A New Circularly Polarized Antenna for GNSS Applications

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A New Circularly Polarized Antenna for GNSS Applications

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***Abstract*— A new and circularly polarized (CP) antenna is proposed for global navigation satellite systems (GNSS) applications. The antenna employs a single feed and two orthogonally elliptical printed dipoles. The dipoles are crossed through a 90° phase delay line of a vacant-quarter printed ring to achieve CP radiation. In order to achieve broad beamwidth, four metallic cylinders are introduced. The proposed antenna has achieved a bandwidth of about 43% from 1.08 to 1.69 GHz for S_{11} < -10 dB. Meanwhile, the CP bandwidth is from 1.55 to 1.63 GHz (L1) and 1.12 to 1.26 GHz (L2, L5) for axial ratio < 3 dB. Additionally, the antenna yields right-hand circular polarization (RHCP) and high antenna efficiency over a wide frequency band. The simulated results have shown that the proposed antenna is a good candidate for GNSS applications.**

***Index Terms*—GNSS, circuarly polarized, broadband antenna, single feed antenna, crossed dipoles, satellite communication.**

I. Introduction

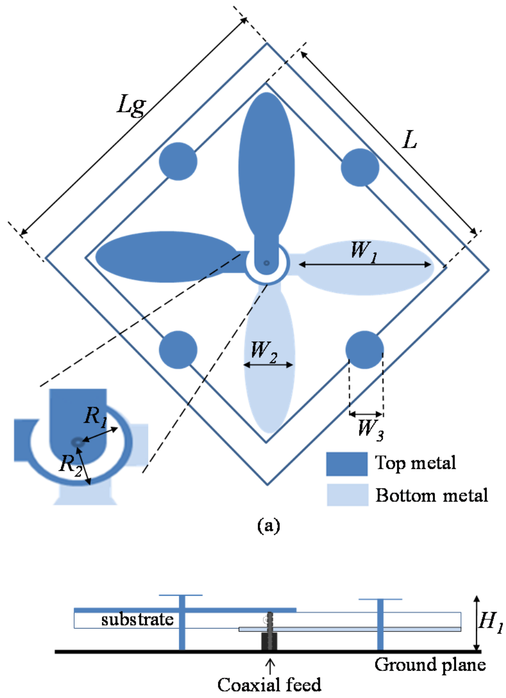
With the deployment of a few noteworthy Global Navigation Satellite Systems (GNSSs) for example Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), European Galileo and Chinese Beidou (Compass), many more frequency bands will be accessible for positioning applications. GNSS applications have multiplied internationally, not only in the military field but also in business and consumer markets.

Global positioning systems typically transmit in circular polarization due to its features of non-sensitive to Faraday rotation introduced by the ionosphere and its potential of reducing polarization mismatch and multipath interferences.

Different designs of single and dual-band CP antennas in the GNSS frequency bands have been reported : e.g., crossed dipole [1], monopole [2], slotted [3], [4], stacked patch [5], [6] and dielectric resonator [7]–[9] antennas. Nevertheless, almost all of these antennas have inadequate 3-dB AR bandwidth to meet the requirements of GNSS applications, due to the lack of techniques to broaden the CP radiation bandwidth. Recently, single-feed CP antennas with a compact radiator have been designed for GNSS applications [10][11]. However, their operational bandwidth does not completely cover the GNSS spectra.

This paper presents a broadband antenna to cover the GPS L1-L5 bands, GLONASS G1, G2 and G3 as well as the Galileo E5a, E5b, E6 and E1bands (1.08 GHz – 1.69 GHz). A printed vacant-quarter ring is used as a 90-degree phase delay line between the dipole pair to produce the CP radiation. The detailed dimensions are presented, and good results are obtained. The CST Microwave Studio is employed for the numerical simulation.

II. Antenna Geometry and Design



(a)

(b)

Fig. 1. Geometry of the proposed antenna : (a) top view and (b) side view

TABLE I. Dimension of the Proposed Antenna

Parameter	*Value (mm)*	*Parameter*	*Value (mm)*
L_g	90.0	L	66.0
R_1	4.7	R_2	5.5
W_1	20.0	W_2	8.0
W_3	8.5	H_1	15..5

Fig. 1 and Table I show the geometry and the dimension of the proposed broadband CP antenna respectively. The antenna comprises two printed cross dipoles and a coaxial line. The dipoles are printed on both sides of a Rogers RO3210 substrate with a relative permittivity of 10.2 and thickness of 1.28mm.

The antenna is composed of four metallic cylinders that are excited by coupling with the elliptical crossed dipole in the center. By adjusting the size of metallic cap and the edge of the dipoles, the coupling strength can be optimized.

The antenna was fed with a 50 Ω coaxial line. The outer conductor of the coaxial line was connected to the dipole arms on the bottom side of the substrate while the inner conductor of the coaxial line was extended through the substrate and connected to the dipole arms on the top side. A vacant-quarter printed ring is used as a 90° phase delay line to generate the CP radiation. The antenna was optimized via CST Simulation Software.

For the initial design of the proposed antenna, it was first design in free space in order to provide resonance in the GPS L1 and L2 bands and then crossed through 90° phase delay line realized by a vacant-quarter printed ring.

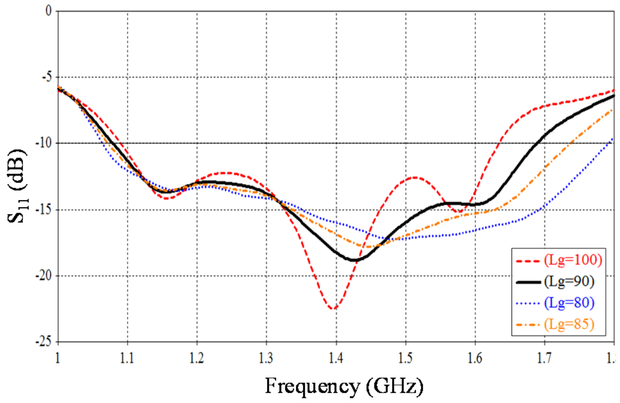


Fig. 2. The simulated S_{11} with different values of *Lg* of the proposed antenna

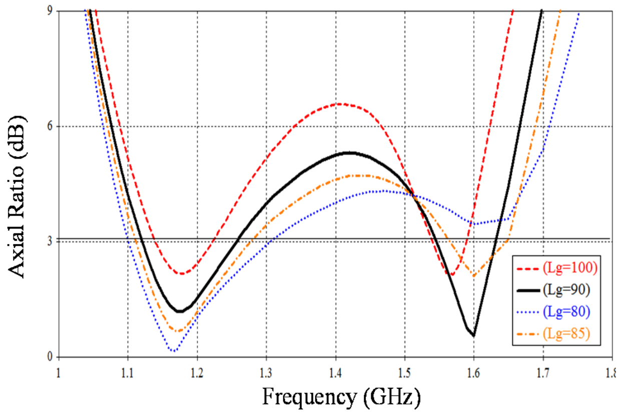


Fig. 3. The simulated axial ratio with different values of *Lg* of the proposed antenna

III. ANTENNA PERFORMANCE

The simulated S_{11}, axial ratio and gain of the antenna with different values of the ground plane length *Lg* are depicted in Figs. 2 to 4, respectively. It can be seen that the bandwidth of the antenna for S_{11} < -10 dB is improved by reducing the size of ground plane. The impedance bandwidth of the antenna covers from 1.08 to 1.69 GHz when the size of ground plane is 90 × 90 mm which is completely cover the entire GPS bands (L1: 1.575 GHz, L2: 1.227 GHz, L3: 1.381 GHz, L4: 1.379 GHz and L5: 1.175 GHz) and Galileo (E1; 1.575 GHz, E5: 1.191 GHz and E6: 1.279 GHz). Meanwhile, the CP bandwidth (AR < 3 dB) shows a decrease at the lower frequency when the size of ground plane is reduced but at the upper frequency bands, the axial ratio is reduced. It covers from 1.55 to 1.63 GHz which involves the L1 and E1 frequency bands and also from 1.12 to 1.26 GHz for L2, L5 and E5.

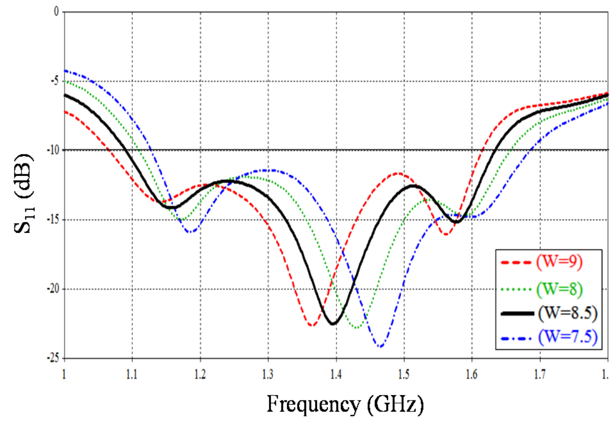


Fig. 4. The simulated S_{11} with different values of *W* of the proposed antenna

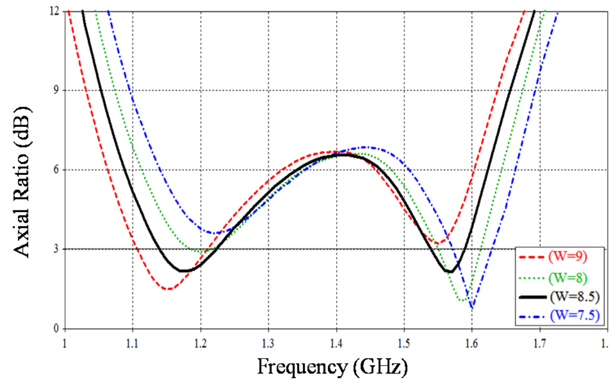


Fig. 5. The simulated axial ratio with different values of *W* of the proposed antenna

In another case, the antenna also simulated with different values of *W* which is the radius of a metallic cap at the upper cylinder. The simulated results of S_{11}, axial ratio and gain are presented in Figs. 4 and 5. It is shown that the impedance bandwidth of the antenna did not change much but the resonant frequency seems to be shifted to the higher frequency bands when the radius of the metallic cap is too small.

However, as shown in the Fig. 5, the CP bandwidth (AR < 3 dB) is highly sensitive to the variation of the metallic cap size. The axial ratio decreased when the size of metallic cap is enlarged at the lower frequency. Meanwhile, at the upper frequency bands, the axial ratio decreased when the size of cap reduced. The optimal value of *W* is 8.5 mm in order to cover the desired bandwidth. Thus, as shown in Fig. 6, when W = 8.5, the CP bandwidth for AR < 3 dB is from 1.13 to 1.22 GHz for L2, L5 and E5 bands and from 1.53 to 1.59 GHz for L1 and E1 bands.

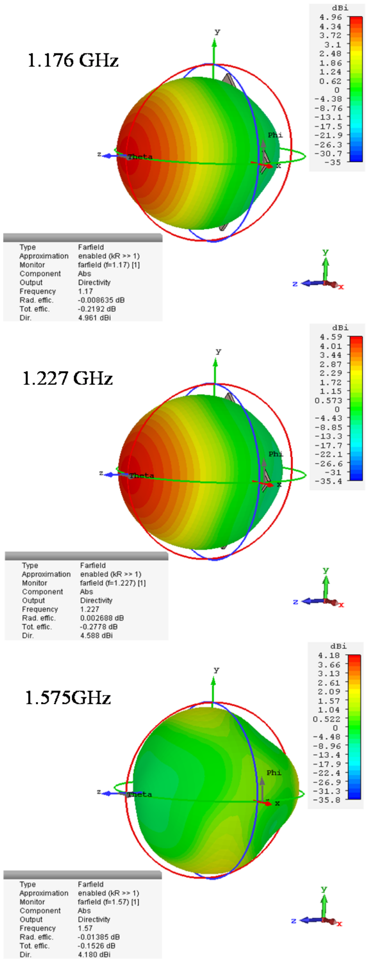


Fig. 6. The simulated 3D radiation pattern of the proposed antenna

The simulated radiation pattern of the antenna is depicted in Fig. 6. It can be seen that the radiation pattern is to be unidirectional with a very broad half power beam width. The maximum gain of the antenna is more than 4 dBi over the broadband.

IV. CONCLUSIONS

In this paper, a new broadband cross-dipole antenna has been proposed and designed for the GNSS applications. The impedance bandwidth is very broad to cover the entire GPS, Galileo and GLONASS bands. The structure of the antenna is compact and unique.

The dimension of the antenna is 90 mm × 90 mm × 15.5 mm which is small and compact. The proposed antenna has simulated bandwidth of 1.08 to 1.69 GHz (610 MHz) for impedance matching S_{11} < -10 dB and 1.12 to 1.26 GHz (140 MHz) and 1.55 to 1.63 GHz (80 MHz) for an AR < 3 dB.

To validate the predicted performance, the antenna is made and measurement validation will be carried out soon – the results will be reported at the conference. All the initial results have demonstrated that the antenna is an excellent candidate for the GNSS applications.

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