# An 8-Pole Quazi-Elliptic Function Filter Realized in 3 Dielectric Resonator Cavities

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## ABSTRACT

An eight-pole quazi-elliptic function filter with two pairs of transmission zeros (8-4) has been synthesized and experimentally realized in two triple-mode and one dual-mode dielectric resonator cavities. This was done by carefully selecting the optimum coupling topology. Subsequently the coupling matrix is generated using computer optimization program without using matrix rotation.

## INTRODUCTION

The history of multi-mode waveguide cavity resonators can be dated back to as early as the 1950's [1]. However, it was in the 1970's from the work of Atia and Williams [2,3] that make dual-mode cavity the dominant circuit element in high performance filter for space applications. With the introduction of dielectric dual-mode filters [4] and triple-mode waveguide filter [5] in the early 1980's, there has been renewed interest in the filter community. Subsequently it was demonstrated that a 5-pole triple/dual-mode 2-cavity dielectric resonator filter [6] is realizable. In this paper the design and experimental results of an 8-pole quazi-elliptic function filter (with two pairs of transmission zeros) realized with three dielectric resonator cavities, of which two cavities are triple-mode and one cavity dual-mode are described. This new filter structure will allow a further reduction of size and weight of dielectric loaded filter networks.

## DETERMINATION OF COUPLING TOPOLOGY

Constrained by mechanical limitation of a triple-mode cavity, a three-cavity 8-pole filter can be built by arranging the cavities in a sequence of triple-dual-triple configuration as shown in Figure 1. Such a mechanical configuration gives rise to different possibilities of coupling sequencing. Each difference sequence can potentially realize different numbers of transmission zeros which is governed by the following equation:

$$P = N - C \qquad (1)$$

where

P = maximum number of transmission zeros able to be supported by the filter structure.
N = Order of filter.
C = Number of cavities between the shortest path from input to output coupling.

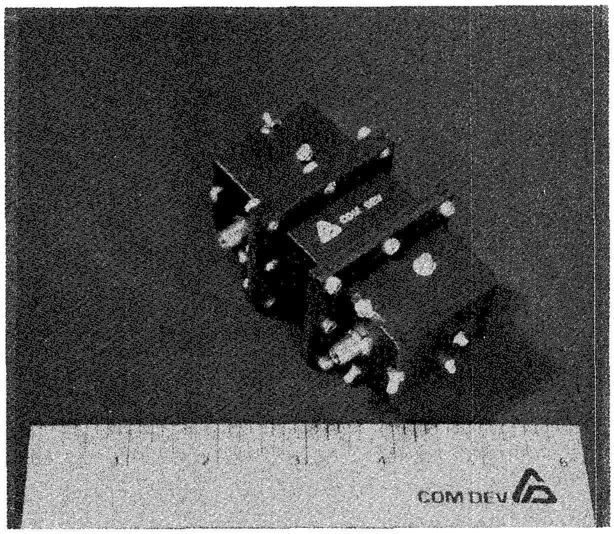


Figure 1 : Picture of the Filter

Equation (1) is important in the selection of coupling matrix sequencing because if $P<4$ an 8-4 filter cannot be realized. On the other hand, if $P>4$, stray cross-coupling in the filter structure will make tuning very difficult. Figure 2 illustrates some possible coupling sequences and maximum number of zeros it can support. Out of the three possible configurations illustrated in Figure 2, option 2 was chosen because it represents the best optimum design for an 8-4 filter.



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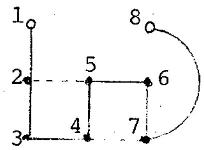
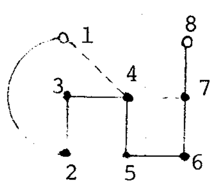
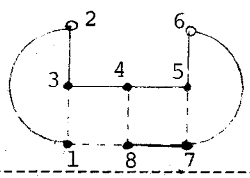
| OPTIONS | ROUTING DESIGN | MAX. POSSIBLE TX. ZERO AND REMARKS |
|---|---|---|
| 1 |  | P = 2<br>$M_{25}$ & $M_{47}$ become dependent variable. |
| 2 |  | P = 4<br>$M_{14}$ & $M_{47}$ are independent variable but need TE to TM coupling between cavities. |
| 3 |  | P = 6<br>Only $M_{57}$ are even mode. All other possible couplings are odd mode. |

Note: ⊙ - TM mode.
● - TE mode.

Figure 2: Path Design for a Triple-Dual-Triple Mode Filter Realization.

## SYNTHESIS OF THE COUPLING MATRIX

The synthesis procedure was started by generating the coupling matrix [7] of the 8-4 filter in its symmetrical configuration as shown in Figure 3(a). An optimization program was used to generate a new set of coupling matrices of which M14 and M47 were the only cross-coupling. This optimization routine is based on the following formula:

$$\text{Min Max } \{f_1, f_2 \ldots . f_n\} \tag{2}$$

where

$$f_1 = |R(\phi, f_1) - S(f_1)|$$

$$\vdots$$

$$f_n = |R(\phi, f_n) - S(f_n)|$$

Such that

$R(\phi, f_i)$ = response of desirable coupling matrix $\phi$ at frequency $f_i$.

$S(f_i)$ = response of the given transfer function at frequency $f_i$.

The advantage of using such an optimization program is that it is not necessary to predetermine the rotation sequencing [8] because the new matrix is not generated by matrix rotation.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | | M12 | | | | | | |
| 2 | M12 | | M23 | | | | M27 | |
| 3 | | M23 | | M34 | | M36 | | |
| 4 | | | M34 | | M45 | | | |
| 5 | | | | M45 | | M56 | | |
| 6 | | | M36 | | M56 | | M67 | |
| 7 | | M27 | | | | M69 | | M78 |
| 8 | | | | | | | M78 | |

Figure 3(a): Coupling Matrix of an 8-4 Filter Dual-Mode Symmetrical Configuration

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | | M12 | | M14 | | | | |
| 2 | M27 | | M23 | | | | | |
| 3 | | M23 | | M34 | | | | |
| 4 | M14 | | M34 | | M48 | | M47 | |
| 5 | | | | M45 | | M56 | | |
| 6 | | | | | M56 | | M67 | |
| 7 | | | | M47 | | M67 | | M78 |
| 8 | | | | | | | M78 | |

Figure 3(b): Coupling Matrix of an 8-4 Filter for a Triple-Dual-Triple-Mode Configuration.

## EXPERIMENTAL FILTERS

Based on the coupling matrix configuration in Figure 3(b) an experimental filter was synthesized to have a center frequency of 3.85 GHz with a bandwidth of 36 MHz. Other specifications of the filter were as follows:

| | | |
|---|---|---|
| Notch Level | = | 35 dB |
| VSWR | = | 1:1.15 |

The measured amplitude response of the filter is shown in Figure 4(a) and the return loss response is shown in Figure 4(b). Measured data indicates excellent correlation with computed performance.

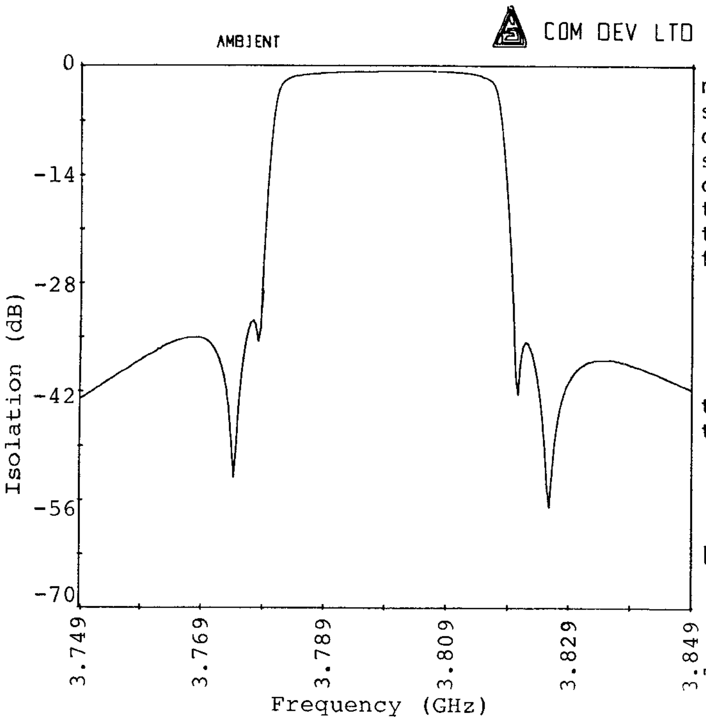



Figure 4(a) : Amplitude Response of the 8-4 Filter

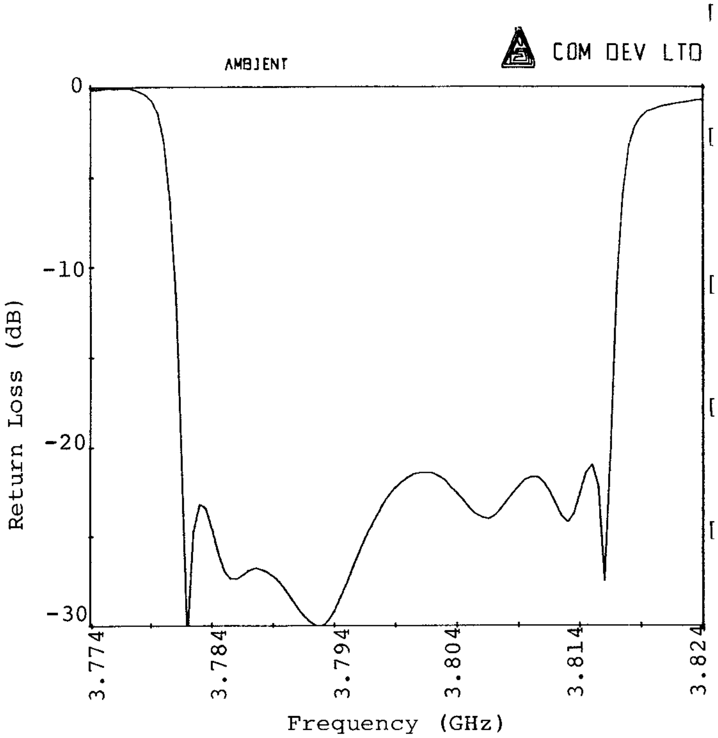



Figure 4(b) : Return Loss Response of the 8-4 Filter

## CONCLUSIONS

By combining two triple-mode and one dual-mode dielectric resonator cavities an 8-4 filter was synthesized and built. Measured results indicate close correlation with theory. This design represents size and weight saving of 25% over existing dual-mode 8-pole dielectric resonator filters and therefore would likely be a strong candidate for the next generation of C-Band input multiplexing filters.

## ACKNOWLEDGEMENT

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## REFERENCES

[1] Lin, W.-G., "Microwave Filters Employing a Single Cavity Excited in More Than One Mode", Journal of Applied Physics, Vol. 22, pp. 989-1001, Aug., 1951.

[2] Williams, A.E., and Atia, A.E., "Dual Mode Canonical Waveguide Filters', IEEE Trans. on MTT, MTT-25, pp. 1021-1026, Dec., 1977.

[3] Atia, A.E., and Williams, A.E., "New Types of Waveguide Bandpass Filters for Satellite Transponders", COMSAT Tech. Review, Vol. 1, No. 1, Fall, 1971, pp. 21-43.

[4] Fiedziuszko, S.J., "Dual-Mode Dielectric Resonator Loaded Cavity Filters", IEEE Trans. on MTT, MTT-30, pp. 1311-1316, September, 1982.

[5] Tang, W.C., and Chaudhuri, S.K., "Triple-Mode True Elliptic-Function Filter Realization for Satellite Transponders", IEEE MTT-S International Microwave Symposium, Boston, Mass., May 31 - June 3, 1983.

[6] Tang, W.C., et al, "Dielectric Resonator Output Multiplexer for C-Band Satellite Applications", IEEE MTT-S Symposium, St. Louis, Missouri, June 4 - 6, 1985.

[7] Cameron, R.J., and Rhodes, J.D., "Asymmetric Realizations for Dual-Mode Bandpass Filters", IEEE Trans. on MTT, MTT-29, pp. 51-58, Jan., 1981.

[8] Cameron, R.J., "A Novel Realisation for Microwave Bandpass Filters", ESA Journal, Vol. 3, 1979, pp. 281 - 287.