WIDEBAND SLOT ANTENNA FOR MIMO SYSTEMS

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ABSTRACT

This paper investigates into the performance of wideband slot antenna for MIMO systems for increasing bandwidth technique. From another research, a large size of traditional antenna which cannot put into wireless communication device is a defect of antenna. The defect can be overcome by increase of bandwidth was adjusted by using L-shape slot etching on the rectangular stub and adding double I shaped stub tuning on ground plane for matching impedance 50 ohm. Then, this paper uses array the adjustable antenna 2 element for increasing efficiency on MIMO system. The antenna structure was designed and fabricated on print circuit board (PCB) with FR4. The operational parameters and characteristics of the proposed antenna were determined by using the simulation software: Finite-difference time-domain on MATLAB programming. The simulation results indicated that the return loss of proposed antenna was reduced less than -10 dB. The proposed antenna is capable of WLAN (IEEE 802.11b/g) /WiMAX (IEEE 802.16e) applications. The simulated bandwidth of proposed antenna is 53.7% (1.88 - 3.26GHz) which was pressed with the average gain value of 5.65 dBi.

1. INTRODUCTION

Presently, the requirement of the wireless local area network (WLAN) based on IEEE 802.11 b/g/n (Parkash D., et al., 2010), (Zhu C., et al., 2012), (Kalraiya S., et al., 2014) and worldwide interoperability for microwave access (WiMAX) based on IEEE 802.16e are becoming increasingly unsustainable in both developing and developed countries. Therefore, the wireless developed organization is considered WLAN for further wireless communication. So for in literature, the antenna structures such as microstrip antenna, monopole antenna or slot antenna have been studied as adjusting structure. Many works have been proposed the structure of rectangular shape to fix in each frequency (Jearapraditkul P., et al., 2008), (Krishna D., et al., 2008). Some studies have been added rectangular waveguide to increase bandwidth and gains (Chaiboon P., et al., 2011), (Naktong W., et al., 2014), (Kaewchan B., et al., 2010), (Tunti-A-longkarn P. et al., 2011) (Zhang L., et al., 2013), (C. A. Balanis, 1982). Therefore, this paper applies the rectangular antenna using L-shape slot, double I-shaped stub tuning on ground plane and adding rectangular waveguide for using WLAN and WiMAX systems.

2. STRUCTURE AND DESIGNING PRINCIPLES

2.1 Antenna Structure

In this paper, the proposed antenna was developed from rectangular slot antenna. The increase of bandwidth from original antenna was studied by using L-shape slot etching on the rectangular stub, adding double I shaped stub tuning on ground plane and adding rectangular waveguide as shown in Fig.1 and 2, respectively. The antenna structure was designed and fabricated on print circuit board (PCB) with FR4 base with the dielectric constant of 4.3 and the thickness (h) of 0.764 mm. by the proposed antenna size as $W1$ = 67 mm and $L1$ = 50 mm. The tuning parameters were width: $W1$ = 67 mm, $W2$ = 63 mm, $W3$= 22 mm and $W4$= 1 mm, $W5$ = 12 mm, $W6$= 2.5 mm and $W7$ = 4 mm, g = 1.3 mm, Length: $L1$ = 50 mm, $L2$ = 36 mm, $L3$ = 38 mm, $L4$ = 14 mm, $L5$= 6 mm, $L6$ and $L7$ = 1 mm, t = 0.017 mm.

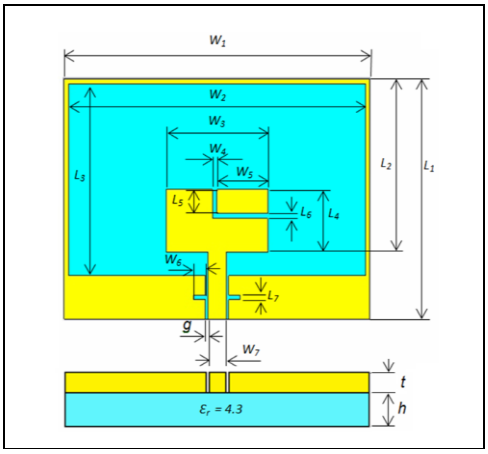

Fig. 1 Model of antenna structure.

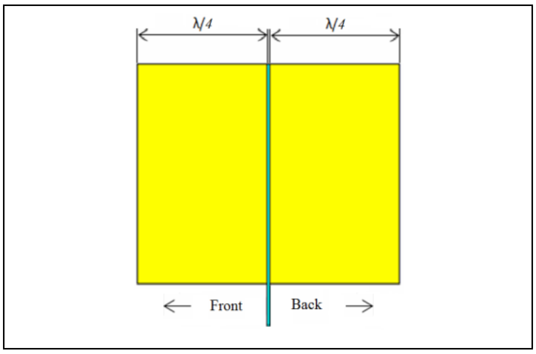

Fig. 2 Waveguide for applying antenna.

Table 1. All parameters of antenna.

Width (mm)		Length (mm)	
W_1	67	L_1	50
W_2	63	L_2	36
W_3	22	L_3	38
W_4	1	L_4	14
W_5	12	L_5	6
W_6	2.5	$L_{6,7}$	1
W_7	4	t	0.017
g	1.3	h	0.764

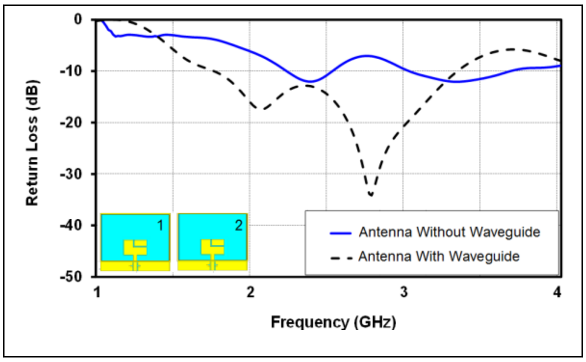

Fig. 3 Simulation results of return loss when adding waveguide.

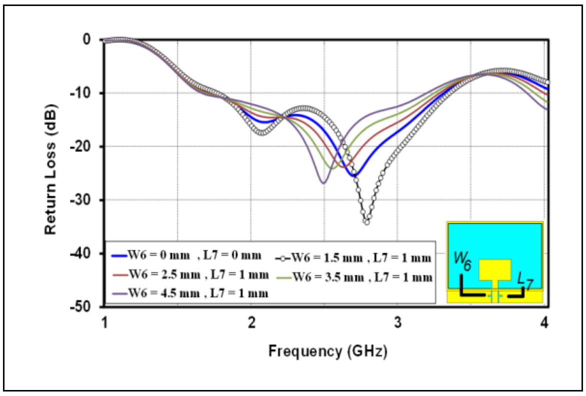

Fig. 4 Simulation results of return loss when adjusting W_6, and W_7.

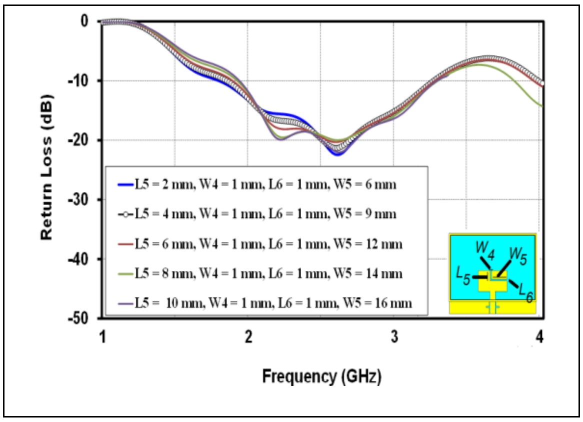

Fig. 5 Simulation results of return loss when adjusts W_4, W_5, L_5 and L_6

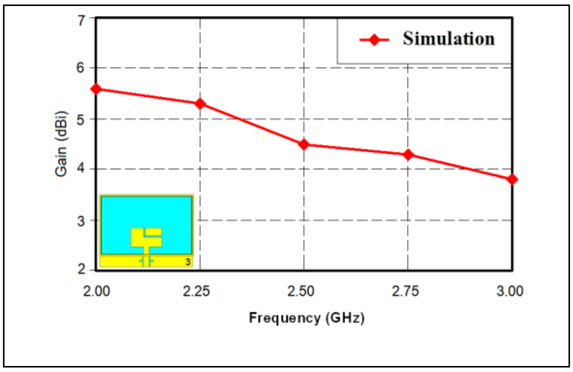

Fig. 6 Simulation results of Gain (dBi).

Table 2. The simulated results.

Type	BW (GHz)	Center Freq.(GHz)	Gain (dBi)	BW (%)
Type 1	2.61 - 2.25	2.43	3.04	14.81
	3.78 - 3.15	3.46	3.16	18.20
Type 2	1.76- 3.38	2.57	5.31	63.03
Type 3	1.85- 3.51	2.68	5.65	61.94

2.2 Simulation Results for Antenna Structure

The operational parameters and characteristics of the proposed antenna were determined by using the simulation software: Finite-difference time-domain on MATLAB programming. The size of both stub tuning are calculated based on wavelength (λ_g) at 2.45GHz. All parameters were adjusted unit antenna reached the maximum efficiency. The simulated all parameter of antenna shown in Table 1.

Based on rectangular antenna structure, the antenna tuning was separated into 3 steps. First, the rectangular antenna structure (Type 1) was added rectangular waveguide (Type 2). The results reveal that the proposed antenna adding waveguide offers a return loss lower than the antenna without waveguide as shown in Fig.3.

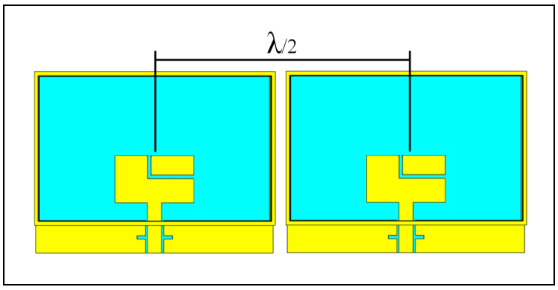

Fig. 7 Array antenna for applying MIMO systems.

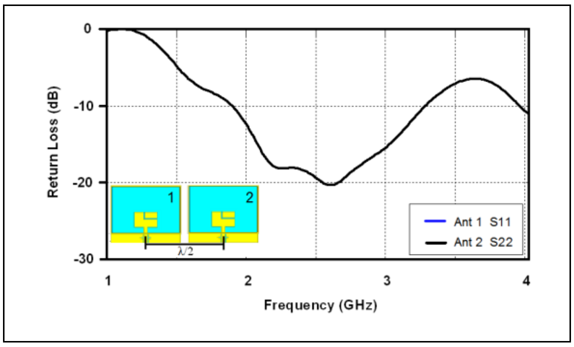

Fig. 8 Simulation results of return loss (S_{11}).

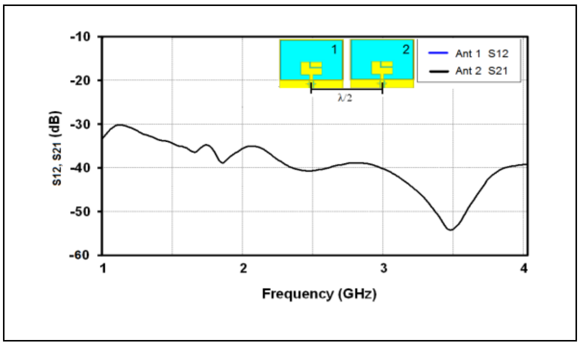

Fig. 9 Simulation results of isolation (S_{12}, S_{21}).

In the second step, the antenna structure was adjusted by etching I-shaped slot on radiation patch under various tuning parameter *W6* (from 0, 1.5, 2.5, 3.5 and 4.5 mm) whereas parameter *L7* value was fixed at 1 mm. After tuning, the best value of *W6* was 2.5 mm at constant value *L7*= 1 mm. The bandwidth of tuning antenna occurred in frequency range was 1.75 – 3.28 GHz (60.95%). The return loss was less than -10dB. But, the impedances bandwidth at 2.45 GHz is 36.97-j6.95 OHM. It has not nearly 50 OHM. Therefore, the tuning of antenna structure in the third step was requested.

In third step, the tuning parameter *W5* started at 6 mm then stepwise increased to 9, 12, 14 and 16 mm while parameter *W4* was fixed at 1 mm. After tuning, it was found that the appropriate value of *W5* was 8 mm at constant value *W4* = 1 mm. Then, the tuning parameter *L5* started at 2 mm then stepwise increased to 4, 6, 8 and 10 mm while parameter *L6* was fixed at 1 mm. After tuning, it was found that the appropriate value of *L5* was 6 mm at constant value *L6* = 1 mm.

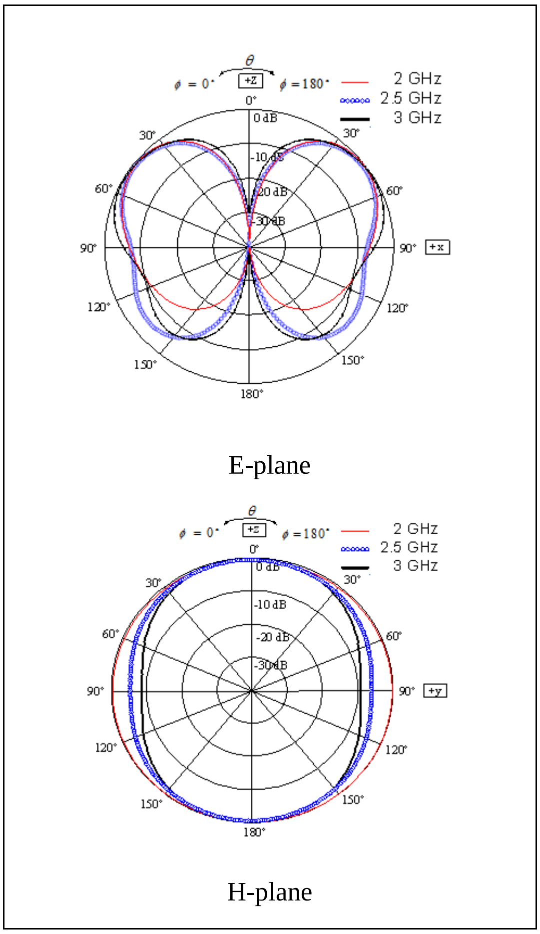

Fig. 10 Simulation results of radiation pattern at 2 GHz, 2.5 GHz and 3 GHz.

Finally, the bandwidth of tuning antenna was 1.85 – 3.51 GHz (61.94%). The impedances bandwidth is nearly 50 OHM. According to simulation results, the return loss in Fig. 5 was lower than Fig.4 when L shaped slot tuning was added. The simulation results indicated that the return loss of proposed antenna was reduced lower than -10 dB. The simulation results of Gain (dBi) as shown in Fig.6. The simulated all parameters (Frequency, Gain and Bandwidth) of antenna with 3 types as shown in Table 2. However, it is impossible to fully know the channel in a real fading environment. Thus, this paper has been studied as array antenna to increase the average gain.

3. ARRAY ANTENNA FOR MIMO SYSTEMS

3.1 Array Antennas

The array antenna for MIMO systems can be shown in Figure 7. The array antenna works well in frequencies 1.85 – 3.51 GHz. Also, it is compact enough to be arranged to form the array having inter-element spacing of half wavelength.

3.2 Simulation Results for Array antennas

The simulation results for array antenna indicated that the return loss of proposed antenna was reduced lower than -10 dB as shown in Fig.8. The isolation of the proposed antenna is shown in Fig.9. According to simulation results, the Gain (dBi) in array antenna was higher than one antenna. The average gain (array antenna) is 6.25 dBi. Also, to increase the number of antenna can improve the average gain. The proposed antenna is capable of WLAN (IEEE 802.11b/g), WiMAX (IEEE 802.16e) applications.

The simulated radiation pattern as E-plane and H-plane at 2 GHz, 2.5 GHz and 3 GHz are shown in Fig.10. According to the results, it was found that the simulated radiation pattern was in good agreement with the theory ones in the pattern of bi-directional.

CONCLUSION

In this paper, the enhancement of bandwidth for rectangular slot antenna with L-shaped slot and double I shaped stub tuning has been studied and applying with array antenna for MIMO system. The simulation results indicated that the return loss of array antenna was reduced lower than -10 dB for application band (2 GHz -3 GHz). The simulated bandwidth of proposed antenna was 53.7% (1.88 - 3.26 GHz) which was pressed with the average gain value of 5.65 dBi.

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NOMENCLATURE

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