A Broadband Transition Between Microstrip and Coplanar Stripline

Tsenchieh Chiu and Yu-Shing Shen

***Abstract*—A design for a broadband microstrip-to-coplanar-stripline transition using broadside-coupled strips is proposed in this letter. Two transitions are designed in back-to-back configuration and the insertion loss is optimized in X-band(8.2 GHz∼12.4 GHz). Both simulation and measurement are in good agreement. The measured bandwidth for 1 dB insertion loss and 20 db return loss is from 6.9 GHz to 12.4 GHz.**

***Index Terms*—Coplanar strips, microstrip, transition.**

I. INTRODUCTION

MICROSTRIP-TO-COPLANAR-STRIPLINE (CPS) transitions have many applications in microwave integrated circuits [1]–[4], such as feeding networks for printed circuit antennas, baluns for balanced mixers, and wafer probes for on-wafer circuit measurement. In the past, different transitions have been proposed in the literatures, and many of those use electromagnetic coupling to provide RF continuity between the CPS strip and microstrip ground plane. To couple the energy into different layer, one strip of the CPS is extended on top of the microstrip ground plane to form a microstrip radial stub. At the frequencies of interest the radial stub functions as a short circuit which connects one of the strips of the CPS and the ground plane [5]. Using the radial stubs, Simons *et al.* [2] propose a CPS-to-microstrip-to-CPS transition with 2.4-dB insertion loss and 10-dB return loss from 5.1 to 6.1 GHz. Suh and Chang [3] also propose a wideband design with insertion loss less than 1 dB and return loss better than 10 dB achieved from 1.4 to 7.3 GHz.

In this letter, the design reported in [2] is significantly improved through computer optimization resulting in enhanced bandwidth and much lower insertion loss. Instead of using radial stub, broadside-coupled strips are used to achieve broadband response and the reduction of the transition area. Also, the shape of the overlapping strips is modified to avoid rapid disruption of the strip edge currents, and therefore better performance of return loss is obtained. Two X-band transitions are designed and measured in back-to-back configuration. The measurement results show good agreement with the simulation using IE3D software. Insertion loss less than 1 dB and return loss better than 20 dB are obtained from 6.9 to 12.4 GHz, which well covers the X-band.

Manuscript received April 22, 2002; revised August 2, 2002. The review of this letter was arranged by Associate Editor Dr. Ruediger Vahldieck.

The authors are with the Graduate Institute of Communication Engineering, National Central University, Chung-Li, Taiwan, R.O.C. (e-mail: tcchiu@ee.ncu.edu.tw).

Digital Object Identifier 10.1109/LMWC.2003.808707

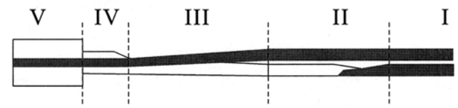

Fig. 1. Configuration of a microstrip-to-CPS transition.

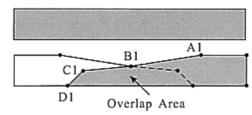

Fig. 2. Top view for the part II of the transition.

II. DESIGN

Fig. 1 shows the configuration of the proposed microstrip-to-CPS transition. The transition is designed to function primarily in X-band (8.2∼12.4 GHz). Arlon 25N is used as the substrate with dielectric constant of 3.25 at 10 GHz and thickness of 18 mil. As shown in Fig. 1, the transition is mainly composed of five parts. The lengths of parts I–V are 8.5 mm, 15.5 mm, 18.0 mm, 6.0 mm, and 6.0 mm, respectively. Part I is a 140 Ω CPS. The strip width and gap of the CPS are 1.5 mm and 0.5 mm, respectively. Part V is a finite-ground-plane 50 Ω microstrip. The widths for the ground plane and the strip of the microstrip are 12.2 mm and 1.1 mm, respectively.

Fig. 2 shows the configuration of part II of the transition. In order to form a virtual short circuit between the coplanar and noncoplanar strips, the overlap area between the top (shaded) and bottom strips should be large enough to provide sufficient electromagnetic coupling at the frequencies of interest. Moreover, the inner edges of the overlap strips are trimmed to avoid abrupt discontinuities for the edge currents, since most of the current distributes along the edges of the strips. The effort of designing this part is mainly on the determination of the positions of points A1, B1, C1, and D1 of the top strip. The shape of the bottom strip is merely the mirrored image of the top strip on different layer. Using IE3D software [6], the coordinates of these point using A1 as a reference are given by A1(0, 0), B1(−3.5 mm, −0.55 mm), C1(−5.75 mm, −0.75 mm), and D1(−6.5 mm, −1.5 mm).

In parts I and II, the electric field is mostly parallel to the substrate, while in part V, it is mostly vertical to the substrate. Thus, the function of the part III is to rotate the electric field by about 90°. The geometry of part IV, as shown in Fig. 3 play an essential role in reducing the return loss of overall transition. While the current distributes mainly on the edges of both strip in parts I, II, and III, it concentrates in the region between strip and ground plane of the microstrip in part V. If the width

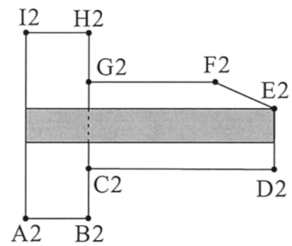

Fig. 3. Top view for the parts IV and V of the transition.

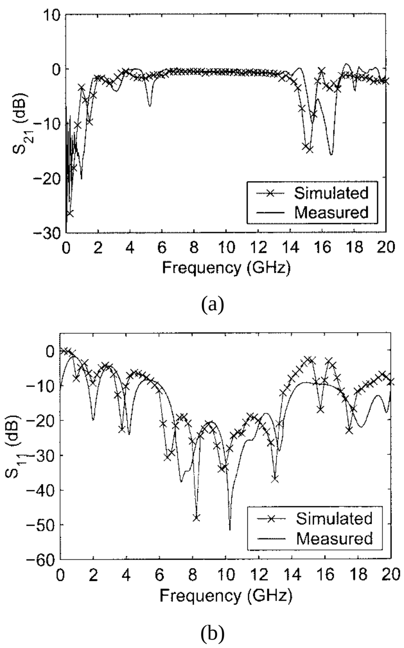

Fig. 4. Simulated and measured (a) insertion loss and (b) return loss versus frequency of the back-to-back microstrip-to-CPS transitions.

of the ground plane is large compared that of the strip, the edge currents of the ground plane can be ignored. Thus, part IV is designed to guide the edge currents of the CPS to the middle region of the ground plane of MS. The main effort of designing part IV is on the determination of the position of points C2 and E2. The position of E2 is set right under the edge of the top strip, which is the similar strategy applied in [3]. Also, adjusting the edge of E2F2 helps in reducing the return loss. The position of C2 is first set at point B2 in order to make the edges C2B2 and A2B2 look continuous. However, it is found the disruption of the edge currents from part III to part V will cause significant return loss. In the design, C2 is moved close to the middle of the ground plane, which is able to guide the edge current into the middle region of the ground plane. Using IE3D software, the coordinates of these points in Fig. 3 are given by B2(0, −6.1 mm), C2(0, −1.4 mm), D2(6 mm, −1.5 mm), E2(6 mm, 0.55 mm), F2(4 mm, 1.4 mm), and G2(0, 1.4 mm).

III. Measurement Results

Two microstrip-to-CPS transitions are fabricated in back-to-back configuration and measured using Rohde and Schwarz ZVK vector network analyzer. Calibration and time-domain procedures are applied to exclude the effect of SMA connectors soldered on microstrips. Fig. 4(a) and (b) show the measured and simulated insertion loss and return loss versus frequency. The simulation and measurement results are in good agreement except at frequencies above 14 GHz. Overall, the 1-dB insertion loss and 15-dB return loss bandwidth for the back-to-back transitions is from 6.5 to 13.8 GHz. The back-to-back transitions also have a 20-dB return loss bandwidth from 6.9 to 12.4 GHz.

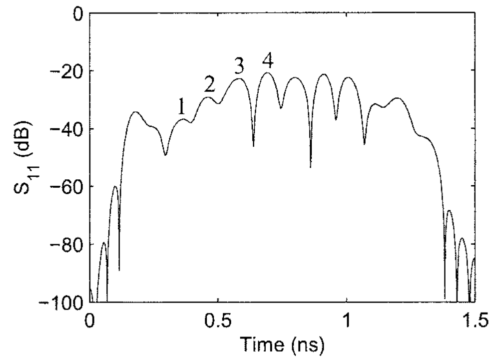

Fig. 5. Time-domain measured return loss of the back-to-back transitions. Peaks #1, #2, and #3 are mainly attributed to the discontinuities at the interfaces between parts V and IV, IV and III, and III and II, respectively. Peak #4 is caused by the discontinuity in part II shown in Fig. 2

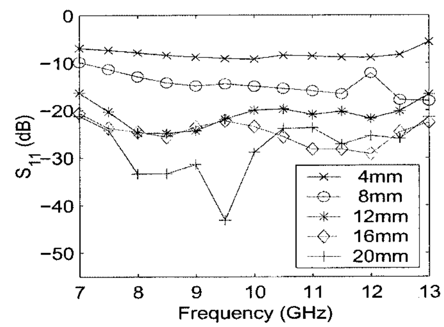

Fig. 6. Simulated return loss of single transition shown in Fig. 1. In the simulation, five different lengths of part III are used. Port 1 is defined at part V.

Fig. 5 shows the measured return loss versus frequency in time domain. Each peak in the Fig. 5 corresponds to one discontinuity in the transitions, and the correspondence between peaks and discontinuities is pinpointed using a probe in the measurement. It is found that part III and, especially, part II, cause major reflection in the transition. If higher return loss can be tolerated, the length of the transition can be reduced. Fig. 6 shows the simulated insertion loss versus frequency for single transition of different length in part III. It is found that if, instead of 20 dB, 10-dB insertion loss is acceptable, the length of part III can be reduced more than 50%.

IV. Conclusion

A broadband microstrip-to-CPS transition is proposed in this letter. Instead of microstrip radial stub, broadside-coupled strips are applied to reduced the overall area of transition. Also the shape of the overlap area in part II and the transition between parts IV and V are adjusted using IE3D sofware to provide better continuity for edge currents. Two transitions are designed in back-to-back configuration and the insertion loss is optimized in X-band (8.2 GHz∼12.4 GHz). Both simulation and measurement are in good agreement. The measured bandwidth for 1 dB insertion loss and 20-db return loss is from 6.9 to 12.4 GHz. When higher return loss is tolerable, the length of the transition can be reduced.

REFERENCES

[1] N. I. Dib, R. N. Simons, and L. P. B. Katehi, "New uniplanar trnasitions for circuit and antenna applications," *IEEE Trans. Microwave Theory Tech.*, vol. 43, pp. 2868–2873, Dec. 1995.

[2] R. N. Simons, N. I. Dib, and L. P. B. Katehi, "Coplanar stripline to microstrip transition," *Electron. Lett.*, vol. 31, no. 20, pp. 1725–1726, Sept. 1995.

[3] Y.-H. Suh and K. Chang, "A wideband coplanar stripline to microstrip transition," *IEEE Microwave Wireless Compon. Lett.*, vol. 11, pp. 28–29, Jan. 2001.

[4] Y. Qian and T. Itoh, "A broadband uniplanar microsrip-to-CPS transition," in *Microwave Conf. Proc., AMPC*, vol. 2, 1997, pp. 609–612.

[5] D. Jaisson, "Transition from a microstrip line to an asymmetrical coplanar waveguide," *Microwave J.*, pp. 112–115, June 1994.

[6] Zeland Sofware Inc., IE3D version 8.2, 2001.