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Study on bandwidth enhancement techniques of microstrip antenna

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Abstract

In this paper we present a Novel Triangular UWB microstrip antenna which offers an ultra-wide bandwidth (UWB) greater than 8 GHz. This optimum antenna design provides satisfactory gain all over the UWB. The study includes partially truncating the ground plane (defected ground), inserting slits in the triangular radiating patch, and using different substrate materials in order to obtain band-notched UWB. The simulation experiments have been carried out using the IE3D Zeland software. The final antenna design is fabricated on two substrates; FR4 and Droid 5880 (Teflon). The practical measurements well agree with the simulation results.

Keywords: Ultra wideband; Microstrip antenna; Defected ground

1. Introduction

UWB over the commercial frequency band from 3.1 to 10.6 GHz was approved by Federal Communication Commission (FCC) in 2002 (Prasad, 2009). Ultra wideband communication systems became a promising technology offering high performance for both the indoor and outdoor wireless communication systems, which allow high data rate with low cost. UWB technology was applied for radar and remote sensing application (Zhu et al., 2011). The UWB antenna is required to achieve high impedance matching (minimum reflections), stable radiation pattern, and linear phase over the UWB frequency range. There are some other existing narrowband systems, such as WLAN (IEEE802.11a and HIPERLAN/2) system in 5.15–5.825 GHz and WiMAX system in 3.4–3.7 GHz. To avoid possible interference between UWB system and WLAN/WiMAX systems, it is desirable to design UWB antennas with dual notched bands in both 3.4–3.7 GHz and 5–6 GHz. In the last few years, band-notched UWB planar antennas based on various techniques have been proposed (Wang et al., 2008; Gayathri et al., 2008; Chen et al., 2010; Ojaroudi et al., 2009a,b, 2011). Nowadays, the planar printed antenna fed with a microstrip line or a coplanar waveguide (CPW) received much attention due to its high radiation efficiency, compact size and can be easily integrated with other circuits (Gayathri et al., 2008; Dong

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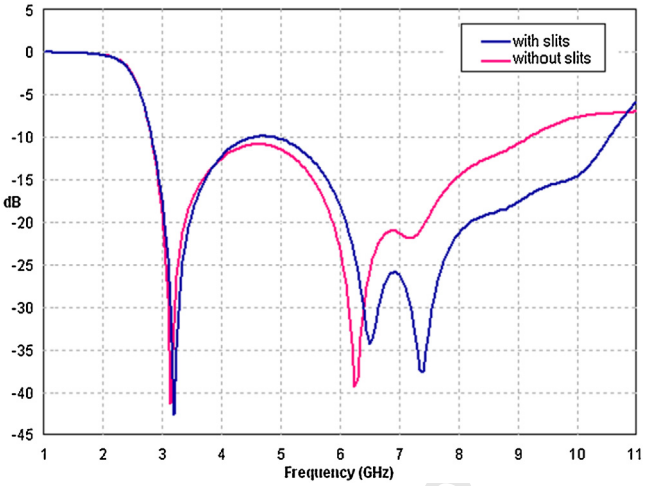

Fig. 1. Return loss of the triangular UWBA with and without a slot and slits with a slot and slits.

et al., 2009; Barbarino and Consoli, 2012). Microstrip UWB antennas are developed in different radiation patches, like fork shape, elliptical shape, square shape, spade shape, circle shape or by making some modifications about the radiating patch (Nikolaou et al., 2009; Dong et al., 2009; Barbarino and Consoli, 2012; Abdelraheem et al., 2013). In this work the UWB antenna is studied using triangular monopole patch. To accomplish our target, we have attempted three approaches of the UWB techniques, these are triangular Patch With Coplanar Feed, triangular UWB Microstrip Antenna with slits and triangular Patch with Defected Ground.

2. Coplanar fed triangular patch

The antenna consists of a triangular patch as the main radiator printed on an FR4 Substrate with dielectric constant $\varepsilon_r = 4.4$ and height $h = 1.6$ mm, and fed with a 50 Ω Coplanar feed line. Simulation results show (Fig. 1) that the antenna provides an UWB of 7.2 GHz from 2.8 to 10 GHz with an average directivity and gain of 5 and 3 dBi respectively.

3. Triangular uwb microstrip antenna with a slot and slits

As shown in Fig. 2, the antenna is printed on FR4 substrate and fed with a 50 Ω coplanar feed line. The simulation results (Fig. 1) show that embedding the slot and the slits in the triangular resonator increase the upper frequency bound resulting in a total bandwidth of 8.3 GHz. The overall bandwidth increased by almost 1.1 GHz and the return loss ($S_{1,1}$) has decreased substantially compared to the original proposed antenna with enhanced antenna gain and directivity. Figs. 3 and 4 illustrate the current distribution and the radiation patterns at different resonant values, while Fig. 5 shows a comparison between simulated and measured results when the substrate is Duriod 5880 ($\varepsilon_r = 2.2$, $h = 1.5748$).

4. Triangular patch with defected ground

The deployment of a defected ground creates additional resonance which in turn increases the overall bandwidth. The lower and upper frequency limits are shifted towards the higher frequency ranges. The bandwidth is divided into four frequency bands with two rejected bands as follows:

First band $F_l = 3.7$, $F_h = 4.662$, B.W. = 962 MHz, average directivity of 3.5 dBi, second band $F_l = 6.098$, $F_h = 7.205$, B.W. = 1.107 GHz, average directivity 6.5 dBi, third band $F_l = 8.05328$, $F_h = 8.76639$, B.W. = 713 MHz average directivity 7 dBi, fourth band $F_l = 11.3115$, $F_h = 11.9877$, B.W. = 676 MHz, average directivity 8.2 dBi, two rejected bands at WiMAX and WLAN regions. The gain is almost uniform over all the bands. Figs. 6 and 7 illustrate the current distribution and radiation patterns at different frequencies.

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