High Port Isolation Co-Located Patch Antenna

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***Abstract*-To fulfill co-located dual-polarized directional radiation, a dual-port patch antenna is presented. Constructed on a microwave PCB, the patch element is a foursquare of two open slots. The designed antenna can radiate the patch antenna mode while fed by the coaxial line (port 1), and the folded dipole mode while fed by the coplanar stripe (port 2). The experimental results show that the operating bandwidth defined by S_{11} or S_{22} less than −10 dB is 2.38–2.48 GHz for port 1, and 2.41–2.47 GHz for port 2. Over the operating band the S_{21} or S_{12} parameters are less than −23 dB.**

I. INTRODUCTION

Using multiple antennas at both the transmitter side and the receiver side can increase the channel capacity without additional frequency spectrum and transmitted power. However, due to the limited space at the size-limited terminal devices, the most critical problem in designing multiple antennas is the severe mutual coupling among them [1]–[3]. So in a small terminal device, polarization diversity antennas are applied to realize the MIMO function [4], [5].

In [6]–[8], the low-profile co-location antennas with coplanar waveguide slots and monopole of ground frame are adopted for the dual-polarized radiation. However, they all are omnidirectional or bidirectional antenna. Fed by downside slot and upside L-shaped feed line the patch antenna has the performance of directional dual-polarized pattern [9]. But with this antenna the back radiation level is large owing to the slots in the ground plane and the L-shaped feed line also enlarges the volume of the antenna.

Here we present the slot-loaded square antenna, which can simultaneously act as the patch antenna and half-wave folded dipole while excited by different ports. This antenna is a co-located dual-port dual-polarized antenna of compact structure. The results show that this antenna has high port isolation.

II. ANTENNA STRUCTURE

The proposed antenna, as shown in Fig. 1, is manufactured on the FR-4 microwave substrate of relative dielectric constant 4.3 and loss tangent 0.01. The thickness of the substrate, which is coated with copper layer of 0.035 mm on the both surfaces, is 3 mm and its size is 80 mm × 80 mm. As present in Fig. 1, the radiation element is cut from the square of side length W. A coaxial feed line port, here defined as port 1, is on the vertical diagonal line and the distance apart from the up apex is Lf. A shallow cut of width Wt is opened on the down apex of the square. Meanwhile two rectangular slots of width Wc and length Lc are extended to the both sides from the top part of the shallow cut. Two conductors of width Wp, length Lp and spacing Wd between them are added as the feed sides of a coplanar stripe (CPS) port, here defined as port 2. The electromagnetic analysis is applied to optimize the antenna structure parameters with the commercial software XFDTD. All the optimized structure parameters are listed in Table I.

From Fig. 1 it is can be conceived that the surface electric current on the radiation patch will mainly flow along the vertical direction when port 1 is excited. However, due to the rectangular slots and the varied longitudinal dimension of the radiator, there will be some horizontal current components near both sides of the radiation patch. But the horizontal components of the radiation electric field over the central line can cancel out of phase. So the vertical radiation polarization can be expected when port 1 is fed.

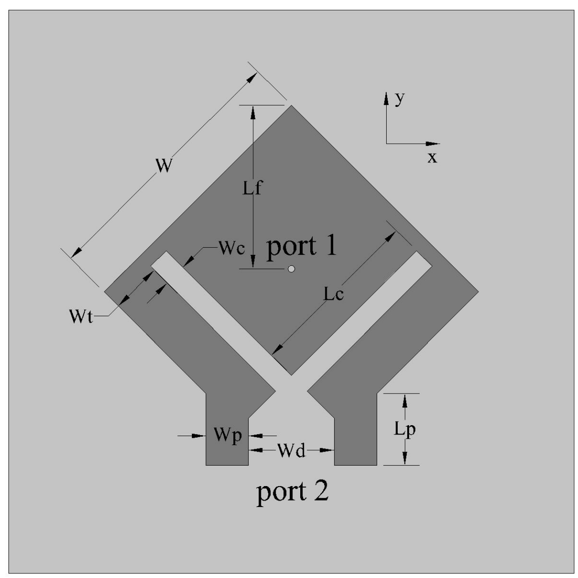

Figure 1. Geometry of the proposed patch antenna (top view).

TABLE I
OPTIMIZED ANTENNA STRUCTURE PARAMETERS

Parameter	W	Lf	Wt	Wc	Lc	Wp	Lp	Wd
Value(mm)	37.5	23.3	7.2	3.1	25.1	6.0	10.2	12.2

On the other hand, when port 2 is excited the patch radiates the patterns as the half-wave folded dipole works. However, this dipole bends up 90 degree angle at symmetric position and the upper rectangular arms are replaced by a small square patch. The reason for bending slots is that the cut position of port 2 is located at the radiation edge of port-1 excited microstrip antenna. If the slots are composed of single horizontal rectangular ring, the coupling between port 1 and port 2 will get strong. On this dipole the current will distribute along the inner edges of the two rectangular slots with the standing wave mode and the square patch arm, which will change the characteristic impedance of port 2, has no effect on the resonant frequency. The main polarization of folded dipole antenna is parallel to the arms. So the bent arms will introduce some vertical component. However, owing to the symmetric structure the vertical component polarization will cancel in spite of the bent arms. Therefore, the dipole antenna will mainly radiate horizontal polarization mode when port 2 works.

According to the proposed structure as shown in Fig. 1 and the structure parameters listed in Table I, a prototype antenna is manufactured with the etching method and the port performances are measured by vector network analyzer AV3629.

III. IMPEDANCE CHARACTERISTICS

Fig. 2 shows the S-parameter curves. It is seen that the simulation operating frequency range is from 2.42 GHz to 2.47 GHz with the S_{11} less than −10 dB while the measurement range is from 2.38 GHz to 2.48 GHz for port 1. Meanwhile with port 2 the simulation band is from 2.42 GHz to 2.47 GHz and the measurement band is from 2.41 GHz to 2.47 GHz.

With port 1 the simulation result shows that there is a notched step in the upper frequency. Fig. 3 shows the input impedance of port 1. It is seen that within the operating frequency band the resistance value in lower frequency is larger than in upper frequency. Although at the upper frequency the reactance approach to zero, the resistance value is also small due to the port-2 effect. So the high frequency resonant effect of port 1 is very weak and the measurement results don’t show the dual-resonant frequency. But the measurement bandwidth is enlarged and shifts to the lower frequency. The reason is that the dielectric loss is not considered in simulation process.

For port 2, the simulation and measurement results of the port S parameters fit very well. However, it is noted that the measurement operating frequency shifts down a bit relative to the simulation. Comparatively speaking, the impedance matching performance of port 1 is better than of port 2. This is because of ground plane effect on the folded dipole, which low the input resistance of port 2. For this reason, the spacing of the coplanar stripes has to be widened to enhance the characteristic impedance to match port impedance.

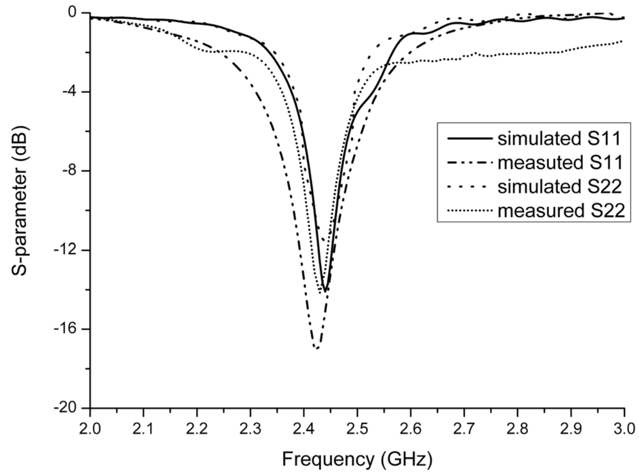

Figure 2. Simulated and measured S parameters of the designed antenna.

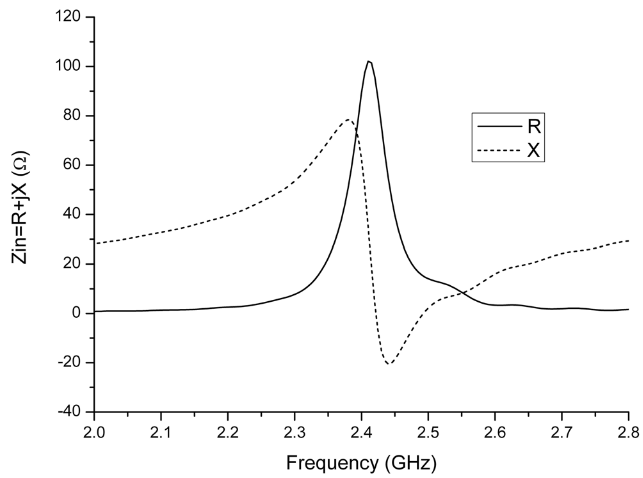

Figure 3. Input impedance of port 1.

With the help of the simulation results (not shown here), it is also seen that when port 2 is excited over the operating frequency the weak inductive reactance is present. At this time the antenna works in the half-wave dipole mode. In other words, this antenna is the deformation of a ring antenna.

IV. PORT ISOLATION

As shown in Fig. 4, it is observed that within the frequency band range from 2.4 GHz to 2.5 GHz, the simulation S_{12} / S_{21} parameters all are less than −32 dB while the measurement results are only less than −23 dB. The reason for the large difference between the simulation and measurement results is that the simulation is processed in ideal conditions. However, it is also can be noticed that the variation tendency of the simulations and measurements is alike but for frequency points of the maximum isolation.

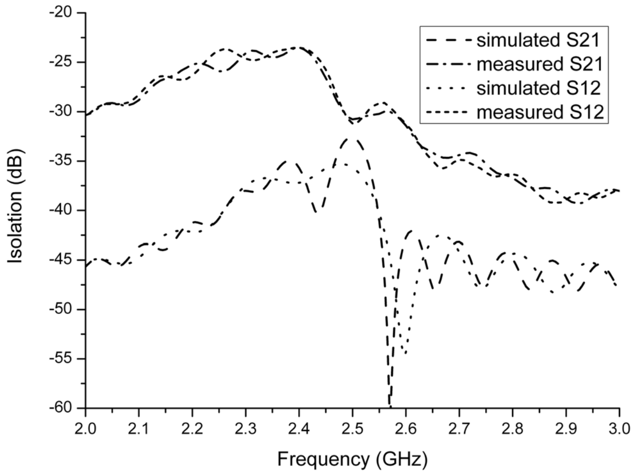

Figure 4. Simulated and measured isolation between ports.

It is the different radiation mechanism of the different port that helps to realize the high port isolation of the presented antenna. When port 1 is excited, as shown in Fig. 5 (a), the antenna surface currents flow vertically along the patch and the electric field mainly distributes on the small patch edge near the slots. At the location of port 2, tow conductors of the CPS have the same direction currents and the same voltage values. So the influence of port 1 on port 2 is little.

When port 2 is excited, the patch surface current flows along the horizontal direction and the electric field distributes mainly on the two side edges. The electric field on the patch central diagonal line is very weak. Therefore, the port 1 impact on the port 2 also is little.

V. CONCLUSIONS

Utilizing the square patch of two side slots in one corner and fed by coaxial line and CPS, the proposed dual-port low-profile antenna can simultaneously work as the microstrip antenna mode and half-wave folded dipole mode. The measurement results show that its operating band defined by S_{11} less than −10dB is from 2.4 GHz to 2.47 GHz and over the working band the port isolation value is larger than 23 dB. This proposed antenna can be the candidate for MIMO WLAN systems.

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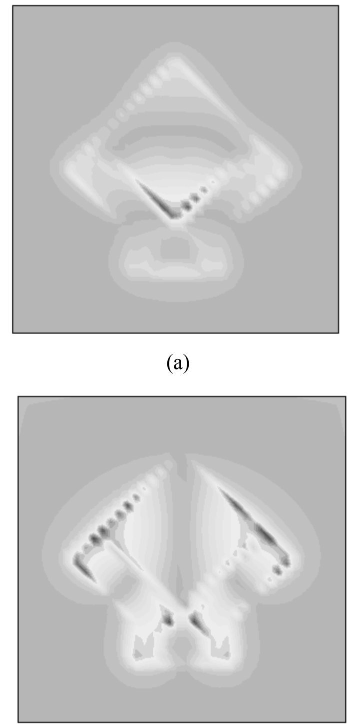

(a)

(b)

Figure 5. Simulation electric field distribution when (a) port 1 excited and (b) port 2 excited.

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