Dual-Band CPW Fed Slotted Antenna for WiMax andWLAN Applications

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***Abstract*—This paper aims to propose a CPW-fed dual band slotted antenna. The proposed antenna is simulated using ADS momentum software on FR4 substrate with 4.4 dielectric constant and 1.58 mm thickness. The antenna is designed to cover two bands, WiMAX IEEE802.16 (3.3-3.6) GHz band and WLAN IEEE802.11a (5.15-5.825) GHz band. The simulation results for return loss, VSWR, radiation pattern, and beamwidths are presented, discussed and compared with other published antennasto evaluate the antenna performance at the desired bands.**

***Keywords*— Dual band; Slotted antenna; WiMAX; WLAN; CPW fed**

I. Introduction

In modern wireless communication systems, there has been a great interest in the utilization of dual band or multiband antennas compared to single band antennas [1].Microstrip antenna is a type of antenna that isdesigned for transmission and reception [2]. Microstrip antennas are popular for their outstanding features such as low profile, low height, low cost, and easy fabrication. On the other hand, the major disadvantages of these antennas are the low and narrow bandwidth [3].Microstrip antennas can be divided by structure into two basic types, namely microstrip patch antenna and microstrip slot antenna [2]. Recent researches on such type of antenna areon the go due to the continuous demand of various wireless communications such as WLAN IEEE802.11a bands 5.15-5.35 GHz, and 5.725-5.825 GHz bands, and WiMax IEEE802.16 3.3-3.6 GHz band [4].

In wireless applications, slot antennas fed by coplanar waveguide (CPW)are much promising design and they have better efficiency than conventional microstrip antenna. CPW fed slot antennas are mostly preferred for wireless application because it has many advantages over other feed lines such as wider bandwidth, low dispersion and lower radiation loss. The most exceptional property of slot antennas is that the bandwidth of the antenna can be adjusted by changing the slot width. The wider bandwidth and the optimum feed structure gives the good impedance matching [5].The CPW-fed antenna has become very popular owing to the simple structure of a single metallic layer, wide bandwidth and easy integration with active devices. For dual-band antenna, the designs of the CPW-fed antennas can satisfy at most one wide band in their two bands. Matching two separated frequency bands is very difficult, particularly when both of them are very wide [1]. Two pairs of tuning strips and a pair of symmetrical rectangular slots etched on each side of the feed line are used in the proposed antenna in [1] to overcome the difficulty of the matching at two separated wide frequency bands.Combination of the CPW feed, antenna shape, and variety of the slot geometry is a solution to improve and enlarge the antenna operating bandwidth [3]. The antenna patch has various shapes such as square, cross, forklike, T, U, C, volcano, and hexagonal shape [6].

To achieve wideband operation and stable performance for planar antennas, different methods have been proposed. These methods includes using resonant structures, parasite elements, filters, slots, different shaped radiators, modifying the shape of the radiator, adding slots on the ground plane, and modifying the shapes of the ground planes. Some researchers also combined several methods together to optimize the designs [7].

This paper aims to propose a new configuration of a dual-band slotted antenna to cover WLAN in the 5.15-5.35 GHz band, and WiMAX in the 3.3-3.6 GHz band. The Advanced Design System (ADS) software is used to simulate the proposed antenna and the results is discussed to evaluate the performance of the antenna.

II. Antenna Geometry

The configuration of the antenna is shown in Fig. 1.

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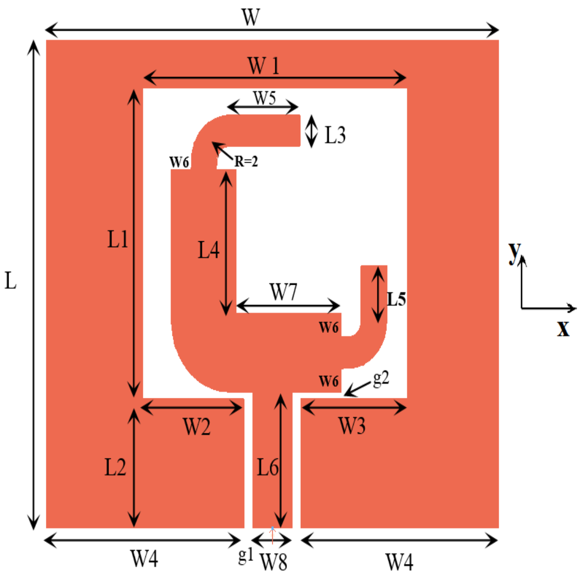

Fig. 1Configuration of a proposed antenna.

This antenna consists of C-shaped radiator fed by CPW line with 50Λ, and it simulated on FR-4 substrate with dielectric constant of 4.4 and a thickness of 1.58 mm.

The dimensions of the antenna are adjusted using ADS software to cover two wireless applications, the dimensions are tabulated in Table I.

TABLE I
DIMENSIONS OF PROPOSED ANTENNA

Parameter	Value (mm)	Parameter	Value (mm)
W	34.8	W5	5.4
L	30.9	W6	1.5
W1	20.4	W7	8.1
W2	7.8	W8	3
W3	8.2	L3	2
W4	15.2	L4	9.1
L1	19.7	L5	5.3
L2	8.2	L6	8.6
g1	0.7	R	2
g2	0.4		

III. SIMULATION RESULTS AND DISCUSSION

The variation of the return loss versus the frequency of the antenna is shown in Fig. 2. It can be seen that the two resonant frequencies are located at the values of 3.495 GHz with return loss -25.63 dB for WiMAX band and 5.229 GHz with return loss -20.118 dB for WLAN band.

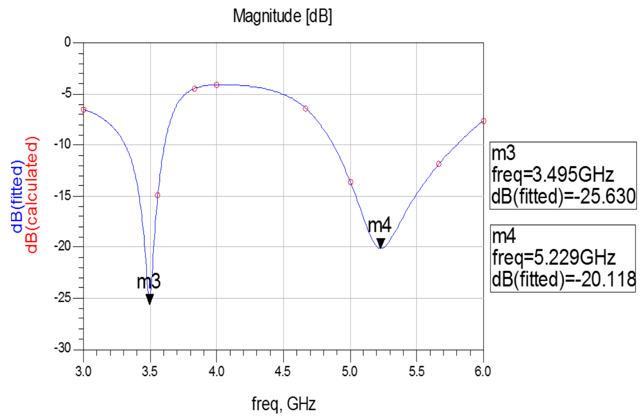

Fig. 2 Return loss versus the frequency of the antenna.

Based on -10 dB return loss, at the first resonant frequency 3.495 GHz, 8.676% impedance bandwidth is obtained, in the range of 3.308-3.608 GHz for WiMAX band; and 17.55% impedance bandwidth is obtained at the second resonant frequency of 5.229 GHz in the frequency range 4.875-5.813 GHz for WLAN band.

Fig. 3 shows the variation of the input impedance with frequency. it can be noted that the simulation results give the acceptable impedance matching at the resonant frequencies, where the impedance at 3.495 GHz is 53.95+j 3.75 Λ, and it is 60.5+j3 Λ at 5.229 GHz.

The simulation results of VSWR versus the frequency are illustrated in Fig. 4. The VSWR is 1.110 at 3.495 GHz for WiMAX application, and it is 1.219 at 5.229 GHz for WLAN application. For VWSR less than 2, from Fig. 4, it can be observed that the slotted antenna covers the WiMAX band in the range of 3.291GHz to 3.616 GHz, and it covers the range of 4.854 GHz to 5.833 GHz for WLAN band.

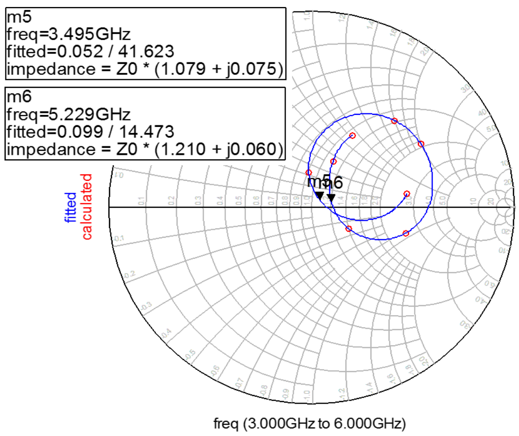

Fig. 3 Variation of impedance versus frequency.

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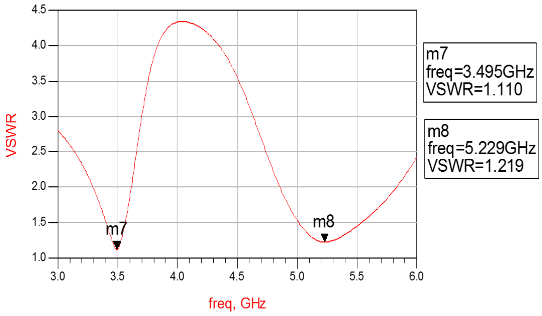


Fig. 4 VSWR versus frequency for the proposed antenna.

The 3D representation of the radiation pattern at 3.5 GHz is shown in Fig. 5.

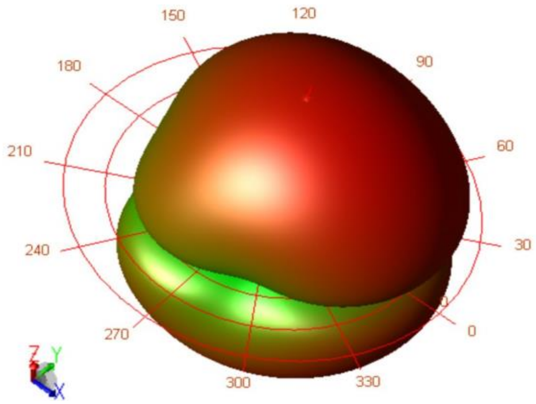


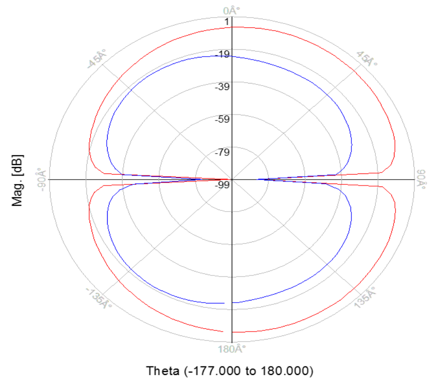
Fig. 53D radiation pattern of the antenna at 3.5 GHz.

At 3.5 GHz, the parameters of the antenna are tabulated in Table II.

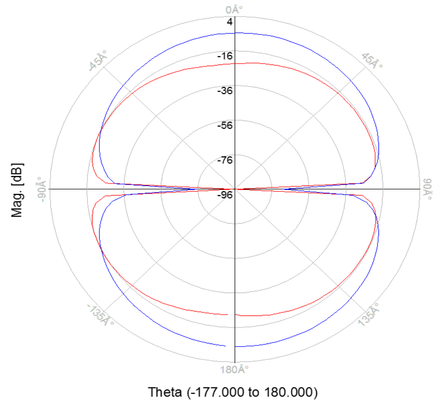
TABLE II
PARAMETRS OF THE ANTENNA AT 3.5 GHZ

Parameter	Value (mm)	
Power radiation (mW)	2.11712	
Effective angle (Steradians)	4.27095	
Directivity (dBi)	4.68685	
Gain (dBi)	3.96365	
Efficiency (%)	84.66	
Maximum intensity (mWatts/steradian)	0.495703	
Angle of U max (theta, phi)	147	19
E(theta) max(mag., phase)	0.178609	-176.816
E(phi) max(mag., phase)	0.584458	-18.6149
E(x) max(mag., phase)	0.0788729	119.561
E(y) max(mag., phase)	0.598171	-16.8799
E(z) max(mag., phase)	0.0972774	3.18421

At 3.5 GHz, the 2D field pattern of the (E_θ) and (E_ϕ) with ϕ=0° in elevation cut (x-z plane) is shown in Fig.6a; and in elevation cut (y-z plane) with ϕ=90° is shown in Fig.6b.



(a) ϕ=0°



(b) ϕ=90°

Fig. 6 Field pattern at 3.5 GHz in (a) x-z plane (b) y-z plane.

From Fig.6, it can be seen that the radiation patterns in the patterns in the x-z plane and y-z plane have the nulls around 90° and -90°, and they are similar to omnidirectional radiation in other directions.

The azimuth cut with θ = 90° is shown in Fig.7. it is clear that the radiation pattern is bidirectional with nearly Fig. of eight pattern.

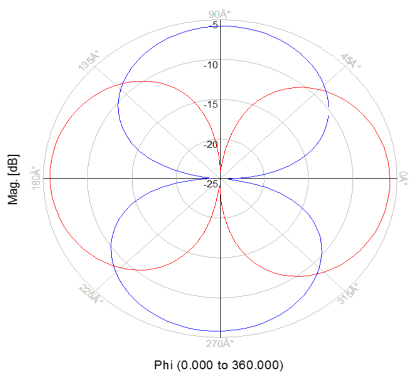


Fig. 7 Field pattern at 3.5 GHz in x-y

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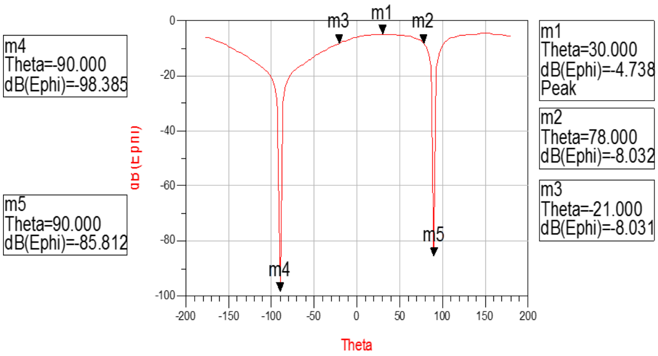
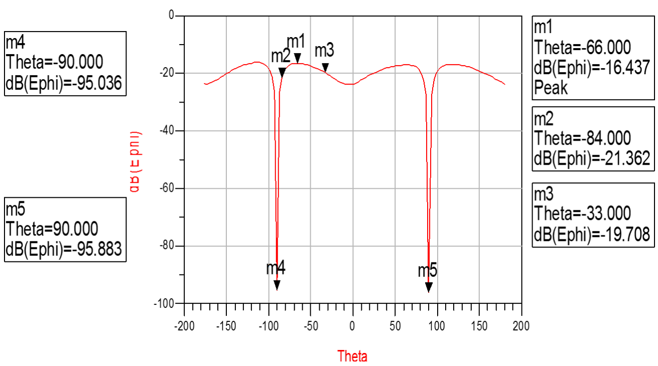
Fig. 8 shows the beamwidths of the antenna. From Fig.8a, it can be observed that the half power beamwidth (HPBW) is 99°, and the first null beamwidth (FNBW) is 180° at $\phi = 0°$; and at $\phi = 90°$ the half power beamwidth (HPBW) is 51°, and the first null beamwidth (FNBW) is 180°, as shown in Fig.8b.



(a) ϕ=0°



(b) ϕ=90°

Fig. 8 Beamwidths of the antenna at 3.5 GHz with (a)) ϕ=0° (b)) ϕ=90°.

Fig.9 shows the 3D representation of the radiation pattern at 5.22 GHz.

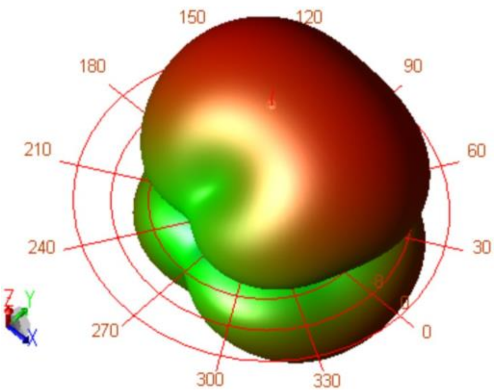


Fig. 9 3D radiation pattern of the antenna at 5.22 GHz.

The parameters of the antenna at 5.22 GHz, are tabulated in Table III.

TABLE III
PARAMETRS OF THE ANTENNA AT 5.22 GHZ

Parameter	Value (mm)	
Power radiation (mW)	1.86415	
Effective angle (Steradians)	3.76521	
Directivity (dBi)	5.23421	
Gain (dBi)	3.99817	
Efficiency (%)	75.231	
Maximum intensity	0.495099	
Angle of U max (theta, phi)	136	134
E(theta) max(mag., phase)	0.0688395	-171.523
E(phi) max(mag., phase)	0.606876	126.035
E(x) max(mag., phase)	0.42174	-58.1119
E(y) max(mag., phase)	0.439188	-49.8418
E(z) max(mag., phase)	0.04782	8.47696

At 5.22 GHz, the 2D field pattern of the (E_θ) and (E_ϕ) with ϕ=0° in elevation cut (x-z plane) is shown in Fig. 10.

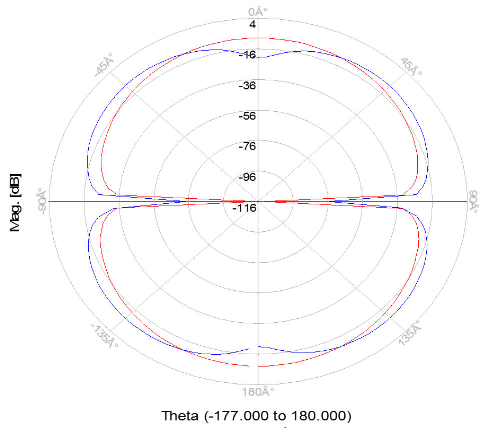


Fig. 10 Field pattern at 5.22 GHz in x-z plane (ϕ=0°)

Fig. 11 shows the 2D field pattern of the (E_θ) and (E_ϕ) and in elevation cut (y-z plane) with ϕ=90° at 5.22 GHz.

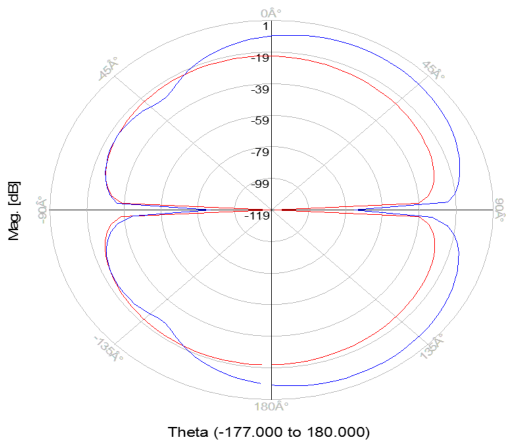


Fig. 11Field pattern at 5.22 GHz in y-z plane (ϕ=90°)

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From Figs. 10-11, it can be noted that the radiation patterns in the patterns in the x-z plane and y-z plane are similar to omnidirectional radiation pattern, and there are nulls around 90° and -90°.

The azimuth cut with θ = 90 is shown in Fig.12. it can be seen that the radiation pattern is bidirectional with nearly Figure of eight pattern.

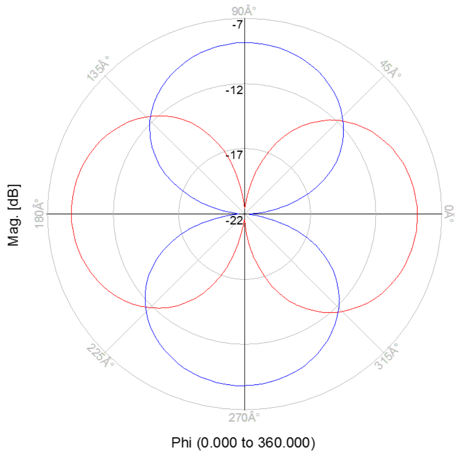


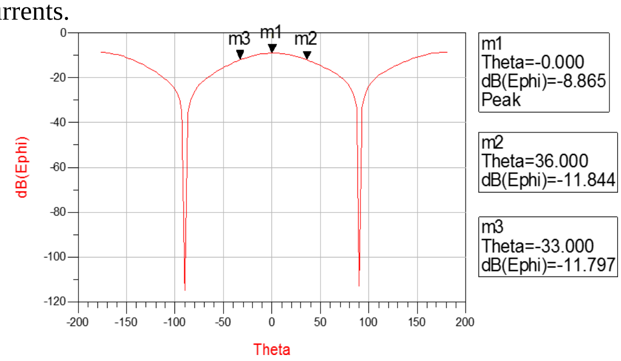
Fig. 12Field pattern at 5.22 GHz in x-y plane

Fig. 13 shows the beamwidths of the antenna. From Fig. 13a, it can be seen that the 3 dB half power beamwidth (HPBW) is 69° in the range of ((-33°) - 36°), and the first null beamwidth (FNBW) is 180° at ϕ = 0°.

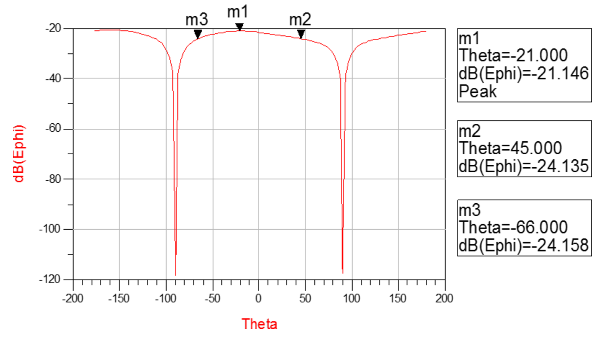
At ϕ = 90° the 3 dB half power beamwidth (HPBW) is 111° in the range of ((-66°) - 45°) , and the first null beamwidth (FNBW) is 180°, as shown in Fig. 13b.

The simulated current distributions at 3.5 GHz and at 5.22 GHz of the proposed antenna are presented in Fig. 14.

Depending on the resonant frequency, Fig. 14 reveals that, current distribution concentrates over the two paths of the currents.

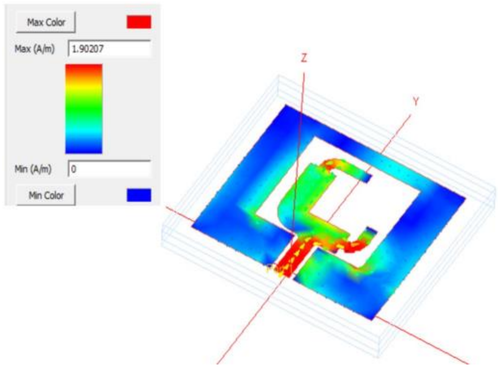


(a) ϕ=0°

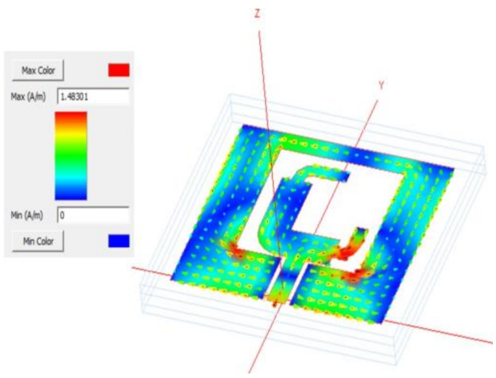


(b) ϕ=90°

Fig. 13Beamwidths of the antenna at 5.22 GHz with (a)) ϕ=0° (b)) ϕ=90°



(a)



(b)

Fig. 14Current distribution of the antenna at (a) 3.5 GHz (b) 5.22 GHz

The comparison between the proposed antenna and other antennas [8-13] is made in Table IV.

TABLE IV
COMPASION THE PROPOSED ANTENNA WITH OTHER ANTENNAS

Published Antenna	Bandwidth (%)	Size of Antenna (mm^2)	Gain (dBi)
[8]	2.4–2.484 GHz, 3.1–5.15 GHz, and 5.825-10.6 GHz	50×24	1 - 4
[9]	2.4–2.484 GHz and	75×75	4

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	5.150–5.950 GHz		
[10]	2.25–2.53 GHz and 5.13–5.99 GHz	60×60	4.8
[11]	2.4–2.484 GHz and 3.1–10.6 GHz	42×46	4
[12]	2.4-2.5 GHz, 3.4-3.7, and 5.15-5.85	13×27.6	0.71 , 1.95, and 2.36
[13]	2.4-2.5 GHz, 3.4-3.7, and 5.15-5.85	20×25	2.6, 2.1, and 3.2
Proposed antenna	3.308-3.608 GHz and 4.875-5.813 GHz	30.9×34.8	3.964 – 3.998

Table IV shows that the proposed antenna has a compact size compared with the other antennas, and it has acceptable gain, and impedance bandwidths for WLAN and WiMAX bands.

IV. Conclusion

In this paper, a CPW-fed dual-band slot antenna was proposed and simulated using ADS Momentum software on FR-4 substrate with 4.4 dielectric constant and 1.58 mm thickness to operate at two wireless communication bands, WiMAX IEEE802.16 (3.3 – 3.6) GHz band, and WLAN IEEE 802.11a (5.15-5.825) band.

Based on the simulation results, it can be concluded that, the simulated antenna has two resonant frequencies, the lower resonant frequency at 3.495 GHz, which covers the 3.5GHz WiMAX band, and the higher resonant frequency at 5.229 GHz which covers the 5.2 GHz WLAN band. Moreover, the antenna has a good impedance matching, where the return loss is better than -10 dB, and VSWR is less than 2 at the resonant frequencies.In addition,the antenna has a total radiation efficiency of 85.66% at 3.5 GHz, and 75.23% at 5.22 GHz, also it has bidirectional radiation pattern in the H-plane whileθ is constant and similar to omnidirectional radiation pattern and nulls around 90° and -90°in E-plane whileϕ is constant.

Therefore, the proposed CPW-fed dual-band slot antenna can be operated with good performance at the desired wireless communication bands.

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