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A Dual Band Triangular Slotted Planar Monopole Circular Antenna for Wi-MAX Applications

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Abstract : *The main objective of this paper is to discuss a design of planar monopole printed antenna for Wi-MAX applications. Proposed antenna consists of a circular radiating patch on the top surface of the FR-4 substrate with isosceles triangular slot in the middle. This design is having a multi-structural defected ground plane for better performance. Proposed design is resonating at 3.5GHz and 5.3GHz of Wi-MAX bands with very less return losses. Proposed antenna also offers suitable impedance bandwidth with stable gain at both the upper and middle bands of IEEE 802.16 standard for Wi-MAX applications. Since, this design is operated as linearly polarized antenna so; it also handles problems associated with dual band antennas, such as cross polarization and spurious radiation. This antenna shows approximate omnidirectional radiation pattern in x-y plane. The proposed antenna is a good candidate for short range wireless communication because of its advantages. In this work, Ansoft HFSS is used for design and simulation of the proposed antenna. The detailed design steps with parameters and measured results are discussed in this paper.*

Keywords: *bandwidth; dual band; gain; high frequency Structure Simulator; isosceles triangular slot; return loss.*

I. Introduction

Growing demand of wireless communication requires the definitions of new standards, which can provide higher speed of data transmission with increased degree of mobility. In Wireless communication WLAN, Wi-Fi, Bluetooth and Wi-MAX applications are increasing rapidly. Among all the emerging standards, one of the most assuring standards is IEEE 802.16 worldwide interoperability for microwave access (Wi-MAX). Generally, microstrip antennas are very good for wireless communication due to their advantages like low cost, light weight, low profile and easy to fabricate. A multiband antenna for fixed and mobile wireless communication applications has received enormous interest in recent decades.

In literature, several microstrip antennas are presented for multiband operations using different techniques for Wi-MAX applications. For the slot antennas, reported in [1-5], multiband resonance is generated using stub to slots. Triple band frequency is achieved using appropriate arc slots with different stubs [1], double U-slot [2] and a pentagonal slot with two embedded circular structures on a rectangular radiating patch [3]. Similarly, rectangular slots and double C slots are also able to generate multiple resonances in [4] and [5]. Embedded Stubs allow more current to flow in radiating part, which gives another resonance band. In [6], different sizes of stubs are embedded to parent structure to get another frequency band. An L-shaped conductor is used to cover Wi-MAX and WLAN band in [7]. Basically, a microstrip patch antenna suffers from the disadvantage of narrow bandwidth. However, various techniques are used to enhance the bandwidth. Even, a defected ground plane can also improve the bandwidth of operation [8]. A Y-shaped strip is used with a circular ring of 2 mm to excite multiple resonances [8]. Some advanced techniques are also used to design antennas for Wi-MAX applications. Such as switchable antennas, that can be able to switch to any frequencies using PIN diodes [9]. Next, a multi layered radiator with a circular slot is presented in [10]. However, all these antennas are good in some aspects, but also trade-off with others. Main drawbacks of multiple band antennas are interference, low return loss (S_{11}) and poor efficiency.

In this paper, proposed antenna is able to give very less return loss in both frequency bands with good efficiency to overcome the drawback of interference. The presented antenna is a good element for short range wireless communication and can be able to handle high data rate transmission. In this paper, isosceles triangular slot circular radiating element with defected ground is studied and it is further simulated and measured.

II. Proposed Antenna Design

Proposed dual band antenna is designed using High frequency structure simulator. This software is a very good full wave analysis simulator for printed structures. The proposed antenna is simulated and fabricated on FR-4 substrate, which is having a thickness of 1.6mm and a dielectric constant of 4.4. Loss tangent of the dielectric material is 0.02. In the figure 1 as shown, the structure of antenna consists of a radiating element on top layer and a defected ground plane conductor on bottom layer of FR-4 substrate.

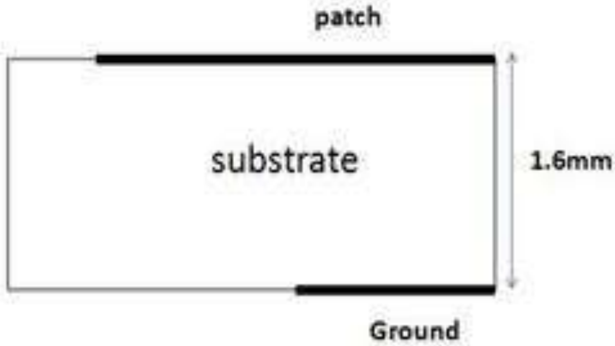
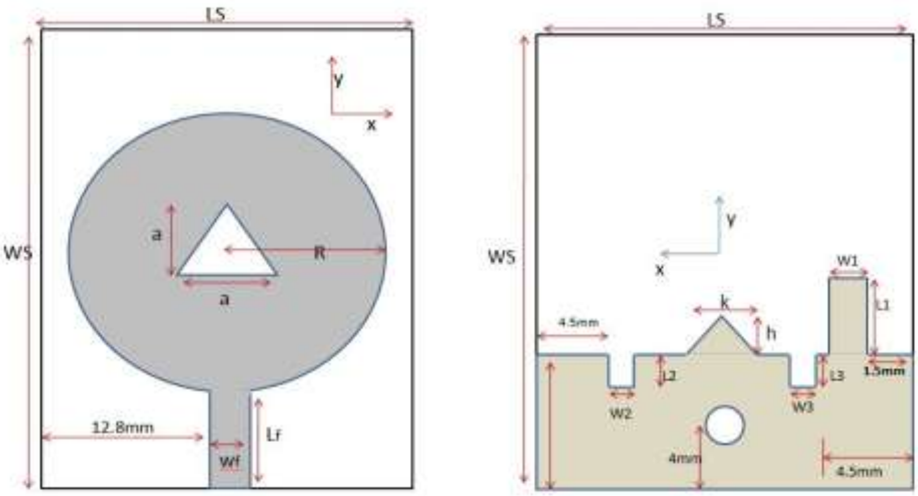


Figure 1: Antenna geometry (side view).

In the figure 2 (a) as shown, the main radiating element of the antenna, which is printed on the top layer of the substrate, consists of a circular patch of radius 'R'. In the middle of the radiating element, an isosceles triangular slot is employed to generate another resonance at 5.5 GHz band. A 50 Ω micro strip line with a width of 'Wf' and length of 'Lf' is adopted for feeding the antenna for matching the impedance bandwidth. Main advantage of using the microstrip line excitation is easy fabrication and simple to match impedance by either adjusting the length and width or by controlling the inset position. A SMA connector has been connected as an interface between VNA and the proposed antenna. Here, width and lengths of the patch are the dimensions calculated as a function of wavelength λ.



(a) (b)

Figure 2: Antenna geometry (a) Top view (b) Bottom view.

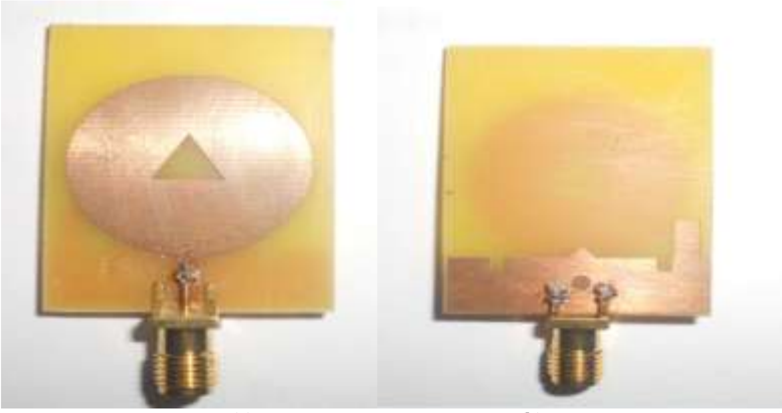
In the figure 2 (b) as shown, defected ground plane is etched from the bottom side of substrate. A circular shaped slot of radius 1.2mm is etched in the ground plane under the micro strip line and makes the antenna to achieve better impedance bandwidth in both bands. A cambered triangular shape at the middle of ground plane and a rectangular shape at the right edge of the ground plane give a shift in the second resonance band towards higher frequency. Two rectangular slots which are symmetric about y-axis, affect the resonance frequencies and impedance bandwidth of the antenna to some extent.

For detailed design, all parameters of the proposed antenna, which are optimized using Ansoft High Frequency Structure Simulator, are shown in Table 1.

TABLE I: PARAMETERS OF THE PROPOSED ANTENNA

Parameter	Size (mm)	Parameter	Size (mm)
Ws	38 mm	L1	5.9 mm
Ls	28 mm	W2	1.5 mm
R	12 mm	L2	1.8 mm
a	6 mm	W3	1.5 mm
Wf	2.4 mm	L3	1.8 mm
Lf	7.07 mm	k	3 mm
W1	2.8 mm	h	1.5 mm

Top and bottom views of the proposed fabricated prototype are shown in figure 3.



(a) (b)

Figure 3: Prototype of the proposed Antenna (a) Top view (b) Bottom view.

III. Results of the Proposed Design

Proposed antenna is simulated using finite element method based HFSS (high frequency structure simulation) software. Simulated return loss vs. Frequency plot of the proposed design is shown in figure 4.

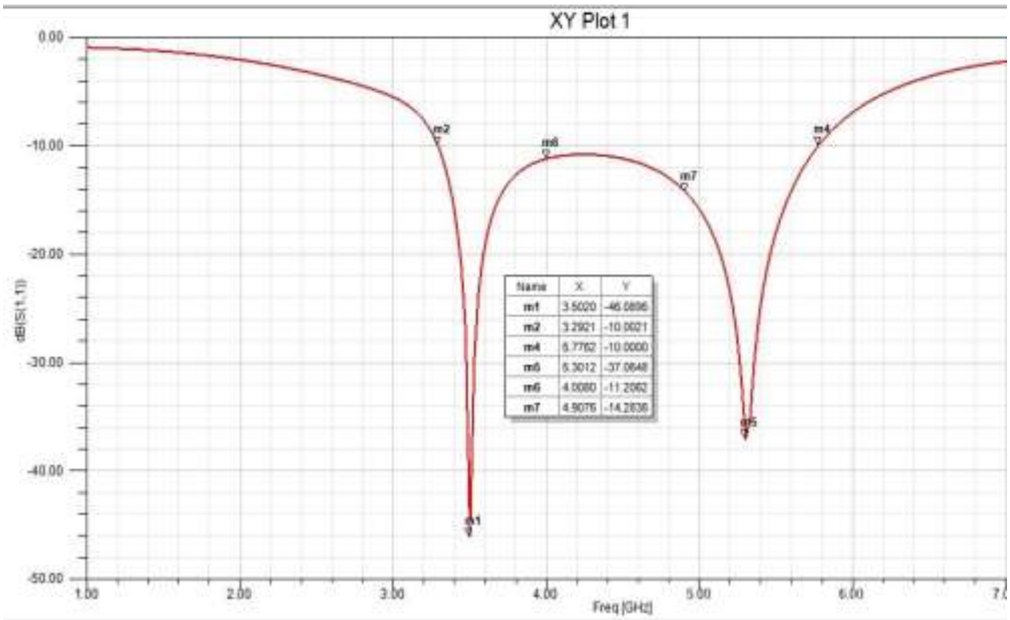


Figure 4: Return Loss vs. frequency plot of the proposed design.

Based on the optimized parameters given in table1, proposed antenna is fabricated and then measured using the antenna measurement equipment. The prototype antenna has terminated with SMA connector for measurement purpose. The proposed antenna is experimentally tested on vector network analyser (Agilent N5230A PNA).

Figure 5: Experimental set up on VNA.

Measured return loss vs. Frequency plot of the proposed design is shown in figure 6.

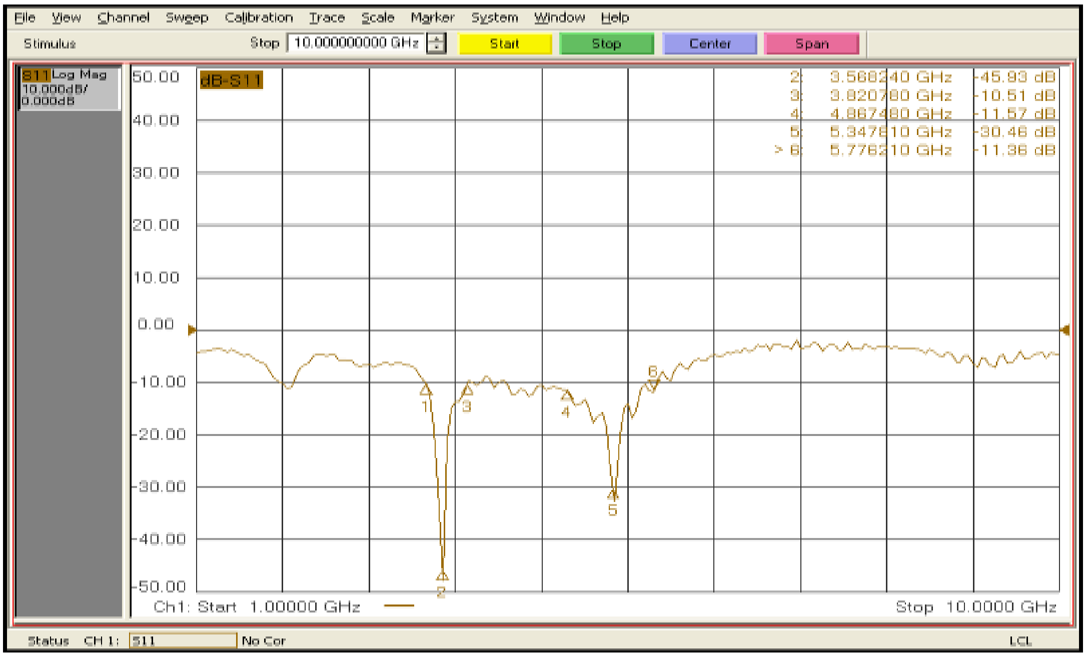


Figure 6: Measured reflection coefficient vs. frequency plot of the proposed dual-frequency planar antenna.

Result shows the satisfactory agreement for the proposed isosceles triangular slot antenna, which is operating at 3.5GHz and 5.3GHz bands. From the experimental result, the measured 10dB return loss bandwidth reaches about 17% (600MHz) for 3.5GHz band (3.2145GHz to 3.82078GHz) and 16.8% (890MHz) for 5.3 GHz band (4.88748 GHz to 5.77821GHz), which meet the bandwidth requirement of Wi-MAX (IEEE802.16). Proposed antenna resonates at 3.568GHz with a minimum return loss of -45.93dB at lower band and 5.347GHz with -30.48 dB at upper band respectively. Although, the discrepancy is between the simulation and measurement has been occurred. The obtained dual bandwidth is adequate for Wi-MAX applications. This discrepancy may be caused by inaccurate prototype implementation. 3-D polar plot of the proposed antenna at 3.5GHz is shown in figure 7. In this case, peak gain is observed as 2.19dBi.

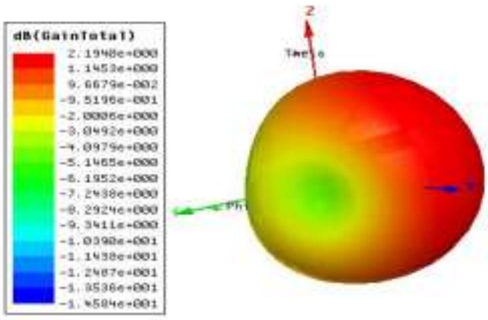


Figure 7: 3-D polar plot of radiation pattern at 3.5GHz.

3-D polar plot of the proposed antenna at 5.3GHz is shown in figure 8. In this case, peak gain is observed as 3.63dBi.

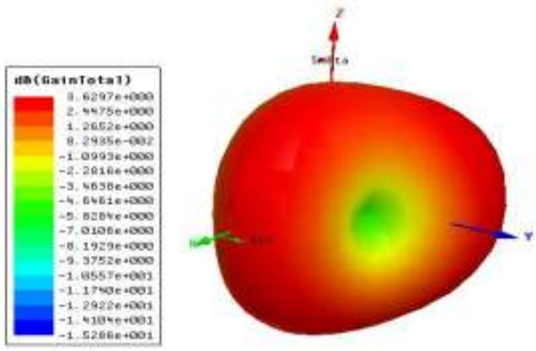


Figure 8: 3-D polar plot of radiation pattern at 5.3GHz.

The simulated gain shows a maximum gain of 2.19 dBi at 3.5GHz and 3.69dBi at 5.3GHz respectively. At the first frequency range, gain increased from -1.58 dBi to 2.19 dBi as the frequency increased from 3.2GHz to 3.6GHz and at the second frequency band, measured gain increased from -1.52 dBi to 3.69 dBi as the frequency fluctuated from 4.9GHz to 5.78GHz. The radiation patterns of the dual-frequency antenna are simulated in the far-field condition. Figure 9 and 10 shows the 2-D radiation pattern of the proposed antenna for both resonant frequencies respectively. The center frequencies of the two operating bands have good broadside and symmetrical radiation patterns.

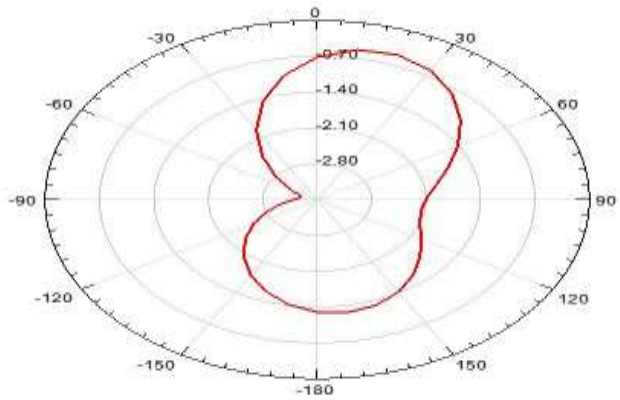


Figure 9: 2-D polar plot of radiation pattern at 3.5GHz.

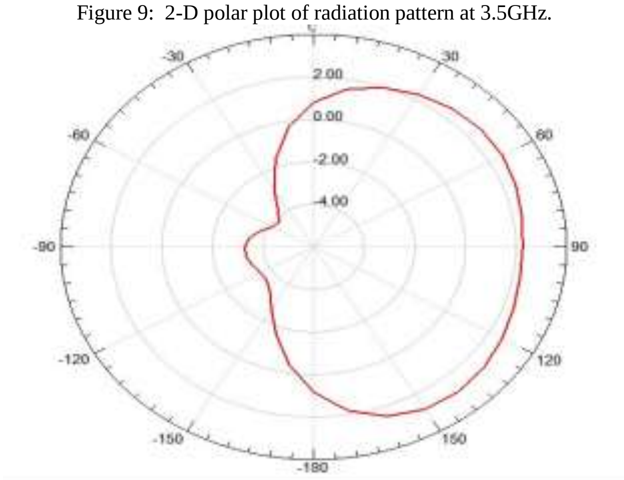


Figure 10: 2-D polar plot of radiation pattern at 5.3GHz.

IV. Conclusion

In this paper, we discussed a 28mm×38mm planar circular monopole antenna for Wi-MAX applications. Proposed antenna is yielding two resonances at 3.5GHz and 5.3GHz with very less return losses. This design is experimentally verified after fabrication. Experimental result is having a good agreement with the simulated result. This paper also discusses proposed antenna gains at required resonances.

Acknowledgements

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