LETTER

A Novel Enhanced Isolation Microstrip Dual-polarization Patch Antenna

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Abstract A novel dual-polarization edge-fed microstrip patch antenna was designed in this letter. In order to increase the isolation between the two ports with different polarizations and reduce the working modes affected by the feed line, two-section continuous current strips were separated from the metal ground plane. The measured result shows that the antenna has a port-to-port isolation better than 28.9dB from 5.725GHz to 5.875GHz, and particularly better than 32.6dB at 5.8GHz, which is improved more than 12dB compared with traditional antennas. Besides, a dual-polarization excitation can be realized within the single patch antenna for a single layer dielectric structure.

Key words: dual-polarization, microstrip antenna, isolation, patch antenna
Classification: Microwave and millimeter wave devices, circuits, and hardware

1. Introduction

Dual-polarization antennas improve the system performance because of polarization diversity or frequency reuse, such as reducing multipath fading, improving channel capacity and measurement accuracy. The 5.725–5.875GHz is the Industrial, Scientific, and Medical (ISM) band, which is used as the common frequency band for point-to-point or point-to-multipoint spread spectrum communication system, high-speed wireless LAN, broadband wireless access system, motion sensors, Bluetooth technology equipment and automatic vehicle identification system. In the modern mobile communication system dual-polarization antennas have received much attention. They are widely used in cellular communication, Multiple-Input Multiple-Output (MIMO) systems, radar systems, and Worldwide Interoperability for Microwave Access (WIMAX). The dual-polarization microstrip patch antenna has the characteristics of light weight, small size, low cost and low profile, so it is convenient to integrate in the structure of building windows, solar panels and display screens. In order to meet these requirements, many dual-polarization microstrip patch antenna designs have been proposed [1]–[23].

However, when dual polarization is realized on microstrip patch antenna, the isolation between ports should be considered, which will seriously affect the performance of the antenna when the isolation between ports is poor. In order to achieve high isolation, various types of studies have been reported. For the reported design in [24], [25], by using the aperture coupling feed, the current discontinuity is reduced, the polarization purity is improved, and the high isolation of microstrip patch antenna is realized. But the structure of multilayer substrate is not only unfavorable to fabricate, but also increasing the volume and cost of antenna. In [26], [27], isolation is improved by adding parasitic patches around the same plane as the antenna, but the added parasitic patches in addition to the cost increase, the specific antenna shape needs a specific parasitic patch shape, which is not conducive to the design of the array antenna. A vertical metal wall is used to converge the surface current in the position of the vertical metal wall to achieve high isolation, but the addition of the metal wall makes the profile increase and is not conducive to the fabrication [28].

The low cost and easy to fabrication are good at commercial realization. So for dual-polarization antenna, it is a meaningful task. In this letter, dual-polarization double inset-fed microstrip patch antenna will be adopted, the novel idea is that continuous current strip is added to connect two sides of feed line. Compared with the double-fed model before continuous current strips are added, the proposed antenna greatly reduces mutual coupling between the two ports.

2. Antenna configuration

Fig.1 shows a printed circuit board (PCB) of the top and bottom of the novel enhanced isolation microstrip dual-polarized patch antenna. Table I shows the design parameters of the front of the proposed antenna, and table II shows the design parameters of continuous current strips. The proposed antenna is a square patch fed by inset microstrip line. The system is achieved on FR4 epoxy with dielectric constant ($\epsilon_r = 4.4$), thickness ($h = 1\text{mm}$), and loss tangent ($\delta = 0.02$) with overall size ($11.8\text{mm} \times 11.8\text{mm} \times 1\text{mm}$), the patch antenna and the floor are both made up with copper (thickness is 0.017 mm).

It is noted that two sides of the feed port are separated by the inset microstrip feed line in the antenna, and the

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Fig. 1: Proposed dual-polarization antenna structure. (a)Front view. (b)Back view.

continuous current strip is connected to the two sides. The proposed antenna is improved from the original dual-port dual-polarization microstrip antenna with orthogonal feed, adding a continuous current strip to connect two sides of one feed line. As can be seen from Fig.1, a continuous current strip consists of two via holes and a slender strip paralleling to the floor surface. The material of via holes and slender strips is copper. Two via holes are connected to a slender strip through medium substrate, and finally the connection with antenna is realized by via holes. The parameters of the proposed antenna can be seen from TABLE I and TABLE

Table I: PARAMETERS OF THE RADIATING PATCH

Parameter	Value(mm)	Parameter	Value(mm)
L	11.8	D	0.3
L_1	3.0	W_1	0.7
L_2	3.2	W_2	0.3
L_3	3.9	W_3	2.2
P_1	0.35	P_2	0.85

Table II: PARAMETERS OF THE CONTINUOUS CURRENT STRIP

Parameter	Value(mm)	Parameter	Value(mm)
L_a	3.0	W_b	0.7
L_b	2.5	D_0	1.7
W_a	1.2	D	0.3

II.

The material, size and shape of the two inset feed ports and the two continuous current strips are the same. HFSS (High-Frequency Structure Simulator) will be used to simulate and optimize the antenna structure.

Fig. 2: the surface current distribution of antennas. (a)Single inset-fed microstrip antenna. (b)Double inset-fed microstrip antenna at $x = L/2, y = 0$ feed.

3. Antenna design

When microstrip antennas are excited at whether microstrip line feed or coaxial feed line port, more than one mode is usually excited. Microstrip antennas are half-wavelength structures and are operated at the fundamental resonant mode TM01 or TM10 in general. For the square microstrip patch antenna, the cavity model is used to judge the current distri-

bution when the patch antenna excites the mode TM₁₀ and TM₀₁ [29]. The square antenna with the length L uses microstrip feed line, and the width is d , which is the effective width of a uniform strip of z -directed source current of 1A [30]. It is supposed that total current is 1A and the thickness is h . If feeding current of the microstrip line is shown in equation (1) below, the surface current can be obtained when the working mode of which is TM₁₀.

$$J_z = \begin{cases} \frac{1}{dh}, & x = \frac{L}{2}, -\frac{W_2}{2} < y < \frac{W_2}{2} \\ 0, & \text{other} \end{cases} \quad (1)$$

Where J_z is the volume current fed for the microstrip line. The distribution of surface current of the patch can be obtained according to the boundary conditions

$$\mathbf{J}_{surf} = -\hat{i}_x j \frac{B_{10}}{\omega \mu_0} \left(\frac{\pi}{L} \right) \cos \frac{\pi x}{L} \quad (2)$$

Where B_{10} is the complex number when point feed is known. From the (1)(2), it can be concluded that:

In mode TM₁₀(edge-fed along a straight line parallel to the x -axis or feed along $x = L/2, y = 0$), a sinusoidal distribution of surface current flows in the x direction. When $x = -L/2$ or $x = L/2$, the surface current is 0, and when $x = 0$, The surface current is the maximum value. When the both two modes need to work on the square patch antenna to realize dual-polarization, the inset microstrip feed line can be carried out around $x = L/2, y = 0$ and $x = 0, y = L/2$, respectively. However, when working mode is mode TM₁₀ which excited by microstrip feed line at $x = L/2, y = 0$, another microstrip feed line at $x = 0, y = L/2$ result in the current discontinuity where the current J_x is the maximum. Similarly, the current discontinuity of mode TM₁₀ is the same circumstance. Current path changes in the double inset structure and results in a poor isolation between the ports. As shown in Fig.2(a) and (b), the added inset-fed line cause the the current discontinuity and the current flows around the inset-fed line the current flows out the antenna. In order to solve the problem caused by the realization of dual polarization antenna, the two sides of the inset structure are connected by continuous current strip. After adding continuous current strip, the current flowing along the embedded structure will flow along the continuous current strip, which reducing the current winding and converging on the port, as shown in Fig.3. Coupling between two ports is reduced.

Flow direction of the part of the surface current is changed by the continuous current strip, which also makes the phase of this part of surface current change. The proposed double fed antenna with the continuous current strip makes the electrical length a little bit more longer than that of the single-fed antennas, but shorter than that of the double fed antennas, so the addition of continuous current strip can make a various center frequency. As shown in Fig.4, the impedance matching band is from 5.77GHz to 5.94GHz. As shown in Fig.5, the isolation of the traditional double

Fig. 3: the surface current distribution of proposed antenna feeding at $x = L/2, y = 0$.

Fig. 4: Comparison of the simulation S-parameters among proposed antenna, traditional antenna, and single inset-fed microstrip antenna.

Fig. 5: Comparison of the simulated isolation between proposed antenna and its conventional counterpart without continuous current strips.

inset-fed microstrip antenna is 18.36dB at 5.8GHz, while the isolation of the proposed antenna is 30.4dB, which has improved approximately 12dB. Besides, isolation better than 27dB covering 5.725GHz to 5.875GHz has been achieved for the proposed antenna. In Fig.6, when $f_0=5.8$ GHz, the

radiation patterns of the proposed antenna excited on $x = L/2, y = 0$ are shown at E-plane and H-plane respectively. The symmetry pattern shows that when $f_0=5.8\text{GHz}$, and the excitation is at another port, the radiation patterns of E-plane and H-plane are the same with those excited on $x = L/2, y = 0$, as shown in Fig.6.

Fig. 6: Simulated and measured radiation patterns of the proposed antenna excitation on the $x = L/2, y = 0$ at 5.8GHz. (a)E-plane. (b)H-planes

4. Experimental measurements

The proposed antenna was fabricated and tested, and the prototypes are shown in Fig.7. Fig.8 shows the simulated and measured return loss and isolation of the proposed antenna. The antenna exhibits a simulated 170MHz matching bandwidth for the band from 5.77GHz to 5.94GHz, while the measured matching bandwidth is about 150MHz, which is from 5.8GHz to 5.95GHz. This antenna is designed for indoor mobile sensors. It works in the upper of the ISM band to avoid interference with 5.8GHz WiFi.

The antenna also exhibits a simulated 30.4dB and a mea-

Fig. 7: Photographs of (a)the front view of proposed antenna. (b)the back view of proposed antenna.

Fig. 8: Simulated and measured return loss and isolation for the proposed antenna.

sured 32.6dB isolation at 5.8GHz. In fig.6(a) and fig.6(b), the simulated and measured radiation patterns of the proposed antenna excited on the $x = L/2, y = 0$ at 5.8GHz are shown at E-plane and H-plane respectively.

Table III compares the performance of the proposed antenna with some already-published results. Compared to [24],[27],[28], the proposed antenna is feasible to fabricate for its single-layer and simple structure. Also, the low cost and single material in substrate is the advantages of proposed antenna. As mentioned in [27], integrated strips at the two port can improve isolation. However, the size of antenna using the continuous current strips is not expanded. The low gain of the proposed antenna is due to the use of FR4, a low-cost dielectric material with high loss.

5. Conclusion

In this letter, a low-profile, low-cost and dual-polarization microstrip patch antenna with enhanced isolation proposed. The simulation and measurement show that the proposed antenna has a good impedance matching at the frequency of 5.8GHz, and a high isolation of 32.6dB is achieved at the meantime. By introducing two additional continuous current strips, the perturbation of the working modes by microstrip feed lines is effectively reduced. The coupling between the

Table III: COMPARISON OF THE PROPOSED AND REFERENCE ANTENNAS

Reference	[24]	[27]	[28]	proposed
size(λ_0^3)	$1.40 \times 1.40 \times 0.12$	$0.45 \times 0.45 \times 0.02$	$0.38 \times 0.38 \times 0.16$	$0.23 \times 0.23 \times 0.02$
structure	the quasi-cross slot	integrated strips at the ports	with vertical metal wall	the continuous current strips
dielectric layer	multilayer	singlelayer	multilayer	singlelayer
relative dielectric constant	2.65, 2.2, 1	1.7	4.4, 1	4.4
BW(MHz)	200	150	500	150
isolation(dB)	> 50	> 20	> 30	26
gain(dBi)	9.6	About 7.8	9.2	3.6
center frequency (GHz)	3.5	2.425	3.55	5.875

two modes is reduced, so as to improve the isolation of dual-polarization antenna. The test results show that the isolation can reach 32.6dB at 5.8GHz, which is better than 14dB without continuous current strip's. In the meanwhile, a single-layer dielectric structure instead of multi-layer dielectric structure is easier to process and realize lower cost.

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