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Compact Ultra-Wideband Antenna With Dual Band Notched Characteristic

Sagar S. Jagtap S. P. Shinde V. U. Deshmukh
V.P.C.O.E. Baramati, Pune University, Maharashtra, India.

Abstract

A novel coplanar waveguide (CPW)-fed compact ultra-wideband (UWB) microstrip antenna is proposed for ultra-wideband applications with dual band notched (3.4GHz / 5.5GHz) characteristics to mitigate the interference of narrowband systems WiMAX and WLAN that co-exist with UWB system. By embedding two nested c shaped slots in the radiating elements dual band filtering property in WiMAX and WLAN are achieved. Proposed design consist hexagonal radiating patch with CPW feeding. By performing optimization on ground plane height and hexagonal patch length bandwidth and gain enhancement are achieved. The simulated result of proposed system shows good impedance matching, constant gain, and stable radiation patterns.

1. Introduction

Although, often considered as a recent technology in wireless communications, ultra wideband (UWB) has actually experienced over 40 years of technological developments. In fact, UWB has its origin in the spark-gap transmission design of Marconi and Hertz in the late 1890. In 2002, the Federal Communication Commission (FCC) in United States officially released the regulations for UWB technology having spectrum allocation of 3.1GHz-10.6GHz with bandwidth of 7.5 GHz[1] The feasible design and implementation of UWB system has become a highly competitive topic in both academy and industry communities of telecommunications. In particular, as a key component of the UWB system, an extremely broadband antenna will be launched in the frequency range from 3.1–10.6 GHz, which has attracted significant research power in the recent years [2]. Challenges of the feasible UWB antenna design include the UWB performances of the impedance matching and radiation stability, the compact appearance of the antenna size, and the low manufacturing cost for consumer electronics applications [3]. Over the nominated bandwidth of UWB system, there are some other narrowband services also exist, which are already occupied frequencies in the UWB frequency range, such as wireless local-area network (WLAN) IEEE802.11a and HIPERLAN/2 WLAN operating in the 5–6 GHz band. In some applications, UWB antenna uses filters to suppress dispensable bands. However, the uses of filters indeed increase the complexity of the UWB system and lead to increase in cost. It is desirable to design the UWB antenna with single notched frequency band in 5–6 GHz to minimize the potential interferences between UWB system and narrowband systems. So far, several design methods and structures have been reported. These UWB antennas with filtering property at the 5–6 GHz band have been proposed not only to mitigate the potential interferences but also to remove the requirement of an extra band stop filter in the system [2][3]. Recently, more and more band-notched UWB antenna designs have been proposed. J.Kim *et al.* proposed a 5.2 GHz notched UWB antenna using slot-type SRR [6] This UWB antenna fulfils all the critical requirements including high radiation efficiency, low-profile, stable radiation patterns and constant gain. However, the input impedance is not well matched at the lowest frequencies (3.1–3.8 GHz). In addition, the notched frequency band from 5–5.3 GH cannot successfully block out the whole WLAN bands. The potential interferences between the UWB and WLAN systems cannot be reduced to the minimum. Yi-Cheng Lin *et al.* discussed the designs of three advanced band-notched (5–6 GHz) UWB rectangular aperture antennas [3]. The antenna structure is simple and the aperture size is compact. Broad impedance bandwidth and stable radiation patterns are obtained, whereas the ground plane dimension is a bit of large. In practice, when integrated with the system board of different ground plane size, the antenna might need a retuning for the optimized dimensions. Wang-Sang Lee *et al.* proposed wideband planar monopole antennas with dual band-notched characteristics [4]. This technique is suitable for creating UWB antenna with narrow frequency notches or for creating multiband antennas. However, the antenna is not suitable for integration with compact systems, because its ground plane is very large and it is perpendicular to the radiator, which limits its applications in compact UWB systems. Furthermore, the bandwidth performance of the antenna is from 2 GHz to 6 GHz, which can not satisfy the demands of UWB system. Based on the above researches in 2008, Qing-Xin Chu proposed a simple and compact CPW-fed planar UWB antenna [5] with dual band-notched characteristics in 3.4 GHz (3.3–3.8 GHz) and 5.5 GHz (5–6 GHz). The dual band-notched operations are achieved by etching two nested C-shaped slots in the rectangular metal radiating but bandwidth is not more enhanced in this design. Based on the above literature we propose a compact hexagonal antenna with CPW feed Hexagon structure gives bandwidth enhancement while ground plane height is optimized for gain enhancement The antenna is simulated and analyzed by using simulation software, Ansoft HFSS.

2. Design of proposed antenna

Figure 1. shows the geometry and configuration of a UWB antenna this design is referred as antenna 1. The proposed antenna is constructed on FR4 epoxy substrate with h=1.6mm, loss tangent=0.02 and dielectric constant 4.4. As shown in Figure 1. hexagonal radiator is fed by a 50 ohm coplanar waveguide (CPW) transmission line Since both the antenna and the feeding are implemented on the same plane, only one layer of substrate with single-sided metallization is used, and the manufacturing of the antenna is very easy and extremely low cost The electromagnetic software Ansoft HFSS 11 is employed to perform the design and optimization process. Table 1. shows optimized dimensions of the proposed design [8][9].dimension for the CPW line are calculated from [10].

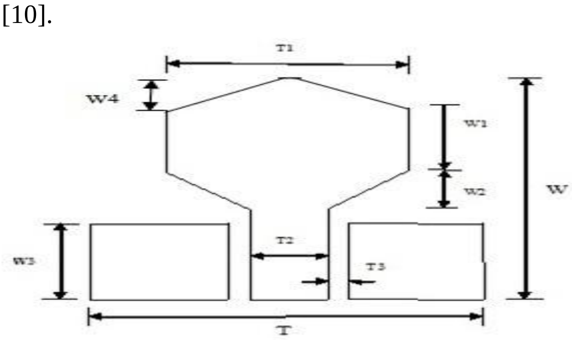

Figure 1. Geometry and configuration of antenna 1

Table 1. Dimensions of antenna 1

Sr. No.	Parameters	Notations	Dimensions (mm)
1	Total length	T	26
2	Total width	W	30
3	Patch length	T1	14
4	Patch width	W1	9
5	Slope at bottom	W2	5.5
6	Feed line width	T3	0.5
7	Ground plane height	W3	13
8	Slope at top	W4	2

2.1. Antenna with dual band notched characteristics

To reduce the interferences from the WiMAX and WLAN systems, the band notched function is desirable in the UWB system. Figure 2. shows the geometry and dimensions of the UWB antenna with filtering property operating in the 5–6 GHz band and 3-4 GHz band and it is denoted as antenna 2. In this design interior C shaped slot is etched to mitigate the interference of WLAN band from 5GHz to 6 GHz. By etching exterior C-shaped slot in the hexagonal radiating patch of antenna 1, a frequency band notch is created to filter out the interference of WiMAX with its designated band. While the band notched design applied to antenna 1, there is no retuning work required for the previously determined dimensions as mentioned above. Mostly it is observed that, the design concept of the notch function is to adjust the total length of the C-shaped slot to be approximately half-wavelength at the desired notched frequency, which makes the input impedance singular. The dimensions of C-slot of antenna are listed in Table 2.

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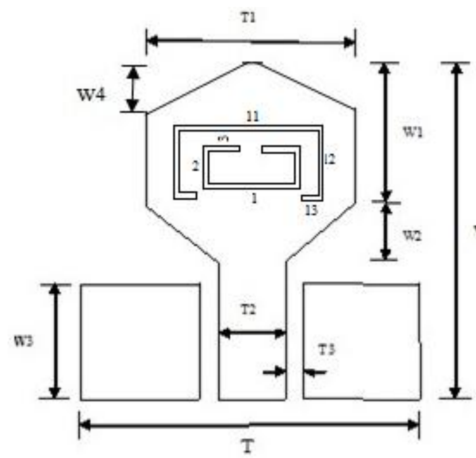

Figure 2. Antenna with nested c shaped slots

Table 2. Dimensions of C slots

Notation	Dimensions (mm)
1	8.2
2	2.6
3	2
11	12.8
12	3.8
13	3.5

Total length of C shaped slot and notch frequency is postulated as,

$$f_{notch} = \frac{c}{2L\sqrt{\varepsilon_{eff}}}$$

where L is the total length of the C-shaped slot, ε_{eff} is the effective dielectric constant, and C is the speed of the light

3. Results and discussion

3.1. Simulated results of antenna 1

Simulated results of s-parameter and VSWR graph shows proposed design covers the designated bandwidth of UWB system from 3.1GHz to more than 10.6GHz.

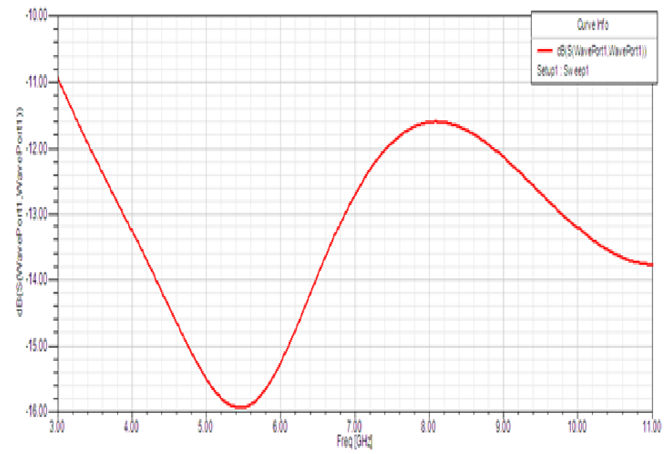

Figure 3. Simulated s parameter of antenna 1

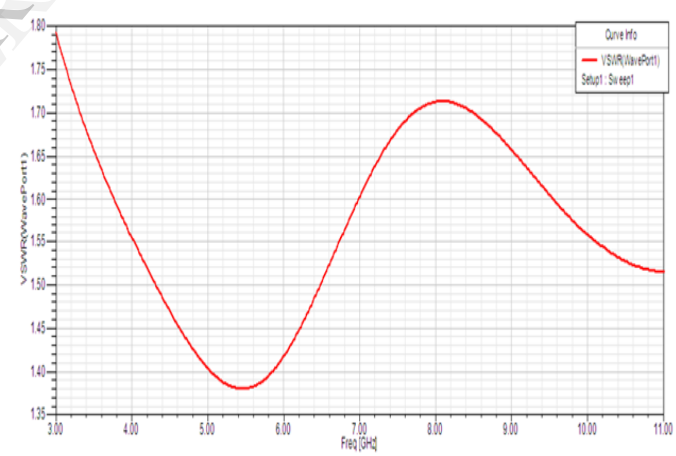

Figure 4. Simulated VSWR of antenna 1

3.2. Simulated result of dual band notched antenna and design

Figure 5. and Figure 6. shows band notched characteristics are achieved by embedding two nested C shaped slot in hexagonal radiating patch . The proposed antenna yields an impedance bandwidth of 3.1–10.6 GHz with VSWR < 2, except the bandwidths of 3.3–3.8 GHz for WiMAX system and 5–6 GHz for IEEE802.11a and HIPERLAN/2 WLAN systems.

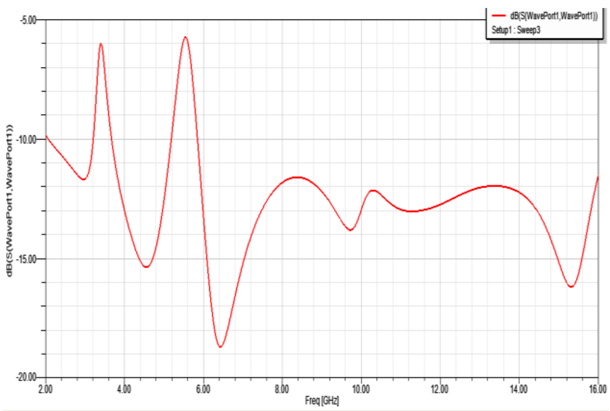

Figure 5. Simulated result of antenna 2 with dual band notched characteristics

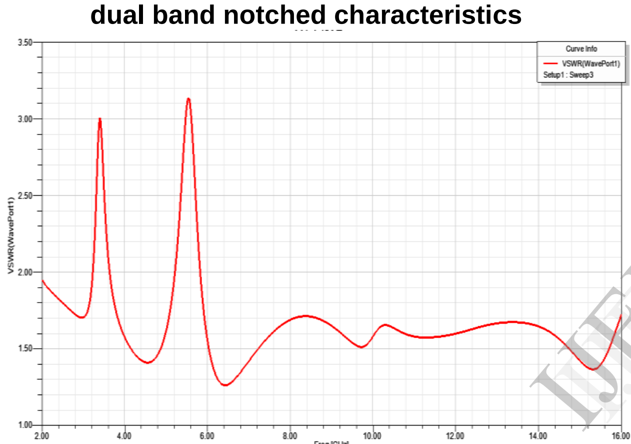

Figure 6. Simulated result of antenna 2 with dual band notched characteristics

3.3.Radiation pattern of antenna 2

From radiation pattern of antenna two we can say that it exhibit bidirectional radiation pattern in the E-plane (YZ plane) and quite Omni directional pattern in H-plane (XY plane).

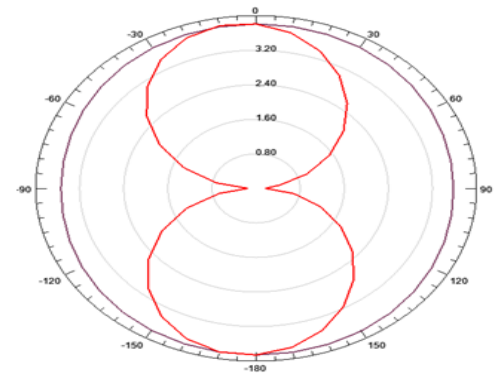

Figure 7. Radiation pattern of antenna 2 at 3.1GHz

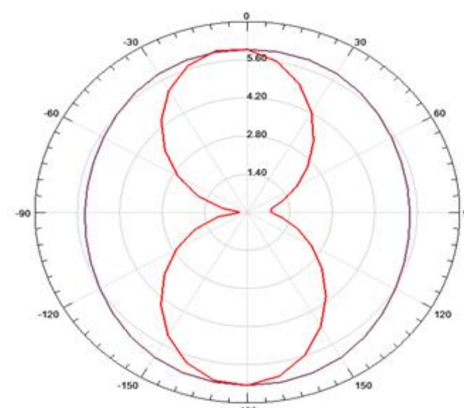

Figure 8. Radiation pattern of antenna 2 at 8 GHz

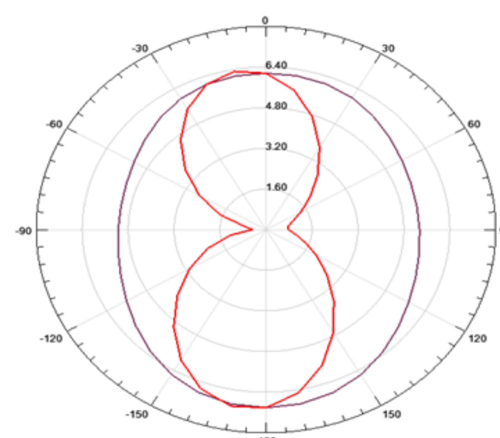

Figure 9. Radiation pattern of antenna 2 at 10 GHz

Table 3. Simulated gain and radiation efficiency of antenna 2

Sr.	Frequency (GHz)	Gain	Radiation efficiency
1	3.1	4.1	90%
2	8	5.60	92%
3	10	6.40	95%

4. Conclusion

To minimize the potential interferences between the UWB system and the narrowband systems, a compact CPW-fed planar UWB antenna with dual rejection bands at WiMAX /WLAN frequencies has been proposed and discussed. The relationship between the total length of the C-shaped slot and the band-rejected operation are observed. Stable radiation patterns and constant gain in the UWB band are obtained. Performing parametric study on the length and width of radiating element bandwidth and gain enhancement are achieved. The simulation results of the proposed antenna show a good agreement in term of the VSWR, antenna gain and radiation patterns. Accordingly, the proposed antenna is expected to be a good candidate in various UWB applications.

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