4.1: INTERDIGITAL, BAND-PASS FILTERS*

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The filters discussed in this paper consist of arrays of TEM-mode transmission line resonators between parallel ground planes. Each resonator line is a quarter-wavelength long at mid-band and is short-circuited at one end and open-circuited at the other--the resonator elements being arranged in a parallel array with the positions of the short-circuited ends alternating. Figure 1 shows a strip-line interdigital filter with its upper ground plane removed.

Two somewhat different approximate design procedures for two different classes of interdigital filters have been developed in this research. The first class of filters applies best to filter designs of narrow or moderate bandwidth. The design procedure for this case

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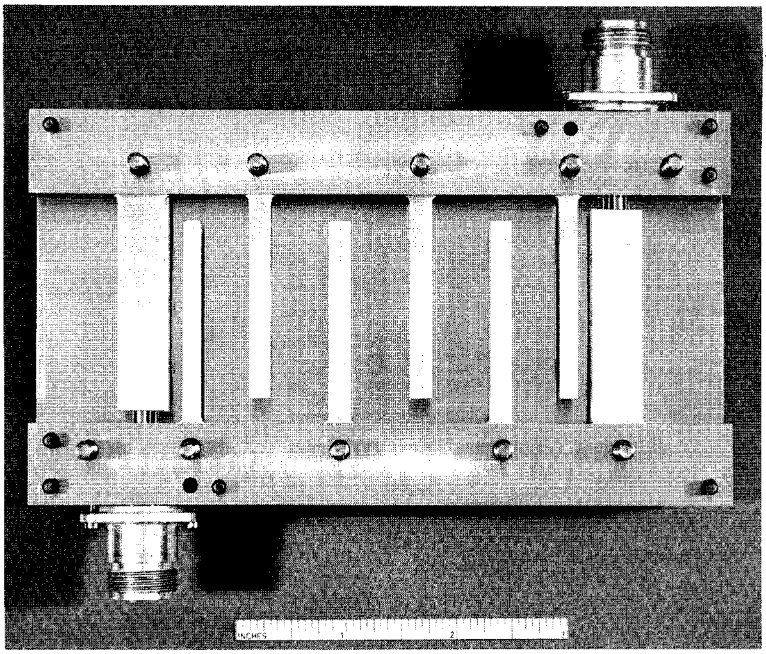

Fig. 1. A six-resonator interdigital band-pass filter designed for 10 percent bandwidth.

introduces an extra line element at each end of the filter which serves as part of an impedance-transforming end section. The filter in Figure 1 is of this type. The six lines in the interior of the filter are resonators while the wide input and output lines at the ends are not. This particular filter has about ten per cent bandwidth and its response is shown in Figure 2.

The second design procedure discussed relates to filters of moderate to wide bandwidths. The filter in Figure 3 is an example of a filter designed by this procedure. In this case, the input and output line elements are open-circuited instead of short-circuited as was the case for the filter in Figure 1, and the input and output line elements serve as resonators as well as serving to provide impedance transformation. The filter shown has eight line elements which serve as eight resonators. The response of this filter is shown in Figure 4. Though in principle both the design procedure used for the filter in Figure 1 and the design procedure used for the filter in Figure 2 can be used for design of either narrow or wideband filters, the first procedure gives more convenient dimensions for narrow-band designs, while the second procedure gives more convenient dimensions for wideband designs.

Both of the design procedures described make use of lumped-element low-pass prototypes as the basis for computing specific designs. (Element values for Tchebyscheff and maximally flat prototypes are available in tabulated form [1].) The design equations provide a

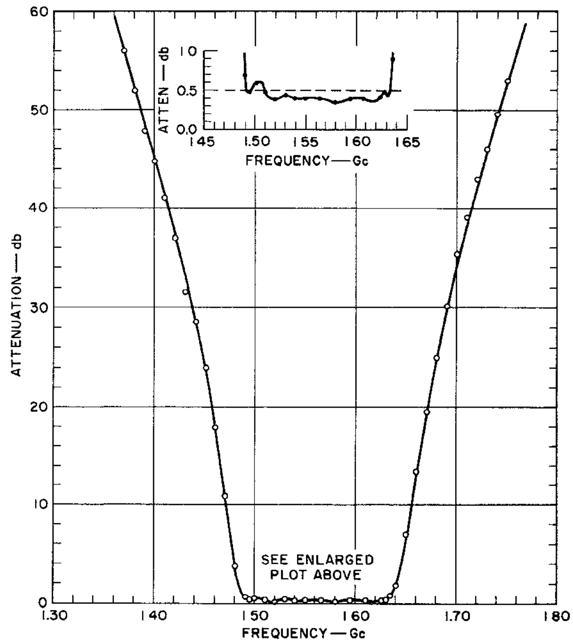

Fig. 2. Measured attenuation characteristic of the filter in Figure 1.

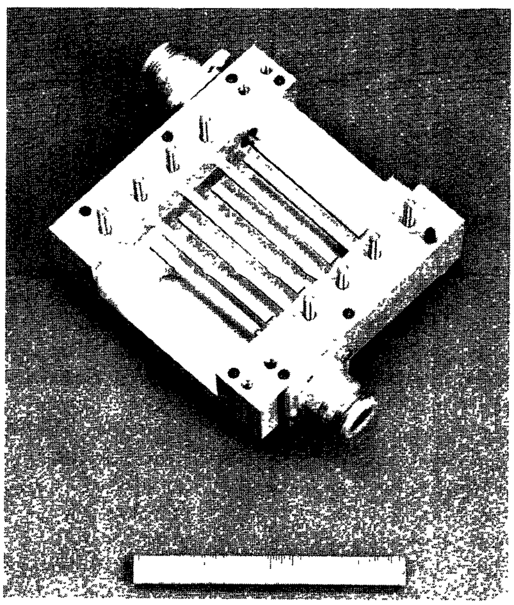
Fig. 3. An eight-resonator interdigital filter designed for an octave bandwidth.

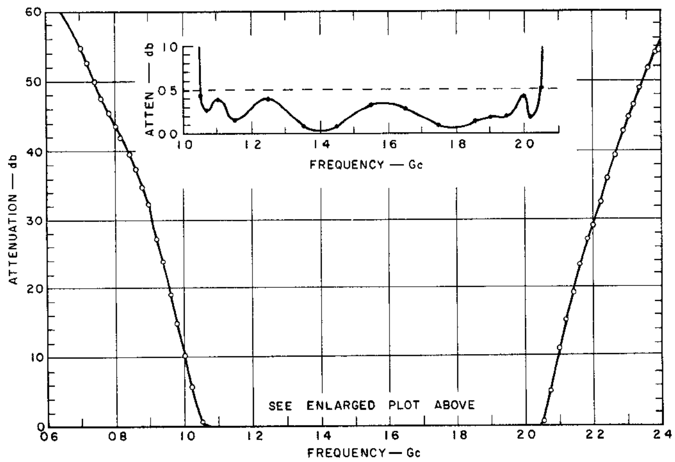

Fig. 4. Measured attenuation characteristic of the filter in Figure 3.

straightforward design procedure which is approximate, but sufficiently accurate for most applications. The design equations give the capacitance per unit length of each line element with respect to ground, and also the capacitances per unit length between each line element and its neighbor on each side. Then if rectangular line elements are used, the actual dimensions of the lines are obtained from the line capacitances by use of Getsinger's charts [2] for the capacitances of rectangular-bar parallel-coupled lines. The design equations for computing the filter line capacitances from the low-pass prototype element values were derived by further application of a previously developed point of view for microwave filter design [3].

Interdigital band-pass filters are seen to have a number of very attractive features. These include:

(1) They are very compact.

(2) The tolerances required in their manufacture are relatively relaxed. (Note that even in the octave-bandwidth filter in Figure 3 the spacings between the line elements are quite sizeable.)

(3) The second pass band is centered at three times the center frequency of the first pass band, and there is no possibility of spurious responses in between. (Note that for filters with half-wavelength parallel-coupled resonators [3,4] even the slightest

mistuning will result in narrow spurious pass bands at twice the frequency of the first pass-band center.)

(4) The rates of cutoff and the strength of the stop bands are enhanced by multiple-order poles of attenuation at DC and at even multiples of the center frequency of the first pass band.

(5) They can be fabricated in structural forms which are self-supporting so that dielectric material need not be used. Thus dielectric loss can be eliminated.

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1. L. Weinberg, "Additional Tables for Design of Optimum Ladder Networks," Parts I and II, Journal of the Franklin Institute 264, 7-23 and 127-138 (1957).

2. W. J. Getsinger and G. L. Matthaei, "Microwave Filters and Coupling Structures," Stanford Research Institute, Quarterly Report 2, SRI Project 3527, Contract DA-36-039-SC-97398.

3. G. L. Matthaei, "Design of Wide-Band (and Narrow-Band) Band-Pass Microwave Filters on the Insertion Loss Basis," Trans. IRE MTT-8, 580-593 (1960).

4. S. B. Cohn, "Parallel-Coupled Transmission-Line-Resonator Filters," Trans. IRE MTT-6, 223-231 (1958).