Power Loss Reduction on Right-Angled CPW Bend Using Finger Slots

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***Abstract*—In this paper, the U-slot is used to suppress the slotline mode of the right-angled coplanar waveguide bend. However, the power loss of the right-angled coplanar waveguide bend using the U-slot would be increased due to the radiation from the U-slot. In order to reduce the power loss, the right-angled coplanar waveguide bend using the finger slots are proposed. The right-angled coplanar waveguide bend using the finger slots can greatly reduce the power loss from 75% to 55% as compared with the right-angled coplanar waveguide bend using the U-slot.**

Keywords—right-angled coplanar waveguide, power loss, finger slots, U-slot.

I. Introduction

Coplanar waveguide (CPW), which is composed of three conductors in the same plane, was proposed by C. P. Wen in 1969 [1]. As compared with the microstrip line, since the three conductors of the CPW are at the same plane, there is no need of vias holes and backside conductors, saving the fabrication cost. Besides, this feature facilitates the parallel connection of the microwave components on the printed circuit board (PCB) [2]. Furthermore, CPWs also have the advantages of low dispersion, crosstalk, and radiation so they are commonly applied in the realization of microwave circuits.

There are two fundamental modes in the CPW, which are the CPW mode and slotline mode [3]. In general, the CPW mode is used to transfer the signal while the slotline mode is considered as the noise. When there is no bending structure in the layout of the CPW, the slotline mode would not be excited. However, since the CPW layouts are congested due to limited PCB sizes, the CPW need to bend in order to bypass the ICs, forming a right-angled bend. When the CPW mode on the CPW passes through the right-angled bend, the slotline mode would be excited.

In order to reduce the slotline mode, some researchers place the bondwire on both sides of the CPW grounds [4]. However, applying the bonding wires during the PCB fabrication process may demand more fabrication cost. Besides, some researchers try to reduce the slotline mode by covering the CPW with an dielectric layer [5]. Although the slotline mode may be reduced, the adoption of the dielectric layer would eventually increase the cost. In order to reduce the cost, the U-slot is utilized to compensate the path difference between the inner and outer slots of the CPW [6]. Although the U-slot can reduce the slotline mode and save the fabrication cost, the power loss is increased due to the radiation from the U-slot. The radiation loss is harmful to the circuits around, which in turn would interfere the surrounding microwave circuits, degrading the performance of the circuits. In order to reduce the power loss, the right-angled coplanar waveguide using the finger slots is proposed. As can be observed from the following section, the power loss is greatly reduced in addition to the cost saving.

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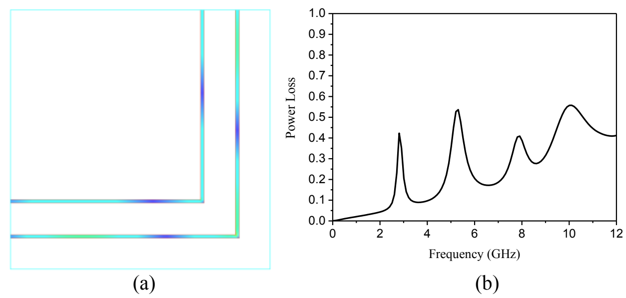


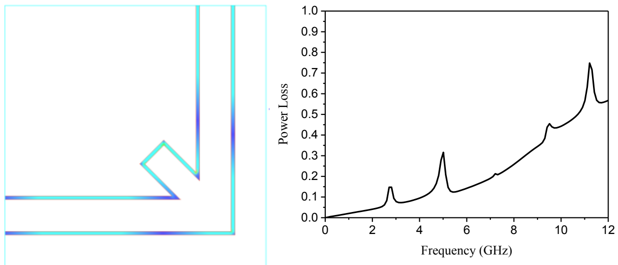
Fig. 1. Conventional right-angled CPW bend. (a) Electric field distribution on the two slots. (b) Frequency response of the power loss.

II. Various Right-Angled CPW Bends

A. Using Conventional Structure

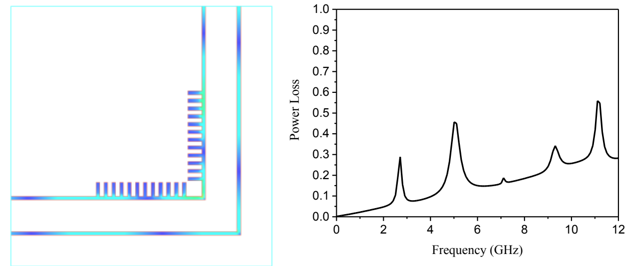
The top view of the conventional right-angled CPW bend is shown in Fig. 1 (a) along with the electric field distributions upon the slots. As can be seen from Fig. 1(a), the electric field distribution at the input port is in phase while the electric field distribution at the output port is out of phase. This means that as the input port is excited with the CPW mode, the CPW mode would be converted into the slotline mode after the CPW mode propagates through the right-angled bend. In order to investigate the power loss, Fig. 1(a) is simulated by ADS and the power loss is calculated from using $1\text{-}|S_{11}|^2\text{-}|S_{21}|^2$. The frequency response of the power loss is shown in Fig. 1(b). As can be seen from Fig. 1(b), the power loss increases with frequency. Besides, peaks which correspond to the half-wavelength resonance of the CPW can be observed. The largest power loss, which has a value of 0.6, occurs around 10 GHz. This means 60% of the power would be lost by using the conventional right-angled bend.

B. Using U-Slot



(a) (b)

Fig. 2. Right-angled CPW bend using the U-slot. (a) Electric field distribution on the two slots. (b) Frequency response of the power loss.



(a) (b)

Fig. 3. Right-angled CPW bend using the finger slots. (a) Electric field distribution on the two slots. (b) Frequency response of the power loss.

In order to eliminate the slotline mode, the right-angled CPW bend using the U-slot is proposed as shown in Fig. 2(a). Also shown in Fig. 2(a) are the electric field distributions on the slots of the right-angled CPW bend using the U-slot. As can be seen from Fig. 2(a), the electric field distributions at the input and output ports are both in phase. This means that as the input port is excited with the CPW mode, the CPW mode would not be converted into the slotline mode after the CPW mode propagates through the right-angled bend. The reason that the CPW mode would be maintained in phase at both the input and output ports is that the inner and outer paths are now of the same length by applying the U-slot to compensate for the path difference between the inner and outer paths. In order to investigate the power loss, Fig. 2(a) is simulated by ADS and the power loss is calculated from using $1-|S_{11}|^2-|S_{21}|^2$. The frequency response of the power loss is shown in Fig. 2(b). As can be seen from Fig. 2(b), the power loss increases with frequency. Besides, peaks which correspond to the half-wavelength resonance of the CPW can be observed. The largest power loss, which has a value of 0.75, occurs around 11.2 GHz. This means 75% of the power would be lost by using the right-angled CPW bend with the U-slot even though the slotline mode has now been eliminated.

C. *Using Finger Slots*

In order to reduce the slotline mode and the power loss at the same time, the right-angled CPW bend using the finger slots is proposed as shown in Fig. 3(a). Also shown in Fig. 3(a) are the electric field distributions on the slots of the right-angled CPW bend using the finger slots. As can be seen from Fig. 3(a), the electric field distributions at the input and output ports are both in phase. This means that the finger slots can compensate for the path difference between the inner and outer paths, giving rise to the in-phase electric field distributions at both the input and output ports. In order to investigate the power loss, Fig. 3(a) is simulated by ADS and the power loss is calculated from using $1-|S_{11}|^2-|S_{21}|^2$. The frequency response of the power loss is shown in Fig. 3(b). As can be seen from Fig. 3(b), the power loss increases with frequency. Besides, peaks which correspond to the half-wavelength resonance of the CPW can be observed. The largest power loss, which has a value of 0.55, occurs around 11.1 GHz. This means 55% of the power would be lost by using the right-angled bend with the finger slots and the slotline mode has now been eliminated.

III. CONCLUSIONS

The conventional right-angled CPW bend suffers from both the excitation of the slotline mode and high power loss. In order to eliminate the slotline mode, the right-angled CPW bend using the U-slot is proposed. Although the slotline mode is eliminated, the power loss is increased from 60% to 75%. In order to reduce the slotline mode and power loss at the same time, the right-angled CPW bend using the finger slots is proposed. Not only is the slotline mode eliminated, but the power loss is reduced from 75% to 55%.

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