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BROADBAND MICROSTRIP ANTENNAS USING COPLANAR FEED-LINE

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Abstract—This paper proposes two novel broadband microstrip antennas using coplanar feed-line. By feeding the patch with a suitable shape of the coplanar line in the slot of the patch, the broadband character is achieved. Compared with the antenna fed by a U-shaped feed-line, the antenna with L-shaped feed-line not only has wider bandwidth but also achieves the circular polarization character. The measured bandwidths of 25% and 34% are achieved, and both of the antennas have good radiation characteristics in the work band.

1. INTRODUCTION

Microstrip antennas are the subject of many research activities among scientists due to their unique advantages, especially low weight, simple structure, and low cost of fabrication. Although in early implementations they suffered from narrow bandwidth, several approaches have been proposed to improve the bandwidth [1, 2]. The latest approaches utilized in antennas with excellent bandwidths are listed as follows: the multi-layer structure [3, 4], slotted antennas [5–11], E-shaped patch antennas [12–14], etc. Most methods [15, 16] seem to get broad bandwidth by changing the shape of the patch or the slots. In this paper, we present a novel method of using a coplanar feed-line in the slot of the patch for coupling the electromagnetic energy; in this way, broadband character can be easily obtained.

Without modifying the antenna geometry or adding special radiating, the radiating microstrip patch is just of simple square shape. It is also worth mentioning that the antennas utilizing L-shaped coplanar feed-line can excite circularly polarized wave. The antennas

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designed for both cases are described and implemented, and details of the experimental results are presented and analyzed.

2. ANTENNA DESIGN AND EXPERIMENTAL RESULTS

2.1. Broadband Microstrip Antenna with U-shaped Coplanar Feed-line

The geometry of the antenna with U-shaped coplanar feed-line is shown in Figure 1. The square patch with length w is fabricated on a substrate of relative permittivity 2.65 and dielectric loss tangent 0.0009. The U-shaped microstrip line of width d is embedded in a U-shaped slot whose size sw is slightly bigger than the line. The line is connected to the antenna through an SMA connector mounted on the ground plane. Above the ground plane is a foam substrate of distance kh.

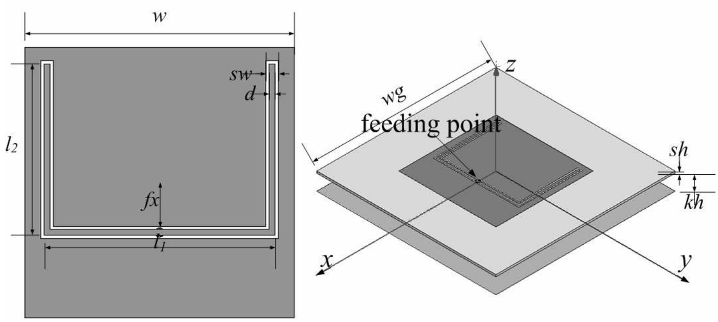

Figure 1. Broadband microstrip antennas with U-shaped coplanar feed-line.

By introducing the coplanar feed line, another new excitation occurs, which results in a new resonant mode. The capacitance introduced by the U-shaped coplanar line and the inductance introduced by coaxial feed generate a LC resonant circuit. So a new resonant frequency was achieved. Adding the resonance formed by the patch, the antenna has dual resonances. By slightly changing the length of the patch and the feed-line, the broadband bandwidth can be easily obtained. The propagation properties of the antennas are simulated with the commercial software HFSS v11.0. The optimized parameters of the antenna sizes are listed in Table 1.

The scattering parameters are measured with Agilent vector network analyzer of model N5230A. The measured reflection coefficient

Table 1. Parameters of the antenna with U-shaped coplanar feed-line. (Units: mm)

gw	w	l_1	l_2	sw	d	fx	sh	Kh
70	38	32.5	24.1	1.7	0.8	7	1	6

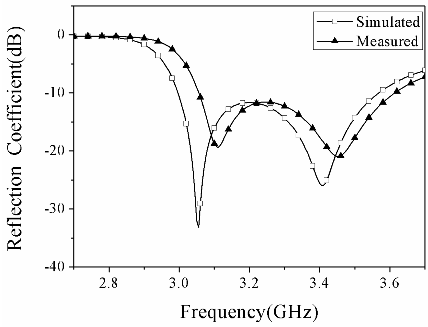

Figure 2. Measured and simulated reflection coefficient for the antennas with U-shaped coplanar feed-line.

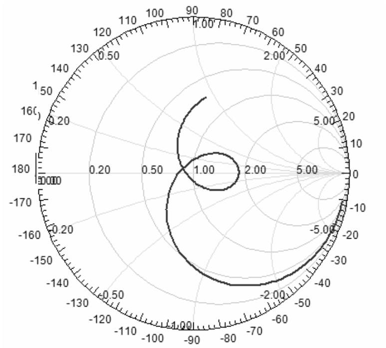

Figure 3. Measured smith chart for the antennas with U-shaped coplanar feed-line.

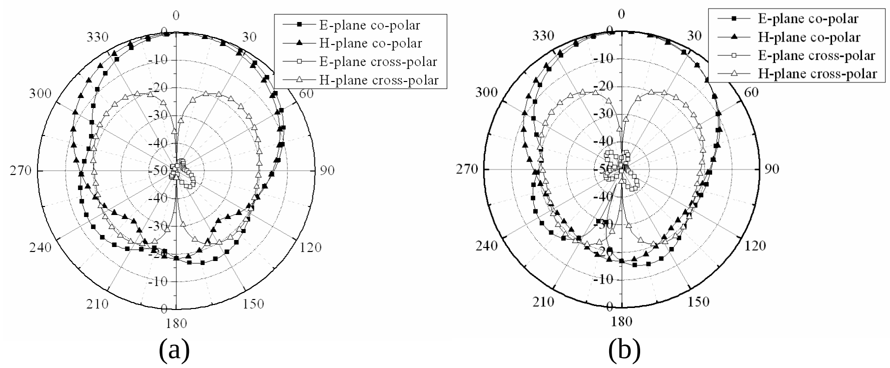

Figure 4. Measured radiation patterns for the antennas with U-shaped coplanar feed-line.

and input impedance are shown in Figures 2 and 3, respectively. Its center frequencies is 3.2 GHz, and the −10 dB rejection bandwidth of the antenna is about 25% (2.96 GHz ∼ 3.76 GHz). Figure 4 shows the measured H- and E-plane radiation patterns at the frequencies of 3.0 GHz and 3.4 GHz, respectively. Figure 5 shows that the antenna has good broadside radiation patterns in the work band. The gain reaches 8.96 dBi at the center frequency of 3.2 GHz.

2.2. Broadband Microstrip Antenna with L-shaped Coplanar Feed-line

Figure 6 shows the configuration of the proposed antenna fed by L-shaped coplanar line. It can be seen that this configuration is similar to the one shown in Figure 1, except that the U-shaped coplanar line is replaced by an L-shaped one.

In this section, the antenna with L-shaped coplanar feed-line is selected for the analysis. Out of the studies in the analysis of the U-shaped coplanar feed-line antenna has come the L-shaped coplanar feed-line antenna analysis that the higher and lower resonant frequencies of which are different. Because the feed-line is asymmetric,

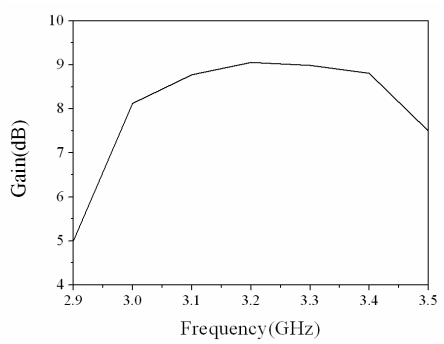

Figure 5. Measured gain of the antennas with U-shaped coplanar feed-line.

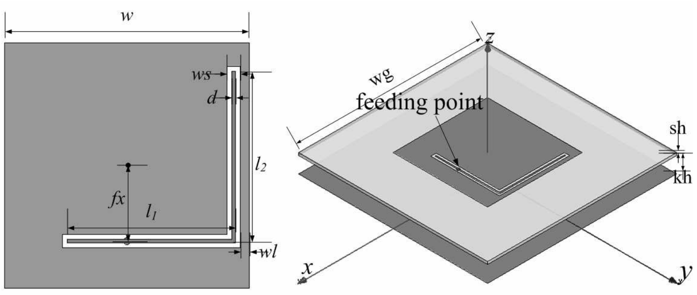

Figure 6. Broadband microstrip antennas with L-shaped coplanar feed-line.

the right and left feed-lines generate two different resonances. Adding the resonance formed by the patch, the triple resonances are achieved. By carefully tuning the lengths of the L-shaped coplanar line, three near-degenerate orthogonal modes are excited while good impedance matching is obtained. The antenna is fed not only by the horizontal coplanar line but also by the vertical one, which results in two orthogonal currents of near equal amplitudes and 90° phase difference. Because the currents generated by the horizontal coplanar feed-line are ahead of the ones generated by the vertical one, left circular polarization is obtained. Therefore, moving the vertical coplanar line to the other side of the antenna will result in a right circular polarization design. Because the 90° phase difference only exists at 3.2 GHz and the phase difference changes very quickly with the frequency changing, the 3 dB axial ratio bandwidth is narrow. The optimized parameters of the antenna sizes are listed in Table 2.

The measured return loss and input impedance on a Smith chart are shown in Figures 7 and 8, respectively. The −10 dB rejection bandwidth of 34.4% (2.7–3.8 GHz) with center frequency at 3.2 GHz is obtained. Figure 9 shows that the 3 dB axial ratio bandwidth is 5% (3.12–3.28 GHz). Measured radiation patterns are also plotted

Table 2. Parameters of the antenna with L-shaped coplanar feed-line. (Units: mm)

gw	w	l_1	l_2	ws	d	fx	sh	wl	kh
70	35	24	24.5	1.9	0.5	10.8	1	1.5	6

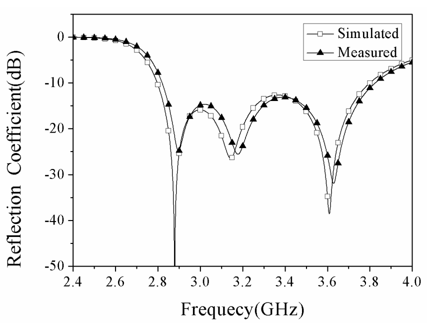

Figure 7. Measured and simulated reflection coefficient for the antennas with L-shaped coplanar feed-line.

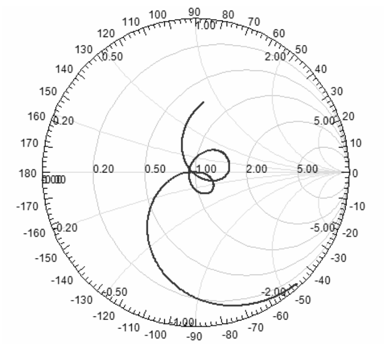

Figure 8. Measured smith chart for the antennas with L-shaped coplanar feed-line.

in Figure 10. The measured gain of the antenna on the operating frequency is shown in Figure 11. Good left-hand circular polarization radiation is obtained, and the antenna gain of 8.35 dBi is observed at the center frequency of 3.2 GHz. Photograph of the antennas is illustrated in Figure 12.

This novel structure makes broadband design much easier to be implemented than the conventional designs with special configurations.

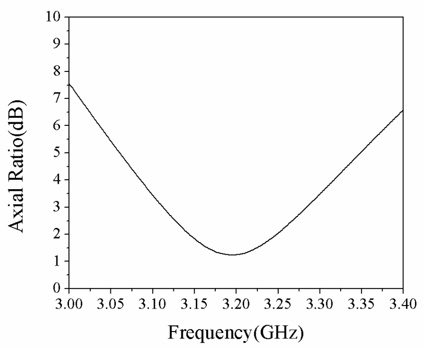

Figure 9. Measured axial ratio of the antennas with L-shaped coplanar feed-line.

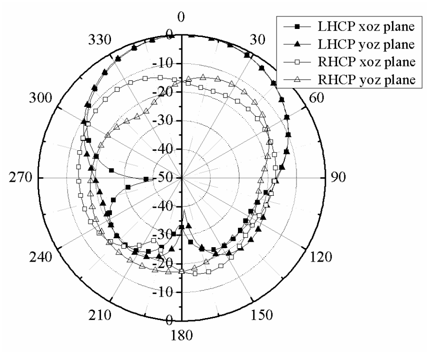

Figure 10. Measured radiation patterns for the antennas with L-shaped coplanar feed-line at 3.2 GHz.

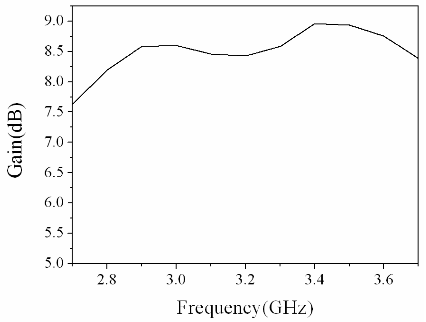

Figure 11. Measured gain of the antennas with L-shaped coplanar feed-line.

Figure 12. Photograph of the two proposed antennas.

3. CONCLUSION

In this paper, two broadband microstrip antennas using coplanar line feeding have been successfully implemented. Results show that, with the present proposed coplanar line feeding, the microstrip bandwidth can be significantly enhanced. This broadband design method is applicable to the microstrip antennas with square patch and circular polarization design.

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