



HI-FI+ GUIDE TO DIGITAL AUDIO

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Media Solutions, Belt Drive CD Player, Digital to Analogue Converter, Phono Amplifier, Integrated Amplifiers, Power Amplifiers, Bipolar Speaker Systems, Accessories

B.M.C. Audio GmbH, Lützowstraße 69, 10785 Berlin, Germany | info@bmc-audio.com | www.bmc-audio.com

HI-FI+ GUIDE TO DIGITAL AUDIO

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ENCYCLOPAEDIA DIGITONIA

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EDITOR, HI-FI+ GUIDE TO DIGITAL AUDIO
PUBLISHER, HI-FI+

Chris Martens
Tel: +1 (512) 419-1513 Office
Tel: +1 (512) 924-5728 Mobile
Email: cmartens@nextscreen.com

EDITOR, HI-FI+ MAGAZINE

Alan Sircom
Email: editor@hifiplus.com

CONTRIBUTING WRITERS

Jason Kennedy
Steven Stone

GRAPHIC DESIGNER

Jenny Watson
Fonthill Creative, Salisbury

ADVERTISING

Tom Hackforth
Tel: +44 (0)1425 655255
Email: tom@hifiplus.com

ASSOCIATE PUBLISHER

Pete Trewin
Tel: +44 (0)1425 655699
Email: pete@hifiplus.com

THE EDITORIAL OFFICE CAN BE
CONTACTED AT:

Hi-Fi+ Editorial
Absolute Multimedia (UK) Ltd
Unit 3, Sandleheath Industrial Estate,
Sandleheath, Hampshire
SP6 1PA
United Kingdom
Tel: +44 (0)1425 655255
Fax: +44 (0)1425 655477
Web: www.hifiplus.com
Absolute Multimedia (UK) Ltd is a
subsidiary of TMM Holdings LLC,
2601 McHale Court, Suite
Austin, Texas 78758, USA

CHAIRMAN AND CEO

Thomas B. Martin, Jr.
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Welcome to the first-ever *Hi-Fi+ Guide to Digital Audio*. This guide represents the second in a series of what we hope will be informative, product-themed, digital buyer's guides published on a quarterly basis. Digital Audio is presently undergoing some seismic paradigm shifts that spell good things to come for music lovers and audiophiles everywhere. Looking ahead, we see four important trends:

- **Digital audio continues to get better:** Digital audio is finally beginning to tap the sonic potential many audiophiles have been hoping for since CDs arrived in the early 1980s. In short, digital sound has finally come of age—showing sophistication and nuance that might once have seemed impossible.
- **Access to high-res digital music is improving:** Today it is easier than ever to access high-quality, high-res music, whether one's preference is for ripping discs, downloading files, or streaming music from a network.
- **Digital audio paradigms are shifting very fast:** We now have more ways to buy or lease digital music, to deliver music to our systems, to store music, and to play music than at any time in the past. The only catch is that system architectures sometimes can be very complex, while products can combine such varied combinations of features that they become difficult to classify.

- **Technology trickle-down is making great digital sound affordable:** As digital audio technology races forward, one wonderful side-benefit is that moderately priced digital audio components are becoming more sonically sophisticated by the minute. Remember: Today's mid-priced models would have been state-of-the-art wonders just a few short years ago.

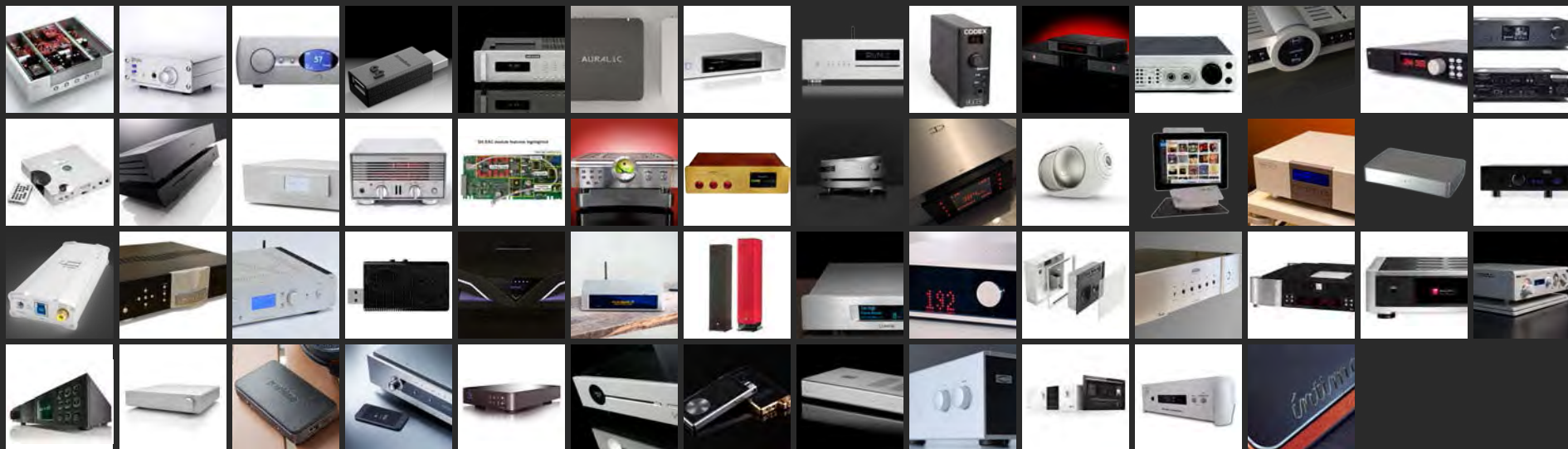
The aim of this Guide is to:

- Show you a wealth of new digital audio products,
- Let you hear the thoughts of visionary digital audio designers on their work,
- Help you learn about new sources of high-res digital music,
- Explain the admittedly tricky subject of digital audio streaming,
- Provide an index of *Hi-Fi+* digital audio reviews,
- Point out noteworthy digital components via our Editors' Choice Awards, and
- Offer a glossary to explain digital audio acronyms and terminology

As always, our goal is to help readers to derive deeper satisfaction from the music they love, while having great fun with carefully selected audio equipment and music systems. We wish you all the best digital audio has to offer, and happy listening.

Chris Martens
Publisher, *Hi-Fi+*

WHAT'S NEW IN DIGITAL AUDIO?



COOL DIGITAL AUDIO PRODUCTS COMING SOON

Abbingdon Music Research AMR 777 Signature Edition components

The all-new AMR 777 SE series components embody the best of old and new technology, with the range comprising the AM-777 Pre-Main Amplifier, CD-777 CD Processor, and DP-777 Digital Processor. All feature the General Electric 5670 valve, AMR Tri-Core Silver capacitors and, in the case of the CD and DP, Quad-Core Digital Engines and a fully digital re-design including a new clock arrangement. Each component advances the sonic attributes of the AMR 'house sound', which above all is geared to provide long-term musical satisfaction. Prices, depending on the model, start just under €3,999 per unit (including VAT).

www.amr-audio.co.uk



Alpha Design Labs GT40-Alpha 'DAC with a difference'

Described as the audiophile's Swiss army knife, this extraordinarily handy little gadget combines a 24-bit/192 kHz USB DAC with an equally high-resolution analogue-to-digital converter, plus an MC/MM phonostage and headphone amp. Simple switching between MM and MC or line input makes conversion from vinyl and other analogue sources to digital a breeze, while adjustable gain and a 'clipping' light ensure consistently successful recordings. The addition of a high-quality analogue volume control allows use as a multi-functional digital and analogue preamplifier, which can be connected direct to a power amp or active speakers. Finally, the headphone amp delivers ample drive for even the most demanding headphones.

Available now (£395).

www.adl-av.com



Audio Alchemy DDP-1 Digital Preamp

The DDP-1 digital preamp is the first product from the newly re-launched Audio Alchemy, a company famous for delivering unprecedented value in high-end audio products. The core of the DDP-1 is a 32/216 PCM/DSD DAC with four digital filter profiles, output resolution adjustment, and a proprietary dual DAC configuration for near-32-bit dynamic range. This section feeds an audiophile-grade analogue preamp with discrete FET driver and output stages and a precision four-gang ALPS potentiometer. Seven digital inputs and three analogue outputs plus XLR, RCA, and headphone outputs provide numerous connection options. A remote control and standard power supply are included; the PS-5 balanced power supply (\$595) is offered as an upgrade. Price: \$1,995; available now.

www.audioalchemy.com



AudioQuest JitterBug USB filter

AudioQuest's JitterBug USB filter helps one to enjoy more beautiful music by using dual-discrete noise-dissipation circuits to reduce the noise and ringing that plague both the data and power lines of USB ports. Noise (energy that shouldn't be there) noticeably compromises the performance of any downstream USB device.

For an additional improvement to the overall sound of a computer-based system, a second JitterBug can be used in parallel to the first. With or without anything plugged into the second JitterBug, it's possible to achieve a meaningful improvement in the overall sound of a system. JitterBug can also be used on streamers, media players, network storage devices, and with mobile devices into A/V receivers and car stereos. Available now (\$49).

www.audioquest.com



Audio Research Reference CD9

Audio Research is known for producing some of the most desirable valve-based audio components in the world. The firm's Reference CD9 (£10,998) is a perfect example: a CD player/DAC that fuses the best dedicated CD transport mechanism available—the Philips PRO2R—with DAC technology derived from Audio Research's brilliant Reference DAC, with a tube-based analogue output stage that delivers an extraordinarily musical performance.

Four digital inputs (including asynchronous USB) ensure external digital sources sound just as sublime as CDs slipped into the player's top-mounted loading bay. Build quality is superb, as expected of this illustrious brand. Finally, quality-conscious listeners seeking a more affordable solution will find ARC's CD6 delivers much of its big brother's magic at a lower price point...

www.audioresearch.com;

UK distributor, www.absolutesounds.com



AURALiC ARIES MINI

Respected worldwide for leadership in wireless high-resolution music streaming with its ARIES streaming bridge, AURALiC introduces the affordable ARIES MINI, bringing advanced wireless streaming, including Quad-Rate DSD\DXD, to a broader market of consumers — literally anyone with a home audio system. The compact ARIES MINI shares all software and hardware functions with the original ARIES.

ARIES MINI features a built-in DAC, analogue outputs, USB input for external flash drives/HDD/SSD, and room for an easily installed internal HDD/SSD, making it ideal for anyone not wanting to invest in a dedicated DSD DAC and/or NAS drive. Also new is an easy, step-by-step NAS Set-Up Guide on its App for iPad\Android smartphones. European availability: Late September. Prices: £349 (includes 19% VAT)\€499 (includes 20% VAT).

www.auralic.com



Aurender N10 Music Player/Server

Following recent introductions of the affordable N100 and N100H, Aurender expands its Music Player/Server offerings with yet another model, the N10. Housed in a full-sized aluminium casing, the N10 delivers Reference Class performance with a feature set to match. Aurender's award-winning App for iPads & Android smartphones incorporates dedicated TIDAL lossless streaming integration plus control of music from Network Attached Storage (NAS) or from an internal 4TB HDD. Playback is via a 240GB SSD caching drive, providing virtually limitless musical enjoyment. Connectivity options include Optical, COAX, BNC, AES/EBU, and USB digital outputs to ensure the highest performance from any DAC. A full-linear power supply plus damped and isolated audio circuitry deliver exceptional audio fidelity. Available now worldwide: (\$7,999)

www.aurender.com



AVM MP 5.2 media player with tube stage

The AVM MP 5.2 combines a CD Player, DAC, and Streaming Client into a multifunctional Media Player, which handles all digital sources and all formats including DSD. The MP 5.2 has a tube stage with custom-made AVM 83T double triodes. The MP 3.2 is designed with solid state output stages. TIDAL and other high-resolution streaming services are supported. All functions may be controlled with the AVM App or with the optional Remote Control RC9. AVM gets an exclusive delivery of a Pure-CD drive from TEAC. The DA section handles digital signals and features switchable upsampling rates up to 192/24 (or DSD). Standard colours are silver and black; the traditional AVM chrome front is available as an optional extra.

www.avm-audio.com



Ayre Acoustics, Inc. Codex headphone amplifier/preamp/DAC

Hand-built in Boulder, Colorado, the multifaceted Codex features twenty years of Ayre's keystone technologies in the most affordable package the firm has ever offered. Delivering the complete emotional impact of your music as the artist intended, the Codex stands as the perfect foundation for your system. Equally adept as a headphone amp, digital preamp, or stand alone USB/Toslink DAC, the fully-balanced, zero-feedback Codex includes two digital inputs, balanced and single-ended headphone outputs on the front as well as balanced and single-ended variable outputs on the back. The estimated retail for the Codex in the UK is £1395; available now.

www.ayre.com



Bel Canto Designs Black three-chassis digital audio system

Black is a high performance integrated three-chassis digital amplification system whose signal path maintains signal source accuracy entirely in the digital domain, without loss or coloration. The system comprises the ASC1 controller and MPS1 monoblock amplifiers. The ASC1 is the controller/master clock that manages all system analogue and digital inputs, volume control and other functions, including Ethernet rendering and custom FIR filters. The ACS1 handles DSD64 files and PCM/DXD files up to 24/384, and provides a low phase-noise 40-femtosecond clock. Each MPS1 incorporates a ULN clock, a fully balanced high dynamic-range DAC, and a custom NCore amplifier delivering up to 1200 Watt into 2 Ohms. Solid aluminium chassis are used throughout. System price: \$50,000; available now.

www.belcantoblack.com



Benchmark Media Systems DAC2 DX

Benchmark Media Systems' newest DAC2-series D/A converter is the DAC2 DX with native DSD and PCM conversion. This latest model has six digital inputs (two SPDIF coaxial, two Toslink optical, one USB, and one AES/EBU XLR). The DAC2 DX includes dual stereo output buses, offering independent fixed or variable gain settings. The DAC2 DX a 126dB signal to noise ration and maintains at least 3.5 wwdB of headroom in the entire conversion system, avoiding clipping caused by inter-sample overs common in digital recordings. Features include: sample-rate display, word-length display, three stereo analogue outputs, digital pass-through function, dual output 0-ohm HPA2 headphone amplifier, asynchronous USB, hybrid gain control, 12V trigger, and an optional IR remote. Price: \$1,895; available now.

www.benchmarkmedia.com



B.M.C. PureMedia multi-function media server/storage management system

PureMedia is a single-chassis component that provides an integrated media-solution for audiophiles (and videophiles). Functionality, playback quality, and completeness of features are outstanding.

PureMedia can be used to:

- Store music, photos, movies, or other media via a standard 2TB drive.
- Play music through outboard DACs or other playback devices via USB, HDMI, or digital outputs.
- Watch movies from PureMedia in fantastic video quality while listening through your audio or AV system.
- Make photo shows with PureMedia, or show smartphone media via PureMedia.
- Stream content via Wi-Fi or use PureMedia as a Wi-Fi access.
- Enjoy add-ons for internet radio and video and music services.
- Rip media via an external drive.
- Control PureMedia via an app for smartphones, tablets, or desktop computers.

www.bmc-audio.de



Bricasti Design M1 DAC

The M1 digital-to-analogue converter is a unique fully balanced dual mono design. Each analogue channel has its own linear power supply plus a third supply that provides isolation and power for the digital processing section. Precision clocking for each channel is done directly at each DAC by DDS (direct digital synthesis), which takes clock-induced jitter to immeasurable levels. The M1 offers five digital inputs; 2 × SPDIF, AES, and USB for complete flexibility for any system, and comes complete with an integrated digital level control and remote, and can be used as a line-level preamplifier for direct drive to the user's power amps. The M1 supports PCM sample rates up to 384k and DSD 128. List price is \$8995.

www.bricasti.com



Cambridge Audio Azur 851N network music player

The Azur 851N is the flagship network music player from London based audio specialists Cambridge Audio.

The 851N offers extensive digital connectivity and playback of all popular codecs up to lossless 24-bit/192kHz files over wired or wireless networks, delivering ultimate performance whatever the source. Twin AD1955 DACs, a 32-bit Blackfin DSP, a high-end digital preamplifier, and a large and fully linear power supply guarantee class leading performance, while the unique ATF2 Audio Upsampling system intelligently upsamples all inputs to 24-bit/384kHz, virtually eliminating jitter.

The 851N supports instant streaming with Spotify Connect, Apple Airplay or aptX Bluetooth, and effortless operation via the Cambridge Connect App or 4.3" colour display, bringing hi-end hi-fi systems into the digital age.

Available now for £1199.95

<https://www.cambridgeaudio.com/products/851/851n>



Chord Electronics Hugo TT DAC

Chord Electronics' Hugo redefined the portable DAC/amp genre and the new Hugo TT takes the groundbreaking formula even further. The TT is bigger and better sounding than its mobile stable mate and offers a host of additional features and connectivity.

Crucially, Hugo TT's larger chassis introduces remote control, an LED display and XLR outputs. In addition, the Hugo TT has double the battery storage of the Hugo and packs 10m microfarads of SuperCap energy storage, improving sound quality.

The Hugo TT supports 32-bit/384kHz audio via coax and USB, and 24-bit/192kHz over optical, plus DSD64 on all inputs and DSD128 via coax or USB (DoP). It also benefits from a high-quality galvanically isolated asynchronous B-type USB connection. Price: £2,995; available now.

www.chordelectronics.co.uk



Computer Audio Design CAD 1543 MKII DAC

Computer Audio Design is a UK audio company that concentrates on getting the most natural, analogue-sounding music possible. We manufacture the 1543 DAC, the CAD Audio Transport (CAT), and the CAD USB Cable, and our products are made by hand in the UK. Our 1543 DAC came out four years ago and was one of the first USB-only DACs on the market. We are just releasing the new upgraded 1543 MKII DAC for £7,250. We do things a bit differently and do not believe in oversampling, 32-bit depth, 352.8kHz sampling rates, filters, etc. Please take a look at our website and read the reviews. A lot of people think we are doing a pretty good job.

www.computeraudiodesign.com



Constellation Audio Cygnus DAC/server/digital file player

Constellation components are created by a high-end dream team, including distinguished designers like John Curl, Bascom King, Peter Madnick, and Demian Martin, and assembled by two of the founders of the world-famous turntable manufacturer Continuum. The Cygnus is part of the company's mid-level Performance Series and is available in two forms: a straightforward DAC (£27,500) and a DAC/Server (£32,900), the latter incorporating a digital file player.

As expected of Constellation, Cygnus is the result of exemplary science and engineering, delivering a level of performance that places it firmly at the top table of high-end audio. Discerning music fans that demand (and can afford) the very best audio equipment for their digital music collections should look no further.

www.constellationaudio.com;

UK distributor, www.absolutesounds.com



Copland DA 215

Founded in the mid-1980s by Olé Möller, the Danish firm Copland has earned a loyal following among the global audio fraternity for components that combine beautiful, minimalist Scandinavian design and thoroughly engaging sound. Its latest creation is the DA 215, a deliciously retro-looking high-resolution DAC, preamp, and valve-driven headphone amp priced at £1,798.

At its core is the peerless 32-bit ESS Sabre 9018 DAC chip, fed with digital audio signals via an asynchronous USB input, which accepts both PCM and DSD files, and three S/PDIF inputs. There's an analogue input, too, plus fixed and variable analogue outputs. The preamp section includes an analogue volume control, while the Class A output stage is derived from Copland's much-admired CDA 825 CD player.

www.copland.dk;

UK distributor, www.absolutesounds.com



Cyrus Qx upsampling DAC module upgrade

Cyrus is pleased to announce that the Qx card upsampling DAC module is available as an in-store upgrade to the 8₂ DAC, Stream XP₂ and Pre₂ DAC.

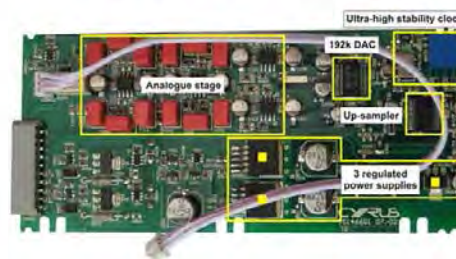
The Qx DAC is a circuit board of made up of audiophile digital and analogue components, which converts your digital sources to analogue in the highest possible resolution.

Although it processes the best 24-bit files in high resolution, the Qx DAC makes the most of any input you supply it with. Whatever the resolution of the incoming digital source, the Qx DAC takes that signal and upsamples it to the highest 192kHz resolution, meaning it will improve the sound of all your connected digital sources.

Available from approved Cyrus retailers now.

www.cyrusaudio.com

QX DAC module features highlighted



Dan D'Agostino Master Audio Systems Momentum Lifestyle Amplifier

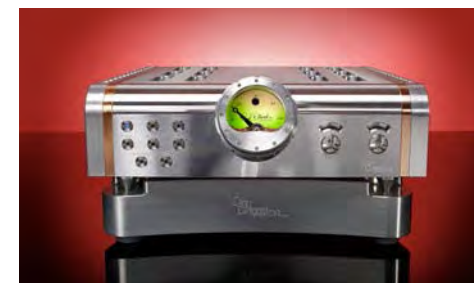
Few designers have earned the almost universal respect afforded to Dan D'Agostino, the legendary founder of Krell. He launched the first product under his own name – the Dan D'Agostino Momentum Monoblock – in 2010; five years later comes the Momentum Lifestyle Amplifier, or MLife for short.

Based on the 200W-per-channel Momentum Integrated Amplifier, the MLife adds streaming capabilities including Bluetooth and Apple AirPlay, with support for music services like Tidal and vTuner internet radio, all controlled via a proprietary iOS/Android app. Beautifully designed and built by hand, MLife is the perfect amplifier for those who wish to include streaming in their daily musical diet, but without the merest whiff of sonic compromise.

Projected retail pricing is expected to be around £45,000.

www.dandagostino.com;

UK distributor, www.absolutesounds.com



darTZeel LHC-208 integrated amplifier/DAC/streamer

The Swiss firm darTZeel proudly announces its new LHC-208, which the company describes as a “danalogue” amplifier—a component designed to fill the gap between conventional DACs and high-performance integrated amps.

First and foremost, the LHC-208 is a 200W-per-channel darTZeel integrated amplifier that delivers the exceptional level of performance expected of the brand. But this is more than an integrated amp; it’s also a network audio player, designed to stream digital music over Ethernet and deliver it with a sound quality to match the very best that high-end analogue audio can offer. With darTZeel’s unique Smart Clock system helping to optimize performance, this is digital streaming at its finest.

The projected retail price is expected to be around £14,000.

www.dartzeel.com

UK distributor: www.absolutesounds.com



dCS launches new Rossini Player and DAC

dCS has launched the new Rossini series – designed to make superb sounding music from any digital source. A complete digital front end, the £15,000 Rossini DAC and £18,000 Rossini Player set the new performance standard for single-box digital systems.

Rossini Player and DAC feature an array of digital audio inputs and are able to stream music over UPnP, from streaming services such as TIDAL™, from Apple devices via Airplay™, and via industry-standard USB, AES, and S/PDIF digital inputs. Rossini Player adds an integral Compact Disc transport.

Designed for flexibility without compromise, both DAC and Player deliver excellent performance by using the very latest dCS Digital Processing Platform and Ring DAC™ technology, originally developed for the Vivaldi series.

Available September 2015.

www.dcsLtd.co.uk



Densen Dino DAC

The Danish high-end manufacturer Densen will, in late October, introduce the first product in Densen’s new Dino range: the Dino DAC. The first thing that catches the eyes is the width of the cabinet, which is half that of a normal Densen product. Next the touch display really stands out, but as usual for Densen the focus is on the internal qualities. The Dino DAC, combines the absolute latest in digital technology as DSD and 384/32, with top notch analogue circuits, based on a Class A preamp stage, using Densen’s unique non-feedback technology. The result is a sound that is liquid, detailed, and transparent, while still maintaining the musicality for which Densen enjoys worldwide renown. The Densen Dino DAC will retail for £2,195.

www.densen.dk



Devialet Phantom & Silver Phantom wireless sound centres

Devialet, a Paris-based high-end audio equipment brand, this year launched two versions of its Phantom wireless sound centre, which has received 88 patents and 45 awards. Phantom took a team of leading product designers 10 years of R&D, resulting in breakthrough technologies such as ADH®, SAM® and HBI®. Despite complex engineering on the inside, the compact, semi-spherical Phantom exudes elegant simplicity on the outside.

Phantom creates the ultimate sound with no distortion, no saturation, and no background noise, from 16Hz to 25kHz. Offering power, precision, and unmatched musicality, Phantom is the first sub-£2000 sound centre that is totally wireless (Wi-Fi and Stereo Bluetooth™). Prices: Phantom, 750 W, 99 dB – £1,390; Silver Phantom, 3000 W, 105 dB – £1,690.

www.devialet.com



Digibit Aria Mini music server

As “one stop” music solutions, new Aria Minis are remarkable digital audio servers. Minis include auto CD ripping, metadata search (including album art), indexing, and internal storage. The custom hardware/software combo populates up to 18 metadata fields by searching multiple on-line databases. In addition to internal storage, streaming may occur from Ethernet drives, USB, and even “linked” hard drives within a Wi-Fi router network.

The Mini requires an iPad (not included), is fanless, supports on-board storage to 2TB, and includes a DAC for PCM files up to 32 bit/384 kHz (DXD) and DSD64/DSD128. Mini is compatible with AirPlay™ and DLNA™ and has search parameters unequalled by the competition. Like the original Aria, no PC is required!

Price: £2,295. Available now.

UK distributor: Auden Distribution,
info@audensistribution.co.uk;

US distributor: Source systems Ltd.,
sourcesystems@cox.net.

ariamusicserver.com/index.php/aria-mini



EMM Labs DA2 DAC

The DA2 is EMM Labs next generation flagship DAC. Ed Meitner has once again created a DAC that significantly improves on transparency, accuracy, and overall sound quality. Along with completely redesigning the analog stages for greater performance, Ed's proprietary MDAC™ is now the world's first true fully discrete DSD1024/16×DSD D/A converter. Our multi-award winning MDAT2™ DSP has also been updated and now does real-time transient detection, processing and up-conversion of both PCM and DSD to DSD1024/16×DSD. Every other system from its proprietary jitter removal MFAST™ to its super accurate clock, MCLK™ has been carefully revised for better sound. The DA2 will be shipping in late fall, MSRP is \$25,000 and up depending on options and finish.

www.emmlabs.com



EXOGAL Ion Digital Amplifier

Presenting the EXOGAL Ion Digital Amplifier, the long-awaited companion to the amazing Comet DAC. The Ion is a specialized high-performance digital amplifier designed to integrate fully with the Comet using the proprietary EXONet interface. The Ion requires no new remotes or separate smart-phone apps. The Comet & Ion combination makes an outstanding Power DAC, providing 250 WPC (into 4Ω) or 125 WPC (into 8Ω).

Available October 2015 worldwide.
Price \$3,250 (\$4,500 w/ Power Supply Upgrade).

www.exogal.com



Hegel HD30 DAC/AirPlay-compatible streamer

The new full size reference DAC from Hegel launches late this year and presents digital to analog conversion at a level higher than ever before. Developing a DAC that offers more than simply fitting the best components off the shelf means creating totally new designs.

In the project of the HD30 we went as far as to improve even the world's best Audio Precision measuring equipment, to detect the minute changes in phase. Understanding that modern people want to combine excellent sound with flexibility and ease of use, the HD30 also offers certified Apple AirPlay, streaming with Hegel's improved re-clocking and digital signal treatment.

The HD30 will launch before Christmas 2015, with an estimated retail price of \$5000.

www.hegel.com



ifi iDAC2 - True Native PCM384/DXD/DSD256 DAC/headamp

The micro iDAC2 is iFi Audio's latest digital-to-analogue converter. As it uses the same Burr-Brown chipset as the Nano and Micro iDSD, it handles PCM384/DXD/DSD256 natively. It runs Class A with an analogue circuit using Elna Silmic II capacitors, TDK COG capacitors, and Vishay MELF resistors – the iDAC2 has them all. It even has a 3.5mm headphone output so it is equally adept at home or on the road. It has an S/PDIF output for streaming to an A/V amplifier. All this comes in one cigarillo-sized, sandblasted aluminium case that sonically, punches well above its class. Price €395 (incl VAT).

www.ifi-audio.com



Krell Digital Vanguard Integrated Amplifier

Krell continues its legacy with the Digital Vanguard integrated amplifier, combining the company's advanced power amplifier technology, a fully discrete Class A preamplifier, and state-of-the-art digital I/O.

The stereo amplifier's 750 VA toroidal transformer and 80,000 microfarads of storage capacitance help effortlessly drive 200W per channel. The current mode preamplifier provides the wide bandwidth necessary to pass high resolution PCM and DSD audio sources with unfettered detail and resolution.

But it's the Digital Vanguard digital module that sets it apart, including USB, HDMI, coax, and optical digital inputs. Users can stream music to the device from Bluetooth sources—like phones, tablets or computers—or they can use dedicated iOS and Android apps to stream Ethernet music. Price: \$5,999. Available now.

www.krellonline.com



Leema Acoustics Libra DAC/preamp

The ex-BBC team at Leema Acoustics in Wales has launched its most advanced product to date: the Libra DAC/preamp (£5,995). Based around Leema's (future-upgradable and field-replaceable) fully balanced Quattro Infinity dual-mono DAC modules, the Libra's inputs offer unrivalled connectivity for the digital age: three coaxial and three optical (24-bit/192kHz/DSD 64); two I2S via RJ45 (24-bit/384kHz, DXD, DSD64/128); two AES/EBU (24-bit/192kHz and DSD64); plus one asynchronous USB (24-bit/384kHz, DXD, DSD64/128).

Libra is also an advanced analogue preamp, with three separate analogue inputs offering both balanced and unbalanced connections; the entire signal path, both digital and analogue, is fully balanced. There's also a high-quality headphone amp and Bluetooth connectivity for simple connection to tablets, smartphones, and compatible digital devices. Available now.

www.leema-acoustics.com



LH Labs Geek Out V2 USB DAC & Headphone Amplifier

Geek Out V2 is a portable DAC and headphone amplifier that connects to your computer or mobile device through a USB port. Designed with the same principle in mind that was used with our original Geek Out, the latest iteration plays real 32-bit/384 kHz PCM audio and DSD128 natively.

Geek Out V2 fully complies with the USB 2.0 Audio Specification making it plug-and-play on USB 2.0 devices with drivers available for non-compliant operating systems. Featuring multiple gain settings of 100mW, 450mW & 1000mW, Geek Out V2 lets you choose your power output to best match your headphones or sensitive IEM's. Geek Out V2 is now available for \$299.

www.lhlab.com



Light Harmonic Da Vinci DAC MKII

Back in 2011, Light Harmonic introduced the world's first 32-bit/384 kHz digital-to-analogue converter. In 2013, they upped the ante with the release of Da Vinci Dual DAC, the world's first dual engine PCM + DSD DAC, called Da Vinci Dual DAC. Now, in 2015, Light Harmonic has released the next logical step in the evolution of the world's highest-achieving DAC. Da Vinci DAC MKII includes the same dual DAC technology as its predecessor, but it takes performance up a notch by decoding PCM music files with up to 768 kHz sample rates in true 32-bit depth while also decoding all DSD files up to 11.289 MHz (DSD256). Pricing: To be announced.

www.lightharmonic.com



Lindemann musicbook: 20/25

In November 2015 Lindemann will release its next substantial firmware update for the musicbook: 20/25 network player. As one of the first in the world, the German manufacturer thereby swings aboard the "airable" train. This new internet radio and podcast software enables network players to access multiple music streaming services. From the start, Lindemann will support TIDAL and DEEZER, both offering music streaming in FLAC 44.1/16 (CD quality); other services will follow. The free web update feature is compatible with all musicbook: 20/25-series players delivered so far. Besides the streaming function, musicbook: 20 (€3,500) and musicbook: 25 (€3,900) offer, among other features, a fully balanced control amplifier and a class A headphone output; the musicbook: 25 also has a CD drive.

www.lindemann-audio.de



Linn Series 5 Systems

Linn's new Series 5 Systems represent a revolutionary concept in high-performance, customisable music systems, delivering world-class sound in a package that can be personalised to complement any décor, while optimising performance for the characteristics of your room and placement of your speakers.

Comprising a Linn network music player and loudspeakers with integrated, fully Aktiv amplification and Exakt electronics on board, Linn Series 5 Systems offer unparalleled musical accuracy within a compact, elegant design that has the power of larger separates systems.

As well as enabling truly linear-phase loudspeakers, Linn's ground-breaking Exakt technology also allows each speaker to be uniquely tuned to the Fabrik covering you choose, enabling unprecedented levels of aesthetic customisation, without performance compromises. Available now from £9,250.

www.linn.co.uk



Lumin D1 network music player

Lumin's D1 network music player is now in global distribution. D1 was developed from flagship products to reach audiophiles seeking excellence at reasonable cost. The D1 provides native decoding of PCM 44.1/16 up to 32/384 DXD and DSD audio files. Proprietary application technology is used for PCM to DSD & DSD to PCM conversion. PCM audio may be up-sampled to 24/192. In addition to network, Airplay, Internet radio and flash playback, D1 is integrated with Tidal and QOBUZ audio streaming. Dual mono Wolfson DACs are included with fully balanced and unbalanced audio outputs. The Lumin control "App" is freely provided for iPad and other devices. Price: £1,595.

UK distributor:

Select Audio, info@selectaudio.co.uk;

US distributor: Source Systems Ltd.,

sourcesystems@cox.net.

www.luminmusic.com



M2Tech Joplin MKII analogue-to-digital converter

Joplin MKII is a new A/D converter providing 384 kHz sampling & 32 bits of resolution that is ideal for digitizing your LPs (or tapes), or outputting the digital file with extreme detail and dimension. An aux S/PDIF input allows for re-using the digital connection for a digital source as well as for redirecting the output from a digital source to a computer. A proprietary FPGA provides a seamless connection between the ADC IC and USB port. The analogue stage is based on the best PGA (Programmable Gain Amplifier) available on the market and allows gain as high as 65dB. A comprehensive set of equalization curves can be selected, to accommodate all LP formats used from 1925 to present day.

UK distributor: [Purité Audio,
puriteaudio@btinternet.com](mailto:puriteaudio@btinternet.com);

US distributor: [Source Systems Ltd.,
sourcesystems@cox.net](mailto:sourcesystems@cox.net).

www.m2tech.biz



Meridian DSP320 DSP-controlled in-wall/in-ceiling loudspeaker

Meridian's DSP320 DSP-controlled loudspeaker is designed for in-ceiling/in-wall use, bringing Meridian performance to any room, discretely. DSP320 is voiced for use with any Meridian DSP loudspeaker or in-wall. Particular care has been taken to minimise the speaker's visual impact on its environment, with installation options including "frameless" and "bezeled" grills. Optimised for sound quality, the paintable metal grills further reducing visual impact on the room.

In addition to Meridian's full compliment of DSP processing and unique wide-range driver technology, the DSP320 features a long-throw "racetrack" woofer for extended bass, and dynamic range that is perfect for today's high-resolution music. It delivers full DSP loudspeaker performance in a compact design, and is MQA-ready. Price: £1,500 per speaker; available now.

www.meridian-audio.com



Metrum Acoustics DACs featuring Transient technology

All Engineering (AE) is primarily known for its brand Metrum Acoustics, which launched its first NOS (non-oversampling) DAC by using industrial chipsets. To get more independence AE decided to create its own DAC chips, also available for OEMs, under the "Transient" brand name. Forward correction techniques guarantee real 24-bit resolution for high-end products such as Metrum's flagship "Pavane" DAC. However, Transient technology is not only available for state of the art products, but is also incorporated in Metrum's new and affordable "Musette" DAC. Compared to typical oversampling DACs the presentation is organic and natural—perhaps as close to fine analogue as digital can get. Pavane and Musette are just the beginning of an entire new range of Metrum product.

www.metrum-acoustics.com

www.transient-audio.nl



MOON by Simaudio 780D DAC

The MOON Evolution 780D elevates digital audio to an all new level through the use of a fully balanced differential design with two DAC chips, each having 16 DAC circuits that can decode all digital audio formats (including native DSD quad and PCM 32-bit / 384kHz). The heir apparent to the world-class MOON 750D, the 780D will unleash dynamics and detail that you never thought existed in your digital audio files.

Digital inputs include our MiND network player, allowing native DSD streaming over Ethernet, and access to TIDAL. Other internal features include our MOON Hybrid Power: a new, ultra-high performance power supply and a modular design to help make this revolutionary DAC future-proof. Price: \$15,000; available now.

www.simaudio.com



NAD Masters M12 +BluOS multifunction digital preamp/DAC

NAD's M12 +BluOS combines network media client, preamp, ADC, DAC, and electronic crossover, into one easily operated and sonically transparent component. Radical all-digital topology boasts 60dB of digital headroom and 130dB of dynamic range, allowing the M12 to create 'ideal' preamp functions like volume, tone controls, and crossover filters using DSP—all integrated into the DAC for minimum path lengths. Network audio is delivered by BluOS™ with its music management solution that integrates local high-res music libraries with music services like Spotify and Tidal, all controlled via a smart device App. MC/MM Phono and balanced audio are supported in addition to every flavour of digital connectivity, including some not yet invented! Modular Design Construction allows future upgrades. Price: £3,699; available now.

www.nadelectronics.com



Nagra HD DAC

Nagra's HD DAC sets a new level for natural sound and definition.

The digital sector uses technology developed for professional music studios. Its circuits, that adopt the DSD 2X (Direct Stream Digital 128) standard, were developed in association with Andreas Koch, the pioneering engineer of the DSD format.

The analogue section is also the object of a superlative approach. Thanks to the quality of the signals supplied by the digital circuits, the traditional steep slope filters have been eliminated. The consequence of this is the preservation of transients and harmonics. Nagra's engineers blessed this section with all the refinements: Ultra high performance drivers, hand-wound transformers, and a tube driven output stage. 25 precision ultra-low-noise internal power supplies drive the unit.

www.nagraaudio.com



Naim Audio NAC-N 272 digital/analogue preamplifier

The Naim NAC-N 272 combines the latest innovations in digital audio technology with classic analogue preamplifier engineering. It samples the best of both worlds to create an immensely musical hi-fi system. Handcrafted in Salisbury, England to take you beyond sound, for a completely immersive music experience. The 272 combines an all-analogue Naim preamplifier with high-resolution UPnP(™) streaming, Spotify® Connect, Bluetooth® (aptX), DAB/FM/iRadio, multiple wired inputs, multiroom capability, and app control for your iOS or Android device. Suggested retail price: £3,300.

www.naimaudio.com



Optoma NuForce DDA120 digital integrated amplifier

Optoma NuForce announces its DDA120 digital integrated amplifier, which accepts analogue, digital, and Bluetooth audio from computers, consumer entertainment products, and streaming devices. It's perfect for those who demand great sound with pure simplicity. The versatile DDA120 provides one analogue input (via RCA jacks), four digital inputs (one USB, one coaxial, and two optical), plus an expansion slot for the NuForce BTR1 Bluetooth receiver dongle.

The DDA120 packs enough power to drive a majority of home speakers with superb dynamics and transparency, delivering a robust 50Wrms/250W peak power output per channel. With its multi-functionality and affordable price, the DDA120 is the only device you'll need to run your home entertainment setup without breaking the bank. Price: \$699; available now.

www.optomausa.com/soundproduct/DDA120



Peachtree Audio shift USB DAC and Headphone Amplifier

Shift is a USB DAC, which provides native decoding of PCM files up to 32-bit/384kHz and DSD 64/128 files. It is small, lightweight, and battery powered and makes an ideal travel companion to enjoy music “on-the-go” while getting the best sound from your headphones. Shift has two USB inputs; one that works with iPhone 6 Plus, iPhone 6, iPhone 5s, iPhone 5c, iPhone 5 and iPod touch (5th generation) and another that works with most Android devices and personal computers (Mac/Windows). Shift can even “top-up” the battery in iOS devices and includes a fixed output mode for use as a stand-alone DAC in a hi-fi system. Shift becomes available in September, priced \$349 SRP.

www.peachtreeaudio.com



Primare Hi-Res Streaming App

The Hi-Res Streaming App completes Primare’s suite of digital playback offerings, already including the Primare App and Bluetooth connectivity, making it easy to enjoy the full range of today’s digital listening options. The app enables playback of high-resolution streaming services through any of Primare’s network-enabled digital devices, including the NP30 network player, MM30 media board, and PRE60 reference preamplifier. Services initially supported include Deezer and Tidal, with more to be added in the future via simple updates. Compatible with both iOS and Android, it’s FREE (download available from the App Store and Google Play), requiring only an account with the preferred music service to realize the pure sound of Primare hi-res streaming. Available January 2016, free of charge.

www.primare.net



PS Audio NuWave DSD DAC

PS Audio announces the NuWave DSD DAC, successor to the popular NuWave DAC. The NuWave DSD adds DSD capability (single- and double-rate) to PCM inputs up to 192/32 from any digital source including I2S, coax and USB. Toslink is limited to 96 kHz; DSD can be input via USB or I2S.

NuWave DSD accepts all signals without Sample Rate Conversion (SRC), processes through a CPLD (Complex Programmable Logic Device), and decodes using a 32-bit ESS Sabre Hyperstream chip. A massive power supply and a unique, fully balanced Class-A output stage ensure a seamless 3-D soundstage, and sound quality hand-tuned and voiced by Paul McGowan.

NuWave DSD performs well above its price-point of £1,150; products are available now.

www.psaudio.com



Quad Artera Play

The British firm Quad marks its 79th year with an all-new range of audio components called Artera. First out of the blocks this autumn is the Artera Play (£1,400): a CD player, DAC, and preamplifier combined in a single elegant chassis, designed in consultation with Rodney Mead—the man responsible for the styling of many classic Quad products.

Artera Play is the first Quad component to incorporate the peerless 32-bit ESS Sabre DAC chip. The asynchronous USB input supports high-resolution PCM files to 32-bit/384kHz resolutions and is also DSD compatible, while the analogue preamp section is a balanced Class A design. Artera Play is design to partner with the Artera Stereo power amp, which uses Quad’s famous Current Dumping technology.

www.quad-hifi.co.uk



Questyle QP1R High-Resolution Audio Player

Questyle Audio proudly announces its high-resolution portable digital audio player (DAP), the QP1R. The QP1R is able to natively process DSD and Double DSD as “TRUE DSD”, as well as PCM up to 24/192kHz, via the Cirrus Logic CS4398 DAC chip. Questyle’s patented, fully discrete Pure Class A “Current Mode” amplifier completely eliminates any Transient Intermodulation Distortion (TIMD), delivering a sound that’s richer and more detailed, yet powerful. With an extremely low 0.15 Ohm output impedance and user-adjustable gain, the player has the ability to drive anything from the most finicky in-ear monitors (IEM) to the most power hungry headphones with dynamics and authority. This is why the QP1R is in a class of its own. Price: \$899. Available now.

www.questyleaudio.com



Schiit Audio Gungnir Multibit DAC

At \$1249, Gungnir Multibit brings the acclaimed multibit technology of Schiit Audio’s flagship Yggdrasil DAC to a more affordable price point. With the only time- and frequency-domain optimized digital filter running on an Analog Devices SHARC processor, four medical/military multi-bit DACs in a hardware balanced configuration, and discrete JFET output buffers, Gungnir Multibit delivers a significant percentage of Yggdrasil’s performance. In addition, Gungnir Multibit incorporates Adapticlock™ regeneration, a unique technology that assesses the quality of the incoming digital signal and routes it to the best possible regeneration technique—VCXO or VCO. Finally, Gungnir’s modular, fully upgradable construction—unique at the price—means that owners of current Gungnirs can upgrade to Gungnir Multibit for \$500.

www.schiit.com/products/



Soulution 760 DAC

Soulution is pleased to announce its new 760 D/A converter, featuring top-class D/A converter stages, an ultra-precise clock generator, and preamplifier grade analogue output stages that translate every music detail in the analogue world. The versatile 760 provides five digital inputs, including AES/EBU, SPDIF, Optical, USB inputs, and LAN connectivity.

The DSP based USB and LAN inputs get synchronised on the ultra-precise, internal master clock and ensure optimal reception of all high-resolution music formats: PCM (16-bit/32kHz to 24-bit/192kHz), and DSD (1bit/2.82 MHz) and double DSD (1bit/5.62 MHz).

The 760 DAC uses a polynom-based upsampling algorithm, digital filters with apodizing characteristics, and Soulution’s innovative Zero-Phase-Technology to ensure perfect treatment of the digital data for best audiophile results.

www.soulution-audio.com



Trinnov Audio Altitude32 high-end AV preamp

Trinnov Audio released a High-End AV Preamp that will satisfy the most demanding audiophiles and home theatre enthusiasts. The Altitude32 provides the same benefits as Trinnov’s High-End Preamplifier Amethyst, and more.

Trinnov’s acclaimed Optimizer technology is included to ensure accurate playback. Its unrivalled power ensures true-to-source reproduction with native 24-bit/192 kHz digital audio processing, without any down-sampling and 64-bits floating-point resolution.

The Altitude32 is available in four different configurations and is upgradable. Starting with 8 channels, the Altitude32 can drive traditional 7.1 surround sound systems, but the channel count can go up to 32 channels with active-crossovers and 3D sound formats.

Trinnov Audio released the Altitude32 at the end of 2014. Prices start at £14,950.

www.trinnov.com/products/home-theater/altitude32



Wadia di122 DAC

A leader in high-performance digital audio since 1988, Wadia Digital continues to push technical and sonic boundaries in its quest to give music lovers the best possible listening experience from digital sources. Inside its classy aluminium and glass casing, the company's entry-level di122 DAC (£1,598), contains sophisticated D/A circuitry to make the most of a wide range of audio formats.

An asynchronous USB input accepts PCM files up to 32-bit/384kHz, while two coaxial inputs and a pair of optical inputs accept data up to 24-bit/192kHz. The USB input is also compatible with DSD64, DSD128, DXD 352.8kHz and DXD 384kHz files, while variable balanced XLR and single-ended RCA analogue outputs, plus a high-performance headphone output, add to the DAC's flexibility.

www.wadia.com

UK distributor: www.absolutesounds.com



Wyred 4 Sound Íntimo headphone amp/DAC from Wyred 4 Sound

The Íntimo is a sonic tour-de-force for the discriminating headphone music lover. From the start, we knew two things were a must: a high-output Class A amplifier and a reference-level DAC for hi-res PCM and DSD files. Other features will include an analogue volume control, touch-sensitive buttons as well as balance, phase, and tone controls. All of this comes in a beautiful, custom chassis perfect for hi-fi rack or desktop.

Two Íntimo versions will be available: single-ended or fully balanced. Both will boast multiple digital inputs, and in the tradition of Wyred 4 Sound, an affordable price. Projected availability: Fall/Winter 2015. Estimated price: \$1,000–\$2,000. Photo is of the demo unit; appearance is subject to change.

wyred4sound.com



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MASTER DESIGNERS: DIGITAL AUDIO EQUIPMENT



HI-FI+ INTERVIEWS TWELVE INFLUENTIAL DIGITAL AUDIO DESIGNERS
ON THE ART AND SCIENCE OF THEIR CRAFT

Scott Berry, Computer Audio Design (CAD)

Hi-Fi+: How did you become interested in digital audio design?

Scott Berry: I am an electrical engineer and did a fair amount of high-speed digital design in my previous jobs for Tektronix and Xerox. I started up Computer Audio Design after moving to the UK from the States. I've always had an interest in music and spent my very first earnings on audio equipment (a Nakamichi 480 cassette deck) when I was just 16. I bought quite a few CD players over the years, but I have always preferred my turntable for serious listening. To my ear, one of the biggest issues that I consistently find with CD players is the inability to reproduce upper frequencies accurately. So I started working on a DAC design for myself (as a hobby) to try to understand the issues and get a sound quality that I preferred.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

Many of the audio DAC designers today focus on producing DACs that have low total harmonic distortion (THD) with test sine wave outputs. While THD is of course important, the various techniques to obtain these low THD results in output sine waves (oversampling, filtering) can in my opinion have detrimental effects on sound quality.

One of the parameters that I feel correlates to sound quality is the impulse response of the DAC. An impulse response is obtained when you send a single sample digital 0dB (maximum output) input into a DAC and then look at the output on an oscilloscope. A resistor ladder Non Over Sampling (NOS) DAC, as used in our 1543 DAC, has an almost perfect impulse response with almost no pre or post ringing. In my experience this measurement appears to correlate quite well with obtaining a more natural sound quality. One of the perceived downsides of NOS design is that an output sine wave is "stepped" and produces a high measured THD. In my experience high THD in this case does not correlate to poor sound quality. If you connect an oscilloscope to a music signal, what you see has very little to do with a test sine wave. In my opinion, designing DACs that can output "perfect" sine waves with low THD does not alone ensure the best sound quality.

There is no single magical part in any Computer Audio Design product that makes them sound the way they do. That said, I do believe strongly in the importance of power supplies. My power supply designs are fundamental to the 1543 DAC sound quality. The resistor ladder digital-to-analogue conversion technology is of course important, but the input interface to the DAC chips, the output stage, vibration control,



and reduction of high frequency noise from the AC mains (power conditioning) and internal components within the DAC are all absolutely crucial. There has to be a synergy within the whole system.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

The CAD 1543 DAC design is pretty unique. Our 1543 DAC uses resistor ladder DAC technology with no oversampling nor any filtering, which is rare these days. Most other DACs on the market make use of delta-sigma D/A technology along with over-sampling and filtering.

We also focus entirely on computer-audio because we believe that even a simple computer connected via USB can out-perform an expensive CD transport connected via S/PDIF.

The output stage of the 1543 DAC is passive, meaning that there are no transistors, op amps, or tubes between the output of the DAC ICs and the RCA connectors on the back of the 1543 DAC. The output voltage signal on the RCA connectors comes directly from the current output of the chips passing through a single extremely high quality resistor made to our specifications. Again, this is an unusual approach – most DACs employ active parts in the output stage.

The mains power conditioning and high frequency noise reduction in the 1543 DAC is, I believe, one of the most extensive in

the industry. The entire case is made from laser cut 10mm thick acrylic which I do not believe any audio manufacturer is doing. We do not use acrylic just to be different, it is actually vastly more complex and expensive to manufacture than aluminium or other metals. We tried using aluminium like most other companies, but acrylic has mechanical and electrical advantages that work extremely well with our design.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

The 1543 DAC is a long-term personal project that we decided to take to commercial production. The 1543 DAC as you can see from above is unlike any other DAC on the market and because of that it sounds unlike any other DAC on the market. It was our first product, and I am very proud of the numerous positive reviews and awards it has won.

The CAD USB cable contains proprietary filtering technology that was just recently awarded a patent. I tried hundreds of different wire materials and configurations before I began to get an idea of what is needed. As an industry our understanding of the requirements of audio USB cable is in its infancy. What works in the analogue interconnect world has little bearing on

Right: CAD's flagship 1543 MkII DAC (top) and companion CAD Audio Transport (bottom)



what happens at USB 2.0 speeds. Think of all the effort made by audio interconnect companies out there over the last 30+ years working on analogue interconnects! Audio USB cables did not really exist until about 3 or 4 years ago.

The name of the company is Computer Audio Design, so we are also trying to understand the key factors in computers that affect sound quality. You can take the same exact software and put it on two different computers and the sound quality will be different. So that tells you the hardware matters. You can change software on a computer and the sound quality changes. So that tells you software matters. Unfortunately, everything matters. To get computer audio to perform at the highest level is extremely complex! Setting up a computer to get the very best out of it is like setting up a high end turntable. It takes skill and patience.

We have combined everything we know about computer hardware and software in our new CAD Audio Transport, or CAT, aimed at making computer audio easy along with offering exceptional sound quality. In my opinion, I feel that computer audio will someday produce a level of sound quality beyond anything that has been produced. I am not saying that we are there yet, but I feel the CAD Audio Transport is a step in that direction.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

There is a massive push right now for higher resolution, higher bit rates, higher sampling frequencies, quad rate DSD, higher oversampling. Higher resolution is a good thing, but it is not without its difficulties. 32-bit? I am not sure how many DACs have a noise floor low enough to fully use 24 bits... There are other factors that influence sound quality in digital audio that to me seem to be being ignored as a result of the marketing push for higher resolution formats and devices.

Another topic that is often overlooked is the impact of cables carrying digital data on sound quality. This is much better understood than it was two or three years ago, but I still see consumers (and audio journalists) who think USB/Ethernet/SATA cables do not matter.

Finally, consumers and the industry need to recognise how important computer hardware and software is to sound quality. If you want to get the best sound quality out of your computer it needs to be setup just for audio use. You cannot use the

Above: CAD Audio Transport

Right: CAD 1543 MkII DAC



computer for surfing the net, for work, or loaning to your kids to play games on. Some of the improvements to both hardware and software are low cost and easy to implement.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

I have talked a bit about this already, but I feel higher-than-CD resolution can be a good thing, as long as the digital device playing the files can do so properly. The 1543 MKII DAC will play PCM natively up to 192KHz. The resistor ladder DAC ICs that are used in the 1543 DAC will play DSD over PCM or what is called “DoP”. Many people have a substantial CD collection. The CD format itself was well conceived, but not always implemented to its full potential. One of our aims at CAD is to get the very best out of CD format as well as the higher resolution formats now available.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

I believe that streaming is probably the future of music playback for many people – the convenience and choice is unbelievable. Customers will no longer purchase music, but subscribe to streaming services that they prefer. Recently more effort is being made by streaming companies to improve the sound quality of their services. Even so, in

my opinion, for people looking for the best sound quality a dedicated music server with locally stored files of CD quality or better is the way to go. The great thing about computer audio is that you can do it all.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

Our next product will concentrate on reducing higher frequency noise, and will be a passive device that can be used with a wide range of audio components.

What do you think the high-performance digital audio marketplace will look like five years from now?

We will have many more computer audio hardware products on the market; at the moment there are only a handful. Today very small companies or individuals are producing most of the audio playback software designed specifically to improve sound quality. I expect larger companies will start trying to improve sound quality with software too, and it’s already happening.

The number of audio streaming providers will increase dramatically, but the big names such as Google, Amazon, Apple, and maybe Facebook will hold the majority of the market for general quality audio streaming. There will be dramatic improvements in sound quality by some streaming companies who will support those customers that are interested in better sound quality.

When you listen for personal enjoyment, what types of music do you most enjoy?

I listen to a wide range of music but concentrate more on “alternative” folk and rock. My music collection has everything from 1960’s rock, Oscar Peterson Jazz, Blues, Gospel, electronic. Since using piano music for testing work I have become a bit of a fan of Schubert and Chopin. I pretty much enjoy listening to most things – as long as it’s on a good system!

I have a large CD collection that I have ripped and I purchase CDs and higher resolution music on line all the time. These days used CDs are incredibly inexpensive and the selection is massive on Amazon and eBay. +



Right: CAD’s sophisticated USB cable

Carlos Candeias of B.M.C. Audio

Hi-Fi+: How did you become interested in digital audio design?

Carlos Candeias: In 1983, by some weekend jobs and diplomatic help for buying in the significantly discounted allied military shops in West Berlin, and I've got the very first CD player model "Philips CD100". It offered the promise of better sound and no more LP troubles—but it wasn't really able to deliver! One year later, when I started studying electronic engineering in Berlin, I started changing DAC sections with pretty satisfying results. Digital audio design, together with speaker design, became kind of a living for me, and two years later in 1986 I founded my first audio company.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

Every single stage within a digital component provides its own kind of sound benefit if designed well. But, besides optimizing single stages, you need new overall concepts for breaking old barriers.

The DAC chip itself is overrated in public discussions concerning its sonic significance.

In simple terms, what do you feel sets your designs and products apart from most other ones the on market?

Our designs are very innovative and advanced in many ways, with clear benefits for the music listening experience. Our designs benefit from our CI (Current Injection) I/V conversion process, our lossless analog volume control, our phase independent non-feedback LEF drivers, and—as the final consequence—the DAPC (Digital/Analogue Power Converter) design itself. All are unique on the market, providing better performance on any domain.

What do you consider your top one or two digital audio product design achievements thus far? What makes those products special from your point of view?

The DAPC enables us to have a DAC output even on the speaker level if required, without any need for preamplifiers, gain stages, lossy volume controls, overall feedback loops, etc. This changes the paradigm of how to design future systems, and how to tie digital and analog domains to each other. Years before, our distinctive "Superlink" digital interface did set benchmarks for CD players.



What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

First, never be so sure of what you know today! Only the ones questioning the status quo will break barriers.

Second, be aware that goals for better audio have to be defined in the artistic domain, translated into a scientific task, and then properly engineered. That's why digital audio design is not easy at all.

Third, watch fashions with a critical mind.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

First, all those formats are just containers and must be filled with excellent recordings in order to have any musical meaning

Second, DXD is PCM! It's just a new term for PCM with 8x the sampling frequency of the 44.1kHz or 48kHz standards. DSD frees digital audio from the sonic influences of FIR filtering. Most people find it sounds more

"fluent" and "analogue-like". But nothing is for free: DSD's need for noise shaping actually causes its own softened sound signature—less precise than PCM. Besides, there is virtually no clean and native DSD approach in music production.

If a DXD recording is free of ultrasonic noise (and unfortunately there is upsampled DXD music on the market with a nasty digital garbage spectrum of noise), FIR filtering is not needed any more. Our DAC changes to NOS (non-oversampling) operation for DXD and that's clearly the winner!

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

Most streaming devices and even dedicated music servers are based on simple consumer solutions and fail to compete with top-grade CD players.

It took us almost two years for the design of an ultimate solution for audio, video, storage and more. The OS must be optimized for this purpose and an audiophile audio engine takes a very different approach to a computer sound system.

Generally every home now needs a server and has multiple devices accessing media content.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

We are now merging audiophile music listening with top-quality video experiences, simply admitting that both are present in most households anyway and that audio is not a religion. For example, my kids discovered the beauty of high quality music by having it always available and by first being attracted by movies.

Hi-Fi+: What do you think the high-performance digital audio marketplace will look like five years from now?

It is hard to tell since we have different movements in parallel. On one side, we see 'normal' luxury customers increasingly discover our levels of quality. On the other side, we see that the purchasing power of average people is decreasing in too many countries. So we expect the middle class products to be weaker, while entry level and luxury products will be fine.

When you listen for personal enjoyment, what types of music do you most enjoy?

Although my collection includes almost everything, during the last years I have started tending more to classical music again. Some circles close in life and for me the love of music all started with a classical education in very young years, complete with attending performances in the Berlin Philharmony...

After being around the globe for decades, our new home and flagship store is just a short walking distance from the Philharmony. +



BMC's UDAC incorporates DAPC (Digital/Analogue Power Converter) technology

Philippe Chambon, Nagra Audio

Hi-Fi+: How did you become interested in digital audio design?

Philippe Chambon: I've been interested in digital audio since the early eighties. Back then I was using a PCM-F1 from Sony coupled with a VCR Recorder, then later I used a PCM 501 and 701 as a master recorder. I remember buying the first Sony CD Player: the CDP-101, as soon as it was out.

I was young then but I had already built my own amplifiers using the first available MOSFET audio transistors from Hitachi, and a pair of Onken subwoofers. Although the new digital tools seemed revolutionary, I felt disturbed by their unnatural sound compared to real music listening.

Years later, during research work at Europe 1, in Paris, I completed a lengthy work of listening and measuring over 50 D/A converters, because I had to find a way to transmit very high quality audio via a microwave link. The solutions offered by broadcasters at the time were not satisfactory. I had chosen Sonic Frontiers, which was using Pacific Microsonic conversion modules and a triode output stage. I had positioned these converters on the Eiffel tower, which at the time had made transmission engineers worried, because they did not understand why I was using this kind of equipment. Later, however,

they would acknowledge the great quality achieved thanks to this equipment...

All this brought me to do some research about the different A/D conversion technologies, keeping mostly in mind the subjective listening feeling, and with the goal to be as close as possible to the truth of the instruments, as they really are, and to preserve the integrity of the emotion.

I did some research about the quality of the clocks, and also about the R2R technology, the PCM704 chips, using if possible no oversampling. At Nagra we have built an R2R prototype converter using only discreet components and ultra-high precision resistors.

Previously I didn't like mono-bit converters, which are mainly used in low cost converters ...until I met Andreas Koch.

His work on digital audio strongly surprised me, as he had managed to follow the same audio quest as mine, but using techniques that were totally different. The quality of the oversampling algorithm coupled with mono-bit converters using discreet components (contrary to the low cost, ready-made budget chips) completely blew me away with its naturalness and sense of reality. It was very close to the real instrument, and at



the same time keeping all the micro details and timing information, which are crucial to render the sense of space, all this with an impressive focus.

We still had to imagine the analog circuits necessary to keep the same level of performance, and since they did not exist, we developed them specifically for the Nagra HD DAC.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

In terms of digital parameters, we would single out: clocking, clock phase noise, quality of digital power supplies, and high precision calculus. This is why we use 72-bit calculation, oversampling method.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

Our unique chance at Nagra is that for more than 60 years, we have been designing state of the art products. This makes available a wide range of expertise in many fields: analogue or digital, electronics or mechanics, PCB design, and so on. Nagra has been involved in many technical breakthroughs for six decades, often bringing new ideas and striving to offer better sound quality. Whenever we work on a new product, no matter its price point, we have behind us years of tradition and extremely high expectations. This makes every Nagra a piece of art, as it needs to reach top-level performance to bear the Nagra logo.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

This is easy as the only design we did in digital in the last three years is the HD DAC!

Fortunately we do not have to make a difficult choice.

The HD DAC is a D/A converter that offers the best technology in terms of digital and analogue. The analogue part of a converter is sometimes regarded as less important, but is actually essential. The HD DAC is a superlative product. It is the first of a new family of products that we have called the HD Line. Nagra products are designed with a non-compromise approach in mind. Though the CLASSIC Line units are compact and sometimes some components would not fit-in. The HD Line's larger dimension allows us to be even more ambitious. In addition the HD Line products have separate power supplies for audio and digital or control; this contributes to a better performance.

The HD DAC is often referred to as "very analogue". This might sound like a paradox for a digital product but actually very much

Above: Nagra's HD DAC is one of the finest DACs Hi-Fi+ Editor Alan Sircom has ever heard

Right: Nagra's HD DAC uses ultra high-quality parts throughout



in the direction we were aiming for. Getting closer to the music and how it sounded live at a concert or in a recording studio.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

The importance of timing in transient response; this is essential in analogue and digital. In the case of digital it is what differs a good algorithm from a great one. It will dramatically alter the image, position, and focus of one instrument in the soundstage. So a perfect timing will make the sound more natural and musical.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

The HD DAC supports all these formats. Nagra was the first company to introduce a high-resolution digital recorder in 1992, the famous Nagra D digital reel to reel recorder. It could do 96 kHz/20-bits and was later on able to do 24-bits when a converter became available. So Nagra has always been proactive and on the leading edge of digital formats.

We believe a good recording will be good on a red-book CD, and we demonstrate that at every show, although the new formats available today 'take you inside the recording studio'. You have now access to the "native" resolution the recording was made originally

on. This is a discussion we always have now with recording and mastering engineers; they know that the resolution they hear in the studio can be directly available to music lovers. In the day of analogue tape, the difference between what the artist heard in the studio and the LP could be extremely frustrating. I remember a story told by Bruce Swedien, Michael Jackson's *Thriller* sound engineer, among many other top artists. They made the first test pressing of *Thriller* and, because it was a bit too long, the sound was really compromise. So they took the difficult decision to cut around 1 minute of each song, to allow the sound to be better on the LP; the rest is history. But today an artist would not have to sacrifice a portion of his songs, as the format in the studio does not have to be converted to a lower resolution format.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

We are lucky to have our own playback solution with the Nagra VI and Nagra Seven. The Nagra Seven plays up to 192/24-bit files from SD cards. The quality is striking. Of course you can get very good results with the right computer set-up. It takes a bit of time and knowledge to have the proper system up and running. We receive a lot of requests to build a music server. At this time we are still evaluating this possibility.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

Nagra is working on a D/A converter that would benefit from the R&D work done on the HD DAC in a more affordable unit. This would be the D/A for our CLASSIC Line. It is based on the digital front-end of the HD DAC with a solid-state analogue output stage. We plan to launch this product in early 2016.

What do you think the high-performance digital audio marketplace will look like five years from now?

It is a very interesting and difficult question to answer. The available bandwidth will allow higher resolution to be available in streaming and not only download. I hope the quality expectation of the young generation will increase because, thanks to the wide bandwidth available, lossy compression based formats will be useless and irrelevant. I hope this will bring some aspiration to listen to better systems and in the end higher resolution formats.

We also hope that technology will allow music creators to promote their music and make it available to a broader audience.

When you listen for personal enjoyment, what types of music do you most enjoy?

I listen to a very large panel of music genres: it can go from middle-ages music to Daft Punk, including also baroque style, great symphonies, classical piano and jazz, and a few great American recordings of the 70s, such as Chicago, Pink Floyd, Dire Straits...

However my genre of predilection is the Baroque music from the 17th and 18th century, with Jean Baptiste Lulli, St Matthew's passion, St Yohannes' Passion, if possible, played on instruments of the era, using the 432 Hz tuning of A. I also like particularly the classical organ repertoire. +

Charles Hansen, Ayre Acoustics

Hi-Fi+: How did you become interested in digital audio design?

Charles Hansen: There were two driving forces. The first was when the LP was still “king of the world”, in the late 1980s. This was an era of superbly innovative designs on the playback side, with things like Bill Firebaugh’s zero-clearance turntable spindle bearing, John Bicht’s air-bearing tonearm, and a completely new level of performance from moving-coil phono cartridges using new advanced material technologies. Times were exciting, and great advances were being made.

I was interested in a no-compromise approach to the full analog record/replay chain and wanted to understand the full possibilities of creating an incredible musical experience, which clearly analog can do. I began to explore, and was a bit taken aback to find fundamental limitations that had no practical solutions that I could see.

As examples of these limitations, the cutterheads used to make an LP acetate have huge resonances in the top octave that are controlled (but not cured) by applying massive amounts of feedback from an incredibly powerful amplifier (hundreds of watts). The basic geometry of the playback stylus motion is not well defined due to the practical limitations of the elastomer

(e.g., rubber) ‘bearing’ that allow the cantilever to move in unwanted ways. These are just two examples, and there are many more, both in LP and magnetic tape.

The second was the realization that early digital audio was not well developed at all. Everybody familiar with high performance analog could easily hear that digital had real problems. The general thinking then was that the CD standard simply set both the sampling rate and bit depth too low. When the DVD spec was finalized in late 1996, Pioneer was pivotal in having 96/24 capability included. That was really the trigger point for me. It seemed that if some of the fundamental limitations of analog could be bypassed, a truly high level of performance could be achieved.

Everybody loves the convenience that digital provides, along with the capability to have perfect copies of a digital master recording. It was obvious that digital would become the dominant method of music playback. Yet digital audio at that time simply didn’t nourish the soul.

That is how I became interested in digital audio design. Was it possible to equal, or even surpass, the best analog reproduction with digital technology? I love challenges and this was a good one.



When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

A real problem is that there are almost no measurable parameters that correlate with perceived sound quality, or even more importantly, on how well the musical experience is communicated to us. This is true for both digital and analog technologies. Given that, I would say that time-related performance is the most critical aspect of sound reproduction in general, and digital is no exception. There is far more to this than just using high sampling rates or a certain digital filter. And there is the issue of feedback and how it is used — preferably not at all.

When I look back at everything I've done, from loudspeakers to analog and digital electronics, I think that there is an underlying thread related to time — both timing issues and the time domain in general. The ear/brain is far more sensitive to time-related information than any other parameter.

Transducer diaphragms (both microphones and loudspeakers) have significant energy storage problems. They 'break up' and release energy in a way that smears the time information, just as a cymbal smears the energy impulse of the stick impact, or a guitar smears the energy impulse of the pick attack. Most loudspeakers claim to be 'reproducers', but in actuality are actually 'producers' (much as musical instruments are) to one degree or another, even most current designs.

In analog circuitry, feedback loops take the time-delayed signal from the output and send it back to the input in an attempt to correct an error that has already occurred. This creates a form of time distortion that cannot currently be measured, yet is clearly audible. The math (and test equipment) tells us that the correction happens quickly enough, but our ears tell us something quite different.

There have been many amplifiers made with adjustable levels of feedback, and changing it changes the sound in obvious ways. Which is correct? I've found the answer to be simple. If feedback is good, use as much as possible — if it's not good, then don't use any. The products that have used very high levels of feedback (yielding incredible measurements) have not stood the test of time and are no longer made. In contrast, more and more designers are copying Ayre's zero-feedback approach. We've never done anything else and we have over two decades of experience in this area.

In digital systems we have the twin errors of insufficient time resolution from a low sampling rate, combined with the energy smear created by the filters required to meet sampling theory requirements. (Analog and digital filters are no different in this regard — there are no free lunches.)

[Right: The new Codex DAC/preamp/headphone amp makes Ayre performance available at a very accessible price](#)



The fact that the filter-less ‘non-oversampling’ D/A converters (which don’t even try to comply with sampling theory) can sound musical provides irrefutable evidence that our understanding of what is truly important to the human ear/brain is currently incomplete.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

My background is in physics, where things are looked at from the level of fundamental principles. This provides a different perspective than a conventional education in engineering.

The difficulty with engineering education is that its vision can be limiting. An engineer experienced in analog design finds many digital concepts to be non-intuitive, abstract, and impenetrable. It took many years for the traditional high-performance analog audio companies to even dip their toes in the complex waters of digital. Many of their early products showed promise, but did not fulfill the potential of digital.

Digital engineers, who tend to approach things from the abstraction that digital theory provides, design nearly all digital audio products. Yet if digital audio actually worked according to theory, then the game would have ended with the introduction of the CD in 1982 – ‘perfect sound forever’. In the real world there are no such things as ones and zeroes traveling down wires. Instead there are electrical fields in the



conductors that create analog voltage levels, which are interpreted as ones and zeroes at imperfectly defined times.

Suddenly there is a lot of room for mischief. All of the limitations of digital audio are actually analog limitations. There are no infinitely steep waveform edges. There is no clock signal that is perfectly uniform, either in time or amplitude. There are no perfect converters between the two domains, yet all audio signals both start and end in the analog domain. The list goes on and on.

In addition all digital audio products have analog audio circuitry as well. Few digital engineers are aware of the subtleties hiding in analog design, where things like the bias level of each stage in the circuit makes a

sonic difference. Many just resort to using pre-packaged IC op-amps, as they have little (or limited) understanding of analog design. Ayre’s digital audio products are rooted in a deep understanding of both domains. Only by knowing the limitations and their causes can we find ways to surmount them.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

Ayre’s first digital product was the D-1 DVD/CD player from 1999. It was one of the very first high-resolution digital players, yet it is still a great sounding piece even today. The D-1 had a slew of radical innovations, and was the first high-performance one-box player during a time when everything else

Above: Ayre created the digital and analogue electronics for Neil Young’s famous PonoPlayer

on the market used separate transport and D/A converter boxes. It remains something of a classic.

Our QB-9 was the world’s first solid-state asynchronous USB DAC, which paved the way for the ongoing revolution in computer-based audio. It was entirely redesigned for the current ‘DSD’ version and is still one of the best sounding DACs available at any price.

A personal favorite is the design Ayre did for Neil Young’s PonoPlayer. You’ve got a source that will store 500 CDs, play back

both high-resolution PCM files and DSD, drives any set of headphones wonderfully, yet fits in your pocket and only costs a few hundred dollars. Its ability to communicate the musical intent of the artist is unparalleled at that price, and I know many people who have replaced their multi-thousand dollar CD players with it because it sounds better. To top it off, Pono has probably sold more players in one year than Ayre has total products in over twenty. To reach that many people and change their relationship to recorded music is very gratifying.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

Adding a feature with digital technology is easy. Translating that into the analog world in a way that grabs our emotions is a much more elusive goal.

There's an old saying, "Performance, features, price — pick any two." That's obviously what separates high-performance audio from the mainstream products. Yet with digital audio it becomes both easy and cheap to add features. People go down their checklist of desired features to make sure all of the boxes are ticked.

There are so many features today that many people tend to think of performance as just another feature. A feature is a quantifiable thing. A product either has remote control or it doesn't. Performance is something else altogether.

Many people try to reduce performance to something like a feature when they attach numbers to things. "What is the maximum sampling rate?", or "What is the signal-to-noise ratio?", or "How many picoseconds of jitter does it have?" None of these numbers will give the slightest clue as to how something actually sounds — or more importantly, how it will make you feel when you listen to music through it.

The true function of a music playback system is to deliver music on command. We play live music and go to concerts to hear our favorite artists live because that experience allows us to feel something deeply fundamental. Music is a uniquely human experience. The latest research shows that it even predates language — in fact it could even be said that music is what makes us human.

To be able to capture that experience and re-experience it on command by simply pressing a button is not merely a feature. It is actually something closer to a miracle. We are very lucky to live in such times.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

The only reason to support any format is for the content that is available. A new format could be developed that would out-perform anything available today, but if there is no music available it would be meaningless to support it.

It's easy to make a higher resolution format. We can have a fabulous musical experience from an analog LP. One can also purchase 45 rpm 12" vinyl that sounds even better. Does that mean we should then develop 100-rpm records? Where do we draw the line? There is a point of diminishing returns — just because you can do something doesn't mean you should.

I would rather have an incredible sounding CD player than an excellent sounding high-resolution player, simply because there is a vastly larger music library available on CD. Given the reality of where the content is means that it is far more important to deliver an exceptional experience from 44/16 than anything else. If one understands how to deliver a truly emotional experience from 44/16, it isn't that difficult to do it with higher resolution formats as well. "God is in the details, as well as the devil". Implementation is everything, and I would far rather listen to a lovingly made standard resolution recording than a carelessly made high resolution one.

DXD is simply high-resolution PCM, but it may well have gone past the point of diminishing returns. Much more importantly, how much content is available in that format?

DSD is a different story altogether. DSD recordings almost universally sound superb. It is also (as former Philips senior engineer Bruno Putzeys points out) "a phenomenally clumsy" format for recording. In my

experience, part of the excellent sound of DSD is the format itself and part comes from the fact that anyone willing to go to all the trouble to use it will make sure everything else is also done properly.

Ayre's approach is to understand exactly what it is about DSD that allows for its high level of performance. And it certainly isn't what we were told it was! It turns out that it is really in the time domain, which is no surprise when we understand our marvelous ear/brain hearing mechanism. Once the principles are understood the question becomes, "can this knowledge be applied to PCM?"

The answer is "yes" — perfectly so for high sampling rates, and much of it can be applied even to 44/16 as well. The result is the superb sound quality of DSD, while avoiding DSD's problems arising from out-of-band noise, plus the ability to use standard tools and techniques in the recording studio. When the widespread content of the CD is factored in, DSD can be seen to be much more valuable as a learning tool than a format per se. Of course there are now thousands of wonderful sounding albums available in DSD format, so it is important to support it and not limit the choice of music that can be played.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

My experience is there is generally an inverse correlation between convenience and performance. AudioQuest does a seminar demonstrating the sound quality of a DAC connected to the data source with Wi-Fi versus connecting with a standard cable. It's not hard to imagine that if a higher quality digital cable can affect the playback quality that going to wireless is a big step backwards in performance and that is exactly what the seminar attendees experience. Yet wireless is certainly convenient...

All of this is still in its infancy. It's taken decades to achieve high quality sound from digital audio. Computer-based systems still have quite a way to go. Why do various bit-perfect file formats sound different? Why do different USB cables create a different musical presentation if one is using an internally clocked asynchronous DAC with galvanic isolation from the computer? These are just a few questions and there's still a lot more to learn.

The fact that there are three or four different ways to store and deliver digital files is proof that none of them are perfect. They all exist because they offer different trade-offs, often in performance versus convenience. And as with all new technologies, things will have changed significantly in five years

and yet again five years after that. I have no doubt that in the near future there will be new ways to deliver music that transcend today's limitations.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

Ayre has just introduced our Codex USB DAC + headphone amp + preamp. The real breakthrough here is bringing an unexpected level of musical connection at a much lower price than before. The flip side of this means that we have also learned how to push the limits of what is possible when the cost is not so tightly constrained.

What do you think the high-performance digital audio marketplace will look like five years from now?

First of all, I don't have a crystal ball, no one does, but there are some trends that seem set to continue.

I was surprised to see how big an impact the PonoPlayer made. We managed to get a lot of Ayre performance from a small, low cost device. This trend is not going to stop — the Codex is an evolution from that. The continuation of increasing processing

Above: The QB-9 DAC is Ayre's digital audio performance leader

Right: Ayre's D-1xe DVD/CD player launched the firm's reputation for building stellar digital audio components



power and reducing storage costs that led to the emergence of digital audio players in the first place is certainly going to continue. If Moore's Law holds true then in 5 years time we will have four times the storage and computing power that we have now, for the same price. Gordon Moore said that "we are on the second half of the chessboard" — the gains are enormous.

Such quantitative changes enable qualitative change too. High res will no longer be an issue, to store, replay, or transport. Lower cost, high-performance systems will be possible and available. We need to work on loudspeaker design though, as improved DAC and amplifier performance needs better loudspeaker systems that match them. I can foresee small powerful systems that have great digital capabilities, don't take a lot of real estate, and embody the core design principles of Ayre that we have pioneered for the past 20 years plus.

Right now, high-resolution audio is an issue in the mainstream. That will become the new normal. Much more important is that people are finally becoming aware of what we've lost when an entire generation has grown up listening to nothing but compressed digital audio played through a cheap portable player. Ayre is helping to restore that loss.

The job of the designer is to deliver convenience and performance, yet doing so at a reasonable price is the trick. That requires new ways of thinking and new solutions. With technology developments, the possibilities are limitless.

When you listen for personal enjoyment, what types of music do you most enjoy?

I love all genres of music. Further I don't limit myself to 'Western' music. I love music of other cultures as well, from Balinese gamelan to Bulgarian vocal music to traditional Chinese instruments to Nubian folk songs. It's all good.

I find I'm particularly attracted to music that has rhythmic complexities and subtleties. I studied African percussion music for a few years, and when you only have percussion, timing is everything — literally! Once I understood what was underneath, I could recognize that it was everywhere in all of my favorite music.

The Beatles were famous for changing time signatures in a song. Listen to 'Strawberry Fields Forever' closely. Not only does the time change, but also everywhere time is warped and twisted in completely unexpected ways — from syncopations in the rhythms to the distinctive drum-work to the orchestral overdubs that cut across the beat. Or any of Beethoven's works — there's always an underlying insistent driving rhythmic force, yet it comes and goes. In Symphony No. 7, he literally pulls the rug out from beneath us in the first movement by stopping the music in what seems to be the middle of a phrase — twice!

Listen to any Hendrix guitar solo and he fluidly and effortlessly moves in a way that is almost free from any rhythmic constraints, and at the same time is incredibly precise.

Or enjoy Shawn Colvin's songwriting. She's the only folk artist I know who's written several songs using 'the Bo Diddley beat' (actually an ancient African rhythm), as she did with 'Polaroids'.

Hamza El Din preserved the unique rhythms of Nubian culture that were nearly destroyed when the High Aswan Dam flooded most of their homelands and dispersed their people. In 'Ollin Arageed' he presents us with the complex tapestry of three interwoven tar (frame drum) beats, overlaid with a clapped rhythm of astounding intricacy.

Before I had children I played in a local Balinese orchestra, Tunas Mekar, a gamelan angklung. Our instruments only had four notes, so melody and harmony are clearly limited. That shifts the focus shifts to the other two fundamental elements of music: dynamics and timing. To play the rapid melodies, alternating notes are played by different players on different instruments, creating an interlocking whole.

I've found that our conscious mind can only focus on one thing at a time. Expanding your awareness to encompass two things simultaneously shuts off the nagging voice in our heads that is always talking to itself. When you silence that voice, there is an infinite number of things that can be heard.

One thing that is clear to me is the power and importance of music. It always has been clear to me, and why I do what I do. Music is elemental and primordial, healing and inspiring in equally measures. It is

how human communication started. Music is sublime and the closer we can get to reproducing how we actually communicate through music, the better we know and understand each other. These are exciting times; we are on the threshold of something wonderful, of that I am sure. Just to be a part of it is a privilege. When I see the look on people's faces when they hear an album through something as small as the PonoPlayer or as refined as our Ayre systems I know in my heart that we are on the right track. That is the reward for all of the effort. It is truly worth it. +

Paul McGowan, PS Audio

Hi-Fi+: How did you become interested in digital audio design?

Paul McGowan: My first introduction to digital audio was in late 1982, when the first CD players from Sony and Philips/Magnavox were produced. They sounded dreadful, but I was intrigued with the concept and hungry to learn more. The first thing we did was replace the output stage of a Magnavox CD player with one of our own design, and this significantly improved sound quality. That was when I first knew we could work with this medium, and my interest was piqued.

The next step in our digital journey was discovering the digital output connector on the back of the Magnavox CD player. At the time we hadn't any idea what its purpose was, and one of my engineers reverse-engineered to S/PDIF output. We built our own receiver and, in 1983, showed a prototype at CES of what would become the world's first high end DAC. We unintentionally created an entire equipment category, one that today is the means by which most music is listened to by audiophiles.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

The output stage and power supply.

The vast majority of high-end DACs utilize off-the-shelf ICs available to every designer. Most companies in our field use the same DAC chips, yet their products sound very different indeed. The biggest differences in sound quality are found in implementation of the voltage to current converter and in the output stage of IC DACs. In PS Audio's case we developed our own discrete current converters, where most companies use op-amps instead. Choice of a discrete op-amp for current to voltage conversion is effective, though the high open loop gain of an inverting I/V converter can lead to harsh and bright sound. Our approach uses discrete means with low open loop gain and zero induced artefacts.

Next in importance is the output stage itself. There are many, many means of designing output stages, including IC op-amps, discrete circuits, tubes, and even transformers. Each must be carefully chosen to perfectly match the sonic characteristics of the preceding DAC circuit. Our DirectStream DAC (based not on an off-the-shelf IC DAC, but a custom FPGA), has one of the simplest output stages



ever made, and it sounds better than any DAC I have ever heard. So, complex isn't always better and simple, properly executed designs can often sound the best.

Last, power supplies have a major impact on sound quality in DACs. The reasons are many, but chief among them is lowered jitter affecting subsystems within the DAC chain. Every time a digital audio circuit switches from a 1 to a 0, there is a change in power supply current that can be reflected throughout the entire chain. Multiply that by billions of bits per second with simultaneous processes occurring and you have a lot of power supply noise that affects everything in the circuit. PS Audio focuses on extremely low impedance, high-speed regulation and star wiring to lower noise, as well as large power supply transformers lowering impedances for the best sound.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

Every step of the design process is evaluated by ear, and design choices are made based on the results of the listening tests. Certainly, a great deal of time and engineering resources are invested in measurement and in design practices learned over decades, but in the end, decisions are based on how they sound. No PS Audio product has ever been produced that

did not follow this lengthy process of design, listen, and design again until it outperforms our expectations. There are others who follow these guidelines as well, and we tip our hat to them for honoring the music first.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

The DirectStream DAC is by far our greatest digital achievement in the last decade, though classic products like the Ultra Analog

series would not be far behind. DirectStream is the creation of designer Ted Smith who spent more than seven years of his life designing, listening, coding, listening, and finally developing for sale what I consider the world's finest sounding DAC, at any price.

DirectStream's construction is unique, and so is the way in which it processes signals. DirectStream is built around an FPGA (Field Programmable Gate Array), rather than the usual DAC chip, and its processing method is as innovative an approach as there has ever

been. Digital data of all kinds are upsampled and converted to DSD, then output at double rate DSD into a simple output stage consisting of a high quality audio output transformer coupled to high speed current buffers. The sound is simply stunning.

The advantages of designing digital products around rewriteable silicon as found in an FPGA include programmability, customization and the ability to update units in the field. To date we have upgraded DirectStream DACs three times by means of freely-given



Right: PS Audio's DirectStream DAC offers an innovative decoding topology and is firmware upgradable for superior sound

downloadable codes. Those upgrades have remapped the DAC's operation for the best sound attainable, and have measurably reduced noise and distortion. That's quite an accomplishment! We're thrilled to be able to offer a product that is obsolescence-proof, and will continue to provide state of the art performance for years to come.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

Bits may be bits most of the time, but the transitions from A-to-D and back to D-to-A ain't easy, and are poorly understood. And control of noise is even more critical in the digital domain than in analog, believe it or not.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

Our DACs and A/D processor support both high-resolution PCM and DSD. High-resolution audio has a number of advantages in sound quality: relaxed filter requirements, lower noise, finer inner detail, and dynamics. However, DACs such as our DirectStream have also advanced the performance levels of good old CDs to the point where differences are increasingly harder to hear. Well recorded CDs can, when played through the right equipment, come close to the performance of both high-resolution PCM and DSD.

In our opinion DSD continues to sound more like the sound of live unamplified music than PCM and it's easy to see why. DSD streams are close to analog in nature and require minimal filtering to convert to analog.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

Relative to optical discs we find the sound of streamed full resolution PCM and DSD generally superior, but much depends on the interface. USB vs. Ethernet with a PS Audio Bridge sound very different. And using a USB regenerator sounds different too. Like cables, digital audio responds to many of the same things analog audio does: careful setup, proper interface cables, power supply improvements, and isolation.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

We just introduced our NuWave DSD DAC, which will outperform DACs at twice its price of \$1299.

Right: PS Audio's Sprout integrated amp/DAC makes an ideal platform for starter systems

We're working on a number of novel approaches to storage and distribution of digital music files, as well as some cost-no-object products which...

well, you'll have to wait and see!

What do you think the high-performance digital audio marketplace will look like five years from now?

We're pretty sure we know how to make great sound. We think the biggest developments in digital audio will be in making it easy to use—for everyone.

When you listen for personal enjoyment, what types of music do you most enjoy?

Classical, mostly opera, mixed in with some jazz. If it's strictly personal without family involved, it's nearly always opera. If more than a few people come to the house to listen, we switch to jazz, which is more widely accepted.

If I am demonstrating the system to people I will play a combination of classical, pop, folk, and a smidge of opera depending on the tolerance levels of those participating. I do try and judge my audience. +



Mike Moffat, Schiit Audio

Hi-Fi+: How did you become interested in digital audio design?

Mike Moffat: I listened to early examples of digital audio reproduction hardware in the early 1980's and was appalled at their horrible sound, particularly in the context of analog reproduction hardware of the period. It started me on the path that became Theta Digital Corporation some 5-6 years later.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

Lack of aberrations not just in the frequency domain and in common distortion measurements, but also in the time domain and in terms of jitter control.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

Experience - I have been doing this for 42 years. I have designed more D/A converters for myself and other companies of all technical descriptions than anyone else.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

First, at the dawn of the digital audio era, I introduced the concept of the D/A converter as a standalone audio component

Second, I pioneered the “mega-combo burrito” DSP-driven digital filter used in the original Theta converters of the late 1980's and that is still offered in the current Schiit Audio Yggdrasil and Gungnir Multibit converters today. This is the only filter to optimize not just for the frequency domain, but also for the time domain as well. It also maintains all of the original samples. Uniquely, it is the reason that Schiit Audio converters (and old Theta Digital gear to a lesser extent) deliver the stunning spatial rendering they do.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

The complete record-playback chain is primarily based on solid hard science.

It is inescapable that some artistry – particularly on the record side, for example, microphone placement – is also involved. This makes audio more complex than that which can be solved on sound science forums. Congruently, it also dictates caution when arguing the merits of technologies such as mounting cones, speaker wire suspenders, magic solutions to be used, etc.

Right: Jason Stoddard-left & Mike Moffat-right of Schiit Audio



What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

Any and all digital audio releases are typically in PCM. There is no way a PCM release can be made 'automagically' better by re-encoding it in some reputedly superior format, be it DSD or whatever. The distortions still add in a square root of the sum of the squares manner. A far more obvious question arises: Unless you either A) really want to hear the 'Exstacy of the Orkney Island Shepherds' or whatever other unique DSD recordings there may be, or B) you have so much money that you want to rebuy your entire music collection all over again re-encoded, why bother?

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

People are creatures of convenience. That is exactly why so many of the current D/A converters are delta sigma types (they are far easier to design). The majority of consumers will go for whatever is the most convenient. Having more bits is usually a good thing

Right: Foregoing delta sigma approaches, Schiit Audio's flagship Yggdrasil DAC uses a so-called 'multibit architecture' for spectacular sound quality



when it comes to streamers/servers; however, remasters in higher def formats may or may not be improvements. Check each one out and may the buyer beware. Users of Schiit upgradable gear are usually just fine with Redbook.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

We will continue to bring multibit technology into the lowest levels of Schiit upgradable gear, since it is so objectively superior to delta sigma.

What do you think the high-performance digital audio marketplace will look like five years from now?

Just like it was 40 years ago: PCM without silly buzzword compliant “new” technologies”. The more things change, the more they stay the same.

When you listen for personal enjoyment, what types of music do you most enjoy?

Any reproduced music originally created by musicians singing or playing instruments; nothing created as rhythmic noise on a computer, and nothing that lacks chord changes. +

Right: Schiit's new Gungnir Multibit makes Yggdrasil's multibit architecture at a more accessible price point



David Steven, dCS

Hi-Fi+: How did you become interested in digital audio design?

David Steven: My Father spent his career in the audio industry and after a number of years working in software development and product management I joined dCS in 2009. It's such an exciting company as we develop our own proprietary hardware and software that is truly state of the art. I see my role at dCS being more focused on developing the product vision and managing/enabling the development process so we continue to innovate and improve our technologies. The real clever digital audio design goes on in our R&D department.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

That's easy! Linearity first, as poor linearity results in a loss of fine detail and a system that is not musical. This is actually very difficult for standard measurement equipment to measure at very low levels, for example -120dB_0 and below. Secondly, jitter rejection, as any variations in a DAC's timing accuracy results in distortion of the output signal – i.e., the music. This is bad! Next it would be filter performance. Unfortunately, there is no “perfect” filter that will be optimum for all recordings but in essence the DAC filter you use affects amplitude response, phase response



(transient performance) and image rejection. All of this is less of a problem at higher sample rates, which is why we lead the market in that direction. Finally, it would be the analogue output performance and specifically you are looking to achieve a low noise floor, low harmonics, but also ensuring that higher order harmonics are not present.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

It's easy to be good but there are very few truly great companies. Just like Rolls Royce and Patek Philippe, great companies—no matter what the industry—offer discerning customers a combination of technological excellence, unparalleled quality, and timeless products. In the world of music recording and digital playback we believe dCS is that company. We are innovators, constantly improving the state of the art in digital, manufacturing and testing to astonishingly high standards, and as a result our products are timeless in their performance and design.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

We have been at the forefront of digital audio for over 25 years and pioneered many breakthrough technologies in digital audio. That is down to the flexibility of our hardware and software but also our ability to anticipate the future. I'm not sure where to begin here but when you look at the revolutionary path our company took in the

recording world you can then start to see the effect these innovations had on the industry as a whole. For example, here is a list of some of our industry 'firsts':

- dCS 900 and 950 - World's first 24-bit Analogue to Digital Converter and Digital to Analogue Converter.
- dCS 904 and 954 - World's first 24/192 capable Analogue to Digital Converter and Digital to Analogue Converter.

- dCS 972 - World's first high res Digital to Digital Converter – enabling the 'Upsampling' effect to be discovered. In the audiophile world you only have to look at the pages of *Hi-Fi+* to see that every digital component now embraces the very technologies we brought to the market. Our finest moment to date was probably the launch of Vivaldi as it was a culmination of our years of technological achievements and sounds absolutely wonderful.

Above: dCS' newest digital audio products comprise two Rossini-series models: a Player (shown here) and a DAC



What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

Measurements are often quoted, but misunderstood or misused. For example, some people work out a DAC's resolution from the audio-band noise specification as perhaps 19 bits. That's not how it works; if the DAC can genuinely reproduce signals down to the 24-bit level, then that is the effective resolution. The importance and usage of a top-rate Master Clock is another area of confusion. The system must be designed with the Clock as an integral part, so that all the sources can lock to it in some way.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

We try to avoid getting dragged into the arms race of chasing ever higher sample rates! We all know high res material sounds fantastic and our products support both DSD and DXD, but often it's the recording itself that determines how enjoyable our listening experience is.

A well-recorded CD can give excellent results on a top-quality system, but the fine detail and presentation will always be limited by the level of detail in the data.

Native DXD offers incredible crystalline clarity, revealing amazing depths of detail, but also laying bare flaws in the recording and mastering process. In comparison, native DSD has a more rounded and often more musical presentation, unveiling nuances you want to hear while concealing flaws that might detract from the pleasure.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

At heart we are a converter company so we have always tried to remain agnostic to how we receive the data. In the early days it was purely silver disc and then we saw a move to computer audio where audio was received via USB. Now we have embraced network streaming from NAS devices and are moving towards Apple Airplay, subscription streaming services and the like. Our challenge as a manufacturer is to make sure that no matter how we receive the 1's and 0's we deliver fantastic sound. In theory, streaming high res audio over a home network should have less jitter and many performance benefits over silver disc, for example, but we all know that there are many variables in a playback system that affect the sound quality so it is impossible to guarantee superior performance 100% of the time.

Right: dCS Rossini DAC



If you are at liberty to say, what will be the next digital audio products from your company, and when?

We have invested a huge amount of resource in our hardware and software. The last few years we have really tried to improve our user interface, network streaming capability and supporting the emerging methods of streaming audio such as Apple Airplay and subscription services. All of this work has been in parallel with our continued efforts to improve the performance of our unique technologies, the dCS Ring DAC and dCS Processing Platform.

I'm happy to say that we have just launched Rossini DAC and Player and these products will ship in September 2015. Rossini has been designed with the future in mind and will make superb sounding digital music from any source more easily accessible.

What do you think the high-performance digital audio marketplace will look like five years from now?

There is definitely an increasing momentum toward streaming and subscription based music services. Bandwidth and connectivity is no longer an issue for most music lovers so I think I speak for most of us when I say I really hope that in the next five years the major labels and streaming services start offering us high res (or even 24/44.1!) on demand. If we can stream 4k videos into our home then why can't we make high res music available on demand too?

When you listen for personal enjoyment, what types of music do you most enjoy?

I have a real eclectic taste in music (it goes with the territory!) and if listening at home I tend to listen to indie rock, pop, and electronic music. However, one of side benefits of this job is that I travel the world listening to and sharing wonderful music. As a result my collection includes all genres from blues to classical to jazz. +

Right: Many regard the dCS Vivaldi digital playback system as the 'gold standard' against which all others must be compared



Robert Stuart, Meridian and MQA

Hi-Fi+: How did you become interested in digital audio design?

Robert 'Bob' Stuart: My interest in audio engineering goes back before digital, having been into it long before the first digital chip existed! I have core skill in analogue design and psychoacoustics, but when digital audio was in its infancy it was the promise of repeatability, dependability, and a secure time-base (when compared to analogue storage and transmission) that motivated me. So my first work in digital audio was in 1980, pre-CD. When it was clear that CD was coming it was a perfect place to evolve my skills.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

A chain is as strong as its weakest link; there is no magic parameter. I think the key to a great product is continuous refinement in many directions and often with each step we see improvements manifest in different aspects of the sound. So, for example, in a DSP loudspeaker everything matters: mechanical, electrical, magnetic, EMC, integrity of signal-processing, driver design and mounting, crossover design, analogue and digital electronics, jitter, box shape ... the list is endless.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

I think my designs reflect a single-minded, uncompromising quest to make the sound better. Plus, only listening is the arbiter (after objective measurements are confirmed), to check against the gold-standard of live natural sound.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

I'm a designer and as a breed we tend to like our latest thing! It's hard to pick two but if you force me I'd answer in this way: for Meridian, the DSP7200 and the 800 Series; for a wider view, MLP and MQA. All of them express my sound-quality ideals.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

First, for consumers it's Numbers—all my research since 1981 has made it clear that sample rate, bit depth and data-rate numbers, while significant, are very poor predictors of sound quality. Second, for those in the recording chain, to remember that proper use of dither should never be optional! Third, for journalists—please don't try to design listening tests to prove MP3 is fine!



What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

This is a complex question. Higher sample rates permit finer temporal resolution, which is important and can be understood from a neuroscientific basis. Higher sample rates also ameliorate embedded defects in the filters commonly used in A/D and D/A converters, but the process is inefficient. PCM and DXD can be linearised and processed; DSD is, in my opinion, a backwater and unsuitable for archives. Meridian products have supported higher-than-CD sample rate and bit-depth since around 1993.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

In general, the PC is a tricky place to handle audio. I prefer dedicated machinery where there is certainty of the signal path. However, the critical item is the renderer where digital is converted to analogue; ideally it lives in a dedicated box where interfering electrical noise and jitter can be minimised.

Right: Through continuing updates, Meridian's 808 Reference CD player has stayed at the forefront of digital audio performance





If you are at liberty to say, what will be the next digital audio products from your company, and when?

Meridian doesn't pre-announce new products. We do anticipate seeing a lot of MQA activity by the time we get to CES.

What do you think the high-performance digital audio marketplace will look like five years from now?

I would hope that our efforts to improve the content delivery chain, by enabling high-quality releases in MQA, will be making a difference. If we are lucky, we can also teach the concepts on which MQA is based and reduce the current 'anarchy of resolutions'. There is only one sound in the studio, so why have such a diversity of deliverables?

Above: Recognising the potential of digital audio early on, Meridian was one of the first to offer a truly high performance CD player such as the very early MCD Pro CD Player shown here

Right: Meridian not only offers digital source components, but digital loudspeakers such as the DSP7200 shown here

When you listen for personal enjoyment, what types of music do you most enjoy?
'Classical'. When alone I will reach for Chamber music, Choral or Song, anywhere from the Renaissance up to the 21st century. +



Gilad Tiefenbrun, Linn

Hi-Fi+: How did you become interested in digital audio design?

Gilad Tiefenbrun: I was an engineer before I came to Linn so when I joined I was presented with the opportunity to use the latest digital techniques to improve audio performance, which was really exciting and alluring.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

Linn's overall design ethos is to extend the digital signal path as far as possible, removing sources of analogue noise and distortion along the way. Keeping the signal digital all the way to the loudspeaker, as we do in Exakt, allows us to achieve performance levels that would be impossible in a traditional analogue system. But of course we can't escape the analogue domain completely – at some point we have to convert our digital signal back into an analogue one. The quality of this conversion is critical to the quality of the overall system, so we focus heavily on parameters such as clock jitter, power supply noise, and circuit layout to ensure that the signal we hear is as close to the original source as possible.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

The design team at Linn possess a unique combination of skills not normally found in a hi-fi company. Having expertise in all areas of software, electronics, mechanics, and acoustics allows us to think differently and design products that are not bound by normal hi-fi conventions.

In the fast moving world of digital audio it is also important to create products that are adaptable and upgradeable. A Klimax DS bought in 2007 can still be updated to run our latest Space Optimisation algorithms, giving the product a whole new lease of life for no additional cost – how cool is that?

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

The original Klimax DS would definitely be up there. It was our first network music player, and probably the first digital product where we were in complete control of the entire signal path from source file to analogue output.

The Klimax Exakt system was also a high point as it finally achieved our long term goal to push the digital path all the way to the loudspeaker. Exakt is actually far more than



a digital transport; it contains powerful DSP algorithms that correct for deficiencies in the loudspeaker and optimise performance for the listening environment. The algorithms had been in development for a number of years, but as is often the case, it took the right combination of minds and disciplines to realise its full potential.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

Digital works best when it does things that can't be done in the analogue world, so I think we should concentrate on the big differences that digital can make: correcting loudspeaker phase and compensating for room acoustics, and spend less time arguing about the relative merits of a \$10k Ethernet cable.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

All three formats have merit as 'packaging' for high res audio, but it is debatable whether we need more than one. DXD is really just PCM at a very high sample rate and offers no benefit in terms of capturing audio bandwidth signals. DSD is a 1-bit format that claims to be the direct output of the ADC used to make the recording, but very rarely is. Our products support PCM, up to 192kHz/24-bit, as this is by far the most common format for studio master recordings. In reality, one can convert between these formats off-line using processes that are essentially lossless in the

Right: Linn Akurate Exakt system

Below: Linn Klimax DS



audio band, so our customers can still enjoy the music in a DSD or DXD file even though we don't explicitly support them.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

Network streaming is by far the best way to play back your digital music, especially when you use a dedicated network music player such as a Linn DS player. In a network streaming system, the player is in complete control of playback quality and all other network influences such as packet jitter and data errors are eliminated by design. The inherent isolation of wired Ethernet and the absence of any noisy disk drives mean that the internal environment of a Linn DS player is ideally suited to high quality audio reproduction.

By contrast, many PC based systems rely on complicated operating system settings in order to guarantee bit perfect operation, especially at studio master sample rates.

The internal environment of a PC is also far from optimal and even external USB DACs can be influenced by noise coupled through shared ground connections.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

Our latest products launched in early September 2015 – two brand new Linn Systems featuring Exakt and Space Optimisation+ technologies – also featured in this guide.

What do you think the high-performance digital audio marketplace will look like five years from now?

Lossless streaming services such as Tidal and Qobuz are gaining traction, and streaming resolutions will inevitably increase as internet bandwidth improves, so it looks like this will eventually become the way many of us consume our music. On the hardware side I think we will see many more network-enabled products as consumers become more comfortable with the technology and audio becomes part of the connected home.

When you listen for personal enjoyment, what types of music do you most enjoy?

The great advantage of owning a Linn System is that because music is reproduced to such a high standard, I can appreciate and enjoy all types of music. +

Right: Linn Klimax Exakt System



Xuanqian Wang, AURALiC

Hi-Fi+: How did you become interested in digital audio design?

Xuanqian Wang: Digital audio design is a domain that allows you to create something very unique — or highly “innovative products”. I like the challenge and that’s the reason we are mostly focusing on digital audio design.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

From the hardware side, the system’s jitter performance contributes most to the sound quality; from the software side, the digital filter algorithm is the key to best sound.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

Unique functionality, better software, and of course better sound quality at comparable prices.

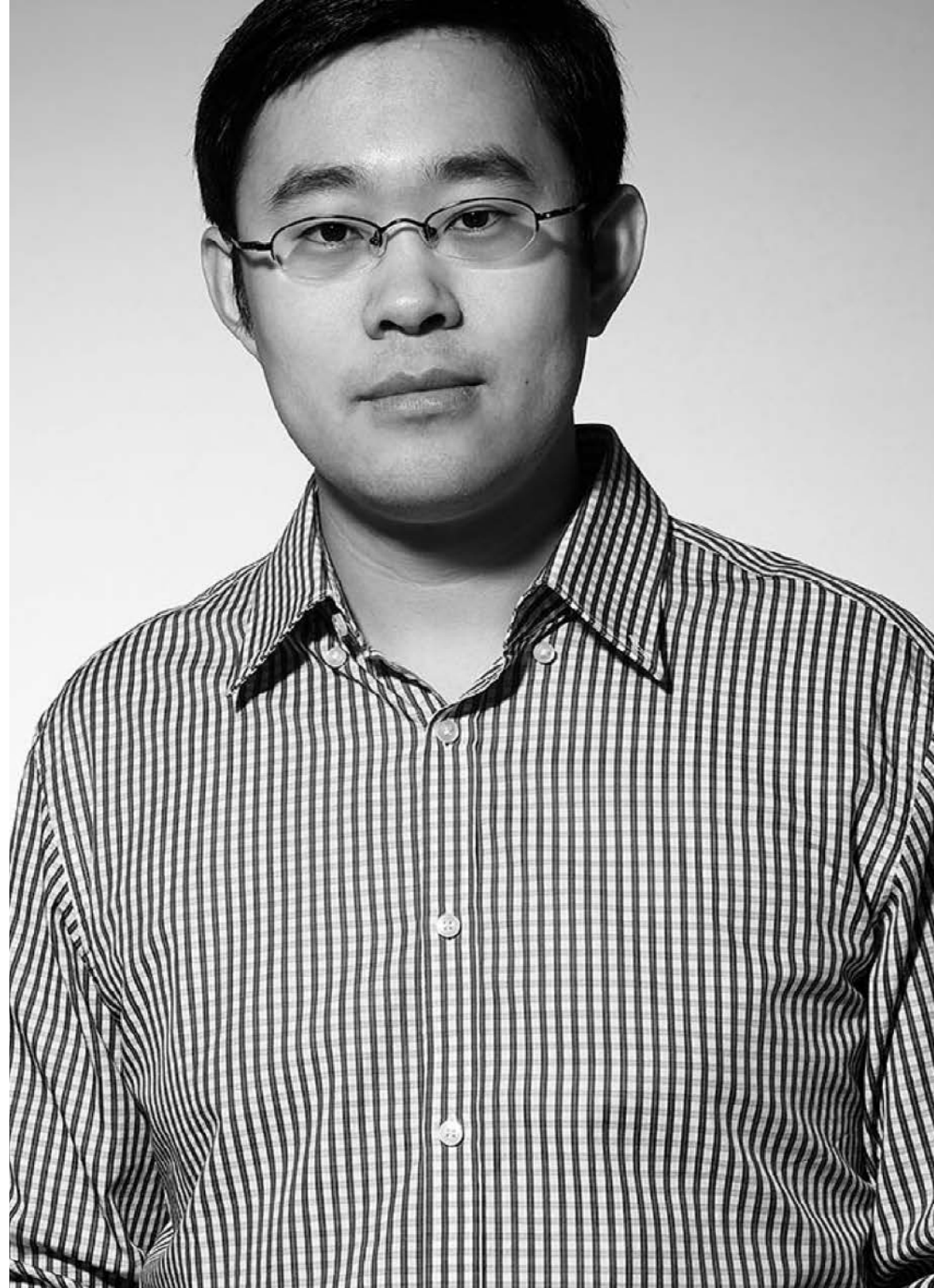
What do you consider your top one or two digital audio design achievements thus far? What makes those products special from your point of view?

The ARIES streaming bridge is no doubt the No. 1 as it has created several innovative new industries and began a new era for music lovers. The VEGA DAC has also become an industry standard and a very successful product.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

Digital audio is changing very fast. The digital audio component will soon become a software-driven product (rather than a “fixed” piece of hardware out of a box). Manufacturers can add new features, functionalities, and improve the sound quality by software updates and it will be almost transparent and extremely beneficial for customers. In the future, you will no longer be buying a “box” or static piece of hardware.

That is perhaps the most important “transition” that consumers have to understand about what is going on in the audio industry today. And I’m referring not only to “Audiophiles”, but anyone who loves to listen to music. It’s the latter group that will drive our industry’s growth. We want both segments of the market to benefit from our work.



What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

The benefit of higher sampling rates is to allow musicians and engineers to more easily create better digital music, but it also requires more data processing capability. As long as the CPU power is not a problem, we can always benefit from higher sampling rates.

AURALiC products support DXD and DSD256 formats, which are the highest resolution formats now available for commercial recordings.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

There is not a lot of difference between a streaming device and a dedicated music server; the only difference is where your music is stored. Both systems can sound very good. The PC-based server is, however, less ideal because the hardware is not designed and optimized for music playback. And, it is hard to maintain the same levels of sound quality on different PC's.

Right: AURALiC's ARIES wireless streaming bridge can turn virtually any DAC into a powerful streaming system



If you are at liberty to say, what will be the next digital audio products from your company, and when?

We will keep focusing on streaming audio, improving the software, adding expanded functionality, and trying to reduce the price of the product to let everyone be able to afford it and benefit from the technology.

What is vital is to make it as easy as possible for everyone to operate—one shouldn't have to be an engineer to set up and enjoy streaming music. It should be for everyone!

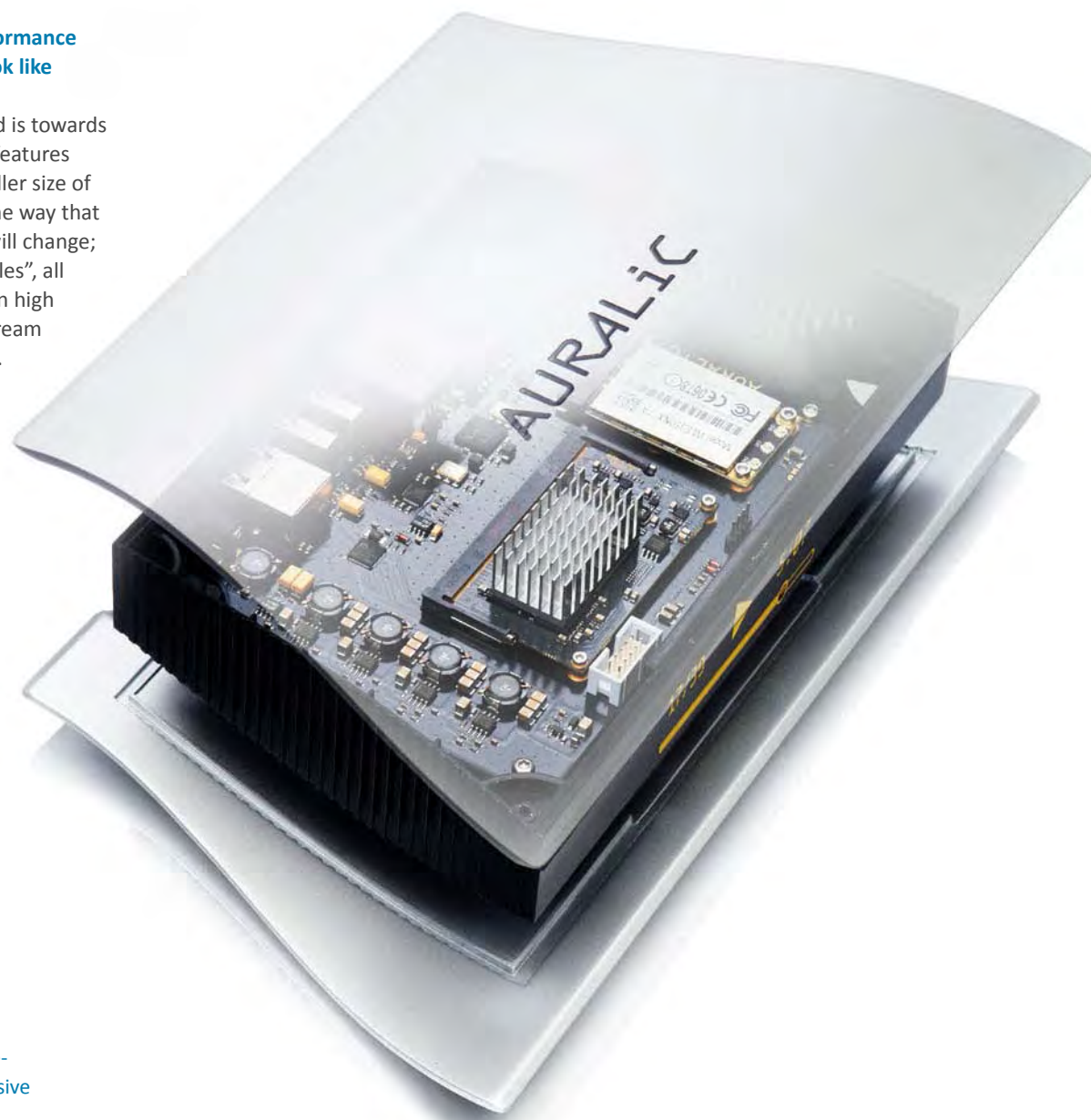


What do you think the high-performance digital audio marketplace will look like five years from now?

From the hardware side, the trend is towards higher integration: to have more features and better sound quality in a smaller size of device. From the software side, the way that people keep and listen to music will change; we will no longer need to keep “files”, all music will be stored in the cloud in high resolution format and ready to stream anytime to many types of devices.

When you listen for personal enjoyment, what types of music do you most enjoy?

Classical music, particular the works of period from J. S. Bach to about Debussy. +



Left: AURALiC ARIES' motherboard

Right: AURALiC's deceptively simple-looking ARIES is chockfull of impressive technical features

Robert Watts, Chord Electronics

Hi-Fi+: How did you become interested in digital audio design?

Robert 'Rob' Watts: Well, I have been an audiophile since a teenager, which was a long time ago – well before digital audio. Then in the early 1980's, digital recordings started to be available on vinyl. I heard some of them, and was initially impressed by the transparency; but then noticed that it lacked musicality – that it was not emotionally involving as analogue master tape. At that time I was studying electronics at university, and sampling theory was part of the course, and I realised that a substantial problem with digital audio was the reconstruction interpolation filter – the FIR filter. I had also studied the physiology of hearing, and knew that timing accuracy was essential for the perception of music. Looking at the sampling theory I knew that time domain (or timing accuracy) performance with digital would need very long tap length filters, and this was impossible with the technology one had in the 1980's.

Indeed, if you use an ideal sinc function impulse response, you will perfectly reconstruct the original bandwidth limited signal – this is what sampling theory proves. Looking at a sinc function, if you were to do this to 16 bits accuracy, you would need 1-million tap FIR filter (taps are part of the FIR filter and more taps mean more processing and more memory, which gives

a handle on how complex the FIR filter is) – something quite impossible. So this seemed a big barrier to digital audio. An additional problem with early digital audio was that they relied on R2R DAC's and because it is impossible to match the resistors, there was a problem with substantial distortion with small signals. Now this problem is the opposite of good analogue systems where distortion increases with larger signals; but with digital distortion increases with small signals. This is the opposite of the ear's performance, where the brain is rather good at accommodating the ear's natural distortion characteristic.

Then CD started, and I abhorred the sound quality of early CD – hard, aggressive, very unmusical sound quality. I put this down to the two problems I have talked about – poor timing accuracy, and poor small signal distortion.

But then in late 1988 I heard the Phillips bitstream DAC, the SAA7320. This was PDM, and is the same technically as DSD 256. This experience surprised me: CD that sounded relatively smooth and musical. So at that point I wanted to develop DAC's and went on to design the Deltec PDM 1. In developing this DAC, I managed to reduce the major digital problem of increasing distortion for small signals by using the PDM chips from Phillips. Since PDM is single bit, it can



be made to have an analogue distortion characteristic in that distortion increases with signal level. But studying the theory of PDM led me to a worrying thought: how can you accurately reproduce small, high frequency signals with only 256 pulses to encode a 22uS sample? Intuitively, it seemed way too small a number.

So I started experimenting with using multiple noise shapers (a noise shaper creates the PDM or DSD 256 bit stream) fed with different randomised data, so adding the outputs together gave more resolution as each noise shaper would have a different sequence. This strategy did indeed give better sound quality, and was in the PDM 1024 DAC.

But I knew that having multiple noise shapers was not solving the problem, just reducing it by a bit; but the fact that it made substantial differences indicated that there was indeed a major problem with resolution of PDM or DSD.

The PDM 1024 used an FPGA (these are blank digital chips upon which you can design your own digital logic) – it was one of the first devices available – to create the randomised data. But FPGA's started to get more advanced, and by 1994 I was capable of doing a noise shaper entirely on an FPGA. So, I acquired FPGA design skills and the tools to design FPGA's and this set me off onto the digital design path, where I was no longer limited by using silicon that is designed for the mass market, but could concentrate only



on high end performance. At this point my Pulse Array DAC was developed. This enabled very high speed noise shaping at 2048 FS, and ran at 5 bits output, so it had much better resolution than 256 DSD/PDM. The approach had other benefits; much lower jitter sensitivity, zero measurable noise floor modulation, and lower out of band noise, which enabled simpler output stages.

With Pulse Array I felt that I had solved one of the major problems of digital – the low level distortion and resolution problem – but that still left the timing problem from sampling theory.

By 1999 FPGA's were capable enough to do FIR filtering as well – so I could look at the timing problem and this led to the development of the WTA filter. This was

initially a 1024 tap filter, and gave substantial improvements in sound quality over the very limited tap FIR filter available then (and still today). So it proved that the timing problems from limited tap length FIR filters did have a severe sound quality consequence. The first product to use this filter was the Chord DAC 64.

Above: Chord Electronics' DAVE DAC (for Digital Audio Veritas Extremis) is by far the highest performance DAC the firm has ever offered

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

The interesting thing about audio is that the ear/brain is an incredibly complex and sophisticated system – we can separate individual sounds out into discrete entities with an illusion of 3D space to an amazing degree of accuracy. And one takes it completely for granted. Science has no idea how the brain manages to create the illusion of sound in 3D space, and that means as engineers we can't take simple models of the ear's performance as the basis to make engineering decisions. For example, if an error is below the threshold of hearing, it's assumed as irrelevant and good enough. But I have been able to perceive errors much smaller than the threshold of hearing, as these errors interfere with brain's processing of the data from the ears – and science has no understanding how the brain processes work.

You can make no assumptions about distortions or errors, which means that all parts of a digital design need thorough listening tests. I have heard unbelievably small errors making an easy to perceive difference, which unfortunately means that there are lots of ways to upset the sound quality. So we are really talking about a very complex mix of different things that can have a very substantial difference to sound quality.

Part of my job is traveling the world at different hi-fi shows, and I get to hear lots of high-end systems. How do these systems



rate against the sound of real unamplified instruments? In my view there are three major limitations:

Perception of depth. I live in Carmarthenshire in the country. I often early in the mornings open the window and just listen from my lab. Birds are tweeting – I shut my eyes and I can tell where a particular bird is to an alarming accuracy – birds 200 feet away

sound 200 feet away. Lambs baaing 300 feet away sound 300 feet away. A dog barking 2 miles away from the farm on the opposite side of valley sounds 2 miles away. But when you listen on high end Hi-Fi the perception of depth is severely limited – it often sounds “flat as a pancake”. So one of my tests is to use a well-recorded organ recorded in a cathedral, and I use this to assess the perception of depth.

Above: Although based on Chord's portable Hugo, the larger HugoTT (for Table-Top) ups the performance ante considerably

Timing. By this I mean the perception of the starting and stopping of a note. When one hears a live acoustic guitar, it is easy to perceive the starting of a note, when the guitar string is first plucked, it is easy to hear the initial starting transient. But hear it on a high-end system, the initial start is a blurred, out-of-focus smear.

Timbre and instrument power. Hear a live unamplified instrument – bright sounding instruments are bright (horns, say), rich sounding ones are smooth and dark (saxophones, say). But on a high end system, the timbre is compressed without a wide range of tonal colours. You can hear some systems sounding rich and smooth – where all instruments are smooth, even the bright ones – or bright systems where everything is hard and bright. The trick is being able to simultaneously portray a wide range of tonal colours.

Additionally, listen to live instruments. They can sound incredibly powerful (even if played at a low volume). On high-end systems the perception of an individual instrument having its own individual power is quashed. Indeed, most systems have a loudest instrument domination effect; your attention is constantly drawn to the loudest instrument, and quiet instruments are drowned out.

In simple terms we are talking about a system being capable of variation: if you can accurately place instruments in space it's better (more space variation); if it can allow

you to perceive the starting and stopping of individual instruments it's better (more timing variation); and if it can simultaneously portray timbre and instrument power it's better (more timbre variations). In short, I use the variation concept as a way of assessing whether a design is transparent or not, as nobody has heard a perfect device, so one has no idea what a truly transparent device would be like.

In simple terms, what do you feel sets your designs and products apart from most other ones on the market?

Looking at the three major problems – depth, timing, and timbre – I have unique solutions to all these problems.

On the perception of depth, this is a very complex subject, and something I am still attempting to fully understand. There are some very bizarre things about how the brain calculates depth and how vanishingly small errors can make a big difference. In the case of DAVE (DAC launched at Munich 2015), because I am using a very large FPGA, I kept on improving the noise shaper without regard to the size of the noise shaper. It was with depth that I had the most interesting experience, and I found

Right: Sporting a radical and highly-capable FPGA-based DAC, the portable Hugo headphone amp/preamp/DAC stunned listeners with performance that challenged many premium-priced, full-size components



significant problems. I kept on improving the noise shaper until I could no longer perceive depth improvements – and I ended up with a massive 17th order device with a unique structure. It has 48-bit resolving capability (it can resolve signals below -300dB), and I have found that this level of accuracy is needed to the correct perception of depth. In terms of resolving abilities this noise shaper is a trillion times more capable than traditional high end noise shapers.

On timing, the biggest influence is down to the FPGA tap length and the interpolation filter. I have created my own interpolation filter, the WTA algorithm, which has been optimised by many listening tests, and is the only algorithm that addresses the sampling timing error. Moreover, Hugo took the record on its launch with the longest tap length filter ever at 26,000, and Dave has now improved upon that at 164,000. With that said, the perception of starting of notes is not just down to the interpolation filter. There are other aspects that are important such as oversampling to 2048 times, which is 32 times more than usual; this allows much better timing accuracy for small signals.

On timbre, this again is a multi-dimensional problem. Certainly noise floor modulation is an important problem – noise floor modulation is where the noise changes with signal. Since white noise is bright, any noise floor modulation hardens up the sound when its bad, but even vanishingly small levels makes smooth instruments sound brighter. Again, the perception of timbre is linked to

other problems, so it is not down to one simple parameter.

But to sum it up I guess my approach is unique – on top of designing for Chord, I have had a very successful career in chip design, so I have the financial freedom now to concentrate only on what interests me. With the fact that I make no assumptions as to what makes a difference to the sound and so listen to everything, and that I uniquely cross the bridge having designed very high performance analogue and very complex digital designs. Another factor is that I have been designing digital for a very long time – it often amuses me when a company launches a product with “new” technology, when I was trying and doing exactly that 25 years ago. That said, designing a DAC from beginning (digital inputs) through the interpolation filters, and noise shapers, plus the digital and analogue part of the DAC gives a unique ability to control every part of the chain. But to do all this expertly has taken a very, very, long time – you could argue that Hugo was a thirty year project.

Moreover, I don’t pretend to know it all – there is still much to discover, which is what keeps me interested!

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

The Chord DAC 64 went some way to solve two of the problems – depth and timing. With the DAC 64 I knew I was on

the right path, but I was limited by FPGA capacity and frankly knowledge. But Hugo attacked all of the problems – timbre being a big improvement. It also had remarkable timing abilities, and resolved sound quality problems I was not even aware of. The odd thing about Hugo was the way it times – it has a very natural flow, and a very engaging rhythmic quality. The biggest surprise was its musicality, in particular the way you could listen to old poor quality recordings and still enjoy them. I found myself listening to much more music, in particular piano music, which before Hugo sounded a jumble of notes. Now you could perceive each key being struck, and how the timbre varied depending upon the pianist!

But there were aspects about the performance that I did not understand. Hugo happened to be the first project that used a major upgrade on all the digital modules in the FPGA. This upgrade was improving aspects that I knew had sound quality aspects, but the surprise was that I was hearing things that were unexpected – the perception of timing for example, it was much better than expected. So the upgrades had unexpectedly brought other improvements too. And it took the DAVE project for me to understand what those parameters were. Once I understood where the performance from Hugo was coming from I could further improve upon it in the DAVE as I had a 10 times larger FPFA than Hugo does. This illustrates that understanding why something has an improvement on sound quality can be very

powerful – it can lead you into areas one would not dream of doing otherwise.

What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

The bit perfect myth. The most important idea for digital audio is sampling theory and understanding that if you do use limited tap length FIR filters this will lead to a degradation in sound quality. Everybody in the audio business forgets or misunderstands sampling theory. But I guess the most important concept here is that the job of a DAC is NOT to reproduce the digital data – but to reproduce as accurately as possible the original analogue signal before it is sampled by the ADC. In order to accurately reproduce the bandwidth limited analogue signal before it is sampled means a very complex digital section, and this flies in the face of analogue practices – where every component, every resistor, every soldered joint makes a difference to sound quality. Digital is not like this, you must have complexity to make it accurate or transparent. My biggest problem is with DSD evangelists who wrongly believe that DSD must be bit perfect and not converted to PCM. But this approach is simply wrong; raw DSD is hopelessly sensitive to jitter and needs very complex analogue filtering and doing it this way gives hard, aggressive sound quality with gurgle noise (idle pattern noise) and distortion. In order to accurately reproduce the analogue signal before the ADC you must convert it to PCM.

Things are way more complex than they seem, and the ear/brain is amazingly sensitive – don't make any assumptions about something not being audible. That said, listening tests themselves are a problem, they need to be very carefully done – it's very easy to make confirmation biases sway you into the wrong direction, so one has to be neutral and careful.

Some listeners listen with their wallets (it costs more must be better) or listen with ideas (this idea is a good one it must sound better) and some people prefer the sound of distortion (it is less musical but more impressive) or listen to the brand (it must be better because it's an 'xxxx' product). But for me, although I do a very large number of listening tests where I try to be as accurate and neutral as possible, this is only a test. The most important aspect is the musicality – that is how enjoyable the music is. And it makes no difference how many clever ideas there are, how much it costs, and what the brand is – musicality is the only final arbiter.

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

All formats are supported. But that said I have big problems with DSD – it is incapable of being transparent, particularly with the perception of depth. Depth depends on extremely accurate rendition of very small signals, and by extremely I mean that there is almost no limit to how accurate small signals need to be for the brain to decode depth. With PCM, a properly dithered signal has no resolution problems – it will encode an infinitely small signal by changing the probability density – but with DSD this does not happen – signals below the DSD noise floor are irretrievably lost.

It amazes me how good red-book (16-bit/44.1 kHz) can be and perhaps this is not so surprising. An infinite tap length FIR filter will make a bandwidth-limited signal's sampling rate (22 kHz, say) irrelevant. It would make no difference if it were sampled at 22uS or 22 pS; either way, you would have identical analogue signals. And 16-bit properly dithered is merely noisy; it is capable of encoding infinitely small signals. So I believe red-book has even further to go.

Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

I used to hear major differences between PC's and laptops. But having put galvanic isolation on Hugo TT, it now means that the source is unimportant, so long as the data is correct. I stream using my main design PC.

One surprising thing: AAC 320 KB can sound surprisingly good, I am often amazed by its musicality!

If you are at liberty to say, what will be the next digital audio products from your company, and when?

Firstly, I am an independent design consultant working with Chord on high-end audio and I create intellectual property for use with audio for silicon chips. But I have two projects that I hope will have profound changes. One of the beauties of Hugo is that it is a simple power DAC – it has a very simple single stage with just two resistors and two capacitors. You can even use it to drive efficient horn loudspeakers, and when you do this the perception of depth is absolutely extraordinary. I have been working on digital power amp technologies for 15 years now, and next year Chord will be releasing power amps that have Hugo's simplicity and transparency but using a new technology.

Secondly, Hugo has gained traction with the pro-audio community where mastering engineers appreciate its transparency and musicality. We will be producing DAC's for pro audio – but more importantly is the ADC using pulse array. It long been my ambition to go from microphone to loudspeaker, and this will enable that!

What do you think the high-performance digital audio marketplace will look like five years from now?

No idea! But I know that I will be doing a full range of digital power amps and WTA filters with 1,000,000+ taps – fulfilling a dream started in 1980. Hopefully, there will be a number of recordings available using my ADC's too!

When you listen for personal enjoyment, what types of music do you most enjoy?

Mostly classical, but I enjoy progressive rock and electronica too. +

Trevor Wilson, Naim Audio

Hi-Fi+: How did you become interested in digital audio design?

Trevor Wilson: I came to Naim Audio via the automotive industry (Bentley), but previous to Bentley I did a PHD in microwave amplifier design at Manchester in the UK. When the opportunity at Naim was offered it appealed to me because of their quality and attention to detail, but also the use of my design skills. Digital audio was very much a key part of my job experience in the last 8 years since Naim Uniti (my first Naim product).

Digital Audio has a way of getting under one's skin as there are so many aspects of performance we cannot measure but which are easily audible on a good system.

When you are developing top-tier digital audio products, which performance parameters do you think have the greatest overall impact on sound quality?

Everything, and I mean everything, affects sound quality. Of course one has to prioritise but we start with power supplies and then consider just how that power is used. Isolation between digital, control, and analogue signals is again essential. This list could go on forever as it all matters; even something as inconsequential looking as the feet on a product has a bearing on the final performance. We like to consider the whole: the mechanical, the electrical, and the electronic design.

In simple terms, what do you feel sets your designs and products apart from most other ones ON the market?

We are not alone, but we believe there are only a few brands/products that deliver the connection to performance we do. The key elements of music are pitch and time. If we can't deliver those correctly the result is musak: music designed not to involve, not to stir the emotions. If a product of ours can't deliver accurate pitch and time it never escapes from R&D.

The markets and various fora tend to use all sorts of terms to express this but I would simply say it's communication.

What do you consider your top one or two product digital audio design achievements thus far? What makes those products special from your point of view?

The NDS network player is our finest digital audio product yet. I'm glad to say Robert Harley (Editor in Chief of The Absolute Sound) seemed to agree with us in his review last year. It's easy to say the sound quality makes it special and that's of course what we all chase, but we believe that products must also now be easy to use for all the family. Less and less high-end systems are now installed in man- or woman- caves; they are in family rooms being enjoyed by all.



What are two or three key aspects of digital audio that you wish consumers (and perhaps audio journalists, as well) better understood? Why?

Computer audio and the digital world has so many areas that are outside the traditional boundaries of audio companies. Cheap/free or poorly configured routers are a real pain issue and the general understanding of the capabilities of wireless networks when related to real time audio streaming demands (as opposed to website browsing). The assumption that because it's digital it doesn't need attention to detail. Attention to setup is just as critical as with a TT/Arm/Cartridge – all digital is not created equal!!

What do you see as the comparative merits of higher-than-CD resolution PCM, DXD, and DSD digital audio file formats? Which of these formats do your top products support and why?

We support DSD64 and PCM up to 192kHz at present. We selected these formats based on market availability/accessibility. We see the priorities as primarily being good music, good recording, and good mastering. Assuming this, the differences between DSD and PCM – while they are there – are largely akin to 'does one prefer jam or marmalade on one's toast for breakfast'. I'd encourage readers to visit our web site (www.naimlabel.com) for examples.



Consumers can potentially deliver digital audio files to their systems in a number of ways. How do you assess the relative benefits of streaming devices, dedicated music servers, or PC-based servers—especially in terms of sound quality?

At Naim we have our own server solution that we strongly believe adds value to the archiving and listening experience for our customers. We decided to offer the solution to our customers (server and streamer and pre/power) in order to manage the whole chain for audio reproduction. We have listened to many other competent solutions (and indeed continue to do so) yet our own we feel imparts an emotional intent to the music that we enjoy.

We have nailed our colours to the mast in a UPnP streaming world and believe this is the best solution. We understand it takes a bit more setting up than a simple Mac and DAC solution, but once set up, the benefits are legion.

If you are at liberty to say, what will be the next digital audio products from your company, and when?

We are in a constant state of development, but as to which products will be next I shall be mute.

Above: "Naim NDS: One of the world's finest digital audio streamers"

What do you think the high-performance digital audio marketplace will look like five years from now?

I think the high-end market will be more digital files-driven (UPnP streamed and PC/Mac/DAC solutions) than now, with CD players being less significant. I see the cloud being far more significant for backup as prices drop, but at the moment I still see the high-end playback from local (NAS) storage. For the medium to lower end, I expect the market to evolve to have a group of innovative, technology driven brands that drive the general trend of the market space product wise, but as to how customers will consume music, that will vary according to the geographic market. Certainly in Europe and the USA, I would expect to see premium streaming services to be a major part in the music consumption with maybe three or four key players.

When you listen for personal enjoyment, what types of music do you most enjoy?

This varies massively with my mood and current work focus/work load. At present I'm in an alternative rock and metal phase. I enjoy the energy and power of bands like Muse but also some more classic rock like AC/DC. I expect my system to do justice to this music as much as it can for the finest audiophile recordings. +



Right: Naim NDS with companion power supply

A SURVEY OF HIGH-QUALITY DIGITAL AUDIO STREAMING & DOWNLOAD SERVICES

Steven Stone

As if we needed another sign that physical media is going the way of the buggy-whip and spats, a longtime fixture on the U.S. music scene, the Columbia House music “club” shuttered their doors recently. And while Record Store Day may be keeping independent record stores in business, music lovers who don’t live in a town that still has a store that sells CDs or records are being forced to find new ways to acquire fresh music. What follows is a list of potential on-line sources for new music with some descriptions of their most salient features.

These music sites and services fall into several categories. First we have Internet sites that sell albums of music via purchased download. Next we have sites that offer subscription services that provide new music downloads on a regular basis. Finally we have subscription streaming services, which offer a library of music that you can listen to anytime without downloading any music files. Each kind of site has advantages and disadvantages and is best suited to different kinds of listeners. This survey will attempt to make it easier for you to decide which services are best for you.



Acoustic Sounds – Super Hi-Res

www.store.acousticsounds.com

At Acoustic Sounds you will find both downloads and physical media in addition to hardware. Downloads are primarily in FLAC format but range from Redbook 44.1/16 all the way up to 352/24 DXD and DSD. At the time of this survey I found 5502 different albums listed for download. 1075 were 44.1/16, 952 were 192/24, and 580 available on DSD. Some titles, such as *Jazz at the Pawnshop*, are available in multiple formats including DSD 64x, 352/24 DXD, multi-channel SACD, 180-gram vinyl, and JVC half-speed mastered vinyl. Looking through the “top sellers” repertoire most of the selections were “boomer rock” with a smattering of jazz and classical. A keyword search for “Beethoven” brought up 332 possible selections while “Kanye West” brought up 4. If you are an audiophile with traditional tastes you will be right at home in Acoustic Sounds’ virtual music shop.



Blue Coast Records

www.bluecoastrecords.com

Based in the Silicon Valley, Blue Coast Records is the brainchild of Cookie Marengo, who is also the recording and mastering engineer for all Blue Coast albums. Most Blue Coast recordings are captured in DSD format while a few others are recording in analogue and then mastered onto DSD format. Releases are available in PCM 44.1/16 WAV, 96/24 PCM WAV in addition to 2.8 DSD in DSF and DFF. The current catalog has over 50 original releases, primarily folk, acoustic, and classical small ensembles. Blue Coast offers Cookie Marengo’s unique auteur’s view on high-resolution recording. Her releases all have a warmth and intimacy in both their aesthetic and sonic viewpoints. If you are a fan of the Windham Hill label’s releases I recommend Special Event 19 Alex de Grassi. You can purchase the entire 10-song album for \$15 for 44.1/16, 96/24, or 2.8 DSD in DSF or DFF. Unlike many sites Blue Coast does not charge a premium for its higher resolution versions.



Bowers & Wilkins Society of Sound

www.bowers-wilkins.com/Society_of_Sound/Society_of_Sound/Music

The Society of Sound is a curated subscription service that offers two newly recorded downloads every month. The curators include Peter Gabriel and the London Symphony Orchestra and according to B&W’s copy, “the music includes artists you know and introduces you to artists you should know.” The trial membership allows you to download a selection of tracks to see if the music suits your tastes. At the time I looked at the site it was featuring an interview with Hannah Peel, Peter Gabriel’s album *So*, and an album by Bjork *Vulnicura*. The Society of Sound also has a download section, which includes a slew of recordings by Maria Callas available as either Apple Lossless or FLAC format. You will also find Mike Oldfield’s *Tubular Bells* available in four different versions including a 2.32 GB Bundle and 5.1 FLAC version, and Peter Gabriel’s *Scratch My Back* project.



HD Tracks

www.hdtracks.com

HD Tracks ranks as one of the most complete music download sites in the world. With all this music to choose from, finding what you want could be daunting, but HD Tracks supplies its potential customers with many ways to find the music they are looking for. You can shop by label; Sony Classical, Warner, Blue Note, Atlantic, ECM, Motown, Verve, and Legacy each have their own dedicated catalog pages. You can also search within a genre for a particular artist. There is even a dedicated Hi-Res store page. On this page you will find 44/1/24, 48/24, 96/25, and 172.6/24, and 192/24 files in AIFF, FLAC, ALS, and WAV formats. By way of an introduction HD Tracks offers a free high-resolution sampler for download that will not only familiarize you with their sound quality, but also give you a chance to try out their download methodology and assure that it works for you.



iTrax

www.itrax.com/Pages/PostSignUp.php

iTrax was launched in November of 2007, making it the world's first high-resolution, digital audio download site. Currently iTrax includes real HD-Audio projects from 2L, Harmonia Mundi, Naxos, and SFS Media in their roster of available releases. The site's current top seller is their iTrax-Sprint Ultra HD sampler, which includes 19 cuts by the likes of John Gorka, Albert Lee, Laurence Juber, Monty Alexander, Carl Verheyen, and Willie Nelson. It is available in 96/24 FLAC and 96/24 WAV formats. If you are looking for DSD or 192/24 or higher resolution PCM, you will not find any here – the site's owner, Mark Waldrep firmly believes that 96/24 is the best combination of resolution and file size, so that is what he offers. He also guarantees that none of the tracks are upsampled 44.1, but genuine high-resolution recordings.



Linn Records

www.linnrecords.com

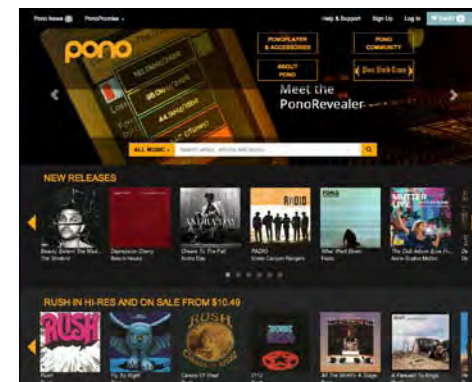
Classical music connoisseurs will find an enticing number of options on the Linn Records site. All of the albums are available in what Linn calls "Studio Master" files which are encoded at 24-bit or higher, and currently up to 192kHz. Most are also available in other formats. Ingrid Fliter's Chopin: Preludes is available in seven different formats including 192/24 FLAC, 192/24 ALCA, 96/24 FLAC, 96/24 ALCA, 44.1/16 FLAC, 44.1/16 ALAC, Compact disc, and 320k MP3. Prices vary from \$11 for the MP3 to \$24 for the 192/24 versions. With approximately 400 titles, most classical, but some folk and pop, Linn Records offers audiophiles the opportunity to compare MP3 and Redbook formats with higher resolution versions. The only omission on the site is that it is not clear which recordings were originally made in high definition and which were upsampled from standard definition albums.



Naim Label

www.naimlabel.com

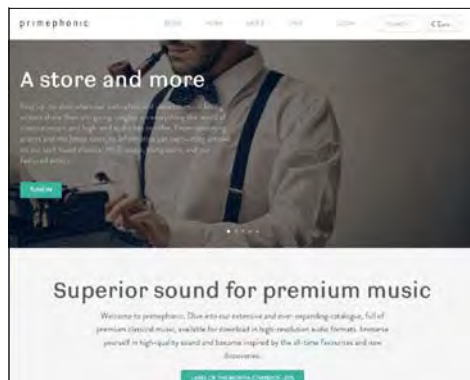
This site features classical, jazz, and "edge" genres. Most of the jazz and edge musicians are names you may not be familiar with (I wasn't) but if you have the time, the site lets you audition all the tracks. The Marc Ford album, for instance, has twelve tracks, all with previews. It is available in 320 k MP3, 44.1/16 WAV, 44.1/16 FLAC, 44.1/16 ALAC, 48/24 WAV, 48/16 FLAC, and 48/16 ALAC. Prices range from \$11.99 for the 320kbps MP3 version to 17.99 for the 48/16 versions. You can also buy individual tracks for between \$.99 and \$1.79. On its classical page you will find performances by the Royal Philharmonic Orchestra. An album of Mozart Wind Serenades is available in 88.2/24 in WAV, FLAC, or ALAC as well as standard and MP3.



Pono Music

www.ponomusic.com

A major part of Neil Young's vision for his Pono player eco-system is the Pono Music site. According to the site it has "over 2 million tracks and still growing" with the focus on pop and rock with a smattering of jazz. Most downloads are available in 44.1/24 and 96/24 resolutions, but a few, such as The Art of John Coltrane The Atlantic Years are available in 192/24. There are still some holes in the site, such as when you select "support" the page requests your Pono employee user name and password, which as a customer you don't have. Given how long the site has been active this gaffe points to a site that is less than fully flight-checked. On the plus side, Pono recently announced that they will institute a free upgrade policy – anytime they release a higher resolution version of an album anyone who previously purchased the album is entitled to an upgrade to the higher resolution copy.



Primephonic

www.primephonic.com

Dedicated exclusively to classical music, Primephonic offers downloads in 44.1/16 as well as 96/24 FLAC and 2.8 (64x) DSD for some selections. Labels represented include Ars Nova, Academy of Ancient Music, BIS, Carpe Diem, Chandos, Delos, Centaur, LSO Live, Naxos, Obsidian, Pentatone, Sarastro, Reference Recordings, Sono Luminous, Wilson Recordings, and others. Prices for albums vary from £9 to £31 depending primarily on the length of the recording. You can, if you wish, even buy individual movements of classical albums. Adrienne Pieczonka's album of Strauss and Wagner Lieder cost £16.49, but individual songs are only 60p each. The website is well designed with nice touches, such as other "related" albums available on the website and its own dedicated download manager.



Qobuz

<http://www.qobuz.com>

Although Qobuz is not yet available in the United States, versions are available for most continental European countries and for the UK. Looking at the Qobuz French site I learned that it offers high-resolution streaming with a deep catalog and a nice clean and easy to navigate interface. Even if you are not a subscriber Qobuz lets you sample 30 seconds of anything in its catalog at VBR 320kbps. The sound was impressive even from this lossy stream. US-based rock fans will discover many performers and bands they have never heard before, which they are free to sample through free 30-second auditions. US-based classical fans will find more on Qobuz to like. The catalog is deep and the sound quality on the selections I sampled, such as Yoon Soo Lee playing Bach's Partita No. 4 in D Major BWV 828 released by Musideco Classical, was surprisingly good.



Sony High-Res Music Services

www.sony.co.uk/electronics/hi-res-audio-music-services

Unlike all the other sites in this survey, You can't buy music from this Sony site, but you can find referral links to most of the other sites in this survey via this Sony page. There are also a couple of sites that are not in this survey, such as the Berlin Philharmonic's download page, Bleep, Cybele, Gimell, and hd-klassik. Naturally this page also links to the Sony Store and Sony support.



The Classical Shop

www.theclassicalshop.net

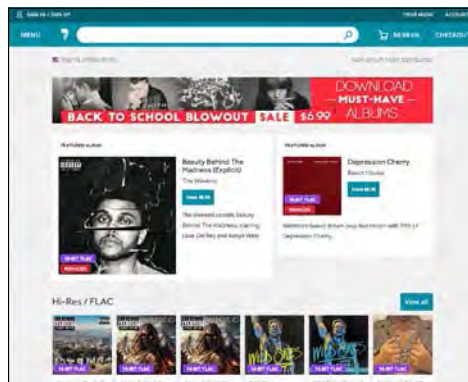
The Classical Shop is a division of Chandos Records and is located in England. They are, in their own words, "one of the world's premium DRM-free download stores dedicated to classical music. As a classical music devotee, you have access to 1 528 287 tracks from the world's leading independent labels, with free sampling of any track." Depending on the album, The Classical shop offers 320kbps MP3, CD-quality 44.1/16, and studio quality at 88.1/24 and 96/24. The price for a full-length studio quality download is £17.99 and individual tracks cost £1.20. The site is well configured with nice touches such as descriptions of each album popping up when you roll your mouse over its image. There are also regular 3-album discounts (33% off when you order three albums) and a monthly newsletter that informs you of new releases.



Tidal/WiMP

www.tidal.com/us, www.wimpmusic.com

Pay no attention to that disastrous news conference; TIDAL is far more than Jay-Z and superstars. With its own dedicated player app and integration into many digital players TIDAL ranks as the most likely to achieve the goal of a fully portable music library (if your library is primarily rock, pop, and jazz). In HiFi mode TIDAL streams in lossless 44.1/16 resolutions and if your connection is poor, it has a lower-resolution stream available. If you are looking for a site to preview new pop music TIDAL is hard to beat with lots of new titles added every week. Appending albums to your own music list is easy, too. All you do is click on the album as a "favorite" and it joins your TIDAL music library. TIDAL's HiFi sound is so good that in A/B tests versus a CD you will be hard-pressed to discern an audible difference.



7 Digital.com

www.7digital.com

Another download service based in Great Britain, 7.Digital.com, has pop, rock, and classical downloads available in 320kbps MP3 and M4A, 44.1/16, 44.1/14, and 96/14 FLAC formats. Most of the tracks can be auditioned and individual tracks can be purchased as well as whole albums. 7 Digital has a section dedicated to high-resolution, but a majority of the music here is 16-bit. Fortunately the formats are all clearly noted, but there is no information about the resolution of the original sources or where the albums were sourced. While 7 Digital.com is certainly not unique in this lack of transparency, it would be far better if customers knew exactly what they were buying. Although 7 Digital has a nice clean, easy to navigate site, it needs something more to differentiate itself from other sites that offer similar inventory options, such as HD-Tracks.

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Survey of High-Quality Digital Audio Streaming & Download Services

Name of Service	URL	Download Service?	Streaming Service?	Pricing?	File Formats Offered?	Highest Resolutions Available?	Global Markets Served?
Acoustic Sounds	store.acousticsounds.com/superhirez	Yes	No	\$10.00 – \$29.98	ALAC, DSD, FLAC	352/24 DXD, 128X DSD, 192/24	Yes
Blue Coast Records	www.bluecoastrecords.com	Yes	No	\$10.50 – \$20.00	WAV, DSF, DFF	2.8MH DSD	Yes
Bowers & Wilkins Society of Sound	www.bowers-wilkins.com/Society_of_Sound/Society_of_Sound/Music	Yes	No	\$16.00 – \$24.00	ALAC, FLAC	96/24	Yes
HD Tracks	www.hdtracks.com	Yes	No	\$9.98 – \$24.98	AIFF, ALAC, FLAC, WAV	352/24	Yes
iTrax	www.itrax.com/Pages/PostSignUp.php	Yes	No	\$9.99 – \$19.99	WAV, FLAC, WMA Lossless, MP3, Doby Digital, DTS	96/24	Yes
Linn Records	www.linnrecords.com	Yes	No	\$11.00 – \$20.00	FLAC, ALAC, MP3	192/24	Yes
Naim Label	www.naimlabel.com	Yes	No	\$11.99 – 21.99	FLAC, WAV, ALAC, MP3	96/24	Yes
Pono Music	www.ponomusic.com	Yes	No	\$7.69 – \$25.69	FLAC	192/24	Yes
Primephonic	www.primephonic.com	Yes	No	€12.99 – €24.99	WAV, FLAC, DSD	2.8 MHz DSD	Yes
Qobuz	www.qobuz.com/fr-fr/ www.qobuz.com/gb-en/plans/ music-streaming-subscriptions	No	Yes	£4.99 – £19.99/ month	MP3, AAC, OGG Vorbis, AAC, AIFF, ALAC, FLAC, WAV	128 kbps, 320kbps, 44.1/16, 44.1/24, 88.2/24, 176.4/24, 192/24	Most continental European countries, the UK, and soon to the US.
Sony High-Res Music Services	www.sony.co.uk/electronics/hi-res-audio-music-services	No: Site is a referral service only.	No: Site is a referral service only.	Not applicable.	Not applicable.	Depends on services referenced.	Yes
The Classical Shop	www.theclassicalshop.net	Yes	No	£7.99 – £13.99	MP3, WMA, FLAC, WAV, AIFF	96/24	Yes
Tidal/WiMP	www.tidal.com/us	No	Yes	\$25.99/month	HIFI	44.1/16	No
7 Digital.com	www.7digital.com	Yes	No	\$9.99 – \$17.99	MP3, FLAC, AAC	44.1/24	Yes

Introduction to streaming

JASON KENNEDY

Streamed audio is not a new format, nor even new technology, but it has taken the place of the CD in many enthusiasts systems. This means it has the characteristics of a format in our world, but streaming's strength is that its almost format free. In theory (and often in practice as well) you can stream existing audio formats on a piece of hardware that can also accommodate future formats. This may require a hardware update, but often a software update over the web is sufficient. Streaming is tremendously flexible in that respect.

But why has streaming proved so popular? There are number of reasons, but prime among them is the ease of access to your music collection. We no longer expect to fine tune a turntable every time we sit down for a session. Instead, we want easy access and good sound. And there's nothing quite as easy as selecting your music on a tablet from the comfort of your listening chair. That's not to say sound quality is secondary however, as a good streaming source is extremely resolute and engaging. The majority of streamers sound more refined than the majority of CD players; pound for pound they are a revelation in this respect. If the harsh glare of digital audio has kept you in the analogue fold you might be pleasantly surprised by the presentation of a decent streamer. Pitting the best streamers against

the best CD players will split opinion of course, but in my experience streamers excel at low level detail, refinement, and openness while disc spinners have the upper hand at timing, and the emotional engagement that good timing delivers. The fact that Naim uses its NDS streamer to demonstrate the megabucks Statement amplifiers rather than the more costly CD555 CD player should tell you something. It's clear from sales data that CD players are being squeezed out by the revival of turntables and the ascent of streamers.

The other obvious advantage streaming devices have in the digital arena is the ability to play higher bit and sample rate recordings. Unlike CD players, streamers are not restricted to the 16-bit/44.1kHz Red Book format. Chipsets exist that can replay sample rates up to 384kHz and quadruple DSD (DSD256), and quite possibly higher by the time you read this. Higher bit and sample rates are not in themselves a panacea for good sound of course; you can probably remember numbers races in the past, such as THD, where better figures did not mean better sound. I heard recently that the BBC used to send FM signals to its transmitters at 13-bit in the 1970s, and FM was considered pretty good back then. Today's DAB broadcasts stretch to 128kbps if you're lucky.



“The CI industry used computer platforms and storage systems to develop means of producing multiroom audio without multiple sources, and companies including Linn and Naim started out in streaming this way.”



History

Streaming started in what is now called the CI or custom installation world back in the 1990s. When you want to send audio to multiple rooms and control it from a single point, you can't beat transmitting that signal through a network. The CI industry used computer platforms and storage systems to develop means of providing multiroom audio without multiple sources, and companies including Linn and Naim started out in streaming this way. Both have now abandoned CI and concentrate on domestic streaming hardware, Linn doing so in the most dramatic fashion, when it announced that it would stop making CD players in late 2009.

The more affordable entry point in the early days was Squeezebox's range of rendering devices or players. Squeezebox released a full-size streamer called the Transporter, but it was the smaller and rather more affordable Touch that captured the attention of enthusiasts. The brand itself has been absorbed into the Logitech fold and most of the Squeezbox hardware is no longer manufactured, but the Touch remains a popular player with numerous mods and tweaks available to the enthusiast. You can even get it to stream the latest music services.

Computing

The computer has always been the basis of digital audio streaming; the least expensive way to dip a toe is to connect a laptop to a DAC via a length of USB cable. This

approach is dubbed the 'push' approach, because the computer 'pushes' the signal to the converter. A streamer on the other hand 'pulls' the data from the source, usually a NAS drive. Using a computer has the advantage of flexibility in the choice of playback software and cost, but to get decent sound quality you need a dedicated computer that has been built with this purpose in mind. This tends to undermine the cheapness factor. In most instances, you need direct access to the computer to control playback, but software such as JRiver Media Center can be controlled with the JRemote app on a tablet. The only other limitation is that USB leads do not perform quite so well if they are over a metre or two long.

A streamer or renderer is built from the ground up as a dedicated audio component, so attention is paid to keeping out RFI through the use of linear power supplies and minimising jitter and the other ills of digital audio that the computer world is not bothered about. Streamers connect to a computer network, where they can pull audio data from a media server, generally a network attached hard drive or NAS with an operating system such as Twonky media onboard. Companies including Naim and more recently Melco offer higher quality servers that can also rip CDs and offer alternative connections alongside the RJ45 socket required for connection to a network wired with Ethernet cable. For best results and high resolution formats a network should be wired rather than wireless, but as

Sonos has proved wireless networks are good enough for many.

Another school of thought is to have the music stored on the player itself, eliminating the need for separate music storage, this is what happens in a Naim HDX and a variety of both high-end and budget products. It simplifies initial set up at the cost of flexibility. But, it does mean that the network is only necessary for control and grabbing metadata and so can be wireless without sonic compromise.

Networking

The network approach means the media server or storage device need not be in the same room as the player, and as NAS drives are not the quietest things, this is quite handy. It also means that multiple players can share the same drive, both wired and wirelessly. One of the nice things about having your music on a network is that any streaming device can access it; in my case that means the iPod Touch that plugs into the kitchen radio, but it could just as easily be a smartphone. And while you need a tablet or smartphone to use the control app for a dedicated streamer, that same handheld device can be both controller and player. Therein lies the rub of course; if you leave the iPad in the kitchen, it won't be on the sofa when you want to choose an album or playlist on the main system.

The playlist is another aspect of streaming that is very popular; essentially it's a means of collecting a selection of tracks in a list

that can be saved. It's a bit like a compilation tape but a lot more flexible as you can have almost as many tracks as you like and you can have the same track on as many playlists as you want. As an old school album listener, this is not something I have adapted to in truth: I tend to play tracks or albums, but rarely get around to building playlists, despite the ease with which it can be achieved. But I get the impression I am in the minority in this regard.

Formats

I mentioned formats earlier. There are many of these to choose from, but if sound quality is important then the list gets a lot shorter. The choice is essentially between those that losslessly compress the audio data such as FLAC and Apple's variant ALAC, and those that do not: WAV, AIFF, and, more recently, DSD. The reason for choosing the lossless formats used to be that they require about half as much storage space, but now that space is so inexpensive, that argument is less valid. What is more important is metadata: all the information about the track including artist, track title, album title, artwork, etc. FLAC, ALAC, and AIFF all support metadata, which means that if you transfer your music collection to a player that uses different software it will be able to display this key information.

However, WAV is regarded by many to be the best of the best. It's not Apple-centric like AIFF and it does not compress data, and so long as you stick with the same software, the metadata is available. It was the exclusive

format of the Naim UnitiServe until last year. The thinking today has swung toward FLAC because of its portability and because a good streamer has no difficulty ‘unpacking’ the FLAC container to expand the data within. The fact that high resolution music files are sold in this format is a factor, but possibly more significant is that not many people can hear the difference on most streamers. Linn’s position is that there is no audible difference.

DSD

On the other side of this fence is that revival of the format that SACD was based on, DSD – a format for which very little mainstream original content is available, yet which has become the flavour of the season in the world of DACs. Even Naim has incorporated DSD compatibility in its NAC-N 272 streaming preamplifier, this despite the fact that the UnitiServe it sells to complement its streamers is not yet DSD compatible. You can get server software that will stream DSD however, Naim use one called MinimServer for its demonstrations.

Another approach to streaming hardware is exemplified by the AURALiC ARIES among a few others. The ARIES is a ‘bridge’, which is essentially a streamer without a DAC. It has USB output for high bit/sample rates as well as S/PDIF outputs on coax and optical. The absence of a converter and analogue output stage makes it less expensive than a high-end streamer, but theoretically able to compete with such things if you already own a serious DAC. There are not many bridges on the market yet, but a high-end British example

turned up at the Bristol show this year; the Stack Audio Onset, with its dCS style casework, looks very promising.

Online sounds

As well as providing easy access to your own music collection, a streamer also opens up the world of Internet radio and streaming services. There are seemingly millions of net radio stations around the world that can be searched for by region or genre, and many can only be accessed online. If you are looking for niche programming, there is no easier way to find it. While sound quality is variable, it’s not a lot worse than other digital broadcasting. In some cases companies get exclusive access to higher quality streams: Naim streamers provide both Naim Radio and Radio Paradise at 320kbps, for instance.

Streaming services are more like an online library from which you can pick and mix tracks, albums, and artists. For sheer breadth of catalogue, it’s hard to beat Spotify but that is limited to 320kbps on its £10/month premium service or 128kbps otherwise. There are two services that offer CD quality

streaming: Qobuz from France and Tidal (also known as ‘WIMP’) from Norway. The catalogues from both are large, if not in Spotify’s league, but don’t include certain major artists (The Beatles are not represented, and neither are artists on the ECM label, which is perhaps more pertinent). Qobuz has a considerably larger classical library of the two and offers a 15-day free trial, Tidal’s trial is only seven days, unless you can pick up a voucher at a show. Both services cost £20 a month and sound quality is pretty good: not quite as good as your own library, but good enough to enjoy on a decent system.

Conclusion

Streaming has not quite scaled the sonic heights of the best analogue and digital sources, but being a young technology in audio terms there is room for improvement in the software provided by some companies. That said, it is 21st century audio technology that need not cost a fortune. I use streaming for the majority of my reviewing work; it doesn’t sound as good as my turntable, but it’s pretty damn fine and a whole lot more user friendly. +



Streaming glossary

Control point: usually an app on a touch screen device that is used to select and play music

Ethernet: a standard for computer networking and the name given to the cabling used to create such networks

Gapless playback: continuous playback of multiple tracks without gaps between them

NAS: network attached storage, usually a hard disk drive controlled by a small dedicated PC

Media server: media storage device with server software onboard, such as a NAS drive

Metadata: tags in a data file that carry information about that file. In streaming audio this means title, artist, album, album artwork, date, etc

Playlist: list of tracks that you build up and save for future playback. Usually created in the control app

Renderer: a streaming source component/player

Ripping: the process of copying music from an optical disc. Turning a CD into a file that can be streamed requires it to be ripped

Switch: in network systems, a junction that shares data across its outputs. Gigabit switches are preferable for audio networks

UPnP: Universal Plug and Play, the protocol for sending data around a network

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- HRT Music Streamer III
- HRT Music Streamer III
- Longdog VDT1
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Headphone & integrated amp/DAC
Integrated amp/DAC
Portable USB headphone amp/DAC
Streaming active audio system
Streaming integrated amplifier
Headphone amp/preamp/DAC
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Headphone amp/preamp/DAC
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EDITORS' CHOICE AWARDS

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EDITORS'
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2015

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2015

DACs



HEADPHONE AMP/DACs & PORTABLE PLAYERS



DISC PLAYERS AND TRANSPORTS



STREAMERS, SERVERS, TUNERS & STREAMING SYSTEMS



PREAMP/DACs & INTEGRATED AMP/DACs



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HI-FI+ EDITORS' CHOICE AWARDS – DACs

AURALiC VEGA Digital Audio Processor

The VEGA is the brainchild of AURALiC's Xuanqian Wang, who is both an accomplished electrical engineer and recording engineer, and a classical pianist to boot (influences readily apparent in the VEGA). The VEGA supports PCM up to 32/384 and DSD64/128, and provides extensive user-selectable digital filter options that allow fine-tuning of the DAC's sonic character. The DAC also incorporates a highly accurate 'Femtoclock' with user configurable control options. The DAC's 'secret weapon' may be its proprietary ORFEO class-A analogue output modules, which give the DAC a sound that deftly balances superb detail and definition with a naturally warm, 'organic-sounding' presentation.

B.M.C. Audio DAC1PreHR

If there were an equivalent to the Richter scale for value for money, B.M.C. Audio would be off the charts! This big, beautifully made combined DAC and digital or analogue preamplifier with its impressive central display makes a bold statement. It also sounds extremely good, with a sound that is fundamentally neutral and effortlessly dynamic, yet capable of great subtlety when required. This is a DAC built with B.M.C. Audio's own amplifiers in mind, as the company's balanced 'Discrete Intelligent Gain Management' architecture allows the digital converter to control the gain of the power amp.

dCS Vivaldi DAC

The Cambridge, UK based firm dCS has long been considered at the forefront of digital audio technology, and the Vivaldi is the company's current top of the range DAC. Little wonder that it we consider it the best DAC we know of. Forming a key component in the multi-component Vivaldi replay system, the DXD-capable DAC is the culmination of years of development in dCS' Ring DAC technology. Vivaldi's performance is hard to summarise because it represents a paradigm shift in digital audio sound quality, but those who hear it praise its uncanny abilities to define texture and expression on any recording.

Exogal Comet

The Comet is part of high-end audio's 'new wave' of game-changing audio. Designed by a team of ex-Wadia engineers as a digital audio nerve centre, replacing both DAC and preamplifier in a next-generation system, the sophisticated Exogal design features a custom DAC made of programmable chips, insuring the Comet isn't going to be sidelined if tomorrow brings new formats, and is best used with Exogal's own app. Upgradable both with firmware and power supply, the Comet DAC is very demanding of digital sources, but at its best can punch well above its weight, creating a clean, crisp, and detailed presentation.



ARIES

Wireless Streaming Bridge

The ARIES serves as a “bridge” between music files on media server or high quality online streaming services and your DAC — enabling DACs for the first time to stream high-resolution music quickly and wirelessly in virtually any sampling rate, including DSD, Double-Rate DSD and DXD.



It is **not** a streamer
It turns your DAC **into** a streamer!



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HI-FI+ EDITORS' CHOICE AWARDS – DACs

Nagra Audio HD DAC

Nagra is one of the world's best-known manufacturers of high-performance professional audio recorders, but that doesn't prepare you for the sheer excellence of the Nagra HD DAC's sound quality. The first in Nagra's new higher-end line, the hybrid DSD-compatible HD DAC bends the rules, especially when used with the company's optional dedicated MPS power supply. Unlike most DACs, the Nagra converts all digital data streams to DSD in order to create a 'phase-perfect' digital architecture. Combine this with a fantastic sounding output stage, and Nagra just makes some of the most 'organic' and 'flowing' sounding digital audio you'll ever experience.



PS Audio DirectStream DAC

The DirectStream DAC supports DSD and PCM playback in an innovative way. The DAC converts all PCM digital audio data to DSD format, upsamples all files to 10X the standard DSD rate, then converts the files down to the double DSD rate for playback. The DAC incorporates a powerful FPGA-based 'DSD Engine' to manage this computation-intensive process. The DirectStream DAC is capable of superb resolution and nuance, with an expansive, free-flowing sound reminiscent of analogue tape, but without the tape hiss. Better still, the DAC's sound continues to improve via periodic PS Audio operating system updates, offered free of charge.



Ones to watch...

Over the next year, *Hi-Fi+* plans to investigate the promising DACs listed below, some of which are likely to become review subjects.

- Benchmark Audio Systems DAC2
- Computer Audio Design CAD 1543 MkII
- Chord Electronics DAVE
- Chord Electronics Hugo TT
- Light Harmonic Da Vinci DAC MKII
- Moon by Simaudio 780D
- PS Audio NuWave DSD DAC
- Schiit Audio Yggdrasil DAC
- Schiit Audio Gungrir Multibit DAC

HI-FI+ EDITORS' CHOICE AWARDS – DISC PLAYERS AND TRANSPORTS

Audio Research Reference CD9

At this point in the optical disc's life, it would be easy to cover the bases and make a player that supports SACD and Blu-ray. But, that isn't how Audio Research rolls. Instead, in its Reference CD9 – only the third Reference disc player in the company's history – Audio Research made the best CD player it possibly could. Although with four digital inputs (including USB, all up to 24/192 precision), the CD9 is more than just a 'CD player'. When tested as part of an all Audio Research system, the CD9's fabulous soundstaging and effortless tonality made it a perfect player.



B.M.C. Audio BDCD1.1

There aren't many CD transports available today, but fewer still when you add 'belt-driven' into the mix. B.M.C. Audio is one of the rare exceptions. This top-loading, phenomenally well-made machine looks a million dollars, but is comparatively affordable. Used as a CD player in its own right, the B.M.C. Audio BDCD1.1 is a formidable performer, but used in context of a full-blown B.M.C. Audio electronics chain, it becomes an unbeatable combination of high-grade build, excellent sound, and great value. If you are looking for a great 'final' CD player, you can't get better: this one might just outlive your great-grandchildren.



Computer Audio Design CAT

If anything marks this period out as one of 'digital transition', it's CAD's CAT. The Computer Audio Design Computer Audio Transport (to use its full moniker) is a truly bespoke, dedicated player/ripper/network storage device for CDs built to your specifications and designed to complement the company's highly respected USB-only 1543 DAC. CAD has long provided best-practice set-up instructions for an audio-only computer, but in the CAT, CAD takes this concept to its logical extreme, right down to modifying the computer motherboard, placing the OS on a separate hard-drive, and replacing the standard switch-mode PSU with a four-in-one external linear design.



dCS Vivaldi CD/SACD transport

In designing the Vivaldi disc transport, dCS pulled out all the stops, leveraging all the skills the company has picked up over years of CD/SACD manufacture, and distilling them into this one disc-spinning box. The result is so good that dCS effectively ended the production of several of its own product lines. Since Esoteric – makers of the VRDS mechanism inside the Vivaldi – no longer supplies drives to rival makers, there can be no more CD/SACD lines from dCS after Vivaldi. Fortunately, dCS have stocked up and SACD's last hope is also its best; Vivaldi offers unparalleled, sublimely natural sound quality.





oppo

More Than Mere Players

OPPO Universal Disc Players like the BDP-103D & 105D aren't just incredible feature-packed Blu-ray players—they're also exceptional direct audio & video sources, making them perfect for the media aficionado who will only settle for perfection. Whether you're upscaling 1080p footage to 4K or enjoying high resolution, lossless audio in several formats, the BDP-103D & 105D are so much more than mere players. Learn more at oppodigital.com today.

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dCS
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HI-FI+ EDITORS' CHOICE AWARDS – DISC PLAYERS AND TRANSPORTS

Oppo Digital BDP-105D/BDP-105EU

Oppo Digital rose to prominence by building sophisticated universal disc players that offer exceptionally rich features sets and superb audio and video performance at down to earth prices. The BDP-105D/BDP-105EU, in turn, are Oppo's flagship Blu-ray universal players/DACs that support virtually every video and audio disc format known to man, while providing sophisticated dual-ESS chip-based DAC sections, complete with fully balanced stereo analogue output circuitry. The BDP-105 series players are not only strong performers in their own right, but also make excellent platforms for exotic, high-end upgrade projects. No other player we know of does so much, for so little.



TAD D1000

Designed as both a headphone/DAC, and a DAC with a CD/SACD transport mechanism, TAD's 1000-series digital player is the company's cheapest digital player, but no one would ever know from build and sound quality terms. A high-end spin out from Pioneer, Technical Audio Devices laboratories was always destined to show what the brand could do when cost and design constraints were removed. As a result, the D1000 player uses an ultra-precision clock to lower the signal/noise ratio, and its own custom current-to-voltage conversion because TAD would not settle for 'regular'. The result is an incredibly communicative and dynamic player.



Ones to watch...

Over the next year, *Hi-Fi+* plans to investigate the promising Disc Players and Transports listed below, some of which are likely to become review subjects.

- Aesthetix Romulus
- dCS Rossini CD players
- Leema Acoustics Spectrum Stream IV
- Roksan Oxygene CD player
- Roksan Blak-series CD player
- Townshend Glastonbury

HI-FI+ EDITORS' CHOICE AWARDS – PREAMP/DACs & INTEGRATED AMP/DACs

Burmester 151 Musiccenter

Following in the footsteps of the large 111 Musiccenter from the company's Reference Line, Burmester's Top Line 151 media player is every bit a 2015 design. It abandons its older brother's front-panel touchscreen (and preamplifier stage), providing instead full control over disc ripping, music playback, and digital radio use through an iPad. The 151 retains mirrored 2TB internal and connections for external storage, disc play or ripping, USB stick playing, 24/192 precision playback, and a basic volume control function. The creamy, expansive, yet surprisingly pacy sounding player might take its time to rip discs, but it clearly rips them right!



Cambridge Audio Azur 851N

Networked audio has sparked a democratising revolt in the audio world, fuelled by companies like Cambridge Audio. Its Azur 851N can cope with signals from MP3 to DSD as a DAC, or a network streamer, but retains the company's strongly value-driven sense of priorities. Set-up and use are easy, and its performance gives the listener a true taste of the best in high-end audio with its engaging and detailed presentation. The sound quality is aided by the 851N upsampling all signals to 24bit/384kHz in a manner that even helps music services like Spotify. The company's Connect app is also excellent.



Devialet Expert 200

French audio enfant terrible Devialet hit the market with the D-Premier in 2009. The brand's next wave of products introduced bigger and smaller amps, including the 170. The company's constant firmware updates have increased the power output of that product, and as a result it's now the (Expert) 200. With a built in 24/384 precision DAC as core to its architecture (analogue sources are digitised), a hybrid Class A/Class D amplifier stage, and an ability to support sources old and new, digital and analogue, Devialet may be focused on its Phantom speakers, but the 200 is still one to watch...



iFi Audio Retro Stereo 50

The Retro Stereo 50 is a valve-powered integrated/headphone amplifier/DAC that, despite its retro name and appearance, is as modern as tomorrow and leverages technical and sonic know-how drawn from parent company Abingdon Music Research. In essence, the amp incorporates versions of iFi's critically acclaimed MM/MC-capable iPhono phono stage and hyper-versatile Micro iDSD DAC, while adding modern Bluetooth capabilities. The 25Wpc valve-powered amp section is an old-school design using quad EL84x and dual ECF82 valves. For many loudspeakers, the amp makes up in nuance and panache what it lacks in outright power output, while also serving as a spectacularly good headphone amp.



peachtree audio



Warning: may cause compulsive listening,
uncontrollable grinning, spontaneous
dancing and prolonged happiness.

peachtreeaudio.com



HI-FI+ EDITORS' CHOICE AWARDS – PREAMP/DACs & INTEGRATED AMP/DACs

Naim Audio SuperUniti

For the last decade, Naim Audio has been at the forefront of network streamed audio, as evidenced by the SuperUniti. Combining an 80W/channel integrated amplifier (not dissimilar in performance and sound to the Naim SuperNAIT) with one of Naim's streaming 'front-ends' has produced a one-box system that – for several years – has been one of the only integrated amplifiers over £2,000 that sold in the UK. Part of the Naim SuperUniti's success comes down to the sheer ease of installation and operation (thanks to some excellent iPad apps), but a lot comes down to that beguiling, intrinsically musical sound it produces.

Peachtree Nova 220SE

Nova-series integrated amp/DACs traditionally have been versatile and offered excellent value for money, but what sets the Nova 220SE apart is that it has stepped up its performance game in a major way. The 220SE uses an ESS 9022-based, 24/192-capable DAC section, a powerful 1170mW headphone amplifier, a user-selectable 6N1P-based valve buffer stage, and a potent 220Wpc ICEpower-based class D amplifier section. The resulting amp/DAC is one of the most nuanced and three-dimensional sounding units Peachtree has yet produced—an amp that, to borrow the words of U.S. President Theodore Roosevelt, manages to, “walk softly and carry a big stick.”

Ones to watch...

Over the next year, *Hi-Fi+* plans to investigate the promising preamp/DACs and Integrated Amp/DACs listed below, some of which are likely to become review subjects.

- DarTZeel LHC208
- Entotem Plato
- Linn Series 5
- Mark Levinson 585
- Quad Artera Player



HI-FI+ EDITORS' CHOICE AWARDS – HEADPHONE AMP/DACs & PORTABLE PLAYERS

Astell & Kern AK380

Astell & Kern's expensive flagship AK380 high-res portable digital audio player justifies its price through its exemplary versatility and stunning sound quality. More a sophisticated digital playback platform than a mere pocket-sized player, the AK380 combines the functions of a music server, a DAC featuring native high-res PCM and DSD decoding, a pristine-sounding headphone amp, and a studio-grade parametric EQ system. Astell & Kern offers an optional high-powered headphone amp, a CD ripper drive, and an I/O dock to expand the AK380's capabilities. Sonically, the player is characterised by its terrific transparency, openness, nuance, and almost boundless attention to detail.



Chord Electronics Hugo

The Chord Hugo is a watershed high-end audio product that forever re-defined what compact, portable, battery-powered headphone amp/DACs can do. Featuring a high-resolution PCM and DSD-capable DAC with a highly advanced, FPGA-based, long tap-length digital filter system, Hugo was at its inception the most sophisticated DAC Chord had ever offered. Indeed, the tiny unit often handily outperformed many more costly, full-size DACs. Add to this Hugo's exceptionally low noise floor, clean and powerful headphone amp, stylish good looks, and exquisite build quality and you have a unit that rightly has become the benchmark for portable products of its kind.



iFi Audio Micro iDSD

An unnamed marketer quipped that winning products are those that arrive 'firstest with the mostest', by which standard the Micro iDSD portable headphone amp/DAC is plainly a winner. The versatile DAC supports such futuristic digital audio standards as PCM at up to 32/768 rates and octa-speed DSD files. Next, the unit includes multiple digital filters, a bass enhancement circuit, and a 3D soundstaging enhancement circuit. Finally, the Micro iDSD provides a robust battery/USB-powered amplifier with multiple gain settings and with voicing by Abingdon Music Research. In short, the Micro iDSD is a tour de force at a surprisingly modest price.



Meridian Audio Prime

The Prime was Meridian Audio's first desktop USB DAC and headphone amp, neatly styled in the livery of the company's classic G series devices, and potentially upgradable by adding a matching Prime power supply. It plays up to 24-bit, 192kHz precision and its two ¼" jack sockets can be used in balanced mode. It includes Analogue Spatial Processing, which helps reduce lateralisation effects that can upset non-headphone users. It's a good sounding headphone DAC, but one that will be transformed soon by the upcoming inclusion of the company's innovative MQA (Master Quality Authenticated) decoding and rendering for appropriately coded recordings.





HI-FI+ EDITORS' CHOICE AWARDS – HEADPHONE AMP/DACs & PORTABLE PLAYERS

Moon by Simaudio 430HAD

Moon's 430HAD leverages everything the Canadian firm has learned about designing high-end amplification and digital audio components in an effort to build a state-of-the-art headphone amp/DAC. The 430HAD's DAC section is high-res PCM and DSD-capable and comes courtesy of a DAC3 module that is indirectly patterned after the firm's full size Neo Series DACs. In turn the 430HAD's potent amplifier section features a low-noise, wide bandwidth, and fully balanced design. After extensive listening, our conclusion was that the 430HAD combined a very, very good DAC section with an absolutely world-class amplifier sure to please even the most finicky 'headphonistas'.



Oppo HA-1

Following in the tradition of Oppo's high-performance/high-value universal disc players, the HA-1 headphone amp/DAC represents an attempt to deliver near top-tier performance at a reasonable price (relative to the capabilities on offer). To this end, the HA-1's high-res PCM/DSD DAC section is essentially a higher performance version of the DAC section from Oppo's critically acclaimed BDP-105 disc player. Then, the HA-1 adds a fully balanced, discrete class A amplifier that can be controlled via an intuitive user interface, complete with a front-panel colour display. When used with top-class headphones, the HA-1 serves up stunning layers of power, subtlety, and finesse.



Ones to watch...

Over the next year, v plans to investigate the promising Headphone Amp/DACs and Portable Digital Audio Players listed below, some of which are likely to become review subjects.

- Astell & Kern AK Junior
- AudioQuest Beetle
- Lotoo PAW Gold
- Peachtree Audio Shift
- Pioneer UA-5
- Questyle QP1R

HI-FI+ EDITORS' CHOICE AWARDS – STREAMERS, SERVERS, TUNERS & STREAMING SYSTEMS

Aurender W20

Although becoming better known for more down-to-earth products (like the Flow portable player), Korean audio brand Aurender started life making more esoteric products like the W20 Music Server. With a chambered aluminium architecture to house sub-systems, and using lithium ion batteries to buffer power idiosyncrasies, the W20 was one of the first 'post-CD' products to demonstrate that all is not lost. The W20 could be considered a 'computer transport' as it does not feature a built in DAC, but it features a range of precision clocks for controlling the best DACs around, as a product of this calibre richly deserves!



Linn Akurate Akudoric Exakt

A true system from front to back, Linn Products' current 'source is in the speaker' ethos is perfectly expressed in this elegant package. Combining network controlled, active loudspeakers with a sophisticated media renderer that can accommodate the dynamics of the room in the digital domain without heavy-handed DSP, Linn's Martini-dry Akurate Exakt may be tough on spell-checkers, but makes a great case for next-generation audio systems. Linn was one of the first big brands to call time on CD, and its development in the networked streaming world has put the company back into being a force to be reckoned with.



Melco N1Z

Melco is the name of the parent company of Buffalo. And the boss of that parent company is a passionate audiophile who discovered the next great audio revolution of streaming was more about computer-based products than audio products. So, the name Melco was pulled out of mothballs, dusted off, and put to work in making audio-dedicated network attached storage/ media players and the equivalent of the digital audio Swiss Army Knife. There are two models in the range; the spinning disc, stripped back N1A and the no-quarter-given N1Z. Either can transform your computer audio playback... especially when running Minimserver software!



Merging NADAC

Merging is best known for its Pyramix DSD recording system and for collaborating with Philips to develop DXD. Now, its exciting Swiss-made networked NADAC arrives as a near consumer equivalent of the Horus and Hapi converters found in the best studios in the world. Using super-robust RAVENNA audio-over-IP networked audio in place of UPnP (or USB), the NADAC is the closest you'll get to the sound of DSD as originally mastered, with phenomenal detail and soundstaging. The NADAC permits completely independent control of its built-in DAC and headphone amplifier, even allowing simultaneous playback of separate music files through both.



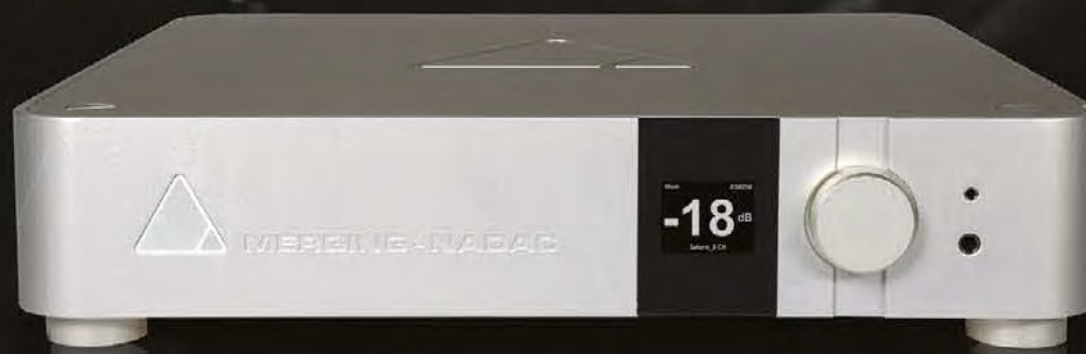
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Introducing NADAC, the network attached DAC that delivers the excellence of the recording studio, into the home environment for the most discerning audiophile.

Developed by Merging Technologies - the world's foremost manufacturer of high-resolution digital audio recording systems, NADAC allows listeners to finally enjoy master quality recordings at home, with the same equipment with which it has been recorded and mastered.

With the introduction of RAVENNA networked audio, supporting all file formats and sample rates from 44.1kHz - 384kHz PCM, DSD 64, 128 and 256, we have totally transformed the performance that can be delivered in the comfort of your home.

QUAD-DSD256
DSD
Direct Stream Digital



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NETWORK ATTACHED DIGITAL TO ANALOGUE CONVERTER

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HI-FI+ EDITORS' CHOICE AWARDS – STREAMERS, SERVERS, TUNERS & STREAMING SYSTEMS

Naim NDS

The current top of the Naim Audio network tree, this two-box media player couples decades of good analogue working practices (such as 'floating' key circuit boards on springs to limit vibration pollution) with one of the best media rendering platforms in the business. The result is not simply good for Naim Audio users, but works universally as a top-class front end for many systems. The Naim NDS marked a renaissance for the brand, and showed the audiophile world what's possible from streaming. Recent updates have brought DSD replay to the table, but that doesn't matter – the NDS is something special.

ReQuest Audio The Beast

The most expensive music server/media player we have ever encountered, The Beast by ReQuest Audio not only lives up to its name, but also lives up to the hype. One of the largest players made, with its touch screen display, a vast range of options and configurations available to the user, The Beast is a difficult device to pin down. Except for one thing – it routinely sounds excellent in all its guises. Even those who steadfastly reject listening to anything digital unless it's on a disc, have been won over by the beauty of The Beast when they heard it.

Ones to watch...

Over the next year, *Hi-Fi+* plans to investigate the promising Servers and Streamers listed below, some of which are likely to become review subjects.

- AURALiC ARIES and ARIES MINI
- Aurender N100H
- Cyrus Stream XSignature
- Leema Acoustics Pulse IV
- Lumin T-1





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Perhaps no single category in all of high-end audio has spawned a more convoluted 'alphabet soup' of technical terms and abbreviations than has digital audio. Indeed, the topic has given rise to so many TLAs (three-letter acronyms) that at times it seems almost impossible to keep them straight in one's mind. We present here a minimalist glossary that, while by no means exhaustive, covers at least a few of the more common acronyms and terms you are apt to encounter when you go shopping for digital audio components.

AAC

This acronym stands for ‘Advanced Audio Coding’, which is one of several coding standards for lossy digital audio compression (see ‘Compression’ in this glossary for more details). AAC was originally developed as the successor of MP3, which is another form of lossy compression. AAC is generally thought to deliver somewhat better sound quality than MP3 for any given bit rate.

AAC comes up often in product specifications sheets because it is the default audio format for such popular products and services as: YouTube, iPhone, iPod, iPad, iTunes, and the Sony PlayStation 3.

ADC

The acronym ADC (sometimes also shown as ‘A/D’) is shorthand for ‘Analogue-to-Digital Converter’. Realistically, not many audiophiles own, or would have any reason to own, ADCs, but it is worth bearing in mind that recording studios and production houses use ADCs in order to create the digital audio music files that most of us enjoy.

ADCs receive analogue audio signals, sample those signals at very high frequencies (under the control of extremely accurate clocks) and then generate digital bit-streams (that is, multi-bit words of digital audio data) that represent the sampled analogue audio signals as accurately as possible. As with any other type of audio equipment, ADCs are not created equal and some have audibly superior performance capabilities to others.

AIFF

This acronym stands for ‘Audio Interchange File Format’, which is a digital audio file format developed by Apple. AIFF stores audio data in uncompressed pulse-code modulation (PCM) format and is therefore lossless. Because they are both uncompressed and lossless, AIFF files require more data storage space than compressed audio files would do, but the trade off—one that many audiophiles happily embrace—is that AIFF introduces no sonically deleterious ‘compression artefacts’ of any kind.

ALAC (and ALE)

The acronym ALAC stands for ‘Apple Lossless Audio Codec’, which is sometimes alternatively called ALE (for ‘Apple Lossless Encoding’). In short, ALAC is a method for compressing digital audio data in a completely lossless manner (meaning all of the original audio data is preserved).

ALAC was initially a proprietary Apple standard, but as of 2011 Apple made the codec available as open source and royalty-free software. Both iTunes and iOS devices support ALAC (whereas Apple systems and devices typically do not support other lossless standards), so that ALAC has become the de facto lossless compression standard for audiophiles who use Apple computers and/or iOS devices.

Note that AIFF and ALAC are not the same things. AIFF digital audio data is not compressed at all and therefore is inherently lossless; ALAC digital audio data

is compressed, but can be decoded for playback in a lossless manner. ALAC digital audio files are roughly one half the size of equivalent uncompressed files.

Bit

One unit of digital data, typically represented by voltages either above or below a clear-cut threshold and by convention held to represent a ‘1’ or a ‘0’ as used in binary numbers. Typically abbreviated as a lower-case ‘b’ – as in, “My DAC can handle PCM digital audio files at resolutions up to 32-bit/384kHz.”

Bit-rate

The speed, expressed in number of bits per second, at which digital audio data is processed or transferred from one device to another or playback. For example, one of the better sounding and more popular forms of MP3 transfers data at 320kbps (kilobits per second).

Byte

An 8-bit ‘word’ of digital data, abbreviated with a capital ‘B’ – as in, “I store my digital music library on a 2TB drive” (where 2TB means ‘2 Terabyte’). The digital word lengths used in digital audio are typically multiples of 8-bits: hence, 16-bit, 24-bit, or 32-bit words are frequently discussed.

CD

The acronym stands for ‘Compact Disc’, a physical storage format for digital audio commercially launched in the early 1980s by Philips and Sony. CDs are polycarbonate discs that incorporate a highly reflective metallic layer upon which ‘pits’ can be etched along with shiny spaces in between the pits, known as ‘lands’. The pits and lands effectively represent the ‘1s’ and ‘0s’ inherent in digital audio data.

By convention, CD standards are set forth in the so-called Red Book, which calls for



the digital audio data to be stored in 16-bit words of data sampled at a rate of 44.1 kHz. When writers talk about ‘CD resolution’ digital audio files, they will often refer to them as ‘16/44.1’ files. While CDs are arguably the most popular digital audio format on the planet, other storage formats are now on the rise, many of them offering resolutions (and, in principle, sound quality) much higher than that of CDs.

Clock

Digital clocks are extremely important in digital audio, both when encoding and decoding or playing back digital audio files. Since clocks govern the precise time intervals at which digital audio files are captured, and then later played back, it is critically important for clocks to be stable and accurate so that the intervals between clock beats are maintained with extreme precision.

The human ear is remarkably sensitive to clock timing errors, so that errors occurring down at the picosecond lever are thought to

be audible. The more accurate, stable, and precise a clock is, the better the sound of the component will be (all other things being equal). Some very high-end components use extremely exotic Rubidium (or ‘atomic’) clocks to achieve the ‘nth’ degree of sound quality.

Codec

A codec is a software or firmware program that can encode or decode a digital audio stream. The term ‘codec’ represents a condensation of the more cumbersome phrase ‘encoder-decoder’. Some popular codecs you may have heard of include MP3, MP4, ALAC, FLAC, Ogg Vorbis, and many more.

Compression

Compression is a data manipulation process where digital audio files are condensed in order to conserve data storage space. It is useful to think of compression, as it applies to digital audio, as a two-part process. First, digital audio files are compressed

to reduce them to a more compact and manageable size for storage; then, later on, the compressed files are decoded or de-compressed for playback. There are many types of audio compression algorithms, but they generally fall into two categories: lossy compression and lossless compression.

Lossy compression algorithms do the most efficient job of compressing data, but with the trade off that—when it comes time to decode the lossy files—only part of the original digital audio data is restored, while some is irretrievably lost (hence the name ‘lossy’). Two of the more popular lossy compression codecs are AAC and MP3.

Lossless compression algorithms are less efficient than lossy algorithms in terms of conserving storage space, but they have the benefit that—when it comes time to decode the files—fully 100% of the original digital audio data is restored. Most audiophiles perceive lossless compression to offer audible performance benefits vs. lossy compression (although there is some debate on this topic).

As broadband internet speeds continue to increase and very high capacity storage devices have become less expensive and more commonly available (even in small, portable, handheld devices) there is less pressure on audiophiles to conserve storage space, so that over time lossless compression algorithms have become increasingly popular. Two of the more popular lossless compression codecs are ALAC and FLAC.

DAC

This acronym stands for ‘Digital-to-Analogue-Converter’, with the DAC serving as an essential ingredient in any digital audio playback device. In simple terms, the job of the DAC is to receive digital audio data at extremely precisely clocked intervals and to convert that data into an analogue output that mirrors (or is proportionate to) the numerical values of the digital audio data received.

DACs can be, and often are, condensed to fit on single integrated circuit chips, with popular DAC makers including firms such as Burr-Brown, ESS, Texas Instruments, Wolfson, and many more. However, it is possible to create DACs from individual, discrete parts—an approach some audio component manufacturers have pursued in the interest of superior sound quality.

Either way, it is important to understand that the DAC devices used in a given component do not necessarily define or determine the component’s characteristic sound (other circuit elements also play a major role in determining sound quality).

DSD

The acronym stands for ‘Direct Stream Digital’, which is a digital audio encoding and decoding system developed by Philips and Sony as the format of choice for use in their higher-than-CD-resolution Super Audio CD discs (commonly called SACDs).

Unlike, PCM (pulse code modulation) formats, which store digital audio data in the form



of 16, 24, or even 32-bit words sampled or clocked at rates ranging from 44.1 to 384 kHz, DSD is a single-bit, delta-sigma modulated encoding process, but with extremely high sampling rates of 2.8224 MHz (known as DSD64) or 5.6448 MHz (known as DSD128). In principle, DSD files are extremely easy to decode for analogue playback, requiring only a basic low-pass filter. Some critics argue that DSD files have high frequency noise issues to contend with and that the delta-sigma process has some inherent errors that are difficult to overcome. Proponents of DSD, however, argue the DSD achieves a smooth, free-flowing, analogue-like sound that is often difficult for PCM to achieve.

While SACD discs have never achieved the popularity of conventional Red Book CDs, their underlying DSD file format has won widespread popularity in recent years, since many music lovers now prefer listening to files downloaded or streamed from the Internet (or a local network). DSD files can be streamed or downloaded via a transfer process called 'DoP', which stands for 'DSD over PCM'. This process does not convert DSD files to PCM format, but rather temporarily stores DSD data in PCM 'data containers' in order to simplify file transfers.

DSP

The acronym stands for 'Digital Signal Processing', a topic that comes up often in discussion of digital audio. One of the beauties of digital audio is the fact that, once analogue signals are converted into digital formats, they can be processed in

ways that would be difficult if not impossible to achieve solely through analogue means. For example, DSP can be used to implement complex digital filtering systems that can shape the sonic character of the ultimate playback presentation in extremely subtle and potentially desirable ways. Likewise, DSP makes possible certain elaborate equalisation (EQ) systems that would be very difficult to execute with a purely analogue EQ system. Finally, DSP allows designers greater control over various sonic variables including noise, transient response, resolution, etc. as well as greater control over various processing/playback artefacts.

Dynamic Range

In audio, dynamic range is the difference between the smallest and the largest usable signal that can be passed through a transmission or playback system; this difference is expressed as a ratio and typically is quoted in dB (decibels). The human ear is said to have about 140dB of dynamic range (which is also, in rough terms, about the same dynamic range as some of today's best microphones).

Since digital audio inherently involves creating digital representations of analogue sound waves, one question that arises is this: "Does the digital system have more or less dynamic range than the analogue signals it is attempting to represent?" All other things being equal, digital components with greater dynamic range often offer superior sound, in part because they do not lose low-level signals in noise, nor do they overload on very high-level signals.

Part of today's emphasis on higher-than-CD-resolution digital audio files involves the fact that 24-bit files offer dramatically higher dynamic range than do the 16-bit files found in CDs.

FLAC

The acronym stands for 'Free Lossless Audio Codec'. FLAC is one of the most popular and widely supported lossless audio codecs in use today, in part because it is an open-source, royalty-free software package, but also because FLAC readily supports metadata tagging, complete with storage of album cover art and the like.

Jitter

As mentioned under 'Clocks', above, timing is absolutely crucial in digital audio with particular emphasis on maintaining absolutely identical time intervals between clock pulses. Unfortunately, nothing is perfect so that small variations or errors between intervals can and do occur—errors called 'jitter', which will usually be quoted as worst case timing variations (for example: 'jitter: < /= 9 picoseconds').

As mentioned elsewhere in this glossary, the ear is extraordinarily sensitive to timing errors and thus can readily differentiate between clocks with errors measured in the parts per million vs. clocks with errors measure in the parts per billion. The point is that, all other things being equal, the digital playback system with the lowest jitter almost invariably sounds best.

kbps and Mbps

The former acronym stands for 'kilobits per second' and the latter for 'megabits per second'; both terms are used to express data transfer speeds. 'kbps' figures often come up in discussion of lossy compression codecs as a means of comparing the net amount of audio data one codec can supply vs. another codec (typically, the higher the data rate, the better the lossy codec's sonic performance will be).

You might, for example, see digital downloads offered in two types of lossy formats: 'MP3 (CBR at 128 kbps) or MP3 (VBR at 320kbps)'—where CBR stands for 'constant bit rate' and



VBR is short for ‘variable bit rate’. In this case, the MP3 128kbps digital audio file would take up less storage space, but the MP3 320kbps digital audio file would offer markedly superior sound quality.

One small tip: In talking or reading about acronyms like these bear in mind that a lower case ‘b’ denotes ‘bits’, while a capital ‘B’ denotes ‘Bytes’.

Metadata

Literally ‘beyond data’, metadata is information about the data itself. For example, in an audio file, this might mean the title track, the artist, the composer, the genre, date of recording, date of composition, the album cover, band members, and more. This information about the music is generally ‘embedded’ within the file itself, to be read and displayed by media players and music servers alike. Metadata is enormously useful for listeners, simply because ‘Good Vibrations’ is a more memorable file name than ‘a156e03c’ to humans. Older file formats (such as WAV) are less robust in preserving metadata than their more modern counterparts.

MP3

MP3 is one of the oldest and most widely supported lossy digital audio compression codecs in the world. Over time MP3, which was created by the Fraunhofer Institute in the early 1990s, has emerged as a free ISO (International Organisation for Standardisation) standard that has also been incorporated by the MPEG (Motion Picture Experts Group) as part of both the MPEG-1 and MPEG-2 Audio Layer III standard.

MP3 was instrumental in the explosive growth that personal digital audio device have enjoyed over the last 15 years or so, because it offered a means of substantially compressing large digital audio files so that even fairly large music libraries could be condensed to fit in devices with limited storage capacity (for example, early generation iPods).

MP3 also served, for many listeners, as an introduction to ‘perceptual coding’, where the general idea is to reduce the amount of data used to represent aspects of sound thought to be beyond the perceptual resolution of most listeners, while devoting data to the aspects of sound most readily heard

and perceived. The concept was to reduce dramatically the amount of data that needed to be stored while still appearing to deliver full fidelity sound for most listeners, most of the time. Naturally, the idea of throwing out potentially useful sonic data did not sit well with most audiophiles and has been a topic of controversy and heated debate ever since.

Networked Audio/Network Streaming

Music stored on a computer can be removed to devices distributed across a home network (more accurately, a LAN or Local Area Network). This typically involves storing music on a computer or network attached storage device, which also runs some form of music server program to store and order these music files. The music itself is played through a ‘media renderer’ in your audio system that is also attached to the same computer network.

Functionally similar to internet streaming, networked audio distributes your own music library within the local network, instead of relying on online providers to stream their own music. While the popularity of personal libraries stored locally looks set to wane as online services proliferate, the networked audio system is a great way to store all your existing music collection in one easily accessible place.

PCM (and LPCM)

The former acronym stands for ‘Pulse-code modulation’, while the latter stands for ‘Linear pulse-code modulation’; both are means of representing analogue audio signals in

a digital format. Many audiophiles use the terms PCM and LPCM interchangeably, though in fact the terms do not mean the same thing. PCM/LPCM is by far the most popular digital audio encoding format in use today.

Both PCM and LPCM sample the amplitude of analogue signals at precise and identical timing intervals. When each sample is taken, the amplitude of the signal is quantized and recorded as a multi-bit digital word. The difference between PCM and LPCM involves the manner in which signal amplitude is quantized; in PCM, samples are quantized to the nearest value within a range of possible digital steps, whereas in LPCM, samples are quantized to steps that are uniform in level.

The quality of PCM and LPCM encoding is largely controlled by two factors: the sampling rate (that is, the rate at which samples are taken) and the bit-depth of the samples taken (that is, the length in bits of the digital words used to represent each sample). As a general rule, all other things being equal, higher sampling rates and greater bit depths equate to better sound quality. Thus, a 24-bit/384kHz file of a song would likely sound superior to a 16-bit/44.1kHz file of the same song, assuming the master recording captured high levels of sonic detail and nuance in the first place.

Resolution

In simple terms, ‘Resolution’ is the catchall phrase most audiophiles use to describe the amount of digital audio data used to represent analogue audio signals. As a



general rule, the less data used the lower the resolution (and sound quality) will be, while the greater the amount of data used the greater the resolution (and sound quality) will be—up to a level where a perceived ‘point of diminishing returns’ is reached.

Generally speaking, lossy compression codecs yield what are considered low-resolution digital audio files. CD files, captured at 16-bits/44.1kHz are considered the standard, and files with higher-than-CD bit-depths and/or sampling rates are considered to be high-resolution files.

Can listeners hear the difference? In a word, yes. The only area where there is room for discussion involves the question, ‘When is high resolution high enough?’

Servers

This term is the shortened form of the term ‘music server’. Typically, music servers provide a means of storing large quantities of digital audio files along with user interfaces that facilitate loading, organising, and playing digital audio files. As a general rule, servers are typically thought to be self-contained units that not only store digital audio files, but also can deliver them for playback on demand.

Streamers

By definition, streamers are network-attached devices that may offer Ethernet, Internet, Wi-Fi, and/or Bluetooth connectivity, or any combination of the above. As a rule, streamers do not have storage of their own (apart from perhaps a relatively small amount

of on-board buffer memory), but rather are capable of detecting, accessing, and playing (or ‘streaming’) digital audio content from other network-attached resources, such as PCs or Macs, smartphones, tablets, or the Internet. Like servers, streamers have user interfaces to allow their owners to view, choose, and play audio content from the available network resources at hand.

UPnP/DLNA

UPnP (Universal Plug and Play) and DLNA (Digital Living Network Alliance) are similar sets of interoperability guidelines, allowing digital media devices to work together with little or no need for complex ‘handshaking’ protocols. Devices that fall under one (or more usually, both) standards are designed to be compatible with one another as standard, and fall into three broad categories for audio systems: control point (which might be an app on a tablet), media renderer (the network-attached DAC or streamer), and media server (that might be a computer or NAS drive).

WMA

This acronym stands for ‘Windows Media Audio’ a family of audio data compression codecs developed by Microsoft that together are part of the Windows Media framework or ‘ecosystem’.

There are four WMA codecs:

- The original WMA codec is a lossy compression algorithm comparable to MP3.
- The WMA PRO codec supports multi-channel or surround sound files (with up to eight discrete channels) and

supports ‘high resolution audio’ (at up to 24-bit/96kHz levels).

- The WMA Lossless codec is a lossless compression algorithm.
- The WMA Voice codec is a low bit-rate, lossy compression algorithm focussed specifically on conversational voice content.

WAV (or WAVE)

This acronym stands for ‘Waveform Audio File Format’, which was developed by Microsoft and IBM and which is an uncompressed and therefore lossless file format that typically uses LPCM encoding. In theory, WAV supports compressed audio as well, though this is rarely seen in actual practice.

WAV and AIFF files are compatible with Windows, Macintosh, and Linux operating systems.

In simple terms, WAV—much like AIFF—is all about preserving maximum sound quality while eliminating compression artefacts of any kind. Two drawbacks are that WAV files take up considerably more storage space than files encoded by lossless compression codecs and that WAV files do not lend themselves to storage of album/song-related metadata. Recognising the sonic potential of WAV, many manufacturers of ripping and/or music server software have come up with workarounds to allow WAV files to be stored with associated metadata. +





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— Marc Mickelson, Editor, The Audio Beat,

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