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QUADRUPLE-MODE FILTERS*

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ABSTRACT

The basic unit of the quadruple-mode filter is a cylindrical cavity designed at the degeneracy of the dual TE_{1mn} and the dual TM_{1pq} modes. The design and performance of a single-cavity, 4-pole elliptic function bandpass filter, centered at 4 GHz, and a two-cavity, 8-pole quasi-elliptic bandpass filter at 12 GHz are described. Both units exhibit excellent correlation between theory and experiment.

INTRODUCTION

The development and application of the dual TE_{11n} mode resonant microwave cylindrical cavity to narrowband filters and equalizers has revolutionized satellite transponder design (1). When compared to single cavity filters, weight and volume reductions of 50 percent are achieved. Using the non-adjacent couplings creates additional savings by generating optimum filter responses.

The use of triple resonances allows further savings of weight and volume. In 1971, Atia and Williams (2) described a 6-pole filter using triple degeneracies. Recently, Tang et al. have continued this work to develop practical designs (3).

This paper extends these concepts to quadruple mode resonances by exploiting the simultaneous degeneracy of both the dual TE and dual TM modes. Experimental results obtained with a single cavity 4-pole elliptic function bandpass filter at 4 GHz, and a two cavity, 8-pole, quasi-elliptic function bandpass filter at 12 GHz show excellent correlation with the predicted performance.

FOUR-POLE FILTERS: SINGLE CAVITY

Figure 1 shows the coupling and tuning screw positions suitable for a single-cavity, 4-pole filter designed at the degeneracy of the dual TE_{112} and dual TM_{110} modes. The TM mode tuning screws 2 and 3 are placed at one cavity end in positions of maximum E_z field, and the coupling between these modes is achieved using screw 23. Coupling between TE modes 1 and 4 and TM modes 2 and 3 is achieved with screws 12 and 34, while the standard TE dual-mode coupling is realized with screw 14.

Since the input/output ports can be achieved with either the TE or TM modes, three possible 4-pole filter geometries exist. Figure 2a shows a typical performance of the 4-pole quadruple-mode bandpass filter with TM input and TM output coaxial ports while Figure 2b illustrates the differences between the out-of-band rejection in the three possible configurations. Responses are well-defined in-band and in the near out-of-band, but direct spurious coupling between the input and output ports limits the out-of-band rejection to approximately 30 dB. Average filter Q's of 15,000 to 20,000 were measured for bandwidths in the range of 0.1 to 0.5 percent.

EIGHT-POLE FILTERS: TWO CAVITIES

By selectively coupling identical quadruple-mode cavities, 8-pole filters can be realized with only two physical cavities. One advantage of the two-cavity, 8-pole filter geometry over the single cavity filter is that the input and output ports can be placed in separate cavities, eliminating spurious input-output coupling. Based on this principle, the important resonant-mode coupling geometries are shown in Figure 3.

Experimental results on a 50-MHz bandwidth, 12-GHz quasi-elliptic filter using the geometry of Figure 3a (coupling

*This paper is based upon work performed at COMSAT Laboratories under the sponsorship of the Communications Satellite Corporation.

1-8, 2-7, and 3-6 = 0) are shown in Figure 4. Excellent agreement with the predicted response has been obtained and the realized average filter Q of 9,000 is consistent with the expected value (about 60 percent of the isolated cavity mode Q's). The out-of-band response shown in Figure 5 compares adjacent resonant spurious modes with their predicted locations.

Figure 6 shows a photograph of the 8-pole filter.

CONCLUSIONS

This paper has described the new quadruple-mode cavity filter, which uses four degenerate modes in a cylindrical cavity. Applications are particularly well-suited to 8-pole bandpass filter designs and the experimental response shows excellent agreement with the predicted performance.

ACKNOWLEDGMENTS

The authors are indebted to Mr. T. Kehoe and Mr. P. Carlton who helped in both the mechanical design and electrical tuning of the filters.

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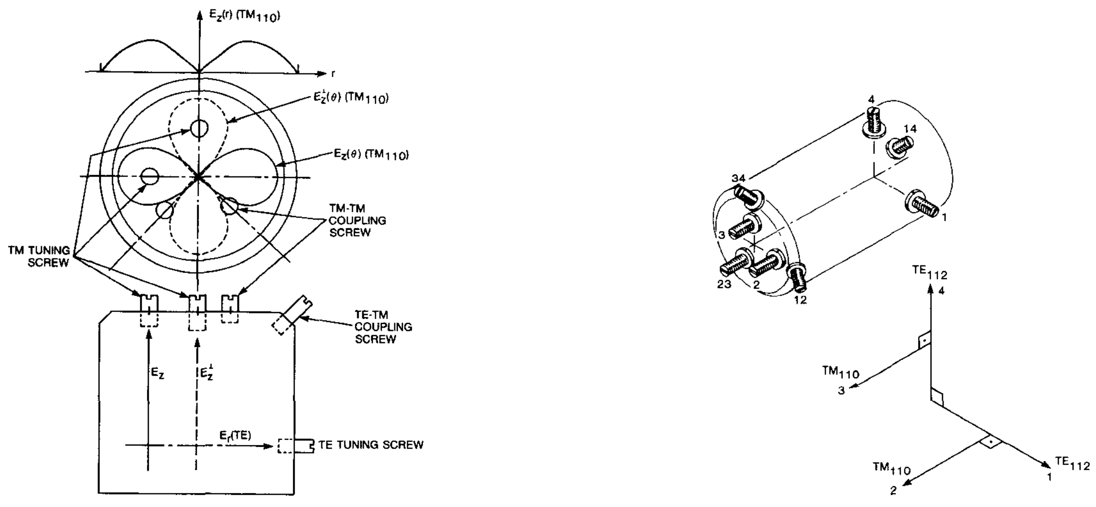
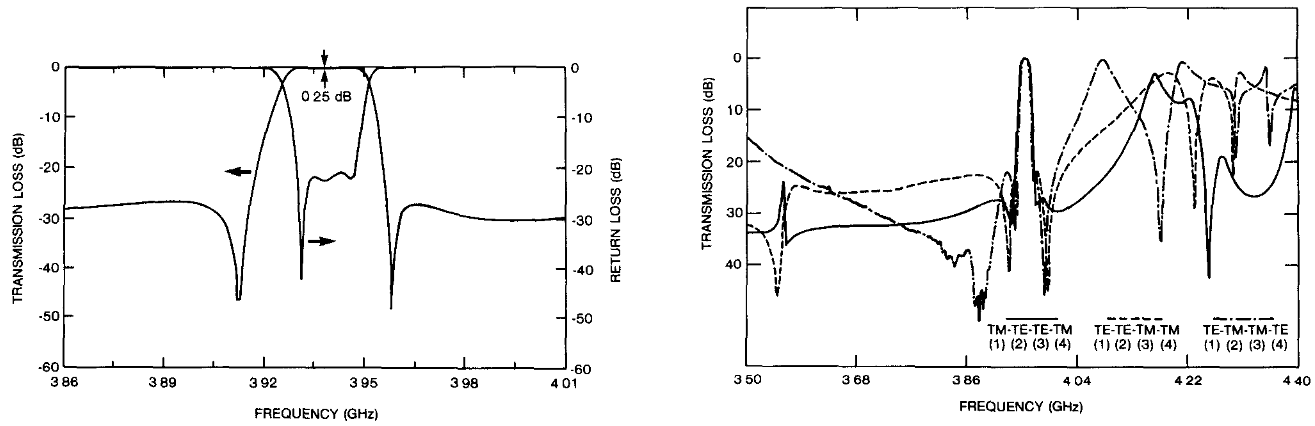


a. Top and Side View

b. Perspective

Figure 1. The Basic Quadruple Mode Cavity



a. Narrowband Frequency Response--TM Input and TM Output Coaxial Ports

b. Wideband Response--All Three Geometries

Figure 2. 4 GHz, 4-Pole Elliptic Function Filter Responses

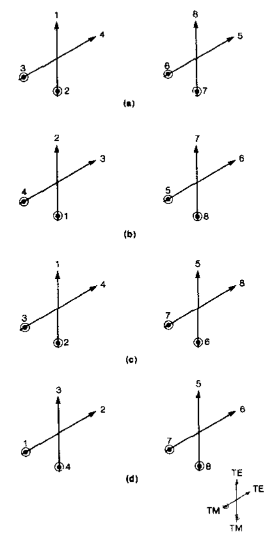


Figure 3. 8-Pole Filter Geometries With Input and Output Ports in Different Physical Cavities

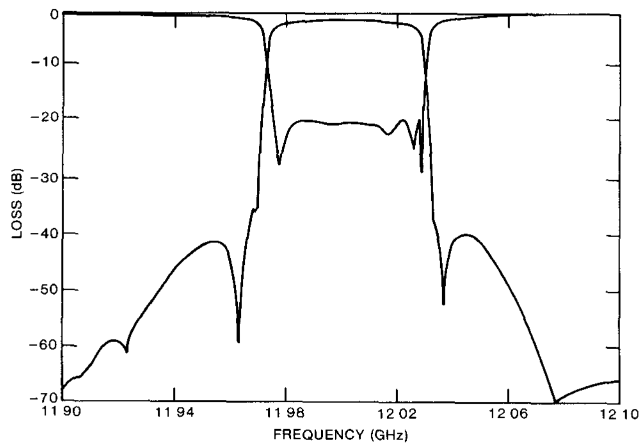


Figure 4. 12-GHz, 8-Pole Quasi-Elliptic Bandpass Filter: In-Band Response

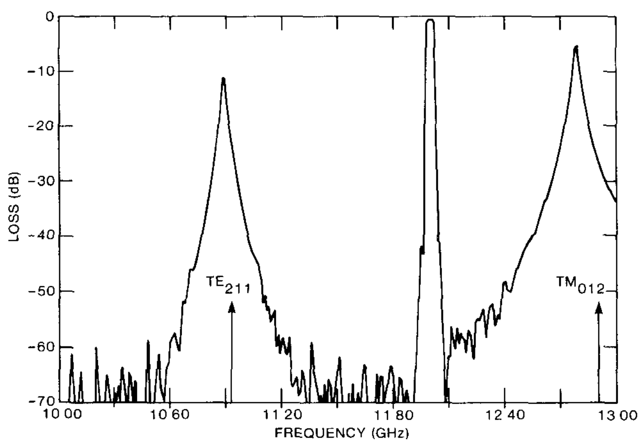


Figure 5. 12-GHz, 8-Pole Quasi-Elliptic Bandpass Filter: Wideband Response

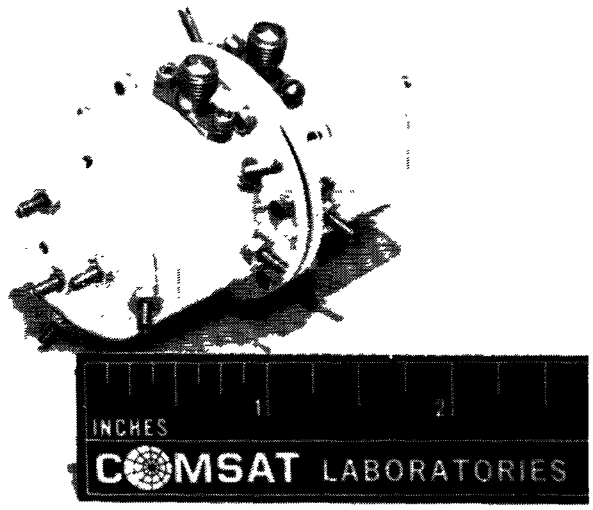


Figure 6. Photograph of 8-Pole, Quadruple-Mode Filter