# CPW-Fed Antenna Design with Increased Bandwidth and WLAN Band-Filtering for UWB Systems

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**Abstract.** A compact coplanar waveguide (CPW)-fed antenna with improved bandwidth and a band-stop property is represented for ultra-wideband (UWB) communications. Its configuration is composed of a modified circular-ring radiation patch with a cross-strip and a pair of protruded arms and a semi-circular ground plane. It is designed on a low-profile FR-4 substrate with δ= 0.02, ε= 4.4, and h=1.6 mm. By modifying the ground plane and also adding a cross-strip into the circular-ring radiation patch, the impedance bandwidth of the antenna for $S_{11}$≤-10 can be improved significantly. The band-notched characteristic of the design is achieved by using the pair of protruded arms. The proposed antenna exhibits a wide usable fractional bandwidth from 3.1 to 24 GHz and a frequency notch-band in 5.5 GHz of WLAN systems. The performance of a 4×4 MIMO configuration for the UWB antenna is also studied and good results are achieved.

**Keywords:** Band-notch antenna, MIMO system, monopole antenna, WLAN, UWB communications.

## 1 Introduction

The wireless communication systems are highly developed in recent years, and the spectrum congestion has been highly increased. Ultra wide band (UWB) wireless communication has gained more attentions recently and became one of the most rapidly developing technologies in wireless applications due to several attractive advantages such as low-power, high-transmission rate, etc [1-2]. The congestion of the frequency spectrum and the interference of various communication systems are considered the most important problems due to the advancement of wireless systems and the sustainable demand for improving the operation bandwidth [3-4]. Commercially, the development of ultra-wideband systems is evident after the allocation of 3.1-10.6 GHz by FCC for this purpose [5]. Low-profile antennas with the low-cost fabrication process and also Omni-directional radiation patterns as well as a large bandwidth are desirable for UWB systems [6-10]. Compact printed antennas are more appropriate to be used in modern UWB systems and hence, so many activities focus on them [11-12]. Consequently, in the open literatures, various planar UWB antennas with excellent performances have been presented [13-15].

As is well known, the operation band of UWB communication technology overlaps that of some other existing narrowband services like WLAN which may cause electromagnetic signal interference. Therefore, UWB antennas with a band-stop performance are required. Different

IMDC-SDSP 2020, June 28-30, Cyberspace
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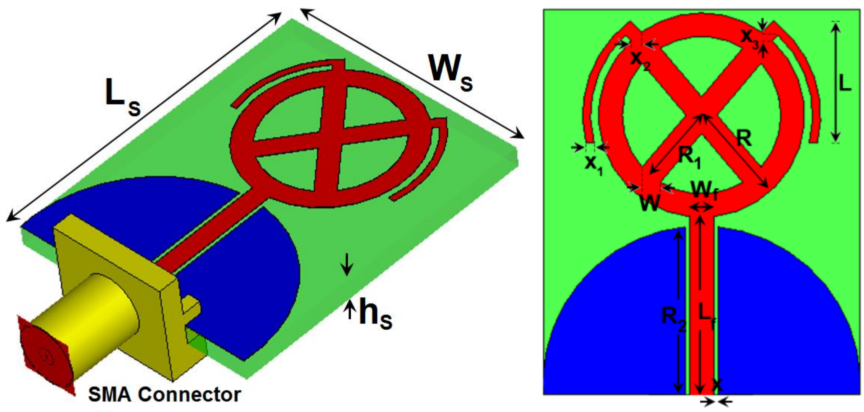
DOI 10.4108/eai.28-6-2020.2297948

methods such as etching slots with various shapes in the microstrip feedline, loading resonators etched on the radiator, or on the ground plane and utilizing EBG structures have been addressed to obtain UWB operation with the capability of band rejection [16-19].

A new UWB planar antenna with improved frequency bandwidth along with a band rejection for WLAN spectrum is presented. By modifying the radiation and ground planes of the introduced monopole antenna, a super wide bandwidth of 148% (from 3.1 to 24 GHz) is obtained for return loss function less than -10 dB. In addition, by placing the protruded parasitic arms, a notched band is implemented to reject the 5.5 GHz WLAN band. The antenna has a compact size of $W_S \times L_S = 20 \times 25\ mm^2$ and provides sufficient properties. Furthermore, a 4×4 MIMO configuration of the antenna is studies. Section II presents the schematic and design details. Its fundamental characteristics are discussed in section III. Section IV investigates the MIMO performance of the antenna. The last Section will conclude this study.

## 2 Design Details

Figure 1 illustrates the schematic of the antenna. Its structure contains a modified radiation patch with a circular-ring shape with a pair of protruded arms and a cross-strip inside and also a modified semi-circular ground plane with FR4 dilectric substrate. The details of the proposed CPW fed monopole antenna are specified in Table. I. The introduced monopole antenna has been fed by using a coplanar waveguide (CPW) feeding technique [20-22]. The CPW-fed antennas are widely used in various applications owing to their excelent characteristics including compact-profile, conformal design, and ext.




(a) (b)

**Fig. 1.** Transparent (a) side and (b) front views of the proposed monopole antenna design.

**Table 1.** Dimensions (in millimeters) of the antenna.

| **Param.** | $W_S$ | $L_S$ | L | $W_f$ | $L_f$ | x |
|---|---|---|---|---|---|---|
| **(mm)** | 20 | 25 | 7.7 | 3 | 11.8 | 0.3 |
| **Param.** | W | R | $R_1$ | $x_1$ | $x_2$ | $x_3$ |
| **(mm)** | 1.5 | 6.5 | 5 | 0.5 | 0.85 | 0.5 |

## 3 The Characteristics of the Antenna

Return loss results of the circular-ring monopole (Fig. 2 (a)), with a modified ground (Fig. 2 (b)), with a cross-strip (Fig. 2 (c)), and the presented antenna design (Fig. 2 (d)) are studied and compared in Fig. 3. It can be observed that the conventional circular-ring antenna cannot achieve a good impedance bandwidth covering UWB spectrum [23-24]. However, by modifying the ground plane to the semi-circular shape, the antenna frequency response in the spectrum range of 7 to 11 GHz has been improved. In addition, by adding a cross-strip, the antenna exhibits a good return loss characteristic covering 3.1 to 24 GHz. Finally, to generate a band-notch, a pair of parasitic arms are inserted in the radiation patch of the monopole antenna.

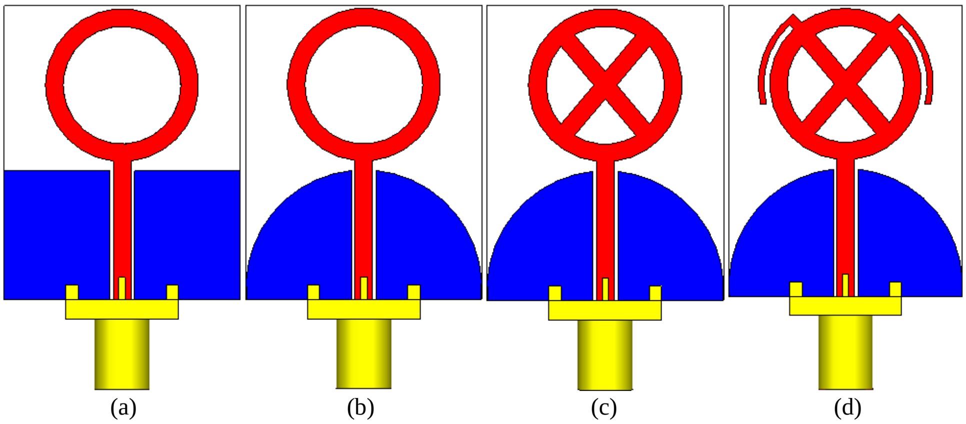



**Fig. 2.** Design evolutions: (a) with circular-ring resonator, (b) with a modified ground structure, (c) with the modified patch and ground structures, and (d) the main design.

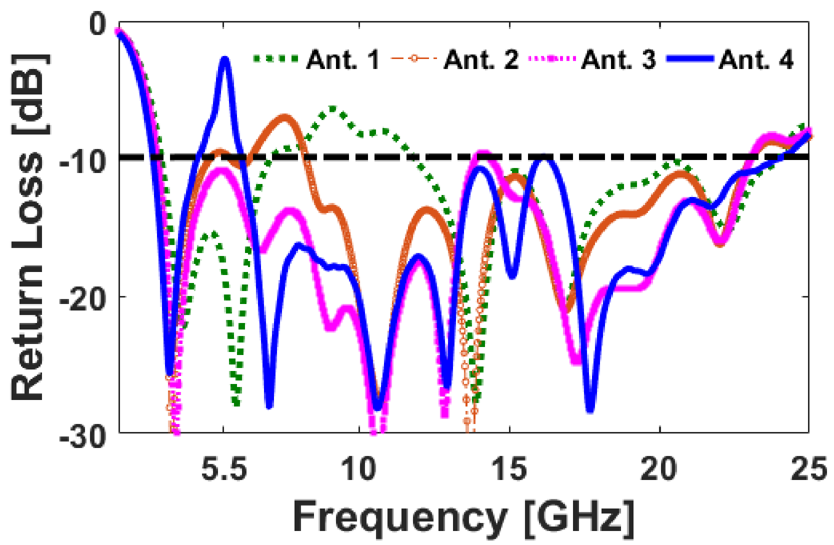



**Fig. 3.** Return loss results for various evolutions represented in Fig. 2.

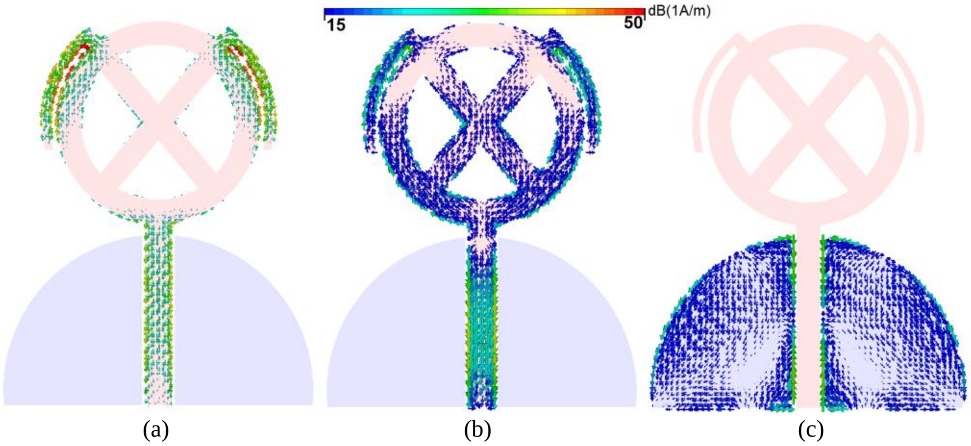



**Fig. 4.** Surface current distributions at (a) 5.5 GHz, (b) 6.5 GHz, and (c) 10 GHz.

To further demonstrate the working mechanism of the design, the current distributions at 5.5 GHz 7 GHz, and 10 GHz are depicted in Fig. 4. It is evident from Fig. 4 (a), at 5.5 GHz (notched), the employed parasitic arms are highly active. According to the current at 7 GHz, it can be found that the flows have been more dominant for the cross-strip inside the circular-ring radiation which verifies its impact on improving the antenna bandwidth at the 7 GHz. Furthermore, from Fig. 4 (c) and compared with Fig. 3, the semicircular ground plane can enhance the antenna bandwidth at upper band of UWB spectrum [25-27]. It should be noted that different configurations of the design exhibit sufficient performance in the upper spectrums (13-24 GHz).

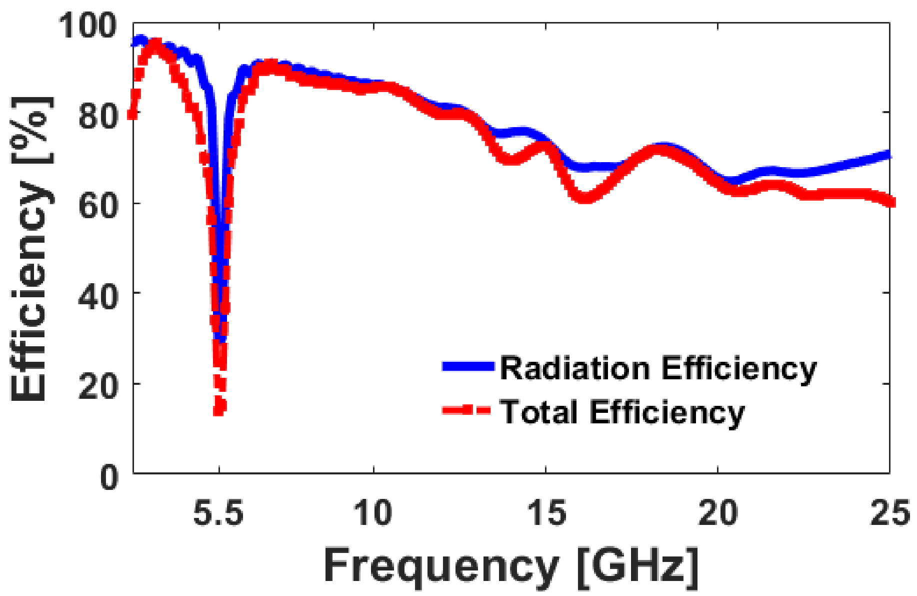



**Fig. 5.** Efficiencies versus frequency.

The simulated efficiencies of the presented antenna are illustrated in Fig. 5. As seen, the presented antenna provides good efficacy characteristics. Obviously, the efficiencies fall sharply in the notch frequency (5.5 GHz), since the radiated power is reflected back to the antenna [28-31]. Apart from the notch frequency, the antenna provides higher than 65% efficiencies. Figure 6 depicts the 2D patterns in H- and E- plane. Because of the symmetrical structure, consistent radiation patterns are obtained for the antenna. As seen, quasi Omni-directional radiation in H-plane and quasi 8-shaped in E-plane are observed [32-36]. However, the radiation patterns a bit deteriorated. The gain characteristic is depicted in Fig. 7. As seen, the antenna offers sufficient gain levels over its operation band. In addition, a sharp decrease is observed at the notch frequency.

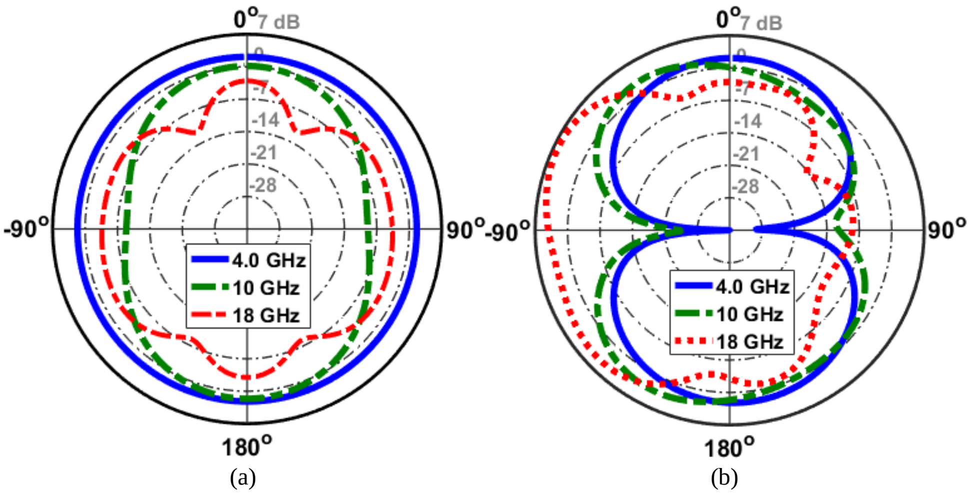



**Fig. 6.** (a) H-plane and (b) E-plane of the radiation.

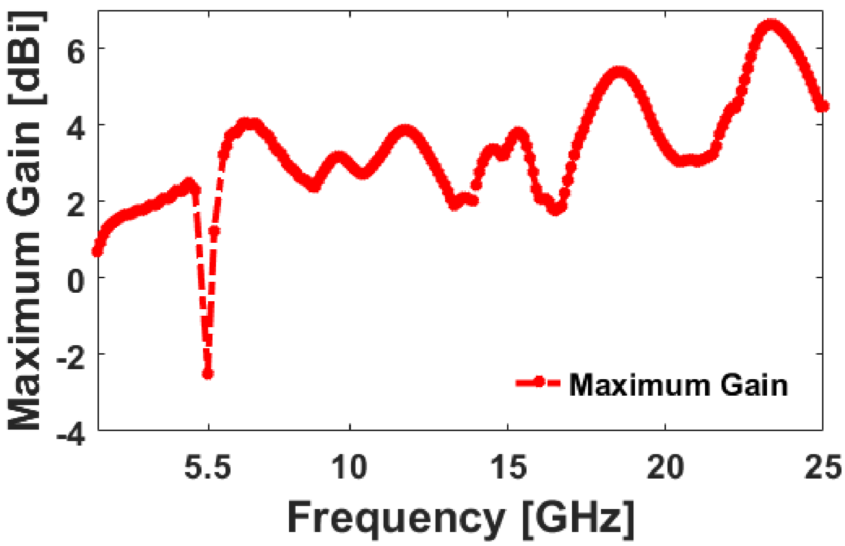



**Fig. 7.** Maximum gain results.

## 4 MIMO Configuration of the Design

A MIMO structure of the presented planar monopole is designed, illustrated in Fig. 8. It contains 4 antennas placed at different sides of the dielectric with the size of 45×45 $mm^2$. Figure 9 illustrates the scattering parameter curves of the MIMO system. It is clearly shown that the MIMO design exhibits good S-parameters working at the same bandwdith of the basic design with sufficient mutual coupling [37-40].

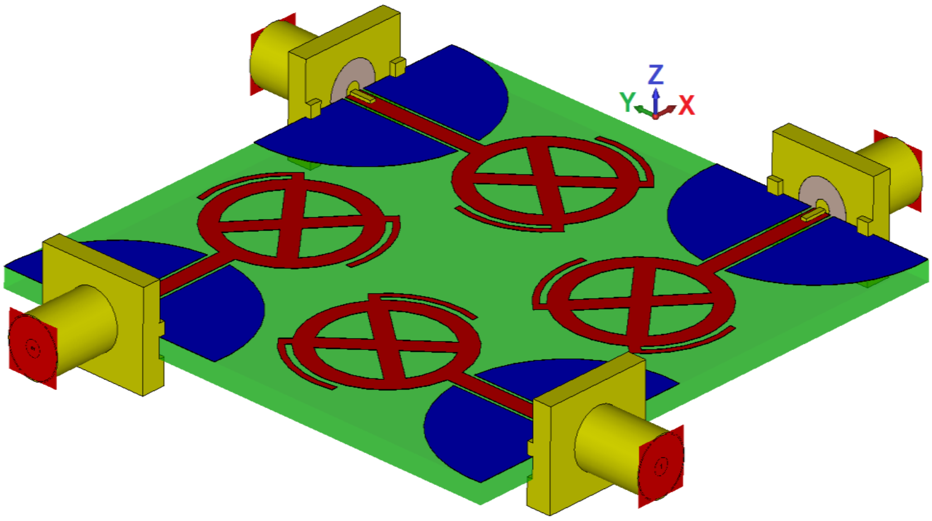



**Fig. 8.** 4×4 MIMO structure of the band-notched antenna.

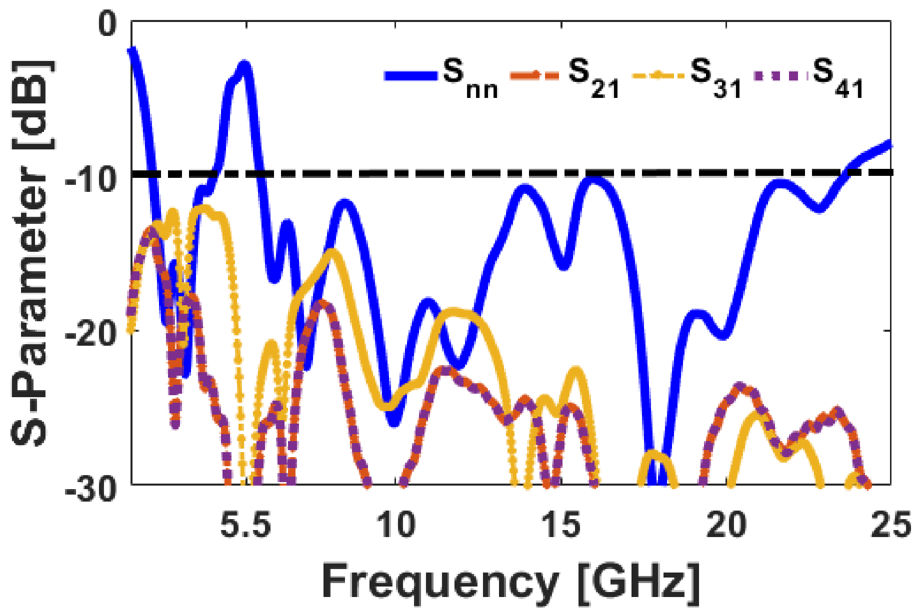



**Fig. 9.** S-parameters of the MIMO structure.

## Conclusion

Design and performance of a planar UWB antenna with WLAN band-stop are studied. The antenna structure contains a CPW circular-ring patch and a semicircular ground plane. By using the modified ground plane and also adding a cross-strip, the antenna bandwidth is improved. The band-notched function of the design is generated by inserting a pair of parasitic arms on the main radiators. Based on the research work discussed above, the notch behavior and bandwidth improvement characteristics are achieved with straightforward structure and novel. The antenna offers good performances and covers the frequency range of 3.1-24 GHz with a notch frequency band at 5.5 GHz. Consistent radiation behavior with approximately flat gain results are observed, except at the notched band. It also exhibits good MIMO performance in 4×4 planar form.

**Acknowledgments.** This work is supported by the European Union's Horizon 2020 research and innovation programme under grant agreement H2020-MSCA-ITN-2016 SECRET-722424.

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