Compact Planar Transmission-line Transition Direct-connecting from a Waveguide to Four Microstrip-lines

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Abstract **– A compact planar transmission-line transition direct-connecting from a waveguide to four microstrip-lines is designed in the submillimeter-wave band. Microstrip array antennas are fed from the back at the center of the antenna for wide frequency bandwidth. To reduce the size of the center feeding circuit, the direct connection of all four microstrip lines into the waveguide is advantageous for radiation performance. For further reduction of the center feeding circuit, the metal pattern under the substrate is extended into the waveguide. Matching characteristics are obtained for compact transitions by optimization of the dimensional parameters in this paper.**

Index Terms **— Submillimeter wave, Transmission-line transition, Microstrip-line, Waveguide**

1. Introduction

Submillimeter-wave technologies have been developed for various applications such as automotive radar systems [1] and wireless communication systems [2]. Microstrip array antennas are quite popular for use in this frequency range. A microstrip-to-waveguide transition can be used for a feeding circuit of the microstrip array fed from the back. Multi microstrip output waveguide transitions are advantageous to reduce the size of the feeding circuit [3]. Radiation performance is also expected to be improved. A compact planar transmission-line transition direct-connecting from a waveguide to four microstrip-lines is designed in this work. Matching characteristics are obtained for compact transitions by optimization of the dimensional parameters.

2. Structure of the Compact Planar Transition from a Waveguide to Four Microstrip-line Ports

Structure of the compact planar transition from a waveguide to four microstrip-line ports is shown in Fig. 1. The input signal from the waveguide propagates and excites the patch on the substrate at the center of the waveguide. The current on the patch couples simultaneously to the end of the four microstrip lines. The input power is divided equally to four microstrip-line ports. Via holes connect the short plane and the ground plane on the both sides of the substrate. They are surrounded around

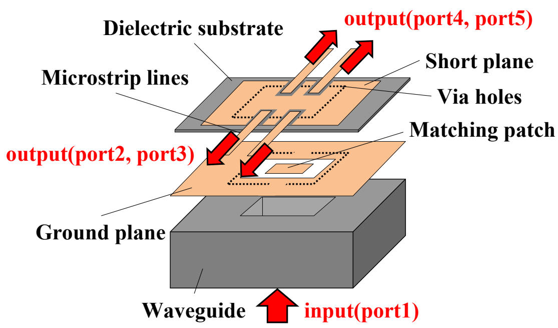
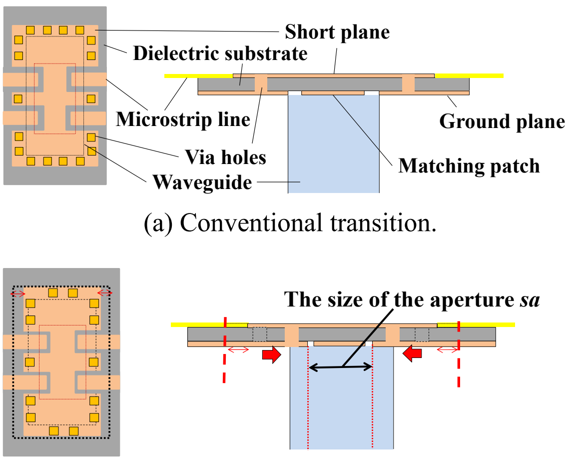


Fig. 1. Structure of the compact planar transition from a waveguide to four microstrip-line ports.



(a) Conventional transition.

(b) Size reduction of the transition.

Fig. 2. Top and cross sectional views of the proposed transition.

the waveguide in the substrate to prevent leakage of parallel plate mode propagating in the substrate. The dielectric material of the substrate is fluorocarbon resin film (thickness t = 0.37 mm, ε_r = 2.17). The size of the waveguide is WR-34 (4.318 x 8.636 mm).

For further size reduction of the transition, the printed patterns on the substrate is optimized. The top and the cross sectional views of the conventional and the proposed transitions are shown in Figs. 2 (a) and (b), respectively. The size of the aperture in the ground plane on the lower plane of the substrate is identical to the size of the waveguide for the conventional transition as shown in Fig. 2 (a). To reduce the spacing between the microstrip lines in the horizontal plane, a part of the ground plane on the lower plane of the substrate is extended into the waveguide for the proposed transition as shown in Fig. 2 (b). However, this causes a change of the resonant frequency. To adjust the resonant frequency to the design, the dimensions of the matching patch and the insertion length are optimized again.

3. Simulated Performance

The performances were simulated by electromagnetic analysis based on the finite element method. The variation of *S*-parameters changing the size *sa* of the aperture in the ground plane is shown Fig. 3. When the size *sa* is smaller, the resonant frequency shifts to lower. The conventional and the compact transition from a waveguide to four microstrip-line ports are shown in Fig. 4. In 25 GHz band, the bandwidth of reflection lower than −10dB of the conventional transition was 2.9 GHz, where the loss was 0.3 dB lower than −6dB for 4-port ideal power division. On the other hand, the bandwidth of reflection lower than −10 dB of the compact transition was 2.2 GHz, where the loss was 0.3 dB lower than −6 dB for 4-port power division, when the size *sa* was 2.9 mm. The electric field distribution in the substrate at 25 GHz is shown in Fig. 5. Strong electric field was observed at two gaps between the patch ends and the waveguide broad walls. They were excited by waveguide TE_{10} mode and coupled to four microstrip-lines.

4. Conclusion

The compact planar transition from a waveguide to four microstrip-line ports were designed and optimized for feeding circuit of center feeding microstrip antennas. For further size reduction of the transition, we reduced the size of aperture in the ground plane and optimized again. The proposed transition was 1.148 mm smaller than the conventional transition.

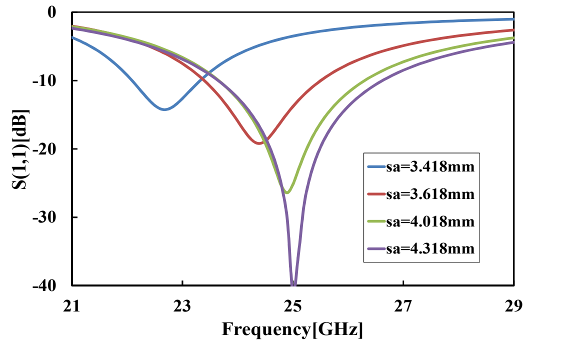


Fig. 3. Variation of reflection changing the size *ma* of aperture in the ground plane.

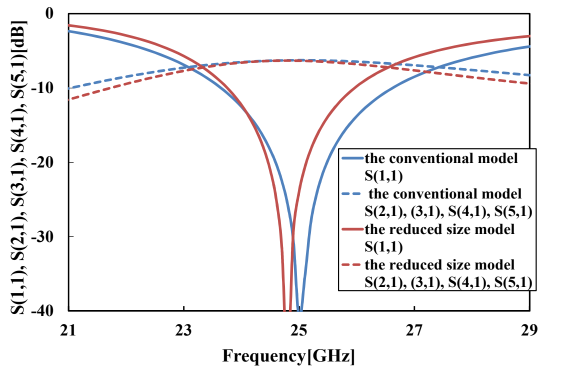


Fig. 4. Characteristics of the conventional and the reduced size of the optimized compact planar transition from a waveguide to four microstrip-line ports.

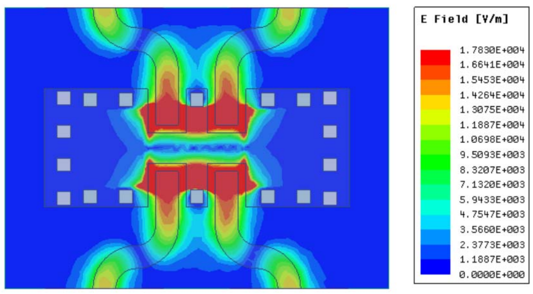


Fig. 5. Transmission characteristics and the effect of the size reduction to the radiation pattern.

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