High power piezoelectric filters

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ABSTRACT

Radio communications and telecommunications systems designers require currently a higher power level at the filters input in order to increase the receiver sensitivity.

In this paper, we present new developments of piezoelectric filters designed with special cut angle quartz crystals and other materials such as Lithium Tantalate and Langasite, allowing to compare the power holding qualities of different cut and different piezoelectric materials.

INTRODUCTION

At a high drive level, the resonator no longer works in linear mode, The resonance frequency changes and in addition the Quality factor decreases. These two phenomena are very harmful to the correct behaviour of the filter, especially when a low group delay variation is mandatory. The reason is that a high drive level causes a phase distortion much more visible than the attenuation distortion .

The objective is to obtain a correct operation at 120 MHz with a + 13 dBm drive level.

AR-Electronique has studied the influence of the input power level on piezoelectric filters taking into account parameters such as frequency, piezoelectric material, cut angle and metallization as well as dimensions and load.

STATE OF THE ART

Standard quartz filters support actually only low drive levels of approximately 0.1 mW, i.e. –10 dBm on 50 Ω, and this depends on frequency.

If this level was sufficient in the past, the increasing of the receiver sensitivity require now an higher power ant that further more at higher frequencies.

In order to compare different realizations we have choose a well used frequency : 120 MHz.

QUARTZ AT CUT FUNDAMENTAL MODE

We have placed in a prominent position the surface state and the metallization holding quality.

We have compare 3 one pole filters at 120 MHz in fundamental mode.

We see on fig 1 the degradation of the response curve in Attenuation in step with input level.

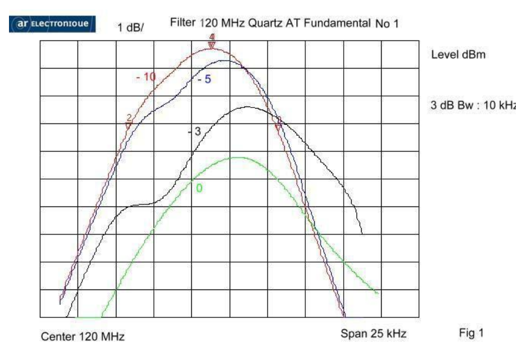

Fig 1

The filter is no more linear since – 5 dBm.

This is due to a very bad surface state of the blanks.

Fig 2 show a filter designed with a resonator having a good surface state but with a metallization not optimised.

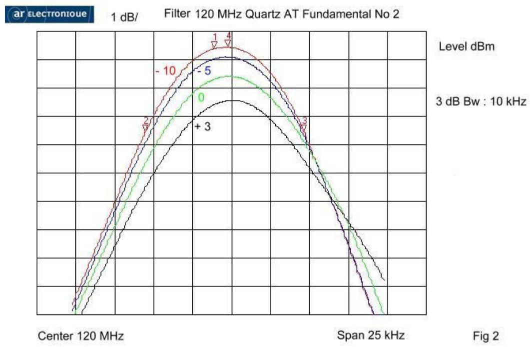

Fig 2

Fig 3 show a correct resonator, a real degradation start at + 3 dbm.

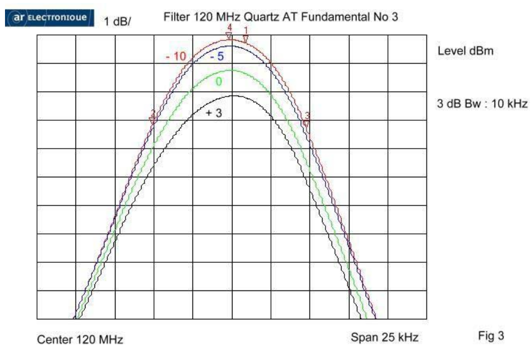

Fig 3

QUARTZ SC CUT 3 rd OVERTONE

The SC cut is well knowed to support high power.

We have optimised the cut and the metallization of the blanks in order to obtain a filter working correctly in a standard temperature range.

We can ascertain on Fig 4 that the transmission curve don't' change really up to + 17 dBm.

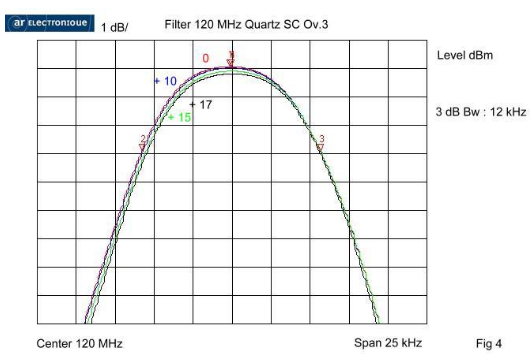

Fig 4

LANGASITE 3 rd OVERTONE

We have manufactured a filter with a Langasite resonator lapped with the ion beam technology and working in 3rd overtone at 120 MHz.

We observe on Fig 5 a degradation starting at + 15 dBm.

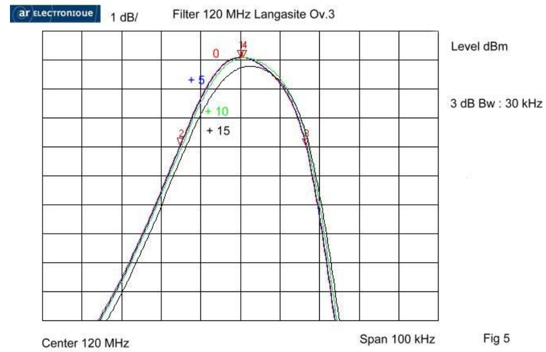

Fig 5

LITHIUM TANTALATE FUNDAMENTAL MODE

Always with the ion beam technology, we have designed a filter using a LiTaO3 resonator working in fundamental mode. This is because this material works correctly in temperature range only in this mode.

A small degradation of the response curve appears at + 17 dBm, see Fig 6 hereunder.

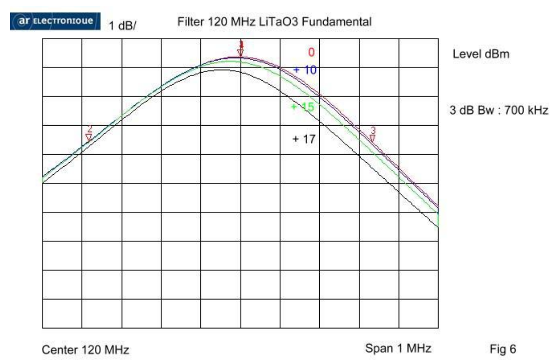

Fig 6

LANGASITE 5 th OVERTONE 200 MHz

In order to improve the working of a Langasite resonator at higher frequencies, we have opimized a filter using a Langasite resonator at 200 MHz in 5 th Overtone.

The responses curves are given on Fig 7. The filter is works relatively correctly up to 0 dBm.

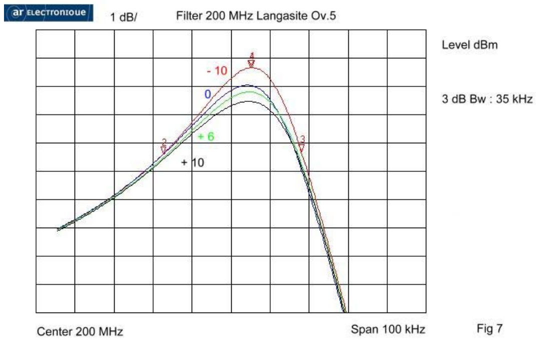

Fig 7

REAL MULTI-POLES FILTERS

On customer request, we have designed a 4 poles filter at 120 MHz with a very wide bandwidth : 140 kHz.
We have used 4 resonators in AT cut. We can see the power influence on the attenuation curves fig 8.

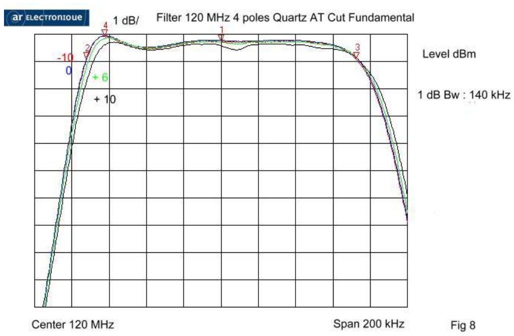

Fig 8

POWER INFLUENCE COMPARISON

In order to place in a prominent position the influence of the power on a real 4 poles AT Cut in fundamental mode filter, we have realized 2 filters at 120 MHz, 3dB Bw : 50 kHz with a specification of group delay variation very hard : < 2 µs in the bandwidth.
The power influence is more visible on the group delay as on the attenuation. In fact the phase change a lot with the power due to the non linear properties of the resonators.

The first example shows a filter designed with 2 monolithic in fundamental mode resonators with a standard process.
Curve fig 9 shows the amplitude variation with different input levels.

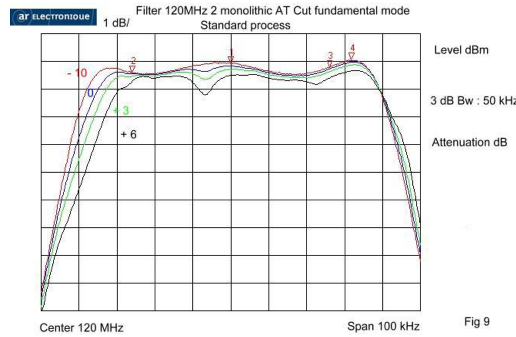

Fig 9

It is more spectacular to observe the phenomenon on the group delay variation fig 10.

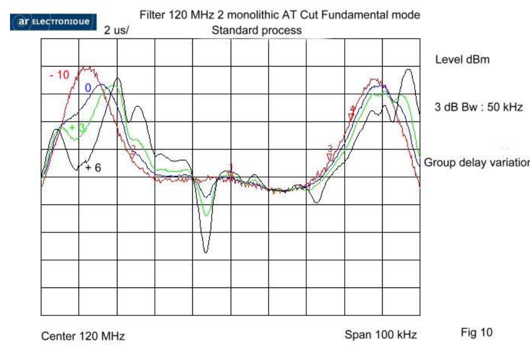

Fig 10

The second example shows the same filter designed with resonators manufactured with a special process in order to obtain an influence of the power more negligible.

Amplitude variation is presented fig 11.

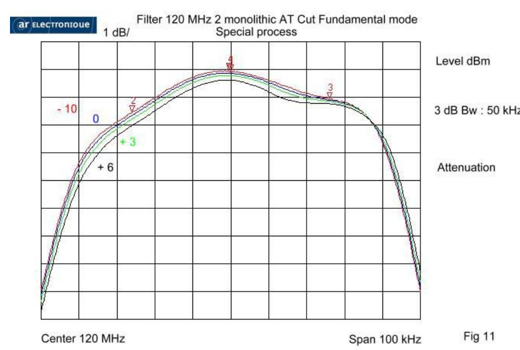

Fig 11

Group delay variation is presented fig 12.

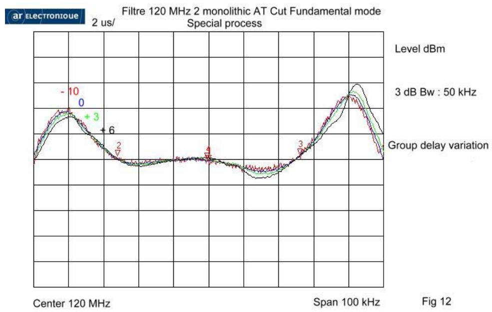

Fig 12

We can really observe the right working of the second filter at relatively high input level

CONCLUSION

Currently AR-Electronique has objectively demonstrated its capacity to produce high frequency filters working at high level.

We have different solutions depending of the bandwidth of the filters working for input levels higher than 0 dBm.

All these realizations demonstrate that there is possibilities to obtain filters working at high level.

We will continue our investigations on this subject by comparing multi-poles filters using other materials like Lithium Tantalate and Langasite and this in step with the relative bandwidth.

AR-Electronique is now involved in industrial manufacturing process of piezoelectric filters enduring high power depending of frequencies and bandwidths.