DUAL MODE CANONICAL WAVEGUIDE FILTERS*

A. E. Atia and A. E. Williams
COMSAT Laboratories
Clarksburg, Maryland 20734

Abstract

This paper presents a new dual mode circular waveguide cavity structure which realizes the general class of coupled cavity transfer functions. Included are the exact elliptic function response and the linear phase and arbitrary phase responses. Experimental data taken on 4- and 8-pole narrowband elliptic function filters centered at approximately 4 GHz are described and shown to correlate well with theory.

Introduction

It has been shown[1] that the general nth even-order transfer function bandpass filter response (including the exact elliptic function) can be generated from a set of multiple-coupled, cascaded, synchronously tuned cavities if additional couplings between cavities 1 to n, 2 to n - 1, etc. are non-zero and of arbitrary sign. This canonical coupling set is achieved by the single mode (TE_{101}) rectangular and dual mode (TE_{101}) square cavity-folded geometries,[2] but cannot be realized by the simpler longitudinal dual mode (TE_{111}) circular cavity filter.[3] Therefore, the advantages of the longitudinal dual mode filter, such as ease of fabrication and low weight and volume, do not coincide with the optimum electrical response.

This paper presents a new dual TE_{111} mode circular waveguide cavity structure which realizes the optimum electrical response and retains all the mechanical advantages of the longitudinal dual mode filter. The filter design procedure is presented with specific emphasis on the input-output port design and on the improvement of the out-of-band rejection. Experimental results for 4- and 8-pole elliptic function narrow-bandpass filters centered at approximately 4 GHz are described.

Filter Configuration

The key to the realization of the new dual mode canonical filter is the recognition that the number of intercavity couplings in the longitudinal dual mode equivalent circuit is identical to that in the canonical equivalent circuits (Figure 1). The canonical set of couplings can therefore be realized within the dual mode geometry by simply renumbering the cavities so that cavities 1 and n, 2 and n - 1, 3 and n - 2, etc. remain within the same physical cavity. "Shunt" couplings are realized by the coupling screws, while "series" couplings are provided by either equal cross slots or circular holes. Comparison of the new dual mode canonical filter (Figure 2a) with the longitudinal dual mode filter (Figure 2b) indicates that the mechanical advantages of low weight and volume and ease of fabrication are retained from the older filter. Further, since the canonical set of couplings is possible, the optimum electrical response can be generated.

The physical dimensions of this new filter, such as cavity diameter, corrected cavity length, and coupling slot dimensions, can be determined by using a procedure similar to that previously described.[4] However, a unique feature is associated with the design of the end physical cavity containing the input-output ports. Some possible configurations are shown in Figure 3. The choice of the particular design is dependent on the filter specification since the spurious coupling which occurs between the ports modifies the out-of-band response. In general, however, satisfactory filter performance can always be achieved with an appropriate choice of structure.

Experimental Responses

A 4-pole elliptic function 40-MHz bandpass filter was designed to operate at 4.138 GHz with a coaxial waveguide input-output port configuration. Experimental results shown in Figure 4 clearly indicate that higher order mode coupling modifies the out-of-band response.

To demonstrate the full advantages of this new canonical dual mode filter, an 8th-order elliptic function response was designed and constructed with a coaxial waveguide port configuration. Experimental results, which correlate well with theory, are shown in Figure 5a. The out-of-band response is shown in Figure 5b.

Conclusions

This paper has described a new dual mode filter which realizes the most general class of coupled cavity transfer functions. Although care must be exercised in the design of the input-output ports, a satisfactory out-of-band response can always be achieved. Experimental results on 4- and 8-pole elliptic function narrowband filters centered at approximately 4 GHz indicate the new filter's potential.

References

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4. G. L. Matthaei, L. Young and E. M. T. Jones, Microwave Filters, Impedance Matching Networks and Coupling Structures, New York: McGraw-Hill, Chapter 5.

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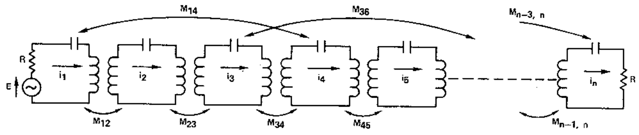

Figure 1a. Longitudinal Dual Mode Equivalent Circuit

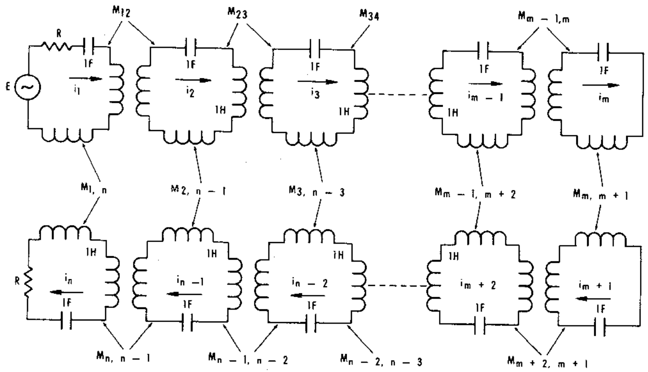

Figure 1b. Canonical Equivalent Circuit

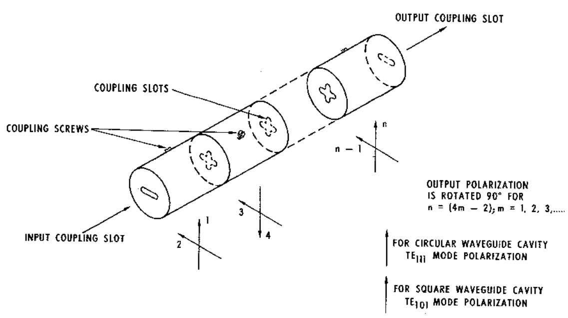

Figure 2a. Longitudinal Dual Mode Filter

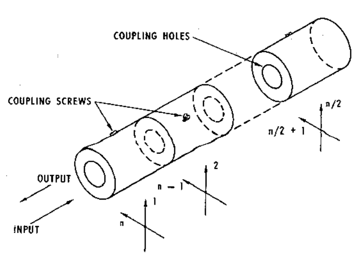

Figure 2b. Dual Mode Canonical Filter

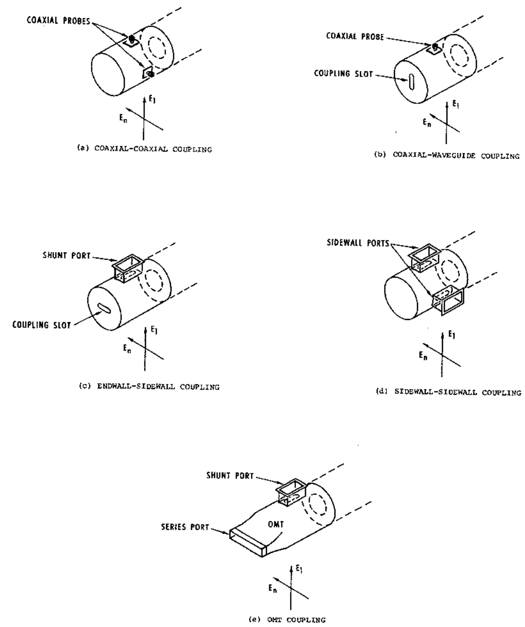

Figure 3. Canonical Filter Input-Output Configurations

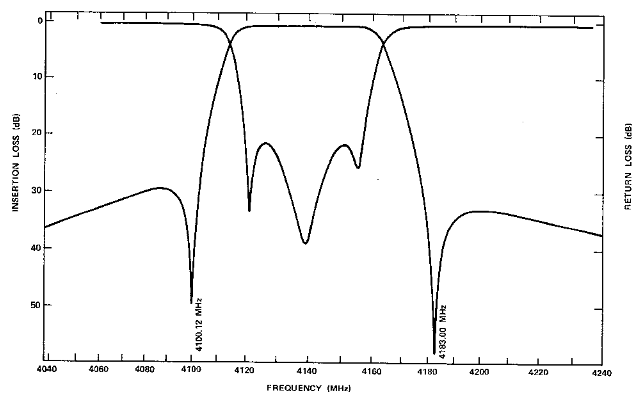

Figure 4a. In-Band Insertion and Return Loss Responses

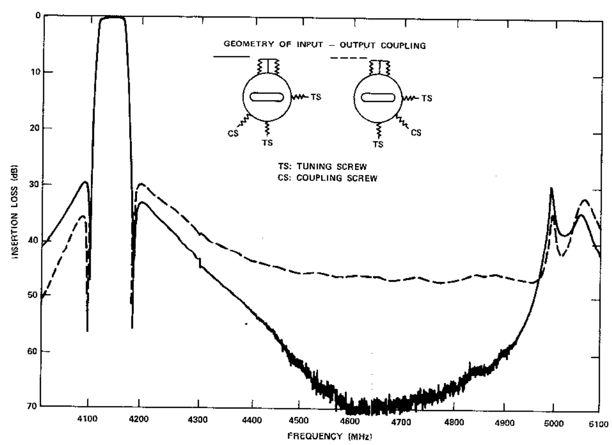

Figure 4b. Canonical Filter Out-of-Band Response

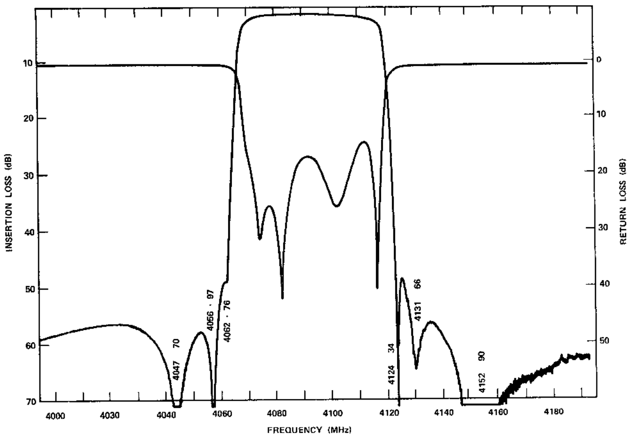

Figure 5a. 8-Pole 40 MHz Bandpass Elliptic Function Filter Insertion and Return Loss Responses

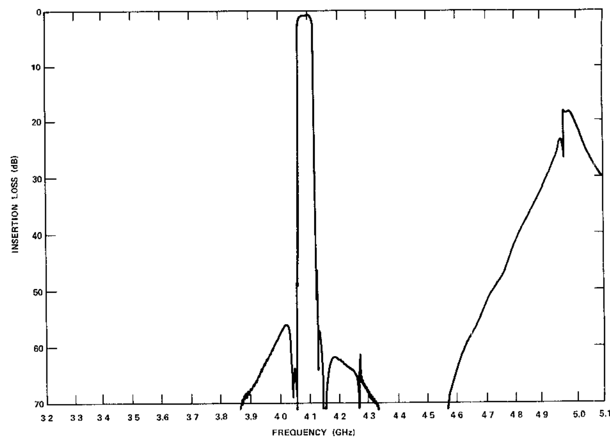

Figure 5b. 8-Pole 40 MHz Bandpass Elliptic Function Filter Out-of-Band Response