DUAL BAND TWO ELEMENTS INVERTED-L ANTENNA FOR 3.5 & 5 GHZ MOBILE WIMAX/ WI-FI APPLICATIONS

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ABSTRACT

This paper presents the numerical simulations of dual band two elements Inverted-L antenna for 3.5 GHz mobile WiMAX and 5 GHz Wi-Fi operation. The proposed antenna is feed by a coaxial connector. The antenna arms effectively control the excited resonant modes for Wi-Fi and mobile WiMAX operation. Total area occupies by the antenna is 20 mm × 30 mm. The antenna contains substantial gain with less than 0.3 and 2 dBi gain variation within the -10 dB return loss bandwidth at 3.5 and 5 GHz operating frequency respectively. In addition, the antenna has achievable bandwidth, return loss and radiation characteristics for both frequencies. Due to the compact area occupied, the proposed antenna is promising to be embedded within the different portable devices employing 3.5 GHz mobile WiMAX and 5 GHz Wi-Fi operation.

KEYWORDS

Inverted-L antenna, Wi-Fi, WiMAX, WLAN.

1. INTRODUCTION

Wireless communications have been developed widely and rapidly in the modern world especially during the last decade. In the near future, the development of the personal communication devices will aim to provide image, DMB (Digital Multimedia Broadcasting), video telephony, speech and data communications at any time-any where around the world using the WLANs (Wireless Local Area Networks). Rapid advances of various WLAN protocols have sparked the requirements for miniaturized multiband antennas with suitable frequency bands appropriate for the Wi-Fi (IEEE 802.11 standard) and mobile WiMAX (IEEE 802.16e-2005 standard) applications are highly desirable. The Wi-Fi operates in the 2.4 GHz band (2.4 GHz-2.5 GHz) and 5 GHz band (5.15-5.35 GHz, 5.47-5.725 GHz and 5.725-5.875 GHz). The mobile WiMAX operating bands are 2.3 GHz (2.3-2.4 GHz), 2.5 GHz (2.5-2.7 GHz) and 3.5 GHz (3.4-3.6 GHz) [11].

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A shorted T-shaped monopole antenna with antenna gain is about 2.0-2.6 and 3.2-3.7 dBi for the 2.4 and 5 GHz band respectively [1]. Uni-planar dual band monopole antenna provides two operating frequency bands for Wi-Fi operation with near about 3 and 5.5 dBi gain at frequency 2.4 and 5.8 GHz respectively [2]. If the monopole antenna is designed in ring shaped or hook shaped the gain is not over 2.8 and 4.29 dBi at frequency 2.4 and 5 GHz respectively [3], [4]. Moreover, dual band slot by using two linear slot are arranged to be close, equilateral triangular slot antenna, compact double L-slit or compact dual band slot antenna has the moderate gain in both frequencies but the antenna geometry are not simple[5]-[8]. Though the dual band rectangular slot antenna has simple geometry but the gain is limited to 4 and 5 dBi at frequency 2.4 and 5 GHz band respectively [9]. The gain of the flat-plate antenna with shorted parasitic element also limited to 3 dBi at 2.4 GHz and 5.5 dBi at 5.2/5.8 GHz operating frequency [10]. All the antennas, i.e., monopole antenna, slot antenna, flat-plate antenna and L-slit antenna provides Wi-Fi operation at 2.4 and 5 GHz frequency bands which is not suitable for the operation of mobile WiMAX frequency band.

It is realized that some low-profile microstrip and printed slot antennas are required for Wi-Fi and mobile WiMAX operations which can overcome the constraints of size, weight, cost, performance, installation complexity and aerodynamic profile. To meet the mentioned constraints, Inverted-L antenna is one of the good candidates. This paper presents the numerical analysis of dual band two elements inverted-L antenna to realize the 3.5 GHz mobile WiMAX and 5 GHz Wi-Fi operation with acceptable return loss, gain and VSWR. For numerical analysis researchers consider the substrate permittivity of the antenna is ε_r= 2.2 (RT/duroid 5880) with substrate thickness 0.127 mm. The analysis is performed numerically using method of moments.

2. ANTENNA DESIGN

Starting from the dual band flat-plate antenna with a shorted parasitic element for 2.4 and 5.2/5.8 GHz operations [10], we examined the possibility of simplifying the structure and designed the antenna not only for Wi-Fi operation but also suitable for mobile WiMAX operation. Figure 1 shows the geometry of the resultant dual band antenna is two elements inverted-L antenna. This modified antenna is assumed to feed by a 50 ohm coaxial cable, with its central conductor connected to the feeding point and its outer conductor connected to the ground plane.

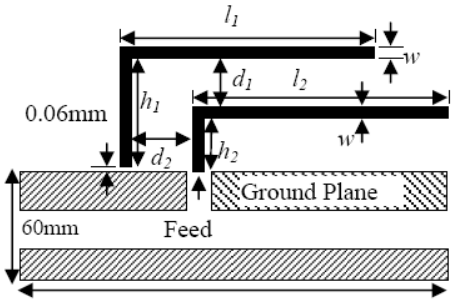

Figure 1. Dual band two elements inverted-L antenna structure

For the numerical simulation the dimension of the ground plane is considered as 60 mm × 60 mm. The proposed antenna provides small dimensions which can be mounted in small devices like cell phone to access the Wi-Fi and mobile WiMAX networks.

Table 1. Design Parameters of the Proposed Dual band two elements Inverted-L Antenna

Parameters	Length (mm)	Antenna Dimension
h_1	16.4	20×30 mm^2
h_2	7	
d_1	7	
d_2	6	
l_1	14	
l_2	16	
w	2	

2. NUMERICAL SIMULATION AND RESULTS

The proposed antenna is constructed and numerically analyzed using method of moments. The numerical results of the antenna are shown below.The simulated return loss is shown in fig. 2 The proposed antenna provides appreciable return loss than the commonly required return loss level of -10 dB. From fig. the lower band has a -10 dB return loss bandwidth of 250 MHz (3400 – 3650 MHz) covering the 3.5 GHz mobile WiMAX operating band (IEEE 802.16e-2005 standard, 3.4-3.6 GHz). The upper band shows a wider bandwidth of 1050 MHz (5150 – 6200 MHz) covering the 5 GHz band for the Wi-Fi operation (IEEE 802.11a standard, 5.15-5.875 GHz).

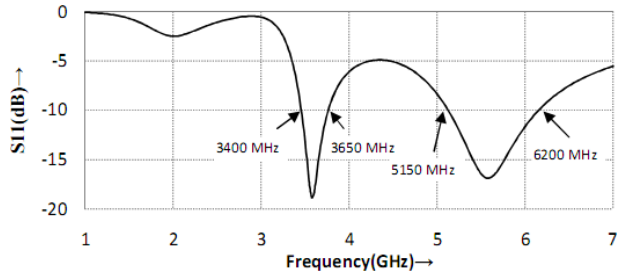

Figure 2. Return loss characterictics of the dual Inverted-L antenna

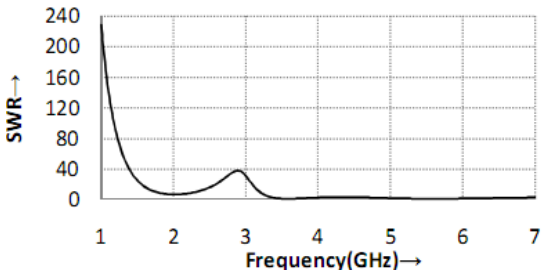

Figure 3. VSWR of proposed two elements inverted-L antenna with frequency (GHz)

Fig. 4. shows the total antenna gain for both of the 3.5 GHz & 5 GHz bands. Fig 5 (a),(b) & (c),(d) indicates the antenna gain and return loss variations for 3.5 GHz and 5 GHz band respectively. It is found that in the 3.5 GHz band , the peak gain is about 7.49 dBi and less than 0.3 dBi of gain variation is observed. In the 5 GHz band, the peak gain reaches about 7.72 dBi and gain variation is less than about 2 dBi.The antenna has stable gain at both operating bands and satisfied the required gain variation for the mobile WiMAX and Wi-Fi operations.

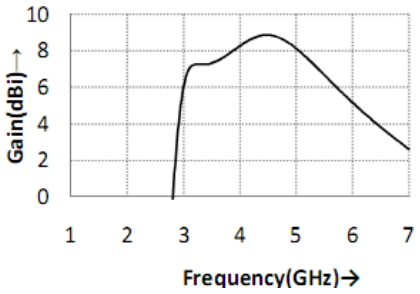

Figure 4. Antenna Gain Versus Frequency graph of the two elements inverted-L antenna

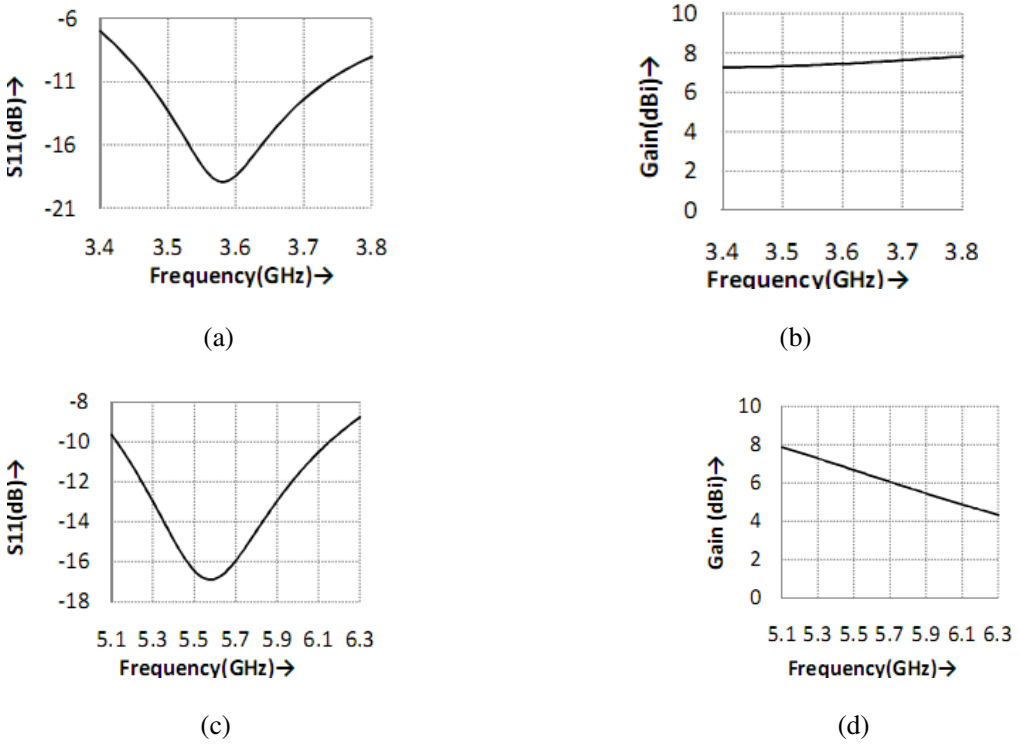

Figure 5. (a),(b) Antenna Return loss and Gain variations at 3.5 GHz band and (c) (d) Antenna Return loss and Gain variations at 5 GHz band

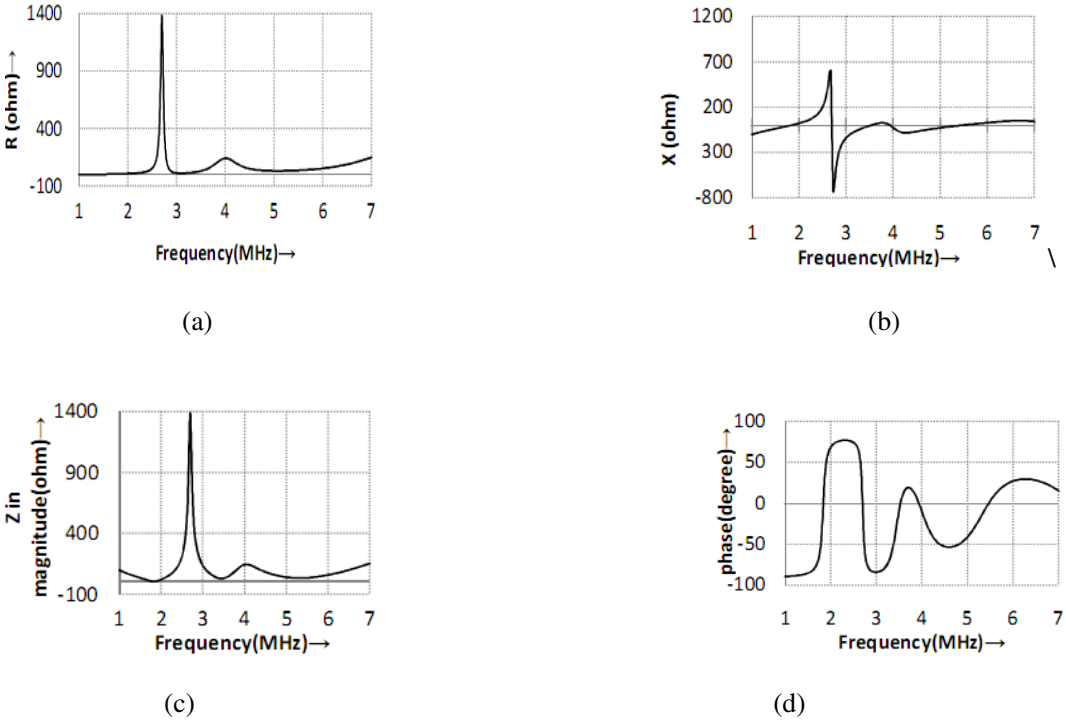

Figure 6. (a),(b),(c),(d)shows Input Impedance of the proposed two elements inverted-L antenna

Figure 7 and 8 shows the radiation patterns of the antenna at 3.5 GHz and at 5 GHz in vertical and horizontal plane respectively. From the radiation pattern, the antenna has acceptable radiation characteristics at both operating frequency bands in horizontal and vertical planes.

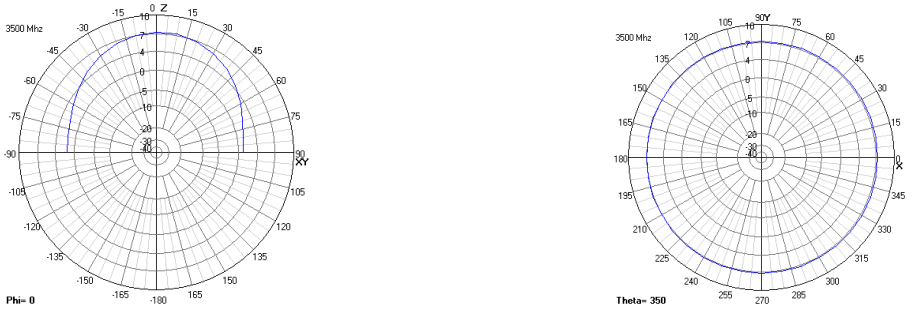

Figure 7. Total Gain pattern of the proposed Inverted-L antenna at 3.5 GHz in (a) vertical plane (b) horizontal plane

(a) (b)

Figure 8. Total Gain pattern of the proposed Inverted-L antenna at 5 GHz in (a) vertical plane (b) horizontal plane

The numerical result shows that, the proposed antenna is suitable for both Wi-Fi and mobile WiMAX operation

4. CONCLUSION

A simple structured dual band single feed inverted-L antenna has been proposed. The bandwidth of both lower and upper bands of the proposed antenna is approximately two times larger than the required bandwidth of 3.5 and 5 GHz operating bands. By the above numerical analysis the proposed antenna appears as an excellent candidate for the mobile WiMAX and Wi-Fi operations. Furthermore, due to the low profile the proposed antenna can be embedded within the wireless devices employing Wi-Fi and mobile WiMAX applications. Our future plan is to reduce the size of the proposed antenna with increased bandwidth and gain.

REFERENCES

[1] C. M. Su, W. S. Chen, Y. T. Cheng, and K. L. Wong, "Shorted T-shaped monopole antenna for 2.4/5 GHz WLAN operation", *Micro. Opt. Technol. Lett.*, Vol. 41, No. 3, pp. 202-203, 2004.

[2] L. C. Chou, and K. L. Wong. "Uni-planar dual-band monopole antenna for 2.4/5 GHz WLAN operation in the laptop computer." *IEEE Transactions on Antennas and Propagation*. Vol. 55. No. 12. pp. 3739-37411. 2007.

[3] G. Zhao, F. S. Zhang, Y. Song, Z. B. Weng, and Y. C. Jiao, "Compact ring monopole antenna with double meander lines for 2.4/5 GHz dual band operation," *Progress in electromagnetic research*, PIER. 72, pp. 187-194, 2007.

[4] C. H. Lee and S. O. Park." A compact printed hook-shaped monopole antenna for 2.4/5 GHz WLAN applications."*Microwave and Optical Technology Letters.*Vol.48. No.2. pp. 327-329. 2006.

[5] C. M. Su, H. T. Chen, F. S. Chang, and K. L. Wong. "Dual band slot antenna for 2.4/5.2 GHz WLAN operation." *Microwave and Optical Technology Letters*.Vol. 35. No. 4. pp. 306-308. 2002.

[6] Jeun-Wen Wu. "2.4/5 GHz dual band triangular slot antenna with compact operation." *Microwave and Optical Technology Letters* .Vol. 45. No. 1. pp. 81-84. 2005.

[7] W. Ren ."Compact dual band slot antenna for 2.4/5 GHz WLAN applications." *Progress in Electromagnetic Research B*. Vol. 8. pp. 319-327. 2008.

[8] T. H. Kim, and D. C. Park. "Compact dual-band antenna with double L-slits for WLAN operation." *IEEE Antennas and Wireless Propagation Letters*. Vol. 4. pp. 249-252. 2005.

[9] H. M. Hsiao, J. W. Wu, Y. D. Wang, J.H. Lu, and S. H. Chang, "Novel dual broadband rectangular slot antenna for 2.4/5 GHz wireless communication," *Micro. Opt. Technol. Lett.*, Vol. 46, No. 3, pp. 197-200, 2005.

[10] K. L. Wong, L. C. Chou, and C. M. Su. "Dual band flat plate antenna with a shorted parasitic element for laptop applications." *IEEE Transactions on Antennas and Propagation*. Vol. 53. No. 1. pp. 539-544. 2005.

[11] L. Pazin, N. Telzhensky, and Y. Leviatan, "Multiband flat-plate inverted-F antenna for Wi-Fi/WiMAX operation," *IEEE antennas and wireless propagation letters*, Vol. 7, pp. 197-200, 2008.

[12] M. Ali, "Analysis of integrated inverted-F antenna for Bluetooth applications," in *Proc. 2000 IEEE Antennas and Propagation Society Conf. Antennas and Propagation for Wireless Communications*, Waltham, MA, pp. 21–24.

[13] R. Ramirez, H. Elsadek, L. Jofre, and D. Flaviis, "Reduced size single and dual band linear polarized microstrip antennas for mobile communications," in *Proc. 2001 IEEE Antennas and Propagation Society Int.Symp.*, vol. 4, Boston, MA, pp. 450–453.

[14] J. R. James, P. S. Hall, and C.Wood, *Microstrip Antennas*. Stevenage, U.K.: Peregrinus, 1981.

[15] C. Soras, M. karaboikis, G. Tsachtsiris, and V. Makios, "Analysis and design of an inverted-F antenna printed on a PCMCIA card for the 2.4 GHz ISM band," *IEEE Antennas Propag. Mag.*, vol. 44, no. 1, pp. 37–44, Feb. 2002.

[16] K. Hirasawa and M. Haneishi, Eds., Analysis, Design, and Measurement of Small and Low-Profile Antennas. Norwood, MA: Artech House, 1992.

[17] W.C. Liu and C. M. Wu. *"CPW*-Fed Shorted F-Shaped Monopole Antenna for 5.8-GHz RFID Application*"*. *Microwave and Optical Technology Letters,* 48(3): 573-575, 2006

[18] Z. N. Chen and M. Y. W. Chia. *"*Broadband Planar Inverted-L Antennas*"*. *IEE Proceedings Microwave Antennas Propagation*, 148(5): 339-342, 2001

[19] S.W. Su, K. L. Wong and H. -T. Chen. *"*Broadband Low-Profile Printed T-Shaped Monopole Antenna for 5-GHz WLAN Operation*"*. *Microwave and Optical Technology Letters,* 42(3): 243-245, 2004

[20] G. J. Burke and A. J. Poggio. *"*Numerical Electromagnetic Code-2*"*. Ver. 5.7.5, Arie Voors, 1981

[21] M. C. T. Huynh. "A Numerical and Experimental Investigation of Planar Inverted-F Antennas for Wireless Communication Applications". M.Sc. Thesis, Virginia Polytechnic Institute and State University, October 2000

[22] Y. D. Lin and P. L. Chi. *"*Tapered Bent Folded Monopole for Dual-Band Wireless Local Area Network (WLAN) Systems*"*. *IEEE Antennas and Wireless Propagation Letters*, 4: 355– 357, 2005

[23] Y. L. Kuo and K. L. Wong. *"*Printed Double-T Monopole Antenna for 2.4/5.2 GHz Dual- Band WLAN Operations*"*. *IEEE Transactions on Antennas and Propagation*, 51(9): 2187– 2192, 2003