



# **Circularly Polarized Microstrip Patch Antenna for WiMAX Applications**

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**ABSTRACT:** Wireless communications need not only compact antennas but also which can radiate efficiently in more than one band. Now-a-days antennas which are been operating at dual frequency are preferred. Generally Microstrip patch antennas which produce circular polarization can be used for this application. Circularly polarized (CP) antennas can resolve the conflicts caused by the transmitter-to-receiver coordination. The main idea is to enhance the bandwidth of operation within a single-feed square patch truncated at its corner. The design involves four slits inserted into a square patch and a T-shape slot is inserted which produces circular polarization between 2.5 GHz and 9 GHz WiMAX applications range. This structure offers size reduction compared to other conventional CP antenna designs. The parameters which are observed are return loss, VSWR, Radiation patterns at two different frequencies from 2.5GHz and 9 GHz.

**KEYWORDS:** Circularly polarization (CP), Worldwide Interoperability for microwave access (WiMAX)

## **I. INTRODUCTION**

The advancement in the wireless communications is more evolved in recent years compared to the past. The necessity is more for compact antennas and which is been operated more than one band. Here, an antenna with a low profile, minor size, and a light weight is required in wireless communications [1]. A patch antenna is a narrow band, fabricated by engraving the antenna element pattern in metal trace to the insulating dielectric substrates such as PCB, with a constant metal layer merged to the opposite side of the substrate which forms a ground plane. Common microstrip patch antenna shapes are elliptical, square, and rectangular and any continuous shape is possible so far [2]. Some use and instant made of patch mounted above a plane and some do not use dielectric substrate. Moreover; this design is appropriate for great importance to design CP microstrip antenna structures with a single feed appliance to keep the configuration compact [3]. In the previous, various single and dual band CP patch antennas are been designed. These predictable designs of single feed square microstrip antennas for circular polarization (CP) are usually achieved by truncating patch corner [4].

Using a square patch and a T-slot we can achieve dual band [11]. By further adjusting the slits lengths these can be achieved by symmetrically truncating technique and feeding the patch using a single feed along the design [5]. Now circular polarization is used, it is the divergence of the electromagnetic wave in which either the electric or the magnetic vector effects a circle perpendicular to the path of the transmission with a frequency equal to that of a wave.

This antenna uses a simple microstrip feed to excite the microstrip patch to enable dual band resonance on a single layered structure. The antenna is enhanced to resonate in two WiMAX bands with synchronized circular polarization at both frequencies. Its low-cost and compactness makes it easy to integrate into portable devices such as WiMAX routers, such that the computers will be connected automatically to the closest available WiMAX antenna and these are operating at 2.5GHz and 9GHz [6].

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## II. ANTENNA DESIGN

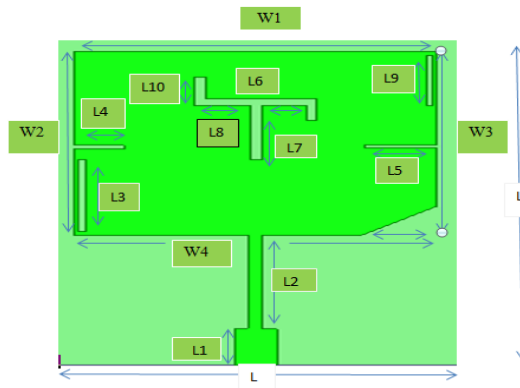


Fig: 1. Design structure of circularly polarized antenna

The Figure 1 indicates that CP at the lower frequency is enabled by the centre asymmetrical T-slot and two diagonally-located, truncated corner [8]. On the other hand, two vertical slits located at the bottom right and top left corners of the patch radiator, further the truncated corner is an imperative element in allowing CP in the upper band[15]. Besides its structural simplicity, ease of fabrication and low cost, this antenna features a satisfactory impedance band-width in the lower band 2 GHz and upper band 9 GHz[9]. This antenna uses a simple microstrip feed to excite the microstrip patch to enable dual band resonance on a single layered structure.

This design is implemented by using the HFSS (High frequency structure simulator). It provides a good CP bandwidth. It can be observed from the simulations that creating asymmetrical corner facilitates the lowering of the axial ratio. Moreover, the corner is also utilized to reverse the negative effect of the parasitic slots on the axial ratio, where their angle optimization enabled the highest possible CP bandwidth for this structure [13].

The simulated antenna is considered in both lower band and higher band. The CP orientation can be changed by varying the truncated corner at the bottom [10]. To enable CP at frequencies, asymmetrical slots and the truncated corner is introduced onto the radiation. Unlike previous designs, this structure uses a simple microstrip feed to excite the microstrip patch to enable dual band on a single layered structure.

To enable CP at both frequencies, asymmetrical slots and the truncated corners introduced onto the patch. On the other hand, two vertical slits located at the bottom right and top left corners of the patch, besides the truncated corner allows the CP in the upper band [7].

Table 1: Dimensions of slots and patch antenna

$W_1$	$L_1$	$L_2$	$L_3$	$L_4$	$L_5$	$L_6$	$L_7$
25mm	1mm	13mm	10mm	3mm	5mm	8mm	8.7mm

$W_1$ - length of the square patch

$L_1$ - length of the feed

$L_2$ -length of the probe

$L_4$ - length of the slot beside T-shape slot

$L_5$ -length of the slot right to the T-shape slot

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$L_6$ -length of T-shape slot

$L_7$ - length of slot above the probe-line feed

$L_3, L_8, L_9, L_{10}$  - length of the slots

## III. DESIGN ANALYSIS

Dielectric substrate(FR4 Substrate)	$\epsilon_r=4.4$
Substrate height (h)	1.6 mm
$W = \frac{c}{2f_0 \sqrt{\frac{\epsilon_r+1}{2}}}$	17.47mm to 34.93 mm
$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}(1+12h/W)^{-1/2}$	4.9 mm
$\Delta l = 0.412h \left[ \frac{\epsilon_{reff}+0.3}{\epsilon_{reff}-0.258} \right] \left[ \frac{W/h+0.264}{W/h+0.3} \right]$	0.7209mm
$L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon_{reff}}}$	13.5mm
$L = L_{eff} - 2\Delta l$	13.5515mm to 27.11 mm

Design parameters:

- FR4 substrate ( $\epsilon_r$ ) = 4.4
- Frequency ( $f_0$ ) = 2.5GHz & 9 GHz
- Height (h) = 1.6mm.
- Practical width (W), W = 25 mm.
- Practical Length (L) L = 25.5 mm.

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Design of microstrip patch antenna using HFSS:

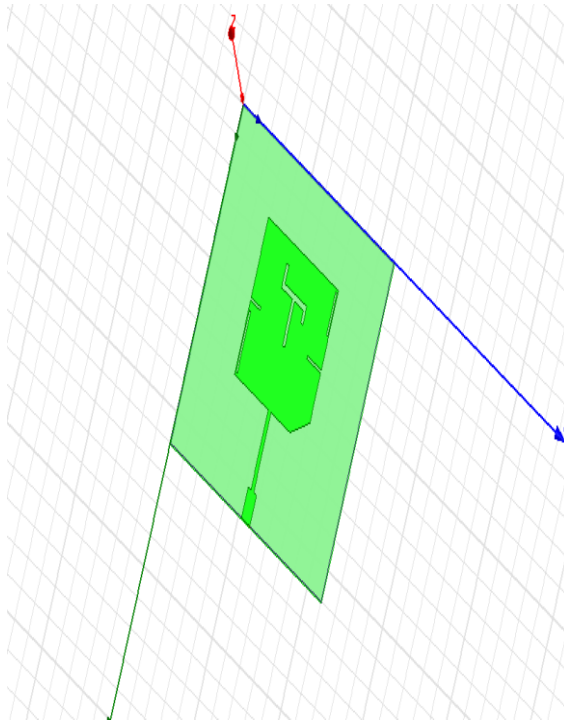


Fig. 2: Design of patch antenna using HFSS

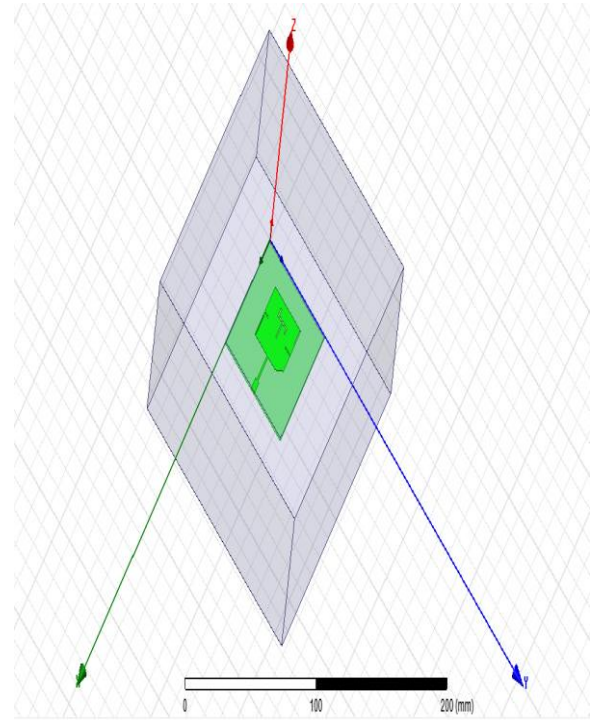


Fig.3: Design of antenna using HFSS with radiation box

As shown in Fig.2 it is the geometrical design of the microstrip patch antenna by using various slots and truncated corner. A good CP bandwidth is also effectively enabled by the conventional technique of edge-chamfering at the resonator patch corner. Furthermore, the corner is utilized to reverse the negative effect of the parasitic slots where the angle optimization enables the highest possible CP bandwidth for the structure.

## IV. SIMULATION RESULTS

The simulation results for microstrip patch antenna carried out at operating frequency 2.5GHz and 9GHz and the results return loss, VSWR, radiation patterns, 3D polar plot are observed. The simulation results of the antenna are observed by using the HFSS software. The simulation was carried out for return loss and VSWR from 1GHz and 10 GHz.

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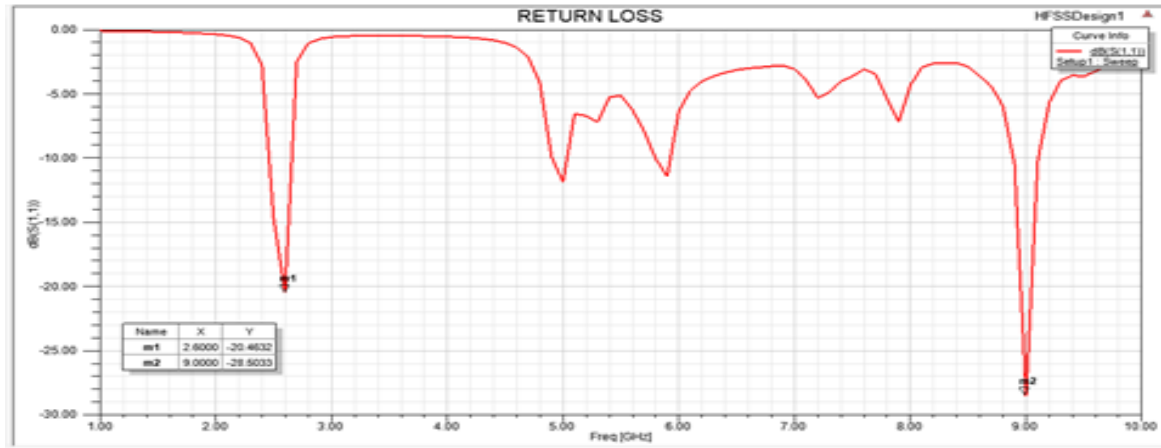


Figure 4: Simulated Return loss of patch antenna carried out from 1GHz to 10GHz.

It is conveyed from Fig.4 the simulated S-parameters of CP antenna operating at 2.5GHz the return loss is about -20.46 dB and 9 GHz the return loss is about -28.50 dB .From the figure 4 it shows that the return loss is less than -10dB so that it operates at 2.5 GHz and 9 GHz.

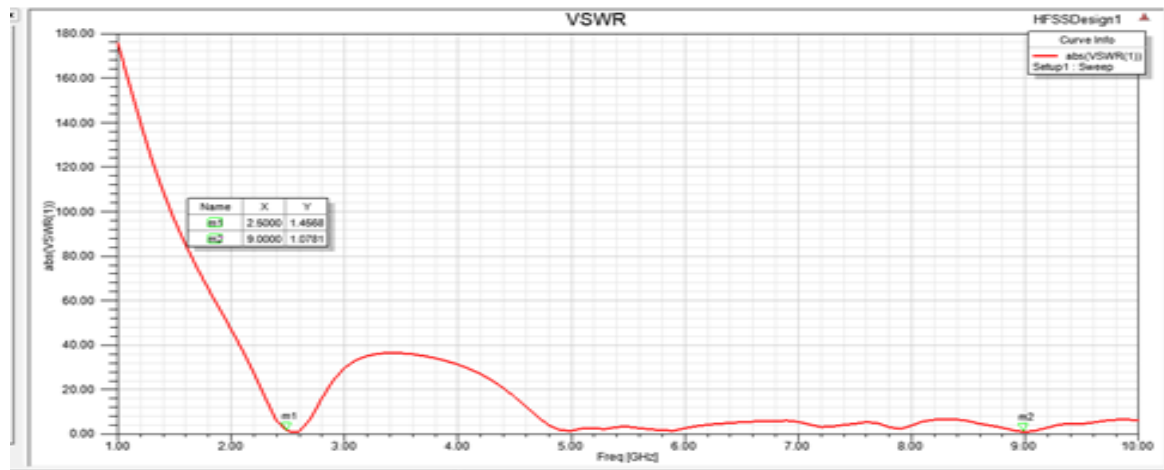


Figure 5: VSWR of CP antenna operating at 2.5GHz and 9 GHz

From the Fig.5 the simulated results of VSWR is carried out from 2GHz and 10GHz. But the operating frequency is at 2.5 GHz to 9GHz. It is clearly observed that the VSWR is <2 at both the operating frequencies.

Table 2: Return loss and VSWR of the antenna

Frequency	Return loss	VSWR
2.5GHz	-20.4622dB	1.45
9GHz	-28.5033dB	1.07

By observing the Table 2 the simulated return loss of CP antenna is operating at 2.5 GHz is about -20.46dB and 9 GHz is about -28.50dB and the VSWR is less than 2 at both the frequencies.

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Table 3: Comparison of antenna design for different substrate materials

Substrate Materials	FR 4	ROGER'S	ARLON
<b>Relative permittivity</b>	4.4	2.2	3.2
<b>Bandwidth</b>	2.5GHz,9GHz	2GHz,9 GHz	2.4GHz,8.7GHz
<b>Gain</b>	2.4052dB	5.0079dB	-1.371dB
<b>Return loss(dB)</b>	-20.46,-28.503	-17.0223,-13.58	-17.0323,-13.58
<b>VSWR</b>	< 2	< 2	< 1.7

By observing the Table 3 , these results indicate a dual band CP operation with two different bands for three different materials. It shows that by using the FR4 substrate efficiency is more compared to other substrate materials. The relative permittivity for FR4 substrate is higher than the other two materials Roger's and Arlon.

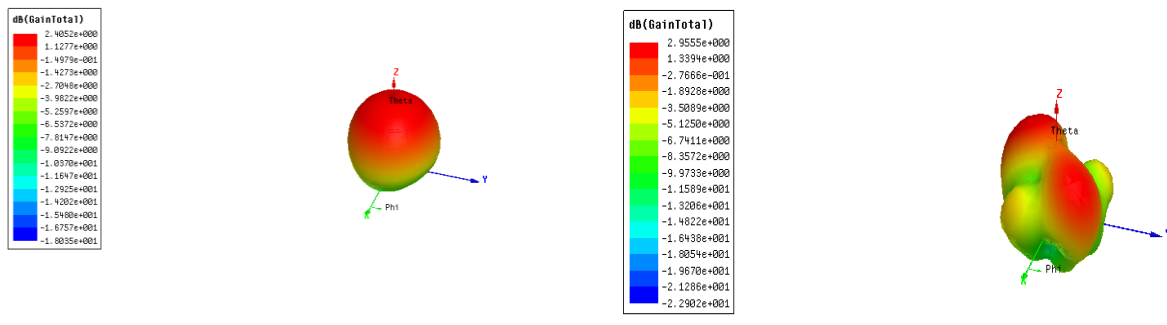


Fig.6: 3D Gain for Microstrip patch antenna at 2.5 GHz and 9 GHz

Fig.6 Represents the reference point (analogous to the origin of a Cartesian system) is called the pole, and the ray from the pole in the reference direction is the polaraxis. The distance from the pole is called the radial coordinate or radius, and the angle is the angular coordinate, polar angle, or azimuth. The 3D Gain for the antenna at 2.5GHz is 2.4dB and at 9 GHz is 2.9 dB.

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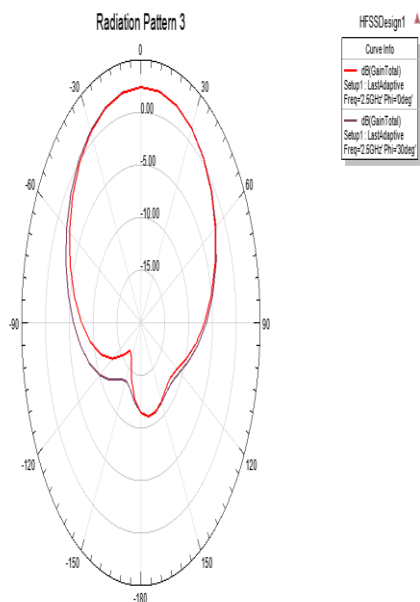


Fig.7: Radiation pattern for patch antenna at 2.5 GHz

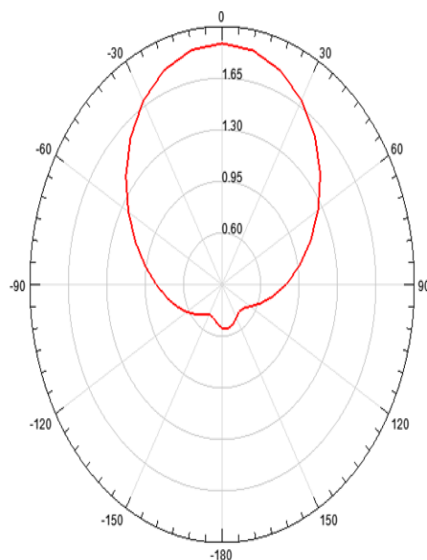


Fig.8: Radiation pattern for patch antenna at 9 GHz

From the Fig. 7 and 8 it is conveyed that the radiation pattern of patch antenna at 2.5 GHz and 9 GHz. On the other hand, the gain is slightly reduced in the upper band due to the expected FR4 losses at higher frequencies especially for a dual band, single patch antenna. The maximum gain at resonant frequency 2GHz is around 2dB and for 9 GHz is around 5 dB.

## V. CONCLUSION

A dual band Microstrip patch antenna has been designed and analysed using HFSS software [ANSYSS]. Here one orthogonal mode is used for the production of circular polarization through the optimization of the slot. Moreover, the CP can be easily controlled through the T-shape slot and the truncated corner. Besides it is a simple and compact topology, the antenna is also low-cost and can be used for WiMAX applications.

This antenna is operated at two frequencies 2.5GHz and 9GHz and can be used for WiMAX applications. From the above results the variation of return loss of the Microstrip patch antenna is considered is below -10dB. The operating frequencies are at 2.5GHz the return loss is about -20.46 dB and 9 GHz the return loss is about -28.50 dB respectively. The VSWR at both the operating frequencies is  $< 2$ .

This work can be further extended by improving the bandwidth. Since cellular mobile is having a Wi-Fi option in the same way with this specific bandwidth a WiMAX option can be placed in that way we can increase number of users.

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