time is spent in interfacing solutions with existing software. A listing of this subroutine in BASIC may be obtained from the author of this paper.

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A Coaxial to Microstrip Transition

E. H. ENGLAND

***Abstract*—A method of obtaining an improved transition, from 0.141-in (3.55-mm) semirigid coaxial to microstrip is described. Further improvements by means of compensation include two fixed types having a reflection coefficient less than 0.005 and an adjustable form capable of producing a "transparent" transition.**

A variety of commercial transitions (launchers) are available, normally in combination with a connector. When used in conjunction with 0.5-mm-thick substrates, these transitions typically have a reflection coefficient (Γ) of 0.03 or more, including the associated connector. Often this is not good enough for precision work.

The transition tab discontinuity was first described by Caulton *et al.* [1] as being capacitive; this is confirmed by time domain reflectometry (TDR) measurements. At 28-pS overall system rise time, TDR also reveals the capacitance to be small in value and discrete. Its effective position appears to be near the tip of the tab and is thought to be partly due to field concentration at any sharp corners on the tab. With this in mind, such corners were rounded off and the length and shape of the tab optimized, experimentally, to produce a minimum Γ.

The transition thus developed is shown in Fig. 1; it is formed directly on the semirigid coaxial thereby avoiding the discontinuity presented by a connector. The tab is shaped, using a needle file, in a simple jig. When used in conjunction with the jig shown in Fig. 2 to launch into 50-Ω microstrip on 0.5-mm sapphire (C axis perpendicular to plane of substrate), this tab gives $\Gamma < 0.01$.

Thought was given to reducing the remaining capacitive effect of the tab described still further. Inductive compensation would give a band-limited solution. Instead, the line capacitance was reduced at the appropriate position by means of a hole in the ground plane (GP) below the tab, as in Fig. 3, placed above a larger hole in the supporting baseplate.

Alternatively, a hole shaped as in Fig. 4 can be used with a solid baseplate if the GP thickness is increased to 40 μm. Either of these methods reduces Γ to less than 0.005.

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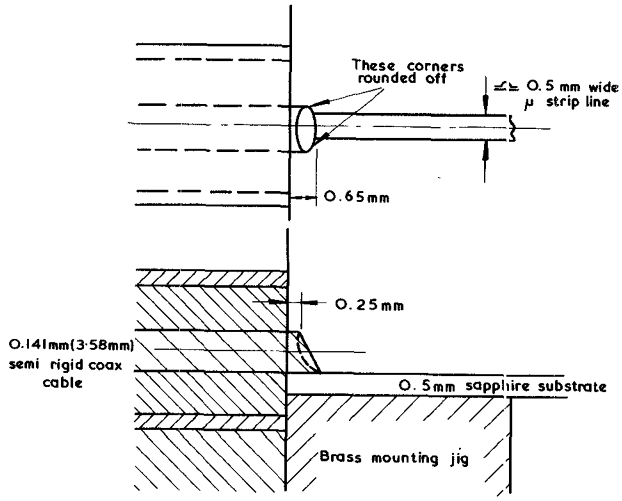

Fig. 1. Details of transition tab.

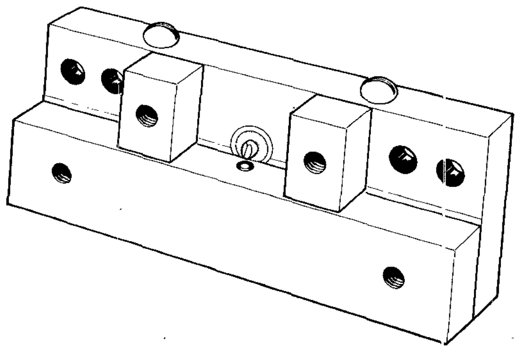

Fig. 2. Transition and substrate holding jig.

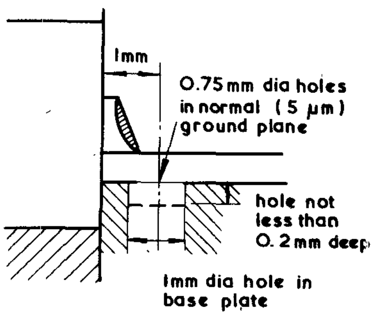

Fig. 3. Fixed compensation hole in normal ground plane.

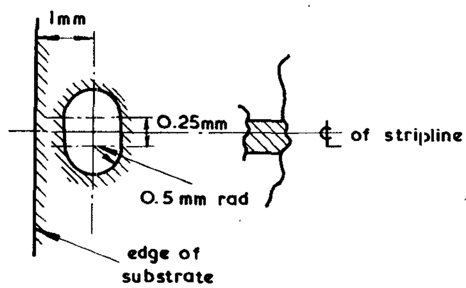

Fig. 4. Fixed compensation hole in thickened ground plane.

Adjustable compensation is achieved using the plunger arrangement of Fig. 5 in conjunction with the GP hole of Fig. 4 (normal GP thickness of 5 μm). With the plunger withdrawn approximately 100 μm away from the substrate, this hole overcompensates the transition. Adjustment of plunger-to-substrate distance X can produce a transition which is virtually transparent when examined by TDR. Measurements made on 25-mm-long 50-Ω microstrip lines on sapphire with properly compensated transitions at each end gave a total insertion loss rising from 0.1 dB at 1.0 GHz to 0.3 dB at 18 GHz. Fig. 6 shows a closeup view of the tab and plunger arrangement.

The launcher described is intended for precision laboratory measurement purposes. It is easily transferred between substrates and has proved very repeatable. Tab dimensions and the position of the GP hole are fairly critical along the line but symmetry about the line is not so important. There should be no air gap between the top of the substrate and the cable dielectric.

For the sapphire-substrate lines previously mentioned the optimum position of the plunger, dimension X in Fig. 5, is approximately 30 μm. Movement of the plunger 25 μm to either side of optimum produces reflections with $\Gamma \simeq 0.005$. The influence of the plunger ceases when X reaches 100 μm.

For use with alumina it has been found that for 0.514-mm-wide lines on 0.5-mm-thick substrates, a GP hole of 1.0-mm diameter is required, positioned over the plunger as in Fig. 5.

While the fully compensated transition is intended for a laboratory environment, it is suggested that the simpler version would be useful in production areas, particularly for automatic testing applications involving testing of individual circuit elements before integration into modules.

The fixed form of Fig. 3 is being used to examine circuits on substrates which have only the pattern on them. The GP used is a solid brass plate, suitably lapped, with 0.75-mm holes at various stations round the edge. Apparently the only penalty incurred in having a separate GP is a slight (10-percent) increase in losses above 10 GHz.

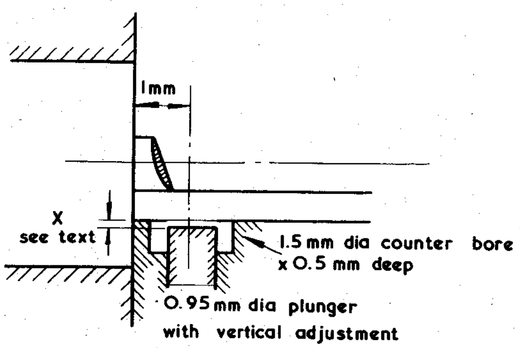

Fig. 5. Adjustable compensation plunger.

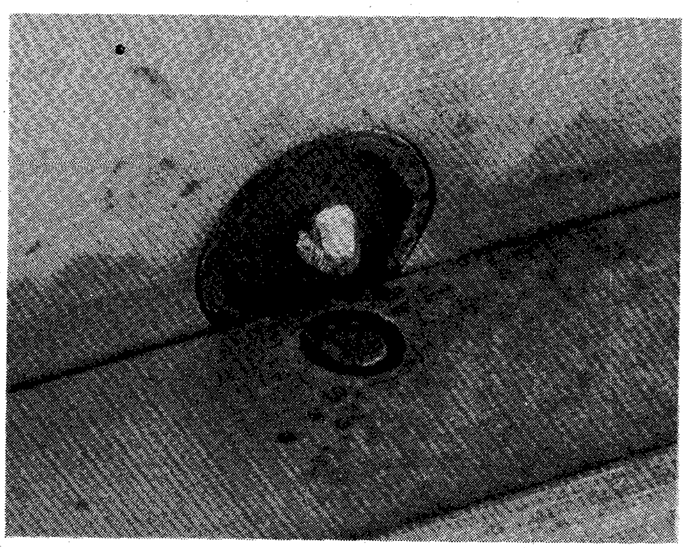

Fig. 6. Detailed view of tab and plunger.

ACKNOWLEDGMENT

The author wishes to thank M. H. N. Potok and other members of the group for useful discussions.

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On an Automatic System for Simultaneous Measurement of Amplitude and Phase of Millimeter-Wave Fields

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***Abstract*—Suggestions are given for improving the vibrating dipole technique for measuring the phase and amplitude of millimeter-wave electric fields in free space. It is shown that the system can be simplified, at the same time reducing certain measurement errors and increasing the system's sensitivity and dynamic range. It is found that significant errors can result if the field being measured varies appreciably in amplitude, and/or if the phase does not vary linearly with position over the dipole's excursions.**

I. INTRODUCTION

Mathews and Stachera recently described a technique for measuring the amplitude and phase of electric field components in free space using a vibrating elemental electric dipole [1]. In another paper appearing in the same issue [2], they describe one method of automating this system for simultaneous amplitude and phase measurements. The chief merit of the vibrating dipole technique over other methods of modulating a scatterer is that the dipole can be made of the order of 1 mm long, permitting measurements of the electric field's fine structure at millimeter wavelengths.

The purpose of this short paper is to suggest three changes in this measurement system which will simplify it, eliminate certain measurement errors, and significantly increase the system's sensitivity and dynamic range.

II. PHASE SHIFTER LOCATION

Fig. 1 shows the modified automated system which operates on the same basic principles as those originally proposed in [2]. One important change is that the phase shifter has been transposed from point S in the antenna arm into the reference signal channel. This change has two main benefits. The first is that the procedure for tuning the antenna is considerably simpler. A mismatch in the antenna arm causes an unmodulated carrier signal to arrive at the detector via the information channel in addition to the unmodulated carrier arriving via the reference channel. Since the mismatch signal also coherently interacts with the modulated signal to produce an

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