

Slotted Conductor-Backed Coplanar Waveguide Antennas

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1. Introduction

Conductor-backed coplanar waveguide (CBCPWs) is a commonly used waveguide structure in planar printed circuits. It was found out that CBCPW always leaks power in a surface-wave form of the background parallel-plate mode [1]-[3], since the phase constant of the guided CBCPW mode is always less than that of the background parallel-plate mode. In waveguide applications, this surface-wave leakage will cause power loss and coupling between neighboring lines, and should be avoided in the operating frequency band using various mode-suppression schemes [4]-[5]. However, in antenna applications, we can place radiating slots on the top conductor or the bottom conductor [6] along the propagation direction of the parallel-plate surface-wave, resulting in a slotted antenna array structure similar to the slotted waveguide antennas in [7] or the radial line slot antenna in [8]. In this paper, we have designed a novel fan-shaped slotted CBCPW antenna operating in Ku band. Its center frequency is 12 GHz and can be used in direct broadcast satellite (DBS) systems.

2. Antenna Design

Fig. 1 illustrates the top view and the cross-sectional view of the antenna structure near the excitation port. For the CBCPW mode, the propagation constants, $k_y = \beta - j\alpha$, can be obtained by the spectral domain approach. They are shown in Fig. 2 with the designed parameters: the dielectric constant $\epsilon_r = 3.55$, the substrate thickness $h = 1.524$ mm, the center feedline width $S = 0.6$ mm, and the gap width $W = 1$ mm. The propagation direction of the parallel-plate surface-wave mode, θ in Fig. 1, can be approximately obtained by $\theta = \cos^{-1}(\beta/k)$, where β is the phase constant of the CBCPW mode and k is the phase constant of the parallel-plate mode. Along the propagation direction of the parallel-plate mode, we place radiating slots that are tilted an angle ϕ from the propagation direction, as shown in Fig. 3. The power guided by the parallel mode can thus be radiated into the air through slots.

The tilt angle ϕ controls the amount of the radiation power. The normalized radiation resistances versus the tilt angle ϕ are shown in Fig 4, where the characteristic impedance Z_0 of the parallel-plate unit cell is 16.73 Ω . Following the design procedure in [8]-[9], we can design a slot array with appropriate tilted radiation slots to achieve a high-gain antenna.

3. Measurement Results

The antenna is designed on the Rogers 4003 substrate, with a dielectric constant $\epsilon_r = 3.55$, a loss tangent $\tan\delta = 0.0027$, and the substrate thickness $h = 1.524$ mm. The CBCPW structure parameters are as follows: the center feedline width $S = 0.6$ mm, and the gap width $W = 1$ mm, and the characteristic impedance of the CBCPW is 100 Ω . A section of tapered line is added to match the characteristic impedance of the 50 Ω SMA connectors. The geometrical parameters used for slots are: the slot width $W_s = 0.5$ mm, the slot length $L_s = 8.6$ mm, the distance between slots on the

same radial line $L_g=13.27$ mm. We put 16 rows of slots on both sides of the top ground plates, and the tilt angle has a minimum value $\phi = 6.1^\circ$ at the first row according to Fig. 4. The tilt angle ϕ is increasing from row to row. There are $(17-n)$ slots on the n -th row. The total number of slots is 272 and the antenna size is 270.2 mm x 268.5 mm. Fig. 5 illustrates the top view of the whole antenna.

In Fig. 6, the measured return loss below -10dB is from 11.22 to 12.35 GHz. This antenna has a 9.4% bandwidth with a center frequency of 12 GHz. Fig. 7 shows the measured and simulated yz -plane copolarization radiation patterns at 12 GHz, with the measured antenna gain being 20.32 dBi and the sidelobe level below -15 dB. The simulation results are obtained by the software *Ansoft HFSS*.

4. Conclusion

This paper presents a novel CBCPW slot array antenna with a slot array. Using appropriate tilt angles, proper arrangement of slots and other optimized parameters, the antenna has a high gain and a low sidelobe level. It is noticed that CBCPW can be used as an excellent antenna structure with its power leakage of the no-cutoff parallel-plate mode.

Acknowledgments

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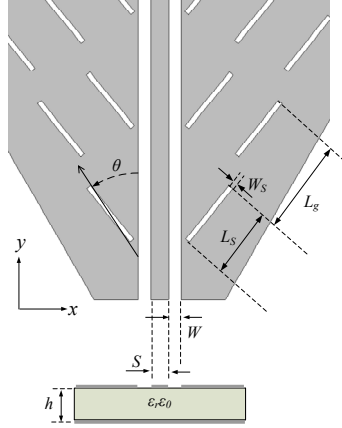


Figure 1: The top view and the cross-sectional view of the antenna

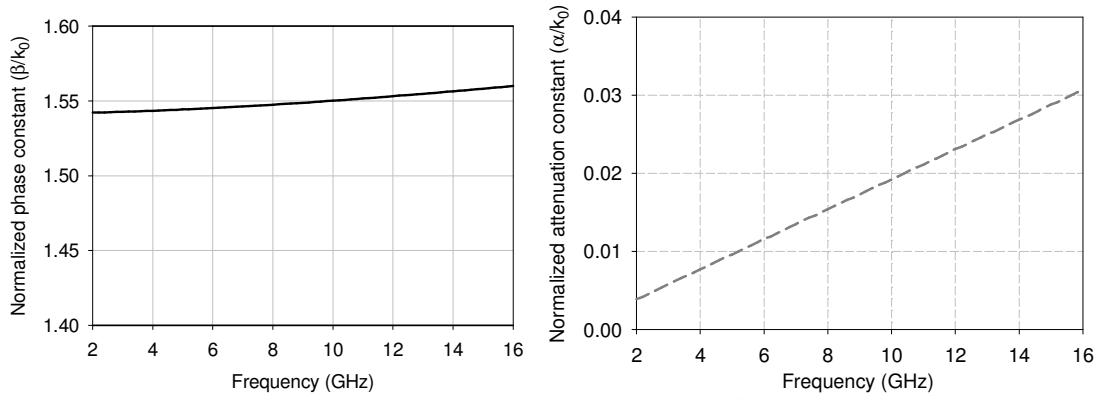


Figure 2: The normalized propagation constants of the CBCPW mode

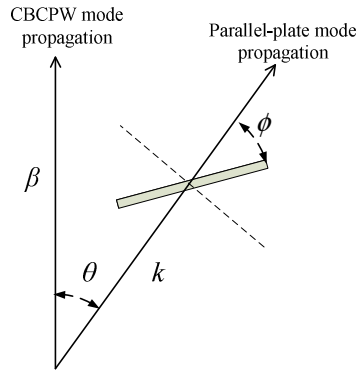


Figure 3: The propagation directions of CBCPW mode and parallel-plate mode

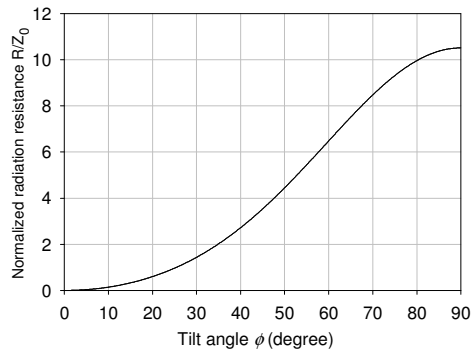


Figure. 4 The normalized radiation resistance versus tilt angle

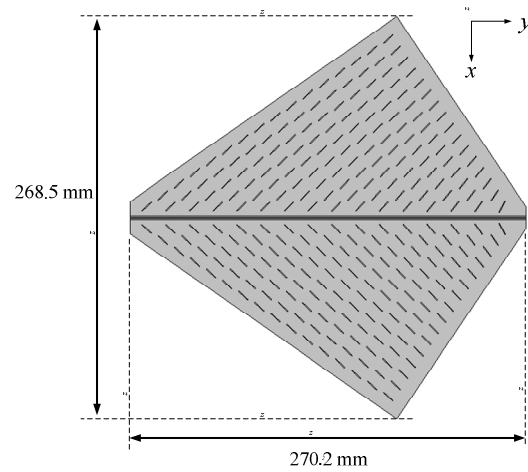


Figure 5: The slotted conductor-backed coplanar waveguide antenna

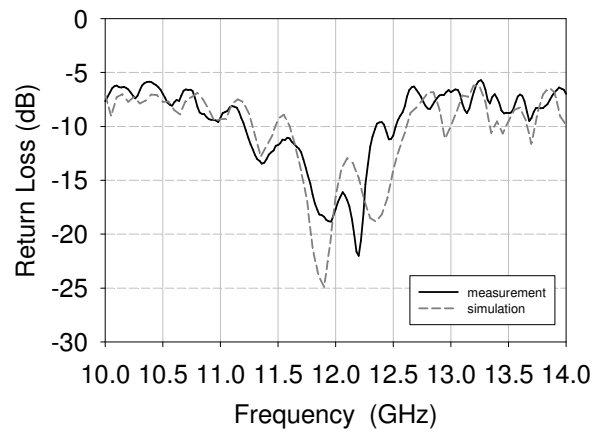


Figure 6: Measured and simulation return losses

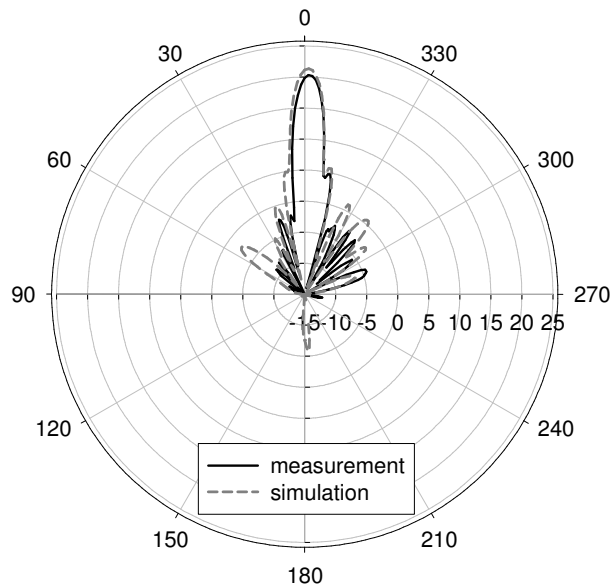


Figure 7: Measured and simulated radiation patterns at 12 GHz