Following tests are all 24 bit file, 44.1, digital loopback tests that never went through any A/D or D/A conversion, but did go through the Windows 32 bit float audio stack.

This multi tone test stimulus generated with REW, 24 bit 44.1 with dither, was used. Distortion components are >170 dB down. Ignore the noise floor, it has FFT gain, but it's "way down there"
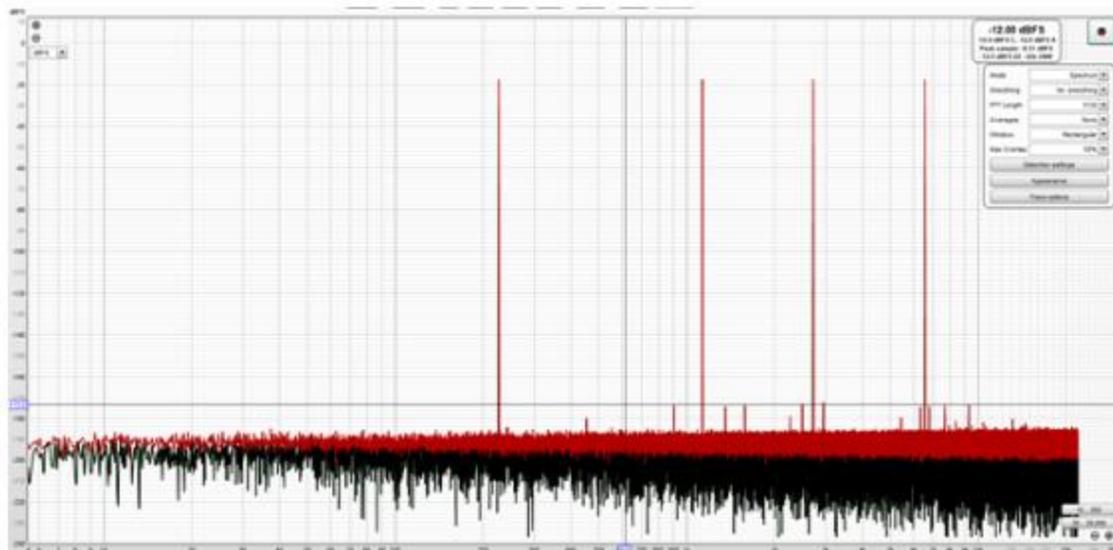
It was then played through the Windows audio stack on my family Dell tower XPS8300, with no volume, no filters, all system sounds off, all effects disabled etc:
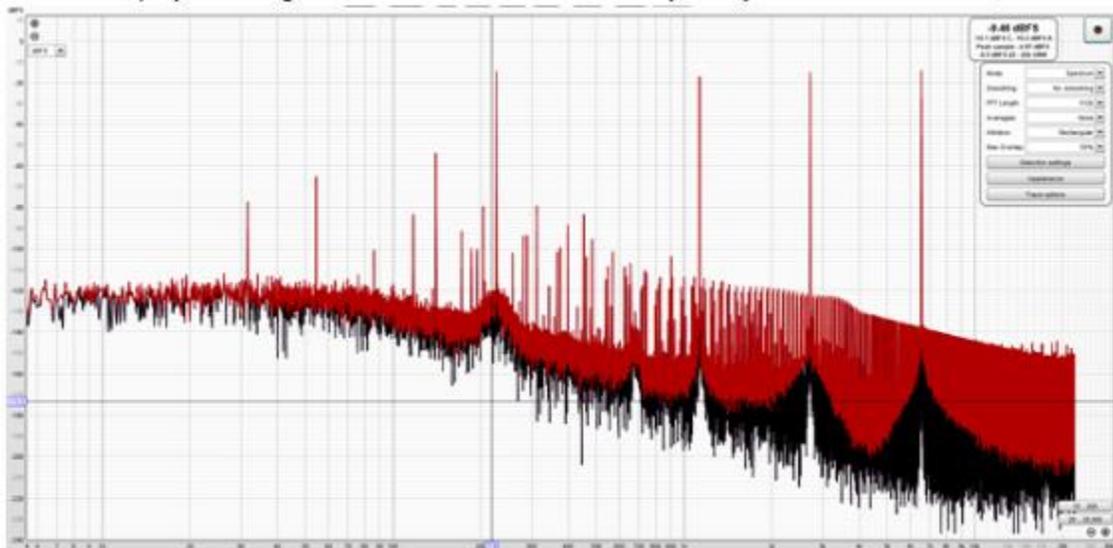

Some hidden non defeatable APO made a mess of it. In casual listening my wife and kids don't notice, but it was easily audible to me. My music system and work PCs don't show this issue, so it's probably tied to an APO for the Dell realtek soundcard. This isn't a one off by any means,

my Tower was highly spec'ed but very common model and brand. I investigated this on line and others have had similar issues with laptops, gaming rigs etc.

To verify the measurement, it was retested with a different spectrum analyzer and the tones playback lowering level (to make sure it wasn't intermediate clipping). Same outcome.

I then installed (free) Equalizer APO (EAPO), and used it to turn off all "original" (stock) system APOs. Bit perfect through the windows audio stack:
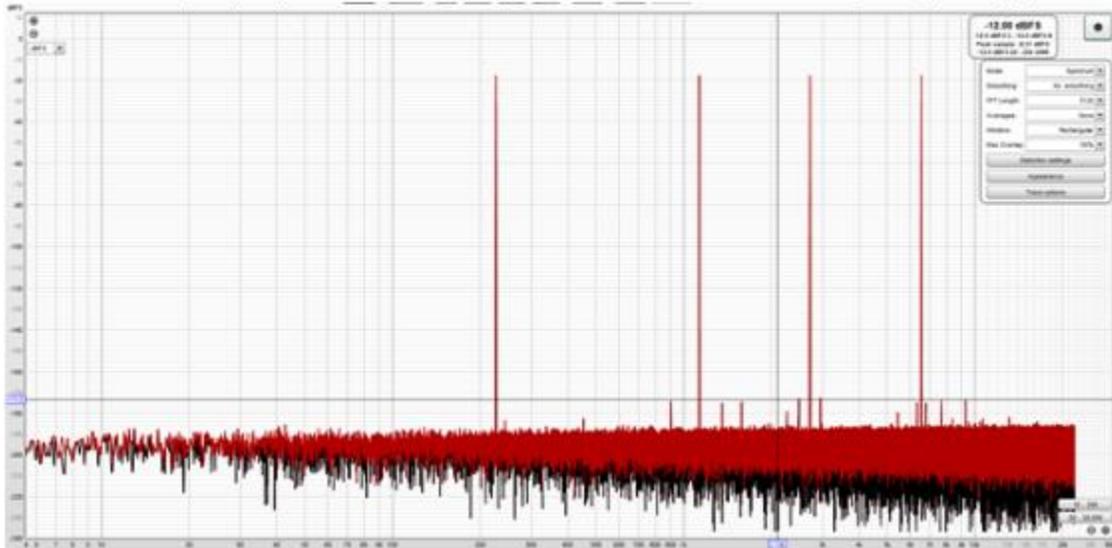

But not out of the woods yet.

Benchmark raised awareness of intersample overs causing distortion with the upsampling inside modern dacs, but there are two other hidden sources of distortion with digital audio:
- high pass filtering changes phase that changes the envelope and can easily increase peak levels. eg https://homerecording.com/bbs/general-discussions/digital-recording-and-computers/high-pass-filter-produces-clipping-348346/#post3939637
- Windows has a little known Audio limiter (CAudioLimiter) as a stack output APO that compresses the system mixer's output to </= -0.12dB.   Modern Cds/downloads easily have peaks at 0 dBFS, & any high pass filtering (sub/sats) can push levels into the danger zone even if starting at lower levels.

Here's another test demonstrating CAudioLimiter.   REW was used to generate a single test tone @ 0 dBFS, 24 bit. The first distortion component is ~ -160 dB (again ignore noise floor due to FFT gain):
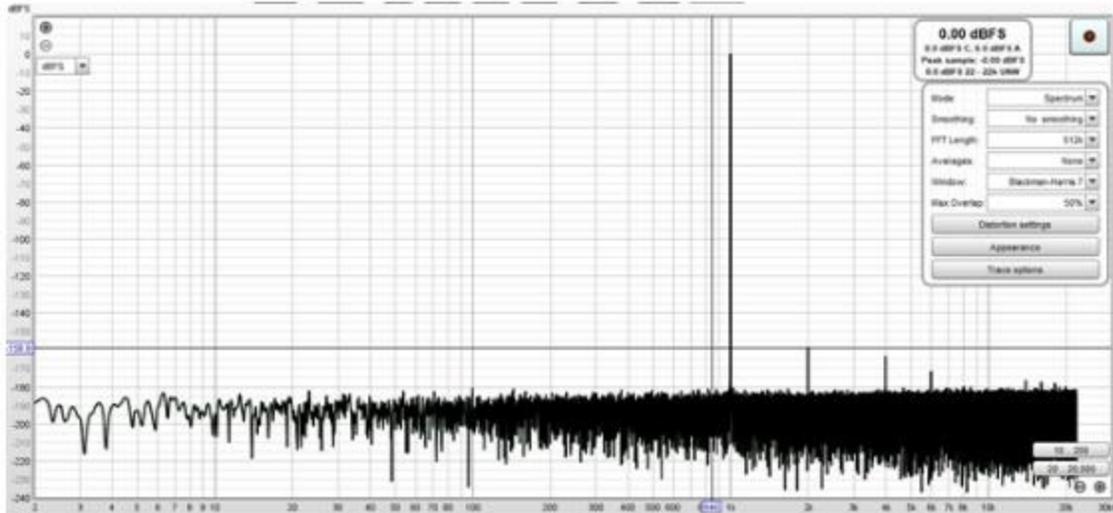
Here's CAudioLimiter's nasty fingerprint when this is played back without any loss. See how the limiter knocks the output down to -0.12 dBFS but adds a spray of distortion:
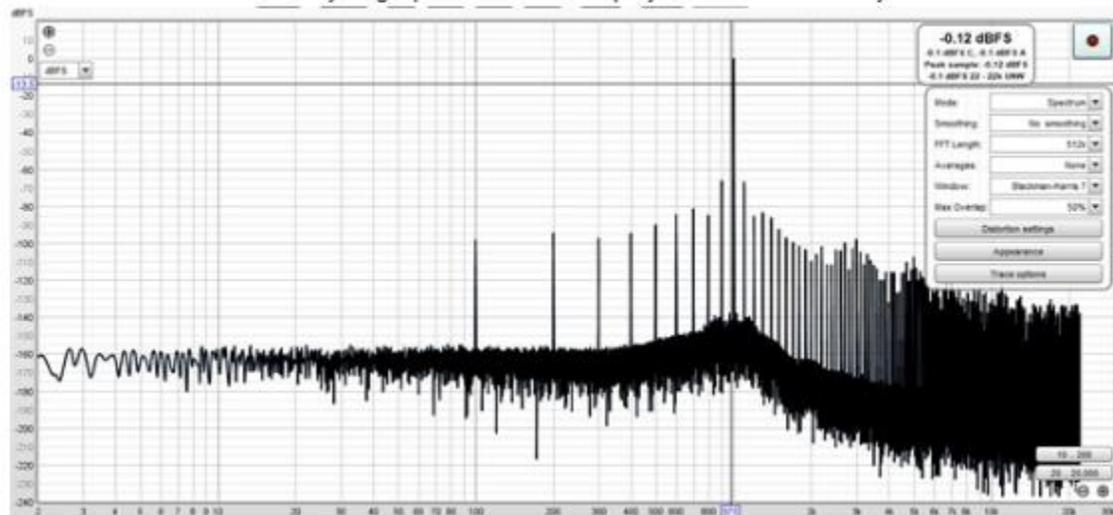
Using EAPO as an input APO, I then dialed in 0.2 dB loss. This completely avoids the CAudioLimiter. I think 150 dB dynamic range to the first distortion component should be good enough for even the fussiest audio junkie:
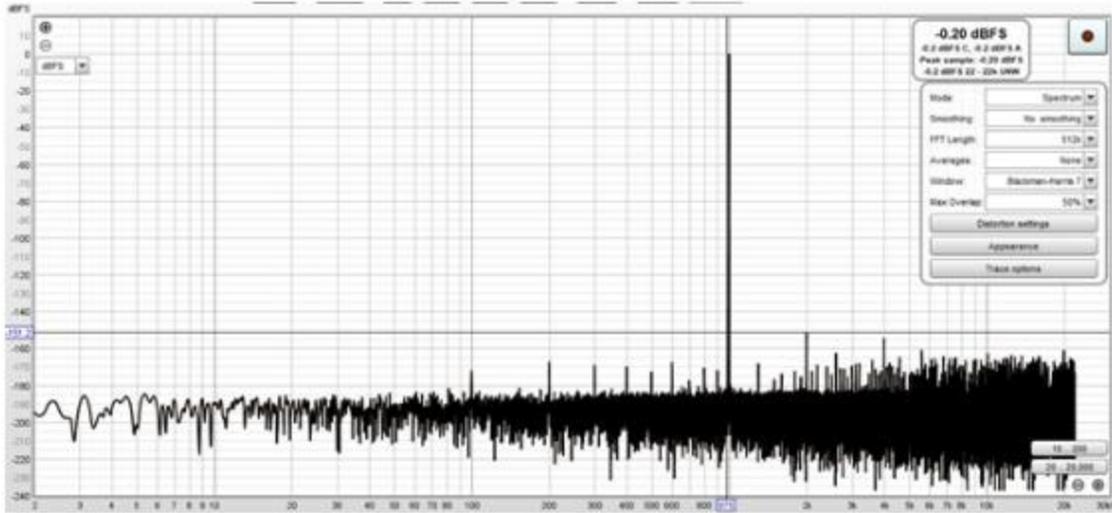
Windows audio gets a deserved bad rap because of possible hidden APOs and because of the always resident CAudioLimiter, exacerbated by high pass filtering. The flame wars get out of control as this is quite audible, but the bits are bits crowd haven't done their homework.

Over time, common practice has become to use Wasapi exclusive or ASIO to avoid Windows audio stack completely, to get "bit perfect".   But that's a huge lost opportunity, we can get better than bit perfect, for free.   Wasapi and ASIO don't support room equalization (or headphone eq, or for recordings with questionable tonal balance or...) unless using an external digital filter (eg RME dac ($$$), dBX processor etc). But even that's not a real high end solution because external digital EQ has HW limited tap counts, and limited frequency resolution at low frequencies. Windows is a far more powerful and higher performing equalizer if set up correctly:
- disable native APOs using (the free) EAPO or test to ensure they're nothing there
- set Windows audio to 24 bits, turn off system sounds etc
- set playback pre gain at ~ -4 dB to avoid the limiter with any filtering, and to avoid intersample overs in the dac chip itself. No need to buy a Benchmark DAC($$$), now free to buy any good USB dac.

Next I tested EAPO with this complex filter set just to make sure that more complex EAPO filtering didn't add noise or distortion.:
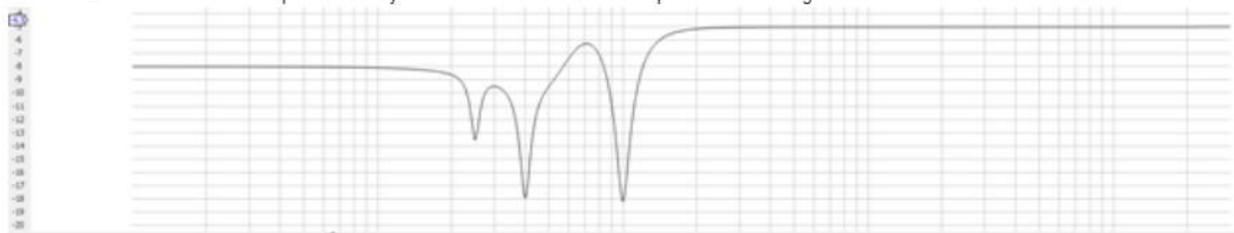
Here's EAPOs digital output with the prior 4 tone REW test stimulus. Faultless, as expected from 32bit float:
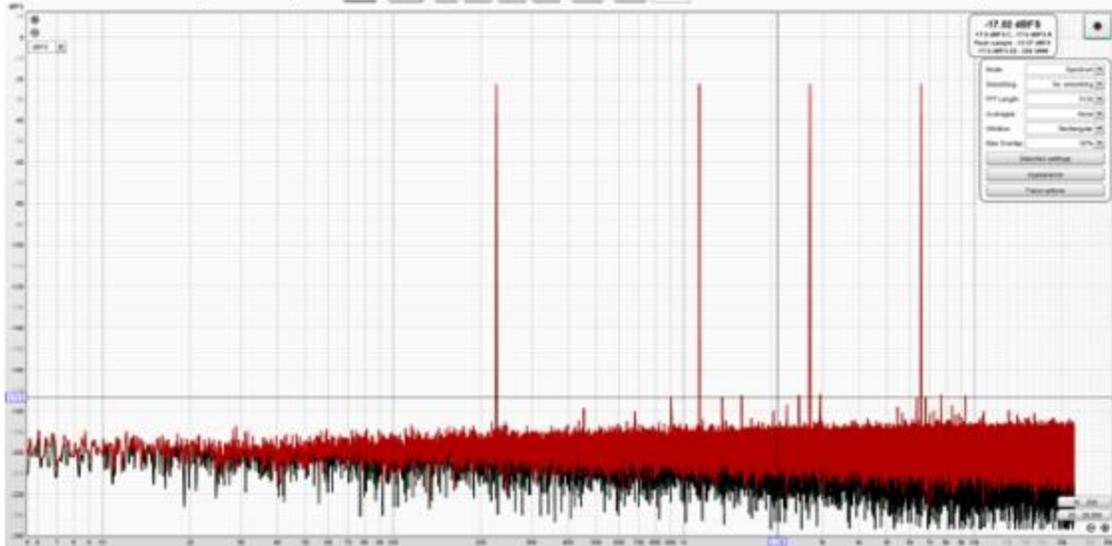
Room correction, headphone EQ etc using REW and EAPO, properly set up, massively increases fidelity beyond any tweak or lateral electronic equipment upgrade. And its global, supporting all streaming sources (Tidal, Qobuz ...) , local files, DLNA, everything. All from a $300 lap top, and external usb dac.

I also own a pile of vinyl and a nice table. For this, I bought a nice external USB A/D (tested in loopback shows >100 dB SNR which blows away the performance of any RIAA pre in front of it), and plumb that through EAPO and get all the same benefits from vinyl. There are a few tricks to get this right, but that's another email.

It's too bad that all this isn't better known, because clean faultless (free) equalization like this provides enormous pleasure and fidelity improvement that I think any open minded audio fan could get behind, and is cheap as chips and sounds amazing.