Triple-band printed polygonal slot antenna for WiMAX applications

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Abstract

Printed polygonal slot antenna fed by a 50-Ω microstrip line with two narrow strips for three-band operation is proposed and experimentally studied. We find the polygonal slot antenna is a broadband effect (1.85GHz~5.83GHz), then, we inserted two narrow strips into the polygonal slot antenna to rejected two bands. By properly choosing the length and location of the two narrow strips, the triple bands of WiMAX can be achieved. The good impedance matching, good radiation patterns, and antenna gain of the proposed antenna are investigated in this paper. The design of the proposed antenna is suitable for WiMAX (Worldwide Interoperability for Microwave Access) applications.

1. INTRODUCTION

In recent years, wireless communications have progressed very rapidly. IEEE 802.16 working Group created a new standard, commonly known as WiMAX, for broadband wireless access at high speed, low cost, which is easy to deploy[1]. WiMAX technology can reach a theoretical 30-mile coverage radius and achieve data rates up to 75 Mbps, throughput closer to the 1.5Mbps performance of typical broadband services[2]. The development of WiMAX technology is the focus of receiving industry immediately. It is important how to design the antennas for WiMAX applications.

The microstrip-line-fed printed slot antennas have broadband, low profile, light weight, easy manufacture and low cost. The designs of broadband slot antenna have been proposed[3]-[5]. However, The triple-band of WiMAX allocates regions 2.495~2.695, 3.25~3.85, 5.25~5.85GHz. We can denote these operating bands as the low band (2.495~2.695GHz), the median band (3.25~3.85GHz), and the high band (5.25~5.85GHz) respectively. Broadband antenna[3]-[5] must add filter to strain dispensable band leading to the cost raise. Therefore, broadband antenna is not extremely suitable for WiMAX bands. A wideband stubby monopole[6] is a broadband effect and the antenna structure is more complex. To design the triple-band which fit the exact bands of WiMAX applications is not easy task.

In this paper, we proposed a new design of microstrp-line-fed printed polygonal slot antenna with two rectangular narrow strips to form the dual band-rejected frequency at 3GHz and 4.5GHz. The proposed antenna can easily be excited by a 50-Ω microstrip-line printed on the dielectric substrate that material is FR-4. In the study, good impedance matching of the antenna design can be obtained and good radiation characteristics are also presented in this paper. Details of the antenna design and the experimental results of the proposed antenna are discussed.

2. ANTENNA DESIGN

Figure 1 shows the geometry of the broadband design of polygonal slot antenna on a dielectric substrate. In this study, the dielectric material is FR-4 that the thickness of h and relative permittivity ε_r . For design convenience, the proposed antenna is fed by a $50-\Omega$ microstrip-line and printed on the dielectric substrate. The microstrip-line was placed symmetrically with respect to the centerline (y axis) of the polygonal slot. Then, by fine tuning the polygonal slot and adjusting the length of the $50-\Omega$ microstrip-line, so as to excite a new resonant mode in the proximity of the fundamental resonant mode, and good impedance matching of the broadband operation can be obtained. Then, we try to produce dual rejected-bands located at the proper frequency to form the triple frequency bands for WiMAX applications.

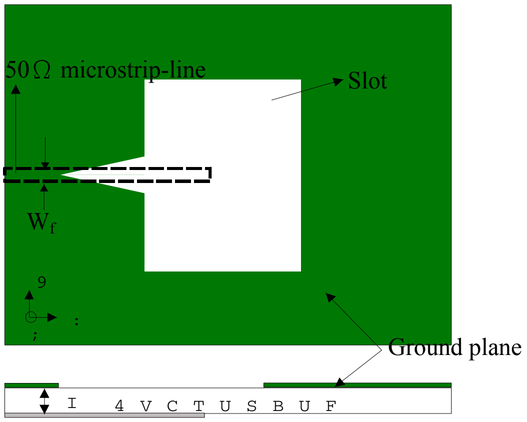


Fig 1. The structure of the broadband polygonal slot antenna

Figure 2 shows the geometry of the triple-band of the polygonal slot antenna on a dielectric substrate. With the use of two narrow strips inserted alone the centerline of the polygonal slot. The strips with width w_s is equal the width w_f of microstrip-line. Due to reject two different frequency bands that the length of strip A is different from strip B. By proper choosing the length of the strip A and strip B. The strip A connected to the ground plane of the polygonal slot antenna is to reject the frequency band from 2.69 to 3.3GHz. The strip B can couple to form a reject frequency band with 50Ω microstrip-line. The length of strip B is approximately quarter wavelength at the center frequency of the 2nd rejected-band (4.525GHz). Because the polygonal slot inserted two strips will reject two rejected bands leading to a triple-band WiMAX operation.

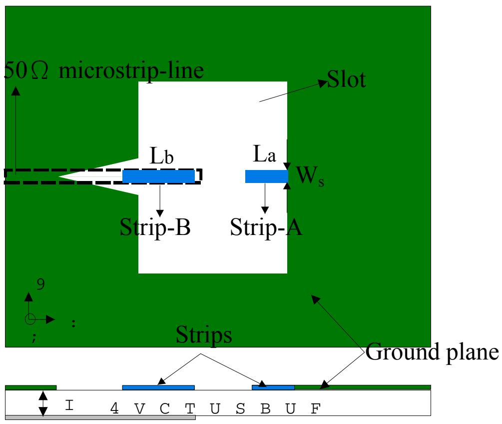


Fig 2. The structure of the proposed antenna inserted strip A and strip B

3. EXPERIMENTAL RESULT AND DISCUSSION

(1) **Polygonal Slot Antenna**

Figure 3 shows the measured and return loss results of the polygonal slot antenna ($W_f = 3mm$, $h = 1.6mm$ $\varepsilon_r = 4.4$, $Ground = 100 \times 80mm^2$). The simulation was performed using the software package from ANSOFT Technologies' High Frequency Structure Simulation, and the result of this prototype of the proposed antenna is measured with HP-8072E network analyzer. The impedance bandwidth was above 100% (1.85~5.83 GHz) at VSWR ≦ 2. We can obviously find that the broadband effect of the polygonal slot is presented in Fig 3.

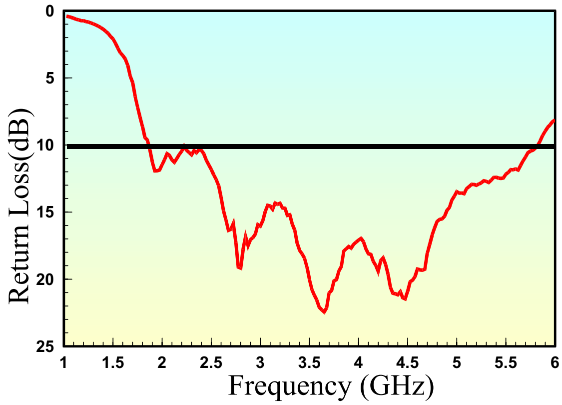


Fig 3. The measured return loss results of the broadband antenna.

(2) **Inserted strip A and strip B proposed antenna design**

Inserted strip A and strip B in the polygonal slot, we find the relatively suitable length of L_a is 9mm, and the optimal length of L_b is 17mm. Inserted strip A and strip B simultaneously in the polygonal slot, the triple-band operation for WiMAX application can be obtained. Figure 4 shows the measured and simulated return loss results of the proposed antenna($W_s = W_f = 3mm$, $L_a = 9mm$, $L_b = 17mm$). The three bandwidths (1.95~2.73, 3.27~3.99, 5.1~<6 GHz) are suitable for frequency bands of WiMAX. Fig 5 and Fig 6 show the measured radiation pattern of the x-z plane and y-z plane at 2.5, 5.75GHz for the proposed design. The radiation characteristics are also investigated. Fig 7 shows the antenna gain of the proposed antenna. The maximum peak antenna gains for three operating bands are measured to be 5.7, 3.9 and 5.8dBi, respectively, and the gain variations for three bands are observed to be less than 2.9dBi. The good characteristic of antenna gain is very suitable for WiMAX applications.

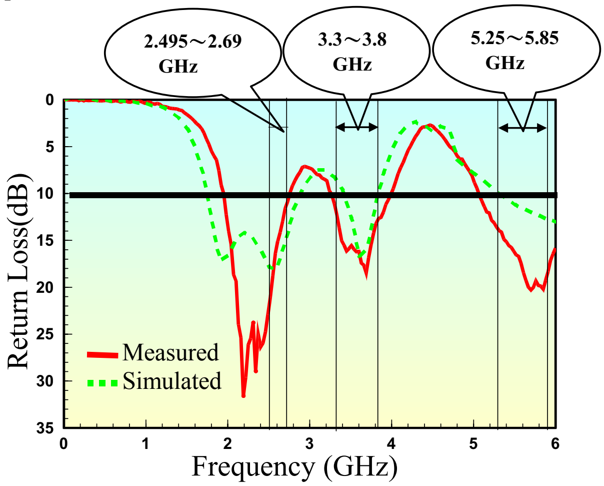
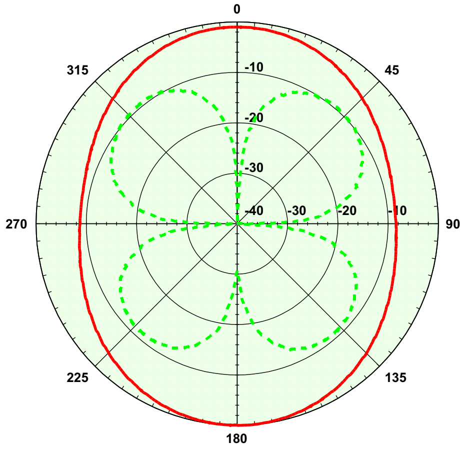


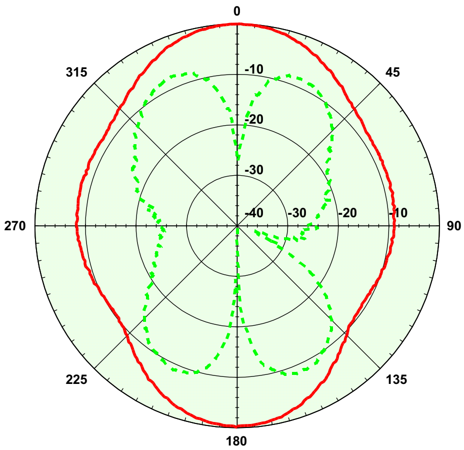
Fig 4. The measured and simulated return loss results for the proposed antenna.

4. CONCLUSION

The novel printed polygonal slot antenna for WiMAX applications has been implemented. By inserting two narrow strips along the centerline of the polygonal slot antenna leading to dual rejected bands, the triple-bands of WiMAX applications for the proposed design can be obtained. The triple-bands of the proposed design are sufficient for WiMAX standard. The proposed antenna can easily excited by a 50-Ω microstrip line printed on the dielectric substrate that material FR-4, and good impedance matching can be obtained for three operating frequency bands of WiMAX. And the proposed antenna with good antenna gain is very suitable for WiMAX applications.

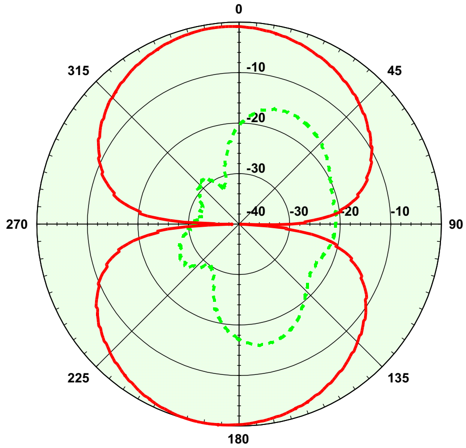


(a)

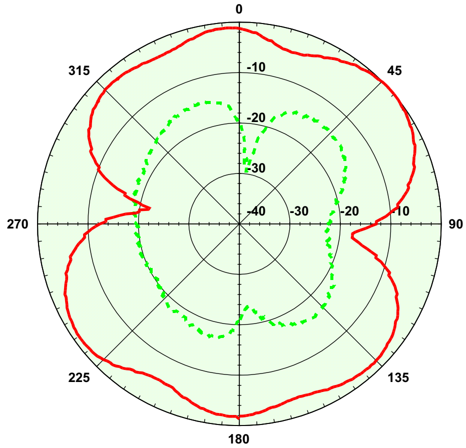


(b)

Fig 5. Measured far-field radiation patterns of the proposed Antenna in the x-z plane at (a) f = 2.5GHz, (b) f = 5.75GHz, (where co-pol presented by solid line, and x-pol presented by dotted line.)

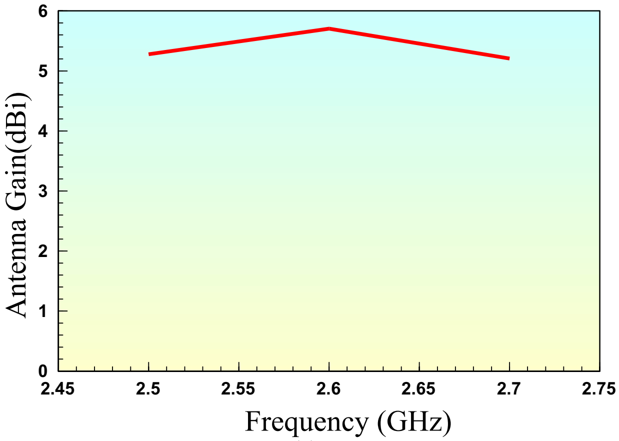


(a)

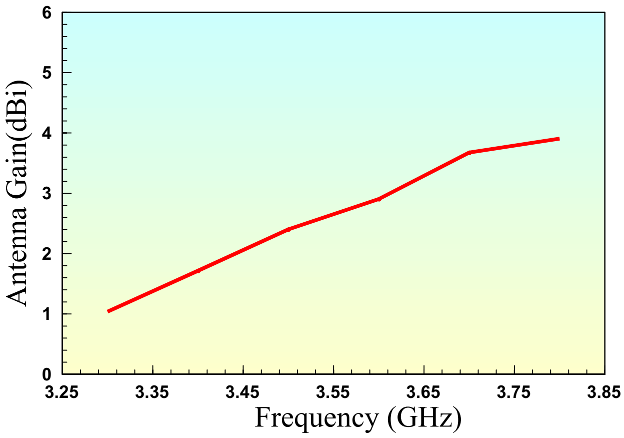


(b)

Fig 6. Measured far-field radiation patterns of the proposed Antenna in the y-z plane at (a) f = 2.5GHz, (b) f = 5.75GHz, (where co-pol presented by solid line, and x-pol presented by dotted line.)



(a)



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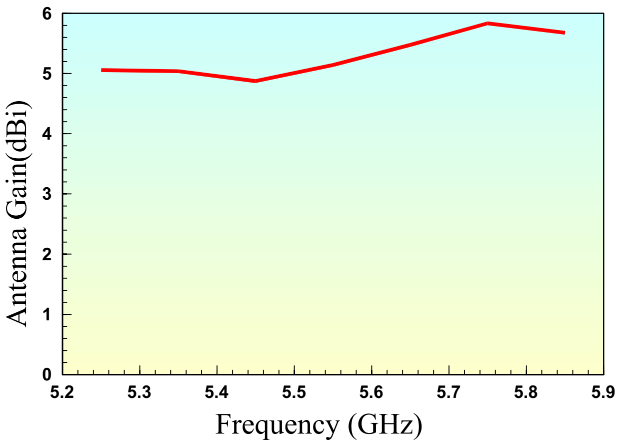

(c)

Fig 7. Measured peak gain of the proposed antenna. (a) low band ; (b) median band ; (c) high band.

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