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# Design of CPW fed Monopole Slot Antenna for WiMAX Applications

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**Abstract**— In this paper, a CPW fed monopole slot antenna is proposed. A rectangular patch embedded to slot antenna is designed on 50x30mm$^2$ RT Duroid substrate with thickness 3.175 and relative permittivity 2.33. The antenna operates at a resonant frequency of 3.5GHz. The maximum gain obtained by proposed antenna is 3.41dBi. The radiation efficiency of antenna is as high as 99.65%. The proposed antenna structure is simulated using Advanced Design System (ADS) software. The acceptable radiation characteristics and obtained results such as return loss, gain, efficiency shows that the designed antenna is well suited for WiMAX application.

**Index Terms**— ADS, CPW, microstrip antennas, monopole antennas, slot antennas, WiMAX, WLAN

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## 1 Introduction

WiMAX (Worldwide interoperatibility for Microwave Access) intended for wireless "Metropolitan Area Network" has been established by IEEE 802.16 working group. It is a 4G wireless technology which offers broadband Access. WiMAX technology is the most rapidly growing area in modern wireless communication. It supports high data rate and reliability of the connection and wide coverage area. WiMAX forum has licensed spectrum profiles: 2.3GHz, 2.5GHz, 3.3GHz and 3.5GHz in an effort to decrease cost. The 3.3GHz and 3.5GHz are suited for fixed as well as mobile application. The standard frequency for WiMAX operation is allocated at 3.4-3.6GHz. WiMAX antennas for car radio, cell phone, FM radio or TV, which are designed to optimize performance for a given application.

In wireless applications, slot antennas fed by coplanar waveguide (CPW) are much promising design and they have better efficiency than conventional microstrip antenna. In CPW feeding, side-plane conductor is ground and center strip carries the signal. CPW fed slot antennas are mostly preferred for wireless application because it has many advantages over other feed lines such as wider bandwidth, lower dispersion and lower radiation loss. The most promising property of slot antenna is by changing the slot width; the bandwidth of antenna can be adjusted. The wider slot gives more bandwidth and the optimum feed structure gives the good impedance matching. In this paper, we propose a CPW-fed slot monopole antenna designed for 3.5GHz frequency for WiMAX application.

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## 2 Related Work

Many antennas are available for WiMAX applications. CPW slot antennas are effective option [1]-[5] because they provide good impedance bandwidth to obtain adequate antenna parameters. F.C. Ren et al. proposed compact slot antenna [6] in 2011. The designed antenna operates over triple frequency ranges 2.4/3.5/5.8 GHz for WLAN/WiMAX application. It consists of an L- shaped microstrip feed line and open ended slot constructed of crossed double T-shaped slots is aimed to obtain resonant modes at 2.4/3.5 GHz. And a via-loaded metal patch connected to the edge of ground is used to obtain resonant modes at 5.8 GHz. Antenna are fabricated on RT Duroid substrate. And the slots are electromagnetically fed by 50Ω microstrip feed line. The adequate bandwidth and radiation properties are obtained over WLAN/WiMAX operating band. But the gain obtained by designed antenna is very low.

Wideband Printed Monopole Antenna [7] was proposed by C.Y Pan et al. for WLAN/WiMAX Applications in 2007. The proposed monopole wideband antenna operates in dual band for WLAN/WiMAX application. The antenna consists of a rectangular monopole with a 50Ω microstrip feed line for excitation and a trapezoid conductor-backed plane for band broadening. The trapezoid conductor-backed plane increases impedance bandwidth of designed antenna.

A.H.Yahia et al. introduced Square-Spiral Slot Antenna [8] in 2012. The proposed antenna consists of two corner truncated square spiral slots with a coplanar waveguide (CPW) feeding structure. It was designed to achieve the 2.0-7.0 GHz bandwidth for WLAN and WiMAX applications. The proposed antenna has a good impedance matching within the frequency range between 2.22 GHz and 6.75 GHz. But the gain and radiation efficiency (40%) of designed antenna is very low for WiMAX application.

Q.Zhao et al. designed a compact wide-slot antenna [9]. It mainly comprises a ground with a wide square slot in the center, a rectangular feeding strip and two pairs of planar inverted L strips (PIL) connecting with the slotted ground. By introducing the two pairs of PIL's, we obtain three resonant frequencies, 2.4/5.5 GHz for WLAN and WiMAX. The antenna gain at 3.5GHz is only about 2.2 dBi.

## 3 Antenna Design

A CPW fed monopole slot antenna for 3.5GHz WiMAX application is shown in Fig.1. Proposed antenna is designed on 50x30 mm² RT Duroid substrate with thickness 3.175mm and a relative permittivity 2.33. To feed the designed antenna a 50Ω CPW fed transmission line is used. L shaped monopole with slot are designed for WiMAX application. Here length L1 and width w2 mainly affects the specified frequency. By changing L1 and w2, the monopole current path got changed and frequency of operation will be affected. The resonant frequency and bandwidth can be optimized by choosing proper parameters L1 and w2.

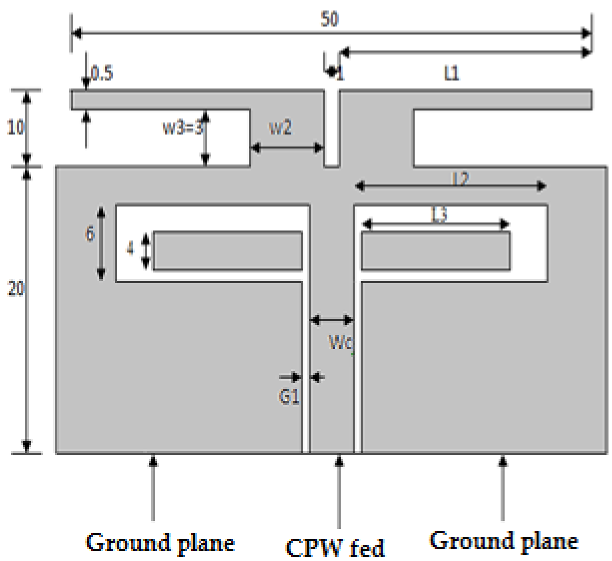


Fig.1 Geometry of CPW fed monopole slot antenna

The width and length of proposed antenna can be calculated as given below,
For efficient radiation width W is given by

$$W = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

Where, C=velocity of light in vacuum
$F_r$= resonant frequency
$\varepsilon_r$ = relative permittivity

The effective dielectric constant can be found by

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \quad (2)$$

The extension length has been adapted into the form

$$\Delta L = 0.421h\frac{(\varepsilon_{eff} + 3)(\frac{W}{h} + 0.624)}{(\varepsilon_{eff} - 0.258)(\frac{W}{h} + 0.8)} \quad (3)$$

Where, h= thickness of substrate

The actual L, in meters is then determined using

$$L = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}} - 2\Delta L \quad (4)$$

The dimension of slot antenna designed for 3.5GHz can be calculated as follows

$$\text{Guide Wavelength, } \lambda_g = \frac{c/f}{\sqrt{\varepsilon_{eff}}} \quad (5)$$

The effective dielectric constant,

$$\varepsilon_{eff} \cong \frac{\varepsilon_r + 1}{2} \quad (6)$$

In this case, $\lambda_g$ at 3.5GHz is 51.48mm. The length of the slot is given as 0.48 $\lambda_g$ i.e. 24.7mm. Width of slot as 0.1 $\lambda_g$ i.e. 5.14mm. The theoretical values calculated here are adjusted to obtain the proper resonant frequency. For proper impedance matching, characteristics impedance of 50Ω with gap G1, width of center strip Wc and length of CPW are 0.4mm, 4mm and 13mm respectively.

## 4 Simulation and Results

### 4.1 S-parameter Plot for Return Loss V/S Frequency

S parameter calculation has been performed for CPW fed monopole slot antenna. The center frequency is selected as the one at which the return loss is minimum. Return Loss S11 is a parameter which indicates how much power is radiated from load to antenna. Fig. 2 shows proposed antenna operates at a center frequency of 3.5GHz and in the prescribed frequency return loss is very low as -18dB.

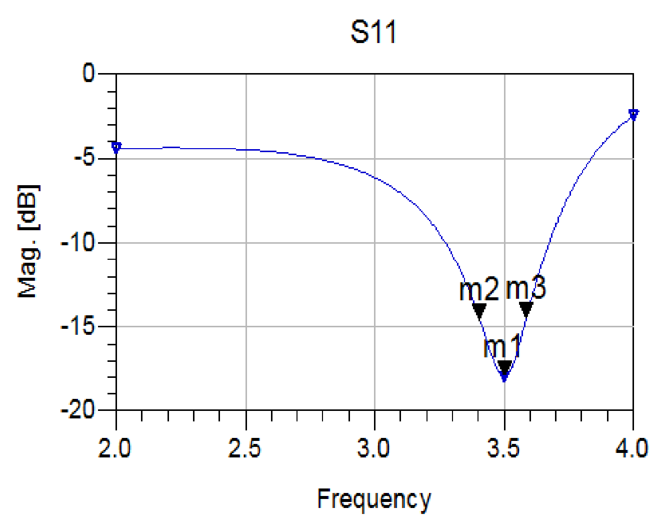


Fig.2 S-parameter plot for return loss v/s frequency for designed antenna

### 4.2 Antenna Parameters

Some of antenna parameters, such as the gain, directivity, power radiated for designed antenna are tabulated below. From the table, it is clear that gain and directivity of proposed antenna is about 3.41dBi and 3.42dBi respectively.

TABLE 1
ANTENNA PARAMETERS FOR DESIGNED ANTENNA

| Parameters | Value | |
|---|---|---|
| Power radiated | 443.24mW | |
| Effective angle | 5.72164 steradians | |
| Directivity | 3.42873 dBi | |
| Gain | 3.41689 dBi | |
| Maximum intensity | 7.05803e-05 mW/steradians | |
| Angle of Umax | 176(theta) | 242(phi) |
| E(theta)max | 0.159735(mag) | 53.8616(phase) |
| E(phi)max | 0.166325(mag) | 74.72(phase) |
| E(x)max | 0.212442(mag) | 68.734(phase) |
| E(y)max | 0.0890142(mag) | 38.789 (phase) |
| E(z)max | 0.111426(mag) | -126.138(phase) |

mW=milliwatt, dB=decibel, Umax=maximum intensity, mag=magnitude

### 4.3 Radiation Pattern of Designed Antennas

The radiation pattern is defined as "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates." The 3D representation of radiation pattern of designed antenna at 3.5GHz is shown in Fig.3.

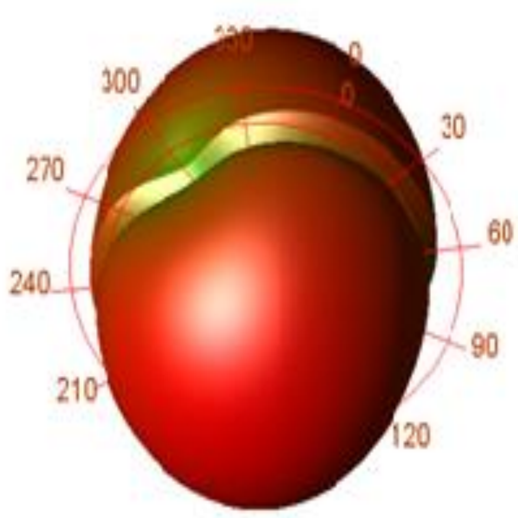


Fig.3 Radiation pattern of designed antenna

### 4.4 Linear Polarization

The Fig.4 shows the linear polarization of the antenna which radiates wholly in one plane containing the direction of propagation. E_co and E_cross are the normalized E field strength of collinear and cross polarized far-field component. E_co is the desired polarization level and E_cross is the actual polarization level or how much decibel it deviates from the actual value.

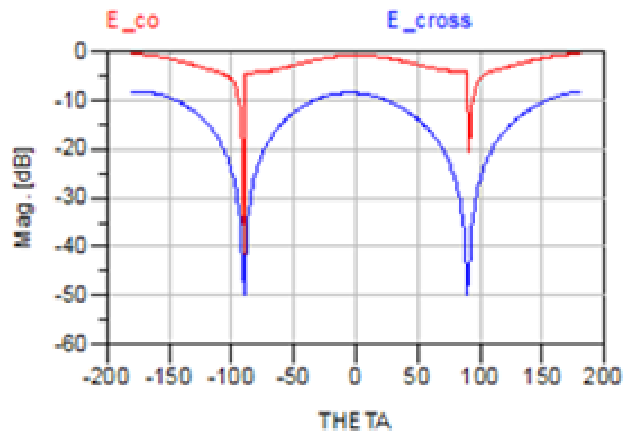


Fig.4 Linear polarization of designed antenna

### 4.5 Circular Polarization

The Fig.5 shows the circular polarization of antenna which can be defined as the polarization in which the electric field of the passing wave does not change strength but only changes in a rotary manner. In circular polarization two components are mainly used right and left components, E_left and E_right.

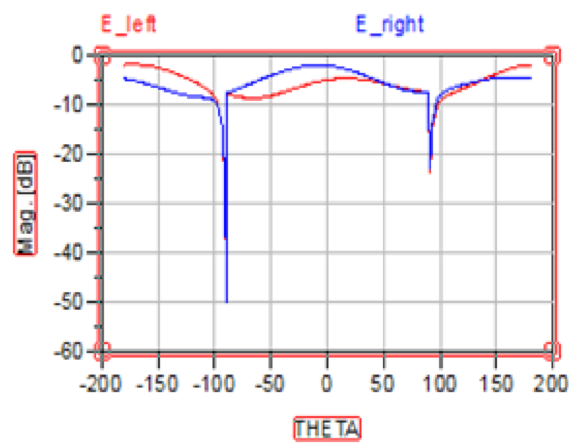


Fig.5 Circular polarization of designed antenna

### 4.6 Efficiency

Efficiency is defined as the ratio of the radiated power (Pr) to the input power (Pi). Efficiency of proposed antenna is as high as 99.65%.

## 5 CONCLUSION

A CPW fed monopole slot antenna is proposed and simulated for WiMAX operation. The return losses of proposed antenna perfectly match the frequency requirement with nearly omnidirectional radiation and gain of 3.416dBi. Antenna is designed on RT Duroid substrate with relative permittivity 2.33 and thickness 3.175. By using ADS software, the characteristics of antenna are investigated and analyzed, including input impedance, return loss and far field radiation pattern etc. It provides acceptable radiation characteristics, stable gain, impedance bandwidth and polarization which shows designed antenna is suitable for WiMAX application. Furthermore antenna will radiate efficiently at 3.5GHz with an efficiency of 99.65%.

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