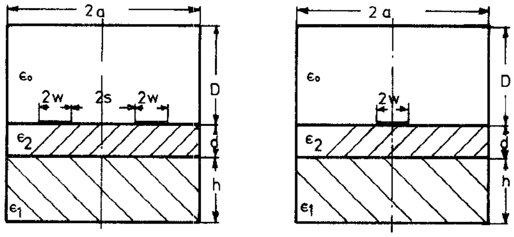

Fig. 1.

LANGUAGE: Fortran IV, IBM 360, ZERO1—343 Cards ZERO2—755 Cards HIGH1—471 Cards, and HIGH2—894 Cards.

AUTHORS: D. Mirshekar-Syahkal and J. Brian Davies, Department of Electronic and Electrical Engineering, University College Torrington Place, London WCIE 7JE, England.

AVAILABILITY: Listings and magnetic tapes of the source program can be obtained from J. B. Davies for the next two years.

DESCRIPTION: These four computer programs are classified into two groups which are complementary to each other. The method of computation is based on the spectral-domain approach [1]–[3]. ZERO1 and ZERO2 are the zeroth-order solutions which can be used in most practical cases. HIGH1 and HIGH2 calculate all the above-mentioned parameters more accurately, since higher order solutions are now considered. Computation time for the ZERO1 and ZERO2 is very much less than for the HIGH1 and HIGH2, ranging from 1 to 6 s on an IBM 360/65. The problems being solved can be seen by considering Fig. 1. Fig. 1(a) shows a typical shielded microstrip on the two layers of substrate, and the same situation is seen in Fig. 1(b) for the coupled microstrip. Removing the first substrate (by putting $h=0$) gives a conventional form of the shielded or coupled microstrip, while letting $h\neq 0$ and $\epsilon_1 \neq \epsilon_0$ gives shielded suspended-substrate versions of microstrip or coupled microstrip. Program ZERO1 (or HIGH1 for higher accuracy) computes both effective dielectric and propagation constants of the line of interest. The method of the spectral domain gives a hybrid-mode solution to these structures, and hence the dispersive nature of them is properly dealt with [1], [3]. ZERO2 (and similarly, HIGH2) computes characteristic impedance, conductor and dielectric losses where, for the last one a perturbation formula is employed that assumes a low-loss substrate. Again, all the parameters are frequency dependent. By suitable choice of dimensions, an open version of the same structure can be examined effectively. All the other information is documented via the comment cards in the computer programs.

References

[1] J. B. Davies and D. Mirshekar-Syahkal, "Spectral domain solution of arbitrary coplanar transmission line with multilayer substrate," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-25, pp. 143–146, Feb. 1977.

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Computer Analysis of Microwave and Millimeter-Wave Mixers

PURPOSE: The program analyzes the performance of single-diode microwave and millimeter-wave mixers. A Schottky-barrier diode is assumed, whose $I-V$ and CV characteristics are known. The diode mount is taken to be lossless, but may have external loads at any number of sideband and local oscillator (LO) harmonic frequencies.

LANGUAGE: FORTRAN IV H (IBM).

AUTHORS: P. H. Siegel is with the Graduate Department of Electrical Engineering, Columbia University, New York, NY 10019, and A. R. Kerr is with the Goddard Institute for Space Studies, NASA Goddard Space Flight Center, New York, NY 10025.

AVAILABILITY: Complete description of the program, including a listing and sample run, is also contained in NASA Technical Memorandum No. 80324 [1]. Card decks can be obtained from the authors at Goddard Institute for Space Studies, NASA Goddard Space Flight Center, New York, NY 10025.

DESCRIPTION: Following recent work on the theory of microwave and millimeter-wave mixers [2], [3] a user oriented mixer analysis program has been written which computes the conversion loss and noise temperature of a mixer, given the diode characteristics and embedding circuit impedances. The program first performs a nonlinear circuit analysis to determine the diode conductance and capacitance waveforms produced by the local oscillator. A small-signal linear analysis is then used to find the input and output impedances and the conversion loss between the mixer ports. Finally, the thermal and shot noise contributions from the diode are determined.

The most difficult step in analyzing a mixer is finding the diode conductance and capacitance waveforms produced by the LO. The technique used in the program is an extension of one developed previously in our laboratory [4], in which the nonlinear problem is solved by considering a series of reflections between the diode and the embedding network. The algorithm operates in the time domain when considering the diode and in the frequency domain when dealing with the embedding network.

The small-signal analysis follows the method of Held and Kerr [2], which is an extension of the original theory of frequency conversion put forward by Torrey and Whitmer [5]. The small-signal properties of the mixer are derived from a knowledge of the diode conductance and capacitance waveforms and the impedance of the embedding network.

The theory of noise in Schottky diode mixers was investigated and put into a form suitable for computer analysis by Held and Kerr [2]. It is based on the earlier work of Uhlir [6] and Dragone [7]. The shot noise of a periodically pumped diode has partially correlated components at the various sideband frequencies. The

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Further information concerning this program can be obtained from the author.

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program takes these components into account as well as the thermal noise from the series resistance of the diode. (The effects of lattice-scattering noise and pump heating may be approximated by a small increase in the physical temperature of the diode series resistance.)

The mixer analysis program allows arbitrary embedding impedances at the harmonics of the local oscillator and the sideband frequencies, and any Schottky diode can be used. The diode series resistance can include a frequency-dependent term due to the skin effect. The program cannot handle diodes with voltage dependent series resistance or in which charge-storage effects are significant, i.e., it is assumed that the carrier-recombination time is small compared to the period of the local oscillator.

In order to run the program the user must supply the embedding impedance seen by the diode at each harmonic of the LO and at the harmonic sidebands, the characteristics of the diode, including the CV dependence, and the operating conditions of the mixer, i.e., the bias voltage applied to the diode, rectified dc current, LO, and intermediate frequencies.

The output of the program includes the large signal current, voltage, conductance, and capacitance waveforms at the diode, the Fourier coefficients of the diode conductance and capacitance, the conversion loss between each pair of sideband frequencies, the IF output impedance, the input impedance at each sideband, and the equivalent single-sideband input noise temperature.

User flexibility has been stressed, and adequate documentation is included in the listing of the program to enable modifications to be made.

The program has been used to investigate the effects of the series inductance and diode capacitance on the performance of some simple mixer circuits with Schottky and Mott diodes [1].

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[1] P. H. Siegel and A. R. Kerr, "A user oriented computer program for the analysis of microwave mixers, and a study of the effects of the series inductance and diode capacitance on the performance of some simple mixer," NASA Goddard Space Flight Ctr., Greenbelt, MD, NASA Tech. Memo. no. 80324, July 1979.
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[7] C. Dragone, "Analysis of thermal and shot noise in pumped resistive diodes," *Bell Syst. Tech. J.*, vol. 47, pp. 1883–1902, 1968.

Mathieu Functions of Integral Orders and Real Arguments

PURPOSE: To compute Mathieu functions, modified Mathieu functions and related parameters for integral orders and real arguments, encountered in wave propagation involving elliptic geometries.

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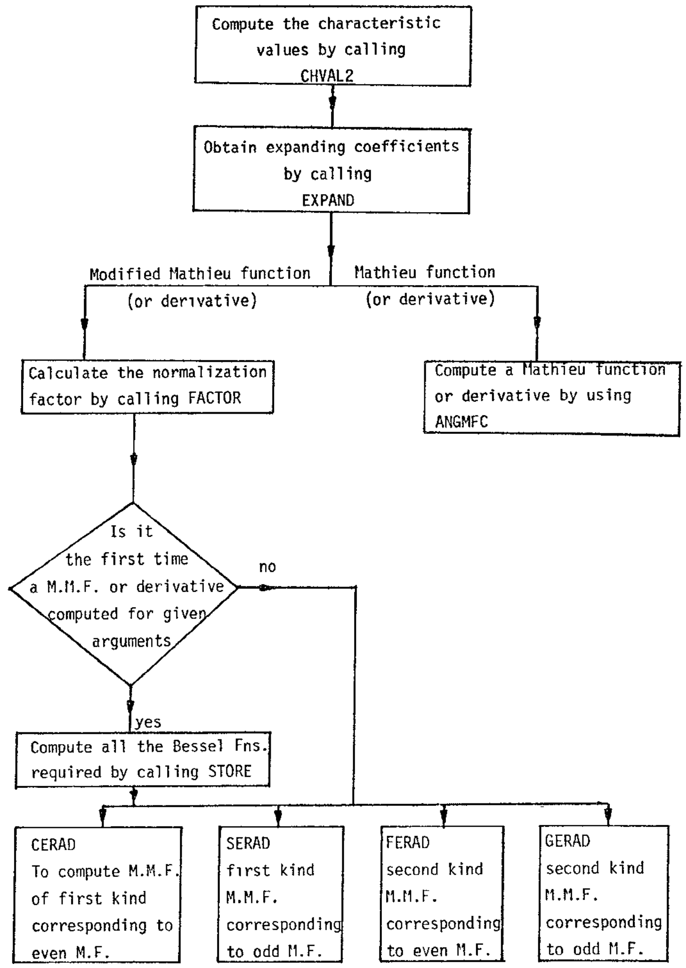

Fig. 1.

LANGUAGE: FORTRAN IV (IBM).

AUTHORS: S. R. Rengarajan and J. E. Lewis are with the Department of Electrical Engineering, University of New Brunswick, Fredericton, NB, Canada E3B 5A3.

AVAILABILITY: ASIS/NAPS document No. NAPS 03572.

DESCRIPTION: Mathieu functions are encountered in the solution of the wave equation in elliptical coordinates. Existing algorithms to compute Mathieu functions [1] are valid only for positive values of the parameter q. However, in problems of slow-wave propagation in waveguides of elliptical cross section, they also are required for negative q [2]. The subroutines in this package compute the Mathieu and modified Mathieu functions and related parameters for all real q. The normalization of the modified Mathieu function employed in this work is the same as that commonly used in the microwave literature and is different from that contained in a previously published program for positive q [1]. In this work Bessel functions, required in the series for modified Mathieu functions, are computed in a separate subroutine and hence the computation of modified Mathieu functions of the same argument but different orders is more efficient than that in [1]. The theory and notations employed are the same as those employed by McLachlan [3].

This computer program consists of nine user-called subprograms and a main program to illustrate their use. Three previ-

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