

# SONY



## **ES Series DVD-Video/CD/SA-CD Players Technical Background**

Version 3.0; June 2, 2003

# Introduction

In 2002, the Sony DVP-NS999ES DVD player established an entirely new Reference Standard for the category. It introduced new advancements in video D/A conversion, new benchmarks in the coordination of audio and video signals and new refinements in the purity and integrity of the digital video signal. Now Sony extends these technological breakthroughs to two additional ES components: the DVP-CX777ES Disc Explorer® 400-disc changer and the DVP-NC555ES 5-disc changer.

It's no accident that these remarkable components come from Sony. And it's no coincidence that they're part of Sony ES, the Elevated Standard in audio and video. After all, Sony co-invented the technology that DVD is based upon—the Compact Disc. We developed the error-correction and coding technology inside every DVD disc and player. And we're involved in every link of the DVD chain, from movie and music production to DVD authoring, mastering and replication. No wonder Sony has consistently created top DVD players.

- **DVP-S7000 (1997).** Sony's first DVD player was quickly hailed by magazine reviewers as the "Reference Standard." It became the centerpiece in the A/V systems used to review DVD titles, televisions and other DVD players.
- **DVP-S7700 (1998).** A long list of audio, video and construction refinements enabled enthusiasts to achieve even higher performance.
- **DVP-S9000ES (2000).** Sony's first DVD player with progressive scan 480P output, this was also the first with Super Audio CD playback and the first to wear the badge of Sony ES.
- **DVP-NS900V (2001).** Sony reinvented progressive scan DVD with pixel-by-pixel I/P conversion and Sony extended Super Audio CD entertainment with multi-channel playback.
- **DVP-NS999ES (2002).** Sony deployed Precision Cinema Progressive™ circuitry, along with a 14-bit/108 MHz video D/A converter, Speaker Time Alignment and Audio-Video Alignment.

Sony's latest DVD-Video players bring this exalted technology to an even broader range of potential customers.

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# **Video Performance**

## **Precision Cinema Progressive™ circuitry (all models)**

The purpose of today's high-end home theater systems is to recreate the look and sound of the movie theater. This includes the vivid detail and seamless coherence of the film frame. A crucial technology for achieving this goal is DVD-Video playback with progressive scanning, "480P" output. This works with the many of today's "HD capable" and "HD monitor" televisions, which offer 480P inputs. For example, Sony markets this capability as the Hi-Scan 1080i™ chassis. In this context, 480P outputs have been promoted as a must-have feature in high-end DVD players. However, there continue to be important differences in how DVD players generate the 480P signal. The DVP-NS999ES was the first to incorporate Sony's Precision Cinema Progressive system, a comprehensive approach that incorporates two significant circuits to deliver a picture that comes closer than ever to the original movie theater experience.

- Pixel-by-Pixel Active interlace-to-progressive (I/P) conversion
- Vertical Edge Compensation

## **Pixel-by-Pixel Active I/P Conversion (all models)**

Interlace-to-Progressive (I/P) conversion is a potentially tricky process. Simplistic solutions like "frame memory" can end up creating motion artifacts that mar the final result. These appear as zipper-like patterns on the left and right edges of moving objects. (See Appendix A for the full story.) Players with "3-2 reverse conversion" overcome this limitation, maintaining the integrity of the original film frames.

But extracting the full potential of the DVD-Video format requires even more. Different types of DVD material require different types of conversion. An I/P conversion strategy optimized for material originally shot on film will not get the best results for material originally shot on video, and vice versa.



*The mathematical algorithms of Sony's Pixel-by-Pixel Active I/P conversion have been committed to silicon in this Large Scale Integrated circuit (LSI), the Sony CXD9698R.*

Sony solves the problem with Pixel-by-Pixel Active I/P conversion that includes built-in motion detection. This enables us to generate the ideal progressive scanning output for each type of DVD source.

- **Film originated material.** For footage originally shot on 24-frames per second film or film-like 24-frame progressive video, the Sony system automatically and flawlessly detects the 3-2 cadence and performs full 3-2 reverse conversion. Mismatched film frames are never "force-fit" into a single video frame. The system adds no motion blurring. You'll enjoy twice the vertical resolution of conventional interlace video, for an experience that's less like watching television and more like watching film.
- **Film originated material on a DVD-R/RW or DVD+R/RW.** DVD recorders complicate the I/P conversion processes, because these recorders capture everything as interlaced video. That means movies, even if they were originally shot on film, are recorded as 30 frames per second interlaced, not 24 frames per second progressive. There are no First Field Repeat Flags (FFRFs), leaving many DVD players unable to guess at the original frame structure. In this case, conventional 3-2 reverse conversion will not work, but Sony's Pixel-by-Pixel Active I/P conversion will. Thanks to built-in motion detection, the Sony system does not depend on FFRFs. So you get accurate reproduction on DVD-R/RW and DVD+R/RW discs.
- **Film material intercut with interlaced video material.** Sony's Pixel-by-Pixel Active I/P conversion applies appropriate processing for film elements and video elements, even when they alternate in rapid-fire sequence, as they might during the "making of" documentary on a movie DVD. The Sony

system instantly recognizes the characteristics and film and video and automatically applies the correct processing for each.

- **Film and interlaced video-originated material in the same scene.** The Sony system performs beautifully even when film and video appear on-screen at the same time, for example, when video-originated subtitles are superimposed over a film-originated scene. Because the Sony system analyzes each individual pixel, it can switch processing modes anywhere—even in the middle of a field! In contrast, conventional systems need to wait until the end of the field before switching between film and video modes.
- **Interlaced video originated material.** Shooting on conventional, interlaced video means capturing a new field of 240 interlaced scanning lines every 1/60 second. When subjects are moving, there can be significant differences from each field to the next. It's a far cry from film origination, where the subjects move each 1/24 second. Combining two video-originated fields of 240 interlaced scanning lines into one frame of 480 progressive scanning lines is no simple task. For this reason, Sony's Pixel-by-Pixel Active I/P conversion applies special processing for video originated material.



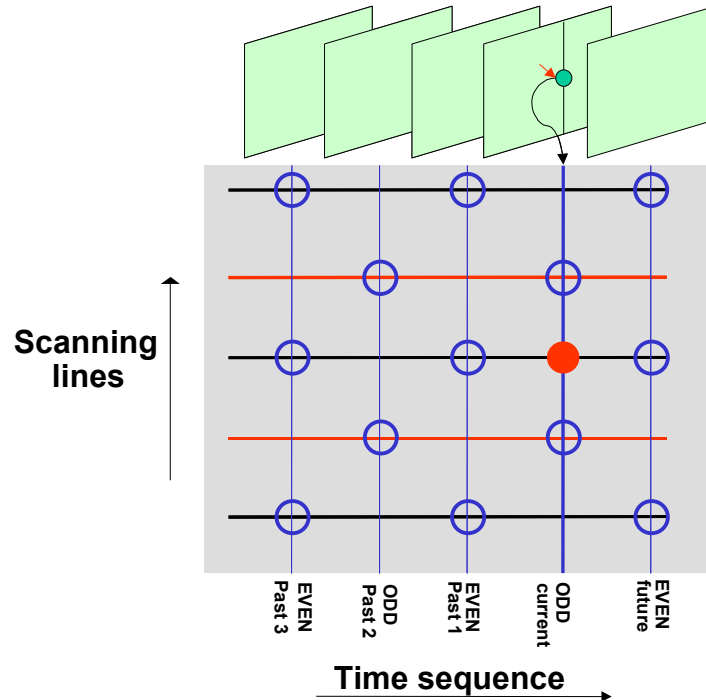
*An on-screen display enables you to adjust the threshold of film and video detection for each individual disc. Sony ES Series DVD-video players can even store your setting for use the next time you play that title!*

In addition, the DVD-Video players of Sony ES enable you to adjust the threshold of film and video detection. So you can optimize the I/P conversion for the specific DVD you're watching. You get I/P conversion that's not only amazingly smooth, but also exquisitely tuned to the individual needs of each DVD. When you're done watching, the players can store the setting in memory. So each time you play that title, you'll automatically get just the right conversion!

### **Three I/P conversion modes for interlaced video origination (all models)**

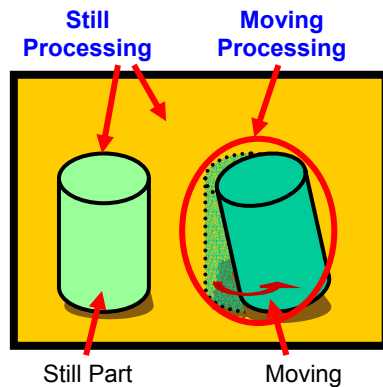
Many of today's DVDs feature concert videos, documentaries, current events, sports, nature footage and other subjects originally captured on conventional, interlaced video. Video based I/P conversion creates new pixels from existing information. For example, to enable progressive scan output of an odd video field, the player must create the pixels that compose all the even

scanning lines. Unfortunately, this can result in motion blur. Horizontal lines in the scene can flicker on and off. Other areas can suffer from an unnatural shimmer. For this reason, any high-end progressive scanning system must solve the problem of motion artifacts for footage shot on video.

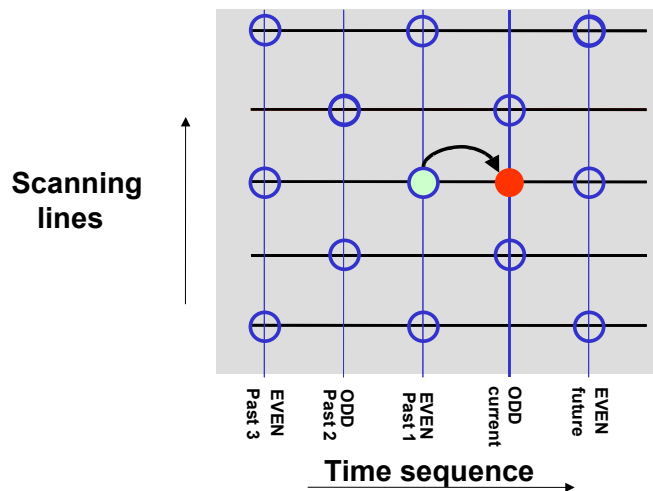


*I/P conversion of interlaced video originated material. The red pixel, on an even scanning line needs to be created for the current, odd field. If not done properly, this can result in zipper-like edges on moving objects, line flicker and unnatural shimmering.*

Sony's Pixel-by-Pixel Active I/P conversion overcomes these problems with built-in motion detection and three distinct video conversion algorithms: one for still objects, a second for moving objects and a third, just for slow-moving objects. As with film origination, the algorithms are applied separately for each individual pixel. So all three can be applied to different parts of any given scene!

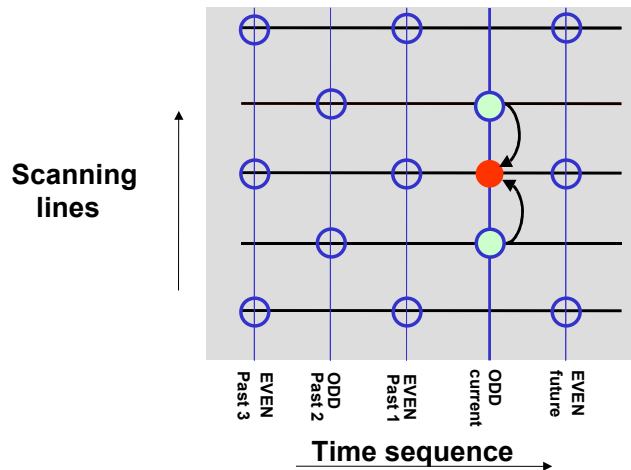


*The typical video frame includes pixels from on-screen objects that can be still, moving and moving slowly. Sony Pixel-by-Pixel Active I/P conversion applies separate processing for each.*



*Still pixels are simply created from the corresponding pixel in the previous field.*

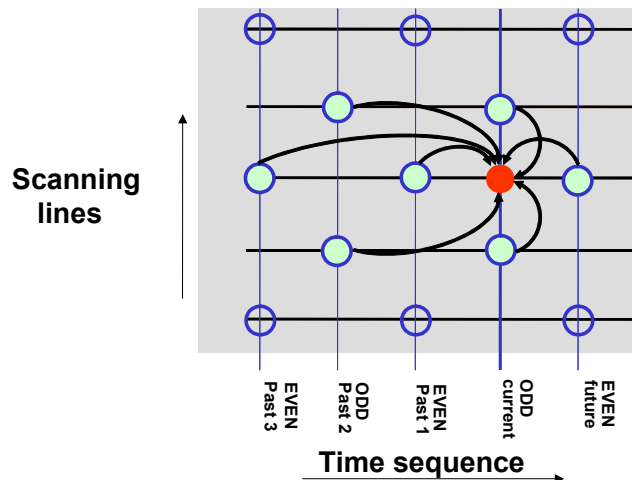
Pixels for still objects are the easiest to handle. When objects are not moving, the player can simply use the corresponding pixel from the previous field. Because there is no motion, these pixels will match perfectly with the current field, creating a seamless progressive scan output.



*Moving pixels are created by composing adjacent pixels in the same field. This minimizes motion blur.*

Pixels for moving objects are created by composing pixels from scanning lines immediately above and below within the same field. Because all information comes from the same 1/60-second slice of time, this suppresses motion artifacts. While this process does not result in the full improvement in vertical resolution, the human eye is less sensitive to detail in moving objects.

Many conventional I/P conversion algorithms have these two modes: still and motion. What's more, the two modes can even coexist in a single frame, sometimes on a pixel-by-pixel basis. However, when objects are moving slowly, the compromise in resolution can be noticeable. And when slow-moving objects come to a complete stop (or still objects go into slow movement), the sudden shift in resolution can be noticeable—and annoying.



*Sony employs a third mode, specifically for slow-moving pixels. These are created by a sophisticated hybrid algorithm, based on seven adjacent pixels.*



Sony's Pixel-by-Pixel I/P conversion overcomes this problem by employing a third mode conversion mode, specifically for slow motion. Slow-moving pixels are composed via a sophisticated hybrid algorithm from seven pixels on adjacent lines and fields, to reduce motion artifacts and annoying resolution shifts to a minimum. This mode delivers superlative resolution on objects that are moving slowly, stopping and starting. So the overall effect is a stunning improvement in image detail, clarity and solidity.

Because the motion detection system operates pixel-by-pixel, the ES Series players can employ all three algorithms *simultaneously*, to optimize *every area* of the video scene. Still backgrounds are impressively sharp and detailed, while moving objects in the same scene are free from motion artifacts. And slow-moving objects don't shift in resolution. You'll see more consistent, more satisfying, more seamless 480P output with a wider variety of discs. The visibility of scanning lines is all but eliminated. Connect a 480P-compatible television, monitor or projector and prepare to be amazed. You'll approach the full glory of high definition picture quality—from today's standard DVDs.

Just as you can adjust the threshold of film/video detection, you can optimize the still/motion detection for the specific requirements of the DVD you're watching. As before, the player can memorize your Still/Motion threshold for favorite discs. So each time you play a title, you'll automatically get just the right conversion!



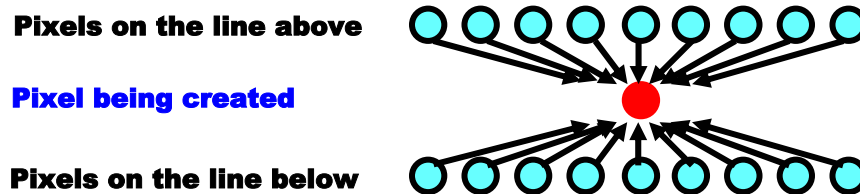
*You can adjust the Still/Motion detection threshold with this on-screen display. As before, you can store your setting for favorite discs in memory.*

## **Vertical Edge Compensation (all models)**

As we've seen, Sony's Pixel-by-Pixel Active I/P conversion of video sources suppresses the zipper-like effect that can occur when moving areas of two interlaced fields are combined in the same progressive frame. It's a major step forward in picture quality. But there is a second, less obvious artifact that can occur in part of the video image part of the time. Most people would not notice the artifact without being told when and where to watch for it. But Sony's program for the ES Series required us to address even subtle distortions.

The problem is jaggedness in the edges that separate areas of the scene, especially when the edges are straight lines, when they're diagonal and when

there's a big difference in contrast between the areas they separate. Rooflines, car hoods, venetian blinds and other lines in the scene can appear with unwanted stair steps not in the original program. Sony's Vertical Edge Compensation controls this artifact.



*Sony's Vertical Edge Compensation uses a broad range of pixels on the lines immediately above and below to calculate a pixel on moving edges. This controls the jaggedness that can sometimes distort edges in the video picture.*

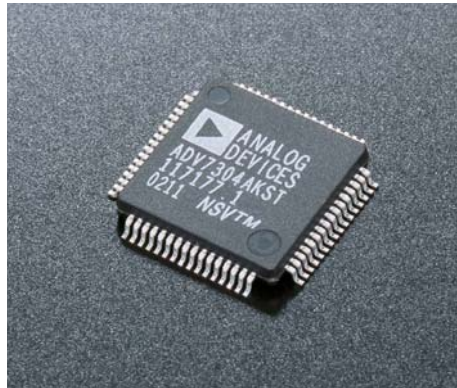
Vertical Edge Compensation uses the built-in motion detection to judge motion at the pixel level and to detect edges. When the circuit detects an edge, it refers to other edges within the field. The circuit then assembles data from a broad range of pixels on the lines immediately above and below to calculate the new pixel. This smooths out the stair steps and results in consistent, natural-looking lines throughout the picture. It's just one more way that Sony raises the standard in DVD-Video picture quality.

### **14-bit D/A Converter (DVP-NS99ES)**

### **12-bit D/A Converter (DVP-NC555ES, CX777ES)**

The binary word length used in video digital-to-analog (D/A) conversion helps determine the gray scale performance of the picture. This can be seen, for example, in the play of light across the face of an actress, as the light of a candle falls off into shadow. Longer word lengths contribute to smoother, more realistic transitions from dark to light.

Starting with the DVP-S7000, Sony led the way with 10-bit video digital-to-analog conversion. The DVP-NS900V raised the performance to 12-bit conversion, producing four times the grayscale levels—performance now also achieved by the DVP-NC555ES and CX777ES. The DVP-NS999ES incorporates the Analog Devices ADV7304A, a 14-bit video D/A converter. This produces yet again four times the grayscale levels—a total of 16 times as many as earlier, 10-bit designs.



*The 14-bit video D/A converter also includes the video encoder and processing for Macrovision™ Copy Protection.*

Sony applies the extended binary word length both to DVD's luminance (Y) black-and-white channel and to DVD's two color difference channels ( $P_B$  and  $P_R$ ). So you get more accurate rendition of colors from the deepest black to the brightest highlights.

**108 MHz D/A converter (DVP-NS999ES)**  
**216 MHz D/A converter (DVP-NC555ES, CX777ES)**

In DVD-Video playback, the ultimate in picture detail comes into direct conflict with the ultimate in picture clarity. Detail is a function of the video "bandwidth" or "frequency response." The highest resolution details occupy the highest video frequencies. Clarity is a function of video "noise." In the worst case, noise appears as "snow" or flecks and specks of unwanted color. In more subtle examples, noise appears as a texture or graininess not present in the original picture. Sony ES Series players achieve a remarkable combination of superb fine picture detail and excellent clarity, thanks to 108 MHz and 216 MHz oversampling in the D/A converter.

To understand how oversampling can have such a powerful effect on picture quality, it helps to understand the concepts of digital sampling and aliasing noise.

Digital recording systems work by "sampling" the original source at a specific rate, or "frequency." The frequency of sampling is determined by the Nyquist Theorem, which dates back to 1928. Harry Nyquist calculated that the sampling frequency needed to be at least twice the highest frequency in the signal you need to record. For Compact Disc, which records audio frequencies up to 20,000 cycles per second (20 kHz), we need 44,100 samples per second (44.1 kHz). Because the video signal is much more complex, the frequencies are far higher. To capture the exceptional fine picture detail of DVD, the black-and-white or "luminance" channel records frequencies out to 6,750,000 Hz (6.75

MHz). This means that DVD samples the video luminance channel at 13,500,000 Hz (13.5 MHz), as part of the DVD-Video format specification.

	<b>Channel Bandwidth</b>	<b>Sampling Frequency</b>
<b>CD Audio</b>	20,000 Hz	44,100 Hz
<b>DVD-Video</b>	6,750,000 Hz	13,500,000 Hz

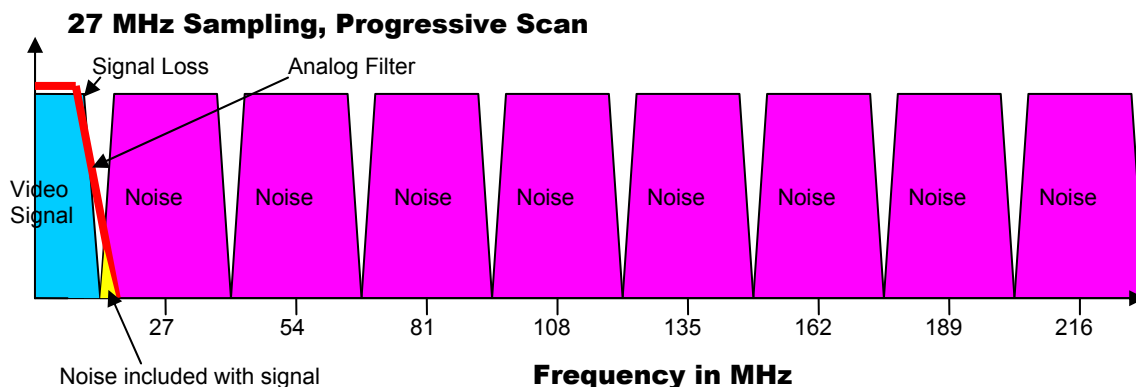
*Digital recording systems sample the analog input signal at a specific rate or frequency at least twice the highest frequency of the channel. For DVD-Video, the sampling frequency is 13,500,000 times per second (13.5 MHz).*

Nyquist sampling only works properly if the analog output is carefully filtered of the aliasing noise that the digital process incurs. Fortunately, the aliasing noise is consistently higher in frequency than the highest video frequencies we want to recover. The noise appears in clusters at each multiple of the sampling frequency, plus and minus the video bandwidth. Unfortunately, the noise is very close to the video frequencies. The player must use a very steep analog filter, which must be carefully constructed to pass all the video frequencies and block all the aliasing noise. Normally, even slight errors in the analog filter could cut the highest video frequencies—degrading picture detail—or allow some aliasing noise to pass through—degrading picture clarity.

While these requirements are difficult for interlace scanning, progressive scanning sets even more stringent requirements. Because progressive scanning outputs twice as many horizontal lines per second, progressive playback effectively doubles channel bandwidth to 13.5 MHz and doubles sampling frequency to 27 MHz. Players need a minimum of 27 MHz sampling in order to output a progressive signal.

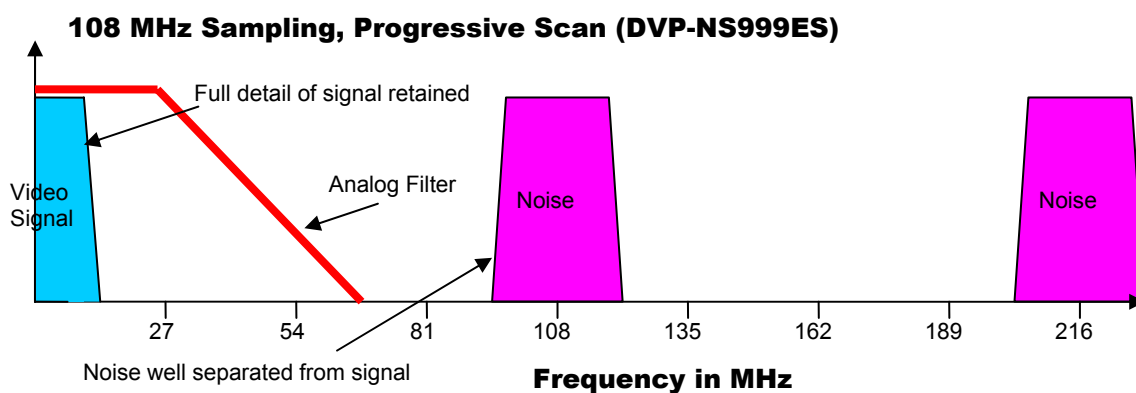
	<b>Luminance Channel (Y) Bandwidth</b>	<b>Luminance Channel (Y) Sampling Frequency</b>
<b>DVD-Video Interlaced Playback</b>	6.75 MHz	13.5 MHz
<b>DVD-Video Progressive Playback</b>	13.5 MHz, effective	27 MHz, effective

*Progressive scanning effectively doubles both the video bandwidth and the sampling frequency. While only the luminance (Y) channel is shown here, this doubling also occurs for the two color difference channels ( $P_B$  and  $P_R$ ).*



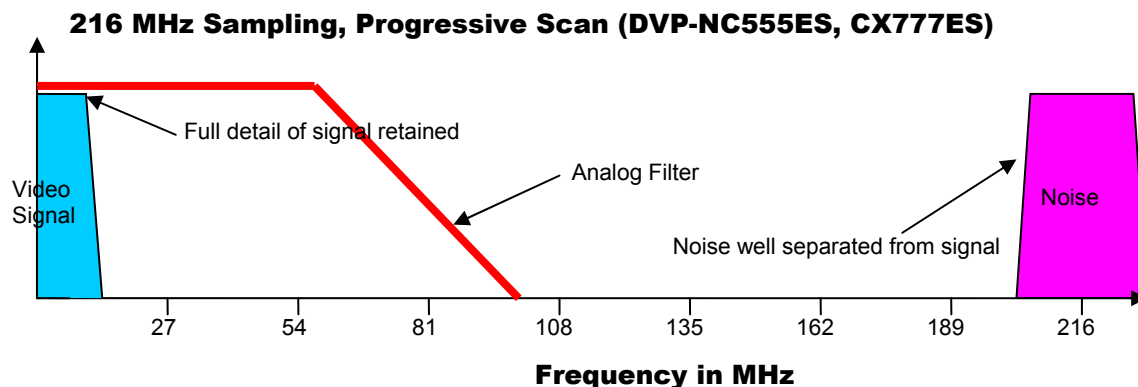
*For progressive scanning, running the D/A converter at the minimum frequency of 27 MHz makes it extremely challenging to design the analog low-pass filter. The filter (red curve) must be steep to avoid cutting into the video signal (blue) or including some of the noise (pink).*

The solution to this problem is to run the A/D converter at a higher frequency than 27 MHz. This process shifts the aliasing noise up in frequency, opening up substantial room between the video signal and the noise. With more room, we can relax the design of the analog filter, which can be far milder in slope, and far more effective at optimizing both the picture detail and the picture clarity.



*Oversampling at the 108 MHz frequency of the DVP-NS999ES makes a huge difference. Now the noise is far removed from the video signal. A gently sloping analog filter can effectively control noise while delivering all the video detail to your television.*

Oversampling has been used successfully in CD players for decades. And while the video equivalent is harder to achieve, the effect is the same. The D/A converter of the DVP-NS999ES shifts the sampling frequency from the standard 13.5 MHz to 108 MHz. For progressive scan playback, that's 4x oversampling. For interlaced playback, it's a whopping 8x oversampling.

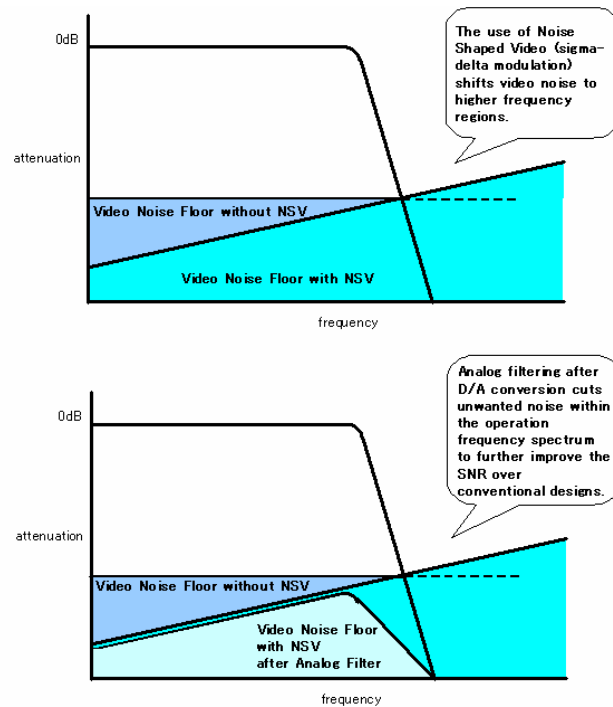


*Oversampling at the 216 MHz frequency of the DVP-NC555ES and DVP-CX777ES is even more dramatic*

The DVP-NC555ES and DVP-CX777ES go further still, all the way to an amazing 216 MHz oversampling. This corresponds to 8x oversampling for progressive scan, 16x for interlaced playback. It's the most powerful oversampling that Sony has ever built into a DVD player. You get superb clarity with the effective suppression of video noise, while enjoying the full video bandwidth for breathtaking picture detail.

### **Noise Shaped Video™ circuitry (all models)**

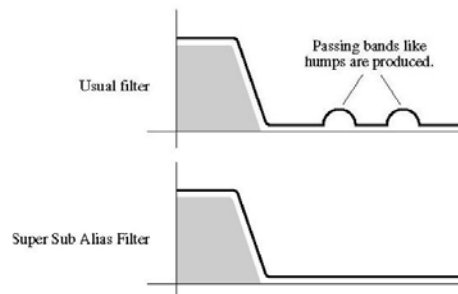
While 108 MHz and 216 MHz oversampling deals with noise outside the video frequency range, another circuit reduces noise within the frequency range. That's important because the perceived transparency and depth of the video image depends on controlling noise. Sony's D/A converter uses Noise Shaped Video circuitry to shift noise from inside the visible frequency range to outside. Even though the overall noise level remains the same, the perceived noise is dramatically reduced. What's more, once shifted, the out-of-band noise is further suppressed by the analog filter. The result is reproduction without flecks or specks of unwanted color. You'll see a video picture that's vibrant, deep, transparent and clean.



*Noise Shaped Video and the higher 108 MHz and 216 MHz sampling frequencies work together to cut video noise for improved transparency and clarity.*

## Super Sub Alias Filter™ circuitry (all models)

The benefit of the 108 MHz and 216 MHz sampling rates is delivered by the Super Sub Alias Filter circuits. In comparison to most previous designs, these filters are now far more effective for two powerful reasons. First, the sampling rates are higher ever. Second, while some previous designs deployed Super Sub Alias Filter circuitry on the black-and-white (luminance) channel only, all ES Series DVD players use these filters on all three video channels: luminance ( $Y$ ), blue color difference ( $P_B$ ) and red color difference ( $P_R$ ). This results in a consistently clean, clear, vibrantly detailed color picture.



*The typical filter leaves traces of the clusters of aliasing noise, which look like lumps in the top diagram. Super Sub Sampling Alias Filter circuits on the  $Y$ ,  $P_B$  and  $P_R$  channels control this aliasing noise more effectively.*

## **"Below Black" reproduction (all models)**

The DVD format dictates specific quantization for specific brightness levels. For example, full black corresponds to a quantization of 16 while full white corresponds to 235. However, direct-view CRTs, plasma panels, CRT projectors and LCD projectors each have specific needs. For example, LCD projectors are subject to "black float" and can benefit from a calibration "below black." CRT direct view televisions tend to lose dark detail when viewed in brightly-lit rooms.

Historically, gamma adjustment has matched the grayscale of a video camera to the general transfer characteristics of CRTs. Sony's Graphical Gamma Adjustment matches the grayscale performance of ES Series DVD players to the specific transfer characteristics of your display. Used with a commercially available calibration disc, the Graphical Gamma Adjustment can achieve ideal reproduction.

The system enables you to make adjustments to gamma much like a graphic equalizer adjusts audio frequency response. As with an audio equalizer, aggressive adjustment can yield unnatural results. The controls are best used to make gamma curves that are smooth and subtle. Sony's control offers eight points of correction, each with 8-bit precision. And you can always return the gamma controls to the industry-standard "flat" state at the touch of a button.



*Graphical Gamma adjustment is like an eight-band graphic equalizer for grayscale and black level.*

## **Video Equalizer (all models)**

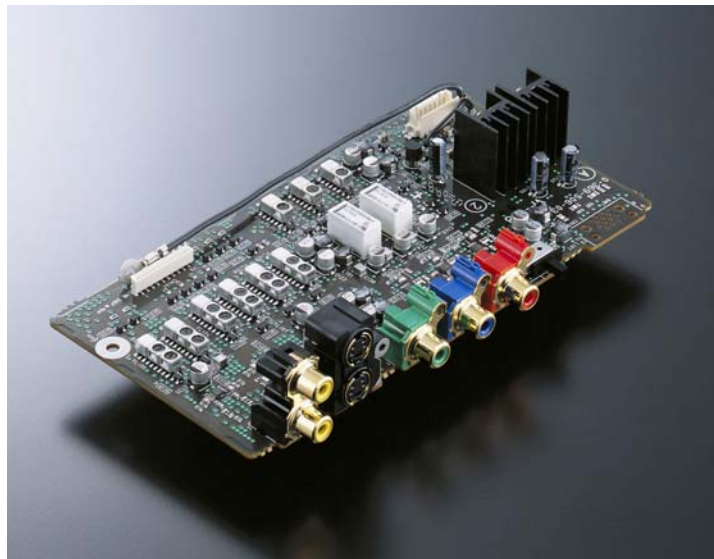
Sony's Video Equalizer enables you to fine-tune the picture quality of each disc you watch. You can adjust Picture, Brightness, Color, Hue and Chroma Delay in addition to Graphical Gamma Adjustment. And once you've optimized the picture for a particular disc, Sony ES Series DVD players can commit your



settings to memory. The DVP-NS999ES has memory for 300 discs. As a 400-disc changer, the DVP-CX777ES has memory for all 400 discs. And the DVP-NS555ES has memory for 30 discs.

### **Separate analog video circuit board with separate power supply (DVP-NS999ES)**

The digital and control circuits of any DVD player generate high-frequency radiation that can affect other circuits in the chassis. This noise can potentially impair low level analog signals. To prevent any cross-interference, Sony carefully separates the digital circuits from the analog circuits, mounting them on separate circuit boards. This maintains the purity of the analog signal for consistently clean video images.



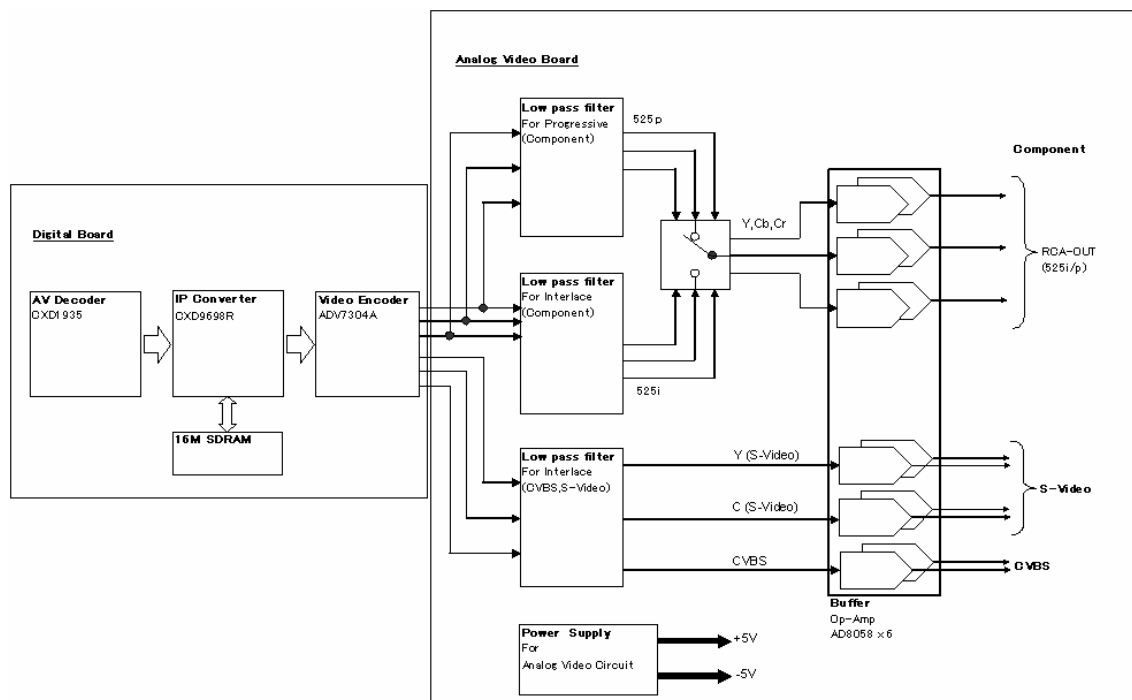
*To maintain the purity of the signal, Sony places the analog video circuitry on a separate board, driven by its own power supply.*

Because digital noise can corrupt the DC voltage, the power supply is another potential path of interference. That's why Sony was the first brand of DVD players to give the analog circuit block its own series power supply. This ensures power that's both abundant and clean.

Sony also uses video filters designed specifically for both interlaced and progressive signals in all three channels (Y,  $P_B$  and  $P_R$ ). All told, there are nine channels of video filtering: interlaced component Y/ $P_B$ / $P_R$ , progressive component Y/ $P_B$ / $P_R$  and Y/ $P_B$ / $P_R$  channels filtered prior to composite or S-Video encoding. Sony engineered each filter to match the specific operation bandwidth and sampling frequencies of the signal. This achieves phase linearity while it holds noise and distortion to a minimum.

## High speed video buffer amplifiers (DVP-NS999ES)

While Sony can control the video signal inside the DVP-NS999ES, there's one aspect we can't control: the cables that convey the signal to your television. In particular, the long cable runs found in many home theater installations can be highly capacitive. This tends to degrade the video signal, softening the picture and limiting the video bandwidth. To counter this possibility, Sony incorporates high-speed video buffer amplifiers. High slew-rate op amps handle large loads with very low overshoot. You get a powerful driving force for the video signals, even over long cable runs. As a result, the video signal delivered to the television has extremely low levels of noise, differential gain and differential phase.



*Block diagram of the DVP-NS999ES video circuit. You can see the separate digital circuit board (left) and analog circuit board (right). At center, you can see the nine channels of low-pass filtering. On the right are the video buffer op amps.*

## Output Capacitor-Less (OCL) coupling (DVP-NS999ES)

In typical audio and video design, an output capacitor prevents the accidental passing of DC offset voltage from one piece of equipment to the next. However, the mere presence of the output capacitor can affect the video frequency response and literally tinge the television picture with unwanted shading. And these effects can't be corrected by your television's picture controls. Sony's answer is a rigorous design that controls DC offset voltages

from the start. You get reliable operation without performance-robbing output capacitors.

### Carefully selected parts (DVP-NS999ES)

More than a labor of technology, the DVP-NS999ES represents the enthusiasm that Sony engineers share with high-end videophiles. That's why the player incorporates a variety of carefully selected resistors, inductors, semiconductors and capacitors. Each plays a specific role in maximizing video performance.

- **Low Distortion Film Capacitors.** While electrolytic capacitors are suited to power supply filtering, film capacitors are especially proficient for sound and picture. Many of these low-distortion capacitors contribute to the outstanding performance of the DVP-NS999ES.
- **Oversized output resistors.** Output resistors determine the impedance of the analog output circuits. Most designers avoid large resistors. But Sony incorporates large resistors of uncommonly tight tolerances. This contributes to the high slew rates required for wideband video.
- **Output Signal Relay.** To simplify connections to your television, the DVP-NS999ES uses a common set of component video terminals for both progressive and interlaced output. Naturally, this requires output switching. While conventional designs use semiconductor switches, Sony employs a high-quality mechanical relay. It's a more expensive design that delivers more positive connections, lower resistance and lower noise across the switch. Progressive and interlaced output can be selected via on-screen menus or via a switch on the rear panel.

### Wide pitch output jacks (DVP-NS999ES, NC555ES)

Sony engineers even anticipated the high-grade output cables that videophiles are likely to use. On the DVP-NS999ES and NC555ES, Sony deliberately spaced the Y/P<sub>B</sub>/P<sub>R</sub> output jacks further apart than common practice, the better to accommodate heavy-gauge cables and plugs!



*The spacing or "pitch" between the component video output jacks is wider than usual, to accommodate heavy-gauge cables and plugs.*

## **Audio Performance**

In addition to DVD-Video and Compact Discs, all of these models also bring home sumptuous high-resolution audio, playing back both stereo and multi-channel Super Audio CDs. You'll hear the inner detail of choral ensembles. The reverberation trailing from a guitar chord. And the acoustic space surrounding the instruments. With Super Audio CD, you hear every nuance of sound reproduced with incredible ease and clarity. (For the full story on Super Audio CD and its innovative Direct Stream Digital™ encoding process, please see Appendix B.)

### **Multi-channel Super Audio CD playback (all models)**

Sony ES Series DVD-Video players take full advantage of the latest generation of multi-channel Super Audio CD music. Multi-channel Super Audio CD gives producers the ability to capture the precise ambience and reverberation that give any concert hall, jazz club or recording studio its characteristic "sound." Multi-channel Super Audio CD doesn't just bring the performer to your room; it puts you into the performer's space. The result can be overwhelming. By combining this fully dimensional soundstage with the uncanny clarity of DSD technology, Sony ES Series DVD players offer music reproduction that's nothing short of brilliant.

### **DSD decoder LSI (all models)**

The Super Audio CD's 1-bit signal is processed and decoded by Sony's CXD2753 DSD decoder LSI. This integrated circuit makes intelligent decisions regarding the incoming data to form the 1-bit audio signal. The LSI first reads the Watermark—a feature protecting Super Audio Compact Discs from piracy—and then decodes the incoming data. The LSI uses internal memory to take data that's output intermittently from the disc, rearrange it and order it into continuous 1-bit audio streams. This LSI also reads sub code data such as the Table of Contents, track number, track time, and text data.



*Multi-channel DSD decoding is handled by a Sony Large-Scale Integrated circuit (LSI), the CXD2753R. It's another of many exclusive Sony LSIs in the ES Series DVD players.*

## **Multi-Channel Management (all models)**

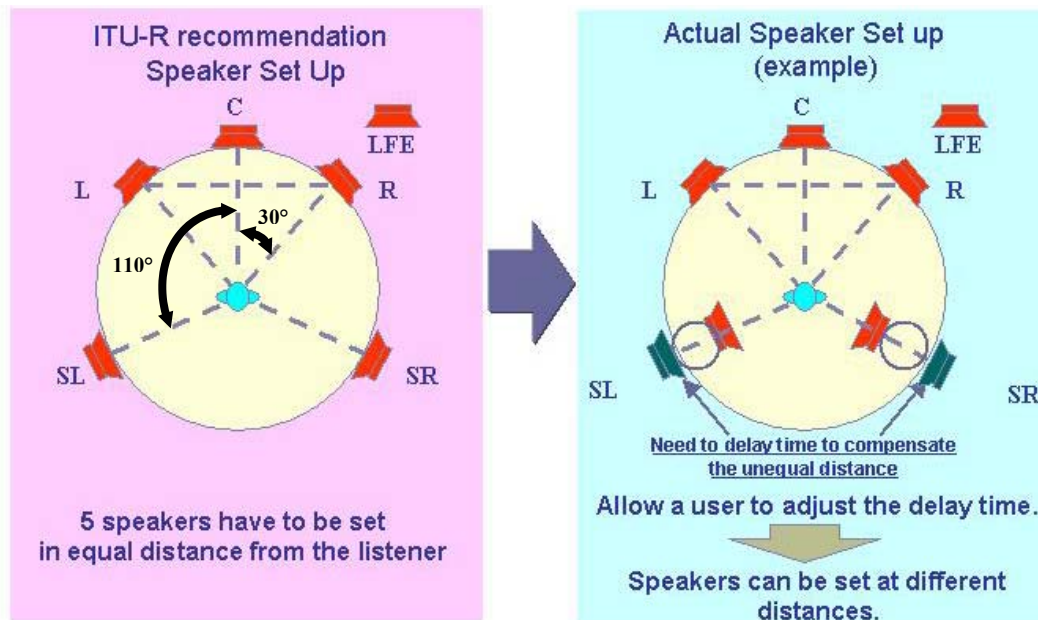
Home theater speaker configurations vary considerably. Some enthusiasts have built upon audiophile-grade stereo systems. These systems may have large, full range Left and Right speakers that produce bass so deep that any subwoofer would be extraneous. In this case, the Left and Right speakers may well be considerably larger than the Center and Surround speakers. Other systems may have five matching satellite speakers, plus a subwoofer. Some systems may have no Center channel speaker, while others have no Surround speakers. The DSD decoder LSI provides multi-channel management to achieve optimal multi-channel reproduction with all these speaker configurations.

## **Speaker Time Alignment (all models)**

For optimum playback, the mastering engineers who create CDs need to anticipate the speaker configuration over which the music will be reproduced. In stereo, that configuration is simple: two identical speakers ideally set an equal distance from the listener. In a multi-channel sound, the ideal is slightly more complex. Multi-channel Super Audio CD is designed to conform to an international standard, called ITU-R. This envisions that the listener sits in the exact center of a circle of five identical speakers, with each speaker occupying a specified position in the circle. (For the Low Frequency Effects or LFE channel, the subwoofer can be flexibly placed outside the circle.)

The ITU-R circle makes a great reference for studio engineers. But few home environments can accommodate exactly this setup. Even if you did have five identical speakers all the way around, the rectangular shape of most rooms

would make it difficult to place all five speakers at equal distance from the listening position.



*Mastering for Super Audio CD multi-channel sound assumes that speakers will be placed according to the international ITU-R standard (left). Unfortunately, most practical listening rooms don't match this standard exactly. Speaker Time Alignment applies a delay to selected speakers to "move" them into proper position (right). In this example, time delay pushes back the apparent position of the SL and SR speakers to match the L, C and R speakers.*

To resolve the problem, Sony developed a 1-bit Digital Signal Processor LSI, the CXD9722. This LSI enables you to apply a carefully timed delay to each individual speaker. Sony provides this delay in 150-microsecond increments. Because most people can't make the mental leap from microseconds to speaker distance, Sony calibrates the delay as distance, in 5-cm (2-inch) increments. Each 150 microseconds of delay "moves" a speaker back 5 cm (2 inches). In this way, Speaker Time Alignment adjusts the "virtual position" of each speaker, enabling you to synchronize the arrival time of sound for all five speakers. You can even change the perceived distance of the subwoofer in relation to the other speakers. With Speaker Time Alignment, you'll experience multi-channel sound as it was meant to be heard. You'll get the effect of perfect speaker placement, even if your actual placement is far less than perfect!





*Sony's powerful CXD9722 handles both Speaker Time Alignment and A/V alignment.*

Incidentally, this adjustment is not duplicated on most A/V receivers. Some receivers can adjust for speaker distance on the multi-channel signals that are decoded in the receiver itself. But most receivers offer no such adjustment for the 5.1-channel analog inputs you'd be using to enjoy multi-channel Super Audio CD.

### **A/V Alignment (all models)**

Today's advanced televisions and video projectors often incorporate sophisticated video signal processing to optimize the image quality. Often, these circuits require buffer memories that result in a slight delay of the video signal. Unfortunately, this can result in a mismatch, where the television picture lags behind the sound from the speakers by some fraction of a second. As you can imagine, the effect can be unnatural and annoying.

That's why Sony built a second major function into the CXD9722 Digital Signal Processor. This integrated circuit enables you to correct time misalignments between the audio and video signals by up to 120 milliseconds, in 10 millisecond increments. This brings your television and your home theater speakers back into alignment. This A/V alignment is performed uniformly on stereo, 5.1 channel and even digital audio outputs.

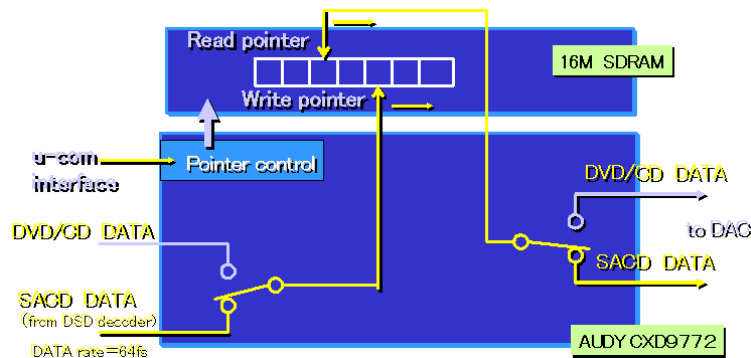
### **Separate speaker settings (all models)**

These DVD players also provide speaker size and location settings for Super Audio CD playback that are separate from the settings you make for DVD-Video and other formats.

### **How the CXD 9722 works (all models)**

As the diagram below shows, the CXD9722 receives input signals from either the DVD/CD Data input terminal or the Super Audio CD Data input terminal,

both on the left. One of the input terminals is selected, and the signal enters and is sent to a 16 Megabit S-DRAM memory. The signal plays out of memory at a fixed time delay that is determined by the user. Both data writing points and data reading points are controlled within the IC using read and write pointers in the control section. All told, there are nine individual blocks in this IC (Front Left, Front Right, Center, Surround Left, Surround Right, Subwoofer, Stereo Left, Stereo Right and Digital Out). Because the nine blocks can be controlled independently, you can create virtual speaker positions ideal for both Super Audio CD and DVD playback. In addition, since all nine blocks can be controlled simultaneously, all signals can be given the same delay to achieve A/V alignment with the television.



*Schematic of the CXD9722 signal processing IC.*

## **High performance audio D/A converters with DSD inputs (all models)**

To elicit the full sound quality from Compact Disc, DVD-Video sound tracks and especially from Super Audio CD, these DVD players incorporate powerful audio D/A conversion technology. The D/A converters can handle DSD inputs for Super Audio CD playback as well as high quality DVD-Video signals up to 192 kHz sampling rate with 24-bit word length. This assures compatibility with the widest range of source material.

The DVP-NS999ES offers even more, with separate Sony D/A converters for multi-channel and stereo programming. Both of these D/A converters include on-board Variable Coefficient digital filters for extremely accurate rendition of the soundfield on DVD-Video and CD. In addition, on-board DSD filters reduce high-frequency noise in Super Audio CD playback. Finally, both D/A converter ICs employ multi-level delta-sigma D/A conversion, which assures both excellent linearity and remarkably low noise.

Balanced outputs on the DVP-NS999ES D/A converters enable balanced transmission of audio signals to the post Low Pass Filter on the audio circuit



board. This suppresses noise caused by fluctuations in the power supply and other externally-induced voltages.

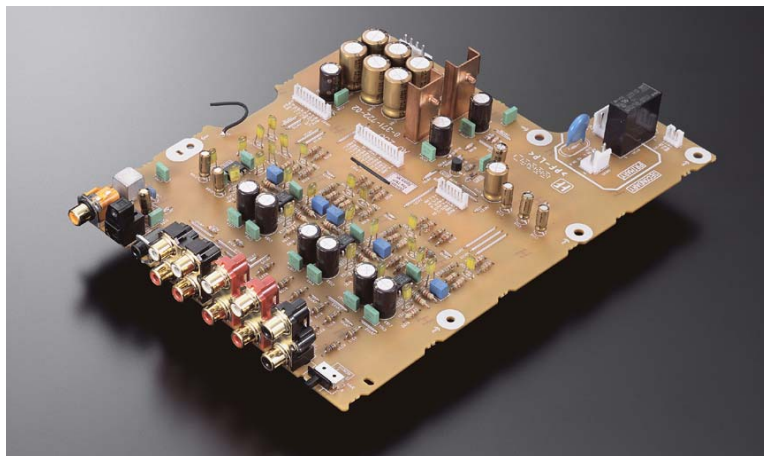


*On the DVP-NS999ES, the Sony CXD9675R (left) is a high performance audio D/A converter for 5.1-channel output. A separate D/A converter, the Sony CXD9674TN (right) serves two-channel stereo sources.*

### **Separate analog audio circuit board (DVP-NS999ES, NC555ES)**

The digital audio, digital video, analog video and servo control circuits inside a DVD player are potential sources of radiated noise. Low-level signals in the analog audio circuits are particularly susceptible to this noise. That's why the DVP-NS999ES and NC555ES isolate the analog audio circuits on their own board. It's one more measure to help maintain the purity of both DVD-Video sound tracks, and Super Audio CD music.

In addition, the DVP-NS999ES uses six separate, identical audio circuits to handle the 5.1 channels. This ensures uniform frequency response and gain characteristics at the output. Sony's careful design not only maintains the sonic purity of multi-channel Super Audio CD signals, but also preserves the crucial left/right and front/rear symmetry of 5.1 DVD-Video surround signals.



*On the DVP-NC555ES, a separate printed circuit board for analog audio employs six separate, identical circuits to handle the 5.1 channels of output.*

## **Audio Shield Plate (DVP-NS999ES)**

The DVP-NS999ES prevents even minute interference between the analog video and analog audio circuit boards. The boards are separated by a substantial shield plate that includes a copper sheet to block radiation.



*This substantial, copper-lined shield plate protects the analog audio board from even subtle distortions caused by the analog video board.*

## **Wideband digital outputs (DVP-NS999ES)**

To deliver a high quality digital signal, the DVP-NS999ES employs a wide-bandwidth optical module. It can achieve transmission speeds over 13 Megabits per second. This offers plenty of headroom for the 4.6 Megabits per second required by 96 kHz/24-bit outputs. The coaxial output delivers comparable quality thanks to a high-performance pulse transformer. Both digital outputs assure superb dynamics while holding noise and distortion to the bare minimum.

## **Audiophile-grade components (DVP-NS999ES)**

Two capacitors with identical circuit values can have quite different sound quality. For this reason, Sony engineers have taken the time to choose top-quality audiophile-grade components throughout the DVP-NS999ES. The op amps, resistors, capacitors and more have been individually selected and matched for their sound quality. For example, carbon resistors with non-magnetic leads have been chosen for their higher handling capacity. We chose film capacitors for their superior audio characteristics. We even considered the power plug. Sony engineers chose a grounded, 3-pin plug for superior mechanical and electrical characteristics.



*Sony's choice of a grounded AC input assures a more stable electrical and mechanical connection.*

## **Gold-plated output jacks (all models)**

To maximize electrical conductivity and minimize the effects of oxidation over time, the audio, composite video, S-Video and component video output jacks are plated with gold. Noise at the contact points is held to a bare minimum.



*You might not notice that the output jacks are plated with gold. But they protect the audio and video signal quality from oxidation which can degrade the output signal over time. And that can make a noticeable difference.*

## **R-Core power transformer (all models)**

The video and control circuits can introduce imperfections to the power supply voltage, which can trigger audio distortions. To protect the audio circuitry, these DVD players use a separate power supply, just for audio. In addition, power supply regulation on the audio circuit board itself helps establish stable operation for the audio D/A converters.

Transformer cores and windings can vibrate and degrade the sound, radiating 60 Hz hum into nearby audio circuits. That's why Sony chose an R-Core design. The R stands for round. Not only is the core round, it has a cylindrical cross section, enabling the transformer windings to be wrapped

without the voids or gaps that permit vibration. This results in far less radiation, far less hum.



*All ES Series DVD players use an R-Core transformer. The transformer pictured here powers the audio circuits of the DVP-NS999ES. The round core with cylindrical cross section enables far more consistent transformer windings—for far less radiated hum.*

### **Video Off and Display Off modes (all models)**

One potential concern with so many types of circuitry in one chassis is mutual interference. Sony minimizes the possibility of radiated interference with power-off configurations that shut down potential sources of noise:

- **Video Off.** Shuts down the video circuitry to eliminate its effect on the audio circuitry.
- **Display Off.** Disables the display for a further reduction in noise.

# Construction Quality

## Anti-resonant chassis design (all models)

Vibration is the enemy of CD, DVD and Super Audio CD players for two powerful reasons. First, vibration in the disc or optical pickup triggers unwanted operation in the tracking servos. This can radiate spurious noise throughout the chassis. And this radiation occurs in exactly the wrong place—near the sensitive low-level optical pickup preamplifier. To make matters worse, vibration can also cause subtle distortions in the audio circuitry. Vibration can have tiny "microphonic" effects on capacitor values and point-to-point wiring. While these distortions are not always apparent to the casual listener, Sony's design program required performance without compromise. For all these reasons, every ES Series DVD player incorporates anti-resonant design.



*The DVP-NC555ES uses a high-strength frame, with a broad plate to separate the chassis into two sections. The disc carousel and drive occupies the bottom while the electronics occupy the top.*

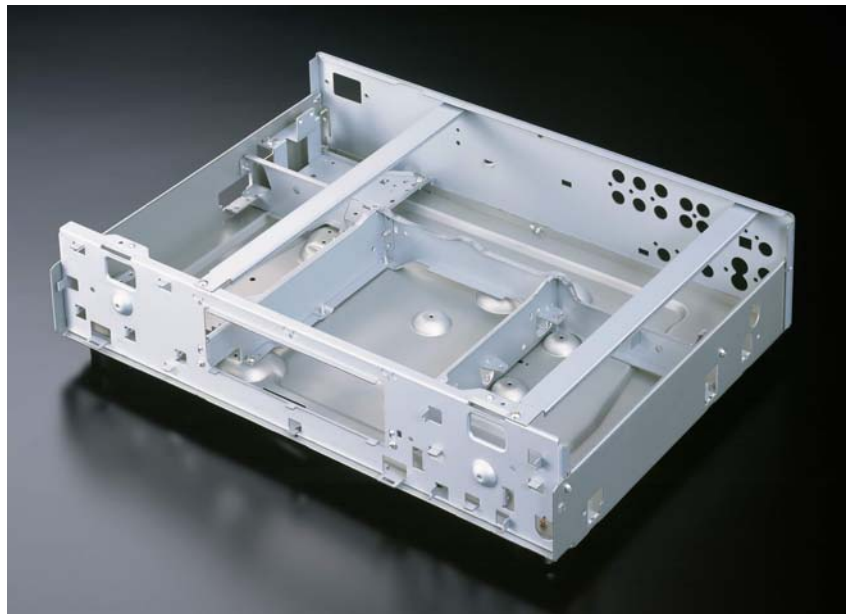
For example, the DVP-NC555ES is built upon a thick, high-strength frame to reduce unwanted resonance and vibration. Because the top and sides of the case are particularly prone to vibration, the case of the DVP-CX777ES incorporates extensive anti-resonant damping material. This helps suppress vibration for cleaner, more natural sound. The DVP-NS999ES goes further still with Sony's Frame and Beam (FB) chassis.



*A generous application of anti-resonant damping materials to the top and sides of the DVP-CX777ES case.*

### **Frame and Beam chassis (DVP-NS999ES)**

Sony's Frame and Beam (FB) chassis uses a thick, high-strength frame which gains additional rigidity from two metal beams that cross the top of the chassis. Extensive internal cross bracing adds even more strength. As a result, the Frame and Beam chassis suppresses vibration.



*The Frame and Beam (FB) construction of the DVP-NS999ES is supremely strong to suppress resonance.*

### **Off center insulator feet (DVP-NS999ES, NC555ES)**

To prevent shelf-borne vibration from entering the chassis, Sony's insulator feet locate the screw hole off center. By varying the radius from screw

to perimeter, this tends to vary the resonant frequency within the foot—diffusing one potential path for vibration. To further deaden vibration, the feet of the DVP-NS999ES use non-rebound rubber on the bottom.



*Locating the insulator feet screw holes off center means a constantly varying radius from the hole to the edge. This diffuses shelf-borne resonance.*

### **Advanced FX Mechanism (DVP-NS999ES)**

Not only the chassis but also the disc drive mechanism itself is designed to minimize resonance. Sony's Advanced FX Mechanism includes four important advancements:

- **The Fixed Base Unit** improves tracking stability and reduces transport vibration at the source.
- **The Hermetic Shutter** controls air-borne vibration.
- **Sony's BMC mechanical deck** helps prevent resonance from affecting disc playback.
- **The Precision Drive™ 2 system** helps provide accurate, uninterrupted playback even with warped, scratched or dirty discs.

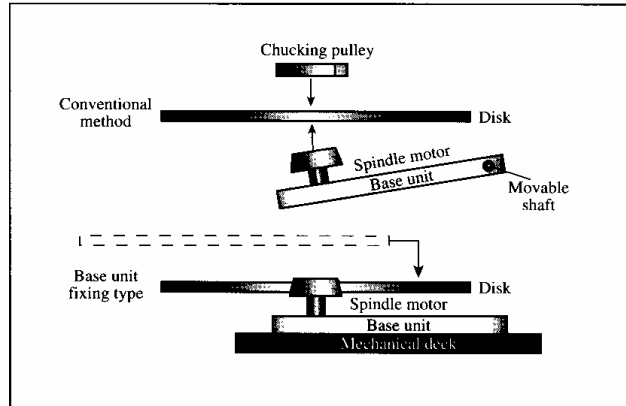
### **Fixed Base Unit Mechanism (DVP-NS999ES)**

On a conventional CD or DVD drive, the spindle, drive motor and optical pickup are mounted on a pivoting base unit. The pivot is necessary because the base unit needs to drop out of the way when the disc drawer is opening and closing. And it needs to swing back up into playing position once a disc has been loaded. Unfortunately, this pivoting mechanism is an open invitation to vibration and resonance.

Sony engineers demanded more. For the DVP-S9000ES, they developed the fixed base unit mechanism. Sony's DVP-NS999ES incorporates the second



generation of this ground-breaking design. In Sony's mechanism, the spindle, motor and optical pickup base unit are rigidly bolted to a sub-chassis, to reduce any possibility of resonance. When you load a disc into the DVP-NS999ES, the disc not only moves laterally into the player, it also descends onto the spindle. Thanks to Sony's design, the disc is always read in a silent, extremely stable non-resonant environment. Vibration is minimized, along with the servo activity that vibration can cause. The sensitive RF preamplifier is protected from servo radiation.



*Conventional DVD players use a pivoting base unit (top), prone to vibration. The Sony DVP-NS999ES uses a rigidly fixed base unit (bottom), minimizing vibration and its consequent distortion.*



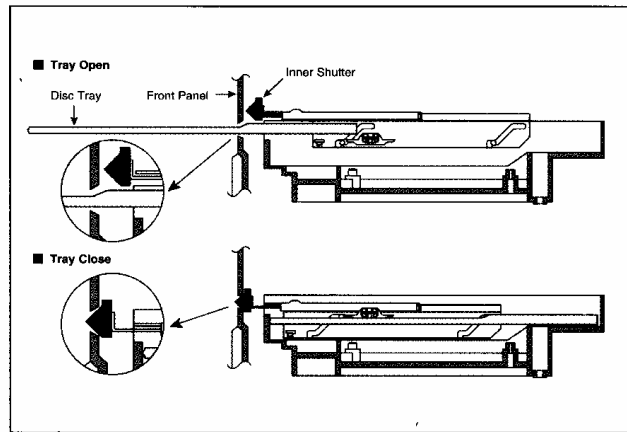
*Front view of Sony's Fixed Base Unit mechanism. The loading tray not only slides into the player, it also descends to the base unit, which is fixed to a non-resonant base.*

## **Hermetic shutter (DVP-NS999ES)**

When it carries the disc down to the fixed base unit, the loading tray no longer acts like a door to seal the front-panel loading slot. Sony engineers



addressed this by creating a hermetic shutter. It forms an airtight seal to protect the disc and pickup from air-borne vibration. Even when the speakers in your room are going full blast, the disc rotates in peace and quiet.



*To seal off the mechanism from air-borne vibration, the inner shutter descends into position during disc playback.*

### **BMC Mechanical Deck (DVP-NS999ES)**

The base unit is mounted on a sub-chassis called the mechanical deck. On the DVP-NS999ES, this is a rigid, honeycomb structure of Sony's Bulk Molding Compound (BMC). Long a fixture in Sony anti-resonant design, BMC is carefully formulated for high strength and high internal loss. Like steel, it has the rigidity required for its structural purpose. But unlike steel, BMC steadfastly resists vibration and resonance. BMC consists of calcium carbonate (a principal component of marble), glass fiber reinforcement and unsaturated polyester. The material is subjected to thermosetting and is formed into the mechanical deck floor, walls and ceiling. Even the disc loading tray is made of non-resonant BMC.



*Sony's Bulk Molding Compound (BMC) is remarkably anti-resonant. And the honeycomb structure of Sony's mechanical deck floor is extensively cross-braced, reducing resonance further still!*

## **Precision Drive™ 2 system (all models)**

The disc condition can have a major effect on proper readout. Ideally, the disc should be flat, centered and free of dust, dirt and scratches. In the real world, no disc is perfect. Slight imperfection in the location of the center hole requires the player to follow a wobble in the track once per rotation. Tilt in the disc surface requires similar, constant adjustment. There are also unavoidable micron-level imperfections, including everyday scratches too small to be seen by the naked eye. Compared to CD, DVD-Video and Super Audio CD use a smaller pit size and shorter laser wavelength that place even greater urgency on accurate tracking. Sony meets these challenges with the Precision Drive 2 system. Sony's system incorporates several advances.

- **Dynamic Tilt Compensation** enables the lens to tilt with each undulation of the disc. It operates by applying highly responsive servo tilt to the pickup. This results in excellent stability for superior readout of warped or eccentric discs.
- **Focus Bias Adjustment** delivers accurate readout from scratched or dirty discs.
- **Sony's High-speed Stepping Motor** provides fast, silent access to DVD chapters and CD tracks.
- **Responsive Servo DSP** shortens the wait from the time you insert a disc until playback begins.

In the real world, no optical disc is perfectly flat and centered. But with Sony's Precision Drive 2 system, it certainly seems that way.



*Sony's Precision Drive 2 mechanism, including the optical block (upper left) and disc spindle (lower right).*

## **Responsive and accurate servo DSP (all models)**

The Precision Drive 2 system of the DVP-NS999ES operates under the control of a fast servo DSP, the Sony CXD9703. It operates at 50 million instructions per second (50 MIPS), an astonishing speed for an ancillary processor. You get instantaneous response to changes in operating conditions, faster and smoother high-speed search and shortened time between disc insertion and playback.

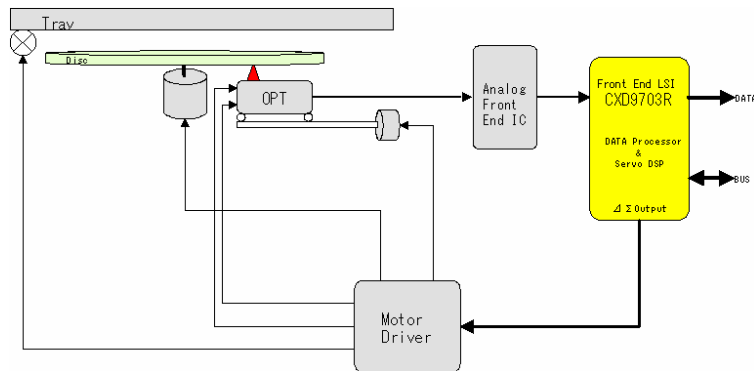


*Sony's servo DSP has an astonishingly fast operation speed of 50 million instructions per second (MIPS).*

## **Delta Sigma 1-bit D/A in the Servo DSP (all models)**

Just as Delta Sigma modulation stands behind the high sampling rates of the Super Audio CD format, Sony has applied Delta Sigma modulation to the servo DSP. The Sony CXD9703 incorporates a 1-bit Delta Sigma Modulation A/D converter to translate the analog input voltages into binary code. In order to drive the focus and tracking actuators, the output of the servo DSP is converted

back to analog using delta sigma modulation at 25 MHz. The D/A converter exhibits superb linearity, equivalent to 10-bit precision. So you get remarkably accurate tracking on DVD, Super Audio CD and CD alike.



*The Sony CXD9703 Servo DSP incorporates an on-board Delta Sigma A/D and D/A converters for exceptional tracking accuracy.*

# Convenience

## Disc Explorer® system (DVP-CX777ES)

With 400 discs of entertainment at your beck and call, the DVP-CX777ES promises that you'll never need to rummage through your shelves or fumble with jewel boxes, searching for the movies and music you want. But delivering on this promise required a fast, easy, electronic way to identify and access your discs. That's exactly what the Disc Explorer system provides. Using your television screen as a Graphic User Interface, the Disc Explorer system delivers easy, on-screen access to your discs alphabetically by title, by disc type, by genre and by "folders" that you can organize and name. The player loads information regarding your 400 discs into memory, so it's always available for instant access and display.

- **Sort by disc type.** The player automatically recognizes disc type such as DVD and CD. So you can scan discs by type.
- **Sort by slot number.** The DVP-CX777ES holds each disc in a sequentially numbered slot. The changer makes it easy to sort and access discs by slot number.
- **Sort by title using CD, SA-CD, DVD Text and Disc Memo® function.** Many discs have text, including disc title, encoded on the signal layer. This information is automatically memorized and displayed by the DVP-CX777ES. In cases where discs do not already have titles, you can create titles using the Disc Memo function. You can also use Disc Memo operation to store artist name, date of purchase or other information about a disc. You can then search discs alphabetically by title.
- **Keyboard Input.** Sony gives you two ways to enter text information for each disc. Use the remote control keys to input any character or plug an industry-standard PC keyboard into the front panel connector and type!
- **Jacket Pictures** recorded onto DVDs appear automatically. If there is no jacket picture, you can create one by freezing any scene on the DVD.
- **Sort by folders.** Sony enables you to organize the 400 discs into four sub-groups. While the folders are initially labeled "A" through "D," you can assign them personalized names, like DAD, KID or JAZ. Even when assigned to these custom folders, discs still appear in the standard folders for "All," "DVD," and "CD."
- **Sort by genre.** You can also sort movies and music by types. So you can immediately scroll through an on-screen list of all your Sci-Fi DVDs, for example, or all your Country Music discs. All told, Sony provides ten movie genres and six music genres, for easy sorting.

## DVD-R/RW DVD+R/RW playback (all models)

In the beginning, the only source of DVD entertainment was packaged media. But that's rapidly changing with DVD burners like those in many Sony VAIO® PCs, home DVD recorders like Sony's RDR-GX7 and DVD camcorders like Sony's DCR-DVD100, DVD200 and DVD300. For this reason, the DVD players of Sony ES are designed to take advantage of a broad range of disc-based entertainment that includes not only DVD-Video, but also DVD-R and DVD-RW discs recorded in the DVD-Video and VR formats; DVD+R and DVD+RW; CD, CD-R CD-RW, CD MP3 and Video CD; as well as Super Audio CD stereo and multi-channel media.

**RS-232C terminal for  
custom installation (DVP-CX777ES)**

With its superb quality and its capacity for any mix of 400 CDs, SA-CDs and DVDs, the DVP-CX777ES is an irresistible candidate for custom installation. Sony makes it even more attractive with a flexible RS-232C interface. This enables custom installers to integrate the DVP-CX777ES with a wide range of third-party control systems.

## Massive aluminum front panel (all models)

All DVD players in the Sony ES Series have simple, powerful styling with a massive, uncluttered aluminum front panel. On the DVP-NS999ES, the fluorescent display window is made of high-hardness acrylic resin, especially formulated to resist scratches.



*The DVP-CX777ES features an elegant, uncluttered aluminum front panel.*

## Silver Cascade Design (DVP-NC555ES)

In addition to its remarkable technology, the DVP-NC555ES inaugurates a new faceplate design exclusive to the Sony ES Series. The "cascade" design sets the primary front panel controls at an angle, so that you can operate the front panel without uncomfortable bending and stooping to identify each control. The silver colored faceplate is made of brushed aluminum and fits in beautifully with conventional audio/video components. But the design really comes into its own when the DVP-NC555ES is combined with other silver cascade components, such as the STR-DA9000ES, DA5000ES and DA3000ES receivers.



*Silver cascade front panel of the STR-DA9000ES.*

Here is a summary of the cosmetics in the 2003 ES Series.

### **SILVER CASCADE FRONT PANELS**

- STR-DA9000ES A/V receiver
- STR-DA5000ES A/V receiver
- STR-DA3000ES A/V receiver
- SCD-XA9000ES SA-CD player
- DVP-NC555ES DVD changer

### **MATCHING SILVER FRONT PANELS**

- STR-DA2000ES A/V receiver
- STR-DA1000ES A/V receiver
- DVP-NS999ES DVD player (Silver or Black)
- DVP-CX777ES DVD changer
- RCD-W2000ES CD recorder
- AVD-C700ES DVD receiver
- AVD-S500ES DVD receiver

## Environmentally friendly (DVP-NS999ES)

To conserve energy, power consumption of the DVP-NS999ES is just 0.3 watts in the Standby mode, while operation automatically shuts down 30 minutes after Stop. In addition, the printed circuit boards are produced without the use of halogen. To conserve natural resources, the carton cushions use 100% recycled polystyrene foam. And over half of the plastic parts used for the front panel assembly are made of vegetable-based plastic material.

## LCD remote control with EasyScroll key (DVP-NS999ES)

The DVP-NS999ES offers a huge number of DVD, CD and Super Audio CD playback options. It's crucial to present those options in a format that's easy to understand and easy to use. That's why Sony supplements on-screen menus with a highly refined remote control, the RM-D150A.

- **Liquid crystal display** puts menu options in the palm of your hand. Backlighting makes the display visible and legible, day or night.
- **EasyScroll key** lets you browse and select menu items using just your thumb. Simply rock the key to scroll up or down, then press the key to make your choice.
- **Graphic user interface.** Sony also organizes all the playback options for maximum clarity and presents them on your television screen.
- **A/V system operation** also controls selected brands of infrared remote televisions and A/V receivers.<sup>1</sup>
- **Sleek, low-profile design** fits comfortably in the hand.



*For comprehensive control made easy, the LCD remote control puts menu options in the palm of your hand.*



## Additional features

- **Responsive front-panel controls.** Front-panel buttons respond to the lightest finger contact.
- **LED/fluorescent display dimmer.** To reduce the possibility of audio noise and to minimize visual distraction during movie playback, the front panel fluorescent display and LEDs can be dimmed.
- **Sound feedback.** Beeps can confirm your selections for both front-panel and remote control commands. If you prefer, the tones can be deactivated for completely silent operation.
- **Picture Memory.** Similar to the customizable wallpaper on a PC, the players can display different scenes in the Stop mode. These can include favorite video scenes stored in memory, along with jacket pictures from CD Extra discs.
- **Bit Rate Display.** Users can track the variable bit rate of MPEG-2 compression with on-screen displays of video and audio bit rates.
- **Layer and Pickup Display.** Sony ES players can show an on-screen graphic representation of your current position on the disc, along with your current layer for dual-layer discs.
- **Parental Controls.** You can password protect the viewing of DVDs, restricting playback to PG versions (on compatible discs) or preventing playback altogether.
- **DVD, SA-CD and CD TEXT display.** Sony players provide scrolling front panel display for the text functions of compatible discs.

## At a Glance

<b>System</b>	<b>DVP-NS999ES</b>	<b>DVP-CX777ES</b>	<b>DVP-NC555ES</b>
Number of Discs	Single disc player	400-disc changer	5-disc changer
DVD-Video, DVD-R/RW (Video Format), DVD-RW (VR Format), DVD+R/RW	Yes	Yes	Yes
CD Audio, CD-R/RW, CD MP3, Video CD	Yes	Yes	Yes
Super Audio CD (stereo and multi-channel)	Yes	Yes	Yes
DVD, CD and Super Audio CD Text display	Yes	Yes	Yes
Precision Drive™ 2 Optical System	Yes	Yes	Yes
Twin Laser Pick up	Yes	Yes	Yes
Dynamic Tilt Compensation	Yes	Yes	Yes
50 million instructions per second (MIPS) servo DSP	Yes	Yes	Yes
Delta Sigma 1-bit D/A in servo DSP	Yes	Yes	Yes
<b>Video</b>	<b>DVP-NS999ES</b>	<b>DVP-CX777ES</b>	<b>DVP-NC555ES</b>
Precision Cinema Progressive™ output	Yes	Yes	Yes
Pixel-by-Pixel Active I/P conversion	Yes	Yes	Yes
Vertical Edge Compensation	Yes	Yes	Yes
Video D/A converter word length	14-bit	12-bit	12-bit
Video D/A converter frequency	108 MHz	216 MHz	216 MHz
Noise Shaped Video circuitry	Yes	Yes	Yes
Super Sub Alias Filter circuitry	Yes	Yes	Yes
Video equalizer with Graphical Gamma Adjustment	Yes	Yes	Yes
Separate analog video circuit board with separate power supply	Yes	-	-
High Speed video buffer amplifiers	Yes	-	-
Output Capacitor-Less coupling	Yes	-	-
Carefully selected parts	Yes	-	-
Wide pitch component output jacks	Yes	-	Yes
<b>Audio</b>	<b>DVP-NS999ES</b>	<b>DVP-CX777ES</b>	<b>DVP-NC555ES</b>
Super Audio CD stereo and multi-channel playback	Yes	Yes	Yes
Built-in Dolby Digital® and DTS® 5.1-channel decoding	Yes	Yes	Yes
96 kHz, 24-bit audio D/A converter	Yes	Yes	Yes
Bass redirection for Super Audio CD, Dolby Digital® and DTS® multi-channel output	Yes	Yes	Yes
Speaker Time Alignment with separate settings for DVD and Super Audio CD	Yes	Yes	Yes
A/V alignment	Yes	Yes	Yes
Dolby Digital® and DTS® pass-through	Yes	Yes	Yes
R-Core transformer	Yes	Yes	Yes
Separate circuit board for analog audio with separate power supply	Yes	-	Yes
Audio shield plate protects analog audio circuit board	Yes	-	-
High-speed digital outputs	Yes	-	-
Audiophile-grade components	Yes	-	-
Gold-plated output jacks	Yes	Yes	Yes
Video Off and Display Off modes for lower noise	Yes	Yes	Yes

<b>Construction</b>	<b>DVP-NS999ES</b>	<b>DVP-CX777ES</b>	<b>DVP-NC555ES</b>
Aluminum front panel	Yes	Yes	Yes
Anti-resonant construction	Yes	Yes	Yes
Frame and Beam (FB) construction	Yes	-	-
Off center insulator feet	Yes	-	Yes
Advanced FX Mechanism	Yes	-	-
Fixed Base Unit	Yes	-	-
Hermetic shutter	Yes	-	-
BMC mechanical deck	Yes	-	-
<b>Convenience</b>	<b>DVP-NS999ES</b>	<b>DVP-CX777ES</b>	<b>DVP-NC555ES</b>
Disc Explorer system	-	Yes	-
LCD remote control with EasyScroll key	Yes	-	-
Multi-brand remote control for televisions and A/V receivers <sup>1</sup>	Yes	Yes	Yes
Jog/shuttle dial	Yes	Yes	-
Playback Memory	300 discs	400 discs	40 discs
Custom Parental Control	300 discs	400 discs	40 discs
SmoothScan™ and SmoothSlow special effects modes	Yes	Yes	Yes

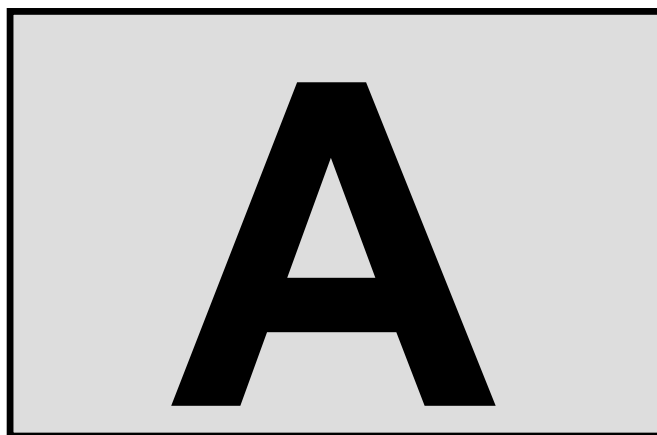


*Originally introduced in black, the DVP-NS999ES is now also available in silver.*

## Appendix A: Progressive, interlace and DVD.

In video, what appears to be a continuously moving image is actually a series of discrete still pictures, called **frames**. On the typical direct-view television, each frame is created on the picture tube by an electron beam that moves from the left edge of the screen to the right, illuminating one **scanning line** at a time. The American EIA television system uses 525 total scanning lines per frame. However, about 45 lines are consumed by the vertical blanking interval and are not displayed on the screen. As a result, the EIA television system is often called **480-line scanning**.

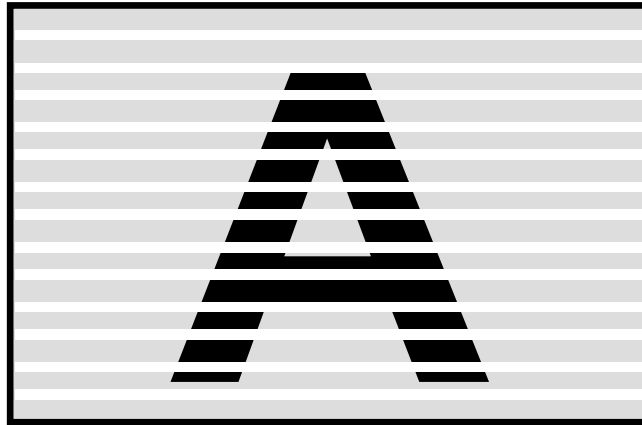
Due to bandwidth limitations from the early years of television, the EIA system was designed to capture 30 frames per second. The natural way to display these images would be to show the scanning lines in sequence, an approach called **progressive scanning**. 480-line progressive scanning at 30 frames per second is abbreviated **480/30P** or **480P** (when discussing the line rate) or **30P** (when discussing the picture rate).



*Progressive scanning creates the picture by illuminating each line from top to bottom until all scanning lines in the frame are completed. Progressive images are clearer, and sharper. The horizontal scanning lines are far less conspicuous.*

Unfortunately, 480/30P creates flicker: the image visibly darkens between frames. In addition, capturing images at 480/30P yields unsatisfactory results in fast-paced action like live sports. For these reasons, the early television engineers developed a solution called **interlace scanning**. Instead of capturing and displaying all 480 lines in their numerical sequence, the EIA system divides the image into two **fields**. The "A" field contains the odd-numbered scanning lines (1, 3, 5, etc.) and lasts 1/60 second. The "B" field contains the even numbered lines and lasts 1/60 second. This system can be abbreviated **480/60i**

or **480i** (when discussing the line rate) or **60i** (when discussing the picture rate). The 480i solution is a compromise that doubles the picture rate but halves the vertical resolution at any given instant. While it is a compromise, the 480i system is highly effective, an elegant engineering solution that has helped make television an essential part of entertainment.



*Interlace scanning divides the frame into two "fields." The first field presents the odd-numbered scanning lines (1, 3, 5, etc.). The second field presents the even-numbered lines. Compared to progressive scanning, picture quality is reduced and the horizontal scanning lines are far more prominent on the screen.*

In the early days of television, when 12-inch diagonal screens were commonly used in living rooms, halving the vertical resolution was not a practical concern. But in today's environment of 61-inch diagonal projection systems, the illusion of a continuous picture on the screen begins to fall apart. Depending on how close you sit to the screen, individual scanning lines become visible and the compromise in vertical resolution becomes an annoyance. That's why many of today's finest big screen televisions have the ability to input and display 480P at 60 frames per second—**480/60P**. When carefully executed, 480/60P can achieve fluid, lifelike fast motion, along with breathtaking image detail. The 480/60P system is also superb for resolving fine print on the screen—one reason why 480/60P is the basis of the popular VGA computer display standard.

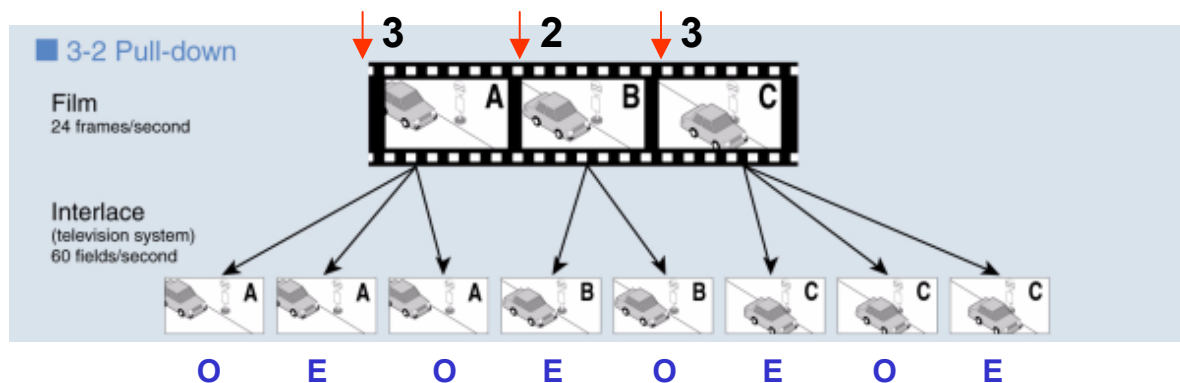
## **Film and video origination**

Movie film is conventionally shot and displayed at 24 frames per second. In the camera, the entire frame of film is exposed at one time. In the theater, the entire frame is projected at one time. Unfortunately, projecting at the native film rate of 24 frames per second creates flicker. That's why movie projectors use a special shutter to display each frame twice, creating the effect of 48 frames per second.

Theatrical release movies aren't the only programs that are originally captured at 24 frames per second on motion picture film. For example, music videos, TV commercials and primetime dramas are often shot on film or film-like 24-frame progressive video. In fact, industry observers estimate that more than 50% of primetime television has been shot on film or 24P video.

## Film-to-video transfer and 3-2 pulldown

We've seen that much of television broadcasting starts out as movie film at 24 frames per second. This means not only has it been converted from film to video, it's been converted from 24 frames per second to 60i. A machine called a telecine performs both conversions. Simple arithmetic says that  $60 \div 24 = 2.5$ . This means that each film frame must convert to an average of 2.5 video fields. A process called 3-2 pulldown performs this conversion. The first film frame is converted to three video fields. The next film frame is converted to two video fields. The next film frame is converted to three video fields, and so on. We get a pattern of 3-2-3-2-3-2 etc, from which 3-2 pulldown gets its name. This pattern averages out to 2.5 video fields for every film frame. The telecine converts a film frame to three video fields by repeating the first field. For example, the first video field may consist of odd scanning lines, the second field consists of even scanning lines and the third field consists of the same odd scanning lines as the first.



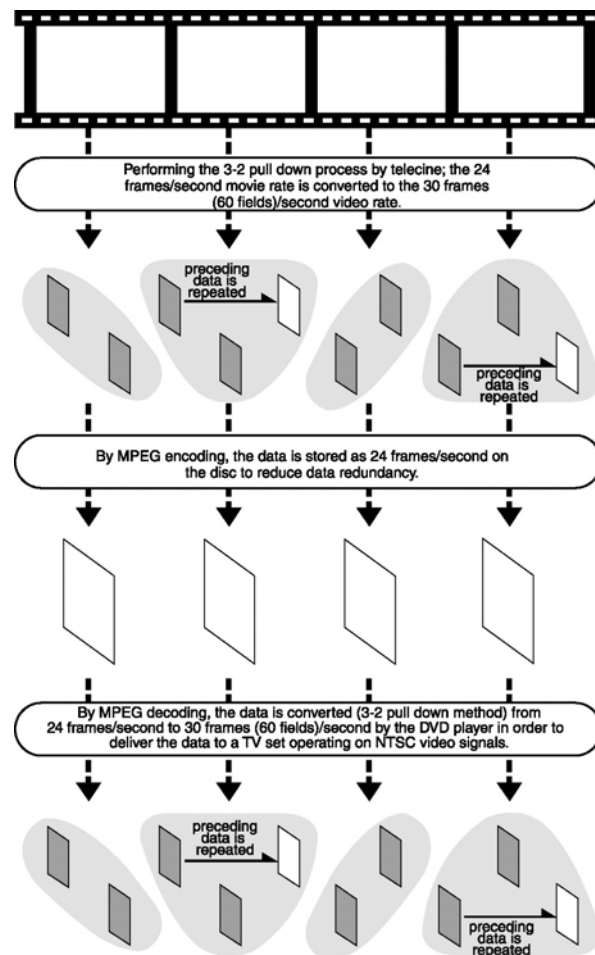
*Thanks to 3-2 pulldown, movie film at 24 frames per second gets transformed to videotape at 60 interlaced fields per second. Movie frame A is converted to three fields. Movie frame B is converted to two fields. Movie frame C is converted to three fields and so on, in a 3-2-3-2-3-2 pattern.*

## Film and video on DVD

In order to fit a feature-length film onto a CD-sized disc, the DVD format employs MPEG-2 digital compression. And one important trick of this compression is to distinguish between footage originally shot on conventional, interlaced video and footage originally shot on film or 24P video. As you would

expect, DVD stores video footage in its native 60i form. But you might be surprised to learn that most DVDs shot on film or 24P video store the images at the native rate of 24 frames per second!

Like material shot on conventional, interlaced video, the typical DVD shot on film is encoded from 60i videotape. But in the DVD authoring process, logic circuits in the majority of high-quality MPEG encoders detect the telltale pattern of 3-2-3-2 in the incoming video fields, the so-called **3-2 cadence**. Since repeated fields would waste precious disc space, the DVD eliminates them and replaces them with **First Field Repeat Flags (FFRFs)** that tell the player which fields to repeat. The remaining fields are reassembled back into their original frames and encoded onto the DVD in progressive scan at 480/24P. This system is 20% more space-efficient than 60i. It's an important advantage because it enables DVDs to hold films that are 20% longer. Or DVDs can encode each frame with 20% more bits, for even better picture quality.



*The DVD stores film-originated material at 24P—the same rate as the original film. First Field Repeat Flags (FFRFs) mark the 3-2 cadence. The DVD player then performs its own 3-2 pulldown to output images at 60i.*

The 24P encoding of film-originated DVDs means that 3-2 pulldown must be performed *in the DVD player* before the picture can be displayed on a conventional television. The exact pattern of 3-2 pulldown can have a subtle effect on the rendering of motion. So it's important that the DVD reproduce the 3-2 pulldown cadence of the original master videotape. That's where the FFRFs come in. They identify each field to be repeated as part of a "3."

## **Interlace-to-progressive (I/P) conversion**

The playback of 480/24P film-originated material has a special property. In material originally shot on 480/60i video, each "B" field represents a slice of time 1/60th second after the corresponding "A" field. To the extent that objects in the frame are moving, the two fields won't match and aren't well suited for direct output in progressive scan.

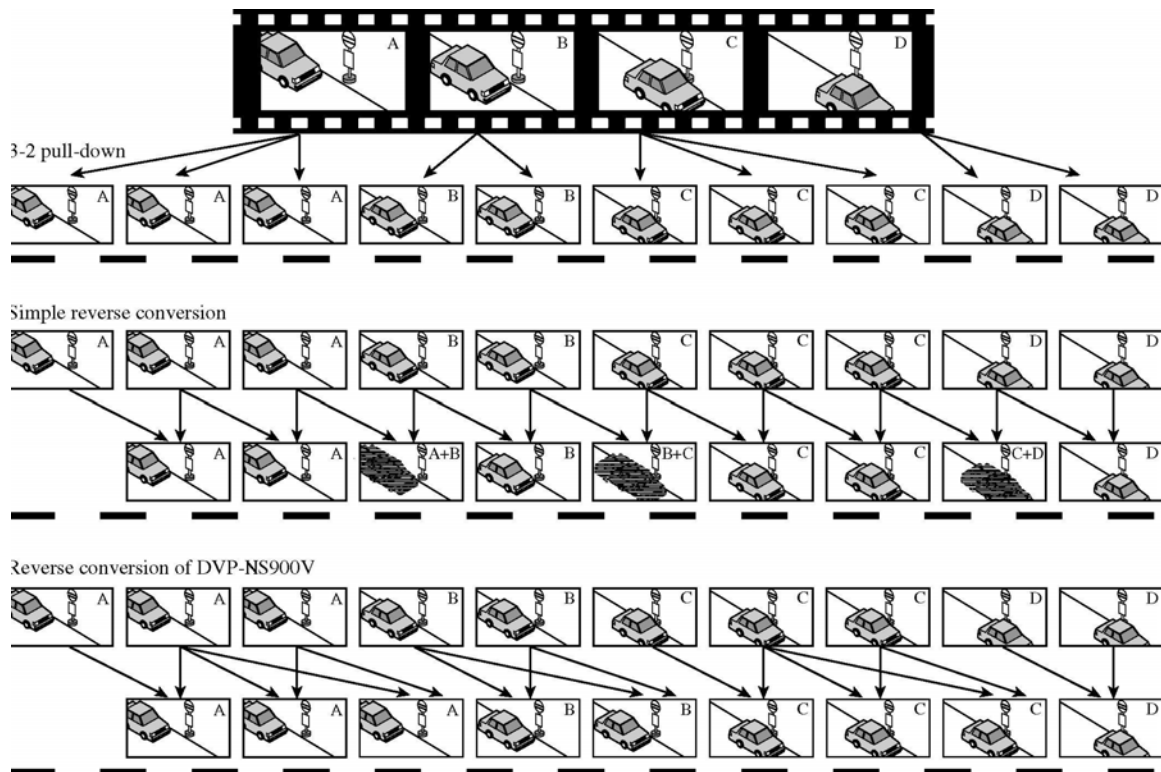
In contrast, 480/24P film-originated DVD is inherently progressive and is beautifully suited to progressive scan display. Ironically, most of today's MPEG decoder chips automatically convert the 480/24P progressive DVD into 480/60i interlaced video. Additional processing is required to convert the 480/60i interlaced signal into a 480/60P progressive signal for output to a compatible television. The required process is called **interlace-to-progressive (I/P) conversion**. Because the process operates on a digital signal in the digital domain, it can result in a super high-quality video source that promises to be the ideal complement to high-end, big-screen televisions with 480P inputs.

## **Frame memory versus full 3-2 reverse conversion**

Unfortunately, not every DVD player with 480P outputs fully delivers on the promise. One potential way to cut corners in 480P output is to adopt relatively inexpensive **frame memory**. However, simple frame memory systems can expose the signal to motion blur on two out of every five video frames. You can see a zipper-like artifact on the left and right side of moving objects.

The cause of these artifacts becomes clear when we review the I/P conversion process. In simple frame memory conversion, the player combines consecutive pairs of fields—no matter what cinema frame they came from. If the two fields came from the same cinema frame, all is well and a beautiful 480P picture results. But if the two fields came from different cinema frames—an event that regularly occurs two times out of five—then images that were captured 1/24 second apart will be artificially combined on the television screen. The result will be a blur of any moving objects in the video picture. These problems are so severe that they undermine the whole reason for getting a progressive scan DVD player in the first place.





At the top are the original film frames, showing a car moving down the street. Next comes the original 3-2 pull-down. Simple frame memory I/P conversion results in a motion blur every time fields from different film frames are combined. (This occurs for two out of every five video frames—or 40% of the time!) At bottom, full 3-2 reverse conversion, as featured in Sony's progressive scan DVD players, preserves the integrity of the original film frames.

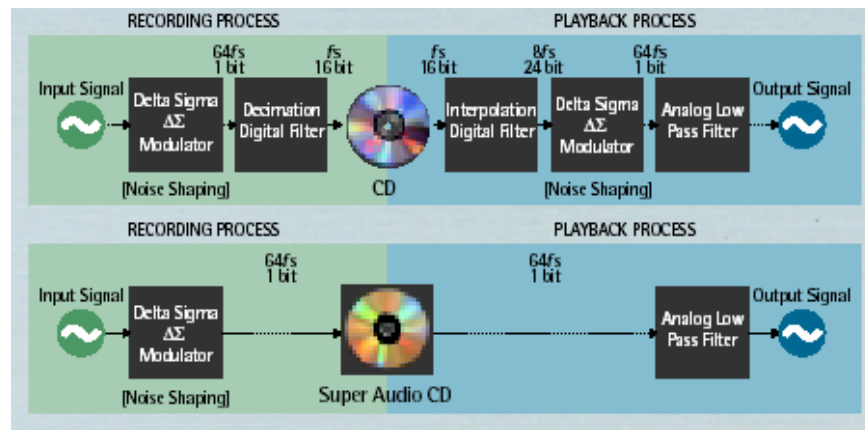
## Appendix B: The Super Audio CD Format

**Because there's so much more to hear.™**

Super Audio CD is the most fundamental improvement in digital music reproduction since the CD itself. No surprise. It comes from the people who invented the CD: Sony and Philips.

### Direct Stream Digital™ encoding

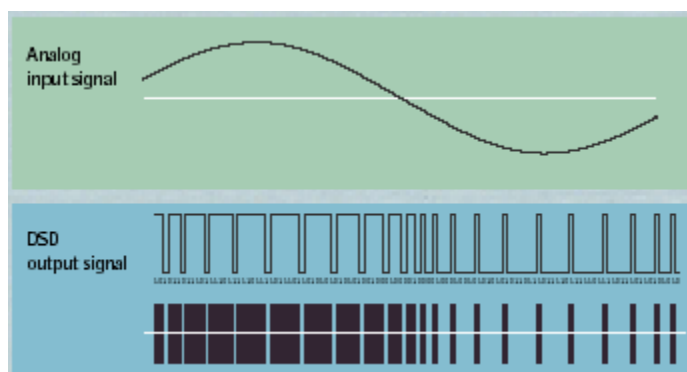
Other digital systems—including the very latest designs—use Pulse Code Modulation (PCM). Unfortunately, PCM record/playback systems require decimation and interpolation filters that can cause problems, including requantization noise, passband ripple and ringing. These degradations can smear musical overtones, muddy the soundstage and compromise overall transparency. Simply increasing the PCM word length to 24 bits or increasing the PCM sampling rate to 96 kHz does nothing to overcome these fundamental problems.



*Compared to CD, Super Audio CD is far simpler. Super Audio CD eliminates decimation and interpolation filters.*

Direct Stream Digital processing eliminates these problems by eliminating the filters. It enables a 1-bit signal to be recorded *directly*. Sony's 1-bit system encodes music at an astonishing 2,822,400 samples per second.

Thanks to DSD encoding, the Super Audio CD format offers frequency response to 100 kHz and a theoretical dynamic range of more than 120 dB. But specifications alone cannot express the DSD advantage. DSD one-bit encoding strips away entire classes of distortion that have always characterized PCM. The DSD system provides nothing less than a quantum leap in music resolution.

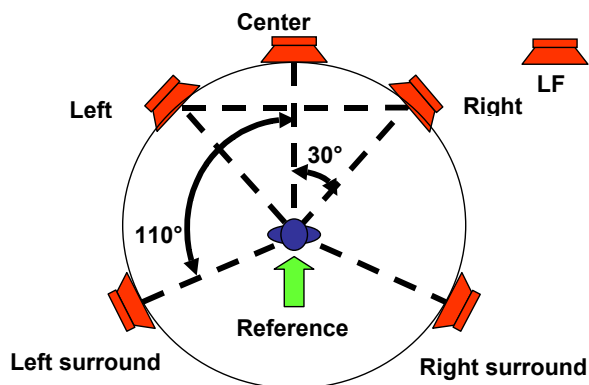


*The DSD pulse train "looks" remarkably like the analog waveform it represents. More pulses point up as the wave goes positive and down as the wave goes negative.*

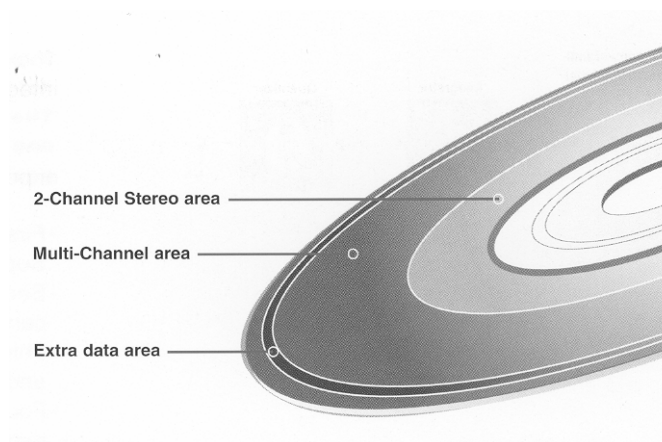
## Multi-channel Super Audio CD

Producers also have the option of creating multi-channel Super Audio CDs that can transport you to the acoustic space of the original recording. You'll hear the most convincing soundstage ever presented at home. Super Audio CD multi-channel sound is based on the international standard ITU-R speaker setup. So it's directly compatible with many of today's home theater speaker systems.

For full compatibility with pure stereo Super Audio CD players, every multi-channel Super Audio CD includes a complete stereo rendition from the hand of the producer. You're never at the mercy of a computerized "fold-down" of the multi-channel mix. You'll always hear the producer's original intent.



*Super Audio CD multi-channel sound is based on the international ITU-R standard.*



*Every multi-channel Super Audio CD includes a separate 2-channel stereo mix, done by the hand of the producer—not by a computer.*

## Backward compatibility

Every Super Audio CD player will play back the 13 billion audio Compact Discs worldwide. So the Super Audio CD format keeps the faith with CD, the most popular digital format of all time. The Super Audio CD format also includes a hybrid disc option that will play back beautifully in more than 700 million CD players, worldwide.

	CD	Super Audio CD (single layer)
Disc diameter	12 cm	12 cm
Disc thickness	1.2 mm	1.2 mm
Playback side	Single	Single
Coding System	16-bit linear PCM encoding	1-bit DSD encoding
Sampling Frequency	44,100 Hz	2,822,400 Hz
Disc data capacity	680 MB	4.7 GB
Disc minimum pit length	0.83 micrometers	0.40 micrometers
Disc track pitch	1.60 micrometers	0.74 micrometers
Laser wavelength	780 nm	650 nm
Lens numerical aperture (NA)	0.45	0.60
Playback frequency range (theoretical)	DC—20,000 Hz	DC—>100,000 Hz
Dynamic range (theoretical)	96 dB (audible range)	More than 120 dB (audible range)
Maximum playback time	Approx. 74 min. (stereo)	Approx. 110 min. (stereo) Approx. 74 min. (multi-channel and stereo)
Additional functions	Text, graphics	Text, graphics, video

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1. Multi-brand remote may not be compatible with some brands or models.