R-2R non-oversampling DAC
Made by: AQ Technologies S.r.l., Milan, Italy
Supplied by: Elite Audio Ltd, Fife
Telephone: 01334 570 666
Web: www.aquahifi.com; www.eliteaudiouk.com
Price: £11,990

AUDIO FILE

hi-fi news OUTSTANDING PRODUCT

Aqua Formula xHD Optologic

The most novel high-end DACs often employ proprietary converter solutions instead of off-the-shelf chipsets. From Italy comes this unique take on the NOS 'ladder DAC'
Review: **Andrew Everard** Lab: **Paul Miller**

As we've seen in the past, notably in our review of its La Voce S2 DAC [*HFN* Aug '16], Italian company Aqua, *aka* AQ Technologies, tends to follow its own path in the design and engineering of its products. Based in Milan, and just coming up to the tenth anniversary of its founding by chief engineer and product designer Cristian Anelli, it bases its work on what it describes as 'dedicated research with creative thinking'.

This has led to a select range of digital products: a £6495 CD transport called La Diva, and a choice of three DACs: the £3395 La Voce S3, the La Scala MkII at £6295 and the flagship £11,990 Formula xHD we have here. All three DACs share a common converter architecture, of which more in a moment, while the pricier two also incorporate what the company calls 'Optologic' technology. The latter refers to the fact that galvanic (and magnetic) isolation, between the DAC's analogue and digital sections, is achieved via opto-couplers. All the same, to describe this as 'our proprietary Optologic D/A conversion system' seems something of a stretch.

STEPS TO SUCCESS

More to the point is the digital-to-analogue conversion set-up here, which eschews off-the-shelf chip-based converters. Its solution is based on a 'ladder' of resistors for each channel or – as in the Formula xHD – two ladders per channel, operated in differential mode for improved resolution and noise cancellation. These are fed with a proprietary digital signal derived from the inputs, generated within a Field Programmable Gate Array (or FPGA). Editor PM describes this in his boxout, p57.

The galvanic isolation bit comes in between the FPGA and the four 'branches' of the R-2R resistor ladders, thus keeping the entire digital conversion section, including the clocking, well away from any interference from the analogue circuitry, and vice-versa. In addition, the Formula xHD uses separate digital and analogue power supplies, all the way to a pair of C-core transformers and is built using discrete components, selected for sound quality and longevity.

The DAC uses no oversampling or digital filtering, and the analogue section is direct-coupled, with no capacitors in the signal path. The outputs are offered on either conventional unbalanced RCAs, or balanced XLRs fed from a transformer-coupled circuit – rare in consumer audio products, but *de rigueur* in the pro audio arena. Also, in common with all Aqua products, this one is of modular construction, with its various sections on separate circuitboards (all the way down to each 'ladder' here being on its own board), not just for ease of servicing but also to allow it to be upgraded in the future.

'There's a fluid, organic quality, and a glow to the concert hall'

WELL CONNECTED

In fact, all three of the company's DACs have already been subject to upgrades and improvements. Not only did the original Formula gain the xHD improvements in format-handling, processing and performance, but the model we have here, to give it its full name, is actually the Formula xHD Rev2. All that aside, the Formula xHD is a pretty simple device, its controls running to nothing more than power, mute and phase inversion flip-switches, plus selectors for the bank of digital inputs to the rear.

In addition to what Aqua calls its AQlink input, an I²S port to match the similar connection on the La Diva transport, using an RJ45 connector, the Formula xHD also offers more standard coaxial digital ins. There's an AES/EBU socket, and an asynchronous USB-B for computer connection, using a proprietary USB receiver implemented on an FPGA. The latter is a fully floating, isolated design that, along with heavily revised firmware for the main FPGA in the conversion system, is central to the xHD's improvements.

Windows users will need to download a driver for the USB option, but as is usual the DAC is plug-and-play with Macs or Linux computers. In addition, the DAC has a modular option – an extra interchangeable input, able to offer an extra AES/EBU or RCA coax, AT&T fibre or an optical Toslink.

Between the switches on the front panel is a bank of LED indicators, which light singly or in pairs to show the type of input signal the DAC is receiving. The single lamps cover sampling rates up to 384kHz, while paired lamps indicate up to 768kHz, and one-bit audio up to DSD512. These higher rates, and input of DSD in native form, are only possible via the USB and AQLink connections as the 'conventional' digital inputs are limited to 192kHz, and DSD via DoP (the custom DSP within the Formula xHD necessarily converts DSD to LPCM to suit the R-2R ladder).

HAND ASSEMBLED

Again, as with other Aqua products, this flagship DAC is entirely hand-built in Italy, and the standard of finish is exceptionally high, with solid anti-resonance aluminium casework finished in Nextel, sitting on four pointed isolating feet and available in a choice of silver or black. So the Formula xHD may be unashamedly expensive, but it's a long way from your average 'chip package, analogue output, power supply and case' design, and there's an awful lot of components hand-assembled together in there [see picture, p56].

An infrared remote handset is optional, but the DAC also offers an RS232 port to the rear for control in custom installations. Or, if you're using it with a computer, you can just select the USB input and forget all about the DAC – yes, all £12k-ish of it! What you're unlikely to forget is the performance of the Formula xHD. I'm not sure of the provenance of the review sample, aside from its grilling on PM's test bench [see Lab Report, p59], but after a week or so of gentle use in my system to let all those components warm up, when serious listening began I was both amazed and charmed by the music singing forth.

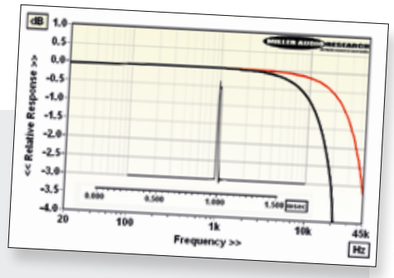
ABOVE: The Formula xHD uses solid aluminium casework with a Nextel finish; switches cover power, mute and phase, plus selectors for the digital inputs, with sampling rate indicator LEDs

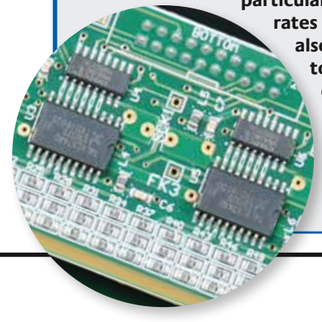
RIGHT: Two transformers [near left] feed separately regulated PSUs [centre left] that supply the XMOS USB input board [top left], Xilinx DSP [lower right], discrete ladder DACs [centre right] and analogue stages [top right]

LYRICAL LADDER

Like MSB [*HFN* Aug '19 & Feb '20], Aqua employs a precision-matched resistor ladder network to convert 'bits' into sequential steps of current. In an R-2R DAC the LSB (Least Significant Bit) is represented by the smallest current source, with each subsequent 'bit' twice the output of the last (a ratio of 1:65,536 over 16-bits). Burr-Brown's Sign Magnitude DACs were a popular commercial example of this technique, employing two R-2R ladder networks with resistors laser-trimmed to achieve a claimed 19-bit accuracy. Indeed, Aqua itself used Burr-Brown PCM1704 DACs in its previous La Voce S2 [*HFN* Aug '16] but, for its Formula xHD, has implemented its own modules, each with 68 chip resistors sequenced through a bank of four 8-bit shift registers [see inset picture].

Aqua's added 'twist' involves running these DACs at the incoming sampling rate, *ie*, with no up- or oversampling or digital filtering. With no time domain distortion, impulse tests [see inset Graph] appear entirely 'natural' with no artificial pre or post ringing (echo). Payback comes with aliasing distortions – particularly troublesome with lower (44.1/48kHz) sample rates [see Lab Report, p59] where the frequency response also rolls away through the treble from –0.8dB/10kHz to –3.1dB/20kHz [black trace, inset Graph]. The best of both worlds is realised at higher sample rates where the response reaches out to –0.6dB/20kHz and –3.2dB/45kHz with 96kHz files [red trace] and –0.1dB/20kHz, –0.6dB/45kHz and –3.0dB/90kHz (192kHz media) and where aliasing distortions are also pushed well out of the audio band. PM





WHIPCRACK FAST

Opening the listening with pianist Anna Fedorova's latest Rachmaninov [Channel Classics CCS42620; DSD128/DXD] I was struck by the clarity with which the Jared Sacks recording was conveyed via the Aqua DAC, especially in the *Rhapsody on a Theme of Paganini*. Not only is the presentation whipcrack fast where required, with a lovely sense of the attack and decay of each note, but the music is supremely easy to enjoy – there's nothing mechanical or artificial going on here – with a fluid, organic quality, and a real glow of the concert-hall ambience.

Even more, this DAC delivers the fluency and emotion of Fedorova's playing in magnificent manner, while giving the playing of the Symphony Orchestra St Gallen, here 'on their home ground' under Modestas Pitrenas, wonderful weight and drama. Nor do you need to stick to ➲

ABOVE: Six digital inputs are offered including S/PDIF (RCA and BNC), AES/EBU (XLR), USB-B for computer connection, I²S 'AQlink' (RJ45) and a module option for one more of the same (also Toslink optical). Fixed analogue outs are offered on single-ended (RCA) and balanced (transformer-coupled XLR) connections

'hi-res' recordings to hear what the Formula xHD can do. Playing *Heart Of A Woman*, Etta James's somewhat glossed-up 1999 album of love songs [Private Music/RCA 01005821802], it's striking how the quality of the voice shines through, even against the lavish arrangements here. It's hardly classic Etta, but it's still something of a spine-tingler in the way the DAC brings out all the scale of the accompanying forces while still retaining focus where it should be.

MAGICAL EXPERIENCE

Streaming the David Bowie *Is it Any Wonder* EP via Qobuz Studio [n/a cat no], the Formula xHD again does that intimacy thing with 'I Can't Read' before slamming and snarling into 'Stay' and then delivering Eno's now-remastered funked-up remix of 'The Man Who Sold The World' with gloriously deep bass and skittering beats behind a close-up yet reverberant view of Bowie's voice. The ability of the Aqua DAC to get deep into a recording and deliver it with crystalline clarity makes it a magical experience.

Whether fed in from a PC via USB, or using the 'conventional' digital inputs, the Formula xHD does a superb job with CD-quality music, even opening up the muddy mix of Billie Eilish's dense *When We All Fall Asleep…* [Interscope/Polydor 7742762]. I'm still not sure this display of youthful precocity is yet a set with which to fall in love, but at least through the Aqua DAC there's a greater awareness of what's going on within the production.

There are no such qualms with the latest remaster of The Tallis Scholars' recording of the Allegri *Miserere* [Gimmell CDGIM639; 192kHz/24-bit], for the combination of the 2019 wash 'n' brush-up and the sheer clarity of the converter brings us very close to 'surround sound' without the extra speakers. The voices soar into the lushly-captured Merton College Chapel acoustic, and Alison Stamp's top notes sound easier than ever. Just close your eyes and wonder at it all.

Similarly, the simplicity of *Raís*, a new album on the 'one take' Just Listen label [JL010; DSD 128], shows the ability of the Formula xHD to thrill with the sheer realism of voices and instruments, whether with the tender numbers or the more dance-influenced tracks, the trio set up and close-miked in a large space – as is all too apparent.

Due to the 'no edits' recording technique, the music has an immediacy that's infectious, and this is matched with a sound to die for, both recorded and reproduced. Dynamics are striking but never irritatingly so. This just sounds like real music, as if you are sitting in front of the performers listening, from each breath and phrase of vocalist Kris Berry to the way pianist Randal Corsen and guitarist Jean-Jacques Rojer are balancing their instruments with the voice.

It's simply a performance, captured, and the Formula xHD brings out all of that sense of listening in, rather than hearing something manufactured in a mix.

HI-FI NEWS VERDICT

The Formula xHD looks costly for a relatively 'featureless' DAC – even one hand-assembled – but then you listen, and it all makes sense. This DAC is revealing without being trying, lush but not bloomy, and above all capable of a sound so musical, whatever the source, that it's impossible not to be captivated. It'll breathe new life into old recordings, and have you exploring many new ones. It's simply magnificent.

Sound Quality: 89%

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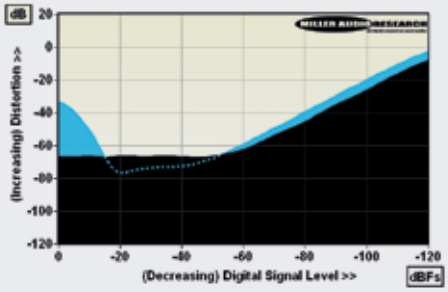
LAB REPORT

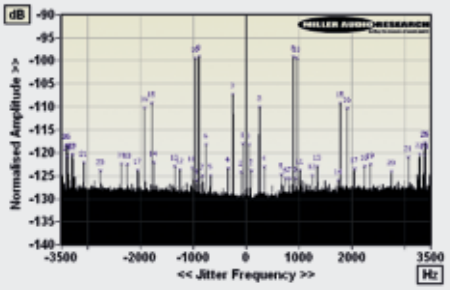
AQUA FORMULA XHD OPTOLOGIC

Although the Formula xHD's R-2R DAC concept shares certain technical parallels with MSB's DACs [*HFN* Aug '19 & Feb '20], its lack of any digital filtering brings it closer to CAD's NOS DAC [*HFN* Mar '16] in 'real world' performance. Aqua's FET-based analogue stage supports a 3.5V transformer-coupled balanced output, the latter isolating the system from circulating RF interference while blocking DC, but it does cause the output impedance to rise from 29ohm at bass/mid frequencies to 69ohm/20kHz. The 113dB A-wtd S/N ratio is up with MSB's DACs but jitter [see Graph 2, below] is slightly worse than both the MSB and CAD implementations at 910psec (48kHz) and 260psec (96kHz). Low-level linearity is excellent, however, with errors of just ±0.4dB over a full 100dB dynamic range.

The drawback of a filterless DAC [see boxout, p57] is the presence of digital 'images' directly outside the audioband – just 1.4dB down with 44.1/48kHz media. This causes moderate IM distortion within the audioband when treble levels are high (–65dB re. 20kHz/–10dBFs), but is less of an issue with 96kHz files and entirely absent at 192kHz+ sample rates. However, the most intriguing feature of the Formula xHD, and the one most likely to (positively) impact its subjective performance, is the remarkable consistency of its distortion vs. level over the top 50dB of its dynamic range [see Graph 1, below]. Distortion is certainly higher at very low and high frequencies at peak output (8% at 20Hz and 1.1% at 20kHz) but from 200Hz-6kHz it hovers almost unwaveringly at 0.04-0.05% over what amounts to the practical dynamic range of most recordings. The distortion is very extended (10th harmonic and beyond) so is more likely a function of the R-2R DAC modules than the analogue stage. **PM**



ABOVE: Distortion vs. 48kHz/24-bit digital signal level over a 120dB dynamic range (1kHz, black; 20kHz, blue)



ABOVE: High res. 48kHz/24-bit jitter spectrum via USB and S/PDIF inputs. Jitter is principally data-induced

HI-FI NEWS SPECIFICATIONS

Maximum output level / Impedance	3.52Vrms / 29-69ohm
A-wtd S/N ratio (S/PDIF / USB)	112.6dB / 112.8dB
Distortion (1kHz, 0dBFs/–30dBFs)	0.044% / 0.046%
Distortion & Noise (20kHz, 0dBFs/–30dBFs)	0.90% / 0.0050%
Freq. resp. (20Hz-20kHz/45kHz/90kHz)	+0.0 to –3.1dB/–3.2dB/–3.0dB
Digital jitter (48kHz / 96kHz)	910psec / 260psec
Resolution (re. –100dBFs / –110dBFs)	±0.4dB / ±0.8dB
Power consumption	9W (2W standby)
Dimensions (WHD) / **Weight**	450x100x370mm / 9kg