Design of a Novel Ultra-Wideband Semicircular Printed Antenna with Dual-Band Notched Characteristic

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Abstract **─** A compact semicircular printed antenna with dual-band notched characteristic is proposed. A narrow rectangular slot is etched on the radiation patch to prevail notch band at 5.13-5.87 GHz for WLAN. By using two circular slots (C-shaped) defected ground structure, another notch band, at 7.59-9.03 GHz for some C-band satellite communication systems, is achieved. Due to the shape of the proposed antenna, the total dimension of this structure occupies very small space. The antenna is successfully simulated and measured. A simple 50-Ω microstrip line is used to excite the slot. The parameters and dimensions of the antenna have been investigated by using HFSS. Results demonstrate that the suggested antenna with small size of 20×20×1 mm^3 has desired bandwidth range from 2.6-13.3 GHz for VSWR≤2, except two notch bands.

Index Terms **─** Band notch, compact, microstrip antenna.

I. INTRODUCTION

High wireless communications is swiftly expanding resulting in a demand for communication systems that are credible. Ultra-wideband (UWB) system is becoming the good candidate of high speed technique for wireless communications. UWB antenna is the key device of the UWB wireless communication system [1]. The ultra-wideband (UWB) microstrip antenna has become very common and is now greatly used for various applications. The high demands on such a communications system have simulated research into many UWB antenna designs [2]. So, UWB antenna is a hot theme in recent years. There are several methods with which one can achieve a band-notched UWB antenna. The most popular approach to introduce such a band-notched function is to embed slots or slit into the radiator or its ground plane [3], [4]. A lot of slot antennas for UWB systems have been developed, such as circular slot antenna [5], square slot antenna. In the whole UWB band which is defined by FCC, there are some narrow bands which have been used for a long time, such as worldwide interoperability for microwave access (WiMAX), wireless local area networks (WLAN) and C-band, X-band [6], [7]. To decrease interference, the traditional method is to add narrow band-stop filter to filter the unrequired signal [6]. In this way the cost of process will rise, make the antenna size very large and also the efficiency and qualification of the antenna will decrease. So to solve this problem a lot of notch-band antennas are recommended. There are several ways with which one can obtain a band-notched UWB antenna. The most popular approach is to insert different kinds of slots in the patch or in the ground plane. Like U-shaped, H-shaped or C-shaped slots. The designs of meandering slot antennas in [8] and [9] use different slots to generate two resonant modes. These slot antennas mentioned are much smaller than the traditional modified monopoles, but their structures are much more complex for the practical engineering applications [10]. Ring antennas with simple structure have been presented in [11], [12], the proposed antenna has one notched band and the slots have some influence on the radiation patterns, and the notch band is difficult to adjust to form a good filter characteristic. The recommended two notch bands can be tuning by changing the dimensions of circular slots on the ground and narrow rectangular slot on the patch.

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In this paper, a compact UWB antenna to exhibit notching method is designed. By embedding two different kinds of slot, dual-band notched characteristic antenna is achieved. To achieve the desired band notched characteristic, the dimensions of this antenna are optimized. It should be noted that the ultra-wideband characteristics from 2.6-13.3 GHz corresponds to 143% total bandwidth. The parameters which influence the act of the antenna are investigated in this paper.

II. ANTENNA DESIGN AND CONFIGURATION

Figure 1 shows the top view of the microstrip antenna with and without slots. The geometry of the suggested antenna is depicted in Fig. 2. It consists of a radiation patch with a semicircular-shaped patch and a partially modified ground plane with two kinds of slots to achieve a broad bandwidth. The antenna is printed on a low-cost FR-4 substrate with dielectric constant ε_r=4.4, loss tangent tanδ= 0.02, and thickness h=1 mm. A 50-Ω microstrip line with width of 1.96 mm to excite the patch is employed. Both the semicircular patch and microstrip line are printed on the same surface of the substrate. The upper narrow rectangular slot can notch the 5.13-5.87 GHz band for WLAN, and the lower C-shaped slot can notch the 7.2 GHz for some C-band satellite communication systems. The centre frequency of the notched bands are 5.3, 8.3 GHz. Both the centre frequencies and the bandwidths of the notched bands can be controlled by adjusting the slotline parameters, such as the length of each segment, the total length of the slotline, etc. [13]. The dimensions of the antenna are given on Table 1.

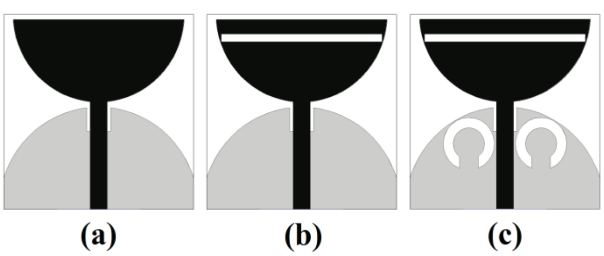

Fig. 1. (a) UWB antenna, (b) antenna with notched characteristic on WLAN band, and (c) proposed antenna.

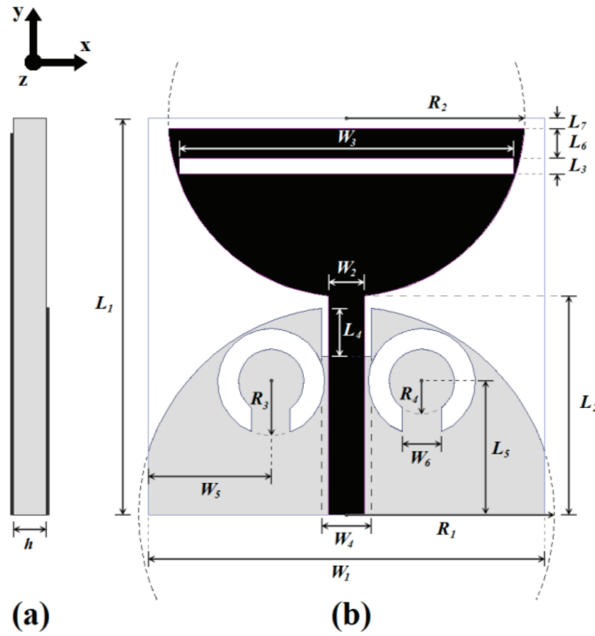

Fig. 2. Geometry of the proposed antenna: (a) side view, and (b) top view.

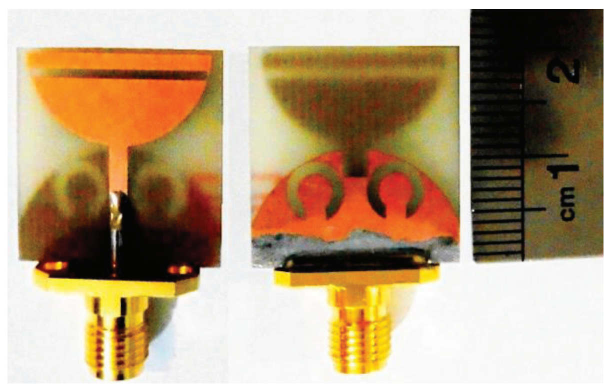

Fig. 3. Photograph of the proposed antenna.

Table 1: Dimensions of the antenna

Parameter	mm	Parameter	mm
R_1	10.5	W_5	6.2
R_2	9	W_6	2
R_3	2.7	L_2	11.1
R_4	1.65	L_3	0.8
W_1= L_1	20	L_5	6.7
W_2	1.96	L_6	1.8
W_3	16.7	L_7	0.5
W_4= L_4	2.5	h	1

III. RESULTS AND ANALYSIS

The HFSS-predicted VSWR [14] against frequency for three structures of the microstrip antenna in Fig. 1 are shown in Fig. 4. In this figure, it is obvious that by using a narrow rectangular slot upon the patch and two slots on the ground the desired bands for WLAN and C-band applications are notched. Influence of the DGS coupling are shown in Fig. 4 (d). It is obvious in Fig. 4 (d), that by eliminating one of C-shaped slots the VSWR characteristic decrease in C-band.

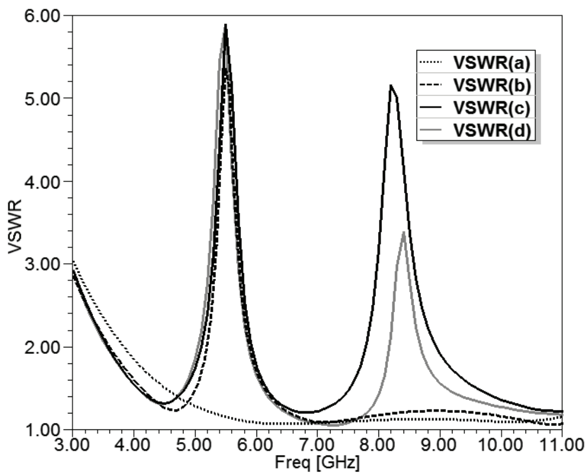

Fig. 4. Simulated VSWR for proposed antenna.

The antenna parameters are studied and the influence of these parameters on the bandwidth are shown in Fig. 5. In Fig. 5 (a), (c), it is obvious that only by variation on L_5 and R_4 the height or the location of the centre frequency of the second band-notched for C-band application is changed. In Fig. 5 (b), by changing the dimensions of the upper rectangular slot on the patch, the variation of the center frequency for WLAN is shown. The antenna is optimised to attain optimum bandwidth in the desired frequency bands. The simulated and measured VSWR for optimization parameters is shown in Fig. 6. In addition, the realized gain in the whole operating band has shown in Fig. 7, as desired in two 5.5 and 8.3 GHz gains decline due to the notch bands. Also, the group delay for the proposed antenna is presented in Fig. 7. It is clear that the variation of the group delay for the proposed antenna is around 1.5 ns for the desired bandwidth, but because of the notch behavior, there is a deviation at the notch frequency in the group delay.

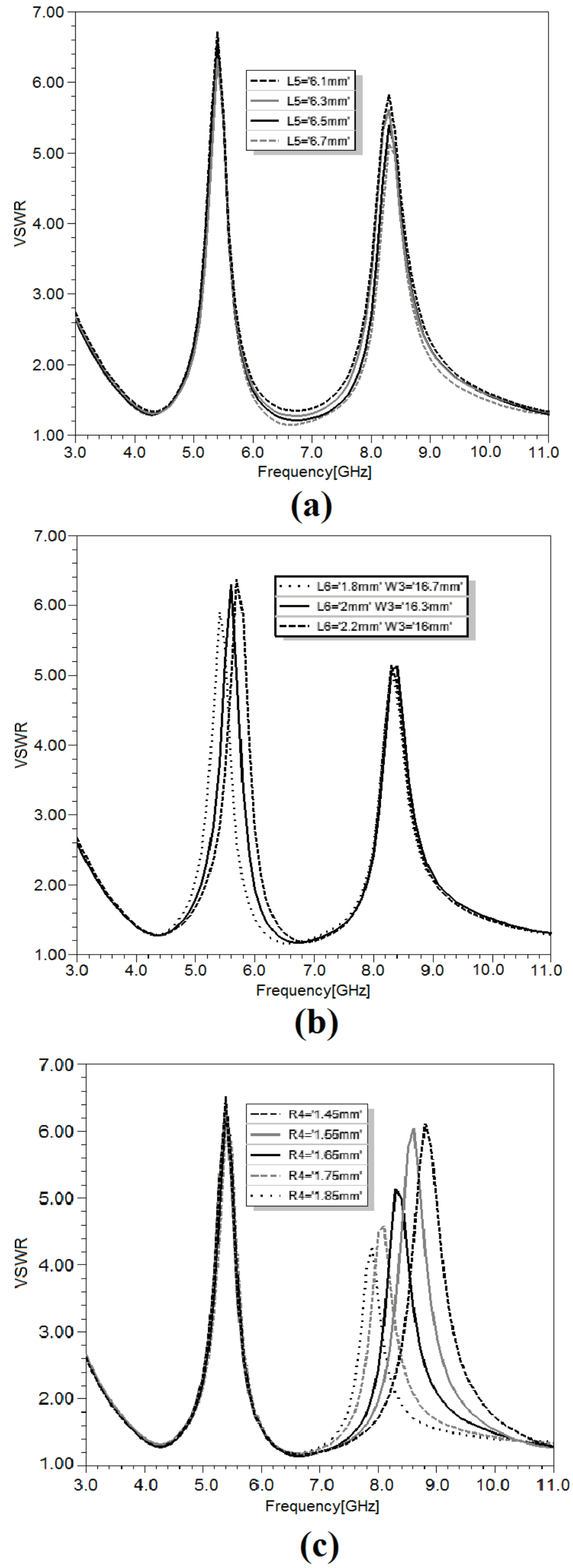

Fig. 5. The simulated VSWR plot for variation of: (a) L_5, (b) L_6, and (c) R_4.

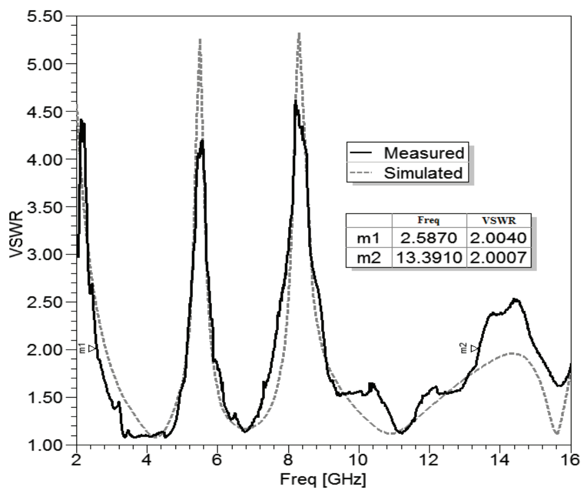

Fig. 6. The simulated and measured VSWR for optimized parameters.

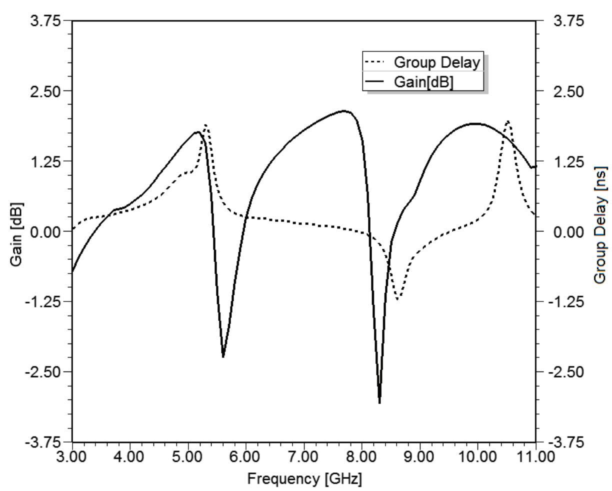

Fig. 7. The peak gain and group delay of the proposed antenna.

The measured and simulation radiation patterns of the proposed antenna at 4.5, 7 and 9.5 GHz are shown in Fig. 8 and Fig. 9. Both the co- and the cross-polar are shown. The antenna gives a nearly omnidirectional radiation pattern in the Z-X plane and a dipole-like radiation pattern in the Y-Z plane. The discrepancy in investigated parameters between simulated and measured results should be mostly attributed to the loss tangent tanδ of the substrate and the tolerance in manufacturing. Eventually it can be said that the simulation and measurment outcomes agree well with each other except two notch bands.

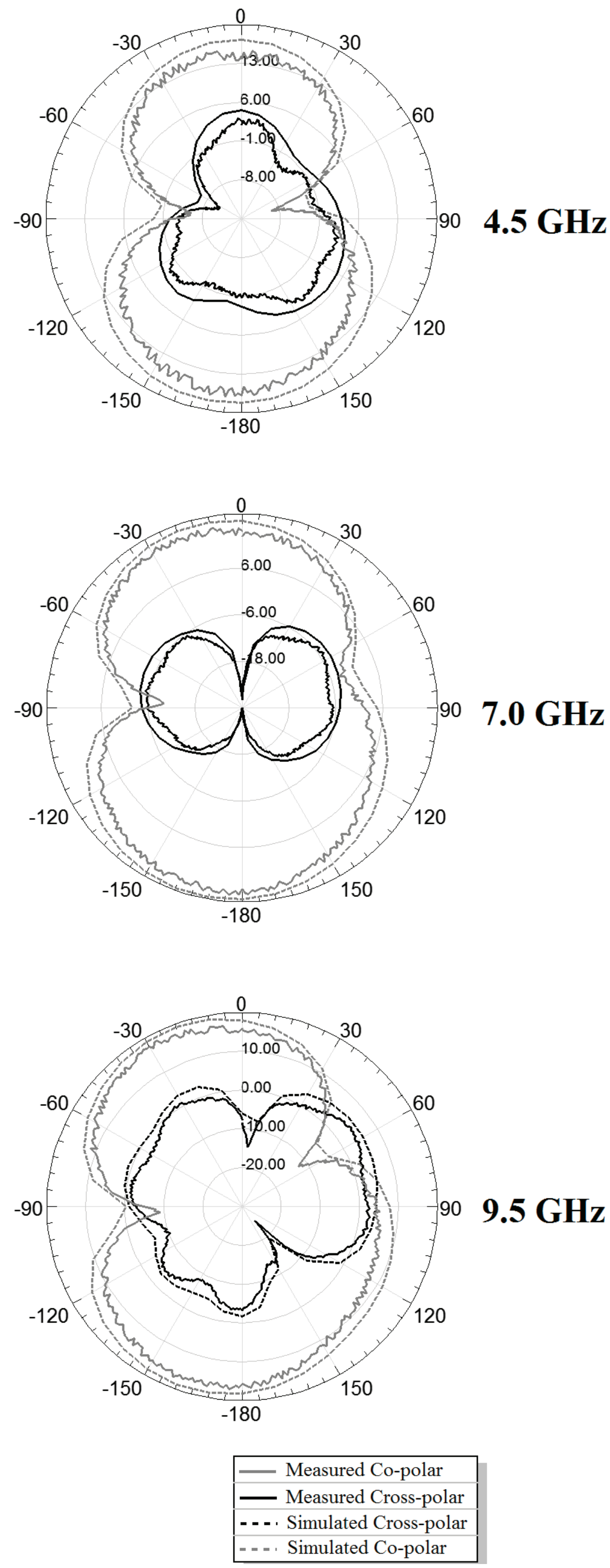

Fig. 8. The measured and simulation radiation patterns (dB) in Y-Z plane.

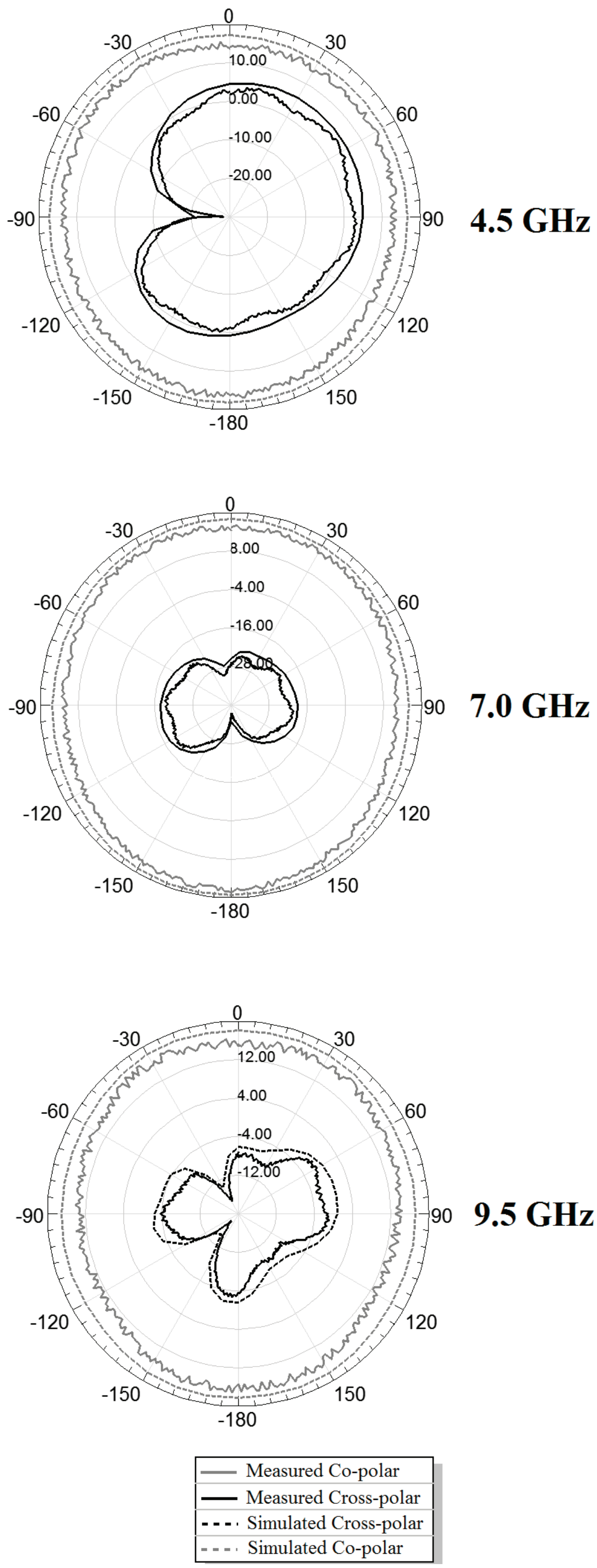

Fig. 9. The measured and Simulation radiation patterns (dB) in Z-X plane.

IV. CONCLUSION

A semicircular printed antenna with dual-band characteristic is presented and discussed. This antenna has a compact and small size 20×20×1 mm^3. This novel microstrip antenna has satisfactory characteristics within its operating bandwidth. To obstruct suppression in the applicable WLAN, and C-band communication systems, pair of symmetrical C-shape slots on the ground and a narrow rectangular slot on the patch is proposed. Prototype of the antenna designed, fabricated, and measured. The suggested low-profile antenna operates from 2.6-13.3 GHz except in two notch bands. The antenna which not only meets the requirement of the UWB systems, but also reduces the potential interference form 5.2 GHz-5.9 GHz for WLAN, 7.8 GHz-9.0 GHz for C-band satellite communications. The measured results show reasonable agreement with the simulated results.

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