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The Cutting Edge

Meridian Audio DSP7200

Digital Active Loudspeaker

Sue Kraft

photography by Joel Salcido

The precision, speed, and balance of Meridian's DSP7200 active loudspeakers are the most compelling argument I've heard to dispel the notion that separates are invariably superior to integrated components. While this prejudice is not unfounded and can, in fact, be true in many cases, when you invest in a "one-box system" from the world leader in digital technology, preconceived notions can easily sprout wings and fly out the window.

Sharing many of the same features as Meridian's state-of-the-art flagship DSP8000 active loudspeaker, the DSP7200 is more compact in design and intended for real-world living environments where space constraints can interfere with optimum setup and performance. My listening room turned out to be a nice fit for these British beauties, making installation a relatively simple task. At 121 pounds each, they may still require an extra hand or two for the grunt work, but after that, as long as you have a pair of inexpensive digital cables (CAT-5 or phono coaxial) along with a source CD player, you're good to go.

I was fortunate enough to have the ultimate in source components on hand, the newly updated Meridian 808.2i CD player/preamp. Both the 808.2i and DSP7200 offer a new SpeakerLink interfacing feature, providing balanced digital, Meridian Comms, and power via RJ45 connectors. You may experience a bit of cable withdrawal without the typical snake pit of wires plunked conspicuously in the middle of your listening room, but your significant other, therapist, and wallet will thank you as cable angst becomes a thing of the past—without any sacrifice in sound or performance. Hook-up was painless: Remove a small access panel on the rear of each speaker, run a CAT-5 cable from the output of the 808.2i to the input of the speaker marked "Master" and then a second cable from the output of the master speaker to the input of the speaker marked "Left," and that's it. My friend (who had assisted with the unpacking) and I both agreed: We could easily live without the busted nails and scraped knuckles you get trying to alligator-wrestle twenty-pound cables into a two-pound space.

> Meridian makes the most compelling argument for integrated components

In the event your room is environmentally challenged, Meridian offers boundary adjustments via the included remote control. There are corrections for corners, speaker placement (too close or too far away from the wall), or subwoofers. And for the tweaker in all of us, there are further fine-tuning controls for bass, treble tilt, listening axis, balance, and absolute phase. For first-time users, the instructions are straightforward and easy to follow. Also, the adjustments are more subtle in nature, not the typical "tone controls" of times past. While you might need an afternoon or two of experimentation to dial in the DSP7200 to your personal tastes, I wouldn't worry. Most of you will be awe-struck by the DSP7200 straight out of the box, and the fine-tuning will simply be icing on the cake. (My biggest problem was just getting used to the feel of the remote. I'm a bit of a klutz when it comes to the two-handed variety.)

Room correction (boundary controls) make for an extremely versatile loudspeaker should you be relegated to a basement or spare bedroom—or forced to relocate. When I was in the market for a new home some years ago, one of my top priorities was to finally have a decent sized listening room to accommodate a larger variety of systems and loudspeakers. Had I the luxury of DSP loudspeakers at the time, my priorities might have been quite different. As it turned out, I found the perfect room complete with fireplace and arched doorways, but now have to squeeze my car into a garage the size of a tool shed. Fellow car enthusiasts know what a difficult trade-off that one can be.

Placing the speakers several feet from the back wall (as recommended) and 7–8' apart yielded a seamless integration seldom (if ever) heard with separate components. While the DSP7200 needed a few days of warm up to fully gel, I was impressed straight away, especially with the extraordinary depth and dimensionality, and the uncanny ability of this speaker to precisely place images in the soundstage. As gorgeous as the DSP7200 may appear on the outside (I've not seen better), the elegantly curved cabinets and high-gloss lacquer finish do not begin to tell the story of the technology within.

The only clues (other than listening) are the massive heatsink fins on the back panels of each speaker. Each of the four drivers (two 8" woofers, one 6" mid, and one 1" aluminum dome tweeter) has its own dedicated 100W Class A amplifier without the degradation often associated with long runs of speaker cable. The DSP7200 also houses the latest in digital converters with four 24-bit, 128x-oversampling DACs in addition to a preamplifier. (For the purposes of this review, I used the built-in passive preamp of the 808.2i.) My only real criticism about the DSP7200 is that I couldn't find a latch to pop open the hood and take a look inside. My eyes and ears have been at odds for months trying to reconcile breathtaking performance with simplicity of operation and design.

I'm still finding it difficult to describe any one aspect of this speaker, as my attention was invariably drawn back to the music. So although my notes are sketchy at best, the experience won't soon (if ever) be forgotten. (Who doesn't have a system or two permanently tucked away in her acoustic memory? This would be one of those for me.) The DSP7200 easily redefines the term "boundary-less soundstage." Most speakers have a soundstage with a definite beginning and end, almost like a box around your system with audible walls. It could be a very large, spacious box, but still a box. The soundstage of the DSP7200 has no walls, similar to what I've only experienced with high-resolution formats. The most noticeable missing wall is in the front. The musicians simply appear in the room, as if sculpted out of thin air, with no regard to speaker location. Only at the live event would you hear something similar. If you're given the opportunity, this one attribute alone would be worth a trip to hear the DSP7200. It is quite spectacular.

The wholeness and precision of images are as good as or better than the best I have heard previously. Unless you are incredibly lucky, it may take years of fine-tuning and component swaps to equal this level of seamless integration. The idea that your dream system could be miles down an ofttimes bumpy road is off-putting to some who might otherwise be interested in high-performance audio. While audiophiles seem to thrive on this rollercoaster ride, there are music lovers who just want to enjoy their favorite artists in the privacy of their own home without all the angst. Not to mention having a conglomeration of mismatched components straight from Lirpa Labs in the middle of their listening/living rooms. (I have been asked several times over the years if I made my own equipment. Though I didn't reply, I assumed that wasn't intended as a compliment.)

From the thundering dynamics of the *Titanic* soundtrack [Sony] to the hauntingly beautiful vocals of Eva Cassidy's *Songbird* [Blix Street] to the tonal purity of Keith Jarrett on piano in *The Carnegie Hall Concert*, the DSP7200 handled every kind of music with expertise. Where I expected a solid-state flavor I heard only neutrality and musicality. The treble was smooth but not smoothed over, and extended as far as I could hear. Every last bit of nuance and whisper-soft detail is extracted, at least all that the recording will now allow us. No doubt within a few years I may be eating my words, as digital has been a work in progress for over 25 years and I wonder sometimes if we've even scratched the surface of its potential.

With a separate, ported enclosure for the two bass drivers, the reach into the bottom octaves of the DSP7200 is impressively deep. But more than the depth, it's the striking quality of the bass that will stay with listeners. The solidity, speed, clarity, and tight control in the bottom end are part and parcel of a near-perfect top-to-bottom seamlessness, which results in accurate and precise images throughout the entire frequency range. It is rare to hear this kind of definition, solidity, and space between images extend so far into the nether regions. You won't need your imagination to fill in the blanks with the DSP7200. All the musical bits are there, recreated in an absolutely stunning fashion. **TAS**

SPECS & PRICING

DSP7200 loudspeaker
Type: Three-and-a-half-way digital active loudspeaker
Driver complement: Two 8" bass, one 6" mid, one 1" aluminum dome tweeter
DACs: Four 24-bit 128x oversampling
Power: Four 100W @ 4 ohms power amplifiers (one per driver)
Frequency response: Within 3dB from 30Hz to over 20 kHz
Inputs: One phono digital (S/PDIF), one balanced digital (AES/EBU) on RJ45 connector
Outputs: One RJ45 with balanced digital and S/PDIF
Dimensions: 42.25" x 13.75" x 16.75"
Weight: 121 lbs. each
Price: $34,995 per pair

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ASSOCIATED EQUIPMENT
Meridian 808.2i CD player; Chang Lightspeed Encounter & CLS 705 powerline filter; Echo Busters & ACS room treatment

Meridian 808.2 Signature Reference CD Player

A Turning Point in CD Sound

Robert Harley

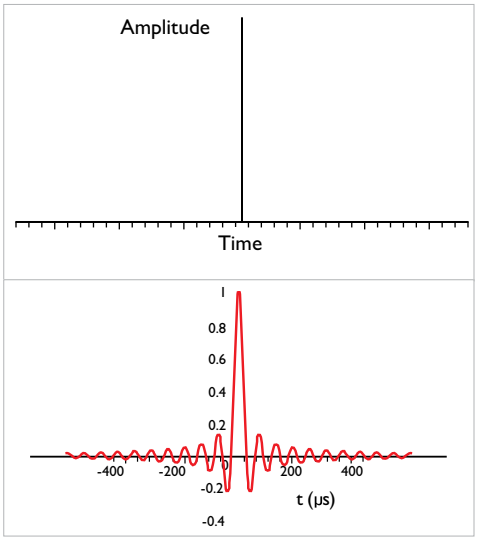
It's been a great privilege to have had a front-row seat listening to and reporting on the improvement in CD sound quality over the past 20 years. Every step forward in playback technology has rendered smoother textures and a more open soundstage, and fostered a greater sense of ease and enjoyment.

Despite these advances, CD has been fundamentally limited, we assumed, by its too-low sampling rate (44.1kHz) and too-short word length (16 bits)—parameters dictated by the state of late-1970s technology. Moreover, the vast majority of CDs in our music libraries were created with sub-optimum conversion and mastering technology, imprinting our favorite music with hardness, glare, and flatness. I've held a secret fantasy of hitting the lottery and using the money to re-master some of my favorite music (none of which has commercial potential), just so that I and other fans could replace our poor-sounding CDs with the best that today's mastering technology can deliver. As much as CD playback has improved, it's still fundamentally limited by the format's parameters, and our libraries are plagued by the distortions introduced by the brickwall filters in A/D converters.

But what if it were possible to design a CD player that didn't suffer from the characteristic distortions we thought were inherent in the format? What if the problems of CD were not primarily the result of the 44.1kHz sampling and 16-bit quantization but rather of another form of distortion that *could be removed* during playback? Could a CD player be designed that would make our CD libraries sound like high-quality re-masterings at worst, and approach the sound of high-resolution at best?

CD playback recently took a step in that direction, courtesy of the Spectral SDR-4000 Pro CD player (reviewed in Issue 190) and the Berkeley Audio Design Alpha DAC (reviewed in Issue 189). Both these devices ameliorated many of the sonic shortcomings that seemed endemic to the CD format. They both employ custom digital filters that avoid a characteristic distortion that is largely responsible for "CD sound."

That distortion is "pre-ringing," illustrated in Figures 1 and 2. Figure 1 is an impulse, created by setting one sample at full scale and all other samples at zero. The horizontal axis is time; the vertical axis is amplitude. The "impulse response" of a perfect system would look like Fig. 1. But in the real world, digital filters spread out that impulse of energy over time (Fig. 2). Notice that some of the impulse's energy appears *before* the impulse itself. This time smear, which can last up to 2ms on either side of the impulse, is called "ringing" (the impulse sets the filter ringing as does a hammer striking a bell), and the energy before the impulse is called "pre-ringing." Pre-ringing is introduced by the brickwall anti-aliasing filter in the A/D converter, as well as by the linear-phase reconstruction filter in CD players. Although analog filters ring because of the resonant elements in their filters, the ringing always occurs *after* the signal that set it ringing, never before it. Pre-ringing is unique to digital audio. Think of the impulse as a musical transient. Now think about how bizarre it is to hear part of a signal before the signal itself. Such a non-causal situation never occurs in nature and, consequently, is highly audible.



Ringing in the audioband can be avoided with high-sample-rate digital audio. This is why, all other factors being equal, 96kHz-sampled audio sounds better than 44.1kHz—not because we can hear information above 20kHz. In fact, this pre-ringing is largely responsible for the characteristic "CD sound" of hard textures, flat soundstages, a top-end that is simultaneously closed-in yet bright, and a general lack of an impression of instruments existing in space. Some recent products with so-called "minimum phase" filters don't exhibit this pre-ringing. These products have greatly improved the musicality of the CD format, and have even allowed us to hear poorly recorded discs with a newfound sense of ease and enjoyment.

Now comes the Meridian 808.2 Signature Reference CD player and its "apodising"[1] digital filter that not only doesn't introduce pre-ringing, but also *removes* pre-ringing that was imposed in the analog-to-digital converter used to record/master the CD (or other subsequent signal processing). This is a startling development; the ability to remove this significant source of degradation that is imprinted on all the music in our CD libraries is nothing short of revolutionary—and a milestone in the history of digital audio. The filter, which has some other interesting properties, is described in detail in a pair of Audio Engineering Society papers by Dr. Peter Craven ("Anti-Alias Filters and System Transient Response at High Sample Rates" and "Controlled Pre-Response Anti-Alias Filters for Use at 96kHz and 192kHz"—see also Bob Stuart's "Coding for High-Resolution Audio Systems"). The papers include an explanation of how the apodising filter can remove ringing already in the signal that was added by digital filters further up the chain.

So how does the 808.2 and its apodising filter sound? In a word or two, very "un-CD-like." Seconds into my first listen to the 808.2 I was immediately stunned by the player's three-dimensionality and the sense of space between instruments. Although I've written in the past that certain digital products had a deep soundstage with instrumental images laid out along a continuum from front to back, none of them equaled the Meridian in this regard. In fact, listening to the 808.2 was like walking into a life-sized diorama, so realistic was the soundstaging. This wasn't one of those differences that you have to listen closely to hear, or one that takes some time to appreciate. Rather, it was a wholesale transformation of the CD listening experience. In this regard, the 808.2 is a singular achievement.

The soundstage was fundamentally different from any other CD I've heard. Conventional digital playback tends to sharpen image outlines and flatten them in an almost cartoonish way. Yes, one can clearly localize an instrument, but the instrument's image has no life and breath surrounding it. The Meridian transforms this aspect of CD playback, presenting images with a halo of air around them and a jaw-dropping sense of the instrument existing in three-dimensional space rather than being pasted against a flat background. I could hear the expanding air around an instrument's dynamic envelope, just as one hears it in life. The mighty Spectral SDR-4000 Pro and the Berkeley Alpha DAC also addressed this shortcoming of CD by opening up the soundstage to an unprecedented degree, but the

FEATURES & FUNCTIONS

The 808.2 comes in two flavors: a straight CD player with a fixed output level (808.2), and a CD player with a variable output and full preamplifier functions (808.2i). The units look identical from the front, and share their styling with other Meridian 800 Series products. And although the 808.2 looks like the 800 CD player, virtually every subsystem is new for Meridian's all-out assault on the state of the art in CD playback.

The front panel contains a large display that shows the disc track and time, function ("Loading," for example), and on the 808.2i version, the selected input and volume setting. The 808i also offers the options of using it in fixed output-level mode and accepting external sources. Transport controls are arranged in a row of very large rectangular buttons beneath the display. A fold-down door, signed by Meridian founders Bob Stuart and Alan Boothroyd, accesses less-used transport controls such as scanning and repeat. The 808.2i version adds source selection and volume buttons behind the door. The remote is a large, two-handed affair that can operate a complete Meridian system. Thankfully, it includes an absolute-polarity switch.

The rear panel contains lots of jacks and connections unique to Meridian (the 808.2 will often be used to drive a pair of Meridian's active digital loudspeakers). In addition to the proprietary Meridian connections, an RS232 port is provided along with three trigger outputs. Analog output is on balanced XLR jacks and unbalanced RCAs, and a digital output is available on an RCA jack. Note, however, that the digital output is at 88.2kHz, not 44.1kHz. The 808.2i version offers six unbalanced analog inputs, three coaxial digital inputs, and two TosLink digital inputs. These inputs can be named by the user, with the name appearing in large letters on the front-panel display.

The 808.2 is the culmination of Meridian's 26 years of experience in CD-player design. The unit is based on a CD-ROM drive with the ability to re-read, at high speed, sections of the disc that contain errors. The data are put through a FIFO (first-in, first-out) buffer, and clocked out with high precision. A DSP with 150 MIPs (millions of instructions per second) of horsepower then upsamples the data to 176.4kHz at 24 bits. As mentioned in the review, the digital filter is a custom design running on a separate DSP platform. The DACs are Delta-Sigma types capable of running at 192kHz. Much attention was paid to minimizing jitter. **RH**

808.2 recreates acoustic spaces, the relationships of instruments to each other and to that space, and the impression of three-dimensionality like no other CD player I've heard. Moreover, this palpability of instrumental images was heightened by the blackness of the 808.2's backgrounds and increased contrast between the instrument and that background. The dead-silence between notes seemed to make images that much more believable as instruments existing in an acoustic. These qualities created an almost spooky sense of palpability and realism.

The way notes decayed was also different from any other CD player I've heard, with the notes seemingly decaying more gradually and hanging in space longer. The sound was the antithesis of dry and truncated. I'm not just talking about the ability to hear deep into the reverberant field of the hall (which the 808.2 is also superb at reproducing), but into the duration and decay of the notes themselves.

The 808.2 playing CDs also sounded very much like a high-resolution source in its ability to resolve individual musical lines, even those of quiet instruments at the back of the stage during loud, dense passages. I experienced a sense of ease, as though my brain weren't working as hard to unravel the sound into musical meanings. Instead, I felt what could be described as "intense relaxation," as the music came to me in an utterly natural, unforced way.

The 808.2's bass and dynamics were good, but not the state-of-the-art as were other aspects of the presentation. The bottom end tended to be polite and refined rather than visceral and driving. The Berkeley Alpha DAC, for example, has deeper extension, more weight, greater muscularity, and wider dynamic impact.

This minor point aside, listening to favorite and familiar music through the 808.2 was mind-blowing. It was as though my CD library had been re-mastered, so great was the improvement. To hear newfound spatiality, bloom, air, dimensionality, and ease in old favorites was immensely rewarding—and a totally unexpected technical achievement. CDs I've listened to for decades opened up and delivered more musical expression than I've heard from them before—or ever expected to hear from them. Of course, poor recordings won't sound like audiophile discs. But the 808.2 will allow them to be heard without being overlaid with the problems we've long associated with CD.

CONCLUSION

The Meridian 808.2 is, in my estimation, the most significant product in the history of the Compact Disc. Through an incredible and unlikely stroke of fortune (the ability to remove pre-ringing after the fact), the genius of the apodising filter's creator (Peter Craven), and Meridian's 26-year expertise in CD player design, our CD collections can be played back with a degree of musical involvement no one in his wildest imagination thought possible from the CD format. **TAS**

[1] **The term "apodising" comes from optics and radio astronomy. Sharp edges at the boundaries of optical lenses or radio dishes create ripples in the diffraction pattern, analogous to the ringing in digital filters. In radio telescopes, the contribution from the outer edge of the disc is attenuated to reduce this effect, a process called "apodisation."**

SPECS & PRICING

808.2 CD player/ 808.2i CD player/preamp
Formats: CD audio, CD-R, CD-RW, MP3
Inputs: Six analog unbalanced phono, three coaxial S/PDIF digital, and two TosLink optical
Outputs: One analog unbalanced, one balanced XLR, one digital S/PDIF coaxial, one RJ45 (AES/EBU) balanced
DACs: 192kHz-capable, 24-bit, Delta Sigma operating at 4x CD sample rate
Dimensions: 18.9" x 6.9" x 16.2"
Weight: 40 lbs.
Price: $15,995 (808.2)/ $16,995 (808.2i)

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In perfect harmony.

Experience exceptional sound in beautiful surroundings – the natural partnership of Meridian's DSP7200 loudspeakers and 808.2 Signature Reference CD Player. Within its elegant, curved profile, the DSP7200 harnesses powerful digital signal processing to reproduce outstandingly pure and dynamic audio. Meanwhile, the 808.2 delivers the best-ever Meridian sound from Compact Disc – thanks to its advanced features, including a proprietary digital filter system that can even correct errors in the original recording, for crystal clear sound and stereo imaging.

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MERIDIAN

Meridian Audio's Bob Stuart

Talks with Robert Harley

J. Robert Stuart is a singular individual in high-end audio as well as in audio science. He brings to high-end product design the insight gained from a formal education in psychoacoustics along with decades of original research in that field. Concomitantly, his scientific work is informed by a high-end aesthetic that embraces the individual listening experience.

The titles of a few of his Audio Engineering Society papers reflect Stuart's decades-long quest to correlate what we can measure with what we can hear: "Predicting the Audibility, Detectability, and Loudness of Errors in Audio Systems," "Estimating the Significance of Errors in Audio Systems," and "Implementation and Measurement with Respect to Human Auditory Capabilities" are just a few of his many published works. He was made a Fellow of the Audio Engineering Society for the first two of those groundbreaking papers. No other person I'm aware of can move so comfortably between the often-conflicting worlds of the audiophile and the academic.

The result is the powerful fusion of the theoretical and the experiential exemplified by the products of Meridian Audio, the company Stuart co-founded in 1977. Among Meridian's innovations are the first "audiophile" CD player in 1983 (a modified Philips machine), the first digital surround-sound processor, the development of the lossless coding algorithm adopted for DVD-Audio (now the basis of Dolby TrueHD), and the first active loudspeaker to use digital signal processing (DSP). Stuart has been at the forefront of improving CD sound, as well as advancing the cause of high-resolution digital audio.

Bob spoke to me by phone from Meridian's factory in Cambridge, England, about his approach to audio design, the new 808.2 CD player, and the evolution of CD sound quality.

Robert Harley: **You are the only high-end designer I know of who has a formal education in psychoacoustics, and who uses that field as a basis for product design. How has your work in psychoacoustics influenced Meridian products?**

Bob Stuart: Oh, completely. Almost every design decision we make in relation to the sound is informed by knowledge about how we hear. Because it's terribly important to know not only the value of each change you make but the way each component of the error the system makes is going to be interpreted.

What we're trying to do with any system is not just to minimize the errors that it makes, but to understand how each error operates in the context of the others. You absolutely have to understand psychoacoustics if you're going to come up with the *value* of the differences.

We've done lots of psychoacoustic modeling, studying it in order to determine where the most important areas are. We're working with all sorts of things ranging from thresholds, to loudness, to how one thing sounds in the presence of another. We work with timing, distortion—how much you can get away with, how much you can't get away with—and whether you're creating an error that is spatially disconnected from the thing that caused it in the first place. All these are very important. So yes, I approach audio design fundamentally from the way we hear.

What we're looking for is not only that we can hear a difference but also that it is more musically satisfying

Robert: **It seems like that would be a logical foundation for anyone designing audio equipment, but no one else seems to take that approach.**

Bob: Yes. It's odd, isn't it?

Robert: **Usually it's an electrical engineering approach.**

Bob: My brain comes at it from different directions. One is a deep love of music. Another is that I've got trained hearing; it started out being acute and then over the years I've learned to recognize certain kinds of things, particularly identifying the cause of a defect.

The errors that occur in an audio system have completely different dimensions. The kind of distortions a loudspeaker makes are completely different sonically from the ones that an amplifier makes, generally speaking. It's really important to understand how a human being responds to sounds. We don't hear sinewaves and noises and clicks and ticks, which are the vectors that electronics and acoustic engineers use to measure systems. When we hear a waveform there's a very complex cognitive process that follows—we immediately externalize that sound as an object. If you design on an electrical engineering basis you'd say that an amplifier only has to be flat from 20Hz to 20kHz and with distortion below "x." You're immediately starting out with a model that says I believe I understand completely how this all works, and I'm not giving any value to the subjective mapping or the interpretive mapping or the cognitive mapping of what's going on. So you can measure something objectively, but you know as well as I do that it's possible to design a system that measures well but is not satisfactory. That's why we inform everything we do not only with psychoacoustics, but with critical listening. You have to listen to everything.

What I think is outrageous is to say we understand everything about how the human hearing system works, because what we do know is that it's incredibly sensitive to certain kinds of differences and very tolerant of others. That's why you can get away with pretty horrific codecs for telephones, and why MP3 doesn't completely destroy the intelligibility of the content.

Robert: **The AES [Audio Engineering Society] tends to reject the individual listening experience, and the high end often relies on less-than-rigorous science in product design. You seem to move quite comfortably between these often opposing worlds.**

Bob: Well, first of all, I don't believe in black magic. Everything we do can be engineered to the best of our understanding.

Robert: **If the sound is different then the signal is different.**

Bob: Yes, the signal's different, or the *context* of the signal is different in some way. Maybe there's something going on which is changing the way we interpret other aspects of the signal. It could be spatial; it could be time-related. One of the reasons this is fascinating is that the very smallest details in the context of the music can make a step change in what we perceive.

Robert: **There's not a linear relationship between the objective magnitude of a change and the musical significance of that change.**

Bob: Absolutely not, and you'll have heard this many times. As you improve a system it'll sound the same, and then suddenly you'll realize that you heard something that you've never heard before. In the early days of CD we were working on a system and were listening to a very familiar recording that had a guitar in the back. One day we realized that we weren't listening to a guitar, but to *two* guitars. It's that kind of step change that is fascinating. Human hearing is non-linear on lots of levels, and because we have memory, we can never perform the same test twice. If a better system lets you hear an instrument you hadn't noticed before, for example, you can go back to a lower-quality system and will always hear that instrument.

Robert: **That brings to mind a conversation we had at CES about why blind listening tests may not be reliable. You said that when exposed to sound, our brain builds a model over time of what's creating that sound. The rapid switching in blind testing doesn't allow that natural process to occur, and we get confused.**

Bob: That's right. Perception happens on lots of different time scales. There's something called the conscious present, which is a period of time over which some of this integration into an object would happen. If you were dropped into a concert hall, how long

would it take you to really understand what it is you're hearing? It can take several seconds, or even minutes, before you're listening fully into the space.

Sometimes when you're looking for a difference between A and B, you can hear it quickly. Other times the difference between A and B can come on a time scale of minutes or even longer where you find that you've changed something and you don't notice a change but find that you have a very different connection to the music. But if you are doing quick switching that mechanism gets broken.

The problem with A/B switching, or blind listening tests, is that it doesn't always eliminate things that we find to be important on a lot of time scales. Obviously you can do blind listening on long time scales, and that's good. I don't tend to do a lot of that, because typically what we're trying to do is work out whether something we're doing has made a difference rather than to prove that you can hear it.

Listening is so multi-dimensional. It's always struck me as quite interesting that I can take a system where the speaker has certain, even gross, defects and maybe an amplifier has others, but we can change something very subtle in the digital signal processing that's feeding that chain and we hear it very clearly because this difference is on a totally different dimension than all the other defects. It's separated and independent, whether it's spatially or whatever it is. We go into listening tests to decide when we stop hearing a distortion rather than just arbitrarily playing one thing and another thing with no knowledge of what's going on. What we're looking for is not only that we can hear a difference but also that it is more musically satisfying. Did it take me closer to the artist? Does it inform me more of what the composer intended? Am I able to tell better what the instruments are? You can't always do that if you're not somehow in control of the parameters. Do you agree?

Bob Stuart and Alan Boothroyd show the 200 Series to HRH The Duke of Edinburgh on the occasion of winning the British Design Awards in 1988.

Robert: Absolutely. There's the related problem of trying to focus on specific aspects of the presentation to identify one over the other and missing the musical qualities you just described. It's those qualities that are the very reason we listen to music in the first place, and those qualities that distinguish very good from mediocre products.

Bob: Exactly. Sometimes it simply doesn't give you the context in which to make the judgment. And memory plays a part, as we discussed. If I'm listening to two presentations of a piece of music and in one of them I suddenly learn something about the performance, then it's going to inform the next one when I go back. So it tends to be something that you can't do too many times. If you had the memory of a goldfish, maybe it would work.

You can make a system which is bad enough that you can't hear the difference between these things, and you can create a set of circumstances where you can't tell the differences. It's been proven elsewhere that if you put people in a stressful situation maybe they can't tell the difference between quite surprising things.

Robert: Let's talk about the evolution of CD playback. When you modified that Phillips player in 1983, did you ever in your wildest imagination think that CD could deliver the level of sound quality that the 808.2 achieves?

Bob: No. We were fiddling about with digital before CD came out and we knew that it had a great potential to be better than analog in certain areas, particularly the area of pitch stability. CD had this attribute but had lots of other problems, and I don't think any of us thought then that 16-bit was enough. It clearly wasn't, from a basic psychoacoustic point of view, and 44kHz was certainly a bit tight. But when CD first came out it was kind of a miracle that it worked at all. You looked at the thing and asked, "How can this work?" Are we glad it wasn't 14 bit? Absolutely. Would we have had a different trajectory if the sample rate had been 48k? Yes, probably.

What I most remember is thinking that we should get involved in this. We looked at the CD, looked at the plans, and took the lid off a player and thought, "Wow! This has been designed by computer engineers, not audio engineers." We could clearly see what they had done wrong, and we saw an opportunity.

Robert: How much better can 44kHz, 16-bit get? Are we running out of all the performance improvements that are possible?

Bob: It's really hard to say that it'll never improve further. In the early days it was about improving the DACs and lowering the jitter. It was only when we were able to apply digital signal processing that we were able to get any more out of CD. From a purely psychoacoustic viewpoint, 16 bits isn't enough to cover the dynamic range we can hear. By using noise shaping we can get a lot closer.

Most recordings don't have an inherent dynamic range of 20 bits. In fact, if you go to a venue and look at the noise of the venue and the noise of the electronics and the microphone's inherent thermal noise, only a few recordings are better than 18 bits. So it's quite hard to get a signal which covers the dynamic range of

human hearing. However, we also know from psychoacoustics that you can hear things below the noise floor, especially if they're structured, and especially if they're correlated to certain signals we're listening to. So down in the threshold area 20 bits are okay, but 24 bits are absolutely much more than we need.

The question is whether the CD coding space [44.1kHz, 16-bit] is good enough. The answer is that it would be nice to have a little bit more, because it cannot transparently bring to a human listener everything that he can hear. In my AES paper on high resolution a few years ago, I asked the question "What are the parameters of a transmission channel that is completely transparent between the performers on a stage of a concert hall and a listener?" The answer is that it's actually more than 20 bits, and it really has to be wider than 44kHz.

Robert: How much of the characteristic "CD sound" that we've been listening to for the past 26 years is attributable to the time-domain distortion introduced by digital filters?

Bob: You've hit it exactly. There are some pretty horrendous digital filters. The easiest kind to build is the FIR [Finite Impulse Response], which has the nice property that it's linear phase, but it has a perplexing quality in that it's non-causal. You can put a signal into it and parts of the signal come out before the signal itself.

We've made 28 models of CD players and every one was better than the one before it, but this step feels like we've arrived somewhere quite new

Robert: The pre-ringing.

Bob: The pre-ringing. One of the big differences between a 96kHz sound and 44kHz is that both of them are going to have pre-ringing, but the ringing frequency is inaudible in the case of 96kHz but clearly audible with 44kHz. Why? Because the filter is going to ring at something below the half-sample rate, which puts the ringing in the audioband with a 44kHz sampling rate. The sampling frequency determines the time-domain performance. But more important is that part of the signal is coming out before the signal itself. We know from psychoacoustics that if the time domain is smeared and you have energy coming out before the main event, it's going to be extremely audible.

We set ourselves a challenge to design a filter for high resolution that didn't have this problem. We did a study with Peter Craven and developed the "apodising" filter that has some very natural properties. It rolls off smoothly above the audioband, and the ringing is gone.

Robert: And this is largely the reason for the 808.2's sound?

Bob: Yes. We were very, very pleased with the filter in listening tests with high-resolution sources. But the case of the 808.2 was a much harder problem. We realized that what makes high resolution sound better was the time-domain behavior, how transients are handled, and how we localize things in the soundfield. The apodising filter allows us to remove all the errors that are upstream. The ringing occurs after the event rather than before it. We would take high-resolution and standard-resolution recordings and ask, "Can we tell the difference using this apodising filter?" Generally the answer was "no." The filter gives us a tremendous coding advantage in making high-resolution recordings, but it also allows listeners to get the most out of the bulk of the catalog, which is on CD.

Robert: This is a really important thing—to extract more music out of the vast CD catalog.

Bob: Absolutely. If you're interested in the music and you want the artist or the performance or the interpretation, you have to listen to CD. We felt that it was time to take everything we learned from high resolution and try to make a CD player that makes CDs sound like high-resolution recordings. What would that CD player be like? It would have a psychoacoustically optimized filter that didn't have pre-ringing and that would remove the ringing from everything that happened before in the A/D converter. It's a complicated filter and it takes an enormous amount of computational power. We designed about 12 filters that measured the same but sounded different from each other. They had slightly different properties that I can't talk about because I'm confident nobody has anything like it.

Once you've listened to a CD played back like this and then go back to a conventional filter, even a very good one, you hear sparkle and glare in the recording. While working on this we used a recording of choral music made in one of Cambridge's chapels. I know the sound of the chapel well. In the silences between the singing, the soundfield was sparkling like it was phosphorescing because of the pre-ringing. The sound is almost a caricature, as though someone took a pencil and drew a hard line around every acoustic object.

Okay, you don't have the very low noise floor of 96/24, but you no longer have this sense that there was a problem at the top end because the sample rate's too low. It's open, and easy, like listening to high-resolution. Should we have done it earlier? Well, that's an interesting question.

Robert: How do you see the future of high resolution?

Bob: It's incredibly important that you capture the content and archive at the highest possible resolution. Even if it's going to be delivered on a storage channel like CD, you absolutely should capture it with all the information that we can hear.

But what intrigues me is that with the 808. 2 we've closed the gap. It takes you back much closer to the mixing desk. We've made 28 models of CD players and every one was better than the one before it, but this step feels like we've arrived somewhere quite new. **TAS**