Design of A Novel Quad-band Circularly Polarized Handset Antenna

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***Abstract* — A novel circularly polarized handset antenna which is compatible with multiple Global Navigation Satellite Systems is proposed. The antenna comprises a palm-size slab as the handset test bench, a small antenna chip mounted at the corner of the slab, three branches, a small patch, and a ground plane with rectangle clearance region. The antenna is featured with several characteristics such as quad frequency band operation, circularly polarized reception, low fabrication cost, compact size. Both of the simulated and measured results are shown to illustrate the good performance of the proposed antenna.**

***Index Terms* — Quad-band, Circular polarization, GNSS, Handset antenna.**

I. INTRODUCTION

The fast growth of wireless communication technology in the last decade demands diversified services from wireless communication devices. The Global Navigation Satellite System(GNSS) is the one of the most successful commercial products, and is being used more and more widely in various areas. To overcome the drawbacks of linear polarization signals, such as the problems of polarization alignment and terrestrial mobile communication systems, inclement weather, ionosphere absorption and multipath effects, circularly polarized(CP) signals are needed in these systems.

Nowadays, the American Global Positioning System(GPS), the Russian GLONASS and the Chinese Beidou navigation systems are already in operation. And EU's Galileo positioning system are scheduled to provide full function in the near future. Integrating multiple navigation systems is a good choice for commercial devices to improve the positioning performance. Our goal in this paper is to develop a compact, low cost, multi-band circularly polarized antenna for handheld navigation devices.

Many methods have been taken to realize circularly polarized reception, such as helixes, four-arm spirals, patches bended monopole and crossed dipoles. The curl antenna [1] uses a bended monopole to yield a CP radiation pattern for satellite communication. Reference[2] presents a compact quadrifilar helix antenna with the self-phasing technique. It is installed externally to the portable de-vice with excellent circular polarization performance. However, it works in one band only and requires a wideband balun as well as a matching network, which, in turn, increases the design complexity.

An alternative approach to producing circular polarization is to create two orthogonal resonant modes on the radiating element with a 90 phase difference. For patch antennas, perturbation cuts or strips are used to produce two perpendicular modes. Many studies have been reported in the literature that describe different methods of achieving multiband. A stacked patch technique with a high permittivity dielectric material is used in [3] to achieve a compact triple band antenna design. However, a dual orthogonal feed is required to drive the antenna. Reference [4] proposes a novel CP antenna design based on stacked patches with a single feed for the GPS operation in L1 (1.575GHz), L2 (1.227GHz), and L5(1.176GHz) band. However, these kinds of antenna's CP bandwidth are usually narrow and cannot meet requirements of modern wireless communication systems.

The previously mentioned antenna types may not be suitable for handheld devices for its large sizes or big weights. So a general solution for portable device antennas is linear polarization. But using linearly polarized antennas to receive CP signals from satellite suffers a 3-dB loss in terms of signal to noise ratio. [5] uses a bended monopole to realize dual-band CP radiation and successfully solved the problem mentioned previously. To study new structure of CP antenna for handset devices, an antenna configuration with CP radiation pattern is proposed in this paper. The antenna comprises a palm sized slab and a small chip which are both made of FR4 substrate. The antenna works at L1 and L2 band of GPS. Actually the working band around L1 is quite broad which can cover all the near bands for other navigation systems like B1 (1.561GHz) band for Compass and L1C/A (1.602GHz) band for GLONASS.

II. ANTENNA DESIGN

The structure of the proposed quad-band circularly polarized GNSS antenna design for handheld devices is illustrated as fig 1. Taking into considerations the effect of the big ground on the handset circuit board, a palm-size test bench is included in the simulation model. The small antenna chip with size of 30mm × 6mm × 1.6mm is fabricated perpendicularly on the corner of the 120mm (L) ×67mm (W) ×1.6mm (h) slab. Both the antenna chip and the slab is made of substrate FR4 with relative permittivity of 4.4 and dielectric loss tangent of 0.02.

TABLE I

Dimensions of the proposed antenna for GNSS handset

Lz	H1	lg	wg	L	W
30	6	40	15	120	67

Unit :mm

The antenna design mainly comprises of a rectangle big ground with a rectangle clearance, three branches (a folded one, a bended one and a meander one), two short pins and a small patch. On the back surface of the slab, the big ground is printed, while on the up surface of the slab and the inner surface of the antenna chip, the three branches are printed. One short pin is placed between the folded branch and the small patch which is printed on the outer surface of the antenna chip, while another shorting pin is used to connect the ground and the end of the meander branch. A 50 ohm coax line is attached to the feed point to connect to the testing instrument. The detailed parameter for the antenna design is given in table 1.

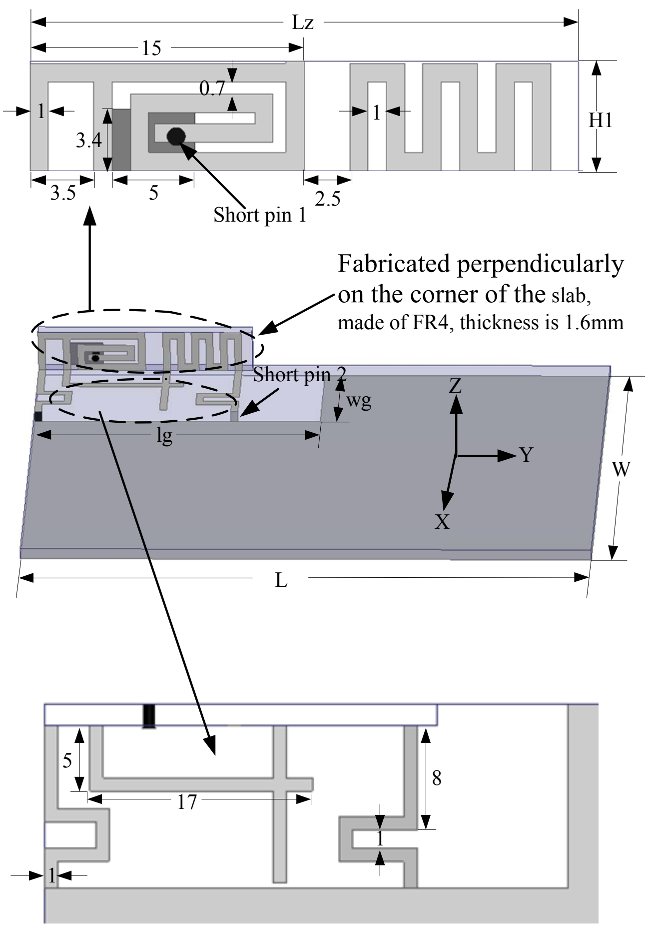


Fig. 1. Detailed geometry of the quad band GNSS reception antenna

In fact, most of the space is occupied by the test bench used to emulate the environment of the hand held devices in which the antenna works, so the space occupied by the antenna is relatively small.

III. Simulation and Measurement Results

The simulation results of the antenna was carried out via HFSS, which is a full wavelength numeric electromagnetic simulation tool. To validate the performance of the antenna design, a prototype was fabricated and the photo of the prototype is shown in fig 2. The measurement was carried out in chamber.

Fig. 2. Fabricated quad band GNSS reception antenna

Fig 3 shows the simulated and the measured return loss. From the figure we can see that the measured and simulated results match well. The -10dB bandwidth is from 1.22GHz to 1.24GHz and from 1.51GHz to 1.66GHz for each operating bands respectively, which cover several frequency bands for navigation systems. Fig 4 compares the measured and simulated axial ratio (AR). At each operating frequency bands the AR is below than 3dB, which means that antenna has a good CP performance. Both Fig.3 and Fig.4 show that the lower band covers L2 band of GPS and the higher frequency band is broad enough to cover all the frequency bands around 1.575GHz for other navigation systems besides GPS L1 band, like B1 band for Compass and L1C/A band for GLONASS.

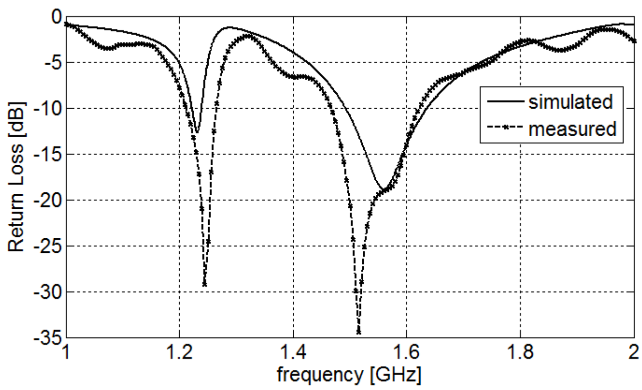


Fig. 3 Comparison of simulated and measured reflection coefficient spectra of the proposed quad-band GNSS reception antenna

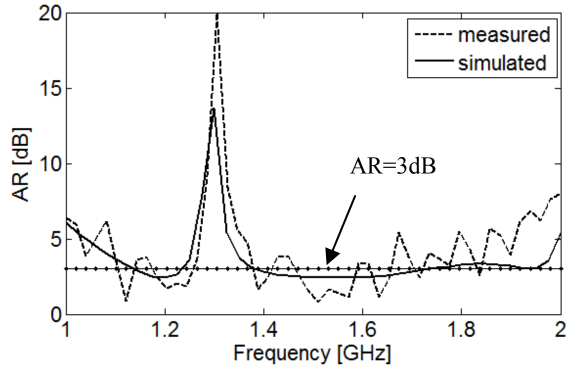


Fig.4 Comparison of simulated and measured axial ratio spectra of the proposed quad band GNSS reception antenna.

Fig.5 shows the measured and simulated radiation patterns of both frequency bands. Both XZ plane and YZ plane patterns are given. Fig.6 is the 3D graph of measured RHCP gain at 1.227GHz and 1.575GHz respectively. The RHCP gain maximum, which is about 1.5dBi, is found about 10 degree away from +z direction, and the 3dB beam width is about 150 degree at 1.227GHz. The measured peak RHCP gain at 1.575GHz is about 3.2dBi, and the beam width is about 120 degree, narrower than the lower band which is caused by the higher peak gain.

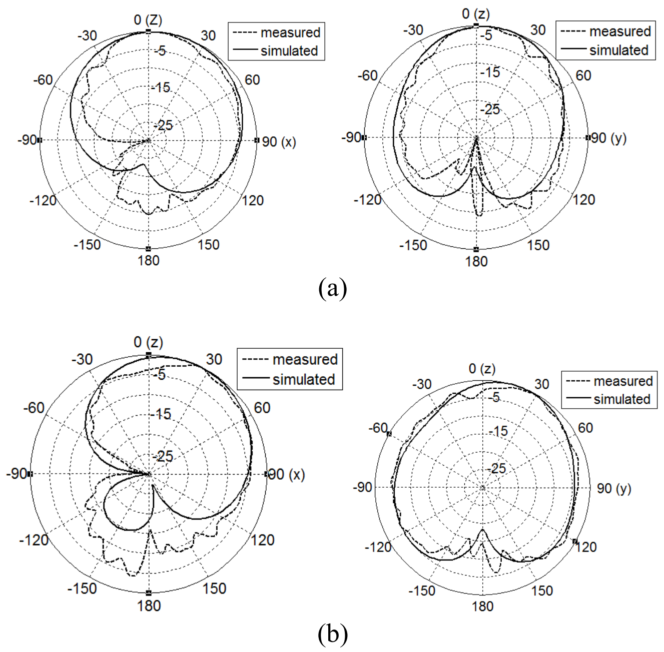
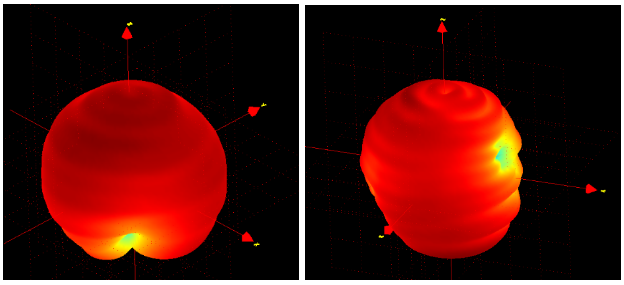


Fig.5 Comparison of simulated and measured radiation patterns of the proposed quad band GNSS reception antenna. (a) at 1.227GHz, (b) at 1.575GHz



(a) (b)

Fig.6. Measured 3D radiation pattern of the proposed quad band GNSS reception antenna. (a) at 1.227GHz, (b) at 1.575GHz

IV. Conclusion

A compact low cost handheld GNSS device antenna for L1 band and L2 band of GPS, B1 band of Compass and L1C/A band of GLONASS was designed and simulated in HFSS. A prototype of the antenna design was fabricated successfully. Both the simulated and measured results demonstrate that the antenna at all operating frequency bands has good circular polarization radiation and impedance matching

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