The Design of a Dual-band antenna for GPS/Beidou Applications

Shenzheng Zuo [1], Luyao Shi[2]， Encheng Wang[2]

[1] Beijing Metstar Radar Co. Ltd
Beijing, China

[2] Information Engineering College, North China University of Technology,
Beijing, China

Abstract

A dual-band circularly polarized microstrip patch antenna for GPS and Beidou applications is proposed and simulated. Compared to existing navigation antennas, this antenna features dual GPS L1 and Beidou L band operation, circular polarization, and excellent near hemispherical coverage. The proposed antenna is formed by two layers of circular patches which is used M-probe as its feed network. The measured results confirm the validity of this design, which can meet the requirement of GPS and Beidou application.

Keywords: *global positioning system, Beidou, circularly polarized , dual-band, navigation antenna*.

1. Introduction

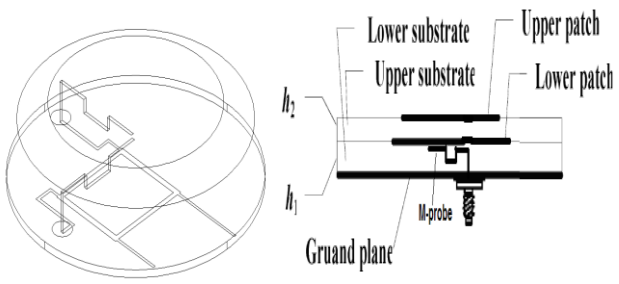
Global navigation satellite system (GNSS) refers to a kind of space navigation technology for navigation and positioning on the ground, sea and space using in the sky of the navigation satellite. With the establishment of China's Beidou satellite COMPASS networks, and with the United States GPS, Russia GLONASS and the European Union GALILEO, they are building the world four big global navigation and positioning system [1]. Also with the development of integrated navigation technology of multi-mode satellite, the design of satellite receiving antenna which can receive multiple frequency signals has received extensive attention. In view of the right-hand circular polarization navigation signal which is launched by the navigation satellite, it requires that in the working band the navigation terminal antenna has good right-hand circular polarization characteristics [2-3]. In order to meet the requirements of multi-mode and multi-band navigation technology, it needs to design an ultra broadband, multi-band and circular polarization antenna.

Microstrip antenna has low profile, light weight, low cost and easy production characteristics, but the inherent defect is narrow band. Therefore how to realize broadband of microstrip antenna with circular polarization characteristics is a hot research topic in recent years [4-5]. In the premise, this paper will study and discuss a navigation antenna structure, focuses on the study of microstrip antenna with circular polarization and miniaturization technology, designed a kind of dual-band antenna structure model. The antenna can work at the L frequency of Beidou, and GPS L1 frequency band

In this paper, we present a novel M-probe feed stacked patch antenna to cover all two bands. It is including the design of the antenna feed network, selection of antenna's feeding methods, simulation and optimal antenna patch, at last analyzing the dielectric substrate, the feed probe, radiation effects of patch shape and height and other parameters on the antenna performance [6-7]. The antenna is using 3dB hybrid as its feeding network, and ensure that the requirements of circular polarization characteristics. It has a great application value; In addition, our proposed antenna is using air as its medium, there by achieving a reduction in design complexity, cost, and assembly time. After continuous processing, testing, and improvement, the antenna’s axis ratio, pattern, gain characteristics are improving. So the antenna can meet the broadband, dual-band and circular polarization requirements [8]

2. Antenna Structure and Design

The geometry of the proposed dual-band antenna is shown in Figure 1. The antenna consists of two stacked patches, two M-probe and a 3dB hybrid. Using air as medium, greatly improving the impedance of the antenna, for the more it reduces the production cost, convenient for later processing test. The 3dB hybrid medium plate of dielectric constant for the general quantity with εr=3.48. As shown in Figure 1, the feed network is composed of a directional coupler. This directional coupler will provide the required two equal signals and a 90 degrees phase difference. The 3dB hybrid is placed a circular version, its semi diameter is R=52mm and thickness is H=3mm.



(a) The overall shape (b) The side view

Fig. 1 proposed circular patch Antenna.

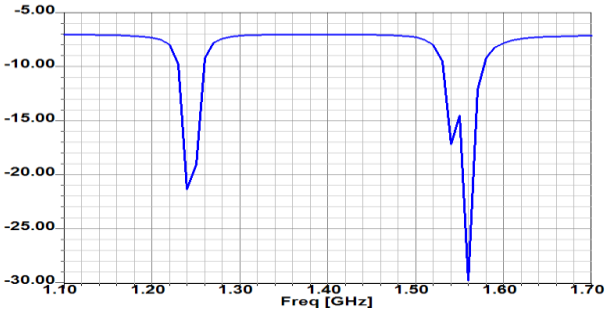


Fig. 2 Return loss of the proposed antenna.

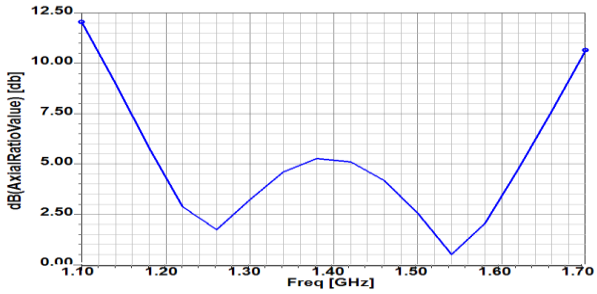


Fig. 3 Axial ratio of the antenna.

The antenna using M-probe coupling feed, due to the adoption of the structure for the antenna, it provides multi-frequency and broadband characteristics [9]. The height of this probe is h=12mm. The top of the M-probe are two circular radiating patches. The lower patch with radius R1 works at a lower frequency, while the upper patch with radius R2 works at a higher frequency. The height of these two layer patches are h1 and h2, respectively [10].

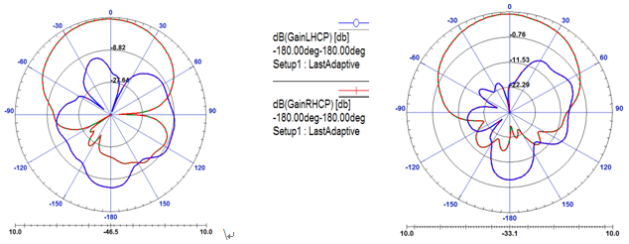
In order to facilitate the design procedure, first the resonant frequencies were computed using the cavity model. The final dimensions were obtained using Ansoft HFSS 10.0. The patch sizes were chosen to achieve resonance at the L band. The following antenna parameters were obtained using Ansoft HFSS 10.0: R1=48mm, R2=35mm, h1=21mm and h2=29.5mm.

3. Experimental Result and Discussion

The return loss of the proposed antenna is shown in Figure 2. At resonant frequencies of 1.26 GHz (Beidou) and 1.575 GHz (GPS) the antenna had return loss at -14.65 dB and -24.3 dB respectively. At low frequency the simulated impedance bandwidth (10dB return loss) is 30MHz from 1.24 GHz to 1.27 GHz and at high frequency the impedance bandwidth is 50MHz from 1.54 GHz to 1.59 GHz.

As shown in Figure 3, the simulated 3 dB axial ratio at L frequency band. This kind of antenna's axial ratio has good dual-band characteristics. It is operating GPS L1 frequency and Beidou L frequency band, respectively. As shown in Fig.3, the 3dB axial ratio bandwidth of GPS L1 frequency is 90MHz from 1.5 GHz to 1.59 GHz and the Beidou L frequency 3dB axial ratio bandwidth is 60MHz from 1.21 GHz to 1.27 GHz. The simulation results of surface, this type of antenna can meet the requirements of multimode satellite navigation technology.

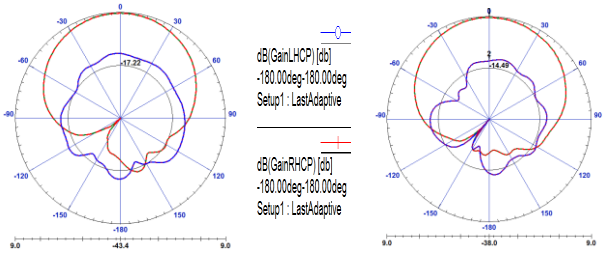
Fig 4(a/b) shows the radiation patterns of the antenna at GPS L1 frequency band. The Fig 4(a) shows the E radiation pattern plane and the Fig 4(b) show the H plane. The antenna radiation pattern has good directional diagram as shown in Fig 4. The right-hand circular polarization (RHCP) gain is 9.088 dB at 1.575 GHz. The gain difference between left-hand circular polarization (LHCP) and RHCP is greater than 13.681 dB at L1 frequency at the broadside direction. The simulation results are based on Ansoft HFSS.



(a) E plane (b) H plane

Fig. 4 Simulated Circularly Polarized Radiation Patterns at 1575MHz.

Fig 5(a/b) shows the radiation patterns of the antenna at Beidou L frequency band. The Fig 5(a) shows the E radiation pattern plane and the Fig 5(b) show the H plane. The right-hand circular polarization (RHCP) gain is 8.560 dB at 1.26 GHz. The gain difference between left-hand circular polarization (LHCP) and RHCP is greater than 19.897 dB at L frequency at the broadside direction.



(a) E plane (b) H plane

Fig. 5 Simulated Circularly Polarized Radiation Patterns at 1.26GHz.

4. The Measurement Result

According to the design and processing of a pair of a dual-band circular polarization microstrip patch antenna. The antenna is a M type probe coupled feed, using air as its medium. The proposed antenna is fabricated and measured. Fig.6 is a photograph of the assembled antenna. Fig.7 shows the measured result of the proposed antenna.

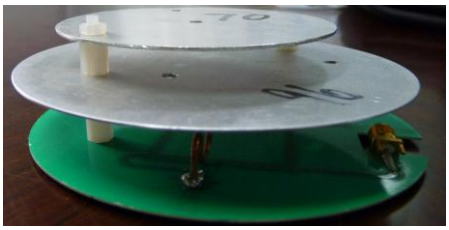


Fig. 6 Photograph of the fabricated antenna.

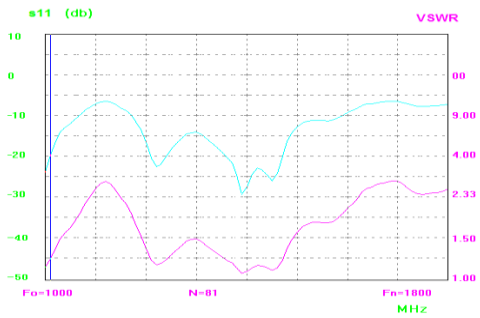


Fig. 7 Measured S11 and VSWR.

The return loss of this antenna and its VSWR (Voltage Standing Wave Ratio) are shown in Fig.7. Although good matching is observed from 1.1 to 1.7 GHz, not all of them are due to good antenna matching. Because the truncated corner is used, the 50-load can absorb all reflected power even when the antenna works at mismatched frequency points.

5. Conclusions

A novel dual-band antenna structure operated at GPS and Beidou frequencies is presented in this letter. It has impedance bandwidths larger than 50MHz and 30MHz at the GPS L1 and Beidou L frequency band, respectively. Measured gains at the broadside direction at GPS L1 and Beidou L are about 10dB and 8.87 dB, respectively. The method of varying the axial ratio is also discussed in this letter.

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Dr Shenzheng Zuo graduated from Beijing University of Posts and Telecommunications. He is an engineer of Beijing Metstar Radar Co.Ltd.

Luyao Shi is a graduate student of Information Engineering College of North China University of Technology.

Dr Encheng Wang graduated from Dalian Maritime University, He is a teacher of Information Engineering College of North China University of Technology.