Design and Simulation of an improved bandwidth V-slotted Patch Antenna for WiMAX

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***Abstract*— A conventional rectangular V-slotted patch antenna is commonly used for 2.4 GHz Wireless local area network (WLAN) applications. The microstrip patch antenna has the inherent characteristic of narrow bandwidth that limits the use of rectangular V-slotted patch antenna for broadband technologies, like world-wide interoperability for microwave access (WiMAX). In this paper, a corner truncated scheme is designed and simulation to improve the operational bandwidth of the subjected antenna to make it operational for WiMAX (2~6 GHZ) applications. The simulation carried out it is shown that by truncating the corners of rectangular V-slotted patch antenna, results in enhanced operational bandwidth and better return loss for WiMAX.**

Keywords— Bandwidth, V-slotted Patch antenna, Wireless LAN, WiMAX.

I. INTRODUCTION

The air interface standard IEEE 802.16 which is commonly mentioned to world-wide interoperability for microwave access (WiMAX) is one of the most popular broadband wireless access technology. The operating frequency range of WiMAX 802.16e which is also known as 2~6 GHz portable wireless metropolitan area network (WMAN). The existing operation frequency of WiMAX systems are 2.4 GHz, 3.5 GHz and 5.2 GHz. The WiMAX technology has occupied all of the wireless communication area and developing this WiMAX system can be best achieved, which based on the ideal model of the WiMAX system [1].

A number of antennas have been proposed for WiMAX technology, but it requires efficient antennas at both ends (transmitter and receiver). These antennas are compact and working on the broadband multiple resonant frequency's. Microstrip patch antennas are conformable to planar and non-planar surfaces, diminutive profiled, easy and economical to construct using the advanced printed circuit technology. Besides these advantages of microstrip patch antenna it has a disadvantage of narrow bandwidth. Various methods have been proposed to enhance the bandwidth of microstrip patch antenna, which includes the use of thicker substrate, multiple resonators etc.

At the present time, there are some methods have been proposed to enhance the WiMAX bandwidth. The dual patch microstrip antenna was proposed to enhance the bandwidth by using a second patch antenna in front of the basic one. This is the stacking patches concept which gives the bandwidth enhancement by using the electromagnetic coupling [5]. The comprehensible bandwidth of microstrip antenna shown the approximately proportional to its volume [7]. Thicker substrates are used for enhancing bandwidth for the microstrip patch antenna, but it has several problems. The thicker substrate causes the radiation efficiency because its support the surface waves, which will deteriorate the radiation pattern and feeding problem technique of the antenna arrays. The higher order z-direction modes, which introducing the impedance of further distortions pattern and characteristics. In [6] a good feeding technique has been proposed for the electromagnetic coupling (instead of direct coupling) technique which is electrically thick microstrip antenna.

Symmetrical sharp V-slotted patch antenna has given the better return loss as compared to rectangular patch antenna [4]. This characteristic of V-slotted patch antenna enables the patch input impedance optimization to be made without moving the feed location. [4]. The limit of the patch antenna inherent characteristic is narrow bandwidth which is used for wireless broadband communication. By using the thicker substrate of the microstrip patch antenna is possible to increase the bandwidth [2]. But this technique arise has several problems of antennas feeding technique [2]. There is an effective method is corner truncated scheme is used to enhance the bandwidth for ultra-wideband (UWB) applications [3]. A monopolar V-shaped slot patch antenna has been proposed for car-to-car and WLAN communications which is vertical polarization [9]. By adding a shorting pin for enhancing the impedance bandwidth of V-shaped slot equilateral triangular patch antenna, which has two operating modes, i.e., TM_{10}, TM_{20}, operating frequency from 4.82 to 6.67 GHz and gain of around 5.0 dBi [9]. There are two types of feeding in microstrip patch antenna are non-contacting scheme is electromagnetic field coupling between the radiating patch and transfer power of microstrip line and the other method is contacting method which the RF power is directly to the radiating patch by using the connecting microstrip line.

In this paper, we design and simulation of an improved bandwidth V-slotted Patch Antenna for WiMAX which is operated for WLAN applications is used as a based model. It is proposed that by the use of the corner truncated patch scheme we can widen the operational bandwidth of the antenna and can achieve better performance in terms of return loss for WiMAX.

II. Problem Statement

A V-slotted rectangular patch antenna has been used for WLAN applications widely. There is a need of adaptation, which can enhance the operational bandwidth of this antenna, so that it can be used for WiMAX applications.

The research problem is “how to enhance the operational bandwidth and return loss of V-slotted rectangular patch antenna to utilize it for WiMAX applications”?

This research problem can be resolved by cutting short the two opposite corners of V-slotted rectangular patch antenna to enhance the operational bandwidth and return loss.

The primary contribution of this project is to present a system for raising the operational bandwidth and return loss of the rectangular V-slotted patch antenna WiMAX. The execution and verification have been performed by utilizing a high frequency structure simulator (Ansoft HFSS).

III. Result And Calculation

To obtain the enhanced operational bandwidth and return loss for V-slotted rectangular patch antenna to resonate at WiMAX frequencies, the truncation of two opposite corners of the rectangular patch is proposed in this paper.

A. Modeling

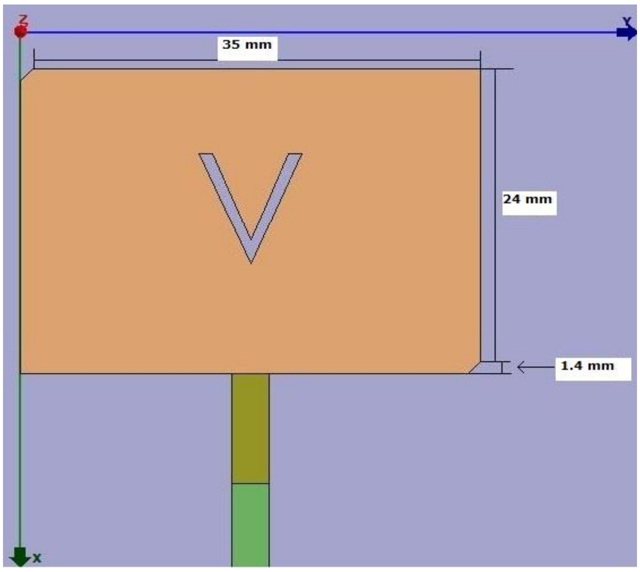

Fig. 1. Corner truncated V-slotted patch antenna.

The geometry of the proposed antenna is shown in Fig. 1 with various dimensions. The antenna is mounted on FR4 substrate having thickness $1.6\ mm$ with relative permittivity of 4.7. Microstrip transmission line of $(17x3)\ mm$ is used to obtain $50\ \Omega$ line. The length and width of the patch have been calculated with the help of general formulas for microstrip patch antenna. By truncating the two opposite corners of the patch with equal length of $1.4142\ mm$, a good impedance match over the frequencies can be excited well. There is tolerance of $\pm 0.0142\ mm$ in truncation of corners in this model to remain on WiMAX frequencies and to avoid significant change in return loss and percentage bandwidth. The normal radiation of the microstrip patch antenna is on its surface. The H-Plane patterns is 0 and the E-Plane patterns are 90. The resonant frequency of microstrip patch antenna of 2.45, 3.5 and 4.65 GHz are described in [10].

B. Resonance frequency

The dimensions of a single rectangular microstrip patch antenna is $L \times W$, f_r is the lowest order resonant frequency which is accurately anticipated from the following equation [8],

$$f_r = \frac{c}{2(L+2\Delta L)\sqrt{\varepsilon_{eff}}} \tag{1}$$

Hear, c is the speed of light.

ΔL is the line extension,

ε_{eff} is the effective dielectric constant.

ε_{eff} and ΔLcan be computed from the following relations,

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+10h/W}}\right) \tag{2}$$

And,

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.285)(\frac{W}{h}+0.823)} \tag{3}$$

C. Implementation and verification

The proposed model is implemented on a high frequency structure simulator (Ansoft HFSS). Return loss and percentage bandwidth for V-slotted rectangular patch antenna without truncation as shown in Fig. 2 and corner truncated V-slotted rectangular patch antenna as shown in Fig. 1 have been analyzed.

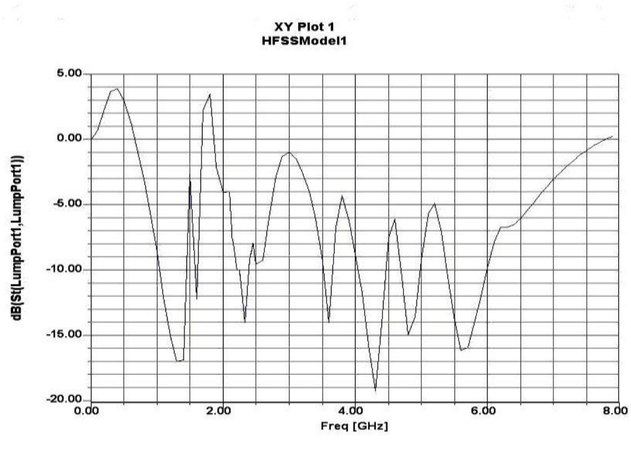

Fig. 2. Simulated return loss of v-slotted rectangular patch antenna without truncation.

TABLE I is the compiled data from Fig. 2 which shows the return loss and percentage bandwidth of V-slotted patch antenna centered on multiple frequencies.

TABLE I. RETURN LOSS AND PERCENTAGE BANDWIDTH FOR V-SLOTTED RECTANGULAR PATCH ANTENNA

Resonant frequency [GHz]	Return loss [dB]	Bandwidth [%]
2.4	-14.00	7.11
3.6	-13.90	3.88
4.3	-19.16	7.9
5.6	-16.05	10.35

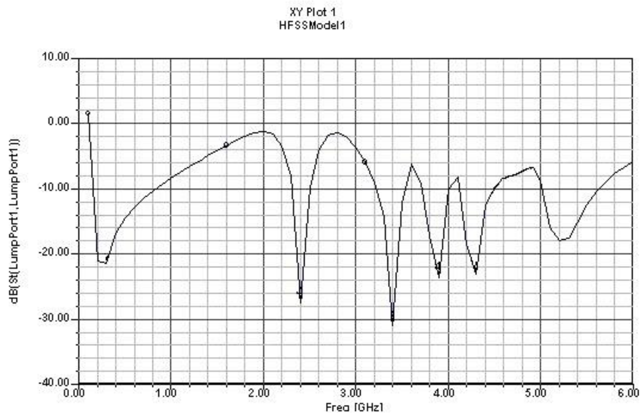

Fig. 3. Simulated return loss of v-slotted rectangular patch antenna with truncation.

TABLE II is compiled data from Fig. 3 which shows the enhanced return loss and percentage bandwidth of V-slotted patch antenna after truncating the corners.

TABLE II. RETURN LOSS AND PERCENTAGE BANDWIDTH FOR CORNER TRUNCATED V-SLOTTED RECTANGULAR PATCH ANTENNA

Resonant frequency [GHz]	Return loss [dB]	Bandwidth [%]
2.4	-27.39	8.33
3.4	-30.99	9.41
3.9	-20.60	7.18
4.3	-23.12	8.83

IV. CONCLUSION

The corner truncated scheme is an efficient technique to raise the operational bandwidth and return loss of V-slotted patch antenna for WiMAX. By cutting short the two opposite corners of the patch 1.18% of the bandwidth has been improved by 1.81 [dB] reduced return loss in WiMAX frequency of 5.2 GHz in comparison with the WiMAX frequency of 5.6 GHz. The antenna is proposed for capable of operating on multiple frequencies which are useful for Bluetooth, Wifi and CDMA 2000/1xEVDO (3G). Future work can be performed by varying the feed type of the antenna to proximity coupled feed or aperture coupled feed to achieve the enhance bandwidth and better return loss.

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