Volume 25 Issue 04, 2022 ISSN: 1005-3026 https://dbdxxb.cn/ Original Research Paper

INVESTIGATIONS OF PRINTED LOG PERIODIC DIPOLE ARRAY ANTENNA WITH DIFFERENT SUBSTRATE MATERIALS

Swetha Velicheti[1], Santosh Pavada[2], Dr. P.Mallikarjuna Rao[3], Dr. M.Satya Anuradha[4]
1, 2,3,4- Dept. of ECE, AUCE, Visakhapatnam, India
Email: swethaphd7@gmail.com

Abstract: LPDA antennas are introduced for the development of broad band applications. A printed log periodic dipole array (PLPDA) antenna using substrates FR4, RT5880 and ARLON is reported in this research. Among 3 substrates, PLPDA with FR4 provides wide bandwidth of 2.75GHz. The designed PLPDA antenna with FR4 exhibiting end-fire radiation over the frequency range of 2.12GHz to 4.87GHz. The peak gain of the designed model is 6.9dBi with VSWR ≤ 2 over the whole operating band. The CST Microwave Studio Suite 2019 is used to design and model the antenna and the corresponding performance characteristics are presented at the end.

Keywords: PLPDA, FR4, RT5880, ARLON.

1. Introduction

LPDA antenna is a multi-element, directional antenna intended to operate across a wide frequency range. D. E. Isbell and R. Du Hamel first introduced it in 1957 [1], and Carrel later developed it in 1961 [2]. Planar log-periodic dipole array (LPDA) antennas have found widespread use in a variety of communication applications due to their wide bandwidth, high gain, and planar profile [3–4]. Later, the fundamental design of a strip line LPDA antenna provided by Campbell was modified successively by a number of researchers to enhance the antenna performance in terms of a broad bandwidth, a small size, an enhanced F2B ratio, a low cross-polarisation level and greater gain[5-7].

In this work, a planar LPDA antenna with different substrate materials is considered, design simulations are carried out and the same are compared. The subsequent sections deal the design of the proposed LPDA followed by the simulation results and measured results.

2. Antenna design

Initially, a standard planar LPDA antenna is designed with FR4 substrate for 2 to 4 GHz frequency band with the help of familiar formulas of standard LPA [8]. Then it is implemented with other substrate materials such as RT5880 and ARLON. The computed design specifications of the conventional LPDA antenna are provided in table-1 & 2 and the corresponding design is shown in fig 1.

Submitted: 08/11/2022 **Accepted**: 27/11/2022

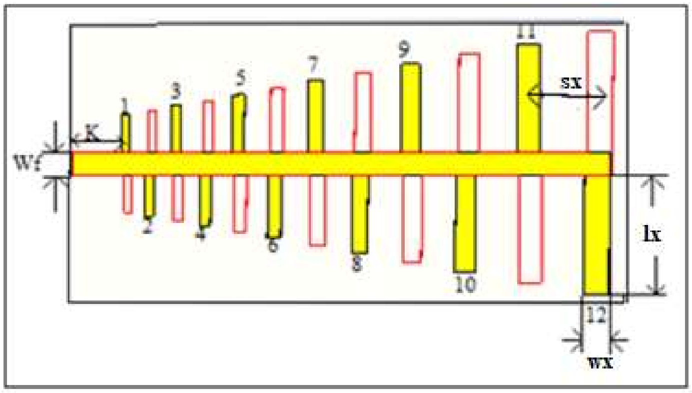


Fig 1. Conventional LPDA

Table 1: Conventional antenna Description

Number of elements (N)	12
Feed width (wf)	4.24mm
Scaling factor(τ)	0.9
Spacing factor(σ)	0.166
Height of the substrate (h)	1.6mm
total dimension of the antenna	52.04 mm x 108.413 mm
Substrate	FR4, RT5880 & ARLON

Table 2: Dimensions of dipoles of the Conventional LPDA

n	lx (mm)	wx (mm)	sx (mm)	n	lx (mm)	wx (mm)	sx (mm)
1	7.02	1.53	4.67	7	13.22	2.88	8.79
2	7.81	1.7	5.19	8	14.69	3.2	9.77
3	8.67	1.89	5.76	9	16.32	3.55	10.85
4	9.64	2.1	6.41	10	18.14	3.95	12.06
5	10.71	2.33	7.12	11	20.16	4.39	13.4
6	11.9	2.59	7.91	12	22.4	4.88	--

3. Simulation Results

The simulation results of the designed antenna are acquired by using CST Microwave Studio. The corresponding results such as Reflection coefficient, VSWR, E-plane & H-plane patterns and Antenna gain for the PLPDA with FR4, RT5880 & ARLON substrate materials are shown in Figs 2,3,4,5 respectively.

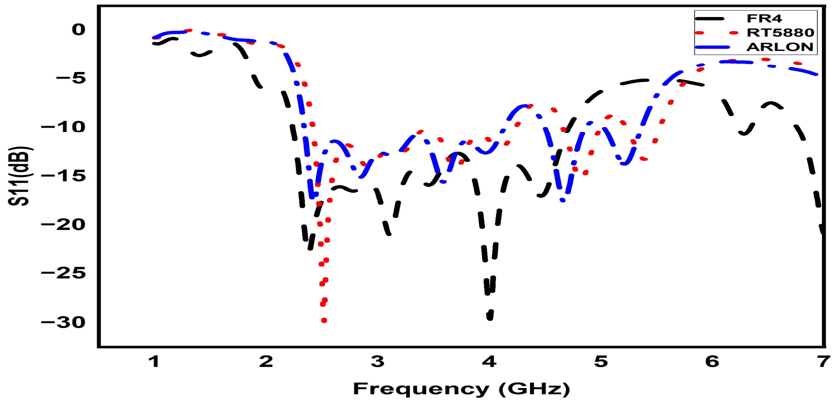


Fig 2. Reflection coefficient of conventional LPDA

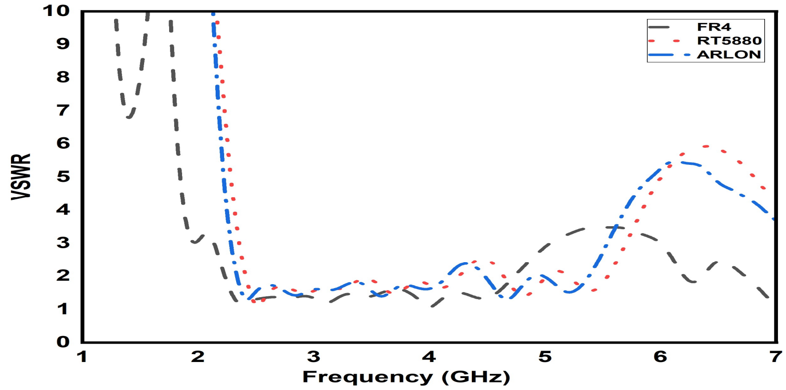


Fig 3. VSWR of conventional LPDA

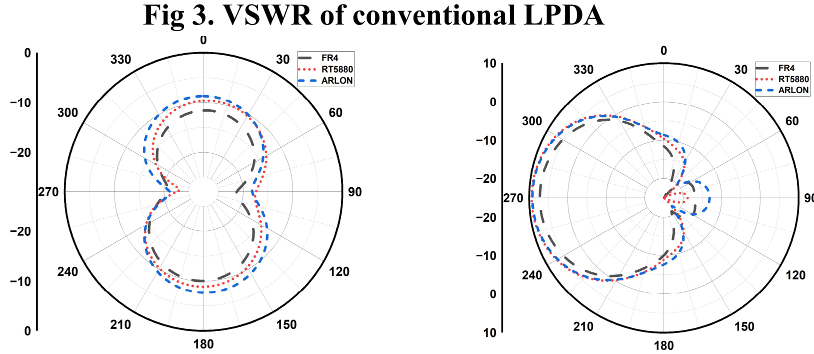


Fig 4. E & H plane radiation patterns at 3GHz

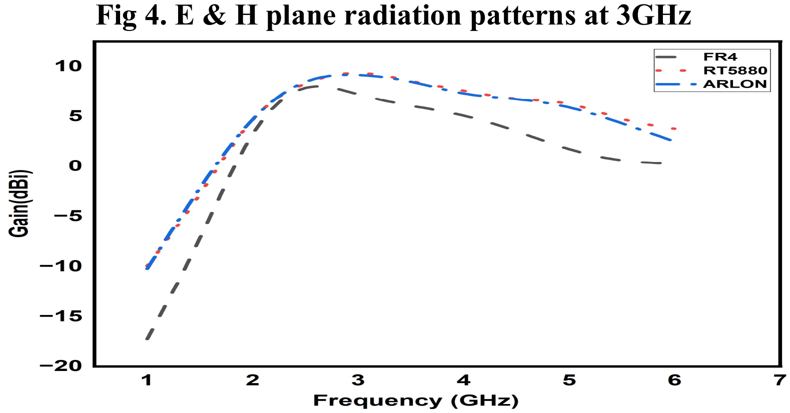


Fig 5. Gain Vs Frequency plot

Table 3: Comparison of printed LPDA antenna with different substrate materials

S.no	Substrate material	Operating frequency band	VSWR	Bandwidth (GHz)
1	FR4	2.24 GHz to 4.73 GHz	≤ 2	2.49
2	RT5880	2.4 GHz to 4.2 GHz	≤ 2	1.8
3	ARLON	2.3 GHz to 4.14 GHz	≤ 2	1.84

Table 3 shows the performance comparison of printed LPDA antenna with different substrate materials. From the results it shows that printed LPDA with FR4 substrate material exhibits better performance in terms of Reflection coefficient, VSWR and bandwidth compared to other substrate materials.

4. Fabrication and Measurement:

The proposed model is fabricated on FR4 substrate with 1.6mm thickness. Prototype and measurement setup of the Proposed LPDA are shown in fig 6. The measured and simulated reflection coefficient and VSWR of the proposed antenna are shown in fig 7(a) & (b). Table 4 shows the corresponding values of simulated and measured results of the proposed LPDA. It shows that measured results are good agreement with simulation results.

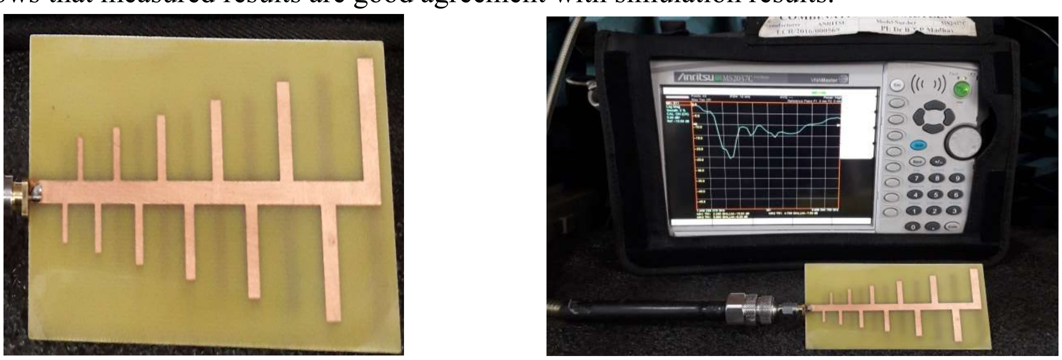
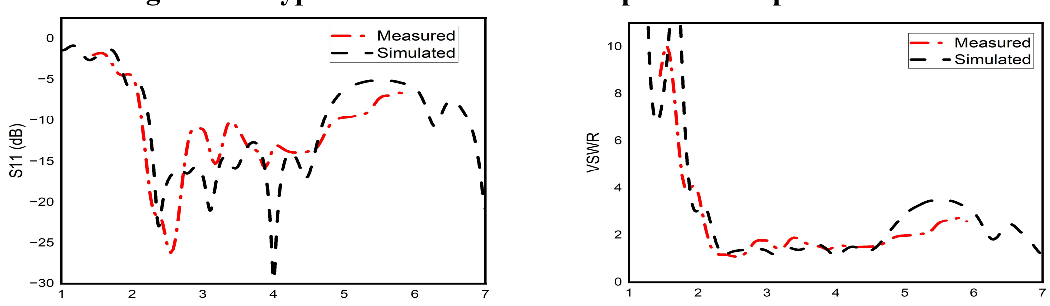


Fig 6. Prototype and measurement setup of the Proposed LPDA



(a) (b)

Fig 7. Measured and simulated Reflection coefficient and VSWR of the Proposed LPDA

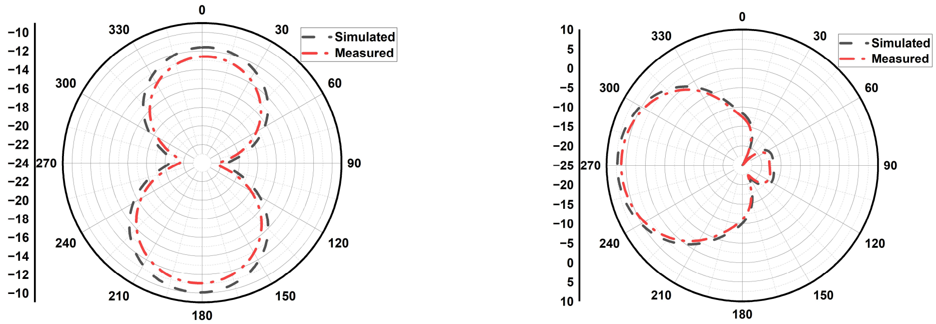


Fig 8. Measured and simulated E & H plane radiation patterns of the Proposed LPDA

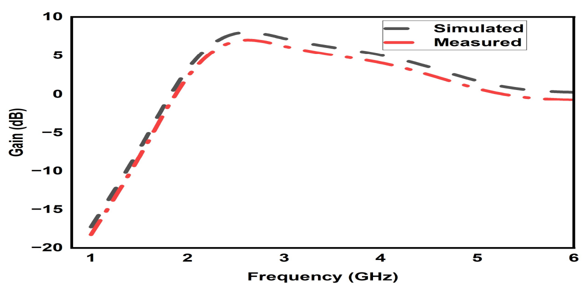


Fig 9. Measured and simulated Gain of the Proposed LPDA

Table 4: Simulated and measured results of proposed LPDA

S.no	Antenna type		Operating frequency band	Reflection Coefficient (dB)	Bandwidth (GHz)	Peak Gain (dBi)	Dimensions
1	Conventional LPDA	Simulated	2.24 GHz to 4.73 GHz	-29	2.5	7.7	52.04 mm x 108.413 mm.
		Measured	2.12 GHz to 4.87 GHz	-25.63	2.75	6.9	

Conclusion:

In this work a printed LPDA antenna with different substrate materials such as FR4, RT5880 and ARLON is designed for broadband (S-band) applications. The performance characteristics such as reflection coefficient, gain, VSWR and radiation patterns of the designed antenna have been simulated for all the three substrate materials and their results are presented in table 3. The printed LPDA with FR4 substrate have S_{11} of below -10 dB over the entire frequency band from 2.12GHz to 4.87GHz and maintains VSWR ≤ 2. The designed model with FR4 has a wide bandwidth with a value of 2.75GHz and a peak gain of 6.9dBi. From the results it shows that the printed LPDA with FR4 substrate offers better performance characteristics than the other two substrate materials and the measured results are in good correlation with simulation results. Therefore, the proposed antennas can be used in WLAN, LTE, WiMAX, and Wi-Fi applications.

References:

[1] DuHamel, R. H., & Isbell, D. E. (1957). Broadband logarithmically periodic antenna structures. *IRE Natl. Convention Rec. Pt*, *1*, 119–128.
[2] Carrel, R. (1961). The Design of log-periodic dipole antennas. *IRE Int. Conv. Rec*, *IX, pt. 1*, 61–75,.
[3] Campbell, C., Traboulay, I., Suthers, M., et al.: 'Design of a stripline logperiodic dipole antenna', IEEE Trans. Antennas Propag., 1977, 25, (5), pp. 718–721, ISSN: 0018-926X.
[4] Pantoja, R., Sapienza, A., Filho, F.M.: 'A microwave printed planar log periodic dipole array antenna', IEEE Trans. Antennas Propag., 1987, 35, (10), pp. 1176–1178, ISSN: 0018-926X).
[5] P. Alakananda, G. Inderjeet, An analysis of log periodic antenna with printed dipoles, IEEE Trans. Antennas Propag. AP-29 (2) (1981) 114–119.
[6] P.R. Pantoja, A.R. Sapienza, F.C. Medeiros, A microwave printed planar log periodic dipole array antenna, IEEE Trans. Antennas Propag. AP-35 (10) (1987) 1176–1178.
[7] N. Galchenko, Sergey Vartanyan, ''Development of electromagnetic methods of printed dipole antenna design," in: International Conference on Mathematical Methods in Electromagnetic Theory – MMET '98, Vol. 2, 562–564, 1998
[8] Balanis, C. A. (2016). *Antenna theory: Analysis and design* (4th ed.). Hoboken, NJ: Wiley-Blackwell.