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Slot loaded UWB antenna: Dual band notched characteristics

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ABSTRACT

This paper introduces a slot loaded CPW feed ultrawideband (UWB) printed monopole antenna (PMA) with dual band-notched characteristics. The antenna uses three rectangular slots to create dual band-notched characteristics in 5.15–5.82 GHz for WLAN, and 7.25–8.39 GHz for uplink and downlink of X-band satellite communication systems, respectively. The proposed antenna has the novel suitability to utilize it for both uplink and downlink satellite communication band notching applications. The proposed UWB antenna has a compact size of 26 × 30 mm^2 and it operates over 3.15 to 10.63 GHz with VSWR < 2. Details of the proposed antenna have been presented along with measured and simulated results.

1. Introduction

WIRELESS communication is the integral part of today's communication scenario and becomes necessity for a long time. Due to cost effective characteristics it receives great attention by the people from academics and industries when federal communication commission (FCC) declared unlicensed radio frequency band 3.1–10.6 GHz for commercial use [1]. Microstrip monopole antennas have attractive merits such as compact size, low cost, ease of fabrication, wide impedance bandwidth and good omnidirectional radiation that makes it favorite for UWB applications [2]. In recent years researchers have improved the various challenges of UWB antennas like, impedance bandwidth, radiation patterns, matching characteristics and size of the antenna. UWB systems have disadvantage that they are very sensitive to electromagnetic interferences with existing narrowband wireless communication systems, so it is necessary to design antennas with multiband filtering characteristics to avoid interferences. UWB includes sub narrowband applications like WiMAX operating in 3.3–3.6 GHz band, C band (3.8–4.2 GHz), WLAN (5.15–5.82 GHz) band and X band satellite communication system operating in 7.25–8.39 GHz band. These bands could be rejected with bandstop filters, but this approach will increase the complexity, cost, size and weight of the system. To resolve these problems alternative methods of band notching have been suggested.

Earlier different methods like, different types of slot on the radiating patch or on the ground plane, split-ring resonators, tuning stubs, meandering, folded strips, electromagnetic band gap (EBG) structure etching on patch/ground plane have been proposed and presented to design UWB antenna with band notch characteristics [3–19]. For example, etching of U slot [3,4], V-shaped slot [5], C-shaped slot [6], S-shaped slot in feed line [7], a quasi-complementary split ring resonator (CSRR) in feed line [8], a quarter-wavelength tuning stub in a large slot on the patch [9], or compact folded stepped impedance resonators (SIRs) or capacitively loaded loop (CCL) resonators in feed [10,11], a parasitic slit along with tuning stub used [12], C shaped slot on patch and L shaped stub on ground [13], semi-circular slot on patch [14], open ended rectangular slots on patch [15].

In this paper, we have proposed a compact CPW feed UWB planar monopole antenna with dual notched bands for 5.15–5.82 GHz band (WLAN) and 7.25–8.39 GHz band (X-band satellite communication). Proposed antenna shows novelty as there is no need to design complex slots on patch/ground or other conventional methods to create notch for X-band satellite communication as in [8,14–19].

Table 1 shows some useful details about the recently proposed printed UWB band notched antennas. Many of the proposed configurations occupy more overall size than antenna presented in this paper and/or fail to create dual notch to reject whole X-band communication (uplink and downlink).

2. Antenna design and analysis

The geometry and configuration of the proposed antenna has been simulated and optimized using Ansoft HFSS 13 and is shown in Fig. 1. This antenna is printed on the FR 4 substrate with thickness of 1.6 mm, dielectric constant of $\varepsilon_r = 4.4$, and loss tangent of 0.02. A CPW feeding with width of the microstrip feed line is 3.00 mm has been used to achieve 50-Ω characteristic impedance. Ground with tapered edge and three rectangular slots have been cut on radiating patch namely S_1, S_2 and S_3 to achieve dual notch at WLAN

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Table 1
Antenna with x-band (satellite) created notches.

Ref.	Size (mm^3)	BW (GHz)	X-band
[6]	$26 \times 30 \times 1.6$	3.1–10.6	Not
[7]	$30 \times 46 \times 0.635$	2.67–12	Not
[8]	$46.4 \times 38.5 \times 1$	2–12.5	Down link
[9]	$24 \times 36 \times 1.524$	3–12	Not
[10]	25×33 mm^2	3.07–10.61	Not
[11]	$27 \times 34 \times 0.787$	3–10.8	Not
[14]	$25 \times 29 \times 0.8$	3–10	Down link
[15]	$19 \times 24 \times 1.2$	2.45–10.65	Down link
[16]	$23 \times 33 \times 0.813$	2–11	Down link
[17]	$26 \times 31.8 \times 1.6$	2.45–12	Up/down link
[18]	$22 \times 32 \times 1.6$	2.83–10.38	Down link
[19]	$30 \times 35 \times 1.6$	3.34–11.37	Up/down link
Proposed	$26 \times 30 \times 1.6$	3.1–10.6	Up/down link

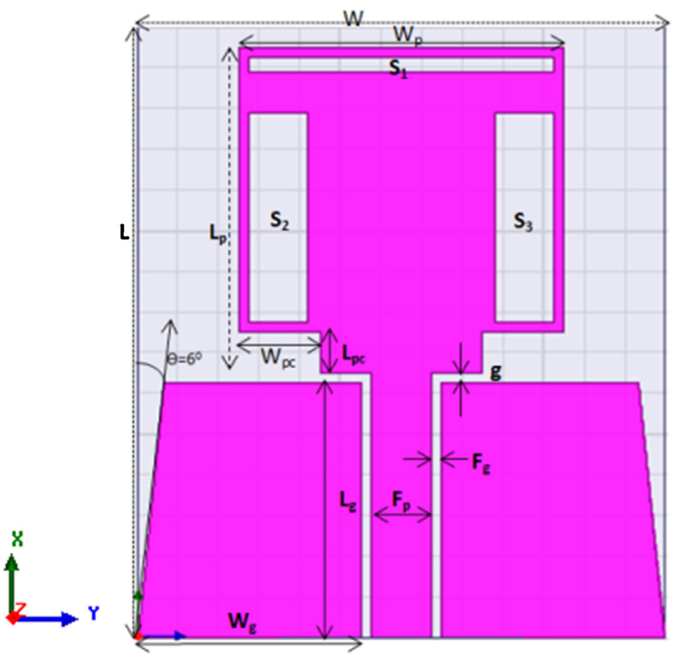

Fig. 1. Design and configuration of UWB dual notch antenna.

Table 2
Optimized dimensions of proposed antenna.

	W	L	W_p	L_p	W_g	L_g
mm	26	30	16	16	11	12.5

	F_p	F_g	W_{pc}	L_{pc}	S_1		S_2		S_3	
					S_{w1}	S_{L1}	S_{w2}	S_{L2}	S_{w3}	S_{L3}
mm	3	0.5	4	2	15	0.75	2.85	10.25	2.85	10.25

and X band respectively. Slots S_2 and S_3 are symmetrical and have been equal dimensions, which provide the notch at X band satellite communication. Slot S_1 provides notch of 5.18–5.82 GHz for WLANs application. The length of the slots at the center frequency of the notched band has been calculated by following Eq. (1) [13].

$$L = \frac{C}{2f\sqrt{(\varepsilon_r + 1)/2}} \quad (1)$$

Here, C is the speed of the light, ε_r is the dielectric constant, f is the center frequency of the notched band and L is the length of the slot.

According to the Eq. (1), the calculated length of the slot S_1 is L_{w1} = 16.33 mm and the optimized practical length of the slot S_1 is 15 mm to create notch at WLAN band. The same equation

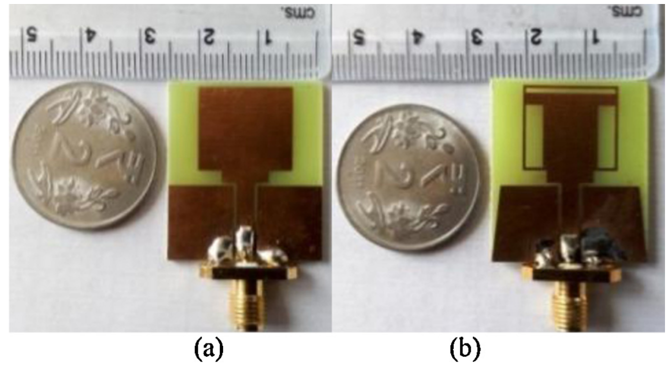

Fig. 2. Fabricated design of UWB antenna. (a) Primary design and (b) Proposed design with two notch bands.

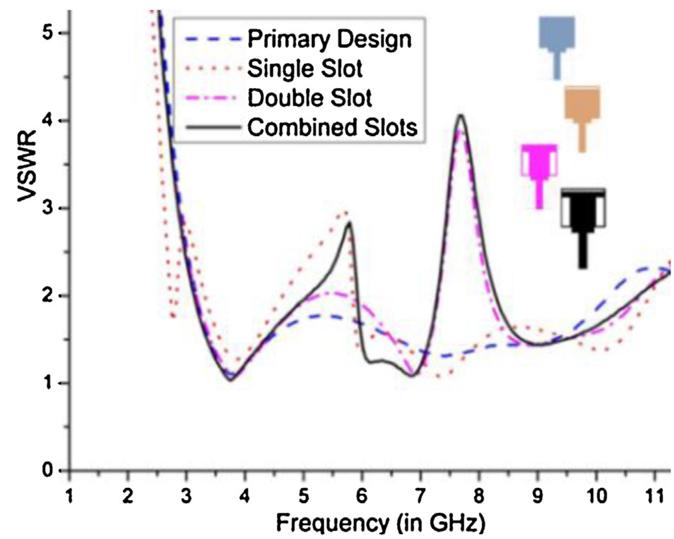

Fig. 3. VSWR due to slots.

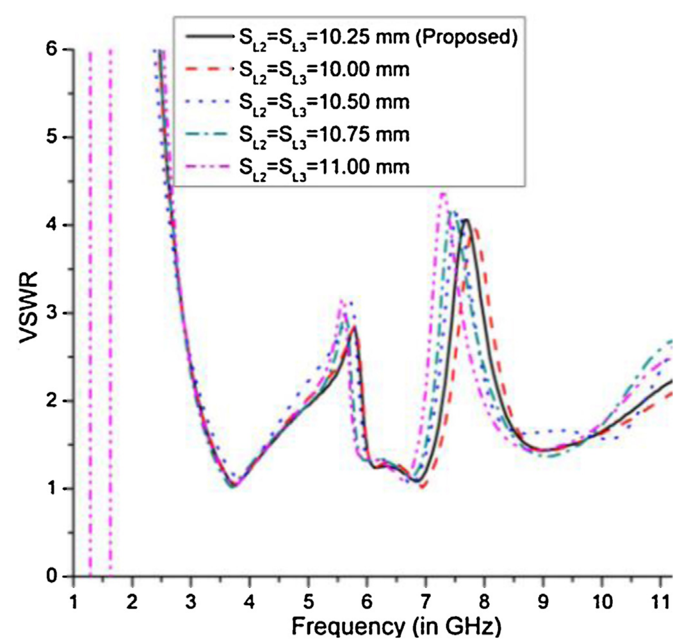

Fig. 4. VSWR variation in optimization of slots S_{L2} and S_{L3}.