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Wideband Patch Antenna with Stable High Gain and Low Cross-Polarization Characteristics

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Abstract—A wideband unidirectional patch antenna with two meandering strips and a Γ-shaped feeding structure is designed. The investigation shows that the antenna achieves an impedance bandwidth of 54.2% for VSWR ≤ 2 and a stable gain of around 9 dBi. The far field radiation patterns with low cross polarization which levels are less than -27 dB, low back radiation and symmetrical E- and H-plane patterns are obtained over the whole operating frequency range.

1. INTRODUCTION

In recent years, with the expeditious development of modern wireless communication systems [1], such as 3G, LTE, WLAN and WiMax, wideband unidirectional antennas with low profile, low cross-polarization, low back-lobe, symmetrical E- and H-plane patterns and stable high gain over the whole operating band is becoming a current research focus. Microstrip patch antenna [2] and short backfire antenna (SBA) [3, 4] are both competitive choices which are attractive for their various advantages, such as unidirectional patterns and high gain. But the narrow bandwidth is a big problem, which limits their applications in wireless communication systems.

Some attractive techniques to increase the impedance bandwidth of patch antennas, such as L-shaped probe feed [5], U-slotted patch [6], folded plate pair [7] and folded shorted patch [8], have been proposed. The impedance bandwidth for VSWR ≤ 2 can be enhanced to over 30%, but they will also result in high cross-polarization radiation or low antenna gain (less than 6 dBi). Patch antenna fed by M-shaped meandering probe was proposed by K. M. Luk [9], it has low cross-polarization level as -20 dB and the impedance bandwidth is 30% for VSWR ≤ 2.

In this letter, a wideband unidirectional patch antenna fed by two meandering strips and a Γ-shaped feeding structure is investigated. In the proposed design, the two meandering strips make the antenna have symmetrical E- and H-plane patterns with low cross polarization, whose levels are less than -27 dB, as the original design's low cross-polarization level is -20 dB [9]. The Γ-shaped feeding structure is introduced to improve the impedance bandwidth. Compared to the original design [9], whose impedance bandwidth is less than 30%, the proposed antenna achieves an impedance bandwidth of 54.2%. A special bending ground plane is used in the proposed patch antenna to stabilize the radiation patterns and antenna can achieved a stable gain around 9 dBi over the whole operating frequency range.

2. ANTENNA DESIGN AND DISCUSSION

The configuration of the proposed antenna and co-ordinate system are shown in Figure 1. The parameters shown in Figure 1 are the optimized parameters. The antenna consists of a 1 mm thick copper rectangular patch with length $L = 0.58\lambda_0$ and width $W = 0.4\lambda_0$ ($\lambda_0 = 102$ mm), a copper

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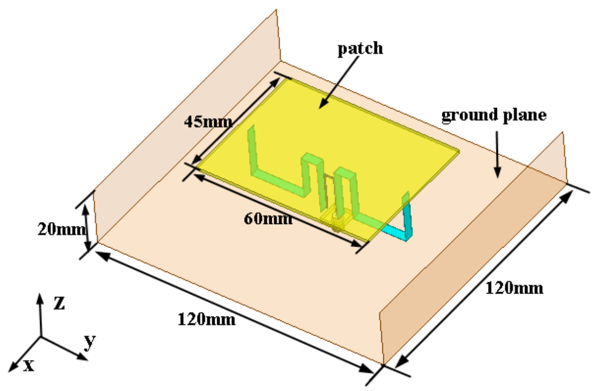
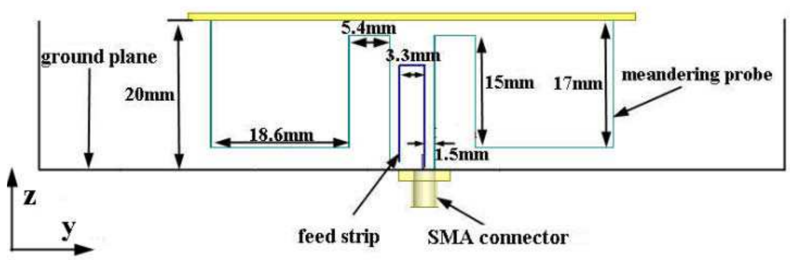
Γ-shaped strip, a pair of meandering copper strips, a bending ground plane and an SMA connector as shown in Figure 1(a). The feed mechanism is a Γ-shaped strip combing with two meandering strips. The Γ-shaped strip comprises three parts as shown in Figure 1(b). The first port can be treated as a $50\,\Omega$ air microstrip line; the second portion is responsible for coupling the electrical energy to the two meandering strips; the remaining coupling strip can be adjusted for impedance matching by selecting appropriate length. The meandering strip, which consists of two horizontal parts and three vertical parts, can be treated as a transformative L-shaped strip which is used to reduce cross-polarization of the proposed antenna. The three vertical portions of the meandering probes excite constructively to



(a)



(b)

Figure 1. Geometry of the proposed patch antenna. (a) 3-D view. (b) Side view.

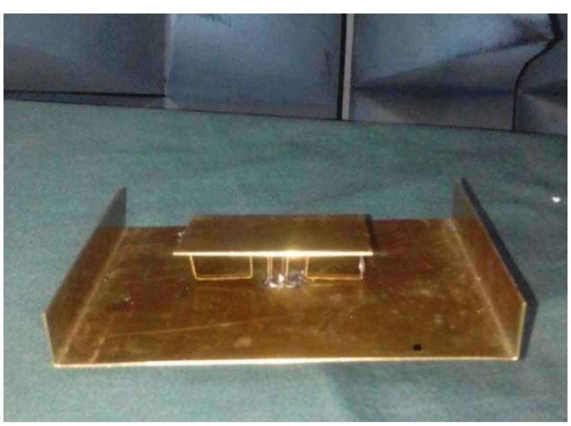


Figure 2. Photograph of proposed antenna.

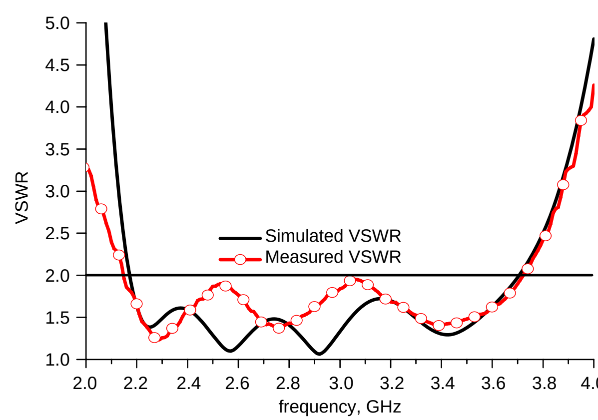


Figure 3. Simulated and measured VSWR of proposed antenna.

co-polarization but destructively to cross-polarization. The horizontal portions introduce capacitances with the radiating patch and the ground plane. The patterns of the patch antenna with normal ground plane are split, and the main beam is shifted away from the broadside direction when it works at high frequency, so a special bending ground plane is used in the proposed patch antenna to stabilize the radiation patterns. A prototype of the proposed antenna fabricated according to the final optimal parameters is shown in Figure 2.

3. EXPERIMENTAL RESULTS

All simulations in this paper were performed by Ansys high frequency structure simulation (HFSS 14). Its optimized parameters are shown in Figure 1. The VSWR was measured using an Agilent E8363B PNA network analyzer. The simulated and measured VSWRs against frequency for the designed antenna are shown in Figure 3. It can be observed from the figure that the measured impedance bandwidths are about 54.2%, ranging from 2.14 to 3.73 GHz, reasonably agreeing with the simulated results.

The E- and H-planes radiation patterns at 2.5, 3 and 3.5 GHz for the designed antenna are shown in Figure 4. It can be observed that the cross-polarization in H-plane is greatly reduced to less than 27 dB due to the feeding structure, and the cross-polarization in E-plane is vanishingly small, because the currents on the vertical portion of meandering feeding strips will not contribute to the E-plane cross-polarization. In all frequencies, the back-lobe is less than -10 dB.

Figure 5 shows the antenna gain variation against frequency. The measured results match well with the simulation results. Within the operating frequency range, the measured antenna gain varies from about 7.8 dBi to 9.5 dBi and a stable gain around 9 dBi while the simulated gain varies from 7.4 to 9.9 dBi.

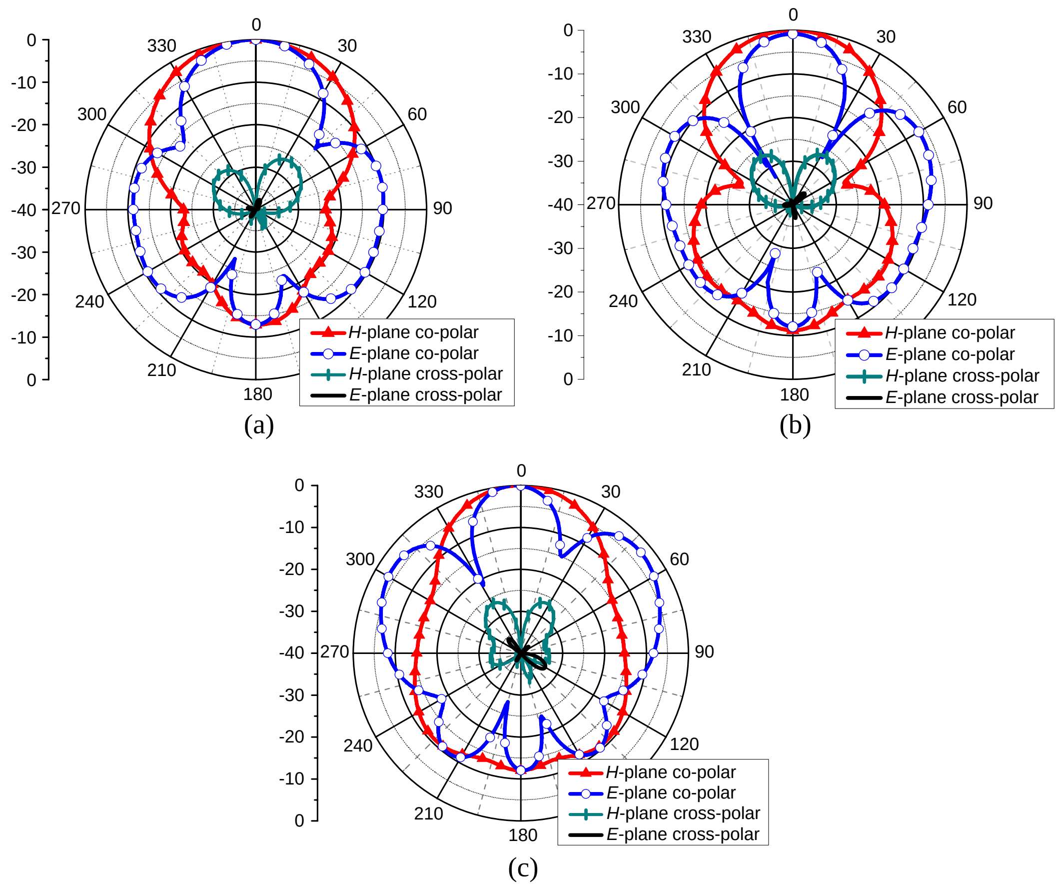


Figure 4. Radiation patterns for proposed antenna. (a) 2.5 GHz. (b) 3 GHz. (c) 3.5 GHz.

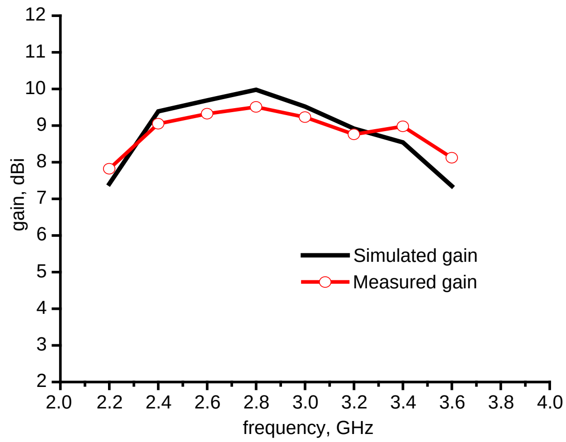


Figure 5. Simulated and measured gain of proposed antenna.

4. CONCLUSIONS

A wideband unidirectional patch antenna with Γ-shaped and two meandering strips feeding structure is designed, simulated, fabricated and tested. The proposed antenna exhibits low cross-polarization whose level is less than -27 dB, with 54.2% impedance bandwidth and good radiation characteristics, symmetrical radiation pattern in both E- and H-planes with an average gain of 9 dBi. Because of these characteristics, the antenna has wide and potential applications in wireless communication.

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