Review Paper On Ultra Wideband Log-Periodic Antenna For Wireless Communication

Prateek Wankhade[1], Prof. Rajesh Nema[2]
Electronics & Communication, NIIST, Bhopal, Rajiv Gandhi Prodyogiki Vishvavidhyalaya

Abstract

Log-periodic array antennas have been investigated over a long period of time, the reason for the same being its provision of a constant radiation performance and good reflection coefficient performance over a wide frequency band, which can be considered as an important characteristic of this type of antennas. It created a high impact on development of new generation antennas with advanced features and wide range of applications. This paper reviews the performance analysis of Periodicity of the input impedance of log-periodic array antennas (2012), ultra wideband PLPDA with multiple notched bands (2011), Compact Ultra-Wideband Directional Printed Antenna with Notched Band (2010), Band notched UWB PLPDA Fed by HMSIW (2009). The paper also discusses the technology incorporated in order to bring about the required changes in terms of improved performance.

Keywords – Half mode substrate integrated waveguide (HMSIW), Printed log periodic dipole antenna (PLPDA), Ultra wideband (UWB), Compact printed log periodic dipole antenna (CPLPDA).

I. Introduction

Ultra wideband (UWB) wireless communication allows low power level and high data rate transmissions have embarked great research interests for wireless communications applications in the 3.1 GHz–10.6 GHz frequency band. High-performance UWB antennas require both good impedance matching and low signal distortion within the specified frequency bands. There have been many reported research works on ultra wideband antenna design. Monopole antenna is one of the typical examples, which can achieve very bandwidth with a simple geometry. However, the radiation pattern of the monopole ultra wideband antenna changes rapidly with frequency, which limits its practical applications. A significant difference between conventional radio transmissions and UWB is that, conventional systems transmit information by varying the power level, frequency, and/or phase of a sinusoidal wave. UWB transmissions transmit information by generating radio energy at specific time intervals and occupying a large bandwidth, thus enabling pulse-position or time modulation. Tapered slot antenna (or Vivaldi antenna) is another typical example of UWB antenna. It radiates or receives power in the end-fire direction using travelling-wave mechanism. The peak radiation is fixed and the radiation pattern is quite stable within the working frequency band. This property makes it, a good alternative for ultra wideband applications; however, the shortcoming of this kind of antenna is large size, generally it requires length of minimum three guided-wavelengths at the lowest working frequency. Printed log-periodic dipole antenna (PLPDA) also radiates in end-fire direction within ultrawide frequency band. With the multiple resonance property, its bandwidth can be increased by enhancing the number of the dipole elements.

Extensive research work is being carried out in the field of antennas. The development in the context of log periodic antenna is our focus area. The following review concentrates on the comparative study of four different research works; in a recent study J. Yang [1] made a theoretical analysis of periodicity for input impedance of a general finite log periodic array. Recent developments illustrate that a log periodic array is infinite at both ends, infinitely large at one end and infinitely small at the other end. In this case input impedance is periodic over the frequency. However in case of practical antennas, infinite log periodic antennas have to be shortened at both the ends, therefore periodicity cannot be maintained. To obtain the performance of such an antenna by numerical method need large computation time. J. Yang presents a method for input impedance of a general finite log periodic array antenna. This formula will help us in determining the input impedance at the higher frequencies by its value at lower frequencies with much less computation time [1]. In log periodic array there are three regions:-

Transmission line REGION (< $\lambda/2$)
Active REGION (= $\lambda/2$)
Stop REGION (> $\lambda/2$)

Figure 1 shows these regions. In transmission line region, elements do not radiate because the size of elements is less than the wavelength. Since the size of elements is equal to the wavelength therefore Active region allows its elements to radiate. Current induced from the active region to the stop region are of the same amplitude and 1800 out of phase, therefore no radiation will be observed in this region.

J. Yang [1] proposed a new periodicity theorem:-

$$Zin (f) = T^{(n)} (f, k) \ominus Zin (f/k^n)$$

Where,

$$T^{(n)} (f, k) = \begin{bmatrix} A^{(n)} & B^{(n)} \\ C^{(n)} & D^{(n)} \end{bmatrix} = \prod_{i=0}^{n-1} T_1 (f/k^{n-i})$$

Operation $\ominus$ means that,

$$T^{(n)} (f, k) \ominus Zin (f/k^n) = \frac{D^{(n)} * Z_{in}(f/K^n) - B^{(n)}}{A^{(n)} - C^{(n)} * Z_{in}(f/K^n)}$$

The new formula of periodicity theorem states that the input impedance of an LPA at a high frequency can be calculated by its value at a low frequency and the ABCD matrix of the first element over a band from the lower frequency to the higher frequency. J. Yang [1] demonstrates the improved performance of an eleven element antenna a by new periodicity theorem in figure 2.

In UWB PLPDAs with multiple notched bands [2]-[4], a section of HMSIW was integrated into the proposed antenna as an ultra-wideband balun in the feeding network and a reflector for the printed dipole array. The proposed PLPDAs with single and multiple notched bands were implemented simply by etching U-shaped slots on the antenna. Unlike the monopole antennas, the proposed PLPDAs radiate power in the end-fire direction. Stable radiation patterns are experimentally confirmed within the whole working frequency bands [2]. Chao Yu et al. [2] present the design structure of the PLPDA with a single notch, which gives the better understanding of the current distribution.

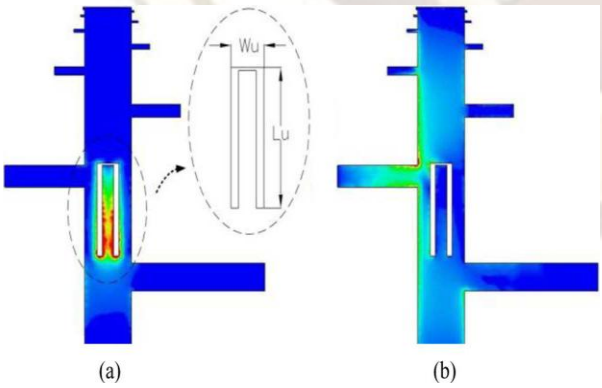

Fig. 3 Simulated current density distributions Of the PLPDA at different frequencies.(a) Notched frequency (5.8 GHz). (b) Working frequency (4.5 GHz).

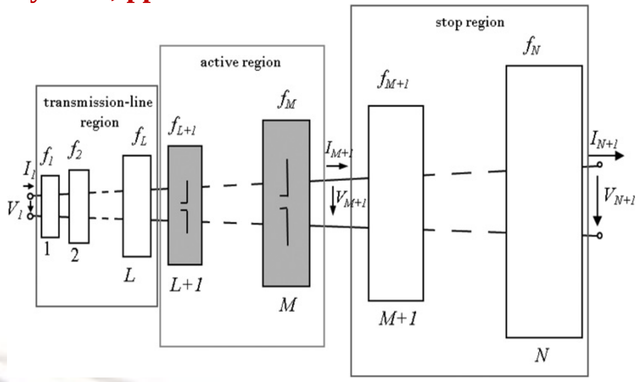

Fig. 1 Block diagram presentation of a general N-element cascaded LPA.

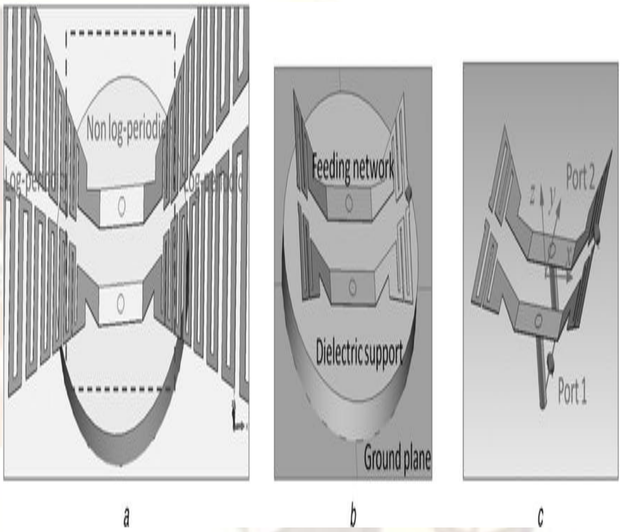

Fig.2. Feeding network of the 1–10 GHz Eleven feed modelled in CST MWS, which includes the first two non-log-periodic dipoles

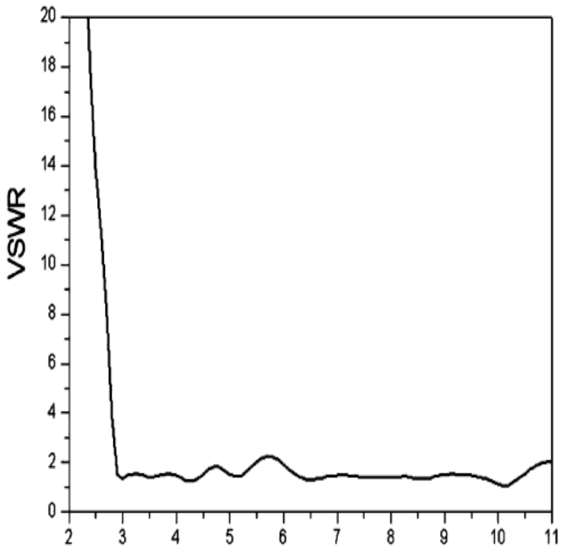

Fig.4 Simulated frequency response of VSWR of the PLPDA

U shaped slot introduced into the PLPDA. Notched frequency is 5.8 GHz and the working frequency is 4.5 GHz [2]. This shows the filter characteristics at the notched frequency 5.8 GHz. At this frequency most of the current distribution will be concentrated across the U shaped slot. Therefore no radiation will be observed. This characteristic will be very helpful in reducing the interference from the other systems which are also working in ultra wideband.

Further Chao Yu et al. [2] have introduced multiple notched bands into PLPDA, up to 4 notch bands have been introduced and corresponding performance of the antenna also demonstrated. Band notched properties are achieved with VSWR less than 2.

In the figure 6, we have depicted the filter characteristics with reference to varying number of notches into the PLPDA.

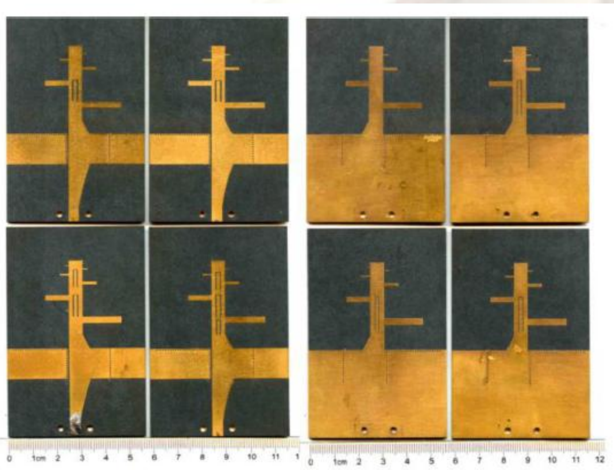

Fig. 5. Photographs of the fabricated PLPDAs with 1, 2, 3, and 4 U-shaped slots.

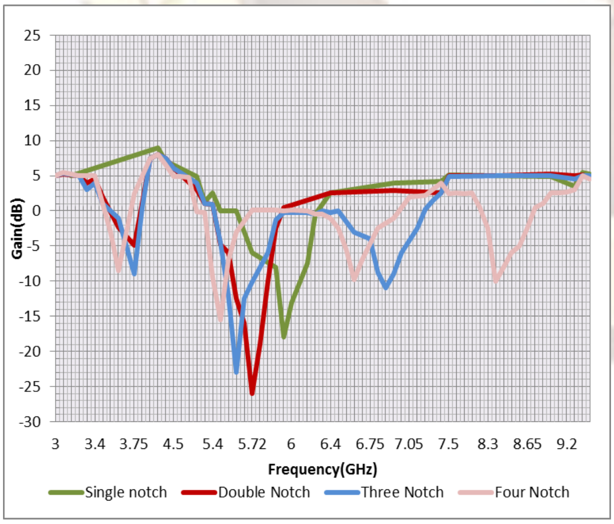

Fig. 6. Comparative analyses of Single Notch, Double Notch, Three Notch and Four Notch

Multiple notch implementations reduce the interference with the existing systems and allow us to make transmission without interfering with other systems. It is clear that we achieve maximum gain, more than i.e. 9 dB with minimum return loss i.e.-18 dB in single notch case. With these properties designed antenna would be much better but with multiple notch systems we can also get nearly good gain and less return loss and also multiple stop band characteristics can be implemented.

A compact UWB PLPDA with a notched band is presented in [3].The layout of this antenna is shown in figure 7. A section of HMSIW is integrated into the proposed antenna as an ultra-wideband balun in the feeding network [2]-[4]. The size is reduced by folding the dipole arms and loading capacitive rectangular patches, and a notched band is generated by etching a U-shaped slot on the antenna. The antenna radiates power in the end-fire direction. Stable radiation patterns are confirmed within the whole working frequency band. [3].

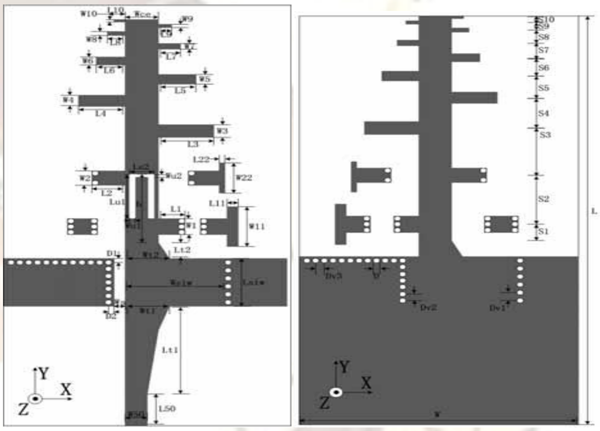

Fig. 7. Layout of the proposed antenna. (a) Top layer. (b) Bottom layer.

A compact printed log-periodic dipole antenna (CPLPDA) with single notched band is proposed for ultra-wideband (UWB) applications. The folded dipole technique is used in designing of the antenna which reduces the width of the largest dipole and capacitive rectangular patches are loaded at the end of the arms for further reducing the size [3]. A notched band is generated by introducing a U shaped slot into the CPLPDA [2]-[3]. The impedance bandwidth with VSWR less than 2 is from 3.1GHz to 10.6 GHz. Graph shows frequency response of the antenna, it covers 3.1 GHz to 10 GHz band. The value of VSWR is less than 2 except at the notched frequency band i.e.5.6 GHz depicted in figure 8.

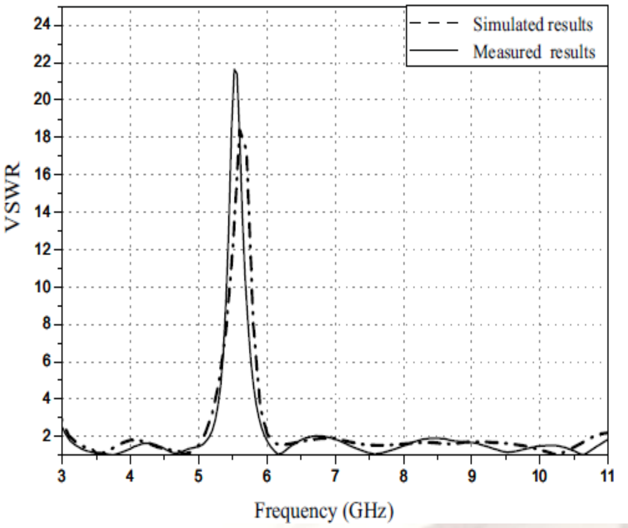

Fig. 8. Simulated and measured VSWR

The radiation pattern of the Compact Ultra Wideband Directional Printed Antenna with Notched Band is in the end fire direction and the average gain of the antenna is 7 dB.

A new band-notched UWB antenna in the category of directional antenna was successfully developed by Chao Yu et al. [4]. Antenna introduces the HMSIW as the feeding system [2]-[4]. With the advantages of HMSIW and PLPDA, the antenna can easily earn mass production with a low cost. By combining the L-shape slot with the proposed UWB antenna, the narrow notch band near 5.5GHz can be created to avoid interferences from other narrowband communication systems in 3.1 GHz to 10.6 GHz frequency band [4].

The antenna is fabricated on Rogers RT/Duroid 5880 substrate [2]-[4].Figure 9 shows the corresponding configuration. The proposed antenna in has dielectric constant ε_r=2.2, loss tangent tan δ=0.0009, and thickness h=1.5748mm. Log-periodic dipole antenna design is found and the scale factor τ=0.61 and spacing factor σ=0.155 are chosen in [2]-[4], which indicates that the number of dipole elements should be 10.

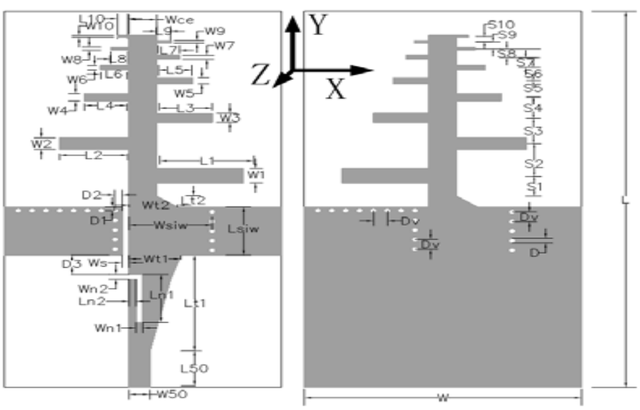

Fig. 9. The configuration of the antenna

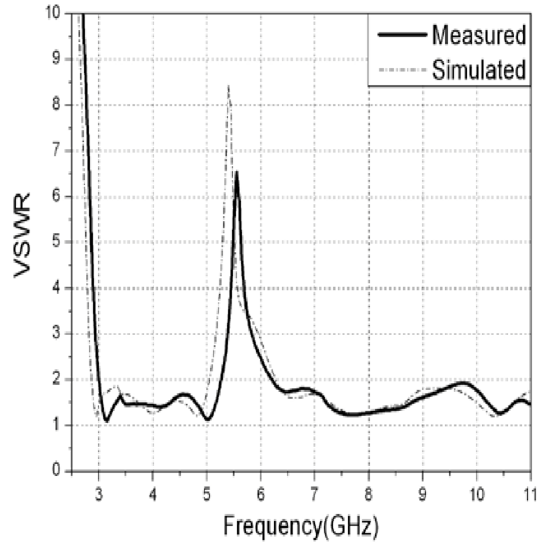

Fig. 10. Measured and Simulated VSWR

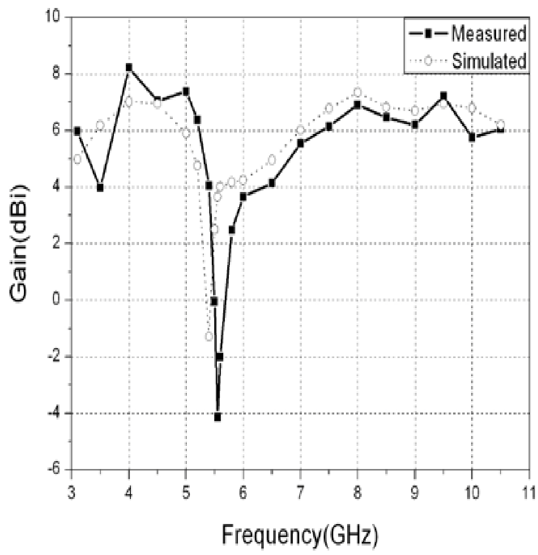

Fig. 11. Measured and simulated gain

Figure 10 and 11 shows that VSWR is less than 2 in the 3.1 GHz to 10.6 GHz frequency band except 5.25 GHz to 6.2 GHz at the notched frequency band and the average gain is 7 dB with -4 dB return loss corresponding to notch frequency. Antenna with L shaped slot indicates good directivity and proves it a good alternative for the category of directional antennas.

II. Conclusion

This review provides an insight in determining the performance of the large LPA antenna. The input impedance at the higher frequencies can be determined with much less computation time by its value at the lower frequencies. It was also inferred that by introducing slot of different shapes (U-shape and L-shape), we can avoid interference near their corresponding band notch frequencies. Folding of dipole arms and loading rectangular patches is helpful in reducing the size of the antenna. This also helps in exploring the filter characteristics.

REFERENCES

[1] J.Yang "Periodicity of the input impedance of log-periodic array antennas" IET Microw. Antennas Propag. 2012, Vol. 6, Issue 10, pp. 1117–1122, ISSN 1751-8725.

[2] Chao Yu, Student Member, IEEE, Wei Hong, Senior Member, IEEE, Leung Chiu, Member, IEEE, Guohua Zhai, Chen Yu, Wei Qin, and Zhenqi Kuai "Ultrawideband Printed Log-Periodic Dipole Antenna With Multiple Notched Bands" IEEE Transactions On Antennas And Propagation, Vol. 59, No. 3, March 2011, pp. 725-732.

[3] Tao Jiang, Wei Hong, Senior Member, IEEE, and Zhenqi Kuai "Compact Ultra-Wideband Directional Printed Antenna with Notched Band" CJMW2011 Proceedings, 2010.

[4] Chao Yu, Wei Hong, Chen Yu, Zhen Qi Kuai, Wei Qin "Band-notched UWB Printed Log-Periodic Dipole Antenna Fed by Half Mode Substrate Integrated Waveguide" The 2009 International Symposium on Antennas and Propagation, pp.496- 499, October 20-23, 2009.

[5] Yan Zhang, Wei Hong, Chen Yu, Zhen-Qi Kuai, Yu-Dan Don, and Jian-Yi 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 Transactions On Antennas And Propagation, Vol. 56, No. 9, pp. 3063-3068, September 2008.

[6] Shih-Yuan Chen, Member, IEEE, Po-Hsiang Wang, and Powen Hsu, Senior Member, IEEE "Uniplanar Log-Periodic Slot Antenna Fed by a CPW for UWB Applications" IEEE Antennas and Wireless Propagation Letters, Vol. 5, pp. 256-259, 2006.

[7] The-Nan Chang and Min-Chi Wu "Band-Notched Design for UWB Antennas" IEEE Antennas and Wireless Propagation Letters, Vol. 7, Pp. 636-640, 2008.

[8] Giovanni Andrea Casula, Paolo Maxia, Giorgio Montisci "Design of a Printed Wide Band Log-Periodic Antenna Dipole Array with a New Feeding Technique" 6th European conference on Antennas and Propagation (EUCAP), pp. 1882-1884, 2011.