International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:2, No:12, 2008

Multiband CPW-Fed Slot Antenna with L-slot Bowtie Tuning Stub

Prapoch Jirasakulporn

***Abstract*—**This paper presents a multiband CPW-fed slot antenna with L-slot bowtie tuning stub. The proposed antenna has been designed for PCS 1900, UMTS, WLAN 802.11 a/b/g and bluetooth applications, with a cost-effective FR4 substrate. The proposed antenna still radiate as omni-directional in azimuth plane and sufficient bandwidth for all above mentions. The proposed antenna works as dual-wideband, bandwidth at low frequency band and high frequency are about 45.49 % and 22.39 % respectively. The experimental results of the constructed prototype are presented and also compared with simulation results using a commercial software tool.

***Keywords*—**multiband antenna, slot antenna, CPW-fed, L-slot bowtie stub

I. Introduction

IN recent years the rapid growth of wireless communication technologies leads to the great demands in using a multi-frequencies band on one device, because the systems want to operate at multi-frequencies in some applications such as mobile applications, picocell base station applications, and Wireless LAN applications. The main purpose is to reduce number of antennas in the systems. The antenna operating in multi-frequency operation band has been invented and it is called a multiband antenna. One application of wireless communications that uses a multiband antenna is WLANs [1]-[2]. Currently, the use of the 2.4 GHz industrial, scientific, and medical (ISM) band is becoming an important mean of wireless communications including WLAN 802.11 a/b/g and buletooth applications, that can provide data rates from 11 Mbps up to 108 Mbps. The operating bands are 2.4-2.4835 GHz and 5.25-5.35 GHz. There were many antennas for the WLAN devices have been developed for these bands [3]-[4].

Feed line is one significance of printed antenna structure, one type of feed line that popular apply to printed antenna is CPW-fed slot antennas, is now increasingly interesting for modern wireless communications. They have many features such as low radiation loss, less dispersion, easy integrated circuits and simple configuration with single metallic layer, and no via holes required. These antennas have recently become more and more attractive. Afterwards, the square slot antenna have been widely studied for broadband operation, especially with coplanar waveguide (CPW) feed lines [5]-[6], but they are quite complicated to design for optimal antennas. Recently, the study of a bow-tie slot antenna with CPW-fed has been presented [7]. This antenna has a geometry structure with bowtie slot antenna fed by a CPW and tuned with tapered tuning stubs. It works as a wideband antenna with a microwave frequency design for X-band and R-band. The advantage of this antenna includes high cross polarization level in the H-plane and can design for different frequency band. Afterwards the another research presented the study of square slot antenna with a U-shaped stub [8] had been presented. The antenna designed for dual wideband, the advantage of this antenna are the relatively small size and works as dual wide bandwidth.

In this study, we propose multiband CPW-fed slot antenna with L-slot bowtie tuning stub, designed for multi operation frequency that covers the PCS 1900(1850-1990 MHz), UMTS (1920-2170 MHz), WLAN 802.11 a/b/g (2400-2483 MHz and 5250-5350 MHz), and buletooth application. All dimension parameters of the proposed antenna has been optimized, with the moment-method based EM simulation with IE3D software to achieve a good multi operation frequency for the proposed antenna. A prototype antenna has been constructed and performance results from simulation and measurement have been compared including return losses, bandwidths, radiation patterns, and gains.

II. Antenna Structure Description

The proposed antenna designed for PCS 1900, UMTS, WLAN 802.11 a/b/g standard is shown in Fig.1. The first step is to design the feed line of the multiband CPW-fed slot antenna with L-slot bowtie tuning stub, with CPW-fed structure defines the fundamental frequency with PCS 1.9 GHz, with FR4 substrate parameter and input impedance 50 Ω. The spacing of feed line and ground plane was chosen to be 0.4 mm, with the Line gauge function of IE3D software to calculate the strip width (W_f) of 5.02 mm and strip length (L_5) of 27.09 mm, from the λ_g = 108.22 mm used to designed the width of slot antenna (W_1) at the half guide wavelength. Afterwards replaced the bowtie tuning stub with the feed line, and on the bowtie stub the L-slot shape had been defected, from the experiment it affected on the second frequency band directly.

The proposed antenna configuration parameters is shown in

F. A. Author is with the Electronics and Telecommunication Engineering Department, Pathumwan Institute of Technology, Bangkok, Thailand, (e-mail: prapojir@hotmail.com).

Fig. 1 in x-y plane and x-z plane, where W_1 and L_1 represent the width and high of the slot antenna, W_2 and L_8 represent the width and high of bowtie stub and θ is the slop of the bowtie stub, and L_3, W_3 and L_4 are the slot width, width and high of the L-slot on bowtie stub respectively. From the simulation results the proposed antenna have been chosen to be W_1 = 40.69 mm, W_2 = 37.8 mm, W_3 = 4.0 mm, W_4 = 18.02 mm, W_5 = 9.94 mm, L_1 = 8.5 mm, L_2 = 28.5 mm, L_3 = 2.65 mm, L_4 = 9.1 mm, L_5 = 27.09 mm, L_6 = 3.28 mm, L_7 = 10.40 mm, L_8 = 20.68 mm, θ = 23.5° and overall dimension with W = 60.87 mm and L = 55.67 mm. From antenna structure that had been described, with IE3D software to achieve operating frequency band covering the PCS 1900, UMTS 2000, and WLAN 802.11 a/b/g standard.

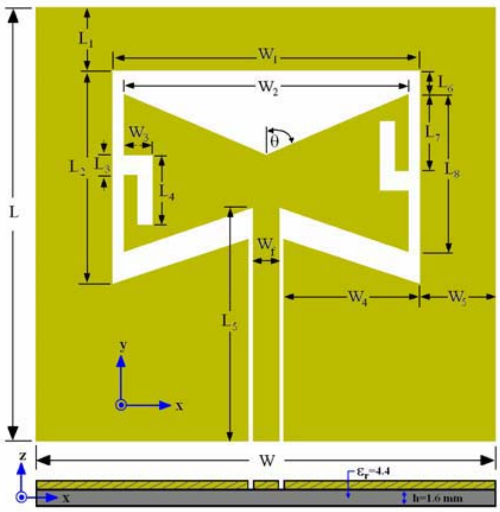

Fig. 1 Structure and geometry of the proposed antenna.

III. Parameter Study

The effect of varying vertical bowtie tuning stub and L-slot dimension has been studied. For the study, W_2 and L_8 the parameters of bowtie stub had been varied, while at the L-slot W_3, L_3 and L_4 to evaluate the matching impedance and frequency bandwidth of the proposed antenna.

The parameter study witch simulation results of W_2 as shown in Fig.2. It affects matching impedance and frequency bandwidth over the frequency band. The width of bowtie stub are profusely affects on impedance matching of low frequency band and bandwidth of high frequency band. In Fig. 3 bowtie stub high L_8 affects on impedance matching of low frequency band and effects on the center frequency and bandwidth of high frequency band. Fig. 4 showed that W_3 are affect on impedance matching of low frequency band, and impedance matching and bandwidth of high frequency band. The return loss on Fig. 5 showed that L_3 affects on matching impedance and frequency bandwidth on high frequency band, and Fig. 6 shown that L_4 are affect on impedance matching of low frequency band, and impedance matching and frequency bandwidth of high frequency band.

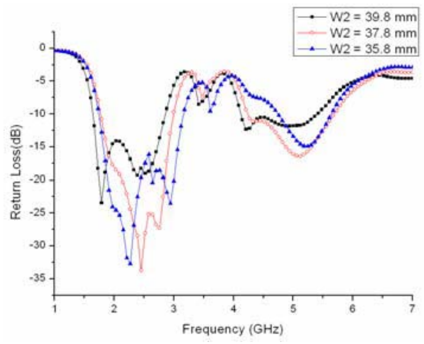

Fig. 2 Simulation return losses for various W_2 of bowtie stub.

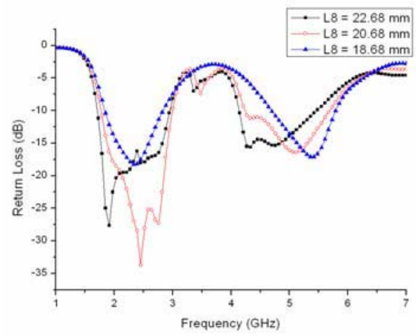

Fig. 3 Simulation return losses for various L_8 of bowtie stub.

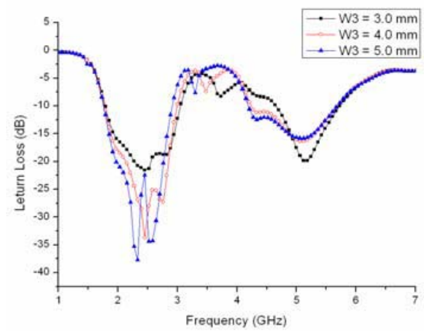

Fig. 4 Simulation return losses for various W_3 of L-slot.

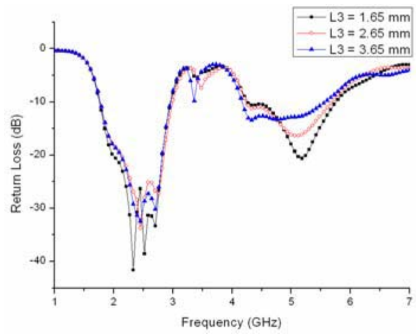

Fig. 5 Simulation return losses for various L_3 of L-slot.

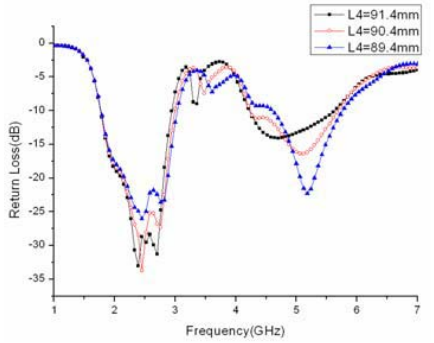

Fig. 6 Simulation return losses for various L_4 of L-slot.

From the study result the parameter W_2 , L_8 and W_3 profusely affects on frequency bandwidth and impedance matching of low frequency band, and parameter W_2, W_3, L_3 and L_4 profusely affects on frequency bandwidth and impedance matching of high frequency band. Therefore, to fix the other parameter and used the profusely affects parameter to tuned the antenna operated over the proper frequency band.

IV. Experiment Results

The proposed antenna was constructed as shown in Fig.7. The return loss of the antenna was measured by a network analyzer R3767CG. Fig. 8 shows the measured return loss compared with the simulated result. The proposed antenna had a little narrow bandwidth with measured than simulated result on both low frequency band and high frequency band, this may be effected by untrustworthy FR4 substrate. Table I compares the result of simulation and measurement bandwidth of low frequency band and high frequency band in term of frequency band width and percent bandwidth. The return loss result was sum up in Table II, examine on PCS, UMTS, WLAN 2.4 GHz and 5.2 GHz standard. The simulation and measurement results showed that the proposed antenna operated over the purpose frequency band.

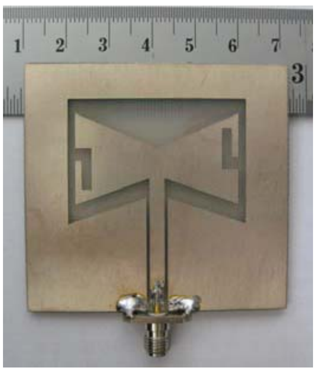

Fig. 7 Illustration of the fabricated prototype antenna.

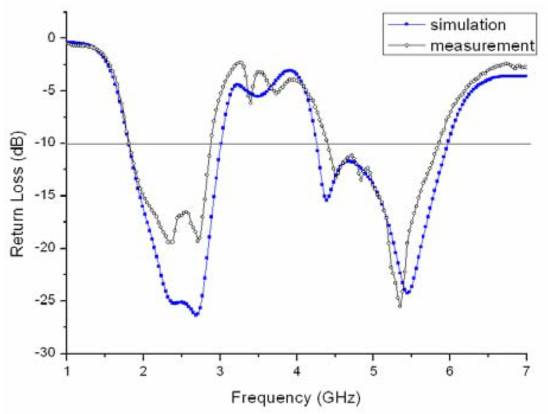

Fig. 8 Simulation and measurement return losses of the proposed antenna.

TABLE I
Comparison Frequency Bandwidth

	Bandwidth			
	Low Frequency Band		High Frequency Band	
	GHz	%	GHz	%
Simulation	1.3 (1.8–3.1)	53.06	1.74 (4.24–5.98)	34.05
Measurement	1.06 (1.8– 2.86)	45.49	1.18 (4.68–5.86)	22.39

TABLE II
Comparison Return Loss

Frequency (gHz)	Return loss (dB)	
	Simulation	Measurement
1.920	-14.6	-13.5
2.045	-16.25	-15.1
2.450	-25.1	-17.5
5.250	-19.6	-21.9

Radiation patter of elevation plane and azimuth plane at center frequency 1.92 GHz and 2.45 GHz of low frequency band, and 5.25 GHz of high frequency band were discussed, from simulation results of the proposed antenna shown in Fig. 8 and Fig. 9 respectively. In elevation plane at low frequency band antenna works as bidirectional pattern, but at high frequency band antenna works like as four-directional the maximum directivity arise at ϕ = 30°, 150°,215° and 325° this may be effect by L-slot structure on bowtie stub. Consider on azimuth plane whole three frequency antenna work as omni-directional pattern, examine on all pattern of whole frequency there have very a little difference in direction gain, at lowest frequency directional gain is highest and become lower conform to higher frequency.

The measured results of co-polarization and cross-polarization patterns of the proposed antenna at whole three frequencies are showed in Fig. 10. The co-polarization measurement at elevation plane of the antenna in harmony of the simulation result, and with low cross-polarization at all frequency, the measured results to be approximate less than -20dB .

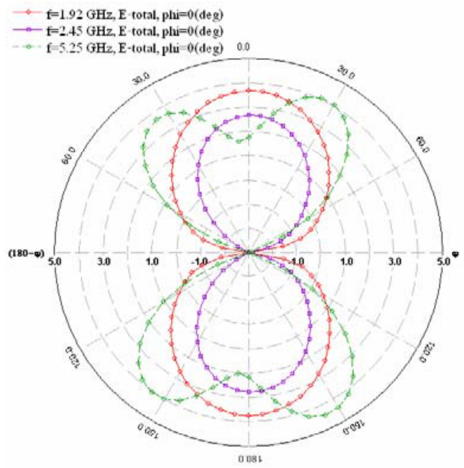

Fig. 8 Simulated results of elevation pattern at center frequency 1.94 GHz 2.45 GHz and 5.25 GHz.

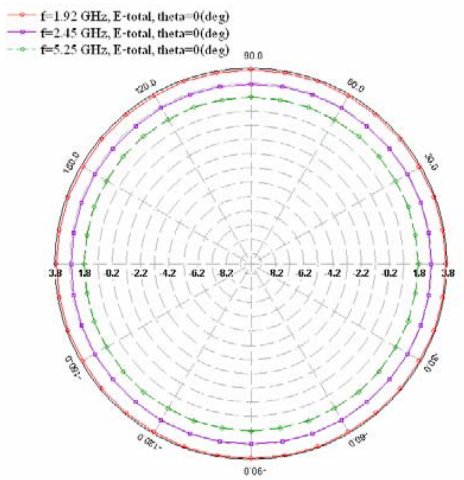

Fig 9 Simulated results of azimuth pattern at center frequency 1.94 GHz 2.45 GHz and 5.25 GHz.

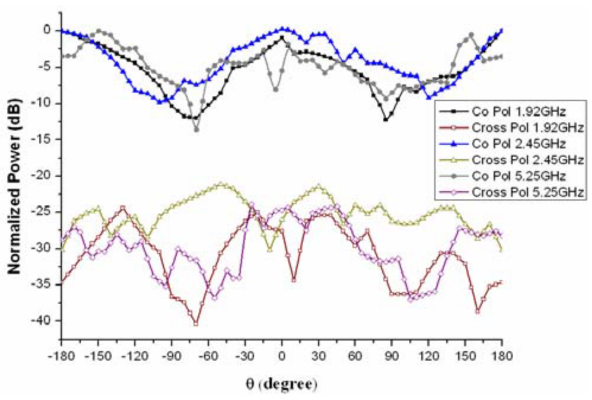

Fig. 10 Measured results of co-polarization and cross-polarization in elevation plane at 1.92 GHz, 2.45GHz and 5.25 GHz.

The azimuth pattern measurement was shown in Fig. 11 the measured results conformed to the simulation result, it is shown that the proposed antenna has a far-field pattern of omni-directional in azimuth plane. Afterward gain simulation and measurement results of proposed antenna are concluded in Table III at center frequency of PCS 1900, UMTS, WLAN 802.11 a/b/g.

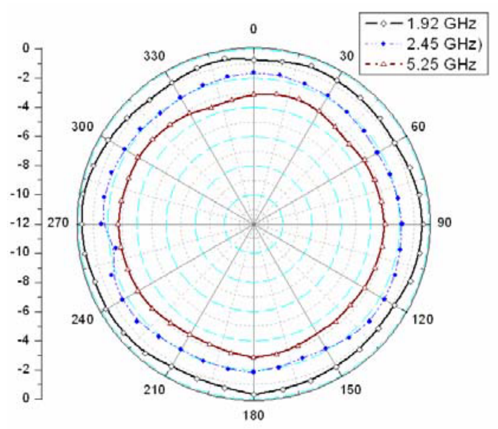

Fig. 11 Measured results of co-polarization in azimuth plane at 1.92 GHz, 2.45 GHz and 5.25 GHz.

Table III
THE PROPOSED ANTENNA GAIN

Frequency (GHz)	Gain (dBi)	
	Simulation	Measurement
1.920	3.76	3.42
2.045	3.85	3.40
2.450	2.91	2.65
5.250	4.57	3.92

V. CONCLUSION

The multiband CPW-fed slot antenna with L-slot bowtie tuning stub was presented with simulation and measurement results. From measured results, the proposed antenna is appropriated to apply for wireless communication systems of PCS 1900, UMTS, WLAN 802.11a/b/g. Furthermore, the proposed antenna has a omni-direction pattern for all frequency bands signifying that the proposed antenna is suitable for using in wireless communications. In addition, key advantage of the proposed antenna is simplicity of designing, simple structure, and cost-effective to manufacture.

REFERENCES

[1] R.K. Raj, M. Joseph, B. Paul, and P. Mohanan, “Compact planar multiband antenna for GPS, DCS, 2.4=5.8 GHz WLAN applications,” Electronics Letters, vol.41, no.6, Mar 2005.
[2] Bin Li and Kwok Wa Leung, “Dielectric-Covered Dual-Slot Antenna for Dualband Applications,” IEEE Trans. Antennas and Propag., vol. 55, no.6, June 2007.
[3] Duixian Liu, Brian Gaucher and Thomas Hildner, “A Dualband Antenna for WLAN Applications,” IEEE Inter. Workshop, pp.201-204, 7-9 Mar 2005.
[4] Zhi Ning Chen, Duixian Liu, Gaucher B., “A Planar Dualband Antenna for 2.4 GHz and UWB Laptop Applications,” IEEE 63rd, vol. 6, 2006.

[5] J.Y. Chiou, J.Y. Sze, and K.L. Wong, "A broad-band CPW-fed strip-loaded square slot antenna," IEEE Trans. Antennas and Propag., vol.51, no.4, Apr 2003.
[6] H.D. Chen, "Broadband CPW-fed square slot antennas with a widened tuning stub," IEEE Trans. Antennas and Propag., vol. 51, no.8, Aug 2003.
[7] A.A. Eldek, A.Z. Elsherbeni, and C.E. Smith, “Characteristics of Bow-Tie Slot Antenna with Tapered Tuning Stubs for Wideband Operation,” Progress in Electromagnetics research, PIER 49, pp. 740–741, 2004.
[8] A.A. Eldek, A.Z. Elsherbeni, and C.E. Smith, “Dual-Wideband Square Slot Antenna with a U-Shaped Printed using Stub for Personal Wireless Communication Systems,” Progress in Electromagnetics research, PIER 53, pp. 319–333, 2005.