Triple Band Double U-Slots Patch Antenna for WiMAX Mobile Applications

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Abstract- A small triple-band 2.7 GHz, 3.2 GHz and 5.3 GHz compact microstrip patch antenna with two U-shaped slots and a small ground plane is presented. It has been developed to be used in future WiMAX technology. The required bandwidths are fulfilled the WiMAX technology 4.8 %, 3 % and 2.5 % respectively. The return loss for the triple band are -18.5 dB, -14.5 dB and -19 respectively.

Keywords: WiMAX Antenna, Double U-Slot, Small Antenaa, Patch Antenna, U-Shape Antenna.

I. INTRODUCTION

The IEEE 802.16 Working Group has established a new standard known as WiMAX (Worldwide Interoperability for Microwave Access) this WiMAX can reach a theoretical up to 30-mile radius coverage. Moreover the data rate concerned for the WiMAX bands is 70 Mbps. Nowadays researches are focusing on how to design an antenna for WiMAX technology. Basically WiMAX has three allocated frequency bands called low band, middle band and high band. The low band has frequency from 2.5 to 2.8 GHz, the middle band has frequency from 3.2 to 3.8 GHz and the high band has 5.2 to 5.8 GHz.

Microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight , low profile planar configuration, low fabrication costs and capability to integrate with microwave integrated circuits technology, the microstrip patch antenna is very well suited for applications such as wireless communications system, cellular phones, pagers, radar systems, and satellite communications systems[1,2]. The main advantage of using Transmission Line feeding is very easy to fabricate and Simple to match by controlling the inset position and relatively simple to model. Narrow bandwidth in microstrip patch antenna is a disadvantage. The broadband characteristic of a microstrip patch antenna with a U-shaped slot has been confirmed by many published results and several design of broadband slots antenna has been reported [3-6]. A multi U-slot Patch antenna has been reported recently for 5 GHz WLAN [7], and also a monopole antenna for WiMAX applications was proposed in [8], a rectangular microstrip antenna with two U-shaped slots on the patch using a foam layer has been reported in [9].

In this paper, a double U-slot microstrip patch antenna is designed and simulated for WiMAX bands with over all dimensions 50 mm x 40 mm and height of 1.5 mm. A parametric study on the structure is made in-order to obtain the best possible size and position of the connectors. Simulation results based on a commercially available Finite Element package, HFSS, on the return loss, and E-, H-plane radiation pattern are provided and discussed.

II. ANTENNA DESIGN

In this paper several parameters have been investigated using Ansoft HFSS software. The design specifications for the Patch Antenna are:

The dielectric material selected for the design is FR4 which has dielectric constant of ($\in r$ =4.4) and height of dielectric substrate (h) = 1.57.The antenna is fed by 50 Ω microstrip line, in a quarter wavelength transformer for impedance matching.

The overall dimensions of the Double U-slot patch are:

- The length (L) and width (W) of the patch are 40 mm and 50 mm respectively.
- The length (L2) and width (W2) are 30 mm and 25 mm.
- The length (La) and width (Wa) are 15 mm and 5 mm.
- The length (Lb) and width (Wb) are 5 mm and 2.5 mm
- The length (Lc) and width (Wc) are 5 mm and 5 mm
- The length (Ld) and width (Wd) are 10 mm and 5 mm.
- The length (Lf) and width (Wf) for the microstrip feeding line are 19.59 mm and 2.75 mm as shown in figure 1.

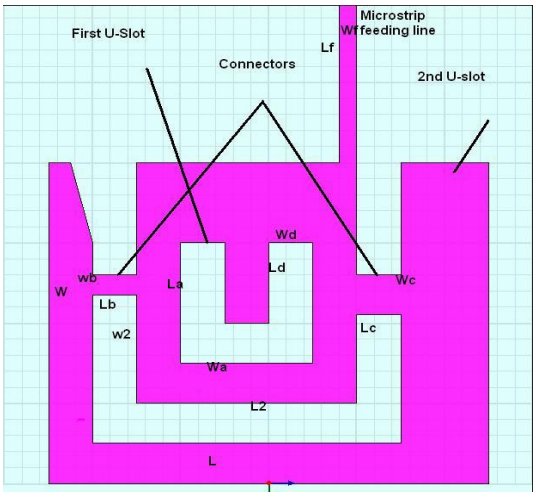

Figure 1 Configuration of the double U-slots Patch antenna on a dielectric substrate.

WiMAX technology has a data rate up to 70 Mbps. Through simulations return loss is measured and observed according to the change in the widths of the connector also E-Plane and H-Plane are simulated as shown in Figure 2 and Figure 3.

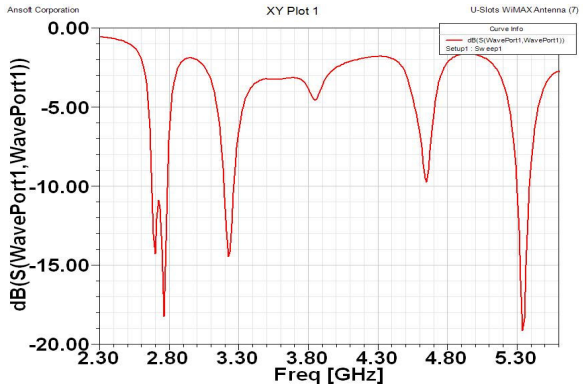

Figure 2: The Simulation result of return loss S11 for the double U-slot WiMAX Antenna.

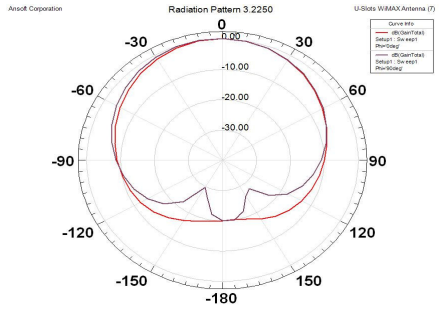

Figure 3a

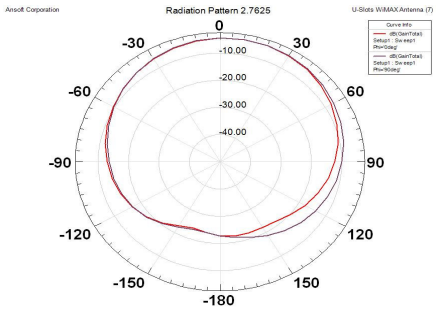

Figure 3b

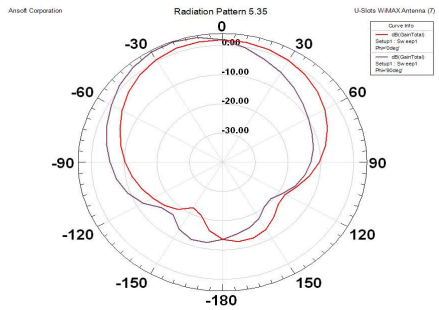

Figure 3c

Figure 3: (a) Radiation Pattern at 2.7 GHz. (b) Radiation Pattern at 3.2 GHz. (c) Radiation Pattern at 5.3 GHz.

Figure 2 shows response for the double U-Slot antenna at three bands which they are 2.7 GHz, 3.2 GHz and 5.3 GHz. The three bands satisfied the bandwidth of the Wimax technology. The impedance bandwidth for the low band is 4.8 % which satisfy the required bandwidth for WiMAX. Also for the middle band the impedance bandwidth is 3 % whereas in the higher band the bandwidth is 2.5 %. The return losses for the three bands are -18.5 dB, -14.5 dB and -19 respectively.

A. The U-Slots with out the Connectors

Basically the design starts with out adding the connectors Wb, Lb and Wc, Lc to the double U-slot. The simulation return loss results for the patch with out the connectors shown in figure 4.

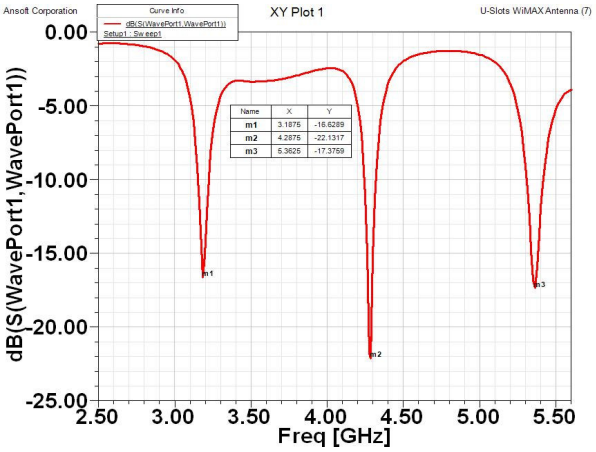

Figure 4 Simulation return loss results for the patch with out the connectors.

From figure 4 it is clear that the operation frequencies have changed and moved from the required operation in addition to this the bandwidth getting smaller.

B. Changing in Wb

Figure 5 shows the simulation results of Wb. Based on the changing of Wb from 2.5mm to 3.5 mm. An increase or decrease in Wb is leading to decrease in the bandwidth and increase in the return loss. The good characteristic of the return loss and the bandwidth is obtained when Wb is 2.5 mm.

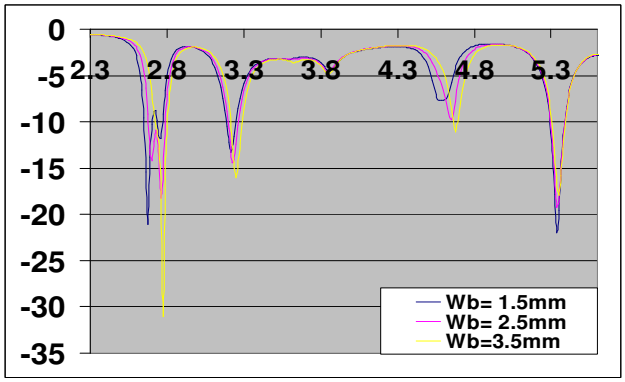

Figure 5: Influence of the width of Wb on the Bandwidth and Return loss.

C. *Changing in Wc*

Figure 6 shows the simulation results of Wc. Based on the variation of Wc from 5mm to 4 mm and to 6 mm. An increase or decrease in Wc is leading to decrease in the bandwidth specially at the low band 2.7 GHz and increase in the return loss when Wc= 4 mm. The good characteristic of the return loss and the bandwidth is obtained when Wc is 5 mm.

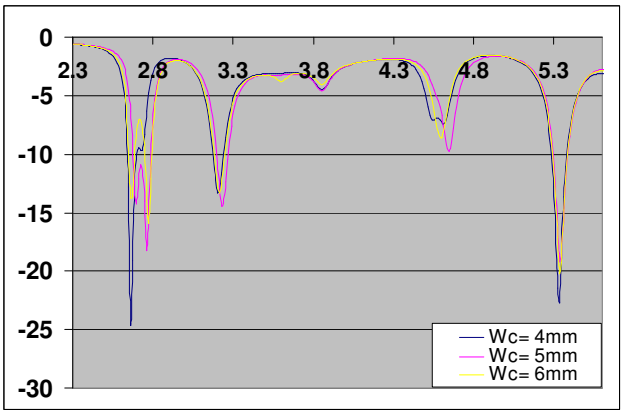

Figure 6: Influence of the width of Wc on the Bandwidth and Return loss.

D. *Changing the Width of (Wa) the first U-Slot*

Figure 7 shows the simulation results of Wa. Based on the changing of Wa from 5 mm to 4 mm and to 6 mm. An increase or decrease in Wa is leading to decrease in the impedance bandwidth and increase in the return loss. The good characteristic of the return loss and the bandwidth is obtained when Wa is 5 mm.

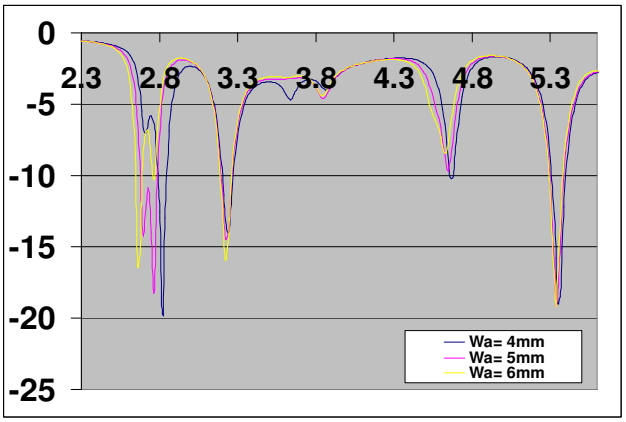

Figure 7: Influence of the width of Wa on the Bandwidth and Return loss.

E. *Changing the width (W) of the second U-Slot*

Figure 8 shows the simulation results of W. Based on the changing of W from 40 mm to 38 mm and to 44 mm. an increase or decrease in W is leading to decrease in the impedance bandwidth and increase in the return loss . The good characteristic of the return loss and the bandwidth is obtained when W is 40 mm.

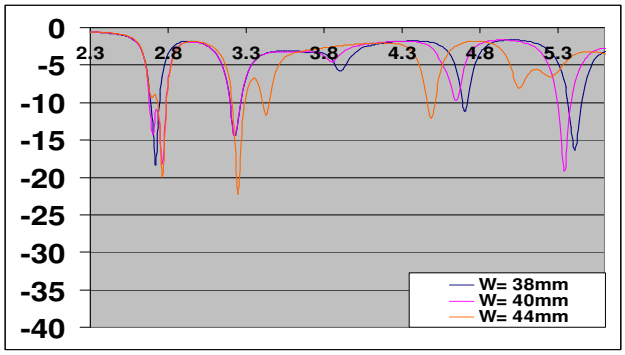

Figure 8: Influence of the width of W on the Bandwidth and Return loss.

III. CONCLUSION

The triple-band behavior at 2.7, 3.2 and 5.3 GHZ has been achieved as well as the bandwidth requirements for WiMAX standards 4.8 %, 3 % and 2.5 % respectively. The return loss for the triple band is -18.5 dB, -14.5 dB and -19 dB respectively. Very broad radiation pattern results have been obtained which seems to be adequate for the envisaged applications.

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