A NEW BROADBAND COPLANAR WAVEGUIDE TO SLOTLINE TRANSITION

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ABSTRACT

A new broadband CPW to slotline transition is proposed and analyzed in this paper. This new transition utilizes CPW-slotline mode conversion phenomenon to convert CPW mode to slotline mode, and the transition bandwidth is broadened by the use of air-bridges. The Finite-Difference Time-Domain (FDTD) method is employed to analyze the transition and a very wide transition bandwidth is observed. A relatively good comparison is made with experiment results further verifies the concept.

INTRODUCTION

Coplanar waveguide to slotline transition has been an important building block in MIC and MMIC due to its uniplanar characteristic. In some applications it is necessary to convert energy from one form to another by using an appropriate transition. Several CPW-slotline transitions have been proposed and analyzed previously [1] [2]. As proposed in [1], the transition is designed by matching the impedance of the CPW with the slotline, and the idea is proven experimentally. Several other types of transitions using different combinations of CPW short and slotline open circuits are provided by Ho [2] and an experimental approach is employed to verify the concept.

In this paper, the idea of a new transition based on CPW-slotline mode conversion characteristic is proposed and a transition bandwidth broadening technique by the use of air-bridges is demonstrated. FDTD method is employed to analyze a back-to-back transition and the design concept of the proposed transition is also verified by experimental results.

DESIGN CONCEPT AND METHOD OF ANALYSIS

One phenomenon which always occurs in CPW circuits is the CPW-slotline mode conversion when the electrical lengths of two slots are different [3]. For those frequencies whose electrical lengths difference is exactly 180^o, CPW mode converts to slotline mode completely as shown in Fig. 1. However for other frequencies whose electrical lengths difference is away from 180^o, the mode conversion decreases gradually. This mode conversion phenomenon is utilized to realize our proposed CPW-slotline transition. Due to the gradual transition from CPW mode to slotline mode, air-bridges help to eliminate slotline mode, therefore increase the transition efficiency. As shown in Fig. 2, the first part of the transition realizes mode conversion function and is then connected to a slotline. An air-bridge is put immediately in front of the mode conversion section to eliminate the reflected slotline mode. The air-bridge, which is used to suppress the slotline mode, also serves the purpose of broadening the transmission efficiency since the reflected slotline mode from the slotline section is bounced back to the slotline section causing another CPW-slotline mode conversion. Due to this ‘‘bouncing back-and-forth’’ behavior, the energy can be converted from CPW mode to slotline mode over a broad frequency range.

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A *3D* FDTD code with Perfectly Matched Layer (PML) ABC has been developed to analyze the proposed transition in this study. Due to the multi-modal fields in the CPW circuit, a post-processing procedure as proposed in [4] is used to separate CPW mode and slotline mode. An FFT is used to convert time domain waveform to frequency domain information and the S-parameters are obtained thereafter.

RESULTS

The wideband CPW to slotline transition (back to back) is analyzed using FDTD for the cases with and without air-bridges. The comparisons, shown in Fig. 3 and Fig. 4, indicate that the transition bandwidth is broadened by the addition of the air-bridges as a result of elimination of the slotline mode.

The proposed transition is also verified by measurements and the experimental data is compared to FDTD simulation result. Since SMA connectors which represent short circuits for slotline mode are used in measurement, it is not easy to distinguish the S-parameters for different modes experimentally [3]. Therefore only S_{21}^{cc} is used to make the comparison since a lot of CPW mode transmissions occur in this structure and slotline modes are in a very low level over a wide frequency range due to the suppression of slotline mode by air-bridges. It should be noted that the result will be deviated when S_{21}^{cc} is low and S_{21}^{sc} is relatively high. The comparison, shown in Fig. 5, indicates a generally good agreement in magnitude and trend.

CONCLUSION

A new type of CPW-slotline transition utilizing mode conversion phenomenon is proposed and demonstrated in this paper. The concept of the new transition is verified both numerically and experimentally. It is indicated from the results that the new transition possesses a wideband transmission as a result of the CPW-slotline mode conversion and the elimination of slotline mode.

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REFERENCES

[1] T. Q. Ho and S. M. Hart, ‘‘A Broad-Band Coplanar Waveguide To Slotline Transition,’’ *IEEE Microwave and Guided Wave Letters*, v. 2, pp.415-416, Oct. 1992.

[2] T. H. Ho, L. Fan and K. Chang, ‘‘Experimental Investigations of CPW-Slotline Transitions for uniplanar MICs,’’ *1993 IEEE MTT-S Int. Microwave Symp. Dig.*, June 1993, pp.877-880.

[3] M. D. Wu, S. M. Deng, R. B. Wu, and Powen Hsu, ‘‘Full-Wave Characterization of the Mode Conversion in a Coplanar Waveguide Right-Angled Bend,’’ *IEEE Trans. Microwave Theory Tech.*, v. 43, pp.2532-2538, Nov. 1995.

[4] M. Rittweger, N. H. L. Koster, S. Kosslowski, R. Bertenburg, S. Heinen, and I. Wolff, ‘‘Full-Wave Analysis of a Modified Coplanar Air Bridge T-Junction’’, *Proc. 21th European Microwave Conf.*, pp.993-998, Stuttgart, 1991.

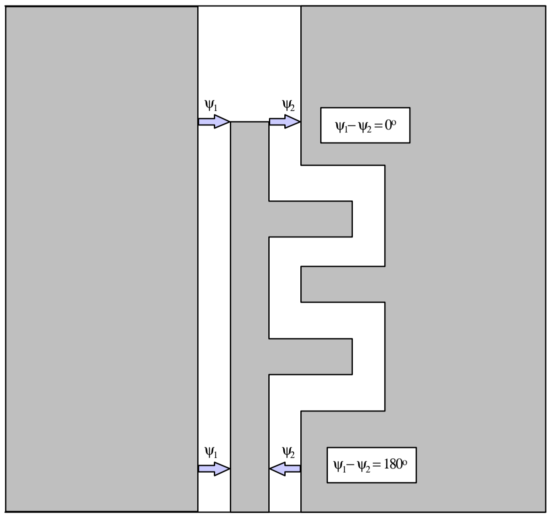

Fig. 1 A conceptual illustration showing CPW-slotline mode conversion.

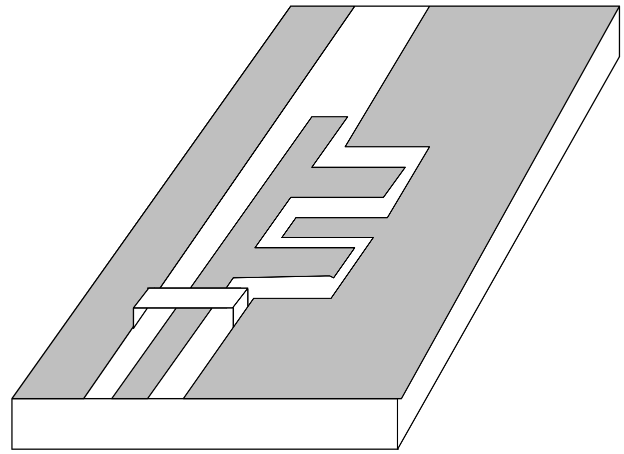

Fig. 2 The proposed new wideband CPW-slotline transition.

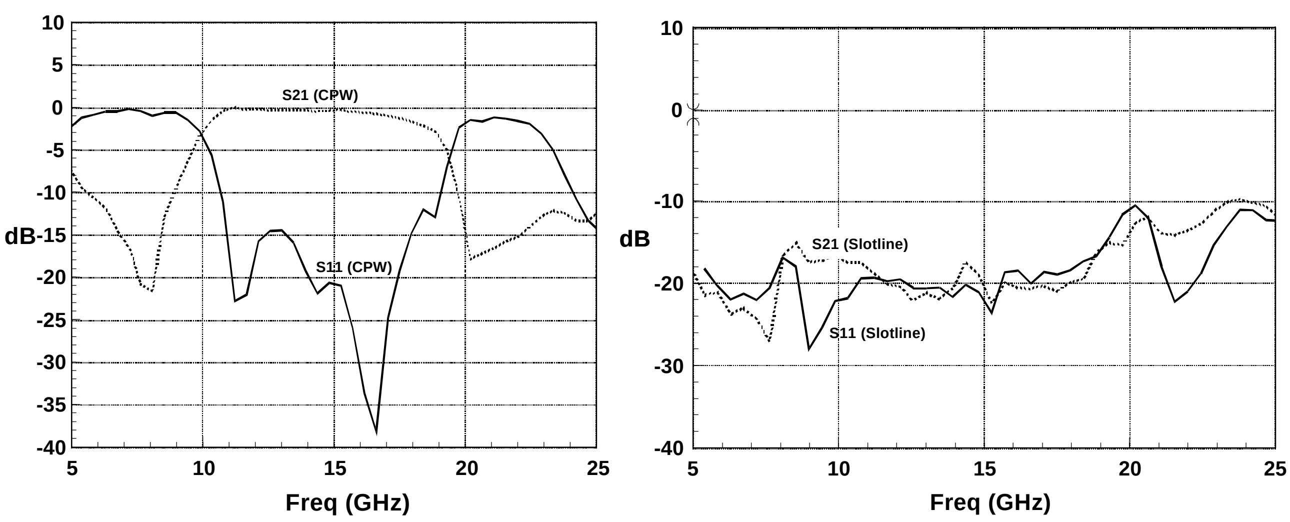

Fig. 3 The FDTD results for the S-parameters of the back-to-back broadband CPW-slotline transition with air-bridges.

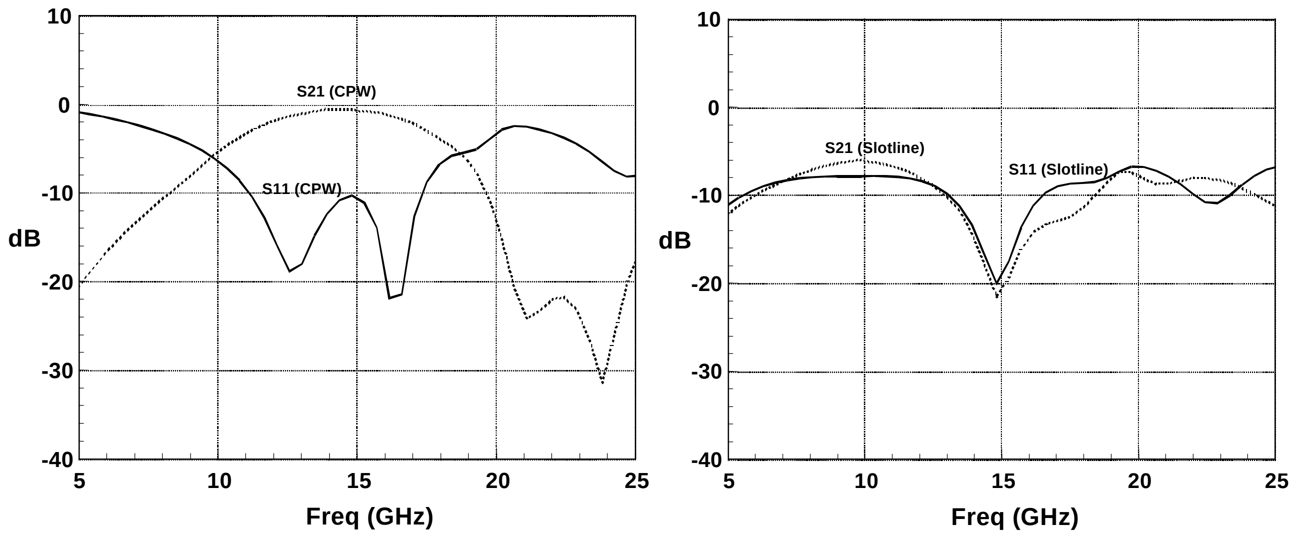

Fig. 4 The FDTD results for the S-parameters of the back-to-back broadband CPW-slotline transition without air-bridges.

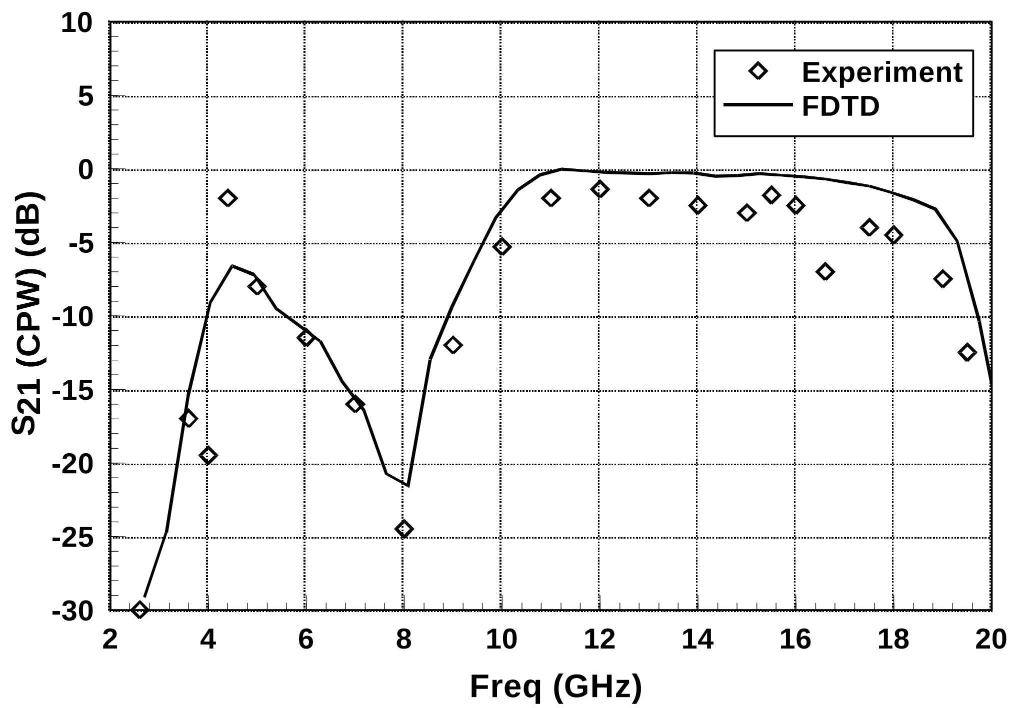

Fig. 5 The comparison of return loss for CPW mode between FDTD result and experimental result for the back-to-back broadband CPW-slotline transition.

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