Transitioning Between Microstrip and Inverted Microstrip

William C. Drach and Thomas E. Koscica

Abstract—**A broadband microstrip to inverted microstrip transition is described. Empirical results are presented. A few applications are discussed.**

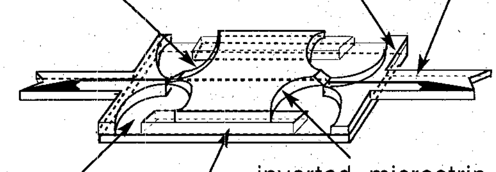
INVERTED microstrip lines incorporate an air gap between the ground plane and the top conductor. As a consequence, the effective dielectric constant is smaller than for an equivalent impedance microstrip line. The lower effective dielectric constant relaxes the mechanical tolerance of the structure as the physical size is allowed to be larger [1]. The presence of the air gap also reduces dielectric and conductor losses. These characteristics are especially important at millimeter wave frequencies and above. A good microstrip to inverted microstrip transition can permit these benefits in practical circuits. In this letter we present the design and performance characteristics of such a microstrip to inverted microstrip transition.

Empirical testing was conducted at Ka-band (26.5–40.0 GHz). The tests were performed using waveguide to microstrip transitions described in [2]. The substrates used in this work were 254 and 381 micron glass-reinforced teflon with a dielectric constant of 2.2. The characteristic impedance Z_o for the microstrip lines was calculated by using the methods in [3] and [4], and Z_o for the inverted microstrip lines was calculated using [5].

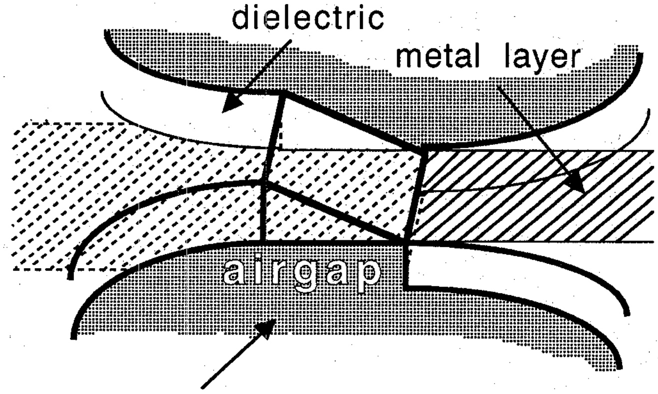
An abrupt transition cannot be introduced between microstrip and inverted microstrip since even for microstrip and inverted microstrip lines of the same impedance, the E-fields do not match in the transmission lines' cross section. The E-field must be redistributed from its geometry in microstrip to match that of inverted microstrip.

The present work addresses this field matching between microstrip and inverted microstrip by gradually removing the dielectric at the transition so that the E-field has a region over which to redistribute itself as it propagates from microstrip to inverted microstrip or vice versa. The method that yielded the least reflection (< -10 dB) and the most transmission (< 0.5-dB ripple) entailed removing the dielectric in a radial pattern as shown in Fig. 1(a). Note also that the inverted microstrip metal and dielectric is further trimmed as detailed in Fig. 1(b).

The empirical testing of this structure indicates the following: The thinner the dielectric substrate supporting the inverted microstrip line, the better the measured performance of the transition. Also, minimizing the attachment overlap of the inverted microstrip to microstrip transition reduces reflection greatly; this occurs since overlap acts as excessive lumped capacitance. Fig. 2 is a total loss verse frequency plot for a symmetric circuit consisting of dual waveguide to 254 micron microstrip transitions and dual transitions from microstrip to inverted microstrip with a 127 micron suspending medium above. Total circuit length is 107 mm with 51 mm of this being the inverted



(a)



(b)

Fig. 1. (a) Perspective view of test circuit. (b) Detail of inverted microstrip to microstrip transition.

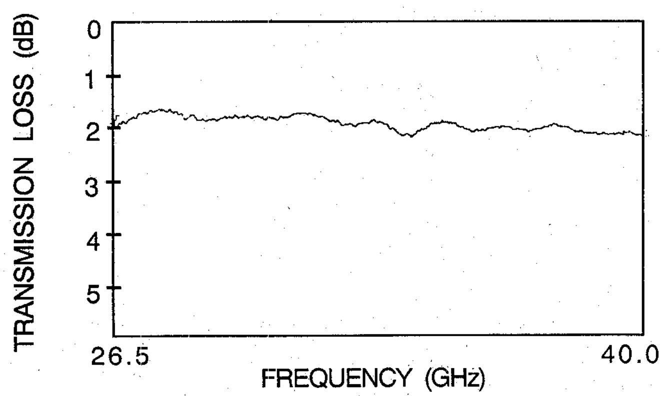


Fig. 2. Total loss verses frequency for circuit of Fig. 1.

Manuscript received October 5, 1990; revised November 21, 1990.
The authors are with the U.S. Army LABCOM/ETDL, SLCET-MP, Fort Monmouth, NJ 07703.
IEEE Log Number 9042243.

microstrip. A smooth radial transition of radius 50 mm caused the least amount of reflection. Total circuit loss was approximately 2 dB, the waveguide to microstrip transitions account for approximately 0.8 dB, the remaining loss of 1.2 dB is due to the microstrip to inverted microstrip transitions at 0.6 dB each. The return loss of each transition section was approximately −10 dB.

Note that this design is most applicable for low dielectric constant substrates. Applications range from low-loss, millimeter-wave transmission lines, which are useful in radar front ends, to the increased ease of using inverted microstrip passive structures; inverted microstrip passive structures are expected to have lower losses than similar structures in microstrip.

References

[1] T. Itoh, "Overview of quasi-planar transmission lines," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-37, pp. 275–280, Feb. 1989.

[2] T. E. Koscica, "Wide-band ground plane dc block and bias feed," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-38, pp. 805–806, June 1990.

[3] J. J. Lev, "Synthesize and analyze microstrip lines," *Microwave and RF*, pp. 111–116, Jan. 1985.

[4] M. Kirschning and R. H. Jansen, "Accurate model for effective dielectric constant of microstrip with validity up to millimeter-wave frequencies," *Electron. Lett.*, pp. 25–26, Feb. 1982.

[5] P. Pramanick and P. Bhartia, "Computer-aided design models for millimeter-wave finlines and suspended substrate microstrip lines," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-33, pp. 1429–1435, Dec. 1985.