

curve *D* to curve *C* in Fig. 2(a) for small values of b/g and by its close approach to line *B* for higher values of g/h and b/g as demonstrated in Fig. 2(b).

Precise calculations of Z_0 in rectangular coax have been made by Skiles and Higgins.⁴ Interpretation of the corner capacitance from the three impedance configurations they calculated gives the points *A* (for $b/g=0$), *B* (for $b/g=1$), and *C* (for $b/g>1$) with their average and maximum and minimum limits. It is seen that Skiles's and Higgins's ranges are in close agreement with the curves. Because comparison of points on Fig. 1 is a more severe test than comparing characteristic impedances, it is concluded that the approximations can give fairly accurate characteristic impedances.

A simple empirical formula for Z_0 was developed by Omar and Miller.⁵ However when points from their formula are plotted as in Fig. 1, large unsystematic deviations occur. A section of line was built for a Z_0 of 50 ohms according to the Omar and Miller formula. The characteristic impedance was observed to be low at 1-4 Gc, and in fact is predicted to be 31 ohms using Fig. 1.

It is hoped that a computer programming of the Skiles's and Higgins's solution will allow a precise plot of Fig. 1 to solve the problem once and for all. A logical extension of the work is to make calculations for $w/h<1$, and to investigate eccentric lines.

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lossy material to give a small spacing from the strip. A sliding clip-on load using this arrangement with carbon-coated card is illustrated in Fig. 1, and a plot of its performance over a 40 per cent frequency band, given in Fig. 2, shows that an excellent match is obtained. In particular, this match is not dependent on accurate alignment of the load.

The mode of operation can be understood from the diagram of electric field distribution given in Fig. 3. This shows the way the transverse electric field diminishes with height above the strip, enabling the lossy material to be introduced initially in a region of low field with little discontinuity.

Fig. 4(a) and (b) show curves of measurements made using an iron-dust loaded

resin as the lossy material (particularly suitable in giving stable contact to the strip for calibrated attenuators). The leading edge of the block is bevelled where it makes contact with the strip. The small diagram in Fig. 4 shows a cross section of the block perpendicular to the plane of the microstrip and parallel to the strip conductor. The block is considerably wider than the strip conductor but, unlike the load of Fig. 1, is not tapered in the transverse direction. The curves illustrate the effect on VSWR of varying the bevel angle θ and the bevel length L . There is an optimum value for both angle and length, the latter corresponding approximately to a quarter wavelength.

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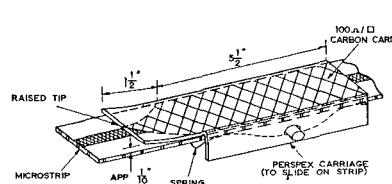


Fig. 1—Microstrip load with raised tip.

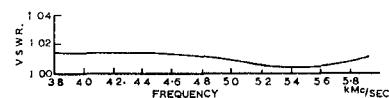


Fig. 2—Plot of VSWR of microstrip load against frequency.

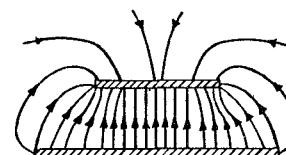
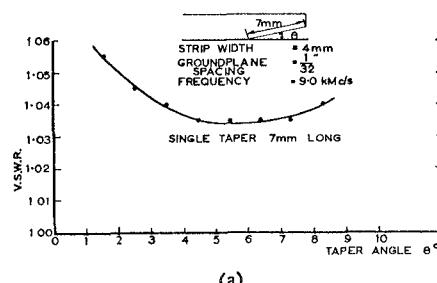
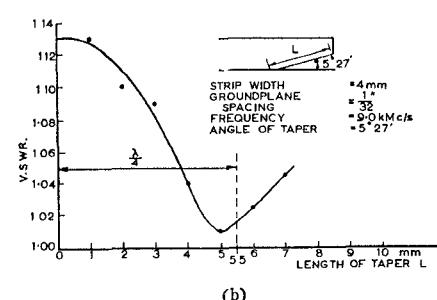


Fig. 3—Electric field distribution for microstrip (without dielectric).



(a)



(b)

Fig. 4—Effect of angle and length on match of taper in lossy material. (a) Plot of VSWR vs taper angle. (b) Plot of VSWR vs length of taper.

An Easy Method of Matching Microstrip Loads and Attenuators*

This note describes a novel method of matching microstrip loads which gives good performance without critical adjustment and is particularly useful when the lossy material has to be chosen for mechanical reasons rather than optimum characteristic impedance. In the present instance, the method was applied to the design of clip-on sliding loads for measurement purposes and to highly stable calibrated attenuators in which a block of iron-dust loaded resin was used as the lossy element.

Microstrip loads normally are made by laying lossy material on the surface of the supporting dielectric, as illustrated in Fig. 1, and obtaining absorption by interaction with the fringe field. Match can be controlled by the surface resistance of the lossy material and also by its shape, but the region of maximum absorption lies in a narrow area close to the strip, so that the latter adjustment is rather sensitive. It has been found that a match is achieved much more easily by raising the leading edge of the

* Received by the PGMTT, December 19, 1960.
Revised manuscript received, January 20, 1961.

An Empirical Design Method for Multisection Ridge-Guide Transducers of Large-Impedance Transformation*

The available analytical design procedures are inadequate for the design of broad-band ridge-guide transducers of large transformation ratio. Various authors¹⁻³ have discussed the problem of obtaining maximum bandwidth with multisection quarter-wave transformers, and recently Young⁴ has extended the treatment to include inhomogeneous transformers where frequency dispersion varies from section to section. There is, however, no exact theory for dealing with the discontinuity susceptances which appear in practice at the junctions between sections and become important when large transformations are being attempted. Further uncertainties arise when ridge guide is used, because there does not yet seem to be agreement on a means of calculating the characteristic impedance which is applicable over the whole range of ridge sizes.

Here we describe an empirical design approach suitable for correcting errors in the initial design of a multisection transducer, and also present a simple dimensional relationship which may enable the effect of discontinuity susceptance of ridge-guide steps to be minimized in the design stage.

The ridge-guide transducer which was developed by this method is illustrated in Fig. 1. It provides a 12.5 to 1 impedance

* Received by the PGMTT, December 19, 1960.
Revised manuscript received, January 20, 1961.

¹ R. E. Collin, "Theory and design of wide-band multisection quarter wave transformers," *PROC. IRE*, vol. 43, pp. 179-185; February, 1955.

² S. B. Cohn, "Optimum design of stepped transmission line transformers," *IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES*, vol. MTT-3, pp. 16-21; April, 1955.

³ M. J. Riblet, "General synthesis of quarter wave impedance transformers," *IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES*, vol. MTT-5, pp. 36-43; January, 1957.

⁴ L. Young, "Inhomogeneous quarter-wave-transformers of two sections," *IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES*, vol. MTT-8, pp. 645-649; November, 1960.