DTEAS: A program from the IBM Scientific Subroutine Package for finding the limit of a sequence by the method of nonlinear transformations.

The subroutines MAHON, BESASM, and HAHN are transcribed from Somlo [2].

Performance

Values computed for the limiting case of a step on one conductor only have been compared with Somlo's published values. The agreement was found to be within about 0.05 percent. For the same limiting case, the values computed by DSCAP1 and DSCAP2 are in agreement within 0.01 percent.

The programs have been run on an IBM 360/67 computer. The time required to compute one value is about 1 min; values for additional frequencies with the same dimensions take about $\frac{1}{2}$ min per frequency.

Storage requirements are 60 000 bytes for DSCAP1 and 80 000 bytes for DSCAP2.

Acknowledgment

The author wishes to thank P. I. Somlo for a copy of the listing of his program.

References

[1] J. R. Whinnery, H. W. Jamieson, and T. E. Robbins, "Coaxial-line discontinuities," *Proc. IRE*, vol. 32, pp. 695–709, Nov. 1944.
[2] P. I. Somlo, "The computation of coaxial line step capacitances," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-15, pp. 48–53, Jan. 1967.

DISFIL, A Computer Program for the Optimum Synthesis of TEM Transmission-Line Filters

PURPOSE: DISFIL uses exact network synthesis techniques to produce the final cascade of unit elements and *LC*-type resonators, for all common kinds of optimum high- or lowpass Butterworth or Chebyshev filters, terminated either at a single side or at both sides in a finite nonzero resistor.

LANGUAGE: Fortran IV; length of card deck 2400 cards.

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AVAILABILITY: ASIS–NAPS Document No. NAPS-01880.

MACHINE REQUIREMENTS: One card reader for input, one line printer for output, or one time-sharing terminal for both. 124 K of memory is required, but using built-in overlay structure, a partition as small as 40 K is sufficient.

DESCRIPTION: DISFIL has been written in order to bring the design of distributed quarter-wave filter structures, based on exact network techniques, into easy reach. For any common kind of commensurate filter two-port, it computes the cascade of shunt- or series-type resonators and the interconnecting transmission lines. The computational method used closely follows the normal synthesis procedure, and needs as input data the ordinary specifications necessary for filter design. The essential steps to be taken are as follows.

1) Determine the equivalent circuit of the physical structure: bandpass or bandstop type, the number m of series- or shunt-type resonators, and the number n of unit elements.

2) Determine whether the circuit is terminated at both sides in a finite nonzero resistor, which is the common situation for filters, or whether there is only one termination, a case that often arises in diplexers where bandpass and bandstop structures are connected in series or parallel.

3) Specify the central frequency f_0 (GHz) and the relative bandwidth w (percent) of the filter.

4) Specify the desired response type, Butterworth or Chebyshev. In the latter case also specify the maximum ripple (dB) allowable over the passband.

The procedure to compute the filter elements is then based on the following definitions.

1) Richards' variable S is defined as

$$S = j\Omega = j \tan \frac{\pi}{2} \frac{f}{f_0}. \tag{1}$$

2) The cutoff point on the Richards-plane imaginary axis is then

$$\Omega_c = \tan \frac{\pi}{2} \left(1 - \frac{w}{200}\right). \tag{2}$$

3) The approximation functions to be used are

$$|Z_{21}(j\Omega)|^2 = \frac{1}{1 + F^2(\Omega)}. \tag{3}$$

For optimum Butterworth filters, we have the following.

a) Bandpass case:

$$F(\Omega) = \left(\frac{\Omega_c}{\Omega}\right)^m \sqrt{\left(\frac{1 + \Omega_c^2}{1 + \Omega^2}\right)^n}. \tag{4}$$

b) Bandstop case:

$$F(\Omega) = \left(\frac{\Omega}{\Omega_c}\right)^m \left(\frac{\Omega}{\Omega_c}\sqrt{\frac{1 + \Omega_c^2}{1 + \Omega^2}}\right)^n. \tag{5}$$

For optimum Chebyshev filters, we have the following (ϵ is the ripple factor).

a) Bandpass case:

$$F(\Omega) = \epsilon \cos \left[m \cos^{-1} \frac{\Omega_c}{\Omega} + n \cos^{-1} \sqrt{\frac{1+\Omega_c^2}{1 + \Omega^2}}\right]. \tag{6}$$

b) Bandstop case:

$$F(\Omega) = \epsilon \cos \left[m \cos^{-1} \frac{\Omega}{\Omega_c} + n \cos^{-1} \frac{\Omega}{\Omega_c}\sqrt{\frac{1+\Omega_c^2}{1 + \Omega^2}}\right]. \tag{7}$$

Expressions (3) to (7), introduced by Horton and Wenzel [1], are called optimum approximation functions, because they treat the unit element as a basic selective element of the cascade.

4) One of the expressions (4) to (7) is used to generate the positive real input impedance of the terminated filter. If the filter has double terminations, (3) is interpreted as the power transfer of the filter, normalized to the available power of the generator:

$$|S_{12}(j\Omega)|^2 = |Z_{12}(j\Omega)|^2. \tag{8}$$

The input impedance is constructed from

$$Z(S) = \frac{1 \pm S_{11}(S)}{1 \mp S_{11}(S)} \tag{9}$$

where

$$S_{11}(S)S_{11}(-S) = 1 - |S_{12}(j\Omega)|^2\big|_{\Omega^2=-S^2}. \tag{10}$$

The plus or minus sign in (9) is chosen in accordance with the singularity type of the equivalent circuit in the stopband.

If there is only one terminating resistance, the approximation function (3) is treated as the real part of the input impedance or admittance of the terminated filter.

5) The input impedance is broken down into its elementary parts by use of a Darlington synthesis technique. The sequence is quite arbitrary, but is conveniently chosen to be the topology of the equivalent circuit.

Using DISFIL, this procedure is reduced to the specification of a valid combination of design parameters. The generation and manipulation of polynomials, finally resulting in the element values of the filter cascade, has been implemented for all valid sets of specification data. Needless to say that the special cases $n = 0$ (classical prototypes) and $m = 0$ (quarter-wave impedance transformers and lowpass filters)

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For program listing, order NAPS-01880 from ASIS National Auxilliary Publications Service, c/o CCM Information Corporation, 909 Third Avenue, New York, N. Y. 10022; remitting $4.00 per microfiche or $13.80 per photocopy.

are also implemented. As a program option, it is also possible to compute the number of resonators of each type (between specified limits) in order to fulfill an attenuation requirement. However, the total number of filter elements is always limited to 20. This is mainly due to the accumulation of roundoff errors inherent with most network synthesis techniques. Running time is very short, but fairly unpredictable due to the root-finding process. A normal case with 7 or 9 elements will take about 4 or 5 s on an IBM 360/65.

The produced output is readily used for practical design purposes; an attenuation versus frequency plot is optional, and the results are the normalized characteristic immittances of the transmission lines. In many cases the only step left is the computation of line dimensions, while for other cases (e.g., interdigital filters) the results are directly usable for capacitance matrix transformations or Kuroda-type element interchanges.

References

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