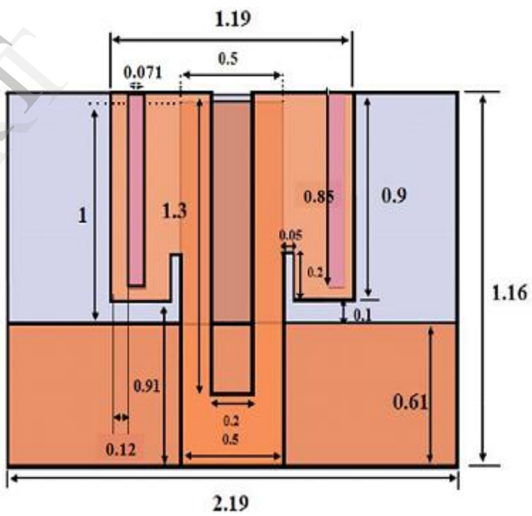


Figure .2 Geometry of the proposed UWB antenna

3. Calculations

(i) Percent bandwidth

$$\boxed{\%Bandwidth=(f_H-f_L)/f_C}$$

f_L =9.25 GHz, f_H =14.2 GHz,fc=10.5 GHz.

%Bandwidth= $(f_H-f_L)/f_C$= (14.2-9.25)/10.5

= 47.14 % w.r.t center frequency 10.5 GHz.

(ii) Fractional Bandwidth

$$\boxed{FBW=2((f_H-f_L)/(f_H+f_L))}$$

FBW= 2((14.2-9.25)/(14.2+9.25))

= 0.422

Where,

F_L ----Lower cut off frequency

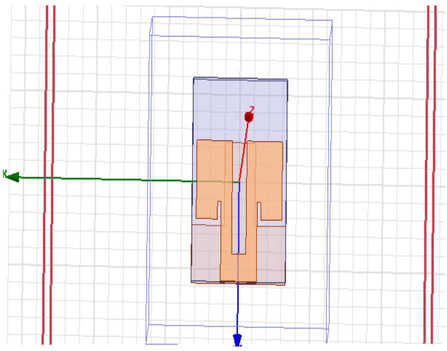
f_H ----Upper cut off frequency

f_C----Center frequency

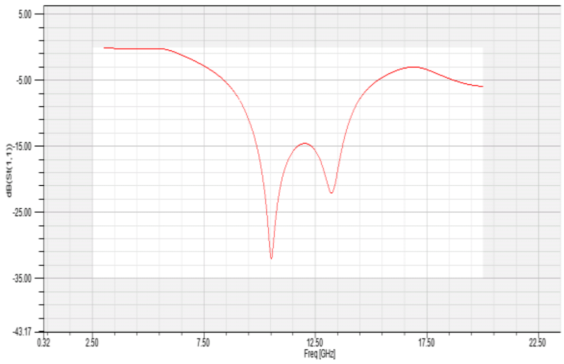
4. Simulation results

4.1 Reference Antenna

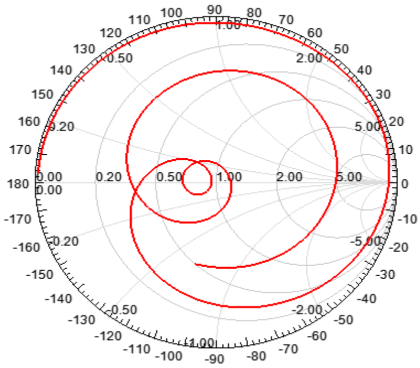
Structure



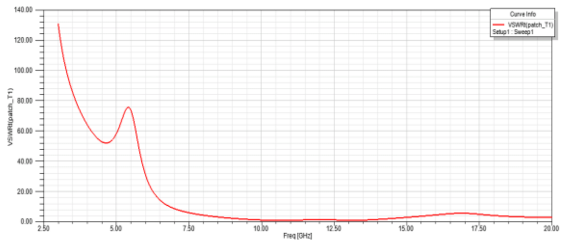
Return loss



Plot of Input impedance

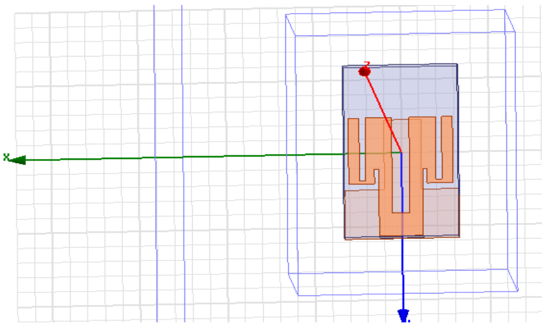


VSWR Plot

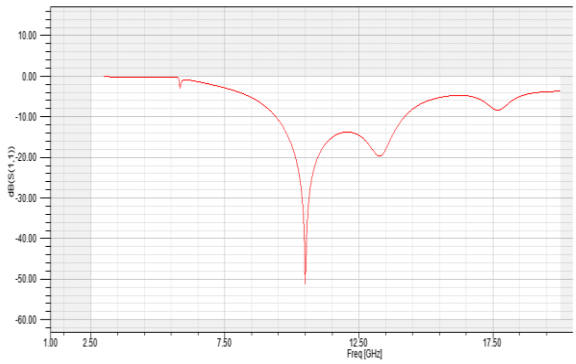


4.2 Proposed Antenna

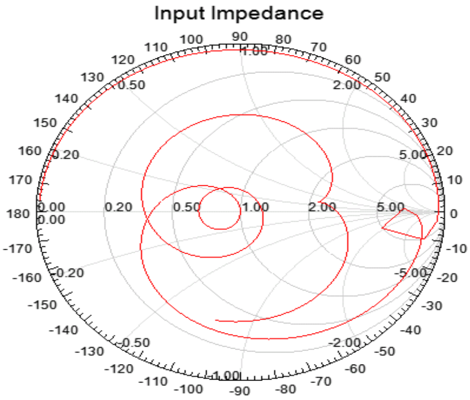
Structure



Return Loss



Plot of Input Impedance



VSWR Plot

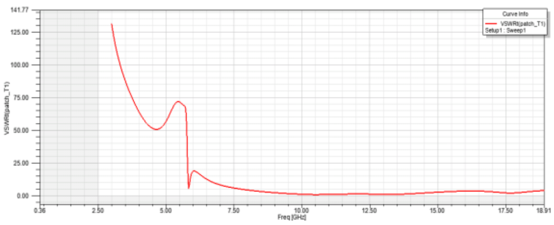


Table 2: Comparison of Reference and Proposed Antenna Configurations

DESCRIPTION	REFERENCE ANTENNA	PROPOSED ANTENNA
Gain (dB)	4.7	5.2
Resonating Frequencies (GHz)	10.5 and 13.0	
Return loss(dB) at **9.25 GHz** **14.2GHz**	- 32 - 22	-51 -40

5. Conclusion

By cutting a slot of of 0.85 x 0.07 cm^2 within the radiating patch at a distance of 0.12cm from the end of the patch, on either sides return loss increases in negative.The proposed antenna exhibits stable far-field radiation characteristics in the entire operating bandwidth with high gain and low cross polarization. The bandwidth of the proposed antenna can be further increased using any of the techniques described above.

6. References

[1] Chandan Raj Asokan, Barath Raj Asokan," Effect of Strip Lined Truncated Ground Plane on Inset Fed Slotted Microstrip UWB Antenna" International Journal of Emerging Technology and Advanced Engineering Volume 3, Issue 9, September 2013.

[2] Esa, Mazlina and Subahir, Suhaila and Ahmad, Norul Husna and Yousof, Sharifah Kamilah, " Inset feed for antenna miniaturization",In National Conference on Telecommunication Technology 2000, 20th-21st Nov. 2000, Hyatt Regency Hotel, Johor Bahru.

[3] Sze J.Y.,Wong K.L.: 'Bandwidth enhancement of a microstrip line fed printed wide slot antenna', IEEE Trans. Antenna Propag., 2001, 49, (7), pp. 1020–1024.

[4] Liu Y.F., Lau K.L., Xue Q., Chan C.H.: 'Experimental studies of printed wide-slot antenna for wide-band applications', IEEE Antenna Wirel. Propag. Lett., 2004, 3, pp. 273–275

[5] Li P., Liang J., Chen X.: 'Study of printed elliptical/circular slot antennas for ultrawideband applications', IEEE Trans. Antennas Propag., 2006, 54, (6), pp. 1670–1675

[6] Sung Y.: 'A printed wide-slot antenna with a modified L-shaped microstrip line for wideband applications', IEEE Trans. Antenna Propag., 2011, 59, (10), pp. 3918–3922

[7] Sung Y.: 'Bandwidth enhancement of a microstrip line-fed printed wide-slot antenna with a parasitic centre patch', IEEE Trans. Antenna Propag., 2012, 60, (4), pp. 1712–1716

[8] Leena Vershney and Jibendu Sekhar Roy, "A Broadband Stepped-Slot Antenna", Microwave Review, December 2009.

[9] Balanis,"Antenna Theory and Design", 3rd Edition.