

# **Comparison between CD-SACD-DVD-a and general discussion of recording quality**

**By Niklas Ladberg**

## **Introduction**

For a while I have been interested to find out how good the new high resolution formats Super Audio CD and DVD-Audio really are? I have visited some demonstrations, but not been impressed which may be due to other causes than the sound formats.

After reading many replies at different forums, it seemed like many audiophiles considered SACD to be better than DVD-Audio. I also thought so until recently read what Ing. Öhman wrote in the Swedish Audio Technical Society \* journal.

(\*A non-profit organisation for sharing interest and knowledge in audio and sound reproduction)

The following are quoted from what Ing. Öhman wrote in the journal:

*"It is nothing less than a tragedy that Sony/Philips system SACD still is considered to be a real competitor to DVD-A, though it has lower real resolution than the CD-system in the highest octave.*

*DVD-A does absolutely offer a much higher dynamic range than CD, but it is very questionable if SACD does.*

*SACD is in the high frequency range quite mediocre, even compared to a good CD-system one-bit DAC, and of course clearly inferior to a CD-player with a real multi-bit converter.*

*On the contrary, DVD-A is in theory 250 times better than the CD-system at all frequencies!*

*In today's reality though, it is hard to achieve such hyper-resolution, but maybe in the future? If the potential exists, recording and playback technology can evolve. Today the DVD-A resolution is about 16 times better than the CD-system and the bandwidth extends up to 100 kHz to be compared with 22,050 Hz for CD."*

Now I became curious! This is the opposite of what I thought. I asked Öhman for a follow up ...

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[Niklas Ladberg: How did you come up with these conclusions?](#)

Ing. Öhman: DSD (the coding technique used in SACD) is much better than CD in the low frequency range. The problems occur at higher frequencies. The noise level in the ultrasound register is more than 100 dB higher (-40dB under maximum output

level, using narrow band analysis) when compared to DVD-A (-144dB under maximum output level, full spectrum noise).

Another way to describe the difference: The noise [power] from SACD is more than 20,000 million times higher than from DVD-A!

But maybe it is more relevant to know that this ultrasound noise from SACD is enough to warm up the tweeters voice coil with some detectable influence on reproduced sound. Besides, the ultrasonic may also affect the audible sound by down mixing in the air, at least at higher sound pressures.

A comparison with CD is harder because of the limited bandwidth of the CD-system. Signal to noise ratios in the range above 22,05 kHz can therefore not be determined, but noise level from CD can be as good as DVD-A – one can always use low pass filter! Then no ultrasound comes out from the CD-player.

The problem with SACD can be shown by theoretical calculations, measurements and by listening. I have done lots of all these three and every one of them points clearly in the same direction: SACD has not more resolution than CD above 10kHz. Our early estimations some years ago have now been confirmed by measurements and listening, made both by us and others. Today, many studies have been done, for example by Stereophile who has tested SACD players several times and confirmed our estimations.

*NL: What does Stereophile say about the limitations of SACD?*

IÖ: Oh, not much in the written tests. Stereophile is an advertisement dependant paper and they are a bit careful to say anything negative about anything, but they present their measurements, often done by the sharp editor in chief John Atkinson. His comments are very informative! Although very careful, any equally sharp reader can decipher Atkinson's opinion from the text.

Stereophile also performed a large subjective listening test between some existing high performance recording formats and SACD was even considered to be inferior to PCM 16bit, 176,4 kHz.

Anyway, one should not take too much notice of "how many" said this or that. What is important is how things really are, not how many people believe this or that. Deciding truths by voting is seldom a good way. It can only show what people believe. Some peoples' beliefs might of course be right, but too often correct information and relevant listening experiences drowns in common misconceptions, preconceived notions and the media background noise.

This happens especially easy in this particular case since DVD-A and SACD never have been compared under equal conditions.

*NL: I read in a technical paper about SACD. Sony writes:*

***"The vast majority of A/D-converters used in PCM recording for conventional CD are 1-bit converters with high sampling frequency"***

*Then it must be better to keep the signal in DSD-format (SACD) than convert the signal to PCM (CD/DVD-A)?*

IÖ: Yes, that is correct, but is it relevant question? The CD-system seems worse than it is when used with a one-bit converter. The problem is not the conversion from a one-bit converter to PCM but the one-bit converter itself!

Besides, the one-bit converters used in CD-players usually have higher resolution than DSD, which only samples 64 times faster than CD-system sample rate (i.e. DSD sampling rate = 2.8 MHz). The low sampling rate in DSD is used because of the systems ineffective coding and lack of storage space. By packing the information it becomes a bit more effective but it still is ineffective compared to PCM.

One-bit converters for CD-players often use sampling rates between 11 and 50 MHz. The best one-bit converter probably is JVC's PEM-DD and it is much better than DSD. This said with reservation, I might have missed some even better one-bit technology than PEM-DD. But as far as I know this is the technology that comes closest to true multi bit technology in resolution.

*NL: I presumed that SACD uses DSD-technique for recording and mastering, but that turned out to be wrong:*

*Press release: "A big surprise at the AES was the confirmation by Sony that DSD technique, used in SACD, uses multi-bit PCM during recording and mastering processes and that only uses one-bit technique as it applies to consumer playback systems. Jim Johnston of AT&T Research speculated that DSD and DVD-A data streams might be able to co-exist if output from different points within the same microprocessor."*

*Apparently they use PCM for recording and mastering, even for SACD. Now the advantage of no conversion between formats suddenly disappears.*

IÖ: Several documents show this is the case. Sony/ Philips has even officially recommended using PCM when editing the recorded material. I think it is a wise recommendation, because every manoeuvre in the PCM-domain is straightforward, easy to make and will not degrade the quality if performed with high enough resolution. Only the DSD-problems remain!

Therefore DVD-A is a purer and more straightforward system. No conversion between different formats and 144dB resolution at all frequencies up to 100kHz. Could it be better? Well of course it can, it can always be better, but DVD-A is good enough. DVD-A is what the CD-system should have been from the beginning!

*NL: Back to the Sony technical paper:*

*"On the playback side, most CD-players utilise one-bit D/A-converter to convert digital signals back to analogue."*

*Is this correct? Don't most CD-players utilise multi bit-converters?*

IÖ: Though some fine multi bit CD-players exists, unfortunately most CD-players today utilise one-bit converters. It is probably a price question. A so-called 24 bit one-

bit converter (working with one bit technology inside but accept 24 bit input) costs about 2-4 dollars including 2 channels and digital filter.

A real 24 bit converter with 96 kHz sampling frequency and 8 times over sampling costs about 10-15 dollars per channel – without the digital filter. For two channels and digital filter it ends up to approximately 40 dollars.

So multi bit technology is ten times more expensive as one-bit technology. Most manufacturers find it easy to choose ... Especially since Hi Fi-magazines and Hi Fi-stores never take a stand and point out the difference.

*NL: From Sony again:*

***"Although the bit numbers is just 1/16 of that used for the CD-format, the sampling frequency is 64 times higher. DSD can accommodate more than 4 times the information as the current format."***

*4 times more information could not be wrong? Or is the depth of bits more important?*

IÖ: The number of the bits is much more important. Actually the DSD-system is theoretically less dense in information than the CD-system. Even when the data is packed (as it is on an SACD) it is still not much better.

When Sony declares that DSD-format can store 4 times the data, they probably mean that there is 4 times the space on the SACD-disc compared to CDs. But since the DSD-coding is so ineffective, the real information is considerable lower.

The resolution/ information doubles when you double the sampling frequency (it is possible to be more specific, but for this example it is enough). But to double the resolution using PCM, you only have to add one more bit. If you go from 1 to 16 bits (adding 15 bits which use approximately 15 times more storage space), the resolution increases 65,536 times (from one step to 65,536 steps).

There is also another essential difference; the increase in resolution you achieve from raising the sampling frequency will be frequency dependant. A one-bit system will therefore have high resolution at low frequencies (where the information theoretically is low) and have low resolution at high frequencies (where the information theoretically is high).

By the use of noise shaping of high order, it is possible to increase the resolution at "quite high frequencies" at the expense of resolution at very high frequencies, but *only* for static, non transient signals. Transient signals will have poor resolution in a one-bit system. If the signal does not endure for a long enough time, the error will not be minimised by the noise shaper of the one bit system.

That's why you can read in documents from Burr Brown (who manufactures both one-bit and multi-bit converters) that you should use multi-bit converters for "*waveform synthesis applications requiring very low distortion and noise*". They have not written this for nothing.

A one-bit converter (i.e. the DSD system) cannot regenerate a short pulse with stringent form. It will change form from moment to moment. Every identical recorded pulse will show up with a new form.

One can always discuss the audibility of such behaviour, and if it is audible, one can discuss how much it disturbs. Objectively good reproduction is not important for everyone. So if the presentation of music is changed in some way, some people might see this as a minor problem, others think it is more serious.

It is beyond discussion that the lower resolution of one-bit systems is a problem under circumstances more precision demanding than audio. When you need both super precision and stability, when you need to know that a generated waveform looks like it is suppose to, nothing but multi-bit converters will do.

My entirely personal opinion/experience is that audio actually demands very high precision, and that the reproduction suffers from the lack of precision from one-bit converters and the DSD-system.

Perhaps I even prefer the old 13-bit PCM-based Denon system from the 70s. It was not a super high-resolution system, but it was as stable as it was consequent! I have a lot of these recordings (reissued on CD) and they actually sound fabulous!

*NL: From Sony's paper ...*

***"In general, the quantisation noise floor resulting from PCM is flat, according to the number of bits. With Delta Sigma modulation the noise floor is subjected to noise shaping. Because the DSD method uses a high sampling frequency, the quantisation noise is shifted to a higher frequency range. This reduces the amount of noise in the audible range for humans, which is relatively low."***

*Is this correct?*

IÖ: Yes, the first part, but one should be careful not to underestimate the hearing, as Sony does – or you end up with systems like SACD! Of course we can only hear single tones up to 20kHz but this does not implicate that we can allow any kind of noise pollution above this frequency. Multiple tones in the ultrasound can create clearly audible phenomenon at higher sound pressures.

It can be discussed if we can tolerate the ultrasound noise generated from SACD. The noise from SACD just above 100kHz is higher in level than most of the treble in the audible range, at least when listening to the majority of acoustical music. It can also be discussed if DSD uses a "high" sampling rate. But apart from that: Yes, without noise shaping it will not work at all and that would be a lot worse. Now it is only a little bit worse than CD in the highest treble.

But why introduce a new super high-resolution system, that is "a little bit worse" than CD? Of course there are advantages when compared to CD also, but the drawbacks of SACD/DSD are completely unnecessary. Shouldn't a new system be better than CD in all aspects?

The noise level in the range above 100kHz is –40dB under maximum signal level (and is thus even visible on an oscilloscope!). The noise is in fact much higher than

any possible music signal in the same frequency range. This can be compared to DVD-A where the noise level is  $-144\text{dB}$  in the whole audible range and also in the ultrasound range.

In reality these figures have not yet been reached in commercially available DVD-audio players, but the potential for future improvements is there. Today, the best DVD-A players reach a signal to noise ratio of about  $120\text{dB}$  ( $0 - 100\text{ kHz}$ ). The figure will be even higher when measured with small band analysis. This is far from  $144\text{ dB}$ , but still very good.

I think it is a little embarrassing that no good DVD-A recordings have been released so far. They have all been of inferior quality. This has of course not made it easier for ordinary people to make a relevant opinion about the differences in the systems. The SACD recordings from Jan-Erik Persson at Opus3 are far superior everything released from DVD-A.

Now, when looking at "recordings in holistic view", the debate of the storing media/system is much less important than the skills of the recording engineer – a good recording stored on compact cassette is far superior to a bad recording stored on DVD-A. But every debate has its time and place. It is not relevant to point out more important issues when we are about to choose a new storage media.

This time the storage media (SACD versus DVD-A) is the question, and it can very easily be distorted by comparing the systems on different recordings. The better recording will always win.

The music is even more important of course, than the recording, but it is entirely subjective – not much to debate about. As an example; my taste in music is disputably deplorable. At least according to some people!

*NL: I continue to read from the press release:*

[http://tinpan.fortunecity.commarrfield/216/pag\\_eng/oct2000.htm](http://tinpan.fortunecity.commarrfield/216/pag_eng/oct2000.htm)

***"The watermarking issue is having a big impact in the 109<sup>th</sup> AES convention at L.A (for the moment only at professional level, but in a future also at a domestically level). A big and increasing number of professionals have pointed out the fact that the actual methods of watermarking introduce sound quality degradation into the supposed high quality recording formats. While the watermarking promotion groups are pushing hard these methods, a group of very well known audio firms (Chesky records etc) and well-known engineers (Tony Faulkner of GRP) are very disappointed of what they consider an audible degradation of the sound quality. The first tests conducted recently in UK and USA (btw, not as impartial as supposed to be due to the use of ultra low quality recordings) using DVD-audio with the watermarking, have shown the fact of this degradation."***

*Is the watermarking of SACD sound degrading?*

IÖ: Well that depends on which watermarking is used! The so called "psychoacoustical water markings" are all sound degrading in various degree and are not associated with any specific storage system.

You can use it with any system of your choice, but it is unclear to what extent they

are used in respective system. As far as I know, no released SACD recordings have used this type of watermarking, but I can be wrong.

The only thing I know for sure is that lots of CD-recordings have this kind of watermarking. But watermarking is a separate problem. It has nothing to do with the either of the recording and storage systems. You can choose not to use it. But the problems built in the DSD-system cannot be excluded!

Just to avoid misunderstandings I want to make a reminder that SACD has higher resolution below 5-10kHz than the CD-system. Exactly where the limit is, where each system (CD or SACD) is better, depends on if you are looking at a static or dynamic signal.

At frequencies below 100-600Hz the SACD-system could theoretically be even better than DVD-Audio, but in reality this is not important. We are talking about so small flaws, far below the hearing threshold, so they can be disregarded. Any specific player however, can be very bad at low frequencies, but not due to the system if SACD or DVD-A is used.

Anyway, in the practical life, it seems like DVD-A wins over SACD at all frequencies, cleaner sound, lower noise, and a completely stable system, free from potential noise shaping algorithmic oscillations.

*NL: How close to the potential resolution do we come with the player existing today?*

IÖ: If we look at the players you can buy today, then the resolution is about 15-30 times lower than the full potential of DVD-Audio. That means 8-16 times better than the CD-system. A big improvement, but still a lot more is possible.

All these comparisons between systems made in "times" are based on pure technical specifications. If you want to have "worst case" audibility, take the logarithm and multiply it by 20, then you get the figures in dB. "15 times better" corresponds to a 23.5 dB lower noise level.

If these figures should be of any use for you, you must have a feeling for "how it sounds when an error signal changes X dB below the music signal". If the changes of the error signal take place below the threshold of hearing, naturally you will hear no difference at all.

Also, different errors have different audibility. Some are easier to detect. Others are more difficult. Some faults/errors are therefore more tolerable even though they are higher in level.

Who said it is supposed to be easy to form relevant opinions?

Relating technical performance to the experienced sound quality should be done with utmost care. My experience is that the quality improvements coming from using more bits are valuable only for high dynamic music material. An 11-bit recording will do fine for extremely compressed "radio-sound".

How people experience sounds in the ultra sound region seems to be quite individual. The most sensitive listeners seem to manage music better with no ultrasounds/ overtones at all, than with music plus ultrasound pollution. Probably no one minds a nicely reproduced ultra sound range (like in DVD-A), but when using such a very capable system, there is no guarantee that recording engineers manage to keep the ultra sound "unpolluted".

When it comes to comparing CD, DVD-A and SACD against each another, it becomes much easier, because at optimum implementation, all error signals in these systems are in the form of noise. But you have to look at every frequency register alone, since the noise character of each format displays different spectral behaviour. I mention this again as I might not have been clear enough earlier in the text.

*NL: Thank you for your time and for answering my questions!*

IÖ: Hope I could straighten out some of your question marks.