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Conformal Printed Log Periodic Microstrip Antenna Array for Triple Band Applications

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Abstract
In this paper, a conformal Printed Log periodic microstrip antenna (LPMA) is proposed for sub-6 GHz (triple band) applications. This antenna consists of twelve rectangular patch elements along with microstrip feed line and those are fabricated on a polyimide substrate with dielectric constant value of 3.3. The adaptability of the antenna is shown by bending the LPMA horizontally and vertically across the angle of 30^0, 45^0 and $60^{0.}$ The execution of the antenna is analysed in terms of its return loss, Gain, H-E plane patterns and efficiency. The designed antenna is capable of operating with the resonant frequencies 2.4 GHz, 4 GHz and 5.9 GHz with the gain of 8.2, 8.9&7.5 dBi respectively, providing voltage standing wave ratio (VSWR) < 2. Using CST software the designed antenna designed, simulated and the estimated results are in great concurrence with the simulation results.

Keywords: LPMA, conformal, triple band

1. Introduction

Planar LPDA antennas [1-7, 20] have been broadly utilized for wide range of wireless applications because of its wide data transmission, high increase and planar profile. It was initially proposed by Dwight E-Isbell and Raymond Du Hamel in 1957 [8] and then developed by Carrel in 1961[9]. Using frequency independent antenna principles, the log-periodic microstrip antenna can be scaled from period-to-period, so that its exhibition is corresponding to the logarithm of frequency [10, 11]. However, planar antennas are frequently not functional for joining onto bended surfaces. In order to overcome this, a conformal [12] or non planar antennas [13] are introduced. To design conformal structures there are various flexible substrates have been investigated [14-17]. However, it can be challenging to design and implement the antenna on very thin substrate. Bandwidth enhancement is mainly depending on substrate thickness [18]. Data transfer capacity is conversely corresponding to the substrate thickness. In addition, a near adaptability examination is useful for analyst working in this space [19].

In this paper, we have investigated the electromagnetic characteristics of the designed antenna which is designed on very thin polyimide substrate having the thickness of 0.1mm. As a result, it is possible to estimate radiation patterns and similar impedance qualities with LPDA under the specified bending configurations. Furthermore, the antenna is meant to be more flexible by using a microstrip feed.

2. Log periodic microstrip antenna design

The log periodic microstrip antenna is designed using flexible substrate i.e. (Polyimide) with dielectric constant value of 3.3 is shown in figure 1. The LPMA consist of 12 elements on each side of the antenna. Initially the scaling and spacing factors $\tau = 0.92$, $\alpha=0.17$ are chosen to achieve the gain of 7.8 dB [9, 10]. After that other design parameters of log periodic antenna are computed, where the length of the longest dipole value is 45mm. In order to achieve the compactness, it is optimized and the optimized length is 24mm. Further the remaining lengths are calculated using design equations [9, 10], the resulting lengths are shown in figure 1. The widths and spacing between the elements are chosen as uniform, those are width=1mm and spacing =5mm. Therefore the total dimension of the antenna is $50x40x0.1mm^3$. All these dipoles of the antenna are fed by an identical microstrip lines on the two sides of the substrate having a width of 2 mm.

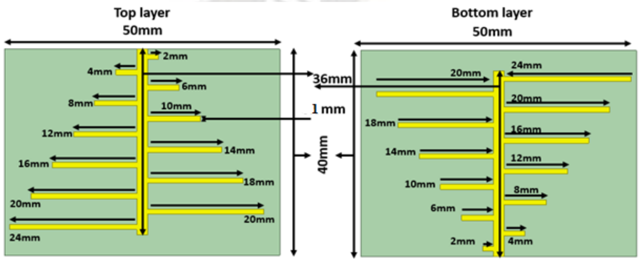
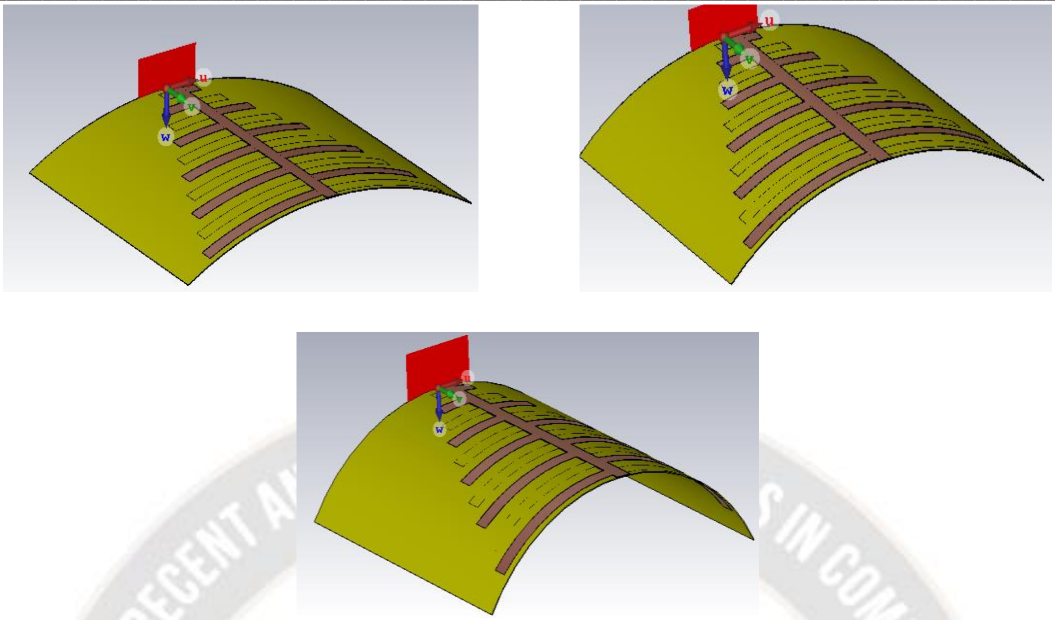


Figure.1 Schematic View of the Proposed Log periodic microstrip antenna top and bottom surfaces.

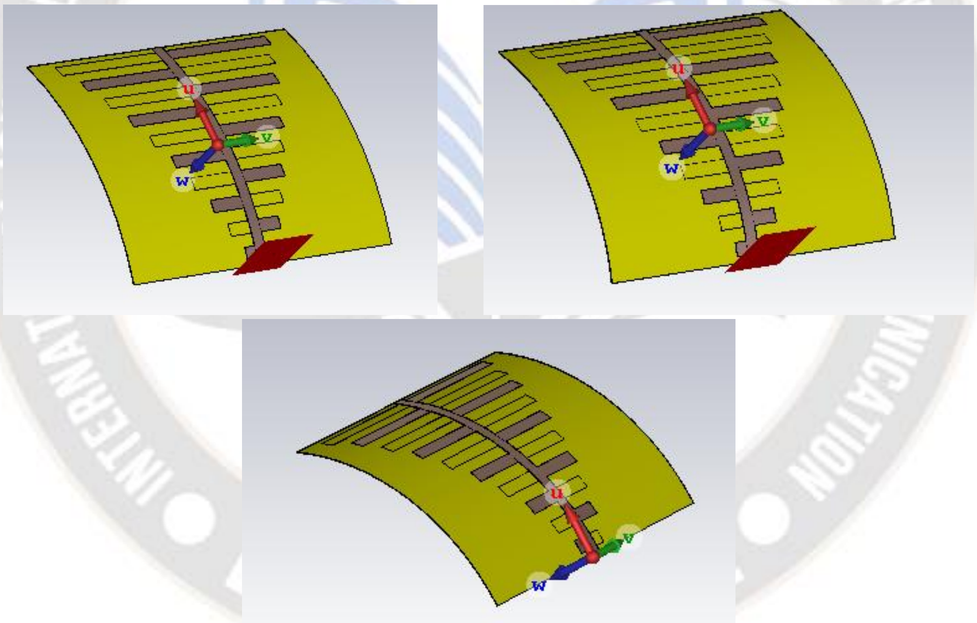
3. Designed antenna Bending analysis

The designed antenna is horizontally and vertically bended across the angle of 30^0, 45^0 and 60^0. The electromagnetic performance of the designed antenna is analyased in value of S11, Gain, efficiencies and radiation patterns. The figure 2 and 3 states the bending analysis of proposed antenna.



(a) (b) (c)

Figure.2. Horizontal cross section of designed antennaacross 30^0, 45^0 and 60^0 degrees



(a) (b) (c)

Figure.3. Vertical cross section of designed antenna across 30^0, 45^0 and 60^0

4. Results and Discussions

Figure 4 states the simulated and measured return loss and VSWR value of designed antenna without bending condition across the operating frequencies of 2.4, 4 and 5.9 GHz with the return loss value below -10dB (i.e., -12dB & – 14dB, -22dB & – 25dB, -18dB & – 22dB) and VSWR < 2 (i.e.,1.1 & 0.6, 1.32 & 0.82, 1.7 & 1.2) respectively.

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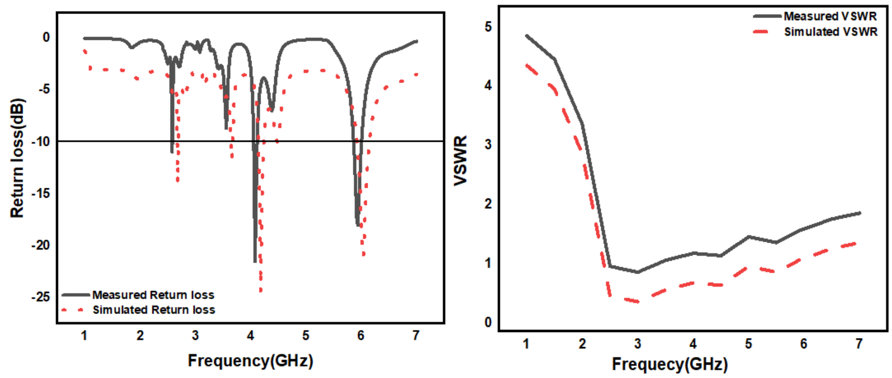
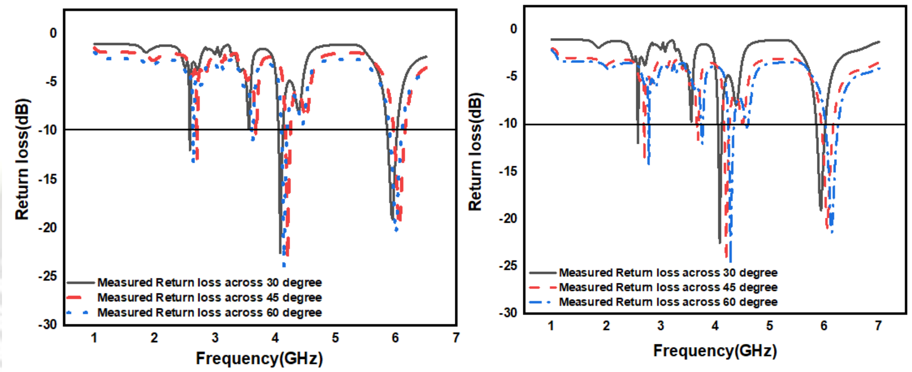


(a) (b)

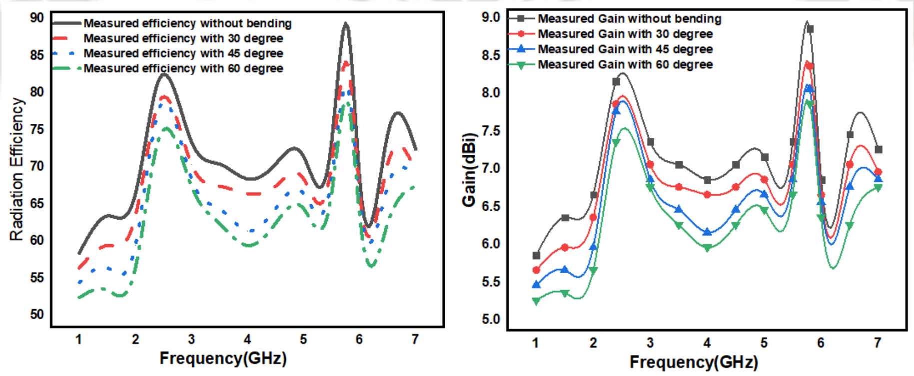
Figure.4 (a) Return loss and (b) VSWR measured and simulated value of designed antenna without bending



(a) (b)

Figure.5. Measured S11 value of proposed log periodic microstrip antenna with bending across 30^0, 45^0 and 60^{0}degrees.

The figure 5 states the S11 value of designed antenna across the bending angle 30^0, 45^0 and 60^0 degrees. The S11 value of designed antenna across the operating frequencies are below -10dB in both horizontal and vertical bending. It was observed that figure 4 and figure 5 stating the negligible variations in the return loss value.



(a) (b)

Figure.6. Measured efficiency and Gain value of designed antenna without bending and with bending across 30^0, 45^0 and 60^0 degrees.

The designed antenna showing the efficiency value of above 70% across all operating frequencies at without bending condition and above 65% at with bending conditions is shown in figure 6 (a). Similarly, from figure 6 (b) the antenna showing the gain value ranges from 6-9 dBi across the working frequency in all bending conditions and non-bending condition across

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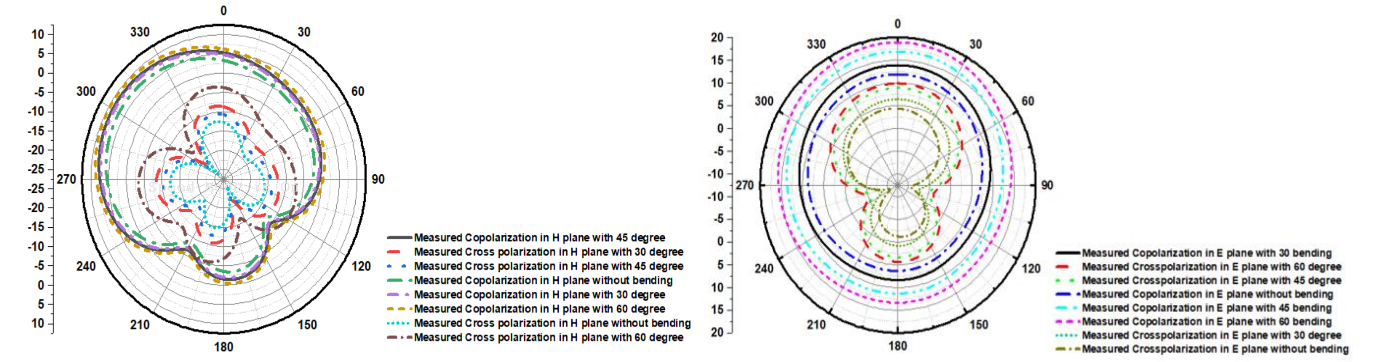
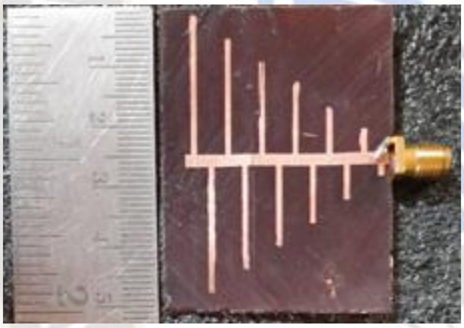


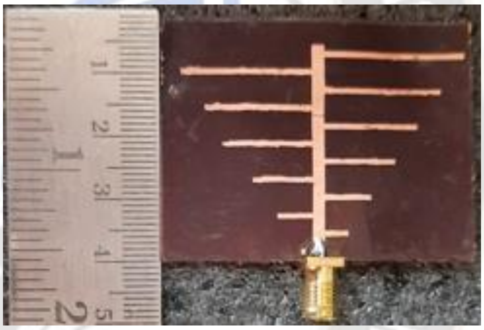
(a) (b)

Figure.7. Radiation patterns H plane and E plane

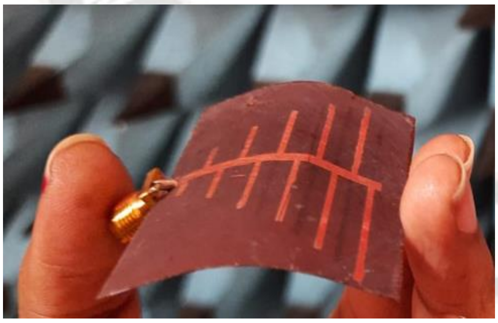
The radiation patterns of the designed antenna across H and E plane at various bending and non-bending angle also stated. The proposed log periodic microstrip antenna showing butterfly shape cross polarization across various bending angles and non-bending angle, similarly across various bending conditions and non bending condition antenna showing maximum co-polarization on the top plane in H plane. Apart from that in E plane the designed antenna showing omnidirectional co-polarization and Dumble shape cross polarization across various bending conditions and non-bending condition across operating frequency stated in figure 7.



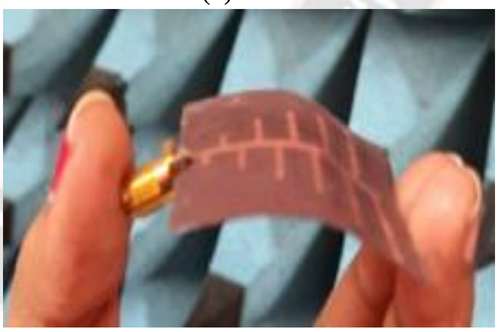
(a)



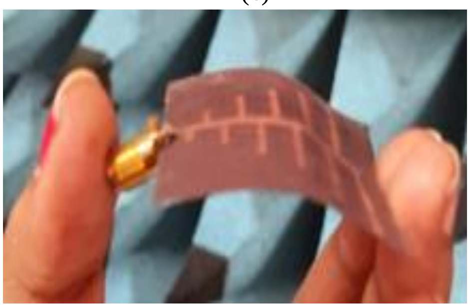
(b)



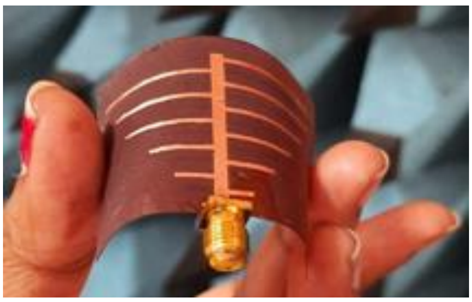
(c)



(d)



(e)



(f)

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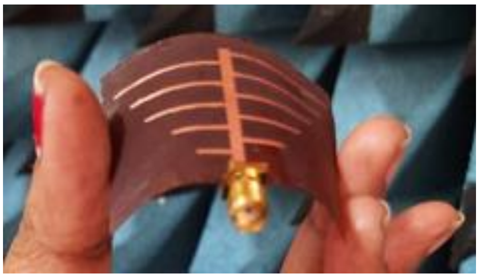
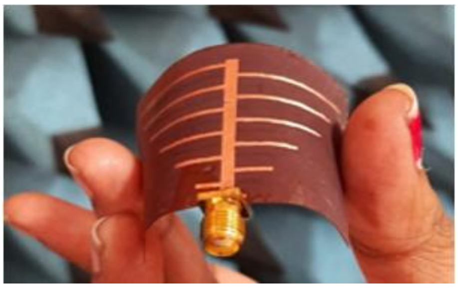


(g)



(h)

Figure.8. (a)-(h) Prototype model with and without bending in anechoic chamber

Figure 8 states the prototype model of the proposed log periodic antenna in various bending conditions and without bending conditions in anechoic chamber. (a-b) designed antenna without bending, (c-e) antenna with vertical bending and (f-h) antenna with horizontal bending.

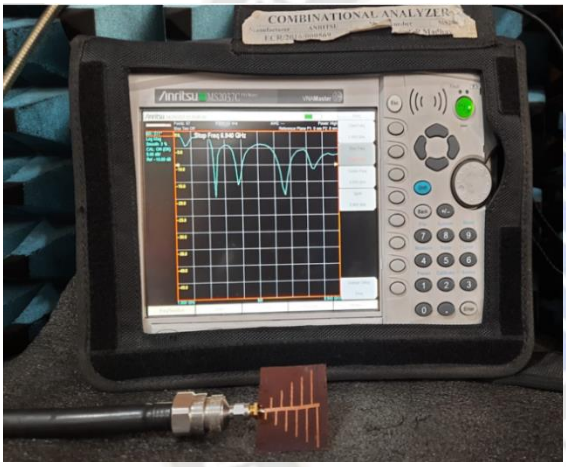


Figure.9. (a) Measurement set up in anechoic chamber with proposed log periodic antenna

The above figure 9 states the measurement set up of designed antenna in anechoic chamber with combinational analyzer.

Table.1. Comparison of designed antenna with existing antennas

Elements	Proposed Antenna	[16]	[17]	[20]
Frequency range	2.4,4 &5.9 GHz	3-12 GHz	1-7 GHz	1.4-12[GHz]
VSWR	0.6,0.82&1.2	1	1.4	1.1
Return loss	-14, -25&-22[dB]	-	-	-
Maximum Gain	8.2,8.9&7.5 [dBi]	-	7 dB	6[dBi]
Maximum radiation efficiency	85	-	-	85
Maximum total efficiency	84	-	-	83
Flexibility	Yes	Yes	Yes	No

5.CONCLUSION

This paper presents LPMA which is planned and simulated utilizing FEM instrument. The designed antenna provides phenomenal gains, VSWR, return loss and efficiencies. As for the working frequencies, the designed antenna shows VSWR values of < 2 and - 10dB separately. The designed antenna is printed on both side of the polyimide layer having 12 elements on each side of the substrate. The optimized antenna furnishes amazing outcomes with gain, VSWR, return loss and efficiencies. For the working frequencies, the simulated antenna is showing VSWR and S11 boundary values < 2 and - 10dB separately. The gain of the antenna is observed in the range of 7.5-8.9dBi. The designed antenna showing good agreement between simulated and measured results. The designed antenna having compact size which is used for sub 6 GHz applications.

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