L-Shaped Monopole Antenna with Modified Partial Ground Plane for Multiband Operation

Prachi Pandey, Neelesh Agrawal, Mukesh Kumar, Navendu Nitin, Anil Kumar

Abstract- In this paper a design of L-shaped monopole antenna (LMA) with modified partial ground plane for multiband operation is presented. The `dimension of proposed antenna is 40× 47 mm2 with 1.6 height using Teflon substrate having dielectric constant 2.1. The ground plane is amended by inserting an anti-symmetric horizontal L-slots. Single band to multiband behaviour is accomplished by applying two horizontal L-slots on partial ground plane of LMA. Both the slots are antisymmetric to Y-axis. The parametric study has also been done which is responsible for antenna behaviour. The operating frequency bands of designed antenna are 2.35-2.91GHz,3.24-3.51GHz ,4.31-5.30GHz and 5.90-6.31GHz which is suitable for Bluetooth (2.4GHZ),WLAN (2.4GHz,5.2GHz), WiMAX (2.3GHz, 2.5GHz, 3.5GHz, 5.2GHz), C-band (4-8GHz) and S-DMB (2.6GHz) applications. By using the HFSS simulator we accomplished that our designed antenna show an enhancement of bandwidth and good matching impedance.

Keywords: LMA, PARTIAL GROUND PLANE, MULTIBAND, L-SLOTS, WLAN, Wi-MAX.

I. INTRODUCTION

Nowadays, antenna develops rapidly, as an significant part of wireless devices. Recently monopole microstrip antennas are important due to its applications and characters namely low profile, small volume, light weight and easy fabrication, attractive for several wireless systems namely Bluetooth, satellite digital multimedia broadcast (SDMB), worldwide Interoperability for Microwave Access (WiMAX) and wireless local area network (WLAN) systems. Different kinds of designs, shapes and techniques has been presented to achieve dual band and multiband operation such as an inverted-F strip, inverted-F adds inverted-L structure [1-2]. In [1] dual-band operation in the 2.4 GHz (2.4-2.484 GHz) and 5.2 GHz (5.15-5.35 GHz) is achieved by integrating F-shaped monopole antenna using microwave substrate with a three metal lines having same width. In [2] combining inverted-F and inverted-L widen the bandwidth of the resonant frequency of the antenna. Bandwidth is enhanced by the insertion of the inverted-L-shaped coupled strip with C-shaped radiating patch [3].

In [4] a meandered T-shaped monopole is proposed for 2.45/5.2/5.8 GHz LAN operations with a long and a short arm strip extended from the feedline. A compact improved T-Form monopole antenna [5] using two asymmetric horizontal strips has been designed to achieve multiband operation. In [6] a C-shaped monopole antenna is designed having a shorted parasitic strip to obtain two separate impedance bandwidth. Frequency agility, improved gain and beam forming can be attained by applying additional dielectric layers. But additional layers increase the weight of the antenna which is again undesirable in wireless environment. Triband has been obtained by using different shapes and techniques [7-11] . Monopole antennas [7] with tuning stubs is used to cover GSM900/1800/1900 frequency bands but it is observed that the antenna's radiation efficiency for GSM1900 band at the reception band (Rx) is somewhat inferior compared with other frequency band. In [8] tri-band resonances are obtained by using hybrid strips with L-shaped patch and meander strip. The toothbrush shaped patch, meander line and inverted U-shaped patch is used in the monopole antenna [9] to create desired 2.4GHz, 3.5GHz, and 5.5GHz bands. In [10] split ring resonators (SRR) is loaded in slot antenna to achieve multiband characteristics and cover 2.6, 4.2, and 4.7 GHz frequency bands. In [11] E-shaped monopole antenna is designed inserted with narrow slots for triband applications. A trapezoid patch with a quasi-fractal ground plane [12] is proposed to obtain operating bands of 1.74–2.38GHz and 4.46–5.56 GHz. A slot monopole antenna with CPW fed [13] is designed which achieve large sufficient for the requisite bandwidth of the 2.4 and 5.2/5.8-GHz WLAN bands. MIMO wireless application has been attained by designing a B-shape monopole antenna [14]. Compact size and wide band in monopole antenna are obtained with the help of asymmetric coplanar strip-fed (ACS) [15]. In [16] multiband behaviour is acquired by introducing F-slot on patch of antenna. This paper demonstrates a L-shaped monopole antenna (LMA) with modified partial ground plane. The LMA is modified with the insertion of anti-symmetric horizontal L-slots to obtain multiband operation. The performance of antenna characteristics with and without slots on the ground are also shown. Thus, the presented antenna (ant.) is acceptable for wireless systems such as Bluetooth, WLAN, WiMAX and S-DMB. The information of the antenna design is bestowed.

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II. DESIGN PROCEDURE

A. Antenna Design And Configuration

The model of designed LMA with DGS is presented in Fig.1. Presented antenna is fed by 50Ω offset microstrip feedline at the Teflon dielectric. Teflon dielectric is used with ε_r=2.6 and height is 1.6mm. Width of microstrip feedline is about 3.2mm. The dimension of presented antenna is taken into consideration from [17]. Geometric specifications of the presented antenna are listed in Table1.

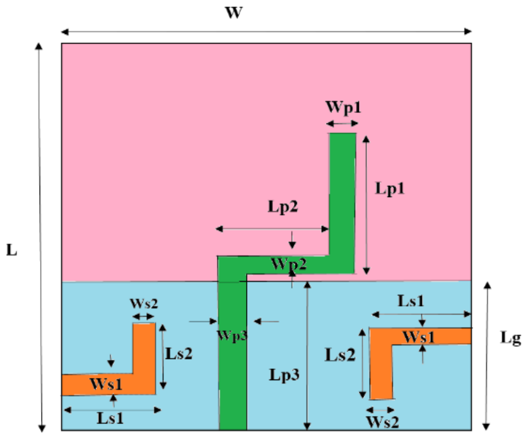


Fig.1. Geometry Of Presented Ant.

Table 1. Parameters Of Presented Ant.

Parameters	Optimized value (mm)	Parameters	Optimized value (mm)
W	40	L	47
Wp1	2	Lp1	19
Wp2	2.2	Lp2	15.4
Wp3	3.2	Lp3	12
Ws1	2	Ls1	11
Ws2	2	Ls2	9
Lg	10		

B. Progression Of Proposed Design

Fig.2 represent the evolution of presented antenna. Antenna1 consist of a L-shaped patch on Teflon substrate, fed with microstrip line is demonstrated in Fig 2(a.). In Fig 2(b.) Antenna2 shows the presented antenna in which the ground plane is modified by cutting an antisymmetric L-shaped slots.

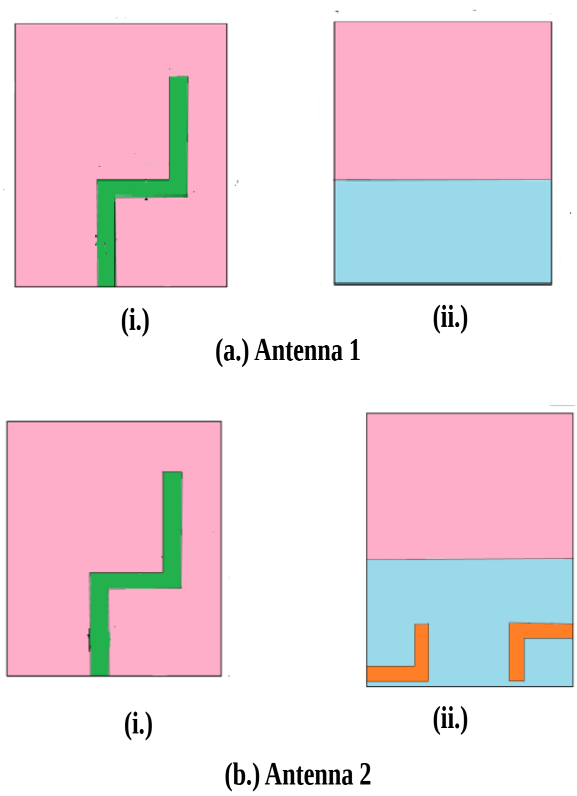


Fig2 (a.)L-Shaped Monopole Ant. (b.) Proposed Ant.

Fig.3 represents the performance analysis of Antenna 1 and Antenna2. The absence of slot in Antenna 1 achieves single band operation therefore, to improve its performance from single band to multiband operation an anti-symmetric horizontal L-slot has been defected in the ground presented in Antenna 2. The slots inserted in the ground plane will modify the current pattern.

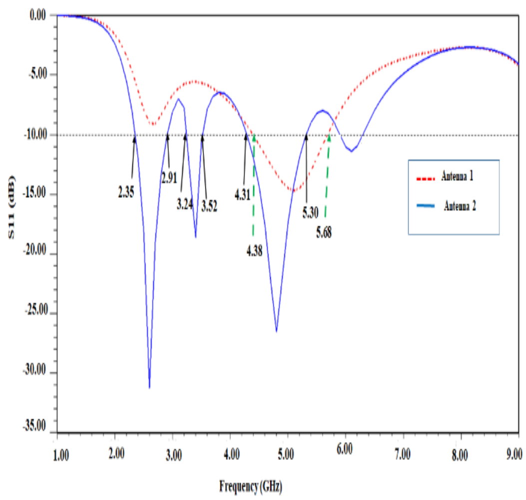


Fig 3. Simulated S11 Of Antenna 1 And Antenna 2

III. PARAMETRIC STUDIES

On the basis of the design there are some parameters which is responsible for multiband operation and have significant consequences on the antenna performance, will be purporting in this paper.

A. *Effect Of Ground Length (Lg)*

The consequences on the characteristic of designed antenna by varying ground length (Lg) is shown in fig.4. The consequence of ground size was more notable in the y-direction caused by the verity that the radiating edges of a microstrip patch antenna are in the x-direction. The value of Lg is varied from 8mm to 12mm with step size 1mm. Antenna covers multiband at both10mm and 11m but antenna covers more frequency ranges at Lg=10mm. For multiband operation Lg is set to be at 10mm.

Table.2 Effect of Lg On Proposed Antenna

Lg	Frequency Bands (GHz)	Maximum S11 (dB)
8	2.31-2.60GHz	-12.98
9	2.36-2.69GHz, 5.70-6.10GHz	-13.38
10	2.35-2.91GHz, 3.24-3.51GHz, 4.31-5.30GHz, 5.90-6.31GHz	-31.00
11	2.45-2.72GHz, 4.21-5.41GHz, 5.84-6.28GHz	-36.75
12	4.23-5.46GHz, 5.78-6.22GHZ	-26.26

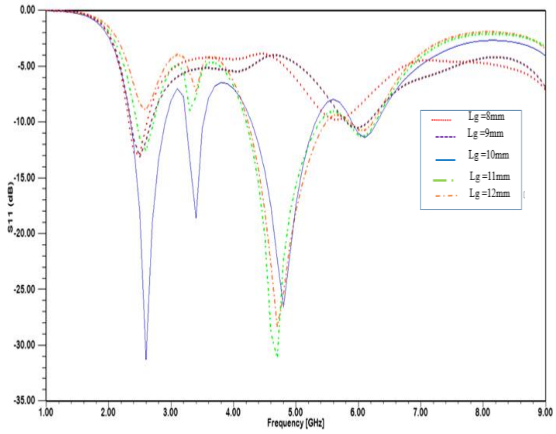


Fig 4. Simulated S11 Of The Presented Ant. With Different Lg

B. *Effect Of Variation Of Shape Of Slots*

Fig.5(a.) and (b.) presents the vertical and the horizontal slots defected on the ground of LMA respectively.

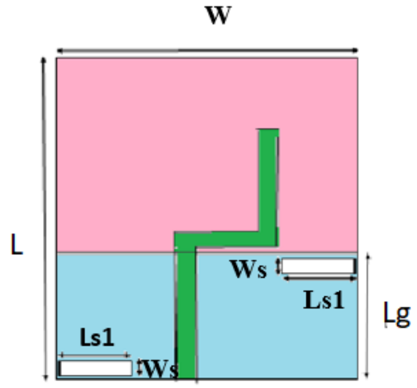
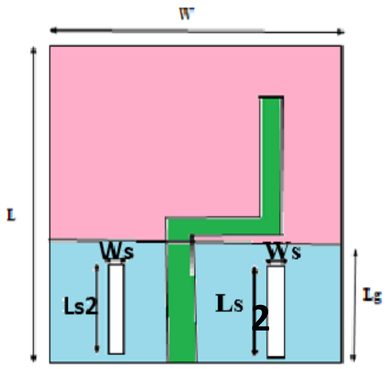


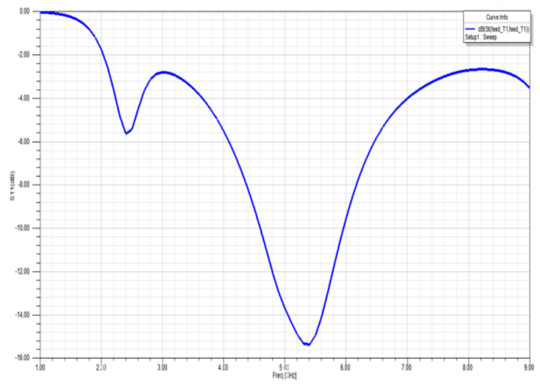
Fig 5. (a.) Horizontal Slot LMA



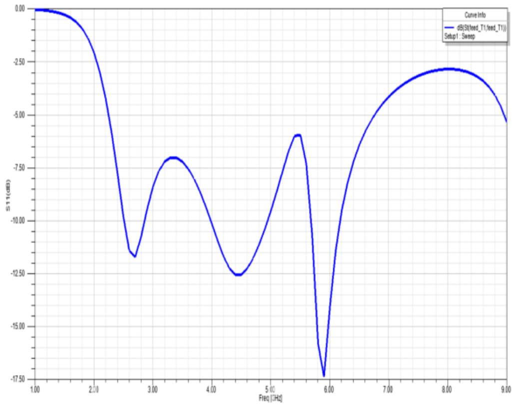
(b.) Vertical Slot LMA

Fig 5. (a.) Horizontal Slot LMA (b.) Vertical Slot LMA

Fig.6(a.) and 6(b.) presents the S11 of horizontal slot LMA and vertical slot LMA. Insertion of the Vertical slot will only cover frequency band from 4.59 to 5.95 GHz while the horizontal slot achieves multiband from 2.47 to 6.04 GHz. The disadvantage of both the antenna is that it doesn't cover 2.4GHz wireless applications. In the designed antenna the antisymmetric L-slot is defected on the ground which achieves multiband including 2.4GHz wireless applications and improved bandwidth.



(a.)



(b.)

Fig 6. (a.) S11 of Vertical Slot LMA (b.) S11 of Horizontal Slot LMA

IV. RESULT AND DISCUSSIONS

LMA with anti-symmetric horizontal L-slots on ground plane is proposed and simulated using HFSS software. In this we will discuss the result of designed antenna in terms of S11, VSWR, gain and radiation pattern as a function of frequency. Simulate return loss of the present antenna is depicted in Fig.7. From simulated result it is concluded that the designed antenna achieves multiband frequencies at 2.34-2.91GHz, 3.24-3.51GHz ,4.28-5.31GH and 5.90-6.31 with fractional bandwidth(S11$< 10dB$) 21.292%,7.94,%,21.45%and6.72% respectively. The designed antenna achieves resonant frequencies at 2.6GHz,3.4GHz, 4.8GHz and 6.1GHz. The antenna is designed at some selected resonating frequency which leads to some bandwidth, then the insertion of slot overlays the fundamental mode of antenna and generates higher order mode which overlays the original bandwidth which gradually increases the overall bandwidth of the antenna.

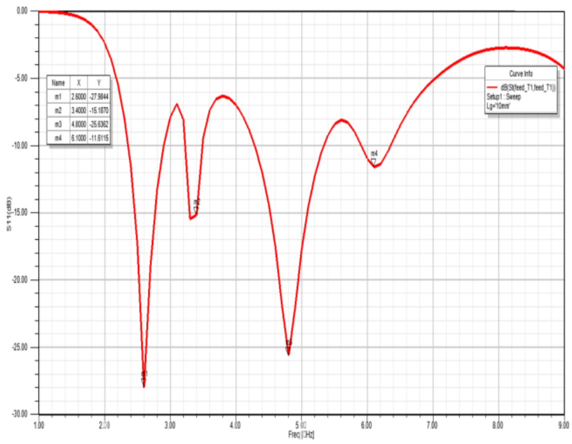


Fig 7. Simulated S11 Of The Designed Ant.

Fig.8 presents the VSWR of the presented antenna. For all resonant frequencies the VSWR ≤ 2 which indicates that the designed antenna has good impedance matching.

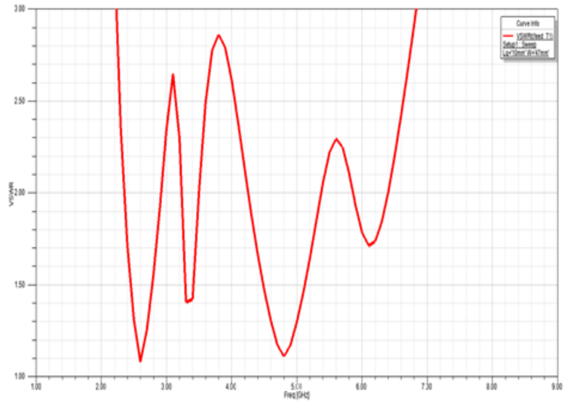


Fig 8. Simulated VSWR Of The Designed Ant.

Simulated gain of designed antenna is manifested in Fig9. From Fig.9 it is perceived that the gain acquired in the operating band is 3.12dB at 4.28GHz. Due to insertion of slot the electrical length of ground enhances. The strong coupling b/w ground and patch cause enhancement in gain. The presented antenna obtains positive gain at all the resonating frequencies which indicate efficient performance of the designed antenna.

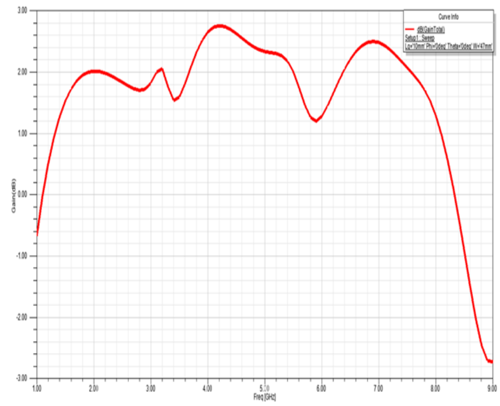


Fig 9. Simulated Gain Of The Designed Ant.

Fig.10 shows the Simulated radiation patterns in decibel scale of designed antenna at 2.6GHZ, 3.4GHZ, 4.8GHZ, 6.1GHZ. The maximum power is radiated at 2.6GHz and shows omnidirectional radiation pattern. The slots are defected onto the ground of the antenna to improve its radiation. Radiated power of the designed antenna changes with different angles at 3.4GHz,4.8GHz and 6.1GHz while it is constant at 2.6GHz.

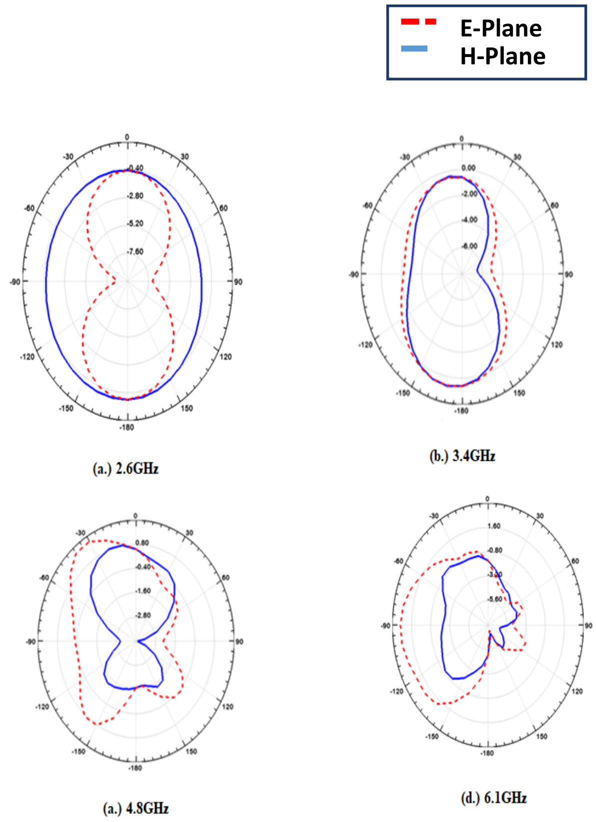


Fig 10. Radiation Patterns Of Designed Ant. At Resonating Frequencies

(a.) 2.6GHZ, (b.)3.4GHZ, (C.)4.8GHZ, (d.)6.1GHz

Table3. presents the overall result of designed antenna presenting the important parameters of the antenna.

Table 3. Result Of Designed Ant.

Parameters	Value
Impedance Bandwidth	2.34-6.31 GHz
Return Loss	-31dB
Resonant Frequency	2.6,3.4,4.8 and 6.1 GHz
Gain	3.12dB
VSWR	≤ 2

Table 4. presents the comparison of impedance bandwidth and size of designed antennas with reference papers.

TABLE 4. Comparison Of The Dimensions And Performance Of The Designed Ant. With Other Ants.

Antenna	Method	Size	Impedance Bandwidth (GHz)
Ref.[2]	Using inverted-F adds inverted-L structure.	350mmx160mm	110MHz and 325MHz
Ref.[4]	Two asymmetric horizontal strips.	40mmx50 mm	0.93 GHz at the frequency band of 2.4 GHz, and 1.41 GHz at the frequency band of 5 GHz.
Ref.[12]	A trapezoid patch and a quasi-fractal slot structure.	110mmx110mm	1.74–2.38 and 4.46–5.56 GHz
Proposed	LMA with anti-symmetric horizontal L-slots.	40x47	2.35-2.91GHz, 3.24-3.52GHz, 4.30-5.30GHz, 5.90-6.31GHz

V. CONCLUSION

The electrically small LMA is introduced for modern wireless communication system. The presented antenna is designed by inserting an anti-symmetric horizontal L-slots in L-shaped monopole antenna to improve its performance from single band to multiband operation. Its simulated -10dB impedance bandwidths are 560MHz (2.35-2.91GHz),280MHz (3.24-3.52GHz),990MHz(4.31-5.30GHz), 410MHz(5.90-6.31GHz) and hence achieve the resonating frequencies at 2.6GHz,3.4GHz ,4.8GHz and 6.1GHz.The simulated result presents the designed antenna which shows the good impedance matching ,efficient performance over an bandwidth of 2.35-6.31GHz which operate for Bluetooth (2.4GHZ),WLAN (2.4GHz,5.2GHz), WiMAX (2.3GHz, 2.5GHz, 3.5GHz, 5.2GHz) , C-band (4-8GHz) and S-DMB (2.6GHz) applications.

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