Auralic VEGA G2 DAC and LEO GX Master Clock Review

John E. Johnson, Jr.

Introduction

A DAC (Digital-to-Analog Converter) is one of the most important components in digital audio. It is responsible for taking the 1's and 0's in the digital bitstream of the music and creating the analog sound that we hear.

For the process to work properly, the timing of the bitstream is critical. That is to say, the 1's and 0's must be presented for decoding (converting to analog) in a precisely timed manner. Otherwise, if the timing is inaccurate, and this is called "Jitter", decoding errors can occur. Take for example Morse Code. The timing of the dots and dashes is necessary for the receiver (the person who decodes the message) to know that a dot is

a dot and a dash is a dash. If another dash comes too soon after a dash, the decoder might mistake the dash to be a dot. Digital bitstream decoding is not exactly like Morse Code, but you get the picture.

Secondly, if the 1's and 0's for a particular "word" (8 bits or 24 bits in length) come too slow, the voltage value for that part of the audio waveform will farther into the waveform than it should be.

The timing of the bitstream (keeping jitter to a minimum) is controlled by a digital clock, and reason I bring up the importance of the digital clock is that the Auralic VEGA G2 DAC, which has a very precise clock by itself, can be accompanied by the Auralic LEO GX Master Clock for even more precise bitstream timing. Yeah, it's expensive, as the total cost of the VEGA G2 and LEO GX is $13,000. But audiophiles will want to have the most precise timing that they can obtain, and this package does just that. I have never seen anything like these two components, as you will discover shortly.

Specifications

- **Product: Auralic VEGA G2 DAC**
- Formats: AIFF, ALAC, APE, DIFF, DSF, FLAC, OGG, WAV, WV, AAC, MP3, MQA, WMA
- Frequency Response: 20 Hz – 20 kHz, +/- 0.1 dB
- THD+N: < 0.00012% (XLR); < 0.00015% (RCA), 20 Hz - 20 kHz at 0 dBFS
- Dynamic Range: 130 dB, 20 Hz – 20 kHz, A-weighted
- Sampling Rate: PCM: 44.1 kHz to 384 kHz in 32 Bit, DSD: DSD64 (2.8224 MHz), DSD128 (5.6448 MHz), DSD256 (11.2896 MHz), DSD512 (22.57892 MHz)
- Control Software: AURALiC Lightning DS for iOS, AURALiC Lightning DS for web browser (device setting only), OpenHome compatible control software (BubbleUPnP, Kazoo), Roon (Roon Core required separately)
- Audio Inputs: Digital Inputs: Lightning-Link, AES/EBU, Coaxial, Toslink, USB Audio, Analog Inputs: RCA Line-stage (2Vrms maximum), Streaming Inputs: uPnP/DLNA Media Server, native TIDAL and Qobuz Sublime+ streaming, Spotify Connect, Internet Radio, RoonReady
- Audio Outputs: Balanced: XLR (4.8 Vrms at 0 dBFS, output impedance 5 ohm), Unbalanced: RCA (4.8 Vrms at 0 dBFS, output impedance 50 ohm), Headphone: 6.35 mm Headphone Jack (output impedance 5 ohm)
- Network: Gigibit Ethernet (wired)
- Dimensions: 13.4" W x 3.2" H x 12.6" D
- Weight: 17.2 pounds (7.8 kg)
- MSRP: $5,999 USA
- Auralic: https://us.auralic.com/

Specifications

- **Product: Auralic LEO GX Master Clock**
- Benchmark: Allan Deviation: 2E-12 (1 second), Equivalent Jitter: 500 times less than an 82 fs femto clock (1 Hz – 10 Hz), Equivalent Phase Noise: - 110 dBc/Hz@1 Hz (Reference Frequency: 10 MHz)
- The Clock: Frequency: 90.3168 MHz (44.1 kHz) | 98.3040MHz (48 kHz), Output Level: 3.3 V CMOS (Direct-to-DAC Design), Reference: Temperature-controlled Rubidium atomic clock, Oscillator: Temperature-controlled SC cut crystal
- System Control: Switch sampling rate automatically via Lightning-Link with G2 DAC
- Power Supply: Dual Purer-Power internal linear power supply, 10 µV low noise designed for audio circuits
- Noise Elimination: Optical isolation between control and clock circuits, EMI-shielding Unity Chassis
- Network: Gigabit Ethernet (For firmware upgrade use)
- Dimensions: 13.4” W x 3.2” H x 12.6” D
- Weight: 17.8 pounds (8.1 kg)
- MSRP: $6,999 USA
- Auralic: https://us.auralic.com

Design

There are several steps in the process of playing a digital music file, either from a disc, a computer, a cell phone, or streamed from a music service on-line, and ending up with analog sound from your speakers or headphones. The first is the bitstream. When you press “Play”, the player releases the bitstream from the music file, which is a series of 1’s and 0’s. If it is a 16 bit file, such as 16/44.1, there are 44,100 samples (“Words”) per second, each of which is a series of 16 1’s and 0’s that are the code for a single voltage on the music waveform. If it is a 24 bit file, such as 24/48, 24/96, or 24/192, each word is a 24 bit code for a single voltage, with 48,000, 96,000, or 192,000 words per second. With each of the words being a code for a single voltage, the thousands of words per second form the entire musical waveform.

The DAC converts the words to the analog musical waveform and feeds that analog signal to an op-amp or discrete amplifier that increases the voltage to a level that a preamplifier can use. The purpose of the preamplifier is to (1) switch between the various sources that a consumer has in his/her audio system, such as a CD player, music streamer, turntable, etc., (2) control the volume of the analog output from the preamplifier, and (3) maintain an optimum output impedance regardless of the volume setting.

Accuracy of the bitstream timing (keeping the jitter as low as possible) is controlled by the clock in the DAC. It uses a crystal to which a voltage is applied, resulting in the crystal oscillating at a very precise frequency, as a “reference” for timing the flow of the 1’s and 0’s accurately so that the digital-to-analog conversion produces a waveform that

is an accurate representation of the original musical signal. If the DAC's clock were not used to set the accuracy of the bitstream flow, it would be vulnerable to whatever the accuracy of the flow of the incoming bitstream was, and in many cases, this would result in a mess. What we want is for the bitstream to be 44,1000, 48,000, 96,000, or 192,000 words per second, with each bit and each word properly spaced in time. That is the responsibility of the clock.

The Auralic VEGA G2 DAC has its own clock, which is extremely accurate. However, the addition of the optional LEO GX Master Clock increases the accuracy, using a rubidium crystal as the reference, and as you will see below in the bench tests, the LEO GX re-clocks incoming bitstreams that have a lot of jitter and reduces it in a huge way (jitter cannot be entirely eliminated).

Setup

Both the VEGA G2 and LEO GX have massive build quality, like the proverbial tank. The two of them together weigh more than 30 pounds.

Here are photos of the inside of each chassis. The first one is the VEGA G2, and the second one is the LEO GX.


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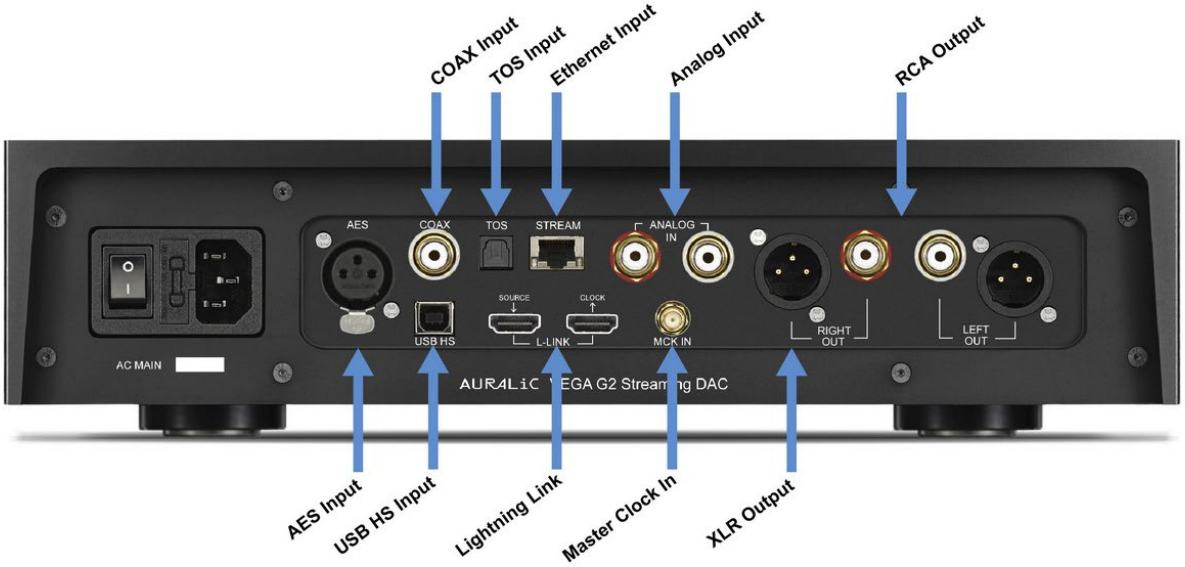
ORFEO
Ultra Low Noise
Class-A Module
Powered by
AURALIC
AURALIC VEGA G2
VEGA G2

You can see from the images that the insides spell out “precision”.

The rear panels are shown below (VEGA G2 then LEO GX).



The Master Clock In (MCK IN) on the VEGA G2 is connected to the MCK OUT on the LEO GX. This is the main communication from the LEO GX to the VEGA G2. There is also a Lightning Link (L-Link) connection between the two components. I connected them using the included cable (HDMI). This provides jitter-free communication between Auralic components.

The MCK cable is highly engineered. It is extremely important, as any significant amount of reactive impedance could affect the digital clock's accuracy when it communicates with the VEGA G2. I don't know how expensive this cable was to make, but I am certain I would not find a generic one for $2.99 anywhere.

VEGA G2 digital inputs include AES (XLR balanced), RCA (Coax), USB (from your computer), and Toslink Optical. Analog outputs include stereo RCA and stereo XLR (balanced). There are also hard-wired network connections that allow firmware updates through your home network and the Internet (from Auralic's website).

A diagram illustrating the effect of jitter is shown below (modified from diagrams copyright Texas Instruments).

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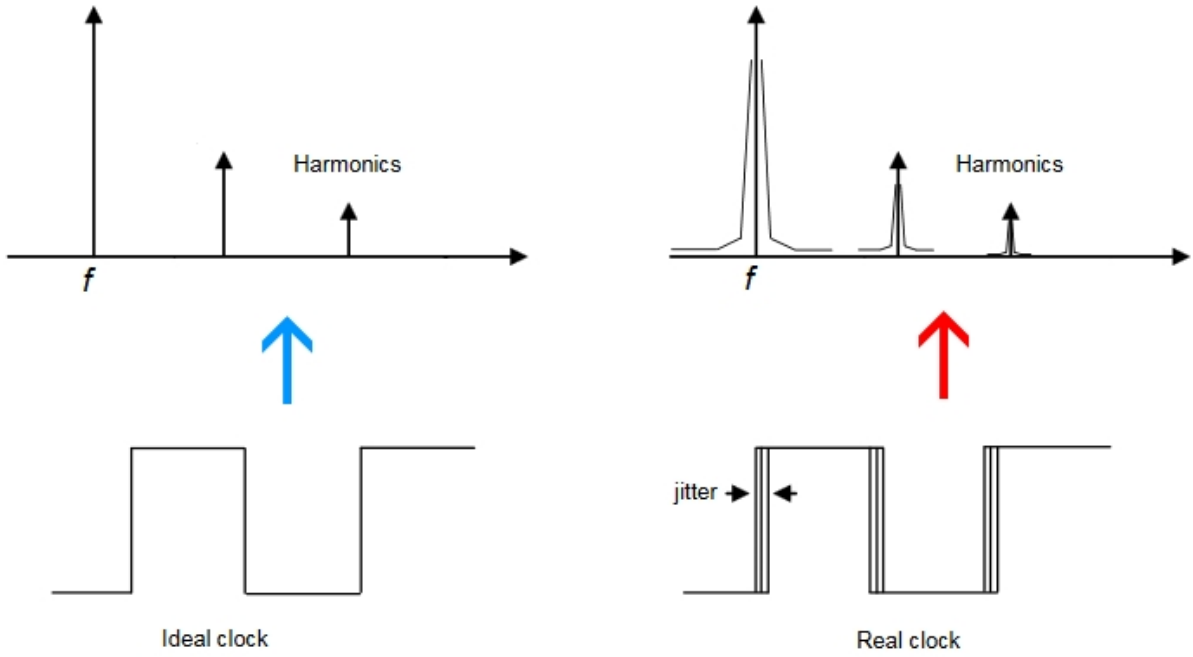


With a perfect (Ideal) clock, the 1's and 0's have no jitter, i.e., the timing is as it should be, shown in the left-hand side of the diagram. Frequencies in the music, and their harmonics, are narrow peaks. With the real world (Real Clock), the 1's and 0's do not arrive exactly when they should, and the frequencies in the music, and their harmonics, appear with widened peaks, especially at the base (right-hand side of the diagram). Some of this is side-band peaks, distorting the music.

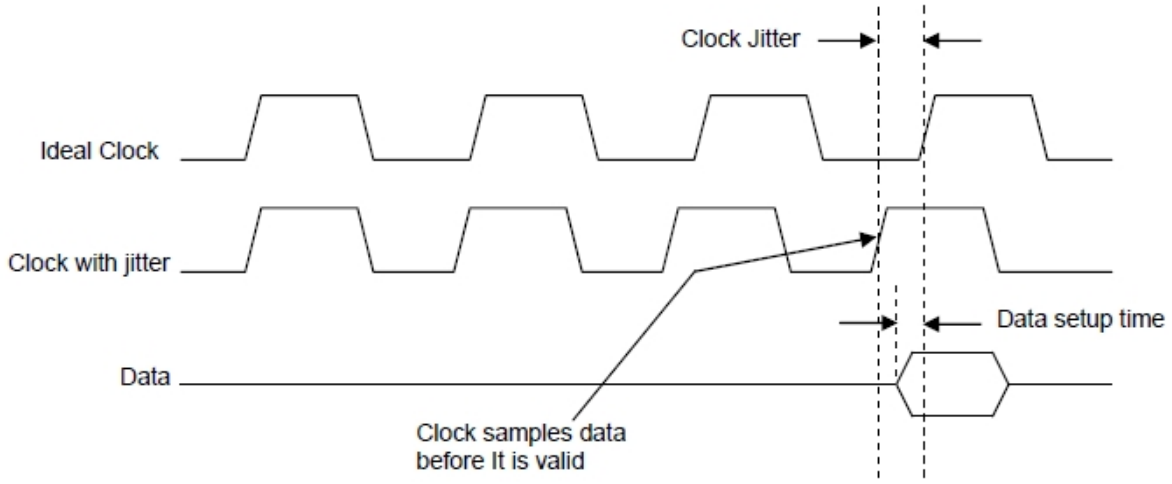
Jitter in a clock signal can be caused by noise from heat, the device itself, and from other circuits.

When jitter is present, as a certain amount is always present since the conversion process is not perfect, all kinds of bad things can happen.

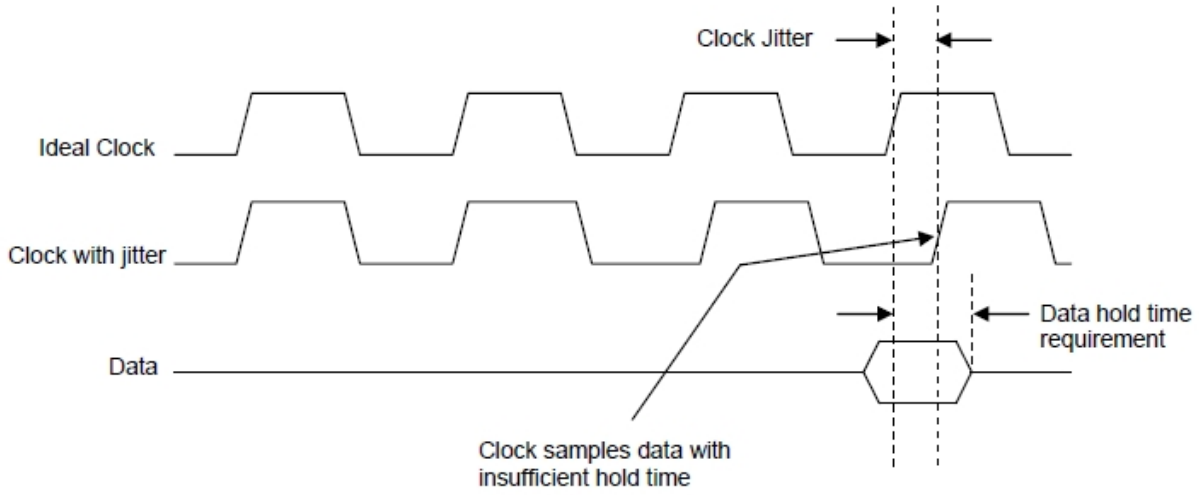
There are several types of jitter. (1) Period Jitter, (2) Cycle-to-Cycle Period Jitter, (3) Long Term Jitter, (4) Phase Jitter, and (5) Time Interval Error. Let's take a look at one of these, Period Jitter. It is the deviation in cycle time of a clock signal with respect to the ideal period over a number of randomly selected cycles.

Here are diagrams of the effects of period jitter with respect to the setup time and data hold time (Copyright Sitime.com).

The setup time is the amount of time that the microprocessor in the DAC needs before the clock rises. If the clock has jitter, and the bits are arriving too soon, the amount of setup time is shortened, and the microprocessor receives incorrect information.



The data hold time is the amount of time that a bit needs to be held in order to be read. If the bit comes too late, again, the microprocessor receives incorrect information.



This is not a paper on jitter, so I won't go into the other types. Just be aware that jitter is an important issue to be addressed in digital audio. That is the function of the clock that comes standard with the Auralic VEGA G2 and is superbly addressed with the Auralic

LEO GX Master Clock option. The effects of jitter can include blurring of high frequency components, such as violins and brass.

In Use

I tested the Auralic VEGA G2 and LEO GX with a digital output from an OPPO UDP-205 Universal Player and the digital output from my computer using a software player configured for digital output through a USB port. To use the Auralic with USB, you need to download the USB driver from the Auralic website.

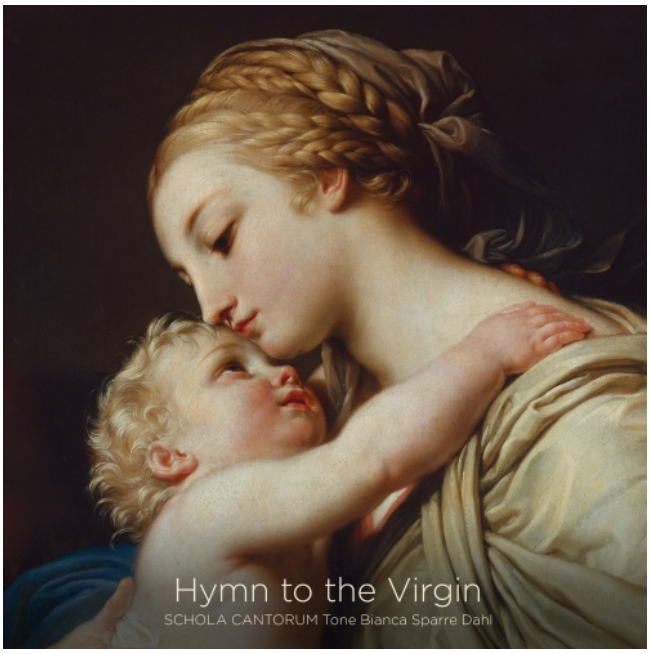
Additional equipment included a Balanced Audio Technology VK-5i Pure Class A Triode Preamplifier (Fully Balanced), Balanced Audio Technology VK-500 Solid State Stereo Power Amplifier (Fully Balanced) (250 Watts per Channel into 8 ohms), and Magnepan 20.7 Planar Magnetic Full-Range Speakers. Cables were Morrow Audio, Wireworld, and Mogami. I also listened to the Auralic using an OPPO HA-1 Heaphone Amplifier and OPPO PM-1 Planar Magnetic Headphones.

Hymn to the Virgin (2L Norway) is one of my favorite albums of all time. It is a high-resolution download album, and I played it from my computer through a USB port to the Auralic, in 24/96 FLAC. It is obviously a Christian music album, but no matter if you are Christian, Jewish, Muslim, atheist, or whatever, if you like choral music, you would love this album.

It sounded a bit clearer with the LEO GX, but the clarity and detail are phenomenal with both products. This is testimony to the clock in the VEGA G2.

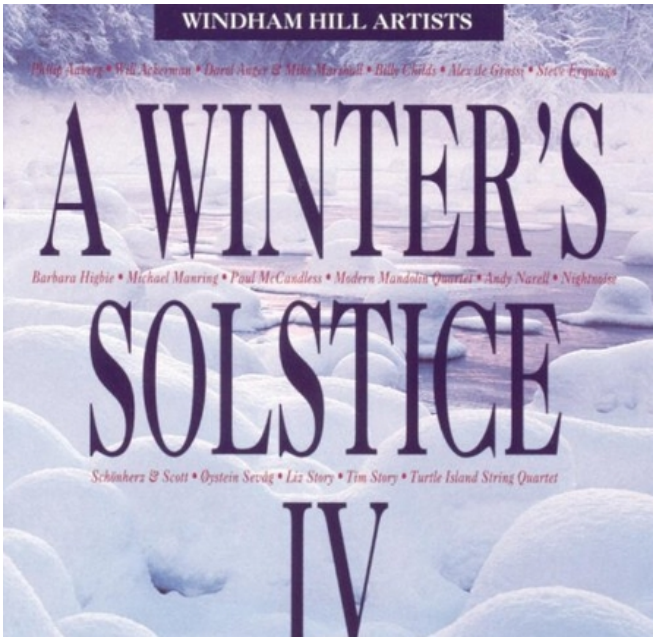
As you will see below in the Bench Tests, no jitter was allowed to pass in 16/44.1 with either setup, and that is probably why 16/44.1 sounded the same with and without the LEO GX, but for high resolution files, jittered bitstreams (I introduced a large amount of jitter using the Audio Precision spectrum analyzer) resulted in a small amount of jitter effects showing up in the analog outputs when the VEGA G2 was used without the LEO GX. When the LEO GX was in the system, there was no visible jitter in the analog output.

I suspect that for bitstreams coming from a computer, phone, or iPad, where the motherboard digital noise can corrupt the effects of the clock, significant amounts of jitter can and probably do occur. I also feel that streaming from a network connection, particularly if it is wireless, can result in higher jitter than found in bitstreams from a physical disc player, such as the OPPO UDP-205. The Auralic has an option for connecting to a network wireless streamer, but I did not explore that particular option. The amount of jitter in streaming situations would depend on the connection, including the speed and amount of noise present. When I used the USB connection from my computer to play digital files, I occasionally felt that the addition of the LEO GX resulted in a cleaner sound. I think those particular files had more jiiter as a result of digital noise contamination from the motherboard.



I also played DSD (SACD) albums (the ISO files) from my computer to the VEGA G2 using Foobar. They sounded very good, or perhaps I should say, really good. These included Lang Lang's *The Chopin Album* (Sony Classical), which has several Etudes and Nocturnes. I was around in the early 1980's when CD players were introduced. I remember thinking that the sound was a bit harsh, but nevertheless, I was in love. Those kinds of issues do not exist anymore, but still, you do need to be careful with all of the sources that you can choose from. A top notch DAC is important to refine the digital music to its best.

A nice wintry album in 16/44.1 that I like is *A Winter's Solstice IV* (Windham Hill). I guess it is obvious what time of year I reviewed the Auralic. This old CD is nearly $30 on Amazon now. It is not an easy album to find in new condition. The OPPO UDP-205 is a superb disc player with several digital outputs. It was originally about $1,300 direct from OPPO. Now, it is available on the Internet from private sellers for nearly three times that price. I am never going to let mine out of my sight, that is for sure.



To reiterate, for 16/44.1, I did not hear any difference between the VEGA G2 alone or with the LEO GX. As I mentioned previously, 16/44.1 jittered bitstreams do not appear to make it through the Auralic components without the jitter being removed when using the VEGA G2 alone or with the LEO GX. However, I will say at this point, that if I were to listen to a lot of streamed music, especially high-resolution, I would get the LEO GX just to insure that no jitter gets through.

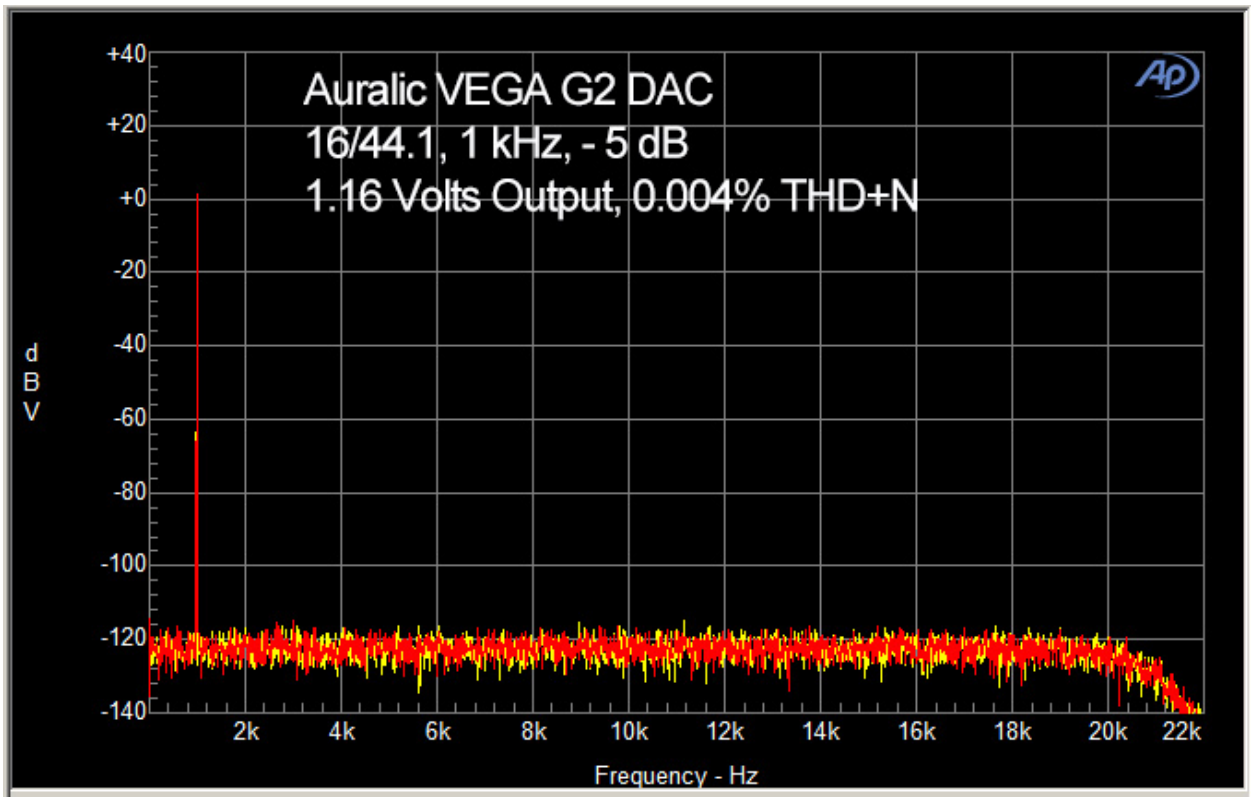
This 24/192 PCM (formatted in FLAC) album, *Piano Improvisations* (2L Norway) is truly excellent. I like in particular track 6, *Seven Eight* with three pianos. Piano is a good instrument for testing audio equipment because the slightest imperfection in the sound is noticeable. I didn't notice any imperfections at all.

I cannot resist good organ music, and this album (16/44.1 CD) *Historical Organs in Poland* (Aulos MusiKado) is a nice example. Organ can blow a listener out of the room, and I like that (occasionally). The Auralic components did not disappoint. I started out in the living room and ended up in the kitchen (good nachos).

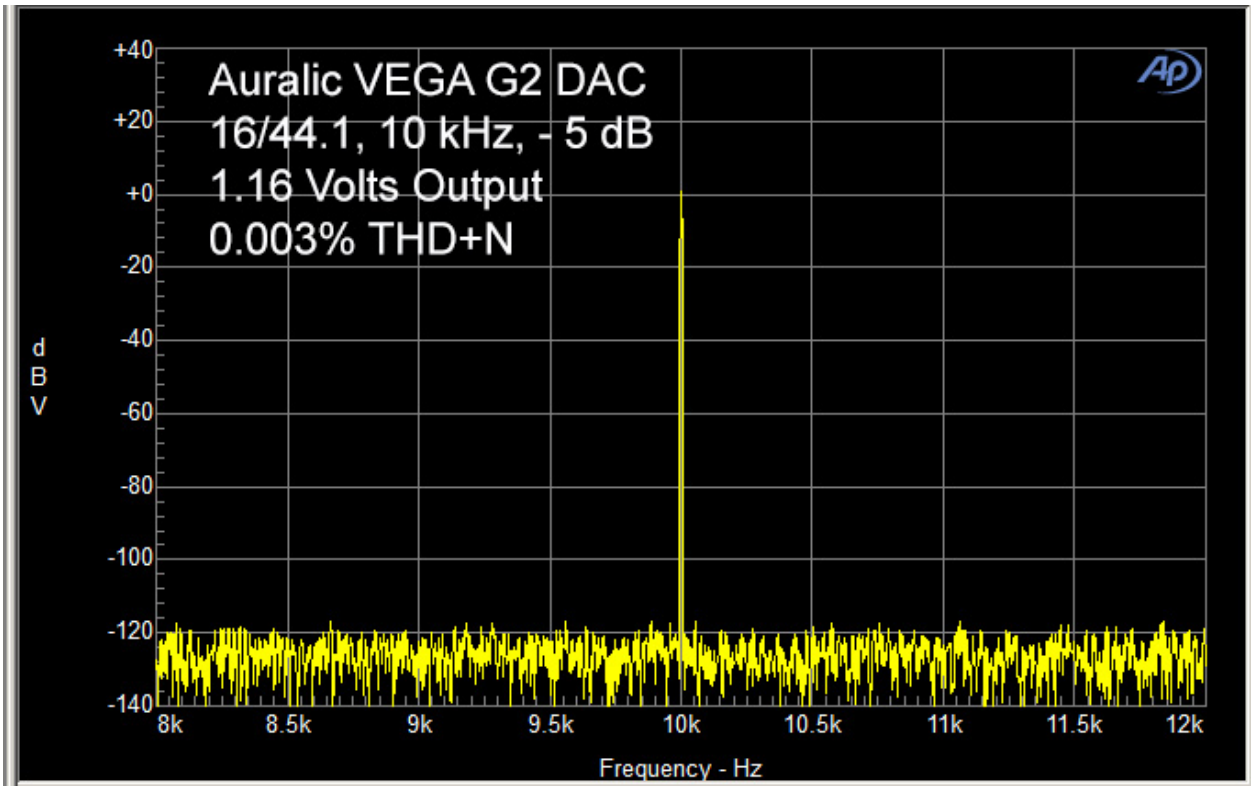
On the Bench

I performed the bench tests using the AES (XLR) digital input and XLR analog balanced outputs from the VEGA G2. I set the volume control on the front of the VEGA G2 to 90 (the control has a maximum setting of 100).

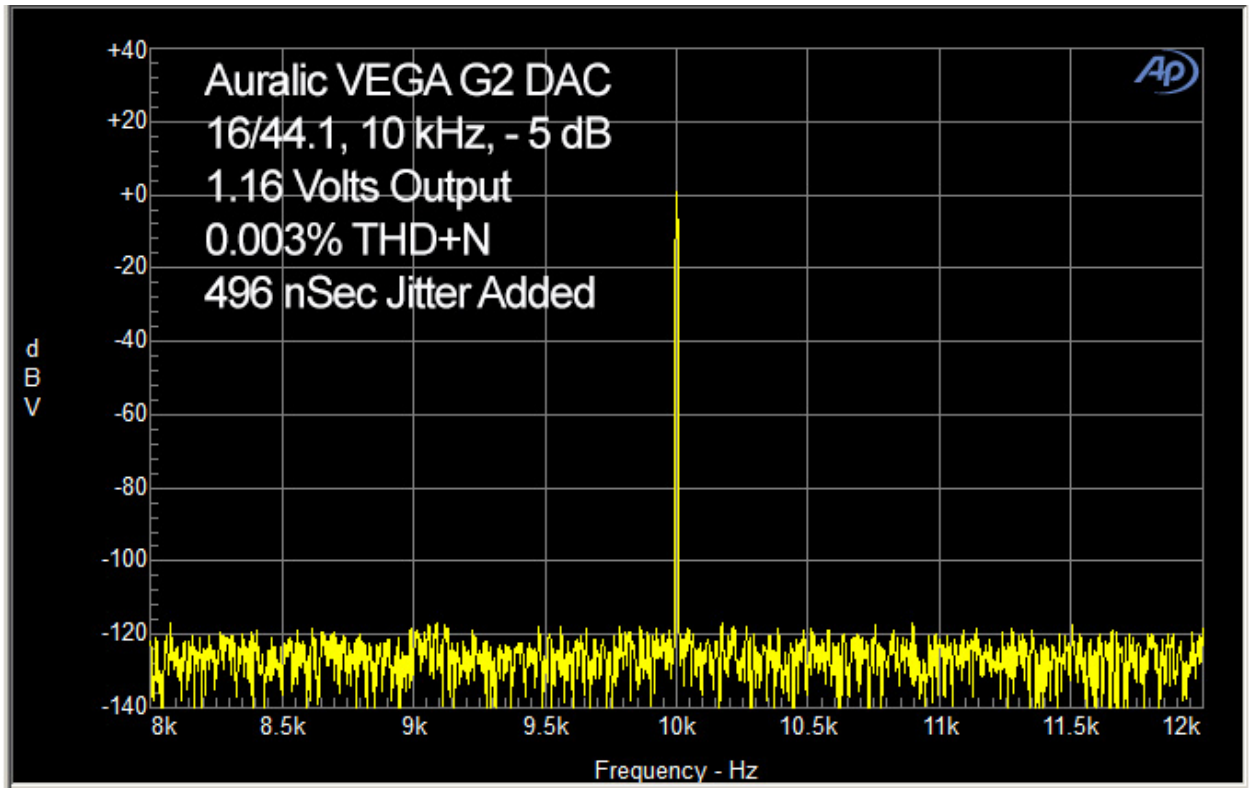
The figure below shows a 1 kHz sine wave at -5 dB (digital volume level, different than the analog voltage output level, which is in dBV). Distortion is almost non-existent. The low amount of noise probably represents the major portion of the THD+N number.



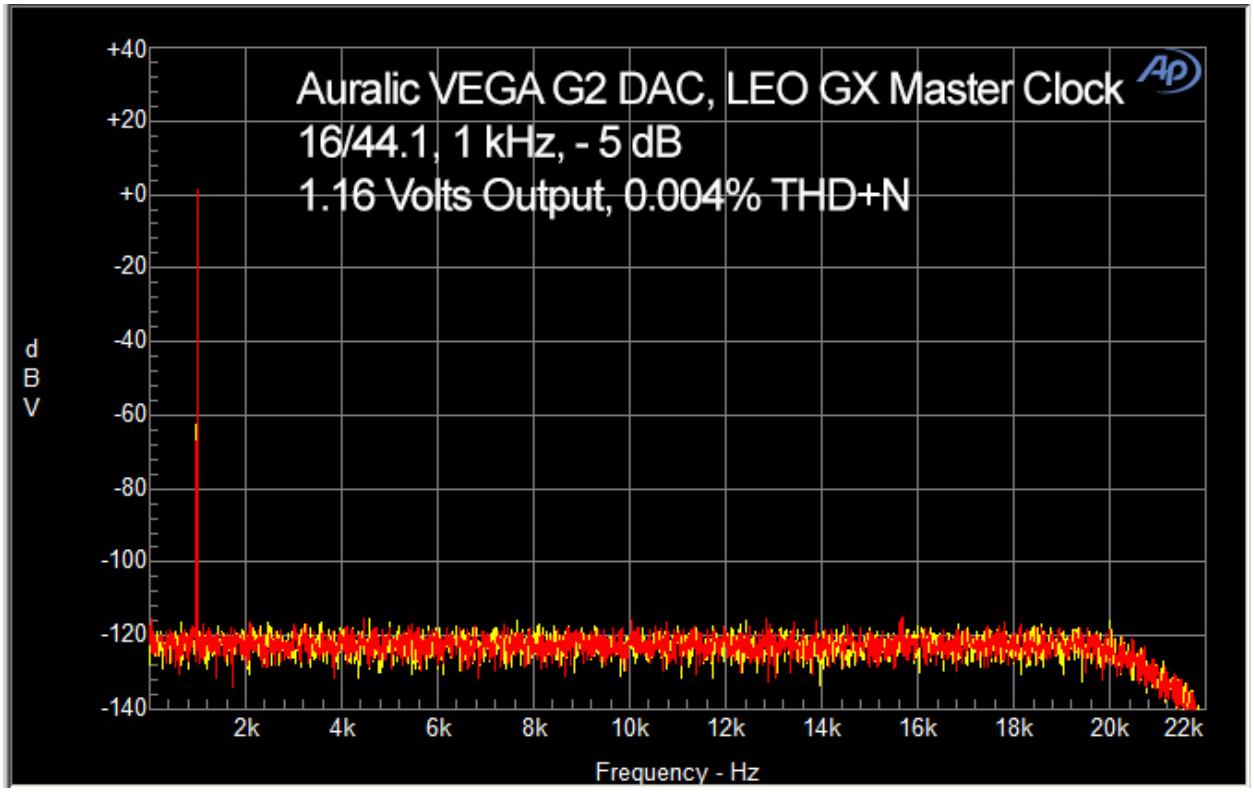
Since we want to look at jitter, I performed a 16/44.1 test using a 10 kHz sine wave, with the spectrum window set to 8 kHz on the left and 12 kHz on the right. First, the spectrum with no jitter added to the test signal. Notice that the 10 kHz peak has no side peaks. This indicates a signal with very low jitter.



In the spectrum shown below, I added 496 nSec (nano-seconds) of 1 kHz sine wave jitter to the test signal. The 10 kHz peak still has no side peaks. So, jitter is suppressed by the Auralic VEGA G2, with no LEO GX attached.

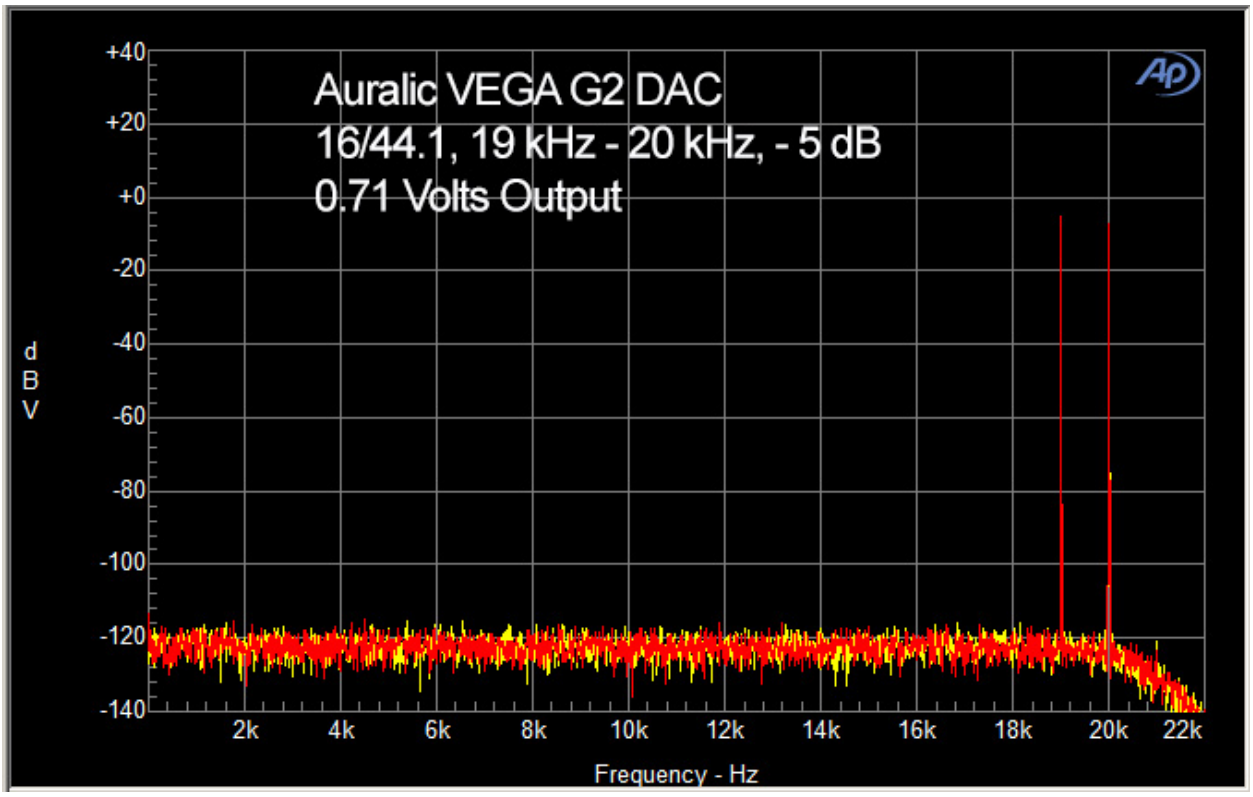


Now let’s look at a 1 kHz sine wave test with the LEO GX Master Clock attached. The distortion is virtually the same as when the LEO GX is not attached. So, distortion-wise, the LEO GX does not change the amount. That is because the VEGA G2 has such low distortion to begin with. However, as you will see, the jitter measurements do show a difference at higher sampling rates.

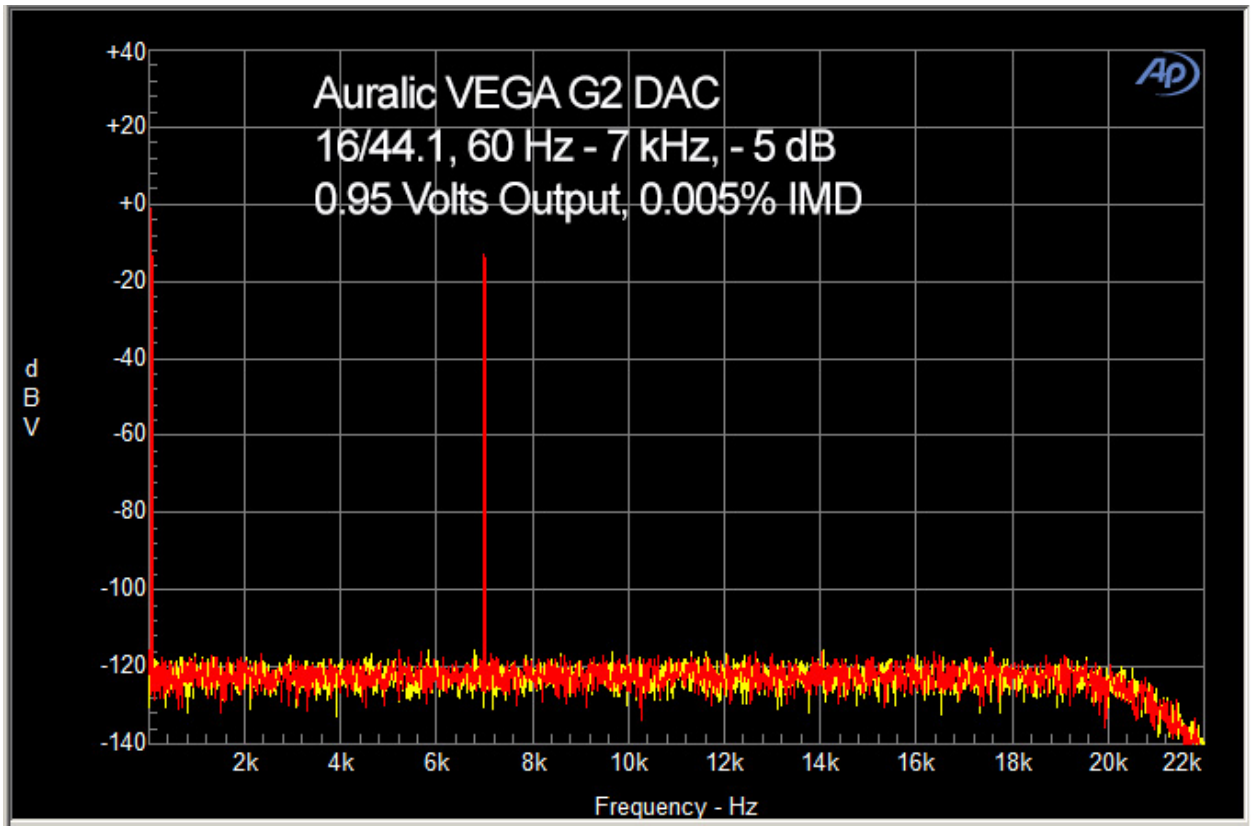


We continue now with further measurements on the VEGA G2 DAC by itself.

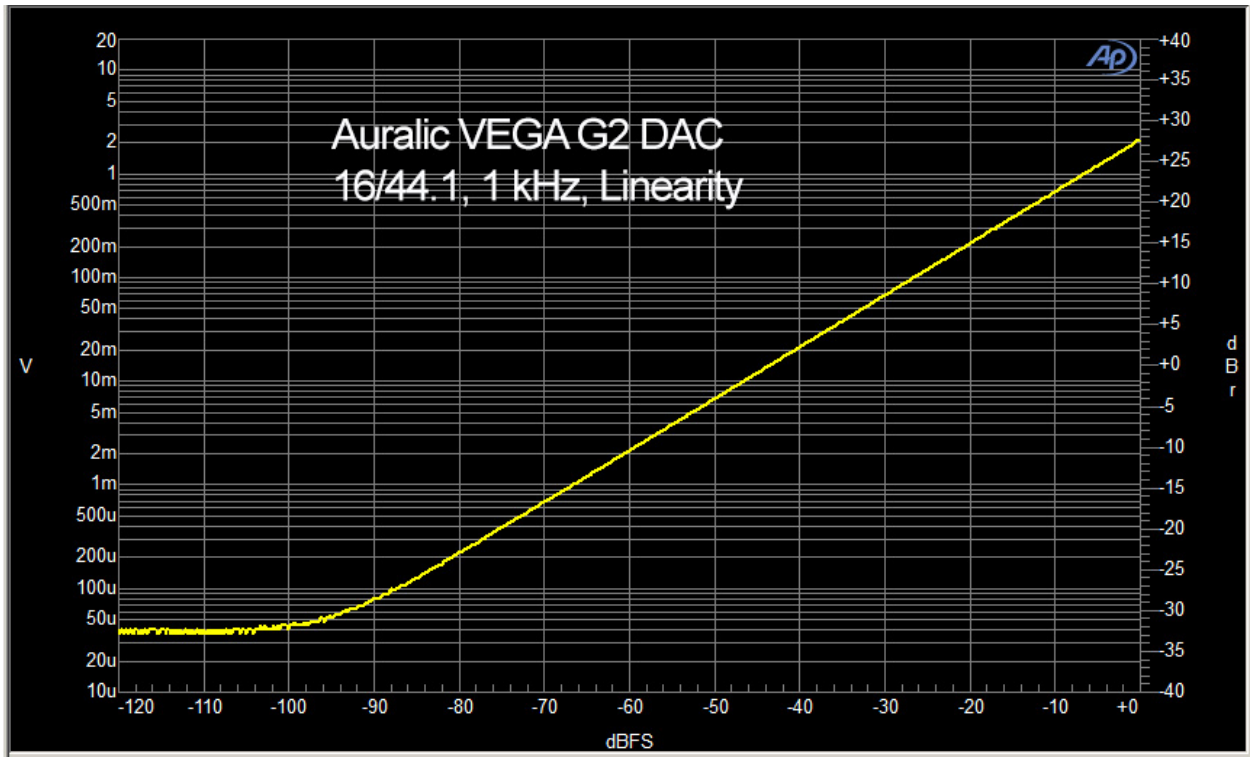
Using 19 kHz and 20 kHz sine waves, the B-A peak at 1 kHz is not visible, if there is one. Something is going on at 21 kHz, but it is so low (-120 dBV), it is insignificant. This peak is also present when the LEO GX is attached.



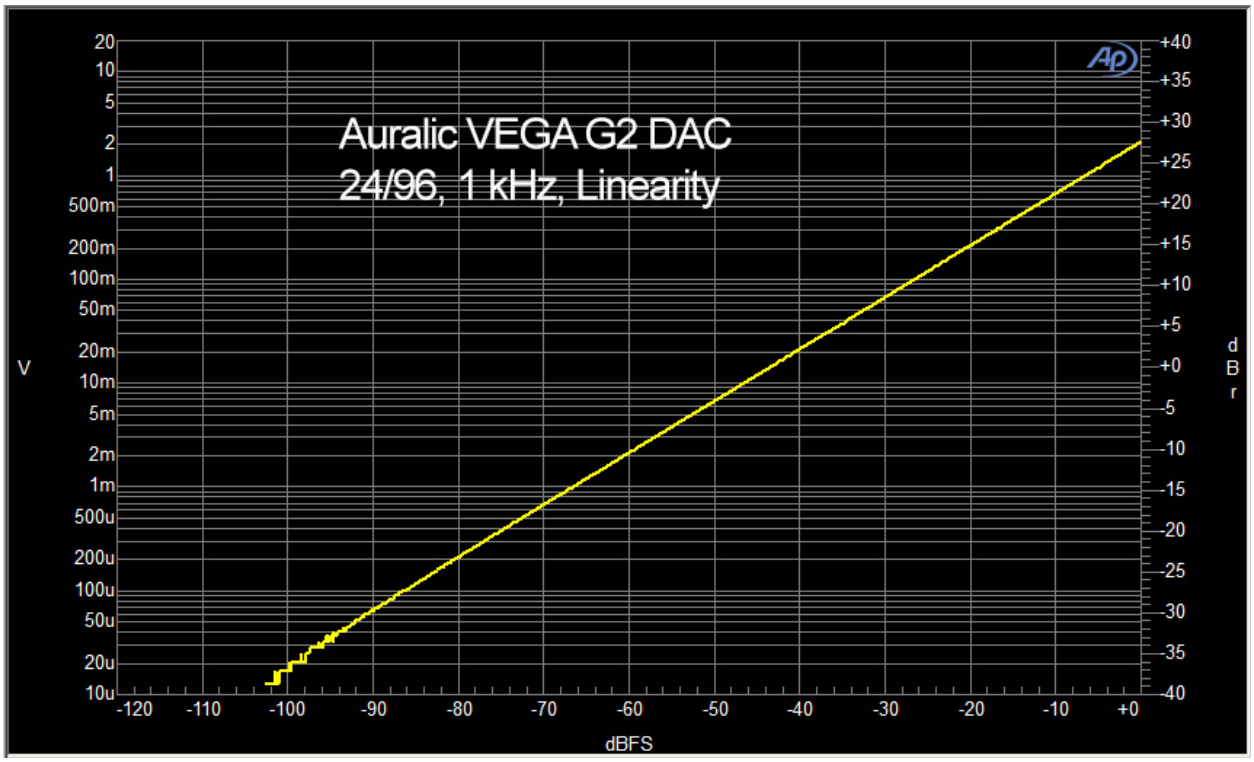
For the IMD test, I used 60 Hz and 7 kHz sine waves. IMD is 0.005%, but no modulation peaks are visible. This is truly exemplary performance. The IMD with the LEO GX attached was exactly the same.



The linearity at 16/44.1 sampling, using a 1 kHz sine wave, is shown below. The VEGA G2 DAC is linear down to almost -100 dBV, which is excellent.



Here is the linearity of a 1 kHz sine wave 24 bit file, in this case, 24/96. You can see that it is linear all the way down to 10 µV – that is, 10 millionths of a volt. At this point, the measurement starts to be noisy, so I did not go any farther. In any case, this is superb.

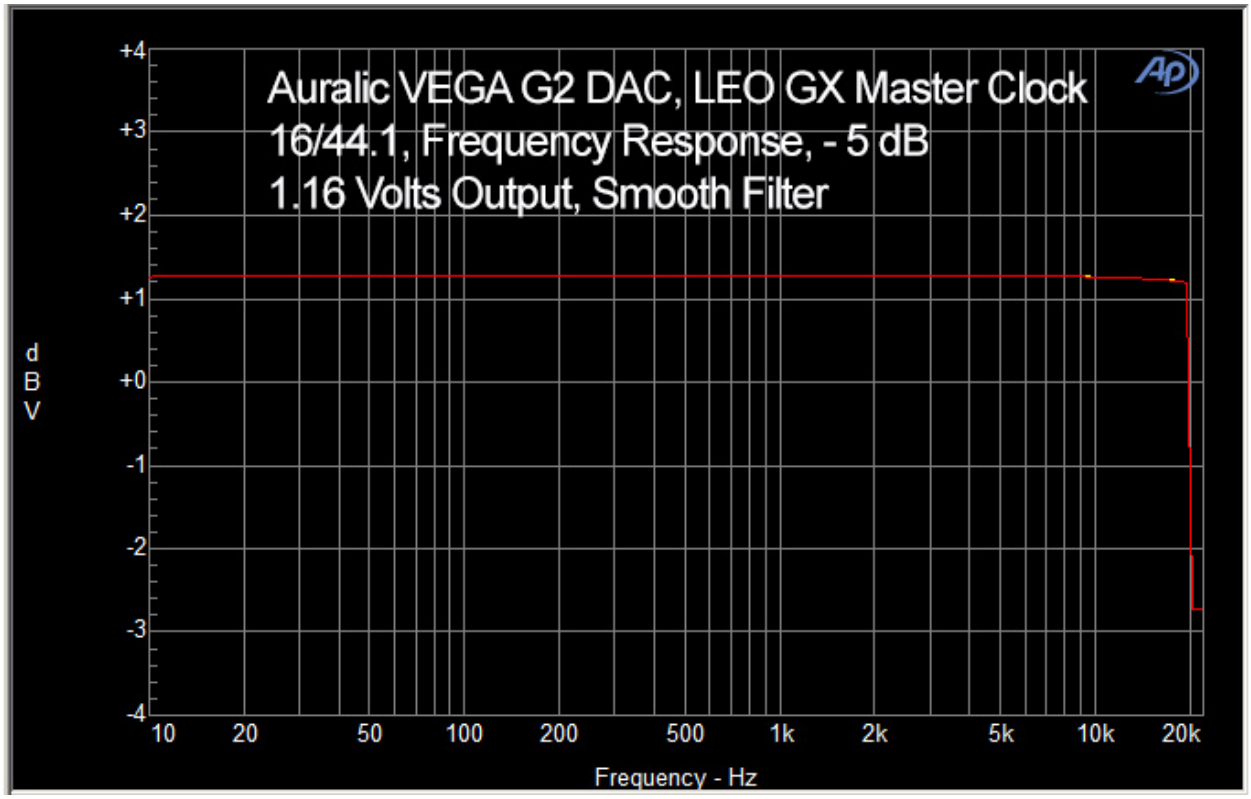


Now let’s take a look at frequency response. The Auralic VEGA G2 DAC has 4 PCM filters that you can use to fine tune the sound to your tastes. They are Smooth, Balance, Dynamic, and Precise.

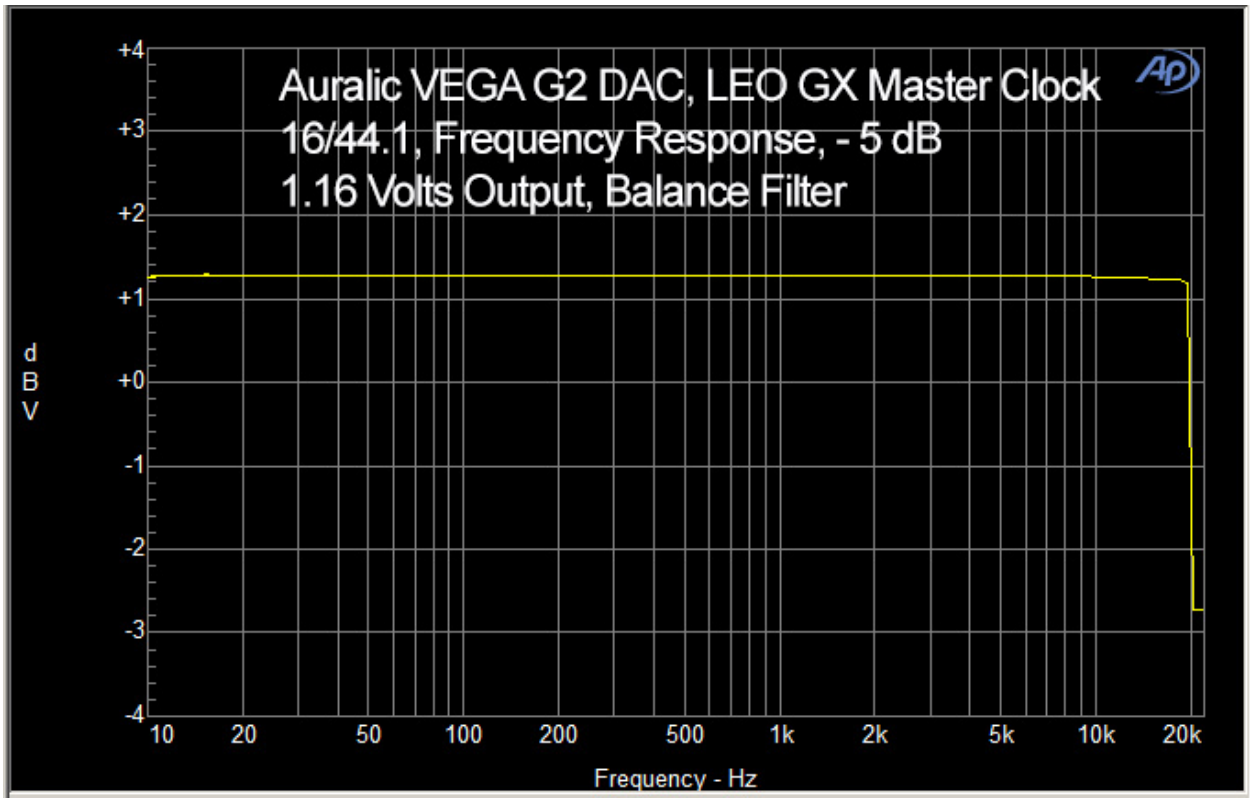
For the following four spectra, I had the LEO GX attached.

Here is the frequency response with the Smooth filter active. I used this filter for all the tests because the instruction manual states that this is the best filter for music listening.

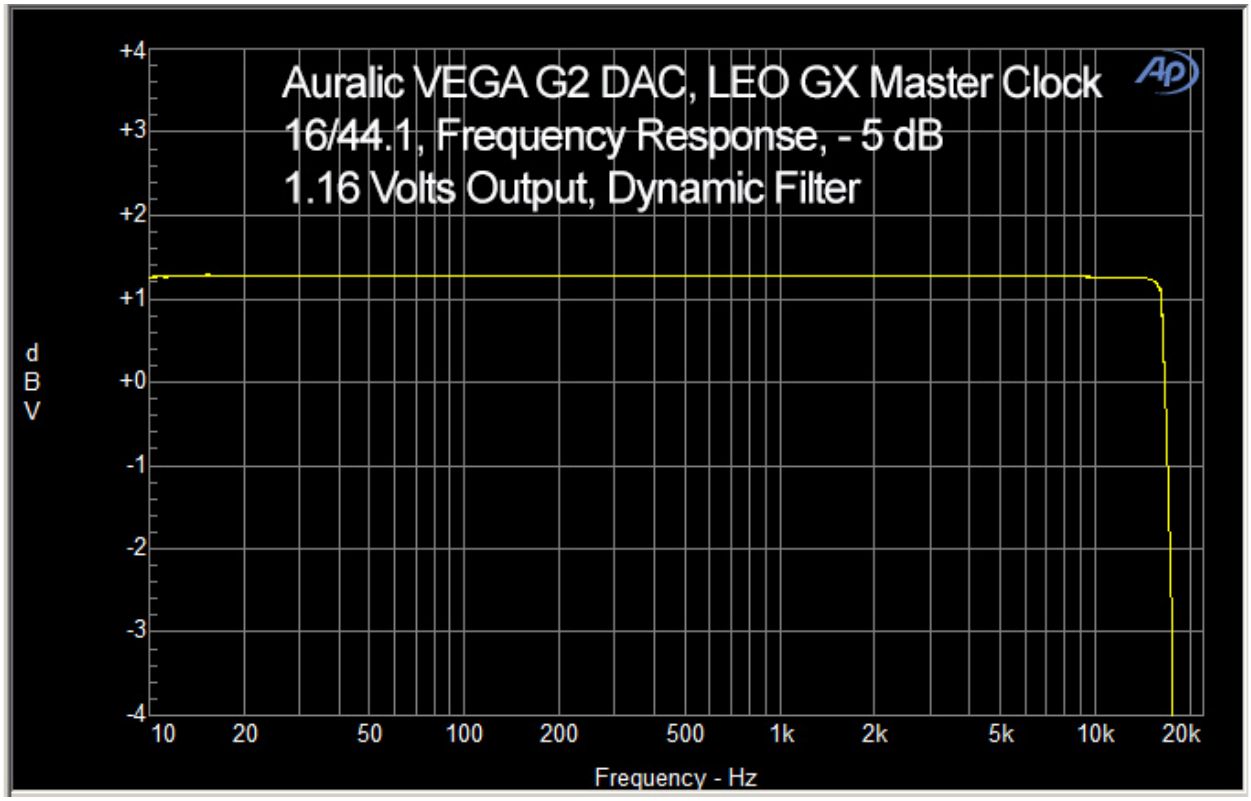
The response is very flat, rolling off only about a tenth of a dB by 20 kHz.



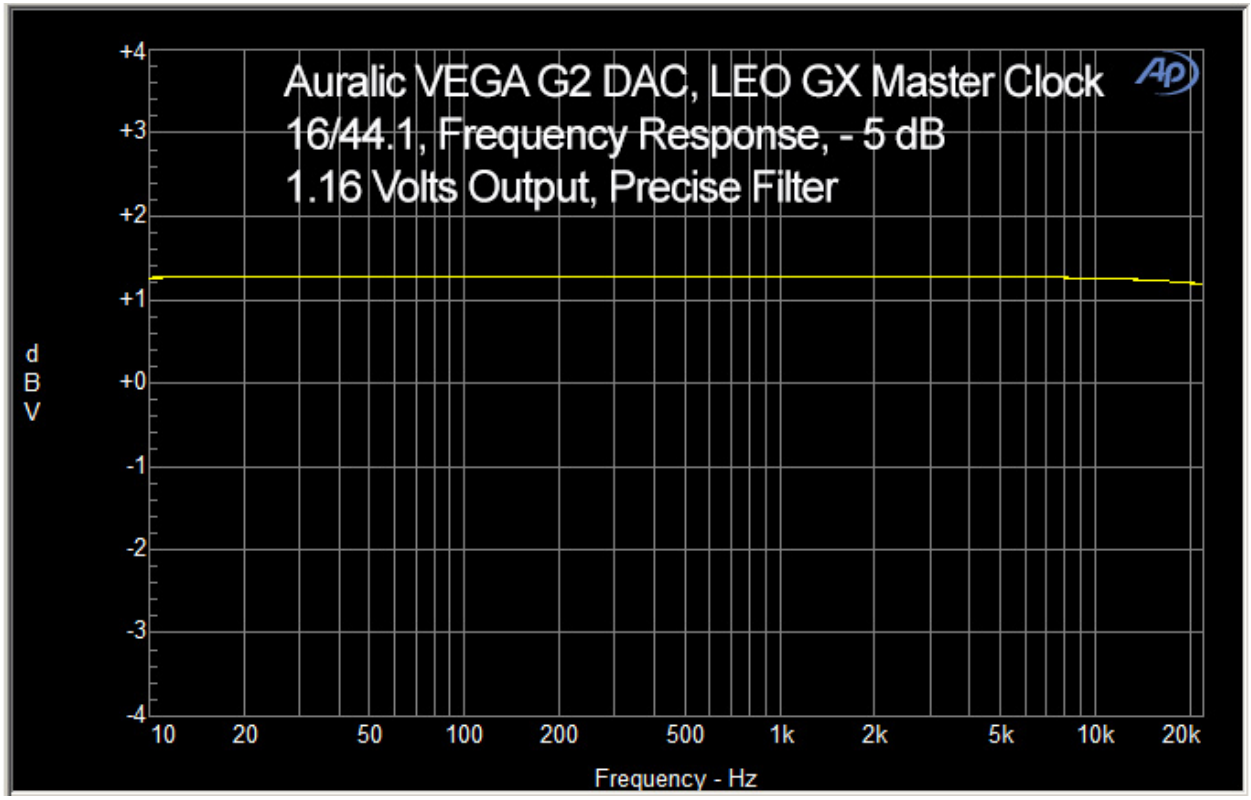
Next, the Balance filter. The frequency response is the same as with the Smooth filter. The differences are in the pass-band, stop-band, group delay, pre-echo, and ringing.



With the Dynamic filter, the response rolls off rapidly above 16 kHz.

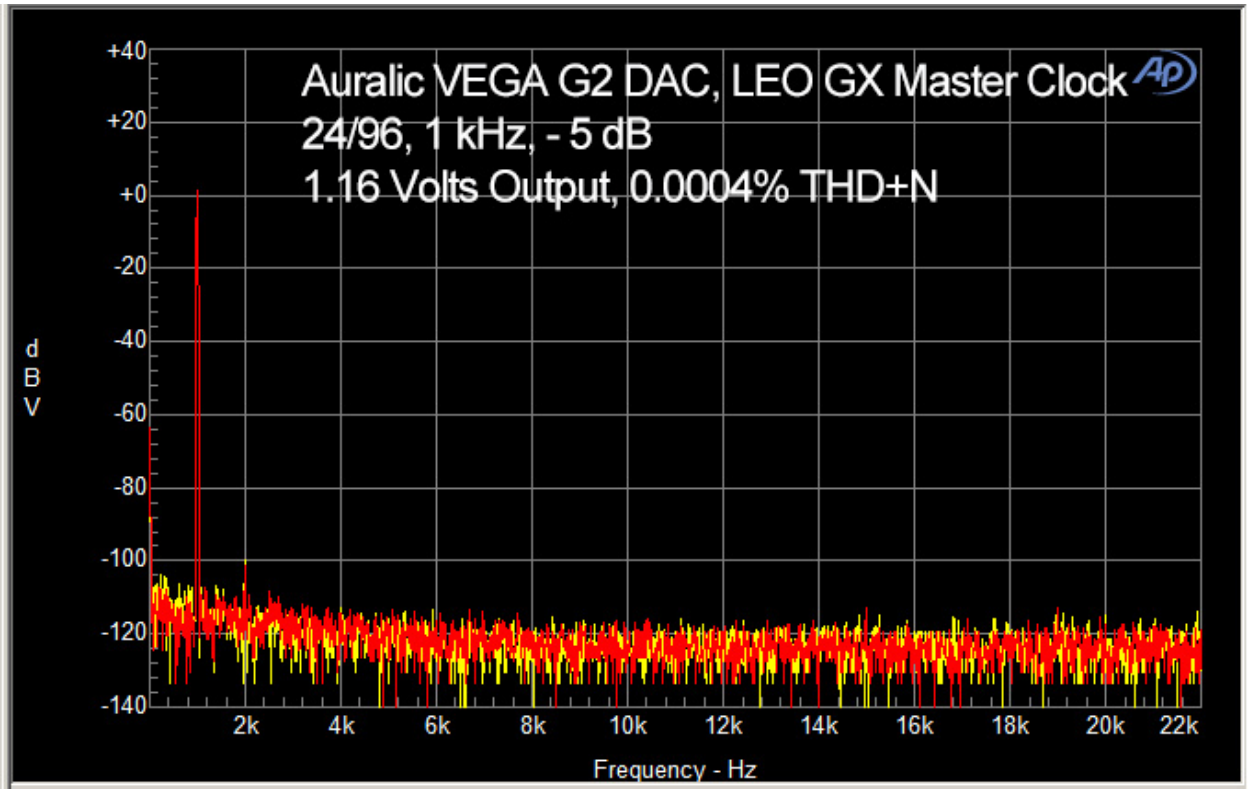


And, the Precise filter. In this case, the response extends to 22 kHz and is down 0.2 dB. With this filter, the effects extend to all the sampling rates, while for the other three filters, the effects do not extend past 22 kHz.

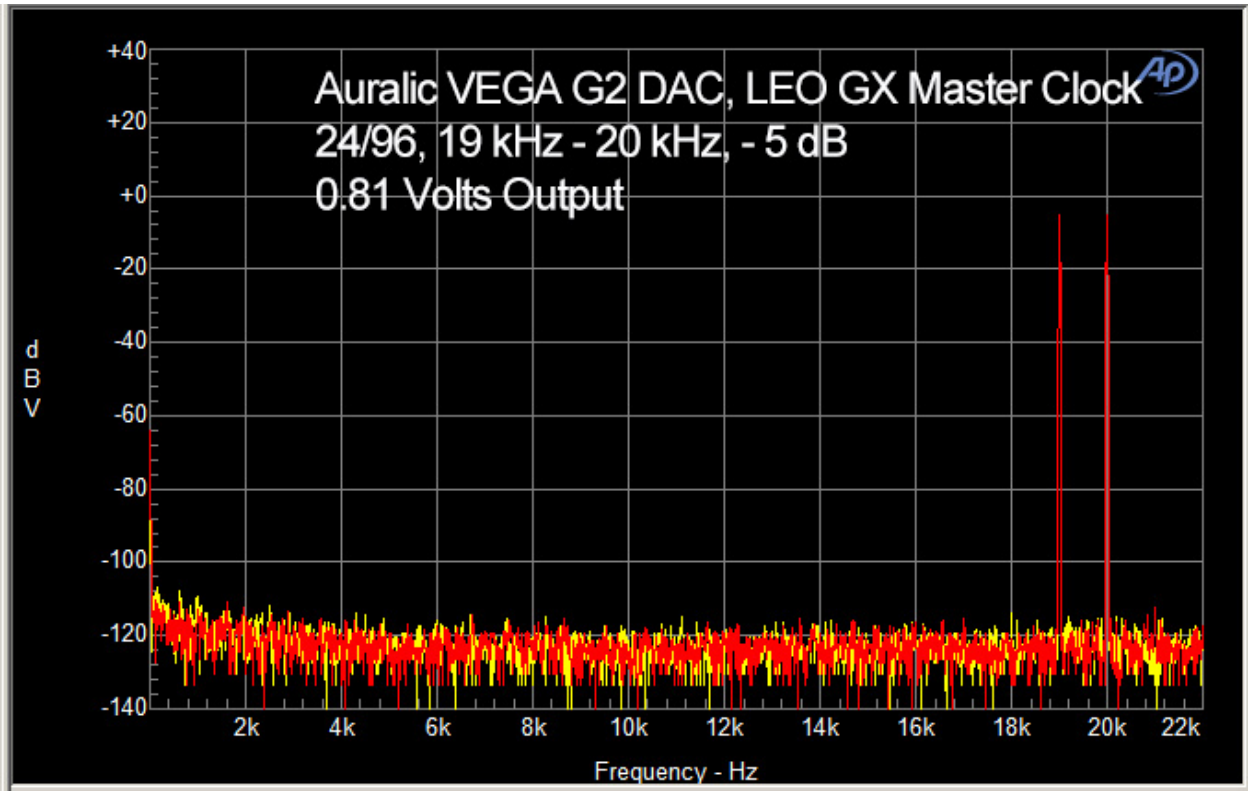


There are also two separate filters that work with DSD (SACD) music. All of the filters do their job in the digital domain.

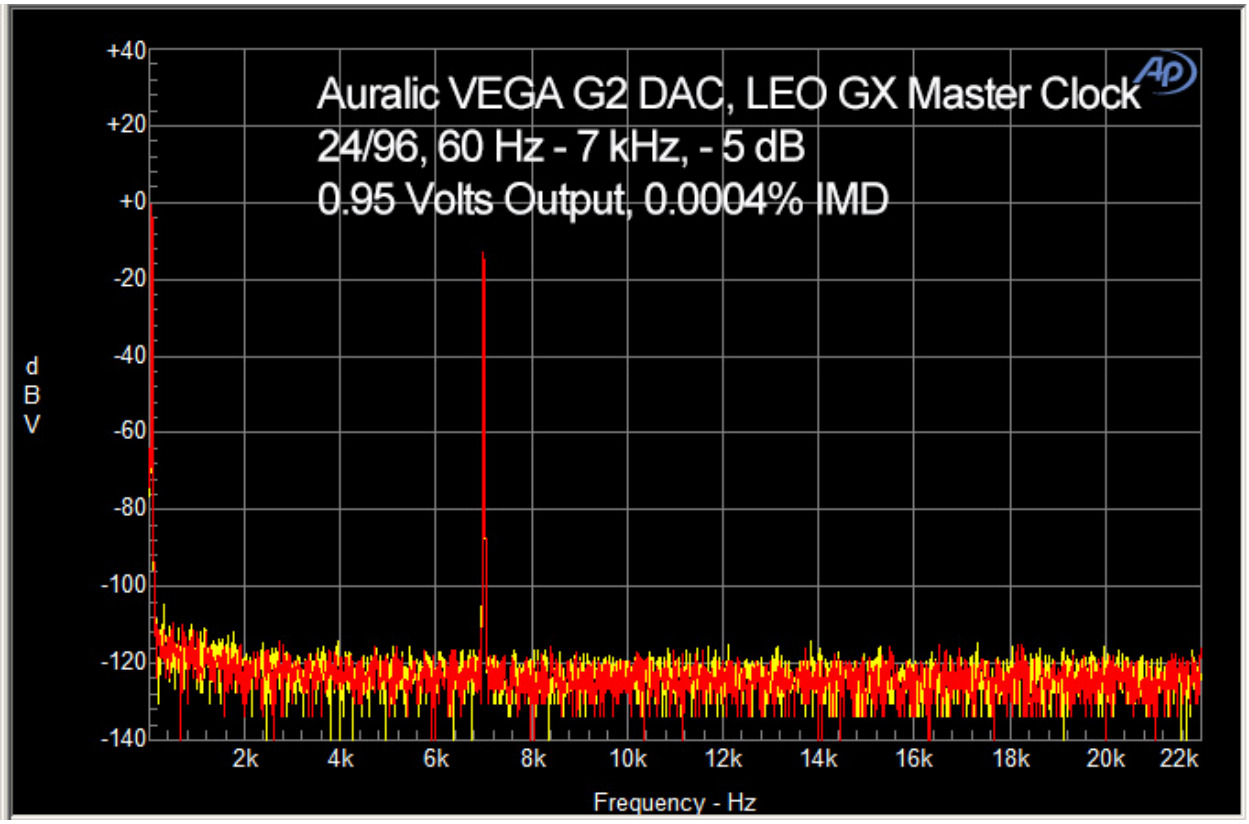
At 24/96 sampling, and with the LEO GX Master Clock attached, the 1 kHz test signal appears to have a very small second harmonic. At -100 dB, this harmonic is inaudible, as it is at the level of 10 millionths of a volt. Overall, the bulk of the noise is lower than it is at 16/44.1 sampling.



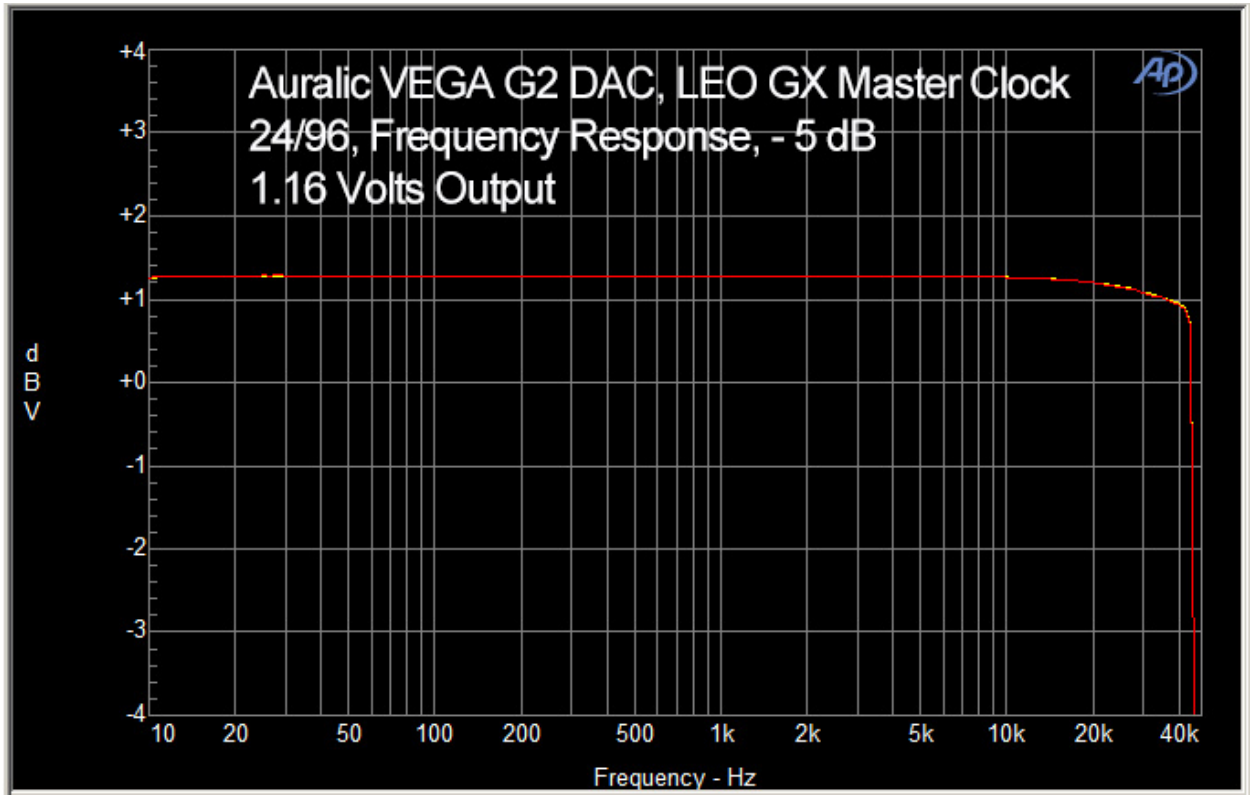
For the 19 kHz – 20 kHz test, there is no B-A peak at 1 kHz. The peaks that are near that point are random. There is a small peak at 21 kHz, but it is at the same level as many of the other random peaks. All of the noise peaks (random or otherwise) are at -110 dBV or lower. Totally inaudible.



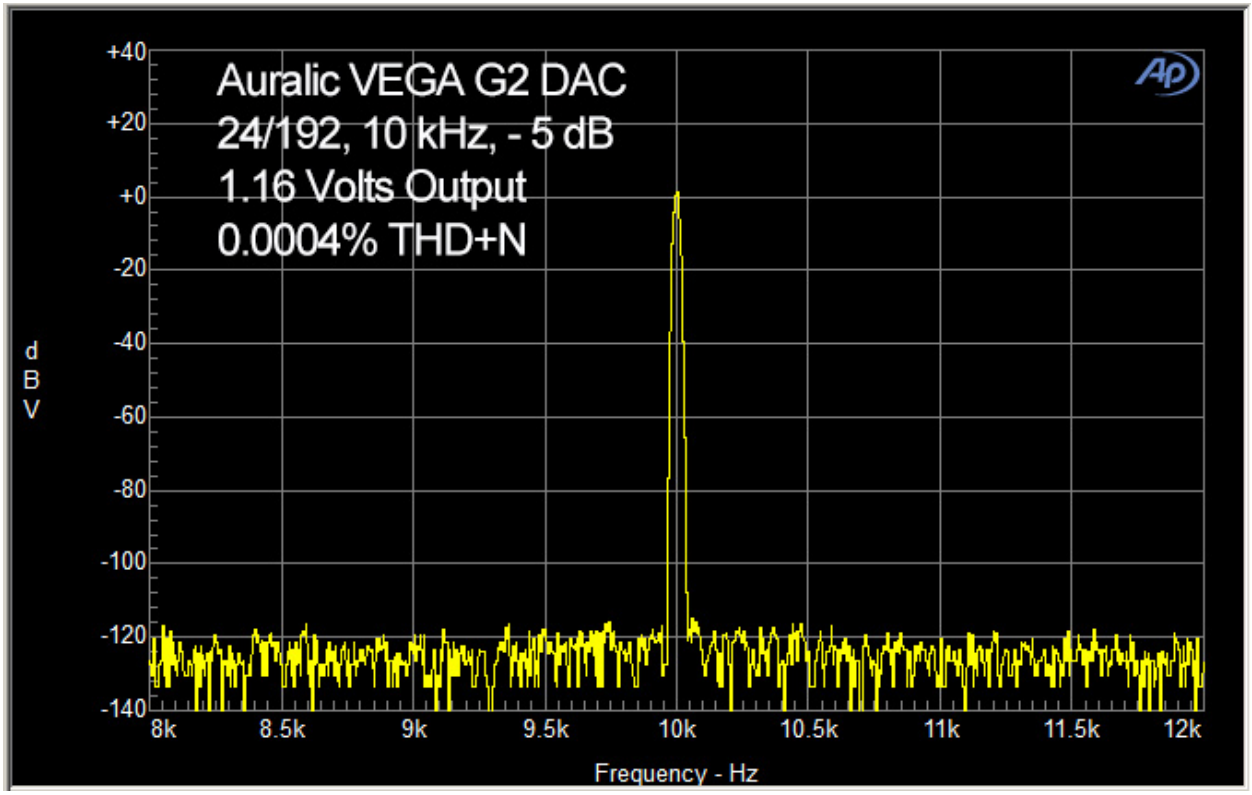
IMD is also pretty much non-existent.



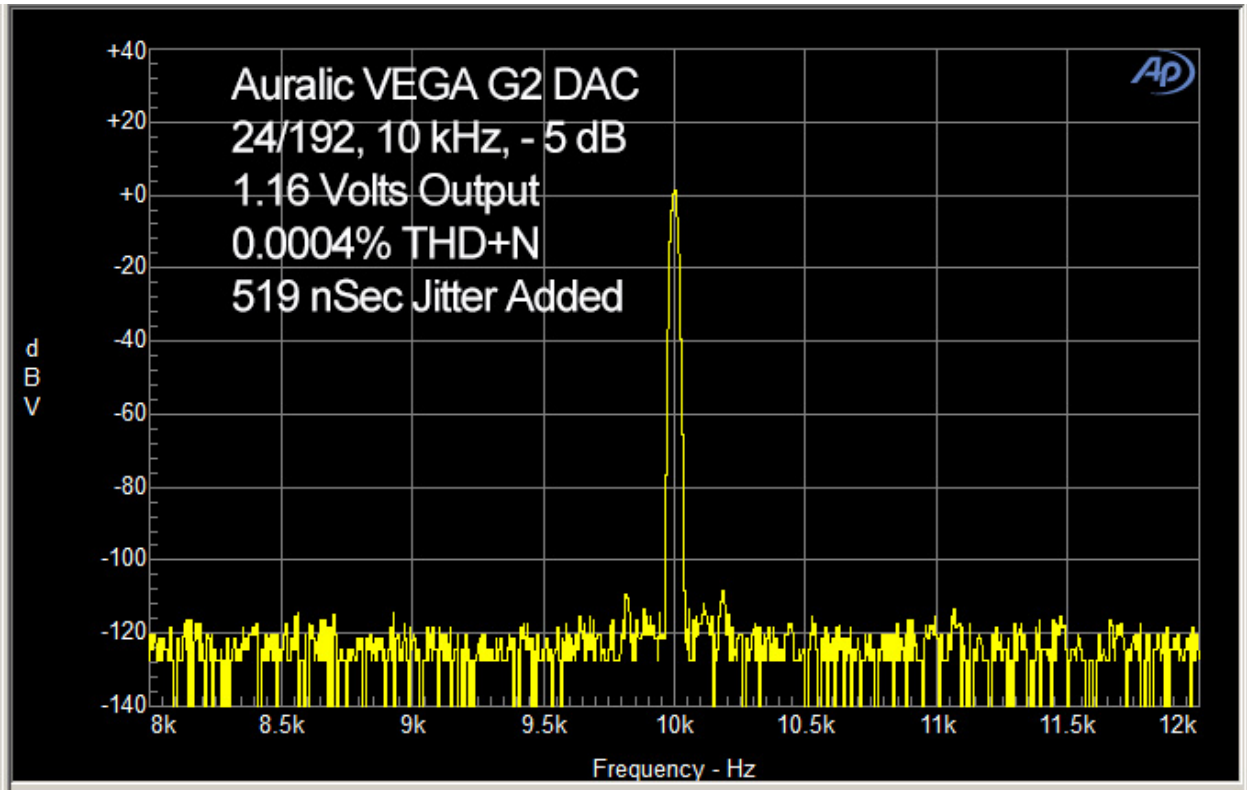
The frequency response is flat to 10 kHz and then rolls off 0.15 dBV at 20 kHz and drops precipitously at 45 kHz.



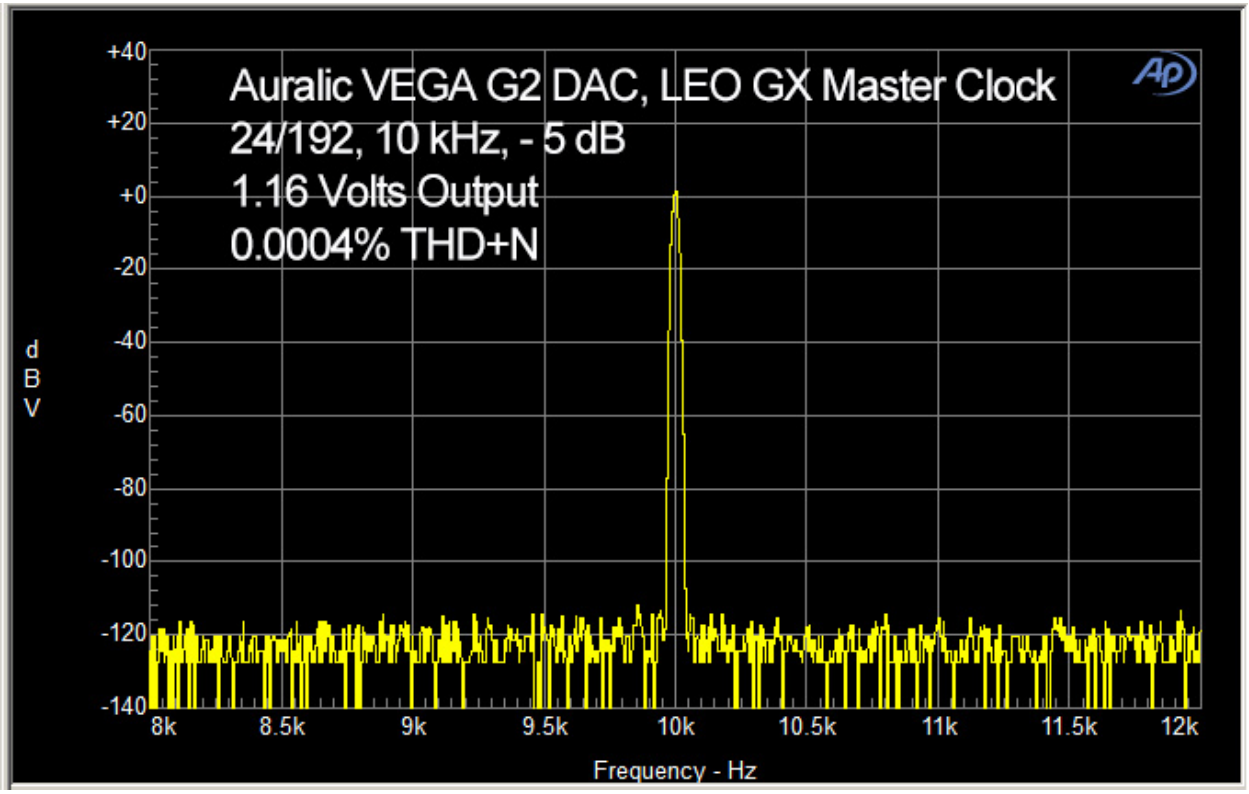
Here is the 10 kHz test for jitter, using 24/192 sampling. First, the Auralic VEGA G2 DAC alone, no jitter.



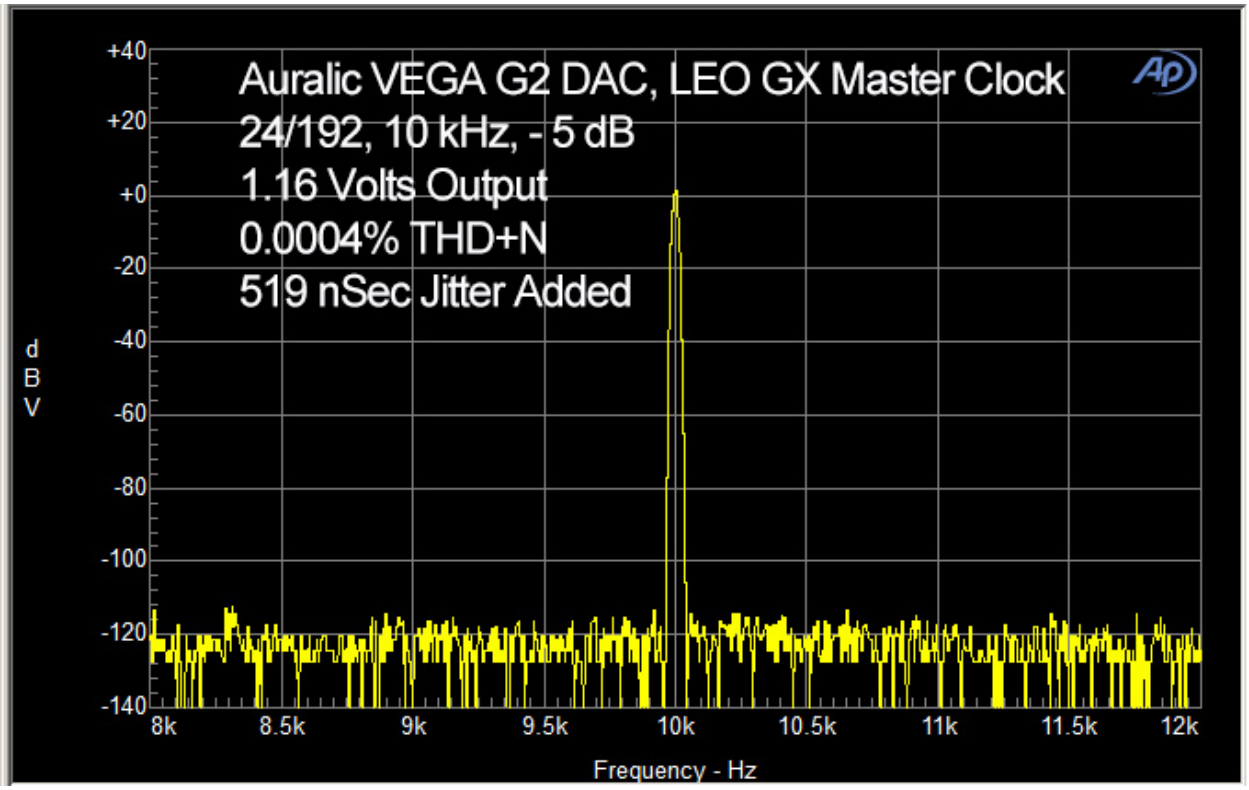
Now, the same test, with 519 nSec of 1 kHz sine wave jitter. You can see the peaks on either side of the base of the test tone. These are some of the characteristic artifacts produced by jitter. I also tried adding 1 nSec of 1 kHz sine wave jitter, and I could see very tiny side peaks (data not shown).



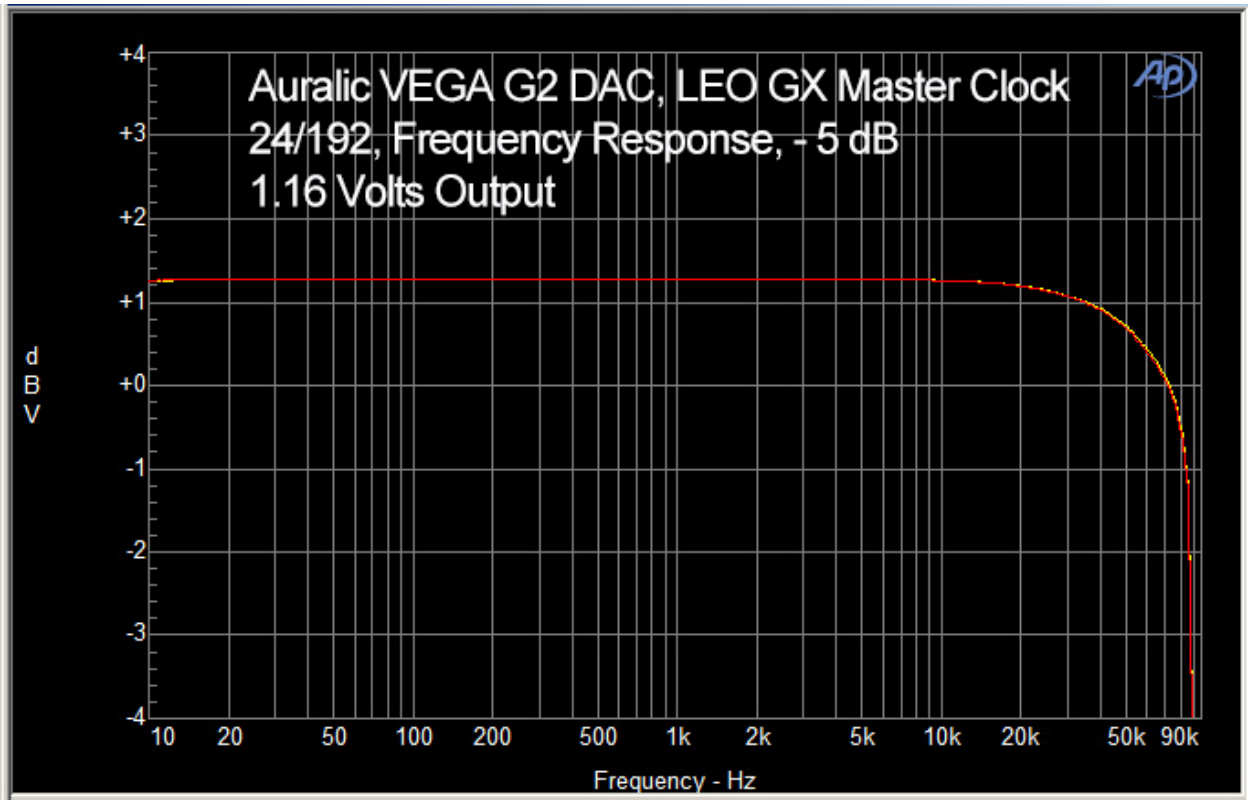
With the LEO GX Master Clock attached, no jitter added.



Now, with 519 nSec jitter added. You can see that the LEO GX suppresses all the jitter.



Here is the frequency response at 24/192. It starts rolling off at 10 kHz and is down 1 dB at 65 kHz.



Conclusions

I don't know how much better digital audio decoding can get. Auralic has achieved a new level of performance with the VEGA G2 DAC and LEO GX Master Clock. The distortion is so low, it is reaching the limits of my Audio Precision spectrum analyzer. Jitter, which is an important issue to be dealt with, is dealt with superbly.

I could not hear any difference between the VEGA G2 alone or with the LEO GX only in 16/44 sampling. I could hear a difference with 24/96 and 24/192 when I streamed the music. This did not occur with all streaming. Just some of it. This was due to the LEO GX' ability to suppress all the jitter that probably is present in some streamed music. The VEGA G2 alone could not suppress all the jitter. Most of it, but not all. The VEGA G2 is a very good DAC. The LEO GX is better at jitter suppression, but both products are excellent. I would recommend the two be purchased by consumers who are streaming all or much of their music rather than playing it from disc.

Likes:

Auralic VEGA G2 DAC:

Terrific sound quality

Excellent jitter suppression

Auralic LEO GX Master Clock:

Even better jitter suppression

Easy integration with VEGA G2 DAC

Would Like to See:

Auralic VEGA G2 DAC:

Choice of “None” in filter menu

HDMI input

Auralic LEO GX Master Clock:

No improvements necessary