A Compact Complementary Split Ring Resonator-Based Notch Design for Wireless Access for Vehicular Environment/WLAN/ITU Band Application

Sanmugasundaram Ravichandran, Natarajan Somasundaram, and Rajkumar Rengasamy

Abstract A compact ultra-wideband (UWB) dual notch band antenna is presented. The proposed antenna possesses staircase typed radiating patch with half a ground, rectangular- and square-shaped complementary split ring resonators (CSRR) which are used for realizing ultra-wideband performance and filtering effects in the antenna structure, respectively. Filtering structure has a small size of $32 \times 20 \times 1.6\ mm^3$, and notching frequencies are obtained at 5.8/5.9 GHz and 8.3 GHz in the ultra-wideband region. Antenna has better reflection coefficient performance from 3.1 to 14 GHz and with filtering effect. Further, it has better radiation characteristics in the desired frequency bands.

Keywords Notch · Ultra-wideband · Compact · Complementary split ring resonator · WLAN · WAVE · ITU

1 Introduction

In modern wireless communication scenario, ultra-wideband communication has become famous one because of its unlicensed wideband frequency from 3.1 to 10.6 GHz allotted by FCC [1]. UWB technique meant for high bandwidth and it covers large wireless communication spectrum. It has average speed of 100 Mbps to 1 Gbps speed; due to this, many researchers have interest on this working area [2, 3]. Though UWB has quit advantages, it has issue of interference with short communication wireless applications such as 3.5 GHz IEEE 802.16 (WiMAX), 5.2/5.8 GHz IEEE 802.11 a (WLAN) and 8 GHz ITU band. Here, intention to design a compact notch band antenna and it address avoiding the interference in short wireless communications. The stop band filtering effect is realized using various methods such as

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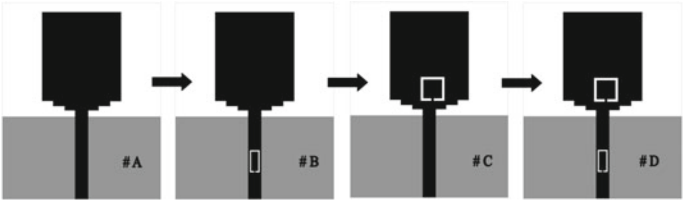


Fig. 1 Development stages of proposed multiband antenna

employing slots in radiating element, ground plane of antenna, introducing slits, embedding the resonators are discussed [4–16]. The single band notch antennas are achieved in [4–7]. The U-shaped slot was embedded to realize notch band performance but only one notch band was achieved [4]. In [5], antenna was designed to suppress unwanted WiMAX application using DGS structures. A compact notch antenna was designed using W-shaped slot in the ground plane with hooked shaped resonator [6]; though antenna has compact structure, it notches only one frequency. In order to cover various wireless applications in a single antenna, dual notch band antennas are used [7–10]. A UWB-based dual notch band antenna was achieved by using DGS structures in [8] but it requires multi-layer structures. A dual notch band antenna was proposed using electromagnetic band gap structures [9, 10]. To achieve more compact-based antennas metamaterial designs can be used by using we can realize gain enhancement, compact size, harmonic reduction and multiband performance [11–13]. Similarly, to realize notch band performance, CSRR/SRR structures were used [14–16]. The above antenna designs were achieved dual notch band performance using metamaterial technique. Here, SRR/CSRR was embedded top/bottom of the substrate of the antenna design.

A coplanar waveguide fed complementary split ring resonator-based notch band antenna is proposed. Antenna consists of two single CSRR structures, one is embedded in feed line and another one in radiating element to achieve the dual notch band antenna performance. It is effectively filtering out 5.8/5.9 GHz (WAVE/WLAN/ITU) and 8 GHz ITU band, respectively. Further, antenna design has decent radiation characteristics in the preferred frequencies expect notch band regions (Figs. 1 and 4).

2 Proposed Antenna Configuration

The proposed ultra-wideband antenna has a small dimension of $32 \times 20 \times 1.6$ mm^3 which is designed commercially available FR4 substrate of thickness 1.6 mm (Fig. 2).

The antenna is fed with 50-Ω conventional microstrip feeding with a semi grounded plane. The microstrip has feed length (F_L) and width (F_w) of 14.5 mm and 2.2 mm, respectively. The model of proposed antenna is shown in Fig. 3.

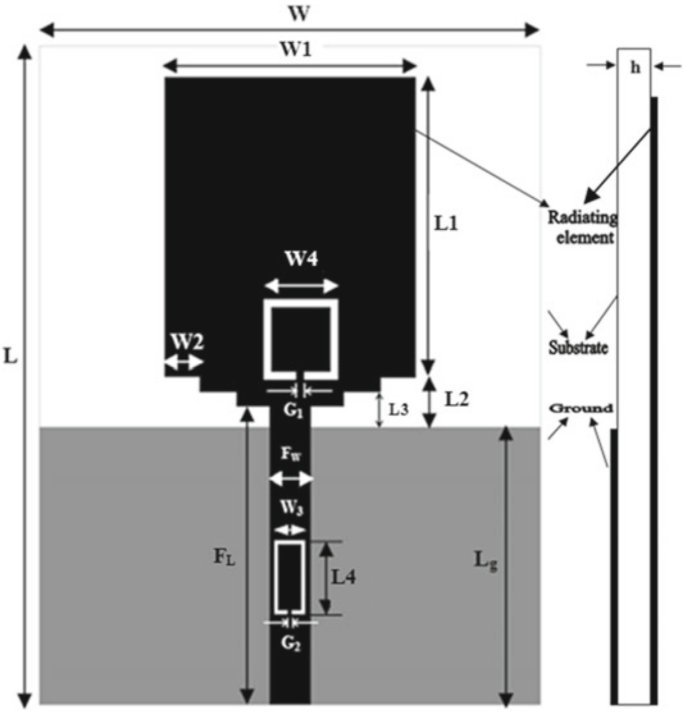


Fig. 2 Geometry of the proposed antenna

Fig. 3 Prototype of dual notch band antenna

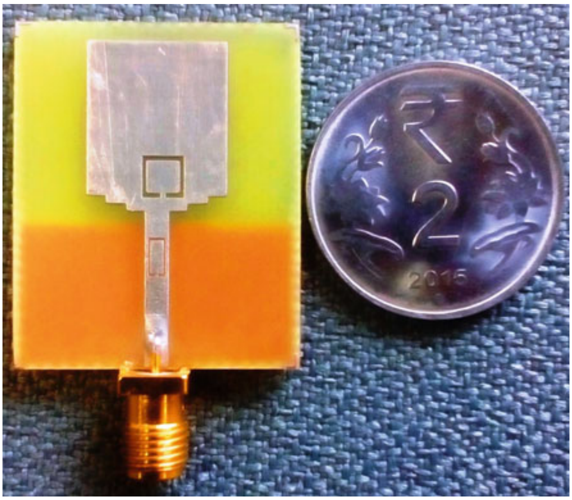


Table 1 Dual notch antenna parameters and dimensions

L	W	L_g	F_L	F_w	W_3	L_4
32	20	13.5	14.5	2.2	1.6	3.6
L_1	L_3	L_2	W_1	W_2	L_3	L_4
14.6	1.7	2.4	13	1.8		3.6
G_1	G_2	W_3	W_4			
0.4	0.2	1.6	3.9			

The dual notch antenna has compact structure by which it has achieved number of notch band performance effectively at 5.8/5.9 and 8.3 GHz. The proposed filtering antenna dimensions are given in Table 1.

3 Results and Discussion

The simulation of dual notch band antenna is completed using high frequency structural simulator (HFSS) V.16.0. The microstrip fed half a grounded antenna (#A) is designed such a way to achieve the ultra-wideband performance. It covers the frequency from 3.2 to 14 GHz effectively. Antenna has achieved UWB performance due to stair cased designed in the main radiating element. Here, each stair case elements used to resonate separate frequencies. The nearer frequencies are merged together to produce to ultra-wide band performance from 3.2 to 14 GHz. To avoid the interferences, notch bands are very useful and achieved the desired notches in the ultra-wide band region, metamaterial-based complementary split ring resonator is introduced at microstrip feeding element of antenna (A) as shown in Fig. 1 (#B) and its reflection coefficient performance is exhibited in Fig. 4 (#B). Here, CSRR is introducing notch band effect at 5.8 GHz. In antenna (#C), square-shaped CSRR structure is introduced at radiating patch of microstrip-based antenna in order to achieve the notch band performance to the application of ITU band (8.05–8.5 GHz). Antenna (#C) notches 8–10 GHz effectively. In antenna (#D), both (#B) and (#C) are clubbed together to produce the dual notch band performance without affecting existing antenna performance. Antenna (#B) and (#C) notch band performances are retained as exhibited in Fig. 4 (#D).

Similarly, voltage standing wave ratio (VSWR) of the evolution of the antennas is depicted in Fig. 5. It depicts that the antennas are having <2 in VSWR scale at the desired frequencies except notch frequencies.

The notch antenna performance can be confirmed through another analysis of antennas impedance measurement. Figure 6 shows that antenna dual notch band antenna performance in which antenna's real and imaginary impedances are presented. Thus, the desired antenna notch frequency (5.8/5.9 and 8.3 GHz) impedances are varied much compared to other frequencies in UWB region. Through the above analysis, it is confirmed that antennas are having better notch effects. Here,

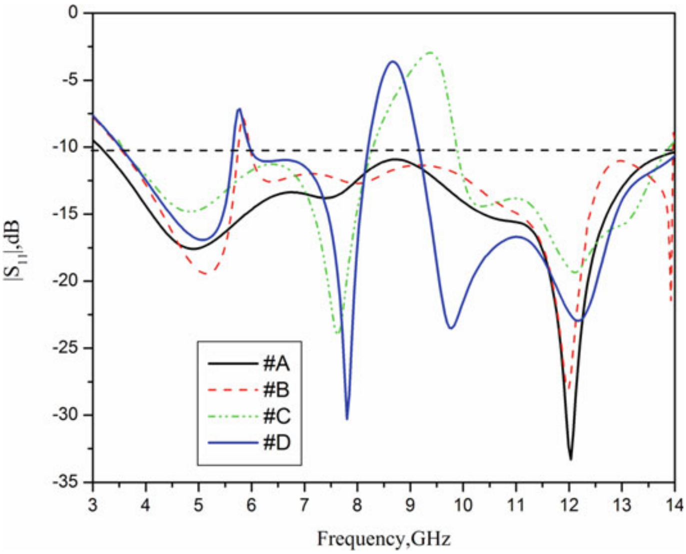


Fig. 4 Reflection coefficient of development stages of the antenna

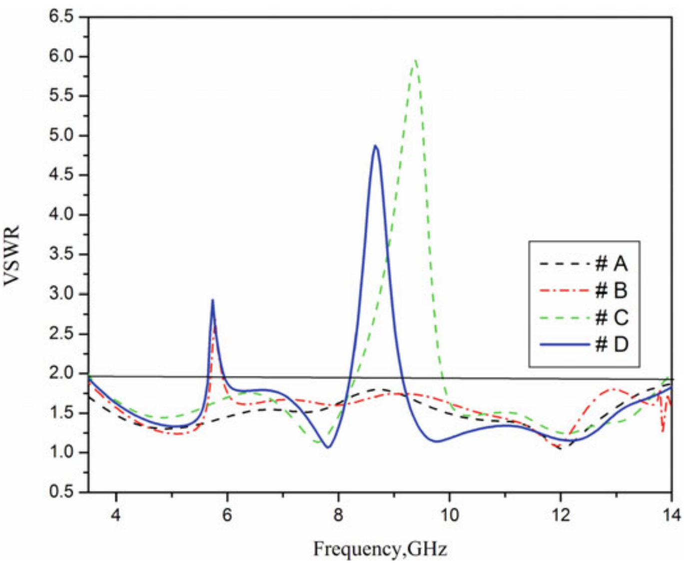


Fig. 5 VSWR of evolution of stages of antenna

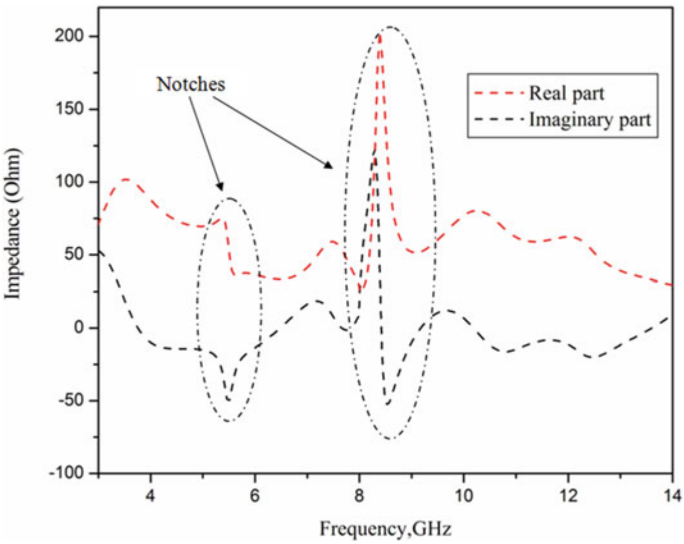


Fig. 6 Impedance performance of the proposed antenna

rectangular-shaped and square-shaped CSRR are having quit effect in achieving the notch band effects at 5.8 and 8.3 GHz.

Figure 7 represents the surface current distribution of the dual notch band

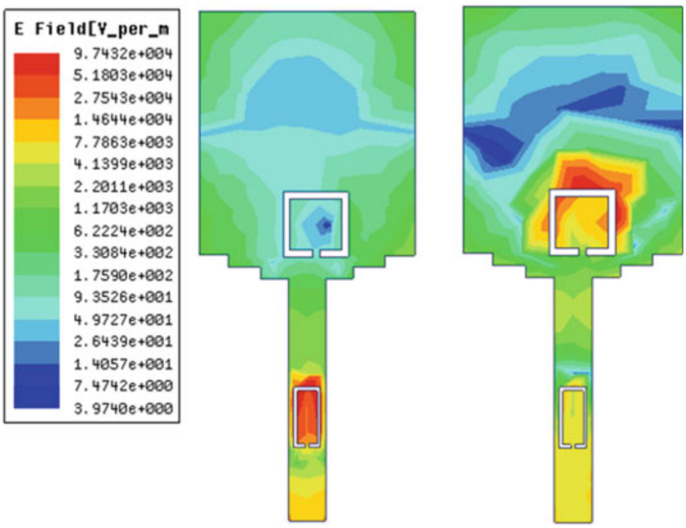


Fig. 7 Surface current distribution of the proposed antenna at **a** 5.8 GHz and **b** 8.3 GHz

antenna. Rectangular-shaped CSRR structure has an impact in the lower frequencies (5.8 GHz), and square-shaped CSRR has an impact at 8.3 GHz which can be confirmed through high current concentration at place of CSRR structure.

The dual band notch antenna radiation characteristics are exhibited in Figs. 8 and 9. It depicts that antennas power distribution in elevation and azimuth planes of the

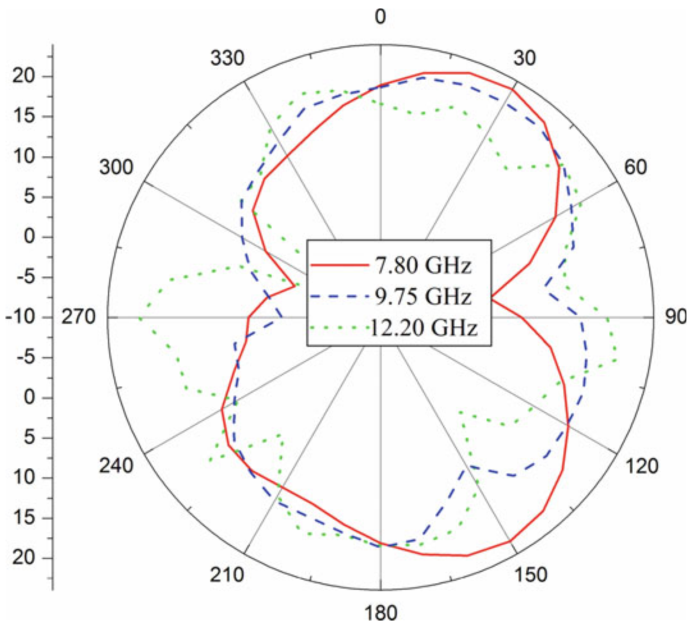
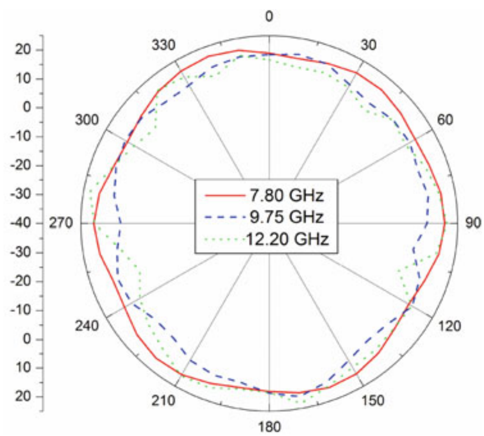


Fig. 8 E-plane radiation patterns for the proposed antenna

Fig. 9 H-plane radiation patterns for the proposed antenna



antenna. Omnidirectional and dipole-shaped radiation pattern is observed in E-plane and H-plane of the antenna, respectively.

The proposed antenna after embedding two CSRR structure has positive gain except the notch band frequencies.

4 Conclusion

A compact dual notched ultra-wideband (UWB) antenna has been presented. Filtering structure has a small size, and notching frequencies are obtained at 5.8/5.9 and 8.3 GHz in the ultra-wideband region. Antenna had cover from 3.1 to 14 GHz and with filtering effect. Further, antenna design has decent radiation characteristics in the preferred frequencies expect notch band regions. Similarly, notch band performance can be improved by introducing various CSRR and SRR structures in the antenna designs. Further, CSRR antenna can be used to cover various frequencies by embedding diodes and it can act as reconfigurable antennas.

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