Dual Band-Notched UWB Antenna for Short Range High Speed Wireless Communication

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ABSTRACT
In this paper, a compact UWB antenna has been proposed to work in the frequency range of 3.1 to 10.6 GHz. Besides this, the proposed antenna also exhibits band-notched characteristics in the WiMAX and WLAN bands which act as interfering bands in the UWB range. The proposed antenna is designed on an FR-4 substrate having dimensions W x L = 18 mm x 30 mm. Simulated S_{11} is less than -10 dB in the entire UWB range except the notch bands. CADFEKO (Suite 6.1) has been used for the design and analysis of the antenna.

General Terms
Compact UWB antenna, Bluetooth, Wi-Fi.

Keywords
WiMAX and WLAN band-notched, V-shaped slot.

1. INTRODUCTION
Short range wireless communication plays a crucial role in our day to day life. There is a growing interoperability between many of the consumer electronics devices such as digital cameras and camcorders, cell phones, portable MP3 and DVD players, HDTVs etc. Many short range wireless technologies like Bluetooth, Wi-Fi, WiMAX and ZigBee provide the ability to connect devices and transfer data wirelessly [1].

Until now, Bluetooth has been the most widely used technology for short range wireless data transfer. It can achieve a data rate maximum up to 3Mbps. Today, it is not unusual for portable devices to have files of several GB in size. Sending a 5GB file across Bluetooth would take almost 15 hours draining the battery of the device. If Wi-Fi is used for sending the same file, then it would take about 13 minutes for the complete file transfer considering the maximum Wi-Fi speed of 54Mbps. So, these technologies are not suitable when large volumes of data are required to be transferred. Thus, the need for a technology arises that can meet the high data rate demands exceeding from 500 Mbps up to several Gbps at very low power consumption. UWB technology has emerged as a solution to overcome the data rate bottlenecks in wireless communication and applications. The advantages of this technology over the existing narrowband technologies include low power consumption and high speed data transfer. It operates in the 3.1 to 10.6 GHz frequency band by sending differs from the other wireless technologies by using multiple frequencies simultaneously rather than transmitting continuously at a specific frequency. A UWB transmitter sends out pulses of duration in the range of nanoseconds to picoseconds. These pulses radiate outward in a wide band, using a proprietary pulse signature. It is because of this property that several UWB networks can co-exist without the problem of interference or data security issues. UWB spectrum has also gained attention because of its unlicensed allocation by FCC in 2002 [2].

Antenna plays a very fundamental role in any wireless technology [3,4]. The main challenge in designing a UWB antenna is maintaining a reflection coefficient value which is less than -10 dB in the entire 7.5 GHz bandwidth. Besides this, another challenge is the rejection of two interfering bands viz. IEEE 802.16 WiMAX system covering 3.3 to 3.6 GHz and the IEEE 802.11a WLAN system covering 5.15 to 5.825 GHz since they are also intended for short range wireless data transfer applications [5].

In this paper, a monopole UWB antenna has been proposed which can operate in the entire 3.1 to 10.6 GHz frequency band with a reflection coefficient value less than -10 dB. The Also, the proposed antenna has band notch characteristics for the WiMAX and the WLAN systems.

2. ANTENNA DESIGN
The antenna is designed on an FR-4 substrate having a thickness of only 0.8mm, W x L = 18 mm x 30 mm, dielectric constant ε_r = 4.4 and dielectric loss tangent of 0.02. A 3mm wide microstrip line has been used to excite the monopole antenna. The antenna has an approximately pentagonal shaped radiating patch on one side and a ground plane splitted in two parts on the other side of the substrate. A V-shaped slot has been etched on the radiating patch to realize a notch in the WLAN band [6]. The length of the required slot can be calculated using equation (1)

$$L = \frac{c}{2f_c \sqrt{\varepsilon_r + ½}} \quad (1)$$

Where c is the speed of light in free space, f_c is the centre frequency of the notched band and ε_r is the dielectric constant. According to equation (1), the length of the slot comes out to be nearly 17 mm. In the design, the length of the slot has been adjusted to 18.4 mm to create a notch at the centre frequency of the WLAN band which is 5.5 GHz. Besides proper length, the slot should also be located at the correct position to create a band notch function. Figure 1 shows the front view of the antenna along with its dimensions and figure 2 shows the dimensions of the V-shaped slot.

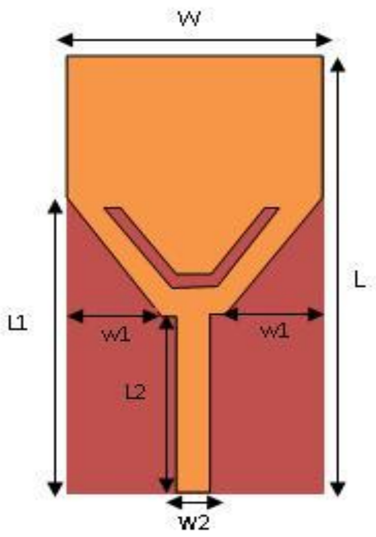

Figure 1: Antenna front view

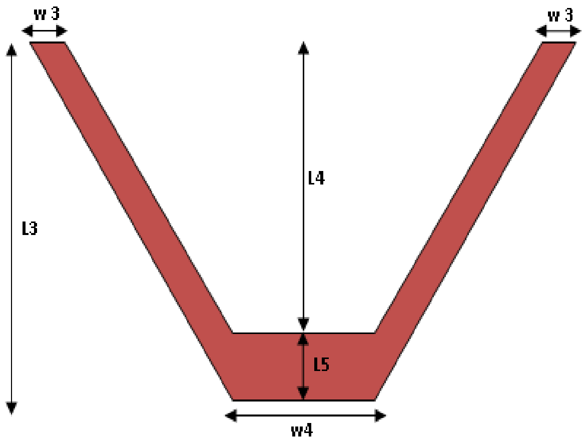

Figure 2: V-shaped Slot

The ground plane of the reference design [7] was modified to create a notch in the WiMAX band. Figure 2 shows the back view of the antenna and figure 3 shows the dimensions of the ground plane.

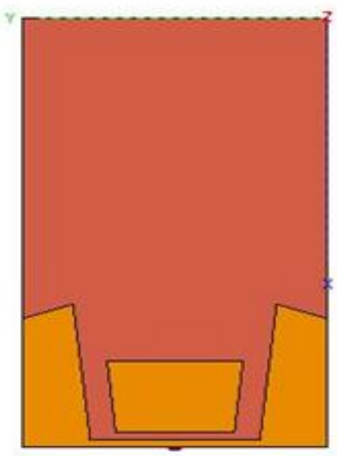

Figure 3: Antenna Back View

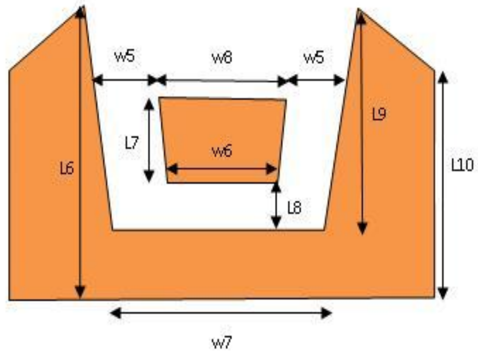

Figure 4: Ground Plane Dimensions

Table 1. Antenna dimensions (all in mm)

Parameter	L	W	L1	L2	L3	L4
Value (mm)	30	18	20	12	5.5	5
Parameter	L5	L6	L7	L8	L9	L10
Value (mm)	0.5	10	5	0.5	9.5	9
Parameter	w1	w2	w3	w4	w5	w6
Value (mm)	7	3	0.5	3	1.5	7
Parameter	w7	w8				
Value (mm)	10	8				

3. RESULTS AND DISCUSSION

This antenna has been designed and simulated using CADFEKO 6.1. Figure 5 shows the simulated S_{11} of the antenna.

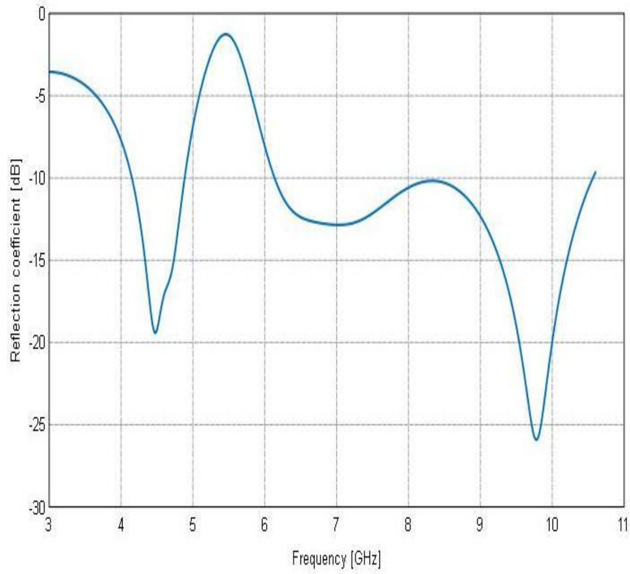

Figure 5: Simulated S_{11} for the antenna

It can be seen from figure 5 that the simulated S_{11} is less than -10 dB in the entire UWB range except in the WiMAX (3.2 to 3.6 GHz) and WLAN (5.15 to 5.825 GHz).

Figure 6 shows the simulated VSWR of the antenna. The antenna has a VSWR value between 1 and 2 in the entire UWB range except the notch bands. It lies around 4.5 in the WiMAX band and around 13 in the WLAN band.

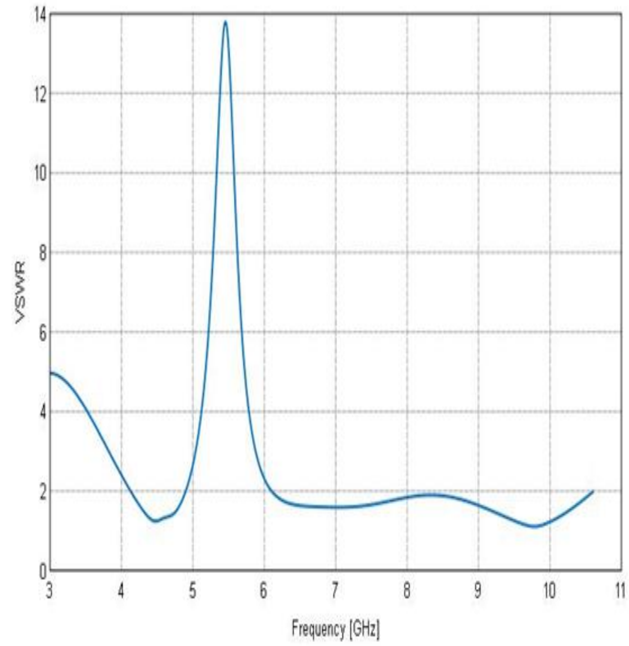

Figure 6: Simulated VSWR

Figure 7 shows the impedance of the antenna in the entire UWB range.

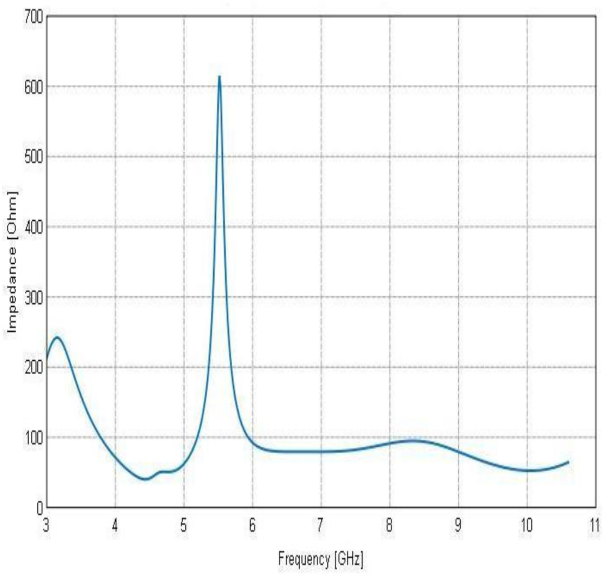

Figure 7: Antenna Impedance

The impedance of the antenna lies very near around 50 Ω in the entire UWB range except the notch bands. This shows that the antenna is very suitable for feeding it with a standard coaxial cable of 50 Ω impedance.

Since a UWB antenna is used for short range wireless data transfer, its radiation pattern should be omni directional. Figure 8 shows the radiation pattern of the antenna at 4.5, 6.2, 8.6 and 10.2 GHz. It can be seen that the radiation pattern of the proposed antenna is nearly omni directional which makes this antenna extremely suitable for short range wireless data transfer.

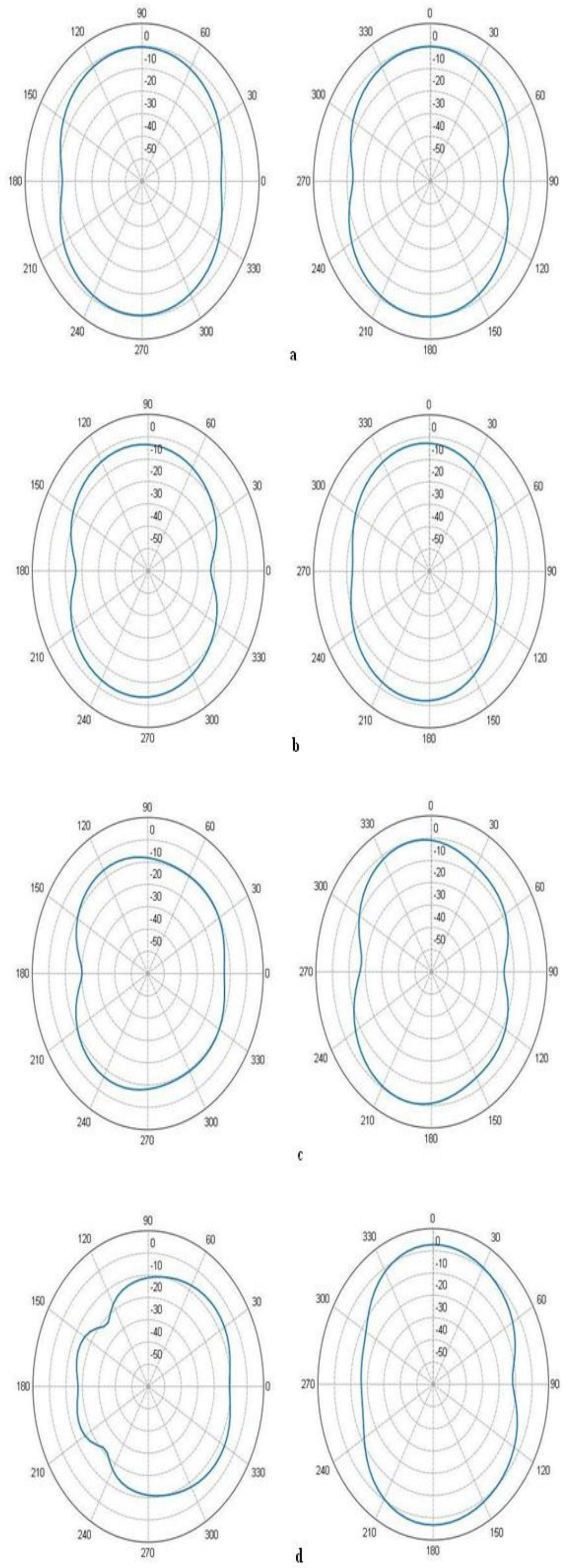

Figure 8: E plane and H plane radiation pattern of the antenna at a) 4.5 GHz b) 6.2 GHz c) 8.6 GHz d) 10.2 GHz

4. CONCLUSION

A compact UWB antenna is proposed in this paper. The antenna is designed on a very small substrate having dimensions W x L = 18 mm x 30 mm. Simulated S_{11} is less than -10 dB in the entire UWB range except the notch bands. A V-shaped slot was used to create a notch in the WLAN band and a modified ground plane splitted in two parts was used to create a notch in the WiMAX band. Simulated results are in good agreement with the standard values.

5. REFERENCES

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