MEANDER LINE AND E-SHAPE ANTENNA'S PARAMETERS ENHANCEMENT FOR WLAN APPLICATIONS

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ABSTRACT: The meander line antennas (MLA) are electrically small antennas that pose several performance related issues such as narrow bandwidth, low gain and high cross polarization levels. In this research enhancement techniques were applied to enhance the gain and the bandwidth of one MLA antenna. Antenna gain of 2.78dB at the resonant frequency of 2.5 GHz, the bandwidth is 440MHz, and return loss is -50dB. Furthermore, a shape modification to E-shape was applied on the antenna resulted in a small antenna gain and significant increase in the bandwidth.

KEYWORDS: MLA, WLAN, enhancement, antenna.

[1] INTRODUCTION

The low-profile antenna has gained significant importance as the demand for the integration of several wireless technologies into dimensionally small antennas increases. The size reduction trends in antennas have resulted in a provoked necessity to maintain the performance characteristics of the antennas. The performance degradation factors such as low gain and radiation inefficiency are conventionally seen as inherent characteristics of small antennas. The microstrip antennas are conformal to both planar and non-planar surfaces. They can be designed with fairly high degree of freedom for the parametric optimization. Low cost of fabrication is an added advantage of microstrip radiators [1]. The design for the frequency bands make some design challenges in the antenna portion of the WLAN applications due to size limitations. If regular antenna designs are used, the size of the antennas will not fit within the small size of the device.

Innovative designs are required to overcome this challenge. Electrically Small Antennas (ESA) are antennas that can be enclosed in a radian sphere, meaning that the relationship $ka < 1$, where $k = 2\pi/\lambda$ and a is the largest diameter of the circle inclosing the complete antenna has to be satisfied [2]. ESAs have high input reactance and low

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input resistance. Therefore, they have high quality factor (Q) and frequency bandwidth. In [3], an expression for the Q was derived and is given by

$$Q = \left(\frac{1}{ka}\right)^3 + \left(\frac{1}{ka}\right) \text{----- (1)}$$

While in [4] an expression for the maximum expected gain from an ESA based on its dimensions was determined. This maximum gain is given by

$$Gain_{max} = (ka)^2 + 2(ka) \text{----- (2)}$$

We show that both equations (1) and (2) do not consider a ground plane near the antenna. We will use the empirical equations to come up with a meander line antenna (MLA) that has a resonant frequency of 2.5 GHz as applied in [5], where we cannot use equations for large antenna to use for the 2.5 GHz band.

The authors in [6] proposed a meander-line structure for PCMCIA cards at 2.4 GHz as shown in Figure 1. The maximum gain of the antenna is 2.76dB and a return loss of about -17dB at the resonant frequency. The substrate material was used is FR4 with $\varepsilon_r = 4.5$ and $\tan \delta = 0.0150$, dielectric height and $H = 1.57$ mm.

In this paper, two modifications were applied to the antenna: the first way is to reduce the ground from 30 mm to 25.38 mm and increase the width line from 0.1 mm to 2.45 mm as shown in Figure. 2, the second modification is changing the shape of MLA to E shape antenna as shown in Figure. 3. The commercial HFSS software package is used for the design, simulate and optimization of the modified MLA antenna.

[2] ANTENNA DESIGN

The first antenna modification is shown in Figure. 2, where the ground is decreased from 43mm to 30mm and the width of MLA is increased from 1mm to 2.45mm. The reduction of the ground plane was implemented to account for the increase of the line in order to achieve the required resonance frequency. The second modification is shown in Figure. 3, where the MLA shape is changed to have an E shape.
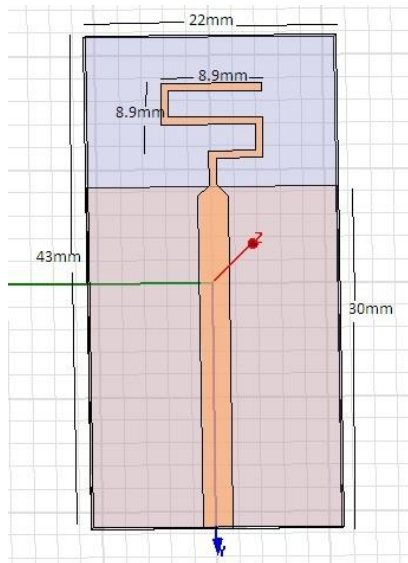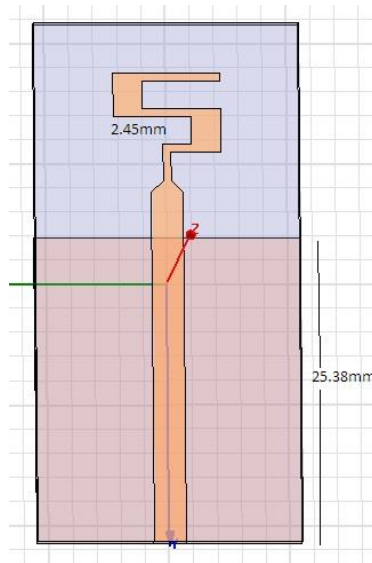
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Figure 1: MLA Antenna shape in [7]

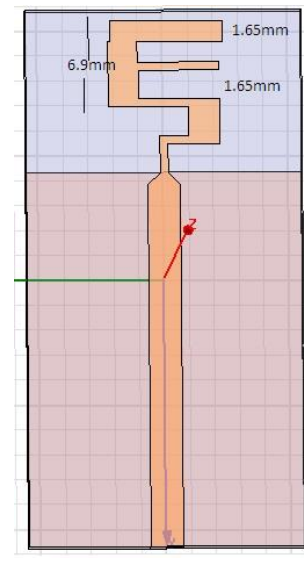Figure 2: The first modification of MLA

Figure 3: The E-shaped MLA antenna

[3] SIMULATED RESULTS

This section presents the simulated results of the two modified MLA antennas. HFSS was used to simulate the antenna in order to obtain several performance parameters such as; return loss, radiation patterns and gain.

A. Modification of the line width.

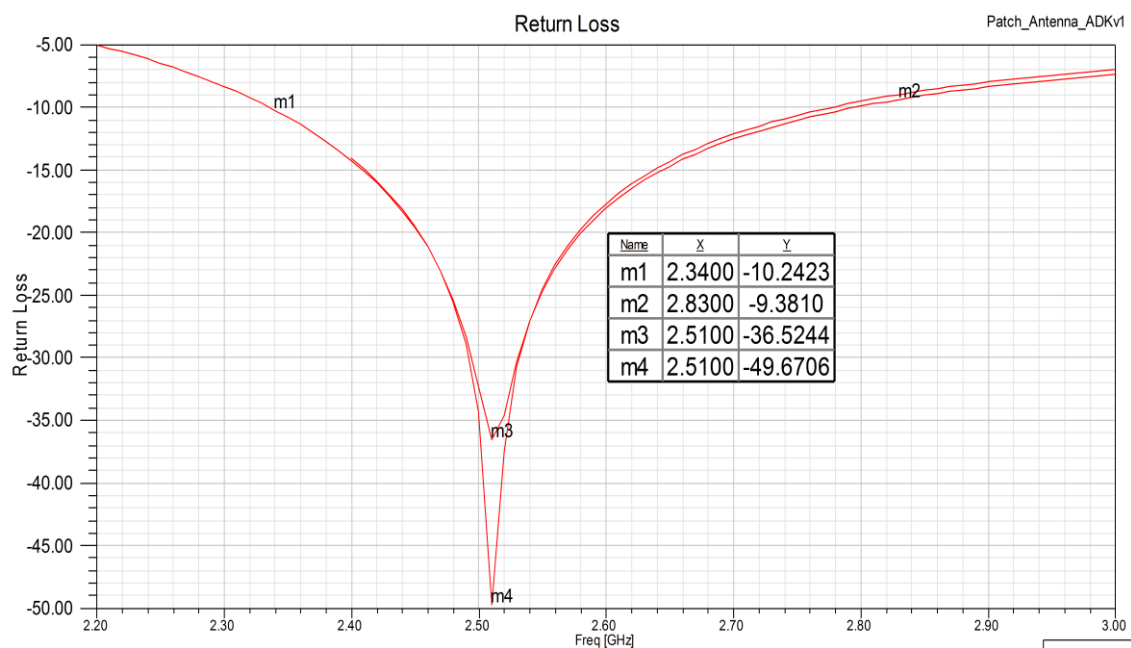| Name	X	Y
m1	2.3400	-10.2423
m2	2.8300	-9.3810
m3	2.5100	-36.5244
m4	2.5100	-49.6706

Figure 4: Return Loss for MLA with modified line width

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Figure 4 illustrates the return loss of the first modification; where it shows a return loss of about -50 dB at the operation frequency of 2.5GHz. The bandwidth calculated at -10dB scale for this band is 440 MHz. The ground plane was optimized for this antenna for the resonance frequency.

The gain is an important criterion to measure the performance of an antenna. As the size of an antenna is reduced to be less than one quarter wavelength at the operating frequency, it becomes highly inefficient and susceptible to high mutual coupling that affects its performance and gain. The gain of this antenna is illustrated in Figure. 5, where the radiation pattern is omnidirectional that similar to the radiation pattern of the dipole antenna.
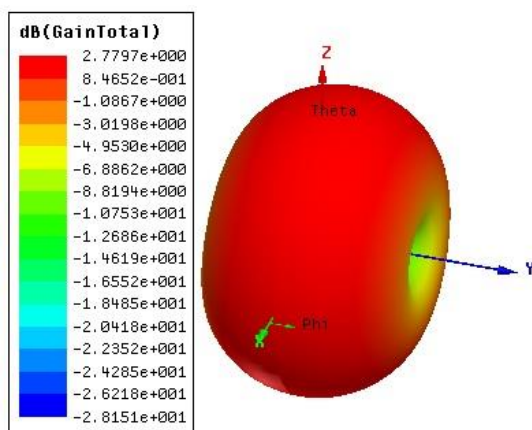

Figure 5: Far-Field Radiation Pattern for MLA with modified line width.

It is of extreme important for the stability of the antenna performance to have near constant gain over the entire bandwidth of operation. Figure 6 shows the radiation pattern of the antenna when phi=0.
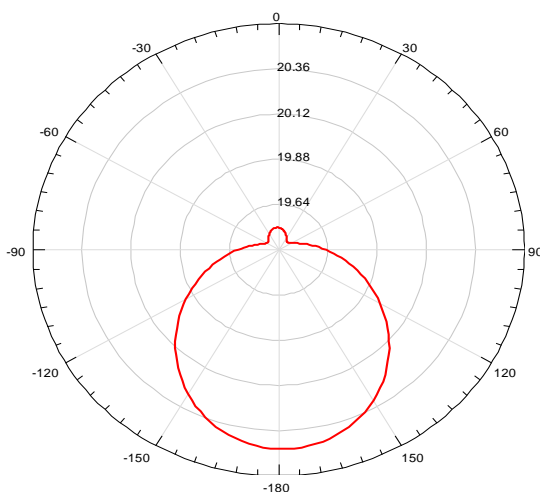

Figure 6: The radiation pattern for MLA with modified line width when phi=0

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B. Modification of the line shape.

Figure 7 illustrates the return loss of the E-shaped MLA; where it shows a return loss of -23 dB at the operation frequency of 2.5GHZ. The bandwidth calculated at -10dB scale for this band is 1GHz which gives an increase of about 600MHz in compare to the original MLA antenna. The simulated far-field radiation patterns of the E-shaped MLA are presented in Figure 8 and Figure 9.
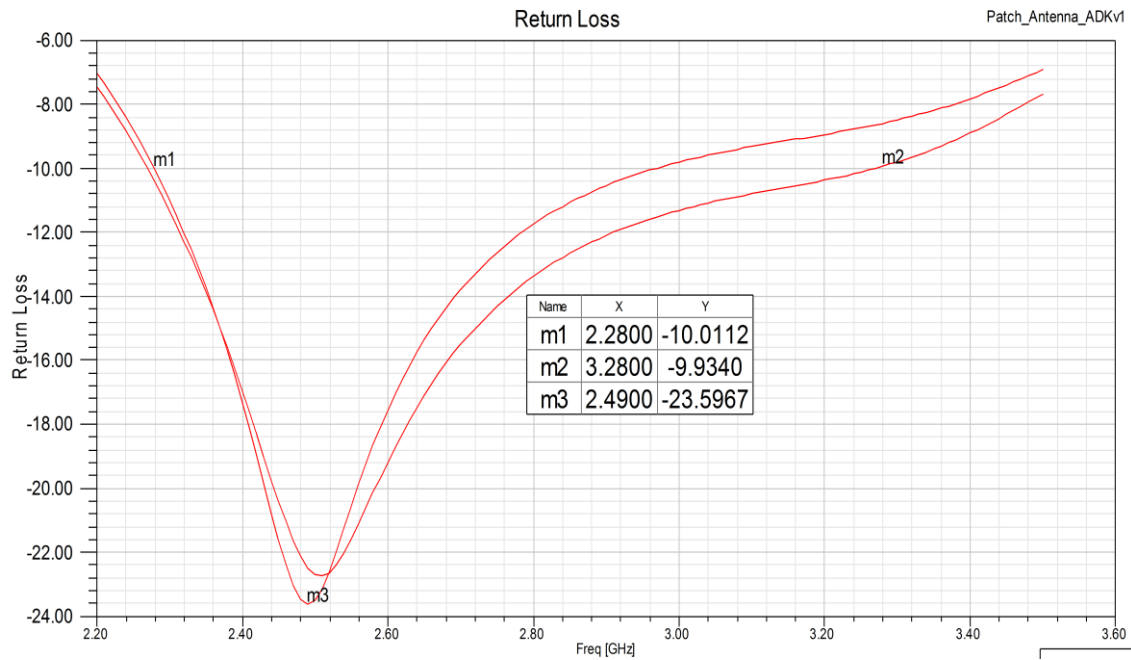

Name	X	Y
m1	2.2800	-10.0112
m2	3.2800	-9.9340
m3	2.4900	-23.5967

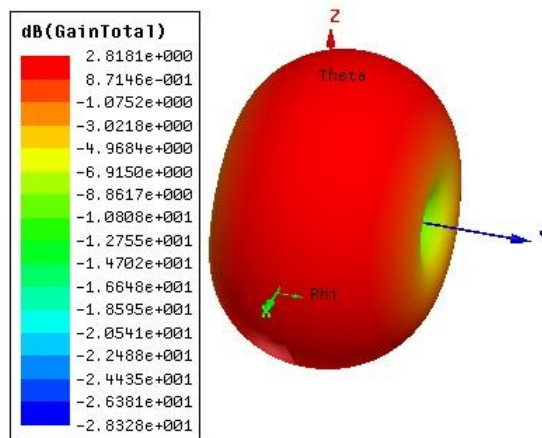Figure 7: Return Loss for the E-shaped MLA antenna

Figure 8: Far-Field Radiation Pattern for the E-shaped MLA antenna

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Table 1 provides a data showing the differences between the original antenna, the MLA with modified line width and the E-shaped MLA antenna, where the MLA with modified line width enhance the bandwidth of about 60 MHz and give a much better return loss; however; it provided a small enhancement in the gain. E-shaped MLA antenna enhanced the bandwidth by about 600 MHz, and enhanced the gain of about 0.5dB.
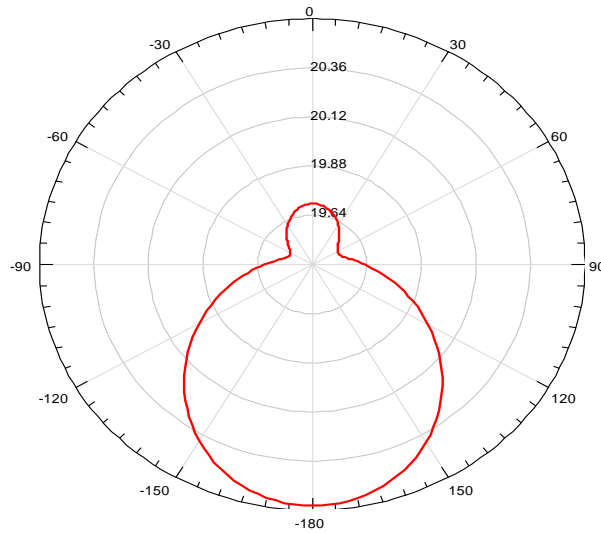

Figure 9: The radiation pattern of the E-shaped MLA antenna when phi=0

Table 1: Performance parameters of antenna by simulation

Parameters	The original MLA	MLA with modified line width	E-shaped MLA
Resonant Frequency	2.4 GHZ	2.5 GHZ	2.5 GHZ
Return Loss	-16 dB	-50 dB	-23 dB
10db bandwidth	380 MHZ	440 MHZ	1 GHZ
Max Gain	2.76	2.78	2.82

[4] CONCLUSIONS

An electrically small MLA antenna operating at the 2.5 GHz was studied in this research using HFSS software package. Modifying the line width of the MLA antenna resulted in a return loss of about -50 dB with small enhancement of the antenna bandwidth. A new E-shaped antenna is studied in this paper. The antenna provided a significant bandwidth enhancement and small gain enhancements. The MLA depicts an overall fair performance and it could be a promising candidate to overcome the deficiencies of the low profile small antennas. Further study is required for the optimization of the E-shaped MLA antenna.

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