A Compact Circular Polarized Antenna with Wide Beamwidths for CNSS Applications

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Abstract—**A compact circular polarized (CP) antenna with wide beamwidths for CNSS applications is proposed in this paper. The CP radiation is produced by four compact symmetrically arranged inverted-F monopoles which are excited through a compact sequential phase feeding network with a 90° phase delay, where the four monopoles. Each inverted-F monopole contains a printed-inductor to reduce the length of primary radiating element. The overall dimension of the proposed antenna is only 0.17 λ_0×0.17 λ_0×0.09 λ_0, where λ_0 is the corresponding free-space wavelength at 1.268 GHz. Simulated results show that the proposed antenna exhibits an impedance bandwidth of 111 MHz (1.211-1.322 GHz) and an axial ratio (AR) bandwidth of 61 MHz (1.242~1.303 GHz). At 1.268 GHz of the CNSS-B3 band, the antenna has an RHCP gain of 3.7 dB, a radiation efficiency of 88.6%, a 3dB AR beamwidth of 107°/100° (XOZ /YOZ planes) and wide half power beamwidths (HPBWs) of about 131°/120° (XOZ /YOZ planes). With these good performances, the antenna can be a good candidate for the CNSS applications.**

Keywords—Compact; circualr polarized; wide HPBWs; inverted-F monopoles

I. INTRODUCTION

Recently, satellite navigation systems have been widely used in human daily life, such as Global Position System (GPS), Galileo Navigation Satellite System (GNSS) and Compass Navigation Satellite System (CNSS). Among them all, CNSS has attracted more and more attentions due to the navigation and positioning services compatible with other systems. Antennas play an important role in CNSS terminal equipment which require antennas to satisfy specific performances such as good CP property and wide beamwidths. Meanwhile, with the dimension of the CNSS terminal equipment becoming smaller, the design of a compact CP antenna with wide beamwidths is highly demanded.

Various types of antennas with CP radiation have been chosen for GPS or CNSS, such as microstrip antennas in [1], quadrifilar helix antenna in [2] and stacked patch antennas in [3]. However, these configurations are generally bulky, which are not desirable for handheld devices. Various kinds of techniques are used to reduce the antenna dimension, such as adopting high-permittivity substrates in [4], grounding the central patches surrounded by a four square-ring-shaped slots in [5], and loading two short probes in parallel in [6]. Although the dimensions are decreased by these methods, they may suffer from complex configurations and narrow radiation patterns with HPBWs less than 100°.

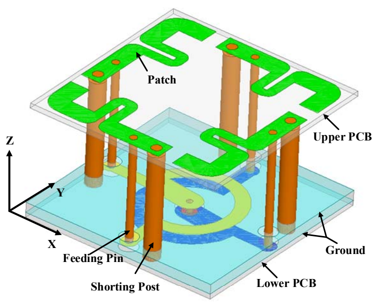
In CNSS applications, antennas need wide HPBWs to improve the coverage area and stabilize the receiving signal. Many researches have been done to broaden the HPBWs, such as loading auxiliary radiators in [7], utilizing the curved dipoles and ground planes in [8]. However, the antennas mentioned above have relatively large dimension.

A compact CP antenna with wide beamwidths for CNSS applications is proposed in this paper. Four compact inverted-F monopoles are arranged symmetrically to the center point and fed by a compact sequential phase feeding network to get the CP radiation. With the use of the shorting technique and printed-inductors, the compactness of the inverted-F monopole is obtained. The overall dimension of the proposed antenna is only 0.17 λ_0×0.17 λ_0×0.09 λ_0, where λ_0 is the corresponding free-space wavelength at 1.268 GHz. The impendence bandwidth ($|S_{11}|$<-10 dB) are 111 MHz (1.211-1.322 GHz), and the AR bandwidth (AR<3dB) are 61 MHz (1.242~1.303 GHz). Meanwhile, the HPBWs at 1.268 GHz is greater than 120°. Details of the proposed antenna design and the simulated results are presented and discussed.

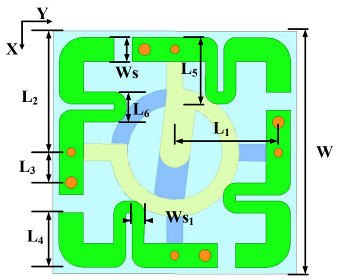
II. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed antenna. The antenna is composed of three parts, namely, the upper printed circuit board (PCB), the lower PCB and the connecting structures. Fig. 1(a) shows the perspective view of the proposed antenna, whereas Fig. 1(b) and Fig. 1 (c) show the geometry of the upper PCB and connecting structures, respectively. The upper PCB is a 1mm-thick FR4 substrate with a relative permittivity of 4.4. The antenna is composed of four compact inverted-F monopoles (with length of L_2, width of W_s) symmetrically to the center point and excited with a 90° phase delay through a compact sequential phase feeding network. A printed inductor (with length of L_5) is inserted in each inverted-F monopole, which is connected to the feeding network by a feeding pin (with radius of 0.75 mm) and shorted to the metal ground by a metallic shorting post (with radius of 1.6 mm).

The lower PCB are composed of three substrates, and both of them are 1mm-thick substrates with a relative permittivity of 2.65. The feeding network is composed of four layers (from the top to the bottom) on the three substrates. Fig. 1(d) shows



(a)



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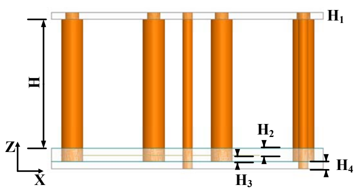

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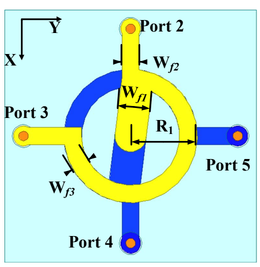
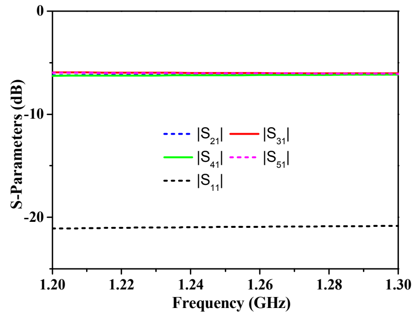


(d)

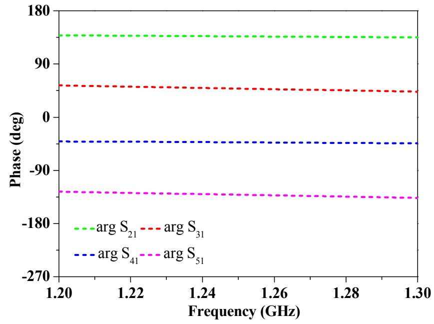
Fig.1 Geometry of the proposed antenna.

(a)3D view. (b)Top view. (c) Side view. (d) Feeding network.

the layout of the feeding lines of the feeding network. A 50Ω coaxial line is used as the input feeding structure, the second layer and the first layer is used as the ground plane. The outer conductor of the coaxial line is connected to the forth layer, whereas the inner conductor is connected to the third layer. Two concentric quarter-transmission rings are etched on the forth and third layers respectively with the same outer radius R_1 and widths (W_{f1}, W_{f2} and W_{f3}). The optimized parameters for the proposed antenna are as follows: L_1=17mm, L_2=19mm, L_3=5mm, L_4=9mm, L_5=11mm, L_6=5mm, W=40mm, W_s=4mm, W_{s1}=2mm, R_1=10.6mm, W_{f1}=5mm, W_{f2}=27mm, W_{f3}=2.8mm, H=19mm, H_1=H_2=H_3=H_4=1mm.



(a)



(b)

Fig.2 The simulated (a) S-parameters and (b) transmission phases of the feeding network.

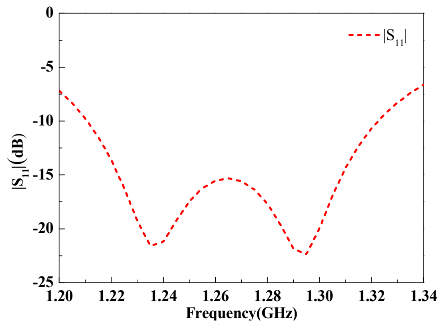
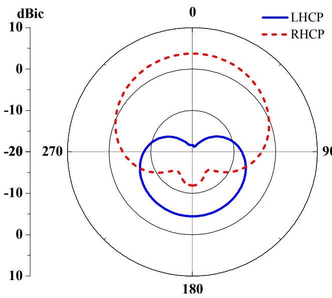
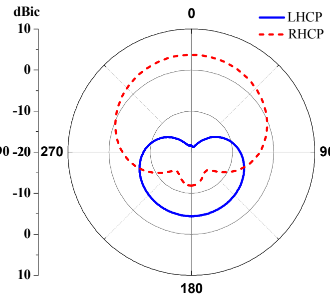


Fig.3 The simualted $|S_{11}|$ of the proposed antenna.



(a)



(b)

Fig.4 The simulated radiation pattern of the proposed antenna at 1.268GHz. (a)XOZ plane. (b)YOZ plane.

III. SIMULATION RESULTS

The simulated S-parameters and transmission phases of the feeding network are shown in Fig. 2. As shown in Fig. 2(a), the transmission coefficients (from $|S_{21}|$ to $|S_{51}|$) are -6.05±0.1 dB, while the reflection coefficients at Port 1 ($|S_{11}|$) is below -21 dB in the frequency range of 1.2-1.3 GHz. Fig. 2(b) indicates that the phase differences of the feeding network are approximately 90°±5° in the frequency range of 1.2-1.3 GHz. The reflection coefficients ($|S_{11}|$) of proposed antenna is below -10 dB in the frequency range of 1.21-1.32 GHz as shown in Fig. 3. The simulated radiation patterns in the XOZ and YOZ plane at 1.268 GHz are shown in Fig. 4. As shown in Fig. 4(a) and Fig. 4(b), the HPBWs at 1.268 GHz is greater than 120°. Fig. 5 shows the simulated AR of the proposed antenna at 1.268GHz and the 3dB AR beamwidth is about 107°/100° (XOZ/YOZ planes). As shown in Fig. 6, the simulated antenna gain is 3.7 dB and the radiation efficiency is 88.6% at 1.268 GHz. Fig.7 indicates the AR bandwidth (AR<3dB) is 61 MHz (1.242~1.303 GHz). The performances of the proposed antenna are summarized in Table I.

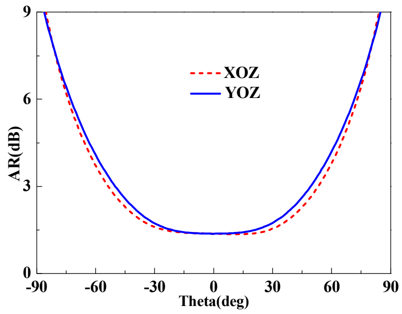


Fig.5 The simulated AR of the proposed antenna at 1.268GHz.

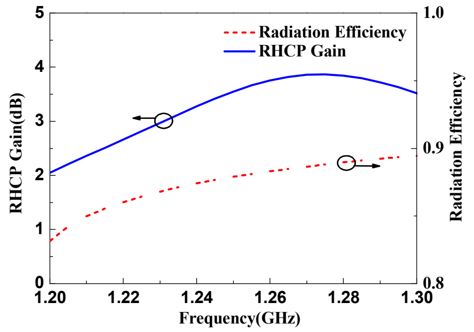


Fig.6 The simulated RHCP Gain and Radiation efficiency of the proposed antenna

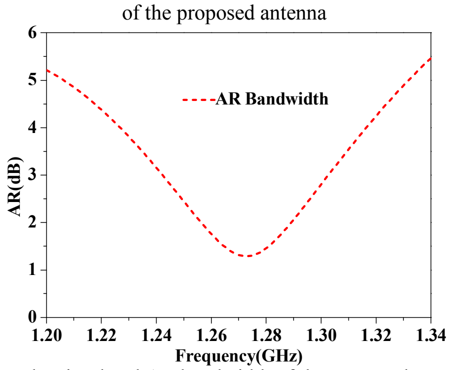


Fig.7 The simulated AR bandwidth of the proposed antenna

TABLE I PERFORMANCE OF THE PROPOSED ANTENNA

Overall Size	10dB $\|S_{11}\|$ band width (%)	3dB AR band width (%)	3dB AR beamwidth (°)		HPBWs (°)		Max Gain (dB)
			XOZ	*YOZ*	*XOZ*	*YOZ*	
$0.17\ \lambda_0\times 0.17\ \lambda_0\times 0.09\ \lambda_0$	8.8%	5.8%	107	100	131	120	3.7

IV. CONCLUSION

A compact CP antenna with wide HPBWs for CNSS applications is proposed in this paper by adopting the shorting technique and printed inductors. Four compact inverted-F monopoles are arranged symmetrically to the center point, where the four monopoles are excited with a compact sequential phase feeding network. The overall dimension of the proposed antenna is only $0.17\ \lambda_0\times0.17\ \lambda_0\times0.09\ \lambda_0$. The impendence bandwidth is 111 MHz (1.211-1.322 GHz) and the AR bandwidth is 61 MHz (1.242~1.303 GHz). At 1.268 GHz, the antenna has a gain of 3.7 dB, a radiation efficiency of 88.6%, a 3dB AR beamwidth of 107°/100° (XOZ /YOZ planes) and wide HPBWs of about 131°/120° (XOZ /YOZ planes). As such, the proposed antenna can be widely used in the CNSS applications.

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