The Effect of Meander Line Slit On Lower Band Printed MIMO Antenna

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***Abstract*— This paper presents the results of a parametric study of the effect of the presence of meander line slit on lower band of printed MIMO antenna. Triple band frequency range from 2.628 – 2.72 GHz; 3.164 – 3.5 GHz; and 3.936 – 5.964 GHz with mutual coupling < -15 dB were achieved. The performances of the proposed antenna on MIMO characteristics are investigated and the details of the design and simulation results are discussed.**

Keywords—MIMO antenna; meander slits, stub.

I. INTRODUCTION

Wireless communication technology's growth rapidly nowadays. The need of higher data transmission requirement in wireless applications such as wireless local area network (WLAN) and worldwide interoperability microwave access (WiMAX) is the driving factor behind this research enhancement to meet up the requirement of wireless applications. Several single element antenna designs covering 3.5/5.5 WiMAX and 5.2/5.8 WLAN proposed by authors in [1-3]. However, multiple input multiple output (MIMO) system is a promising approach to improve reliability and enhance channel capacity in wireless mobile communications[4]. The MIMO technology using multiple antennas at both transmitting and receiving end of the system promises of maximizing channel capacity with enhanced data rate in a rich scattering environment [4-6]. The main challenge in designing MIMO antenna in a small space is the mutual coupling between the antenna elements. Lower mutual coupling can result in higher antenna efficiencies and lower correlation coefficient[7]. Several approaches have been made to mitigate this problem in [8-13].

In this paper, a small size of printed MIMO antenna design with overall dimensions of 31 mm x 25 mm is proposed. The antenna working on triple band operations which cover WLAN (5.2/5.8GHz) and (2.5/3.5/ 5.5GHz) WiMAX. The antennas are constructed from two circle patches with meander line cut on the patch and L stub employed on the ground plane to reduce the coupling between elements. Details design consideration of the proposed antenna design and the simulation result are presented and discussed.

II. ANTENNA DESIGN STRUCTURE

A. Antenna Configuration. Fig. 1 shows the geometric configuration of the proposed 2 x 2 symmetrically printed circle patch antennas with a radius of 7 mm and a meander line slit etched on it. The inter-element separation distance is 13 mm (0.108λ at wavelength of 2.5 GHz) which each elements are fed by 50 Ω microstrip feedline. The rectangular ground plane with dimensions of 31 mm x 10 mm is placed at the back of substrate. Hence, to increase the bandwidth and reduce the coupling between the elements, two semi circular slots with radius of 3.5 mm and two L stubs were etched and employed on the ground, respectively. The gap between these two branches stub is 4 mm. The antennas are printed on a substrate with permittivity of 4.3, and thickness of 1.6 mm.

B.Antenna Analysis. By aligning two circle patches along y-axis, the wideband performance can be obtained. Nevertheless, the mutual coupling will be higher at lower frequencies band. Therefore, to reduce the mutual coupling, two L stubs are employed on the ground plane. It can be observed that, after the stubs were employed, the mutual coupling at lower frequency band has been reduced. However, the stub deteriorated the impedance bandwidth at lower band and increased the coupling at higher frequency. Hence, to mitigate these problems, we introduced the meander line slits on the patches. As the result, the frequency is shifted to lower bands (as in Fig. 2). The comparison of S-Parameters between reference and proposed antennas are shown in Fig.2. The reference antenna is simulated without the existing of the L-Stub, meander slit and semi-circle slot. While, the proposed antenna consists of L stub, meander slit line, and semi-circle slot.

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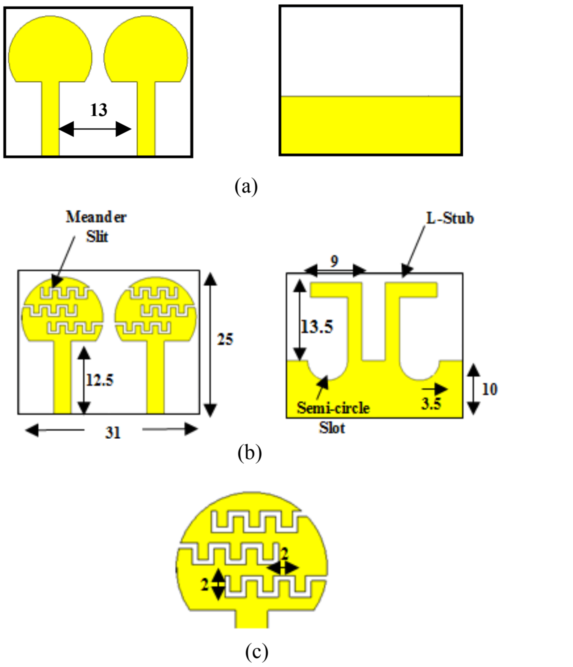

Fig.1. Configuration of the proposed antenna; (a) Reference Antenna (without semi-circle slot and meander line); (b) Proposed Antenna (L- stub, semi-circle slot and meander line); (c) Meander slits configuration (in mm).

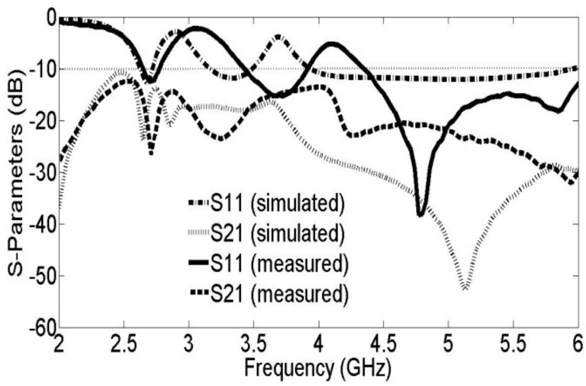

Fig.2. Comparison of S-Parameters between reference and proposed antenna.

III. PARAMETRIC STUDY: EFFECT OF MEANDER LINE SLIT

A. *Effect of Number Iteration on Lower Frequency*

The meander line design is performed from the iteration of the U slit design. As the iteration of the U slit gradually increased, the frequency response slightly shifted to lower frequency band. Fig.3 shows the development of U slit from zero to fifth iteration. The effect of U slit iteration on lower frequencies are plotted in Fig.4.

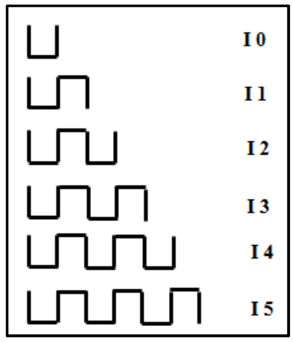

Fig.3. U slit from zero to fifth iteration.

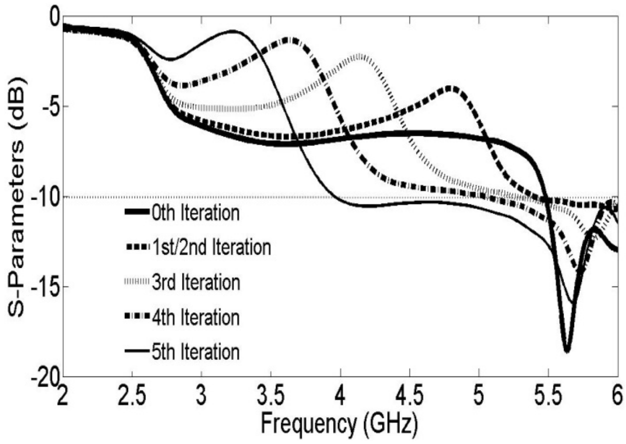

Fig.4. Changes in S_{11} by increased number of iteration.

B. *Effect of Opposite Direction of Meander Slits Towards S-Parameters*

The number of meander line also affects the S-parameters performance. As shown in Fig. 5, by increases the number of meander lines, the frequency response will resonates to lower band and minor significant effects on mutual coupling were found.

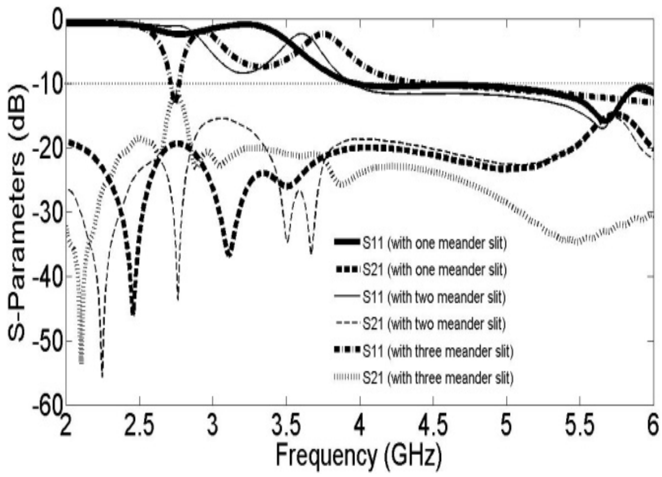

Fig.5. Changes in S-Parameters with different number of the meander slit.

IV. RESULTS AND DISCUSSION

To enhance the impedance bandwidth of the proposed antenna, two semi-circle slots were etched on the ground plane. The comparisons of S-parameters with and without the semi-circle slots are plotted in Fig.6. It is clearly seen that the bandwidth on lower frequency is enhanced from 1.8 % (2.716 – 2.768 GHz) to 3.4 % (2.628 – 2.72 GHz) and the frequency on the lower band has been shifted down from 2.716 - 2.768 GHz / 4.416 - 6 GHz to 2.628 – 2.72 / 3.168 – 3.5 / 3.936 – 5.964 GHz.

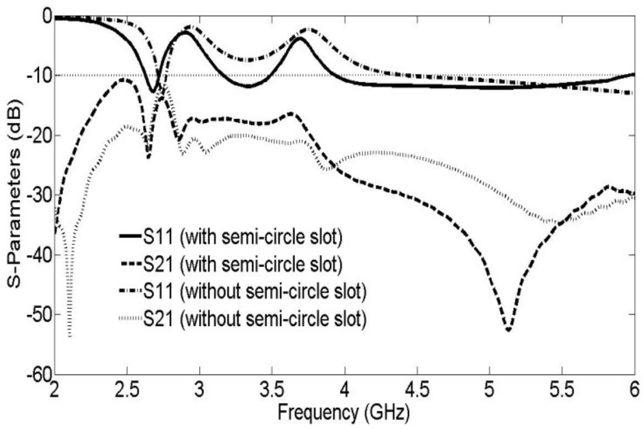

Fig.6. Comparison of S-parameters with and without semi-circle slot.

To validate the simulated results, a prototype of the proposed antenna was fabricated and tested, as shown in Fig. 7. The measured and simulated S-parameters are plotted in Fig. 8. As clearly seen, the resonant frequencies were slightly shifted between the simulated and measured result and it still within the frequency bands of interest. This inconsistency of results may probably due to the measurement tolerances.

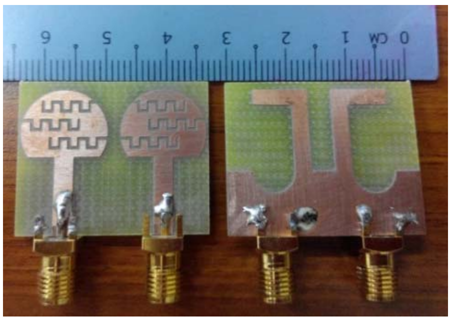

Fig.7.Practical prototype of the proposed antenna.

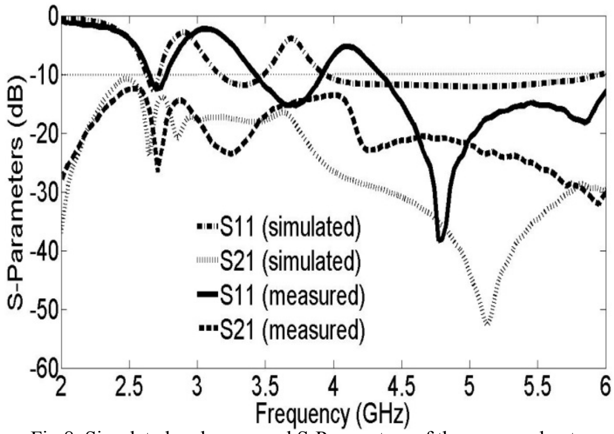

Fig.8. Simulated and measured S-Parameters of the proposed antenna.

V. MIMO ANTENNA PERFORMANCES

To evaluate the capabilities of MIMO/diversity antenna, the envelope correlation coefficient (ECC) is an important criterion to be presented. The envelope correlation of the MIMO antenna system can be expressed using following equation [14]:

$$\rho_e = \frac{\left|S_{11}^{*}S_{12}+S_{21}^{*}S_{22}\right|^2}{\left(1-\left|S_{11}\right|^2-\left|S_{21}\right|^2\right)\left(1-\left|S_{22}\right|^2-\left|S_{12}\right|^2\right)} \quad (1)$$

The simulated envelope correlation coefficient of the proposed antenna showed in Fig.9. As it can be seen, the simulated ECC within the frequency bands of interest is always less than 0.02 and it fulfils the characteristic of diversity $p_e<0.5$[15]. The envelope correlation and the others MIMO antenna performances such as capacity loss, total active reflection coefficient (TARC) [16] and channel capacity [17] are summarized in Table 1. From Table 1, it can be observed that the proposed have low loss and good performance for envelope correlation, TARC and channel capacity.

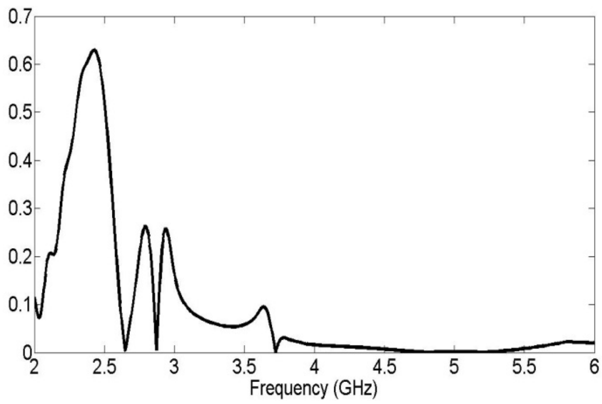

Fig.9.Simulated envelope correlation coefficient of the proposed antenna.

TABLE I

MIMO performance	3.5 GHz	5.5 GHz	5.2 GHz	5.8 GHz
ECC	0.058	0.0003	0.008	0.022
TARC (dB)	-11.72	-14.72	-14.27	-13.56
Capacity Loss (bit/s/Hz)	0.5432	0.3541	0.3752	0.4135

Simulated radiation patterns at four frequencies 3.5, 5.2, 5.5 and 5.5 GHz in x-z plane and y-z planes are depicted in Fig.8 and Fig.9 respectively. The results show that the radiation patterns are stable across the frequencies band.

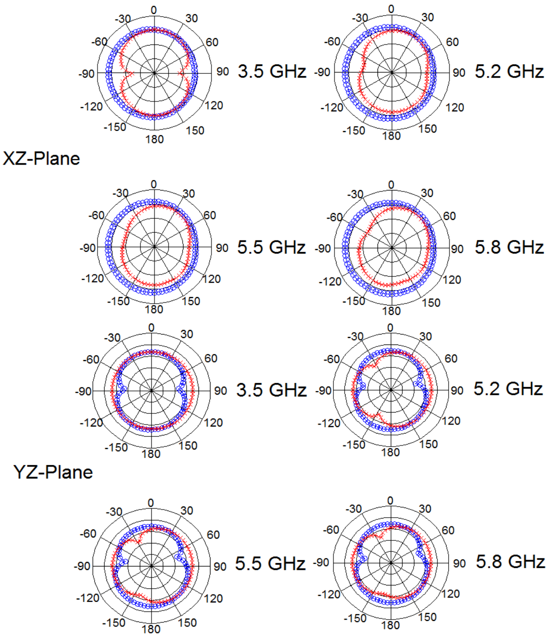

Fig.10. Simulated radiation patterns of the proposed antenna for 3.5 GHz, 5.2 GHz, 5.5 GHz and 5.8 GHz in x-z plane and y-z plane. Port1 is excited and port 2 is terminated. "xxxx" simulated co-polarization, "oooo" simulated cross-polarization.

VI. CONCLUSION

A small size, printed MIMO antenna has been studied in this paper. By implementing the L-stub, the MIMO antenna performances (mutual coupling, envelope correlation coefficient, TARC and capacity loss) can be improved significantly over the frequency bands and the meander line achieved lower frequency band. It has been shows that, the proposed antenna has met the requirement of MIMO practical antenna

ACKNOWLEDGEMENT

The authors of this paper wish to acknowledge the funding of this project by Universiti Tun Hussein Onn Malaysia under GIPS CoE Vot No. 1411.

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