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Design and Simulation of Triangular Shaped Meander-Line Antenna

Syed Md. Anwarul Islam, M. Tanseer Ali and Ashiqur Rahman

***Abstract*— This paper, illustrates a 2.45 GHz triangular-shaped meander line antenna's design, simulation, and efficiency. Parametric studies which include the number of turns, line thickness, ground width, length, and line space are discussed in order to achieve the optimum value of meander line antenna's gain. For the simulation, CST software is used. The antenna is studied on a 1.6 mm thick FR4 substratum and 4.6 relative permittivity. This paper also shows the calculations of Total efficiency, Radiation efficiency, S11, VSWR which is -4.499 dB, -4.498 dB, 2.45GHz, 1.0241. For WLAN systems, the designed antenna has a great chance to be implemented.**

Keywords—MLA, triangular shape, wireless, communication, parameter, simulate

I. INTRODUCTION

In recent years, wireless communications have evolved very a bruptly, and many devices are becoming smaller in size because of antennas being used in wireless systems are getting smaller in size accordingly with design and directional, omnidirectional radiation. Modern monocular or helical antennas have been used extensively for WLAN communication technology [1].

Besides these antennas meliorate the volume of the structure and superseded by the internal antenna [2][3][4]. Among several different antennas, Meander Line Antenna (MLA) is chosen because it offers compact size characteristics, inexpensive prices and easy manufacturing [5][6][7]. All these outstanding features can be found in meander line antenna in the compact size, lightweight, convenient and inexpensive. These exceptional characteristics make meander line antenna common and usable in many aspects of communication systems. The wire is continuously folded in the meander-line antenna to decrease its length of resonance. If the total length of the fixed axial length escalates, the resonant frequency will be dropped. These antennas performance features differ in different geometry and in the total length of wire.

Syed Md. Anwarul Islam
Dept. of Electrical and Electronic Engineering (EEE)
American International University Bangladesh.
Email: prottoyanwarul01@gmail.com

M. Tanseer Ali
Dept. of Electrical and Electronic Engineering (EEE) American International University Bangladesh.
Email: **tanseer@aiub.edu**

Ashiqur Rahman
Institue of Multidisciplinary Research for Advance Materials (IMRAM)
Tohoku University
Email: ashu_rahman@yahoo.com

This paper discusses the analytical technique based on the experimental system for calculating the resonant frequency bandwidth and gaining the triangular-shaped meander line antenna. The first section describes the design of the meander-line antenna. CST software was basically used to design antennas and to analyze the patterns of the radiation. Each electrical property such as resonant frequency, bandwidth, and gain depicted by CST SIMULATOR. No. patch (N), line width (W), antenna width (Wg), length (Lg), line space (S) are the important parameters for the design. Wireless local area network is one of the wireless communication applications, 2.4GHz-2.48GHz, and 5.152GHz-5.825 GHz are the frequencies. So many prototype antennas can lastly be designed and manufactured from the recommended antenna for WLAN apps.

II. STRUCTURE OF ANTENNA AND SPECIFICATION

An equilateral triangular meander line antenna is designed, consisting of a patch, ground, and substratum. The patch and ground consist of copper and FR4 are used as a substratum. The FR4's width is 1.6 mm and the antenna width is 1.67 mm. The waveguide port is linked underneath the feed line and the input energy is supplied from here.
Various parameters of the meander line antenna can be determined from the following equations,

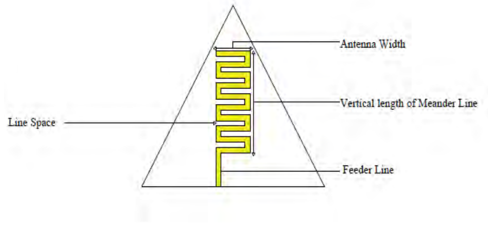
$$width, w = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r+1}{2}}} \qquad (1)$$

Here,
fr = Resonance Frequency (404 MHz)
c = Speed of Light (3*108 m/s)
εr = Relative permittivity of the dielectric substrate (4.3)
Effective Dielectric Constant,

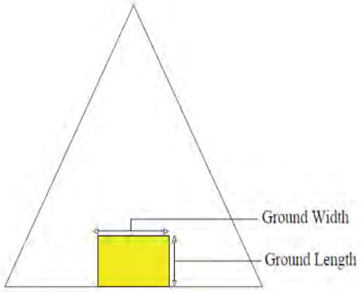
$$\varepsilon_{eff} = \frac{\varepsilon+1}{2} + \frac{\epsilon-2}{2}\frac{1}{\sqrt{1+\frac{12h}{w}}} \qquad (2)$$

W = Width of the Patch
h = Thickness
The simulated architectural view of the front side and backside of the meander line antenna is depicted with the assistance of CST MICROWAVE STUDIO in Figure 1(a) and 1(b). The

radiating parts have 10 numbers of turns with a microstrip feed line technique and the ground plane is positioned on the rear side of the meander line antenna.



(a)Front view



(b) Back view

Fig 1: Simulated design of MLA (a) Front view (b) Back view

TABLE I. SPECIFICATION OF MEANDER LINE ANTENNA

Parameters	Dimension (mm)
Thickness of FR4	1.6
Feed width (W)	3.5
Number of patch (N)	10
Antenna width (Wa)	23.68
Ground width (Wg)	35
Vertical length of MLA (Lg)	65
Ground length (L)	100
Line space	3

III. RESULTS AND DISCUSSION

Throughout this paper, three parametric contexts have been analyzed, which are a number of turns, feed width (W) and ground width (L). TABLE II demonstrates the analytical number of turns. When the number of turns is 10, S11 return loss is-38.473925 dB this is the optimum result of return loss. As the number of turns increased and so the return loss is decreased below-10 dB. However, a number of turns have an immense effect on return loss, but it does not influence the resonant frequency that fixes at 2.45 GHz.

TABLE II. ANALYSIS OF NUMBER OF TURNS

No. of Turns	Resonant Frequency (GHz)	Return Loss [S11] (dB)
14	2.45	-2.9669715
12	2.45	-2.262659
10	2.45	-38.473925
8	2.452	-8.0093093
6	2.45	-4.050914

TABLE III shows the parametric studies of the meander line antenna's feed line width. When the width of the feed line is 3.5 mm, S11 return loss is -38.473925db and it is the optimum result of return loss. As the width of the feed, the line is decreased (3mm and 2.5mm) and increased (4mm and 4.5mm) the result of S11 return loss is not anyway near to the optimum value.

TABLE III. PARAMETRIC STUDIES OF THE WIDTH OF FEEDLINE

Thickness of feed Line (mm)	Resonant Frequency (GHz)	Return Loss [S11] (dB)
2.5	2.45	-5.1139286
3	2.45	-10.762537
3.5	2.45	-38.473925
4	2.45	-7.8884765
4.5	2.45	-3.9071999

TABLE IV Shows the variable data of the ground width of the meander line antenna. The ground width varies between 25 mm and 45 mm. The meander line antenna functions at a frequency of 2.45 GHz when the ground width is 35 mm and the return loss is -38.473925 dB which is the optimum return loss expected result. As the ground width decreases to (30 mm and 25 mm) and increases to (40 mm and 45 mm), the return loss expected to result from S11 is not up to the best possible value. It is also noted from this table that the operating frequency changed to the right and vice versa when the ground width is reduced.

TABLE IV. PARAMETRIC STUDIES OF THE WIDTH OF GROUND

Thickness of Ground (mm)	Resonant Frequency (GHz)	Return Loss [S11] (dB)
25	2.59	-13.05809
30	2.50	-21.111649
35	2.45	-38.473925
40	2.38	-31.816911
45	2.31	-27.245793

Parameter S11 or coefficient of reflection measures the number of radiated or reflected power from an antenna [8]. The frequency in GHz is shown in Figure 2, X-axis, and Y-axis demonstrates the loss of return in dB. The constructed antenna's operating frequency and return loss is 2.45 GHz and -38.473836 dB. It is noted that when a straight line is drawn at -10 dB, the constructed antenna has a bandwidth of 61.3 MHz.

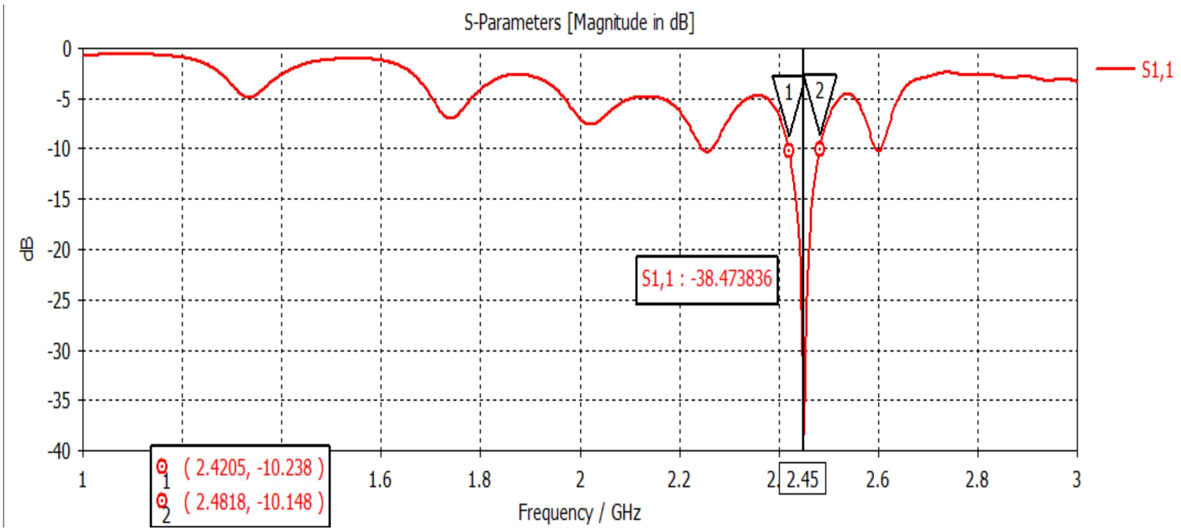


Figure 2: S11 parameter of the antenna

In Figure 3, the constructed antenna’s radiation character is shown. The antenna's directness is 6.89 dBi. It is also observed that the designed antenna's overall effectiveness and radiation effectiveness is -4.499 dB and -4.498 dB.

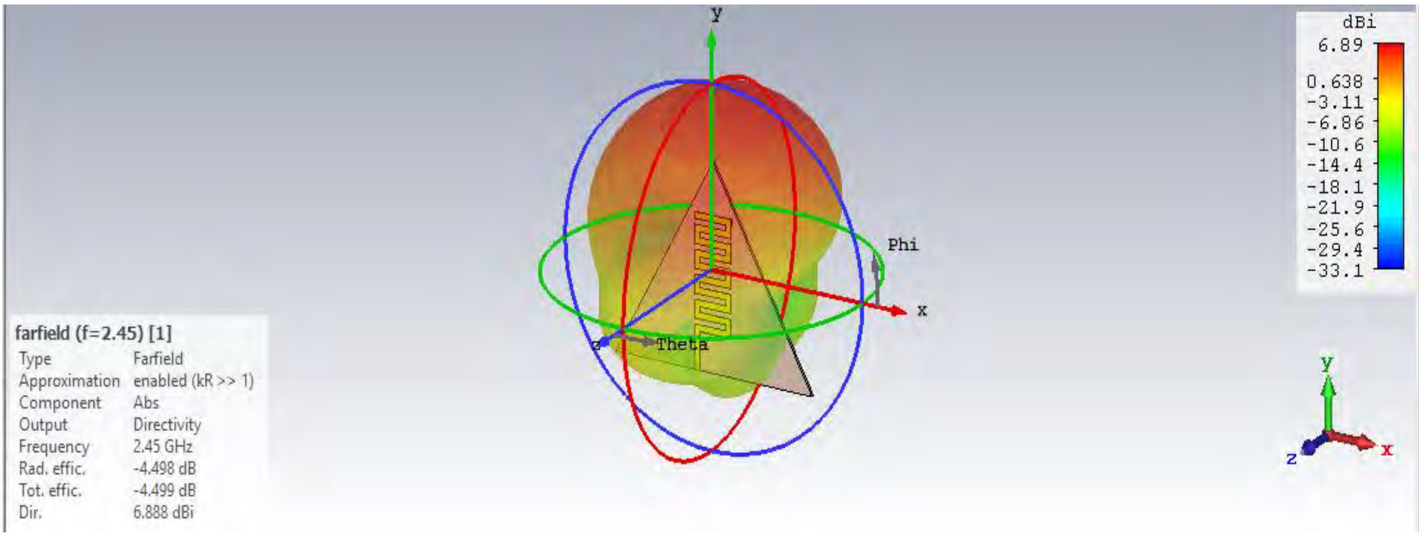


Figure 3: 3D View of the constructed antenna's far-field radiation pattern

Designed the antenna’s polar view of the far-field radiation pattern is observed in figure 4. The magnitude of the main lobe is 6.66 dBi. Its angular width is 112.7 deg and main lobe direction is 79.0 deg.

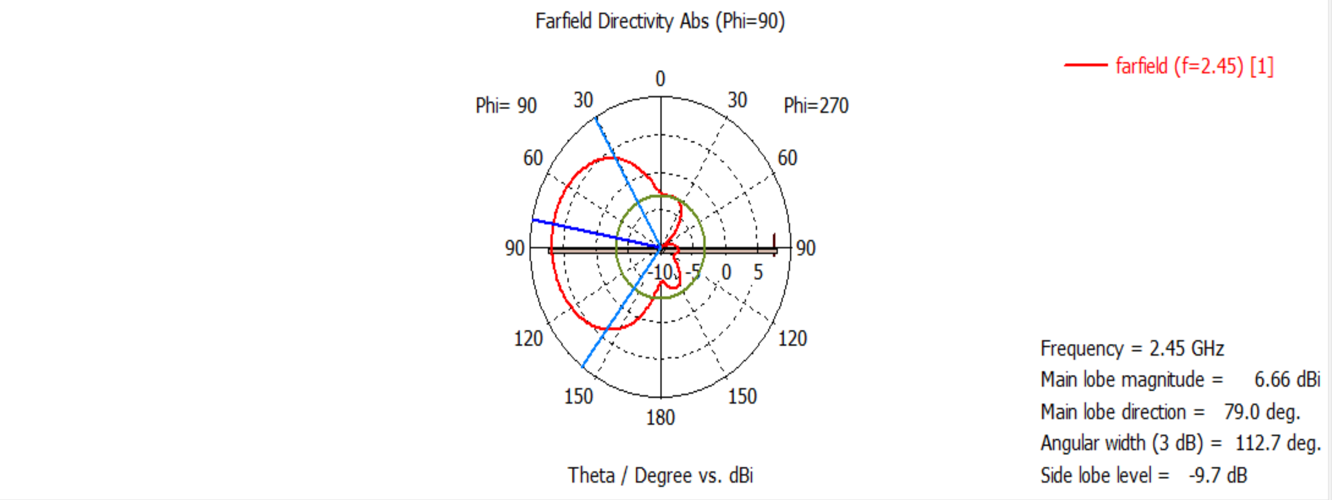


Figure 4: Polar view of the far-field radiation pattern of the designed antenna

In Figure 5, X-axis depicts the GHz frequency and Y-axis depicts the standing wave ratio of voltage (VSWR). VSWR measures the signal reflected the power and is a reflection coefficient function [8]. For a better antenna output, VSWR must be between 1 and 2 [8]. For the constructed antenna, 1.0241 VSWR is measured at a resonant frequency of 2.45 GHz.

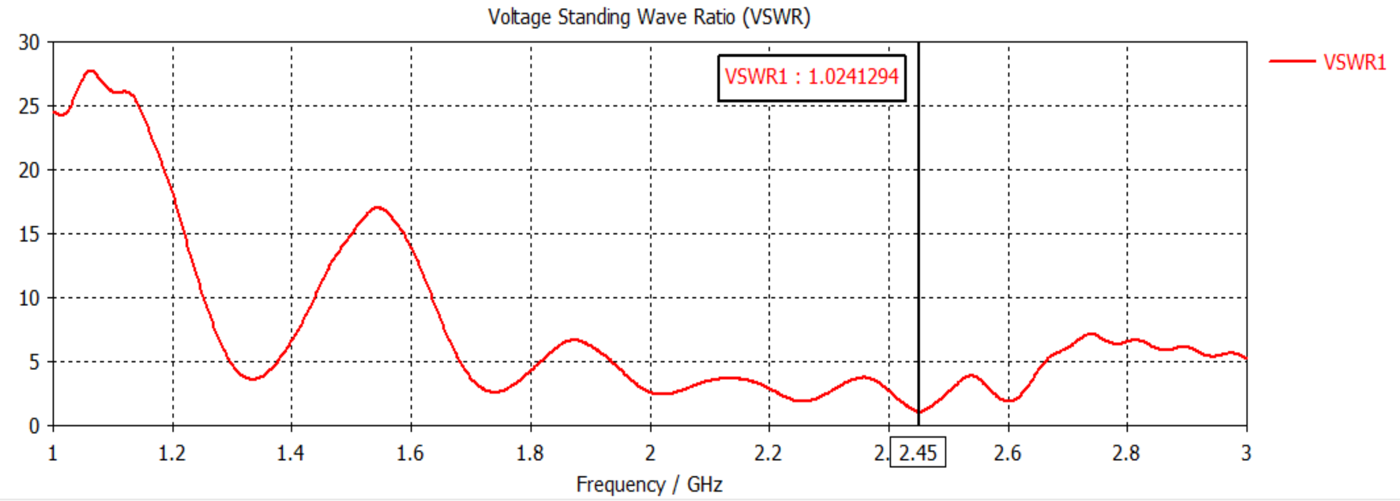


Figure 5: VSWAR of the proposed antenna

IV. COMPARISON WITH OTHER WORK

The first reference used in the comparison TABLE V is [9] Design and simulation of meander line antenna for LTE band. This team has successfully implemented and verified the antenna for LTE band and designed by using HFSS simulation software. They have improved the radiation efficiency up to 80% and bandwidth up to 45MHz. Besides, they have intended to design a log-periodic for improving the bandwidth up to 130 MHz and radiation efficiency up to 60%. 2nd reference is taken from [10] Design Analysis of 2.45 GHz Meander Line Antenna (MLA). The return loss of this antenna is -45 dB and a gain of 3.248 dB. 3rd reference result is taken from [11] Design of Meander Line Antenna for Operating Frequency of 2.5 GHz. This antenna provides us a good reflection coefficient, fine radiation pattern and a gain enhancement of 7.2 dB and return loss of -20 dB. The simulation was performed with the help of High-Frequency Structure Simulator (HFSS). Lastly proposed antenna's simulation result was compared with [12] Resonant Frequency, Bandwidth, and Gain of Meander Line Antenna.

TABLE V. COMPARISON WITH DIFFERENT RESEARCH PAPERS

Referenced Works	**Bandwidth**	**Return loss [S11] (dB)**	**VSWR**	**Total efficiency**	**Radiation efficiency**
[9]	45 MHz	-20.8578dB	-	-	-
[10]	0.22 GHz	-36.1 dB -10 dB	-	1.257	1.256
[11]	-	-20 dB	-	-	-
[12]	220 MHz 230 MHz 730 MHz	-10 dB	-	-	-
Proposed work	61.3 MHz	-38.473925 dB	1.0241	-4.499 dB	-4.498 dB

V. Conclusion

In this paper, a meander line antenna is operating in the ISM band is demonstrated. For WLAN systems, this antenna is designed. The resonant frequency of the designed antenna is 2.45 GHz and a bandwidth of 61.3 MHz. At the resonant frequency, the return loss of the antenna is found -38.473925 dB. Copper is used as a patch and ground in this designed antenna. It is also observed that the antenna's VSWR is 1.0241 at the resonant frequency. This study has shown that the parametric results of a number of turns, feed line width and antenna ground width have a huge impact on obtaining the optimal return loss value of -38.473925 dB. From this result, this is expected that the proposed antenna has a huge potential in WLAN application. With the proposed antenna, there is an opportunity to do research on the biomedical sector and it could be repeated for nanosatellite antenna design as well.

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Syed Md. Anwarul Islam Received his B. Sc. Eng. and M. Sc. Eng. Degree in Electrical and Electronic Engineering from American International University-Bangladesh. His research interest is power electronics, Electric Vehicle, Antenna design and optimization, robotics. He is currently working as a Teaching Assistant (TA) under the department of Faculty of Engineering, American International University-Bangladesh.

Ashiqur Rahman (PhD),Experienced Research Associate with a demonstrated history of working in the higher education industry. Skilled in 3G, Wideband Code Division Multiple Access (WCDMA), PDH, LTE, and Radio Frequency (RF). Strong research professional with a PhD focused in Electronics and Communications Engineering from Universiti Kebangsaan Malaysia. So far, I am author of 9 scientific research journal, published including one in "Scientific Reports" from Nature publication. My research experience on flexible material antenna can keep contribution in the research activities in the field of flexible antenna design for microwave imaging, wearable sensor and energy harvesting application.

M. Tanseer Ali (PhD), Received Doctor of Engineering degree from University of Greenwich(UK), 2013. His research interest is focused on Analog Electronics, RF/Microwave Circuits and Systems, Nano-electronics, Nuclear Power,Solid State Circuits. Currently he is working as Senior Assistant professor in the department of EEE, AIUB.