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Compact Hybrid Choke Rings for Dual- Band Circularly Polarized GPS Antenna

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ABSTRACT: This letter presents the compact hybrid choke rings for the dual-band circularly polarized global positioning system (GPS) antenna, in order to suppress the surface wave propagation and reduce the back lobe levels. The designed dual-band circularly polarized antenna is center-fed and composed of two radiation patches. The novel compact hybrid choke rings are introduced to reduce the radiation back lobes and improve the front to back ratio effectively. The measured results show that the return loss of the antenna is greater than 10 dB and the bandwidth covers GPS L2 from 1.168 to 1.238 GHz and GPS L1 from 1.543 to 1.599 GHz. In the working bands, the front to back ratio of the proposed antenna is greater than 30 dB.

KEYWORDS: Center-fed, choke rings, circularly polarized.

I. INTRODUCTION

THE global navigation satellite system plays an indispensable role in transportation navigation, satellite communications, environmental supervision, and military defense [1]–[3]. With the rapid development of the global positioning system (GPS), there has been a much higher demand for the positioning accuracy. As a critical component closely related to the overall performance of the navigation system, antennas play the key role in receiving and transmitting electromagnetic wave signals in the whole system. Due to the reflection of objects around the antenna, some signals from the satellite system will be reflected into multipath interference signals, which could be received by the navigation system and thus introduce inevitable measurement errors [4]–[8]. The size of the back lobe determines the antimultipath interference ability of the antenna to a certain extent. The smaller the back lobes, the more useful it is to resist the multipath interference. Many neoteric designs have been proposed to reduce this effect, among which the multipath choke rings are the most extensive methods used to suppress the surface wave propagation and reduce the back lobe levels of the antennas [9]–[11]. To acquire a better wideband or multiband performance, the choke- ring ground is usually composed of multilayer metal rings placed in the horizontal direction with a depth of about one quarter wavelength, and the antenna is set at the center to mitigate the backlobes without deteriorating other properties [12]–[15]. The diameter of the overall antenna system would be very large, resulting in a bulky and heavy profile along with the relatively high expense. In this letter, we present a novel design of the compact hybrid choke rings for the dual-band right- hand circularly polarized (RHCP) GPS antenna. Compared with the existing largediameter coaxial choke rings placed in horizontal direction, the compact hybrid choke rings are constructed through employing multilayer vertical choke rings underneath the horizontal ones. The overall aperture diameter of the antenna system can then be effectively reduced, and the surface wave's propagation has also been suppressed efficiently. The proposed design could provide a new method for the best compromise between the aperture diameter and overall profile in actual application. The reminder of this letter is organized as follows: Section II introduces the hybrid choke-ring antenna. SectionIII presents and discusses the simulated and measured results. Finally, Section IV concludes this letter.

II. RELATED WORK

The dual-band RHCP antenna is presented. The feed port of the whole antenna is located at the geometric center of the radiation patch, and the center-fed technology is introduced to minimize theinfluence of the probe on the crosspolarized radiation and achieve the high-performance symmetric radiation pattern [16]–[18]. The overall antenna consists of a radiation patch, a parasitic patch, a folded ground with two layers of horizontal coaxial choke rings, and two underneath layers of vertical choke rings. The radiation patch along with the parasitic patch are etched on the two substrate layers made of FR4 (dielectric constant of 4.4, loss tangent of 0.002) with thicknesses of

0.8 mm and 4 mm, respectively. The stacked architecture is employed for the dual-band design, and the dualband operation along with the good impedance matching could be achieved for the antenna by adjusting the air-gap thickness between the two substrates.The upper parasitic radiation patch is operating at the high-frequency band and integrated with a cross slot and a circular ring slot to suppress unwanted current distribution and improve the axial ratio (AR) performance. The lower radiation patch operates at the lower bands, which is loaded with a split circular ring slot to obtain the circularly polarized radiation. Besides, the diagonals of the two patches are both integrated with a pair of small square stubs to improve the dual-band AR performance.

0.9

A reflecting cavity is arranged underneath the antenna to reduce the back lobes. To further suppress the surface wave propagation and reduce the back lobe levels of the above antenna, the compact hybrid choke rings are designed, which consist of two layers of horizontal coaxial choke rings and two layers of vertical choke rings. There into, the multilayer vertical choke rings are placed underneath the horizontal ones and the overall dimensions of the antenna system could thus be effectively reduced. The two-layer annular choke rings are successively distributed around the outer circumference of the antenna from the axis outward, and both choke rings are connected with the metal ground plane. From inside to outside, the depths of the horizontal metal rings decrease successively. The vertical choke rings placed underneath the horizontal ones adopt the laminated longitudinal mode to lower the overall diameter and further reduce the backward edge diffraction.The compact hybrid choke rings, composed of both horizontal and vertical choke structures around the central feed antenna, could effectively suppress the propagation of surface wave, and the back lobes of the antenna are thus greatly reduced. the simulated return losses of the dual-band antenna both with and without the hybrid choke rings, and little variation has been observed for the two conditions. The proposed choke-ring antenna has a return loss greater than 10 dB in both frequency bands, including 1.195–1.248 GHz and 1.552–1.599 GHz.

The simulated radiation patterns in E-plane of the dual-band antenna for three different situations, that is, without choke rings, with only horizontal choke rings, and with hybrid choke rings. It is observed that, the antenna gains for RHCP are obviously improved for both frequency bands through integrating the choke rings. As for the back lobes, there is also significant reduction obtained, along with the front to back ratio of the antenna improved, especially for the cross polarization LHCP. Through integrating the vertical choke rings, the back lobes are furtherly suppressed for both frequency bands, when comparing with that of only horizontal choke rings. Thesimulated front to back ratio of antenna is improved from 14.4 dB to 39.5 dB for L2 bands, while that for L1 bands is improved from 20.87 dB to 30.2 dB

III. PROPOSED ALGORITHM

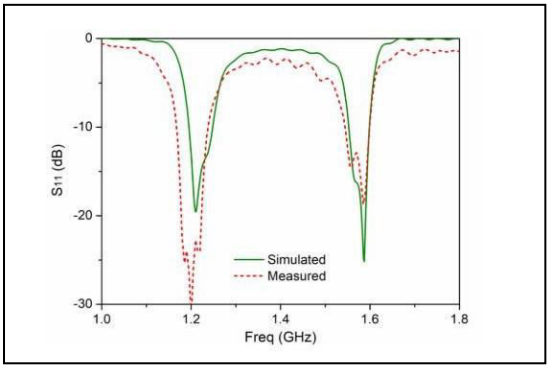

Fig 1 (a)

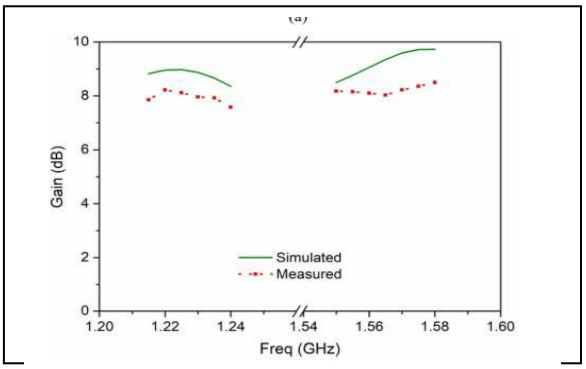

Fig 1 (b)

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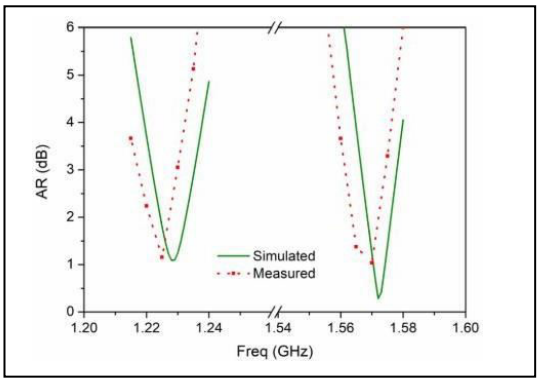


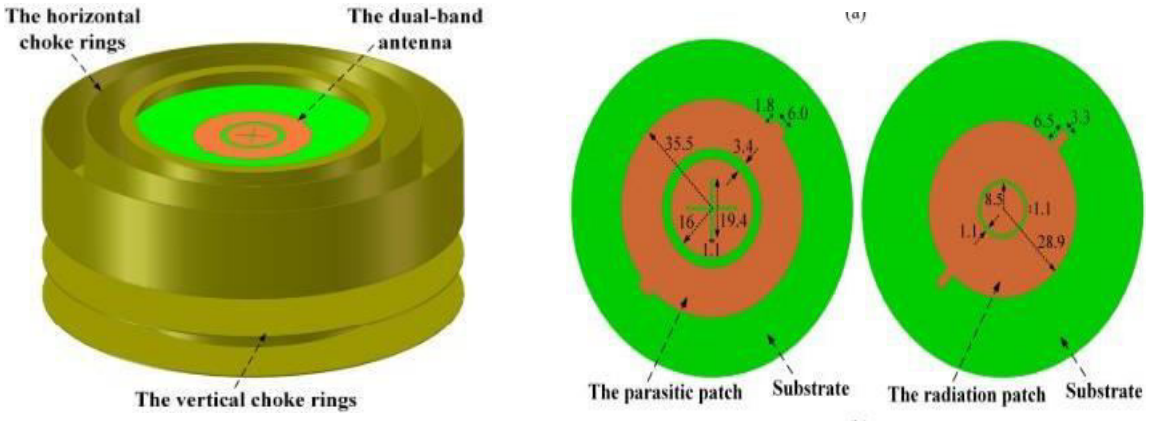
Fig 1(3)

In order to verify the effectiveness and feasibility of the proposed hybrid choke-ring antenna, the physical prototype of the antenna was fabricated, assembled, and measured in the far- field microwave anechoic chamber. The actual test scenario diagram is shown in Fig. 1 in an anechoic chamber. Fig. 1 presents the simulated and measured dual-band performance of the proposed hybrid choke-ring antenna. The measured reflection coefficients show that, the bandwidth for return loss greater than 10 dB covers two frequency bands, including 1.168–1.238 GHz and 1.543–1.599 GHz. Fig. 1(b) presents the simulated and measured gains of the proposed antenna, where the measured gains are about 1 dB lower than the simulated ones. The simulated and measured AR performances versus frequency are presented in Fig. 1(c), and the AR is below 3 dB for both frequency bands, covering 1.207–1.221 GHz and 1.557– 1.569 GHz. Some discrepancies are revealed of the dual-band performance between the simulated and measured results, and both frequency bands are slightly deflected to the low frequency, which is mainly caused by the actual higher dielectric constant of the used substrate FR4 than that for simulation.

Fig. 1 the normalized radiation patterns of the dualband choke-ring antenna for both H- plane and E-plane at the center frequencies of the two operation bands, and the measured results coincide well with the simulated ones. The measured results show that, the front to back ratios of the two operation bands are both larger than 30 dB.

The simulated and measured results of the antenna's AR are presented in Fig. 7. It is observed that, the measured 3 dB AR beamwidth at the center frequencies of the two operation bands covers −90° to 53° and −53° to 62°, respectively. The measured results are basicallycoincident with the simulation ones.

IV. SIMULATION RESULTS



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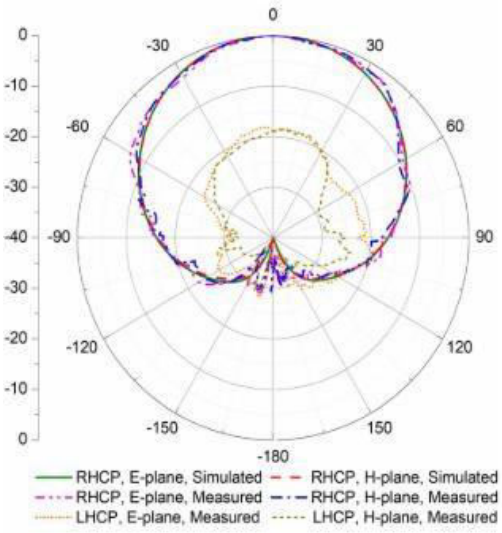

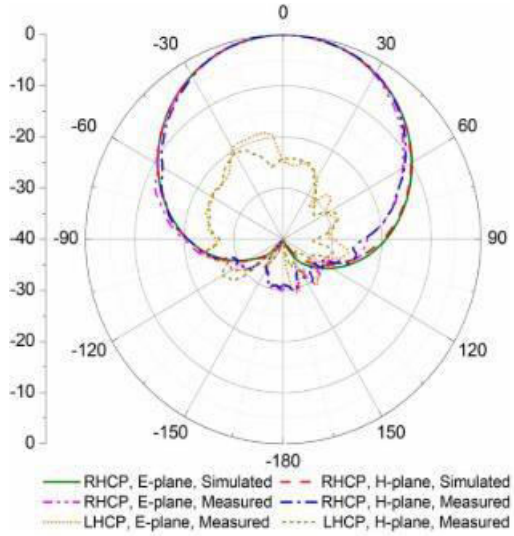

V. CONCLUSION AND FUTURE WORK

This letter presents the compact hybrid choke rings for the dual-band circularly polarized GPS antenna. Through using multilayer vertical choke rings underneath the horizontal ones, the overall dimensions of the antenna system can be effectively reduced, and the surface waves propagation has also been suppressed efficiently. The proposed antenna could bevery suitable for the high-precision GPS system.

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