A Designed Diverse-Frequency Single Pole Antenna for Wi-MAX Systems

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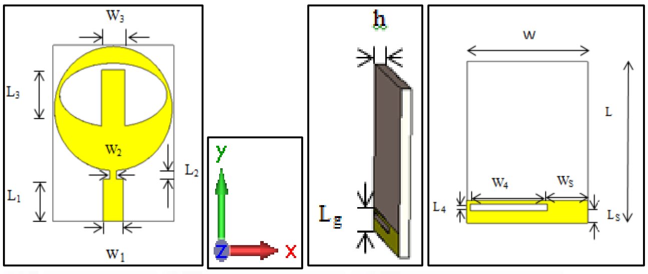
Abstract— In this paper an innovative compact tri frequency single pole antenna with elliptical slot, is presented for Wi-MAX applications. This antenna composed microstrip-fed circular disc with elliptical slot included a strip, and a ground plane with rectangular slot. The presented antenna has compact size of 18 × 25 × 1.6 mm3 and simple structure which covers 2.36-2.88, 3.38-3.70 and 4.97-6.42GHz frequencies for and Wi-MAX systems.

Key words: Single Pole Antenna, Circular Disc, Tri Band Antenna, Wi-MAX, Defected Ground Plane

I. Introduction

IN RECENT TIMES, wireless communication for wireless local area network has practiced terrific growth. Antenna needs to operate in lower band ranges from 2.4 to 2. 484 GHz, in mid band ranges from 5.15 to 5.35 GHz and in upper band ranges from 5.725 to 5.825 GHz. For Wi-MAX antenna needs to operate in lower band ranges from 2.5 to 2.69, in mid band ranges from 3.4 to 3.70 and in upper band ranges from 5.25 to 5.85 GHz. Thus, a combo diverse-functional communication system is currently developed, for which dual or diverse-band antennas are required. Printed single pole antenna having characteristic of producing diverse pole band, as they exhibit low profile, compact size, easy fabrication, low cost, and easy integration and also, the Omni-directional radiation characteristics of single pole antenna make them appropriate for indoor environment. Many antennas has already presented for and Wi-MAX applications but they are not able to cover all three bands and also having relatively larger size. Double-T single pole antenna [1] proposed for, covers lower and mid band for (this antenna is only suitable for dual band operation of).Dual-Band Spiraled PIFA and Coupling PIFA [4] are not able to cover all frequencies of. The contemporary fastest and robust works in the 5–6 GHz band, which can provide consistent high-speed connectivity of approximately 50Mbps between notebook computers, PCs, private organizers and other wireless digital appliances, thus antenna needs to operate in higher band also. E-shaped patch antenna [2] covers 5–6 GHz band. The Double L-Slits antenna [3], the G-shaped antenna [7] and the 9-shaped antenna [8] are only suitable for applications. Antenna [5]-[6] covers all bands of and Wi-MAX. Antenna [9] is also good for both and Wi-MAX systems, while antenna [10] does not cover lower band for both. Antenna [11]-[12]-[13] cover all desirable bands. These all antennas have disadvantage of reasonably larger size. An innovative microstrip-fed improved circular antenna is proposed for and Wi-MAX systems in this paper. The proposed antenna has a compact size compare to the antenna stated overhead. The antenna consists of a modified circular disc with elliptical slot, a vertically placed rectangular strip and a ground plane with rectangular slot. It significantly covers all the frequency bands, needed for and Wi-MAX applications. Details of the antenna design and simulation results (parameter studies, and experimental results such as |S11| curves, radiation patterns, and antenna gains) are precisely observed and discussed. In Section II, the configurations of the antenna are described. Section II also shows the principle and methodology of the antenna. The result and discussion is presented in Section III. Finally, a conclusion is drawn in Section IV.

II. Antenna Design



(a) (b) (c)

Fig. 1: (a) Front View (b) Side View (c) Rear View

Figure. 1 demonstrates the geometry of the proposed single pole antenna. A 50Ω microstrip line is etched as the feeding structure on the FR-4 substrate with relative permittivity 4.4, loss tangent 0.025, and thickness 1.6mm.The proposed antenna having substrate size of 25 mm × 18 mm. The width of feed line is fixed to W_1= 3mm to achieve better antenna performance. The feed line is attached with modified circular disc with elliptical slot and this combination is responsible for two operating (lower and upper) bands with partial ground plane. By introducing a vertically rectangular strip on elliptical slot the mid operating band is obtained. The |S11| curve for proposed antenna shows in Figure. 2

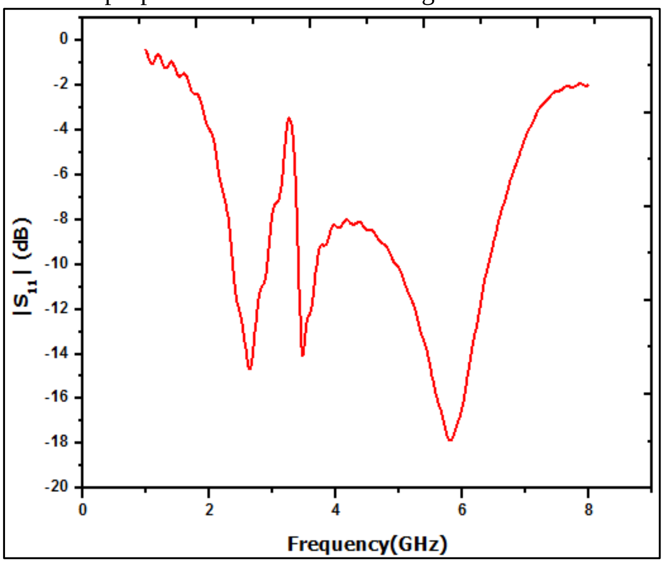


Fig. 2: Simulated S_{11} Curve for Proposed Antenna

Parameter	Size	Parameter	Size
L_1	6mm	W_1	3mm
L_2	1.25mm	W_2	1mm
L_3	8.09mm	W_3	3.5mm
L_4	1mm	W_4	11.5mm
L_S	1.55mm	W_S	6mm
L_g	3.5mm		

Table 1:

The parameters of the designed antenna are simulated and optimized by CST simulation tool and are revealed in Table I.

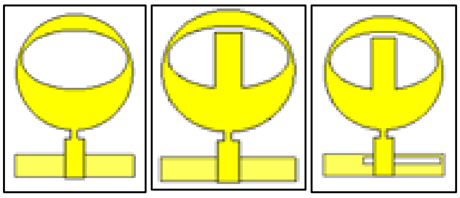


Fig. 3: Design Process of the Proposed Antenna

The circular disc is mided at (0, 3.5), having diameter of 17.6mm. The elliptical slot made over circular disc, having dimension of major axis a=16mm and minor axis b=9mm mided at (0, 5.425). Figure. 3 reveals the design process to understanding the radiation mechanism of tri band antenna. Figure. 4 shows the |S11| curves for antenna presented in Figure. 3. Antenna I is a circular disc single pole antenna having elliptical slot. This antenna operates at two bands 2.4-2.95 and 5.25-5.60 GHz. In antenna II, one more resonant mode is excited, by adding a vertically strip over elliptical slot, has operating bands are 2.38-2.88, 3.38-3.66 and 6.37-6.77 GHz. In antenna III, a rectangular slot has made on ground plane to obtain better impedance matching at higher frequency band. Three operating bands of antenna III are 2.36-2.88, 3.38-3.70 and 4.97-6.42GHz. Thus, antenna III satisfies all requirements of and Wi-MAX systems.

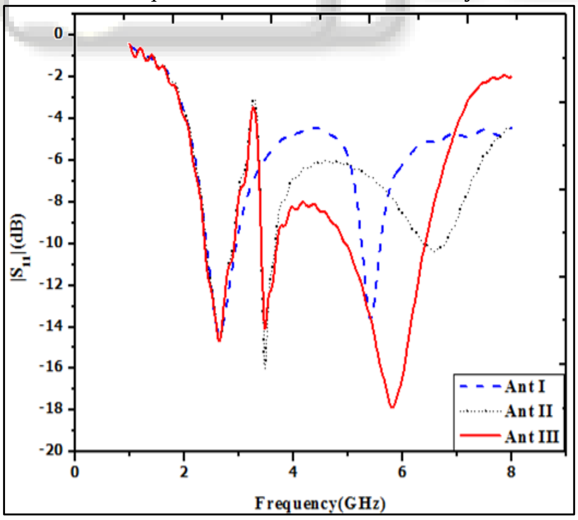


Fig. 4: Simulated S11 Curve of the Antenna Involved in the Design

III. RESULT & DISCUSSION

According to the antenna structure above and the optimized parameters, a prototype is fabricated and measured. The simulation results of Antenna III for return loss vs. frequency presented in Figure. 3. From this simulated |S11 | curve, it is obviously clear that for S11<−10 dB, the simulated three operating bands are 2.36–2.88, 3.38–3.70, and 4.97–6.42 GHz respectively, which shows the preferred operating bands are successfully excited. Thus presented antenna covers complete -10 dB impendence bandwidths for both and Wi-MAX applications. To examine the tri-band operating radiation mechanism of the antenna, the simulated current distributions at mid frequencies 2.63, 3.48 and 5.8 GHz are presented in Figure. 5. From the Figureure 5(a), it is clearly seen that the surface current at 2.63 GHz is mostly distributed along the feed line strip and circular disc, which specifies that the lower resonant frequency is excited due to feed line strip and circular disc. Figureure 5(b) shows the surface current distribution at 3.48 GHz frequency, it is observed that the surface current is circulated along the vertically originated strip and elliptical slot, thus it is responsible for excitation of resonant mode at 3.48GHz frequency. Figure 5(c) shows surface current distribution for antenna II at 6.54 GHz frequency, in which surface current again spread across circular disc and feed line strip, thus it is clear evidence that circular disc and feed line strip generate two resonant modes at lower and higher frequencies. The surface current distribution for proposed antenna at 5.8GHz shown in Figureure 5(d).It is seen that surface current distributed along the rectangular slot. By figureure 5(a) and 5(b) it is concluded that higher resonant mode is shifted from 6.54 to 5.8GHz frequency due to presence of rectangular slot. Thus, the bandwidth of proposed antenna at higher mode becomes wider than bandwidth of antenna II. To attain liberated frequency control some parameters are inspected. Variation in length of rectangular slot affects the higher frequency.

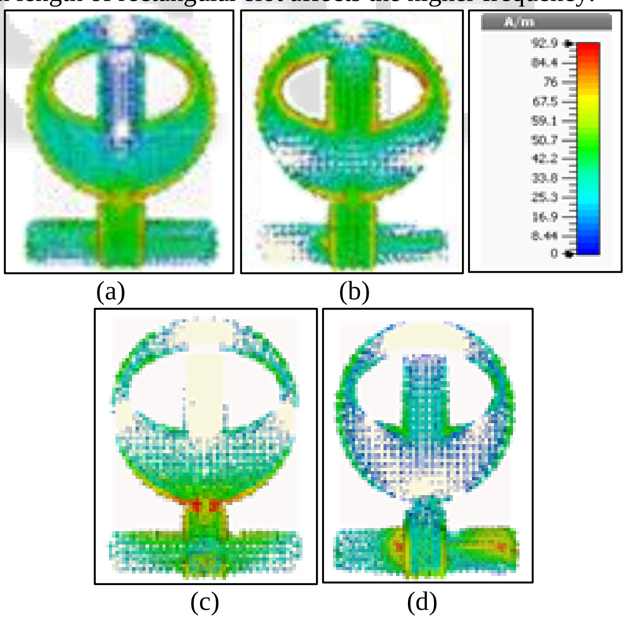


Fig. 5: Simulated Surface Current Distribution of the Proposed Antenna at (a) 2.63 (b) 3.48 (d) 5.8 GHz and (c) Antenna II at 6.54 GHz

Figureure 6(a) shows the | S_{11}| plot for variation in rectangular slot, it can be seen that by increasing W_4, the higher band shift towards left while remaining bands are unchanged. Figureure 6(b) shows middle band varies (towards left) with increase of W_3, while lower and higher band remains invariable. The operating bands can be tuned, by optimization of these parameters values.

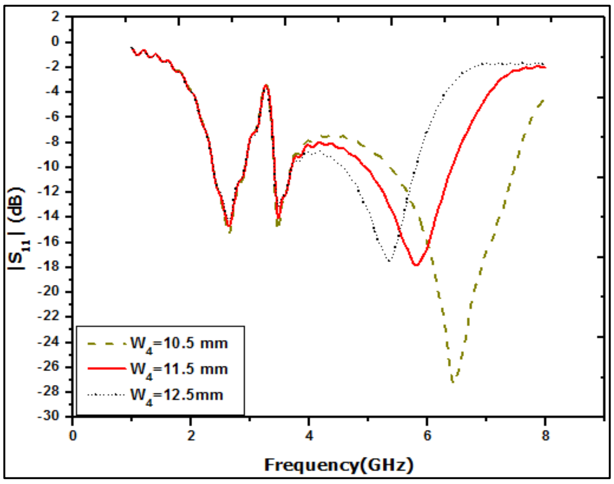


Fig. 6 (a): The S11 Curve of the Proposed Antenna by Tuning Parameter W_4

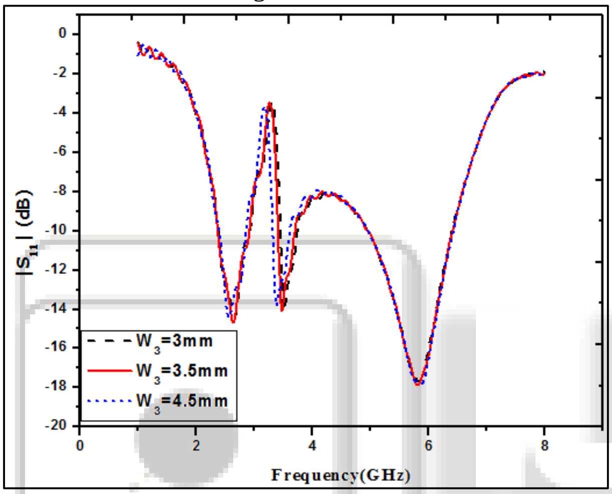


Fig. 6 (b): The S11 Curve of the Proposed Antenna by Tuning Parameter W_3

Figure. 7 shows, efficiency of proposed antenna, which are 63% at 2.63 GHz, 58% at 3.48 GHz and 72% at 5.8 GHz frequency.

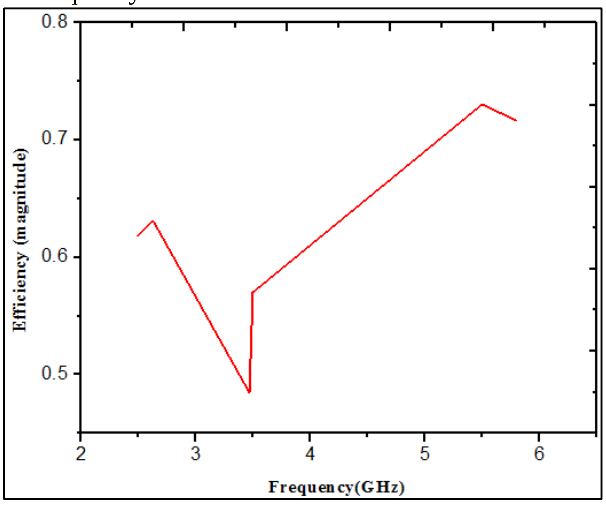
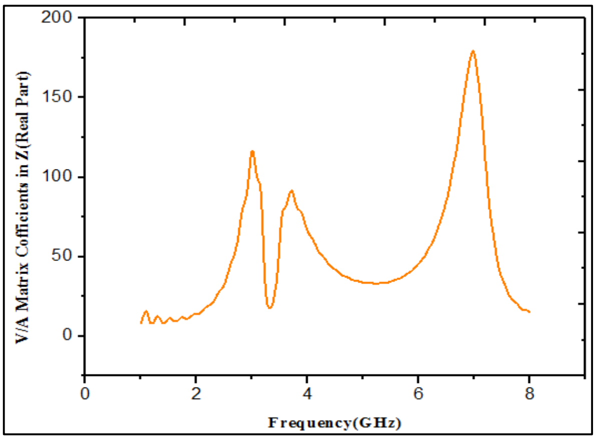
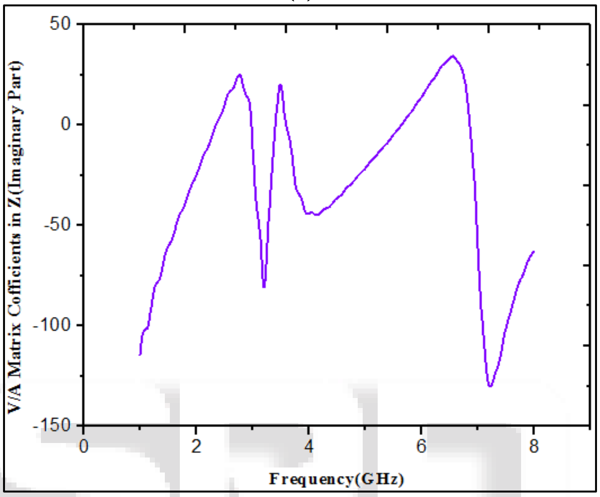


Fig. 7: Efficiency of Proposed Antenna

Figure. 8 (a) and (b) shows real and imaginary plot of Impedance-Matrix for proposed antenna. It can be clearly see that the value of impedance at mid frequencies approaches to 50 ohm.



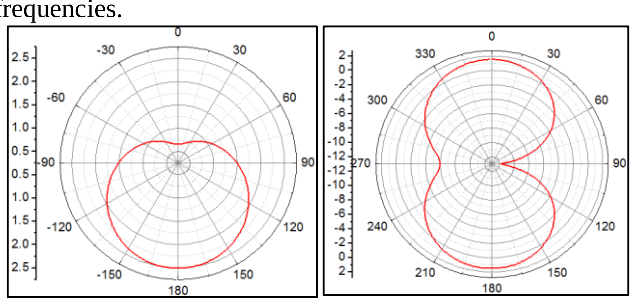
(a)



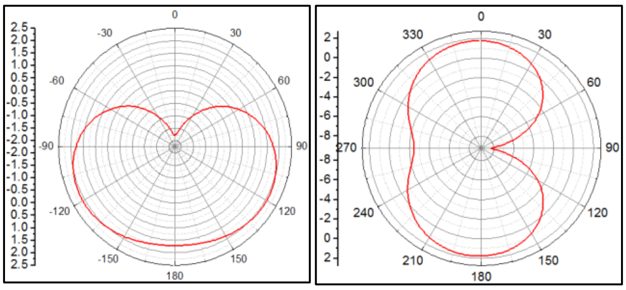
(b)

Figure. 8: (a) Real Part of Z-Matrix (b) Imaginary Part of Z-Matrix

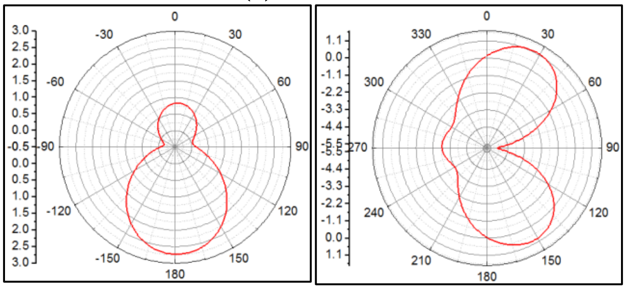
The far-field radiation characteristics of proposed antenna are also considered through simulation. Figure. 9 (a), (b) and (c) shows the simulated radiation patterns at 2.63, 3.48, and 5.8 GHz frequency for E and H- plane, respectively. The designed antenna has peak gain of 2.7 dBi at 2.63 GHz, 2.45 dBi at 3.48 GHz and 2.96 dBi at 5.8 GHz frequency. Thus, it is observed that proposed single pole antenna has almost omnidirectional radiation pattern for all resonant frequencies.



(a) 2.63 GHz



(b) 3.48 GHz



(c) 5.8 GHz

E-Plane(x-y Plane) H-Plane(y-z Plane)

Fig. 9: Simulated Radiation Pattern at (a) 2.63 GHz, (b) 3.48 GHz, (c) 5.8 GHz

IV. CONCLUSION

A simple microstrip-fed tri band single pole antenna intended for and Wi-MAX system is presented. By attaching a vertically strip in a circular disc with elliptical slot and making a rectangular slot on ground plane, the antenna can produce three resonant modes and operates in 2.63, 3.48 and 5.8 GHz bands for desired applications. This single pole antenna has small size of 18 × 25 × 1.6 mm3. The antenna exhibits nearly an omnidirectional radiation pattern at desired frequency bands. The compact size, reasonable gains, and easy construction make the antenna appropriate contender for Wi-MAX applications.

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