Design and Simulation of Meander Line Antenna for Operating Frequency at 2.5 GHz Based on Defected Ground Structure

Mohammed Sadiq, Nasri Bin Sulaiman, Maryam Biti Mohd, and Mohd Nizar Hamidon

Abstract Meander line antenna (MLA) with defected ground structure, which resonant at 2.5 GHz, has been designed and examined in this paper. The antenna was built on a FR4 ($r = 4.5$) substrate with a thickness of 1.1 mm and a loss tangent of 0.025. To evaluate the antenna's performance, features were used operational bandwidth, gain, return loss, and radiation pattern. We achieve a return loss of −17 dB, a bandwidth of 57 MHz, and a gain of 3.21 dB using defective ground structure (DGS). The antenna is 34 28 1.1 mm^3, which is a relatively small space.

Keywords S parameter · Antenna · MLA · SAR

1 Introduction

The growth of fast-developing wireless communication applications, it was aided by the development of compact-integrated printed antennas. Because of their advantages of being lightweight, small, conformal, and having a high bandwidth, they are becoming more widely utilized in wireless communication systems [1]. Meander line is the best solution for wireless communication applications such as radio frequency identification tags, USB dongles, Bluetooth headsets, mobile phones, and so on. The

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Meander line antenna is a type of printed antenna in which the wire structure is embedded on a dielectric substrate to achieve downsizing in size [2]. A meander line antenna is a combination of conventional wire and planer strip line in its most basic form. MLA was developed by a series of studies describes a variety of meander line antenna configurations, including log periodic MLAs, and MLAs with varying vertical segment thicknesses. In this study, we modify the antenna in [4] by using defected ground structure (DGS) [5] instead of coplanar waveguide [7–12] to lower the size of the antenna by half.

2 Antenna Design

2.1 Methodology

The proposed antenna has a small compact dimension of (34 × 28 × 1.1) mm^3. In addition, instead of coplanar waveguide line, we use the partial ground loaded with defected ground structure (DGS) Fig. 1 shows the proposed antenna. The proposed ground is shown in Fig. 2. A substrate with ($\varepsilon_r = 4.5$) thickness 1.1 mm. The proposed DGS antenna consists of six branches. All the dimensions are labeled in Table 1.

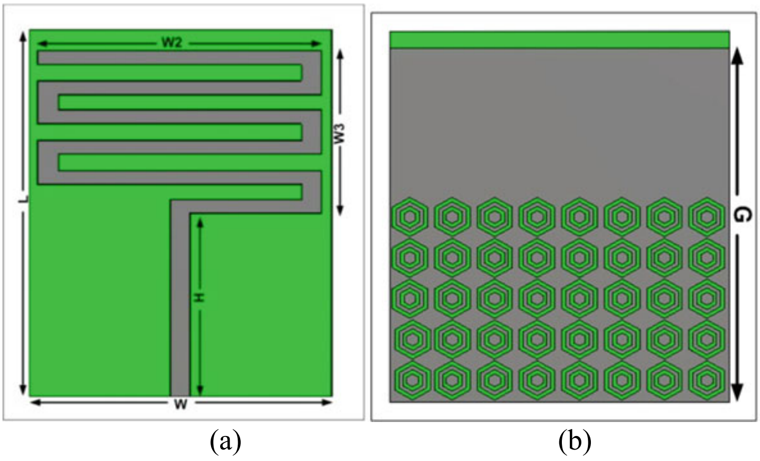

Fig. 1 Geometry of the proposed antenna. **a** Front. **b** Back

Table 1 Proposed antenna (all dimensions in mm)

Parameter	W	L	W2	W3	H	G	a	D	S
Value	28	32	28	15	13	23	3.6	2	0.4

Table 2 Simulations for impedance calculation

H	W	ε	Impedance
1.5	2	4.5	58.4
1	1.5	4.5	54.23
1.1	2	4.5	50

2.2 Impedance Matching

The substrate and feed line thickness have been determined to suit the resistance required 50 impedance calculation software, as shown in Fig. 3, was used to calculate impedance with respect to the height of the substrate and width of the feed line of MLA. Table 2 shows these figures.

2.3 Results and Discussion

Using the −10 dB return loss as a benchmark. The following stages are used to investigate the effect on return loss for various parameter values:

First step: Change the ground height (G) from 17 to 23 mm with step 3 mm increments while keeping the other settings the same. Figure 4 depicts the return loss characteristic. The best return loss S11 value is found when (G) equals 23 mm, 2.5 GHz resonant frequency, and we get bandwidth is 62 MHz. Indicating that the ground height has an impact on the operating frequency and bandwidth. Table 3 shows the various simulation results achieved for altering ground width height.

Second step: Change the feed line's height (H) from (13 to 17 mm) with step 2 mm and without any change in the other parameters. Figure 5 depicts the return loss characteristic. The best value of return loss S11 is determined; when (H) equals 13 mm, the bandwidth is 57 MHz. Table 4 shows the various simulation results achieved with different ground width height.

Figure 6 show the omnidirectional radiation pattern of MLA with gain calculations at main lobe gives 3.21 dB which is very suitable for offered applications.

2.4 SAR Calculations

SAR values are also determined using a10-g reference of human tissue mass [8–10], as shown in Fig. 7. Table 5 illustrates the averaged 10-g SAR when the antenna is relatively close to the body at the aforementioned operating frequency.

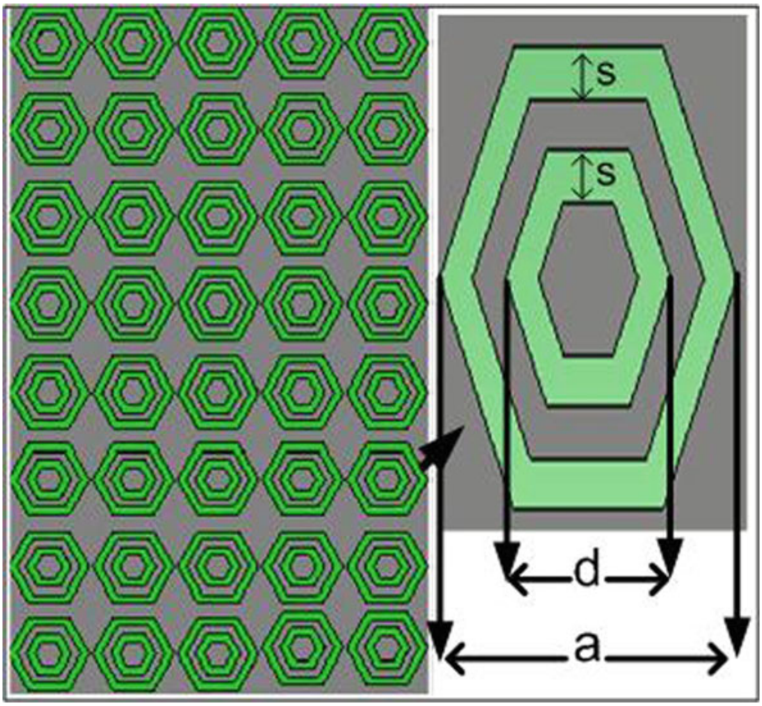

Fig. 2 Geometries of DGS

Table 3 Simulations for different height of the ground (G)

G (mm)	F-start (GHz)	F-stop (GHz)	BW (MHz)
23	2.439	2.501	62
20	2.457	2.517	60
17	2.492	2.551	59

3 Comparison Between Our MLA at 2.5 GHz and MLA at 2.5 GHz in [4]

The authors suggested in the design [4] that 2.5 GHz where HFSS software was used to design and simulate a model antenna as shown in Fig. 8 which consists of a substrate with ($\varepsilon r = 2.5$), and it has thickness equal to 2 mm. A patch antenna with area of 72.625 mm × 72.612 mm × 2 mm. Figure 9 shows the return loss of this antenna. The 3D radiation pattern is shown in Fig. 10.

We see that the previous antenna is a good design for 2.5; our MLA the gain is (3.21 dB). Furthermore, the thickness of our ML is half that of [4]. Table 6 shows the differences between the MLA in [4] and our MLA.

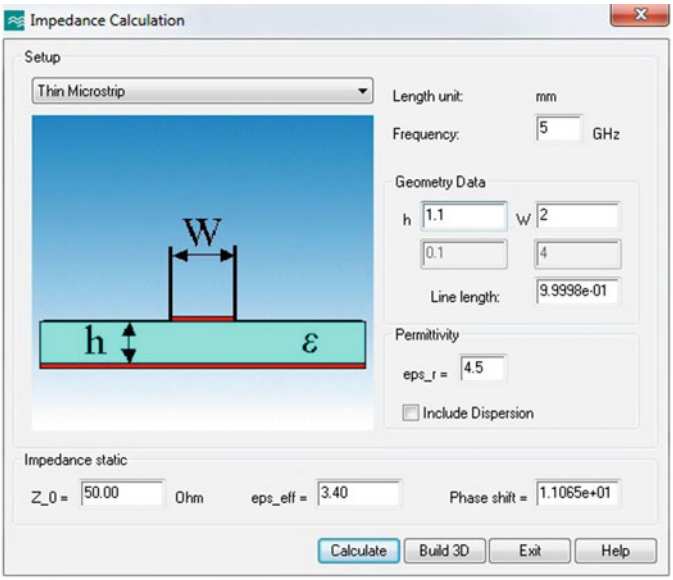

Fig. 3 Impedance calculation

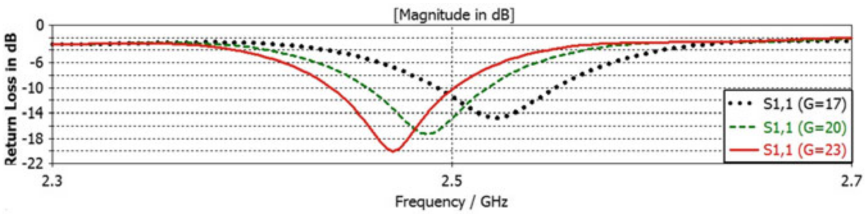

Fig. 4 Return loss (S11) for different ground heights (G)

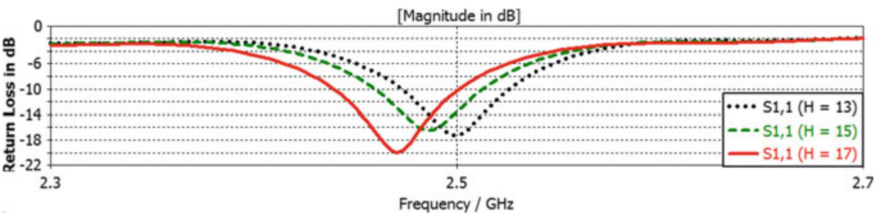

Fig. 5 Effect of different feed line heights (H)

Table 4 Simulations for different height of the feed line (H)

H (mm)	F-start (GHz)	F-stop (GHz)	BW (MHz)
13	2.469	2.526	57
15	2.459	2.512	53
17	2.439	2.501	62

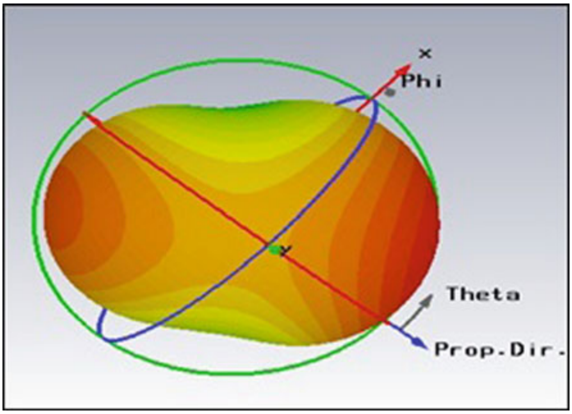

Fig. 6 3D pattern of MLA at 2.5 GHz

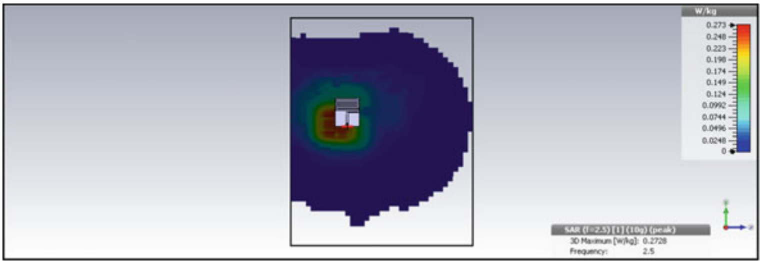

Fig. 7 CTIA-defined talking position

Table 5 SAR values

F	2.5 GHz
SAR (W/kg)—10 g	0.273

4 Conclusion

Meander line antennas have the following advantages: small size, low profile, low cost, and simplicity. Because of these advantages, Meander line antennas are quite common and can be used in a variety of communication systems, including RFID and WLAN. The microstrip patch antenna (meander line antenna MLA) for 2.5 GHz was developed, implemented, and tested in this study using CST Microwave Studio 2014. The diameter of higher for substrate, feed line, and ground is all examined in the MLA parametric studies. We were able to minimize the antenna size by using a defective ground structure. The antenna's SAR values are within acceptable safety limits. Return loss is reduced to −17 dB; bandwidth is increased to 57 MHz, and

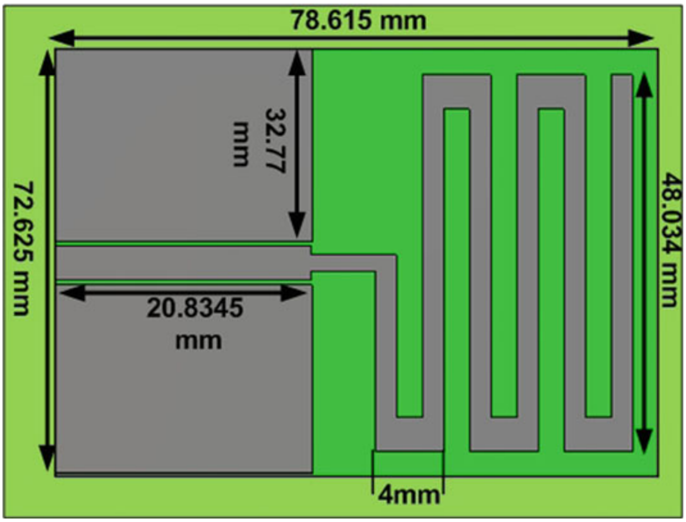

Fig. 8 HFSS design for the MLA in [4]

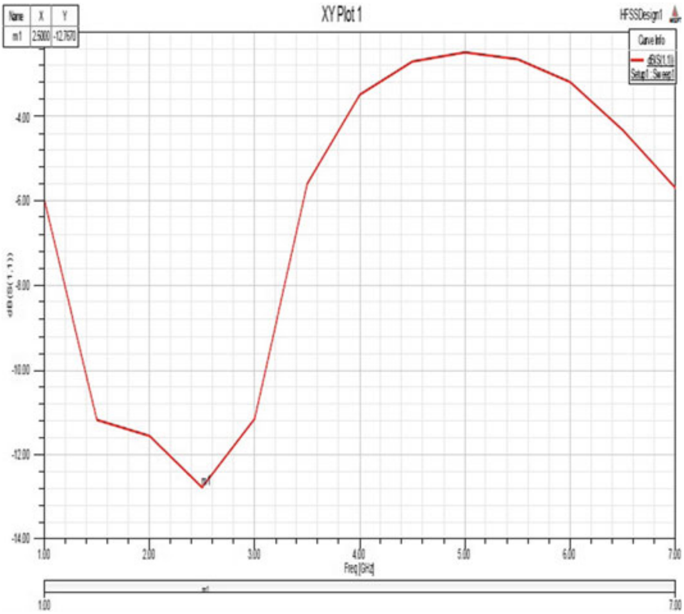

Fig. 9 Return loss for the MLA in [4]

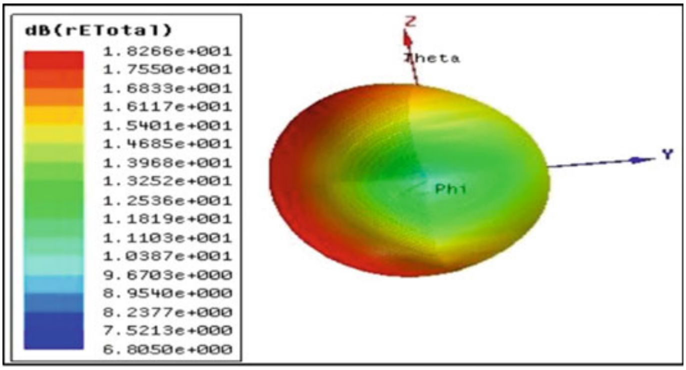

Fig. 10 3D radiation pattern in [4]

Table 6 Difference between the MLA in [4] and our MLA

	Our MLA	MLA in [4]
ε_r	4.5	2.5
Thickness	1.1 mm	2 mm
Return loss S11	−17 dB	−13 dB
No. of line	6	6

gain enhancement is 3.21 dB. The results of a simulation are provided. The proposed antenna has a lot of potential for use in wireless devices like phones and tablets.

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