Compact Ultra wideband Log-Periodic Dipole Antenna with WLAN Rejection by using U-shape Ground Structure

Y.Viwin Singh, S.Sweetline Shamini

ABSTRACT—In this paper, compact Log-periodic dipole antenna with single band notched characteristics is presented by introducing different ground structure (DGS). The proposed antenna consists of U-shape ground structure that produces WLAN band-notched rejection characteristics from 5.1 GHz to 5.9 GHz and size of the antenna is reduced to improve the compactness. This band notch is proposed for Ultra wideband applications. The Voltage Standing Wave Ratio (VSWR) is less than 2 between 3.1 GHz to 10.6 GHz. The proposed antenna with WLAN rejection frequency notch is designed, fabricated.

General Terms—Different Ground Structure, Frequency-notched antenna, Log-Periodic dipole antenna, Ultra wideband, Voltage Standing Wave Ratio.

1. INTRODUCTION

In the present scenario UWB wireless communications have become increasingly popular for research in the 3.1 GHz to 10.6 GHz band. Since it allows communication at low power levels and high data rate transmissions. Many researches on the UWB antenna have resulted in various designs of the same. Typical candidate for UWB applications is monopole antenna because it can achieve very wide frequency band with a simple design. However these antennas are large size, and hence printed Log-Periodic dipole antenna (PLPDA) can be considered over monopole antenna.

Existing works on Log-Periodic antenna shows that feeding is brought about by coaxial cable [3]. However when frequency increases their performance degrades. Whereas in multilayer process feeding networks by stripline was done [5]. There are many wireless communication systems with frequencies that are overlapped by the UWB system and hence notching is required for blocking these bands from UWB system's interference. Some of these bands include WiMAX (3.4GHz – 3.6 GHz) and WLAN (5.1 GHz – 5.9 GHz).

For the purpose of notching many simple ways have been introduced in the design of UWB antennas.

- *Viwin singh.Y is currently pursuing masters degree program in communication systems in easwari engineering college, ramapuram, Chennai, India. PH-9629624746. E-mail: vwnsingh@gmail.com*
- *Sweetline shamini.S is currently pursuing masters degree program in applied electronics in j.j engineering college, trichy, India. E-mail:visha89@gmail.com*

These include U-shaped slots [6], [7], L-shaped slots [8], H-shaped slots [9], parasitic strips [10], [11] and also resonators like split ring resonators [12], complimentary split ring resonators [13], coplanar resonant cells [14], Half mode substrate integrated waveguide (HMSIW) cavities [15], etc

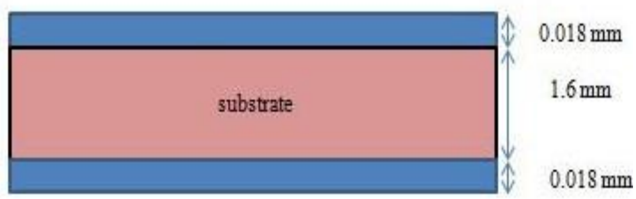

Fig 1 : Thickness of different layers

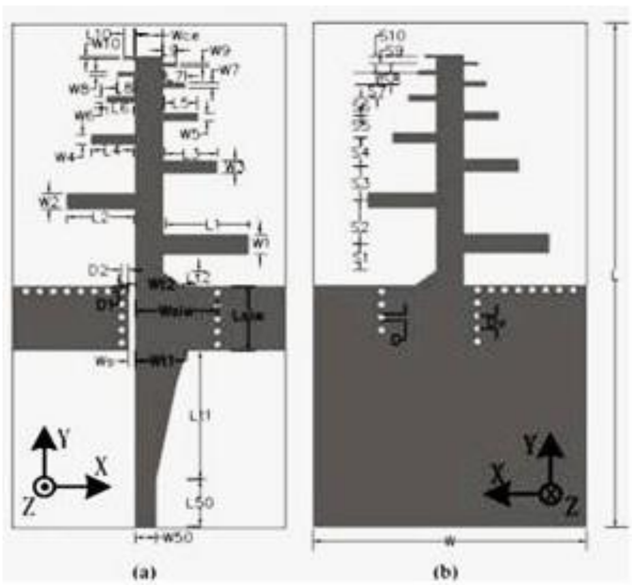

Fig 2: Layout of PLDPA (a) Top layer (b) Bottom layer

In this paper a simple PLPDA antenna is designed as an UWB antenna and notching characteristics have been brought about by introducing U-shaped slot in the ground structure.

This modified ground structure brings about the notching in the WLAN (5.2 GHz – 5.9 GHz) band. The main advantage of this design compared to the existing system is that the substrate used is FR4 which brings about good cost efficiency and compatibility in size.

2. DESIGN OF THE PLPDA

Fig.1 shows the different layers of the PLPDA. The top layer represents the radiating patch, the middle represents the substrate and the bottom layer represents the ground plane. Here the radiating patch and the ground patch made of annealed copper and the substrate is made of FR4. The dielectric constant of FR4 is 4.3 and thickness is 1.6mm. The FR4 is cheap when compare to Roger RT/DURIOD 5880 which was used in existing PLPDA model.

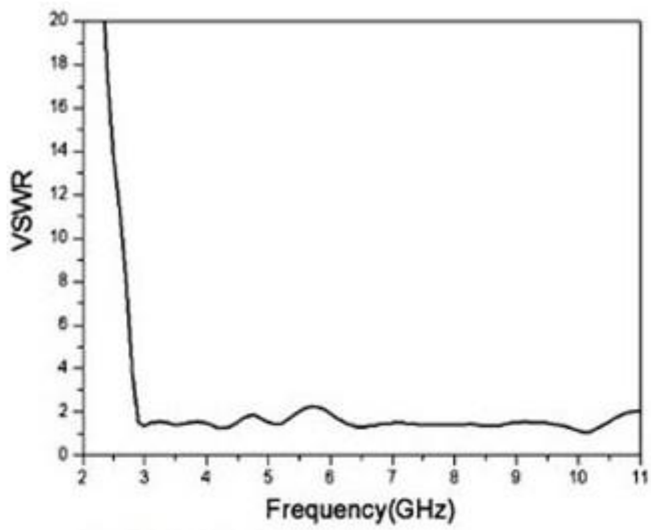

Fig 3: VSWR of PLPDA

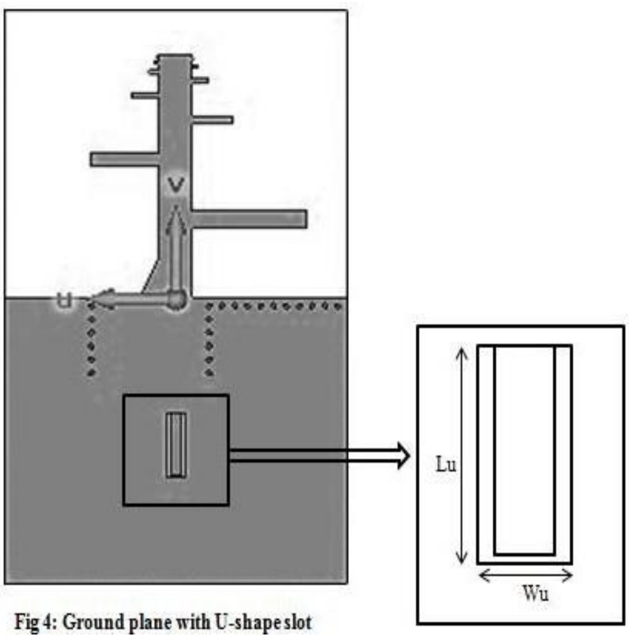

Fig 4: Ground plane with U-shape slot

A. Design of dipole array

The design method of LPDA in [24],[25]. The scale factor τ, spacing factor σ and the number of dipole elements N should be known in the first step and it is determined to be τ = 0.61 , σ = 0.155 and N =10 [1]. Next the length of the longest dipole L1 which responses to the lowest resonance frequency fmin , can be calculated by

$$L1 = \frac{\lambda_{effmax}}{4} \quad (1)$$

Where λ_{effmax} is the longest operating wavelength. Its value can be determined by

$$\lambda_{effmax} = \frac{c}{f_{min}\sqrt{\varepsilon_{eff}}} \quad (2)$$

ε_{eff} is effective dielectric constant.

Table 1. Parameter specifications (unit MM)

D = 0.5	L4=2.95	Lsiw=9.38	S6=1.05	W3=0.91
D1=0.5	L5=1.79	Lt1=12.6	S7=0.5	W4=0.56
D2=0.5	L6=1.09	Lt2=4.2	S8=0.4	W5=0.5
Dv=1	L7=0.66	S1=4.44	S9=0.4	W6=0.3
L=64.19	L8=0.40	S2=6.79	S10=0.3	W7=0.2
L1=13.3	L9=0.24	S3=4.41	W=39.9	W8-0.2
L2=7.93	L10=0.15	S4=2.695	W1=1.89	W9=0.2
L3=4.83	L50=4.9	S5=1.64	W2=1.47	W10=0.2
W50=3.1	Wce=3.92	Ws=0.5	Wsiw=11.69	Wt1=6.23
Wt2=6.09	Lu=7.25	Wu=2.3		

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \frac{1}{\sqrt{1 + \frac{12h}{W1}}} \quad (3)$$

ε_r is the relative permittivity of the substrate, h is the substrate thickness, W1 is the width of the longest dipole.

$$\frac{L_{n+1}}{L_n} = \frac{W_{n+1}}{W_n} \quad (4)$$

Where n = 1, 2, 3, ….. , 10.

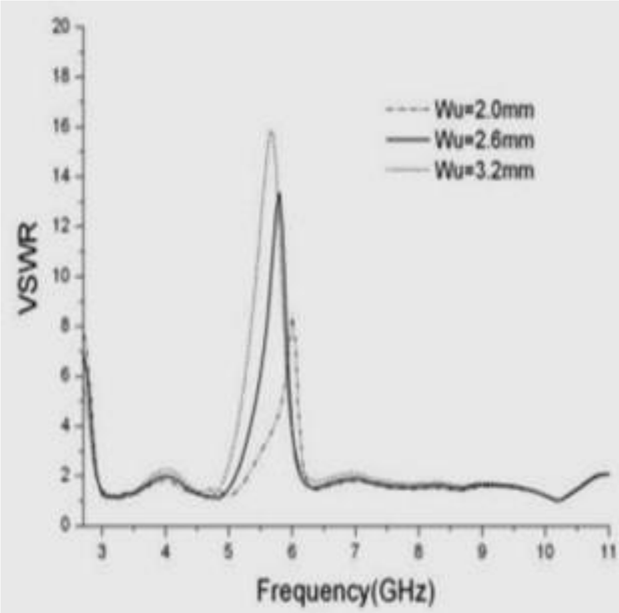

Fig 6: VSWR of PLPDA with U shape slot (responses with different widths)

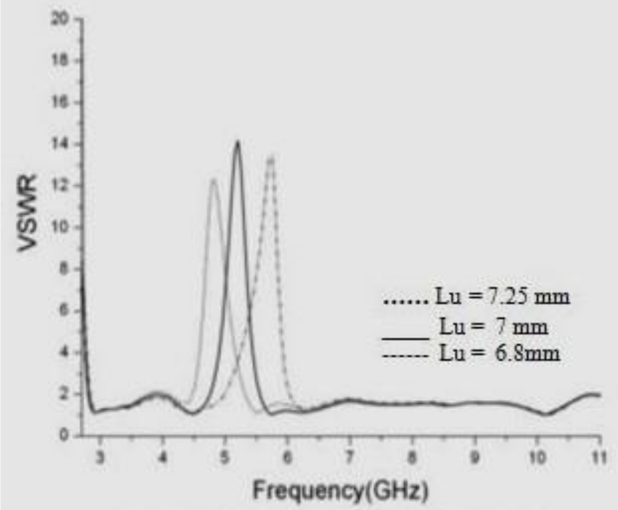

Fig 5: VSWR of PLPDA with U-shaped slot (response with different Length)

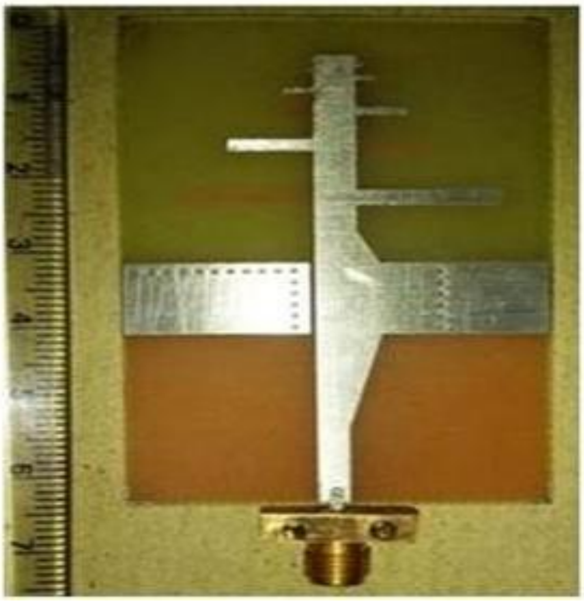

Fig 7: TOP PLANE

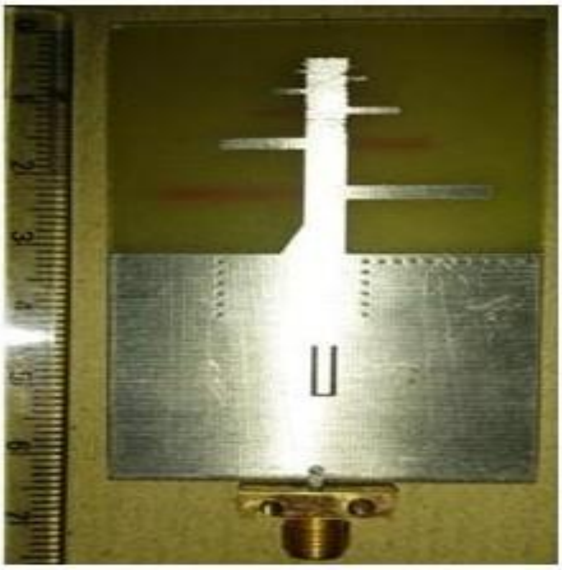

Fig 8: BOTTOM PLANE

Where f_{notch} is the slot resonance frequency. The effective dielectric constant can be calculated by the microstrip line case as listed in (3).

3. RESULT ANALYSIS

PLPDA with the notch band at 5.2 GHz – 5.9 GHz has been presented. It was fabricated by the standard printed circuit board fabrication process. The FR4 used as the dielectric substrate with the dielectric constant of 4.3 and substrate thickness of 1.6mm. fig 5 and 6 shows the frequency responses of VSWR .

It covers the frequency band of 3.1 GHz to 10.6 GHz with the notch characteristics. The values of the VSWR are less than 2 other than the notch frequency bands. The good agreement between the performances of the simulation and measurement is obtained with small discrepancies which are acceptable and it may be due to dielectric substrate's permittivity fluctuation. The U-shaped slot's dimensions can be tuned to obtain different notched frequencies for different wireless standards.

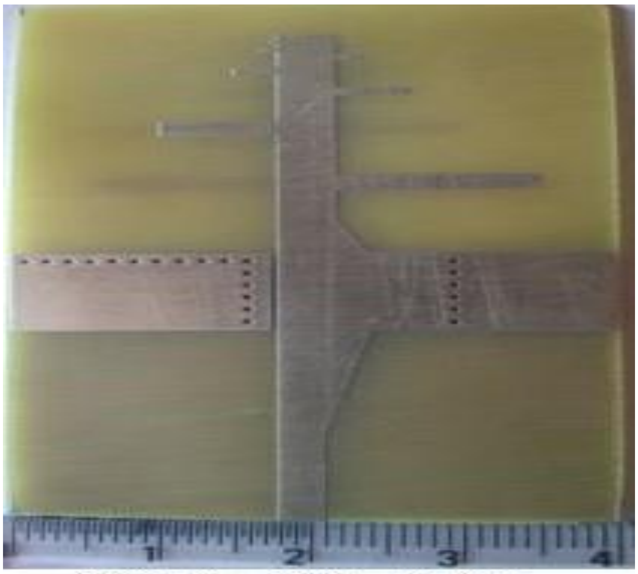

Fig 9: Reduced Width of PLPDA

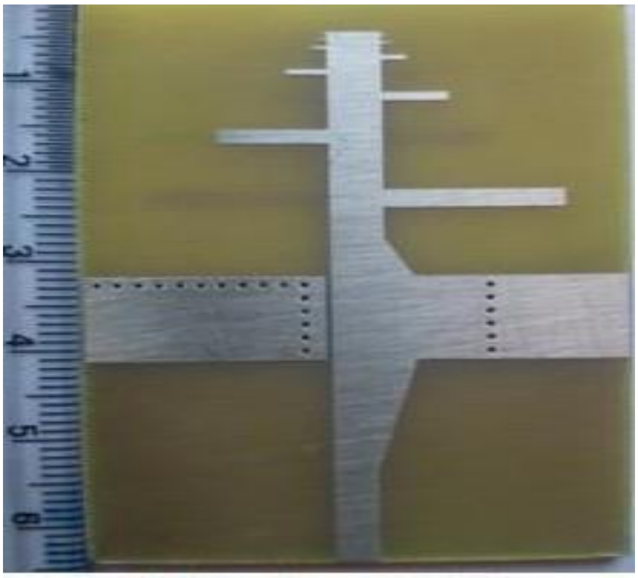

Fig 10: Reduced Length of PLPDA

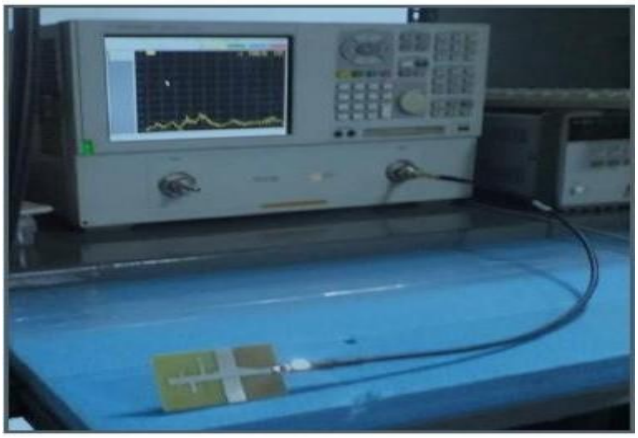

Fig 11: REAL TIME MEASUREMENT SETUP

4. CONCLUSION

In this paper, UWB PLPDA with single notch band is presented. The notching has been obtained by etching U-Shape slot on the ground plane of the antenna. The substrate used enables cost efficient with 90% reduction and compatible design with 30% reduction in the size of the antenna compared to the one which is existing [1]. Unlike monopole antenna the proposed PLPDA radiate power in the endfire direction which gives stable radiation pattern within the whole working frequency bands.

5. REFERENCES

[1] Chao Yu, Wei Hong, Leng Chiu, Guohua Zhai, Chen Yu, Wei Qin and Zhenqi Kuai "Ultra wideband Printed Log-Periodic Dipole antenna with multiple notched bands" IEEE transaction on antennas and propagation, VOL.59, No.3, march 2011.

[2] S. Y. Chen, P. H. Wang, and P. Hsu, "Uniplanar log-periodic slot antenna fed by a CPW for UWB applications," IEEE Antennas WirelessPropag. Lett., vol. 5, no. 1, pp. 256-259, Dec. 2006.

[3] M. M. Tajdini and M. Shahabadi, "Wideband planar log-periodic antenna," in Proc. Int. Workshop on Antenna Technology-IWAT'07, Mar.2007, pp. 331-334.

[4] J. Mruk, M. Uhm, and D. Filipovic, "Dual-wideband log-periodic antennas," in Proc. IEEE AP-S. Int. Symp., Jul. 2008, pp. 1-4.

[5] R. Pantoja, A. Sapienza, and F. M. Filho, "A microwave printed planar log-periodic dipole array antenna," IEEE Trans. Antennas Propag., vol.35, no. 10, pp. 1176-1178, Oct. 1987.

[6] Y. J. Cho, K. H. Kim, D. H. Choi, S. S. Lee, and S. O. Park, "A miniature UWB planar monopole antenna with 5-GHz band-rejection filter and the time-domain characteristics," IEEE Trans. Antennas Propag., vol. 54, no. 5, pp. 1453-1460, May 2006.

[7] W. S. Lee, D. Z. Kim, K. J. Kim, and J. W. Yu, "Wideband planar monopole antennas with dual band-notched characteristics," IEEE Trans. Microw. Theory Tech., vol. 54, no. 6, pp. 2800-2806, Jun. 2006.

[8] J. Y. Deng, Y. Z. Yin, S. G. Zhou, and Q. Z. Liu, "Compact ultrawideband antenna with tri-band notched characteristic," Electron. Lett., vol. 44, no. 21, pp. 1231-1233, Oct. 2008.

[9] K. H. Kim, Y. J. Cho, S. H. Hwang, and S. O. Park, "Band-notched UWB planar monopole antenna with two parasitic patches," Electron.Lett., vol. 41, no. 14, pp. 783-785, Jul. 2005.

[10] K. H. Kim and S. O. Park, "Analysis of the small band-rejected antenna with the parasitic strip for UWB," IEEE Trans. Antennas Propag., vol. 54, no. 6, pp. 1688-1692, Jun. 2006.

[11] Y. Zhang, W. Hong, C. Yu, Z. Q. Kuai, Y. D. Dong, and J. Y.Zhou, "Planar ultrawideband antennas with multiple notched bands based on etched slots on the patch and/or split ring resonators on the feed line," IEEE Trans. Antennas Propag., vol. 56, no. 9, pp. 3063-3068, Sep.2008.