

Listening Comparison Of Digital Audio Filters

Having had the opportunity to compare Pacific Microsonics PMD-100, PMD-200 and Burr Brown DF1704 filters in parts improved Assemblage DAC-3.0 and 3.1, I feel compelled to report significant differences I heard between these filters. Many have proposed that the most significant differences in digital sound would come from the particular filtering strategies used. Given a generally high quality platform in which to explore the sonic effects of the different filters, it does appear that filters are responsible for very significant differences in sound quality.

Let me state that this is not intended to be a scientific experiment, but subjective evaluations by one or two open-minded listeners. I have little doubt that these same differences and preferences could be easily shown in double blind perception experiments. The filter and DAC designers have presumably performed such experiments in addition to informal listening tests.

Filter Background

A little background on the role of these filters will help frame their role and importance. When an analog audio signal, such as sounds from microphone, are converted to digital and from digital back to analog, one of the side effects of the conversion are *aliases* or *images*. These images or aliases are duplicates of the original signal shifted up in frequency by the (over)-sampling frequency. The purpose of the *reconstruction* filter, also known as an *anti-aliasing* or *anti-imaging* filter is to remove these frequency shifted images.

Early CD players and digital recorders often implemented these filters as extremely steep "brick wall" analog filters with a high number of poles and a lot of potential for phase shift and ringing. Either of these could result in difficulty for the electronics that followed and possibly audible artifacts for the listener for example caused by excess and unnatural ultrasonic energy or altering the phase information in the reconstructed signal.

Many people suspected that brick wall filters damaged sound and that better filtering would do less damage. For example, Philips, co-inventors of the Compact Disc with Sony, recognized this problem and used digital domain Bessel filters followed by gentle analog filters in their early CD players. It was felt that this combination of Bessel and low-order analog filters would do a better job of preserving phase information of the audio signal than steep brick wall filters, and listening tests of the time seemed to confirm this. It's worth mentioning that this division of labor between filters is also more "natural" in that the digital filters are asked to do what they're good at, such as steep cutoffs with little phase shift, and the more gentle analog filters mean fewer unwanted analog side effects. Current reconstruction filters generally follow this model of digital filtering followed by gentle analog filters. All filters in this review follow this pattern, for example.

Oversampling also plays a major role in this story. Oversampling moves the aliases higher in

frequency so that a more gentle (less steep) analog filter can be used. For example, with 8 times oversampling common in digital filters today, the first alias of 44.1 kHz CDs appears at 176.4 kHz. A filter that needs to roll off a 176.4 kHz signal will be much gentler to the original signal than one that must do most of the work between 20 and 22.05 kHz. The gentler filter has less effect on the desired signal output, and this may be a major reason high sampling rates such as 96 kHz and 192 kHz, or SACDs high DSD bitrate sound better. This effect may help explain why ordinary Compact Discs upsampled to higher rates seem to gain a large jump in sound quality on good systems. Even gentle analog filters seem to have an audible effect, and moving them further away from the signal seems to improve sound.

Equipment

Some information about the hardware platform and some of the recordings used to evaluate these filters is also appropriate. The DACs used are Assemblage DAC-3.0 and 3.1 models, both with improved parts such as K grade PCM1704 DACs, OPA627BP the top-grade of these extremely high performance opamps, Caddock resistors in the analog signal path, Oscon capacitors on DAC chip reference pins, etc. Most of these are part of the Signature or Platinum upgrade kits offered by The Parts Connection, makers of Assemblage gear. (The Parts Connection is a division of Sonic Frontiers.) The B grade op amps are above the usual upgrade A op amps however. The 3.0 had additional HexFREDs in the raw digital supplies and had the original Signature Holco as low-value (8 or 10 Ohm) series output resistors. The 3.1 Platinum had Black Gate capacitors in place of many of the 3.0's Panasonic HFQs, but simpler soft recovery diodes for the digital supply and and more generic precision output resistors, possibly Roederstein Resistors. HexFREDs were used in all output board raw power supply rectifier positions. The design of these DACs is technically very competent and their sound is very good.

On the DAC-3.0 and 3.1, the filter is on the same input board that also has PLLs, polarity inversion, and input selection and conditioning. The board is a separate module with standardized inputs and outputs so they can be swapped between versions. The Parts Connection hopes to offer the input board with the PMD-200 from the 3.1 as a retrofit to the 3.0. All that's needed to swap boards is to remove the cover, unscrew the board and rear panel connectors, and desolder the BNC and RCA cables. As the saying goes, installation is the reverse of disassembly. There are other differences on the input boards, but the biggest one is the filter set. For example, the 3.1 has dual PLLs, but they are bypassed when using the I2Se interface described below, so they had no effect on the comparisons described here. I evaluated both input boards in both DACs, and the bulk of the sonic differences followed the input boards, suggesting that the filters were a major source of the differences heard.

We also used the Assemblage D2D-1 to upsample to 96 kHz and interpolate to 24-bit word sizes. The D2D-1 also features dual PLLs to dejitter, and a low-jitter I2Se interface to the DAC. The I2Se features separate clock and data lines which eliminates one of the largest jitter generation mechanisms commonly found in consumer digital audio, the S/PDIF or AES/EBU digital interface. These common

consumer digital interfaces usually found on coaxial, XLR or Toslink connections combine clock and data on a single signal, which creates significant data-related jitter. This inferior design is not found on professional digital audio interfaces such as SDIF or TDIF which have separate clock and data lines, as does I2Se.

All comparisons were made in their most favorable mode. The PMD-200 and DF1704 can accept 96 x 24, so they were upsampled and interpolated to those resolutions. (The PMD-200 and do 192 kHz sampling, but the Crystal chipsets used in the Assemblage gear max out at 96 kHz.) The PMD-100 can accept 48 kHz x 24 bit data so it was used that way. This should have given an edge to the 1704 over the PMD-100, but that turned out not to be enough of an advantage. For every filter, sound quality improved as word bit lengths and sampling rates increased. Even though this effect may perhaps be expectable, the reasons for it are not entirely clear. Regardless, this is what we heard.

We set both DACs' HDCD scaling jumpers to be fixed rather than automatic. Automatic HDCD gain scaling is the factory setting and required under the HDCD license, but it attenuates non-HDCD discs in the digital domain resulting in a fewer bits output and a corresponding loss of resolution. In fixed mode, HDCD discs sound several dB quieter on average than non-HDCD, but the full digital resolution of all sources is preserved.

While the PMD-100's dither is non-adjustable, the PMD-200 offers a choice of several dither modes from none to maximum. In addition to having different gross magnitudes, the dither modes also use different algorithms to produce their dither. We ran in the factory default of minimum dither. (The no dither mode is disrecommended for listening purposes by Pacific Microsonics.) Comparing the different available dither modes would be an interesting future experiment.

An unmodified Pioneer DV-414 DVD Video player was used as transport, sending S/PDIF audio data to the D2D-1 via generic 75 Ohm coaxial cable. D2D-1 was connected to the DAC under test via a Sonic Frontiers I2Se cable. The balance of the two systems included a Headroom headphone amp and Sennheiser HD-580 on one, and Spectral DMC-20 preamp, Pass X350 amp, Dunlavy SCV, Nordost SPM Reference and Quattro Fil cabling on the other. Both systems are very high resolution. The headphone setup has less resolution in some respects but has slightly cleaner top and bottom ends probably due to a lack of room interactions. Both systems were well-burned-in over months to years.

Music

Some of the upsampled CDs used to compare filters included Cowboy Junkies' *Trinity Sessions*, Aaron Copland's *Fanfare for the Common Man* on Telarc, The Eagles' *Hell Freezes Over*. 96 kHz x 24-bit DVD-Videos included mostly tracks found on the Chesky DVD sampler and test disc, but also other tracks from Sara K.'s *Hobo*, Dave's True Story *Sex Without Bodies*, Classic Records' Rachmaninoff *Symphonic Dances*, Classic Records' *Either Way* with Zoot Sims and Al Cohn. The first two are modern 96 x 24 digital recordings while the latter two are transfers from analog master tape recorded

in the 1960s. Don't let anyone tell you old recordings are inferior; these had better sound than many modern recordings.

Results

It's worth noting that the differences between filters became more obvious after hearing the PMD-200. Its very high sound quality helped educate our ears to the new range of resolution possible. It also helped to have listened to the PMD-100 in this equipment configuration over more than a year. This gave a solid basis for comparison, and made the differences far more apparent. While the DF1704s sound was noticeably different from the PMD-100 when first compared more than a year ago, the differences are more pronounced and obvious with a more familiarized and better educated ear.

Comparing the PMD-100 to DF1704, the 1704 was harder, grainier and generally sounded like it had less resolution. Applause at the end of *Hotel California* on the Eagles' reunion album was harsh and unpleasant on the 1704 and much smoother and "rounder," yet clearer and much more distinct on the PMD-100. On *Hotel California* and *Wasted Time*, kick drum, piano, voice and string sound was much more convincing, natural and pleasant on the PMD-100. Applause leading into *Tequilla Sunrise* was much softer and more natural on the PMD-100 than DF1704. Vocal and instrument sounds were much more natural, "round," and pleasant sounding. The PMD-100 portrayed more detail, decay and space around the gong and tympani on Copland's *Fanfare* than the DF1704. The 1704 sounded more artificial and "hifi", grainier, veiled and less clear. The PMD-100 again sounded more natural. The horn recording on the Copland disc has a few audible flaws (probably digital recorder or microphone artifacts) but was generally better on the PMD-100 than the DF1704. Margo Timmons voice, bass, and percussion sounds on *Trinity Sessions* were more realistic and detailed using the PMD-100. Trinity Sessions' reverberation, a strong point of the recording, was also more natural on the PMD-100 than on DF1704.

Comparing the PMD-100 to PMD-200 I was struck that the PMD-200 is vastly better than the PMD-100. To put it bluntly the PMD-200 blows away the PMD-100 in terms of resolution, detail, harmonics, reverberation, soundstage clarity, openness and image localization and snap. The 200 makes the 100 sound fuzzy and grainy in comparison. The PMD-100 is comparatively vastly superior to the DF1704, so the PMD-200's strides towards great sound are that much more impressive. On *Fanfare*, the PMD-200 presents tympani membrane sounds with vastly more clarity, and the gong's metallic sounds, harmonic changes during decay, and vibrato modulations are also much clearer. It's as if you can hear what's really going on within the metal and drum membrane. String and piano sound is also much clearer using the PMD-200. In a visual metaphor, the PMD-100 seems like an realistic painting versus the PMD-200's photograph. Hall reverberation is more clearly recreated with the PMD-200, resulting in a more spacious, open and natural sounding room. On Timmons' voice and Trinity Sessions instruments in general the PMD-200 brings forth much more spatial and harmonic information. Decay of rim taps is much cleaner. Room sound is more obvious and clean. The general sound is more natural and realistic.

The difference between these versions of Pacific Microsonics filters is of a different kind than the difference between the PMD-100 and DF1704. Given that the earlier PMD-100 and DF1704 filters are from a closer generations while the PMD-200 is based on a fairly powerful 100 MIPS Motorola DSP, this performance gap seems reasonable. (The DF1704 is actually a later design than the PMD-100, so it should have had the advantage of newer technology.) The DF1704 is also based on completely different design principles. PMD-100 and PMD-200 do some of the same things well, mostly in naturalness of sound, and come from some of the same designers.

Switching back to a comparison of the older filters, a few audio writers have expressed a preference for the DF1704 over the PMD-100. I would describe the DF1704 as harder and more "hi-fi" than the PMD-100, which to my ears sounds far more natural. The brain is marvelously adaptive; it's what makes humans survive and thrive. Is it possible that these listeners have become accustomed to the harder "digital" sound that the DF1704 produces and have come to associate it, perhaps subconsciously, with "quality"? While that may be an open question, I prefer the naturalness and apparently cleaner resolution of harmonics of the PMD-100.

Acknowledgements

Pacific Microsonics, and in particular the filter designers, are to be commended on an outstanding job and a significant advancement in the art and science of digital audio sound reproduction embodied in the PMD-200. The PMD-100 was perhaps the best digital filter of it's time. The PMD-200 continues the tradition of excellence by catapulting digital sound quality into a new arena. Thanks also to my friend for letting me borrow his 3.1 and PMD-200 input board for evaluation and comparison, and for listening tests on his system during which we also borrowed his ears. So Parts Connection, can I get my new input board now? :-)