Compact ultra-wideband antenna with band-notched based on defected ground structure

Reza Karimian, Hamed Tadayon

EE department, Iran University of Science and Technology (IUST), Tehran 1684613114, Iran
E-mail: reza.bahnemiri@gmail.com; rezakarimian@elec.iust.ac.ir

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Abstract: A simple and very compact planar monopole ultra-wideband antenna with a 3.5 GHz band rejection is proposed in this Letter. The compact antenna is etched on an FR4 substrate with the size of 14 × 16 × 1 mm^3, consists of a tree-shaped radiation patch with modified ground structure. To reject certain frequency band, a pair of parallel strip patch, acting as a parasitic element is used. Prototype of the proposed antenna was constructed and measured. The measured impedance bandwidth of the realised antenna with optimal parameters is from 2.6 to 12 GHz (128%) for voltage standing wave ratio <2 with an unwanted band notched from 3.3 to 4 GHz. Moreover, the antenna has good omnidirectional radiation patterns in the *H*-plane.

1 Introduction

Since the approval by the Federal Communication Commission of a 3.1–10.6 GHz frequency band allocation to the ultra-wideband (UWB) radio technology, there have been considerable research efforts dedicated to this promising technology worldwide. However, there are several narrowband wireless systems with work bands below 10 GHz, such as IEEE 802.16 worldwide interoperability for microwave access system operating at 3.3–3.7 GHz, which may cause severe electromagnetic interference to the UWB systems. Therefore it is desirable to design UWB antennas with band-notched performance in those frequency bands to avoid potential interference.

Therefore many techniques are implemented to achieve band-notched function in the literature on band-notched antennas. The widely used methods are etching slots on the patch or on the ground plane, that is, such as an open-ended L-shaped slot [1] and a C-shaped slot [2]. Introducing parasitic strips near the radiation elements or the ground plane is another way to create notched bands [3]. A slot-type split ring resonator has been etched on the patch to obtain a good performance [4]. In [5], an UWB antenna with band-notched characteristics has been realised by using a tuning stub. An UWB antenna with a folded strip to generate a notched band has been proposed in [6]. In this Letter, a novel and compact ultra-wideband printed monopole antenna with a band-notched performance for UWB application is proposed. The antenna consists of a tree-shaped radiation patch, a modified ground plane. The notched frequency is determined by the microstrip resonator under the radiation patch which coupled electromagnetic waves at the notched frequency to the ground plane. This resonator acts like a parasitic element.

2 Antenna geometry and design

Fig. 1 shows the geometry and configuration of the proposed antenna and a photograph of some fabricated prototypes. This antenna is fabricated on FR-4 substrate with relative dielectric constant of $\varepsilon_r = 4.4$ and thickness of $h = 1$ mm. The radiation monopole and feeding mechanism are printed on the top side of the substrate, whereas the ground plane is printed on the bottom side. The size of the proposed antenna is only 14 × 16 × 1 mm^3.

There is a sharp and sudden discontinuity in the connection point between the microstrip-fed-line and the patch, if the fed-line connects to a simple square patch. This may be a significant factor for lowering the bandwidth and degrading the radiation performance at the higher frequencies. To mitigate the problem, we try to obtain a balance between the vertical and horizontal surface currents on the patch.

In this Letter, a modified ground plane structure is employed to achieve the desired ultra-wide bandwidth operation as well. As it can be seen in Fig. 1*b*, the truncated ground plane comprises a trapezoid notched-centred under the feed-line in the vicinity of the patch, and the truncated edge side acts as an impedance matching element. Since the truncation creates a capacitive load that

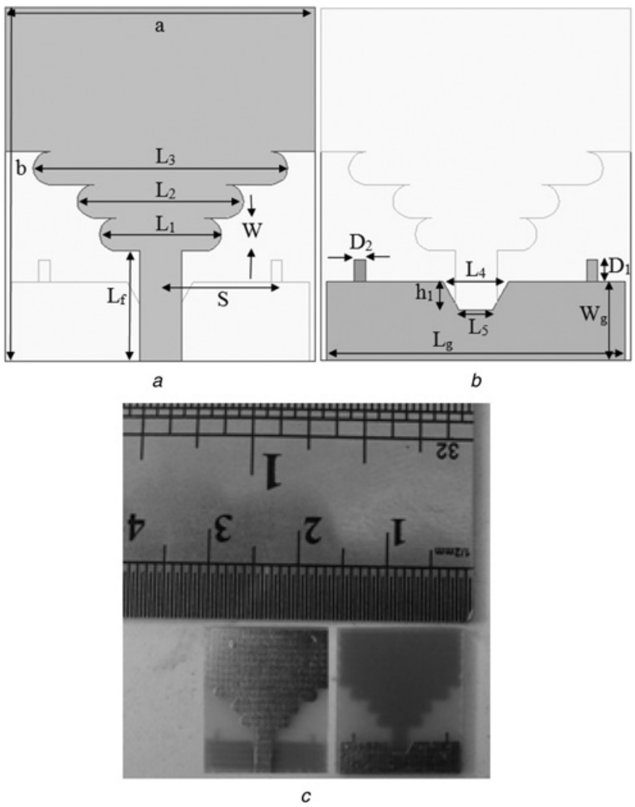

Fig. 1 *Geometry of the the proposed band-notched UWB antenna*
a Front view
b Bottom view
c Photograph of fabricated antenna

Table 1 Dimensions of the the proposed antenna

a	b	L_1	L_2	L_3	L_4	L_5	L_f	W	S	D_1	D_2	L_g	W_g	h_1
14	16	5.5	7.5	11.5	3	1.5	5	1.5	5.25	1	0.5	13.5	3.6	1.3

Unit: mm.

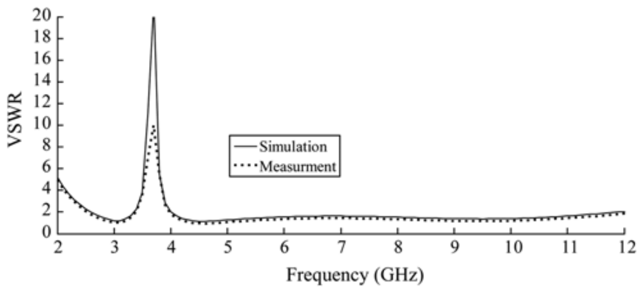

Fig. 2 *Simulated and measured VSWR characteristics of the proposed antenna*

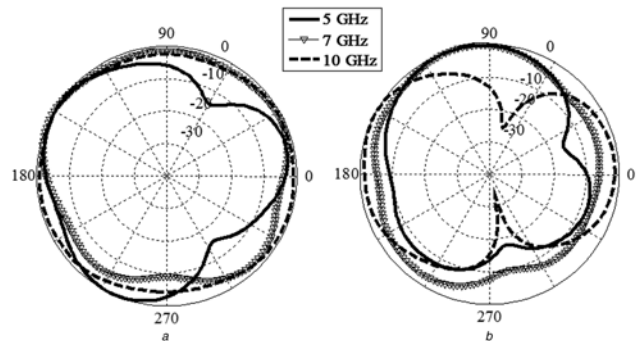

Fig. 3 *Radiation patterns of the proposed antenna*
a H-plane
b E-plane

neutralises the inductive nature of the patch to produce nearly pure resistive impedance.

The rejected frequency at 3.5 GHz is realised by etching a pair of branches into the modified ground plane. This microstrip resonator, acting like parasitic elements, are placed on the opposite side of the planar monopole antenna and coupled to a return signal on the ground (imaging part) of the planar monopole antenna.

By fixing optimum parameters of the proposed antenna, good impedance matching through the operation wideband can be achieved. Table 1 summarises the dimensions of the proposed antenna.

3 Results and discussion

The proposed antenna has been analysed and optimised by Ansoft high-frequency structure simulator, which is based on the finite element technique. The antenna was measured in an anechoic chamber using and E8361C vector network analyser. Fig. 2 shows simulated and measured voltage standing wave ratio (VSWR) against frequency for the proposed antenna. It is observed from Fig. 2 that the measured impedance bandwidth (VSWR $\leq$ 2) of the proposed antenna is from 2.9 to 12 GHz, covering the entire UWB frequency band with notched bands of 3.3–4 GHz. The measured results are in good agreement with those of the simulation. The discrepancy in VSWR between simulated and measured results should be mostly attributed to the loss tangent tan δ of the FR4 substrate, influence of the feeding cable and inaccuracies in the fabrication process. Fig. 3 shows the measured radiation patterns for 5, 7, and 10 GHz. For brevity, only the co-polarisation field is shown here. It can be observed that the *H*-plane radiation patterns are almost omnidirectional and the *E*-plane patterns are monopole like.

4 Conclusion

To avoid potential interference between the UWB system and narrowband systems, a compact band-notched UWB antenna is proposed and discussed in this Letter. The notched band is achieved by using parasitic element resonator on the bottom side of the tree-shaped radiation patch. By using some curves and modified ground plane, a bandwidth of wider than 2.6–12 GHz is achieved. Measured result show that the proposed antenna guarantees the desired frequency bandwidth with band notched and keeps omnidirectional radiation performance successfully.

5 References

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