Computer Networks and Communications

Design 3.5 Antenna using Planar Technique for Dual Band Applications

M.Z.A. Abd. Aziz, M. Md. Shukor, M.K. Suaidi
Center for Telecommunication Research and Innovation (CeTRI), Fac. Of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, Melaka, Malaysia
mohamadzoinol@utem.edu.my

Abstract

This paper presents the antenna with radiation structure of *3.5* for dual band applications. This antenna is designed and simulated using CST Studio Suite software. The basic shape structures are designed at frequency 2.4 GHz based on radiating structure *5* and 5.2 GHz based on radiating structure *3*. Then both structures are combined to achieve dual band resonant. The techniques that have been used to achieve dual band resonant are by designing the *3.5* shaped using planar structures. The changes on the position of radiating structure *3* effects the resonant frequency, return loss and gain.

Keywords - Dual band, coplanar waveguide, gain, microstrip, planar, radiating structure, resonant frequency, return loss.

1 INTRODUCTION

Nowadays wireless communications is rapid in increasingly the technology development. The rapid progress promises to make interactive voice, data and video services available anytime and anyplace. Wireless communication systems come in variety of different sizes ranging from small hand-held devices to wireless local area networks [1].

In the wireless systems there are lot types of antennas that have been developed for its commercial. As mention before, the higher demands of wireless portable devices have drag to the developing of dual band antennas which have multi applications and also can provide large bandwidth so that it can cover all operating frequencies needed in the system [2-5].

The antennas also need to satisfy the IEEE802.11 WLAN standards. People found that wireless portable devices are very attractive because the user can use the devices without any cables and they also can move anywhere as long as they in the coverage area. There is also a reason of developing a dual band antenna to increase the bandwidth. The popularity of wireless communications has made the system need to be more specific regarding the capacities it can carry and also the speed of the transmission [6-9].

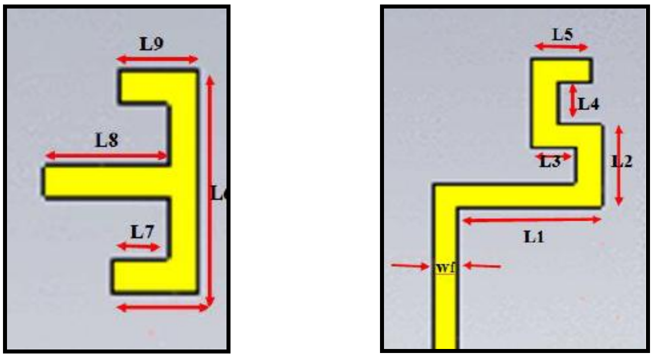
2 ANTENNA DESIGN

Previous work has been done on the novel compact printed antenna with radiating structure of *2.5* for dual band applications at 2.4 GHz and 5.2/5.8 GHz [2]. This paper proposed different radiating structure for same applications. The radiating structure that has been proposed in this paper is *3.5*.

The basic structure for the *3.5* antenna consists of 3 layers which are patch, dielectric substrate and ground plane as shown in Figure 1. The top layer is patch or antenna layer which is the radiator that made from the copper (annealed) with thickness of 0.035 mm. Then, the second layer is dielectric substrate (80 mm×80 mm). In this paper the material that has been used for dielectric substrate is FR4 board with thickness of 1.6 mm, dielectric constant of 4.4 and tangent loss of 0.019. While the bottom layer is the ground plane that 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 proposed antenna was designed and simulated using CST Studio Suite software.

The lengths of the radiating structure *3* and *5* are based on the $\frac{\lambda_g}{4}$. [10-13]. The radiating structure with length L_1 = 17.44 mm is at 2.4 GHz while radiating structure with length L_2 = 8.05 mm is at 5.2

GHz are shown in Fig. 1. The feeding methods that have been used in this paper are microstrip feed line. The feed line is inserted at the radiating structure *5* to achieved dual band at 2.4 GHz and 5.2 GHz. The antenna dimensions are shown in Table 1.



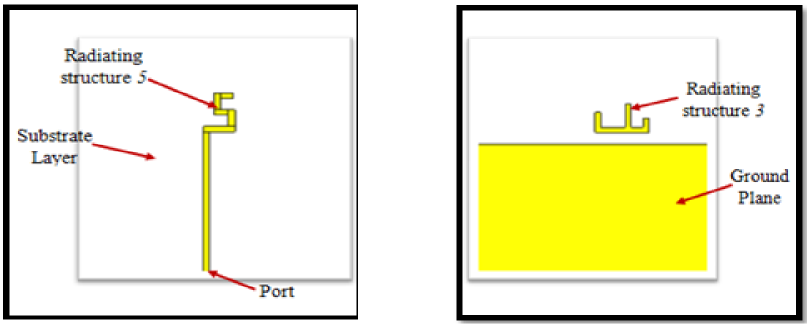
(a) (b)

Fig.1. Antenna geometry (a) Structure *3* (b) Structure *5*

Table 1. The dimensions of the *3.5* antenna in mm

Symbol	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	LF	WF
Dimension	12.5	5	3.3	3.5	4.5	16.67	3	7.5	3	2.39	46.5	1.913

The basic structure of *3* and *5* is designed. Then, both structures *3* and *5* are combined to form *3.5*-shaped antenna. The planar techniques have been used to achieve dual band frequencies. The radiating structure *5* is designed at the front plane. The radiating structure *3* is placed at the same plane with the ground plane. The position of the radiating structure *3* is rotate 90° to achieve dual band at 2.4 GHz and 5.2 GHz. The structures of the proposed antenna are shown in Fig. 2.



(a) (b)

Fig.2. Proposed Antenna (a) Front view (b) Back view

3 RESULTS AND ANALYSIS

The prototype of the antenna is shown in Fig. 3. The results of the return loss, bandwidth, gain, directivity, radiation efficiency are observed at 2.4 GHz and 5.2 GHz. Then the results of the return loss, bandwidth and gain at 2.4 GHz and 5.2 GHz are compared between the simulation and measurements.

(a) (b)

Fig. 3. Antenna Prototype of design *B1* (a) Front view (b) Back view

A. Return loss

For simulation the return loss of the proposed antenna for the 2.4 GHz is -11.038 dB while for 5.2 GHz is -15.948 dB. While for the measurement, the return loss is -19.339 dB for 2.4 GHz and -11.216 dB for 5.2 GHz. Fig. 4 is shown the comparison of the return loss between the simulation and measurement of the proposed antenna. Both frequencies have return loss below -10 dB so that the signal is 90% transmitted and only 10% reflected back.

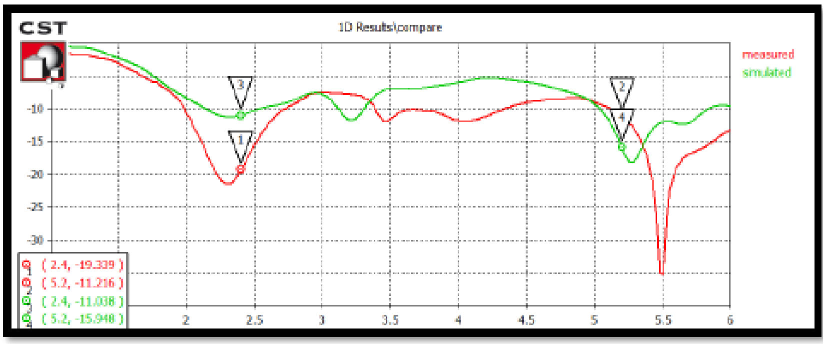


Fig. 4. Comparison between simulation and measurement results of the return loss

B. Bandwidth

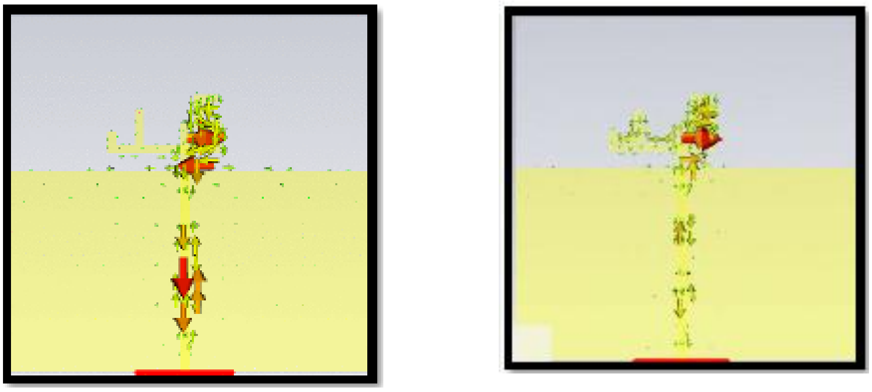
The bandwidth from the simulation for 2.4 GHz is 403.13 MHz and 5.2 GHz is 806.26 MHz. The measurement bandwidth for 2.4 GHz is 764.14 MHz and for 5.2 GHz is 878.64 MHz. The bandwidth can cover the operating frequencies at 2.4 GHz and 5.2 GHz.

C. Gain and Directivity

The gain for 2.4 GHz is 2.863 dB and for 5.2 GHz is 4.577 dB. The directivity for 2.4 GHz is 2.936 dBi and for 5.2 GHz is 6.291 dBi.

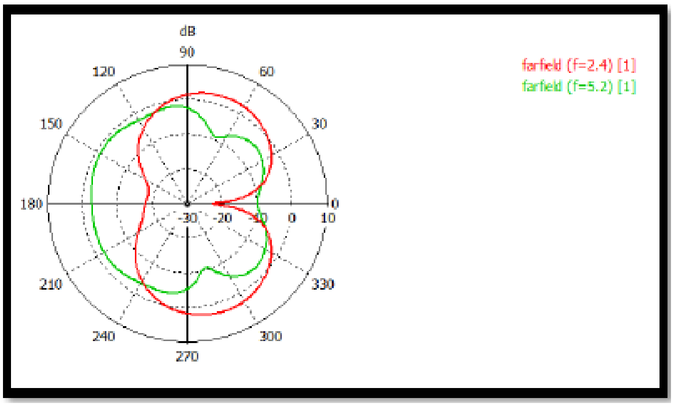
D. Radiation efficiency and Surface Current

While the radiation efficiency for 2.4 GHz is -0.07257 dB and for 5.2 GHz is -1.714 dB. Fig. 5 is shown the surface current at 2.4 GHz and also 5.2 GHz. Fig. 6 is shown the radiation pattern at 2.4 GHz and 5.2 GHz.

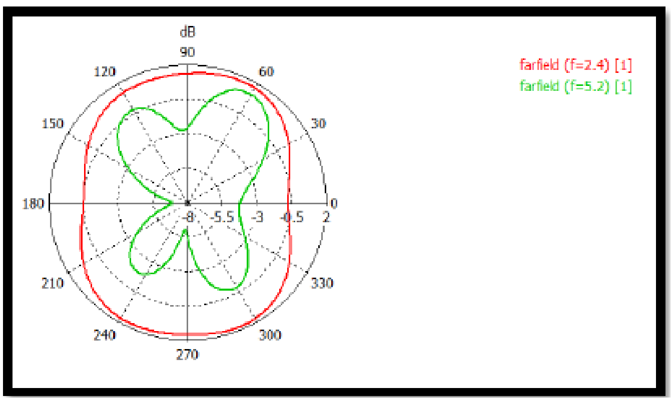


(a) (b)

Fig. 5. Surface current at the (a) 2.4 GHz (b) 5.2 GHz



(a)



(b)

Fig. 6. Radiation pattern at the 2.4 GHz and 5.2 GHz (a) ϕ = 90°(b) 0°

Table 2 is shown the results from the simulation of the return loss, bandwidth, gain, directivity and efficiency of the proposed antenna at frequency 2.4 GHz and 5.2 GHz. Table 3 is shown the comparison between the simulation and measurement results of the return loss, bandwidth and gain of the proposed antenna at frequency 2.4 GHz and 5.2 GHz.

Table 2. The return loss, bandwidth, gain, directivity and efficiency of the proposed antenna

Frequency (GHz)	**2.4**	**5.2**
Return Loss (dB)	-11.038	-15.948
Bandwidth (MHz)	403.13	806.26
Gain (dB)	2.863	4.577
Directivity (dBi)	2.936	6.291
Efficiency (dB)	-0.07257	-1.714

Table 3. Comparison between simulation and measurement results of the return loss, bandwidth and gain of the proposed antenna at 2.4 GHz and 5.2 GHz

Frequency	**2.4 GHz**		**5.2 GHz**	
	Simulation	Measurement	Simulation	Measurement
Return loss (dB)	-11.038	-19.339	-15.948	-11.216
Bandwidth (MHz)	403.13	764.14	806.26	878.64
Gain (dB)	2.863	1.443	4.577	2.251

There is a little bit different between the simulation and the measurement results. This is due to the environmental effect when the measurement process, fabrication process and also the soldering effect that need to take into account.

4 CONCLUSION

A *3.5* antenna is proposed in this paper. The planar technique has been applied to the proposed antenna. Most of the measurement results are agreed with the simulation results but there are still a few different between simulation and measurement results. The position of the radiating structure *3* affects the lower and upper frequency. The proposed antenna is a very attractive solution for small portable devices and for systems where compact antennas that can operate with a small ground plane are required. The combination of the radiating structure *3* and *5* produced dual band resonance frequencies. A future work is needed to increase the gain at the 2.4 GHz.

References

[1] Li. R., Wu. T and Tentzeris. M, “A dual band unidirectional coplanar antenna for 2.4-5-GHz wireless applications,” in Proc. Microwave Conference, 2008. APMC 2008, Asia Pacific, pp 1-4, Dec. 2008.

[2] Papantonis.S and Episkopou. E, “Compact dual band Printed 2.5-shaped antenna for WLAN applications,” in Proc. Machine Copy for Proofreading, pp 1-13, 2011.

[3] Park. S. Y., Oh. S. J., Park. J. K. and Kim. J. S., “Dual band antenna for WLAN/UWB applications,” in Proc. Microwave Conference, 2009. APMC 2009, Asia Pacific, pp. 2707-2710, Dec. 2009.

[4] Karakoussis G.P., Kostaridis A.I., Biniaris C.G., Kaklamani D.I., “A dual-band inverted-F antenna printed on a PC card for the ISM and UNNI bands,” in Proc. Wireless Communications and Networking, 2003.IEEE, vol.1, pp. 88-92, Mac. 2003.

[5] Lan K., Chaudhuri S.K., Safavi-Naeini S., “A compact wide-dualband antenna for bluetooth and wireless LAN applications,” in Proc. Antennas and Propagation Society International Symposium, 2003. IEEE, vol.2, pp. 926 – 929, June 2003.

[6] Vij. V. *Wireless Communication*. New Delhi: Laxmi Publications, Pvt. Ltd. 1-10; 2010.

[7] Mukandatimana M.C., Denidni T.A., Talbi L., “Design of a new dualband CPW-fed slot antenna for ISM applications,” in Proc. Vehicular Technology Conference, 2004. VTC 2004-Spring. 2004 IEEE 59th,vol.1, pp.6-9, May 2004.

[8] Pan C.Y., Huang C.H., Horng T.S., “A novel printed G-shaped monopole antenna for dual-band WLAN applications,” in Proc. Antennas and Propagation Society International Symposium, 2004.IEEE, vol.3, pp. 3099 – 3102, June 2004.

[9] Huang. Y., Boyle. K. *Antennas from Theory to Practice*. United Kingdom: John Wiley & Sons, Ltd. 1-6; 2008.

[10] Pozar. D. M. Microwave Engineering. 3rd edition. United States: John Wiley & Sons, Inc. 633-635; 2005.

[11] Sadiku. M. N. O. Elements of Electromagnetic.4th edition. New York: Oxford University Press. Inc. 535; 2007.

[12] Tomasi. W. Electronic Communications Systems. 5th Edition. Singapore: Prentice Hall. 632; 2004.

[13] Balanis C. A. Modern Antenna Handbook. Hoboken, New Jersey: John Wiley & Sons, Ltd. 2011.