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Design of Log Periodic Dipole Array with FEM and FDTD Based Analysis for GSM, PCS, Industry Standard Medical and Wi-Fi Communication Applications

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ABSTRACT

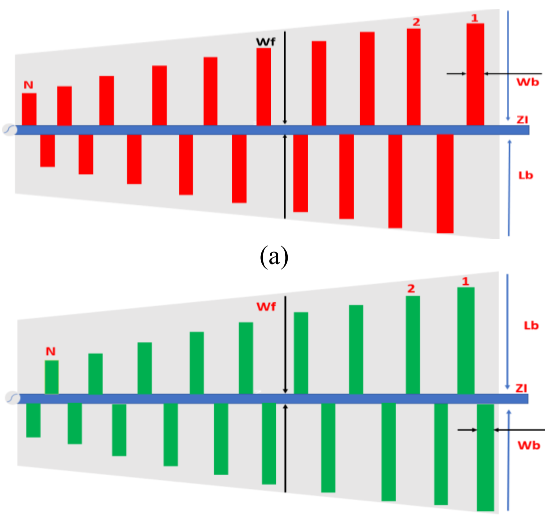
There is a need of low profile and multiband antennas in various fields of wireless communication lower band applications. Suitable gain with higher data rates for future communication modules in compact range is most challenging for design engineers. In this paper, Log Periodic Dipole Array antenna was designed and proposed for frequency range from 900 MHz to 2.6 GHz, operating frequency for the proposed antenna is 0.9 GHz (GSM), 2.1 GHz (PCS) and 2.4 GHz Industry standard Medical (ISM) and Wi-Fi applications. The modelled antenna constructed on FR4 substrate with height of 1.6mm, and analysed with electromagnetic simulation software like Magus, CST (Computer Simulation Technology) and HFSS (High Frequency structure simulator) tools. The proposed antenna has advantages like wideband, simple design, antenna results indicate the reflection coefficient value below -10dB for whole band from 900 MHz to 2600 MHz. The proposed antenna showing overall gain of 6 dB. Several antenna parameters are evaluated in Finite Element Method (FEM) and Finite Difference Time Domain (FDTD) and provided comparative analysis in this work.

1. INTRODUCTION

The fast advancement in communication system has expanded the need of wide data transmission. Regardless of its massiveness Log Periodic Dipole Array antenna is utilized to satisfy wide transmission capacity and high addition prerequisite. LPDA is equipped for chipping away at High frequency, extremely high frequency and super high frequency. Log periodic antenna was concocted by Dwight E. Isbell and Raymond Duhamel was authorized by Urbana Champaign at University of Illinois. The principal creation of this sort of antenna was to expand the helpful frequency band of UHF and VHF antenna. LPDA antenna is a dipole antenna with longest dipole fills in as reflector and progressive dipoles go about as chiefs. Data transmission is improved by adding the quantity of dipoles. All dipoles in LPDA are dynamic components resonate at its specific community frequency gave that the dipole length ought to be half of the frequency. The longest dipole resonates at least frequency and briefest dipole resounds at most elevated frequency. Printed microstrip antennas are low in cost, minimal, lightweight and compact size. In 2018, 2 to 18 GHz conformal and low-profile log periodic antenna on barrel shaped conductor is planned. It utilizes monopoles of various height for the high band, collapsed formal hat monopoles for the low band and formal hat shaped monopoles for the center band. The formal hat's help to accomplish a position of safety of the monopoles while the collapsing is to keep a decent information obstruction at the low band. At base miniature strip line is utilized to take care of the exhibit [1]. A printed log occasional monopole antenna is planned and created in 2018. 12 monopoles are planned on single side of substrate, working from 8.4 to 14.6 GHz frequency reach and this antenna is created utilizing standard circuit board measure [2]. In 2011, a super wide band log intermittent antenna is arranged having many indented groups. This indent antenna is intended for transfer speed 3.1 GHz to 10.6 GHz. A few antennas were intended for frequencies of 3.5 GHz, 5.5 GHz, 6.8 GHz and 8.5 GHz [3]. In 2014, high increase log occasional antenna was planned utilizing Taguchi introduced intrusive weed advancement. What's more, this streamlining is utilized to shift the principal flap somewhat from flat plane and for invalid filling under the fundamental projection [4]. Mistry et al. [5] have planned an LPA which has 12 dipoles. The working scope of these antenna is 0.8 GHz to 2.5 GHz. The remarkable thing done in this antenna is that the substrate thickness of epoxy FR4 material is 1mm. Furthermore, ordinarily the thickness of substrate is 1.6 mm. Furthermore, the feed line utilized is 1 mm. A low-profile dual band antenna constructed for WLAN application stated in ref. [6] where the slots are placed in the antenna in which PIN diodes are placed for reconfigurability. A circularly energized 2x2 notched array of circular patch antenna [7] exhibited to work at WLAN applications. Proposed antenna is showing acquire than 13 dB and axial ratio proportion transfer speed of 15% in the working band. The proposed Sierpinski fractal opening antenna [8] capacities in multiband frequencies subsequently this antenna can be used in numerous correspondence advancements like Wi-Fi, WiMAX and WLAN. The parametric investigation is too performed and investigated in this paper. This antenna has a compact size a where the quantity of working frequencies and the increase of the proposed antenna is higher than the reference antenna. Likewise, the proposed antenna capacities in various frequencies not at all like other reference antennas which have either single frequency or double frequency of activity. The square fractal log periodic antenna [9] was designed for UWB application which showing stable gain in desired band. The size of the antenna was adjusted up to 23%. Time domain analysis of the log periodic antenna also analysed. The printed log periodic antenna [10] showing high gain value, low return loss and wide bandwidth by optimizing the width of the antenna, the antenna possessing coaxial feed which was optimized again. This antenna is more suitable for high power application. Wankhade and Nema [11] state the impact of UWB log periodic antenna compare with conventional narrow band antenna. The UWB antenna provides more efficiency than conventional antennas with low rates and high ease of fabrication. Casula et al. [12] states the printed log periodic antenna which is used for broad band application using CPW feed. The modelled antenna showing minimum size. Khaleghi et al. [13] states impulse radiating periodic antenna which was fabricated on RT-duroid material which showing very minimum return loss with parameter optimization techniques. This antenna is also used for broad band application. Several antennas are designed by researchers for Wi-Fi, WiMAX, WLAN, DRSC applications for Vehicular, commercial, medical and military applications [14-21].

This present work states the design and simulation of proposed LPA which results in GPS, PCS, ISM and Wi-Fi applications is analyzed and presented. The subsequent sections deal the design of the proposed LPA and followed by the results and discussion of the proposed LPA.

2. PROPOSED ANTENNA DESCRIPTION



(a)

(b)

Figure 1. (a) Top side of the designed antenna, (b) Bottom side of the designed antenna

The designed Log Periodic Array antenna is constructed on FR-4 epoxy substrate having the thickness of 1.6mm. This antenna is mandate and shows end fire radiation design. In LPDA, it is seen that from longest dipole to most limited dipole, the length, width and separating between the dipoles diminishes continuously. The dispersing of the dipoles is the logarithmic function of frequency addressed by dividing factor. The radiation design displayed in Figure 1 is end fire radiation design with least side flaps and back projections. Side flaps and back projections show the losses. S addresses the separating between the dipoles, L is the length of dipoles, and the radiation design is along Y-axis. LPDA is described with the dynamic district and inactive region. The idle part is additionally called as latent district. The components close to the half frequency dipole will transmit so the locale where emanating components are available is called as dynamic district. The most limited components are too capacitive to even think about transmitting appropriately. Furthermore, the dipoles longer than the half frequency dipole will likewise not emanate as expected. So, the more drawn out and more limited dipoles than the half frequency dipoles are remembered for dormant locale. The proposed antenna device description shown in Table 1, these are calculated using following two basic equations of LPA.

Figure 2 showing the sid view of the designed antenna. The height of the substrate and the dielectric material side view can be observed from this figure.

$$\tau = L_{n+1} / L_n \tag{1}$$

$$\sigma = S_n / 2L_n \tag{2}$$

Figure 2. Side view of the designed antenna

Table 1. Proposed antenna description

N	Number of elements	19
Wf	Feedline width	2.9 mm
τ	Scale factor	0.89
σ	Spacing Factor	0.17
H	Substrate Height	1.6 mm
ε_r	Relative permittivity	4.3
Lb	Base element length	193.1mm
Wb	Base element width	17.46mm
Sb	Base element spacing	61.83mm
X	Device X-dimension	193.1mm
Y	Device Y-dimension	503.8mm
Z	Device Z-dimension	1.6 mm

3. RESULTS AND DISCUSSION

The proposed LPDA showing the return loss and VSWR value of -24dB, -24.5dB and -21dB, 1.1,1.2 and 2 across the target frequency of 0.9,2.1 and 2.4 GHz which are used for GSM, PCS, ISM and Wi-Fi application which was simulated using Magus software shown in Figure 3.

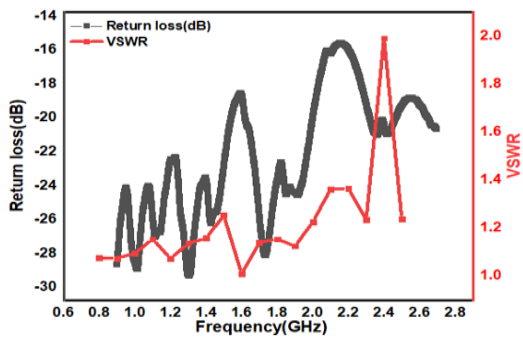
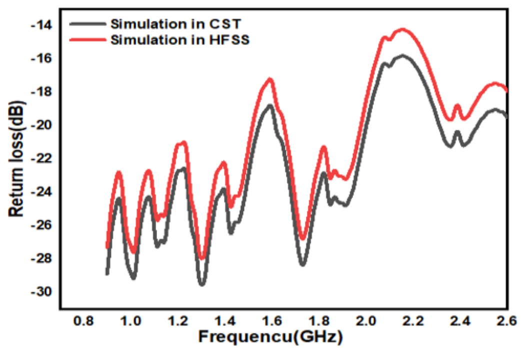
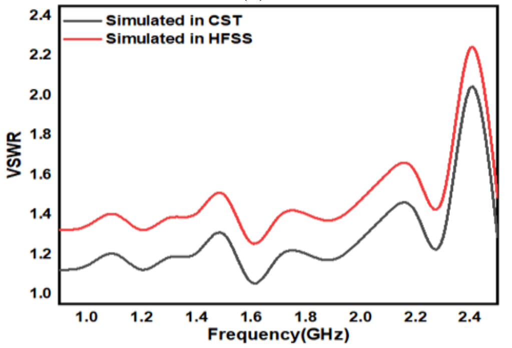


Figure 3. Return loss and VSWR of proposed antenna in Magus Software



(a)



(b)

Figure 4. (a) and (b) Simulated S_{11} and VSWR of designed antenna in CST and HFSS software

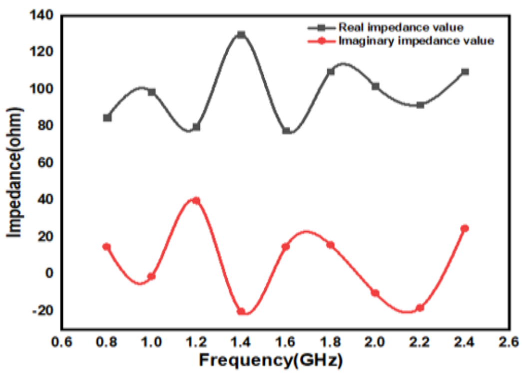


Figure 5. Impedance value of proposed LPDA antenna

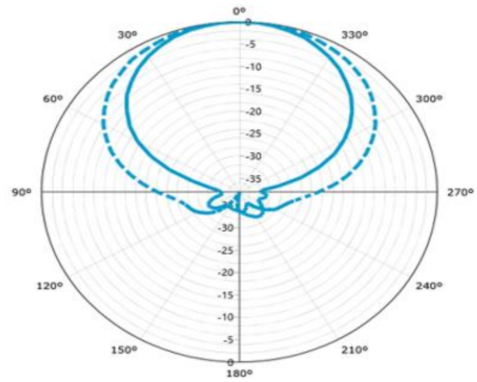
The proposed LPDA antenna showing the return loss value less than -10 dB and VSWR value of 2:1 across the target frequency of 0.9, 2.1 and 2.4 GHz which are used for GSM, PCS and Wi-Fi application. The simulated characteristics using HFSS and CST software are shown in Figure 4 (a) and (b).

The proposed LPDA antenna showing the impedance matching across the target frequency like 0.9, 2.1 and 2.4 GHz are shown in Figure 5.

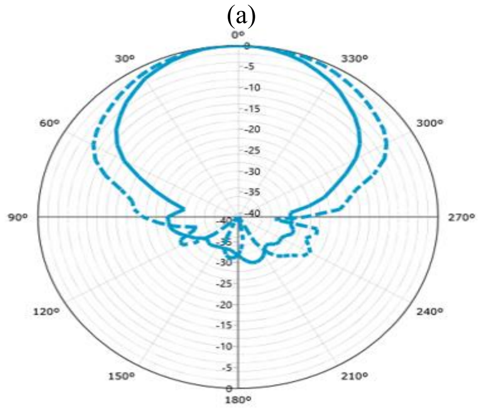
The proposed LPDA antenna showing the radiation pattern values in directional manner across the operating frequency 0.9, 2.1 and 2.4 GHz in Figure 6.

The proposed LPDA antenna showing the peak gain value of 9dBi, 9.2 dBi and 9.4 dBi across the target frequency of 0.9, 2.1 and 2.4 GHz in Figure 7.

The proposed LPDA antenna showing the peak gain value of 6.7 dBi, 6.6 dBi across the target frequency of 0.9 GHz, similarly the antenna showing the peak gain value of 6.2 dBi, 6.1 dBi across the target frequency of 2.1 GHz, finally the proposed antenna showing the peak gain value of 6.2 dBi, 6.1 dBi across the target frequency of 2.4 GHz in both CST and HFSS tools which shown in Figure 8.



(a)



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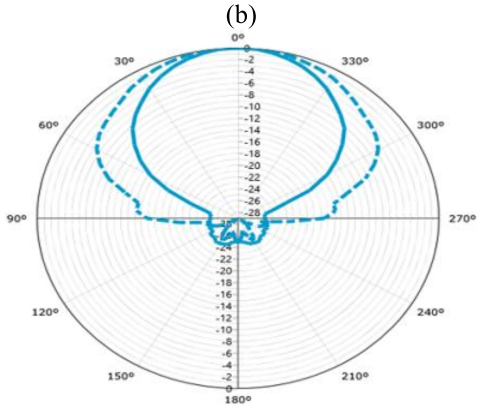
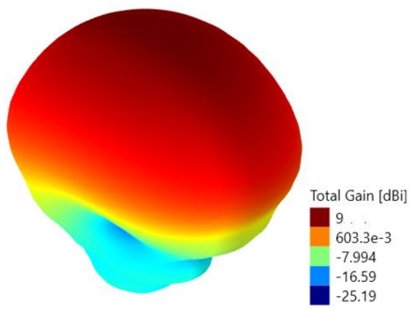
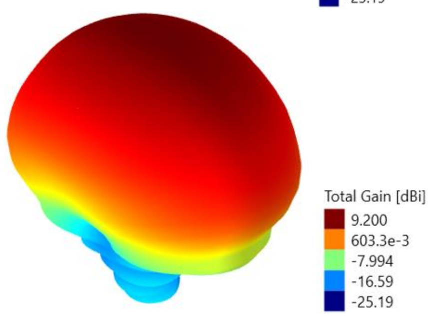


(c)

Figure 6. Radiation analysis of designed LPDA antenna in Magus Software





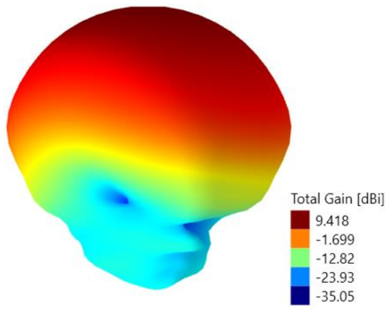


Figure 7. Gain value of proposed LPDA antenna in Magus Software

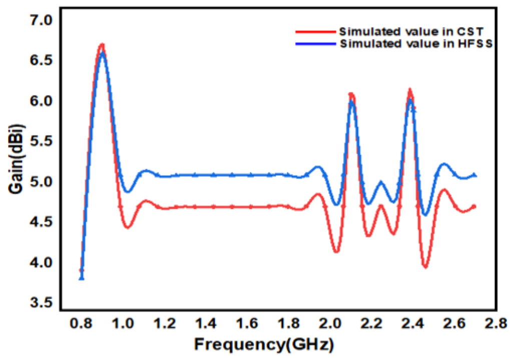


Figure 8. Gain value of designed LPDA antenna in HFSS, CST

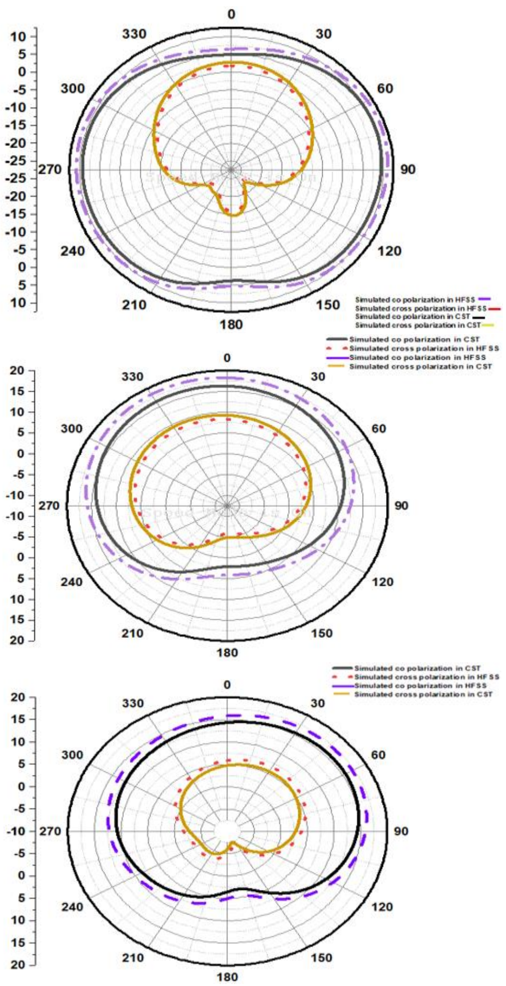


Figure 9. Radiation patterns of proposed LPDA antenna in HFSS, CST at three bands

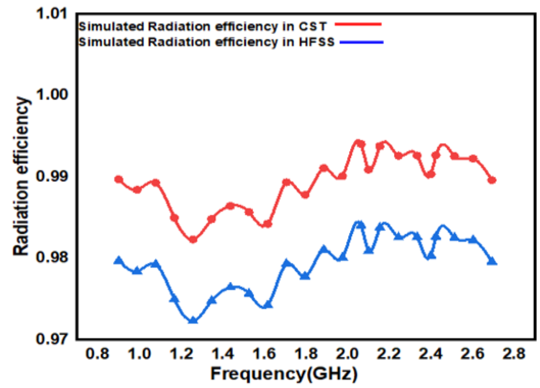


Figure 10. Radiation efficiency of designed LPDA antenna in HFSS, CST

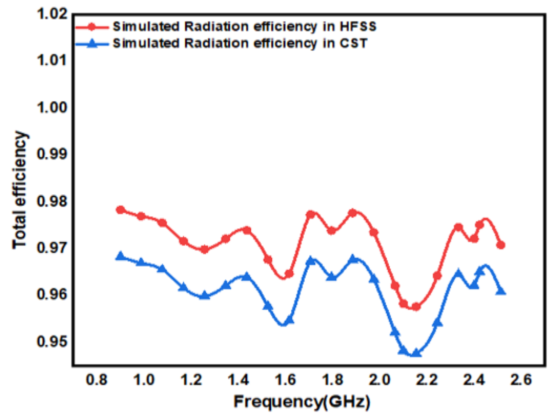
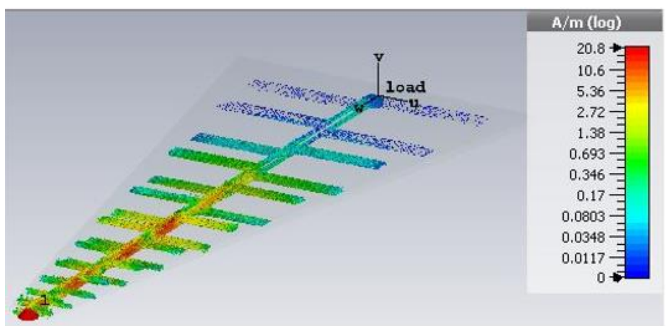


Figure 11. Total efficiency of proposed LPDA antenna in HFSS, CST

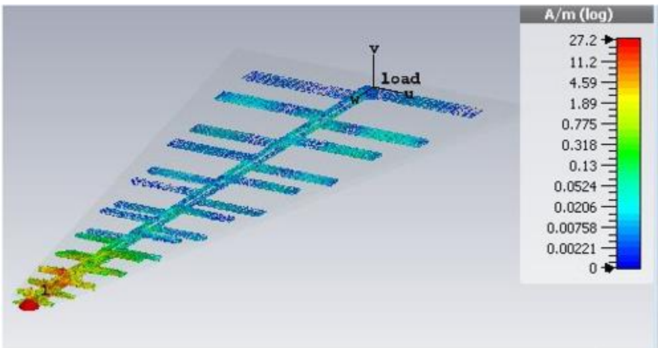
The proposed LPDA antenna showing the radiation pattern values in directional manner across the operating frequency 0.9, 2.1 and 2.4 GHz in Figure 9 which was simulated using both HFSS and CST.

The proposed LPDA antenna showing the radiation efficiency value of 0.99, 0.98 across the target frequency of 0.9 GHz, similarly the antenna showing the radiation efficiency value of 0.99, 0.98 across the target frequency of 2.1 GHz, finally the proposed antenna showing the radiation efficiency value of 0.99, 0.98 across the target frequency of 2.4 GHz in CST and HFSS tool as shown in Figure 10.

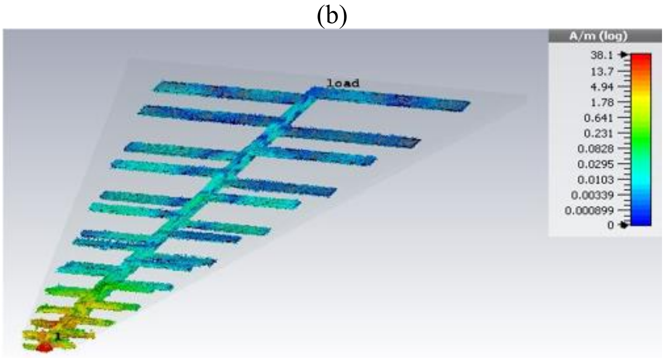
The proposed LPDA antenna showing the total efficiency value of 0.97, 0.98 across the target frequency of 0.9 GHz, similarly the antenna showing the total efficiency value of 0.96, 0.95 across the target frequency of 2.1 GHz, finally the proposed antenna showing the total efficiency value of 0.96, 0.97 across the target frequency of 2.4 GHz in CST and HFSS tool as shown in Figure 11.



(a)



(b)



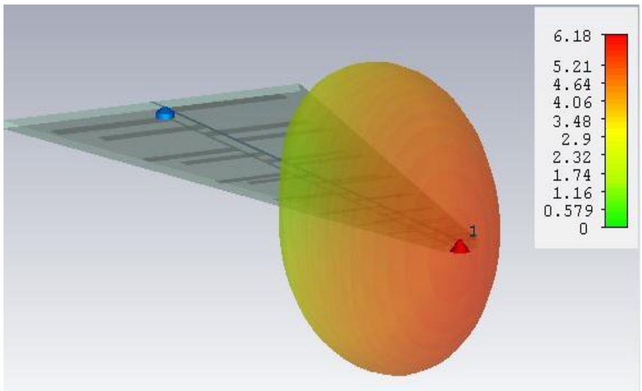
(c)

Figure 12. Current on surface of designed LPDA antenna at 0.9, 2.1 and 2.4 GHz in CST software

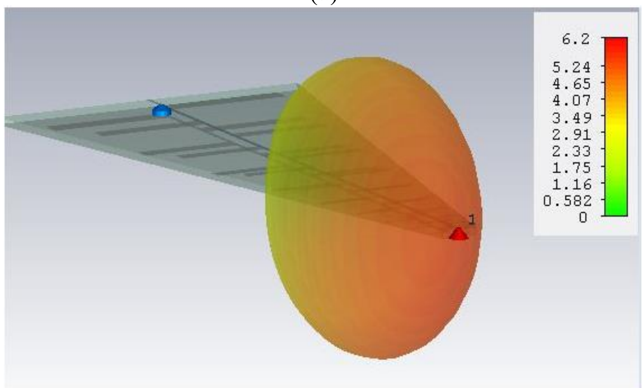
The proposed LPDA antenna showing the surface current distribution value of 20.8 across the target frequency of 0.9 GHz, similarly the antenna showing the surface current distribution value of 27.2 across the target frequency of 2.1 GHz, finally the proposed antenna showing current intensity value of 38.1 across the target frequency of 2.4 GHz in Figure 12 which is simulated using CST software. As the frequency shifts towards right the surface current distribution increases.

The proposed LPDA antenna showing the peak gain value of 6.18 across the target frequency of 0.9GHz, similarly the antenna showing the peak gain value of 6.2 across the target frequency of 2.1 GHz, finally the proposed antenna showing peak gain value of 6.96 across the target frequency of 2.4 GHz in Figure 13 which is simulated using CST software.

Table 2 compares the dielectric, feeding method, return loss, target frequency, bandwidth, and gain of the existing previous researcher's LPDA antennas with the proposed model. The microstrip line feeding has been used in the current design for simple excitation. The operating bands are towards lower band, and which are very suitable for mobile communication applications. The bandwidth is little bit low, but the gain is superior when compared with literature. Where gain of the proposed antenna is high and it is designed for 0.9 GHz (GSM), 2.1 GHz (PCS) and 2.4 GHz Industry standard Medical (ISM) and Wi-Fi applications.



(a)



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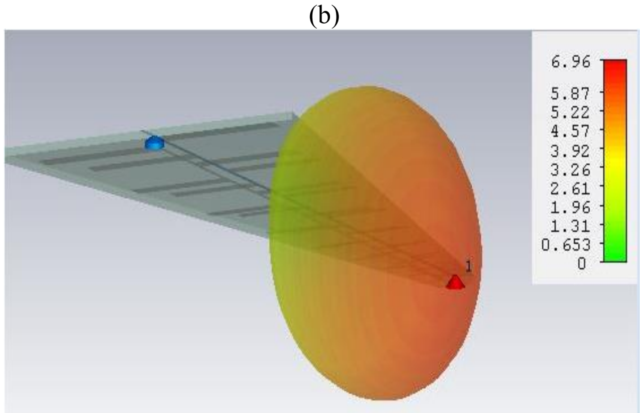

(c)

Figure 13. 3D gain of designed LPDA antenna at 0.9, 2.1 and 2.4 GHz

Table 2. Comparative analysis

Ref. No	Dielectric	Feeding method	S_{11} (dB)	Target frequency (GHz)	B. W (GHz)	Gain dBi
[9]	Roger R04003	Proximity feed	-45dB	3.1to10.6	7.5	8.5
[10]	NX9300	Coaxial feed	-35dB	2 to 4	2	8
[11]	RT/Duroid 5870	Probe feed	-35dB	4.3 to 8.5	4.2	NA
[12]	Arlon AD450	CPW Feed	-29dB	3 to 6	3	7.5
[13]	RT/Duroid 5880	NA	-51dB	3 to 10	7	NA
Proposed work	FR-4	Micro strip feed	-30dB	0.9, 2.1 & 2.4	2.5	9, 9.2 and 9.4 (Magus) 6.7, 6.2 and 6.2 (CST) 6.6, 6.1and 6.1 (HFSS)

4. CONCLUSIONS

The proposed LPDA antenna is simulated using various software like Magus, HFSS and CST. The proposed antenna showing high performance value in terms of antenna parameters. The proposed antenna showing high peak gain values of 6.18, 6.2 and 6.96 dB across the target frequency values of 0.9, 2.1 and 2.4 GHz. Proposed antenna showing high antenna performance value in terms of its efficiency, return loss, surface current distribution and VSWR. A simple, cost-effective structure and wide bandwidth with high gain are reasonable properties to use this antenna for various communication applications such as GSM, PCS, Industry standard Medical (ISM) and Wi-Fi applications.

The current design in future can be converted into a flexible design by considering conformal materials like polyimide and polymer materials. The gain and efficiency can be improved with converting this structure to array design. The low bandwidth constraint can be solved with introducing metamaterial concept in the design.

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