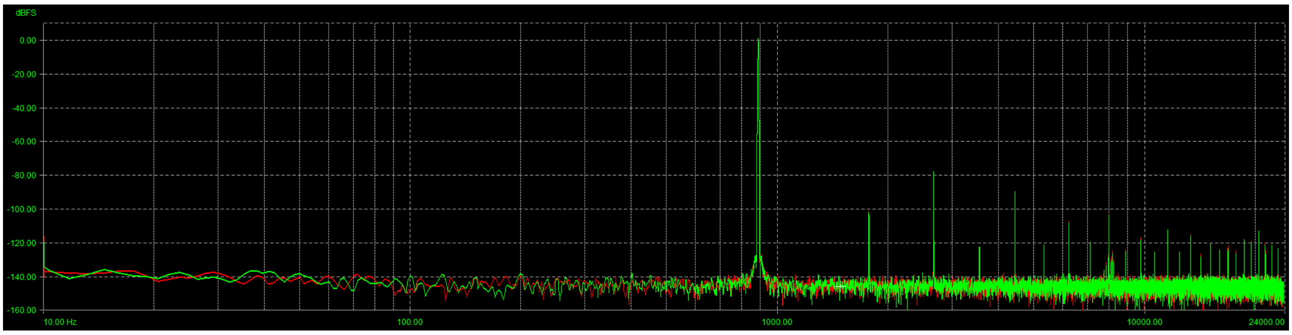
The Metrum Acoustics DAC3 module, our latest in DAC technology.

The following text is technical in nature, while understandable for audio aficionados. It handles the measurement data of the Metrum Acoustics Adagio, using 4 DAC3 modules per channel. Topics discuss the resolution, timing accuracy and linearity of the DAC3 module.



Input digital signal is 0dBFS at 882 Hz (Red = right, Green = left). The lower the noisefloor, the better. The residuals inherent to NOS conversion are on the right side and measure -100dB for the 2nd harmonic and -80dB for the 3rd harmonic.

Resolution - bits:
The red book standard for CD media dictates a 44.1 kHz bitrate with a resolution of 16 bits. In the industry, 6.02 dB per bit of information is encoded. 16 bits then leads to a -96dB noise floor.
24 bits theoretically composes a -144dB noise floor.
Does this mean that the more bits I have, the less noise I have? Potentially, yes. If the equipment that converts and reproduces the signal is up for the task. A noisy link in the chain can increase the noise floor, which audio manufacturers are trying to keep as low as possible. How low?
The dB scale is logarithmic, and a 120dB is a difference of 1000000 between the lowest and highest signal and 140 dB equals a difference of 10 million. Reaching these noise figures is no small feat, as the Johnson (or thermal) noise in a 1k resistor is already approaching 2 micro volts. That is 126 dB away from the 4.2 volt output of the Adagio (20 log (2*10^-6 / 4.2) = 126). This indicates that the DAC modules and associated power supplies are really really really quiet.

In the DAC3 equipped Adagio, the difference can be calculated with the following formula:
Gain (or loss) in dB = 20*log(Vin/Vout)
140 = 20 log (Vin/Vout)
On our trusty calculator: 140/20 2nd log = 10,000,000
So if we take Vout as 4.2 volt (max output on Adagio), Vout (the noise voltage) is calculated as 420 microvolts.

The measured signal to noise ratio of the DAC is 140 dB, which approaches 21.6 effective bits of musical information. When looking at the competition, these specifications are met by very few DACs. For a NOS DAC, which usually measures rather poorly, the Metrum Acoustics DAC3 module measures surprisingly well, while not showing any pre- or post ringing which is associated with oversampling DAC designs.

The number of bits translates to resolution (more bits is a higher resolution). This translates to the power to discriminate between steps of output voltage, but also the power and ability to discriminate instruments from each other when listening to music.
DAC1 accepted 16 bits input, DAC2 and DAC3 are both 24 bit designs.

In a standard living room the background noise level is 30 dB, maybe 25 dB at night To play the full dynamic range of the Metrum Acoustics Adagio DAC, we would need to play at 30 + 140 = 170 dB sound pressure level. That is louder than a shotgun at 1 metre!

Timing:

The well know jitter bug... books have been written about it. Why is it important to have accuracte timing in a DAC?

The hearing system is very precise in detecting differences in time of arrival of sounds between the left and right ear. When a sound is observed in the right ear first, and then the left ear, the sound is usually perceived as coming from the right of the head. When the timing of the sound wave is disturbed, this influences the ability to discriminate where the sound originated. For example, if a violin is recorded live to 2-track and reproduced in stereo, the ability to pinpoint the location of the violin in the room (not taking room reflections into account) is a function of the timing accuracy of the system as a whole. For the DAC, this means that timing should be as accurate as possible. Otherwise, the 'image' of the violin is smeared in time and thus space, resulting in a smudge that is larger than the pinpoint it should be. The larger the inacurracies in timing, the larger the smudge. Imagine what happens to an orchestra... they would be all over the place, or even on top of each other.

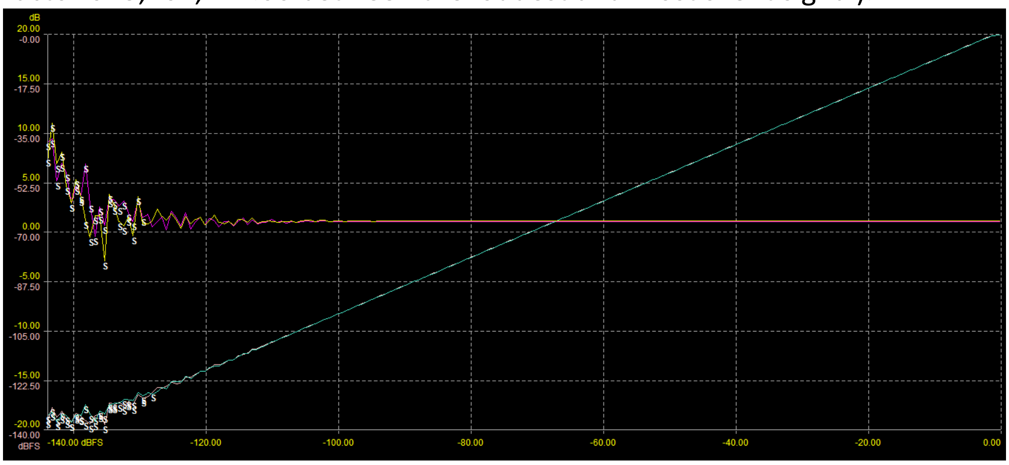
The DAC3 module has an FPGA on board that is optimized for accurate timing. The DAC module converts the Digital input signal to Analog output like clockwork. The delay time in the selected FPGA is measured in the order of nanoseconds. Due to synchronous forward correction, we were not even able to measure the time differences with our audio analyser.

Linearity:

The 'higher' or better the linearity, the better the lowest signals (silent passages) can be discriminated. Technically, it is very difficult to be linear at very low signal levels, because of noise and distortion. Furthermore, it is very hard to make a linear R2R ladder that divides voltages by a large number (in our case, around 10 million). Temperature effects and small deviations during chip production processes play a role in non-linearity.

DAC3 linearity is measured as follows:

In the Adagio with DACs, **linearity** is present until roughly -130 dB, equating to 130 / 6.02 = 21.59 bits (and a factor of 3,162,277.66 between the loudest and most silent signal).



The Green line shows the absolute linearity. The Pink/Yellow line shows the abberation from linearity (digital signal generated by analyser and measured back by analogue inputs of analyser), where smaller deviations are better.