Zen and the art of digital technology

LEST YOU FEEL THAT THIS PUBLICATION IS ANTI-CD WE HAVE ENLISTED THE TALENTS OF DR MALCOLM OMAR HAWKSFORD THE CD GURU.

Digital audio is often criticised by audiophiles as being in some way inferior to pure analogue. Criticisms vary from accusations of sterility to comments that it sounds veiled and lacking in that quintessential ingredient of musicality. I believe that this viewpoint may have much to do with the renaissance of valve circuitry, where the listener perceives virtue in the archaic technology of glowing tubes, plated metalwork, precious metals and the sonic signature intrinsic to many a thermionic amplifier. We even see this technology being applied to some CD players which use valves in the final stage of signal processing, as information flows from a digital to an analogue representation, in a final attempt to embed an analogue character to the sound — or should that read lack of transistor character.

A system that can simultaneously please several senses, that is sonically enlightening, is visually elegant and has an aesthetic and engineering beauty that extends from the material to the tactile, will endow confidence and excitement in the brain's pleasure centres. The harmonising of several sensual responses creates a sum that transcends the individual parts. Are we then using such an approach as a surrogate for technological deficiency?

I admit that valve technology offers a certain fascination and can deliver exemplary performance, but I am not convinced that it is necessary in the quest for ultimate sound quality, especially as the intelligent use of digital signal processing becomes more commonplace and is interfaced with correctly designed analogue circuitry.

The translation of an acoustical event through several energy conversions and stages of signal processing requires a precision that extends beyond everyday experience, especially as much of the performance must be gained open loop with little opportunity for correction other than in a local sense. In my view, simplicity is the key, especially within analogue stages, and this simplicity is proportional to the final quality of reproduced sound.

But even after the nostalgia has subsided, we are still faced with the question, 'Is digital audio flawed and is there a performance barrier that will ultimately bound sonic performance?'. Maybe this question is too premature. We sit at the dawn of creating a new era of virtual sonic reality, although to date the technology is not yet in place. So the question must be restricted to two channel stereo and a comparison made between existing analogue and digital systems. There are a number of arguments I would like to develop. However, I would like to open with my own opinion on digital encoding to counteract some of the persisting misconceptions that abound in the audiophile world, and to make clear the direction from which I approach our subject.

Fundamentally, I believe the theory that describes the digitisation of an analogue signal and its translation back to analogue

using uniform sampling and uniform quantisation with dither is exact. It fully defines performance boundaries which are sufficient to meet the requirements of the most exacting audiophile. The performance of a correctly functioning 16-bit system sampled at 44.1 kHz (with one proviso relating to ultrasonic bandwidth) is adequate for and possibly greater than that required for near perfect audio signal communication within a two channel stereo context. In simple terms uniform sampling will restrict the bandwidth to around 20 kHz while, with optimum dither and uniform quantisation, the quantisation distortion will translate to a benign and barely audible noise. This will behave in an identical manner to a low-level additional noise which is no more intrusive than the analogue noise generated by an amplifier. I believe this to be fact, and I leave it to my critics to disprove this statement in a scientifically acceptable way.

So what is all the fuss about; why do some digital systems and many recordings sound poor, and why are some DACs so expensive? At a high level, the answer is straightforward. The performance of electronics that try to meet the theoretical performance targets is deficient. In practice it is extremely difficult to design electronics that are so transparent that the boundaries dictated by the 16-bit/44.1 kHz specification is the limiting factor. Unfortunately, the imperfections at the ADC and DAC gateways are rarely musical and can endow the sound with an electronic and veiled quality that makes relaxation difficult, and a preference for pursuing other activities after about 20 minutes. There is by the uncertainty principle a fundamental law which implies that a piece of hardware can never be exact in its performance, and therefore by implication will embed a sonic signature, however small.

At the time when compact disc first entered the marketplace, my attention was focused on the design of analogue amplifiers for moving coil cartridges. This task proved more demanding than text book electronics would suggest, and several years passed until a definitive solution emerged that has already stood a 10 year test of time. This design is the kernel of the LFD MC disc preamplifier, but I must also acknowledge the significant contribution from Dr Richard Bews of LFD Audio. Richard has shown me the critical path of component selection which has proved crucial in maximising overall performance. I mention this design not only because it taught me to appreciate the interrelationship between topological minimalisation, de-sensitisation of power supplies, grounding architectures and component choice, but also because the same problems are encountered in the design of current-to-voltage converters (ie trans-resistance amplifiers) in multi-bit DACS. In fact the problems are so similar that they hold a significant fraction of the key to achieving the ultimate performance of a DAC.

Consequently, as an adjunct to my claim for digital coding theory, I would like to emphasise that the design of a DAC (or indeed, ADC) depends as much upon the analogue as the digital design, assuming of course that the digital processing is correct in an algorithmic sense, and that the interfacing protocols are also correct. Indeed, I prescribe to the view that the system is essentially analogue; it is only the information and the interpretation of it that is digital.

There are many factors that relate to the performance of a DAC, and in a more general sense a CD player, and I shall be debating these further in the future. My aim is to show a pathway to how the best performance can be achieved in the context of a digital system, to impart a better understanding of the principles, and to reflect upon the developing digital technology that promises to redefine the way we perceive an audio system. Clearly we are now poised at a technological juncture, and audio will never be the same again.

To conclude, I would like to reflect on two recent experiences, both to illustrate the performance convergence of analogue and digital audio, and to demonstrate how digital

audio can move on to extend the performance of your hi-fi system.

Last year, I had the opportunity to compare a recently developed DAC by SME with a very high quality analogue system that used the SME Model 30 turntable with Series V arm, LFD MC1 battery disc preamplifier, Krell reference power amplifiers and mass loaded and structurally enhanced Quad ELS63 loudspeakers. The comparison was performed in the music room of SME's Alastair Robertson Aikman, with access to the same recordings on both vinyl and polycarbonate (ie CD). After approximate synchronisation, the two systems could be auditioned, and the performance convergence was remarkable. This underpinned my faith in digital coding theory and also showed that when the colorations inherent in all analogue replay systems are reduced, then there is a correctness to the sound that transcends the method of storage. In this comparison I include all aspects of reproduced sound, from stereo presentation to scale, transient attack and overall tonal balance.

The second example I would like to describe relates to work done at Essex University on the digital correction of loudspeakers. Once a signal is in the digital domain it is possible to introduce exact mathematical processing without suffering the deficiencies of complicated analogue circuits with their loss of transparency, and transfer function alignment problems where phase response correction is virtually impossible.

The processor is inserted between a CD transport and an outboard DAC. The processor implements a digital filter whose transfer function is the inverse of the loudspeaker. Consequently, the overall system exhibits a near flat amplitude response with almost zero overall phase distortion; crossover defects are also corrected, at least with respect to the on-axis performance. Thus the system can to a certain extent cheat on the loudspeaker designer, and compensate for errors which are often too difficult to control by traditional analogue design. Some loudspeaker companies have hitherto been reluctant to embrace this technology, which they incorrectly see as a criticism of their products. In truth, the technique is a new tool that can be used to fine tune the performance of a loudspeaker in order to achieve greater overall accuracy. In fact our experience suggests that the better the quality of the loudspeaker the more rewarding are the benefits of fine tuning. Remember, analogue quality is not compromised as the additional processing is purely within the digital domain. This technology is here to stay and is I believe a pointer to the future.

We therefore have a powerful means of improving the performance of a sound system in a way that is difficult to achieve with pure analogue. Consequently, digital systems have the inherent ability to extend performance to a level of accuracy greater than that normally encountered. And if you return to the premise that digital audio need not be flawed, then the future is indeed bright, and we ought to be moving to embrace the new opportunities rather than looking back to a past era. Of course, the electronic design needs to be exemplary for these advantages to accrue, but doing this correctly need not be expensive. In fact it is the nature of things digital that costs can be reduced, given time. This should act as a warning for an industry that remains complacent with the ways of the past. However, the technology is now in place and can and will form a rewarding and exciting upgrade path.

In optimising the performance of a CD system there are several issues that need attention. These relate to the conversion method, jitter performance and special coding techniques that can extend the performance of the medium. In particular I want to address the question of audio bandwidth and the future role of surround sound, which in many ways is the final challenge in digital audio. In the meantime open your mind to the intelligent use of digital signal processing. The electronics are getting better and some designers really do care about sound quality.