Example 3

A field cable of $Z_0=25$ ohms has a solid conductor with 40 per cent of the conductivity of copper, made of copper-covered nonmagnetic steel, diameter 25 mils.

Attenuation at 200 Mc (the outer metal is copper, which alone is to be considered at 10 Mc and higher frequency):

$$A = 2.2 \times \frac{8.4 \times 14.14}{25} \times 1.6$$

$$= 16.7 \text{ db}/100 \text{ ft.}$$

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Broad-band Coaxial-to-Stripline Transitions

Butt transitions between coaxial line and shielded stripline are simple and economical to manufacture. Levy[1] has pointed out that such transitions are not properly matched because the fringing field of the stripline is intercepted by the outer conductor of the coaxial line, and in addition the inner conductors of the two lines have different dimensions. His broad-band coaxial-to-stripline transition requires a tapered length of rectangular coaxial line and he deduced that the VSWR of this system is less than 1.02 up to 11 kMc.

This communication will show that a broad-band transition may be obtained using a compensated butt junction. The discontinuity capacity introduced by the butt is compensated for by displacing the junction of the inner conductors with respect to that of the outer conductors.

Transitions from 50-ohm coaxial line to two types of 50-ohm shielded stripline are described below.

Stripline with Brass Center Strip

This type of stripline [Fig. 1(a)] consists of a brass strip between two parallel flat brass plates. The dimensions are such that the characteristic impedance of the line is 50 ohms.

The compensated butt junction and its connection to a coaxial slotted line[2] are shown in Figs. 2 and 3.

The performance of the 50-ohm coaxial slotted line mated to a special N-type connector containing a standard polytetrafluotoethylene support bead [Fig. 3(c)] was first assessed. A VSWR plot from 3 to 12 kMc is shown in Fig. 4 and it can be seen that the maximum VSWR is 1.035.

The standard P.T.F.E. support bead was replaced by the compensated but junction (Figs. 2 and 3). Optimum performance was obtained when the inner conductor of the coaxial line projected into the stripline by 0.033 inches. A VSWR plot from 3 to 12 kMc is shown in Fig. 4 and the maximum VSWR is 1.035. It was found that the length of the compensating section could be varied by ± 0.002 inches without increasing the maximum VSWR.

From a comparison of the two VSWR plots shown in Fig. 4 it can be seen that the compensated butt junction has no greater effect on the maximum VSWR than one end of the standard P.T.F.E. support bead. If we assume that each end of the two compensated P.T.F.E. support beads (one being within the slotted line) contributes equally to the maximum VSWR then we may conclude that the maximum VSWR of the coaxial-to-stripline transition alone is probably better than 1.01.

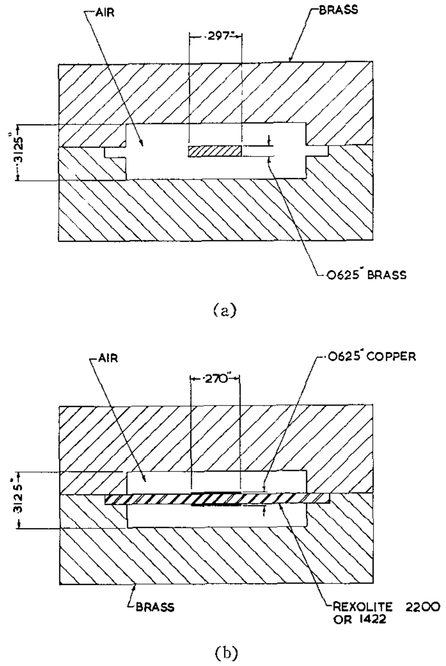

Fig. 1—Shielded stripline systems. (a) Solid brass strips. (b) Copper clad rexolite card.

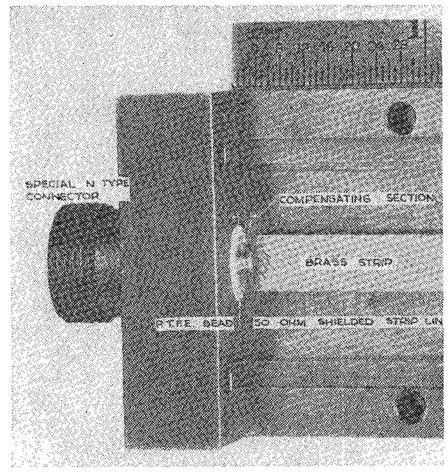

Fig. 2—Compensated coaxial-to-stripline butt transition.

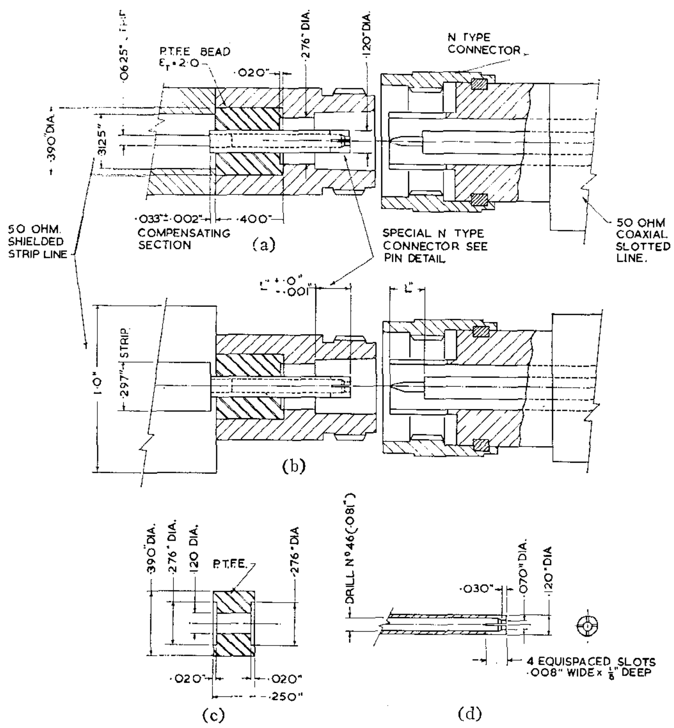

Fig. 3—Details of the compensated coaxial-to-shielded stripline butt transition mated to a coaxial slotted line. (a) Elevation. (b) Plan. (c) Standard 50-ohm air coaxial line support bead. (d) Pin detail.

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[1] R. Levy, "New coaxial-to-stripline transformers using rectangular lines," IRE Trans. on Microwave Theory and Techniques, vol. MTT-9, pp. 273–274; May, 1961.

[2] A Hewlett Packard Model 806B Coaxial Slotted Line was used for this investigation.

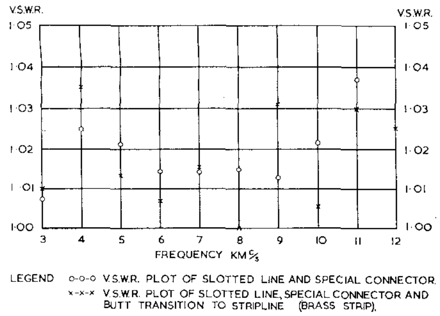

Fig. 4—VSWR plot from 3 to 12 kMc of the compensated butt coaxial-to-stripline transition.

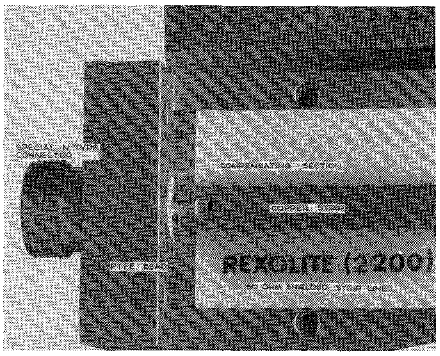

Fig. 5—Compensated coaxial-to-stripline butt transition.

With careful manufacture and use of the special N-type connector junction it has been found that results consistent with those given in Fig. 4 may be obtained to within 1.005 VSWR.

The compensated butt junction described above is easily made and lends itself particularly to interdigital stripline filters.[3]

Stripline with Copper Clad Rexolite Card

This type of stripline [Fig. 1(b)] consists of a copper clad rexolite card between two parallel flat brass plates. The copper is removed to leave two central strips slightly narrower than the solid brass strip discussed previously. The characteristic impedance of this line is also 50 ohms.

The compensated butt junction is shown in Fig. 5; details of the junction region appear in Fig. 6. The connection of this type of junction to the coaxial slotted line is similar to that for the first type of transition (Fig. 3).

Since the rexolite card is not as rigid as a solid brass strip it was necessary to slot the inner conductor of the coaxial line to receive the card. This was found to provide a rugged connection leading to repeatable experimental results. In the region of the overlap the capacity per unit length of line is increased and it was found necessary to remove the rexolite almost to the copper strip in compensation.

The optimum performance was obtained when the inner conductor of the coaxial line projected into the stripline by 0.013 in ±0.0015 inches. A VSWR plot from 4 to 11 kMc is shown in Fig. 7 and the maximum VSWR is 1.05. The VSWR plot of the coaxial slotted line and a standard P.T.F.E. support bead is reproduced in Fig. 7 for comparison.

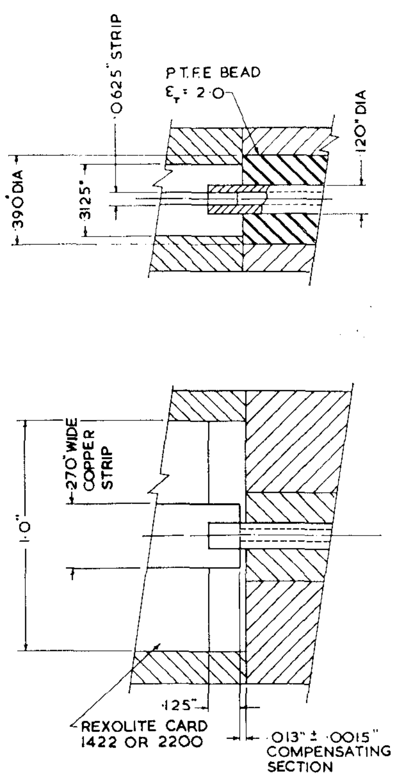

Fig. 6—The compensating section for the transition to rexolite supported stripline.

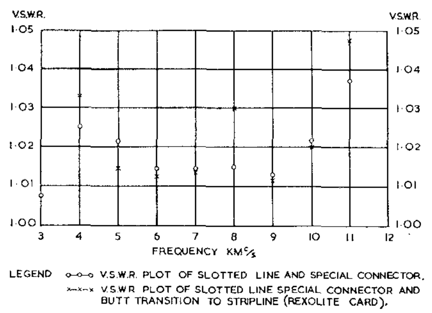

Fig. 7—VSWR plot from 4 to 11 kMc of the compensated butt coaxial-to-stripline transition.

Two types of rexolite were used, namely, Rexolite 1422 and Rexolite 2200. Samples of each from different batches were compared and the maximum VSWR deviation at any frequency was 1.015. Reasoning as for the first type of transition we may conclude from Fig. 7 that the maximum VSWR of the coaxial-to-stripline transition alone is probably better than 1.025.

This is another type of easily manufactured butt transition and would be useful for direct coupled resonator filters[4] using capacitive gaps in the copper strip.

[3] G. L. Matthaei, "Interdigital band-pass filters," IRE Trans. on Microwave Theory and Techniques, vol. MTT-10, pp. 479–491; November, 1962.

[4] S. B. Cohn, "Direct-coupled-resonator filters," Proc. IRE, vol. 45, pp. 187–196; February, 1957.

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Experimental Verification of the Phase Relationships in Parametric Amplifiers

The purpose of this communication is to present experimental evidence to show that the phase of the amplified signal in a three-frequency parametric amplifier is independent of the phase of the pump, while the phase of the idler varies directly with the phase of the pump.

The frequency relationship, $f_p = f_s + f_i$ [1] and the phase constant relationship for traveling-wave structures $\beta_p = \beta_s \pm \beta_i$ [2] are the well-known conservation of energy and momentum equations, respectively, which govern the behavior of parametric amplifiers.

However, after the discovery of the parametric amplifier [3], it was found that the degenerate parametric amplifier was unique in that there was an additional relationship required concerning the phase of the signal frequency to the phase of the pump frequency [4]–[7]. In this case maximum gain occurred when $\Theta_s = \Theta_p/2$, minimum gain occurred when $\Theta_s = \Theta_p/2 + \pi/2$, (where Θ_s, Θ_p are the signal and pump phases, respectively) and intermediate gains occurred at intermediate phases [8]. The nondegenerate parametric amplifier was found apparently to amplify signals independent of the pump phase.

Analyses by Heffner and Wade [9], by Tien [10], and by others have shown that the amplified signal output is independent of the pump phase, but that the idler current (output) is dependent on the pump phase. Thus, it has been stated that $\Theta_p = \Theta_s + \Theta_i$, where Θ_i is the phase of the idler current (or voltage). The following results confirm this prediction.

A parametric amplifier was used which could function both as a one-port reflection-type parametric amplifier and as a two-port frequency converter parametric amplifier. The amplifier used was originally developed by Bossard and Pettai [11]. When operated in the reflection mode, it gave the following results: signal band, 2000 to 3000 Mc; gain, 9.5 db; 3-db bandwidth, 830 Mc; noise figure, 1.8 db; pump frequency, 12,250 Mc [12].

In order to measure the phase of the amplifier signal with respect to the phase of

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