International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

Multiband Log Periodic Microstrip Antenna for UWB Applications

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Abstract: *This paper presents design of Multiband Log-Periodic Microstrip Antenna for UWB Applications. The proposed structure is a log-periodic antenna on both top and bottom layers of substrate with eleven rectangular patches arranged with different scaling factors so as to achieve the wide band characteristics. The increasing sizes of the rectangular patches are introduced so as to increase the gain with reduced coupling losses. The structure is designed over FR-4 Substrate with the relative permittivity of 4.4 having a thickness of 1.6mm. The proposed design reports a bandwidth of 2.6 GHz operating from 2.4 Ghz-5 GHz with a Return loss greater than -10dB and VSWR values less than 2. The structure offers a gain of 3.1 dB. The structure is analysed with different coupling gaps between the patches and the feed line on different substrates. The simulation of the design is carried out using Ansys HFSS 19.0 and the prototype of the same has been fabricated. The results of the both are compared and it is observed that the similarities between them have been achieved and the results of the same have been reported. The micro-strip medium here has both top and bottom layers to create broadband configuration using log-periodic structure. The size of the patches increases as goes on to achieve selective bandwidths. The return loss along the band of 2.4GHZ to 10.6GHZ, of which it covers the Ultra Wideband frequency. Key Words: Broadband antennas, Log-Periodic antennas, Microstrip antennas, Ultra Wideband (UWB) antennas.*

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1. INTRODUCTION

Now-a-days, there are currently increasing demands for novel ultra wideband (UWB) antennas with low-profile structures, constant directional radiation patterns, and radiation in broadband for both military and commercial applications [1], [2]. Microstrip antennas have some attractive merits like very low-profile and broadside radiation patterns with medium gains, which have been considered as excellent conformal radiators for a long time [3]. However, a traditional single-element microstrip antenna has inherently narrow impedance bandwidth. Before start designing the wide-band and UWB antennas, the design principles, procedures, and antennas' characteristics should be considered and known. Moreover, the microstrip antennas' design techniques, different structures and shapes [3] – [6], analysis, and feeding methods apply to improve the antennas' characteristics and performances. Series-fed log-periodic microstrip antennas were firstly introduced for bandwidth enhancement. After that, other feeding structures like –microstrip feeding, direct feeding, slot-coupled feeding, inset feeding for LPMAs were also reported [10]. This article provides the state of the art on the field of UWB antennas designed for wireless communication applications.

A UWB traveling-wave LPMA was usually terminated by a matched load to absorb the terminal energy and prevent reflections from the end of feeding line, which could improve its impedance matching and radiation patterns considerably at the band edge. A large scale factor as 1.1 for UWB LPMAs is firstly reported and discussed [6]. A novel loss-free compensating stub is also proposed for the termination and bandwidth enhancement of the proposed antenna [7], the configuration of the proposed LPMA is described in this. It concludes research insight for future research directive suggestions such as how loading can affect and improve the BW for wide-band and UWB antennas and how it can keep the antenna dimensions miniaturized while the antenna characteristics are not affecting a lot [8], [9]. To design and apply the UWB antenna, the related working BW should be considered according to the Federal Communications Commission (FCC) and the required frequency bandwidth area. A comprehensive review of recent scientific articles was presented in this paper to provide antenna designers a valuable tool in their designing process and showing techniques in widening BW. This antenna will be operated in broadband. This paper was emphasized mostly on antenna geometries, radiation characteristics, widening BW techniques, materials, and numerical tools applied to design the antennas.

This communication presents a multiband transmission line coupled log periodic microstrip antenna for UWB applications. A novel loss-free compensating stub is also proposed for the termination and bandwidth enhancement of the proposed antennas. The introduction of this paper is presented in Section I. The design approach of the proposed antenna is described in Section II. Evolution of design is presented in Section III for better understanding of this antenna, while the simulated and measured results are presented and discussed and also compared in Section IV. This entire paper is concluded in Section V.

2. ANTENNA DESIGN APPROACH

In this, the proposed antenna is designed overFR4 substrate with a relative permittivity of 4.4 and the thickness of the sheet is 1.6 mm. The antenna is 120mmx80mm. This is composed of one input port along with 100Ω resistor connecting the transmission line.

Next the patches are separated in log periodic structure, along with gap g that is between the rectangular patches.

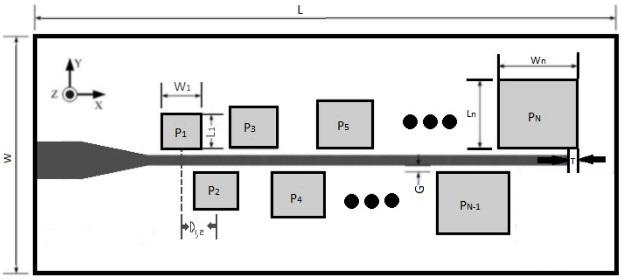


Fig. 1Structural configuration of the proposed antenna

For better results the log periodic patches are moved in different directions, placed in different positions so to make the antenna radiated in different bandwidths providing broadband. The log periodic structure is as shown in fig. with all its dimensions mentioned in the below table.

Table -1: Dimensions Log Log Periodic Antenna

n	11	$D_{1,2}$	13 mm
L	120 mm	W	80 mm
L1	13 mm	W1	15 mm
G	0.2 mm	T	4 mm

3. EVOLUTION OF DESIGN

In this section we make out the design of Log Periodic Antenna [10].

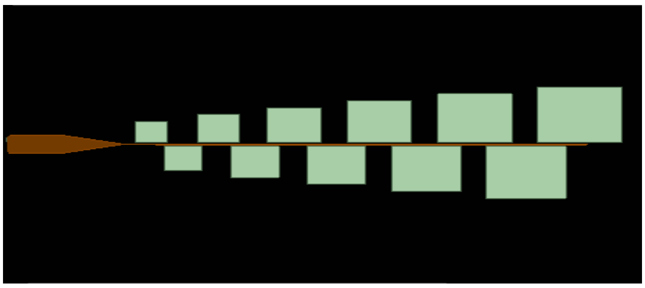


Fig. 2 Log Periodic antenna with gap g = 0.4 mm

Initially, there will be some coupling gap g = 0.4 mm, which is referred as "under coupled" which was made to consider every result particularly and by simulated this gives results as shown in figure.

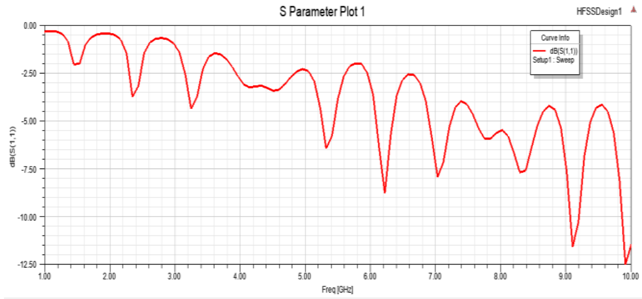


Fig. 3 Simulated return loss of log periodic antenna with coupling gap g=0.4 mm

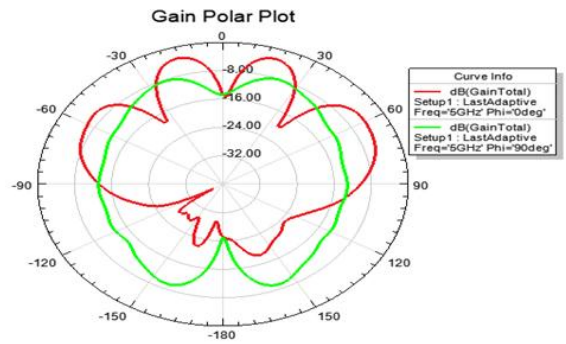


Fig. 4 Simulated polar plot of log periodic antenna with coupling gap g=0.4 mm

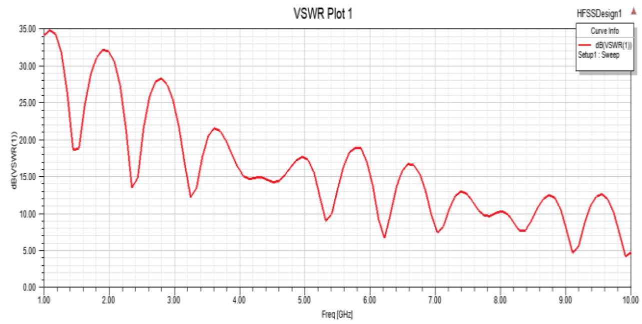


Fig. 5 VSWR plot

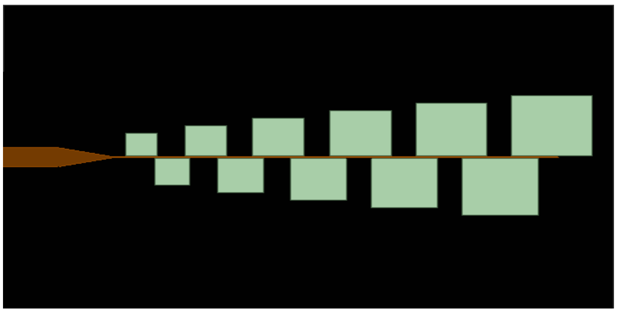


Fig. 6 Log Periodic antenna with gap g = 0.2 mm

In the second case coupling gap g = 0.2 mm, which is referred as "critical coupled" which shows similar results combining both for g = 0.2 mm, 0.4 mm as compared with the proposed designed antenna.

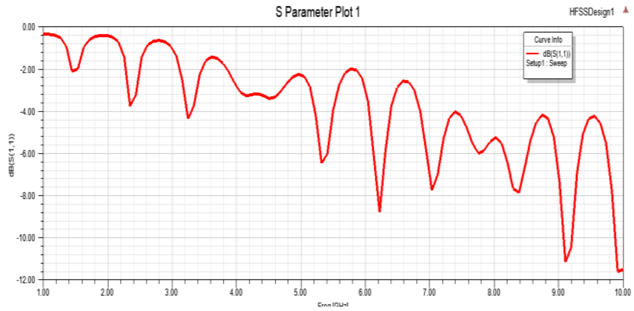


Fig. 7 Simulated return loss of log periodic antenna with coupling gap g=0.2 mm

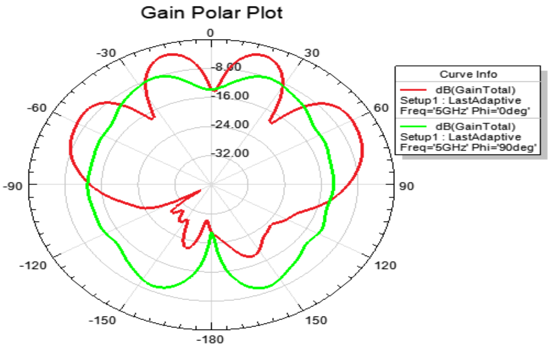


Fig. 8 Simulated polar plot of log periodic antenna with coupling gap g=0.2 mm

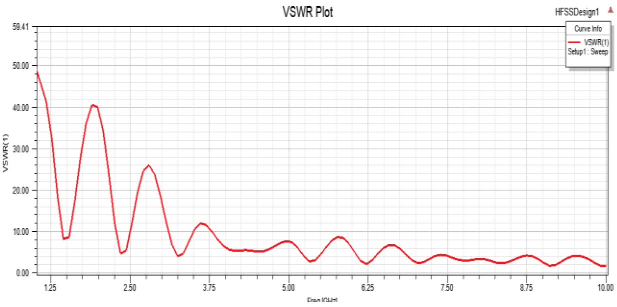


Fig. 9 VSWR plot

For improving these results, the coupling gap is reduced and the patches will be integrated with microstrip patch line as shown in figure.

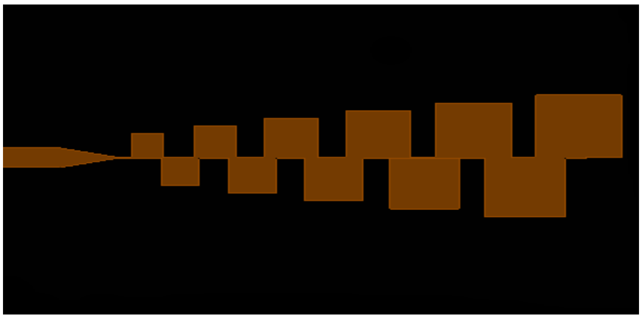


Fig. 10 Design of proposed log periodic antenna

This design is finalized as the return loss we have got is lesser than -10.00 db. Also because of improved bandwidth, from range of to which are useful in many applications.

4. DISCUSSION OF RESULTS

The modified Multiband Log Periodic microstrip antenna is demonstrated and results are discussed. Simulations of this are performed on commercially available tool, Ansys HFSS version 19. This is popular for simulating high-performance fields based on finite element method(FEM) which is used for solving any 3D geometry mostly at high range frequencies.

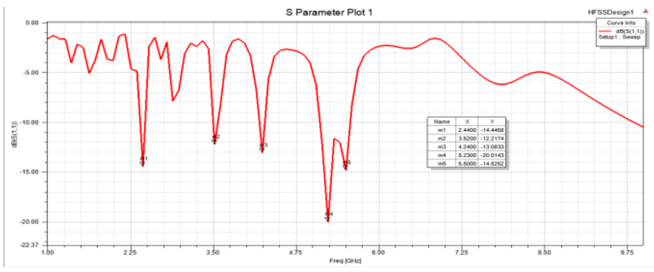


Fig. 12 Simulated S-Parameters of log periodic antenna

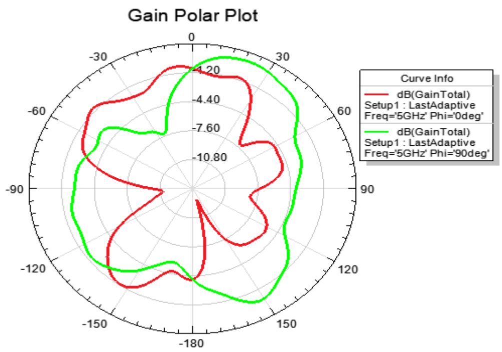


Fig. 13Polar Plot

The VSWR of the simulated antenna which we have got is lesser than 2 and it approximates to unity as shown below which makes the designed antenna efficient.

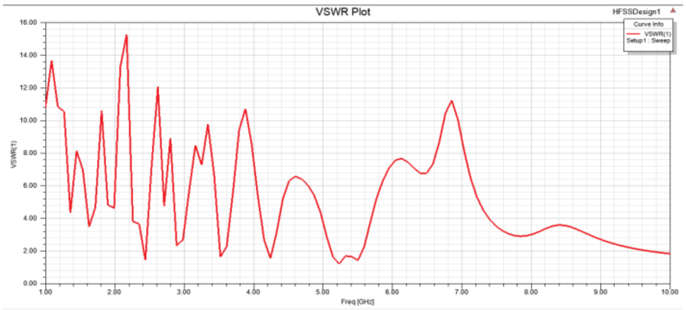
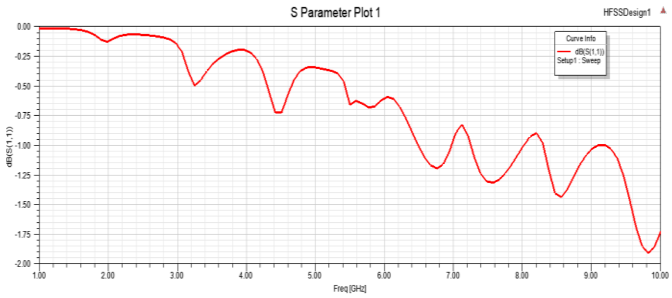


Fig. 14 VSWR (Voltage Standing Wave Ratio) Plot

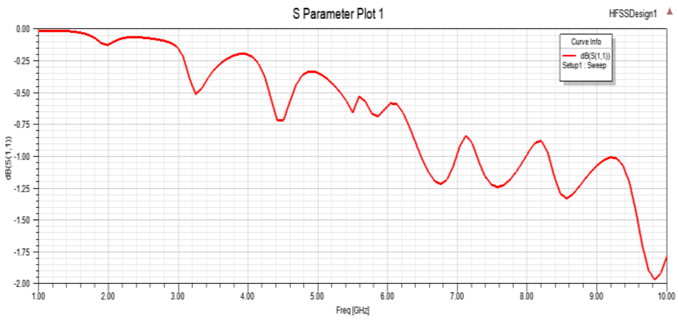
The above figures show the log periodic and return loss characteristics of broadband and it shows the antenna is radiated from 2.4 GHz.

The antenna shows a most effective gain of about 3.1 dB, and provides directivity which will be operated in ultra wideband frequency.

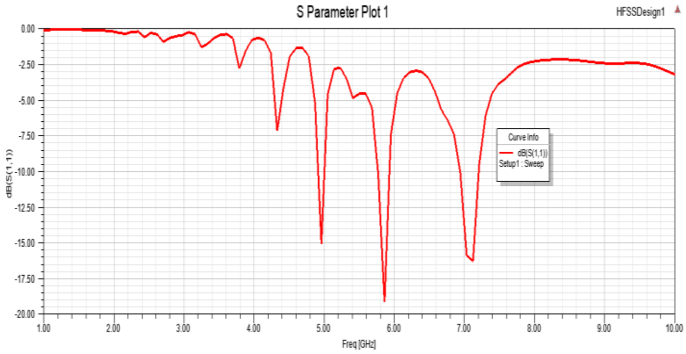
N we are comparing the results with a different substrate to make sure that our simulated results are efficient, both for fabrication and also simulation. The substrate used to compare the results is Teflon with a relative permittivity of 2.1. The following are the results that are simulated by using HFSS software.



(a)



(b)

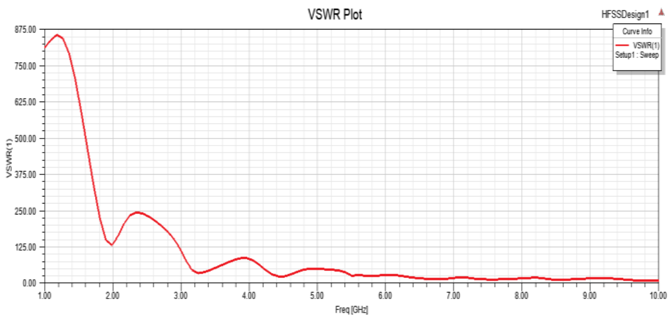


(c)

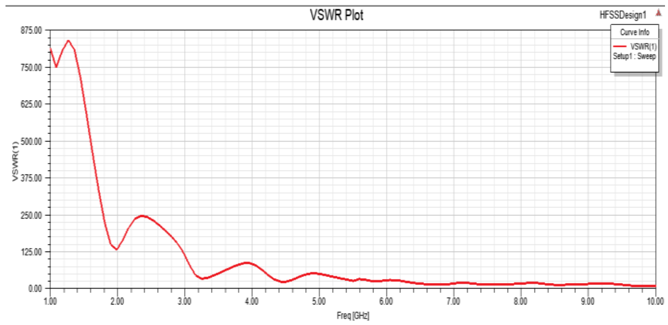
Fig. 15 Simulated return loss of log periodic antenna using Teflon substrate with coupling gaps (a) g=0.4 mm, (b) g=0.2 mm, (c) g=0 mm

As clearly observing the return loss, the return loss compared with the FR4 substrate is better than the Teflon substrate, in addition to this FR4 is less economical compared with Teflon.

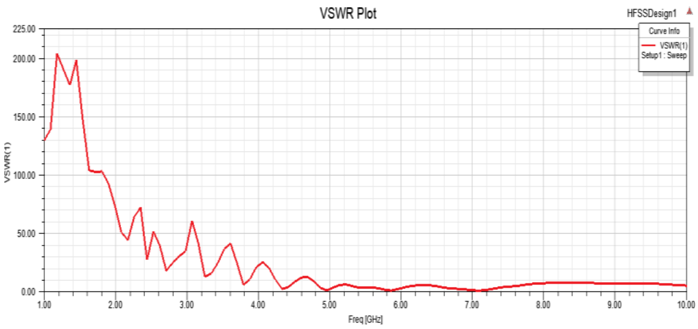
Now VSWR (Voltage Standing Wave Ratio) graphs of the Teflon material is shown below which shows poor results when compared with the FR4 substrate material. The following are the simulated VSWR's of Teflon material with different coupling gaps.



(a)

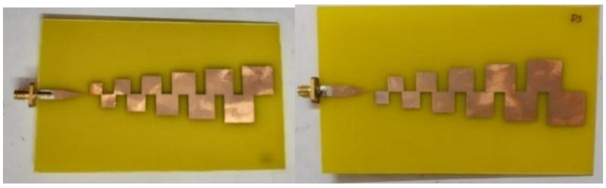


(b)



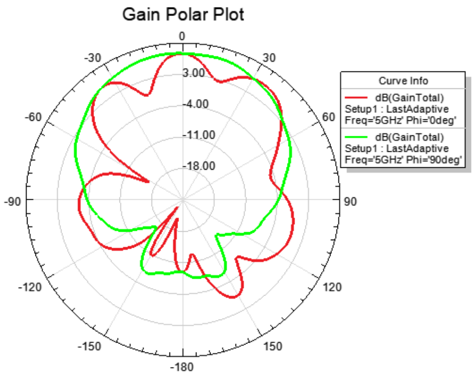
(c)

Fig. 16 Simulated VSWR of log periodic antenna using Teflon substrate with coupling gaps (a) g=0.4 mm, (b) g=0.2 mm, (c) g=0 mm

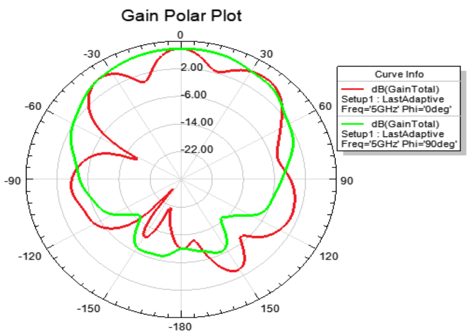


(a) (b)

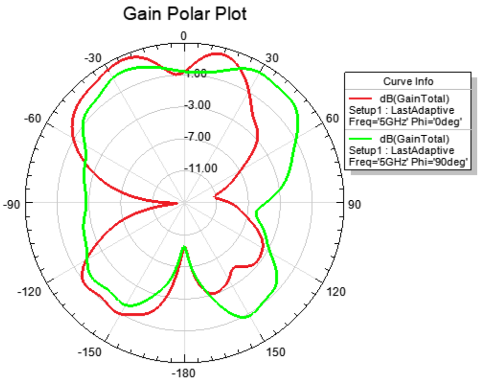
Fig. 17 (a) top view of antenna, (b) bottom view of antenna



(a)



(b)



(b)

Fig. 18 Simulated Polar Plot of log periodic antenna using Teflon substrate with coupling gaps (a) g=0.4 mm, (b) g=0.2 mm, (c) g=0 mm

The above plot shows 2D polar plots of log periodic antenna using Teflon as the substrate with different coupling gaps.

Table -2: Dimensions Log Log Periodic Antenna

Substrate	Bandwidth	Gain	VSWR
Teflon (g=0.4 mm)	-	-8.9	< 3.5
FR4 (g=0.4 mm)	9.02-10 GHz	-9.4	< 5
Teflon (g=0.2 mm)	-	-1.1	< 3
FR4 (g=0.2 mm)	9.04-10 GHz	-2.6	<3
Teflon (g=0 mm)	4.9-7.3 GHz	6.1	< 2.5
FR4 (g=0 mm)	2.4-5.6 GHz	3.1	< 2

As shown in the above table the comparison of different substrates with different coupling gaps g, the antenna parameters shown in the range of UWB frequencies, the null blank shows that the antenna is not radiating over UWB.

5. CONCLUSIONS

A multiband log-periodic microstrip antenna for UWB applications was presented. Furthermore, instead of using an absorbing terminal loading, a novel loss-free compensating stub was also proposed. The impedance bandwidth (with measured VSWR < 2) of the example antenna with only 11 elements is from 2.44–5.56 GHz. Both numerical and experimental results show that the proposed antenna will be operated in some portion of the UWB, very low-profile and low fabrication cost, which are suitable for various broadband applications.

ACKNOWLEDGEMENT

The authors would like to acknowledge the RF & MWE group, Department of E.C.E, Vardhaman college of Engineering, Hyderabad for granting the permission to use the available simulation environment Ansys- HFSS and testing facilities to produce the results

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