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A BROADBAND CPW-FED T-SHAPE SLOT ANTENNA

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Abstract—A novel broadband design of a coplanar waveguide (CPW) fed T-shape slot antenna is proposed and experimentally studied. The size of the proposed antenna is reduced by over 26% compared to the reported wide slot antenna. The obtained results show that the impedance bandwidth, determined by 10-dB return loss, of the proposed slot antenna can be as large as 5690 MHz or about 121% centered at about 4.695 GHz. The design considerations for achieving broadband operation of the proposed slot antenna are described, and experimental results are presented.

1. INTRODUCTION

Recently, wireless communications have been developed widely and rapidly, which leads to a great demand in designing broadband antennas for mobile terminals [1–4]. Among various forms of planar antennas, coplanar waveguide-fed printed slot antennas have the simplest structure of a single metallic layer. Because the CPW-fed wide slot antennas have the advantages of wide bandwidth and easy integration with monolithic microwave integrated circuit, the designs of the CPW-fed wide slot antennas have recently received much attention. For a simple CPW-fed square slot antenna, the impedance bandwidth (10-dB return loss bandwidth) can reach about 30%. A few attempts have been made to increase the bandwidth of CPW-fed antennas. As for the reported CPW-fed slot antennas with strip-loaded [5] or with a widened tuning stub [6] can reach 60%.

In this paper, another broadband design for a CPW-fed wide slot antenna is proposed. For this design, T-shape slot is used, and the size of the proposed antenna (60 mm × 60 mm) is reduced by 26.5% compared to the report wide slot antenna (70 mm × 70 mm) [5, 6].

The proposed CPW-fed wide slot antenna can have an impedance bandwidth larger than 120%, about four times of a simple CPW-fed wide slot antenna, and is also greater than those that have been reported for broadband CPW-fed wide slot antennas. In this study, several designs are experimentally investigated, and the characteristics of the input impedance, radiation patterns and antenna gains are analyzed and discussed. From the experimental results, the operation mode has an impedance bandwidth of about 5690 MHz (1850–7540 MHz) that covers the PCS band (1.85–1.99 GHz), 3G band (1.92–2.17 GHz), Bluetooth band (2.4–2.48 GHz), DMB band (2.605–2.665 GHz) and WLAN band (2.4/5.2/5.8 GHz). Details of the proposed antenna design and experimental results are presented and discussed.

2. ANTENNA DESIGN

Figure 1 shows the structure and dimensions of the proposed antenna, whose conductor is fabricated on an inexpensive FR4 substrate with the dielectric constant of 4.4 and the substrate thickness of 1.6 mm. The antenna shape and its dimensions were first searched by using the Ansoft's High Frequency Structure Simulator (HFSS) and then the optimal dimensions were determined from experimental adjustment. A 50 Ω CPW, having a signal strip of thickness w and a gap of distance

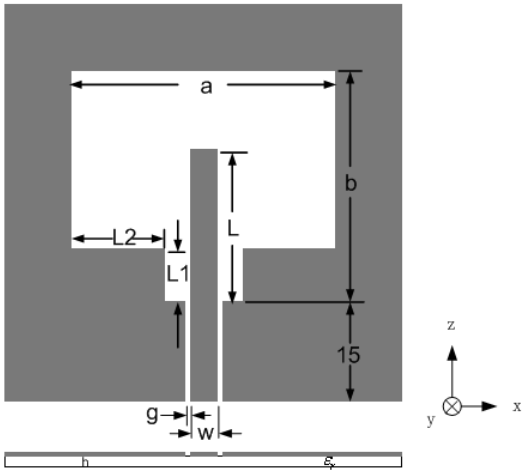


Figure 1. Geometry of the proposed CPW-fed T-shape slot antenna (in mm).

g between the signal strip and the coplanar ground plane, is used to excite the T-shape slot. For achieving efficient excitation and good impedance matching, the signal strip of the CPW should be protruded into the T-shape slot; the length of the protruded signal strip is denoted as L here. The printed T-shape slot is defined by its length a, b, $L1$ and $L2$. The optimal length of L is found to be about 0.55 to 0.575 times the T-shape slot's length (a). By varying the length of $L1$ and $L2$, the wideband operation of the T-shape antenna can be excited with good impedance matching. By following the obtained simple design rules ($L1$ about $0.15a$–$0.2a$, and $L2$ about $0.35a$–$0.4a$), bandwidth enhancement of a CPW-fed T-shape slot antenna is obtained.

3. EXPERIMENT RESULTS

Table 1 gives the antenna parameters and the measured center frequency and bandwidth for the constructed prototypes with various lengths of $L1$ and $L2$. Measured results of the return loss against frequency are also presented in Fig. 2. It is clearly seen that owing to the configuration of the T-shape slot antenna, a new resonant mode is excited. When proper $L1$ and $L2$ are selected, this new resonant mode can be shifted close to the antenna's fundamental resonant mode, resulting in a wide impedance bandwidth. From the results obtained, the maximum impedance bandwidth is as large as 5690 MHz or about 121% centered at about 4.695 GHz.

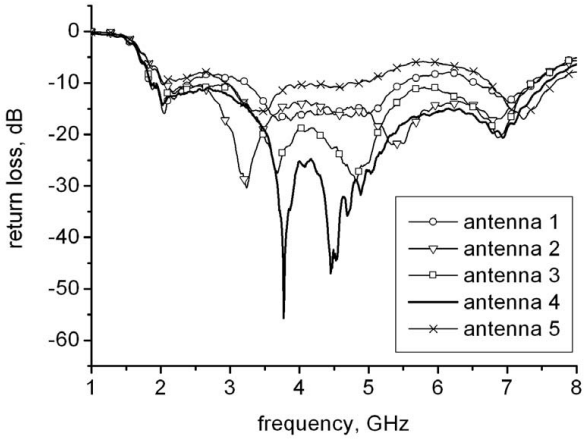
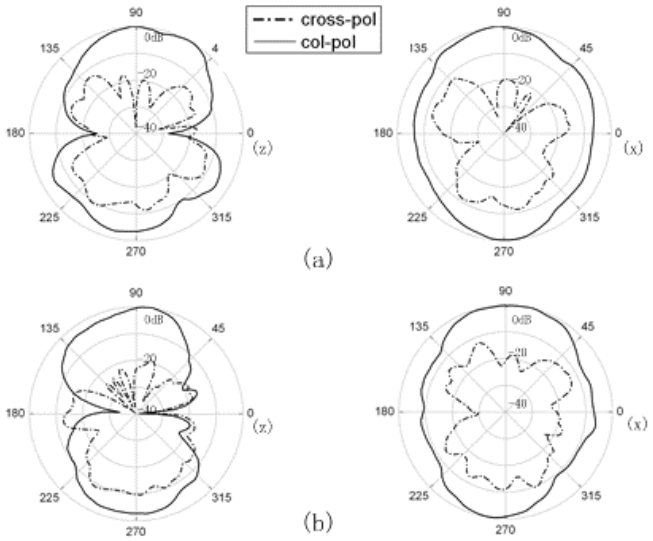


Figure 2. Measured return loss against frequency for the proposed antenna. Parameters are described in Table 1.

Table 1. Performance of the proposed antenna with a fixed length of (L) of 22.5 mm, $a \times b = 40\,\text{mm} \times 35\,\text{mm}$, $\varepsilon_r = 4.4$, $h = 1.6\,\text{mm}$, ground-plane size= 60 mm×60 mm.

antenna	$L1$ (mm)	$L2$ (mm)	f_c (MHz)	Bandwidth (MHz) %
1	8	12	4270	2280,52
2	8	16	4700	5300,113
3	8	14	4610	5500,119
4	6	14	4695	5690,121
5	10	14	3920	1920,49

Radiation characteristics of the antenna at operating frequencies within the impedance bandwidth obtained have also been studied. Fig. 3 plots the measured radiation patterns in the y-z plane and x-y plane for frequencies within the impedance bandwidth of the proposed antenna with $L1 = 6\,\text{mm}$, $L2 = 14\,\text{mm}$ (antenna4). The measured results show that the near omnidirectional radiation pattern can be obtained. It is because the symmetrical configuration of the T-shape slot antenna. The measured antenna (antenna4) gain against frequency is presented in Fig. 4. Results show that the proposed antenna has a peak antenna gain of about 4.8 dBi, with gain variations less than 3 dBi across the operating bandwidth from 1.8 GHz to 6 GHz.



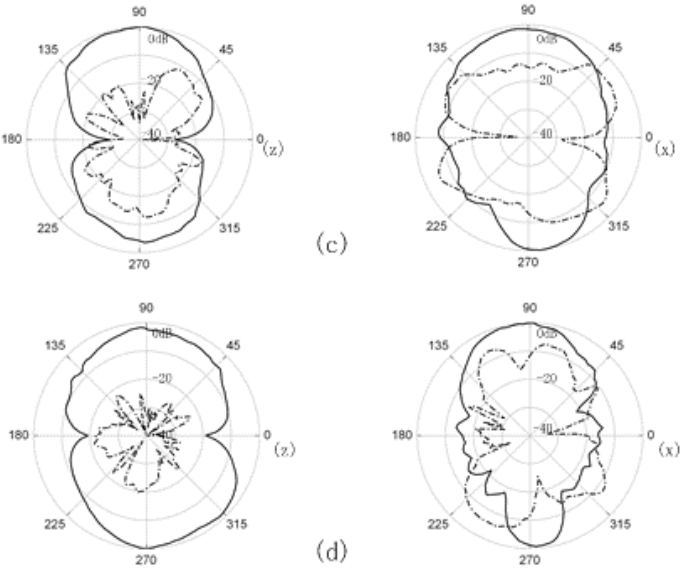


Figure 3. Measured radiation patterns for antenna 4, (a) 1.8 GHz, (b) 2.4 GHz, (c) 3.5 GHz, (d) 5.2 GHz.

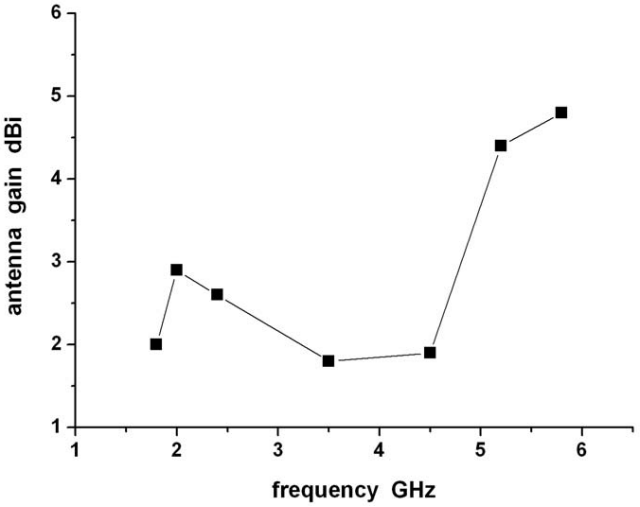


Figure 4. Measured antenna gains for antenna 4.

4. CONCLUSION

CPW-fed T-shape slot antennas for broadband operation have been designed and successfully implemented. The maximum impedance bandwidth reaching about 121% has been obtained and the size of the proposed antenna is reduced by 26.5%. In addition to the advantages of low cost, simple structure, and wide operating band, the proposed T-shape slot antenna has nearly omnidirectional radiation for all operating bands including PCS, 3G, Bluetooth, DMB and WANL and gain variation of the range in each of the bands can be less than 3 dBi.

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