CIRCUIT DESIGN OF A MULTI-CUT-OFF FREQUENCIES COMPRESSION FILTER.

Sébastien VILALTE

August 25th 2004.

Laboratoire d'Annecy le Vieux de Physique des Particules
B.P. 110 74941 ANNECY-LE-VIEUX CEDEX France.
Phone : 33 4 50 09 16 00
Fax : 33 4 50 25 94 95
e-mail : vilalte@lapp.in2p3.fr

ABSTRACT:

The compression filter, which is described here, is an electronic developed for the VIRGO experiment. This electronic is able to make an output compression filtering for the demodulated signals. The existing filter is a mezzanine board, which performs two 2^{nd} order filters: the gain increases from 1 to 35,5 between 2Hz and 12Hz.

The multi-cut-off frequencies filter performs the same transfer function but the cut-off frequencies can be shifted from 2Hz-12Hz to 20Hz-120Hz and 200Hz-1200Hz. As it has to replace the existing filter, it has been implemented in a mezzanine version too.

The frequencies are selected using an input voltage level detection or manually on the front-panel.

CONTENTS:

1- <u>Introduction: principle and general description of the *compression filter*.</u>

The multi-cut-off frequencies compression filter is an upgrade of the already existing compression filter.

It is mounted in a mezzanine version on the demodulation boards to amplify the signal by a factor ≈35,5 since 12Hz frequency.
As the upgrade filters have to replace the old ones, we had to develop them in the same mezzanine configuration. The upgrade electronic has to perform the same functionalities in term of transfer function shape but with different couples of cut-off frequencies and with a bypass option:

- 2Hz-12Hz
- 20Hz-120Hz
- 200Hz-1200Hz
- Bypass

The frequency can be selected manually by the use of a rotary switch at the front panel or using an external analog level typically performed by a DAC: with threshold voltages of 0,5V ; 1,5V ; 2,5V ; 3,5V , the selection voltages to apply are 0V ; 1V ; 2V ; 3V and 4V.

As the amplifier is used in an inverter mode, the bypass mode has a –1 gain on the amplifier bandwidth (4,5MHz).

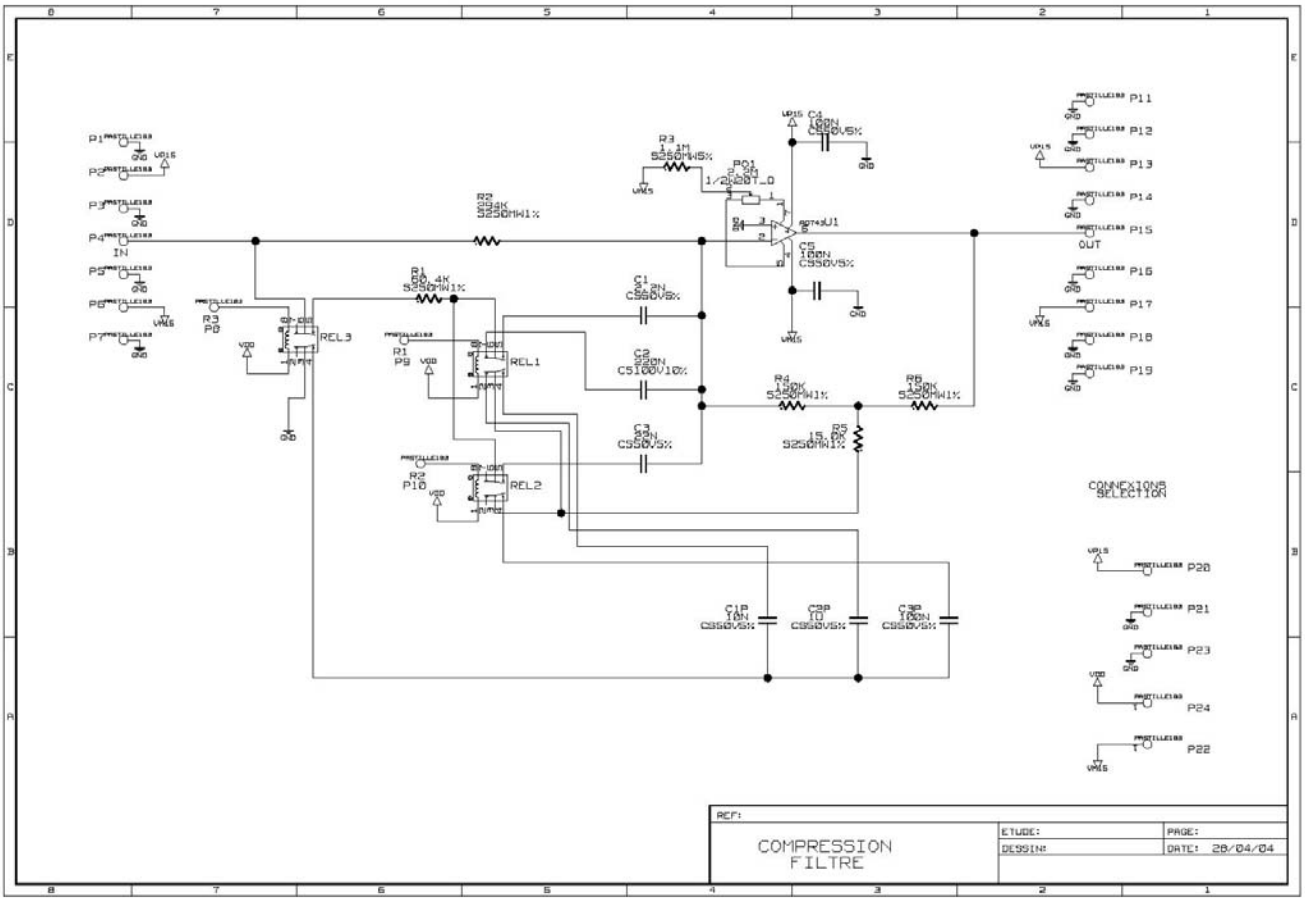
The new mezzanine cannot perform the functionalities with the same dimension board. So we implemented two mezzanines in two floors:
one for the filtering with components switching and one for the channel selection.

2- Technical description and solutions.

The signal is filtered using an active Op. amp. Filter.
Typically, capacitors are switched to slide cut-off frequencies using reed relays. We preferred to use relays than analogue switches (solid state) because of the switch resistance non-linearity. Their disadvantages are the dimensions and the power consumption.

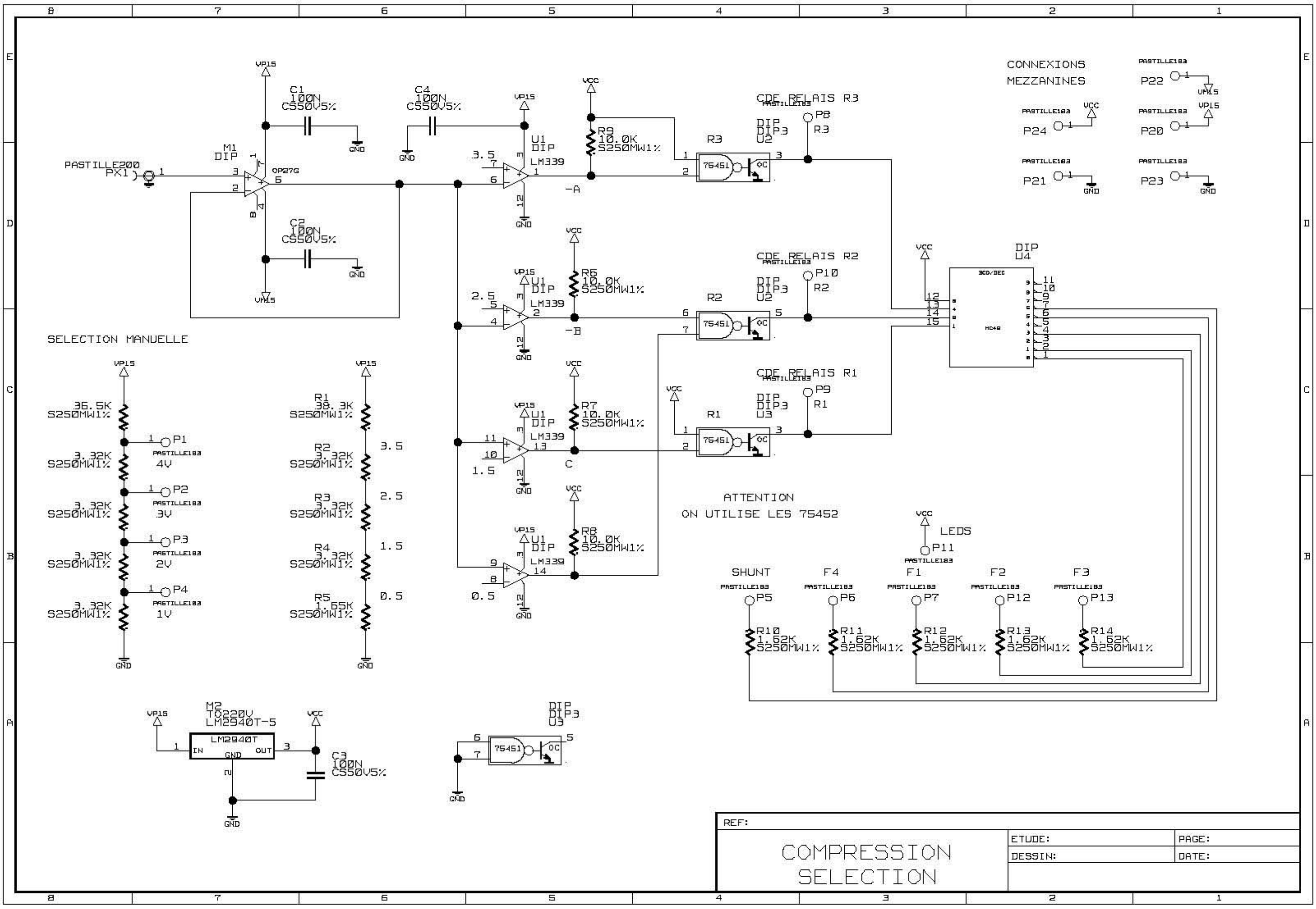
2-1 Compression mezzanine board:*(cf. following schematic)*

The mezzanine close to demodulation board is performing the different cut-off frequencies. Three commands allow to switch relays and so to switch capacitors for different cut-off frequencies: relays R1, R2 & R3.



The mezzanine on top directly generates these three commands: ***selection board***.

<u>***2-2 Selection mezzanine board:***</u>*(cf. following schematic)*



Whatever the type of external selection (manual or DAC), the selection voltage is compared to 4 threshold voltages (0,5V ; 1,5V ; 2,5V ; 3,5V) performed using resistors bridge. So, at the output of the 4 comparators, we have a 4 bits digital word, which can be decoded to control the relays (cf. ABCD).

We used an OP27 op-amp in a follower mode to buffer the input signal.

In fact, with 4 bits we will obtain 4 cut-off frequencies.
We will see two are very closed due to the capacitances.

In the following table, we have the output comparators states (ABCD) and the corresponding relays states (R1, R2, R3) for the different input levels.
1 indicates the relay is closed, 0 indicates it is open and X indicates the state has no importance for the output signal.
Vcde is the input selection voltage.

Vcde	Channel	A	B	C	D	R3	R1	R2
4 V	bypass	1	1	1	1	0	X	X
3 V	F4	0	1	1	1	1	1	0
2 V	F3	0	0	1	1	1	1	1
1 V	F2	0	0	0	1	1	0	1
0 V	F1	0	0	0	0	1	0	0

Because of the relays coil consumption, we used buffers to control them. The open collector buffer SN75452 is used as a serial switch for the coil supply. As it performs a NAND operation too, we didn't have to use digital parts and we decoded the relays controls as follows:

$$R3=\overline{A}$$

$$R1=C$$

$$R2=\overline{B}.D$$

The comparators outputs have been decoded using a BCD to decimal converter to control the front panel DELs that indicate the active channel.

The following table indicates the selected equivalent capacitances for the different channels:

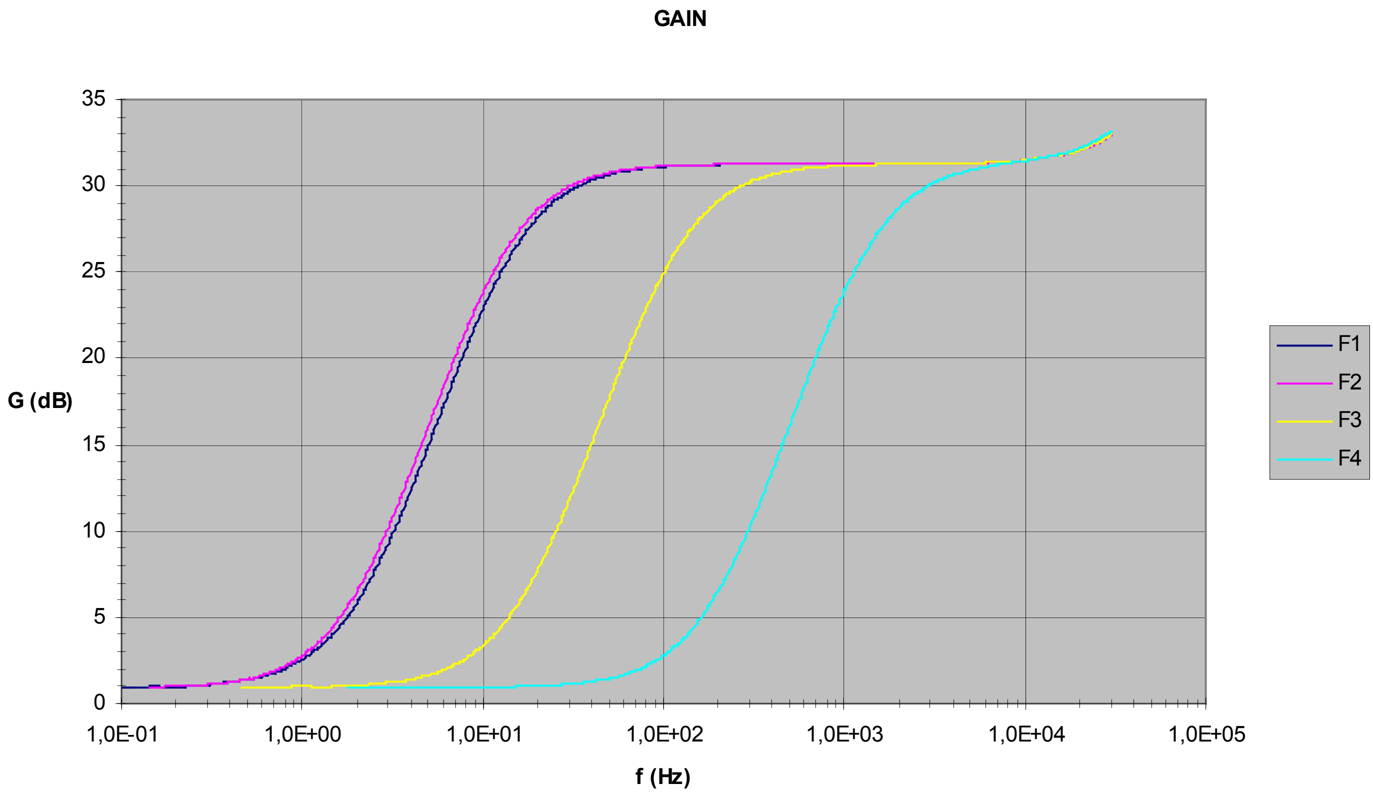
Vcde	Channel	Equivalent capacitance
4 V	bypass	bypass
3 V	F4	C1 & C1p
2 V	F3	C1 //C3 & C1p //C3p
1 V	F2	C2 //C3 & C2p //C3p
0 V	F1	C2 & C2p

3- ***Tests & finalising.***

Transfer functions:

We performed transfer functions using a frequency analyser.

The F1 and F2 curves are very close because C2#C2//C3 and C2p#C2p//C3p



The obtained cut-off frequencies and gains are those foreseen.

4- **Conclusions.**

This filter is designed to replace the existing compression filter without any change on the demodulation board except for the front panel.

So, It will be easy to integrate to any beam demodulation.
The different cut-off frequencies will allow to adapt online the compression to the different signals at the outputs of the interferometer.