I. INTRODUCTION

The development in communication systems requires the need of low cost, highly efficient and low profile antennas that are capable of providing high performance over wide range of frequencies [1]. Wireless local area networks are used worldwide. Microstrip patch antennas are the best suited antennas and an ideal choice due to their light weight, ease of fabrication and conformability over microwave circuits for WLAN and WiMAX. Various approaches have been taken to suit the need of wireless communication applications including modification of substrate parameters and the patch shape. Conventional antenna designs yield circular polarization by either inserting perturbation elements at the boundary of a circular patch or by cutting diagonal slots along the patch [2]. Circular polarization has been observed typically in circular, square and triangular microstrip patches [3]. An E-shape antenna can be easily constructed by cutting two slots from a rectangular patch which yields circular polarization.

In this paper a rectangular microstrip patch antenna having a total area 1073 mm cut into an E-shape slot with reduced total radiating area 825 mm design has been proposed with the sides of the patch being truncated. Experimental geometry of the antenna and the simulated results yielding circular polarization are presented and discussed.

II. MATHEMATICAL ANALYSIS

To design a rectangular microstrip patch antenna following parameters such as dielectric constant (εr), resonant frequency (fr), and height of the substrate (h) should be considered for calculating the length and the width of the patch [4].

\[ W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \]  

(1.1)

Effective dielectric constant of antenna is

\[ \varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \left[ 1 + \frac{12h^2}{W^2} \right]^{\frac{1}{2}} \]  

(1.2)

Effective dielectric length of antenna is

\[ L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \]  

(1.3)

The extended length (ΔL) of antenna is

\[ \Delta L = 0.421h \left( \frac{\varepsilon_{eff}+0.3}{\varepsilon_{eff}-0.258} \right) \left( \frac{W}{h} + 0.264 \right) \]  

(1.4)

The length is

\[ L = L_{eff} - 2\Delta L \]  

(1.5)

III. ANTENNA DESIGN

The antenna design is shown in fig.1 proposed modified E-Shape rectangular microstrip patch antenna having dimension length (L) 29mm, width (W) 37mm, and thickness (h) 1.5mm. The substrate of the patch is glass epoxy having dielectric constant = 4.3 [5]. The patch is cut into slot w1 = 6mm and w2 = 18mm for the E-shape and is truncated along the corners. The corners are truncated such that a square slot of 4*4 dimension is obtained.
Figure 1: Geometry of the proposed antenna

Table I

<table>
<thead>
<tr>
<th>Antenna Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric constant</td>
<td>4.3</td>
</tr>
<tr>
<td>Thickness(h)</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>Length(L)</td>
<td>29 mm</td>
</tr>
<tr>
<td>Width(W)</td>
<td>37 mm</td>
</tr>
<tr>
<td>Cut width w1</td>
<td>6 mm</td>
</tr>
<tr>
<td>Cut width w2</td>
<td>18 mm</td>
</tr>
<tr>
<td>Length d1</td>
<td>4 mm</td>
</tr>
<tr>
<td>Width d2</td>
<td>4 mm</td>
</tr>
</tbody>
</table>

The proposed antenna simulated using IE3D simulator is operated at frequencies 2.82 GHz, 3.9 GHz, 4.75 GHz and 6.2 GHz.

IV. RESULT AND DISCUSSION

The antenna designed is operable at frequencies 2.82 GHz, 3.9 GHz, 4.75 GHz and 6.2 GHz. The simulations are done using IE3D simulator from Zeland.

A. Smith Chart

B. Return Loss Measurement

Figure 2: Smith chart

Figure 3: Return loss v/s Frequency
Return loss = -10.26 dB at 2.82 GHz
Return loss = -17.36 dB at 3.9 GHz
Return loss = -12.67 dB at 4.75 GHz
Return loss = -12.42 dB at 6.2 GHz

C. VSWR Measurement

VSWR = 1.9 at 2.82 GHz.
VSWR = 1.3 at 3.9 GHz.
VSWR = 1.6 at 4.75 GHz.
VSWR = 1.5 at 6.2 GHz.

D. Axial Ratio

Axial ratio = 1.103 dB at 4.7GHz

E. Gain

Gain = 3.5 dBi at 5.85GHz

F. Directivity

Directivity = 10 dBi at 5.85 GHz
G. Radiation Pattern

The 2D elevation and azimuth angle pattern for the antenna are shown below in fig. 8 and fig. 9.

Figure 8: Elevation Pattern

Figure 9: Azimuth Pattern

V. CONCLUSION

The design of modified E-Shape microstrip patch antennas can be widely used in WLAN and WiMAX applications. The modified E-shape microstrip patch antenna is designed and the results are simulated using IE3D simulator. The optimized antenna parameter results show that the antenna yields circular polarization having an axial ratio of 1.103 dB at 4.7 GHz, VSWR 1.9, 1.3, 1.6 and 1.5 at 2.8 GHz, 3.9 GHz, 4.75 GHz and 6.2 GHz. The gain of the antenna is 3.5 dBi at 5.85 GHz.

REFERENCES