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A compact wideband monopole antenna fed by coplanar waveguide

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Abstract. A compact wideband printed antenna fed by coplanar waveguide (CPW) is presented in this paper. The wideband characteristic is achieved by coupling three monopole resonant modes of the proposed antenna. The proposed antenna is built and simulated to verify the design strategy. A wide impedance bandwidth of 100.5% (1.7866-5.3953 GHz) with S11< -10 dB is achieved. The proposed antenna has stable performance, including bi-directional radiation pattern and gain. It also shows the merits of low cost and simple structure.

1. Introduction

Recently, with the rapid development of modern wireless communication technology, the design of wideband antennas is more important. Printed planar antennas have the advantages of light weight, low profile, easy fabrication, low cost. The wideband antennas have the basic demand of good impedance matching and stable radiation patterns in the operation band.

In order to attain wider bandwidths, many impedance matching techniques have been used. A reconfigurable wideband and multi-band patch antenna with dual-patch elements and C-Slots was reported in [1], and an impedance bandwidth of 33.52% could be obtained in the wideband mode. Some printed wide slot antennas were extensively researched, like wide rectangular slot [2-4], bow-tie slots [5].

In this paper, a compact wideband printed antenna fed by coplanar waveguide for wideband wireless communication is proposed. To analyze the proposed antenna, High Frequency Structure Simulator (HFSS) software is used. A parametric analysis has been carried out, and the current distributions at three different resonant frequencies have been analyzed. The proposed antenna has wide impedance bandwidth of 100.5% (S11 < -10 dB) ranging from 1.7866 GHz to 5.3953 GHz, and bi-directional radiation patterns in the whole band.

2. Antenna configuration and design

The configuration of the proposed antenna is shown in Fig. 1. The size of 1.6-mm-thick FR4 substrate is $L\times W$, with a relative permittivity of 4.4 and a loss tangent of 0.02. The width of both U-shape monopoles is uniform and is defined as W_L. The length of upper branch of the left U-shape monopole is Wa. The width of the slot between two upper branches of both U-shape monopoles is W_g. CPW-Fed microstrip line has width of W_f, and the microstrip line length is L_f. The distance between co-planar ground and the microstrip line is denoted by S.

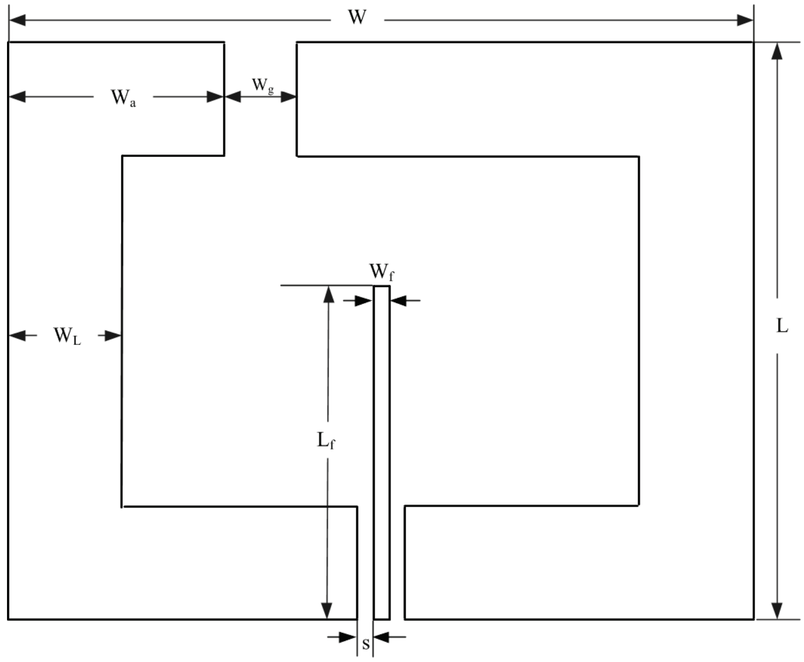

Fig. 1. Configuration of the proposed antenna.

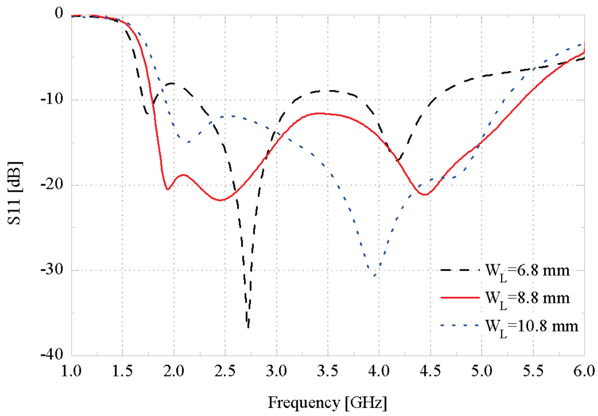

Fig. 2. Simulated reflection coefficient of the antenna with different W_L.

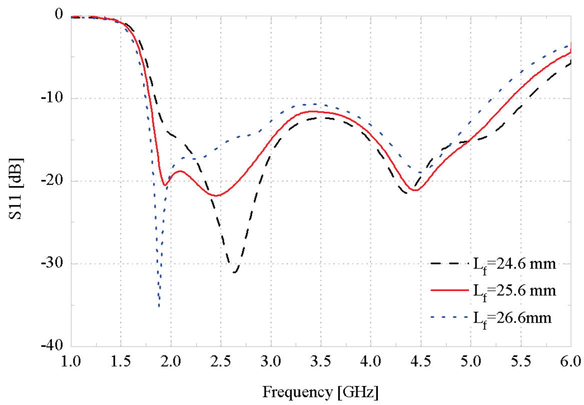

Fig. 3. Simulated reflection coefficient of the antenna with different L_f.

HFSS is used for the parameter optimization. Fig. 2 presents the simulated reflection coefficient of the proposed antenna with different W_L. The simulated results show that the lowest resonant frequency becomes higher as the width W_L increases. When the width of W_L is 8.8 mm, the proposed antenna has the best impedance matching properties. Fig.3 indicates simulated reflection coefficient of the antenna with different L_f. As we all know, the highest resonant frequency is observed to become lower as the length L_f increases. When the length of L_f is 25.6 mm, the impedance matching properties show the best. The microstrip line not only feeds to excite the compact wideband antenna but also works as a radiator. Other parameters can also be optimized for best matching performance with HFSS. The final design parameter values of the proposed antenna are shown in Table 1.

Table 1. final design parameters

Parameter	L	W	W_a	W_g	W_L	L_f	W_f	S
Value (mm)	45	57.4	16.7	6	8.8	25.6	1.2	1

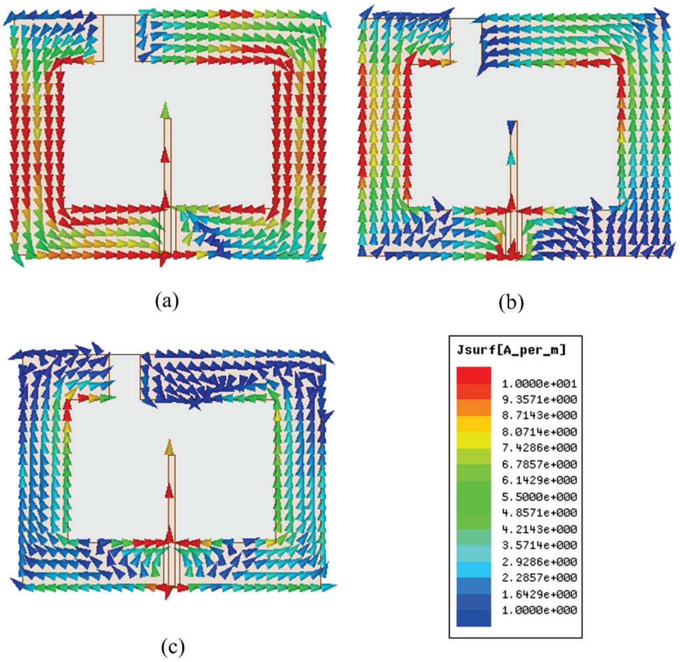

Fig. 4. Current distributions of the proposed antenna at: (a) 2 GHz; (b) 3 GHz; (c) 4.44 GHz.

Fig. 4 shows the current distributions of the proposed antenna at 2 GHz, 3 GHz and 4.44 GHz to analyze the operation modes. Fig. 4(a) shows the first resonance mode. The current distribution is mainly concentrated at both U-shape monopoles. It's a monopole mode, and the resonant frequency is mainly decided by the total length of both U-shape monopoles. Fig. 4(b) shows the second resonance mode. The current distribution is mainly concentrated at the left U-shape monopoles. It's also monopole mode, and the resonant frequency is mainly due to the length of the left U-shape monopoles. Fig. 4(c) shows the third resonance mode. It's also monopole mode. The length of the microstrip line above co-planar ground is $\lambda/4$ (λ is the resonance wavelength), and the current distribution is mainly concentrated at the microstrip line. Therefore, wide impedance bandwidth can be achieved by coupling these three monopole modes. For the lower band, both U-shape monopoles are the main radiators; for the middle band, the left U-shape monopole is the main radiator; for the higher band, the microstrip line is the main radiator.

3. Simulation results and analysis

Fig. 5 illustrates the simulated reflection coefficients of the proposed antenna. The simulated -10-dB bandwidth of reflection coefficients is 3.6087 GHz (1.7866–5.3953 GHz, 100.5%).

Fig. 6(a) to 6(c) show the simulated normalized radiation patterns in the X-Y and the Y-Z planes of the proposed antenna at 2 GHz, 3 GHz and 4.44 GHz, respectively. As we can see, at all these given frequencies, radiation patterns are stably bi-directional. The 3-dB beamwidths at different frequencies are defined to be the sums of 3-dB beamwidths in two different directions (+Y and -Y directions).The 3-dB beamwidths are 150° in the H-plane (X-Y plane) and 110° in the E-plane (Y-Z plane) at 2 GHz. The 3-dB beamwidths are 150° and 155° in the H-plane (X-Y plane) and the E-plane (Y-Z plane) at 3

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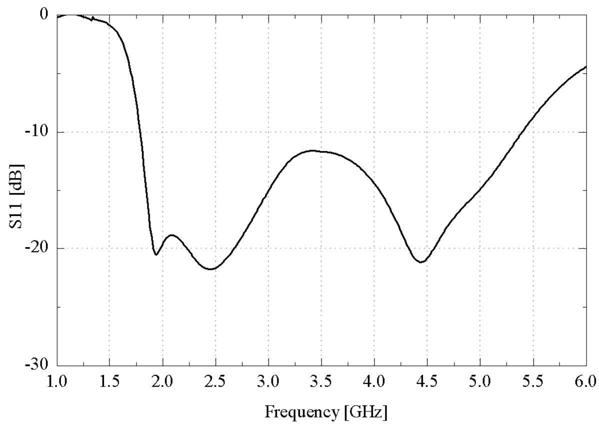

Fig. 5. Simulated reflection coefficient of the proposed antenna

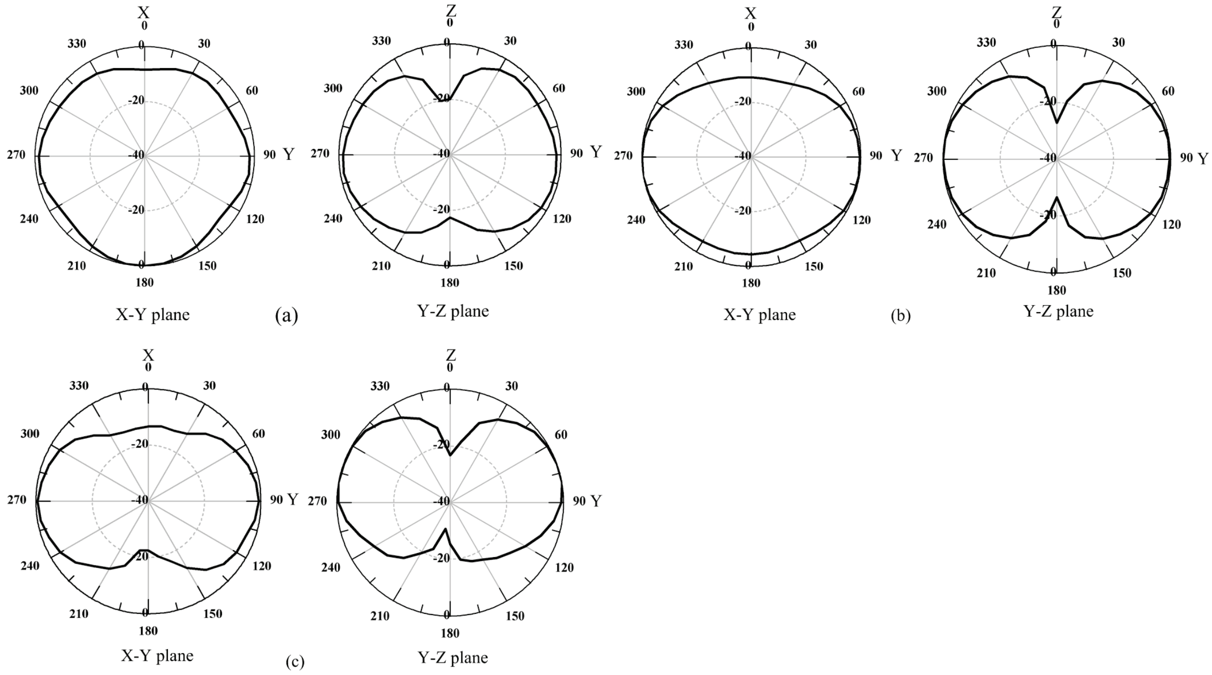

Fig. 6. The simulated normalized radiation patterns of the proposed antenna: (a) 2 GHz; (b) 3 GHz; (c) 4.44 GHz.

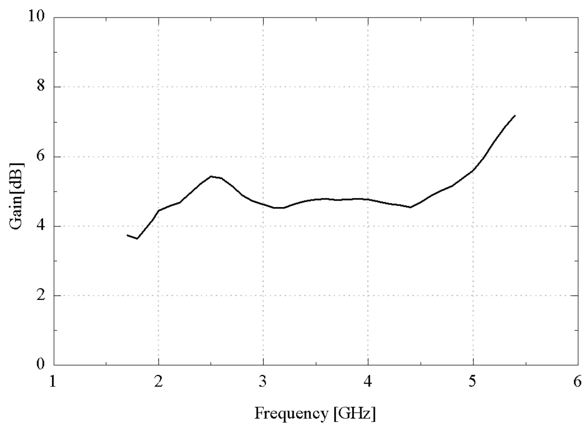

Fig. 7. The simulated gain of the proposed antenna

GHz. The 3-dB beamwidths are 100° and 120° in the H-plane (X-Y plane) and the E-plane (Y-Z plane) at 4.44 GHz.

Fig. 7 shows the realized gain variation with frequency of the proposed antenna. In the band between 1.7866 and 5.3953 GHz, the minimum gain is at 1.8 GHz with a value 3.65 dBi and the maximum gain is at 5.3953 GHz with a value 7.18 dBi.

4. Conclusion

In this paper, a compact wideband printed antenna fed by coplanar waveguide for wireless communication is presented. The overall dimensions of the proposed antenna are 45×57.4×1.6 mm^3, and the structure is simple and compact. By exciting different radiators at different operation bands, the wideband characteristic is achieved. The simulated -10-dB bandwidth of reflection coefficients is 100.5% (1.7866–5.3953 GHz). The radiation patterns are stably bi-directional in the whole band. The proposed antenna has good application value for a wideband wireless communication system.

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