DESIGN AND REALIZATION OF A FOUR POLE ELLIPTIC MICROWAVE FILTER USING LOW DIELECTRIC LOADED CAVITIES

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ABSTRACT

The aim to increase the ellectrica properties of high power narrow band width filters required for space applications leads us to propose an alternative to classical circular metallic cavities. The introduction of dielectric media in metallic cavities permits to obtain high unloaded quality factor in devices of reduced sizes. An experimental four pole dual mode elliptic filter is constructed using these resonators. The test results are in excellent agreement with the filtering objective.

INTRODUCTION

During the last years the electrical and mechanical requirements on filters placed in output multiplexers for space applications have become more and more demanding.

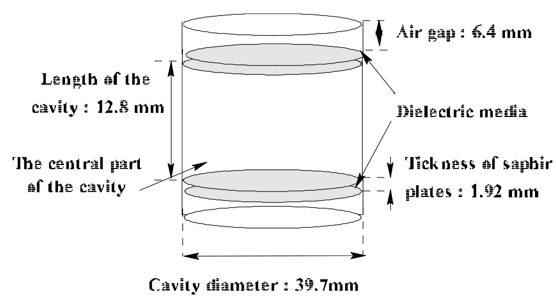
The reduction of scarce resources on a spacecraft like weight and volume has been constant. Dual mode circular waveguide filters are then usually employed for these applications because they provide minimum mass and volume for a given unloaded quality factor Q_0 and they are well suited for the filtering of high microwave power [1], [2]. Nowadays unloaded quality factors about 13 000 on the TE_{113} are obtained in a classical metallic cavity in the X band of frequency.

But for spatial applications it would be relevant to improve these values. Our aim is to propose an alternative to classical circular metallic cavities technique to improve their electrical performances for a given device bulk. A solution is known in which low losses dielectric media are introduced to reduce considerably the losses of classical metallic cavities [3].In this article, we couple two of these dielectric loaded cavity resonators to realize a four pole elliptic circular waveguide cavity filter.

I - MULTILAYERED CAVITY

To decrease efficiently losses on metallic surfaces, we have proposed to place λ/4 dielectric media between the resonant volume and the parallel plates of the cavity (figure 1).

The TE_{111} mode is excited in the structure. The electromagnetic fields are confined between the dielectric plates.



Presentation of the multilayered cavity
- Figure 1 -

	Empty cavity (TE113 mode)		Multilayered cavity	
	Simulated	Measured	Simulated	Measured
F_0 GHz	15.892	15.87	12.500	12.548
Q_0	9000	8502	15200	14600

D = 39.7 mm H = 12.8 mm Egap = 6.4 mm

Ediel = 1.92 mm F/tan = 1e5 GHz σ = 1.5*1e7 S/m

- Table 1 -

A low losses saphir material (real permitivity : 10 ; loss tangent : 10^{-4}) has been chosen and we have measured the electrical performances of this multilayered cavity. A comparison between the electrical performances of a classical cavity excited

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on the TE_{113} mode and this multilayered cavity excited on the TE_{111} mode is proposed in table 1. We can notice that for the same volume the multilayered cavity on the TE_{111} mode presents a higher Q_0 factor than a classical cavity on the TE_{113} mode.

II - EXCITATION OF TE_{111} MODE

At first, we have defined the topology of the structure (the D/Hratio, the number, the kind and the thickness of dielectric media) and optimized it to obtain a high Q_0 factor and a good isolation in the frequency band [10,95 - 12,75 GHz].

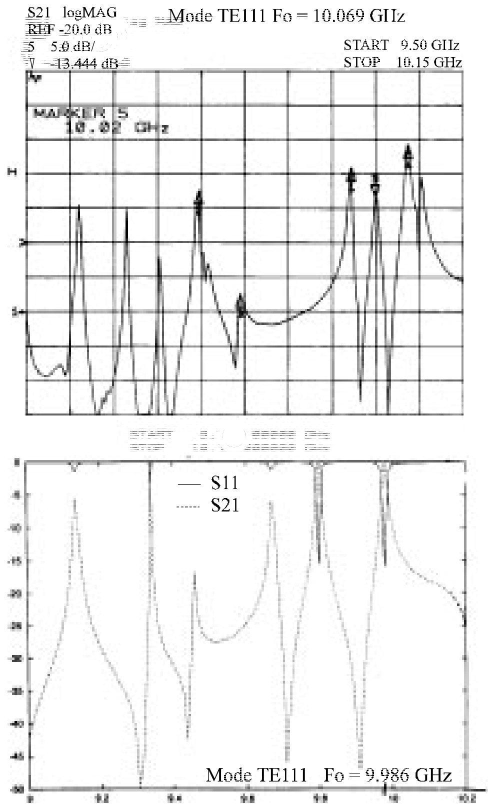
Let us consider that the cavity has its optimum dimensions (figure 1). Then we study the behaviour of the dielectric loaded resonator when it is excited on one of the two polarisations of the TE_{111} mode by rectangular metallic waveguides (WR 90) through rectangular irises.

Two solutions are proposed for the positioning of the waveguides. First, the rectangular waveguides are connected to the cylindrical wall of the multilayered cavity.

The figure 2 shows the evolution of the transmission coefficient as the function of the frequency for the multilayered cavity. As can be seen in theoretical and experimental results, spurious modes (resonance in the dielectric media) disturb the isolation of the mode TE_{111} in the frequency band of interest [10,95 GHz - 12,75 GHz]. Then the multilayered cavity is fed by two rectangular waveguides which are placed at the top and the bottom of the cavity (figure 6).

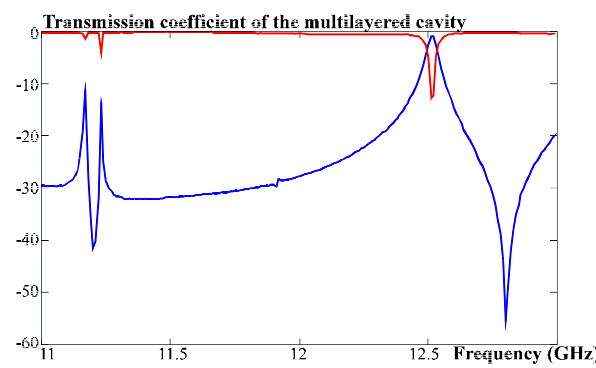
The isolation of the TE_{111} mode of the multilayered cavity can be now compared to the empty cavity one : the waveguide discontinuities are placed far away from the dielectric plates, and spurious modes, then are not at all excited in these media (figure 3).

The figure 4 shows the evolution of the external quality factor Q_e [4] as the function of the dimensions of the rectangular irises. The agreement between the measurement and the full wave finite element method [5] simulation is excellent. The levels of the input and output coupling are satisfaying for filtering applications.

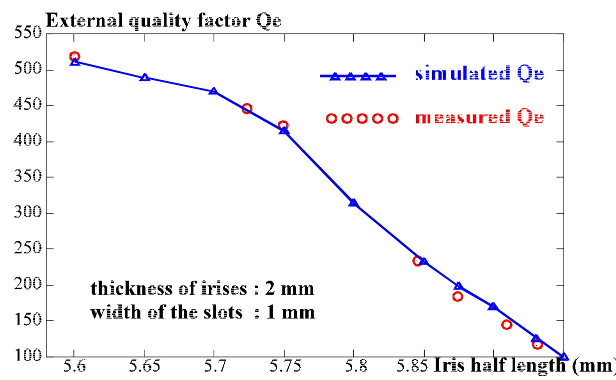


Transmission coefficient of the multilayered cavity

- Figure 2 -



- Figure 3 -



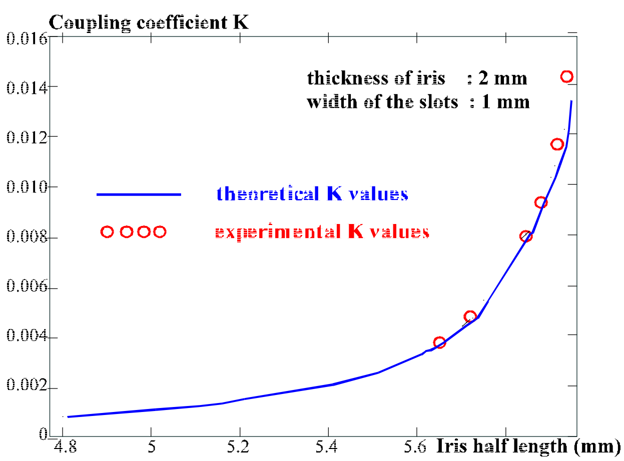
- Figure 4 -

III - COUPLING COEFFICIENT BETWEEN TWO MULTILAYERED CAVITIES

We must couple dielectric loaded resonators for filtering applications. A coupling coefficient k is then defined [6] to characterize the level of the field interaction between cavities.

We have shown that we can obtain a high coupling between each identical polarization of the two cavities through a rectangular iris without exciting the spurious modes in dielectric plates and modifying the resonator topology.

Theoretical and experimental k values variations as a function of the iris length are presented in figure†5.



- Figure 5 -

IV - FILTER DESIGN AND TEST RESULTS

The verification of the design expounded above has been accomplished by constructing a four-pole elliptic circular waveguide cavity filter.

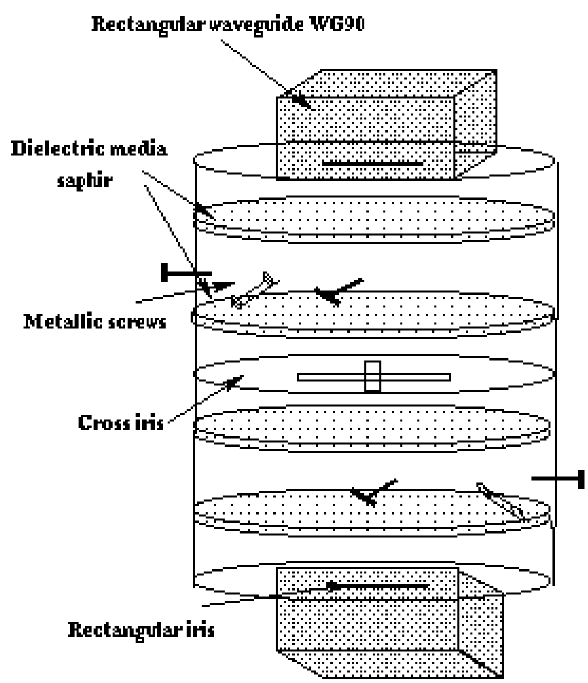
The desired electrical characteristics of the filter are :

Center frequency : 12,39 GHz
Bandwidth : 50 MHz
Minimum return losses : ≥22 dB
Out of band rejection : ≥15 dB

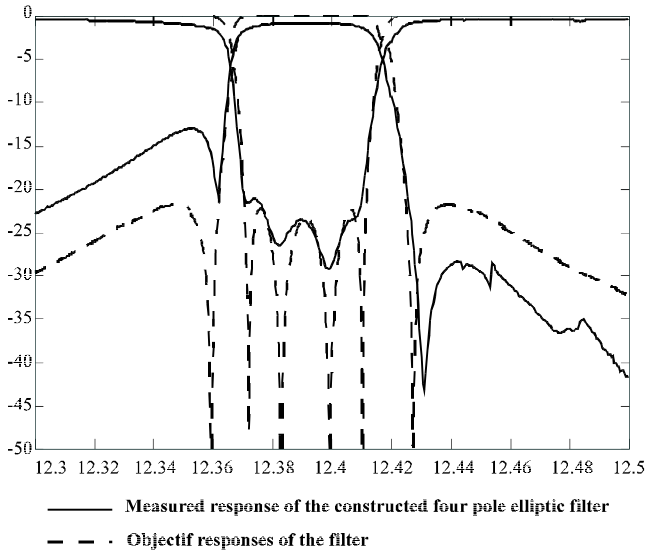
The figure 6 represents the design filter configuration.

The filter is composed of two circular multilayered cavities connected by two identical slots to the input and output rectangular waveguides (WR 90). A cross iris connects also both cavities. A classical technique, using metallic screws, is applied to modify the resonant frequencies, and to impose the directions of the two polarizations of the TE_{111} mode in each cavity.

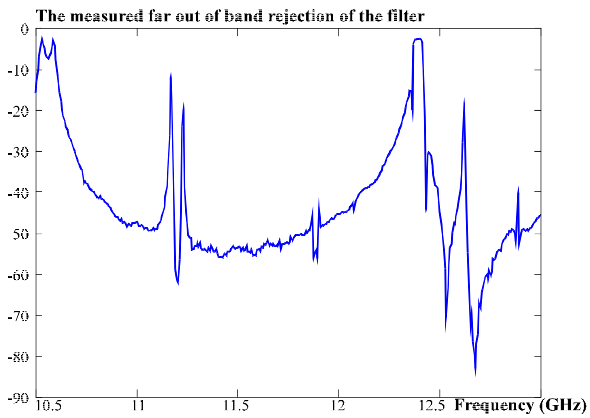
The designed filter enclosure was constructed on bass. Figure 7 represents the comparison between the measurement and the objective responses of the filter in its operational band. A good agreement between these responses is observed. Figure 8 presents the measured far out of band rejection of the constructed four pole elliptic filter. There is no spurious modes to disturb the responses of this filter in the frequency band [11,23 - 12,63 GHz].



- Figure 6 -



- Figure 7 -



- Figure 8 -

CONCLUSION

The introduction of dielectric interfaces in metallic cavities has show it efficiency [3]. The present study has permitted to display advantages in using dielectric loaded cavity for filtering applications. It permits to obtain high unloaded quality factor while reducing mass and volume devices.

The frequency isolation of the TE_{111} mode confined between the dielectric plates is similar to the empty cavity one.

The computer coupling coefficients are in fair agreement with the measured results. A four pole elliptic function filter is designed, constructed and tested. The measured frequency responses verify the theoretical requirements.

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