International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
NATIONAL CONFERENCE on Developments, Advances & Trends in Engineering Sciences
(NCDATES- 09th & 10th January 2015)

RESEARCH ARTICLE OPEN ACCESS

Compact Microstrip Patch Antenna for Dual Band WLAN

G.Archana1, K.Praveena2 , Dr. A Srinivasula Reddy3
Department of Electronics and Communication Engineering1,2,3, CMR Engineering College, JNTU, Hyderabad
aarchana9@gmail.com, praveenakaitha@gmail.com, svas_a@yahoo.com
Kandlakoya(V),Medchal Road,Hyderabad-501401,Telangana State, India.

Abstract—
High-gain antennas best for covering long distance communication applications. This paper describes a High-gain, dual band L- shaped Micro strip patch antenna is printed on a FR-4 substrate for WLAN systems, and has dimensions of 60 × 70 ×1.6mm^3 with a ground plane .The dual-band operation is obtained by embedding a pair of L-shaped slots. This proposed antenna is simulated using a CST microwave studio suite^{TM} 2010. The simulated results shown the proposed micro strip patch antenna achieves a frequency range from 5.0 GHz to 6.0 GHz (return loss less than -10dB), so maximum gain with the values of 8.4 and 7.1 dB are achieved in the lower and higher frequency band respectively. This antenna satisfies the requirements of wireless local area network(WLAN)IEEE802.11a(in the frequency range 5.15~5.35G Hz, 5.725~5.825GHz) within a 2:1 VSWR.The return loss, radiation pattern, voltage standing wave ratio(VSWR),gain and the critical design parameters are also investigated in detail. Simulated results verify that the presented antenna is a good solution for dual-band WLAN applications.
Keywords-*Microstrip,L-shaped patch antenna,Dual band, WLAN.*

I.INTRODUCTION

Wireless Local Area Network (WLAN) is one of the most widely used technologies in today's world. It is recognized as a reliable and cost effective solution for wireless high speed data connectivity. THE wireless local area networks (WLANs) working at IEEE 802.11a employs the higher frequency band 5.15-5.35GHz band and 5.725-5.825GHz band. Due to its higher cost, 802.11a is usually found on business networks. It is different from country to country. In the United States, the frequency ranges from 5.15–5.35 GHz and from 5.725–5.825 GHz, while in Europe, the frequency covers 5.15–5.35 GHz and 5.470–5.725 GHz, respectively. Nowadays, dual-band WLAN systems combining IEEE 802.11a/b/g standards are becoming more attractive [4]. A dual-band/wideband antenna is a key component for such communication systems [4]–[15], especially for "universal" applications, where it should be covering the whole 5.15-5.35-GH band and 5.725–5.825-GHz band for dual WLAN band. Such dual-band antennas with single feed have been proposed in various configurations [4], [6], [7], [8], [10], [11]. These antennas either provide inadequate coverage at the 5-GHz band [6], [7], [8], [10], or they cannot be easily integrated in portable devices [4], [11]. Furthermore, the gains of previously published single-fed dual-band antennas are lower than 6 dBi [4]–[12]. The gains of the antennas proposed in [13]–[15] are much higher, but also less than 8 dBi. Larger return loss indicates higher power being radiated by the antenna which eventually increases the gain [16]. The proposed antenna is matched to the cable impedance where the reflection, |Γ| = 0. This means that all power is transmitted to the antenna and there is no reflection [17]. The optimal VSWR is 1.Those designed low-profile antennas are suitable for portable devices, but in applications such as long-range communications or point-to-point communications devices running on battery, high gain of WLAN antenna is necessary, and the antennas previously published have difficulty to meet the requirement. In this letter, a single-fed dual-band antenna covering IEEE 802.11a for WLAN applications is presented. The maximum gains of the two bands are 8.4 and 7.1dBi, making the proposed antenna appropriate for high-gain applications

II.ANTENNA DESIGN

Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Fig. 2,. Dielectric constant of the substrate (Єr) is typically in the range 2.2< Єr <12 [1]. The patch is generally made up of conducting material such as PEC (Perfect electric conductor)and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.Microstrip patch antennas, radiate primarily because of the fringing fields between the patch edge and the ground plane as shown in Fig. 1, [2].

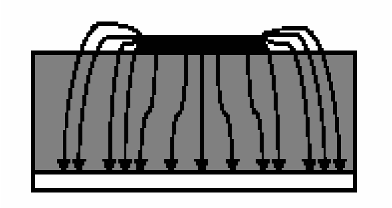
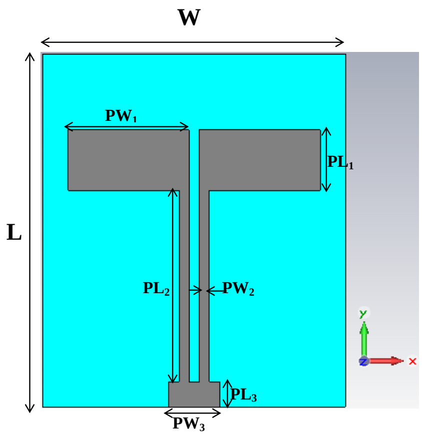


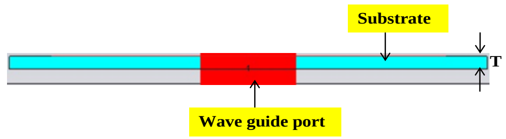
Fig . **1.** Electric Field Lines

Fig. 2, shows the geometry of the proposed dual band microstrip patch antenna. It is fabricated on FR4 substrate of dimensions (70×60mm^2) with a dielectric constant of 4.5 and a substrate thickness of 1.6 mm [3]. The top and bottom patches printed on the substrate are the radiating structure and the ground plane. Because of the rectangular radiator, the radiating structure consists of a two L-shaped patches with one separated strip(5×10×0.05mm^3),and notice that, there is a ground plane printed on the back of the substrate as a size of 70×60×0.05mm^3

The dimensions given in the figure are for achieving dual WLAN band 5.15-5.35GHz and 5.725-5.825 GHz operations, and are obtained with the aid of the simulation software CST microwave studio suite™ 2010.The dimensions of the rectangular FR4 substrate are W×L. The dual L-slots are located symmetrically the center line of the patch and have a narrow width of S.



(a)



(b)

Fig. 2. (a) Front View and (b) Bottom view of the proposed antenna structure

The dimensions of vertical and horizontal arms of L-slots are denoted as PL1 and PW1.The symbol; PL2 and PW2 represent the length and width of L-shape strips. The patch thickness of PEC material is 0.05mm.

Table 1: THE OPTIMAL DIMENSIONS OF THE DESIGNED ANTENNA ARE AS FOLLOWS:

Parameters	L	W	T	S	PW_1	PL_2	PW_2	PL_3	PW_3
Unit(mm)	70	60	1.6	2	24	38	2	5	10

III. SIMULATED RESULTS AND DISCUSSION

In this section, simulated frequency responses of reflection coefficients, VSWR, radiation patterns and peak gains of the proposed antenna are presented. The simulations are carried out using CST microwave studio suiteTM 2010.

Fig. .3, shows the simulated return loss (s11) of the proposed antenna. Return loss is a convenient way to characterize the input and output signal sources. S11 represents how much power is reflected from the antenna. If S11=0 dB, it shows that all power is reflected from the antenna and nothing is radiated. The simulated result indicates that the proposed antenna has two resonant frequencies. The resonant frequency at lower band locates at about 5.18GHz, with the -10dB impedance bandwidth from 5.1GHz to 5.28GHz band. At higher band, the resonant frequency locates at about 5.8GHz, with the -10dB impedance bandwidth from 5.77GHz to 5.83GHz band. The final design chosen from the optimization of patch dimensions as the return loss illustrates the largest value, -35.5743dB at resonant frequency 5.18GHz, and -32.46dB at resonant frequency 5.8GHz. Larger return loss indicates higher power being radiated by the antenna which eventually increases the gain. In other word, the increase in S11 shows that the antenna has a better reflection coefficient and power reaches the load with minimum losses [16]. It shows that two desired operating frequencies are successfully excited and can meet the bandwidth requirement of 802.11a for 5.18/5.8 GHz dual-band applications.

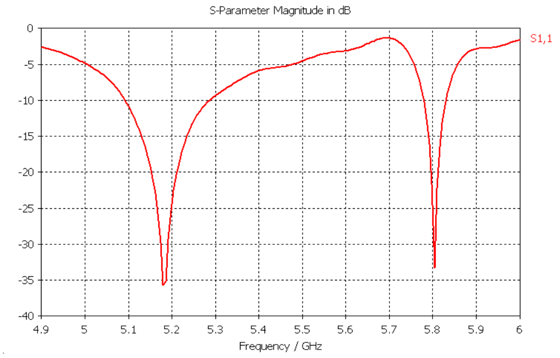


Fig. 3. Simulated return loss for the proposed dual band microstrip patch antenna at 5.18 GHz and 5.8 GHz.

IV. PARAMETER STUDY

This section presents the important parameters, such as PL1and different dielectric constant (Єr) values of substrate. Which influence the operating frequency bands of 5.18 and 5.8GHz, and then the parameter effects of the proposed antenna on impedance bandwidth are illustrated.

A. Effect of parameter PL1

The antenna configuration parameters, as illustrated in Table 1, have been chosen and the parameter PL1 has been varied (PL1=11mm, 13mm).The return losses of the designed antenna are shown in Fig. 4. As the PL1 decreases, the return loss of the first resonant frequency becomes worse and the resonant frequency increases. The first resonant frequency is affected largely between the frequencies of 5.5GHz to 5.6GHz. The second resonant frequency is varying slightly. In this case, the appropriate parameter PL1=12mm is chosen.

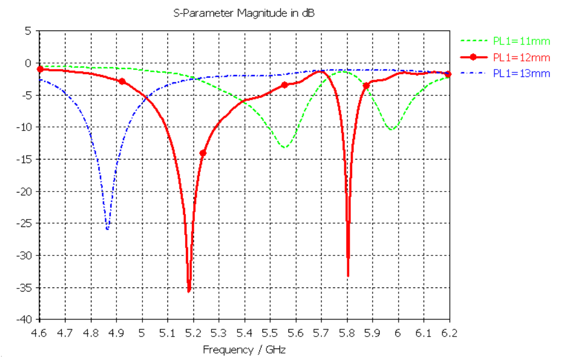


Fig. 4. Return losses from optimization of patch (PL1) of antenna

B. Effect of Dielectric constant

In order to improve the bandwidth, the parameter PL1=12mm has been selected from the previous step, and the dielectric constant is varied to be 4.4, 4.7 and 5. The return losses with variation of Єr are depicted in Fig. 5,. As the Єr decreases, the first and the second two resonant frequencies is shifted to the right. As the Єr increases the first and the second two resonant frequencies is shifted to the left then the coverage of band is missing so considering the FR4 substrate dielectric constant 4.5 is preferred to cover the WLAN frequency band.

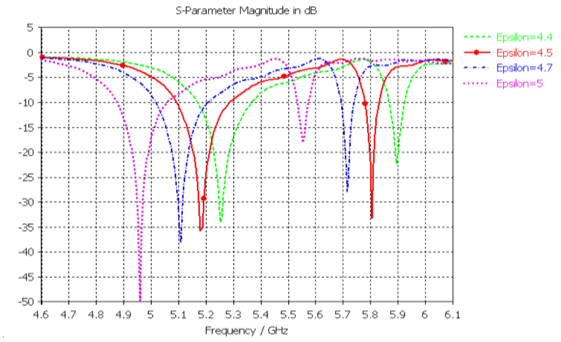


Fig. 5. Return losses from optimization of dielectric constant of the substrate

V. Gain and Directivity

Table.II shows the gain and directivity of the proposed antenna at both bands. In the 5.18GHz band, the peak gain is about 8.43dB (shows in fig. 7,) and simulated peak directivity is 8.34dBi. The peak gain can reach about 7.17dB at 5.8GHz (shows in fig. 8,) and peak directivity is 7.02dBi.The Gain curve follows the Directivity curve over the entire frequency range. It is observed from 5GHz to 6GHz range. The high gain and directivity in 5.18GHz and 5.8GHz band can completely meet the requirement of the long distance wireless communications.

Table II. GAIN/DIRECTIVITY OF THE PROPOSED ANTENNA

Frequency		**Gain/dB**	**Directivity/dBi**
Lower WLAN Band	5	7.769	7.70
	5.1	8.179	8.0
	5.18	8.436	8.34
	5.2	8.46	8.37
	5.25	8.64	8.52
	5.3	8.67	8.58
	5.4	8.87	8.7
Upper WLAN Band	5.7	7.7	7.4
	5.8	7.17	7.02
	5.9	8.49	8.32
	6	7.3	7.1

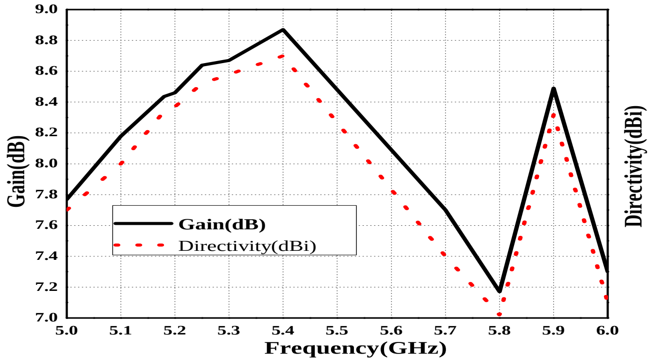


Fig. 6 Gain (dB)/Directivity (dBi) versus Frequency (GHz) of proposed antenna

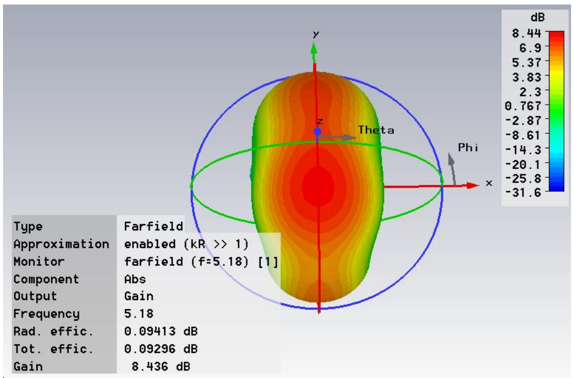


Fig. 7. The radiation pattern of the microstrip patch antenna at 5.18GHz

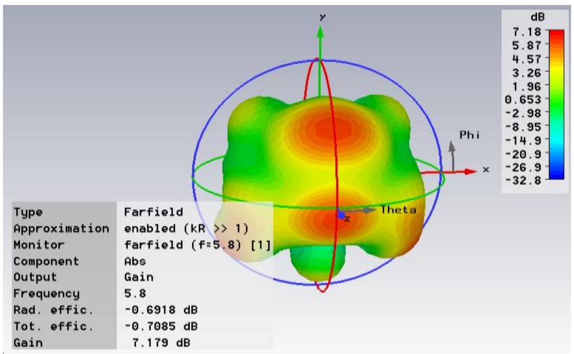
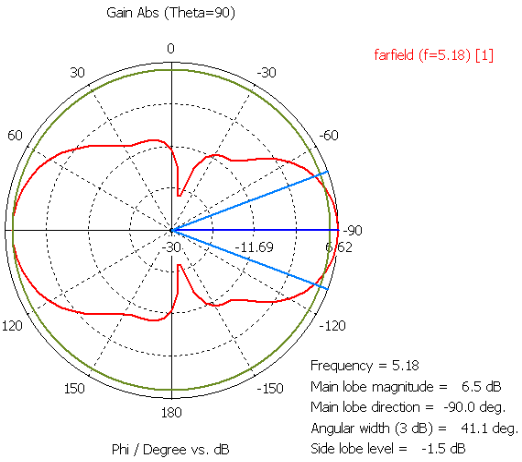


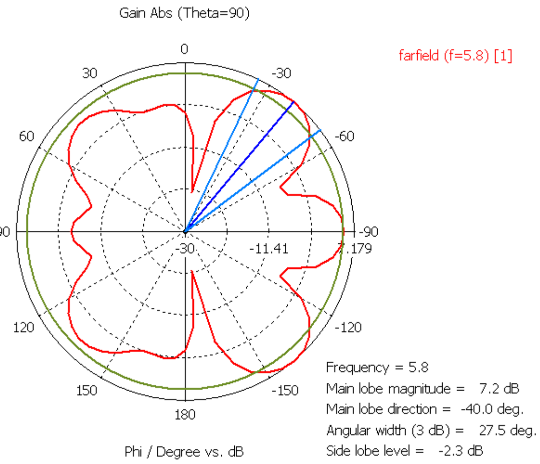
Fig. 8 The radiation pattern of the microstrip patch antenna at 5.8GHz

A. Radiation Pattern Characteristics

The simulated far field radiation patterns of E-Plane and H-Plane of the proposed dual microstrip antenna are shown in Fig. 8, and 9.The simulated radiation patterns at resonant frequency (5.18GHz and 5.8GHz) show that the E-Plane radiation pattern is in end fire direction against frequency and H-Plane can be seen that the total radiation power is nearly omni-directional.We can observe the H-plane pattern at 5.7GHz and 6GHz in fig. 9. b, d.The antenna achieved a gain of 8.4 dB at 5.18 GHz and 7.17dB at 5.8GHz.

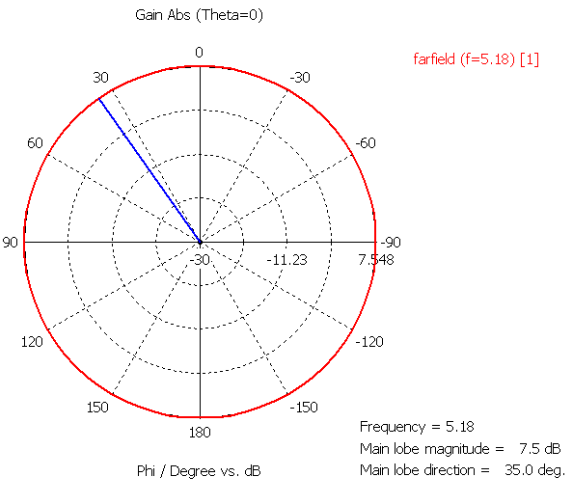


(a). E-Plane at 5.18GHz

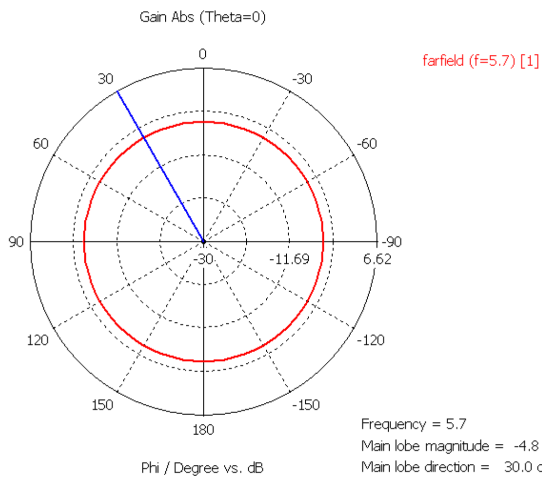


(b) E-Plane at 5.8GHz

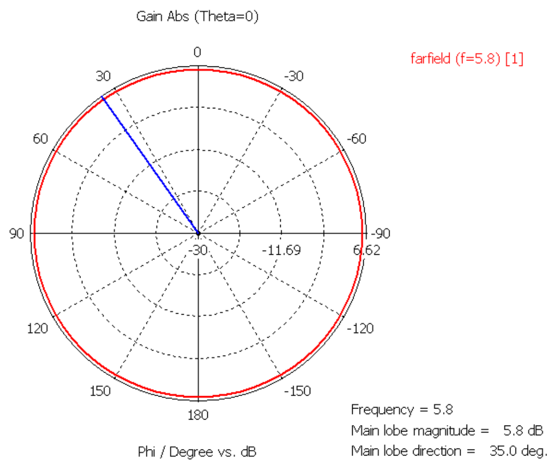
Fig. 9. Simulated E plane radiation patterns of proposed antenna at (a) 5.18GHz (b) 5.8GHz



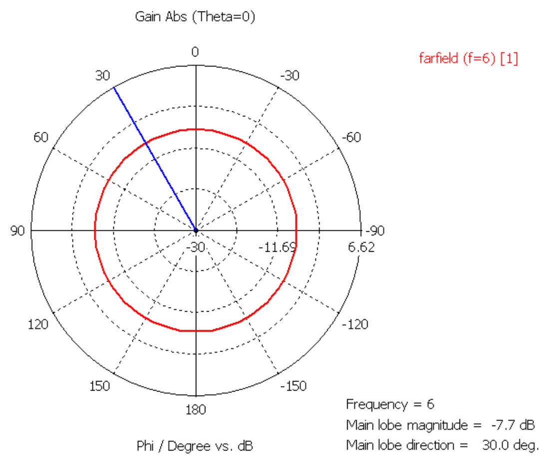
(a). H-Plane at 5.18GHz



(b) H-Plane at 5.7GHz



(c) H-Plane at 5.8GHz



(d) H-plane at 6GHz

Fig. 10. Fairfield H-plane radiation patterns of proposed antenna at (a) 5.18GHz (b) 5.7GHz, (c) 5.8GHz, (d) 6GHz.

B. Voltage Standing Wave Ratio

The simulation result of Voltage Standing Wave Ratio, VSWR is shown in Fig. 11, below. VSWR is an important specification for all microwave devices. It measures how well an antenna is matched to the cable impedance where the reflection, |Γ| = 0. This means that all power is transmitted to the antenna and there is no reflection [17]. The optimal VSWR is 1. By referring to Fig. 11, at operating frequency 5.18GHz, the VSWR value obtained is 1.034 and second operating frequency 5.8GHz, the VSWR value obtained is 1.0538. This dual band microstrip antenna could provide sufficiently wide impedance bandwidth VSWR<2 covering WLAN band (5.1-5.28GHzand5.77-5.83 GHz Fig. 11, shows the simulated VSWR versus frequency of the proposed antenna. It shows that the antenna is near to perfect matching.

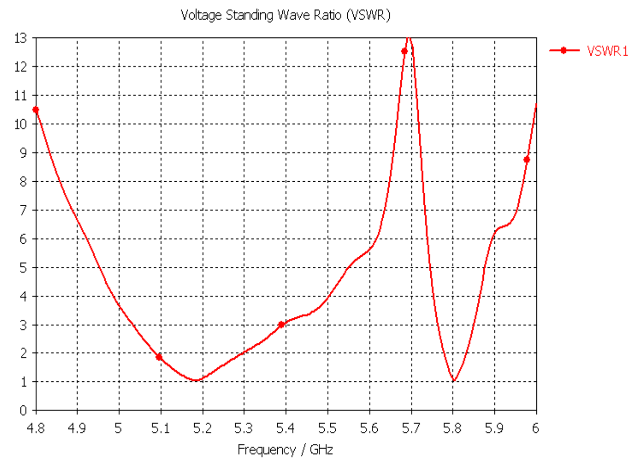


Fig. 11. Simulated VSWR of the proposed antenna.

VI.CONCLUSION

A compact high-gain, dual-band microstrip antenna is presented in this paper for WLAN and long-distance communication applications. The frequency bands with return loss below -10 dB cover universally the IEEE 802.11a standards (5.15-5.35GHz and 5.725-5.825GHz) with maximum gain values of 8.4 and 7.1 dB in the lower and higher frequency bands, respectively. The design of this work gives the following results; the return loss in the operating frequency of 5.18GHz is equal to -35.57dB and of 5.8GHz is equal to -32.46dB. The VSWR obtained at 5.18GHz is equal to 1.034 and at 5.8GHz is equal to1.0538. Taken as a whole, the performance of the antenna meets the desired requirements in terms of return loss, high gain and VSWR at the desired operating frequency. From this paper, it can be concluded that, the performance of the microstrip antenna depends heavily on the dimension of the slot. As the width and length of the slot increase, the return loss (S11) and VSWR increase but the gain decreases. Other factors that can contribute in the antenna performance are the type, thickness and dielectric constant of substrate.

Because of using a FR-4substrate, the proposed antenna production costs are reduced. It is seen that the proposed antenna achieved good performance, simple structure, and it can be constructed with a lower cost, this will meet the requirements of WLAN applications with smaller size.

REFERENCES

[1] Eldek, "Analysis and Design of Wideband Slot and Printed Antennas for Phased Array Antenna Systems," in Electrical Engineering. vol. PhD: University of Messisippi, November 2004.

[2] N.N.Rao,"Elements of engineering Electromagnetic", PHI-India, pp [674-685],2000

[3] Asrokin, A. Rahim, M.K.A. Aziz, M.Z.A.A. "Dual band microstrip antenna for wireless LAN application," Applied Electromagnetics, 2005. APACE 2005. Asia-Pacific Conference on , vol., no., pp.4 pp., 20-21 Dec. 2005

[4] Y. Cao, C. Lu, and Y. Zhang, "A compact dual band miniaturized antenna forWLANoperation," in Proc. ICMMT, Apr. 2008, pp. 416–419.

[5] Q. He, B. Wang, and J. He, "Wideband and dual-band design of a printed dipole antenna," IEEE Antennas Wireless Propag. Lett. vol.7, pp. 1–4, 2008.

[6] M. J. Kim, C. S. Cho, and J. Kim, "A dual band printed dipole antenna with spiral structure for WLAN application," IEEE Microw. Wireless Compon. Lett., vol. 15, no. 12, pp. 910–912, Dec. 2005.

[7] R. K. Joshi and A. R. Harish, "A modified bow-tie antenna for dual band applications," IEEE Antennas Wireless Propag. Lett. vol. 6, pp. 468–471, 2007.

[8] B. S. Izquierdo and J. C. Batchelor, "A dual band belt antenna," in Proc. iWAT, 2008, pp. 374–377.

[9] J. Sze, C. Hsu, and S. Hsu, "Design of a compact dual-band annularring slot antenna," IEEE Antennas Wireless Propag. Lett. vol. 6, pp.423–426, 2007.

[10] B. Li and K. W. Leung, "Dielectric-covered dual-slot antenna for dual band applications," IEEE Trans. Antennas Propag., vol. 55, no. 6, pp.1768– 1773, Jun. 2007.

[11] M. Wong, A. R. Sebak, and T. A. Denidni, "Analysis of a dual-band dual slot omnidirectional stripline antenna," IEEE Antennas Wireless Propag. Lett., vol. 6, pp. 199–202, 2007.

[12] K. Chung, S. Hong, and J. Choi, "Ultrawide-band printed monopole antenna with band-notch filter," Microw. Antennas Propag., vol. 1, no.2, pp. 518–522, 2007.

[13] K. Lau, H. Wong, C. Mak, K. Luk, and K. Lee, "A vertical patch antenna for dual-band operation," IEEE Antennas Wireless Propag. Lett.,vol. 5, pp. 95–97, 2006.

[14] H. F. Hammad, Y. M. M. Antar, and A. P. Freundorfer, "Dual band aperture coupled antenna using spur line," Electron. Lett., vol. 33, no.25, pp. 2088–2090, 1997.

[15] K. Oh, B. Kim, and J. Choi, "Design of dual and wideband aperture stacked patch antenna with double-sided notches," Electron. Lett., vol.40, no. 11, pp. 643–645, 2004.

[16] G. K. S. a. F. U. M. Dogan, "Optimization of Aperture Coupled Microstrip Patch Antenna," Progress in Elecromagnetics Research Symposium proceedings, Cambridge, USA, pp. 657-660, 2010.

[17] A.Balanis, Antenna Theory, 2nd. Edition ed. Arizona State University: John Wiley & Sons,Inc, 1997. 2011 IEEE International Conference on System Engineering and Technology (ICSET)124