Letters

Attenuation and Phase-Shift Coefficients in Dielectric-Loaded Periodic Waveguides

B. MINAKOVIC AND S. GOKGOR

Abstract—**Attenuation in a waveguide, periodically loaded with dielectric disk, i.e., partially filled, can be considerably higher than when it is completely filled. For a relatively small dielectric loss, phase coefficients are negligibly affected.**

Attenuation and phase-shift calculations have been carried out for a number of modes propagating in a circular waveguide [1], [2], periodically loaded with dielectric disks (Fig. 1). The analysis includes both metal and dielectric losses.

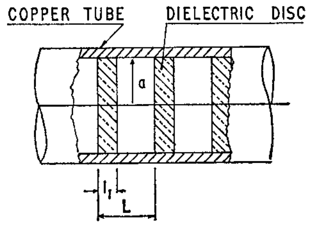

Fig. 1. Periodic waveguide loaded with dielectric disks.

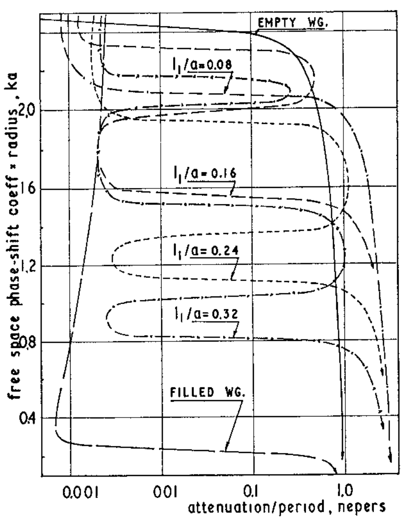

Fig. 2. Typical solution for attenuation coefficients: TM_{01} mode, $L/a = 0.4$, relative dielectric constant 95 (titanium dioxide); $\tan \delta = 5 \times 10^{-4}$; radius 5.33 mm.

The explicit expressions for attenuation and phase-shift coefficients were derived by setting up an appropriate complex wave matrix for each uniform region within one period, then cascading all matrices, and finally applying Floquet's theorem to account for periodicity. The expressions were computer tabulated for a range of parameters of practical interest, and one of the typical solutions is given in Fig. 2.

An interesting and somewhat unexpected feature of these results is that in a number of cases, attenuation is considerably higher when a waveguide is partially filled, i.e., disk loaded, than when it is completely filled. This is evident from Fig. 2, where for $l_1/a = 0.32$ and 0.24, attenuation is 0.0026 and 0.0030 Np/period, respectively, against 0.0012 and 0.0016 for a completely filled guide. Similar results were obtained for TE_{11} and TE_{01} modes, both in a circular waveguide.

Phase-shift coefficients are negligibly affected by loss, except in the vicinity of stopbands, and even then by only about 0.01 percent. This is a typical figure for relatively low-loss loading but, of course, it would increase for a very lossy material.

References

[1] B. Minakovic, "Studies in electron acceleration," Dep. Eng. Sci., Univ. of Oxford, Oxford, England, Rep. 1014, 1966.
[2] S. Gokgor, "A study of pulse compression structures," D. Phil. thesis, Dep. Elec. Sci., Univ. of Oxford, Oxford, England, 1971.

Manuscript received October 18, 1971.
B. Minakovic is with the Department of Engineering Science, Oxford University, Oxford, England.
S. Gokgor is with the Allen Clark Research Centre, Plessey Company Ltd., Towcester, England.

Comments on "Calculation of Capacitance Coefficients for a System of Irregular Finite Conductors on a Dielectric Sheet"

A. B. BIRTLES AND B. J. MAYO

Abstract—**An improvement in Patel's method using triangular conductor subsections is presented.**

Further to the analysis given in the above paper by Patel,[1] it may be of interest to note that work of a similar nature has been performed by the authors of the present letter using conductor subsections in the shape of triangles as well as rectangles.

In general, this involves a knowledge of integrals of the type

$$I = \int_{y_1}^{y_2} \int_{x_g(y)}^{x_h(y)} \frac{dxdy}{\sqrt{x^2 + y^2 + t^2}}$$

which, in the case when x_g and x_h are linear functions of y, describe in essence the electrostatic potential distribution due to a uniformly charged triangular sheet. Integrals of this type have been evaluated in closed form [1], and are given below.

By suitable orientation of the coordinate axes, the triangular subsection under consideration may be defined by the three points (x_1, y_1), (x_2, y_1), and (x_3, y_2). The result then is

$$I = t[F_6(a_2, b_2, u_2) - F_6(a_2, b_2, u_1) - F_6(a_1, b_1, u_2) + F_6(a_1, b_1, u_1)]$$

where

$u_1 = y_1/t;$
$u_2 = y_2/t;$
$a_1 = (x_1y_2 - x_3y_1)/(t(y_2 - y_1));$
$a_2 = (x_2y_2 - x_3y_1)/(t(y_2 - y_1));$
$b_1 = (x_3 - x_1)/(y_2 - y_1);$
$b_2 = (x_3 - x_2)/(y_2 - y_1);$
$F_6(a, b, u) = F_2 + aF_5 + (a + (b^2/a))F_{11};$
$F_2 = u \sinh^{-1} [(a + bu)/(1 + u^2)^{1/2}];$
$U = 1 + a^2 + 2abu + (1 + b^2)u^2;$
$F_5 = (1 + b^2)^{-1/2} \log [U^{1/2} + u(1 + b^2)^{1/2} + ab(1 + b^2)^{-1/2}];$
$q = (a^2 + b^2)/|a|;$
$\gamma = 1 + (b^2/a^2);$
$\alpha = \gamma + ((a^2 + b^2)^2/a^2);$
$T = [\alpha((bu + a)^2/(au - b)^2) + \gamma]^{1/2};$
$F_{11} = 1/q \tan^{-1} (T/q)$, for $q > 0$;
$= -1/T$, for $q = 0$.

In the case of a right-angled triangle ($x_3 = x_1$), the last two terms in the expression for I simplify to $-F_1(a_1, u_2) + F_1(a_1, u_1)$, where

$$F_1(a, u) = a \sinh^{-1}[u/(1 + a^2)^{1/2}] + u \sinh^{-1}[a/(1 + u^2)^{1/2}] + \tan^{-1}[(1 + a^2 + u^2)^{1/2}/au].$$

Manuscript received March 22, 1972. This work was supported under a CVD contract and is published by permission of the Ministry of Defence (Procurement Executive).
A. B. Birtles is with the Water Resources Board, Reading, Berks., England.
B. J. Mayo is with EMI Ltd., Hayes, Middlesex, England.
[1] P. D. Patel, *IEEE Trans. Microwave Theory Tech.*, vol. MTT-19, pp. 862–869, Nov. 1971.