Dual function flexible coplanar waveguide for feeding antenna of balanced structure

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Abstract- **A flexible coplanar waveguide (CPW) design is presented suitable for feeding planar antenna with a balanced structure. Two features are provided by the flexible design, transition from balance on the antenna side to unbalance on the receiver side; transformation of characteristic input impedance of the antenna to the value of a standard load. It is essential for the CPW to be bended to fit the purposes hence the effect of bending of CPW on the transmission performance and method to feed planar antenna are investigated. The common mode propagation due to the inserted feedline is observed and the solution to eliminate the auxiliary common-mode effect in the structure is also discussed.**

I. INTRODUCTION

Coplanar waveguide (CPW) offers several advantages over conventional microstrip line: it facilitates easy shunt as well as series mounting of active and passive devices, it eliminates the need for wrap-around and via-holes, and it has a low radiation loss [1]. It is widely used in circuits of radio frequency. Flexible electronics or front-ends become a trend, hence fabrication of antenna and its feedline by complete printing is desired in many fields.

In this paper, the CPW based on flexible substrate is developed to feed the planar antenna with a differential structure[2][3]. The CPW serves as antenna feedline and impedance matching network at the same time. The planar antenna array is above the groundplane with a specified distance. The flexible CPW is bended and attached to the antenna radiators at one end and the other end extending to the same level as the ground plane. The two CPWs can be in offset position vertically and perpendicular to each other to accommodate dual polarized antennas. However, the common mode propagation will be introduced and mixed with antenna radiation to degrade the overall performance[4][5][6][7][8]. This has been shown as a challenge in feeding planar antenna with a balanced configuration[9][10][11]. In particular, wideband planar arrays are desired in every aspect of microwave applications from radio astronomy to satellite communication. Hence a simple solution to feed wideband planar array of balanced structure becomes increasingly important. A CPW design based on flexible substrate is proposed in this paper and the solution to eliminate the unintended common mode effect is also investigated.

The paper is organized as follows. The two flexible CPW designs are introduced in Section II, the associated flexible CPW feed are fabricated and measured in Section III; Section IV concludes the paper.

II. DESIGN OF THE FLEXIBLE CPW

In response to requirements from different planar antennas, we have designed two types of flexible CPWs. The design 1 is to convert the impedance to a higher value, from 50 ohms to 120 ohms for feeding antenna elements in an array; the design 2 is to transform the characteristic impedance from 50 ohms to 25 ohms. The impedance of CPW is decided by four parameters: the dielectric constant of the substrate, thickness of the conductive material, the width of the trace and the spacing to the ground plane. The cross section of CPW is shown in Fig. 1. The values for these parameters are calculated based on the chosen material of substrate. As it is essential for the CPWs to be bended to fit the purpose, hence the thickness of the substrate needs to be small. The parameters for both designs are summarized in the TABLE I.

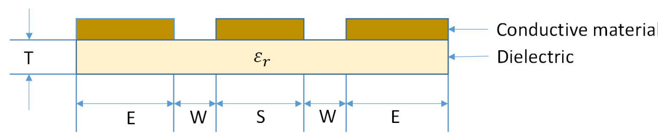


Figure 1. The cross section of CPW design.

TABLE I
CPW DESIGN ON FLEXIBLE SUBSTRATE

CPW Design 1 (1.7 - 4.5GHz)		
	Receiver side	Antenna side
ε_r	2.55	
T	0.25 mm	0.25 mm
E	1.1 mm	0.875 mm
W	0.15 mm	0.7 mm
S	2.5 mm	0.6 mm
CPW design 2 (1-4GHz)		
ε_r	10.2	
T	0.762 mm	0.762 mm
E	3 mm	1.57 mm
W	0.4 mm	0.18 mm
S	1.2 mm	4.5 mm

III. MEASUREMENT AND VERIFICATION

For the design 1, Rogers AD255C (ε_r= 2.55) with thickness of 0.25mm is used as the substrate. It provides a very good flexibility and the reflection coefficient for a face-to-face configuration is given in Fig. 2. A sound impedance matching is observed across the frequency range between 1.7 and 5.9GHz. The transmission coefficient for a face-to-face configuration of the design 1 is shown in Fig. 3, it is indicated that when the radius for bending is changed from 16mm to 29.5mm, the transmission starts to degrade at higher frequency end, however, for the frequencies at 4GHz and below, the influence from bending is limited even if the radius for bending is as large as 29.5mm. For the design 2, F_4BTM-1/2 (ε_r= 10.2) with thickness of 0.762mm is used, it provided a less flexibility but yield a better resistance to bending. The transmission coefficient for a face-to-face configuration is shown in Fig. 4. It is observed that there is minor difference in tranmission coefficient for the CPW to be bended with various radius from 16mm to 19mm.

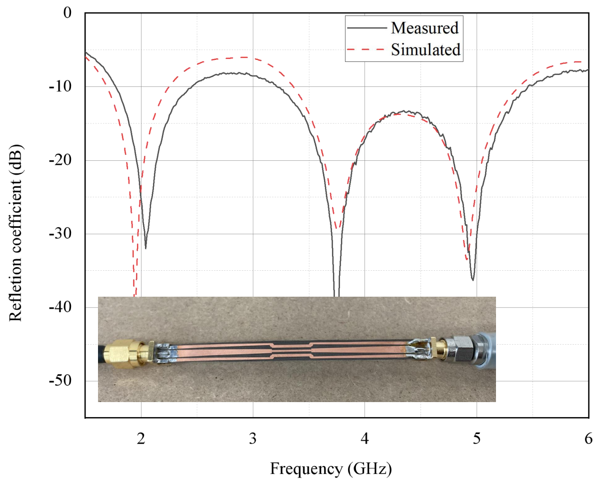


Figure 2. The reflection coefficient of the CPW for feed, the inset is the fabricated CPW in back-to-back configuration for the design 1.

The fabricated CPWs in standalone configuration for the design 1 and design 2 are shown in Fig. 5. They can be used to feed planar antenna with a balanced configuration by bending.

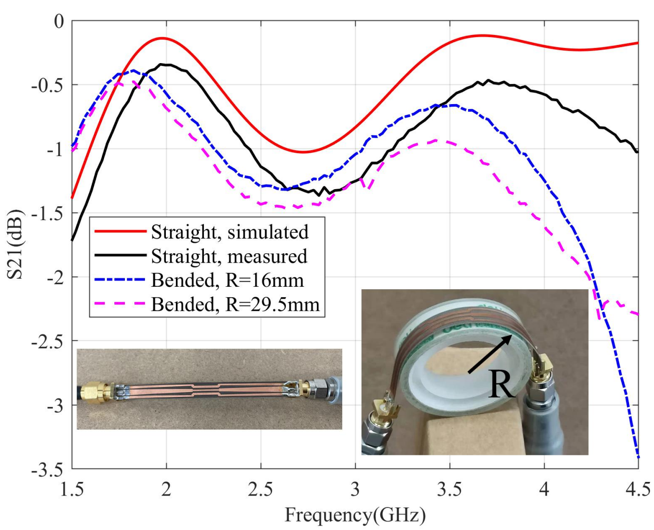


Figure 3. The S21 parameter of the CPW design 1, the right inset is the fabricated CPW in one bending configuration for characterization measurement.

A planar disk dipole is designed and fabricated to test the feeding method by using the flexible CPW of design 2. The centre operation frequency of the planar dipole is 2.4GHz, the distance from the antenna plane to the ground plane is 23mm. The fabricated prototype is shown in Fig. 6. The reflection coefficient for the planar antenna with CPW feed from measurement and simulation is shown in Fig. 7.

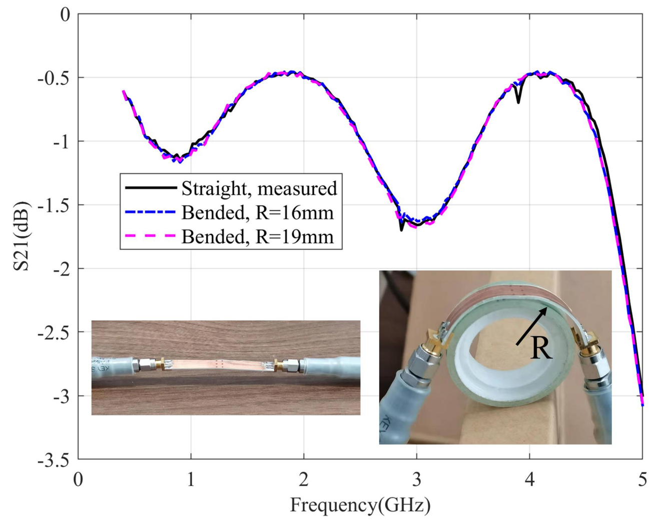
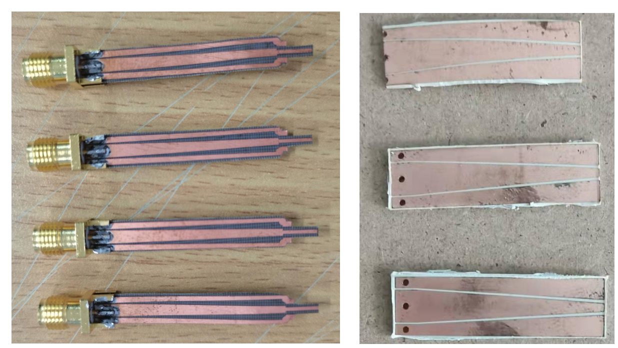


Figure 4. The S21 parameters of the CPW design 2, the right inset is the fabricated CPW in one bending configuration for characterization measurement.



(a) CPW with impedance 120 ohm (b) CPW with impedance 25 ohm

Figure 5. Two coplanar waveguide designs fabricated.

It is observed that an resonance at 0.72GHz will be present due to the common mode propagation from the CPW feedline. Hence a parity line is introduced at the opposite side of the CPW to counter this effect. The principle is to form an electrical loop which is shorter than the wavelength at the resonant frequency. This is extremely important for antennas in an array environment where ultrawide frequency bandwidth can be achieved and the resonance frequency point may be within the operational frequency band.

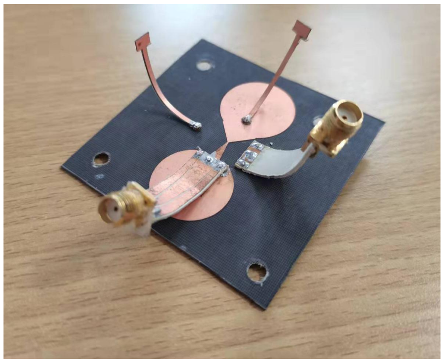


Figure 6. The CPW design 2 is used to feed the planar antenna at 2.4GHz.

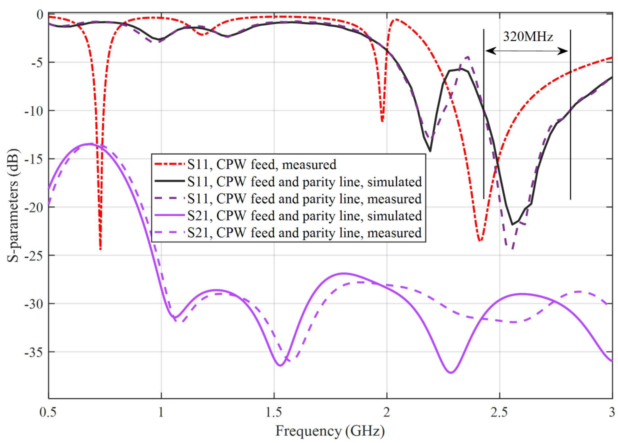


Figure 7. The S parameters for the planar antenna with CPW feed.

As shown in Fig. 7, the CPW can be used to feed the planar antenna, but the frequency may be shifted to a higher band. With a parity line introduced, the resonance caused by the common mode propagation can be eliminated successfully. In future research, the CPW design based on the flexible substrate will be used to feed planar antenna arrays.

IV. Conclusion

Two CPW designs based on flexible substrate have been demonstrated to show stable transmission coefficient with various bending radius on them. This allows to use them to feed planar antenna with balanced configuration. One planar antenna operating at 2.4GHz has been fed through one of the CPW design, the results indicate that this type of planar antenna can be fed with the flexible CPW design. It signify that the antenna and the feedline can both be mechanically flexible allowing a complete conformal design. It open a door to have completely printed antenna arrays including their feedlines. This extends the suitability of the antenna or array for a wider range of applications.

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