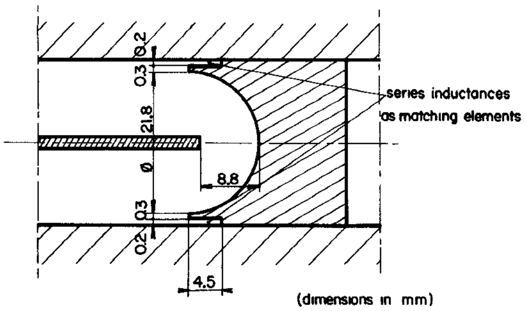

Fig. 2 Full band matched constant radius E bend.

obtained by matching the discontinuity by series inductances, formed by the short and narrow gaps between the plunger and the broad faces. The gap dimensions were optimized empirically (Fig. 2). As the residual reflection (though no more than one percent) was still too much for a periodic reflection, the idea was abandoned for the Reflectoscope. A straight piece of precision drawn waveguide, although about 3 m long, was, therefore, used. However, the design of the bend, as shown in Fig. 2, may be of interest for applications with less severe demands.

Of course, Kashyap's solution of a flat plunger is simpler, but far more critical and extremely narrow band; also, total reflection will occur somewhere in the waveguide band and this could have serious consequences. The simple modifications, described above, thus confer considerable benefits.

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Determination of Conductor Losses in Planar Waveguide Structures (A Comment to Some Published Results for Microstrips and Microslots)

REINHOLD PREGLA

***Abstract*—Waveguide conductor losses are mostly determined from the fields in the lossless case. In planar waveguide structures with sharp edges special care has to be taken, because then the fields can be quite different from those in the lossless case. This paper will explain why the calculated results are poor in some cases.**

The attenuation constant α of a wave in a waveguide is given by

$$\alpha = \frac{1}{2}\frac{P_d}{P} \tag{1}$$

where P is the power transmitted by the wave and P_d is the time average of the dissipated power per unit length. The result of this equation is exact if P_d and P are determined exactly. In practice, however, most difficulties arise in the determination of P_d,

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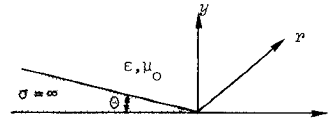

Fig. 1. A perfectly conducting wedge.

which, especially for conductor losses, cannot be carried out exactly. In many cases the part of P_d, that is due to conductor losses, can be approximated by

$$P_d = R_s \int_C |H_t|^2 \, dZ \tag{2}$$

where R_s is the surface resistance and $|H_t|$ is the amplitude of the magnetic field at the conductor surface (C) in the lossless case. Equation (2) gives accurate results only, if the fields in the lossy and the lossless cases are approximately the same. An important exception to this occurs at sharp points and corners extending outward from conductors [1]. The reason for this is, that for both cases the fields are too different. Therefore, it is not allowed to use (2) for the calculation of the losses of planar waveguides such as microstrips, microslots, etc. (which some authors do).

Some mathematical arguments will be given here. Because of the edge condition [2] for a perfectly conducting wedge (Fig. 1) the field $|H_t|$ increases for small values of r as

$$|H_t| \sim \frac{1}{\sqrt{r}} \tag{3}$$

for an infinitely thin plate ($\theta = 0$) and as

$$|H_t| \sim \frac{1}{\sqrt[3]{r}} \tag{4}$$

for a 90° wedge ($\theta = \pi/2$). In both cases the field has a singularity at the edge, but if the conductivity remains finite, the field decreases to a finite value. Thus the difference is considerable. A calculation of conductor losses on the strips in microstrips or microslots with the field for lossless and infinitely thin strips gives not only poor results, but is principally impossible: With a behavior according to (3) the integrand in (2) has a pole of first order and the integral does not exist. Therefore, it is clear that the calculations of conductor losses in [3] "are very sensitive to the order of solution." The solution cannot converge with increasing order; the results are useless.

The same principal error is found in the so-called "thin strip program" in [4]. In this program too, the calculated losses should increase indefinitely with increasing order of solution for the current distribution. Considered physically, it is clear that it is impossible to use the field of the infinitely thin conductors, because there must be a certain volume into which the field can penetrate in the lossy case.

If the fields of lossless conductors with finite thickness and rectangular cross sections are used for the calculation [4]–[7], the integral in (2) remains finite, because the field behavior at the corners is according to (4). However, the current density in the real case is not infinite, so this will lead to an error in the theoretical results, which is as yet unknown, because the real current distribution in the lossy case is not known. Especially for the odd mode of coupled microstrips [5]–[7] and for microslots, where the losses arise essentially from the adjacent edges, the error might be considerable. Therefore, it should be clear that the theoretical results for the attenuation constant should not be used uncritically.

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Correction to "Accurate Resonant Frequencies of Dielectric Resonators"

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After a study (ATP 2365 of the French CNRS) we have detected an error in Fig. 11 of the above paper.[1] In fact, it is necessary to replace the curves of this figure by those presented here.

This modification is necessitated because of the bad initialization of the computer program which gives a wrong result for resonant frequency of the TE_{11p} mode of the rectangular dielectric resonator.

However, this error has no effect on the validity of the method presented in the above paper.[1] To verify this we present in Table I, theoretical and experimental results obtained by using a rectangular resonator of permittivity $\varepsilon_r = 36$. There is a good agreement between measured (f_e) and calculated (f_t) resonant frequencies of magnetic dipolar (TE_{11p}) mode.

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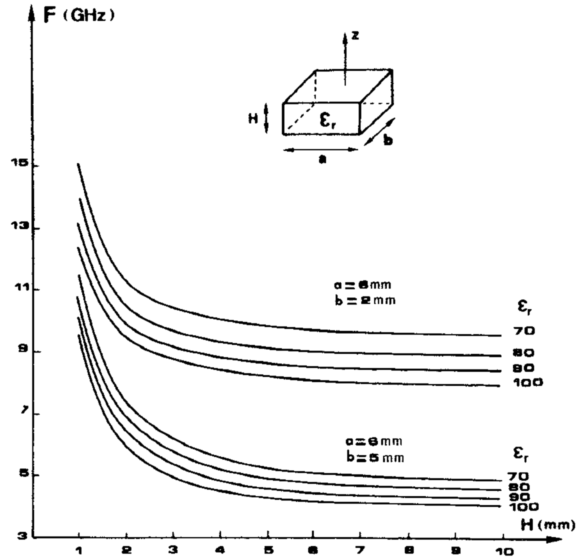

Fig. 1. Resonant frequencies of the TE_{11p} mode of a isolated rectangular resonator.

TABLE I
RESONANT FREQUENCY OF THE TE_{11p} MODE OF DIELECTRIC ($\varepsilon_r = 36$) RECTANGULAR RESONATOR OF CROSS SECTION ($a = 6$ mm, $b = 5$ mm)

H (mm)	7,96	6	4,1	2,2
f_t (MHz)	6866	7110	7770	9680
f_e (MHz)	6730	7010	7728	9460
accuracy : $\frac{f_t - f_e}{f_t}$ in percent	2	1,5	0,6	2

We can also note that such a disagreement does not exist with the circular shape, also investigated in the above paper[1] and for which the initialization of the computer program is good.

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