A CPW Fed Patch Antenna for WiMAX/HPERLAN/2 Applications

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Abstract—This paper presents a simple H-shaped patch antenna which uses coplanar waveguide as feed element. This antenna operates at 5.55GHz frequency which can be used either for IEEE 802.16 WiMAX (5.25GHz-5.85GHz) or HPERLAN/2 (5.470GHz-5.725GHz) applications. The measured -10dB impedance bandwidth is about 1288MHz (5.33GHz-6.61GHz). The effect of substrate thickness, substrate dielectric constant and centre strip slot width has been evaluated. Two dimensional radiation patterns with elevation and azimuth angles, VSWR<2, Return loss of -35dB, antenna efficiency about 75%, gain 2.6dBi are obtained. The compact aperture area of the antenna is 32.2 X 18.1 mm². The results of antenna are simulated by using Zeeland’s MOM based IE3D tool.

Index Terms—Patch Antennas, CPW feed, WiMAX, HPERLAN, Return loss, Gain.

I. INTRODUCTION

The need for wireless broadband communications has increased rapidly in recent years demanding quality of service, security, handover, and increased throughput for the wireless local area networks (WLANs). The main aim of future wireless communication is high speed networking system for multimedia communication [1]. The most important high data rate wireless broadband networking systems for future wireless communications are High Performance Local Area Network type 1 and 2 (HPERLAN/1 and HPERLAN/2) which use the frequency bands 5.15GHz-5.35GHz and 5.47GHz-5.725GHz. HPERLAN/2 has a very high transmission rate up to 54Mbit/s [2]-[6]. The bands assigned for WiMAX (Worldwide Interoperability Microwave Access) based on IEEE 802.16 are 2.5/3.5/5.5GHz (2500–2690/3400–3690/5250–5850 MHz) [7], [9]. The modern wireless communication systems require the antennas for different systems and standards with characteristics like compact, broadband, multiple resonant frequencies and moderate gain [8]. Recently, due to its many attractive features such as wide bandwidth, low cross polarization, radiation loss, less dispersion, uni planar nature, no soldering point, and easy integration with active devices or monolithic microwave integrated circuits (MMICs), the coplanar waveguide (CPW)-fed antenna has been used as an alternative to conventional antennas for different wireless communication systems [10]. In this paper, a novel and simple antenna design has been carried out. An H-Shaped patch antenna fed by a CPW transmission line in a single-layer substrate is studied. With this CPW-fed scheme, the manufacture cost of the antenna can be reduced as low as possible. Details of the investigations based on simulations of the proposed antenna for wireless applications are described. The results are simulated using commercial IE3D simulator which is full wave electromagnetic simulation software for the microwave and millimetre wave integrated circuits [11]. The proposed antenna structure and design is given in section II. The numerical results are discussed in section III.

II. PROPOSED Antenna Structure AND DESIGN

![Figure 1. Layout of the proposed Antenna](image)

The geometrical configuration of the proposed CPW-fed slot antenna is shown in Fig.1. The designed antenna is etched on a single layer of RT duroid 606 substrate whose dielectric constant is \( \varepsilon_r = 6.15 \) which is 32.2 X 18.1mm² in dimension. The antenna is symmetrical with respect to the longitudinal direction, whose main structure is a H-shaped patch and a balance-shaped strip with Co-planar waveguide (CPW) feed line. The geometrical parameters are adjusted carefully and finally the antenna dimensions are obtained to be \( L_1=5\text{mm}, \ L_2=3\text{mm}, \ L_3=1.6\text{mm}, \ L_4=13\text{mm}, \ L_5=5\text{mm}, \ W_1=8.1\text{mm}, \ W_2=15.1\text{mm}, \ W_3=2\text{mm}, \ W_4=5\text{mm}, \ W_5=1\text{mm}, \ a=6.15 \). The substrate thickness \( t=1.5\text{mm} \).

III. INFERENCES FROM SIMULATIONS AND DISCUSSIONS

To investigate the performance of the proposed antenna configuration in terms of achieving the required results a commercially available moment method based CAD tool IE3D, was used for required numerical analysis and obtaining...
the proper geometrical parameters in Fig. 1. The primary formulation of the IE3D software is an integral equation obtained through the use of Green’s function. IE3D breaks down the structure to be modeled into numerous meshes whose co-ordinates are modeled as a matrix. It calculates the analytical integral over all these meshes by filling the matrix elements for every single frequency.

A. Return Loss

The simulated return loss coefficients for substrate thickness $t=1.5$mm are shown in Fig. 2. It can be noted that for frequency range 5.33GHz-6.61GHz a bandwidth of 1288MHz for a -10 dB return loss is observed at 5.54 GHz operating frequency. The return loss at this resonant frequency is obtained as -35dB. The return loss curve is obtained more accurately by taking 20 cells per wavelength. Since the operating frequency falls within the frequency range 5.25GHz-5.85GHz, this antenna can be used for IEEE 802.16 WiMAX/ HIPERLAN/2 applications.

B. Radiation Pattern with Elevation and Azimuth angles

The far-field radiation patterns at the operating frequency for the constructed prototype of the proposed antenna are also examined. Figs. 3 $E_{\phi}$ polarization pattern elevation cuts ($y-z$ plane and $x-z$ plane), for the antenna at 5.54GHz. From the below figure it is observed that cross polarisation is less than co-polarisation, hence it results in reduced cross talk.

C. Antenna Gain and Efficiency

The measured antenna gain against frequency for the proposed antenna across the operating band is shown in Fig. 4 and efficiency curve is given in Fig. 5. It is observed that a gain of about 2.6dBi and efficiency of about 75% at 5.54GHz is obtained.

D. Voltage Standing Wave Ratio

It is clear from Fig. 6 that the simulated voltage standing wave ratio (VSWR) of the proposed antenna is less than 2 throughout the frequency range of 5.33GHz to 6.61GHz, which is desired. At resonant frequency VSWR value is 1.0441 which is very close to the ideal value 1.
E. Smith Chart

The Fig. 7 shows the obtained Smith chart for the antenna. The impedance of the antenna at resonant frequency is 50.83Ω which close to ideal value 50Ω. It is clear from the figure that at resonance almost proper impedance matching occurred which results in reduced losses. From the above results it is clear that the proposed antenna is suitable for WiMAX or HIPERLAN/2 applications with acceptable gain and efficiency and with reduced losses and cross talk.

![Smith Chart](image)

Figure 7. Smith Chart of the antenna

F. Comparisons of Return Loss

The effect of dielectric constant of the substrate, its thickness and slot width $L_2$ are evaluated by varying the dielectric constant from 2.2 to 6.15 and thickness of the substrate from 1mm to 3.5mm and centre strip slot width $L_2$ from 1mm to 4mm and the obtained return losses are compared. The compared resonant frequency and $S_{11}$ values are tabulated in Table I and Table II respectively and corresponding curves are shown in Figures 8-10.

| Table I. Effect of Dielectric Constant on $S_{11}$ Resonant Frequency $f_r$ and Bandwidth |
|---|---|---|---|
| $\epsilon_r$ | $f_r$(in GHz) | $S_{11}$ (in dB) at $f_r$ | Bandwidth(MHz) |
| 2.2 | 8.28 | -21.42 | 1278 |
| 4.4 | 5.56 | -21.38 | 1475 |
| 6.15 | 5.33 | -35.00 | 1258 |
| 10.2 | 4.93 | -39.77 | 969 |

| Table II. Effect of Substrate Thickness on $S_{11}$ Resonant Frequency $f_r$ and Bandwidth |
|---|---|---|---|
| $t$(mm) | $f_r$(in GHz) | $S_{11}$ (in dB) at $f_r$ | Bandwidth(MHz) |
| 1.0 | 5.93 | -22.94 | 1300 |
| 1.3 | 5.55 | -35.00 | 1296 |
| 2.0 | 5.24 | -40.00 | 1375 |
| 2.3 | 5.00 | -26.71 | 1446 |
| 3.0 | 4.74 | -35.67 | 861 |
| 3.5 | 4.57 | -31.81 | 885 |

![Figure 8](image)

Figure 8. Measured return loss for the proposed antenna with different dielectric constants. Other parameters are the same as in Fig. 1.

![Figure 9](image)

Figure 9. Measured return loss for the proposed antenna with different substrate thickness $t$. Other parameters are the same as in Fig. 1.

![Figure 10](image)

Figure 10. Measured return loss for the proposed antenna with different centre strip slot width $L_2$. Other parameters are the same as in Fig. 1.
After few repeated simulations using IE3D, it is found that for \( \epsilon_r=6.15, t=1.5\text{mm} \) and \( L_2=3\text{mm} \) the results are more accurate and resonant frequencies fall in WiMAX and HIPERLAN/2 applications. Moreover it is observed that increase in the dielectric constant results in decrease in resonant frequency and by increasing the substrate thickness decreases the resonant frequency. It is also observed by increasing \( L_2 \) there is a corresponding increase in resonant frequency and bandwidth.

IV. CONCLUSION

In this paper, a CPW fed H-shaped patch antenna is proposed which does not require external matching circuit. The dimension of the antenna is 32.2 X 18.1\text{mm}^2. By changing dielectric constant and substrate thickness, and centre strip slot width the desired resonant frequency band is achieved. The desired antenna gain, efficiency, radiation pattern and VSWR (<2) are obtained. The results are found suitable for WiMAX and HIPERLAN/2 wireless applications. As an extension of this work, numerical analysis techniques are being investigated to bring out a mathematical model for the proposed patch antenna.

REFERENCES