www.audioxpress.com

audioxpress

ADVANCING THE EVOLUTION OF AUDIO TECHNOLOGY

NOVEMBER 2019 EXCERPT

Fresh From the Bench

Benchmark HPA4 Headphone/Line Amplifier

In this article, Gary Galo reviews the Benchmark HPA4, a reference headphone/line amplifier designed to deliver amplification of analog sources for audio enthusiasts, mixing and mastering engineers, and music aficionados in homes, recording studios, and mastering suites. Resulting from Benchmark's collaboration with THX, the HPA4 features a THX-888 headphone amplifier for an output signal with high voltage, current, and and power complemented by low distortion, noise, and crosstalk.

By
Gary Galo
(United States)

Photo 1: This is Benchmark's HPA4 Headphone Amplifier/Line Amplifier. This new product combines the LA4 Line Amplifier with a state-of-the-art headphone amp.

Benchmark Media Systems, Inc.
203 East Hampton Place, Suite 2
Syracuse, NY 13206
800-262-4675
www.benchmarkmedia.com
Price: $3,099 US
Optional Remote Control: $100 US

The HPA4 is the latest product from Benchmark Media Systems, an upstate New York audio manufacturer. Benchmark calls it a headphone amplifier, but it's really two products in one, combining the LA4 Line Amplifier introduced in 2018, with a headphone amplifier (see **Photo 1**). It is also based on the same THX Achromatic Audio Amplifier technology used in Benchmark's acclaimed AHB2 power amplifier. The signal path in the HPA4 is entirely analog, with four stereo, line-level inputs—two fully balanced XLR and two unbalanced RCA (see **Photo 2**). Outputs include stereo balanced XLR, a summed-mono balanced XLR, and stereo unbalanced RCA. The HPA4 is designed for full, professional operating levels using the XLR I/O, up to +28 dB, or 19.5 VRMS, in and out.

Overview

Nearly all of the control functions are accessed through the front-panel touchscreen (see **Photo 3**). The only visible control is a large volume knob on the left side. Features include separate volume and balance adjustments for the headphone and line outputs and individual gain adjustment for each input, up to ±10 dB. The gain adjustments are handy for matching playback levels between various source components. The Settings menu allows customizing various functions, including input identification and screen brightness. There are also a variety of powering options, including 12 V triggering. Benchmark's clear, well-written manual explains everything in detail, and is available as a download on its website.

The HPA4 is designed to be used with the same optional remote control as Benchmark's digital-to-analog converters (DACs). Benchmark has a firmware upgrade for its DAC2 and DAC3 converters that will enable the DACs to be put in a Compatibility Mode for use with the HPA4. The new firmware is V. 2.0 and consists of an 8-pin DIP module that plugs into an empty socket on the DAC's main PC board. The firmware upgrade costs $59 US and can be found on the Support/Parts page of the website. The Compatibility Mode avoids duplicating DAC and HPA4 functions. Input Selection and Volume now control the HPA4. The old firmware can be re-activated by moving a jumper on the PC board.

Photo 2: The rear panel of the HPA4 includes two stereo balanced XLR inputs and two stereo unbalanced RCA inputs. The fully-balanced outputs include stereo and summed-mono XLR connections, along with stereo unbalanced RCA connectors. The 12 V trigger connections can be used as either inputs or outputs, and the power connector accepts standard IEC power cords.

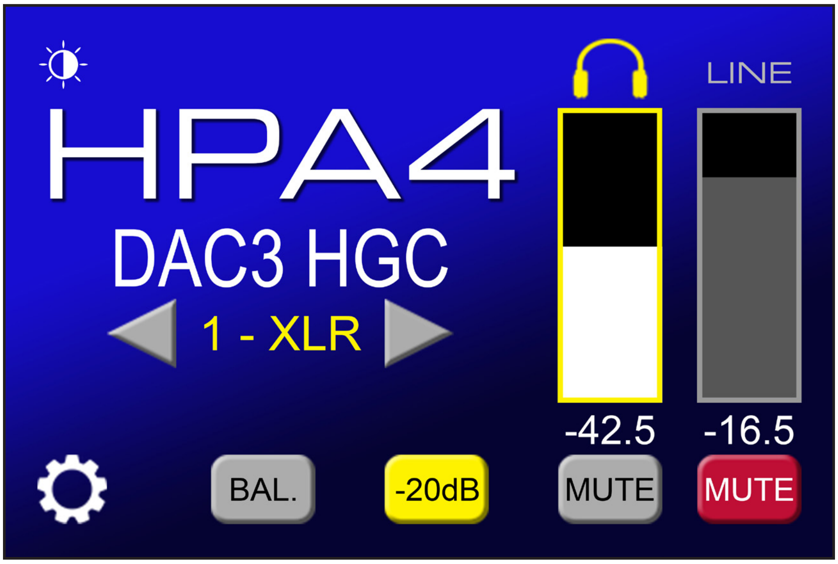

Photo 3: The attractive touchscreen display controls most of the functions of the HPA4. Channel balance can be separately adjusted for the headphone and line output groups. The gear symbol in the lower right selects the Settings menu. Volume can be individually trimmed for each of the four inputs, and the user can give each input a custom name.

Relay Volume Control

Benchmark's website offers a good overview of the innovative technology used in the HPA4, and a look "under the hood" reveals a clean and sophisticated execution (see **Photo 4**). The line amplification and volume control circuitry are on the upper, stacked PC boards, toward the rear panel. Each board contains five Texas Instruments LME49860 dual op-amps, the same low-distortion, low-noise, high-output current device used in the DAC2 and DAC3. The balanced inputs are terminated differentially, to achieve the highest-possible common-mode rejection. Benchmark uses a double-differential system, which is essentially differential in and differential out, so internally the amplification circuitry is also fully-balanced.

Volume control is accomplished with a unique system of precision relays with gold-plated contacts, and low-impedance resistor networks made with 0.1% tolerance precision resistors. To keep the noise levels as low as possible, Benchmark uses thin-film resistors with low temperature coefficients and conservative power ratings. The relay/resistor networks are actively buffered—the buffering provides high input impedances and low output impedances. The volume adjustments are accomplished with a hybrid of attenuators inside the feedback loops of the active devices, and passive inter-stage attenuation.

There are four independent, fully-balanced, 256-step volume controls—two for the line outputs and two for the headphone outputs. None of this would be possible without the digital control board, which is the bottom rear PC board partially visible in

Photo 4. The heart of this board is a Xilinx Spartan 6-series Field-Programmable Gate Array (FPGA) chip. The volume control knob operates an optical rotary encoder that turns continuously in either direction. The encoder includes an acceleration feature, which makes it easy to make large changes in volume very quickly, while allowing precise adjustments when the knob is rotated more slowly. When rotated slowly, each detent results in a 0.5 dB change, so the 256 steps cover a 128 dB range. The FPGA chip also provides precisely timed, make-before-break relay connections, eliminating the pops, clicks, and zipper noises often associated with relay switching, no matter how fast the volume control is rotated.

It's no secret that potentiometers in the signal path can add small amounts of noise and distortion, and with current measurement technology (e.g., the Audio Precision AP2722 system used by Benchmark) that noise and distortion can often be measured. When you're dealing with equipment capable of noise and distortion in the neighborhood of -130 dB, everything matters, and with a signal path as transparent as a DAC3/HPA4/AHB2 system, signal degradations masked by less capable equipment now become audible. Adding a balance potentiometer will make things even worse.

Even the best stereo potentiometers rarely have channel-to-channel tracking better than 1 dB across their rotation. Integrated circuit (IC) volume controls can be precise, but none are sonically transparent enough for perfectionist applications. The accuracy issue can be addressed with stepped attenuators and precision resistors, but I haven't seen any beyond 64 positions, making fine adjustments impossible. No stepped attenuator can offer more than a fraction of Benchmark's 256 positions, in 0.5 dB increments.

The relay system makes it possible to adjust channel balance and the gain of individual inputs, without any additional controls or circuitry. The FPGA chip simply switches the volume attenuator relays as needed to achieve these adjustments. Input switching and output muting are also done with relays, all controlled by the FPGA (see **Photo 5**). Benchmark has an application note on its website offering further details on the relay system, and how it's been implemented with the LME49860 op-amps. The complete app note provides additional technical information and is well worth reading.

I measured the review sample using my HP/Agilent 34401A's decibel function and found the channel-to-channel tracking to be within 0.02 dB over a 0 dB to -40 dB range (I didn't see the need to continue measuring below -40 dB). This certainly lives up to Benchmark's claim of "near perfect" tracking. I also found the accuracy of the 0.5 dB increments to be within 0.02 dB over the same range. This is extraordinary accuracy!

THX AAA Headphone Amplifier

THX's Achromatic Audio Amplifier topology uses feed-forward error correction to reduce distortion by 20 dB to 40 dB. The crossover distortion produced by conventional Class AB amplifiers is virtually eliminated. With feed-forward error correction, amplifier errors are extracted from the output audio signal, inverted in polarity and fed to the output to cancel the errors. A small, error-correction amplifier is needed to buffer the error signal, and any amplifier employing error correction can be no better than the error-correction amplifier itself. This is the technology used in the AHB2 power amplifier, and THX has recently applied this concept to a line of headphone amplifiers.

THX lists seven AAA headphone amplifiers on its website, covering low-cost, mobile applications

Photo 4: This is an inside view of the HPA4. The stacked left and right line amplifier circuit boards are visible toward the rear panel. Each line amp board contains active circuitry based on LME49860 op-amps and volume switching using gold-contact relays and 0.1% precision resistors. The THX-888 headphone amplifier board is on the bottom, toward the front. The digital control board is partially hidden by the analog boards, and the switching-mode power supply module is on the left.

to high-end, high-power audiophile-grade designs. Benchmark wanted a headphone amplifier with the same level of performance as the AHB2 power amp, so nothing short of the top-of-the-line would suffice. That top-of-the-line amplifier is the THX AAA888. The 888 is not a module, but rather a circuit topology that manufacturers can incorporate into their own PCB layouts. Benchmark actually participated in the final development of the 888 amplifier, which is a dual-mono design using a pair of Texas Instruments (TI) OPA564 power IC op-amps, one per channel.

The HPA4 includes both a 1/4" phone and an XLR4 connector for the headphone outputs. John Siau, Benchmark's VP and Director of Engineering, notes that the main advantage of the XLR4 connector is lower contact resistance than a 1/4" phone tip-ring-sleeve (TRS) interface. If a TRS connector must be used, it should have clean, gold-plated contacts. The outputs of each OPA564 drive the positive terminals of the headphone connectors.

Driving headphone voice coils differentially has gained some popularity in certain audio circles, but Benchmark's view is that this has no performance advantage because a transducer can't tell the difference between balanced and single-ended drive. The quality of the ground connection is crucial, and the XLR4 connector eliminates the shared ground connection between the two channels. Benchmark's favorite headphone has been the Sennheiser HD-650, which you can purchase on Benchmark's website. These headphones are supplied with a removable cord, terminated in a 1/4" TRS phone plug. But, Sennheiser also makes an upgrade cable, the CH 650 S, which has a 4-pin XLR connector.

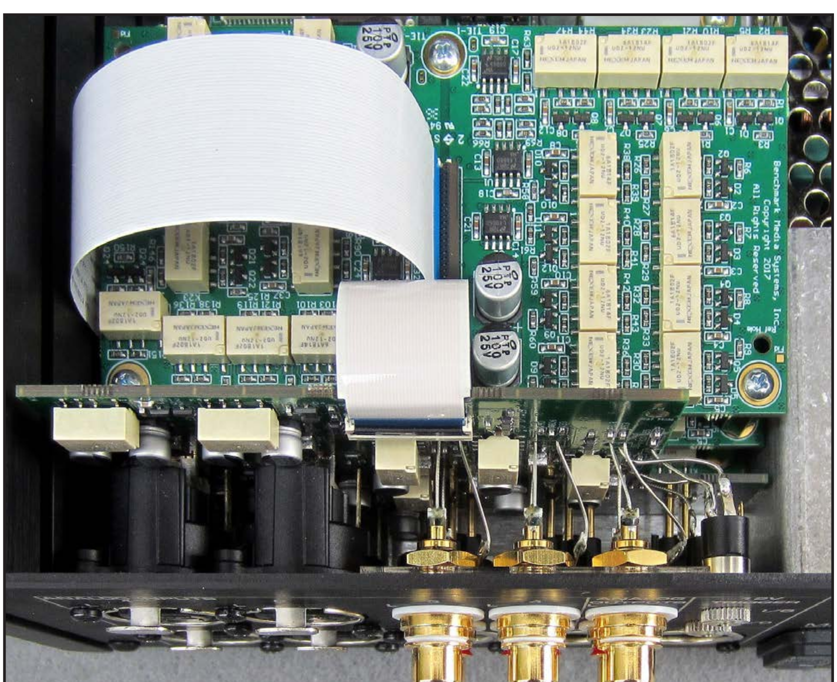

Photo 5: This is another inside view of the HPA4, showing the vertical input/output board and one of the analog boards. All input switching is done with gold-contact relays. The use of relays for volume control and input switching is more precise than conventional methods, and eliminates wiring between the controls and PC boards. This helps ensure the lowest-possible noise and distortion.

The OPA564 comes in a 20-pin PowerPAD package and is capable of delivering 1.5 A of output current. PowerPAD is a package developed by TI that provides efficient thermal transfer to a solder pad on the PCB. An application report is available on the TI website. Benchmark rates the headphone amplifier at 6 W into 16 Ω, so this really is a small power amplifier rather than one of the high-current op-amps more typically used in headphone amplifiers.

The headphone amp in the HPA4 has an output impedance of near-zero ohms. This is because there are no series resistors at the outputs of the OPA564 amplifiers, which would seriously degrade damping factor. Series resistors also change the headphone's frequency response because the impedance of a headphone, like nearly any transducer, changes with frequency. The THX AAA technology keeps the distortion levels extremely low even when driving difficult, low-impedance loads. The headphone amp includes protection against DC offset, clipping, short-circuits, as well as excessive temperature and output current. Any faults will trigger the output muting relays, protecting your headphones and your ears.

TI also specifies a full-power bandwidth of 1.5 MHz and a slew rate of 40 V/µSec. The 888 also uses a pair of OPA1612A dual op-amps as the error-correction amplifiers. The OPA1612A's rated THD of 0.000015% makes it ideal for this purpose. By itself, TI specifies THD for the OPA564 as 0.003%, or -90 dB. THX's AAA feed-forward error correction reduces the headphone amplifier THD to 0.00006%, or -125 dB. For those who are used to thinking of THD in percent, the formula for conversion to decibels is: dB = 20Log(%/100).

There's an online calculator for conversion in either direction on the Sengpiel Audio website. Benchmark's Application Note "Interpreting THD Measurements" is also worth reading.

Benchmark is a firm believer in switching-mode power supplies because they eliminate the hum fields caused by conventional, 60 Hz power transformers. Switching supplies are necessary to achieve signal-to-noise ratios (SNR) that realize the full potential of 24-bit DACs. Switching-mode power supplies (SMPS) have a bad reputation in some audio circles but, like any other design concept, execution is everything.

Benchmark achieves superior audio performance by using a power supply that operates at a switching frequency of 800 kHz—much higher than many switching-mode supplies. The HPA4 uses the same power supply module that Benchmark has used successfully in the DAC2 and DAC3 converters. Equally important is power supply filtering and regulation. For Benchmark, these are long-solved problems, as the superior performance of its DACs shows. The lack of radiated hum fields from Benchmark's products means that the HPA4, DAC, and AHB2 power amp can be stacked one on top of another with no degradation in noise performance.

The construction quality of Benchmark products has always been very high, and the HPA4 lives up to their reputation. This 8-pound chunk exudes quality as soon as you lift it out of the box. The front and side panels are anodized, machined aluminum, and the rear panel and bottom plate are 0.125" (3.18 mm) anodized aluminum stock. The front panel is 0.25" (6.35 mm) thick, matching the appearance of their DACs and power amp; the side panels are 0.84" thick (21.3 mm), which contribute to the robust feel, and also provide effective heat dissipation.

Performance

Benchmark lists an array of impressive specifications for the HPA4 (see **Table 1**). The line amplifier and headphone amp have -3 dB points of 0.1 Hz to 500 kHz, and THD of -125 dB (0.00006 %). The ultra-wide bandwidth ensures virtually perfect differential phase response well beyond the audible spectrum. Benchmark's frequency-response graphs show a ruler-flat frequency response for the line amplifier from 10 Hz to 200 kHz (the frequency limits of the Audio Precision AP2722). With the headphone amplifier driving 300 Ω and 16 Ω, the response is down 0.8 dB and 1.1 dB, respectively, at 200 kHz. The phase response of the headphone amplifier with a 300 Ω load is within 0.1°, 10 Hz to 200 kHz. The unweighted line amplifier SNR of -135 dB, 20 Hz to 20 kHz, actually exceeds that of the DAC3 HGC and the AHB2; SNR at the headphone output is -131 dB.

The instruction manual has 18 performance graphs done on the Audio Precision system, showing the outstanding measured performance of the HPA4. I've picked a few to illustrate the unit's extremely low noise and distortion (the full manual is available as a download on Benchmark's website).

The graphs in **Figure 1** show Fast Fourier Transform (FFT) plots of the HPA4's idle channel noise, balanced in to balanced out (see Figure 1a) and balanced in to headphone out (see Figure 1b). The left and right scales are calibrated relative to +28 and +22 dBu, respectively (+22 dBu is the level required to drive the headphone amp and the AHB2 power amp to their full, rated output). The graphs show that the headphone amplifier retains the exceptional noise performance of the line amplifier,

Specifications for Benchmark's HPA4

THX-888 Headphone Output
THD: < -125 dB (0.00006%)
SNR: > 131 dB, unweighted, 20-20 kHz
SNR: > 135 dB, A-weighted
Frequency Response: - 0.003 dB at 10 Hz, -0.001 dB at 20 kHz
- 3 dB Bandwidth exceeds 0.1 Hz to 500 kHz
Output Impedance: near 0 Ω
Output Noise: < 2.45 μV at Unity Gain, 20-20 kHz
Maximum Output Power: 6 W into 16 Ω
Maximum Output Current: 1.5 A
Maximum Output Voltage: 11.5 Vrms into 300 Ω
Crosstalk: < -133 dB at 1 kHz, -115 dB at 10 kHz (XLR4)

Balanced Line Outputs
THD: < -125 dB (0.00006%)
SNR: > 135 dB, unweighted, 20-20 kHz
SNR: > 137 dB, A-weighted
Frequency Response: - 0.003 dB at 10 Hz, -0.001 dB at 20 kHz
- 3 dB Bandwidth exceeds 0.1 Hz to 500 kHz
Output Impedance: 60 Ω
Output Noise: < 1.9 μV at Unity Gain, 20-20 kHz
Maximum Input and Output Voltage: 20 Vrms (+28 dBu)
Crosstalk: < -133 dB at 1 kHz, -116 dB at 10 kHz

Dimensions
8.65" W x 3.88" H x 8.33" D - Including Feet
8.65" W x 3.47" H x 8.33" D - Excluding Feet

Weight
8.0 lbs., 12 lbs. shipping

Power Consumption
18 W Typical Input Power
35 W Maximum Input power
0.33 W Standby Power (when off)
Internal Universal Power Supply

Table 1: Manufacturer's specifications for the HPA4

About the Author

Gary Galo retired in 2014 after 38 years as Audio Engineer at The Crane School of Music, SUNY at Potsdam, NY. He now works as a volunteer in the Crane Recording Archive doing preservation, restoration, and digital transfer of vintage Crane recordings. He is also a Crane alumnus, having received a BM in Music Education in 1973 and an MA in Music History and Literature in 1974. Gary is a widely published author with more than 300 articles and reviews on both musical and technical subjects, in over a dozen publications. Gary has been writing for *audioXpress* and its predecessors since the early 1980s. He has been an active member of the Association for Recorded Sound Collections (ARSC) since 1989, and a frequent recording and book reviewer for the *ARSC Journal*. He has given numerous presentations at ARSC annual conferences, many of which have been published in the *ARSC Journal*. He was the Sound Recording Review Editor of the *ARSC Journal* from 1995-2012, and co-chair of the ARSC Technical committee from 1996-2014. Gary has also published numerous book reviews in *Notes: Quarterly Journal of the Music Library Association*, written for the *Newsletter of the Wilhelm Furtwängler Society of America*, *Toccata: Journal of the Leopold Stokowski Society*, and he is the author of the "Loudspeaker" entry in *The Encyclopedia of Recorded Sound* in the US. He has also written several articles for *Linear Audio*. He is a member of the Audio Engineering Society, the Boston Audio Society, and the Société Wilhelm Furtwängler.

with idle noise at or below -160 dB over most of the audible spectrum.

Figure 2 shows AC line-related hum at the headphone output. The graph shows hum to be at least -152 dB relative to the headphone amp's maximum output of +22 dBu. This graph makes a good case for a properly designed SMPS, which virtually eliminates any trace of power line hum.

The graphs shown in **Figure 3** are FFT plots showing total harmonic distortion (THD) of a 1 kHz tone, at an output level of +22 dBu. The upper graph (a) is balanced in to balanced out. The third harmonic measures better than -124 dB (0.00006%) and the fifth harmonic measures better than -141 dB (0.000009%). The lower graph (b) is balanced in to headphone out, with the headphone output driving its full rated 6 W into a 16 Ω load. The second harmonic measures better than -127.5 dB (0.00004 %) and the third harmonic measures better than -126.5 dB (0.00005 %). The manual also contains 10 kHz THD comparisons of the line and headphone outputs—they're essentially identical, with second and third harmonics measuring better than -124 dB (0.00006%) at both outputs. A 16 Ω load at an output level of 6 W is a worst-case situation, not likely to be encountered in any real-world application, by anyone who values their hearing (!). The fact that the headphone output shows essentially no degradation of the signal fed to it, under extreme output and loading conditions, is a testament to the effectiveness of the THX AAA error correction. Benchmark's data shows the measured performance of the HPA4 to be state-of-the-art, and beyond reproach.

Figure 1: These graphs show FFT plots of the HPA4's idle channel noise, balanced in to balanced out (a) and balanced in to headphone out (b). Green is the left channel, red is the right channel, and yellow is the summed mono output in the top graph (a) only. The left and right scales are calibrated relative to +28 and +22 dBu, respectively. The graphs show that the headphone amplifier retains the exceptional noise performance of the line amplifier, with idle noise at or below -160 dB over most of the audible spectrum. All of Benchmark's measurement graphs are done with the Audio Precision AP2722. (Image courtesy of Benchmark Media Systems)

Listening

I'm using the HPA4 as a line amplifier connected between my DAC3 HGC and pair of AHB2 power amps. I have one AHB2 per channel, in stereo mode, passively bi-amping my Audio Concepts Sapphire III/Sub 1 loudspeaker systems. The AHB2 power amps are set to Benchmark's recommended +22 dBu, which is their lowest sensitivity position (toggle switches all the way down). The output attenuators on the DAC3 are set to 0 dB, and for most of my listening, I've set the DAC3 in Compatibility Mode.

My OPPO Digital UDP-205 digital player's HDMI 2 output feeds a KanexPro HDMI De-Embedder which, in turn, is connected to one of the DAC3's S/PDIF inputs. I also connect the OPPO Digital player's balanced analog outputs directly to the XLR2 inputs on the HPA4, to play SACDs in native DSD mode. All analog interconnections are balanced, using D.H. Labs Air Matrix cables and Neutrik gold-plated XLR connectors.

With the DAC3 HGC connected directly to my AHB2 power amps, my system has performed superbly, with excellent detail and sound-stage reproduction, and a sonic presentation that provides hours of fatigue-free listening. Given the superb measured performance of the HPA4, I expected the HPA4 line amplifier to be sonically transparent, so it would not degrade the output of the DAC3 HGC, In other words, its presence in the signal path would not be detectable. What I heard was not at all what I expected. What I've heard, consistently, is an across-the-board improvement over the DAC3 driving the power amps directly. On my system, several things are obvious: greater inner detail and resolution; larger and more precise soundstage; noticeably improved dynamics, low-frequency extension and control. I wasn't prepared for this!

In my memorial tribute to C. Victor Campos (*audioXpress*, March 2018) I mentioned the large quantity of 15-IPS copies of master tapes he had acquired from major record companies, for his program "Adventures in Sound" that aired on WGBH-FM in the 1970s. I did high-resolution digital transfers of several of his favorite tapes for him between 2010 and 2016—some of the original recordings are revered by audiophiles.

My digital transfers of these superb tapes have been staples of my own audio listening, for equipment evaluation, and sheer musical and sonic pleasure. I have played them dozens of times and should, by now, intimately know their sonic qualities. I was wrong. With the HPA4 in my system, I hear inner details and subtle soundstage cues that I had not previously experienced on these recordings. Some of these recordings have low-frequency extension and weight that I didn't know were there. The dynamic range also seems wider. In pieces that begin softly and end with a full orchestra, I've found that I need to start at a lower subjective volume than before, in order to keep levels comfortable at the end. I've noticed these improvements in all of my reference recordings, whether CDs or higher-resolution sources.

How can this be? I posed that question to John Siau. He provided a detailed explanation of how inserting the HPA4 in the signal path actually results in lower noise than with the DAC3 HGC feeding the AHB2 directly. Running the DAC3 HGC

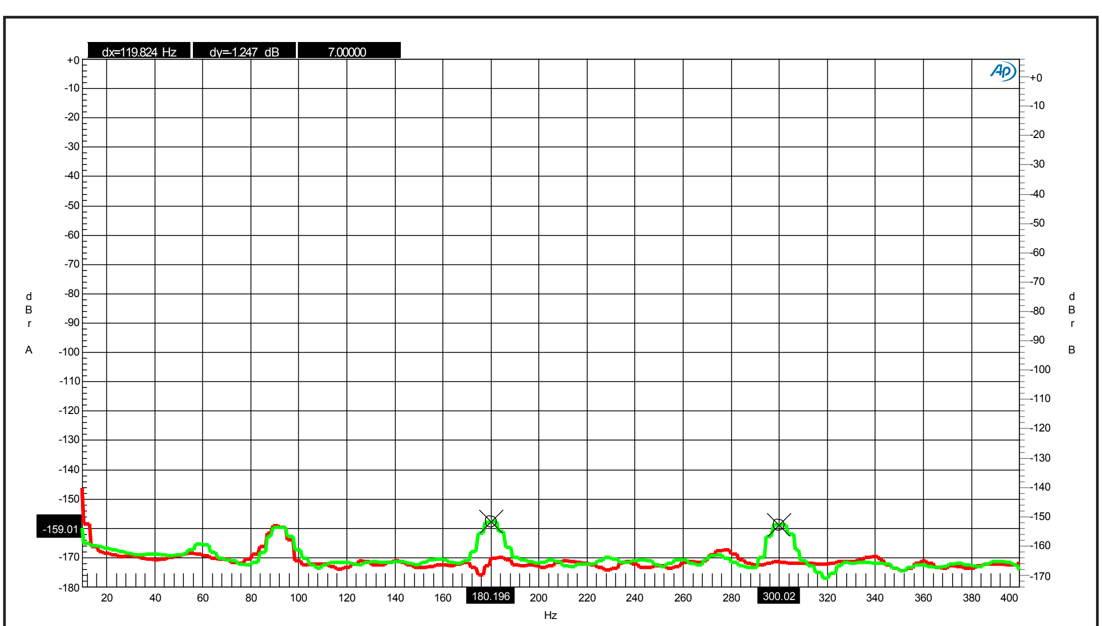

Figure 2: This graph shows AC line-related hum at the headphone output. The graph shows hum to be at least -152 dB relative to the headphone amp's maximum output of +22 dBu. The switching-mode power supply, which doesn't use a conventional 60 Hz power transformer, virtually eliminates any trace of power line hum. (Image courtesy of Benchmark Media Systems)

in Compatibility Mode allows the DAC to operate at maximum SNR. Running the DAC3 HGC directly into the AHB2 gives the following SNR results:

Full system output: System SNR = 125 dB
-6 dB output: System SNR = 119 dB
-8 dB output: System SNR = 117 dB

Inserting the HPA4 line amp in the signal path results in improved SNR at the same system output levels:

Full system output: System SNR = 127 dB
-6 dB output: System SNR = ~125 dB
-8 dB output: System SNR = 125 dB

But, I suspect there is more going on here than just an improvement in SNR. Siau confirmed that with the DAC3 HGC in Compatibility Mode, the 32-bit digital volume control in the ES9028PRO DAC chip is out of the picture. As good as that digital volume control is, system performance may not be as transparent as it is with the analog relay volume control in the HPA4. In its two-page cut sheet describing the HPA4, Benchmark notes that the fully-analog relay gain control is "more resolving" than the 32-bit digital gain control in the DAC3.

This prompted me to conduct an experiment. In Compatibility Mode, the DAC3 HGC's volume control is positioned at 2:00, and the calibrated output level is 3.5 dB below maximum output. Since the ES9028PRO's digital volume control is bypassed, that 3.5 dB reduction in level is accomplished entirely by the DAC3's analog volume control. What would happen if the DAC3 were taken out of Compatibility Mode, and run with the volume control at full rotation?

I set the XLR1 input level trim on the HPA4 to -3.5 dB, to compensate for the 3.5 dB increase in level from the DAC. So, the system playback level remained unchanged. What I heard was a subtle increase in ambience retrieval, which put the entire soundstage just a bit further back, behind the front plane of my loudspeakers, than before. In addition to directly driving the AHB2s, I've also had my own custom-built preamp in the line between the DAC3 HGC and the power amps. My preamp has the transformer-coupled balanced outputs I described in the February 2019 issue of *audioXpress*. With this arrangement, I normally had the DAC3's volume control at 2:00, to bring the volume control on my preamp closer to the center of its rotation. I tried this same experiment with my own preamp in the line and could not really hear any difference between the DAC3 at full volume or at 2:00. It's now obvious that my preamp was masking a difference that that the HPA4 easily reveals.

I shared my reactions with Siau and he noted one caveat: Running the DAC's volume control at maximum reduces the headroom available for inter-sample overs (see Benchmark's App Note on intersample overs, and my review of the DAC2 DX). He noted that the 3.5 dB reduction with the output level calibrated is to allow sufficient headroom for the reproduction of intersample peaks. Running the DAC's volume at maximum reduces the available headroom.

I listen to classical music almost exclusively. Classical music tends to have wide dynamic range, with much of the program material in most pieces well below maximum level. On a lot of popular music recordings, dynamic range is much more limited. I've viewed many such recordings on my digital editor and observed long stretches—and sometimes entire songs—where the volume is at or close to maximum level. This will make intersample overs a potentially greater problem, since they can occur much more frequently. I suggest trying my experiment with the music you enjoy to see what your ears tell you. As I explained in my DAC2 DX

Reources

Benchmark Application Notes, Benchmark Media Systems, Inc., https://benchmarkmedia.com/blogs/application_notes.

G. Galo, "A Transformer-Coupled Output for Solid-State Preamps," *audioXpress*, February 2019.

———, "OPPO Digital UDP-205," audioXpess, November 2017, www.audioxpress.com/article/oppo-digital-udp-205-review-a-4k-ultra-hd-audiophile-blu-ray-disc-player

———, "Benchmark DAC3 HGC," *audioXpress*, July 2017, www.audioxpress.com/article/fresh-from-the-bench-benchmark-dac3-hgc-stereo-d-a-converter

———, "KanexPro HDMI De-Embedder" *audioXpress*, July 2016.

———, "Benchmark DAC2 DX," *audioXpress* website, July 2015, www.audioxpress.com/article/Fresh-from-the-Bench-Benchmark-DAC2-DX-Stereo-D-A-Converter

———, "Benchmark AHB2," audioXpress, April 2015, www.audioxpress.com/article/Fresh-from-the-Bench-Benchmark-AHB2-Stereo-Power-Amplifier

Sources

THX AAA Headphone Amplifiers
THX, Ltd. | www.thx.com/mobile/aaa

Texas Instruments PowerPAD IC Package
Texas Instruments |
www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=slma002&fileType=pdf

Converting THD decibel to Percent and Vice Versa
Sengpiel Audio | www.sengpielaudio.com/calculator-thd.htm

review, intersample overs are only a problem with sample rates of 48 kHz or lower. At higher sample rates, they're not an issue.

I evaluated the headphone amplifier with my AKG K-240 headphones, which have a nominal impedance of 62 Ω. The HPA4 drives these headphones with ease, with plenty of headroom, and seemingly no sonic character of its own. What you hear from the line amplifier is faithfully passed to your headphones, with the same level of detail and resolution. The THX AAA error correction really does provide the same benefits for headphones that the AHB2 does for loudspeakers. Compared to the already-excellent headphone amp in the DAC3 HGC, the HPA4 is simply cleaner, more spacious and more detailed, with better dynamics and better low-frequency extension and control.

The AHB2 power amps have always left me with the impression that they have unlimited speed—no audio signal is capable of out-running them. This, no doubt, contributes to their subjectively crisp, clean performance, free of any transient smearing. I have the same reaction to the line amp and the headphone amp in the HPA4. By comparison, my own preamp seems just a bit sluggish.

Like the other Benchmark products I use, the line amp and the headphone amplifier achieve exceptional detail without any exaggeration in the

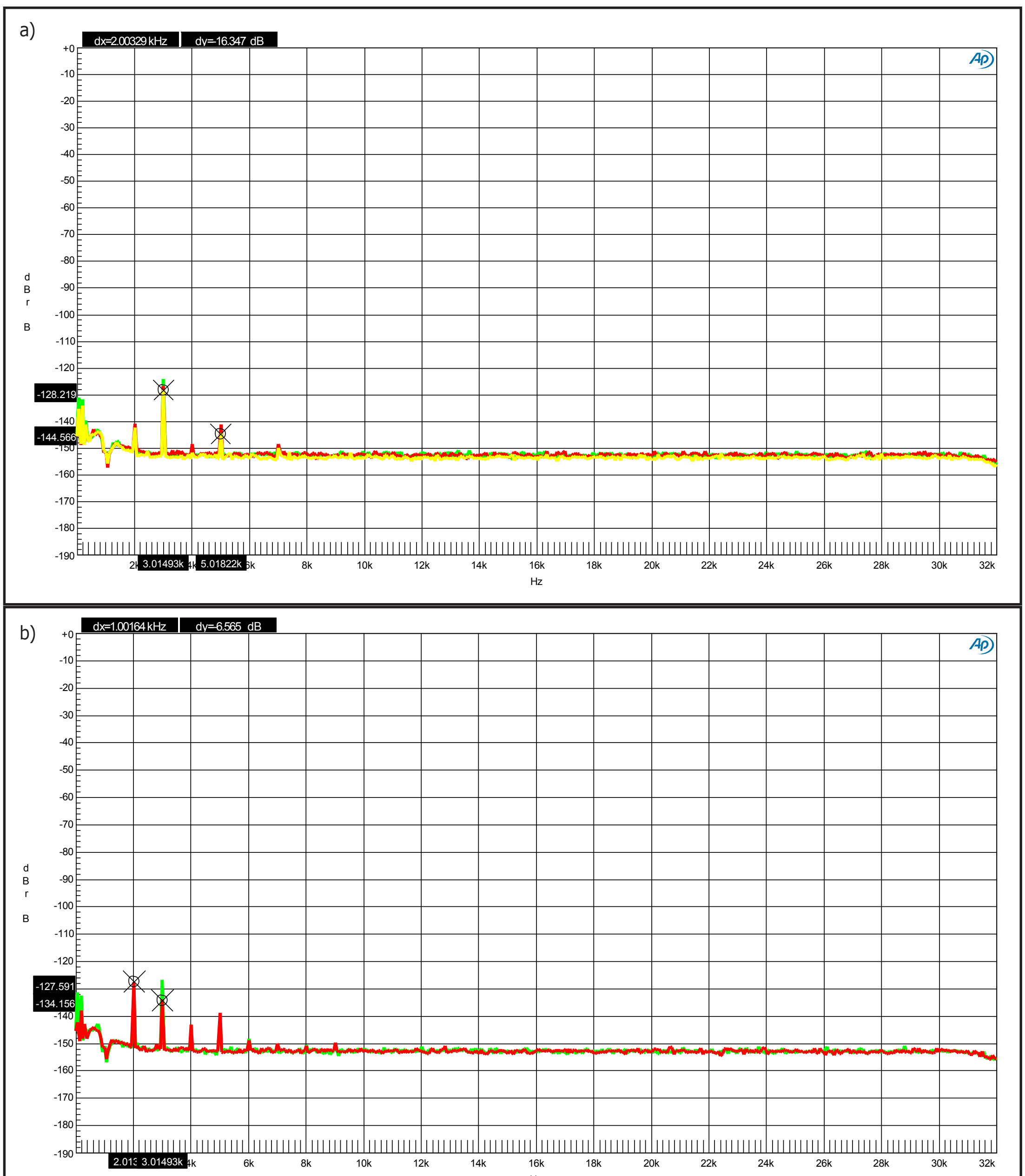

Figure 3: These graphs are FFT plots showing the THD of a 1 kHz tone, at an output level of +22 dBu. The upper graph (a) is balanced in to balanced out. Green, red and yellow are left, right, and summed mono, respectively. The third harmonic measures better than -124 dB (0.00006%) and the fifth harmonic measures better than -141 dB (0.000009%). The lower graph (b) is balanced in to headphone out, with the headphone output driving its full rated 6 W into a 16 Ω load. Green and red are left and right. The second harmonic measures better than -127.5 dB (0.00004 %) and the third harmonic measures better than -126.5 dB (0.00005 %).
(Images courtesy of Benchmark Media Systems)

treble region. The HPA4 is tonally neutral and does not contribute any brightness or harshness to the sonic presentation—it has provided me with many hours of fatigue-free listening. The audio professional will find the HPA4 to be an accurate, reference-quality tool for evaluation of their work, whether in the recording studio or in the field. For the audio enthusiast, the HPA4 will provide listening that's as musically satisfying as the recordings in their collections. The audio it's fed from your source is what you will hear—no more and no less. And, that's exactly as I want it. Although the HPA4 makes a synergetic match to Benchmark's own DACs and power amp, it should enhance the performance of any audio system. Its flexible gain adjustments will allow it to interface easily with consumer and professional equipment.

Ear vs Measurement

Benchmark addressed the issue of measurements versus listening head-on in an application note posted on its website (posted March 19, 2016; go to Company/About Us). These four points summarize its views:

- Transparent products will usually produce an impressive set of measurements.
- Non-transparent products will usually produce a "poor" set of measurements.
- Impressive measurements do not necessarily guarantee that transparency has been achieved.
- Transparency must be confirmed with listening tests.

Benchmark notes that it has sometimes found that a design that measured well still exhibited problems in listening test. These experiences have helped the company refine its measurements so they correlate better with what their ears tell them. The audiophile world has traditionally been divided into two camps—the purely subjective, who believe that measurements are meaningless, and that our ears tell everything we need to know; and the purely objective, who believe that anyone claiming to hear things that are not measurable are delusional and lacking in scientific rigor. Benchmark occupies the sensible middle-ground, which is why its products have received acclaim by users on both sides of the fence. I agree with Benchmark's views on this still-contentious issue.

The HPA4 is the latest embodiment of its design philosophy. You'll have a tough time finding a cleaner, quieter, more transparent line amplifier and headphone amplifier anywhere, at any price. I found it to be a new reference. Once I heard it, I could not live without it, so I purchased the review sample. The HPA4 deserves my highest recommendation.