The Effect of Conductor Line to Meander Line Antenna Design

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Abstract— In this paper, the meander line antenna have been designed to operate at 2.4-GHz for WLAN application. Two different designs of meander line antenna are investigates, without conductor line and with conductor line. The Microwave Office software is used for simulation design process. The antenna is fabricated on a double-sided FR-4 printed circuit board using an etching technique. Then the design has been tested with the Advantest Network Analyzer. The comparison between simulation and measurement results for the return loss and radiation patterns were presented. A bandwidth of 152MHz and return loss of -37.7dB were obtained at frequency 2.4GHz. The gain is comparable to microstrip yagi antenna.

Keywords: Meander; meander line antenna; wireless LAN; microstrip antenna.

1. Introduction

Microstrip antenna is one of the popular technique uses today. The meander line microstrip antenna is design base on the wavelength of the interested frequency. Modern designs of wireless communication systems are featured in light weight, small size, high frequency operation, and transmission efficiency. In the future use of higher frequency communication, the possible of applying the antenna design for wireless communication that should be expanded in scope to cover the frequency range from the 0.9-3.0 GHz is design. In this project, the characteristic of a printed meander line antenna for WLAN application, 2.4GHz has been studied. The design of the meander line antenna has small dimension, and approximately 50Ω input impedance. It begun with designed using Microwave Office software and printed on FR4 board used the etched techniques. Lastly it has been measured and compared to the simulation result.

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2. Meander Line Antenna

Meander line antenna is one type of the microstrip antennas. Meander line technology allows designing antennas with a small size and provides wideband performance [1]. Meander line antennas are an interesting class of resonant antennas and they have been widely studied in order to reduce the size of the radiating elements in wire antennas: monopole, dipole and folded dipole type antennas [2]. In meander line antenna the wire is continuously folded intended to reduce the resonant length. Increasing the total wire length in antenna of fixed axial length lowers its resonant frequency. According to S. Best, when made to be resonant at the same frequency, the performance characteristics of these antennas are independently of the differences in their geometry or total wire length [3]. Uniform U- MLA structures, the geometry are described to 3 parameters: the number of turn, length of the horizontal and vertical section. For NU-MLA these are no tied values for the variables [4].The operating frequency are the frequency where the reflection coefficients are less then -20dB [5]. The good return loss for antenna is less than -10dB [5].

3. Dimension Calculation

In this paper, the antenna design will used microstrip technology and FR4 board for the material substrates. The dielectric constant is ε_r=4.7, loss tangent $\tan\delta = 0.019$, and the thickness *d*=1.6mm. The conductor width (*W*) of rectangular patch can be found by using equation (1) and (2) below.

$$\frac{W}{d} = \frac{8e^{A}}{e^{2A}-2} \qquad (1)$$

$$A = \frac{Z_o}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right) \qquad (2)$$

Where

ε_r - Dielectric Constant of a microstrip line

d - Substrates thickness

Z_o -Characteristic impedance

The calculated length and width are *L*= 61.278mm and horizontal length, *W*= 36.9891mm. The value of conductor width is *W*=3.024mm. The effective dielectric constant of a microstrip line for *W/h* >1, $\varepsilon_r = 3.3933$. The wavelength of the antenna $\lambda_o = 67.8576mm$. The design calculation is given by [6].

4. Antenna Design: Simulated and Measured Results.

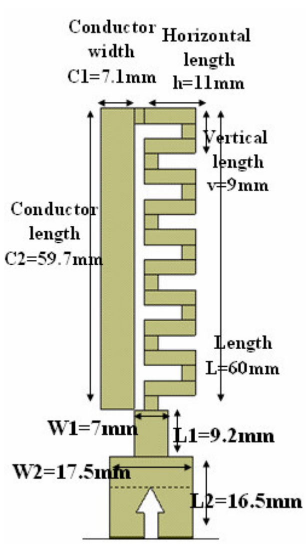


Figure 1: Meander line antenna with conductor line (Design I).

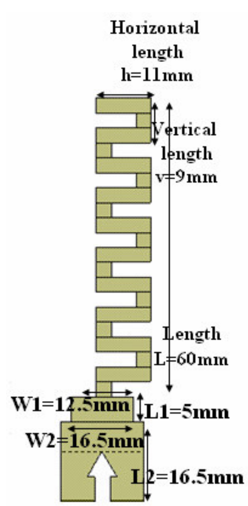


Figure 2: Meander line antenna without conductor line (Design II).

Figure 3: Photograph of the meander line antenna with conductor line.

In order to provide an accurate antenna design, the investigation effects of dimension to the meander line antenna has been done. The parameters of the meander line antenna which is considered in this paper are horizontal length (*h*), vertical length (*v*), conductor line length (*C2*), conductor line width (*C1*) and the number of turn (*N*). Table 1 shows the frequency response and return loss base on the effects of different horizontal length.

Table 1: The effect of horizontal length (h).

Length of horizontal (mm)	Design I		Design II	
	Frequency response (GHz)	Return Loss (dB)	Frequency response (GHz)	Return Loss (dB)
9	2.2	-18.82	2.8	-7..07
10	2.1	-15.36	2.6	-7.33
11	2.4	-37.7	2.4	-19.57
12	2.6	-29	2.7	-8.902
13	2.2	-12.63	2.6	-14.32

Table 1 shows the horizontal with length of 11mm will give the best return loss for Design I. The frequency response is found at 2.4GHz with return loss=-37.7dB. The return loss of -19.57dB was obtained at the same frequency for Design II.

Table 2: The effects of vertical length (v).

Length of vertical (mm)	Design I		Design II	
	Frequency response (GHz)	Return Loss (dB)	Frequency response (GHz)	Return Loss (dB)
7	2.5	-9.45	2.6	-4.76
8	2.5	-9.1	2.5	-7.34
9	2.4	-37.7	2.4	-19.57
10	2.4	-25.99	2.3	-2.831
11	2.3	-5.46	2.2	-9.9

The effect of vertical line length (*v*) to the design are summarize in Table 2. Design I shows that *v*=9.0mm will give a return loss of -37.7dB. While, Design II shows that, *v*=9.0mm will give a return loss of -19.57dB at 2.4GHz.

Table 3: The effects of conductor length (C2).

Length (mm)	Frequency response (GHz)	Return Loss (dB)
50.7	2.5	-24.79
53.7	2.5	-21.97
56.7	2.5	-10.83
59.7	2.4	-37.7
62.7	2.4	-25.1

Table 3 shows that the conductor length of 59.7mm for Design I produces frequency response at 2.4GHz with a return loss of -37.7dB.

Table 4: The effects on conductor width (C1).

Width (mm)	Frequency response (GHz)	Return Loss (dB)
3.1	2.4	-14.7
5.1	2.4	-31.03
7.1	2.4	-37.7
9.1	2.4	-46.43
12.1	2.4	-11.07

Table 4 summarizes the effects on conductor width for Design I. The length of conductor width C1= 7.1mm produces a frequency response at 2.4GHz with return loss -37.7dB.

Table 5: The effects on number of turn (N).

Number of turn	Design I		Design II	
	Frequency response (GHz)	Return Loss (dB)	Frequency response (GHz)	Return Loss (dB)
3	2.6	-14.69	2.7	-4.39
4	2.6	-16.68	2.1	-6.38
5	2.4	-37.7	2.4	-19.57
6	2.8	-4.47	2.6	-1.78
7	2.8	-6.61	2.6	-5.42

Table 5 shows that the number of turn *N*=5 for Design I will produce a return loss of -37.7dB at 2.4GHz. While Design II shows that *N*=5 will give frequency response at 2.4GHz with a return loss of -19.57dB. The effect on horizontal length (*h*) increased (Design I and II); the return loss is decreased. The effect on vertical length (*v*) and conductor length (*C2*) increased (Design I and Design II); the frequency response is decreased and return loss are unstable. The effect on conductor width (*C1*) increased; the frequency responses remain at 2.4GHz and the return loss is decreased, except for the length at 12.1mm. The effect on number of turn (*N*) increased; the frequency response and the return loss are unstable for both type of antenna. Base on the analysis that has been done, the dimension of the meander line antenna which operates at 2.4GHz frequency can be determined. In order to design the best resonant at 2.4GHz, the following parameters are set:

Table 6: Parameter for Design I.

Parameter	Length (mm)
Conductor width (C1)	7.1
Conductor length (C2)	59.7
Horizontal (h)	11
Vertical (v)	9
Number of turn (N)	5

4.1 Simulation Result

Figure 4 shows the return loss for Design I and Design II. The simulation result for Design I shows that the operating frequency of 2.4 GHz with -37.70dB of return loss as shown in Figure 4. The bandwidth of the design is 152MHz (2.64%). For design 2, the bandwidth is 128MHz (1.79%).

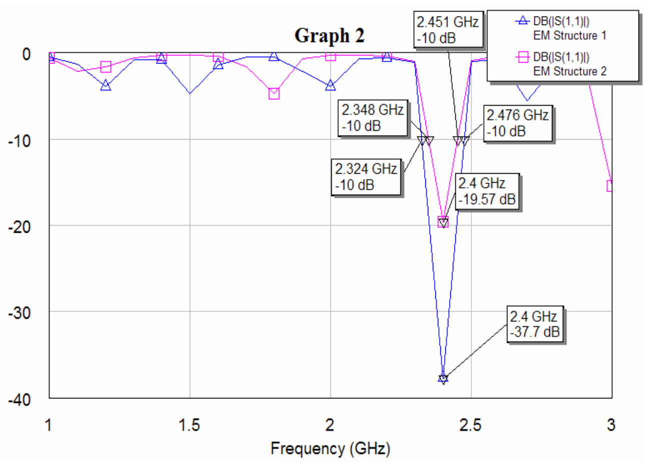
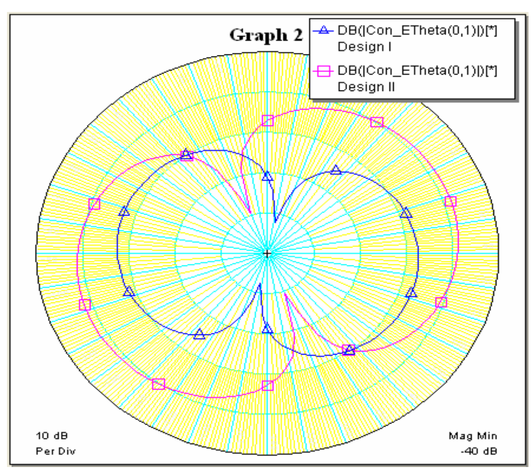


Figure 4: Frequency response for Design I and Design II.



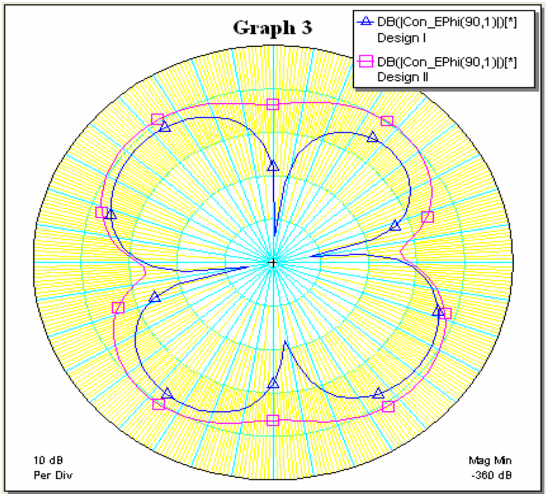


Figure 5: The radiation pattern for Design I and Design II at frequency 2.4GHz.

Figure 5 shows the radiation pattern for Design I and Design II at frequency 2.4GHz. The simulated gain of the antenna is 7.32dB. The HPBW for Design I is 88^0 (H-field), and 48^0 for E-field. The HPBW for Design II is 84^0 (H-field), and 52^0 for E-field.

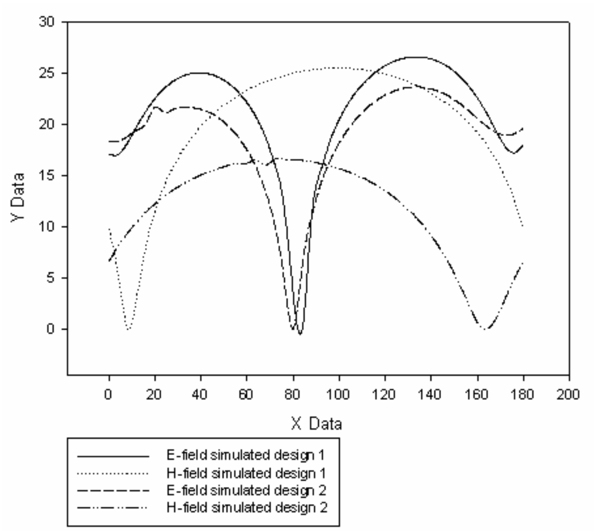


Figure 6: The radiation pattern for Design I and Design II at frequency 2.4GHz.

4.2 Measurement Result

The measured result of return loss in room temperature becomes large compared to the simulation result. From the measured result in Figure 7 shows that the frequency response has been shifted to the right hand side for 0.01MHz. The bandwidth for measurement is lower, which is 38MHz compared with simulation. This is maybe cause by imperfection in fabrication process and the effect of the cable connector in addition to errors in processing. The HPBW for Design I is 62^0 (H-field) and 73^0 for E-field.

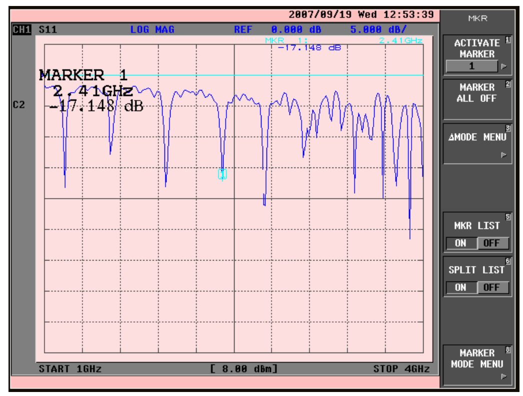


Figure 7: The result measurement.

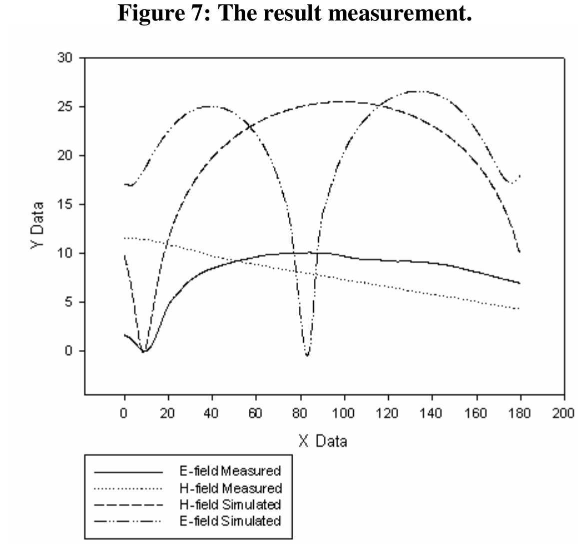


Figure 8: Measured and simulated radiation pattern at 2.4GHz (Design I).

5. Conclusion

The meander line antenna design with conductor line will provide better performance. The horizontal length *h*=11mm, the vertical length *v*=9mm, conductor length *C2*=59.7mm, conductor width *C1*=7.1 and number of turn *N*=5 is choose for the frequency operation at 2.4 GHz. The best return loss for the antenna is -37.70 dB (simulated) and -17.15 dB (measured) at frequency 2.4 GHz.

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