Abstract — In the proposed work Slotted MIMO antenna for Wireless Router or Access point is presented. It supports both WLAN (2.4 & 5.2 GHz) & Wi-Max (2.5 & 3.5 GHz) bands of operation. U-slots & Rectangular slots are used in rectangular patches to obtain frequency, bandwidth of antenna. Simulated Bandwidths are WLAN (200MHz at 2.4 GHz & 800MHz at 5.2 GHz) & Wi-Max (200 MHz at 2.5 GHz & 300MHz at 3.5GHz). Gain of the Antenna is in range of 8.97 – 9.91 dB. Envelope Correlation coefficient (ECC) is below 0.3

Keywords — ECC, MIMO, Router, WLAN, WiMax.

I. INTRODUCTION

Revolutionary applications on wireless devices like tab, mobile, laptop etc. are demanding high data rates. Ever increasing subscribers are consuming network capacity. New applications like streaming videos require improved data rates, range & reliability. Different technologies as WLAN, Wi-Max, 3G-UMTS & 4G-LTE are exploited to provide high capacity reliable network. Wireless Router or Access Point plays a key role to deliver data traffic to end user. Wireless router should possess higher capacity, improved range & reliability [1]. Wireless router performance will be limited due to multipath fading, obstacles & interferences. Multiple input multiple output (MIMO) antenna system will be useful for Wireless router to improve system capacity, reliability, spectral efficiency and signal to noise ratio (SNR) without additional bandwidth or power [2]. MIMO also mitigates fading effects.

The work proposes antenna of Wireless Router or Access Point (AP) for WLAN & Wi-MAX applications. Conventional external dipole antennas [4] are widely used in many wireless routers. However, they are not pleasing to the end user from an aesthetic point of view and prone to be vandalized. Microstrip antennas are light weight, low profile, can be easily integrated with microwave integrated circuits, also support dual and triple frequency operations are suitable for router [2]. Various antennas are studied in this regard. Shorted monopoles in MIMO configuration have been proposed as an alternative to conventional router antennas [3].

Low-profile meandered loop antennas with MIMO implementations that cover multiple communication bands for wireless routers and access points are presented [4]. In [5] a low-cost, printed three-antenna system using Dual-Polarized Dual-Loop suitable to be embedded inside a wireless access point for MIMO applications in the 2.4 GHz and 5.2 GHz WLAN bands is presented. Novel F-shaped microstrip slot antenna for WLAN and WiMAX multiple-input–multiple-output (MIMO) systems is presented [6]. Here centre frequencies are adjusted by the slot lengths. Similarly a novel compact single feed quad-band planar inverted F-antenna (PIFA) is presented in [7]. Here U-shaped slots are added with certain dimensions and at appropriate positions for frequencies of operation. To study slots in detail, this work also referred Dual-Band Slotted Rectangular Microstrip Antenna [8] where formulas are presented for dual band rectangular & U-slot patch. Also referred [9] where U-Slots in the design of Dual-Band & Triple-Band Patch antennas are given.

The proposed work made use of different slots such as rectangular, U and rectangular patch antenna array to implement MIMO, for WLAN (2.4 & 5.2 GHz) & Wi-Max (2.5 & 3.5 GHz) bands. Antenna design parameters like bandwidth, gain, reflection coefficient, mutual coupling, correlation, diversity, size etc. are optimized. Antenna simulation software ADS is used to design.

II. ANTENNA DESIGN

The proposed antenna as shown in Fig.1-(a) has size of 15.5 X 16.0 cm². The antenna is using substrate as air in between two FR4 (1.6mm) substrates. Two rectangular patches with U-slot are used for WLAN. Similarly two rectangular patches with rectangular slots are used for Wi-Max. Patches are kept orthogonal to reduce mutual coupling. Similarly spatial diversity is maintained by keeping them at distance (7cm). WLAN patch (Fig. 1-(b)) has size of 29 x 33 mm². U-slot reduces size of the patch & also improves bandwidth. U-slot has width 12.5 mm & length 27mm. WiMax patch (Fig. 1-(c)) has size of 23 x 28 mm². Two rectangular slots are used large one has length 14.5mm & other two has length 5mm with width 2mm. Large slot is used for 2.5GHz & short slots are used for 3.5 GHz to increase bandwidth.
Mutual coupling must be low for better performance of MIMO antenna is shown in Fig. 3 for Antenna-1. It is well below -15dB at operating band of frequency. Similar results for Antenna-2.

### III. SIMULATION RESULTS

Fig. 2-(a) is showing simulated results of scattering parameters for WLAN Antenna 1 & 2. Here $S_{11}, S_{22}$ are taken equal to -10dB. Bandwidth at 2.4 GHz band is 200MHz (2.35 to 2.55 GHz) where required is 83 MHz (2.4 to 2.483 GHz) [10]. Similarly for 5.2 GHz band bandwidth is 800MHz (4.8 to 5.6 GHz) where required is 200 MHz (5.15 to 5.35GHz) [10].

Similarly Fig. 2-(b) is showing simulated results of scattering parameters for WiMax Antenna 3 & 4. Here $S_{33}, S_{44}$ are taken equal to -10dB. Bandwidth at 2.5 GHz band is 200MHz (2.5 to 2.7 GHz). Similarly for 3.5 GHz band bandwidth is 300MHz (3.4 to 3.7 GHz) as per requirement [10]. Table I. shows results. Similarly efficiency of antenna is above 92%.

<table>
<thead>
<tr>
<th>Antenna</th>
<th>Freq. Band</th>
<th>Bandwidth</th>
<th>Gain</th>
</tr>
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<tbody>
<tr>
<td>1, 2</td>
<td>2.4 GHz</td>
<td>200 MHz</td>
<td>9.88 dB</td>
</tr>
<tr>
<td>1, 2</td>
<td>5.2 GHz</td>
<td>800 MHz</td>
<td>8.97 dB</td>
</tr>
<tr>
<td>3, 4</td>
<td>2.5 GHz</td>
<td>200 MHz</td>
<td>9.91 dB</td>
</tr>
<tr>
<td>3, 4</td>
<td>3.5 GHz</td>
<td>300 MHz</td>
<td>9.65 dB</td>
</tr>
</tbody>
</table>
Mutual coupling results for Antenna-4 are shown in Fig. 4; all mutual couplings are below -15dB at operating frequencies. Similar results observed for Antenna-3.

MIMO performance is also measured with Envelope Correlation Coefficient (ECC) is should be below 0.5 [4]. It is plotted in Fig. 5. At operating frequencies (2.5/3.5/5.2GHz) it is below 0.3 For WLAN & Wi-Max Antenna. The ECC equation is [4].

\[
\rho = \frac{|S_{11}'S_{12} + S_{21}'S_{22}|^2}{(1-|S_{11}|^2 - |S_{21}|^2)(1-|S_{22}|^2 - |S_{12}|^2)} \quad \text{(1)}
\]

All above parameters like mutual coupling, ECC provides better diversity for MIMO operations. 3-D antenna patterns are shown in Fig. 6. As seen in figure patterns are nearly omnidirectional as required for router antenna.
Fig.6-(c) 3D Antenna Pattern for Antenna 3 & 4 at 2.5 GHz

Fig.6-(d) 3D Antenna Pattern for Antenna 3 & 4 at 3.5 GHz

IV. CONCLUSION

Wireless Router Antenna operates on both WLAN (2.4/5.2 GHz) & Wi-MAX (2.5/3.5 GHz) bands. MIMO will increase capacity required for router. Bandwidth provided is 200-800MHz as per required band. Max. Gain is 9.91dB. Antenna provides better diversity by keeping mutual coupling below -15dB, also ECC is below 0.3. All above are simulated results. Overall it is high capacity & low cost solution for router.

REFERENCES