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Triple band notch UWB printed monopole antenna with enhanced bandwidth

Pritam S. Bakariya*, Santanu Dwari, Manas Sarkar

Department of Electronics Engineering, Indian School of Mines, Dhanbad, Jharkhand 826004, India

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ABSTRACT

In this paper, a compact triple band-notched ultra-wideband (UWB) printed monopole antenna is proposed with enhanced bandwidth. It exhibits a stable omnidirectional radiation pattern and a dipole-like pattern in the H-plane and E-plane, respectively, for the entire UWB. The antenna consists of a rectangular patch with two bevels. To realize notch characteristics in WiMax (3.3–3.7 GHz) and WLAN (5.15–5.85 GHz) band, two round shaped slots of half wavelength are inserted in radiating patch. The rectangular ground plane has two bevels in upper edge to enhance bandwidth which cover the frequency range from 3 to 15 GHz. The two bevels also help in getting impedance matching especially beyond 10.6 GHz. A pair of C-shaped slots is etched in ground plane to get a third notch in X-band satellite communication band (7.1–7.76 GHz). The effects of each individual slot on band notch characteristics are also investigated. The proposed antenna exhibits stable gain throughout the UWB and it also has a very good capability to suppress gain at notched band. Moreover, the designed antenna has a compact size of 31 mm × 22 mm.

1. Introduction

With the development of the modern communication, ultra-wideband (UWB) technology has drawn wide interest from the researcher for increasing the data rate in wireless communication, since the Federal Communications Commission (FCC) released 3.1–10.6 GHz as an unlicensed band for radio communication [1]. Being an essential part of an UWB system, the UWB antenna has been paid more and more attention. Recently, due to many attractive features like the low profile, light weight, and low cost, printed monopole antennas are the most frequently used antennas for UWB applications. The Federal Communications Commission permitted very low power emission level to UWB communication systems operating in 3.1–10.6 GHz which is easily interfered by the nearby communication systems such as WiMax communication system operating at 3.5 GHz (3300–3690 MHz), WLAN system operating at 5.2 GHz (5150–5350 MHz) and 5.8 GHz (5725–5875 MHz), and X-band downlink communication frequency operating at 7.5 GHz (7100–7760 MHz). The interferences of these narrowband communication systems with UWB systems can be avoided by using the band stop filer. But it will increase size, cost, and complexity of the system. So, the better way to avoid interference is using UWB antenna having band notch characteristic within itself.

In recent years, many techniques have been proposed to design notched band antennas. The most general method to create notch is to insert slits or slots on the patch or on the ground plane, i.e., elliptical/circular slot [2,3], and rectangle slot [4]. Another technique to achieve band-notched function is to add parasitic elements [5,6]. A split ring resonator (SRR) type slot has been etched on the patch to obtain notch characteristic at WiMax and WLAN [7]. In [8], an electromagnetic bandgap structure is used to create a band notch characteristic. In [9,10], a printed slot antenna fed by coplanar waveguide (CPW) and microstrip line with multiband rejection characteristics is proposed. A UWB antenna with a W-shaped parasitic strip and T-shaped slot to generate dual notched band has been proposed in [11]. A simple microstrip line fed UWB patch antenna has been presented to achieve the triple band-notched characteristics using Closed-Loop Ring Resonators [12]. Also, many other techniques have been proposed to create a triple band notch in [13–17].

However, it is still an interesting task for researchers to design an ultra-wideband antenna with multiple notched-bands without degrading the performance of the antenna. One challenging task for designer of multi-band notched antenna is to minimize fabrication cost and the mutual coupling of parasitic strips and slots because of small area available for them within the antenna. The coupling effect increases with closeness of two notched

* Corresponding author. Tel.: +91 9905896998.
E-mail addresses: pritam.gs@gmail.com (P.S. Bakariya), sdwari@gmail.com (S. Dwari), mns_sarcar@yahoo.com (M. Sarkar).

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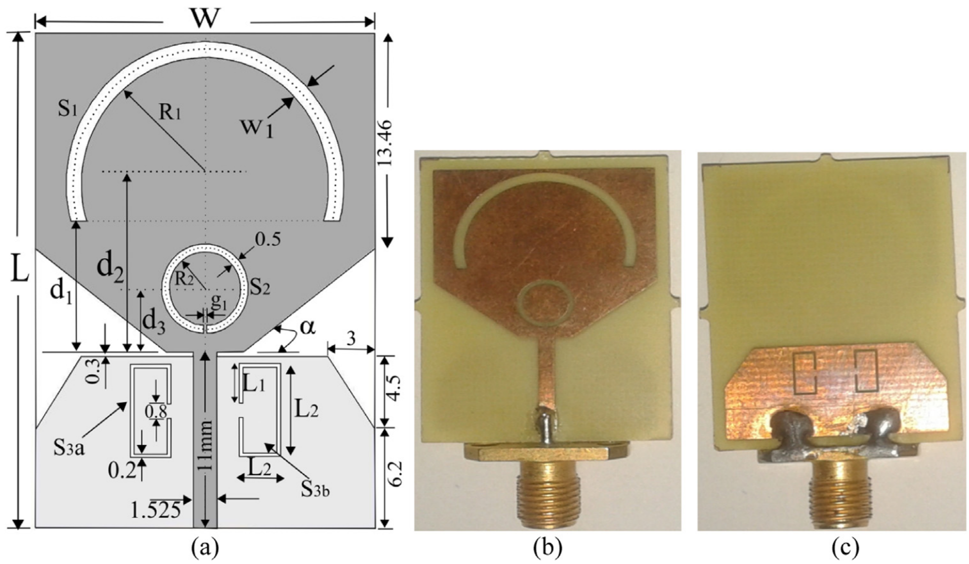

Fig. 1. Layout of proposed UWB antenna. (a) Schematic diagram; (b) front view of fabricated antenna; (c) bottom view.

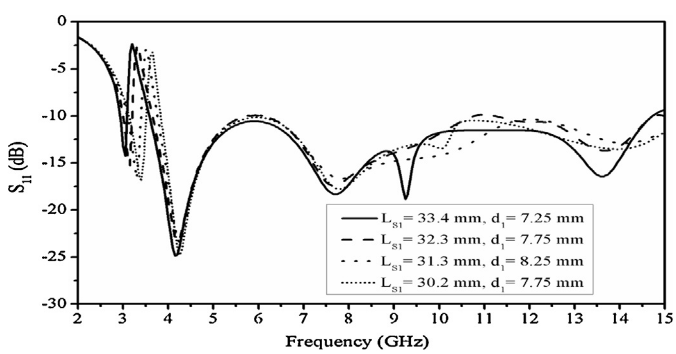

Fig. 2. Length optimization of slot S_1 by changing d_1.

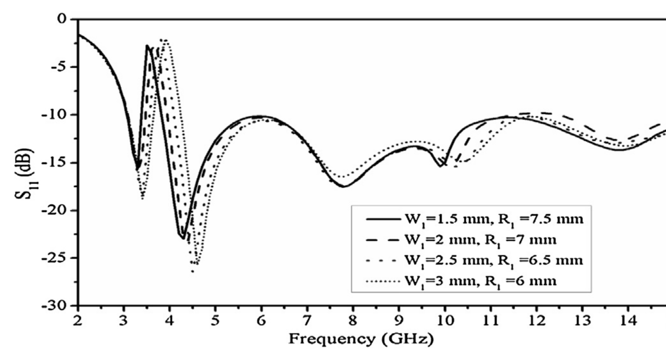

Fig. 3. Width optimization of slot S_1 by changing R_1.

frequencies due to which it requires more time for succeeding antenna design goals. For the designer of UWB antenna with band-notch characteristic, it is needed to investigate novel antennas which are compact in size, planar and easy in fabrication. The antenna should have good performance in terms of bandwidth, radiation patterns, and gain. It should also have independent control over each notch band.

In this paper, a rectangular monopole antenna with a triple band-notched characteristic is presented. Two bevels in lower edge of patch and two bevels in upper edge of ground plane are introduced to increase the impedance bandwidth which covers 3–15 GHz. Additionally, this antenna has a triple band reject characteristics at WiMax band, WLAN band, and X-band downlink band. The antenna shows a stable omnidirectional radiation pattern and a dipole-like pattern in the H-plane and E-plane, respectively, for the entire UWB.

2. Antenna design

The geometry and configuration of the proposed antenna are shown in Fig. 1. The antenna is fed by a 50-Ω microstrip line. The antenna is realized on FR4 substrate of 0.8 mm thickness with a dielectric constant of 4.4 and loss tangent of 0.02. The antenna has a compact size of 31 mm × 22 mm. The antenna is composed of a planar radiating patch with two round slots S_1 and S_2 and two bevels in lower edge of radiating patch. A modified planer rectangular ground plane has a pair of C-shaped slots and two bevels in upper edge. The two bevels in the ground plane are introduced to increase the impedance bandwidth which can be controlled by adjusting the dimension of the ground bevels. The simulation was performed using commercial software Ansoft HFSS 14 to optimize the parameters shown in Fig. 1. In order to optimize final design, several aspects were considered like impedance bandwidth, the bandwidth of the notched bands and the level of band rejection at notched frequency. The optimal antenna parameters are obtained as follows: $L = 31$ mm, $W = 22$ mm, $d_1 = 8.25$ mm, $d_2 = 10.5$ mm, $d_3 = 4$ mm, $W_1 = 1$ mm, $W_2 = 0.5$ mm, $R_1 = 8$ mm,

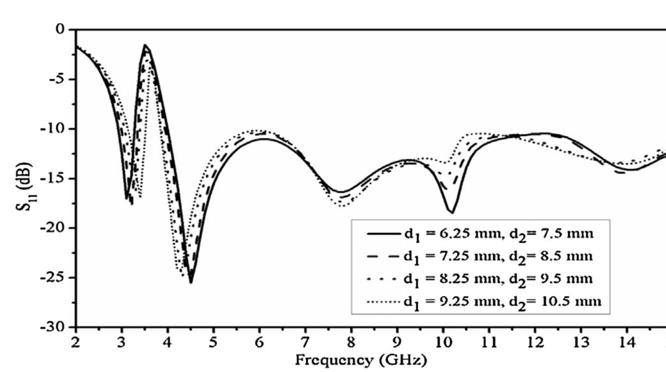

Fig. 4. Position optimization of slot S_1 by changing d_1 and d_2.