Computer Program Descriptions

Computation of the Equivalent Circuit Parameters for a Junction between Empty and Side-Slab-Filled Rectangular Waveguides (REACTANS)

PURPOSE: To obtain the equivalent circuit parameters for a junction between empty and side-slab-filled rectangular waveguides [see Fig. 1(a)].[1]

LANGUAGE: Fortran IV, source deck length 443 cards (comment cards included).

AUTHORS: C. T. M. Chang was with the High Energy Facilities Division, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, Ill. 60439. He is currently with Texas Instruments, Incorporated, P. O. Box 5936, MS145 Dallas, Tex. 75222.

AVAILABILITY: ASIS/NAPS Document No. 02356.

DESCRIPTION: REACTANS is divided into three parts: 1) calculations of the complex values of propagation constants and characteristic wave impedances for the two waveguides; 2) calculation of the transmitting and reflecting fields for waves with a unit input from one or the other port of the waveguide junction; and 3) conversion of the results from part 2) into normalized parameters (impedances and admittance) of the equivalent circuit shown in Fig. 1(b).

These three parts correspond roughly to the developments given in Sections II, III, and IV of a recent paper [1]. All the input and output variables are listed in Table I.

In part 1) the separation constant γ_m is obtained from searching for zeros of a dispersion function by using Descartes' rules of signs. Since γ_m can be both real and purely imaginary, by defining $x = \alpha_m\tau$, $y = |\gamma_m|(l-\tau)$, $r = \tau/(l-\tau)$, and $K^2 = (\epsilon_r - 1)k_0^2\tau^2$, one can rewrite the dispersion relation [1, eq. 7] in the functional form of

$$\begin{aligned} D(x,y) &= ry\sin x\sin y - x\cos x\cos y, \qquad K^2 < x^2 \\ &= ry\sin x\sinh y + \cos x\cosh y, \qquad K^2 > x^2 \end{aligned} \tag{1}$$

to avoid searching for zeros in a complex plane. Also, the constraint [1, eq. 8] between x and y becomes

$$x = \left[K^2 \pm \frac{r^2y^2}{(l-\tau)^2}\right]^{1/2} \tag{2}$$

where the upper and lower signs apply to $x^2 > K^2$ and $x^2 < K^2$, respectively.

To obtain the transmitting fields a_m', a complex matrix inversion subroutine CROUTC [2] is called. This subroutine uses the Crout method and is supplied by B. S. Garbor of the Argonne National Laboratory. It is included in the program listing. The program is written for double-precision computation, which is essential if some accuracy is required when IBM360 computers are used. Typical running time is less than 1 min for ten sets of input with $N = 20$. The total core storage is less than 220K, if IBM 360 Fortran IVH compiler is employed.

Accuracy:

1) The accuracies of the waveguide parameters (γ_m, α_m, h_m, z_m, etc.) are determined by that of y, which is set to be $10^{-12}\Delta$. (Δ can be set in accordance with the accuracy required. It is set to be 0.025π in the listing.)

2) The accuracies of x_1, x_2, and b_m depend on the terms used in the approximation. These accuracies can be estimated by comparing the approximation. These accuracies can be estimated by comparing the corresponding values obtained from the N- and $N+1$-term approximations. Typical values of these obtained from 20- and 21-term approximation agree to better than 10^{-5}.

Limitations:

1) Since the two-port equivalent circuit is based on the fact that only the dominant TE_{01} mode propagates in each waveguide, it is not valid for cases in which higher order modes may also propagate. The propagation TE_{03} modes causes an error of division by zero.

2) The dimension of the present program is written to allow $1 < N \leq 50$.

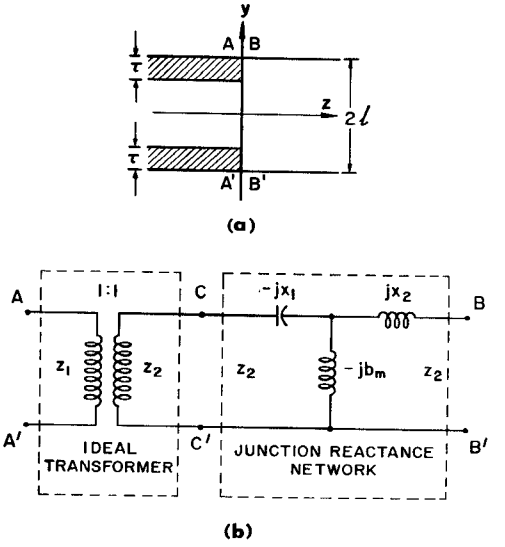

Fig. 1.

TABLE I
THE INPUT[a] AND OUTPUT VARIABLES

Variables	Fortran Name	Description
ℓ	EL	Half of the long dimension of the metal waveguide in meters.
τ	TAU	Thickness of the dielectric slabs in meters.
ϵ_r	EPSR	Relative dielectric constant of the slab material.
f	F	Operating frequency in GHz.
N	JMAX	Number indicating the number of terms included in the finite-term approximation.
h_1, h_1'	H1, H2	Propagation constants for TE_{01} modes in the loaded and unloaded waveguides (L and UW.G.), respectively.
d_L, d_L'	DL1, DL2	Decay lengths of TE_{03} modes in L and UW.G., respectively.
z_1, z_2	Z1, Z2	Normalized characteristic wave impedance in L and UW.G., respectively.
x_1, x_2	X1, X2	Normalized series impedances of the junction-reactance network (JRN).
b_m	BM	Normalized shunt admittance of JRN.

[a] The first five in this table are the input variables.

Limitations:

1) Since the two-port equivalent circuit is based on the fact that only the dominant TE_{01} mode propagates in each waveguide, it is not valid for cases in which higher order modes may also propagate. The propagation TE_{03} modes causes an error of division by zero.

2) The dimension of the present program is written to allow $1 < N \leq 50$.

Manuscript received July 11, 1973; revised September 17, 1973. This work was supported by the U. S. Army Electronics Command.

See NAPS Document No. 02356 for 9 pages of supplementary material. Order from ASIS/NAPS, c/o Microfiche Publications, 305 E. 46th St., New York, N. Y. 10017. Remit in advance for each NAPS accession number $1.50 for microfiche or $5.30 for photocopies. Make checks payable to Microfiche Publications.

[1] Similar programs REACTANT, REACTANP, REACTANA, REACTANB, and REACTAND for calculations of equivalent circuit parameters, of junctions given in [1, Fig. 1(b)–(f)], respectively, can be obtained from the author.

REFERENCES

[1] C. T. M. Chang, "Equivalent circuit for partially dielectric-filled rectangular-waveguide junctions," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-21, pp. 403–411, June 1973.

[2] Subroutine CROUTC, System/360 Library Subroutine ANL F455 S, Appl. Math. Div., Argonne Nat. Lab., Argonne, Ill.