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A CPW-Fed Antenna with the Elliptical-shaped forms on the patch for Bandwidth Enhancement

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Abstract

This study presents a novel design of a printed elliptical-shaped antenna with coplanar waveguide (CPW) feed for multi-operating bands of the wireless communication systems and ultra wideband (UWB) communication systems. shaped patch. By using of a pair of ellipse-shape-combined (ESC) form on the patch and half The radiator of the antenna is a slotted elliptical-ellipse-shaped slot inside initial patch, the proposed antenna can be used in multiband wireless operations, covering the DCS (1.71–1.88 GHz), PCS (1.85–1.99 GHz), UMTS (1.92–2.17 GHz), 2.4-GHz WLAN (2.4–2.484 GHz), Mobile-WiMAX(2.5–2.69 GHz) and 5-GHzWLAN (5.15–5.825 GHz) bands. By inserting an ellipse-shape-combined (ESC) form with variable dimensions on the patch, additional resonances are excited and hence much wider impedance bandwidth can be obtained, especially at the higher band. The proposed antenna operates in the adopted bandwidth (3.1-10.6 GHz) with $S_{11} <$ 10 dB, and covers it very well between 1.65 and 20 GHz, which provides fractional bandwidths of more than 170 %. The antenna has a desirable S_{11} level, radiation pattern and gain characteristics for multi-operating bands.

Keywords: Multiband antenna, ultra widwband (UWB) antenna, coplanar waveguide (CPW) antennas

INTRODUCTION

There is a tremendous increase in the applications that use the ultrawideband (UWB) technology and multiband operations of wireless communication system [1]. There has been great progress in the design of ultra wideband antennas and devices in recent years. In particular, planar monopole antennas have attracted much interest for multiband applications due to their simple geometry and good impedance properties. In the design of a monopole antenna, the shape of the antenna patch, the ground plane, and the geometry of the ground plane slots are of great importance [2-3]. The main parameters in designing UWB antennas, especially for indoor applications, are easy to manufacture structure, compact size, and omnidirectional radiation pattern across the band from 3.1 GHz to 10.6 GHz. In most reported antennas, up to now, the slots have been used for improving the lower frequency of the band and enhancing the upper frequency of the band. Many designs are available in the literature concerning the monopole antenna with multi-band characteristics. Those designs use different types of slots and slits in the radiator, the ground plane or even in the feeder to achieve the required multiband-operating characteristics with different structures [4-12]. In this letter, the main target is to present a novel structure with a step-by-step design procedure. The main radiator of the proposed antenna is a simple elliptical-shaped patch and impedance bandwidth is enhanced by using slotted patch. In this antenna, using a pair of ellipse-shape-combined (ESC) design on the patch and a half-ellipse-shaped slot in the patch a proper control on the upper and lower frequencies of the band can be achieved. By using ESC-form inside the patch, additional resonances are excited, and hence the bandwidth is increased, especially at the higher band. The proposed antenna simultaneously satisfies the 10 dB S_{11} requirement for DCS (Digital Communication System, 1.71–1.88 GHz), US-PCS (US-Personal Communication System, 1.85–1.99 GHz), UMTS (Universal Mobile Communication Systems, 1.92–2.17 GHz), 2.4 GHz-WLAN (Wireless Local Area Network, 2.4 – 2.483 GHz), WiMaX (Worldwide Interoperability for Microwave Access, 2.5–2.69 GHz), and S-DMB (Satellite-Digital Mobile Broadcasting, 2.6–2.65 GHz) in the lower band and 5 GHz-WLAN (Wireless Local Area Network, 5.15–5.825 GHz) in the upper band. Also, the measured results show that the proposed antenna operates over the frequency band between 1.65 and 20 GHz (170%), defined by S11 < - 10 dB for use in UWB communication systems. The presented design is validated by simulations and measurements.

MATERIALS AND METHODS

Figure 1 shows the configuration of the CPW-fed proposed antenna which consists of an ellipse-shaped patch as the main radiator, a circular-shaped ground plane. In this design, the antenna is constructed with a substrate made of FR4, with the thickness 1.6 mm and the relative dielectric constant 4.4. For 50Ω input impedance matching, the CPW feedline has the center width of $W_c = 3$ mm and $g_c = 0.3$ mm. The optimization of the structure is obtained using the Ansoft simulation software high frequency structure simulator (HFSS). A pair of ellipse-shape-combined (ESC) form on the patch is connected to the CPW ground plane. The major and minor radii of the elliptical-combined patch are (b_1, b_2) and (a_1, a_2) respectively. By properly adjusting the dimension of the semi-ellipse-shaped patch structure the impedance matching of the proposed antenna improves, which produces wider impedance bandwidth. The gap between patch and CPW-ground plane is 0.2 mm. In addition, for increasing the lower frequency band and improving impedance matching and to access as multi-operating bands of the wireless communication systems, a half- ellipse-shaped slot is located in the patch. The major and minor radii of the elliptical-combined ground are b_3 and a_3 respectively. In most of the monopole antennas, the modified ground plane acts as an impedance matching circuit. In the proposed antenna, there is a direct relation between the gap distance separating the radiator and the ground and the elasticity ratio. In other words, a carefully selected value for the gap means an improved impedance matching, and thus an improved performance, especially at the upper frequency band. The circular form on the ground plane is designed for a further improvement in the impedance matching.

The optimal parameters of the constructed antenna are as follows: $W_{sub} = 40$ mm, $L_{Sub} = 44$ mm, R = 21 mm, $a_1 = 7$ mm, $b_1 = 15$ mm, $a_2 = 4$ mm, $b_2 = 16$ mm, $g_c = 0.3$ mm, $W_c = 3$ mm, L = 3.5 mm, gap = 0.2 mm, $a_3 = 14$ mm, $b_3 = 3$ mm.

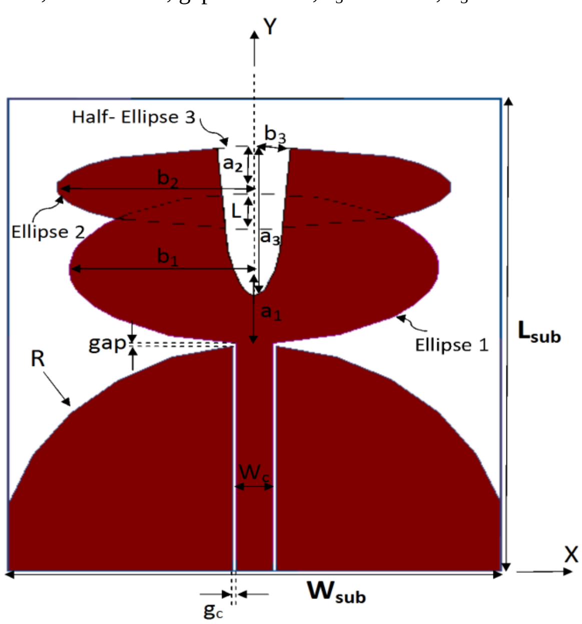

Figure 1. Configuration of the proposed antenna with a pair of ellipse-shape-combined (ESC) form on the patch

RESULTS AND DISCUSSION

After introducing the proposed antenna, we investigate the difference values of a_1, a_3, b_1 and b_2 parameters. In this parametric study, the best value for each parameter has been chosen, and by fixing it, we optimize the remainder of the parameters.

Figure 2 shows the simulated S_{11} curves with the different values for b_1, while a_1 in 7 mm is fixed. It can be seen from this figure that by using of different structures of the antenna with $a_1 = b_1$ and $a_1 > b_1$ forms in manner indicated in figure 2, the impedance matching is poor at the frequency band over 4 GHz. From the simulation results in this figure, it is found that by using of $a_1 < b_1$ structure increase the sensitivity of the upper frequency than the lower frequency. Therefore, doing several experiments, b_1 in 15mm is fixed for $a_1 < b_1$. Figure 3 shows the effect of the size of the half-ellipse-shaped slot on the patch without changing its position and the simulated S_{11} for different values of the structures. In this Figure, it is clear that choosing a suitable size for the slot improves the performance significantly, especially at around 6 GHz. Also, It is clearly observed that the parameter a_3, b_2 are critical parameter to control the performance at the upper frequency. According to the simulated results, the optimized value of 3 mm for a_3 is found.

The design antenna was fabricated (Figure 4) and tested. The impedance bandwidth with different structures of the proposed antenna was tested by using an Agilent 8722ES Vector Network Analyzer (VNA), as indicated in Figure 5. In the proposed antenna with form of ellipse-shaped patch and without slot inside it in the manner indicated in Figure 5a and Figure 5b, the impedance matching is poor at the frequency band over 6 GHz as shown in Figure 6. Using a pair of Ellipse-Shaped-Combined (ESC) form on the patch and a half-ellipse slot inside patch in the manner shown in Figure 5c, a proper control on the upper and lower frequencies of the band can be achieved as shown in Figure 6. It can be observed that by using structure of Figure 5c, the lowest frequency is significantly decreased from 2.2 to 1.65 GHz for access to DCS (1.71–1.88 GHz), PCS (1.85–1.99 GHz) and UMTS (1.92–2.17 GHz) bands. Figure 6 clearly shows that the impedance bandwidth of proposed antenna ranges from 1.65 to 20 GHz in measurement, which covers the entire ultra wideband band and in multiband wireless operations, covering the DCS (1.71–1.88 GHz), PCS (1.85–1.99 GHz), UMTS (1.92–2.17 GHz), 2.4-GHz WLAN (2.4–2.484 GHz), Mobile-WiMAX(2.5–2.69 GHz) and 5-GHzWLAN (5.15–5.825 GHz) bands. A very good agreement between the simulated and measured results can be seen in Figure 6 except at the lower frequency band and a slight down shift. Figure 7 shows the measured gain from 1 GHz to 11 GHz for the developed antenna. From this figure, it is possible to see that the gain varies from 0.8 dBi at 2 GHz to 3.8 dBi at 11GHz. Figure 8 shows the measured radiation pattern at the frequencies 2, 4, 7 and 9GHz, in the *x-z* plane and *y-z* planes. From an overall view of these radiation patterns, the proposed antenna behaves quite similarly to the typical printed monopoles in the lower and middle frequency bands. The H-plane patterns are almost omnidirectional, but more directive at the higher band.

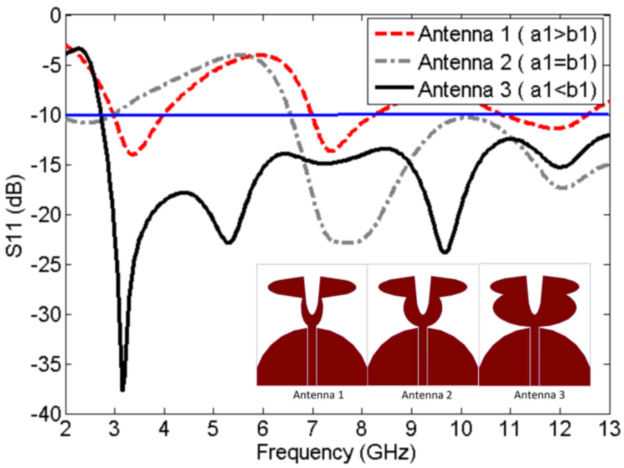

Figure 2. Simulated S_{11} characteristics of the proposed antenna with various values of a_1, b_1 (a_1 in 7 mm is fixed)

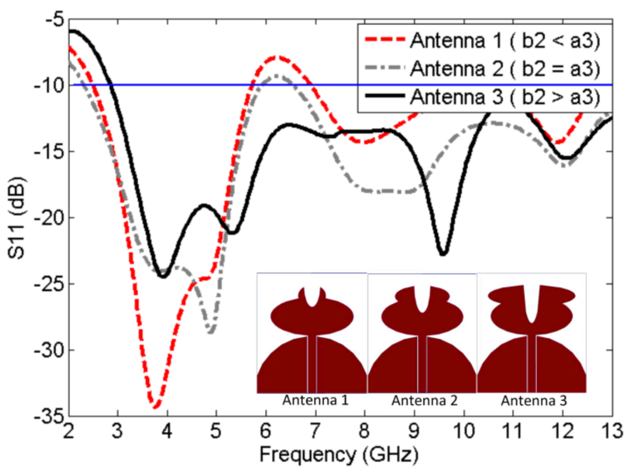

Figure 3. Simulated S_{11} characteristics of the proposed antenna with various values of a_3, b_2 (b_3 in 3 mm and a_2 in 4mm is fixed)

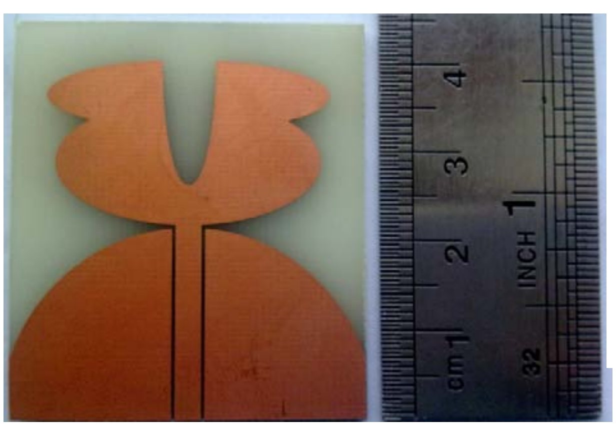

Figure 4. Photograph of the printed monopole antenna (front)

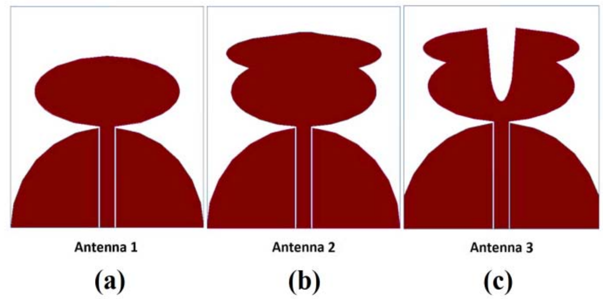

Figure 5. The proposed antenna with different structures. (a) Antenna with one of ellipse on the patch. (b) Antenna with a pair of ellipse-shape-combined (ESC) form. (c) Proposed antenna with a half-ellipse slot inside the initial patch

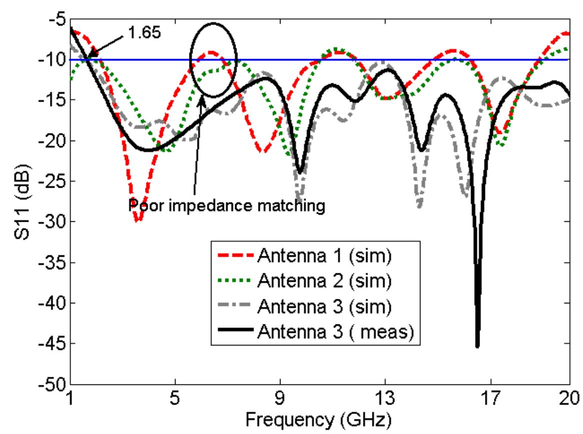

Figure 6. Comparison between measured and Simulated S_{11} characteristics for different structures of antenna shown in Figure 5

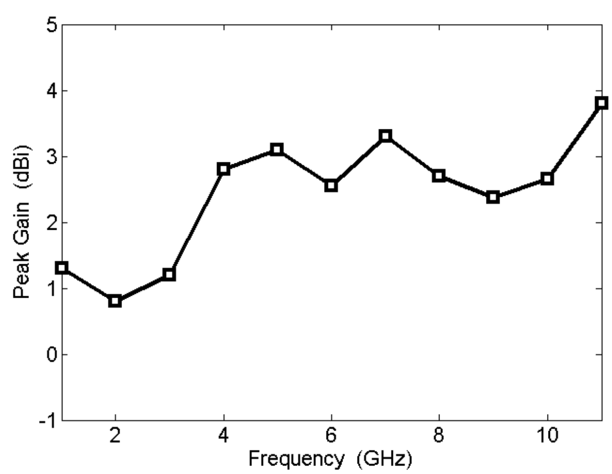

Figure 7. Measured antenna gain of the proposed antenna

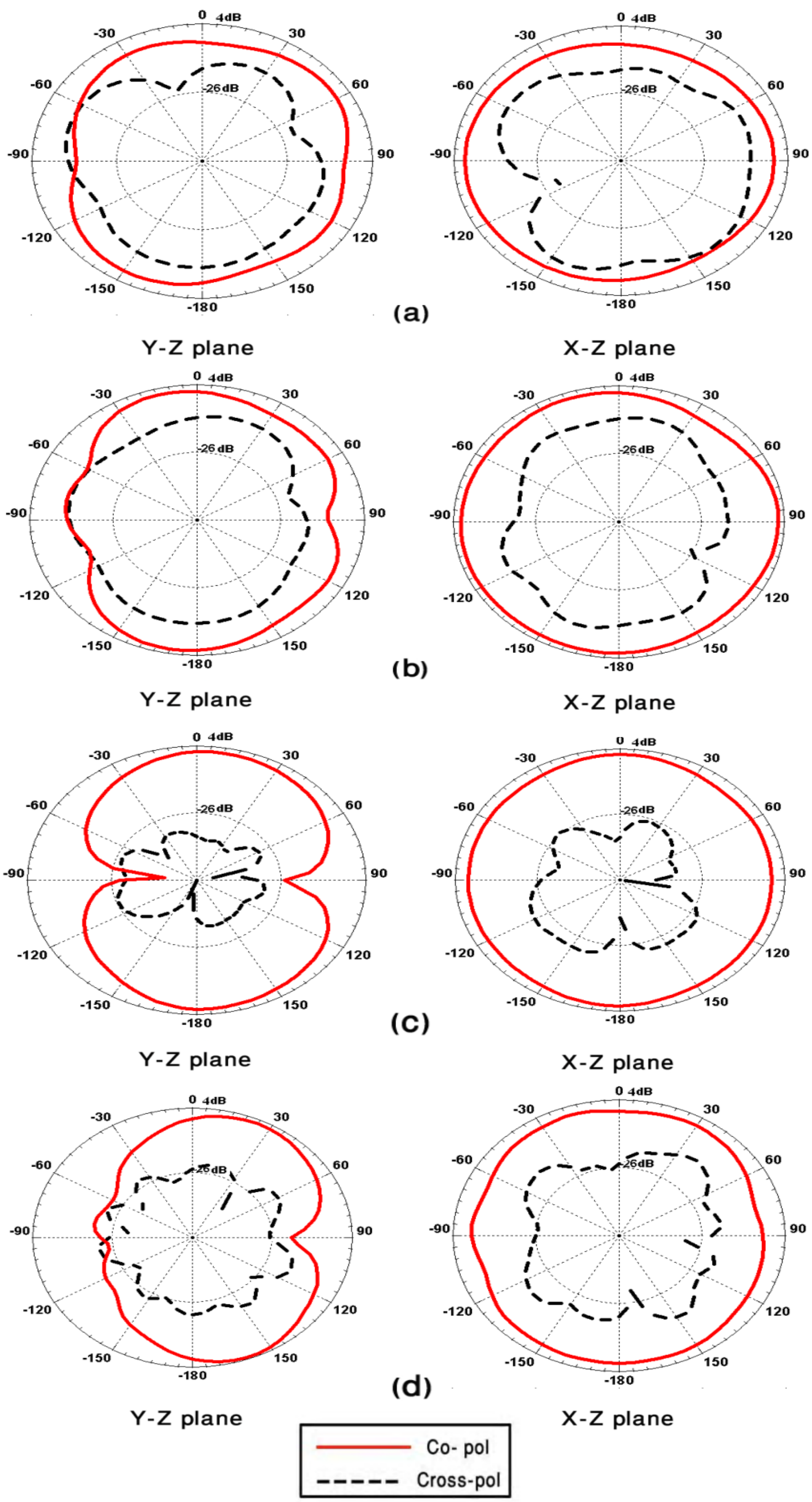

Figure 8. Measured radiation patterns of the proposed antenna: (a) 2 GHz; (b) 4 GHz; (c) 7 GHz; and (d) 9 GHz. Solid line: co-polarization; dashed line: cross- polarization.

CONCLUSION

A novel and simple of a cpw-fed printed monopole antenna with multiband performance is proposed. The radiator of the antenna is with a pair of the ellipse-shaped-combined (ESC) form on the patch. The size of the circular-shape form in the ground plane has been optimized. By properly adjusting the dimension of the semi-ellipse-shaped patch structure the impedance matching of the proposed antenna improves, which produces wider impedance bandwidth. A half- ellipse-shaped slot inside patch with proper dimensions is used to extend the bandwidth of the antenna. Experimental results demonstrate that the simple design with the half-ellipse-shaped slot inside initial patch and a pair of ellipse-shaped-combined (ESC) form, and with the appropriate tuning of dimensions, the appropriate operating bandwidth, measured gain and radiation patterns for DCS/PCS/UMTS/2.4-GHz WLAN/Mobile-WiMAX/5-GHz WLAN, and UWB (3.1-10.6 GHz) applications can be achieved.

REFERENCES

[1] First Report and Order in the Matter of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems. ET Docket 98–153, Federal Communications Commission, FCC 02–48, April 22, 2002.

[2] M. Moosazadeh, C. Ghobadi, and M. Dousti, "Small monopole antenna with checkered- shaped patch for UWB application," IEEE Antennas and Wireless Propagation Letters, vol. 9, pp. 1014–1017, 2010.

[3] M. Moosazadeh, and Z. Esmati, "A CPW-FED antenna with the circular shaped form with the slots for UWB application," Microwave and Optical Technology Letters, vol. 53, pp. 2945-2949, 2011.

[4] W.C. Liu, J.L. Jaw, and B.C. Chen, "Triple-band CPW-fed monopole antenna with branch strips for wireless applications, " Microwave and Optical Technology Letters, vol. 50, pp. 2794–2797, 2009.

[5] J.N. Lee, J.H. Kim, J.K. Park, and J.S. Kim, "Design of dual-band antenna with u-shaped open stub for WLAN/UWB applications, " Microwave and Optical Technology Letters, vol. 51, pp. 284–289, 2009.

[6] G. M. Yang, R. H. Jin, G. B. Xiao, C. Vittoria, V. G. Harris, and N. X. Sun, "Ultrawideband (UWB) antennas with multiresonant split-ring loops," IEEE Transactions on Antennas and Propagation, vol. 57, pp. 256–260, 2009.

[7] D.D. Krishna, M. Gopikrishna, C.K. Anandan, P. Mohanan, and K. Vasudevan, "CPW-Fed koch fractal slot antenna for WLAN/WiMAX applications," IEEE Antennas wireless propagation Letters, vol. 7, pp. 389-392, 2008.

[8] K.G. Thomas and M. Sreenivasan, "Compact triple band antenna for WLAN/WiMAX applications," Electronics Letters, vol. 45, pp. 811-813, 2009.

[9] G. Augustin, P. C. Bybi, V. P. Sarin, P. Mohanan, C. K. Aanandan, and K. Vasudevan, "A compact dual-band planar antenna for DCS-1900/ PCS/PHS, WCDMA/IMT-2000, and WLAN applications," IEEE Antennas Wireless Propagation Letters, vol. 7, pp. 108–111, 2008.

[10] W. C. Liu, M. Ghavami, and W. C. Chung, "Triple-frequency meandered monopole antenna with shorted parasitic strips for wireless application," IET Microwave Antennas Propagation, vol. 3, pp. 1110–1117, 2009.

[11] V. P. Sarin, V. Deepu, C. K. Aanandan, P. Mohanan, and K.Vasudevan, "Wideband printed microstrip antenna for wireless communications," IEEE Antennas Wireless Propagation Letters, vol. 8, pp. 779–781, 2009.

[12] C. S. Liu, C. N. Chiu, and S. M. Deng, "A compact disc-slit monopole antenna for mobile devices," IEEE Antennas Wireless Propagation Letters, vol. 7, pp. 251–254, 2008.