## Compact Planar Inverted-F Antenna (PIFA) for WiMAX Application

H. F. AbuTarboush*[1], R. Nilavalan[1], D. Budimir[2] and H. S. Al-Raweshidy[1]
[1]Wireless Network and Communication Research Centre, Brunel University, West London, UB8 3PH
[2]Wireless Communications Research Group, University of Westminster, London, W1W 6UW

### Introduction

With the rapid growth of the wireless mobile communication technology, the future technologies need a very small antenna and also the need of multi-band antenna is increased to avoid using two antennas and to allow video, voice and data information to be transmitted. There is an increase demand for multi-wide and wide-band antennas that can be easily integrated with the communication system. the advantage of planar inverted-F antenna (PIFA) make them popular in many applications requiring a low profile antenna, PIFA antenna is promising to be a good candidate for the future technology due to the flexibility of the structure as it can be easily incorporate into the communication equipments . 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. Many researchers have studied different structure and different techniques to increase the bandwidth and to have multi-band in one antenna. A monopole antenna for WiMAX applications was proposed in [1], Double U-slot has been reported recently with 3 bands for WiMAX application[2], PIFA for triple-band has been introduced [3] using two shorting strip. In addition to that, by employing two shorting walls to the patch antenna, a wider impedance bandwidth has been achieved [4].

In this paper, four slots have been applied to a PIFA to accomplish three bands compact antenna to be used for WiMAX application 2.6, 3.6 and 5.6 GHz. A parametric study on the four slots is made in-order to obtain the required band and to fulfill the requirement of WiMAX applications.

### Antenna Structure and Fabrication

The dielectric material selected for the design is FR4 which has dielectric constant of $\varepsilon_{r} = 4.4$ and height of dielectric substrate (h) = 1.57mm as shown in fig. 1. The dimensions of the proposed antenna are shown in table1. The antenna is fed by $50\ \Omega$ microstrip line, in a quarter wavelength transformer for impedance matching. The fabricated antenna can be seen in fig. 2. The gap between the radiated patch and the ground plane has been filled with foam layer with dielectric constant = 1. The frequency responses of the measured and simulated reflection coefficients are shown in fig. 2. A good agreement between the simulated and measured results can be observed.

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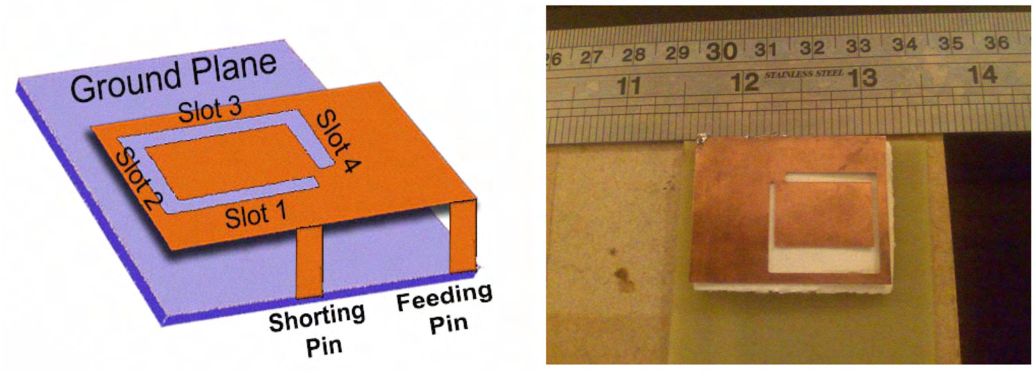



(a) (b)

Figure 1. (a) Configuration of the proposed PIFA antenna with four slots on the top patch (b) Prototype of the Proposed Antenna

TABLE I
The overall dimensions of the proposed antenna (UNIT: mm)

| W | L | Slot 1 | Slot 2 | Slot 3 |
|---|---|---|---|---|
| 38 | 29.59 | 2 x 20 | 1 x 20 | 5 x 21 |
| Slot 4 | Shorting pin | Feeding pin | Ground plane | |
| 1 x 18 | 6 x 1.5 | 3 x 6 | 50 x 50 | |

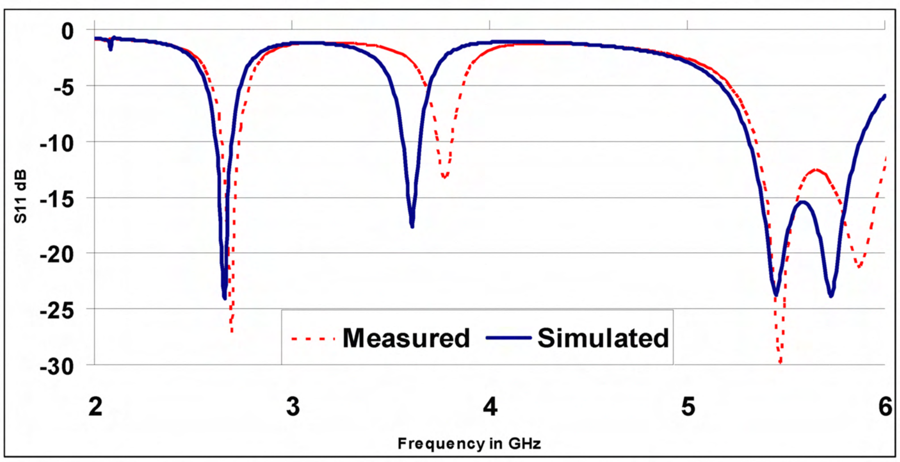
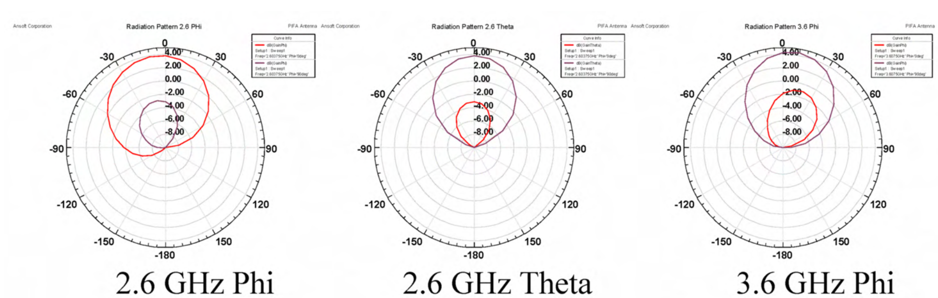
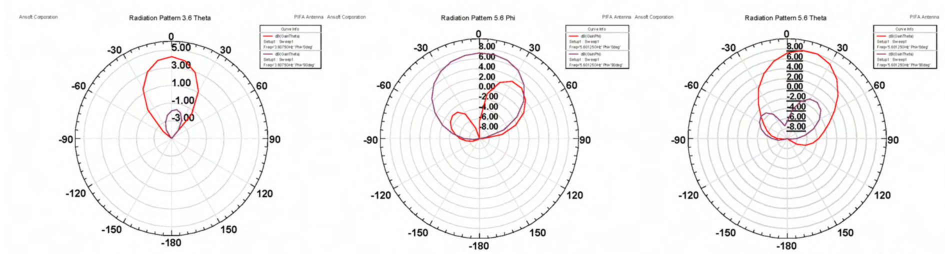



Figure 2. The simulated and measured return loss for the proposed antenna

The co and cross polarization radiation patterns for E- and H-plane at 2.6, 3.6 and 5.6 GHz for the WiMAX application are shown in fig.3.






3.6 GHz Theta 5.6 GHz phi 5.6 GHz Thet

Figure 3. Radiation pattern for 2.6, 3.6 and 5.6 GHz.

### A. The effect of the top patch without slots

The proposed antenna consists of a ground plane, shorting pin, top plate, and four slots on the top patch. The effect of the top patch without slots is shown in fig. 4 and table II, by comparing the response from the patch without slots with the response from the proposed antenna, it is clear that, without slots, the first band is in a higher mode at 3.1GHz, the second band is at 4.5 GHz with -6 dB return loss which has a higher band than the proposed one, however, the third band has shown no difference in the frequency response at 5.6 GHz but the only different is the impedance bandwidth has narrowed to 2% with -16dB.

### B. The effect of slot 1

It has been confirmed that adding slots can increase or decrease the frequency response of the antenna to higher band or to a lower band, not only that but also it can change the bandwidth response, that is due to the current on the patch has to travel longer than without slots. In this case by adding slot 1 with a size of 1 x 20mm the response of the return loss has a little improves comparing to the response without slots, the only different that slot 1 has made is, shifted the frequency of the second band to lower band from 4.5 GHz to 4 GHz.

### C. The effect of slot 1 and 2

The target is to reach the three bands for WiMAX applications with the required bandwidth to fulfill the requirement of the WiMAX system. Therefore, by inserting slot 1 and slot 2 to the top patch, a great improvement on the resonant frequency as can be seen from fig. 4 and table II. Comparing with the patch without slots, the resonant frequencies have shifted from 3.1, 4.5 and 5.6 GHz to 2.8, 3.6 and 5.6GHz. The total size of slot 2 is 1 x 20mm..

### D. The effect of slot 1, 2 and 3

In order to generate the resonance at a lower frequency, it is important to achieve a long current path; therefore, placing slot 3 near to the concentration of the current path at the top patch will help in decreasing the resonance frequency to a lower band. Fig. 4 and table II show the response after adding the third slots to the top patch. The total size of slot 3 is 5 x 21mm, the width of the third slot is slightly bigger than slot 1 and 2, this is because the current distribution is concentration around this area and broaden the width of slot 3 will increase the bandwidth of the third band. After inserting slot 4, the bandwidth noticeable changed from 2% to 10%.

TABLE II

The effect of the slots on the antenna responses

| | No Slots | Slot 1 | Slot 1 and 2 | Slot 1, 2 and 3 | Proposed Antenna |
|---|---|---|---|---|---|
| Frequency 1 | 3.1 GHz | 3.1 GHz | 2.8 GH | 2.8 GHz | 2.6 GHz |
| Bandwidth f1 | 2.95% | 2.95% | -- | 2% | 3.81% |
| Frequency 2 | 4.5 GHz | 4 GHz | 3.6 GHz | 3.6 GHz | 3.6 GHz |
| Bandwidth f2 | -- | -- | 2.5% | 2.95% | 2.77% |
| Frequency 3 | 5.6 GHz | 5.6 GHz | 5.6 GHz | 5.6 GHz | 5.6 GHz |
| Bandwidth f3 | 5.89% | 5.90% | 2.66% | 3.77% | 10.21% |

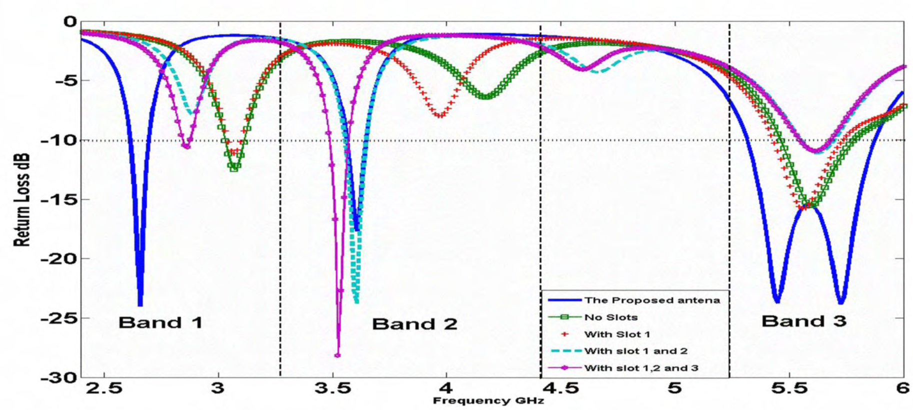



Figure 4. The effect of the slots on the antenna response

## Conclusion

This paper has focused on the development of multi-band planer inverted-F antenna for use in the three bands WiMAX application. Four slots have been added on the radiated patch to give the required three bands for the WiMAX 2.6, 3.6 and 5.6 GHz, the effect of each slot has been discussed. Both simulated and measured results have been presented.

## References

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