





Many readers draw a parallel between very high-end audio products and sports cars such as those made by Ferrari, Lamborghini, and McLaren. But there's a class of audio components that transcends this comparison. Such products are more rightly compared with automobiles in the "hypercar" category. This is the rarified realm of the Pininfarina Battista at \$2.5 million, or the Rimac C_Two at \$2 million.

Description

Wadax is a ten-year-old Spanish manufacturer of high-end audio electronics specializing in digital sources. The company's products are distributed around the world and have received critical acclaim. The company's new Reference DAC is a three-piece affair, comprising the main unit and two outboard power supplies. That description, however, doesn't begin to convey its sheer size, mass, and "wow factor." The DAC itself weighs 100 pounds, and each power supply comes in at 40 pounds—that's right, a 180-pound digital-to-analog converter. If you plan on placing the supplies next to the DAC, you'll need a wider than normal platform; together the array is just over 34" wide. I positioned the DAC on the top shelf of a Critical Mass Systems Olympus rack, and the power supplies on the shelf below it. Each chassis' styling is cleverly designed to create a seamless appearance, whether the supplies are next to the DAC or on an adjacent shelf. Either way, the Reference DAC makes quite a visual statement.

That statement is amplified by the product's bold and adventurous industrial design. The Reference DAC has a unique aesthetic that is at once modern and retro. With its large round source-selecting buttons and display window, and lavish chrome accents, it almost has a steampunk vibe. The metal trim around the controls and display can be ordered in a gold finish rather than chrome.

The DAC's main chassis comprises three sections that merge into a coherent whole. The center section houses the control electronics, and each outer section contain the left and right channel circuitry, respectively. The unit is supported on eight feet, four under each of the side modules with the center section floating between them. Machined spiked feet thread into the chassis. Wadax recommended that I replace the feet with RevOpods by Arya Audio of England (see sidebar).

The Reference DAC incorporates full MQA decoding, is compatible with DSD up to DSD256, and PCM up to 384kHz/32-bit. Digital inputs include two each AES/EBU, SPDIF on RCA jacks, SPDIF on BNC jacks, and one USB. There is no network jack; the Reference DAC is designed to be used with a server, such as Wadax's Atlantis Server. In addition to these industry-standard inputs, the Reference also offers a proprietary digital input via the Native Wadax Reference Link for connection to the Wadax Transport. This connection, carried on three balanced cables, transmits the left channel, right channel, and clock separately, plus one RJ45 jack for synchronizing and signaling protocol between the source and DAC. When the Reference DAC is connected to the Wadax Transport through this interface, the DAC is the master clock.

This is the optimal way to transmit digital audio; the ubiquitous single-cable interface is a concession to convenience. A



The Wadax Atlantis Reference DAC, priced at \$145,000, is the audio equivalent of those hypercars. It is an exercise in building the world's best-sounding digital-to-analog converter without restraints in cost or size. As with hypercars, audio products in this realm allow designers to explore new ideas and technologies that push forward the edge of the art. Such products serve as a laboratory for developing circuits and techniques that may eventually migrate to lower-priced components.

When I was offered the Reference DAC for review, I was taken aback by the price but intrigued by the opportunity to hear such an ambitious effort. I've been closely following the evolution of digital playback for nearly 32 years, having reviewed such landmark products as the Stax X-1t (the first DAC to use UltraAnalog converters in 1989), Wadia 2000, Mark Levinson No.30, Theta DS Pro (in various generations), Linn Karik/Numerik and CD12, Spectral SDR-2000, Meridian 808 v6 (first MQA DAC), Berkeley Alpha DAC Reference, and the dCS Vivaldi.

Just how good can digital get? Is there a fundamental limit on sound quality imposed by chopping up an analog waveform, converting it into numbers, and then putting those numbers back into a continuous waveform? Or can digital audio's sonic shortcomings be overcome with advanced new decoding technologies? The Wadax Reference DAC is a good candidate for answering these questions.



Listening

Having followed the continuing improvements in digital-audio reproduction, I've often wondered how much more there is to be gained by better digital-to-analog conversion. It's readily apparent that more recent analog-to-digital converters, operating at a higher sampling rate and with lower jitter and better filtering, produce better-sounding digital files than older converters (primarily recordings made with the ubiquitous Sony PCM-1610 and PCM-1630 up until the mid-1990s). The question is whether the limitations of the 44.1kHz/16-bit format, and the distortions those sub-optimal A/D converters imposed on the music, render moot further improvements in D/A conversion. Remember that jitter in the A/D converter's clock, as well as its linearity errors, are permanently embedded in the digital bitstream.

conventional single-cable interface (SPDIF and AES/EBU) carries a single signal that emerges the left channel, right channel, and clock. The clock must then be recovered from the signal at the DAC, where it becomes the timing reference for the DAC. This recovered clock is prone to jitter, or timing errors. It's a far better approach for the DAC's clock to be the timing reference, with the source component locking to that clock.

Software updates are made possible via service USB and Ethernet jacks. The DAC's rear panel also has two jacks to accept the power umbilical cables from the two mono power supplies. (You'll need two power cords, one for each power supply.) The main chassis' card-cage construction provides for future hardware upgrades and expansion. The Reference DAC is fully software updatable, and the modular construction also allows for hardware updates. Future upgradability is an important factor in a product of this price.

Analog output is provided only on balanced XLR jacks. The user can select, from the front panel, a nominal analog-output level of 1V, 2V, or 4V. This allows you to set the Reference DAC's output to a level that best matches your preamplifier and power amplifier's gain structure. The Reference DAC offers a feature unique in my experience: variable output impedance. From the front panel, you can choose an output impedance of 0, 10, 50, 75, or 600 ohms. The output impedance you select will change the sound in a subtle way so that you can fine-tune the Reference DAC to your system. I'll have more to say about this feature later.

See the sidebar for more on the Reference DAC's design. For some background on Wadax, I've included an interview with the company founder, Javier Guadalajara.

In other words, are we trying to extract information that simply isn't there?

The only way to answer that question is by listening to those recordings through better and better DACs. So far, I've been encouraged by how today's best DACs manage to make standard-res more listenable than in the past. But listening to the Wadax Reference DAC has left absolutely no doubt about that question: The Reference DAC reveals that all digital sources, from standard-resolution files made with primitive A/D converters to today's state-of-the-art hi-res recordings, can sound far more musical than I had thought possible. The Reference DAC opens up a new vista on digital audio, revealing the dimensionality, bloom, detail, and timbral realism that have heretofore been locked away.

A few weeks before receiving the Reference DAC I'd discovered a wonderful album by the Finish chamber-music group Ensemble Ambrosius, called *The Zappa Album*. The group performs modern music, as well as original arrangements of Zappa compositions, on baroque

The Reference DAC rendered a wholesale improvement that was immediately apparent as a significant step forward in digital-audio reproduction.

instruments. Although Zappa and baroque instruments may seem like strange bedfellows, the album works brilliantly. I'd been listening to some of these compositions since my early teens, but these arrangements, and their performances, provided an entirely fresh perspective on Zappa's brilliance as a composer. It was like looking at familiar multifaceted diamond from an entirely new angle. The album, recorded at 44.1kHz/16-bit in 2000, had been in heavy rotation for a few weeks when the Reference DAC arrived, and was the first music I played on the new converter.

Seconds into the first piece, I was floored by just how different the Reference DAC sounded than other digital. It wasn't the kind of difference that you have to go back and forth a few times to hear, weighing the virtues against the shortcomings. Rather, the Reference DAC rendered a wholesale improvement that was immediately apparent as a significant step forward in digital-audio reproduction.

Two aspects of the presentation, in particular, stood out at first listen—a smoothness and liquidity of timbre, and the huge, deep, and stunningly three-dimensional soundstage. Taking the timbral reproduction first, the Reference DAC seemed to strip away the ever-present patina of hardness, glare, and edge that give digitally reproduced music an artificiality that never really fools the brain into thinking it's the real thing. We've all lived with these limitations of digital—textures are thinned, tone colors bleached, and instrumental timbre is overlaid with a whitish haze. Although these artifacts have been greatly reduced in recent years, even the best DACs have not completely banished this character. The Reference DAC, in one giant leap, makes digital sound utterly smooth, liquid, and analog-like. This is not an incremental improvement, but rather a step function that takes the sound of digital to an entirely new realm of realism, musicality, and listener involvement. Freed from an overlay of digital artifacts, tone colors took on a rich vibrancy that was startling. The baroque instruments of the Ensemble Ambrosius were vividly rendered with color, texture, and detail in a way that brought a newfound sense of hearing the music itself and not a facsimile of it. It was interesting to hear how such a dramatic reduction in digital artifacts allowed the instrument's richness and density of tone color to be revealed. A consequence of this simultaneous reduction in distortion and increase in micro-detail was an absolutely staggering image palpability. The feeling of instruments and voices existing before me was astonishingly realistic and believable.

The second striking aspect of the Reference DAC's sound was a three-dimensionality that I had never before heard from digital. As spacious and dimensional as some of today's best DACs can be, the Reference DAC was in another league. It opened up the soundstage in every dimension,

It was as though the music were made up of a single organic whole rather than from a collection of discrete components.

particularly depth. There was tangible space and air between each instrument, with the entire ensemble surrounded by the acoustic of the recording venue. Each instrument was bathed in a halo of bloom, sounding so much more like a group of individual instruments within an acoustic space and less like two-dimensional images on a flat canvas. Jonathan Valin coined the term “action” to describe how this bloom expands dynamically around an instrument as it articulates each note, a quality the Reference DAC had in spades. The Reference DAC beautifully recreated the way an instrument's dynamic envelope expands into the space around it, bringing a sense of lifelike realism to the music.

Keep in mind that this was from a 20-year-old standard-resolution recording.

Moving on to other music, the Reference DAC's lack of timbral artifacts was readily apparent on a wide variety of instruments. Massed strings lacked the glassy sheen that diminishes the sense of body, texture, and warmth one hears in the concert hall. The leading edges of piano transients, particularly forte passages played in the instrument's upper register, were utterly smooth and natural rather than clanky. Vocals had a richness and body devoid of stridency. Singers sounded more human and less mechanical, with a harmonic warmth that was unlike any digital I've heard. Consequently, I felt a greater sense of direct and intimate communication with the vocalist, from Norah Jones on the album *Day Breaks* to Luciana Souza's beautiful rendition of Joni Mitchell's “Amelia” from the Herbie Hancock album *River: The Joni Letters* (both Tidal MQA). The presentation was completely relaxed and organic, without the trace of metallic edge that often gives digital its whitish sterility. Timbres had a richness and density of texture that contributed to the realism, and also fostered a deeper and more relaxed engagement with the



Arya Audio RevOpods Damping Feet

AT WADAX'S REQUEST, I received eight RevOpod Damping Feet made by the British company Arya Audio (the Reference DAC rests on eight footers rather than the usual four). The devices are distributed in the U.S. by Liquid Hi-Fi in Charlotte, North Carolina.

The RevOpod is an intricately built mechanism for dissipating vibration in audio equipment. The conical-shaped device can sit under a component, or screw into the component's chassis in place of stock feet. Each set of four comes with a variety of threaded adapter posts to match the thread size of your equipment.

The RevOpod is built from 35 separate parts and assembled to very tight tolerances. An ingenious feature allows each RevOpod to be height adjusted in 50-micron steps, with the steps indicated by an audible click as a ring is rotated. This feature also allows the RevOpod to adapt to uneven surfaces. RevOpod describes this mechanism: "Rotation of the outer ring moves an inner element up or down, translating the rotary motion of the ring into linear movement of an inner cylinder."

All the structural parts are machined from solid billets of stainless steel, and a Delrin insert couples the pod to the surface on which it sits. The build and finish quality are extraordinary. The chrome-like finish is realized by hand polishing the stainless steel. Black versions are coated with titanium-nitride in a high-temperature vacuum chamber. The rings can be ordered in a shiny chrome-like or gold-colored finish. The price is \$1200 per set of four for the "chrome" finish, and \$1295 per set for black.

The designer, Arthur Marker, based the design on the so-called "pot bearings" found in vibration control of heavy structures such as bridges. Marker has an MSc in Engineering Acoustics from the Institute of Sound and Vibration Research in the UK, and a BSc in electrical engineering from University Stuttgart, Germany. The device is reportedly the result of two years of development work.

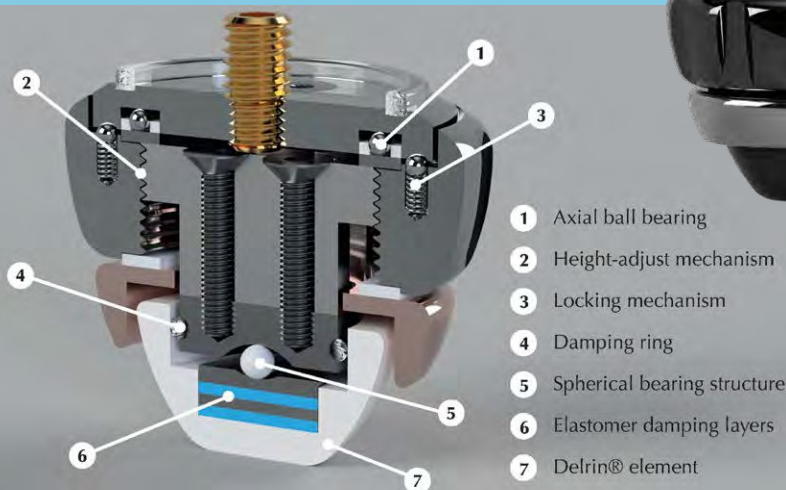
After listening to the Reference DAC with the stock feet for about a month, I switched to the RevOpods. I heard an immediate increase in clarity, bass definition, and dynamics. Fine details were more clearly resolved, particularly low-level reverberation decay. This contributed to the Reference DAC's three-dimensionality and spacious sound. At \$2400 for a set of eight, the RevOpods should be considered mandatory for the Reference DAC. I look forward to trying the RevOpods with other products.

The lack of glare and grain described earlier extends all the way to the top octave, giving the treble a crystalline purity.

music. I heard another quality that was hard to pin down, but is best described as a harmonic coherence, or continuousness, from top to bottom. It was as though the music were made up of a single organic whole rather than from a collection of discrete components. The treble didn't sound disconnected from the rest of the spectrum, but rather like a natural extension of the upper midrange. Interestingly, this quality was affected by the output-impedance setting mentioned earlier. When set correctly for my system (75 ohms, in my case), the presentation seemed to have a greater degree of this harmonic coherence.

The effect of these sonic qualities on the listening experience went beyond a greater sense of realism. The Reference DAC induced a relaxed ease that made my ears figuratively "open up" rather than unconsciously (or sometimes consciously) tensing. It was possible to listen at louder levels comfortably, and for longer periods.

The Reference DAC's liquidity was most apparent through the upper-midrange and treble, the region where digital audio's shortcomings have previously been the most obvious. But the Reference DAC's reproduction of the low bass through the upper-bass was also extraordinary. The resolution of inner detail, tone color, and dynamic inflection through the bass rendered low-frequency sounds as a rich and intricately detailed tapestry of timbres, harmonics, dynamic shadings, and rhythmic flow. The bottom end had tremendous weight, solidity, and authority. Left-hand piano lines were dense, rich, warm, and thunderously powerful. The low-tuned toms of drummer Simon Philips' kit on his album *Protocol II* were rendered by the Reference DAC with a physically startling impact, along with tremendous resolution of the attack of the stick hitting the drumhead, followed by the deep resonance



of the air within the drum and then by a natural decay. The Reference DAC conjured a vivid mental picture of a person playing the drums rather than just the sound of the kit. The Reference DAC's extreme bottom-end extension was by far the deepest I've heard, with a center-of-the-earth solidity and power. On organist Virgil Fox's *The Bach Gamut* (176/24), the Reference DAC seemed to have another octave of extension at the extreme bottom end. I could feel my listening room being pressurized by the organ's 32-foot pipes (16Hz notes) to an unprecedented degree. It's worth noting that the

Wilson Subsonic subwoofers have a -3dB point of 10Hz, and are thus able to reproduce organ pedal tones with authority.

The Reference DAC overcomes another hurdle of digital audio—the tendency for the top octave to sound closed in, yet bright. That may sound like a contradiction in terms, but digital seems to lack what I heard a famous recording engineer describe as “air riding above the top octave.” He was describing the sense of openness, like removing a lid over the music. Despite sounding closed in, digital's brightness comes from the glare in the treble, not from an excess of energy. That's one area where good analog beats digital; it has the top-octave open-

ness and air without excessive treble energy. The Reference DAC has this tangible sense of air, yet is utterly smooth in tonal balance. The lack of glare and grain described earlier extends all the way to the very top, giving the treble a crystalline purity.

All these qualities were presented against an absolutely silent background. The blackness amplified the tangibility and immediacy of instrumental and vocal images by creating a greater contrast. The seemingly non-existent noise floor also allowed the Reference DAC to reach down and resolve the very finest micro-structure of instrumental timbre, spatial cues, vibrato, and hall ambience. Significantly, this very high resolution was presented within a completely relaxed rendering that never called attention to the detail.

The Reference DAC excelled at maintaining clarity of instrumental lines, even during dense passages, complex arrangements, and large ensembles. Listen, for example, to Keith Johnson's remarkable recording of the Dallas Winds performing music from John Williams' film scores in 176kHz/24-bit (*John Williams at the Movies*, Reference Recordings). Even very quiet flute lines were clearly audible during the tuttis of the low-brass section. This lack of homogenization made music more intelligible and rewarding.

Finally, DSD reproduction was superb. Higher-speed DSD (DSD256) with the widest filter setting (80kHz) delivered a stunning openness, transparency, and sense of “you-are-there” realism.



Atlantis Server

A few weeks after installing the Reference DAC, Wadax sent me its Atlantis Server (\$24,000). The Atlantis Server is a turnkey system with 2TB of internal solid-state memory and expansion slots for additional SSDs. It serves as a Roon Core (installed at the factory), and comes with a lifetime subscription to that music-management software. Including Roon makes so much more sense than offering a proprietary music-management app that will undoubtedly be inferior to Roon. When connected to the Internet, Roon software updates are automatic. The Atlantis is truly plug-and-play, and compatible with any DAC. USB output is standard but you can add, via its modular construction, other outputs include SPDIF on RCA jack, SPDIF on BNC jack, and AES/EBU. The Atlantis Server can be configured or serviced remotely, if needed.

This is the fourth-generation server from Wadax. The design pays careful attention to the power supply, grounding, and keeping the USB output free from noise contamination. The power supply features dual transformers along with circuitry to prevent noise on the AC line from getting onto the ground plane. Wadax has developed techniques for lowering noise that involve, among other techniques, a proprietary method of galvanic isolation.

I found that the Atlantis Server was the best sonic match for the Reference DAC. It produced extremely quiet backgrounds, which helped the Reference DAC resolve the very lowest level timbral and spatial cues. The Atlantis Server had a very relaxed and organic sound that fostered a sense of ease and involvement. I also liked having the Roon Core reside in the server rather than having to turn on my PC to run Roon Core, as I've done with some other Roon-compatible products.

As good as the Atlantis Server is, Wadax is preparing to ship the Reference Server, which will have the same form factor and size as the Reference DAC's main unit, with a price likely to be commensurate with that of the Reference DAC. It will use a proprietary optical interface, realized with an optical module inserted into the Reference DAC. Wadax plans to send me one—I'll have a follow-up report in a future issue.



Conclusion

The Wadax Reference DAC is not only the best-sounding DAC I've heard, it's the best sounding by a significant margin. It sounds different from other DACs, most notably in the two areas where digital has traditionally fallen short: tonal rendering and soundstaging. This DAC strips away any hint of hardness, glare, and edge, leaving behind a totally natural presentation of tone color that produces a startling immediacy and realism. This relaxed ease fosters an immediate musical involvement that cannot be overstated. Moreover, the absence of artifacts allows for long listening sessions without fatigue—always a good sign. The second area is the Reference DAC's unparalleled dimensionality, depth, spaciousness, and bloom. Correctly reproducing the spatial aspects of a recording goes a long way toward the impression of realism.

Those two qualities alone would be enough to justify the Wadax Reference DAC's status as the state of the art. But they are just the foundation for myriad other virtues, including the top-to-bottom harmonic coherence, massive resolving power, fine resolution of dynamic shadings, and bottom-end warmth and weight.

Perhaps best of all, the Reference DAC didn't just sound spectacular on hi-res recordings, but also breathed new musicality into the large catalog of music encoded in standard resolution, much of it made with low-quality A/D converters. I was amazed to hear familiar recordings with a newfound warmth and liquidity, depth and space between in-

struments, and resolution of the recording venue's acoustics.

The micro-resolution of inner timbral details, the utterly natural warmth and body of instrumental and vocal textures, resolution of fine ambient cues, and lifelike portrayal of micro- and macro-transient information all add up to a listening experience that's unlike any I've experienced from digital audio.

With regard to features and operation, the Reference DAC and Atlantis Server have no functional limitations. With full MQA decoding, DSD capability, and Roon Core running on the Atlantis Server, the pair makes a fully capable digital front end. The Reference DAC's modular architecture and updateable software assure that the DAC can accommodate new technologies, important in a product of this price.

Although I've dissected the Reference DAC's sound into component parts for this review, the real-world listening experience is nothing like hearing the music as separate elements to be critiqued. Rather, the Reference DAC has so little sonic signature that it makes you immediately forget about the sound and become totally captivated by the music. There is no greater aspiration for any audio component—and no higher praise that I can confer on the Wadax Reference DAC.

Specs & Pricing

Reference DAC

Inputs: 2x AES/EBU (32–192kHz), 2x SPDIF on BNC jacks (32–192kHz), 2x SPDIF on RCA jacks (32–192kHz), 1x USB (32–384kHz, 16–32 bits, DSD up to DSD256)

Outputs: Balanced on XLR jacks

Features: Separate monaural power supplies, MQA decoding, polarity inversion, variable output impedance, variable output voltage (1V, 2V, 4V), Native Wadax Reference Link to Wadax Transport, Phono Wadax Link to Wadax Trio Phono

User interface: 5" capacitive touch-screen color display, 800x400

Output impedance: 0.15 ohms, 10 ohms, 50 ohms, 75 ohms, 600 ohms, user selectable

Service ports: Ethernet and USB

Dimensions: 18.89" x 10.43" x 17.12" (main unit); 7.16" x 10.43" x 14.96" (each power supply)

Weight: 100 lbs. (main unit); 40 lbs. (each power supply)

Price: \$145,000

Atlantis Server

Outputs: 2x USB (standard); Optional: 1x SPDIF on BNC jack (32–192kHz), 1x SPDIF on RCA jack (32–192kHz), 1 x AES/EBU

User interface: 5" 800 x 400-pixel capacitive touchscreen color display

Control and library management: Roon (lifetime subscription included)

Dimensions: 19.7" x 4.88" x 13.89"

Weight: 40 lbs.

Price: \$24,000

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Associated Equipment

Analog source: Basis Audio A.J. Conti Transcendence turntable with SuperArm 12.5 tonearm; Air Tight Opus cartridge; Moon 810LP phonostage; DS Audio ST-50 stylus cleaner

Digital source: Aurender W20SE and Wadax Atlantis servers; Shunyata Sigma USB cable; UpTone Audio EtherREGEN Ethernet switch

Amplification: Constellation Altair 2 preamplifier; Constellation Hercules 2 monoblock power amplifiers

AC Power: Shunyata Everest 8000 conditioner, Omega and Sigma NR V2 power cords; Shunyata AC outlets, five dedicated 20A lines wired with identical-length 10AWG

Support: Critical Mass Systems Olympus equipment racks and Olympus amplifier stands; Center-Stage² isolation, Ayra Audio RevOpods isolation

Cables: AudioQuest WEL Signature interconnects and AudioQuest Dragon Zero and Dragon Bass loudspeaker cables

Acoustics: Acoustic Geometry Pro Room Pack 12

Room: Purpose-built; Acoustic Sciences Corporation Iso-Wall System

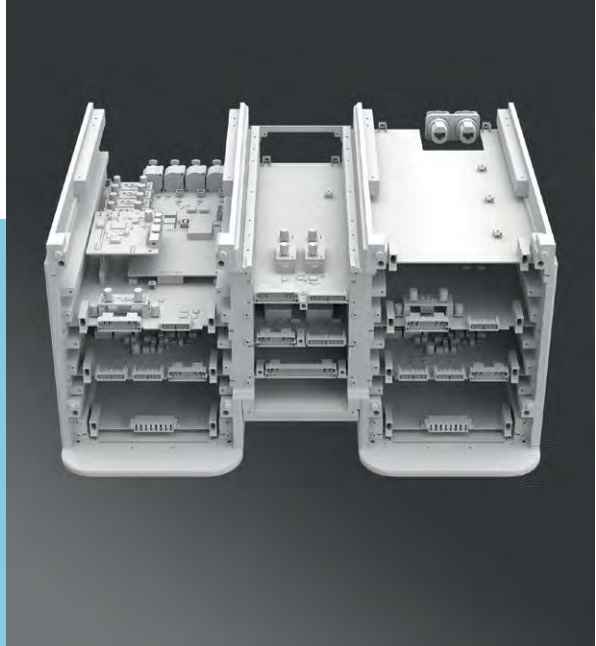
Reference DAC Technical Description

Starting with the power supply, each of the dual-chassis supplies features five custom-wound transformers followed by three stages of cascaded regulation. These regulated DC voltages are carried by the umbilical cords to the DAC where they are further regulated next to the circuits they supply. In total, the power supply contains a whopping 30 separate regulation stages. Using so many transformers and separate regulation stages isolates the sub-systems from each other and helps lower the noise on the supply voltages. The cascaded regulation results in purer and cleaner DC voltages; the output of one regulator is fed to the input of another regulator. A voltage regulator maintains a constant output voltage despite fluctuations at the input (in theory, but no regulator is perfect, thus the need for cascaded regulation). The Reference DAC has the most elaborate power-supply design and execution of any product I've reviewed. Wadax claims that the power supply's total noise level is 0.5 μ V (half a millionth of a volt), measured over a bandwidth of 1Hz to 100kHz—an astonishing specification.

The digital-to-analog conversion circuitry is differential, with separate signal paths for the left channel + and - signals, and for the right channel + and - signals. The DAC is a Texas Instruments Sigma-Delta type, with only a section of the DAC chip used. Wadax has replaced many of the DAC functions with its own circuitry.

The most interesting aspect of the Reference DAC's design is Wadax's "musicIC" chip that corrects errors introduced by the DAC, the current-to-voltage converter, data-correlated jitter, the analog output stage, and even some of the effects of the power supply. Here's how it works. Wadax measures the errors introduced by the conversion and amplification circuits, and then programs the musicIC chip to introduce, in the digital domain, an inverse of those errors before digital-to-analog conversion. It's similar to feedback in that the process corrects errors, but unlike feedback the musicIC doesn't wait for the error to occur and then send the feedback signal to correct the error. There's no time lag as there is with a feedback loop. The signal is modified in advance rather than measured and corrected on the fly. This approach, based on something called Adaptive Delta Hilbert Mapping, reportedly removes the DAC's sonic signature and other artifacts from the output signal. Wadax introduced this feed-forward concept back in 2010, and was the first high-end company to create a custom integrated circuit. The Reference DAC is the first Wadax product to benefit from a new musicIC chip that has much greater processing power than those used previously. This additional processing power confers greater correction capability, particularly in correcting time-domain artifacts. Wadax believes that the time alignment between an instrument's fundamentals and harmonics is of utmost importance to fidelity. Wadax designed its own measurement procedures to understand and quantify the errors that needed to be corrected by the musicIC chip. The chip also upsamples the input signal to 352kHz or 384kHz, depending on the frequency of the input signal. Incidentally, the chip operates with 128-bit fixed-point processing.

The analog output stage reportedly plays a large role in the Reference DAC's sound. It is a three-stage discrete differential circuit that



can deliver a robust 1W of output power—a level far higher than that needed to drive a preamplifier's input. When decoding DSD signals, four output filters are available. The most open filter, with a cutoff frequency of 80kHz, is for higher DSD rates and systems that won't be bothered by the high levels of noise just above the audioband present in the DSD format. The higher the DSD rate, the higher in frequency the ultrasonic noise is pushed, which allows for a higher cutoff frequency in the analog output filter.

The user-selectable output impedance mentioned earlier is realized by varying the bias of transistors in the output stage. Wadax maintains that the optimum output impedance of a source depends on the cables and system to which that source is connected. According to Wadax, a less-than-ideal output impedance for a particular system can introduce timing errors that propagate through the system to the loudspeakers, where they are heard as a reduction in timbral realism. Wadax believes that if the harmonics aren't perfectly time aligned with the fundamentals, the brain has to focus on putting the sonic components together, which leads to reduced realism and thus listener involvement. A forthcoming software update will provide 16 levels of output impedance rather than the five levels in the review sample's software.

Much attention was paid to physically isolating sub-systems from each other. In addition to separate left- and right-channel power supplies in outboard chassis, the main unit is split into three sections, left channel, right channel, and digital electronics. The chassis is rigidly constructed from machined aluminum to reduce vibration (see photo).

Overall, the Reference DAC's design and build-quality reflect innovative thinking and no-holds-barred execution. In addition to the ten custom power transformers, the Reference DAC features 23 separate printed circuit boards and more than 5500 discrete components. It is the product of more than 30,000 man-hours of development. With that much engineering and the obviously expensive construction, the Reference seems more like a platform to explore the state of the art than a commercially profitable product.