Australian Journal of Basic and Applied Sciences, 5(10): 1524-1527, 2011
ISSN 1991-8178

New Compact Triple-Band Microstrip Triangular Patch Antenna for WLAN/WiMAX Applications

Mehdi Abioghli

Meshkin Shahr Branch, Islamic Azad University, Meshkin Shahr, Iran

Abstract: In this paper, we propose a novel microstrip antenna for operating over a three frequency bands, covering the 2.4/5.2/5.8 GHz WLAN and 2.5/3.5/5.5GHz WiMAX bands. The proposed antenna occupies an area of 30 mm × 40mm, when printed on FR4 substrate (ε_r=4.4, h=0.8mm). The antenna comprises of a triangular patch section, L-shaped parasitic elements on the edges of triangular patch and a 50Ω microstrip transmission line for excitation. Compact size, low cost and good radiation parameters respect to the previous designs are the most important advantages of the proposed antenna.

Key word: Triple-Band, Microstrip Antenna, Parasitic elements, Triangular, WLAN, WiMAX.

INTRODUCTION

The demand for compact size, light weight and low cost antennas has increased in the recent years with the widespread deployment of wireless communications, like the wireless local area networks (WLAN). WLAN's are designed to operate in the 2.4 GHz (2.4–2.48 GHz) and 5 GHz frequency bands (5.15–5.35 GHz and 5.725–5.825 GHz). Also WiMAX (Worldwide Interoperability for Microwave Access) which is allocated the 2.5–2.69/3.4–3.69/5.25–5.85 GHz bands. In (Chou and Wong, 2007), a uni-planar dual-band monopole antenna for 2.4/5 GHz WLAN operation in the laptop computers was introduced, which had a simple structure consisting of a driven strip and a coupled strip. In (Joshi and Harish, 2007) a printed bow-tie antenna with triangular shaped parasitic elements was proposed for the same applications. The authors in (Chien-Yuan Pan, *et al*., 2007) proposed Dual wideband Printed monopole antenna for WLAN/WiMAX applications. Reference (Wen-Shan Chen and Kuang-Yuan Ku, 2008) reported novel design of the band-rejected function has been proposed by inserting strips on wideband printed open slot antenna by choosing the proper parameters of the strips, to provide, triple bands operation. In (Deepti Das Krishna, *et al*., 2008) a dual wide-band CPW-fed modified Koch fractal Printed slot antenna was proposed for the WLAN and WiMAx applications. The authors in (See Pan, *et al*., 2008) proposed a dual-frequency planar inverted F-L-antenna (PIFLA) that could provide a compromise between size reduction and attainable bandwidth.

In this paper, we introduce a novel triple band microstrip triangular antenna. In order to attain the triple-band characteristics, the antenna has three L-shaped parasitic elements on the edges of triangular patch. It has been observed that the three resonant frequencies of the antenna could be independently varied by changing the dimensions of the structure. Specifically, modifying the patch dimensions alters the resonance at 3.5GHz, and the L- shape parasitic elements in the edges of triangular patch affect the resonances at 2.5GHz and 5.25GHz. In other words the three resonance bands are isolated. Since the proposed antenna design is based on analytical relations, this structure can be used to design in other frequencies and applications.

MATERIALS AND METHODS

This paper is consisted of three main parts. In Section I, antenna design procedure is presented. Then, Results and Discussion is given in Section II. Finally, concluding remarks are made in Section Conclusion.

Antenna Design:

Fig.1 shows the geometry of the proposed triple-band antenna for 2.4/5.2/5.8 GHz WLAN and 2.5/3.5/5.5 GHz WiMAX bands applications. The antenna is printed on a 0.8-mm thick FR4 substrate, and comprises of a triangular patch section and two L-shaped parasitic elements and ABC element on the edges of the patch. The antenna is fed by a 50Ω microstrip transmission line. In order to achieve good impedance matching over three bands, the width W_f of the microstrip feed line was calculated and found out to be equal to 1.5mm. The ground plane has the length of L_g and width of W_g. In this design, the triangular section controls the 3.5 GHz operating band of the proposed antenna. The L-shaped parasitic elements on the arms of triangular patch are used to generate a new (higher) resonant mode at 5.25 GHz. The ramification Line (ABC) is used to generate another resonant mode at 2.5 GHz. It should be noted that since the induced current at the edges of the triangular patch is high, this locations are selected for inserting two L-shaped parasitic elements and ramification Line. A commercial software package, Ansoft HFSS, has been used to model the proposed antenna, whose electrical

Corresponding Auhor: Mehdi Abioghli,Meshkin Shahr Branch, Islamic Azad University, Meshkin Shahr, Iran
E-mail: m.abioghli@meshkin-iau.ac.ir

characteristics and radiation performance are thoroughly analyzed as well. The numerical method base of this package is namely finite element method (FEM).

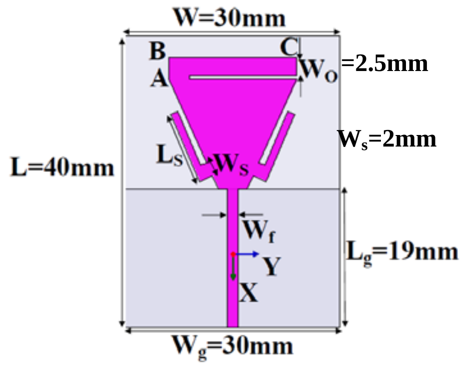

Fig. 1: The proposed printed triple-band antenna structure.

RESULT AND DISCUSSION

In order to achieve a good impedance matching over three bands, The width Wg of the ground plane is found out to be equal to 30mm and the length L_g was 19mm. simulated return loss of antenna for various ground-plane widths was also studied. Small effects on the 5.2 GHz band and much larger effects on the 2.4 GHz band are seen. This is probably because the operating frequencies in the 2.4 GHz band have a wavelength more comparable to the dimensions of the ground plane, and thus a larger effect is expected. The simulation result for return loss of the antenna of Fig. 1 is shown in Fig. 2. From this figure it is clearly seen that a first resonant mode is covering the 2.5 GHz band. This resonant mode has 405 MHz (2395–2800MHz) of 10dB impedance bandwidth. This resonant mod is generated by adding the ABC element. The length of AB and BC are 3mm and 18mm respectively. In order to obtain a good impedance matching over 2.5GHz band, the width W_o of the ramification Line should be equal 2.5mm. The VSWR 2:1 bandwidth is seen to be 900MHz (3380-4280MHz) and 1200MHz (5000-6200MHz) at 3.5 and 5.25 GHz frequency bands, respectively. The triangular section controls the 3.5 GHz operating band of the proposed antenna. By adding two L-shaped parasitic elements of width W_s=2 mm and length L_s=12 mm an additional resonant mode at about 5.25 GHz is obtained. This resonant frequency is primarily obtained by the L-shaped parasitic elements, which provide a resonant path length of about 12 mm (L_s + W_s) that is about 21% of the wavelength at 5.25 GHz. As it was mentioned previously, the generation of the higher resonant frequency by L-shaped parasitic elements would affect the original resonant frequency of triangular patch. This is due to the fact that the locations of the parasitic elements are in the current distribution path of the 3.5GHz resonant frequency. The locations of the parasitic elements have a minimal effect on the 3.5GHz resonant frequency, and the structure behaves as a proper triple-band antenna for WLAN/WiMAX applications. The simulated principal plane normalized radiation patterns of the proposed antenna at 2.5/3.5/5.5 GHz are shown in Fig. 3. As it can be observed nearly omnidirectional radiation patterns are achieved at three operating frequency bands.

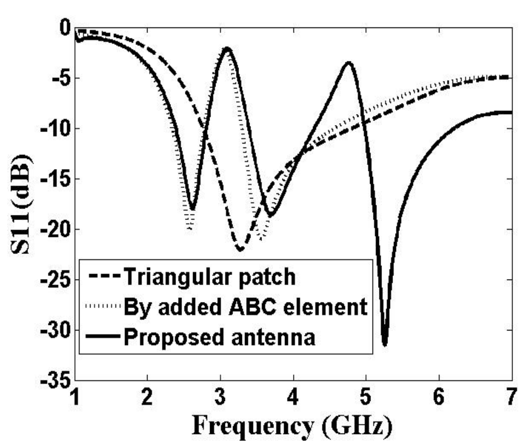

Fig. 2: Simulated return loss of the proposed antenna.

The antenna peak gains of 4.9dBi and 2.5dBi and 4.6dBi are achieved at 2.4GHz and 3.5GHz and 5.25GHz bands, respectively. Fig. 4 presents the simulated surface current distributions on the proposed antenna at 2.5GHz and 3.5GHz and 5.25GHz frequencies. It is seen that strong current density flow is through the edges of triangular patch at the frequency of 3.5GHz, while at 2.5GHz, the ramification Line has the strong current density. Also, it is seen that strong current density flow is through the L-shape parasitic elements at the 5.25GHz.

Parametric Study:

The effects of W_o on the resonance frequency and obtained impedance bandwidth are studied. The value of W_o is varied from 1–2.5 mm. Very small effects on the lower and upper resonant modes are also seen. For the 3.5GHz band, the resonance frequency generally decreases by increasing W_o, although the impedance matching levels are not affected. Also, the effects of W_s on the resonance frequency and obtained impedance bandwidth are studied. The value of W_s is varied from 2–5 mm. For the lower and upper bands, the resonance frequencies are not affected, although the impedance matching levels are affected. Conversely, by increasing W_s, the second resonance frequency (3.5GHz) and corresponding bandwidth increased.

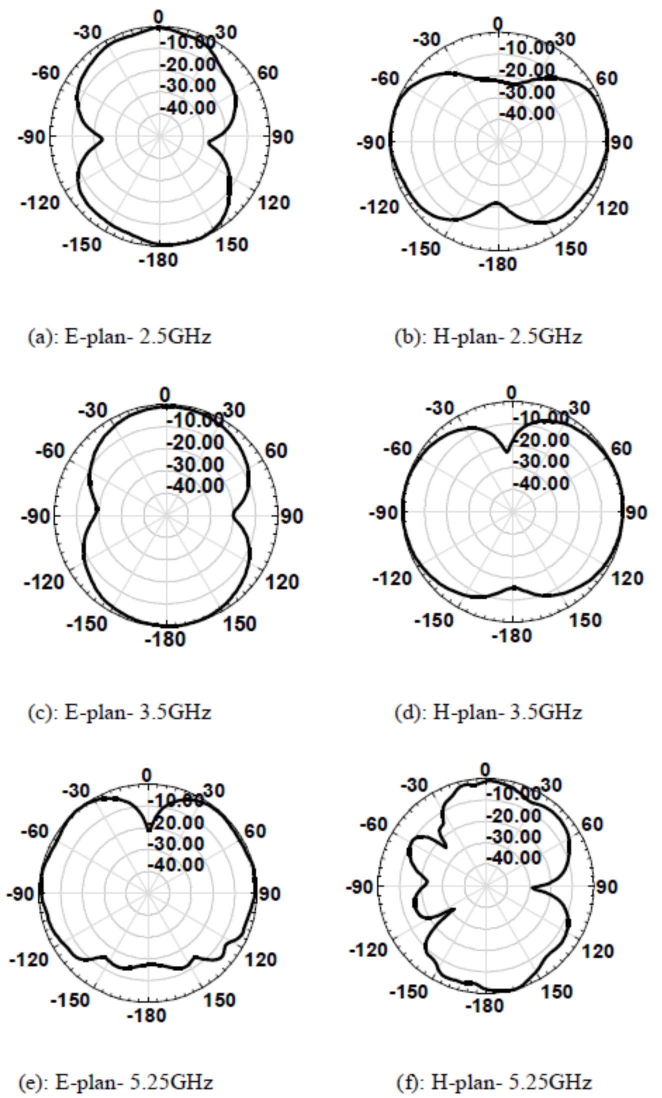

Fig. 3: Normalized radiation patterns of the proposed antenna.

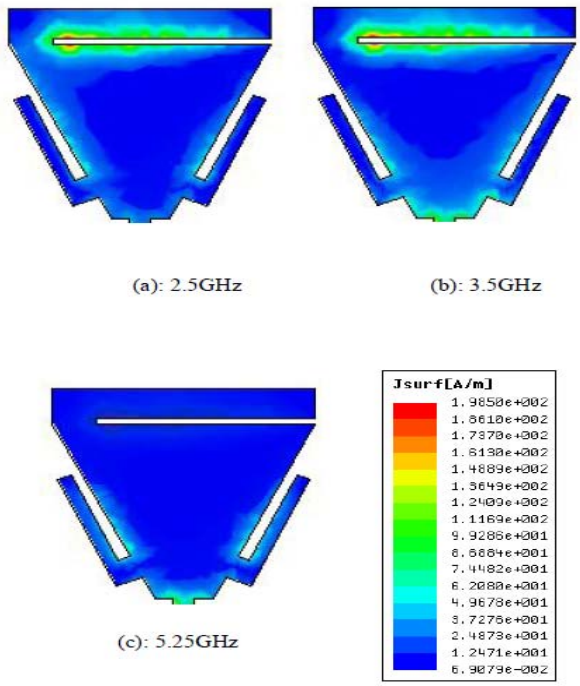

Fig. 4: The simulated surface current distributions.

Conclusion:

Triple-band operations of a novel printed triangular patch antenna have been demonstrated. That is suitable for WLAN and WiMAX operations in the 2.5/3/5/5.25GHz bands. The VSWR 2:1 bandwidth in the 2.5GHz band was 405MHz, while the VSWR 2:1 bandwidth in the 3.5GHz and 5.25GHz bands were 900MHz and 1200MHz respectively. These bandwidths exceed the requirements of any WLAN and WiMAX applications. It was also shown that the 3.5GHz frequency band can be chosen by adjusting the length of the triangular patch and that of the 2.5GHz operation band can be easily set by adjusting the length of the ramification Line. The 5.25GHz operation band can be easily set by adjusting the length of the L-shaped parasitic elements. The nearly omnidirectional radiation patterns are achieved over the interested operating frequency bands.

ACKNOWLEDGMENTS

The author would like to thank the Meshkin Shahr Branch, Islamic Azad University, Meshkin Shahr, Iran for financially supporting this research.

REFERENCES

Chien-Yuan Pan, Tzyy-Sheng Horng, Wen-Shan Chen and Chien-Hsiang Huang, 2007. “Dual Wideband Printed Monopole Antenna for WLAN/WiMAX Applications.” IEEE Antennas and Wireless Propagation Letters, 6: 149-151.

Chou, L.C. and K.L. Wong, 2007. “Uni-Planar Dual-Band Monopole Antenna for 2.4/5 GHz WLAN Operation in the Laptop Computer.” IEEE Trans. Antennas Propag.

Deepti Das Krishna, M. Gopikrishna, C.K. Anandan, P. Mohanan and K. Vasudevan, 2008. “CPW-Fed Koch Fractal Slot Antenna for WLAN/WiMAX Applications.” IEEE Antennas and Wireless Propagation Letters, pp: 389-392.

Ravi Kumar Joshi and Ayyangar Ranganath Harish,2007. “A Modified Bow-Tie Antenna for Dual Band Applications.” IEEE Antennas and Wireless Propagation Letters.

See, C.H., R.A. Abd-Alhameed, D. Zhou and P.S. Excell, 2008. “Dual-Frequency Planar Inverted F-L-Antenna (PIFLA) for WLAN and Short Range Communication Systems.” IEEE Trans. Antennas Propag.

Wen-Shan Chen and Kuang-Yuan Ku,2008. “Band-Rejected Design of the Printed Open Slot Antenna for WLAN/WiMAX Operation.” IEEE Trans. Antennas Propag.