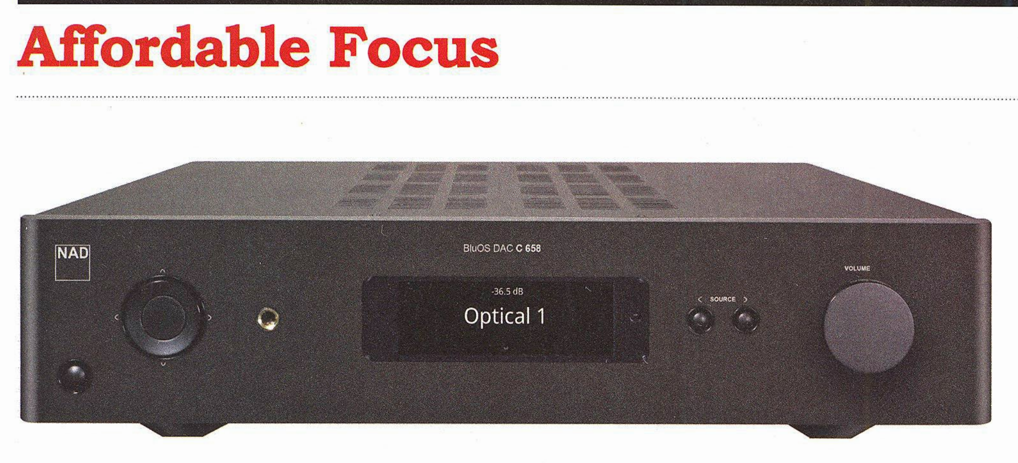


NAD C658 Streaming DAC and C298 Power Amplifier

Dynamic Duo

Robert Harley

NAD's new C658 streaming DAC packs a huge number of advanced technologies and capabilities into an affordable package. The C658 is a BluOs-enabled streamer that incorporates a DAC with MQA decoding, support for about a dozen music-streaming services, network connectivity, a full suite of preamplifier functions, a moving-magnet phonostage, two subwoofer outputs with configurable crossover, and Dirac Live DSP room correction. You can add inputs now and in the future, thanks to NAD's Modular Design Construction architecture. The C658 even has a Bluetooth aptX HD receiver/transmitter so that you can listen to music through your wireless headphones. The price? $1649.

A logical partner for the C658 is NAD's brand-new, $1999 C298 stereo power amplifier. It, too, is packed with features, including balanced and single-ended inputs, variable gain, line outputs for daisy-chaining multiple amplifiers, a bridging function for monaural operation, an auto-on feature when signal is detected, and remote control. The C298 is one of the first amplifiers to feature a new circuit, called Eigentakt, that is a significant advance in Class D amplification. The Eigentakt output-stage module, created by a new Danish company called Purifi, has extraordinary specifications, including vanishingly low distortion or noise. The design effort was led by Bruno Putzeys, one of the brightest thinkers in switching-amplifier design (Putzeys created the Hypex Ncore Class D module that is the basis for dozens of high-end amplifiers. I describe this new switching-amplifier module, which you are likely to see in many upcoming high-end products, in a sidebar.)

The C298 is the third NAD amplifier based on the Eigentakt module. The previous iterations are the Masters M33 and M28, each priced at $4999. The C298 is the company's first attempt to bring the technology to a much lower price point, largely by eschewing the fancy casework of the Masters Series. The C298 is rated at 185Wpc into 8 ohms and 340Wpc into 4 ohms, with a dynamic power rating of 260W into 8 ohms, 490W into 4 ohms, and 570W into 2 ohms. When bridged to

The C298 is the third NAD amplifier based on the Eigentakt module.

operate as a monoblock, the C298 can output a staggering 1000W into 8 ohms.

The C658 network streaming DAC can accept a wide range of inputs (see Specs & Pricing), but will probably be used primarily via its integral support for music-streaming services, and be controlled through the BluOS app. (A full-function remote control is also included with the C658.) BluOS is a wireless digital ecosystem for connecting and controlling a variety of products, including whole-house wireless-audio distribution. BluOS is a multi-room wireless platform developed by Lenbrook International, and is a sister brand to NAD. BluOS offers a full suite of compatible products for any application. After downloading the app (iOS or Android), you select the BluOS device to stream to, choose music from a streaming service, and enjoy. I logged in to my Tidal and Qobuz accounts, which gave me access to all the music I wanted. You can also connect to any network-attached drives and play music stored on them. Music management is handled through the BluOS app. The C658 shows up as a Roon endpoint (the C658 was recently Roon certified). BluOS recently made a deal with the Neil Young Archives to provide BluOS users full and free access to the iconic musician's catalog, all in high resolution. BluOS is compatible with PCM up to 192kHz/24-bit, but lacks

DSD support. The optional USB input module will accept DSD up to DSD512, but converts it to PCM at 192/24. The module also accepts USB 2 audio from a computer. Finally, the BluOS app offers a range of free Internet radio services in addition to the paid streaming platforms.

The C658 also allows you to name inputs, set auto-standby time, disable inputs, select between fixed and variable output levels (fixed is the "theater-bypass" mode), trim the gain on each input, engage or bypass the tone (bass and treble) controls, and adjust the display brightness. On the technology side, it's built around the ESS Sabre 32-bit DAC. The volume control operates in the digital domain, except when the C658 is in the analog-bypass mode.

The C658 is the first NAD Classic Series two-channel product to incorporate Dirac Live. Dirac Live is a DSP room- and speaker-correction system that measures the frequency response and time signature of the sound at the listening position. From this measurement data, Dirac calculates a series of filters that flatten the frequency response and assure correct phase response at the listening seat. Those filters are then downloaded into the C658, which processes the audio signal before the C658's digital-to-analog conversion stage. In essence, the system "pre-distorts" the audio signal in a way that is the inverse of the distortion created by your speakers and room. That is, Dirac Live modifies the signal driving your loudspeakers so that the final result at your ears is flat in frequency, with most of the sound energy in the room arriving at your ears in phase. Dirac Live doesn't just look at amplitude information, but also at the room's time signature. It distinguishes between deleterious reflections, such as floor and ceiling bounce, and later-occurring and lower-amplitude reflections that sound like natural reverberation.

The version of Dirac Live included with the C658 corrects frequencies up to 500Hz. For the full-frequency-range version, you must pay $99 for the software upgrade. A future software upgrade will provide extensive control over the C658's subwoofer-output signals. Specifically, it will include a bass-management function as well as clever tricks, such as causing one subwoofer's output to cancel a standing wave created by the other subwoofer. That feature is like having an active room-resonance-cancelling device built right into the C658 (provided that you have two subs). The C658 hardware, including the two subwoofer outputs, can accommodate this new feature when it becomes available.

Because Dirac Live operates in the digital domain, analog signals at the C658's input are digitized, processed, and converted back to analog at 192kHz/24-bit. Fortunately, you can bypass the digital conversion on specified analog inputs so that the C658 operates as a pure analog preamplifier. Those bypassed inputs, however, cannot be processed with Dirac Live, and the DSP subwoofer crossover won't be accessible. (See the sidebar for more about setting up and running Dirac Live.)

Overall, the C658 was fairly easy to operate considering its extensive features and capabilities. I quickly became accustomed to the BluOS app. In typical NAD tradition, the two products' casework is utilitarian rather than lavish; NAD spends the parts-budget on those components that affect the sound quality. If you

Specs & Pricing

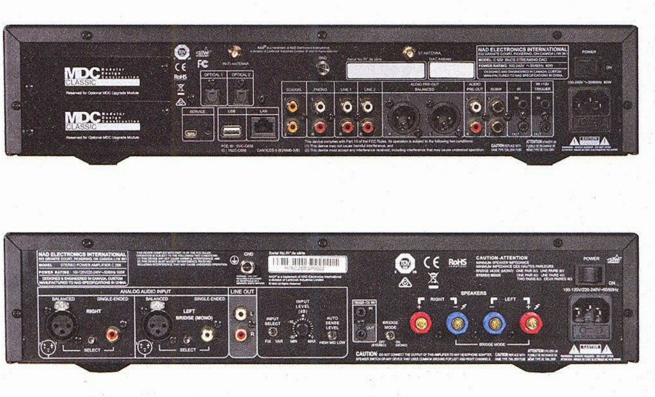
C658

Digital inputs: USB, 2x coaxial, 2x TosLink, Gigabit Ethernet RJ45, Wi-Fi 5 (802.11 ac/n), Bluetooth aptX HD (two-way); Apple AirPlay2, HDMI on optional MDC board
Analog inputs: Line in x2 (unbalanced), phono (mm, >80mV overload margin)
Analog outputs: Balanced on XLR jacks, single-ended on RCA jacks, subwoofer output x2
Other input/outputs: IR in/out, 12V trigger in/out, service USB
Formats supported: MP3, AAC, WMA, OGG, WMA-L, ALAC, OPUS, MQA, FLAC, WAV, AIFF; converted DSD supported only via BluOS desktop app
Dimensions: 17 1/8" x 3 15/16" x 16"
Weight: 22.3 lbs.
Price: $1649

C298

Output power: 185Wpc into 8 ohms, 340Wpc into 4 ohms
IHF dynamic output power: 260Wpc into 8 ohms, 490Wpc into 4 ohms, 570Wpc into 2 ohms
Mono IHF dynamic power: 1000W into 8 ohms, 1100W into 4 ohms
Inputs: Balanced on XLR jacks, single-ended on RCA jacks
THD: 0.005% at 1W-185W
SN ratio: >98dB (A-weighed, 1W output into 8 ohms)
Input impedance: 56k ohms single-ended or balanced
Dimensions: 17 1/8" x 4¾" x 15 3/8"
Weight: 24.7 lbs.
Price: $1999

NAD ELECTRONICS
633 Granite Court
Pickering Ontario
L1W 3K1 Canada
nadelectronics.com



prefer a more upscale chassis, NAD offers the Master Series of components.

Listening

I auditioned the C658 and C298 separately in my reference system before using them as a pair. This put each product under the microscope of reference-quality sources, electronics, cables, and the Wilson Chronosonic XVX loudspeakers. For a more real-world situation, I paired the two NAD components with a speaker of commensurate price, the Focal Chora 826, a floorstanding three-way that sells for $2200-per-pair (review upcoming in the April issue). The complete system, without cables, was $5848. I ran balanced interconnects between the two NAD components.

I connected the C658 to my network via an Ethernet cable. NAD also sent to me the Bluesound Pulse 2i, an all-in-one tabletop system ($699) that connects to the BluOS network wirelessly (as I used it) or via an Ethernet port. NAD wanted me to experience how products like the Pulse 2i allow BluOS to function as a whole-house wireless audio system. I wasn't expecting to receive the Pulse 2i, but discovered that it was a great way to have music outside the listening room. There's the joke that the audiophile's way of realizing whole-house audio is to open the listening room door and turn up the volume. I must confess to taking that approach myself. But the ability to place the Pulse 2i in the kitchen, for example, and have full wireless access to high-resolution streaming music controlled by my iPad was compelling.

Starting with the C298, the amplifier had more than enough power to drive the Wilson Chronosonic XVX to any listening level without strain. Even on music with very wide dynamic range (*John Williams at the Movies* on Reference Recordings) the C298 had plenty of pluck. Peaks were reproduced effortlessly; the bottom end stayed tight and defined at high playback levels; and the soundstage didn't collapse during the loudest and most complex passages. NAD has long been a proponent of amplification with lots of dynamic headroom, which could be defined as the difference between the amplifier's continuous power rating on the spec sheet and the clipping point on musical peaks. This approach makes sense; music is dynamic and much of its expressiveness is contained within those dynamic contrasts, and not on steady-state tones. It's worth noting that the Eigentakt Class D output module is rated at 400W, but NAD specifies the C298's output power at 185Wpc into 8 ohms. Clearly, there's a generous amount of headroom.

As with other Class D amplifiers I've auditioned, the C298's bass reproduction was outstanding. This amplifier goes deep, has a nice sense of heft and weight through the midbass, and has terrific dynamic punch on instruments such as kickdrum. An acid-test of bottom-end impact is the track "Octopia" from drummer Simon Philips' album *Protocol II* (Qobuz 96/24). In addition to first-rate performances by the entire band (including great guitar work by Andy Timmons), this album showcases Philips' phenomenal talent, recorded with spectacular drum sound. His huge kit includes many low-tuned toms that put the C298 to the test. The C298 did justice to this album, sounding like an unflappable powerhouse and reproducing the kit with effortless dynamics and impact.

But it wasn't just all sledgehammer impact; the C298 also revealed dynamic subtleties and nuance. Throughout the listening, I noticed that the C298 had an unusually satisfying ability to convey music's rhythmic flow and forward propulsion, from the funky grooves on bassist Brian Bromberg's *Thicker than Water* (Tidal MQA) to Ray Brown's hard-swinging acoustic bass on *Soular Energy*. This could be the result of the C298's extremely low output-impedance, which translates to the amplifier having an iron-fisted grip over the loudspeakers' woofers—either the Wilson's 12.5" and 10.5" drivers or the pair of 6.5" woofers in the Focal speakers.

The midrange had a nice presence on Norah Jones' voice on her album *Day Breaks* (Tidal MQA). Her vocal had good tonality, too, with just a touch of added sibilance. The upper-midrange to lower-treble was a bit forward in perspective, but only a bit. This character brought cymbals and the upper harmonics of instruments to the fore, imparting a lively quality to the sound. Significantly, the C298 lacked the "chalky" haze over the mids and treble that I've heard from other switching amplifiers. Instrumental timbre was fairly natural, with excellent resolution of inner textural detail. The C298 was also remarkably adept at revealing subtle instrumental lines. It was easy to hear low-level instruments in the mix or at the back of the hall. The C298's soundstaging was outstanding—big, open, spacious, and detailed, with precise image placement. If you think of amplifiers in this price range as sounding flat, congealed, and a little grainy

It was supremely musical and engaging, particularly the wonderful sense of rhythmic drive and ability to convey dynamic shadings and expression.

(compared to reference amplifiers), you'll be in for a pleasant surprise with the C298.

Dropping the C298 into the middle of a system with $800k worth of source components, electronics, cables, and loudspeakers revealed just what a spectacular bargain this amplifier is. Although not the last word in timbral liquidity, the C298 does just about everything else at a level far above what its price would suggest. It was supremely musical and engaging, particularly the wonderful sense of rhythmic drive and ability to convey dynamic shadings and expression. I have not auditioned many Class D amplifiers, but can confidently say that the C298 is the best switching amplifier I've heard.

The C658, in this same system but feeding my reference amplifiers, revealed a good-sounding DAC at this price level. The overall tonal balance was neutral, but with a slight treble emphasis, heard as a bit of additional sibilance on voices. The top end also had a touch of sheen overlying instrumental timbre, and a slight layer of grain. This tended to affect recordings that are inherently bright, rather than blanketing all music. It's by no means a deal-breaker, but I've heard smoother-sounding DACs.

I was particularly impressed by the C658's resolution through the midrange; the NAD revealed subtleties of texture and dynamics that are commendable for its price. The bottom end was well defined, and favored articulation over weight, making it easy to follow bass lines. Importantly, the C658 didn't compress images in the soundstage into two-dimensional representations; rather, image outlines had some tangible space and air around them. The C658 had a good ability to present instruments and voices within a soundstage that was wide and well defined. Dynamics were similarly impressive, with the C658 having the ability to convey subtle nuances of dynamic expression such as gently struck cymbals.

To get a better feel for the C658's DAC section performance, I compared it to the AudioQuest DragonFly Red, a $199 overachiever. Although the two products couldn't be more different in function and capabilities (the DragonFly is a USB stick with no features other than MQA decoding), the AudioQuest, nonetheless, provides a benchmark for what is possible at an entry-level price. The NAD's bass was a little lighter in weight but more detailed than that of the DragonFly, which was a bit loose and billowy. With the NAD it was easier to follow bass lines, and the overall tonal balance sounded more natural, with the bass better integrated into the rest of the music. The C658 had a much wider and deeper soundstage, with greater spread and separation of instruments in the hall or in the multichannel mix. I also heard greater midrange resolution from the NAD, which better revealed subtle details about how instruments make sounds. The acoustic guitar accompaniment on Norah Jones' "Come Away With Me" sounded more natural and realistic through the NAD. Overall, the C658 was significantly better sounding than the DragonFly Red. It may not seem fair to compare a $199 USB stick to a $1649 full-featured product; nevertheless, the comparison puts the C658's DAC performance into perspective. Although you can find better-sounding DACs at the C658's price, they won't have the NAD's extensive capabilities—full preamplifier functions, phonostage, subwoofer outputs with configurable crossover, streaming under BluOS control, and, most significantly, Dirac Live DSP room correction.

Next, I moved on from the Wilson Chronosonics and listened to the C658 and C298 driving the Focal Chora 826 for some time before engaging Dirac Live room correction. (See the sidebar on setting up and running Dirac Live.) Starting with the stock version that corrects up to 500Hz, I could see in the measured response two peaks of excessive energy in the range from about 80Hz to 180Hz, with two dips below 80Hz. The target curve showed a smoother response after correction, with the gently rising bass of the NAD target curve. In the listening seat, engaging Dirac resulted in more low bass and less midbass bloat. The Focal Chora 826 almost sounded almost like a different speaker in the low end, with greater depth and extension. Kickdrum had more impact, with seemingly much steeper and faster transient attack, coupled with quicker decay. The musical effect was greater punctuation of the rhythm. With the midbass bloat removed, it was much easier to hear nuances in bass playing; pitches were more clearly articulated; and, most significantly, I could more easily hear the starts and stops of each note. With Dirac, individual notes were more distinct in pitch and dynamics. This was true across a wide range of music, from Ray Brown's acoustic bass on the previously mentioned *Soular Energy* to Brian Bromberg on *Thicker than Water*. The overall tonal balance was somewhat lighter and leaner, but this leaning out of the midbass was entirely salubrious; the sound still had plenty of weight and authority, but was cleaner, tighter, and more intelligible.

That impression was with the Dirac version that comes free with the C658, which corrects up to 500Hz. Below this frequency is where room modes are most problematic, and this version of Dirac results in a remarkable transformation of the bass and low bass.

I then switched to the full-frequency-range version, a $99 upgrade, and again measured the system and loaded the new filters from my PC into the C658. I've generally believed that it's best not to try to correct higher frequencies with DSP, for several reasons. First, it's easy to dramatically change the sound of your speakers (which you presumably like) and get "lost in the woods" trying to find the right tonal balance. It's easier to do more harm than good. Second, correcting higher frequencies is much more technically challenging than correcting lower frequencies. In my previous experience, it's best to use DSP to fix the bass and leave the rest of the spectrum alone.

But that wasn't the case with Dirac Live. The bass improvements just described

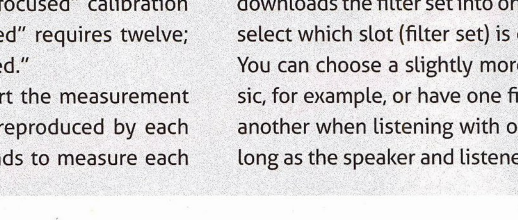
Dirac Live made the $2200-per-pair Focal speakers sound like more expensive models.

were all there, but the effect on the midrange and treble was equally remarkable. Using the NAD target curve (the frequency response the correction system aims for), Dirac didn't fundamentally change the Focal Chora 826's smooth and flat tonal balance. Instead, engaging full-range Dirac produced a startling improvements in image specificity, in clarity, in the ability to hear individual instruments through the mix, and in transient response. Sounds started and stopped faster, with less overhang. I also heard a smoother upper-midrange and treble, with less hash. The sound was overall more refined. The impression of individual instruments within a soundstage was heightened.

The full-frequency version of Dirac Live is the most impressive DSP correction system I've heard. It is well worth the $99 upgrade. In fact, it made the $2200-per-pair Focal speakers sound like more expensive models.

I next tried Dirac Live with the Wilson Chronosonic XVX, a speaker with much greater bass extension than the Focal. The Wilsons are perfectly positioned in my built-from-scratch listening room, which has good dimensional ratios for evenly distributing room modes. Even with these advantages, rooms will still create peaks and dips in frequency response, caused by the interaction of direct and reflected waves, and between

Dirac Live Setup



SETTING UP DIRAC LIVE is fairly straightforward. The program runs on a Windows or Mac PC, as well as on iOS and Android devices. I downloaded Dirac Live from the NAD website for my Windows 10 PC. The program instructs you to connect the included measurement microphone to the computer running the software. A graphic representation of a listener on a couch prompts you to take measurements of your speaker and room at the indicated positions around the listening area, and in the order specified. This part of the setup really requires a microphone stand to position the microphone correctly. Hearing protection is also recommended unless you like listening to repeated frequency sweeps.

You can specify one of three listening situations: "tightly focused" for optimizing the correction for a single seat; "focused" for a somewhat wider area suitable for two listeners; and "wide" for many listeners on a couch. The "tightly focused" calibration requires nine microphone locations; "focused" requires twelve; and "wide" seventeen. I chose "tightly focused."

With the microphone in position, you start the measurement and the C658 outputs a test signal that is reproduced by each loudspeaker in turn. It takes about 30 seconds to measure each microphone position. Once all the measurements have been taken, the software shows you your system's frequency response (or impulse response), along with the target curve for the correction. You can use the stock Dirac target curve, NAD's recommended target, or a variety of others that are available on Dirac's website. At this stage is also possible to create your own target curve by moving the curve up or down at certain frequencies. You can see in the illustration the response curve of the Focal Chora 826, along with the target curve with its rising bass response. You can think of these two curves as the actual response (measured) and the desired response (target curve).

Once you've set the target curve, either manually by moving the target curve up or down at certain frequencies, or loading a standard target curve (recommended), the software calculates the filters appropriate for your speaker, room, and target curve, and then downloads the filter set into one of five "slots" in the C658. You can select which slot (filter set) is engaged via the C658's front panel. You can choose a slightly more "live" target curve for certain music, for example, or have one filter set for single-seat listening and another when listening with others. This calibration is good for as long as the speaker and listener positions are the same.

different reflected waves. Two waves combine constructively to produce a peak of energy at certain frequencies, or destructively to create a dip at certain frequencies. Those frequencies are determined by the room's dimensions. After measuring the system and loading the correction filters for the Wilsons into the C658, I compared with no correction. I did hear an improvement in the bass, but it was an order of magnitude less than with the Focals. The bottom end was a bit more muscular and defined, with slightly better transient performance.

After lots of swapping individual components in and out of the reference system, and experimenting with Dirac, I finally settled in for some music listening to the system as it was intended; the NAD pair driving the Focal Chora 826 with Dirac properly calibrated. I have to say that the performance of this $5848 system was outstanding, particularly in the bass. The bottom end was quick, articulate, punchy, and had outstanding resolution of pitch and dynamic shading. It was truly a full-range system with a terrific bottom end, a quality that's very difficult to achieve without spending a lot more money.

Conclusion

The C658 and C298 can serve as the heart of a capable and powerful music system. The C658 streaming DAC is loaded with all the features needed in today's digital streaming world, has expandable inputs to accommodate future interfaces, and the BluOS app provides easy and intuitive control over a music library. The C658 can also serve as the heart of a whole-house wireless system. The C298 amplifier is a powerhouse that will drive virtually any loudspeaker. It also has qualities that are consistent with much more expensive amplifiers, including superb soundstaging, clarity of instrumental line, and good resolution of timbre. Bass and dynamics are spectacular, with excellent rendering of pitch and clarity of bass lines. The overall sound is slightly forward in perspective through the midrange and treble, a character that suggests attention to system matching. I can see the C298 delivering terrific performance when paired with much more expensive components. It's that good.

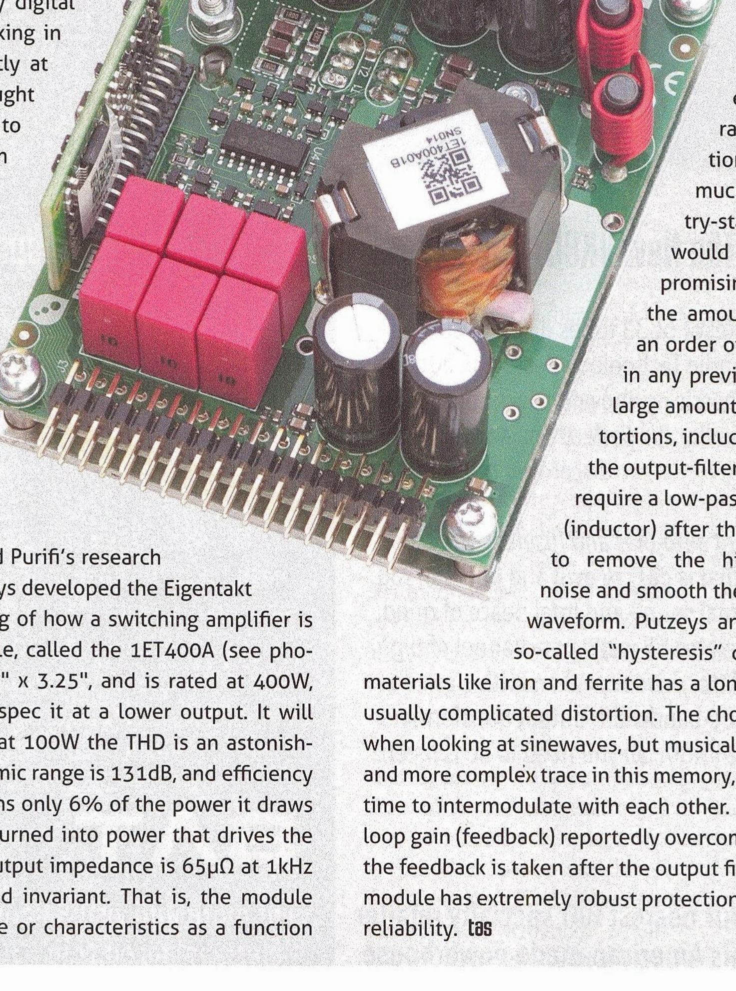
I would have recommended this pair without Dirac Live, but this DSP speaker- and room-correction system vaults the performance to a new level, without the sonic compromises I've heard from some other DSP systems. The improvement in bass extension, clarity, and dynamics is astounding. The full-frequency version of Dirac brings newfound image specificity along with far more lifelike reproduction of transients.

Considered alone or as a duo, the C658 and C298 deliver exceptional performance and value.

Purifi Eigentakt Explained

PURIFI IS A DANISH COMPANY founded to develop and bring to market innovative audio technologies. The company operates like a scientific research lab, but one that sells parts to audio-equipment manufacturers. The company's first two offerings are a 6.5" driver and the Eigentakt Class D power-output module used in the C298. Eigentakt means "self-oscillating" or "self-clocking" in German, which describes how the circuit operates.

Development of the module was led by one of Purifi's co-founders, Bruno Putzeys. Purifi's other co-founders are Lars Risbo and Peter Lyngdorf. Lyngdorf founded or co-founded many companies including DALI loudspeakers, TacT, Steinway-Lyngdorf, and the giant Scandinavian and European retail chain Hi-Fi Klubben. Bruno Putzeys is the brilliant designer behind the Hypex Ncore Class D amplifier module, which is generally considered to be the best sounding of all the available modules. Lars Risbo designed the TacT Millennium amplifier in 1998, the world's first truly digital amplifier. Risbo has been working in related fields ever since, mostly at Texas Instruments, which bought his company to gain access to the technology. The Millennium takes in SPDIF audio data, and then converts PCM to a pulse stream that turns the transistors in the switching output stage on and off, eliminating all active electronics from the signal path. I reviewed the Millennium at its introduction more than 20 years ago, and we recently named it one of the Most Significant Amplifiers of All Time.



While Risbo went on to head Purifi's research into loudspeaker drivers, Putzeys developed the Eigentakt concept, a significant rethinking of how a switching amplifier is designed. The Eigentakt module, called the 1ET400A (see photo), measures about 2.5" x 1.3" x 3.25", and is rated at 400W, although most manufacturers spec it at a lower output. It will output 400W at 1% THD, but at 100W the THD is an astonishingly low 0.00017%. The dynamic range is 131dB, and efficiency is greater than 94%. That means only 6% of the power it draws is wasted as heat rather than turned into power that drives the loudspeaker. The Eigentakt's output impedance is 65μΩ at 1kHz (not a misprint), making it load invariant. That is, the module doesn't change its performance or characteristics as a function of the impedance of the speaker it is driving. Like Putzeys' previous designs, Eigentakt has a low voltage gain. This requires a gain stage to boost the level driving the Eigentakt module. Purifi offers a gain stage, although I expect high-end companies will choose to create their own.

The module is reportedly not fussy about the quality of the power supply. This is not trivial: in a switching amplifier, the output transistors are turned fully on or fully off. They function as switches rather than as linear gain devices. When fully on, they connect the DC power supply directly to the loudspeaker (through a filter). This normally places greater demands on the power supply's freedom from noise and ripple (ripple is vestiges of the 60Hz AC line overlaying the DC supply). In order to become insensitive to this and other sources of distortion, a Class D amplifier needs a sophisticated error-correction mechanism.

The module's secret sauce is Purifi's mathematical model of a self-oscillating amplifier. This model is so accurate that the error-correction circuit can be pushed much further than industry-standard rules-of-thumb would allow, all without compromising stability. Specifically, the amount of error correction is an order of magnitude greater than in any previous Class D circuits. This large amount of feedback reduces distortions, including the sonic footprint of the output-filter choke. Class D amplifiers require a low-pass filter with a large choke (inductor) after the switching output stage to remove the high-frequency switching noise and smooth the signal into a continuous waveform. Putzeys and Risbo discovered that so-called "hysteresis" distortion from magnetic materials like iron and ferrite has a long "memory," causing unusually complicated distortion. The choke appears to be benign when looking at sinewaves, but musical transients leave a longer and more complex trace in this memory, causing signals spaced in time to intermodulate with each other. The Eigentakt's very high loop gain (feedback) reportedly overcomes this problem because the feedback is taken after the output filter. Finally, the Eigentakt module has extremely robust protection systems that increase its reliability. tas