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DUAL MODE DIELECTRIC RESONATOR FILTERS WITHOUT IRIS‡

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ABSTRACT

Two filter realizations using dual mode dielectric resonators in a simple tubular enclosure are described. The new configurations do not require iris to achieve the coupling among the resonators;thus eliminating expensively machined parts with tight tolerances. They also achieve lower midband insertion loss than comparable filters with iris, because conduction currents on the cavity ends are eliminated. Measured results on two 4-pole elliptic function experimental filters realized in the new structures agreed closely with theory.

1. INTRODUCTION

Dual mode filter realizations previously reported in the literature, both in air-filled[1],[2] or dielectrically loaded[3] cavities require that physically adjacent resonators be coupled to each other through iris. Generally, the iris must be produced (e.g. machined and silverplated) to a high degree of precision to provide the required accuracy for the achievement of the desired filters response. Extremely tight tolerances on the iris dimensions is a major cost factor in these types of filters.

This paper presents two novel realizations of dual mode dielectric resonator filters in simple structures which completely eliminate the need for iris. These high quality filters can be inexpensively manufactured, without compromising the most optimum achievable electrical performance. Further, the new filters have lower losses than the corresponding realizations with iris, because the conduction currents on the iris are eliminated.

2. FILTER REALIZATIONS AND DESIGN

It is known[4] that the most general band pass transfer function realizable by a multiple coupled cavity structure can be reduced to a canonical form containing the minimum number of coupling elements. An equivalent circuit of this canonical form is shown in Fig. 1. It consists of two halves each of which has a number of identical resonant circuits coupled in cascade by frequency invariant coupling elements having the same sign. Each resonant circuit in one half is coupled to the corresponding circuit in the other half by means of a specified sign (either positive or negative) cross coupling element. Realization of the canonical form using dielectric loaded resonators excited in hybrid (HEH_{11} modes)[5] is shown in Fig. 2. This realization is similar to the realization of the circular waveguide form excited in TE_{111} modes described in Reference [2]. In Fig. 2, the cascade couplings are provided by circular iris separating the dielectric resonators. The cross couplings are realized by coupling screws located at 45° angle to the directions of the degenerate dual modes. The relative signs of any two cross couplings is determined by the relative directions of the corresponding coupling screws (same sign for parallel screws and opposite signs for perpendicular screws).

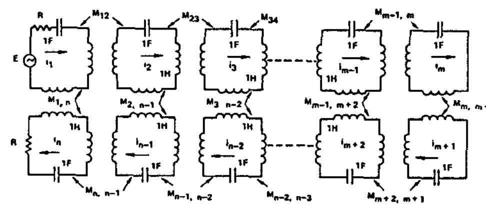

Fig. 1 Canonical form of the equivalent circuit of n=2m coupled cavities.

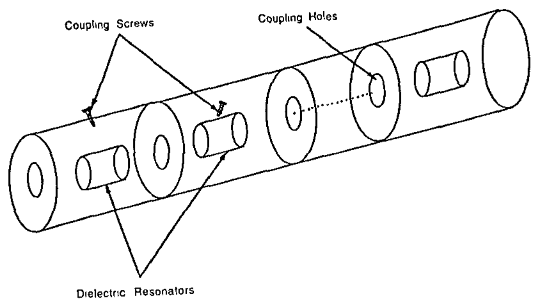

Fig. 2 Dielectric loaded cirular waveguide canonical dual mode filter with coupling holes.

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The same canonical form can also be realized by the new structure shown in Fig. 3, which has no iris. Proper cascade coupling values between any two adjacent dual mode resonators excited in the hybrid modes are obtained by adjusting the spacing S between the resonators. The input and output ports of the filter are located in the same physical cavity and can be realized in a number of ways[2], two of which are shown in Fig. 4. The coaxial probes in Fig. 4-a couple the radial electric fields of each of the two orthogonal dual modes of the resonators. The amount of coupling (or external Q) is controlled by the depth of penetration and the probe's thickness (diameter). The maximum isolation achievable between the input and output ports in this case is partly limited by the ability to maintain the probes mechanically at right angle with respect to each other, and partly by the spurious mode couplings. Experimental results show that about 30 dB isolation can be achieved by the two orthogonal probes coupling.

The configuration shown in Fig. 4-b has one coaxial probe port (as in Fig. 4-a). The other port is a dipole or a loop[6] that couples to the magnetic field of the mode near the end wall of the resonator. The configuration of Fig. 4-b should provide better isolation between the input and output ports than the two orthogonal probes of Fig. 4-a, since it is less susceptible to spurious couplings.

Non canonical realizations (e.g. longitudinal dual mode filters [1], [3]) or nonsymmetrical canonical filters where input and output ports must be located in different physical resonators require unequal couplings between any two corresponding modes of adjacent dual mode resonators. Since in the above structure these couplings are always equal, a modification is needed to achieve these more desirable realizations. The configuration of Fig. 5 achieves non equal couplings between the pairs of modes. This figure shows a 4-pole elliptic function filter with input and output ports in two different cavities. The spacing s between the two resonators is adjusted to correspond to slightly less than the minimum of the required couplings M_{14} and M_{23}. Then the two sets of coupling screws located midway between the resonators are inserted to achieve the precise desired values of these unequal couplings. It is important to note that the insertion of the screws parallel to the electric fields of a pair of modes actually increases the coupling between these two modes.

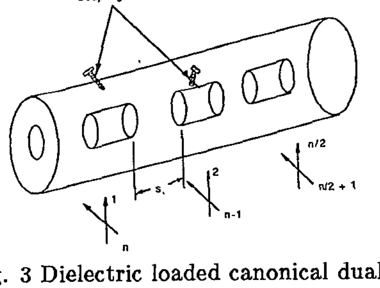

Fig. 3 Dielectric loaded canonical dual mode filter with no coupling holes.

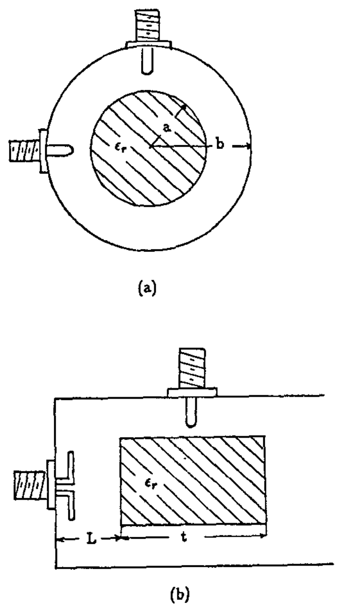

Fig. 4 Input/output coupling
(a) Two coaxial probes.
(b) coaxial input, and dipole (or loop) output.

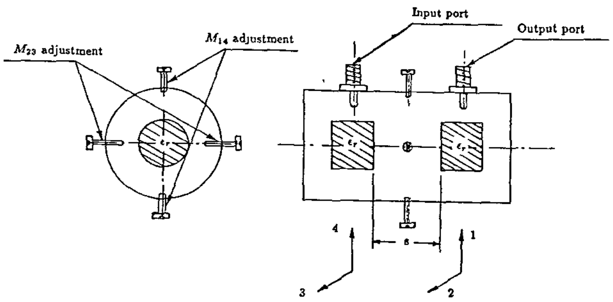

Fig. 5 Realization of unequal coupling between two dual mode dielectric resonator without iris.

Parameters required for the design of this type of filters are: resonant frequency of the dual hybrid mode dielectric resonators in the cylindrical tube, coupling between two adjacent resonators and the external Q of the probe, dipole or coupling loop. These parameters could be determined both theoretically by numerical methods and by experimental measurements. Experimentally measured data showing the variation of the coupling coefficient between two resonators as a function of their separation are given in Fig. 6. Method of theoretical calculations of the coupling are described in [7].

3. EXPERIMENTAL FILTER DESIGN AND RESULTS

To verify the theory two experimental 4-pole elliptic function filters were designed, constructed and tested. The parameters of the filters chosen are given in Table 1.

A photograph of one of the experimental filters is shown in Fig. 7.

Measured and computed insertion and return loss frequency responses of these canonical and longitudinal dual mode filters are shown in Fig. 8 and 9 respectively. The improved out-of band isolation in Fig. 9 is due to locating input and output ports in two different resonators.

By proper selection of the diameter to length ratio of the dielectric resonator (greater than 4) the closest spurious mode appearing in the filter response is at least 1000 MHz. above the filters center frequency of 3.92 GHz.

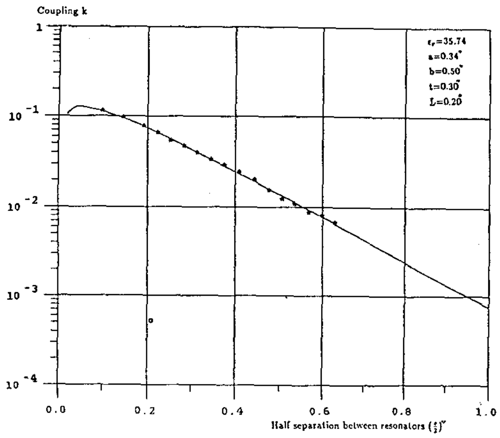

Fig. 6. Measured coupling between two resonators for the hybrid HEH_{11} mode.

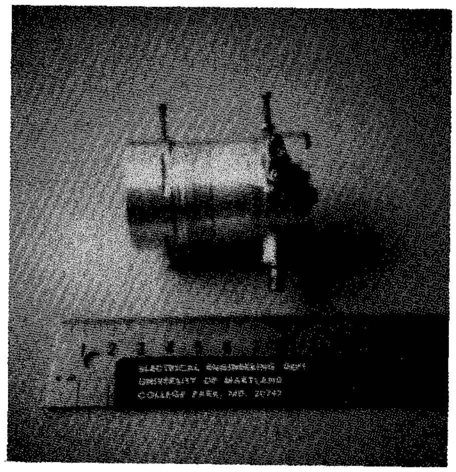

Fig. 7. Photograph of the experimental Filter

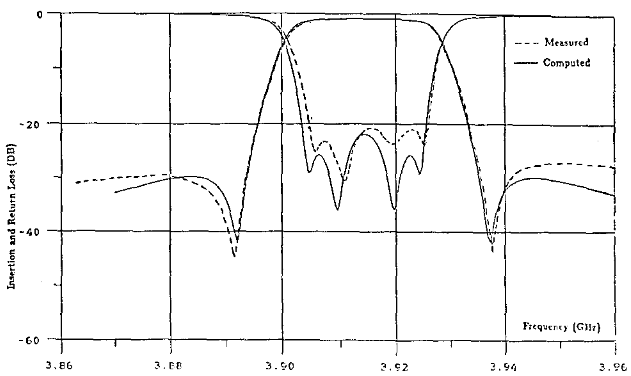

Fig. 8 Measured and computed insertion and return loss of the filter.

Table 1. Filters Parameters

Parameter	Canonical Filter	Longitudinal Filter
Center Frequency (GHz)	3.9145	3.920
Bandwidth (MHz)	21.0	47.0
Normalized input impedance R_1	1.300	1.150
Normalized output impedance R_2	1.300	1.150
Coupling Matrix M	0 .98 0 −.21 .98 0 .84 0 0 .84 0 .98 −.21 0 .98 0	0. .86 0 −0.26 .86 0. .80 0 0 .80 .0 .86 −0.26 0 .86 0

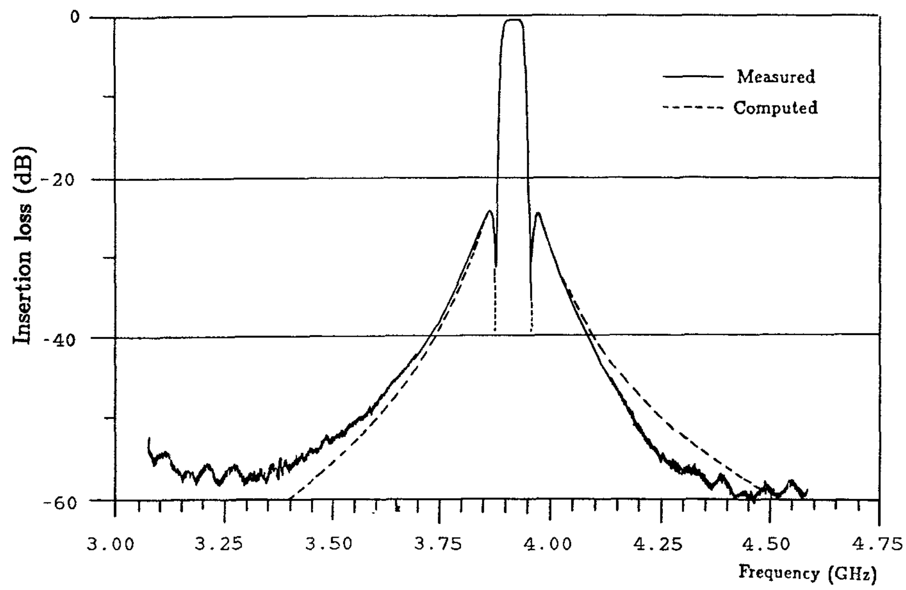

Fig. 9 Measured and computed insertion loss response of a 4-pole longitudinal dual mode dielectric resonator filter.

The total length of a canonical filter will depend on its bandwidth, but typically will be about 15% longer than a corresponding filter with iris. The longitudinal dual mode filters is longer than the canonical dual mode without iris due to the small value of M_{14}.

4. CONCLUSIONS

The novel realizations of the dual hybrid mode dielectric resonator filters described achieves the most optimum response, and simple inexpensive structures that do not require any iris. Measured results on the experimental 4-pole elliptic function filters are in excellent agreement with theoretical calculations. These realizations can open the door for using these high quality microwave filters in applications previously not possible because of high cost of the earlier known realizations.

Acknowledgment

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