Microstrip Fed Coplanar Stripline Tee Junction Using Coupled Coplanar Stripline

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Abstract — **A microstrip fed coplanar stripline (CPS) tee junction was developed using a coupled coplanar stripline (CCPS) without bonding wire. The new tee junction equally splits the power to each output port with an insertion loss of 0.7 dB from 2 GHz to 4.15 GHz. The tee junction can serve as a microstrip to CPS transition to feed dipole antennas and other applications. A wideband CPS-to-microstrip transition was developed and used for conducting measurements. The two back-to-back transitions have an insertion loss of less than 3 dB and a return loss better than 10 dB for the frequency range from 1.3 GHz to 13.3 GHz (1:10.2).**

I. Introduction

Coplanar stripline (CPS) is a useful transmission line for feeding printed dipole antenna [1] and solid state device integration. It has attractive features such as small dispersion, small discontinuity parasitics, and simple implementation of open-ended or short-ended strips. Recent studies on CPS are discontinuities such as open and short circuits, series gap, spur-slot and spur-strip [2], bandstop [3] and bandpass [4] filters using the spur-strip and the spur-slot resonators. A lumped-element CPS lowpass filter was designed [5], and a CPS lowpass filter using a transverse slit and a parallel-coupled gap of CPS discontinuities was presented [6]. Little work has been reported for CPS tee junctions. A CPS tee junction was introduced [3] and, a coplanar waveguide (CPW) fed CPS tee junction was developed for the twin dipole antenna feeding [7]. Both methods require bonding wires.

In this paper, a new microstrip fed CPS tee junction using coupled coplanar stripline (CCPS) is introduced. The CCPS has about 0.5 dB insertion loss deterioration compared to the original CPS, and the return loss is better than 10 dB from 1.7 GHz to 7.58 GHz. The 1 dB insertion loss deterioration bandwidth ranges from 1.7 GHz to 13.3 GHz. The new tee junction equally splits the power to each output port with an insertion loss of 0.7 dB from 2 GHz to 4.15 GHz.

For broadband measurement purposes, a new CPS to microstrip transition was developed. The back-to-back transition has an insertion of loss less than 3 dB and a return loss better than 10 dB for the frequency range from 1.3 GHz to 13.3 GHz (1:10.2).

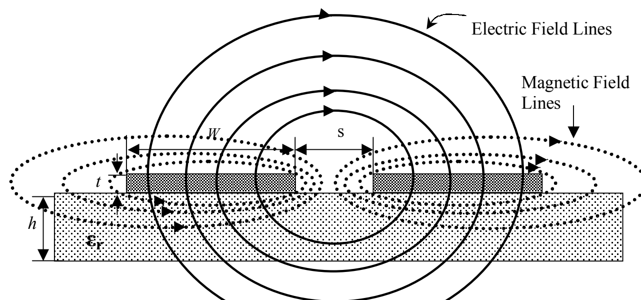

Fig. 1. Coplanar stripling structure.

The circuit simulations were performed with the aid of IE3D software [8], which uses the method of moment algorithm for full wave electromagnetic simulation. The theoretical results agree fairly well with measurement data.

II. Microstrip-to-CPS-to-Microstrip Back-to-Back Transitions Developed for CPS Components Measurements

The structure of CPS is shown in Fig. 1. The circuit was fabricated on the RT/Duroid 5870 substrate with 1 oz. copper metallization, 20 mil substrate height and the dielectric constant of 2.33. Strip width (W) and gap between the strips (s) are 1.5 mm and 0.6 mm, respectively. As shown in Fig. 1, electric field lines of CPS are directed from one conductor to the other. Electric field lines for microstrip are directed from top layer conductor to bottom layer ground plane metallization. The radial stub is used to accomplish the rotation of the electric filed lines. A wideband coupling can be accomplished by terminating one of the CPS strips with a radial stub as shown in Fig. 2. The radial stub was optimized using IE3D with a radius of 5.5 mm and a rotation angle (ϕ) of 30^o. Since it does not employ any quarter wavelength

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transformers, which would limit the bandwidth, wideband performance can be achieved.

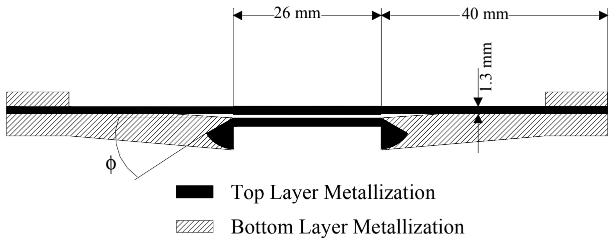


Fig. 2. The structure of microstrip-to-CPS-to-microstrip back-to-back transition.

This type of CPS-to-microstrip transition, using a coupling method, was first proposed by Simons et al. [9] in 1995 with a narrow bandwidth of 2.4 dB back-to-back insertion loss from 5.1 GHz to 6.1 GHz (1:1.2). Narrow bandwidth would exclude its use to serve as the tool for broadband measurements.

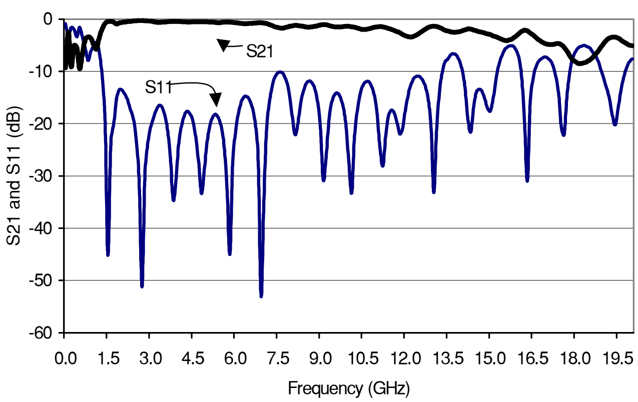


Fig. 3. Measured return and insertion loss of the back-to-back transition.

The results of two back-to-back CPS-to-microstrip transitions are illustrated in Fig. 3. The CPS-to-microstrip transition exhibits wideband performance from 1.3 GHz to 13.3 GHz (1:10.2) with an insertion loss of less than 3 dB and a return loss of better than 10 dB for the two back-to-back transitions. The broadband transition can be used effectively for CPS component measurements and evaluation.

III. MICROSTRIP FED CPS TEE JUNCTION DESIGN USING COUPLED COPLANAR STRIPLINE

The structure of coupled coplanar stripline (CCPS) is depicted in Fig. 4 (b). One of the CPS strips is discontinued and is terminated with radial stubs with a rotation angle of 30° and a radius of 1.5 mm for coupling to the bottom layer metallization. The bottom layer metallization, which is coupled from the top layer's radial stubs, works as a CPS strip shown in Fig. 4 (c). The radial stub is used to accomplish the smooth field transition.

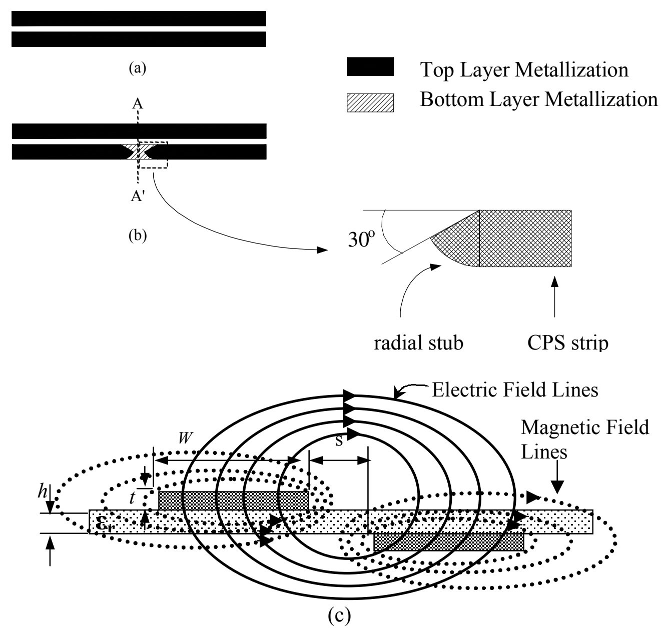


Fig. 4. Coupled coplanar stripline (CCPS) structure (a) Original CPS, (b) CCPS, (c) Cross-sectional view at A-A' with fields distributions of the CCPS for different layers of metallization.

Performance was measured with the new CPS-to-microstrip transition presented at section II and the results are given in Fig. 5. Fig. 5 shows that the insertion loss of CCPS is around 0.5 dB deterioration compared with that of original CPS for the frequency range from 1.7 GHz to 7.58 GHz and the return loss is better than 10 dB.

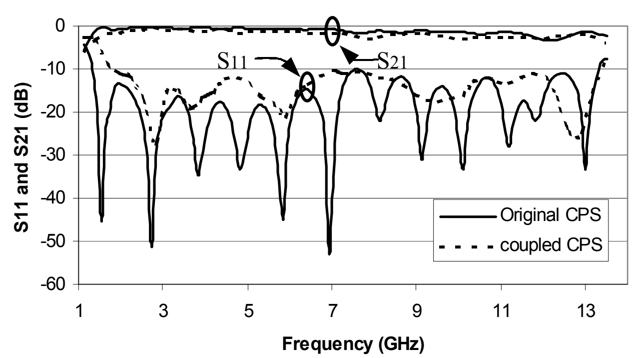


Fig. 5. Frequency responses comparison between CPS and CCPS.

Insertion loss deterioration of less than 1 dB covers the wider frequency range from 1.7 GHz to 13.3 GHz.

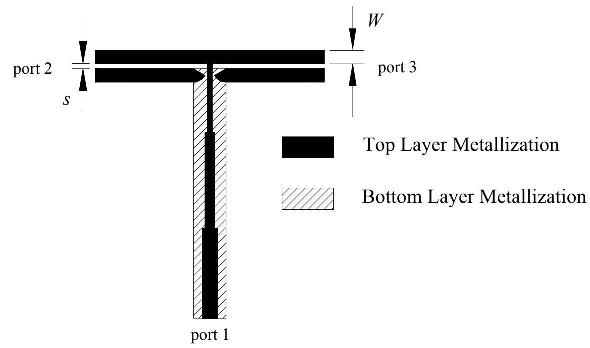
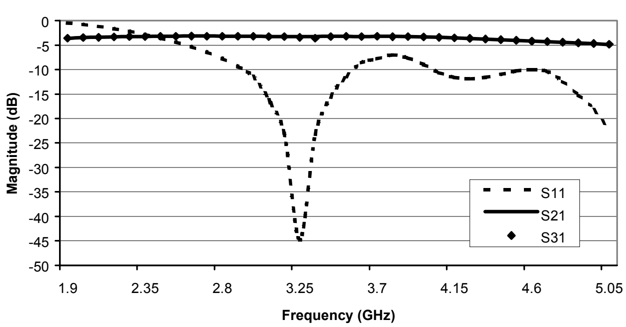
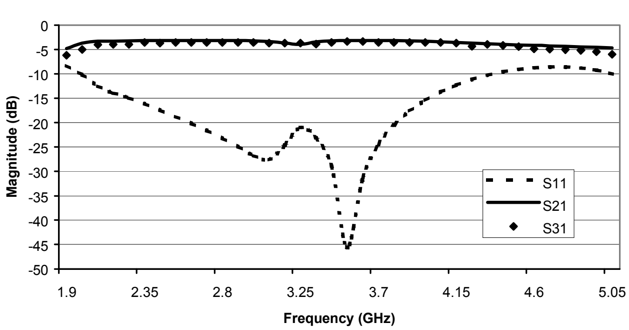


Fig. 6. The configuration of microstrip fed CPS tee junction.

The configuration of tee junction is illustrated in Fig. 6. Characteristic impedance of the CCPS is 184 Ω and the microstrip feed line has the input impedance of 50 Ω. A quarter wavelength transformer was used to transform microstrip's impedance from 50 Ω to 92 Ω. Part of the microstrip feed line's ground plane forms the coupled coplanar stripline (CCPS).



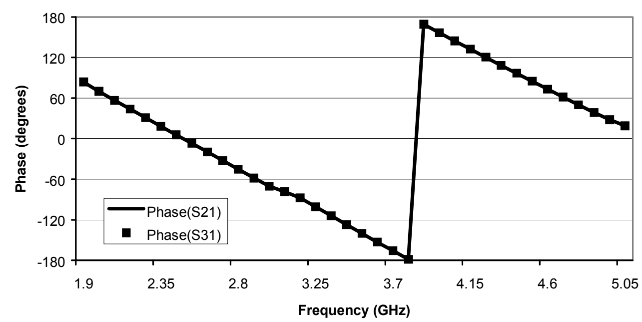
(a)



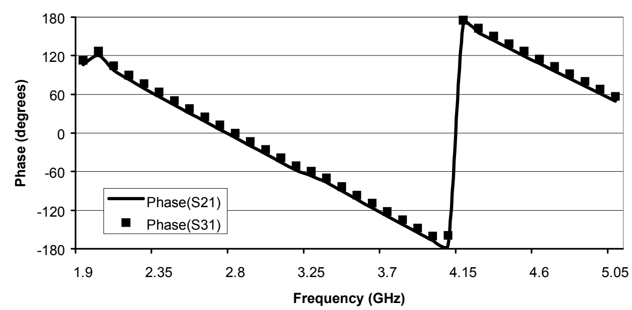
(b)

Fig. 7. Frequency responses of the tee junction (a) simulated, (b) measured.

The tee junction was measured using the new CPS-to-microstrip transition presented in section II. The measured and simulated frequency responses of the tee junction are shown in Fig. 7. For an ideal lossless tee junction, it equally splits the power into each output port with S_{21} = S_{31}= -3 dB. The measurements in Fig. 7 show an insertion loss of 0.7 dB and a return loss of better than 10 dB from 2 GHz to 4.15 GHz. Measured phases are almost identical at each output port as shown in Fig. 8 (b).



(a)



(b)

Fig. 8. Phase responses of the tee junction (a) simulated, (b) measured.

IV. CONCLUSIONS

A microstrip fed CPS tee junction was developed using a coupled coplanar stripline (CCPS), which does not require bonding wire. The tee junction demonstrated equal power splitting at each output port with 0.7 dB insertion loss for the frequency range from 2 GHz to 4.15 GHz. The tee junction should be useful for many applications such as feeding a dipole antenna array and various other CPS components.

V. ACKNOWLEDGEMENTS

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