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# CPW-Coupled-Fed Elliptical Monopole Antenna for UWB Applications

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**Abstract** — In this paper, a coplanar-waveguide (CPW)-coupled-fed elliptical monopole antenna (CCFEMA) is presented for UWB applications. The antenna has a large bandwidth covering the frequency band from 2.8 GHz to 16.5 GHz with return loss larger than 10 dB and radiation pattern similar to that of a dipole antenna. With an appropriate modification of the radiation patches, a band-notched antenna based on the CCFEMA can also be designed to have a good band-notched performance for the band from 5.0 GHz to 6.0 GHz to avoid interfering with WLAN. The return loss, radiation pattern, peak gain, efficiency and band-notched characteristic of the antenna are studied using computer simulation. For verification, a prototyped antenna is also fabricated and then measured using the antenna measurement system, Satimo Starlab. The results show that the proposed antenna is a good candidate for UWB applications.

**Index Terms** — Monopole Antenna, Ultrawideband (UWB) Antenna, Band-notch, CPW-Coupled-Fed.

## I. INTRODUCTION

Since the unlicensed frequency band of 3.1-10.6 GHz has been released for Ultrawideband (UWB) technology and applications in 2002 by the Federal Communications Commission (FCC) [1], UWB systems have received much attention because the inherent properties of low power consumption and high data rate which promise solutions for short-range and high-speed indoor mobile communications. To design an antenna to operate in the UWB band is quite challenging because it has to satisfy the requirements such as UWB impedance bandwidth, omnidirectional radiation pattern, constant gain, high radiation efficiency, constant group delay, low profile and easy manufacturing [2].

Various shapes, such as square [3], circular [4], pentagonal [5], hexagonal [6], elliptical [7], ring [8] and trapezoidal [9], various configurations including monopoles [3-5, 7-9], dipoles [10] and slot antennas [6] and various feeding structures such as microstrip [3-4, 7-8], co-planar-waveguide (CPW) [5-6, 9] and coaxial [11] have been proposed for the designs of UWB antennas. However, a CPW-coupled-fed elliptical monopole UWB antenna has not been reported yet.

In this paper, the novel design of a CPW-coupled-fed elliptical monopole antenna (CCFEMA) is presented. Furthermore, to avoid interfering with WLAN, by simple and proper modification of the radiator, a band-notched characteristic is added to the CCFEMA. The two designs are studied using the computer simulation tool CST MWS 2010 and the antenna measurement system, Satimo Starlab. The simulated and measured results on the radiation patterns, peak gains, and efficiencies agree well and show good performances for UWB applications. The group-delay characteristics of the proposed antennas are also investigated.

## II. ANTENNA DESIGN

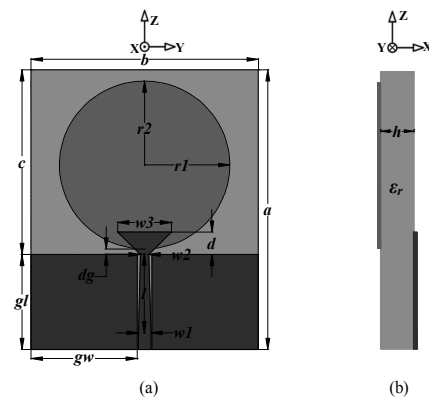


Fig. 1. Configuration of the proposed UWB CCFEMA antenna. (a) Back view and (b) side view.  $\epsilon_r = 3.5$ ,  $t = 0.8$  mm,  $r1 = 12$  mm,  $r2 = 12$  mm,  $w1 = 1.6$  mm,  $w2 = 1.2$  mm,  $w3 = 7.6$  mm,  $d = 3.2$  mm,  $dg = 0.8$  mm,  $a = 40$  mm,  $b = 32$  mm,  $c = 26.4$  mm,  $gl = 13.6$  mm,  $gw = 15$  mm

The configuration of the CCFEMA is shown in Fig. 1. The antenna is composed of a radiation patch and a feeding structure mounted on the front and back surfaces, respectively, of the substrate with dielectric constant  $\epsilon_r$  and thickness  $t$ . The radiation patch has a simple elliptical shape with half minor axes  $r1$  and major axes  $r2$  in the  $y$  and  $z$  directions, respectively. The feeding structure is a CPW-transmission line ended with a trapezium of topline  $w3$ , baseline  $w2$  and height  $d$ . The width of the CPW-feed

line changes from  $w1$  to  $w2$  to achieve good impedance match.

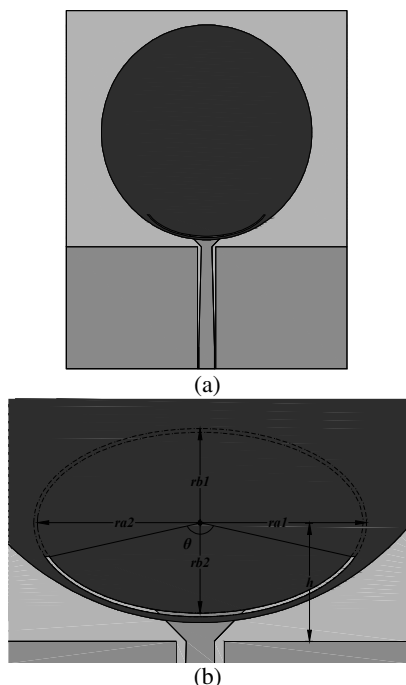


Fig. 2 Configuration of band-notched CCFEMA antenna. (a) Top view (b) Magnified of arc slot.  $h = 5$  mm,  $\theta = 155^\circ$ ,  $ra1 = 7.2$  mm,  $ra2 = 7$  mm,  $rb1 = 4$  mm,  $rb2 = 3.8$  mm.

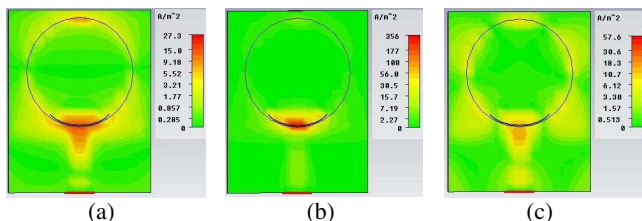


Fig. 3 Surface current distribution of band-notched CCFEMA at (a) 3 GHz, (b) 5.5 GHz and (c) 9 GHz

To avoid interfering with WLAN, a band-notched characteristic is obtained by cutting an arc slot on the radiation patch as shown in Fig. 2. By adjusting the parameters of the arc slot, a notch in 5-6 GHz can be achieved.

Figures 3(a), 3(b) and 3(c) show the surface current distributions of the band-notched CCFEMA at 3, 5.5 and 9 GHz, respectively. At 3 and 9 GHz, Figs. 3(a) and 3(c) show that majority of the current flows from the CPW-feed line and couples to the radiator and finally radiates into free space. However, at 5.5 GHz, the energy is confined in the arc slot and is much more than those in the main radiator of the antenna, so it does not get radiated.

### III. RESULTS AND DISCUSSIONS

Based on the design described previously, both the CCFEMA and band-notched CCFEMA have been simulated and measured. They are fabricated on the substrates with an area of  $40 \times 32$  mm<sup>2</sup> as shown in Fig. 4. Each is fed at the bottom edge with a 50 -SMA connector. The structure is simple and easy to be fabricated. Computer simulations of the antennas are done using the software tool, CST MWS 2010, and the measurements including return losses and radiation patterns are performed in the Satimo Starlab.

The simulated and measured return losses of the CCFEMA are shown in Fig. 5(a). It can be seen that, with return loss larger than 10 dB, the simulated impedance bandwidth is from 2.4 GHz to 15.5 GHz and measured impedance bandwidth is from 2.8 GHz to 16.5 GHz. Both impedance bandwidths cover the desired 3.1–10.6 GHz UWB. The simulated and measured results for the band-notched CCFEMA are shown in Fig. 5(b). Compared with the CCFEMA, it can be found there is a stop band from 5.0 GHz to 6.0 GHz.

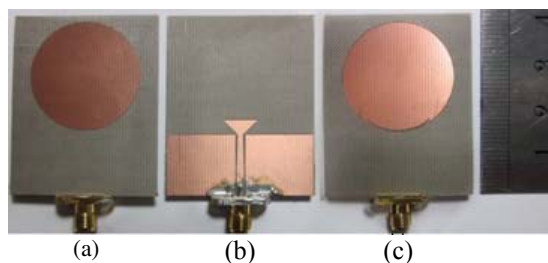


Fig. 4 Photograph of CCFEMA. (a) front view CCFEMA, (b) back view CCFEMA and (c) front view band-notched CCFEMA

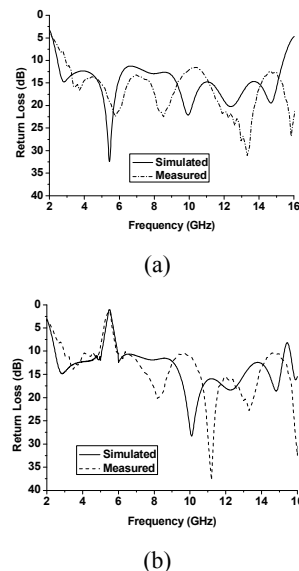


Fig. 5 Return loss of (a) CCFEMA and (b) band-notched CCFEMA

The simulated and measured radiation patterns of the CCFEMA in the x-y, y-z planes at 3.0, 6.0, 9.0, 12.0 and 15.0 GHz are shown in Fig. 6. The patterns in the x-y plane are all approximately omnidirectional. The radiation patterns in the y-z planes are symmetrical along the  $y = 0$  planes. Because the wavelength is much larger than the antenna size at  $f = 3.0$  GHz, the patterns are approximately symmetrical in the spaces  $z > 0$  and  $z < 0$ . The maximum radiation direction is in the x-y plane. As the electrical length of the radiator increases with higher frequency, however, asymmetry in patterns caused by that of the radiator and the CPW feeding structure are evident, as can be seen at 6.0, 9.0, 12.0 and 15.0 GHz. When the increase of frequency continues, the radiation patterns split and side lobes appear. The patterns of the antenna are similar to those of a conventional dipole antenna.

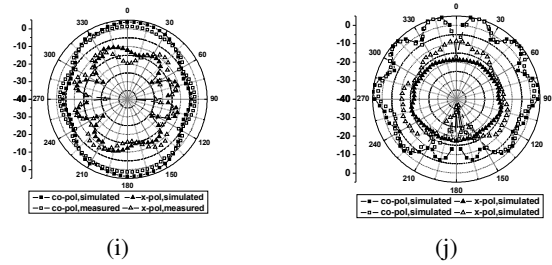
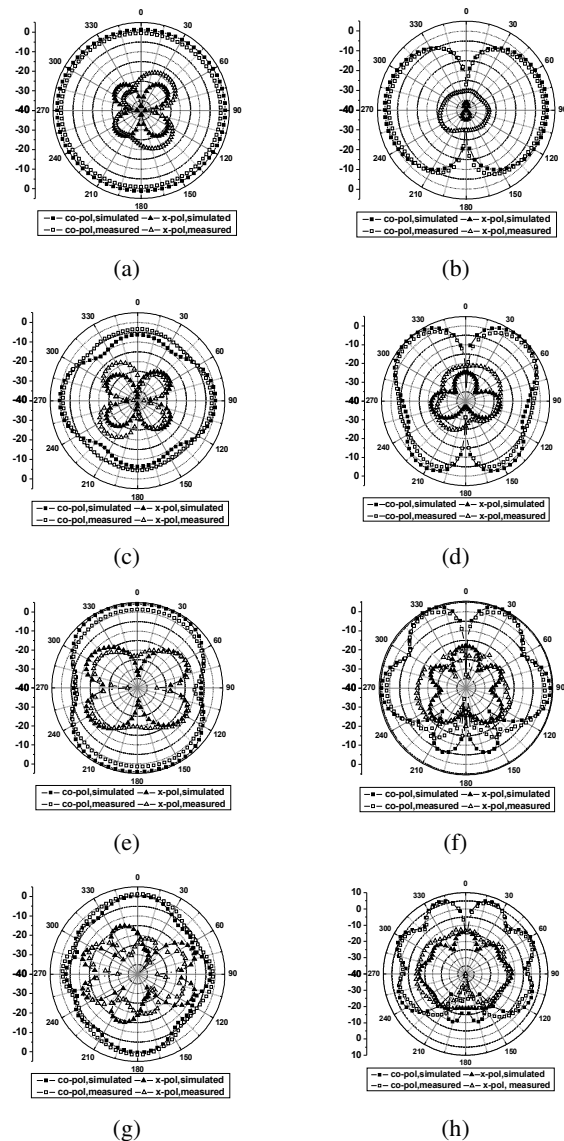


Fig. 6 Simulated and measured radiation patterns of CCFEMA. (a) 3 GHz in x-y plane; (b) 3 GHz in y-z plane; (c) 6 GHz in x-y plane; (d) 6 GHz in y-z plane; (e) 9 GHz in x-y plane; (f) 9 GHz in y-z plane; (g) 12 GHz in x-y plane; (h) 12 GHz in y-z plane; (i) 15GHz in x-y plane and (j) 15GHz in y-z plane

The simulated and measured peak gains and efficiencies of the CCFEMA and the band-notched CCFEMA are shown in Figs. 7 and 8, respectively. It can be seen that the band-notched CCFEMA obviously has very low gain and low efficiency in the notched frequency band from 5.0 GHz to 6.0 GHz, where the antenna gain is suppressed from about 4 to -4 dBi and the radiation efficiency is reduced from about 95% to 15%.

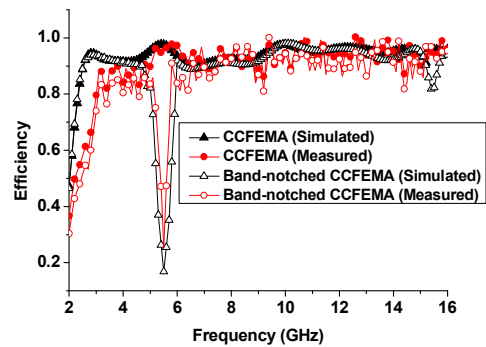


Fig. 7 Efficiencies of CCFEMA and band-notched CCFEMA

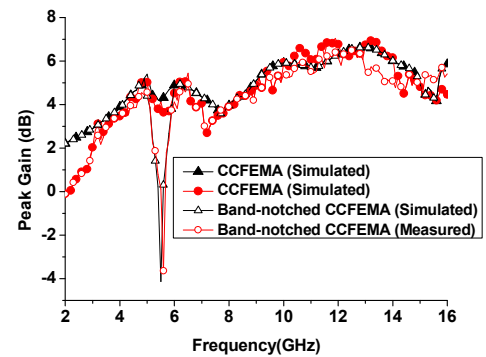


Fig. 8 Peak gains of CCFEMA and band-notched CCFEMA

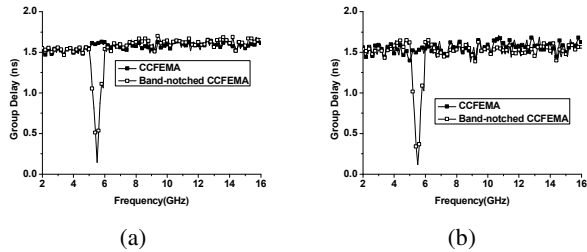


Fig. 9 Measured group delay of CCFEMA and band-notched CCFEMA. (a) face-to-face and (b) side-by-side

Finally, the group-delay characteristics between a pair of CCFEMA and a pair of band-notched CCFEMA have also been measured inside an anechoic chamber. In the measurements, the distance between the transmitted and received antennas was 35 cm. Without loss of generality, two special cases, i.e., with the antennas placed face-to-face and side-by-side at different azimuth angles on the  $x$ - $y$  plane, were used for measurements. The results are showed in Fig. 9, indicating that, in both cases, the group delays are about 1.5 ns across the frequency band except in the notched band of the band-notched CCFEMA. The group delay characteristics is relatively flat, indicating that the antenna have good linear transmission performances and so could be useful for multi-band UWB or impulse UWB radios applications.

#### IV. CONCLUSIONS

The design of a CCFEMA for UWB applications has been presented and fabricated. The antenna is small and simple. With a CPW-coupled-fed structure and an elliptical radiation patch, the antenna can be designed for a wide operation bandwidth of 2.8-16.5 GHz and its radiation patterns are approximately omnidirectional. By cutting an arc slot on the radiator, a band notch from 5.0 GHz to 6.0 GHz can be introduced to the characteristic to avoid interfering with WLAN. Both the simulated and measured results have indicated that the CCFEMA are suitable for UWB applications.

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