A Dual-band Circularly Polarized Antenna with Novel Feeding Method for BDS, GPS and GLONASS Application

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Abstract— In this paper, a dual-band circularly polarized antenna is proposed. This antenna constructs with two layers, which provides two working frequency bands. One of the bands operates at the BDS B3 (1268.52 ± 10 MHz). The other band concludes the GPS L_1 (1575.42 ± 10 MHz) and GLONASS L_1 (1602 ± 8 MHz). By changing the length and width of four slots on each patch, its circular polarization performance and working bandwidth can be adjusted. The multistacked patches fed through two coaxial probes which provide two different input signal. To the probe feed on the lower patchit do not connect direct to the lower patch but solder to a small disc on the upper patch. By adjusting these parameters, we will obtain better impedance matching performance.

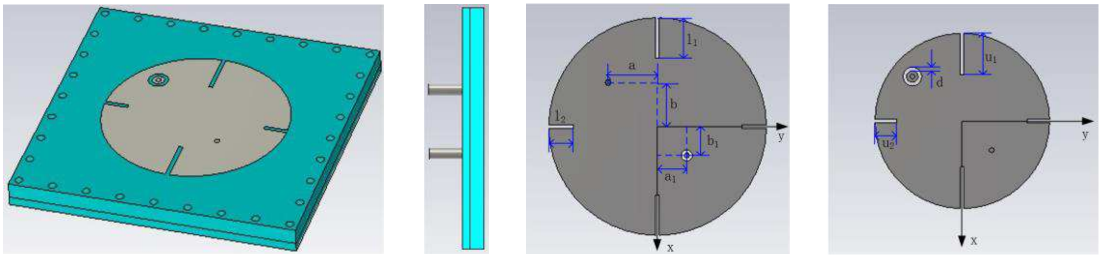
1. INTRODUCTION

Dual-band or tri-band circularly polarized antennas has been widely used in a compatible navigation systems. It has been reported that a multiband antenna can be realized by patches stacked [1] and cutting slots on the patch will achieve circularly polarization under the condition of single feed [2]. In [3], a S-shaped slotted patch antenna is proposed for dual-band operation of circularly polarization. The frequency ratio of this antenna is controlled by adjusting the S-shaped slot arm lengths. For other methods, [4] designed a circularly polarized cavity-backed annular slot antenna for GPS L_1 and L_2 bands. And [5] describes a multi-band circularly polarized printed slot antenna which covers 1.5 GHz for GPS, 2.4 GHz for Bluetooth, and 3.75 GHz for WiMAX. In this paper, we design a dual-band circularly polarized antenna using stacked patches. At the same time, we improve the method of feeding to the lower patch which avoids the problems of soldering and make very small impact on upper patch.

2. ANTENNA DESIGN

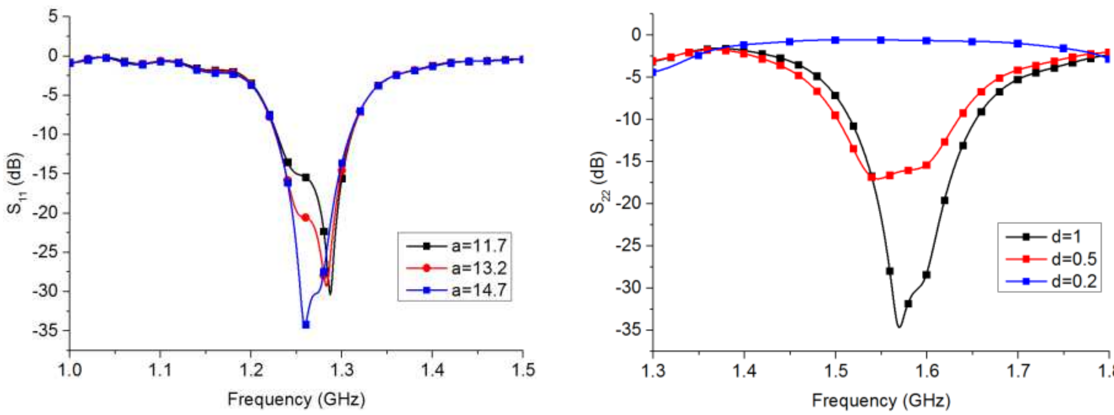
The proposed stacked patch antenna structure is shown in Fig. 1. This antenna is constructed of two round patches stacked on one another. Each layer fed by an individual coaxial probe. Both of the patches are etched on the FR4 substrate with relative permittivity $\varepsilon_r = 4.6$ and $\tan\delta = 0.02$. The lower and upper patch has a thickness of 2.3 mm and 4 mm respectively. The ground plane size is $72\,\text{mm} \times 72\,\text{mm}$. The radius is 29 mm for the lower patch and 23.1 mm for the upper patch. The antenna type in [7] is adopted in this paper. The common method for a single-fed patch antenna to activate circular polarization wave is to disturb the path of the current [6]. So the four slots etched on the patches are used to excite orthogonal resonant modes. The width of the slots is 1 mm. For the lower patch, the lengths of the slotted pair alone the x- and y-direction are l_1 and l_2 respectively. For the upper patch, they are u_1 and u_2 alone the x- and y-direction. A $50\,\Omega$ coaxial probe connected to the upper patch through the lower patch via a hole. The position of this feed point is as shown in Fig. 1. To the lower patch, the probe do not connect to it directly but solder to a small disc on the upper patch. The radius of the small disc is 1.5 mm. The width of the slot between the disc and upper patch is $d = 1$ mm. The location of the small disc is shown in Fig. 1.

The radius of each patch has been discussed in [7]. By changing the length and width of four slots on each patch, its circular polarization performance and working bandwidth can be adjusted. If the patch center is defined as the origin of the coordinate, feed at line $y = x$ will excite left hand circular polarization and $y = -x$ will excite right hand polarization. Actually, despite the structure of patch is symmetric, the two feed probes and small disc on the upper patch breaks the symmetry. So the best impedance matching point will deviate from the $y = x$ and $y = -x$ line. Fig. 2(a) shows the impedance when changing a only. The feed to lower patch is connected with the lower patch and the small disc. Because the dimension of the small disc is far less than the patch, this port can be considered as open and parallel with a capacitor (the slot between disc and upper patch). Therefore, the small disc dimension has little impact to lower patch, but the width of slot has a big impact to the upper patch as shown in Fig. 2(b).



(a) (b) (c) (d)

Figure 1. Structure of the proposed antenna. (l_1 = 10.75 mm, l_2 = 6.5 mm, u_1 = 11 mm, u_2 = 5.85 mm, a = 13.2 mm, b = 11.7 mm, a_1 = 7.8 mm, b_1 = 7.7 mm). (a) Perspective view. (b) Side view. (c) Lower patch. (d) Upper patch.

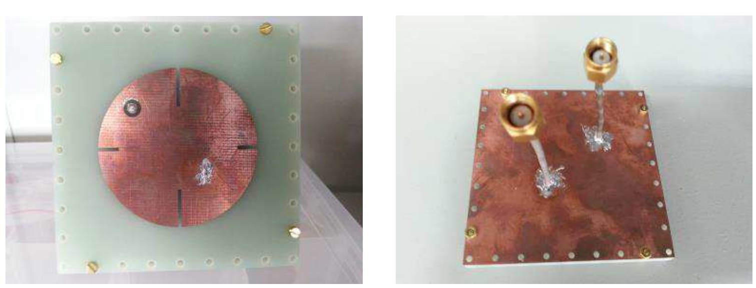


(a) (b)

Figure 2. The influence of some parameters on the simulated return loss. (a) Simulated S_{11} for different feed position. (b) Simulated S_{22} for different gap width.

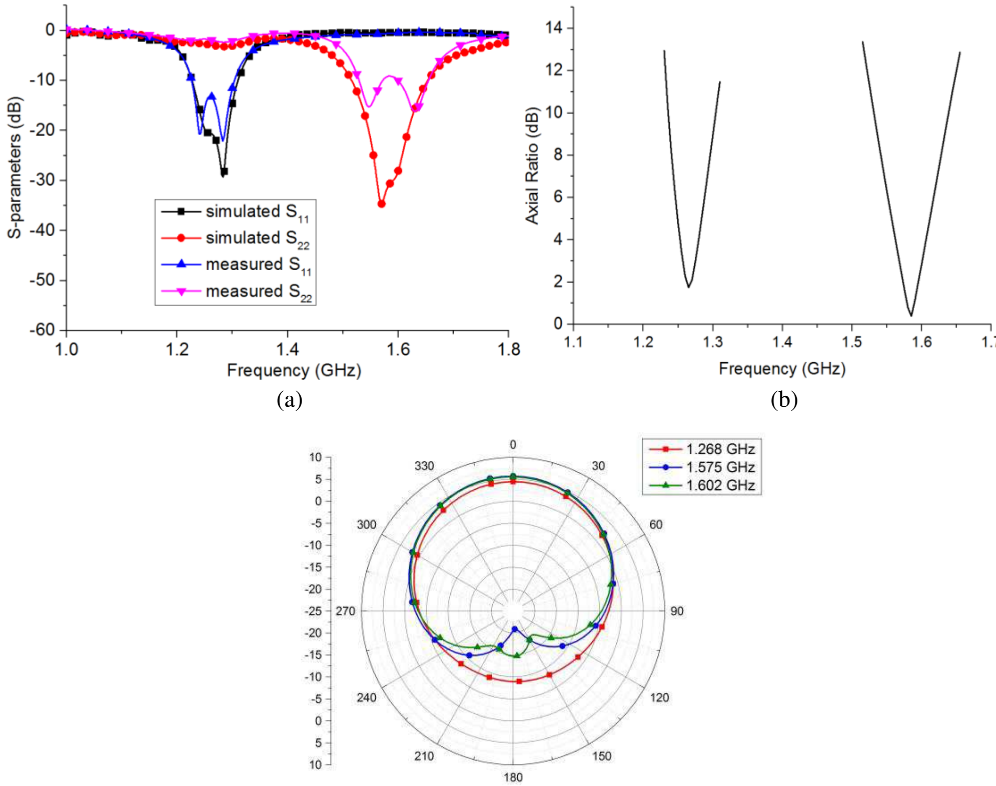
3. RESULTS AND DISGUSSION

In this paper, The radius of the disc and the gap width has small impact on the input impedance of two frequency band. By adjusting these parameters, we will obtain better impedance matching performance. The proposed antenna is optimized by the electromagnetic simulation package of computer simulation technology (CST) microwave studio. Fig. 3 shows the photograph of top and bottom view of this antenna. The simulation shows good agreement with the experimental results of the return loss for the proposed antenna in Fig. 4(a). The 10 dB impedance bandwidth of the measured return loss is from 1.227 GHz to 1.303 GHz and from 1.53 GHz to 1.654 GHz. Fig. 4(b) shows the simulated axial ratio for the two operating bands. The AR for 1.268 GHz (DBS B3), 1.575 GHz (GPS L_1) and 1.602 GHz (GLONASS L_1) is 1.86 dB, 1.67 dB and 3.25 dB respectively. Fig. 4(c) shows the radiation pattern for the three frequency. The comparisons are listed in Table 1. Compared to other multiband circularly polarized antenna, we can easily observe that the fabricated antenna exhibits better performances in bandwidth and size.



(a) (b)

Figure 3. The photograph of the proposed antenna. (a) Top view. (b) Bottom view.



(a) (b) (c)

Figure 4. The simulated and measured results for the proposed antenna. (a) Simulated and measured return loss. (b) Simulated AR for the proposed antenna. (c) Simulated radiation pattern for the proposed antenna.

Table 1.

References	Center Frequency (GHz)	10 dB Return Loss BW (%)	3 dB AR BW (%)	Size (mm)
[1]	1.176, 1.227, 1.575	1.7, 2, 2.5	3.4, 0.81, 0.83	$80 \times 80 \times 4.724$
[3]	1.2, 1.54	16, 12.5	6.9, 0.6	$115 \times 115 \times 21.5$
[4]	1.2, 1.575	3.7, 1.2	0.9, 0.6	$100 \times 100 \times 20$
this work	1.268, 1.585	6.54, 8.7	1.34, 2.02	$72 \times 72 \times 6.3$

4. CONCLUSSIONS

A dual-band circularly polarized antenna with a new feeding method is proposed in this paper. The stacked patches has been used to obtain dual-band operation. The thickness of the upper substrate is increased to broaden the bandwidth. A new feeding method is used in the lower patch, which make the assembly of the multistacked substrates easier and is conducive to error reduction. The simulated and measured results show that, this antenna can meet the requirements of using in DBS, GPS and GLONASS navigation system.

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