IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
ISSN: 2278-2834, ISBN: 2278-8735. Volume 3, Issue 6(Nov. - Dec. 2012), PP 01-06
www.iosrjournals.org

Investigation of Dual Meander Slot to Microstrip Patch Antenna

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Abstract: *A dual microstrip meander slot antenna is presented for Wireless Local Area Network (WLAN) application. The proposed antenna comprises a rectangular microstrip patch element embedded with two meander slots. The parametric study is performed to investigate the characteristic of microstrip patch antenna with double meandered slots compared to the same microstrip patch antenna with a single meandered slot. Microstrip patch antenna with dual meander slot can achieve return loss until -24.54dB. However the gain of the antenna is lower than microstrip patch antenna with single meander slot. Other antenna parameters are also investigated such as bandwidth, radiation patterns and directivity have been observed and simulated. The proposed antenna has been designed and simulated by using CST Studio Suite 2010.*
Keywords - *Dual Meander Slot, Microstrip Patch Antenna, Simulated, Single Meander Slot, WLAN*

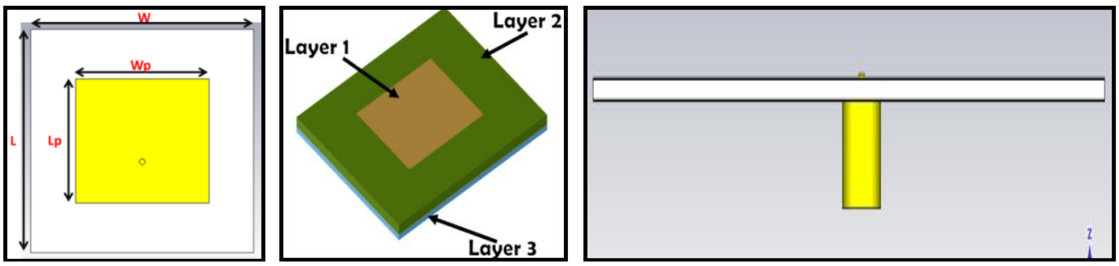
I. Introduction

Meander line antenna is one type of the microstrip antennas [1]. Meander line technology allows designing antenna with a small size and provides wideband performance [2]. Having advantage to miniaturize antenna like other proposed methods [3] [4] [5], slotted meander line antenna is chosen because it is able to reduce the size of antenna. It is smaller and very flexible to be shifted or relocated [6]. The performance of the slotted meander line antenna depends on various factors such as the position of meander slots and number of turns of the meander line. Parasitic element also could affect the result of meander line antenna as in [7]. This includes the number of meander slot existed in particular antenna.

A microstrip patch antenna has been used to investigate the difference of performance between single meander slot and dual meander slot in variety positions. Microstrip antenna was chosen because of its numerous advantages; such as easy integration with impressed circuits, low cost, and low profile despite of its disadvantages of small impedance bandwidth [8]. Microstrip antenna also is able to generate variety patterns of polarizations including x-linear and x-circular [9] [10].The slotted meander line antennas has been designed to operate at 2.4GHz as it approaches the industrial, scientific and medical radio bands under WLAN interoperability [11]. The good return loss for antenna is less than -10 dB [12].

II. Antenna Design

The geometry for the slotted meander line antenna consists of 3 layers which are patch (Layer 1), dielectric substrate (Layer 2) and ground plane (Layer 3) as shown in Fig. 1. The antenna was simulated on FR4 substrate with dielectric constant of 4.4 and thickness of 1.6 mm. While the upper and bottom layer for patch and ground plane used material from the copper annealed with thickness of 0.035 mm. The ground also consists of SMA connecter which used as RF connecter to connect the 50 Ω coaxial cable and the 50 Ω microstrip lines on a board. The geometry of the microstrip patch antenna is shown in Fig. 1. The basis of the antenna structure is chosen to be a rectangular patch element with dimensions of width W_p and length L_p.



(a) (b) (c)

Figure 1: Structure of microstrip antenna; (a) Front view (b) Perspective view (c) Side view

Patch length and width are calculated by using transmission line model. Formula for patch width [13,14] is given by:

$$W = \frac{1}{2f(\sqrt{\varepsilon_0 \mu_0})}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

And length is given by:

$$L = \frac{1}{2f(\sqrt{\varepsilon_{eff}})} - 2\Delta L \quad (2)$$

Parametric study method is used to obtain the best dimension of microstrip patch antenna to achieve 2.4GHz operation.

Meander Slot Antenna

Fig.2 below shows the parameters of the meander slot that will be used in all designs of slotted meander line antenna. Basically it consists of the width of horizontal length W_H, length of horizontal line L_H, width of vertical line W_V, length of vertical line L_V and the number of turn, N. For all designed structure, the width of the horizontal line, W_H is fixed to 1mm.

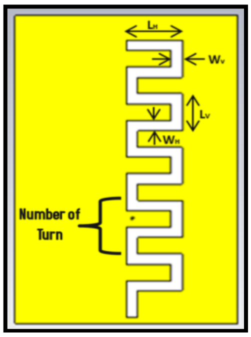


Figure 2: Design parameter of slotted meander line antenna

a) Single meander slot antenna

For single meander slot parametric study process, the location of slotted meander line on the rectangular patch of antenna is investigated as shown in Fig. 3. This slotted meander line has a number of turn of 6. It is located at the right, left, top and bottom of the probe feed to observe the behavior of each location.

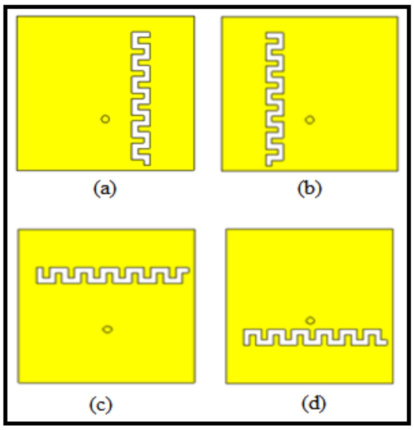


Figure 3: Microstrip single meander slot antenna structure (a) Right (b) Left (c) Up (d) Down side

b) Dual Meander Slot Antenna

For dual meander slot parametric study process, the location of both slotted meander line on the rectangular patch of antenna is varied. The effects of the different design of antennas are investigated. Fig. 4, Fig. 5 and Fig. 6 below shows the design of microstrip dual meander slot antenna.

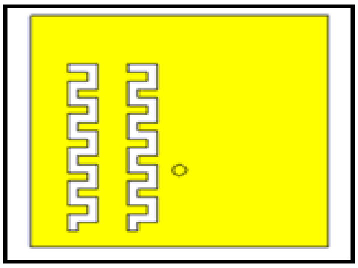


Figure 4: Design 1 of microstrip dual meander slot antenna

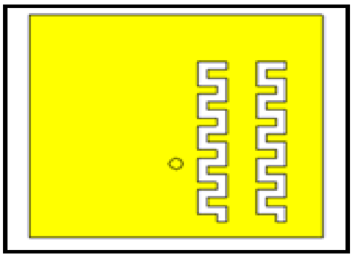


Figure 5: Design 2 of microstrip dual meander slot antenna

Basically, Design 1 and Design 2 shows in Fig. 4 and Fig. 5 have similar structure of meander slot but differs in terms of position.

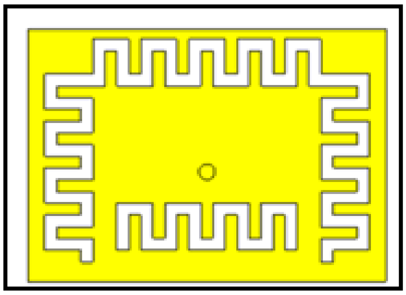


Figure 6: Design 3 of microstrip dual meander slot antenna

Design 3 in Fig. 6 consists of 3 meander slots which have been combined to form a single 'U' shaped of meander slot. Another meander slot is added at top of the 'U' shaped meander slot.

III. Experimental Results And Analysis

The simulation results are separated between single meander slot antenna and dual meander slot antenna to be compared. Return loss, bandwidth, gain and directivity are included.

i) Single meander slot antenna

A. Return Loss

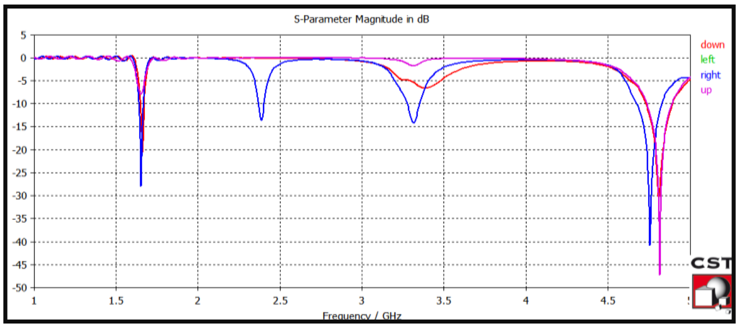


Figure 7: Return Loss of Microstrip Single Meander Slot Antenna

Fig. 7 shows the return loss of single meander slot at 4 positions as shown in Fig. 3. The same return loss is obtained when the slot is positioned at left and right of the probe with value of -13.633 dB at 2.4GHz. While no return loss can be achieved when the meander slot is located at the top and bottom of the probe feed.

B. Bandwidth

From the simulation results, the bandwidth range of the single meander slot antenna is from 2.3698 GHz to 2.4034 GHz for right and left position. The bandwidth is approximately 33.7 MHz.

C. Gain and directivity

From the results of gain and directivity shown in Table 1 below, the microstrip antenna has the same value of gain and directivity when the meander slot is located at right and left of the probe feed.

TABLE 1
Gain and Directivity of Single Meander Slot Antenna

Position	Gain (dB)	Directivity (dBi)
Up	-1.932	4.951
Down	3.147	5.827
Right	4.079	6.209
Left	4.079	6.209

ii) Double meander slot antenna (Design 3)

The results from the simulations were then validated with experimental measurements of a prototype as shown in Fig. 8.

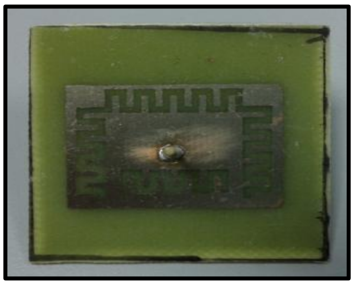


Figure 8: Antenna Prototype of Design 3

Fig. 9 shows the return loss of double meander slot in Fig. 6.

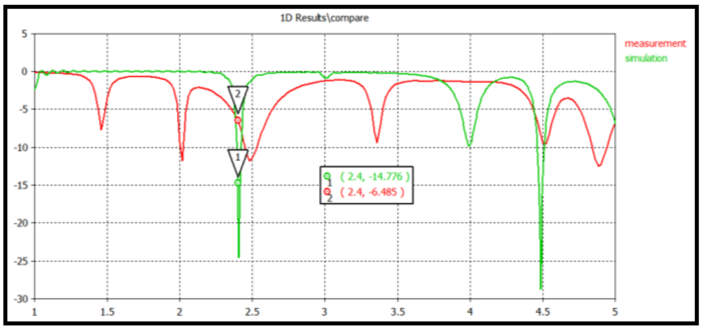


Figure 9: Return loss of microstrip double meander slot antenna

From the graph, Design 3 antenna achieves return loss of -24.55 dB for simulation. It is caused by the high number of turn for the meander slot which is 13.

As for the measured result, this antenna did not able to get a return loss lower than -10dB at 2.4GHz. It only managed to achieve -6.49 dB which is not reaching the minimum 90% of antenna efficiency. The resonant frequency shifted until 2.48 GHz to get a return loss of -11.52 dB.

The bandwidth for Design 3 antenna is 29.48 MHz for the simulation part. The directivity for this antenna at 2.4 GHz is 5.396 dBi while the gain is 1.464 dB. The results are tabulated as shown in Table 2 below.

TABLE 2
Simulation and Measurement Result Of Design 3 Antenna

Result	**Freq.**	**RL**	**BW**	**Gain**
Sim.	2.41 GHz	-24.54 dB	29.48 MHz	1.46 dB
Mea.	2.48 GHz	-6.49 dB	NA	-1.43 dB

While the radiation efficiency for 2.4 GHz is -3.932 dB and which is more than 50% efficiency where the antenna receives more than 50% of power transmitted. The surface current is shown in Fig. 10.

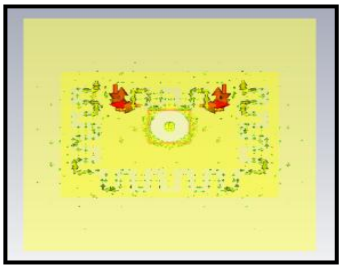
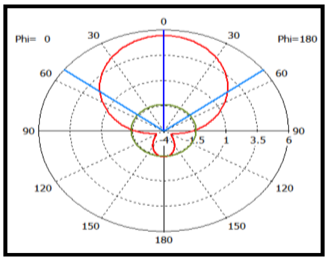
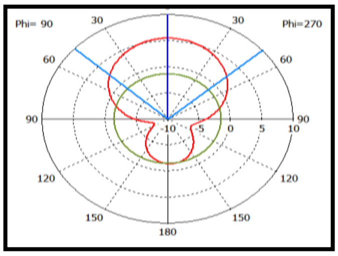


Figure 10: Surface Current of Design 3 Antenna at 2.4 Ghz

The radiation patterns for the (total) electric field at 2.4 GHz have a few nulls in the radiation patterns but the holds directional characteristics.



(a)



(b)

Figure 11: Radiation pattern at the 2.4GHz with (a) ø = 90° (b) ø = 0°

IV. Conclusion

In this paper, the behavior and performance of dual meander slot antennas has been investigated. They have been chosen to operate at 2.4GHz for ISM band application. Compared to single meander slot antenna, dual meander slot antenna managed to achieve higher value of return loss but have lower value in terms of bandwidth and gain. Dual meander slot has the operation band of antenna going from 2.417GHz to 2.472GHz and represents 40.7% for $\|S_{11}\| \leq 10$dB.

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