

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. +