TAPERED TRANSITION TO SUBSTRATE INTEGRATED WAVEGUIDE FOR MMIC`S

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Abstract- Usually transitions from microstrip line to rectangular waveguide are made with three-dimensional (3-D) complex mounting structures. In this paper, a new planar platform is developed in which the microstrip line and rectangular waveguide are fully integrated on the same substrate, and they are interconnected via a simple taper. Our experiments at 29 GHz show that an effective bandwidth of 11% at 21 dB return loss is obtained with an in-band insertion loss better than 0.6 dB. The new transition allows a complete integration of waveguide components on substrate with MIC's and MMIC's.
**Keywords – Integrated rectangular waveguide, Microstrip to waveguide transition**

1. INTRODUCTION

RECTANGULAR waveguide can be used to design high quality components but requires complex transitions to integrated planar circuits. Several studies of transitions between microstrip line and rectangular waveguide have been reported [1]. However, typical integration schemes from rectangular waveguide with planar structure are bulky and usually require a precision machining process, which is difficult to achieve at millimeter-wave frequencies for mass production. The transitions always consist of two or more separate pieces that require judicious assembly, and a tuning mechanism is also generally essential. Furthermore, the planar substrate has to be cut into a specific shape. These constraints make integration difficult and costly [2].

A straightforward solution is to integrate the rectangular waveguide into the microstrip substrate. This will surely reduce the Q factor of the waveguide because of dielectric filling and volume reduction, but the entire circuit including planar circuit, transition and waveguide can be constructed using standard PCB or other planar processing techniques. In this letter, a new integrated platform of microstrip line and rectangular waveguide is presented, in which the two dissimilar structures are oriented in the same axis, thereby reducing the total size required for the transition [3]. This transition structure makes use of a tapered microstrip line to excite the waveguide mode. The waveguide is synthesized on the substrate with linear arrays of metallized via holes in our experiments, but metallized grooves could also be used. Since all the components are designed on the same substrate, a planar fabrication technique can guarantee excellent mechanical tolerances as well as tuning-free design [4] [5][6] [7]. This is in particular of interest for multilayered processes such as low-temperature co-fired ceramic (LTCC) platforms. In this paper, a microstrip transition to substrate integrated waveguide is proposed whose effective bandwidth is 11% at 29 GHz.

2. DESIGN OF THE PROPOSED TRANSITION

Fig. 1(a) shows the proposed transition from microstrip line to rectangular waveguide within the same dielectric substrate. The structure consists of a tapered microstrip line section microstrip that connects a 50Ω microstrip line and the integrated waveguide. The taper is used to transform the quasi-TEM mode of the microstrip line into the TE10 mode in the waveguide. As indicated in Fig. 1(b), the line is well suited to excite the waveguide because the electric fields of the two dissimilar structures are approximately oriented in the same direction and also they share the same profile [4]- [5]. The design of such a transition is simple and straightforward. First, the size of the

(a)   (b)   (c)
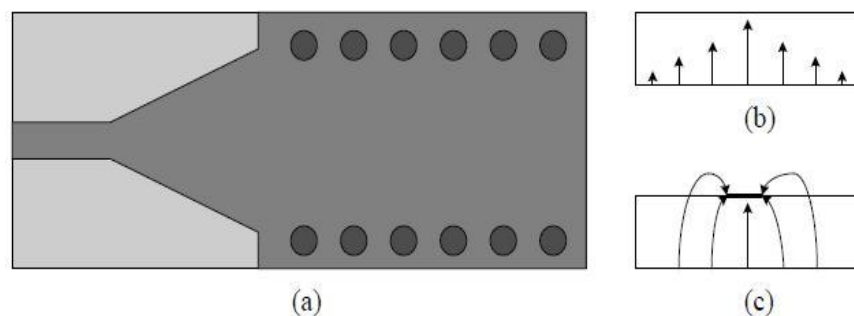
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Fig. 1. Microstrip line to SIW transition with tapered microstrip feeding: (a) transition structure; (b) electric field distribution in SIW cross section, and (c) electric field distribution in MSL cross section

waveguide can be determined by considering the dielectric effect and well-established waveguide theory. The tapered section is then designed that interrelates the line width of the 50Ω microstrip with the width of the integrated waveguide.
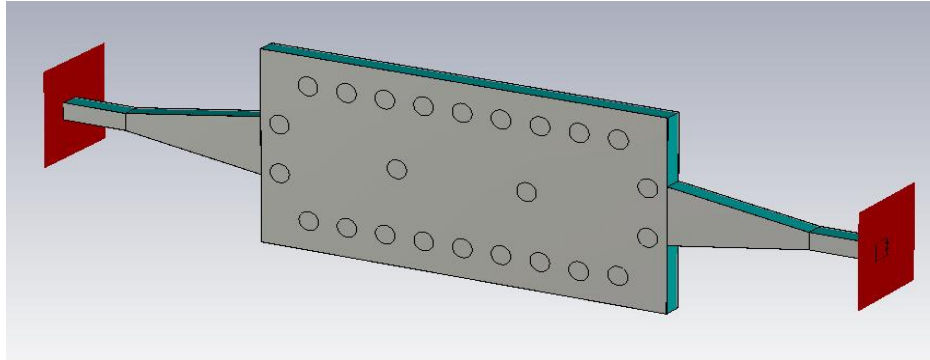

Fig. 2 Microstrip Line to Substrate Integrated Waveguide transition

It is known that the propagation constant of the TE10 mode is only related to the width of waveguide. Therefore, the height or thickness of the waveguide can be reduced without much influence on the TE10 mode propagation, thus allowing its integration into a thin substrate that could reduce the radiation loss of the microstrip line. Nevertheless, reducing the height will increase the conductor loss in both the microstrip line and rectangular waveguide. At millimeter-wave frequencies, the waveguide section is usually small and the conductor loss can be controlled at relatively low level. The sidewalls of the rectangular waveguide can be realized within the substrate by using a metallized post technique (arrays of vias) or a metallized groove technique, both illustrated in Fig. 2. In the plane, the ground plane of the microstrip line becomes one metallic wall for the waveguide while the tapered microstrip section provides the other metallic wall. This arrangement completes the waveguide structure. This scheme allows the design of very compact waveguide components with low loss such as   junctions and filters.

A linearly tapered microstrip is used, and this smooth tran- sition ensures a field matching between microstrip and rectangular waveguide over a broad bandwidth. The length and width of the taper, referring to Fig. 3, should be modeled and optimized over the desired frequency bandwidth. In our work, a commercial finite element method (FEM) package is used to carry out the transition design [5].

3. STRUCTURE DIMENSIONS
To verify the proposed concept, a transition working in the LMDS frequency range is designed and measured. The whole structure consists of two back-to-back transitions separated by an integrated waveguide with a length of 16 mm. The circuit is constructed on a 0.44 mm thick dielectric substrate with The dimensions referring to Fig. 1 are selected as follows:

microstrip line and a waveguide operating from 24 to 34 GHz. The two electrical walls in the   -plane are constructed with 0.762 mm via-hole arrays. The spacing between two adjacent vias is also 0.762 mm. An HP8510 network analyzer and a Wiltron test fixture are used to measure the circuit with a TRL calibration.
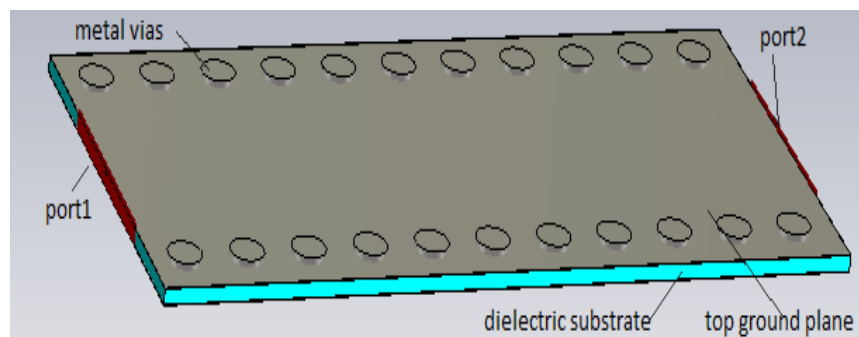

Fig. 3 Substrate Integrated Waveguide (SIW)

4. SIMULATED RESULTS
Fig. 4 shows our simulated and measured results, which involve 1.6 mm microstrip line section (0.762 mm before each transition), the two transitions and 17 mm synthesized rectangular waveguide.
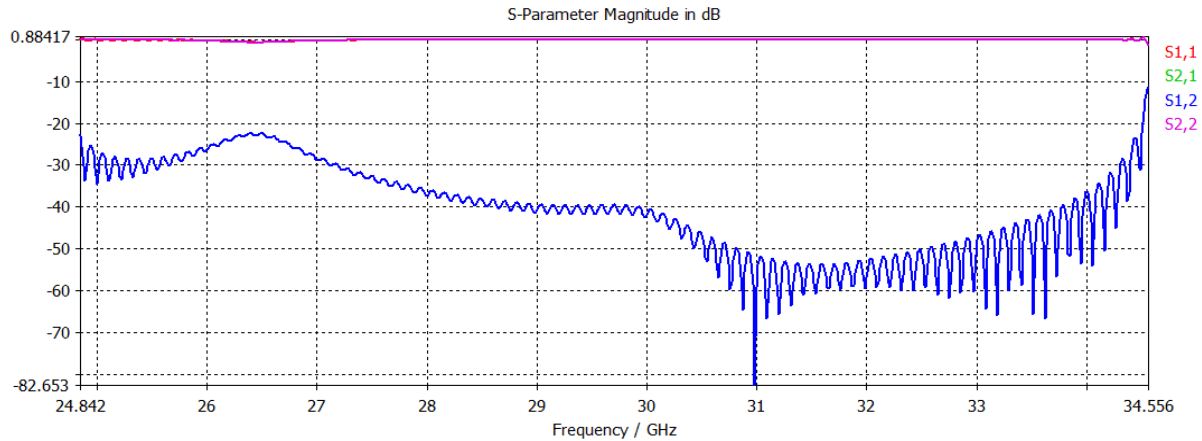
Fig. 4 Simulated results of SIW structure

A bandwidth of more than 11% is obtained here for 22 dB return loss from 24 to 34 GHz. The measured insertion loss is better than 0.6 dB in the entire band. We can see that the measured insertion loss is sometimes better than the simulated one. This may be explained by the fact that the substrate loss tangent at 10 GHz given by the manufacturer is used in the simulation. The value around 29 GHz should be lower.

5. CONCLUSION

A new planar platform integrating microstrip line and rectangular waveguide has been presented, which involves a new tran sition between the two dissimilar structures. It allows the design of a completely integrated planar circuit of microstrip and wave- guide on the same substrate without any mechanical assembly or tuning. With its direct integration, small size and low loss, this new scheme is well suited for circuit design at millimeter-wave frequencies. It can be used to integrate passive waveguide components with MIC and MMIC active circuits.

6. REFERENCES:

[1]   Pozar, David M. Microwave Engineering. Hoboken, NJ :Wiley, 2012. Print.
[2]   Chandan Kumar Ghosh and Susanta Kumar Parui "Design Analysis and Optimization of a Slotted Microstrip Patch Antenna Array at Frequency 5.25 GHz for WLAN-SDMA System" International Journal on Electrical Engineering and Informatics Volume 2, No. 2, August 2010.
[3]   R.E Collin, "Foundation for Microwave Engineering", Wiley Publications, 1998.
[4]   B.N. Das, K.V.S., V.R. Prasad, and K.V.S. Rao, "Excitation of waveguide using stripline and microstrip-line-fed slots," IEEE Trans. Microwave Theory, Tech., vol. 34, pp 321-327, Mar. 1986.
[5]   Aman Dahiya, Anand Pratap Singh Sengar, Dhirendra Kumar, Arun Kumar, "A Critical Review of Substrate Integrated Waveguide for Microwave Applications" International Conference on Computational Intelligence & Communication Technology (CICT-2016) IEEE computer society, pp. 495-499 , Ghaziabad, India Feb. 2016.
[6]   Aman Kumari, Dhirendra Kumar, Arun Kumar "Dual-band Substrate Integrated Waveguide (SIW) Band Pass Filter for scientific Radar applications," International Journal of Information Technology, Feb. 2018.
[7]   Anand Pratap Singh, Aman Dahiya, "Reconfigurable Smart Antenna for Wireless Communication Devices," International Journal of Engineering & Technology, pp. 456-459. February, vol. 7, no. 5, pp. 271-271, 2018.