APN 002 Damping oscillator distortion

In measurement systems today, the limiting element is the oscillator.
Modern DACs reaches about -108dB THD and Wien-Bridge RC-oscillators can be as low as -115dB THD, but with difficulties getting the level stable.

An approach to overcome this distortion limits is to filter it down (see fig.1).

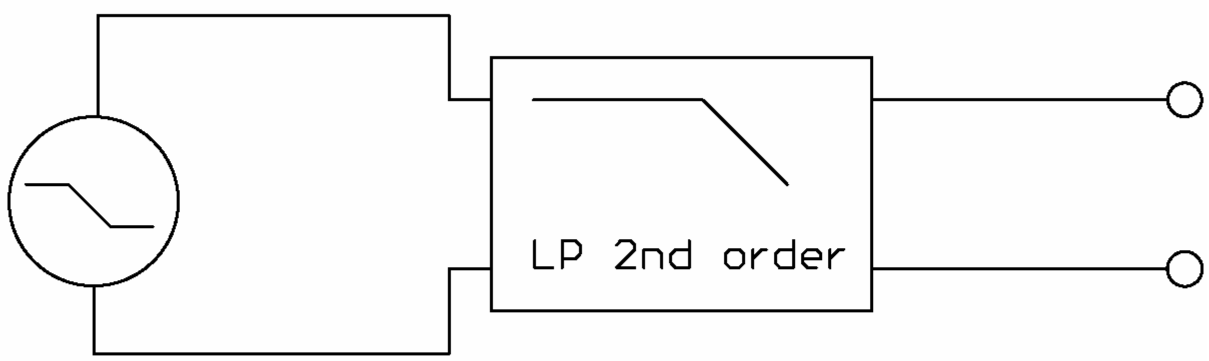

fig. 1

But if an oscillator with tunable frequency is needed, almost all 2nd order active filters became hard to tune (Sallen key or MFB).

One solution is the State-Variable-Filter (SVF) architecture, where only 2 resistors need to be changed for small steps in frequency, or 2 capacitors for range settings.

Unfortunately, nobody has published THD measurements on this filter.

Since 2009, there are OPAMPS available with vanishing low distortion, the LM4562 and the LME497xx series by National Semi.

With this opamps, it’s possible to push k2 down by ~25dB and k3 by ~30dB.

Another advantage in the use of an SVF is to set Q without affecting f.
In this APN, Q was set to ~10, so frequencys below **and** above the Lowpass frequency are also damped (see fig.3). This decreases noise in the interesting audio band and makes it easier to detect harmonics in the FFT.

If you zoom into the transition band, you will see that the -3dB corners are at about +/- 5 % of the tuned frequency and -6dB is about +/- 10%. This gives the chance to use bigger stepsize in tunable filters, as the gain loss can be calculated and be compensated by more (or less) input gain to get the same output gain.

e.g. If you use a DAC, you can use the same filter components (and not to switch the tuned frequency of the filter) to produce fine stepped frequencys. If using a tuned freq. of 1kHz, the DACs output freq. can be 900-1100 Hz without changing the filters frequency.

As it can bee seen in the measurement diagrams, distortion levels below -130dB can be achieved with this approach.

All measurements were taken on a simple breadboard, therefore the noise in the freq. range 0-200Hz is a bit higher than using a standard PCB.

Shematic and Freq. response

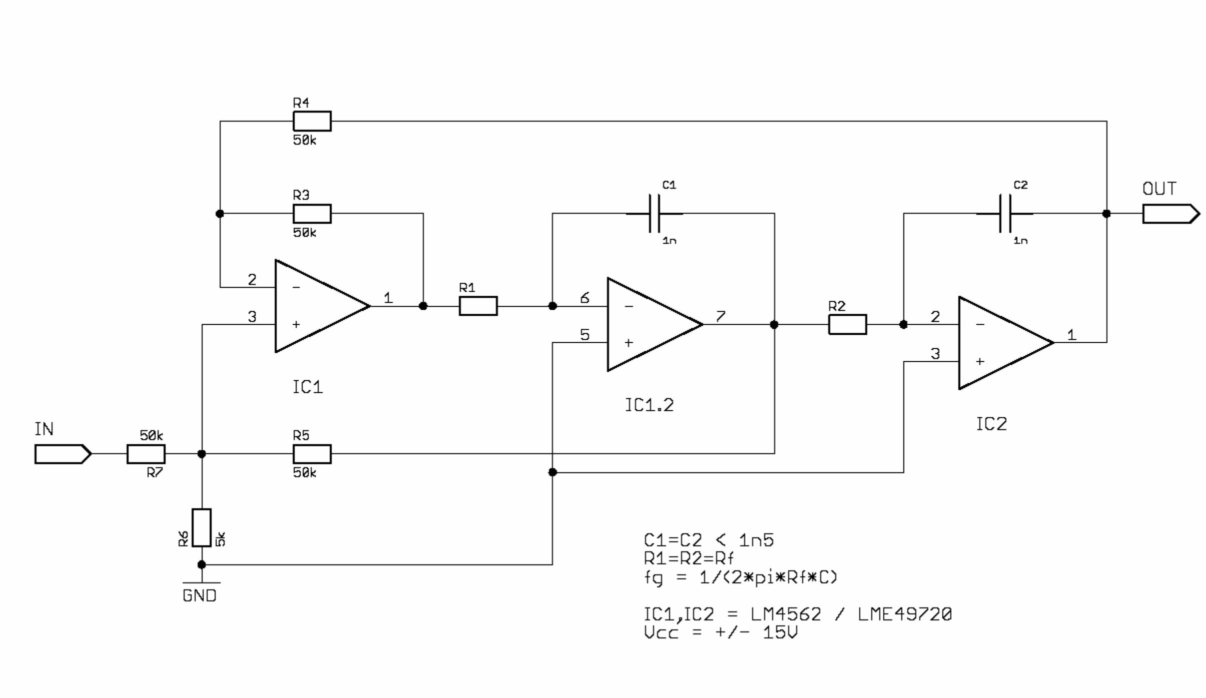

fig. 2

The shematic can bee seen in fig.2
This is a standard State-Variable-Filter with Q ~ 10 in Lowpass configuration. Keep in mind, that C1 and C2 should be not higher in value than 1n5, else the Opamp output has difficulties to drive the cap and introduces distortion.

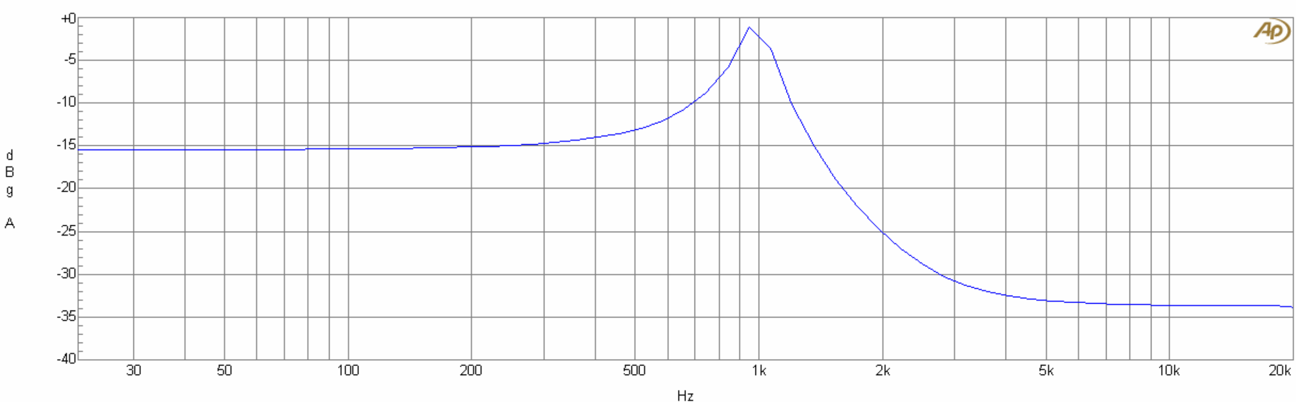

fig. 3

In fig.3, the frequency response is shown (1kHz filter).

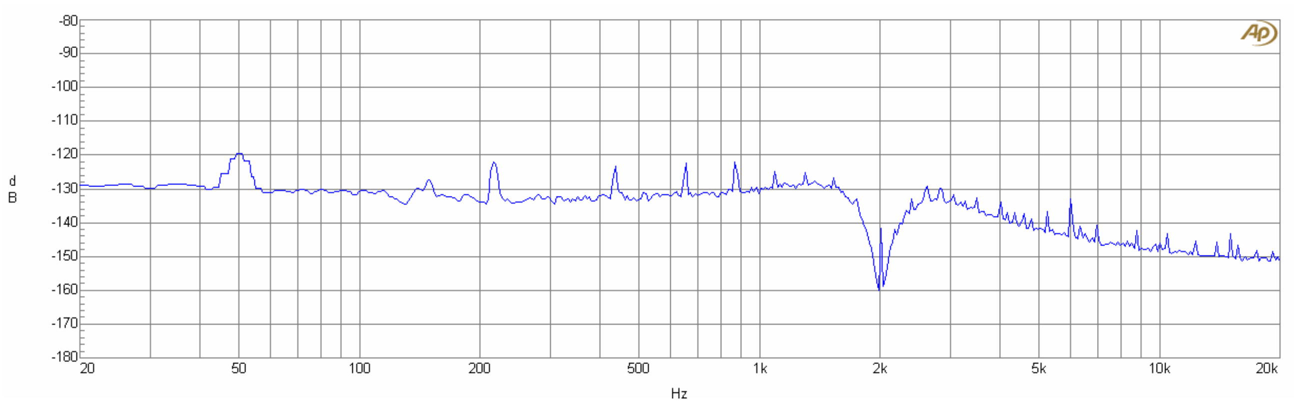

fig. 4

In fig.4, the LP is set to 2kHz and a 2kHz testone with 3.5Vrms is applied to its input.
The notch behaviour at 2kHz is the notch in the measurement system.
As it can be seen, k2 (4kHz) and k3 (6kHz) are well below 130dB. This FFT was 32 times averaged to get viewable results. OP used was the LM4562.
The LM4562 has a distortion of ~ -130dB @ 2kHz (datasheet)

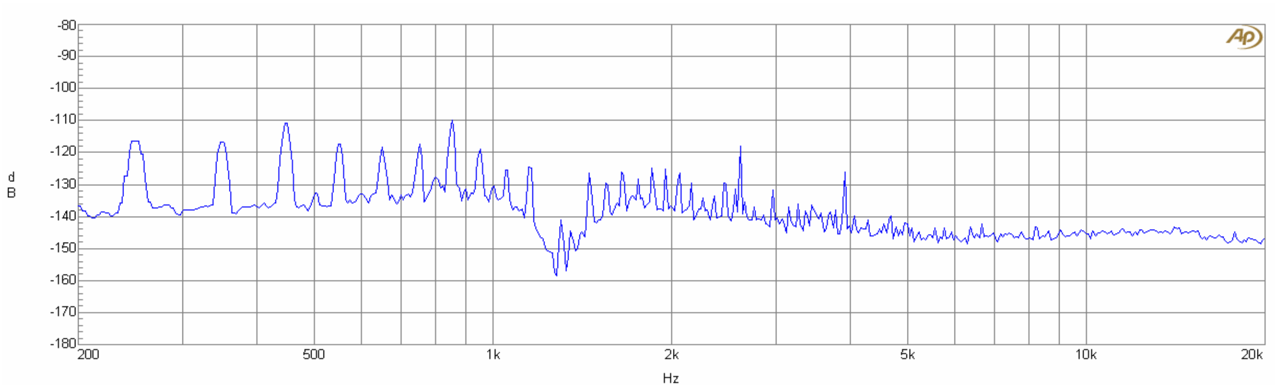

fig. 5

In fig.5, the LP is set to 1.3kHz and a 1.3kHz testone with 2.0Vrms is applied to its input.
As it can be seen, k2 (2.6kHz) and k3 (3.9kHz) are below 120dB. This FFT was 32 times averaged to get viewable results. OP used was the OPA134.
The OPA134 has a distortion of ~ -120dB @ 1.3kHz & 2V (datasheet)

Amplitude	Distortion	comment	OpAmp
1 Vrms	< -125 dB	Dist. not detectable, noise to high	LM4562
2 Vrms	< -130 dB		LM4562
3 Vrms	< -130 dB		LM4562
5 Vrms	- 125dB	almost K3	LM4562
2 Vrms	- 120dB		OPA134
1 Vrms	- 105dB		UAF42