

# DESIGN AND SIMULATION OF MEANDER LINE ANTENNA FOR LTE BAND

Bedir Yousif, Mohammed Sadiq, Maher Abdelrazzak

**Abstract**— LTE is a standard for wireless data communications technology and an evolution of the GSM/UMTS standards. Meander line antenna (MLA) is the most usage of antenna that use in LTE. This paper proposes an electrically two type of small-size antenna that is based on the meander antenna structure that operates in the 2.4 GHz band of LTE. These types are MLA with different length and different thickness and log periodic MLA of vertical segment. Designs are optimized to improve radiation efficiency up to 80% , remove the ripples Which represents the simple loss of power and the band width up to 130 MHz.

**Index Terms** meander line antenna, MLA, LTE, Design MLA, Simulation MLA, Log periodic MLA

## 1 INTRODUCTION

In recent years, the rapid advances in wireless communications applications lead engineers to develop integrated small print antennas. They are widely used in wireless communication systems due to advantages such as: Lightweight, Compact, Conformal, good efficiency, bandwidth. Due to its simplicity and ease of integration in the meander line antennas it led to the orientation to be used in mobile communications. A more compact design of a meander line antenna was designed to operate at 2.4-GHz for a wireless local area network (WLAN) application [1]. Previous studies have addressed the design classic meander line [2]. Low Bandwidth of the classic meander line antennas is a problem [3], as the classic meander line antenna is one of the microstrip antennas [4].

In [5] described the different designs of meander line antenna such as, MLA with different thickness of vertical segment and Log periodic MLA. In this paper we applying some changes in classic meander line antenna such as, sweeping the MLA length, width, and feed line dimensions to optimize the properties of antenna parameters. Design procedure, simulation for return loss, and radiation pattern component are presented for each one.

## 2 ANTENNA DESIGN

The MLA can be in a dipole or ground plane format. To make the overall antenna shorter fold the conductors back and forth, which is shown in Fig. 1. It is a smaller area, but the radiation resistance, efficiency and bandwidth decrease [6]. The parameters of meander shape, for example  $H$ ,  $L_a$ ,  $L_b$  and  $L_c$  shown as in the figure will affect the antenna performance parameter [7]. In order to find the best antenna solution, different values of meander width are simu-

lated and studied. A meander-line antenna can be realized by bending the conventional linear monopole antenna to decrease the size of antenna [4]. Three types of feed structure can be implemented in proposed antenna, CPW feed (Coplanar Waveguide), Inset Feed, and Microstrip Feed.

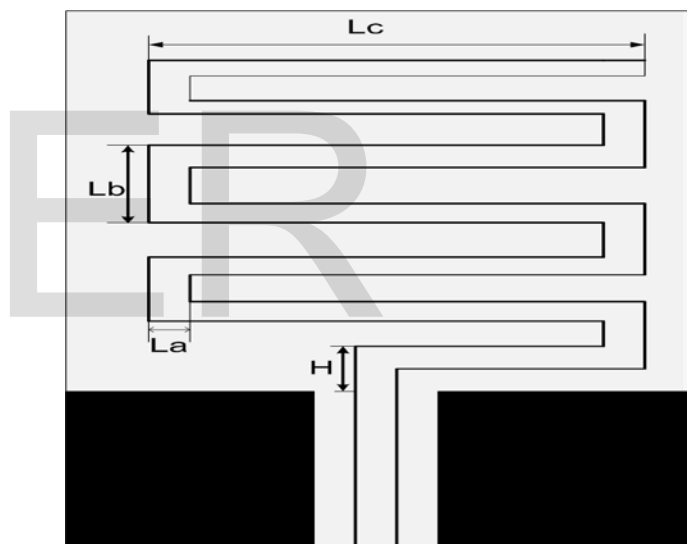


Fig. 1. Shape of Meander Line Antenna (MLA).

A coplanar line is a structure in which all the conductors supporting wave propagation are located on the same plane, i.e. generally the top of a dielectric substrate. There exist two main types of coplanar lines: the first, called coplanar waveguide (CPW), is composed of a median metallic strip separated by two narrow slits from an infinite ground plane, as shown in Fig. 2. The characteristic dimensions of a CPW are the central strip width  $W$  and the width of the slots  $s$ . The structure is obviously symmetrical along a vertical plane running in the middle of the central strip. The other is the complementary of that topology, consisting of two strips running side by side. Coplanar line, called a coplanar slot (CPS), as illustrated in Fig. 3.

- *Bedir Yousif* is currently assistant professor at faculty of engineering Kafrelsheikh University, Egypt, 002-01062602180. E-mail: [bedir.yousif@gmail.com](mailto:bedir.yousif@gmail.com)
- *Mohammed Sadiq* is currently pursuing masters degree program in communications engineering in Mansoura University, Egypt, 002-01090288833. E-mail: [engmohammedalkaabi@gmail.com](mailto:engmohammedalkaabi@gmail.com)
- *Maher Abdelrazzak* is currently professor and head of electronics and communications department, faculty of engineering Mansoura University, Egypt, 002-01141060606. E-mail: [maher1@ieee.org](mailto:maher1@ieee.org)

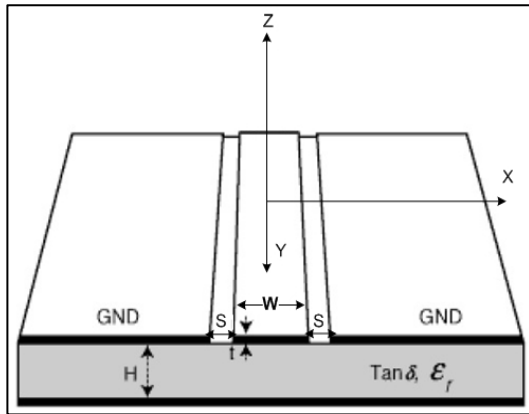


Fig. 2: coplanar waveguide line

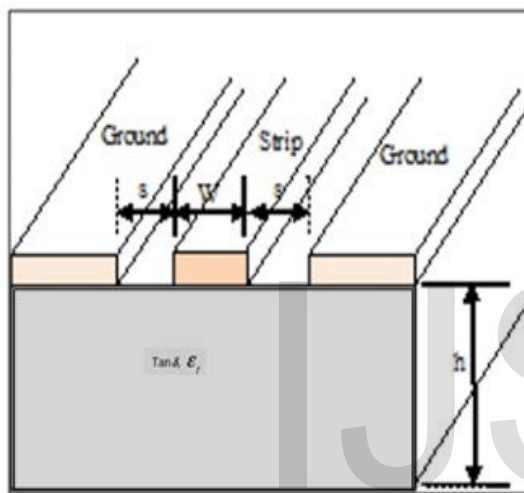


Fig. 3: coplanar slot (CPS)

The microstrip-line feed is easy to fabricate, simple to match by controlling the inset position and rather simple to model. However as the substrate thickness increases, surface waves and spurious feed radiation increase, which for practical designs limit the bandwidth (typically 2–5%).

Advantages of CPW feed over Microstrip Feed: Low Dispersion, Low Radiation Leakage, Ground plane not interdependent, and radiation from feed structure are negligible because of coplanar waveguide is excited in odd mode of coupled slot. This feature is useful in design of antenna arrays since mutual coupling between adjacent lines is minimized [4]. The antenna designs will use microstrip technology and FR4 board for the material substrates [8]. The dielectric constant is  $\epsilon=4.4$ , loss tangent  $\tan \delta = 0.02$  and the thickness  $d=1\text{mm}$ . Two different designs of meander line antenna described in next section:

## 2.1 MLA WITH DIFFERENT THICKNESS AND DIFFERENT LENGTH OF VERTICAL SEGMENT.

WLAN it is an important application of meander line antenna is in wireless communication systems [9,10]. In these applications, bandwidth is an important factor. As it mentioned before meander line antenna has low efficiency [4]. In this design, we make some changes on MLA length, width, and feed line dimensions, it might get better results. Fig. 4 shows MLA with different

thickness and different length of vertical segment with dimension of  $30 \times 42 \times 1\text{ mm}$ . Values of the resonant frequency parameters are set using HFSS software by the following steps.

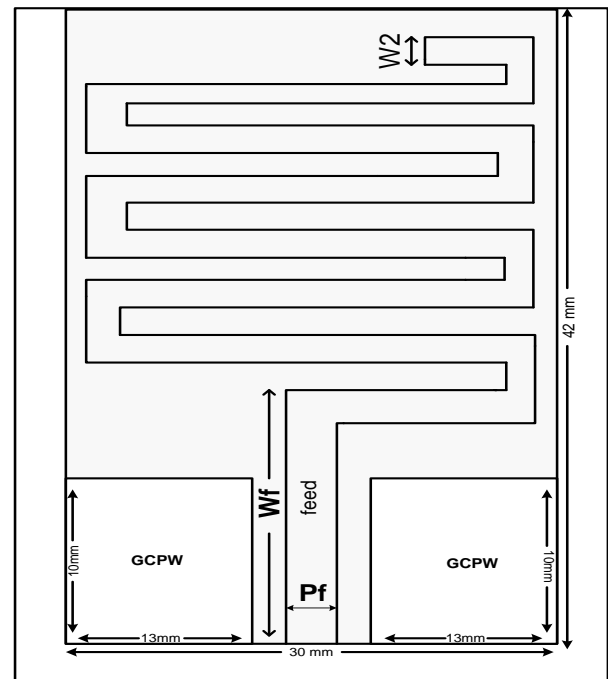


Fig. 4: MLA with different thickness and different length of vertical segment

**Step 1:** Vary width  $W_f$  by step 1 mm from 11 mm to 13 mm and fix all other parameters. The characteristic of the return loss is shown in Fig. 5 It is shown that, width  $W_f$  could affect on the resonant frequency and bandwidth, where the optimum value Of return loss  $S_{11}$  is found at  $W_f$  equals 13 mm, where the resonant frequency is 2.4 GHz, the bandwidth is 45 MHz. Different simulation results obtained for varying width  $W_f$  is shown in table 1.

Table .1 Simulation for different width  $W_f$

Height [mm]	F-start	F-stop	Max Gain	BW [MHz]
11	2.371	2.417	-1.987	46
12	2.308	2.360	-2.867	52
13	2.380	2.425	-2.115	45

Now in the next step we will parameterize the thickness  $P_f$ .

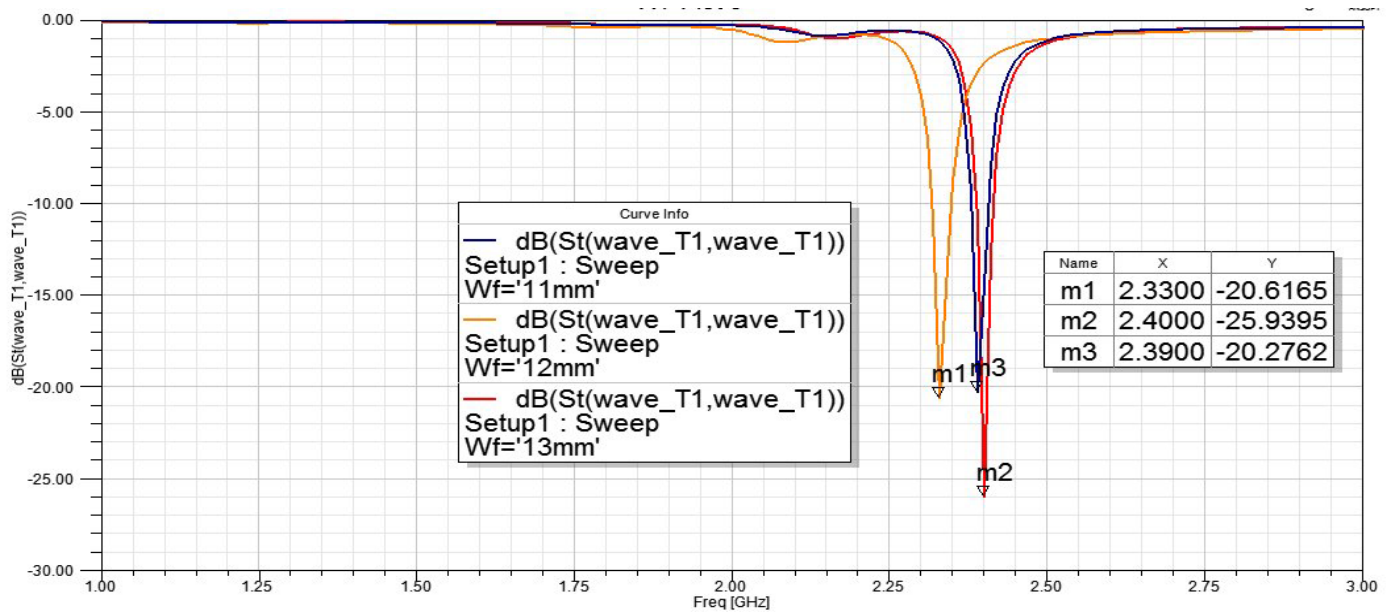


Fig. 5: Return loss for different width  $Wf$

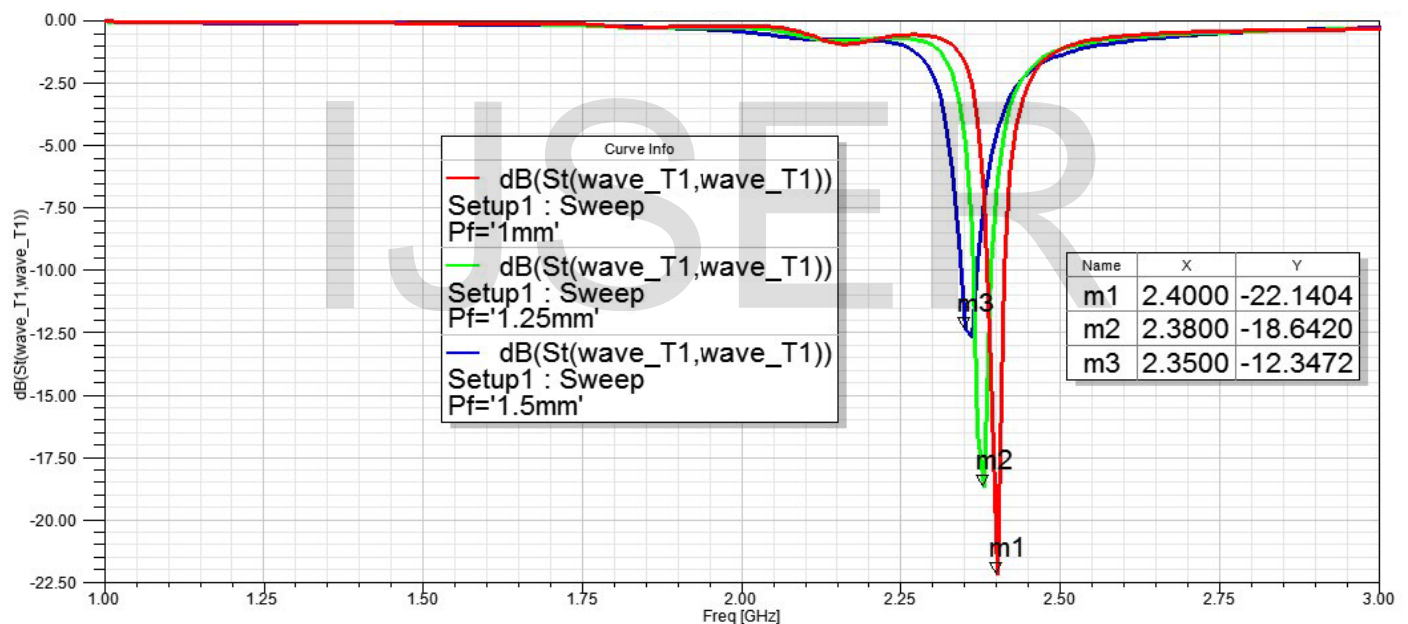


Fig. 6: Return loss for different thickness  $pf$

Table. 2 Simulation for different  $Pf$

Pf [mm]	F-start	F-stop	Max Gain	BW [MHz]
1	2.380	2.425	-2.115	45
1.25	2.375	2.425	-2.115	50
1.5	2.341	2.397	-2.115	56

**Step 2:** Vary thickness  $Pf$  by step 0.25 mm from 1 mm to 1.5 mm and fix all other parameters. The characteristic of the return loss is shown in Fig. 6. It is shown that, thickness  $Pf$  could affect on the resonant frequency and bandwidth, where the optimum value of return loss  $S_{11}$  is found at  $Pf$  equal 1mm, where the resonant frequency is 2.4GHz, The bandwidth is 45 MHz. Different simulation results obtained for varying thickness  $Pf$  is shown in table. 2.

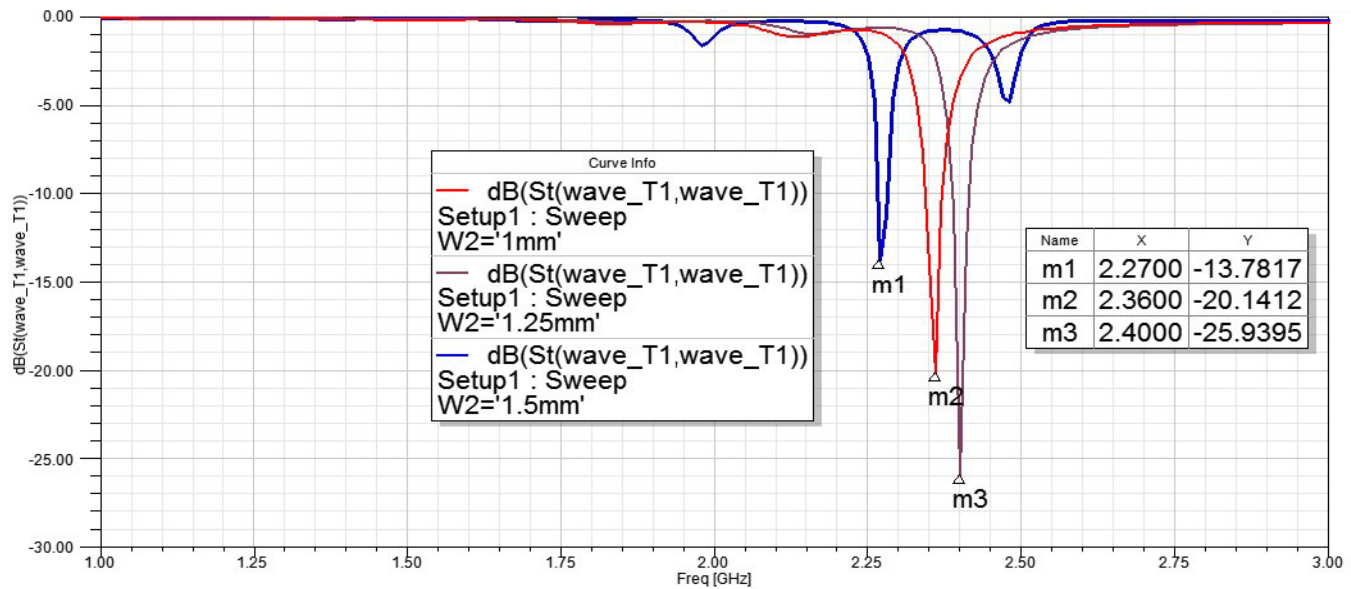


Fig. 7: Return loss for different width W2

Now the next step investigates width W2.

**Step 3:** Vary width W2 by step 0.25 mm from 1 mm to 1.5 mm and 1mm, where the resonant frequency is 2.4GHz, fix all other parameters. The characteristic of the return loss is shown in Fig.7 It is shown that, width W2 could affect on the resonant frequency and bandwidth, where the optimum value of return loss S11 is found at W2 equal 1.25 mm, where the resonant frequency is 2.4 GHz, the bandwidth is 45 MHz. Different simulation results obtained for varying width W2 is shown in table. 3.

Table. 3 Simulation for different width W2

W2 [mm]	F-start	F-stop	Max Gain	BW [MHz]
1	2.334	2.383	-2.397	49
1.25	2.380	2.425	-2.115	45
1.5	2.261	2.288	-2.397	27

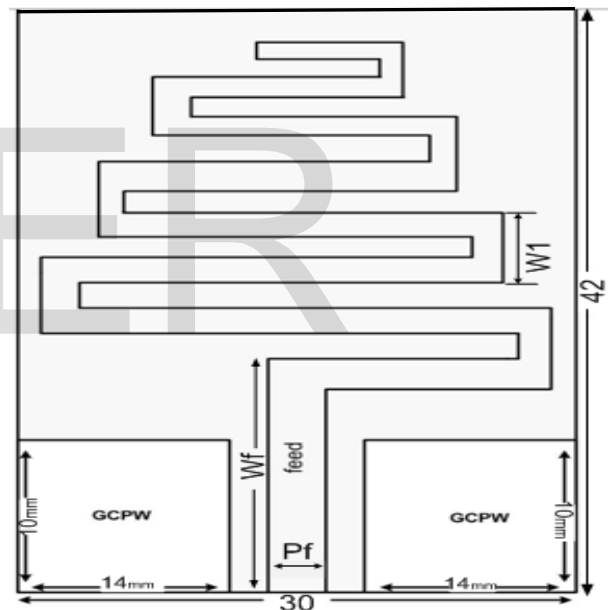


Fig. 8: Log periodic MLA

## 2.2. LOG PERIODIC MLA

The increasing use of wireless communication systems, demands the antennas for different systems and standards with properties like compact, broadband and multiple resonant frequencies [11]. Fig. 8 shows illustration of this antenna. Log periodic MLA with dimension of  $30 \times 42 \times 1$  mm has been designed to improve bandwidth. Values of the resonant frequency parameters are set by the same previous three steps in MLA.

**Step 1:** Vary width Wf by step 1 mm from 13 mm to 15 mm and fix all other parameters. . The characteristic of the return loss is shown in Fig. 9 It is shown that, width Wf could affect on the resonant frequency and bandwidth, where the optimum value of return loss S11 is found at Wf equals 13 mm, where the resonant frequency is 2.4 GHz, the bandwidth is 130 MHz. Different simulation results obtained For varying width Wf is shown in table 4.

Table 4 Simulation for different width Wf

Height [mm]	F-start	F-stop	Max Gain	BW [MHz]
13	2.369	2.507	-14.304	138
14	2.328	2.478	-12.923	150
15	2.338	2.468	-12.599	130



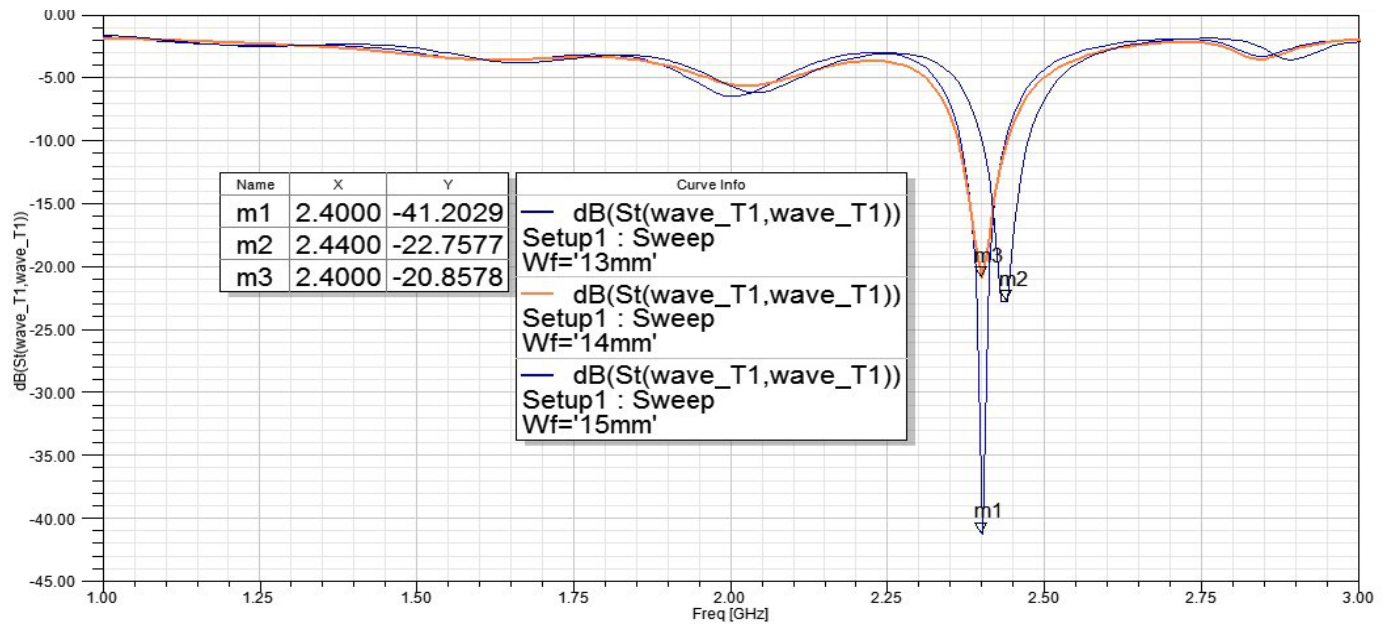


Fig. 9: Return loss for different width  $W_f$

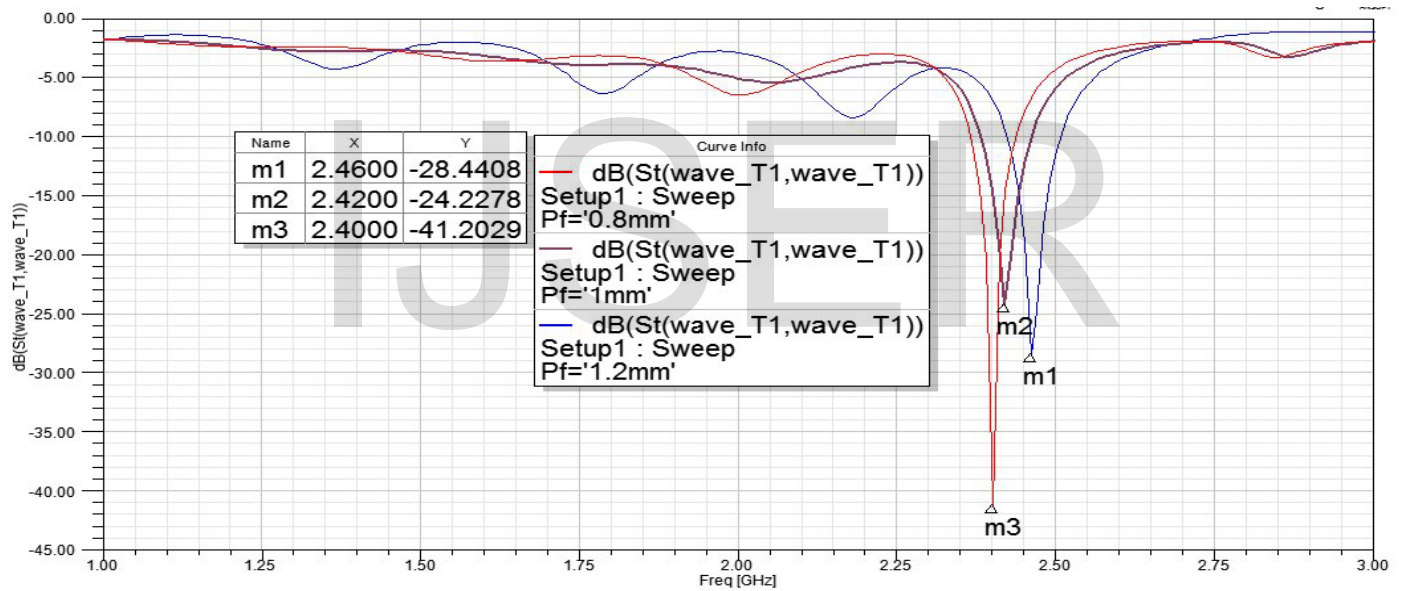


Fig. 10: Return loss for different thickness  $P_f$

Now in the next step we will parameterize the thickness  $P_f$ .

**Step 2:** Vary thickness  $P_f$  by step 0.2 mm from 0.8 mm to 1.2 mm and fix all other parameters. The characteristic of the return loss is shown in Fig. 10. It is shown that, thickness  $P_f$  could affect the resonant frequency and bandwidth, where the optimum value of return loss  $S_{11}$  is found at  $P_f$  equal 0.8 mm, where the resonant frequency is 2.4 GHz, the bandwidth is 130 MHz. Different simulation results obtained for varying thickness  $P_f$  is shown in table 5.

Table. 5 Simulation for different  $P_f$

$P_f$ [mm]	F-start	F-stop	Max Gain	BW [MHz]
0.8	2.338	2.468	-12.599	130
1	2.350	2.498	-13.780	148
1.2	2.388	2.542	-12.991	154

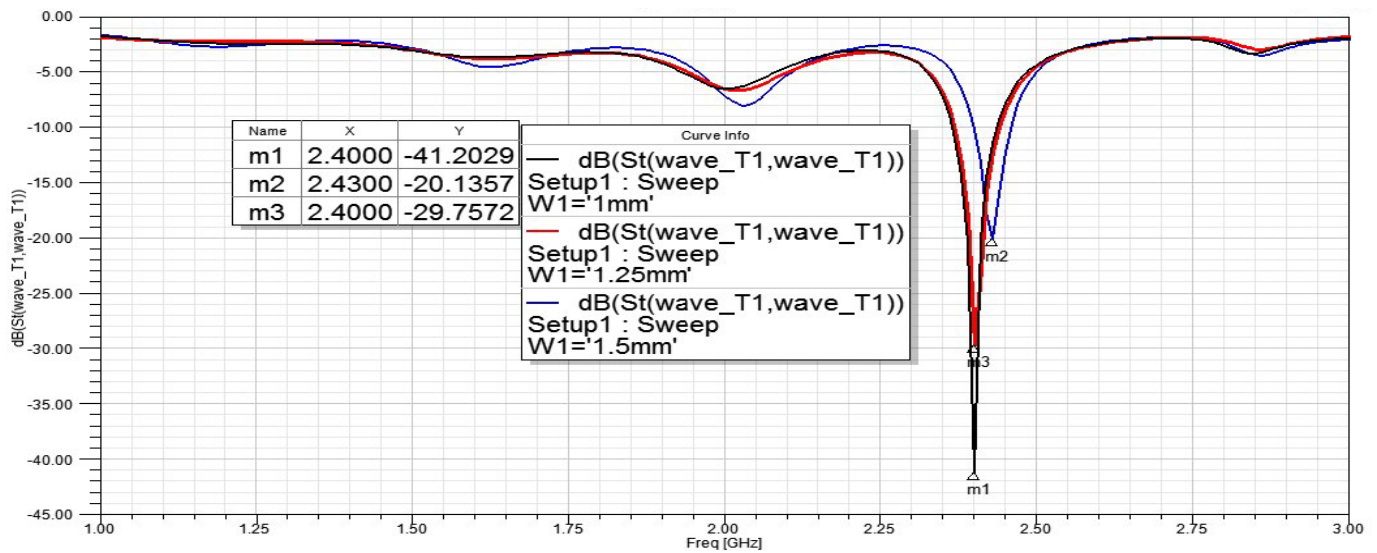


Fig. 11: Return loss for different width  $W1$

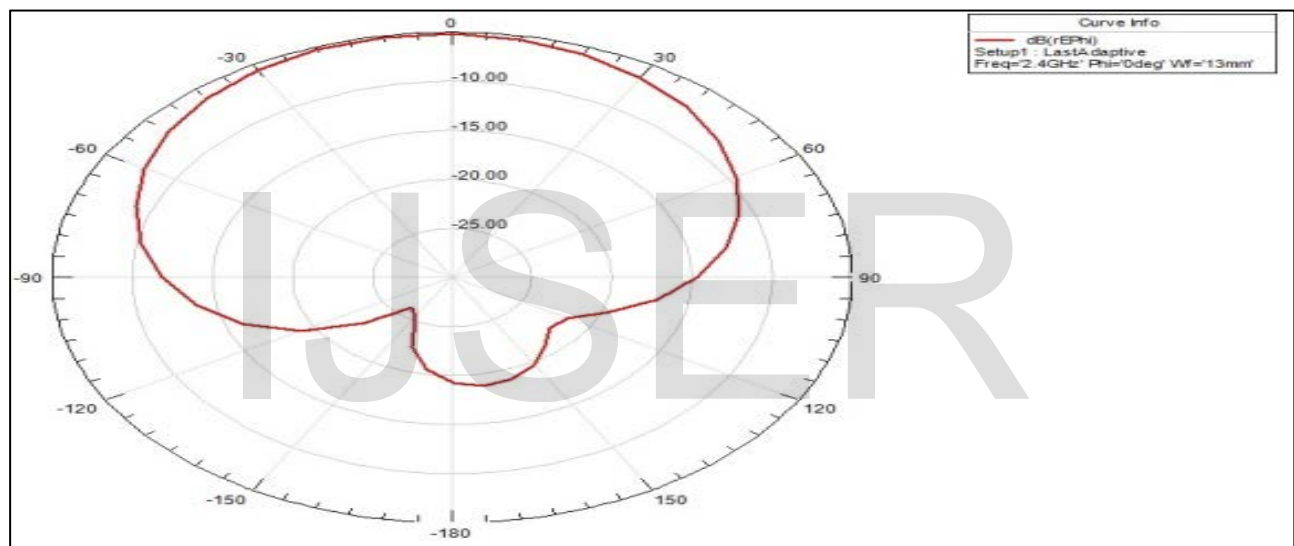


Fig. 12: radiation pattern of MLA

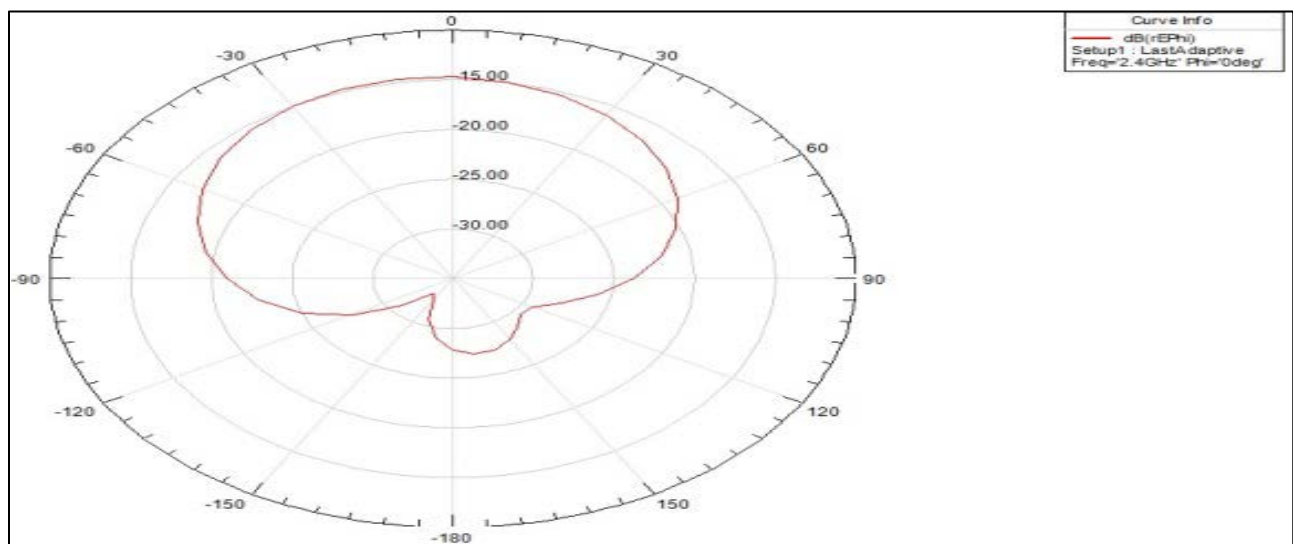


Fig. 13: radiation pattern of Log periodic MLA

Now the next step investigates the width  $W1$ .

**Step 3:** Vary width W1 by step 0.25 mm from 1 mm to 1.5 mm and fix all other parameters. The characteristic of the return loss is shown in Fig. 11 it is shown that, width W1 could affect the resonant frequency and bandwidth, where the optimum value of return loss S11 is found at W1 equal 1.25 mm, where the resonant frequency is 2.4 GHz, the bandwidth is 130 MHz. Different simulation results obtained for varying width W1 is shown in table. 6.

Table. 6 Simulation for different width W1

W1 [mm]	F-start	F-stop	Max Gain	BW [MHz]
1	2.338	2.468	-12.599	130
1.25	2.340	2.473	-12.707	133
1.5	2.374	2.486	-13.701	112

Fig. 12 and 13 show the Omni-directional radiation pattern of MLA and Log periodic MLA respectively. As seen, the designed antenna has very linear-polarized characteristics. Fig. 14 and 15 show the 3D pattern of MLA and Log periodic MLA respectively.

### 3. VALIDATION OF DESIGN AND SIMULATOR

Fig. 16 shows a comparison between HFSS simulator and simulator result from reference [5]. We observe an exact correspondence between the two models for the parameter  $42 \times 30 \times 1$  mm.

### 4. CONCLUSION

The small size, low profile, simple and cheap all these good properties can find in meander line antenna. These good features make meander line antenna very popular and usable in many aspect of communication systems such as RFID and WLAN. Classic meander line antenna has some disadvantages. They have low efficiency, low bandwidth. In this paper, Meander Line Antenna (MLA) for 2.4 GHz is proposed, implemented and verified using HFSS simulation software, with applying some changes in classic meander line antenna, two shape of meander line antennas have been proposed to improve these issues. Meander line antenna with different length and different thickness of vertical segment has been presented with improve radiation efficiency up to 80% , and bandwidth up to 45 MHz . Furthermore, log periodic have been designed to improvements the bandwidth up to 130 MHz, and radiation efficiency up to 60%. There is further scope of work in log periodic MLA, one can repeat the design to the dual band antenna.

### REFERENCES

- [1] C.-C. Lin, S.-W. Kuo and H.-R. Chuang, "2.4-GHz Printed Meander-Line Antenna for USBWLAN with Notebook-PC Housing," Microwave and Wireless Components Letters, IEEE, Vol. 15, No. 9, 2005.
- [2] Ma, MJ and Deng, K , " The study and implementation of meander line antenna for an integrated transceiver design" MSc Thesis University of CAVL in Electronics/Telecommunications,2010.

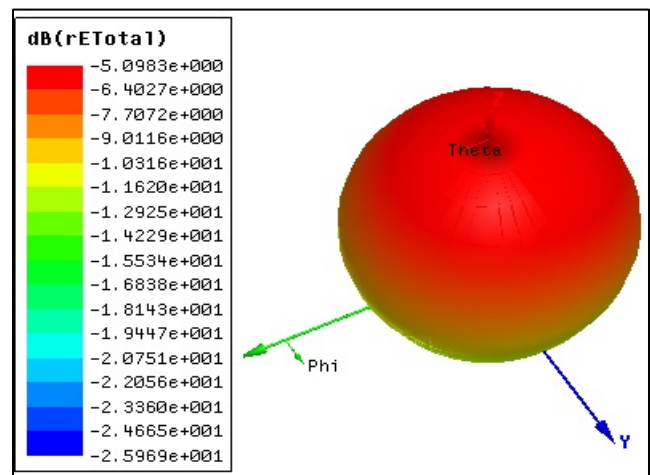


Fig. 14: 3D electrical pattern of MLA with different thickness and different length of vertical segment.

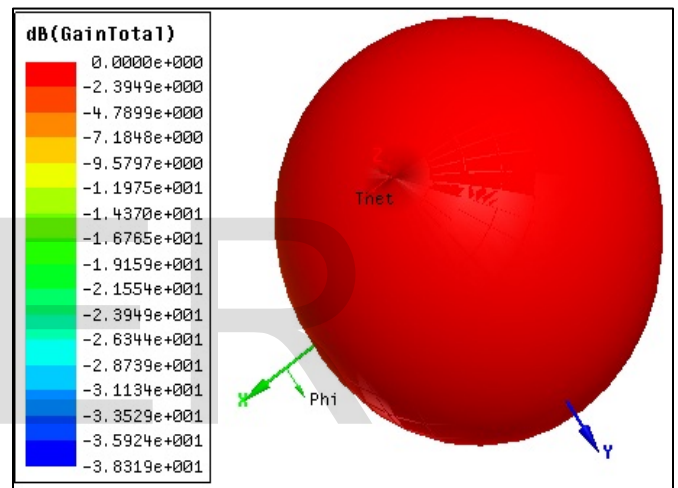


Fig. 15: 3D electrical pattern of log periodic MLA.

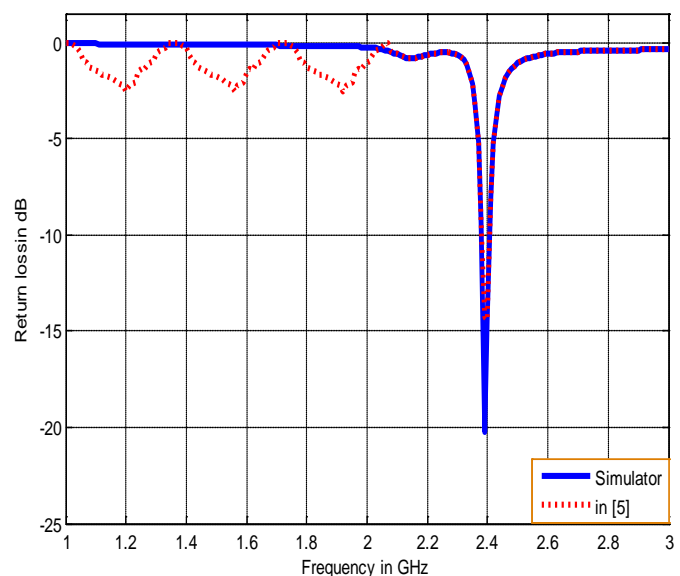


Fig. 16: Comparison between HFSS simulator and simulator result in [5]

- [3] T.Endo, Y. Sunahara, S. Satoh, and T. Katagi, "Resonant fre-

- quency and radiation efficiency of meander line antennas," Electronics and Communications in Japan, Part 2, Vol. 83, No. 1, 2000.
- [4] Balanis, C. A., Antenna Theory Analysis and Design, 3rd Edition, Copyright 2005 by John Wiley & Sons, Inc.
- [5] A.Jahanbakhshi<sup>1</sup>, Gh.Moradi<sup>2</sup>, and R. Sarraf Shirazi<sup>2</sup>, "Design and Simulation of Different Types of Meander Line Antennas with Improved Efficiency", 1Amirkabir University of Technology, Iran Electrical Department, Amirkabir University of Technology, Iran, 2012.
- [6] E .Louis, Frenzel, , "Printed-Circuit-Board Antennas", Frenzel, pp.1-2, March 31, 2005.
- [7] I-Fong Chen and Chia-Mei Peng, Compact Modified Pentaband Meander-Line Antenna for Mobile Handsets Applications, IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 10, 2011.
- [8] D. Misman, I. A. Salamat, M. F. Abdul Kadir, M. R. Che Rose, M. S. R. Mohd Shah, M. Z.A. Abd. Aziz, M. N. Husain, P.J Soh," The Study of Different Impedance Meander Line for Planar Antenna Design ",2008 .
- [9] S. Manchanda, M. Hatwar, and B .Abhishek. "Design of Meander Line Antenna for Operating Frequency of 2.5 GHz." International Journal of Computer Applications, Vol. 93, No. 19, 2014.
- [10] N. I. M.Elamin, T. A. Rahman, and A. Y. Abdulrahman." New Adjustable Slot Meander Patch Antenna for 4G Handheld Devices."IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 12, 2013
- [11] J. Mruk, M.Uhm, and D. Filipovic. "Dual-wideband log periodic antennas." Antennas and Propagation Society International Symposium, IEEE, 2008.