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Design of Compact CPW-Fed Microstrip Slotted Multiband Antenna for Wireless Applications

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Abstract*— In this paper, a slotted micro-strip multiband antenna fed by a coplanar waveguide (CPW) for Wireless applications is proposed. The antenna consists of a rectangular metal radiating patch of dimensions 30 x 20 x 1.6 mm3 comprises four L-shaped slots and one rectangular slot etched in it. By introducing the slots, five resonant frequencies including 2.4/5.2/5.8 GHz for WLAN, and 2.5/3.5 GHz for WiMAX, are excited. The simulated results show that the proposed antenna has five fine impedance bandwidths (S11< -10 dB) of 0.11 GHz (2.54–2.65 GHz), 0.10 GHz (3.76–3.86 GHz), 0.11 GHz (5.11-5.22 GHz) for WiMAX band and WLAN band in lower frequency bands. For the upper bands impedance bandwidth reach 0.53 GHz (8.84-9.37 GHz) and 0.57 GHz (12.25–12.82 GHz) which are capable to cover the satellite and fixed microwave communication bands. Furthermore, the obtained radiation patterns are Quasi Omni-directional patterns in E-plane, and Omni-directional pattern in H-plane.
***Keywords*— CPW-feed, Multiband, Microstrip Slot antennas, WIMAX/WLAN, Wireless.**

I. INTRODUCTION

With the evolution of modern wireless communications systems, there is increase in demand of such device which has more than one communication standard into a single platform. Demand for antennas has increased dramatically which are capable to be embedded in devices. With time and requirements, microstrip antennas can meet these requirements. Due to the limited space, it often requires the antenna can work at several frequencies simultaneously [1]. Therefore, there are various multiband antennas that have been developed over the years, which can be utilized to achieve multiband operations, such as PIFA [2], monopole antenna [3], patch antenna [4], slot antenna [5-8], while slot antennas are attractive due to their wide impedance bandwidth. In addition, they are totally uni-planar and can simply be integrated with active devices. In this paper, a microstrip slotted multiband antenna for wireless applications is proposed, which is fed by a coplanar waveguide (CPW) shown in figure 1.

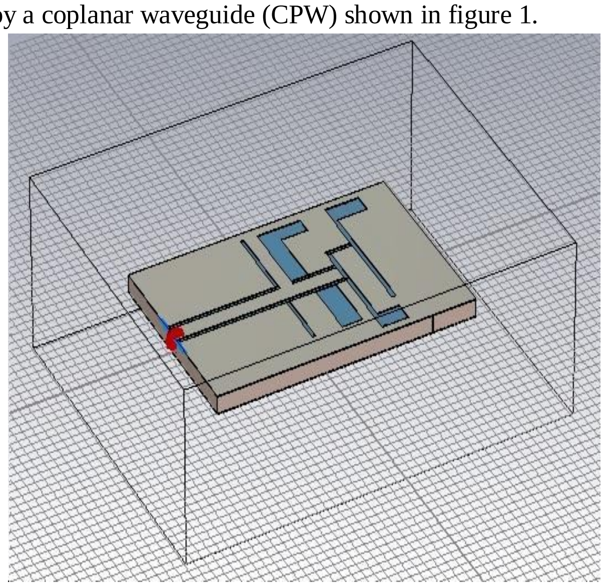

Fig 1 The geometry of proposed antenna

The antenna consists of a CPW feed line, a substrate, and a rectangular patch on which four simple L-shaped slots with an additional rectangular slot are etched. The rectangular and L-shaped slots are able to achieve multiband frequencies and also provide a broadband operation at high frequency. The five operation bandwidths of the proposed antenna are 0.11 GHz (2.54–2.65 GHz), 0.10 GHz (3.76–3.86 GHz), 0.11 GHz (5.11-5.22 GHz) for WiMAX and WLAN in lower frequency bands and 0.53 GHz (8.84-9.37

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GHz) and 0.57 GHz (12.25–12.82 GHz) for the upper frequency bands with VSWR≤2 and return loss S11 <-10dB.

II. ANTENNA DESIGN

The proposed Geometric configuration of the antenna is presented in figure 1. The optimal geometrical parameters of the proposed antenna are obtained by using CST-MWS simulation software v13.0. The conventional CPW-fed slot patch antenna for multi-band application has narrow bandwidth in the lower frequency band, which may not be conducive to some wireless applications. Two parallel slots are incorporated in the rectangular patch to provide CPW fed to perturb the surface current path. Four L-shaped slots with an additional rectangular slot are etched into the rectangle patch, which effectively offer wider impedance bandwidth. Also, the simulated result of a reference antenna with variation in the slots is also shown for comparison. In order to investigate the effects of the slots, we simulated three models with some variation regarding slot size shown in figure 2. Adjusting the size of slot S1, S2 and S4 the final antenna 3 is obtained. All these changes results in the minimum return losses (S11) below -10dB and the VSWR ≤ 2 at those frequency ranges at which the return losses are below -10dB. The Antenna design 3 has good performance over the Antenna design 1 and design 2 by reduction of return loss at lower band as well as at higher band. Antenna 3 covers the required bandwidths of the 2.4/5.2/5.8 GHz (WLAN), 3.5/5.5 GHz (WiMAX) in lower frequency bands and 8.025-10 GHz (SHF) for satellite and fixed microwave communication bands.

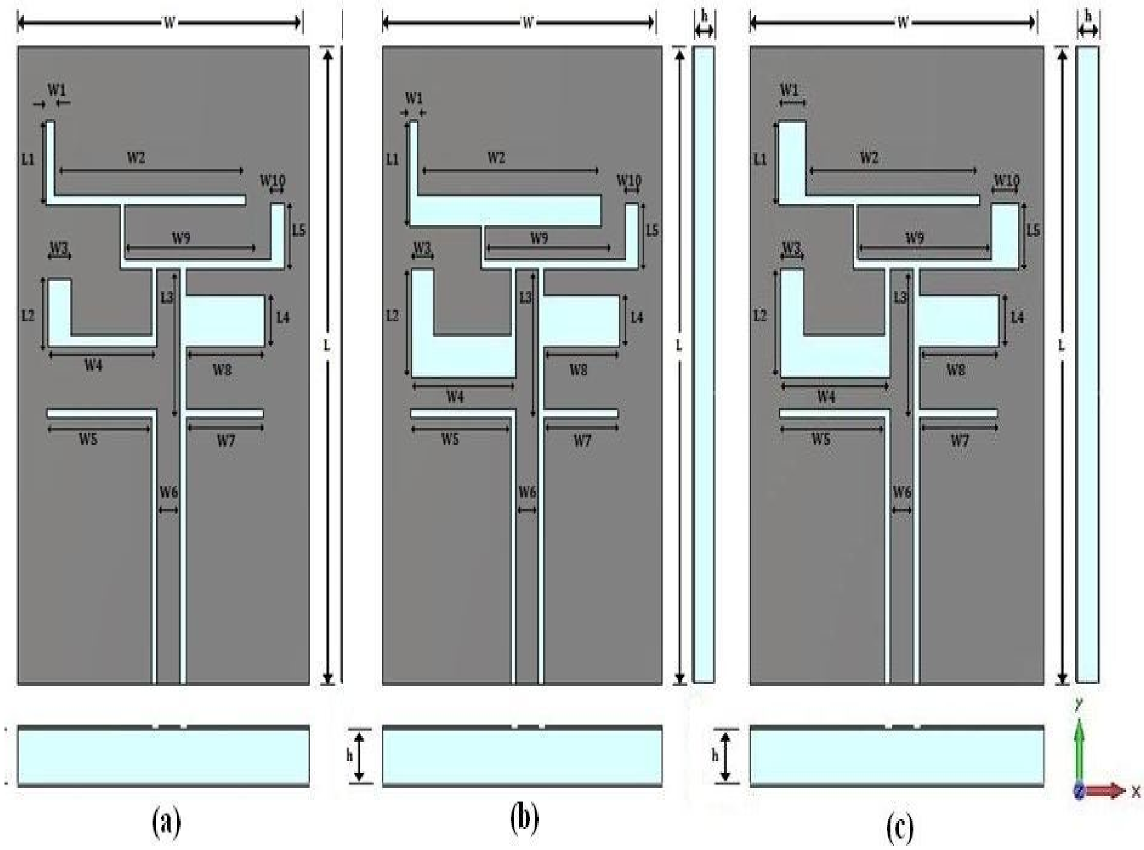

Fig 2 Geometries of (a) Antenna 1, (b) Antenna 2 and (c) Antenna 3

On the different operating resonant frequencies the surface current distributions of the proposed antenna are also studies and shown in figure 3. In figure 3(a), according to surface current distribution, the first resonant frequency 2.59 GHz is determined along the first slot as it is the longest current path. As shown in figure 3(b), at the WIMAX band of 3.8 GHz, since the surface current mainly exists around the edge of the second L-shaped slot. In figure 3(c), at the second band of WLAN (5.15-5.35 GHz), current is concentrated around the third L-slot, which means that the L-slot has influence of the frequency of 5.16 GHz. In figure 3(d) and 3(e), the surface current mainly exists around the edge of the new etched L-shaped slot on the rectangular patch, which means that the new etched L shaped slot has influence of the frequency of 9.056 and 12.42 GHz.

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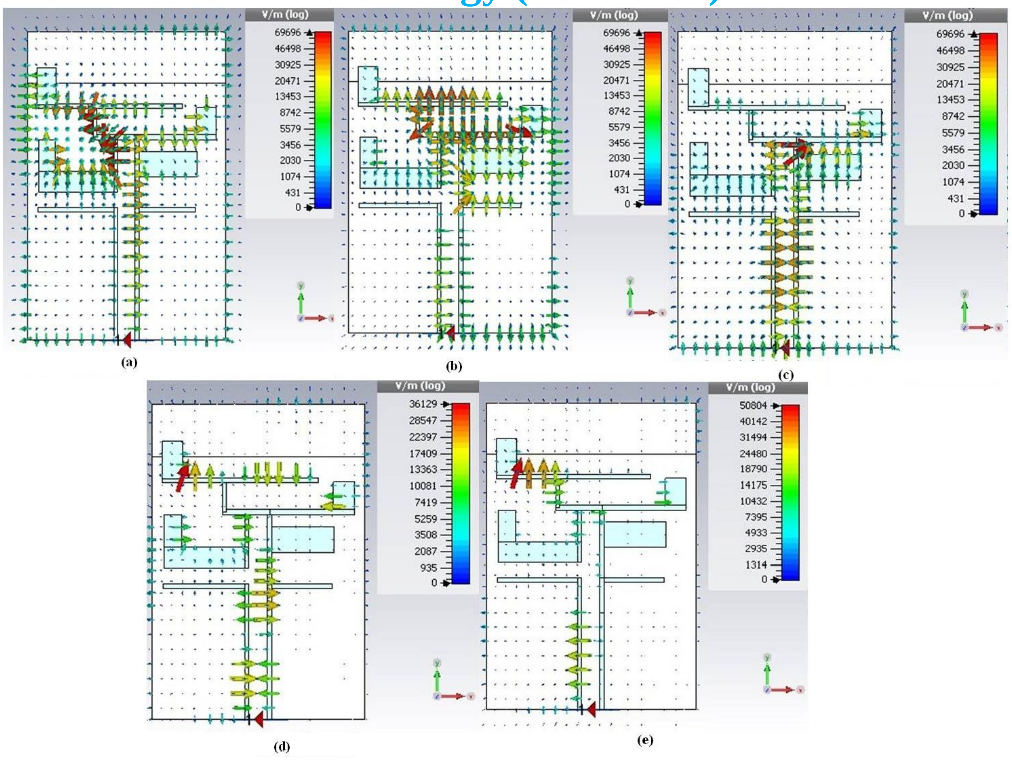

Fig 3 Surface current distribution of the proposed antenna

The CPW feed line has a signal strip width of 1.74 mm and a gap distance of 0.4 mm between the signal strip and the coplanar ground plane, corresponding to the 50Ω-characteristic impedance and provides good impedance matching. All the detailed parameters of the proposed antenna are summarized in Table 1 and the dimensions with performances of these three antennas are shown in Table 2.

TABLE 1: PROPOSED ANTENNA PARAMETERS (MM)

L	W	W1	L1	W2	L2	W3	L3	W4
30	20	2	4	12.8	5.1	1.7	6.6	8
L4	W5	L5	W6	W7	W8	W9	W10	h
2.4	7.73	3.1	1.74	5.73	5.88	10.5	2	1.6

TABLE 2: THE OPTIMIZE DIMENSIONAL (MM) AND PERFORMANCES OF THE THREE ANTENNAS

Parameter	Antenna 1	Antenna 2	Antenna 3
W_1	0.4	0.4	2
L_1	4	5	4
W_2	14.4	14.4	12.8
L_2	3.6	5.1	5.1
W_9	11.5	11.5	10.5
W_{10}	1	1	2
f_{C1}	2.77	2.70	2.59
f_{C2}	3.90	3.87	3.82
f_{C3}	5.13	5.16	5.17
f_{C4}	8.98	9.08	9.06
f_{C5}	12.404	12.27	12.42

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f_{C1}, f_{C2}, f_{C3}, f_{C4} and f_{C5} are the center frequency of the five operating bands, respectively.

III. SIMULATED RESULTS

All simulations were carried out using an EM field solver based on the finite integration technique (FIT) i.e. CST Microwave Studio V 13.0. Figure 4, presents the simulated S-parameter against the frequency for this antenna. It is seen from the simulated results that five operating bands centered at about 2.59 GHz, 3.82 GHz, 5.17 GHz, 9.06 GHz and 12.42 GHz are excited with good impedance matching. The -10dB impedance bandwidths for the lower frequency bands reach 0.11 GHz (2.54–2.65 GHz) and 0.10 GHz (3.76–3.86 GHz) for (2.5–2.69 GHz/3.3–3.7 GHz) WiMAX band and of 0.11 GHz (5.11-5.22 GHz) for the (2.4–2.485 GHz/5.15–5.35 GHz/5.725–5.825 GHz) WLAN band. The -10dB impedance bandwidths for the upper frequency bands reach 0.53 GHz (8.84-9.37 GHz) and 0.57 GHz (12.25–12.82 GHz) for satellite and fixed microwave communication bands. The simulated results for three antennas are shown below.

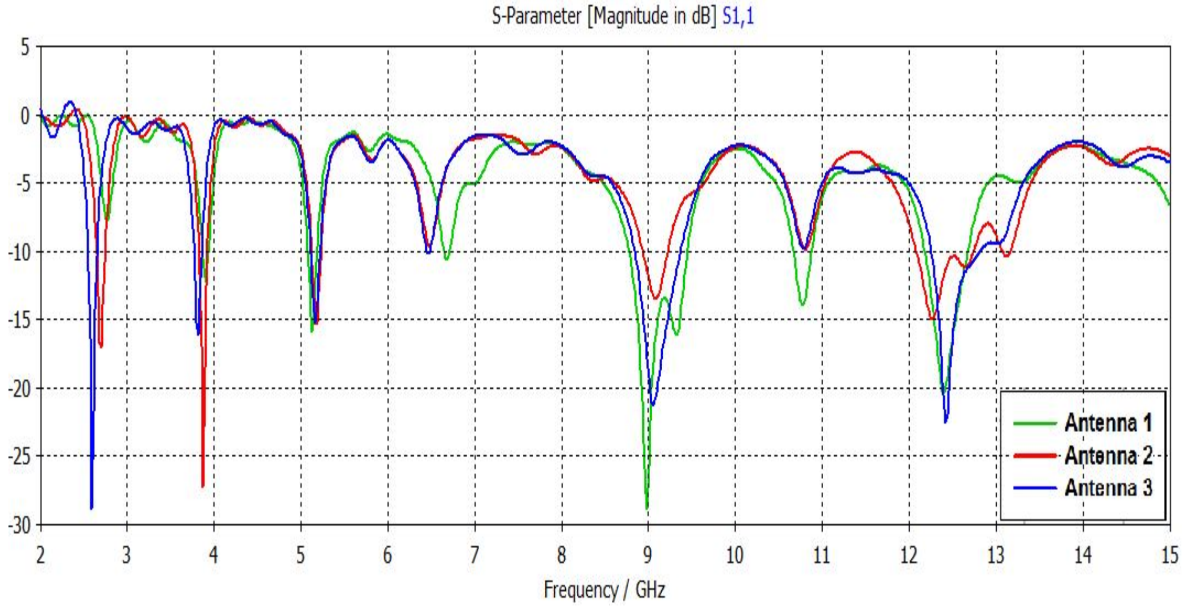

Fig 4 Return Loss (S11) for Antenna 1, Antenna 2 and Antenna 3.

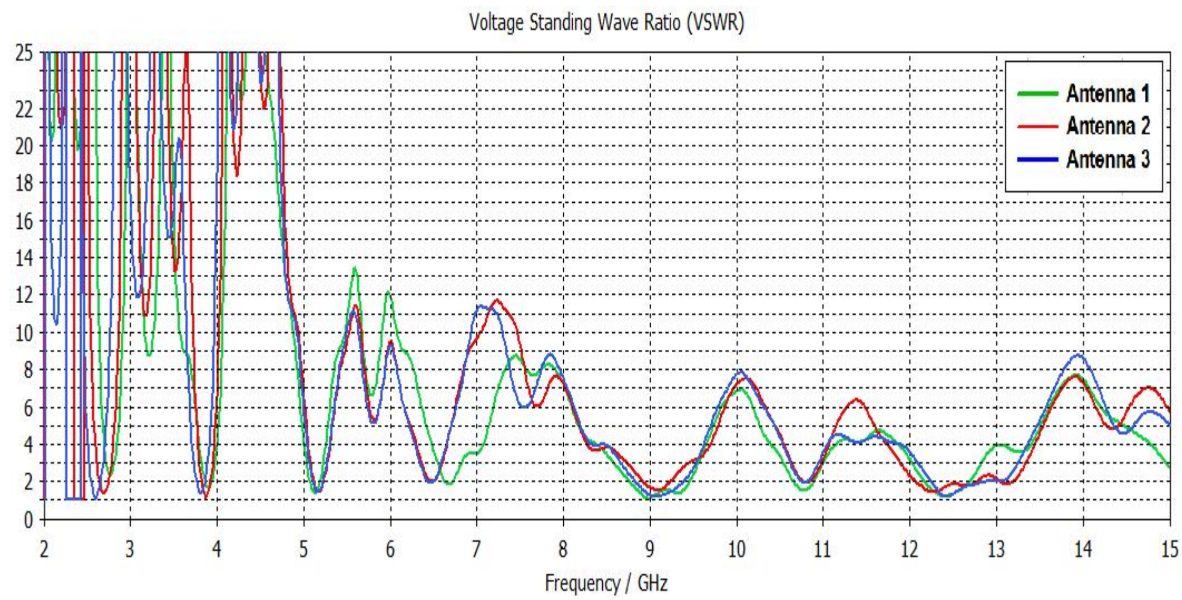

Fig 5 VSWR for Antenna 1, Antenna 2 and Antenna 3.

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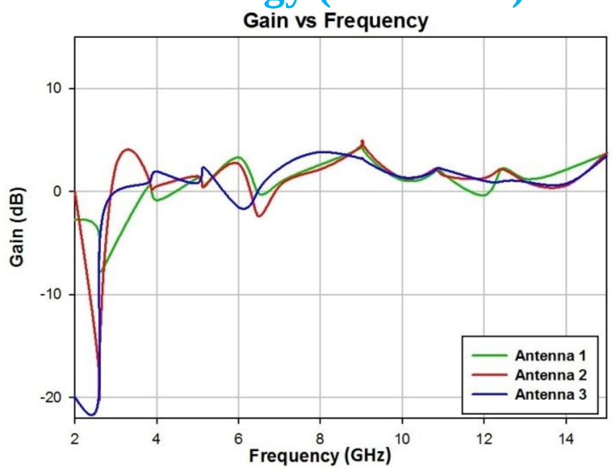
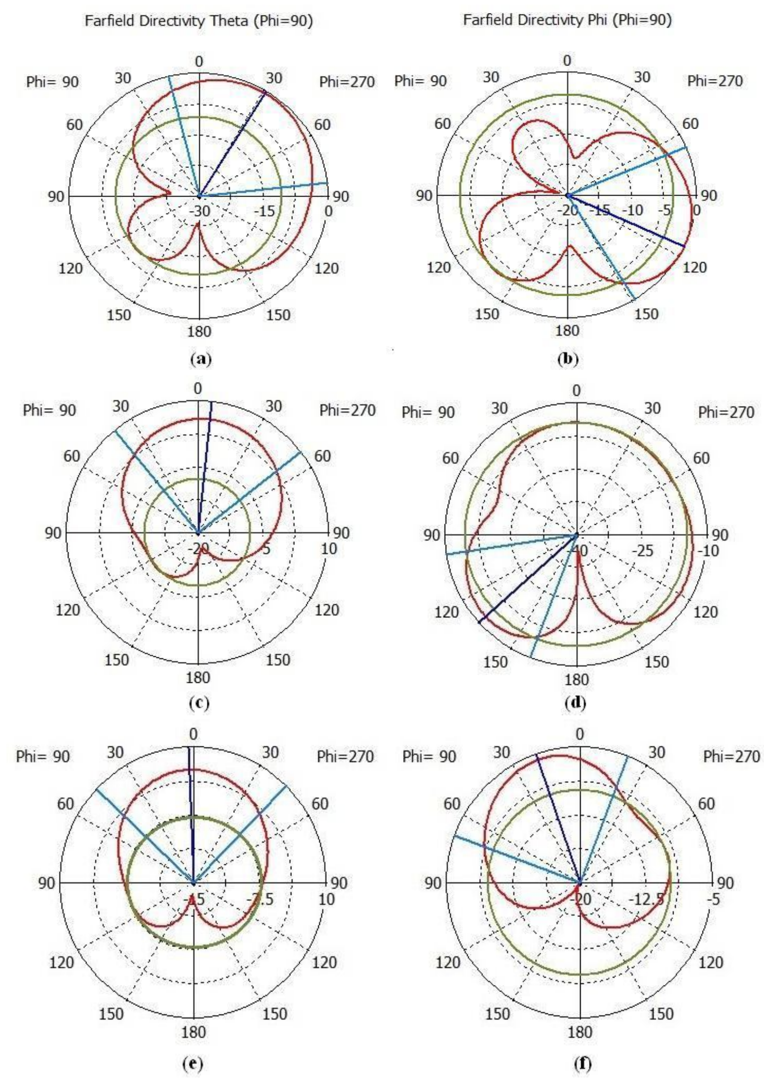


Fig 6 Simulated gains of Antenna 1, Antenna 2 and Antenna 3.

Figure 7, shows the simulated far field patterns of proposed antenna (antenna 3) in both the XZ plane (E-plane) and YZ plane (H-plane) at its five resonant frequencies. All of the five resonant frequencies have Quasi Omni-directional patterns in E-plane and Omni-directional patterns in H-plane with low level of cross-polarization causes due to the difference of vertical and horizontal current distributions on the slotted patch.



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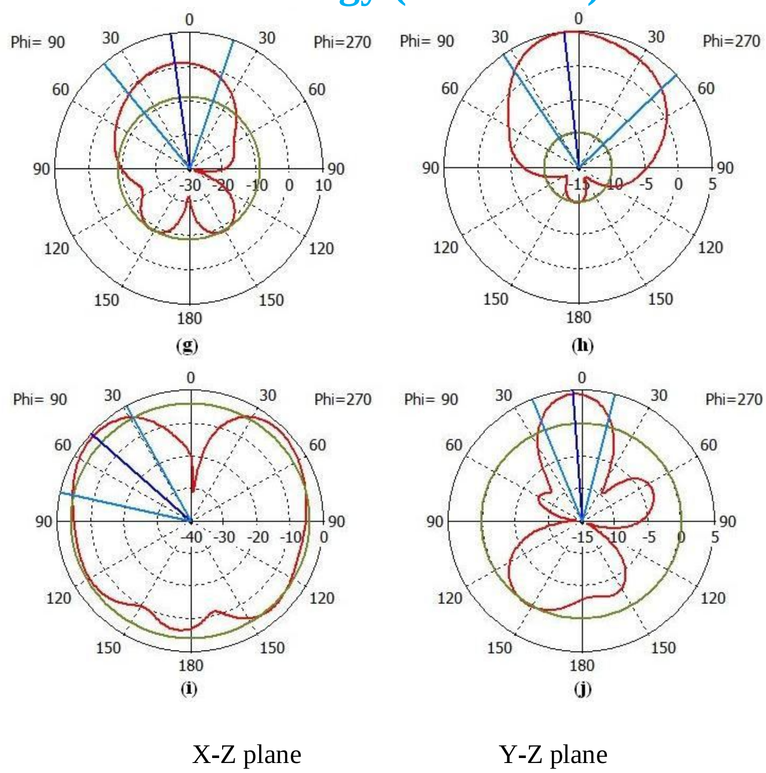

Fig 7 Simulated radiation pattern for the proposed antenna at: (a) 2.94 GHz; (b) 3.8 GHz; (c) 5.16 GHz; and (d) 9.05 GHz (e) 12.42.

IV. CONCLUSIONS

A CPW feed microstrip slot antenna with a single layer substrate has been experimentally and software based studied and presented. CPW feed Slotted microstrip antenna with size 25x20x1.6 mm3 gives the best performance for all the discuss antenna parameters. Multi-band resonance having five operating band and achieve radiation performance to support the wireless communication systems including 2.5/3.5 GHz WiMAX, 2.4/5.2/5.8 GHz WLAN and 8.025-10 GHz (SHF) for satellite and fixed microwave applications. The simulated return loss for this a negative which states that the losses are minimize during the transmission. The VSWR for the proposed antenna has a good value over the operating frequencies, it indicate that the level of mismatch is not so high in the operating bands. Moreover, the certain parts of the antennas have definite connections with the resonant frequencies, with the help of broad frequency tuning ability the resonant frequencies can be controlled easily. Good antenna radiation performance of operating frequencies across the five bands can also be obtained.

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