HIGH POWER C-BAND DIELECTRIC RESONATOR FILTERS FOR OUTPUT MULTIPLEXERS

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Abstract **— This paper presents a new type of Dielectric Resonator filter for space application with high power behavior. Two filters was built and tested under high RF power in space environment. We applied up to 150 Watts at the input of the first filter and until 280 watt at the input of the second without any mechanical or electrical degradation. Out-of-band carrier and multipactor tests were also performed on this last filter with very good results. Band pass Dielectric Resonator filters for Output Multiplexer (OMUX) applications could be then considered.**

I. INTRODUCTION

Dielectric resonators filters are commonly used in satellite payload, especially in the input C-band or Ku band multiplexers. Generally the DR are centered and held in position inside the metallic cavities with a low loss mounting [1]-[2]. If this conception fulfils perfectly the input section payload requirements, the severe constraints set by the high power in the output section make its using impossible up to few watts. In fact the DR is isolated in the middle of the cavity by a low calorific value material and the heat due to the dielectric losses can't be correctly evacuated so the temperature increases considerably until the deterioration of the filter.

If in the past the power uses on C-band satellite output section was relatively low (< 40 Watts), now satellites such as M2A require up to 120 Watts at the input of the OMUX filters which is quite unthinkable with classical DR filters.

ALCATEL SPACE INDUSTRIES in collaboration with the University of LIMOGES has developed and patented a new dual mode Dielectric Resonators filter design with high RF capability, high quality factor and significant reduction of the mass and the dimensions comparatively to conventional filters.

This paper presents the new DR topology, the filters design and the experimental results.

II. SQUARE PLATE DIELECTRIC RESONATOR PRINCIPLE

To evacuate easily the heat outside the DR it is preferable to have the DR in direct contact with the metal housing. Many solutions have been studied and the one that gave us very good results is shown in figure 1.

A square plate dielectric resonator is chamfered at the edges and mounted inside the cavity with a very good electrical and mechanical contacts [3].

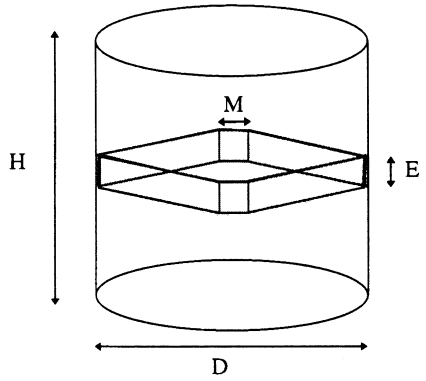


Fig. 1. Square plate DR principle.

The dimensions of the composite resonator were carefully studied in order to reach the best compromise between electrical and mechanical parameters.

The unloaded quality factor then obtained is greater than 13000.

Comparatively to the thin wall Invar cavities filter, the mass and the dimensions of the square plate DR cavities filter are reduced of about 50%. In the case of the OMUX the reduction of the mass and the footprint is respectively 40% and 58% (Measured on the 5 channels QM presented in chapter III-C)

III. HIGH POWER FILTER EXPERIMENTATION

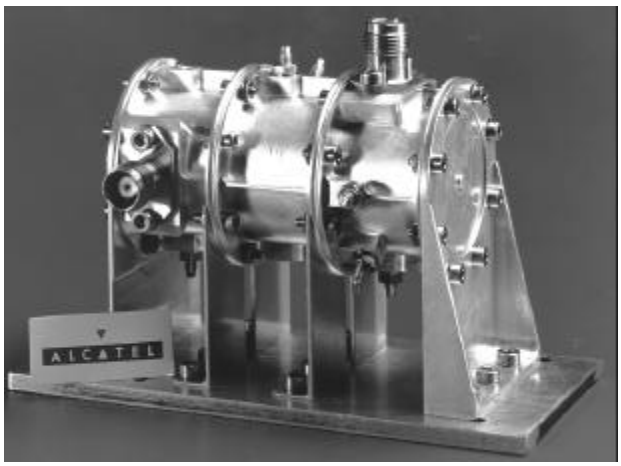
Two filters was designed. One 6 stages elegant breadboard with coaxial TNC input and output connectors, and one 5 stages qualification model with ½ WR 229 waveguide input and output. The first filter was tested under 150 Watts at center frequency. The second filter was tested until 280 watts at center frequency, 180 watts at out-of-band frequency (worst case thermal dissipation). Multipactor test was also conducted until 180 Watts.

A. Coaxial I/O 6 stages filter

We have designed a six stages quasi-elliptic filter with two transmission zeroes. The useful bandwidth is 36 MHz. The input and output connectors are high power TNC models.

The elegant breadboard filter is shown in the following photograph.

The measured electrical performances : Insertion losses, near selectivity and input/output return losses are shown in figures 2 and 3, respectively.



Coaxial I/O 6 stages DR filter

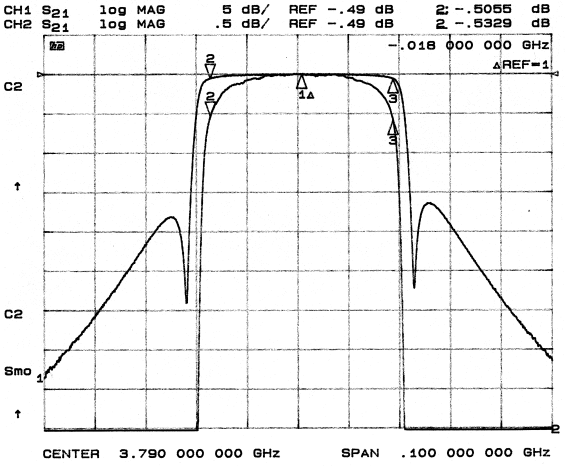


Fig. 2. Insertion Loss and selectivity.

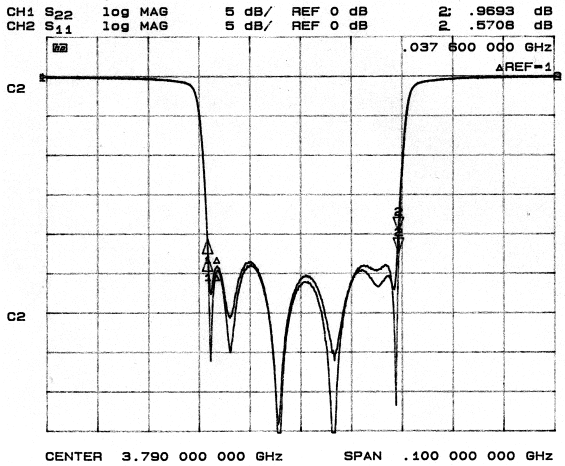


Fig. 3. Input and Output Return Losses.

The high power test was conducted under high vacuum by step of 25 Watts until 150 Watts. Each step had a duration of 1 hour minimum. One set of tests was performed at a temperature control (baseplate temperature) of 25 °C. and a second set at 65°C.

The comparison measurement of the filter before high power test and after each set of test shown that no variation of the electrical performances had occurred. At the end of the tests the filter was disassembled and carefully inspected. The control shown no degradation of any pieces.

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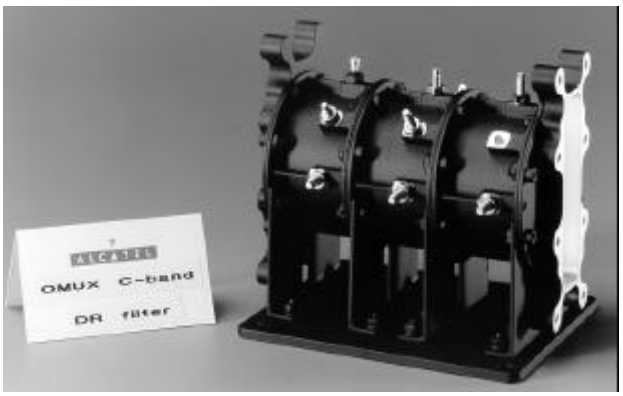
B. Half Height WR229 I/O 5 stages Filter

This filter is a five stages quasi-elliptic filter with two transmission zeroes. The useful bandwidth is 36 MHz. In order to feed this filter with a higher input power than the above filter we have replace the TNC I/O by ½ WR 229 I/O waveguide.

The qualification model filter is shown in the following photograph. Paint with a thermal emissivity of 0.9 was applied.



WR229 I/O 6 stages DR filter

Comparatively to the empty thin wall Invar cavities filter, the square plate DR filter has a reduced mass of 40 % and the volume is divided by 2.

The measured electrical performances : the near selectivity and the input return loss are given in figures 4 and 5, respectively.

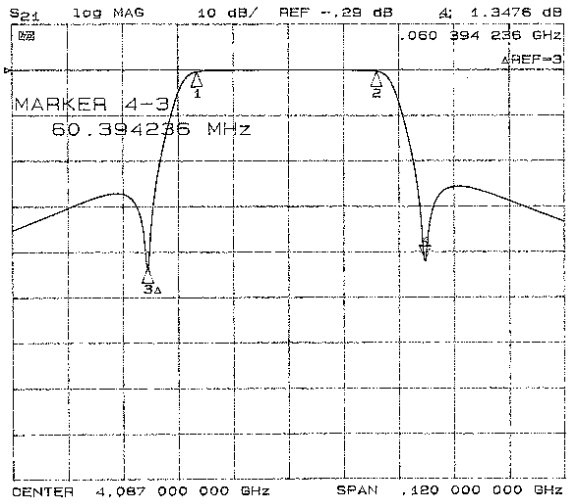


Fig. 4. Selectivity.

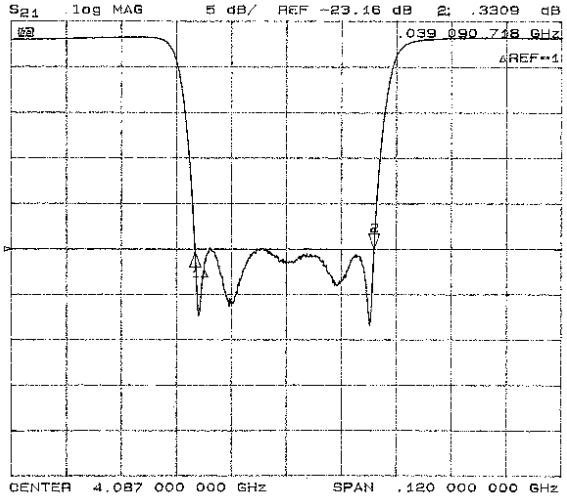


Fig. 5. Input Return Loss.

The following high power tests under vacuum have been performed:

1 Power handling at centre frequency until 140 Watts.

2 Out-of band power handling until 140 Watts.

3 Power handling at centre frequency until 280 Watts (test bench limit)

4 Out-of band power handling until 180 Watts (test bench limit)

5 Multipactor test until 180 watts.

The comparison of the initial and final tests shows that the electrical performances have not been modified during the environmental tests. The high power handling at center frequency and out-of-band frequency was demonstrated with respectively 180 et 280 Watts at the input of the filter. No degradation of the electrical performances was detected. No multipactor effect was detected during the multipactor test. Severe thermal and mechanical (vibration and shocks) tests were also performed on the QM filter.

All those tests were successful and demonstrate the feasibility of a C band high power OMUX.

C. *Five channel Output Multiplexer*

High power operation up to 180 W is now possible with this new technology. Alcatel Space has scheduled a development program to deliver high power Dielectric Resonators C-band OMUX.

A 5 channels qualification OMUX was tuned and tested under the most actual severe space environmental requirements :

-Thermal vacuum test,

-Mechanical test – vibration & shock (until 2000g).,

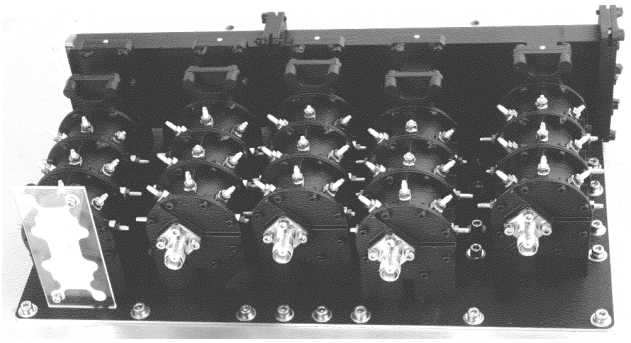
-High power handling test – at center frequency & out-of band at worst case thermal dissipation – under 80Watts,

-Multipactor test until 160 watts per channels

The high power tests were conducted at 25°C. and 85°C.

All the environmental tests were successfully conducted.

The following photograph and the figures 6 and 7 show the EQM and the electrical results of this Omux



Five channel EQM Omux

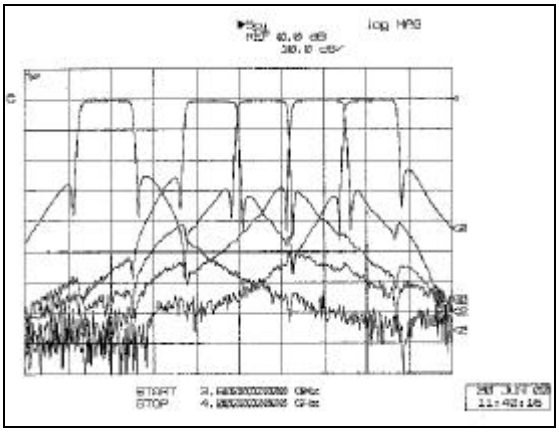


Fig. 6. Omux Selectivity

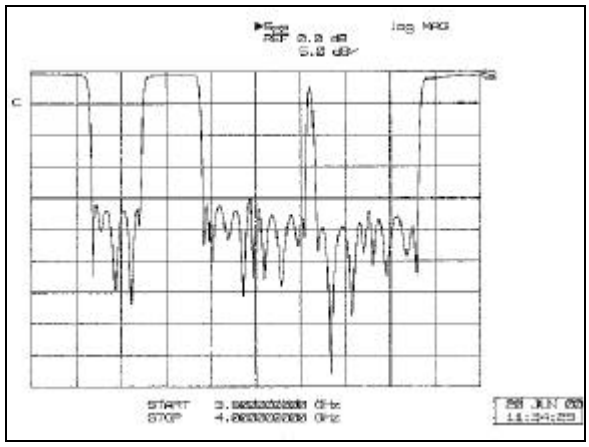


Fig. 7. Omux Output Return Loss

IV. CONCLUSION

A new DR filter has been designed and we have demonstrated the excellent thermal, mechanical and electrical behavior of the square plate DR principle during high power tests under vacuum and high qualification temperature conditions.

The feasibility of high power C-band Output Multiplexer is demonstrated.

Flight models (6 and 13 channels) are now under development and a delivery date planed mid 2001.

REFERENCES

[1] S.J. Fiedziuszko, "Dual-mode Dielectric Resonator Loaded Cavity Filters" *IEEE Trans. Microwave theory tech*. vol. MTT-30, N°. 9, September 1982.

[2] JM. Gueble, S. Vigneron, P. Guillon, "Study and design of dielectric resonators microwave filters" Extrait de la revue "*L'Onde Electrique*" September -October 1990, Vol. 70, n° 5.

[3] S. Moraud, Y. Latouche, "A new Dielectric Loaded Cavity for High Power Microwave Filtering" *IEEE MTT-S International Microwave Symposium Digest*, vol. 2, June 17-21 1996.