COMPUTER-AIDED DESIGN OF A WAVEGUIDE MULTIPLEXER

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Abstract

A procedure based on an analysis algorithm and interactive program is described for the design of waveguide multiplexers. Simple rules, which enable the designer to quickly find a near-optimum design in a small number of iteration steps, are given. An example of a 6-channel communications multiplexer, which utilizes narrow-bandpass elliptic function waveguide filters, is also included.

Introduction

Figure 1 shows the multiplexer and its equivalent circuit. When separately and individually connected to matched loads and driven by matched sources, all filters have the same low-pass normalized characteristics. This enables individual filter tuning prior to multiplexer assembly, thus considerably reducing the effort involved in practical alignment of the multiplexer. Hence, the design procedure consists of optimum determination of filter spacing.

Analysis

An efficient and easily programmable analysis algorithm for the circuit is derived. The 2-port Y parameters of all of the filters can be derived from four normalized polynomials.[1] Starting at the short-circuit end, the algorithm successively computes the insertion loss ratios and the reflection coefficients of every filter at any given frequency.

Design Procedure

The design procedure can be summarized as follows:

1. Individual filters are synthesized to meet the required selectivity and in-band flatness by using the methods described in References 1 and 2.

2. Initial spacings are chosen according to the rule

$$\ell_o = 0; \ \ell_k - \ell_{k-1} = \frac{\lambda gk}{2}; \ k = 1, 2, \ldots, N$$

3. Return losses at the filter's center frequencies are computed. The spacing of the filter having the worst return loss is changed according to the following rule: The filter is moved closer to the short circuit if better return loss occurs at a frequency lower than mid-band frequency, and vice versa.

4. Step 3 is repeated until all return losses meet the specifications.

5. Fine tuning for flatness is accomplished by varying the first coupling in each filter in small increments. This does not deteriorate the return losses of the other filters.

Example

Convergence of the design procedure presented here proved to be remarkably fast; for all spacings, only two iteration cycles were needed to obtain return losses better than 20 dB at the band centers. Table 1 gives initial and final positions and return losses. Figure 2 shows the overall return loss and insertion loss of the multiplexer.

Conclusion

A simple procedure for computer-aided design of waveguide multiplexers has been presented. An efficient, easily programmable analysis algorithm and a few rules have been used in an interactive program to arrive quickly at the desired design. Filters used can be synthesized and tuned separately and individually, which greatly facilitates practical alignment of the complete multiplexer.

References

1. A. E. Atia and A. E. Williams, "Narrow-Band Waveguide Filters," IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-20, April 1972, pp. 258–265.

2. J. K. Skwirzynski, Design Theory and Data for Electrical Filters, New Jersey: D. Van Nostrand and Co., Ltd., 1965.

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Table 1. Initial and Final Positions and Return Losses of Waveguide Filters

Filter No., k	Center Frequency, f_{ok} (GHz)	Spacing, ℓ_k (in.)		Return Loss at f_{ok} (dB)	
		Initial	After 2 Cycles	Initial	After 2 Cycles
1	3.720	2.203	1.830	11.78	24.87
2	3.800	4.319	4.090	13.91	22.29
3	3.880	6.353	6.145	13.06	35.78
4	3.960	8.314	8.145	9.51	32.56
5	4.040	10.213	10.045	3.94	22.43
6	4.120	12.051	12.900	0.20	22.93

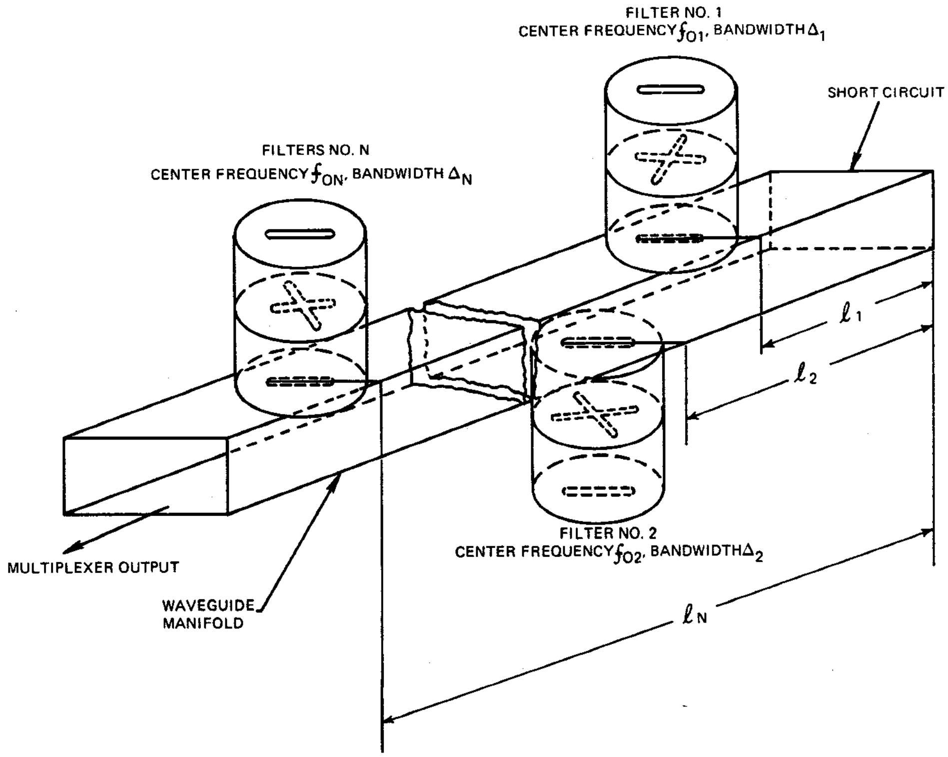

FIG. 1a. WAVEGUIDE MANIFOLD TYPE MULTIPLEXER

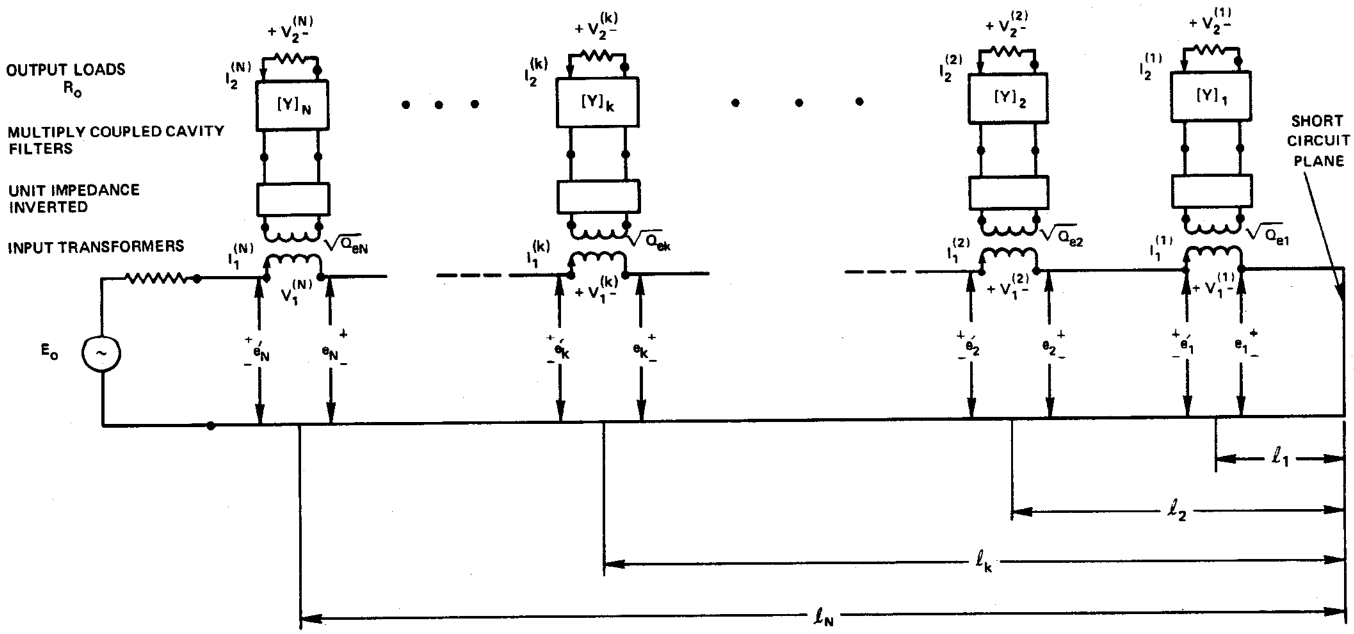

FIG. 1b. EQUIVALENT CIRCUIT OF A WAVEGUIDE SERIES CONNECTED MULTIPLEXER

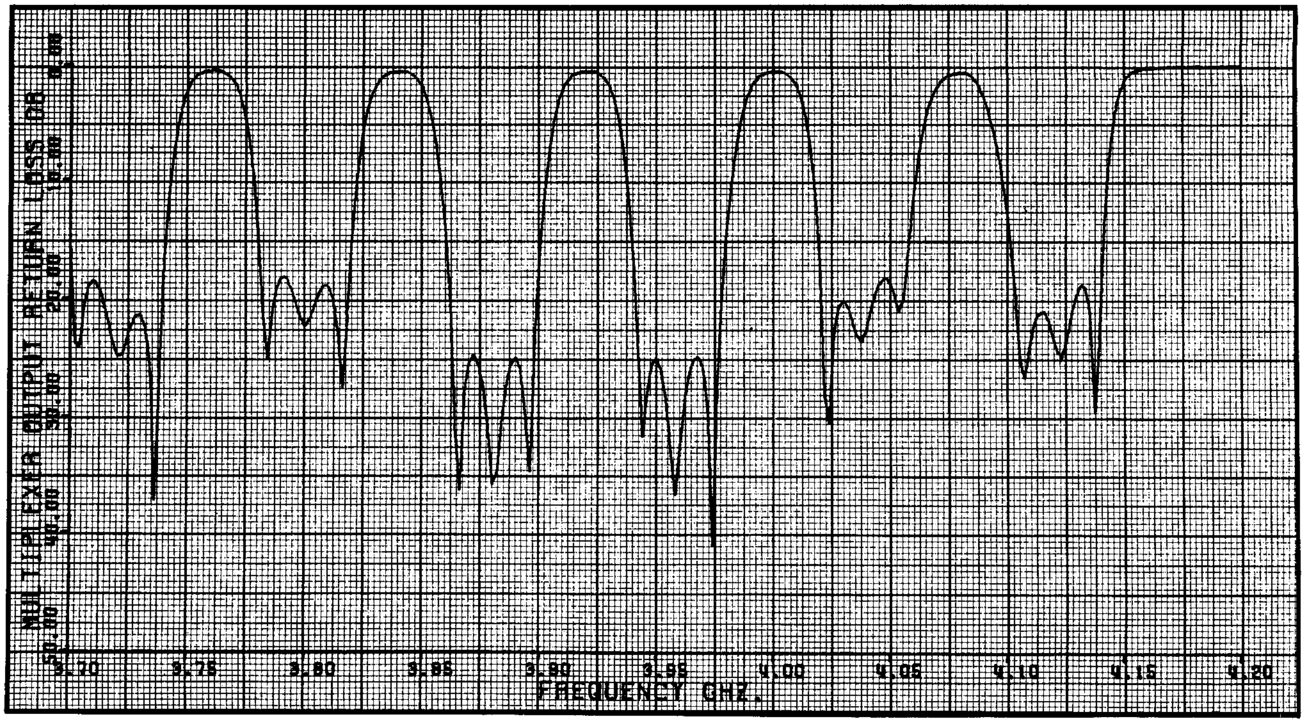

FIG. 2a. RETURN LOSS OF THE 6-CHANNEL MULTIPLEXER

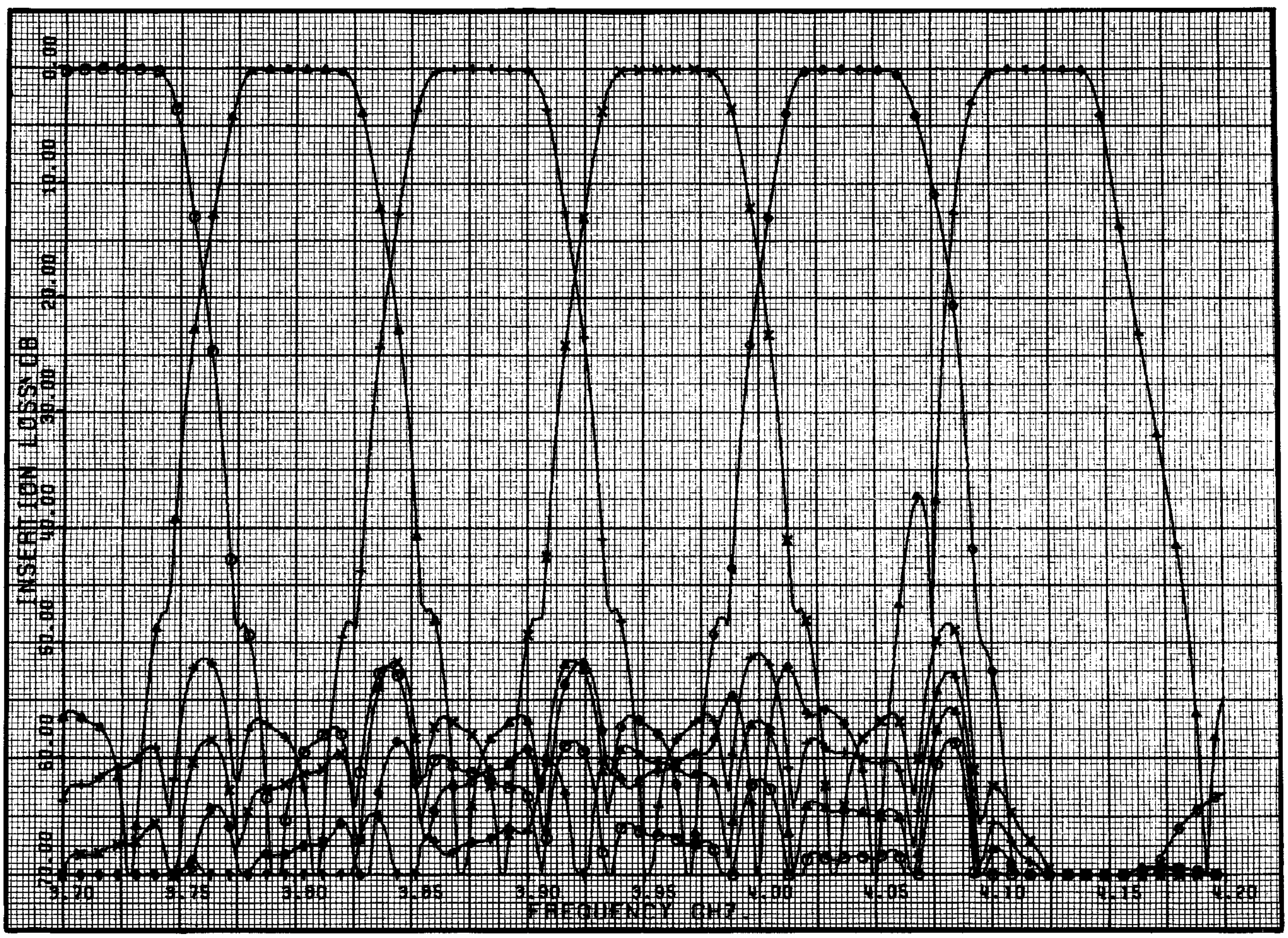

FIG. 2b. INSERTION LOSS OF THE 6-CHANNEL MULTIPLEXER