A Novel Thin-Film UWB Antennas with Single or Dual Band-Notched Performances

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Abstract

In this paper, we present a novel thin-film ultra-wideband (UWB) antennas with single or dual-band notched characteristics. A CPW-fed rectangular patch with a fork-like tuning stub radiates through a rectangular aperture, which ensures UWB impedance matching from 3.1 GHz to 10.6 GHz. In order to avoid interference with WiMAX applications at 3.3-3.7 GHz and WLAN applications at 5.1-5.8 GHz, the antenna is slightly modified to reject undesired band. A U-like slot ,and rectangular slot are etched on the ground plane at the notch frequencies. The designed antennas have a small size of 34.5×27.3 mm^2 and thickness 0.3 mm. The VSWR, gain, and radiation patterns of the fabricated antennas are presented. A prototype was fabricated and measured, and the obtained experimental results agree with simulations.

Keywords : UWB antennas Single or Dual band-notched Thin-film U-like slot, and rectangular slot

1. Introduction

Federal Communications Commission (FCC),2002 was allocation of frequency band from 3.1 to10.6 GHz for ultra-wideband (UWB) approved rules for the commercial use. The UWB frequency band are existing wireless local area network (WLAN) bands such as the 5.2 GHz(5150–5350 MHz) and 5.8 GHz (5725–5825 MHz) bands and Worldwide Interoperability of Microwave Access (WiMAX) system from 3.3-3.7 GHz which might interfere with UWB operations [1]-[3]. In order to avoid interference among these bands, UWB system with frequency rejected function is desirable instead of using band-notched filter circuitry. In particular, the antenna of ultra-wide bandwidth is the key component of the UWB system and has attracted significant research power in the past few years. Challenges of the feasible UWB antenna design include the ultra-wideband performances of the impedance matching and notch frequency response, the compact appearance of the antenna size. The planar UWB antenna designs in the recent literature. The advantages of slot antennas include wide bandwidth performance and a fork-like stub for excitation such that a broad bandwidth can be achieved [4]-[5]. In this paper, the design antennas of using CPW-fed rectangular patch with a fork-like tuning stub which ensures UWB impedance matching from 3.1 GHz to 10.6 GHz. The rectangular slot with first notch frequency response of 5.1 to 5.8 GHz, and The U-like slot with second notch frequency response of 3.3 to 3.7 are proposed. The simulation is conducted using the commercially available Zeland IE3D simulation software. The compact antennas area of 34.5×27.3 mm^2, and thickness 0.3 mm are achieved. Finally, the thin-film UWB antennas with single of dual band-notched at WiMAX/WLAN frequencies are successfully designed, simulated, and measured, show good impedance matching, stable gain and near omnidirectional radiation patterns.

2. UWB Antenna Designs

The antennas were fabricated on Mylar film with the dielectric constant 3.2, thickness of substrate 0.3 mm. In order to reduce the interference from the existing narrow communication systems, the band-notched function is desirable in the UWB system. Three types of thin-film antennas are presented, and their geometries are shown in Fig 1. The first design is UWB antenna by using CPW-fed rectangular patch with a fork-like tuning stub which ensures UWB impedance matching from 3.1 GHz to 10.6 GHz is presented in Fig 1(a). The second design the geometry of UWB antenna with single band-notch by using rectangular slot at first notch frequency response of 5.1 to 5.8 GHz is presented in Fig 1(b). By addition the rectangular slot on the ground plane of UWB antenna. In general, the main aim behind the design methodology of the notch function is to tune the total length of the rectangular slot approximately equal to the half guided wavelength (λg) of the desired notch frequency, which provides the input impedance singular. At the desired notch frequency, the current distribution is around the rectangular shaped slot. Hence, a destructive interference for the excited surface current will occur, which causes the antenna to be non responsive at that frequency. The input impedance closer to the feed point, changes abruptly making large reflections at the required notch frequency. The expression for the length of the rectangular shaped slot for a given notch frequency (f_{n1}) is given by (1)

$$f_{n1} = \frac{c}{2L_{n1}\sqrt{\varepsilon_{eff}}} \tag{1}$$

Figure 1(c) shows the geometry of the UWB antenna with dual band-notch characteristic. By addition U-like slot on ground plate of UWB to obtained second band-notch at 3.3-3.7 GHz are achieved. The expression for the length of the U-like slot for a given notch frequency (f_{n2}) is given by (2)

$$f_{n2} = \frac{c}{(4W_{n2} + 2L_{n2} - 4L_u)\sqrt{\varepsilon_{eff}}} \tag{2}$$

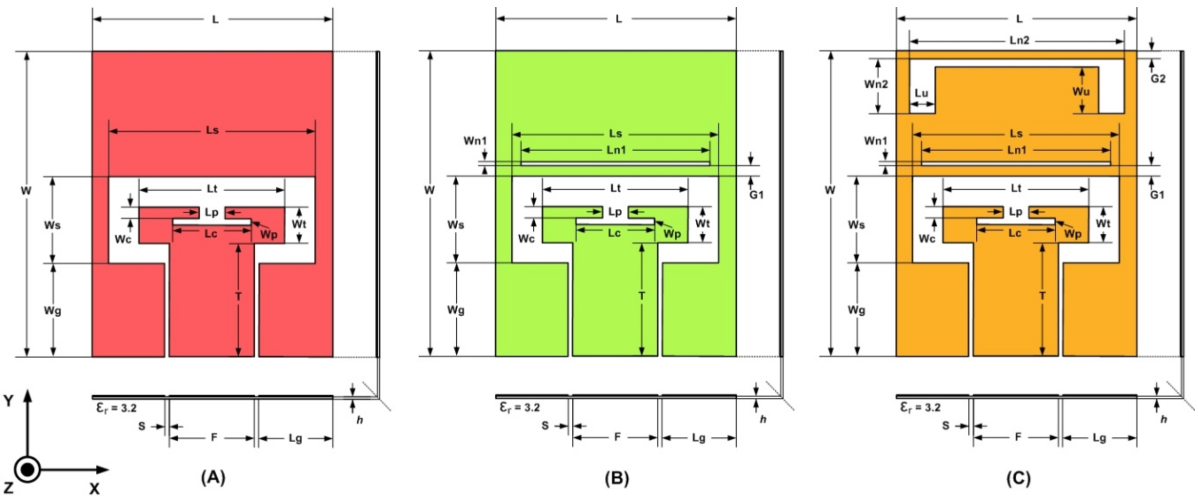

Figure 1.Geometries of the antennas. (a) UWB antenna, (b) UWB antenna with single band-notched and (c) UWB antenna with dual band-notched.

Finally, based on the design rules, an improved UWB antenna with dual band-notched properties in the WiMAX/WLAN bands is successfully designed. The design parameters are *Ws* = 9.8 mm, *Ls* = 23.3 mm, *Wt* = 4 mm, *Lt* = 16.5 mm, *Wc* = 1.2 mm, *Lc* = 9 mm, *Wp* = 0.8 mm, *Lp* = 3 mm, *Wg* = 10.5 mm, *Lg* = 8.3 mm, *T* = 12.7 mm, *F* = 9.7 mm, *S* = 0.5 mm, *G1* = 1.35 mm, *Wn1* = 0.5 mm, *Ln1* = 21.47 mm, *G2* = 0.75 mm, *Wn2* = 6.3 mm, *Wu* = 5.3 mm, *Ln2* = 24.3 mm, *Lu* = 2.75 mm.

3. Result of UWB Antenna

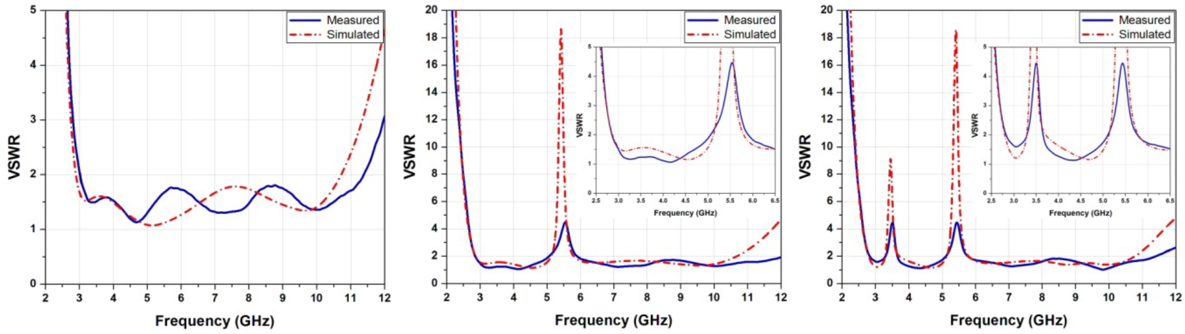

Figure 2. Measured VSWR of the UWB antennas

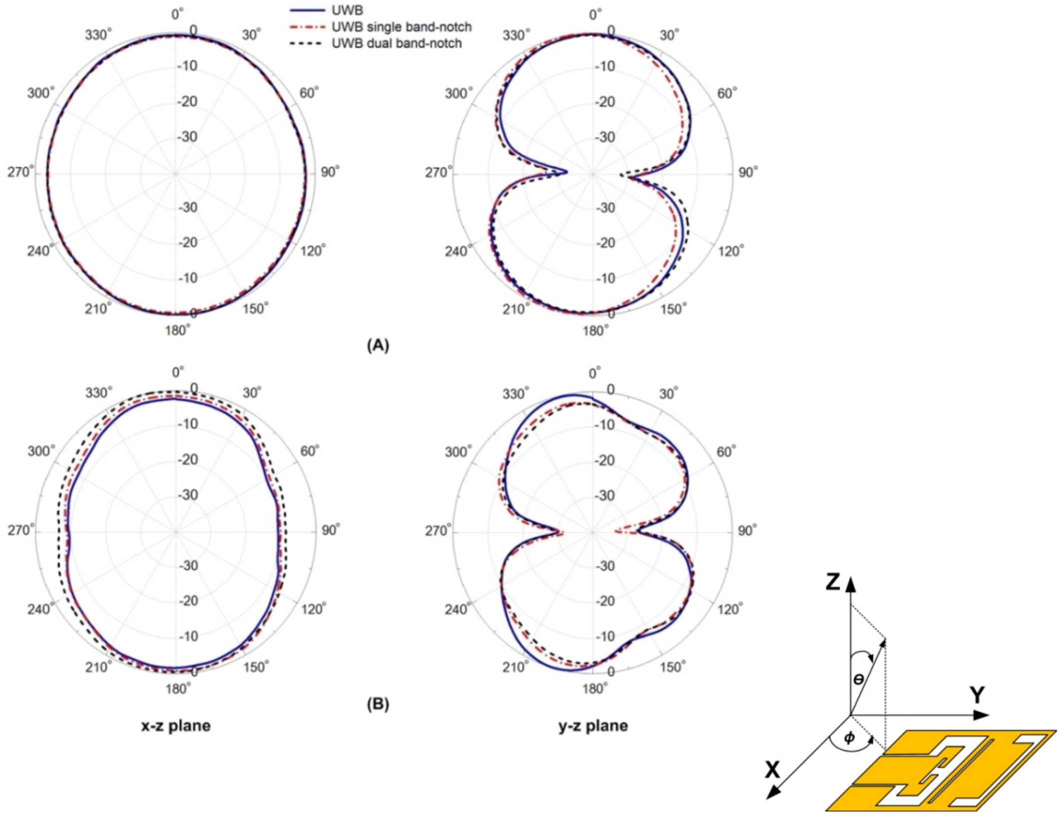

Figure 3. Measured radiation patterns for UWB antenna with dual band-notch
(a) f_1 = 4.5 GHz, (b) f_2 = 7.0 GHz

Figure 2 shows simulated and measured VSWR against frequency for the proposed antenna. Furthermore, the simulated result of a reference antenna without notched characteristics is also shown for comparison. It can be observed that the designed antennas have wideband performance of 3-11.4 GHz for VSWR < 2, covering the entire UWB frequency band with first band-notch of 5.1-5.8 GHz for WLAN, and second band-notched 3.3-3.7 GHz for WiMAX.

The measured radiation patterns of the proposed antennas in the *H*-plane (xz-plane) and *E*-plane (yz-plane) for two different frequencies 4.5 GHz, and 7 GHz are shown in Fig 3. The proposed antennas are characterized by an omnidirectional pattern in the xz-plane while it is a quasi-omnidirectional pattern in the yz-plane. It is obvious from these results that the radiation patterns are acceptable over the UWB bandwidth. Figure 4 shows the measured gain of the proposed antennas. Sharp gain decreases occur in the vicinity of 3.5 and 5.5 GHz bands. However, for the other frequencies outside the rejected band, the antenna gain is nearly constant in the entire UWB band.

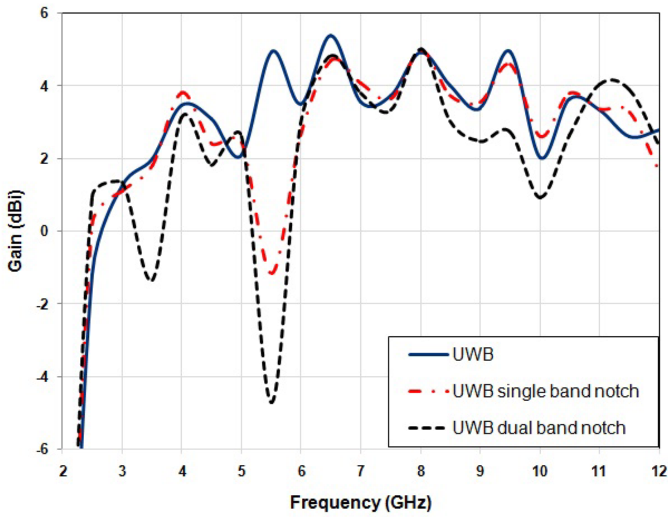

Figure 4. Measured Gain of proposed antennas

4. Conclusion

We proposed single or dual band-notch UWB antenna with using independent controllable rejected band characteristics. The antenna is designed to reduce the ground plane effects by cutting a notch from the radiator. The parametric study showed that the slot length can control the rejected frequency of the band-notch. The proposed first notch of UWB antenna can avoid interference problem for 5.15-5.8 GHz band in simulation, which is corresponding to 5.1–5.8 GHz in measurement. The proposed second notch of UWB antenna can avoid interference problem for 3.3-3.65 GHz band in simulation, which is corresponding to 3.3-3.7 GHz in measurement. Finally, a thin-film UWB antennas are successfully designed, simulated, and measured, showing good impedance matching, stable gain and near omnidirectional radiation patterns. Accordingly, the proposed antennas are expected to be a good candidate in various UWB systems.

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