Why 64-bit processing?

The Fast Fourier Transform (FFT), as implemented in ARTA, can process data in 64-bit and 32-bit floating point format. Click on menu item **Setup->Use 64bit FFT,** enables ARTA to use the 64-bit data format for FFT, otherwise ARTA uses 32-bit data format.

Both versions will give the same result for spectrum and frequency response estimation as long as we use them for processing of analog data that has been acquired with standard A/D converters. We can then confidently state that ARTA, as a system, is capable of measuring THD+N down to the order of 0.0003162% (-110 dB).

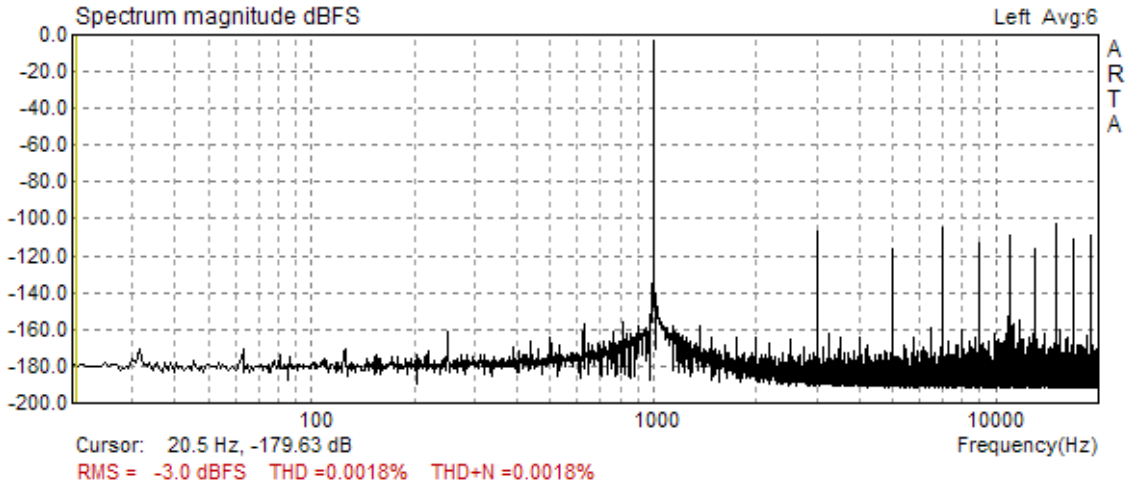

Figure 1. ARTA 32-bit processed FFT spectrum of a 1 kHz signal measured with Terratec EWX 24/96 SPIDF I/O (loop-back-mode, 16-bit resolution with no dither applied, Kaiser window).

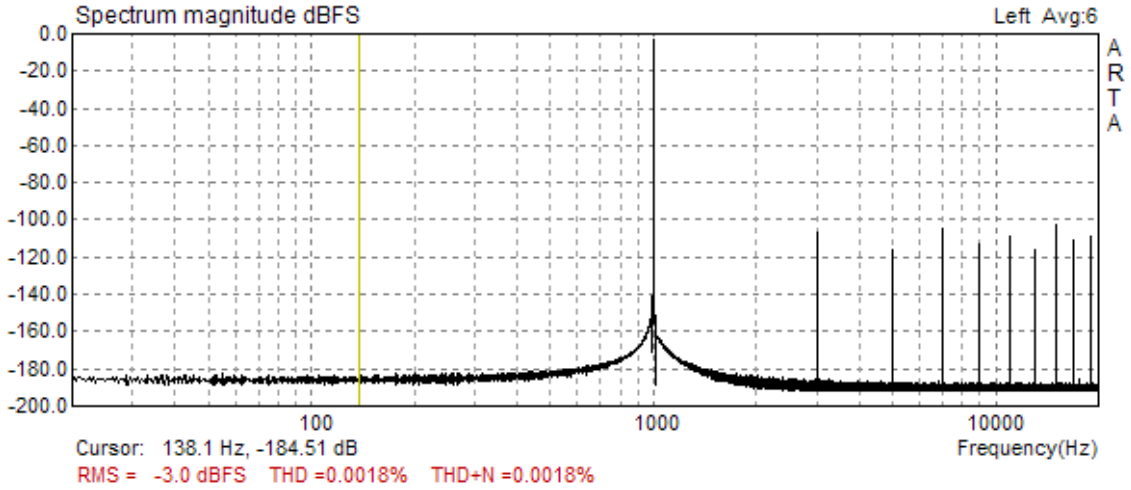

Figure 2. ARTA 64-bit processed FFT spectrum of a 1 kHz signal measured with Terratec EWX 24/96 SPIDF I/O (loop-back mode, 16-bit resolution with no dither applied, Kaiser window)

Many sound cards have digital I/O channels (S/PDIF and AES/EBU). This means that ARTA should be capable of analyzing discrete digital signals. In that case it is necessary to have a processing engine that is capable of measuring THD+N down to the order of 0.00001% (-140 dB). Processing with 64-bit data format is targeted for that purpose: the analysis of digital transmission and applied dithering algorithms.

We will show that by the following example.

Both **Figure 1.** and **Figure 2.** show the 1 kHz FFT spectrum of a Terratec EWX 24/96, S/PDIF I/O in loop-back-mode calculated with 32-bit and 64-bit processing respectively. The Wave Format setting is 16-bit resolution without the application of dither.

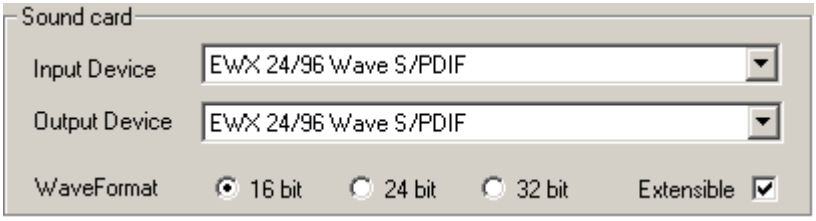

Figure 3. Soundcard 16-bit resolution setup

Results for THD and THD+N are same in both cases, but it is clearly visible that 64-bit processing gives much less "numerical noise". Also obvious is that the harmonic distortion is much higher than the noise level.

Now let's consider intentionally adding a form of noise called dither to the sine generator output. Dither is used to randomize quantization error and reduce harmonic distortion.

If the user is concerned that we are adding noise to a signal, remember that all commercially produced music CDs have dither added during the mastering process.

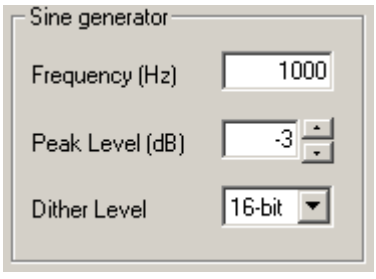

Figure 4. Adding dither noise to sine generator output

Both Figure 5. and 6. show a spectrum with added dither (at a level of 18-bit and 16-bit LSB). The measurements clearly show that THD is much lower with added dither, but THD+N is slightly higher. Note that 16-bit dithering has totally eliminated the higher harmonic components and all distortion is due to the noise.

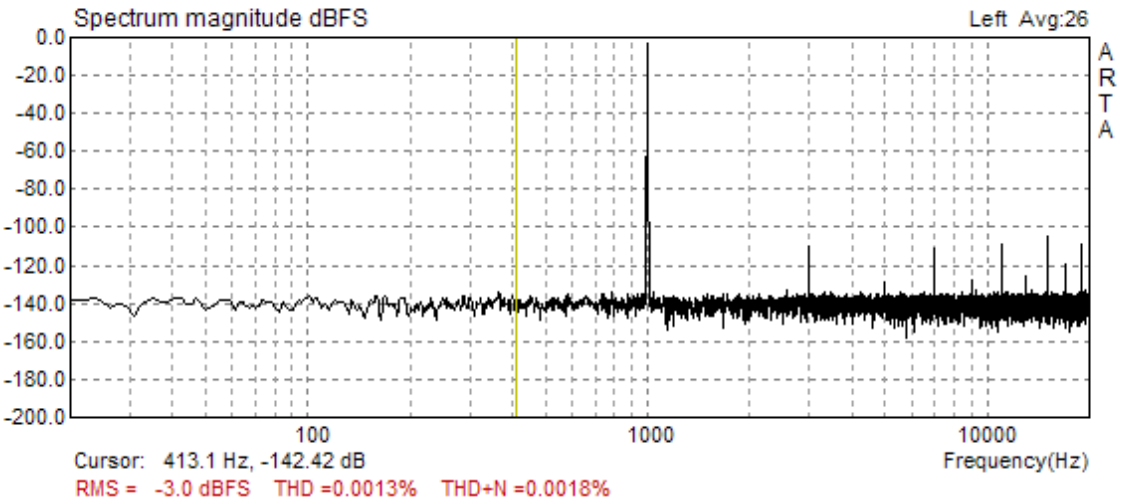

Figure 5. ARTA 64-bit processed FFT spectrum of a 1 kHz signal measured with Terratec EWX 24/96, S/PIDF I/O (loop-back-mode, 16-bit resolution with 18-bit dither applied)

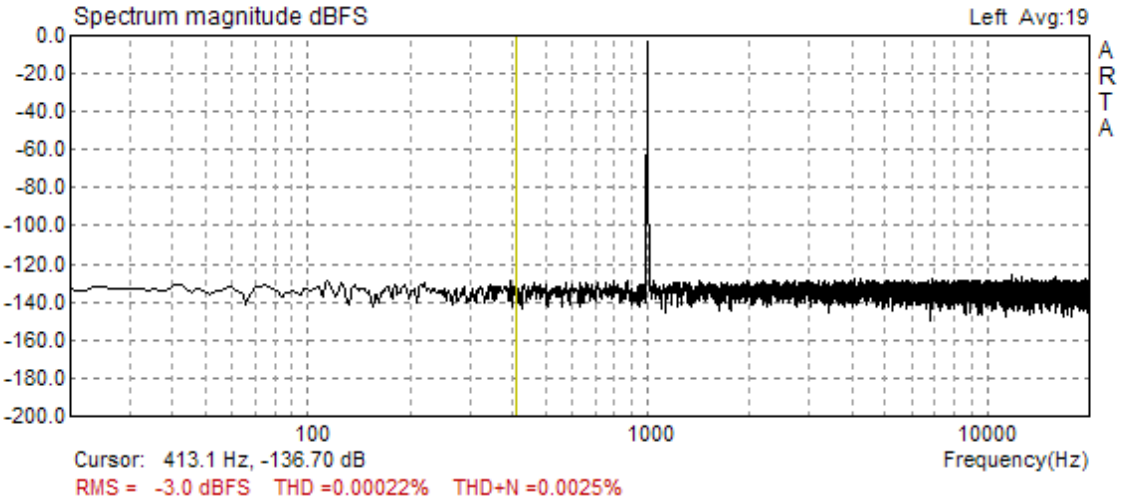

Figure 6. ARTA 64-bit processed FFT spectrum of a 1 kHz signal measured with Terratec EWX 24/96, S/PIDF I/O (loop-back-mode, 16-bit resolution with 16-bit dither applied)

Now if we put ARTA in 24-bit resolution mode, we get the spectrum of a 1 kHz sine signal as shown in Fig. 8.

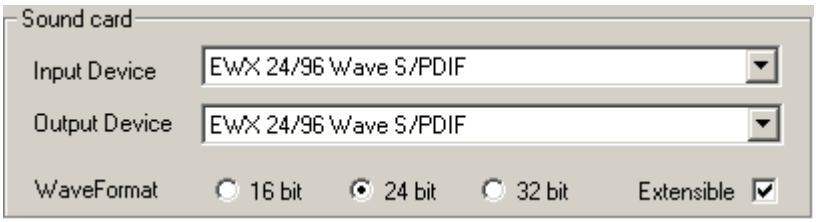

Figure 7 Soundcard 24-bit resolution setup

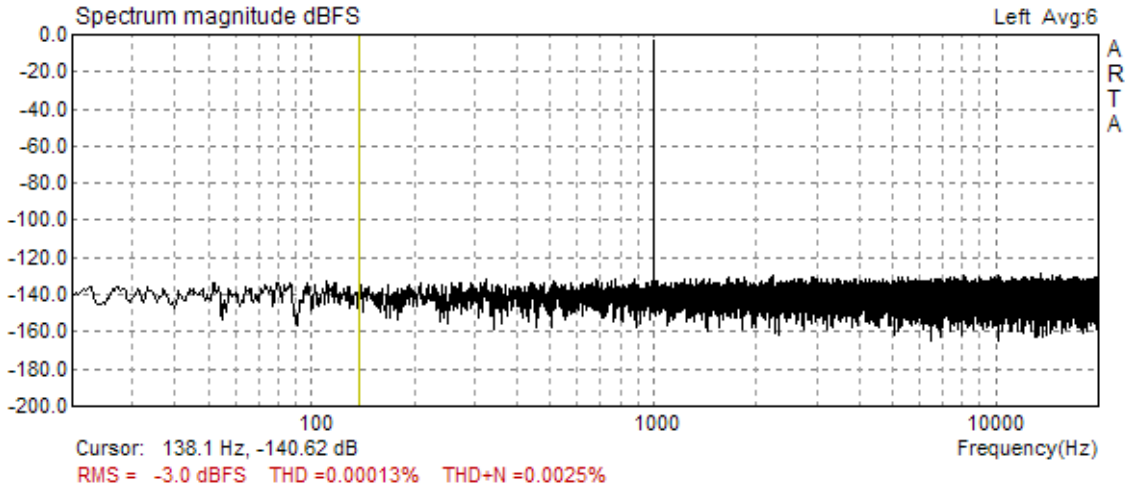

Figure 8. ARTA 64-bit processed FFT spectrum of a 1 kHz signal - measured with Terratec EWX 24/96, S/PIDF I/O (loop-back-mode, 24-bit resolution with no dither applied in ARTA)

Although the measurements A/D resolution is much higher than with 16-bit resolution we get the same results as with 16-bit resolution and applied dither. It is obvious that the manufacturer of the soundcard has applied a dithering algorithm in the card's driver software.

We can conclude that in this case of 24-bit resolution it is not necessary to apply additional dither, as it already has been applied. We also can conclude there is no benefit of using a 24-bit resolution in signal generation, as the card itself gives the same resolution as in the dithered 16-bit resolution mode.

Finally, we can ask what is the best results we can expect from an ideal system with a 24-bit resolution.

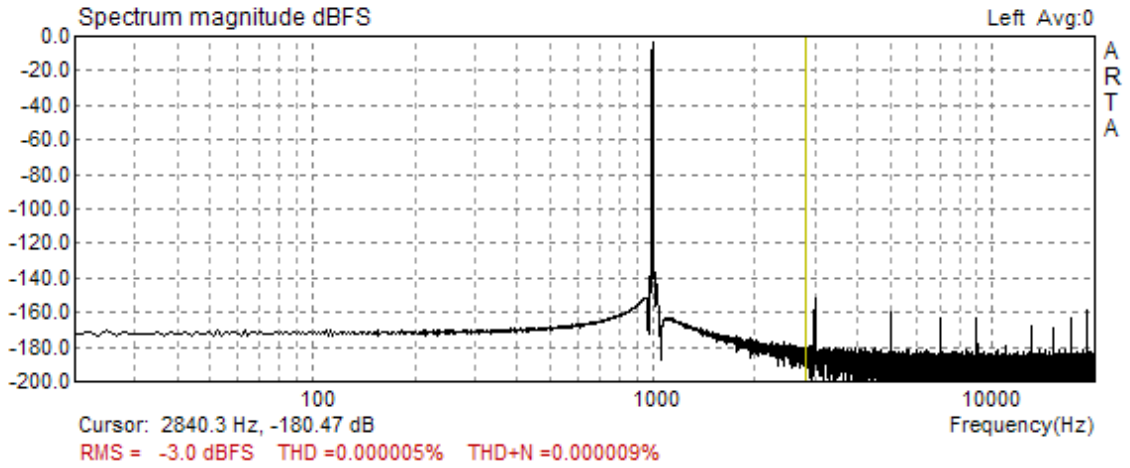

Figure 9. Numerical simulation of a spectrum and quantization distortions of a 1kHz sine signal in an ideal system with a 24-bit resolution (Kaiser window).

Figure 9. shows that in an ideal system with 24-bit resolution, THD and THD+N are lower than 0.00001% (-140 dB).

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Summary: 64-bit data processing uses more memory (1 MB) than 32-bit data processing and requires more processor time for FFT, but it gives a more precise evaluation of modern high resolution audio systems. It also enables us to make THD+N measurements which are lower than any analog-based distortion measuring equipment.

For practical acoustical measurements, there is no need to use the 64-bit FFT data size.