

**SONY**<sup>®</sup>



## **ES Series Receivers Technical Background**

Version 1.1; May 25, 2005

## A new generation of A/V receivers

Digital home theater continues to advance at breakneck speed. You can listen to upgraded surround sound formats, including Dolby Digital® EX 6.1 channel sound, dts® ES discrete 6.1 and dts Neo6:cinema. You can watch High Definition video from over-the-air broadcasting, cable, satellite, HDV camcorders, HD home videocassette recorders and HD digital video recorders. You can enjoy surround sound from as many as nine speakers.

At the heart of the home theater—switching it all, decoding it all and reproducing all the sound—stands the A/V receiver. And this single component is challenged as never before. How do you coordinate and switch all those sources, preserving audio and video in their most pristine form? How do you pack all those channels of amplification in a single chassis and still deliver the quality and power that home theater requires? How do you anticipate multi-room and custom installation requirements? These questions are daunting. And the answers determine the quality and suitability of any modern A/V receiver.

The engineers of Sony ES Series don't simply answer these questions. They help drive the technology that brings these questions into being. Thanks in part to this expertise, Sony's ES Series receivers have been praised by equipment reviewers, cherished by home theater enthusiasts and scrutinized by an entire industry. Sony's latest ES Series A/V receivers, particularly the STR-DA7100ES, establish an important benchmark in home theater design with three crucial advantages:

- S-Master Pro digital amplifiers with 32-bit processing and a new generation of MOS FET output transistors.
- HDMI inputs, upconversion, switching and output.
- i.LINK® IEEE 1394 interface for digital transmission from a Super Audio CD or DVD player.

In this way, our latest A/V receivers carry forward the proud tradition of the Sony ES Series, the Elevated Standard in audio and video.

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## **Digital home theater and the ES Series**

The engineers of the Sony ES Series haven't simply witnessed the digital home theater revolution. They've been driving it forward. After all, it was Sony that launched and spearheaded so many of the entertainment formats that define digital home theater. We co-invented the Compact Disc, DVD and Super Audio CD. We're a global leader in professional High Definition production equipment, as well as a leader in HDTVs. We've launched consumer High Definition camcorders. And in Japan, we marketed the world's first Blu-ray Disc™ High Definition recorder.

This heritage, unmatched in home entertainment, has inspired Sony engineers since the very birth of the ES Series, leading us to create landmarks in home entertainment:

- The world's first CD player with digital output and the world's first outboard D/A converter (CDP-650ES and DAS-702ES, 1985).
- The world's first all-digital preamplifier (TA-E1000ESD, 1989).
- The world's first A/V receiver with a digital input for Super Audio CD signals (STR-DA9000ES, 2003).
- Digital amplification in a high-end A/V receiver (STR-DA9000ES, 2003).
- A/V receiver with two DVI inputs with switching and output (STR-DA9000ES, 2003).

Sony's latest A/V receivers are worthy successors, bringing this heritage to a new generation of home entertainment enthusiasts.

# **S-Master Pro amplifier with 32-bit DSP**

The video signal in home theater is increasingly digital from the latest digital cinematography in Hollywood through digital transmission channels to digital television display panels. The audio in home theater is increasingly digital from the microphone mixing console through the distribution channels, to the digital inputs and digital signal processing of your A/V receiver. With digital sources, digital switching and digital preamplification, it was only a matter of time until the power amplifier also made the move from analog to digital.

Even so, some observers were surprised in 2003 when Sony introduced ES Series A/V receivers with a digital amplifier we called S-Master Pro. Fiercely independent critics evaluated the Sony STR-DA9000ES receiver using the finest source material and ancillary equipment. Their response was overwhelming. They brought out their highest superlatives, calling the sound of the DA9000ES "airy," "delicate," "pure," "relaxed," "open," "fantastic," and "a revelation."

Not content with establishing a new benchmark in A/V receiver sound quality, the engineers of Sony's ES Series continue to press ahead with an upgraded, 32-bit S-Master Pro LSI, redesigned MOS FET transistors and a fresh approach to transistor cooling.

<b>Process</b>	<b>S-Master</b>	<b>"Digital Drive" S-Master</b>	<b>S-Master Pro</b>	<b>S-Master Pro (2005)</b>
<b>Generation</b>	First	Second	Third	Fourth
<b>Introduction</b>	2001	2002	2003	2005
<b>Technologies</b>	<ul style="list-style-type: none"><li>• Clean Data Cycle</li><li>• C-PLM</li><li>• S-TACT</li></ul>	<ul style="list-style-type: none"><li>• Clean Data Cycle</li><li>• C-PLM</li><li>• S-TACT</li><li>• Pulse Height Volume Control</li></ul>	<ul style="list-style-type: none"><li>• Clean Data Cycle</li><li>• C-PLM</li><li>• S-TACT</li><li>• Pulse Height Volume Control</li><li>• DC Phase Linearizer</li><li>• Discrete Output Transistors</li></ul>	<ul style="list-style-type: none"><li>• 32-bit S-Master Pro DSP</li><li>• Clean Data Cycle</li><li>• C-PLM</li><li>• S-TACT</li><li>• Pulse Height Volume Control</li><li>• Integrated DC Phase Linearizer</li><li>• Discrete MOS FET Output Transistors, redesigned cooling</li></ul>

## Why Digital Amplification?

After decades of engineering practice, the limitations and awkward characteristics of traditional amplifiers have become so familiar that most engineers don't even notice them:

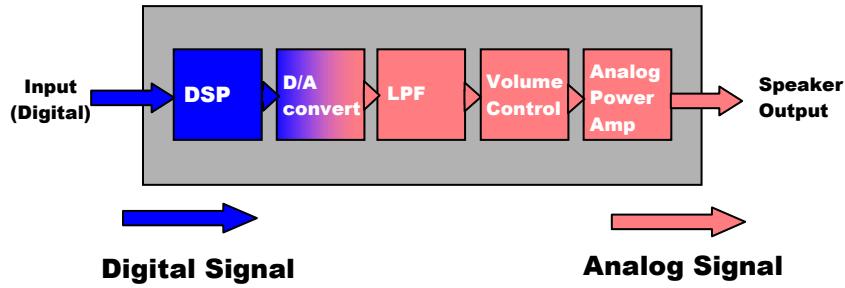
- **Complexity.** In the context of today's home theater receivers, you have digital source material processed through a digital preamplifier—only to be converted to analog prior to amplification.
- **Heat generation.** Conventional power output transistors throw off much of their power as heat. And heat is always bad for electronics.
- **Thermal modulation distortion.** Changes in the audio signal cause immediate changes in the output transistor temperature, which in turn cause changes in transistor performance! This is thermal modulation distortion.
- **Crossover distortion.** Conventional transistor pairs create crossover distortion, which becomes particularly audible during quiet passages. The normal solution is amplifier bias—which means more heat!
- **Open-loop distortion.** Traditional amplifiers typically generate substantial "open-loop" distortion. The Negative Feedback (NFB) used to correct this can trigger other problems like Transient Intermodulation Distortion.

Commonly understood for decades, these limitations are so thoroughly ingrained in home audio design that they're considered "inevitable." Resolving these issues means accepting massive heat sinks, tolerating circuitous signal paths and chasing down transient distortions. Sony engineers sought a better way. Sony's S-Master Pro circuitry overcomes these fundamental constraints by completely replacing analog amplification with digital technology.

Digital amplifiers had been around for decades, outside the mainstream of home audio. But great strides in Large Scale Integration (LSI), 1-bit processing and faster MOS FET output transistors have opened the door to a new generation of digital amplifier technology.

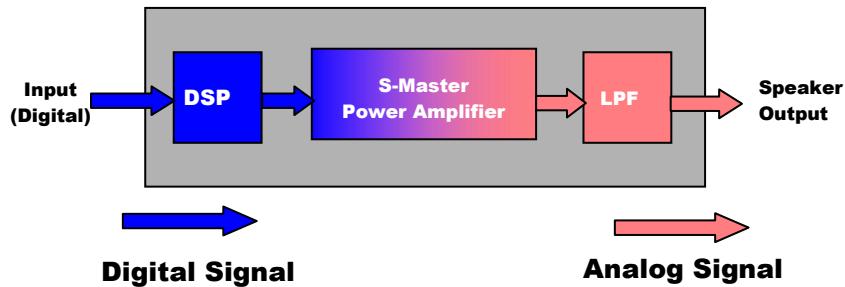
## S-Master Pro: principle of operation

In the context of a modern A/V receiver, traditional power amplifiers require the needless complexity of D/A conversion, Low Pass Filtering (LPF) and analog volume control prior to the input.



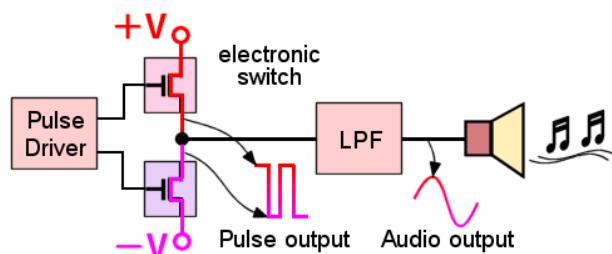
*The conventional A/V receiver is anything but simple. The signal must run through a gantlet of processes and stages.*

The Sony S-Master Pro amplifier is dramatically different. There is no Digital-to-Analog (D/A) converter. Instead, the amplifier accepts all digital signals directly, whether they're multi-bit Pulse Code Modulation (PCM) or 1-bit Direct Stream Digital™ pulses from Super Audio CD. Even analog inputs are converted to DSD. The output of the S-Master Pro amplifier goes through a single Low Pass Filter to provide the wattage that drives the speakers. In this way, the signal remains digital until the last possible instant.



*The Sony S-Master Pro amplifier dramatically simplifies receiver design. And in high fidelity, simpler is better.*

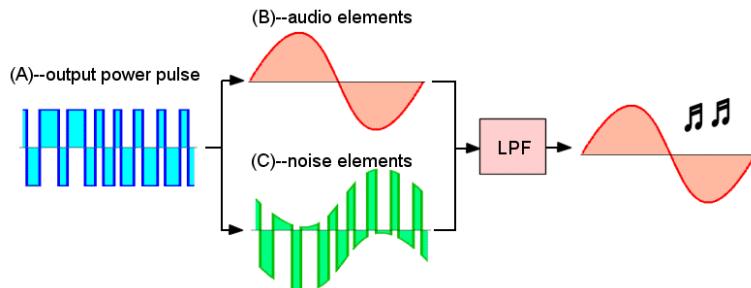
The S-Master power amplifier generates a 1-bit pulse stream to switch pairs of MOS FET power output transistors on and off. The resulting output has more than enough wattage to drive a loudspeaker.



*The output transistors act like an on/off switch for the power supply voltage. The Low Pass Filter (LPF) converts the amplified pulses to a smooth, continuous analog waveform.*

The S-Master 1-bit pulse stream has much in common with the Direct Stream Digital signal that Sony developed for Super Audio CD. If you look

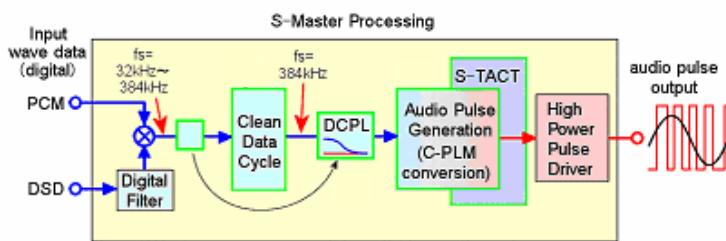
carefully at the pulses, you'll see that where the audio waveform is positive, the pulses are mostly 1. Where the audio waveform is negative, the pulses are mostly 0. In this way, a 1-bit pulse stream can represent the audio signal. As with a DSD signal, a Low Pass Filter (LPF) is all you need to recover the original audio signal.



*In the diagram above, (A) represents the output power pulse stream. This combines two components, the original audio signal (B) and a noise component (C). The audio signal (B) looks smooth and continuous because the frequencies are low. The noise component (C) looks abrupt and spiky because the frequencies are high. The Low Pass Filter (LPF) effectively separates out the audio signal, for extremely accurate music reproduction.*

## Inside the S-Master Pro process

While Sony's S-Master Pro amplifier is simple in principle, the fidelity of the output signal depends on getting each pulse exactly right. That is, the leading and trailing edges of each pulse must have the right timing—and the height of each pulse must be carefully controlled. This is comparable to the requirements for Super Audio CD playback. So to accomplish these goals, Sony used technologies developed for our legendary SCD-1 Super Audio CD player.



*Sony's CXD9773Q S-Master Pro LSI incorporates several stages of crucial signal processing.*

In specific, the S-Master Pro LSI incorporates five important technologies:

- **Clean Data Cycle.** "Jitter" or time-base errors can degrade the accuracy of digital signals. That's why the first stage of the S-Master Pro process is Sony's Clean Data Cycle. This regenerates the digital signal with time-axis accuracy equivalent to the original A/D converter at the recording studio. In

this way, jitter is completely eliminated—and the integrity of the original musical signal is restored.

- **DC Phase Linearizer (DCPL).** Interaction between traditional amplifiers and real-world loudspeakers cause significant departure from phase linearity at frequencies below 30 or 50 Hz. These shifts have a subtle effect, creating warmer and more accessible bass. Sony's DC Phase Linearizer gives you several control positions, including Off, enabling you to adjust low-frequency phase shift and restore this effect.
- **Complementary Pulse Length Modulation (C-PLM).** Previous digital amplifiers have used a 1-bit technology called Pulse Width Modulation or PWM. Those digital amplifiers varied the width of pulses. Unfortunately, PWM tends to expose the signal to second-order harmonic distortion. C-PLM effectively controls the distortion, maintaining the integrity of the musical signal.
- **Synchronous Time Accuracy Controller (S-TACT).** Because C-PLM conversion expresses the music in a different digital form, the signal requires another round of correction for time-base errors. Synchronous Time Accuracy Controller (S-TACT), originally developed for Sony's SCD-1 Super Audio CD player, effectively clears pulse generator jitter by referencing the output directly to the master clock. This establishes extremely accurate pulse timing for amazingly low distortion.
- **Pulse Height Volume Control.** Most digital volume controls work by Digital Signal Processing, an approach that sacrifices detail in the least significant bit. Sony's Pulse Height Volume control adjusts the 1-bit C-PLM stream by adjusting the regulator that supplies voltage to the power pulse generator. Because this method does not modify or reshape the original digital samples, there's no loss of information, no loss of detail. Sound quality is maintained from very low volume settings all the way to maximum.

## S-Master Pro Benefits

Sony's S-Master Pro design delivers a host of benefits.

- **Simplicity.** Digital signals remain in the digital domain until the last possible moment. The purity and clarity of digital source material is maintained.
- **Low heat generation.** With S-Master Pro, the output MOS FET transistors simply switch between fully On and fully Off states. The transistors operate at nearly maximum thermal efficiency. This has a profound impact on the physical design of the power amplifier.
  - The amps can be far more compact, because the heat sinks take up far less space. This is a major consideration when you have seven amplifiers, each putting out 170 watts per channel (all channels driven, 8 ohms, 20 to 20,000 Hz, at 0.15% THD).

- Instead of isolating the power amplifier because it runs too hot, the amps can be located anywhere in the chassis that makes the most sense.
  - With this new freedom in locating the amplifier, the circuit paths inside the chassis can be rationalized. In Sony's words, they can be made "short, simple and straight."
- **Minimum thermal modulation distortion.** In traditional amplifiers, the output transistors must reproduce the waveform directly. This means the heat inside the transistors changes rapidly—getting hotter during the middle ranges of the audio waveform when the transistor is inefficient. Unfortunately, the changing heat can degrade the electrical performance of the transistor, generating thermal modulation distortion. Because the S-Master Pro transistors simply switch from full-on to full-off. There's almost no power wasted as heat. So thermal modulation is held to a minimum.
- **No crossover distortion.** Conventional power amplifiers use separate transistors to reproduce the upper and lower halves of the waveform. This tends to generate the glitches of crossover distortion, which is particularly audible when the music is soft. Because the S-Master Pro amplifier uses pulse density, the output transistors do not generate the waveform. Any switching glitches get *removed from the music by the low pass filter*. In this way, the system is immune to crossover distortion, even when the music or movie sound track is particularly soft.
- **Superb open-loop performance.** Traditional amplifiers typically generate substantial distortion in "open-loop" mode. That's why analog amps use Negative Feedback (NFB). Unfortunately, NFB exposes the signal to Transient Intermodulation Distortion and other dynamic problems. In contrast, the Sony S-Master Pro amplifier achieves excellent fidelity without any negative feedback at all! Distortion remains low without any sacrifice in transient and dynamic characteristics. Music comes alive.

Independent reviewers have heaped praise on Sony's S-Master Pro amplifier. But you don't need a magazine review (or a white paper) to appreciate the results. Use good speakers, a suitable disc player and a Super Audio Compact Disc that you know well. Then sit back and listen carefully. Dynamics are powerful but not forced. Bass is vigorous but not boomy. Music is rendered in very high resolution, against a background of silky silence.

## The 32-bit Upgrade

Where the acclaimed STR-DA9000ES took advantage of 24-bit S-Master Pro processing, Sony's latest design boasts the superior precision of Sony's 32-bit processing. Sony proudly presents a masterpiece of integrated circuitry, Sony's CXD9773Q Large Scale Integrated circuit (LSI).



*As a primary manufacturer of Large Scale Integrated circuits (LSIs), Sony has the freedom to pursue innovative thinking like S-Master Pro and then express this thinking in silicon. The result is Sony's own CXD9773Q.*

- **Superior dynamic range.** The previous S-Master Pro LSI achieved 24-bit processing at 1024 fs. This translates to an impressive 34 bits of resolution at the 48 kHz sampling rate (fs). The new CXD9773Q goes much further, with 32-bit processing at 1024 fs. Internal dynamic range at the 48 kHz sampling rate is improved from 180 dB to 228 dB. When Super Audio CD signals are sampled at 8 fs, the internal dynamic range improves from 162 dB to 210 dB out to nearly 100 kHz. Clearly, the new 32-bit processor has more than enough dynamic range for the most demanding digital audio sources.
- **Higher accuracy for the Clean Data Cycle.** Because one-bit digital signals depend on the accuracy of the time domain, Sony suppresses jitter with Clean Data Cycle. Our 24-bit processor achieved a theoretical accuracy of 40 femtoseconds. One femtosecond is  $1/1,000,000,000,000,000$  second (in scientific notation,  $10^{-15}$  second). For comparison, it takes a billion femtoseconds to equal one nanosecond. Stated another way, there are as many femtoseconds in one full second as there are seconds in 30 million years!

So it's fair to say that accuracy of 40 femtoseconds is fairly precise. However our 32-bit processor goes well beyond this, to an accuracy of 0.08 femtoseconds (or 80 attoseconds, if you prefer). This is about the same time it takes an electron to fluctuate within a single lattice of a metal crystal. So we can say that the 32-bit Clean Data Cycle reduces jitter to the theoretical minimum. (Note: This measure, 80 attoseconds is roughly four orders of magnitude more precise than the jitter induced by chassis vibration. From a practical standpoint, suppressing chassis vibration has a great impact on the final sound quality.)

- **Built in DC Phase Linearizer.** Where Sony's 24-bit LSI required a second chip to contain the DC Phase Linearizer, this circuitry is built right into Sony's 32-bit design. The process is performed by Infinite Impulse Response (IIR) calculation, which processes more data in less time.

In this way, Sony has taken the critically-acclaimed S-Master Pro amplifier to a higher level of precision and performance. Those fortunate enough to own of the STR-DA7100ES will experience superb clarity of expression, relaxed listening hour after hour, and the effortless dynamics to handle everything from a the Dies Irae of Verdi's Requiem to the meteor impacts of the latest action movie.

## **Toroidal Low Pass Filter**

The Low Pass Filter is a crucial stage in any digital amplifier. The filter must have a turnover frequency high enough for high-resolution audio, yet have a cutoff characteristic steep enough to suppress high-frequency noise elements. In this way, the filter has a major influence on sound quality. That's why the engineers of Sony ES selected the filter parts carefully and methodically. Instead of choosing less expensive cylinder-type coils, the ES engineers chose exotic toroidal coils, optimized for sound. Customers will never see these toroidal coils, but they will hear the benefits in clean, open, non-fatiguing music reproduction.



*Shown here wrapped in black, the toroidal coils of Sony's Low Pass Filters are more expensive. But their contribution to sound is more than worth the price.*

## **MOS FET Output Transistors**

In traditional amplifiers, the output transistors or ICs directly shape the analog waveform. For this reason, traditional amplifiers are extremely sensitive to the selection, configuration, bias current and heat sinking of their output devices. By their design, digital amplifiers are inherently less sensitive to these factors. That's why some previous digital amplifiers have used relatively inexpensive integrated circuit op-amps at the output. But Sony ES engineers were after the best possible sound. So they selected deluxe Metal Oxide

Semiconductor Field Effect Transistors (MOS FETs), four per channel, for the STR-DA7100ES. The result is another measure of signal integrity.

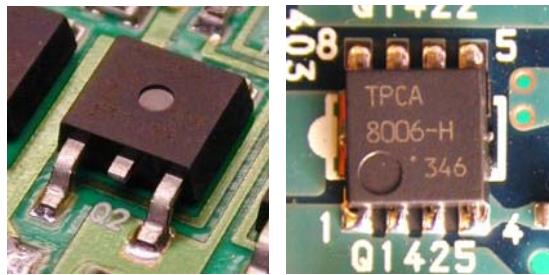


*A detail of the power amplifier circuit board of the STR-DA7100ES. The twelve black chips are the MOS FET output transistors for three channels (4 MOS FETs per channel).*

Sony output transistors are remarkable for their internal wiring and bonding, their unique packaging and the way they're configured on the power amplifier circuit board. Consider the packaging.

## MOS FET Thermal Packaging

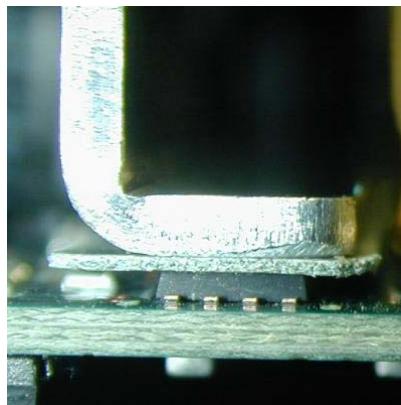
Conventional output transistors have two distinct sides. The bottom is designed to radiate heat, and is usually attached to a metal heat sink. The top is fashioned from molded plastic, from which heat cannot escape. No matter how much cooling may be available at the top, the plastic package is too thick to conduct heat away from the transistor.



*On the left, the MOS FET output transistor used in Sony's STR-DA9000ES was 2 to 3 mm thick. At right, the MOS FETs used in the DA7100ES is 1 mm thick or less, for far better dissipation of heat.*

The power MOS FETs in Sony's STR-DA7100ES are of a dramatically different design, 50 to 70% thinner than the transistors used for the DA9000ES. Even more important is the top molding of the transistor package, which is now 80% thinner than the previous design. The plastic itself is a resin of high thermal conductivity, designed from the outset to encourage the flow of heat, not block it. This thermal design—which runs counter to every practice in traditional amplifiers—makes perfect sense considering the low heat generation of Sony's S-Master Pro digital amplifier.

Sony takes advantage of this thermal design by coupling the heat sink to the top of the MOS FET transistors, leaving the bottom to face a four-layer circuit board, on which the transistors are surface mounted. Where most amplifiers require thick aluminum heat sinks with many ribs to radiate the heat, the STR-DA7100ES can use a single, simple sheet of metal with no ribs at all!



*Extreme close-up of a single MOS FET output transistor (middle), bonded to the L-shaped bracket of the heat sink. The transistor is surface mounted to a four-layer circuit board (bottom).*



*On the left, the STR-DA7100ES power amplifier without the heat sink. The four large black ICs in the middle are Sony's S-Master Pro 32-bit LSIs, the CXD9773Q. On the right, the same circuit board with heat sink in position.*

Again, this runs counter to previous design practices for traditional amplifiers. Typically, output transistors generate so much heat that they need to

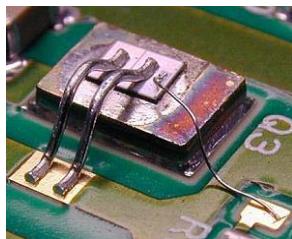
be isolated from other circuits. On big amps, you'll usually find the output transistors bonded to heavy aluminum heat sinks somewhere at the back or sides of the chassis. Thanks to the cool running of Sony's S-Master Pro amplifier, the MOS FETs are located where the circuit topology is shortest and simplest—lined up side-by-side, right in the middle of the power amplifier circuit board. In fact, the transistors can be so close together that the STR-DA7100ES amplifier section is some 70% smaller than the DA9000ES amp section! And the board itself is located in the middle of the DA7100ES chassis.

As a result, the music is less exposed to vibration, radiated hum and noise. Operation is cool and consistent. And nothing intrudes between you and the sound.

	<b>Traditional amplifier</b>	<b>STR-DA7100ES</b>
<b>Transistor heat</b>	Major design concern	Minor issue
<b>Transistor packing</b>	Widely separated	Close together
<b>Transistor location</b>	Away from heat-sensitive parts	Surface mount directly on the amplifier circuit board
<b>Transistor heat radiation</b>	From the bottom	From the top
<b>Heat sinks</b>	Massive radiating fins made of die cast aluminum (on the better amplifiers)	A single sheet of metal
<b>Space requirements</b>	Major, for high powered amplifiers	70% smaller than the STR-DA9000ES—and far, far smaller than analog amps of comparable power
<b>Amplifier board location</b>	Isolated, to protect other circuits from heat	Wherever it makes the most sense for the shortest possible signal paths
<b>Overall chassis topology</b>	Circuitous, because of output transistor heat	Short, simple and straight

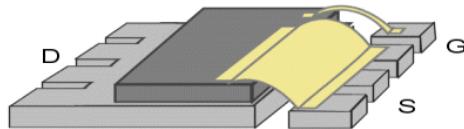
## Molecular Bonding

Even inside the MOS FET output transistors, Sony innovations are at work. Sony uses a new refinement of our molecular bonding technique to attach the transistor leads. In the STR-DA9000ES, the MOS FETs use "double wire molecular bonding" with two bonding wires, each rated for 15 amps of current. As a result, the DA9000ES MOS FET binding wires had 30 amp capacity. This was sufficient for the transistor's rated instantaneous current supply of 24 amps.

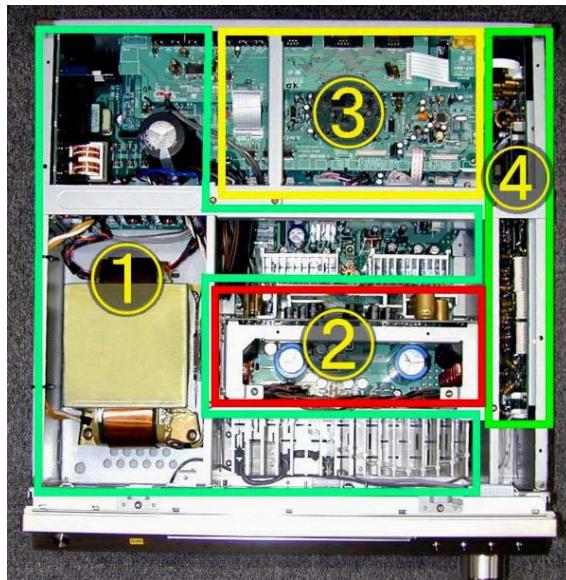


*The bare transistor for the STR-DA9000ES MOS FET, showing the double wire molecular bonding.*

Building on this experience, the redesigned MOS FETs for the STR-DA7100 use "sheet metal molecular bonding." In this design, the semiconductor and the three Source electrodes are connected by an aluminum sheet. (The other electrode is the Gate. The Drain on the bottom of the FET is die attached.) While the double wire bonding of the DA9000ES achieved a low resistance of 5 milliohms, the sheet metal bonding of the DA7100ES reduces this to just 1 milliohm or less. Also current capacity is increased and internal resistance of the MOS FET is cut in half. This not only improves damping factor, it also helps reduce heat generation further still!



*Illustration of the bare transistor of the STR-DA7100ES MOS FET, showing connections for Source (S), Gate (G) and Drain (D). Sheet metal molecular bonding provides the Source connection at 80% reduced resistance, compared to the MOS FETs of the DA9000ES.*

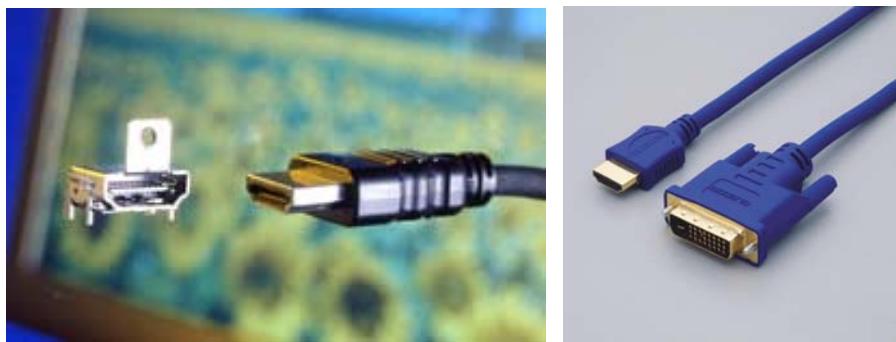


*Internal layout of the DA7100ES. (1) Power supply. (2) S-Master Pro. (3) Preamp and video section. (4) Input signal processing. Note how small the power amplifier is.*

## HDMI inputs and switching

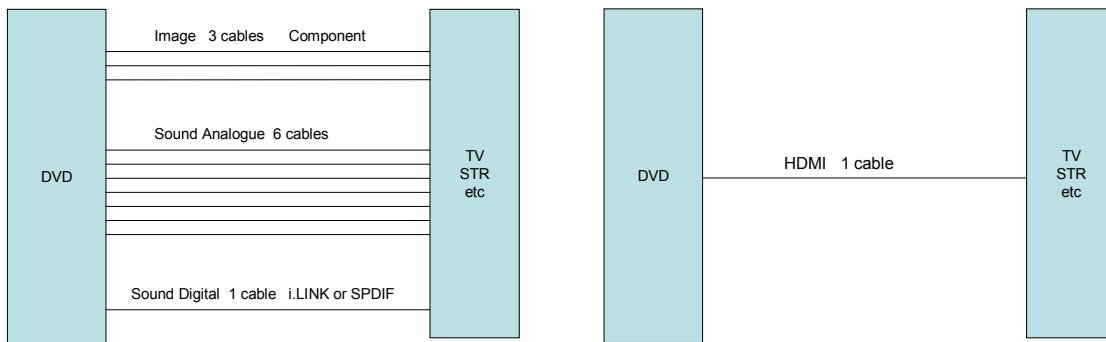
Home video connections represent a definite hierarchy of picture quality. At the bottom rung of the ladder, almost not worth mentioning, is the RF connection, which conveys a home video signal to your television as TV Channel 3 or 4. Far better is the composite video connection. Better still is S-Video. One of the best analog connections is Y/Pb/Pr component video, which is capable of going beyond conventional 480i Standard Definition signals and supporting 480p and High Definition 720p and 1080i.

But the best available connections are in the digital domain. And Sony has been quick to take advantage. Our STR-DA9000ES was one of the first A/V receivers to offer not one, but two Digital Visual Interface (DVI) inputs, with switching between them and a DVI output to the television.



*On the left, an HDMI plug and its corresponding jack. On the right, an optional DVI-to-HDMI adaptor cable enables you to connect DVI equipment to the STR-DA7100ES receiver,*

Now the STR-DA7100 goes a giant step further with the High Definition Multimedia Interface (HDMI). Established in September 2003, HDMI is an extension of the DVI digital interface. While DVI is limited to video only, HDMI can transmit uncompressed High Definition digital video and digital audio via a single cable. This greatly simplifies system set-up, replacing as many as ten analog and digital connections with just one cable! In addition to providing 480p, 720p or 1080i, the HDMI output of Sony ES Series DVD players can support digital video in both RGB and Y/Cb/Cr form.



*Before HDMI (left), you needed nine cables to get component video and 5.1-channel analog audio from your DVD player and into your receiver. If you wanted digital audio as well, that would mean a tenth cable. HDMI conveys both video and audio with full resolution and digital precision—all on a single cable!*

The options for audio are equally rich. For example, the HDMI output of Sony ES Series DVD players can support a full range of digital audio, including 2-channel stereo PCM, Dolby Digital® and DTS® 5.1-channel compressed audio and even uncompressed multi-channel PCM audio! With so many choices for video and audio output, you may wonder whether users will be knowledgeable enough to get the best performance from their systems. Is RGB preferable to Y/Cb/Cr? Is 720p better suited to their television or 1080i? While users will have their choice from a menu of options, HDMI offers a simpler way.

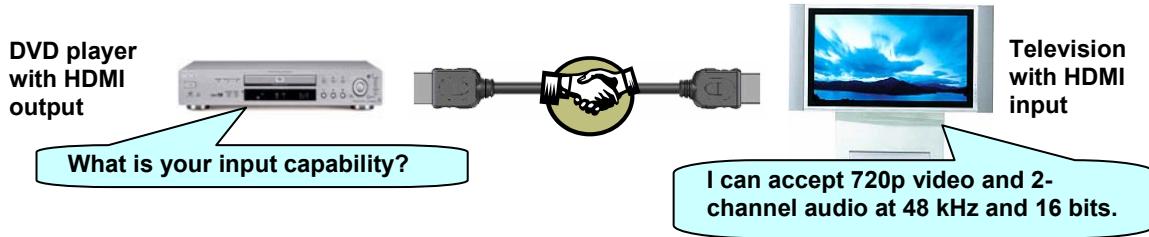
## Component-to-component communication

A system called “product unique key exchange” enables connected equipment to automatically confirm the type of component connected through HDMI. In addition, a source component (such as Sony's DVP-NS9100ES DVD player) can automatically transfer the appropriate audio and video by checking the input capabilities of product next to it (such as an HDMI equipped television or A/V receiver). In this way, the equipment can *automatically* choose the highest performance audio and video formats that the source and target components both have in common!

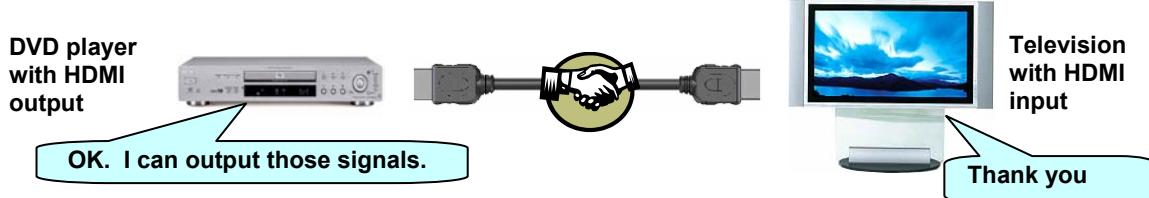
Consider what happens when you connect an HDMI equipped DVD player to an HDMI equipped television. On first connection the two components exchange basic information—they "introduce themselves."



Next, the components communicate their input/output capabilities.



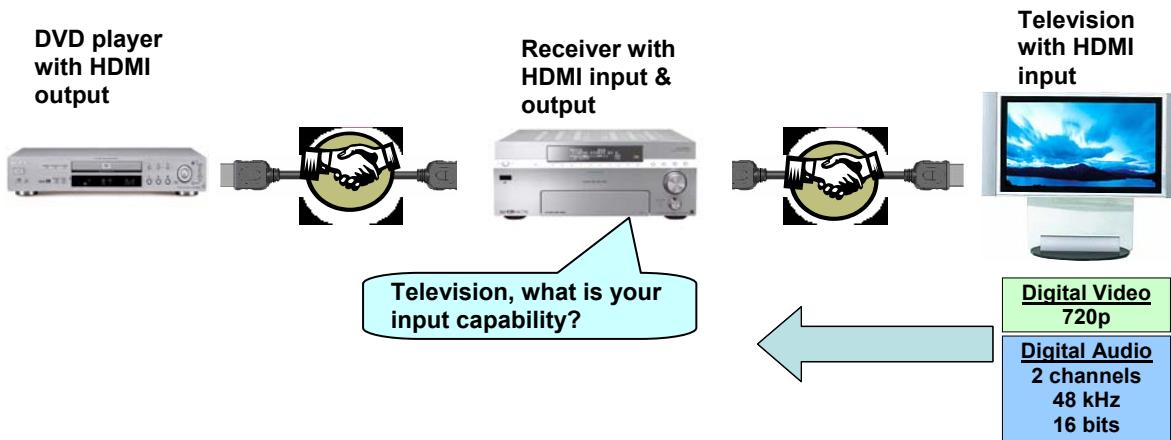
Finally, the components agree on the highest available quality options for digital audio and video—and then automatically transfer content at that quality!



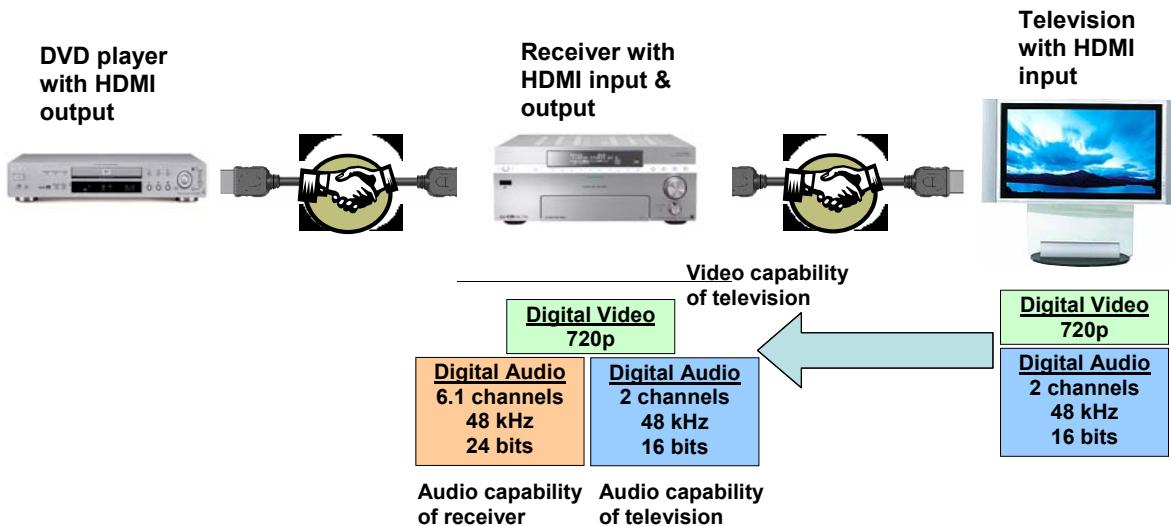
We've considered just a DVD player and a television. But the dynamic changes when you insert the STR-DA7100ES into the reproduction chain. In this case, the source component DVD player can *only* talk to the next component in the chain, the receiver.



The receiver must then communicate with the television and mediate the content exchange for the entire system. The receiver automatically passes through the television's video requirements back to the source component. In the case of this illustration, the television is asking for 720p.



Now the receiver has two sets of audio capability to consider. The receiver itself can handle 6.1 channels of very high quality. As you would expect, the television can only handle two channels at somewhat more modest quality. The question: which of these requirements will the receiver communicate back to the source component? Two settings on the STR-DA7100ES receiver let you choose.



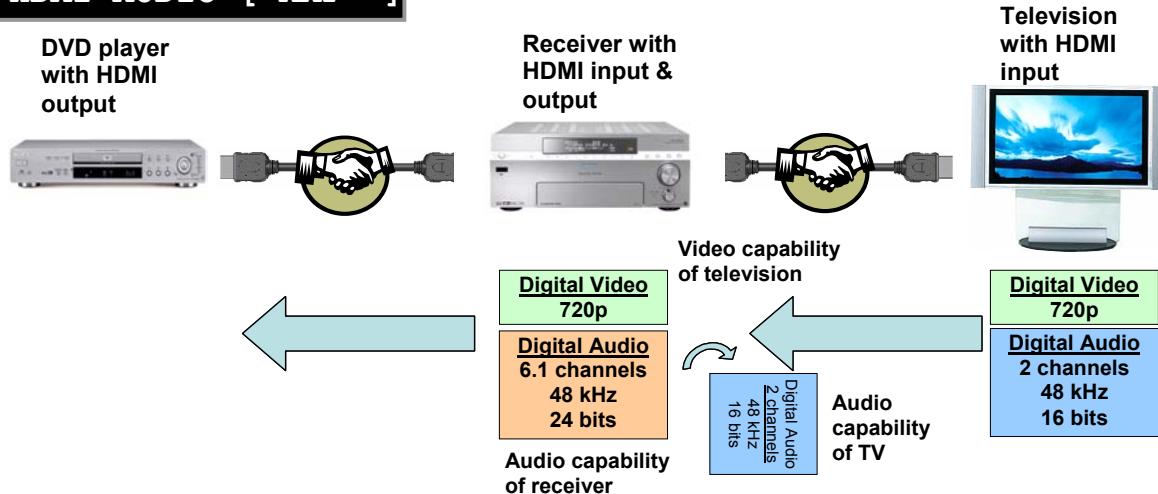
The default mode is HDMI AUDIO [AMP], which chooses the audio based on the highest capability of the receiver itself. As an option, you can choose HDMI AUDIO [AMP + TV], which chooses audio based on the highest capability that the television and receiver have in common. This will typically be limited by the television to 2-channel sound.

## HDMI AUDIO [ AMP ] : Default

### HDMI AUDIO [AMP+TV]

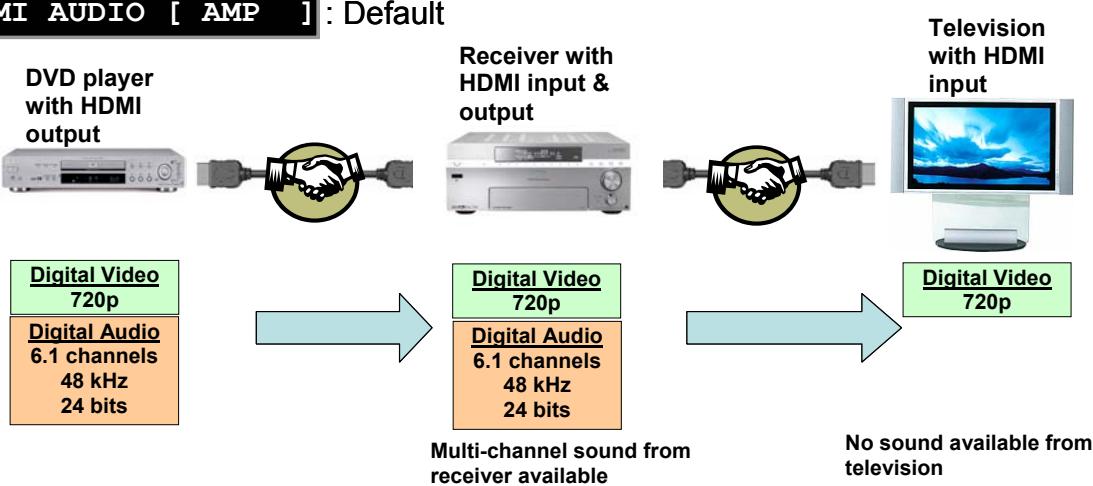
When you choose HDMI AUDIO [AMP], the receiver ignores the television's request for audio and submits its own audio specification back to the HDMI source component.

#### HDMI AUDIO [ AMP ]

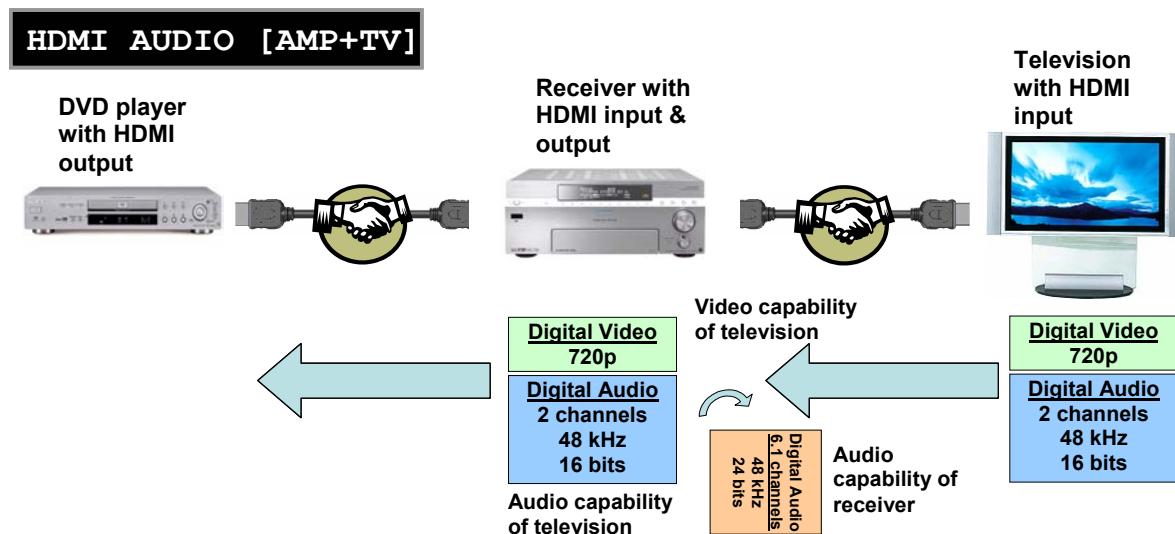


Now the DVD player can satisfy both the television's request for 720p and the receiver's request for 6.1-channel audio. The audio is available on the receiver only. Since 6.1-channel sound is beyond its capabilities, the television cannot play sound.

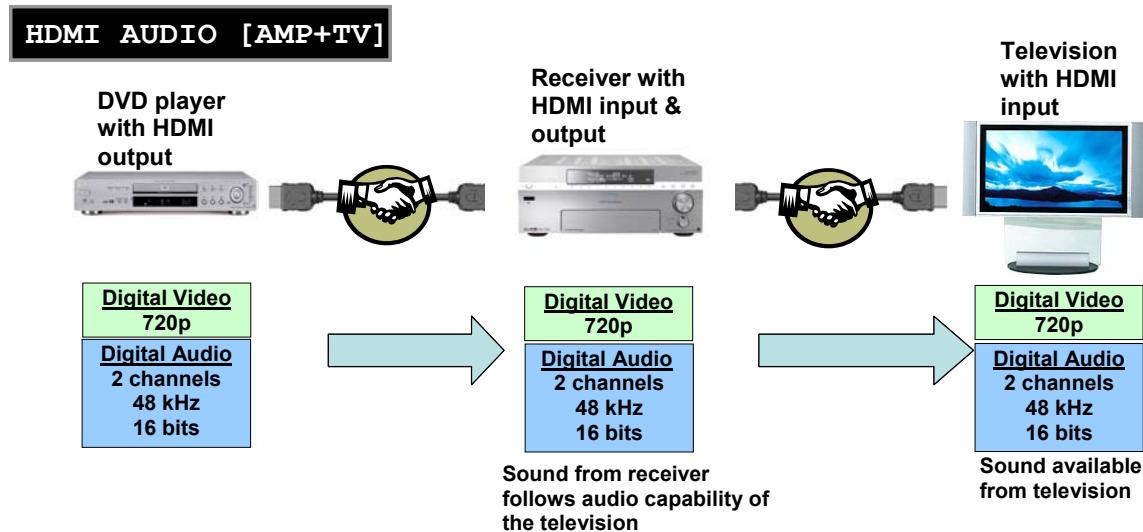
#### HDMI AUDIO [ AMP ] : Default



Choosing HDMI AUDIO [AMP+TV] sets up a different set of capabilities. In this case, the receiver ignores its own highest audio capabilities and passes the television's request for audio back to the source component.



Once again, the DVD player can satisfy both requests. However this time, the 2-channel audio is available for playback on both the STR-DA7100ES receiver and the television.



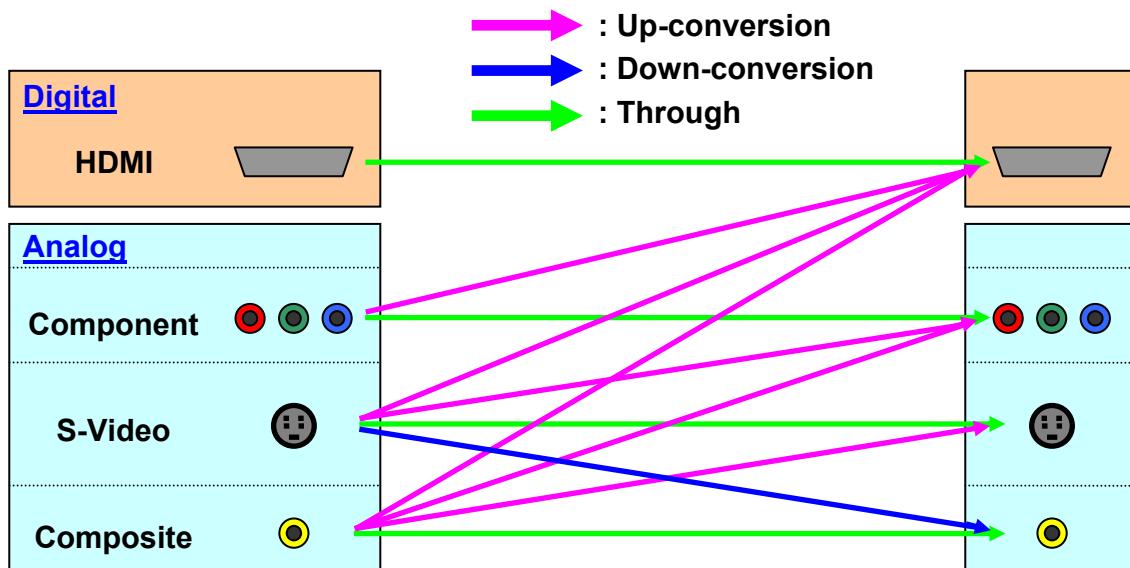
As you can see, the selection process is easy and automatic and delivers the very highest digital quality with the minimum of fuss.

Please note that some restrictions apply.

- **AC Power.** All components must be switched on in order for the system to work. You can't use HDMI connections through the receiver if the receiver is switched off.
- **Anti-piracy.** To prevent the piracy of very high quality digital signals, HDMI also incorporates a security method called High-bandwidth Digital Content Protection (HDCP). This encrypts the signal so that only authorized devices can decode the data into pictures and sound. HDMI is for playback only, meaning that content distributed via HDMI cannot be recorded.
- **Super Audio CD.** As of January 2005, standards for sending Super Audio CD sound over HDMI had not been established. For this reason, Super Audio CD sound is not available over the HDMI outputs of Super Audio CD players.

## HDMI switching and upconversion

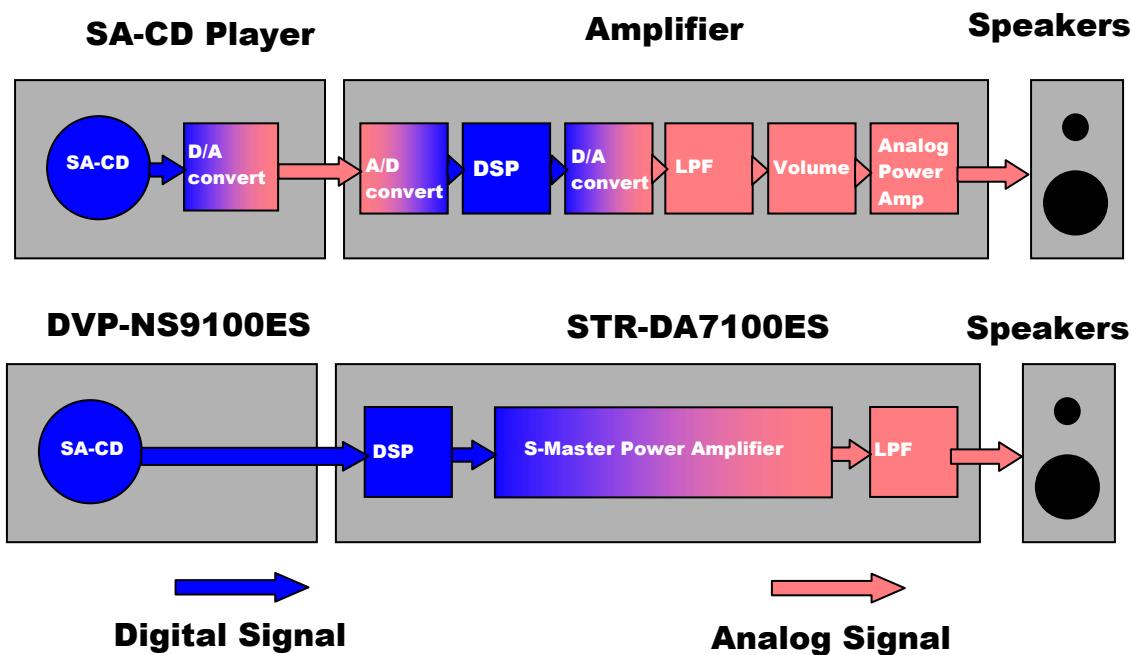
The STR-DA7100ES can switch between two HDMI sources and send the selected signal to a television, using two HDMI inputs and one output. But there's more. The receiver will also *upconvert* any composite video, S-Video or analog component video source to the HDMI digital output. This means your television can be left on the HDMI input only, with all input source selection done at the receiver. But it's about more than convenience. It's also ideal for installations where the television is positioned at some distance from the source components. In this case, the digital HDMI cable helps protect the video signal from the "differential gain" and "differential phase" distortions caused by long runs of analog cable.



*Thanks to video upconversion to HDMI, you can have the convenience of all your home video sources directed to a single output for your television.*

## i.LINK® Digital Audio Interface

From the initial launch of Super Audio Compact Disc, the 1-bit Direct Stream Digital™ pulse train was always converted to analog prior to output from the player. While SA-CD players have included coaxial and optical digital outputs, these outputs handled CD signals exclusively. The SCD-XA9000ES was Sony's first SA-CD player to provide an i.LINK digital output for the 1-bit DSD signal. And the STR-DA9000ES was Sony's first receiver to incorporate an i.LINK digital input. The DA71000ES carries this ability forward, maintaining the signal in the digital domain and simplifying the signal path. The i.LINK interface also enables a single digital cable to take the place of six analog cables.



*Typical SA-CD reproduction involves numerous D/A and A/D conversions. Connected to a compatible SA-CD player, the STR-DA7100ES maintains the signal in digital form.*

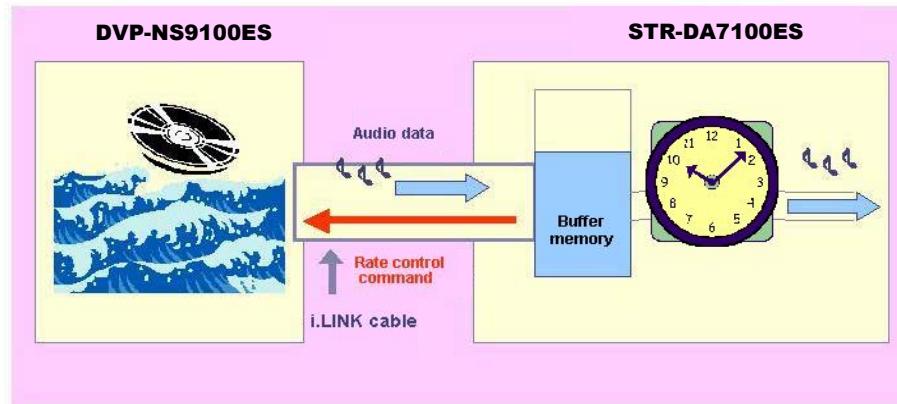
The i.LINK digital audio interface uses Digital Transmission Content Protection (DTCP), a robust system that protects the music from piracy. The application of the i.LINK (IEEE 1394) interface to digital audio is clearly different from—and not compatible with—previous i.LINK interface applications for DV camcorders, PC peripherals and professional digital video systems. You can only connect the STR-DA7100ES i.LINK interface to a compatible digital audio output, such as that on the SCD-XA9000ES SA-CD/CD player and the DVP-NS9100ES DVD/SA-CD/CD player.

## Controlling the signal flow with HATS

The design of the interface is exceptional because communicating six streams of 2.8224 MHz digital samples raises exceptional challenges. Conveying 1-bit signals at such high data rates and synchronizing the signals with the receiver's master clock would normally expose the signal to the time-base errors called jitter. Jitter translates directly into time-based distortion of the audio waveform.

Sony overcame this challenge with the High quality digital Audio Transmission System (HATS). HATS uses "command-based rate control of isochronous data flow" to solve the problem. The system incorporates three principal elements.

1. **Variable-speed transmission** from the player.
2. **Buffer memory** in the receiver.
3. **Command signals** from the receiver to the player, controlling transmission speed.



*With Sony HATS, audio data flows from the player to the receiver's buffer memory, according to rate control commands from the receiver. Reproduction in the receiver achieves the full time base accuracy of the receiver's quartz crystal master clock.*

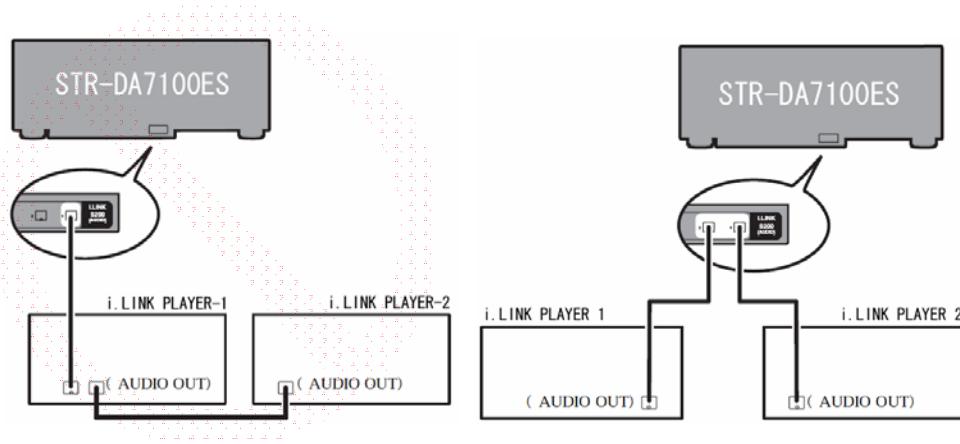
The receiver continually monitors the amount of audio data in its buffer memory. When the buffer memory reaches its lower limit, the receiver commands the player to increase data transmission speed. When the buffer memory reaches its upper limit, the receiver commands the player to decrease transmission speed. And when the buffer memory is between the upper and lower limits, the receiver commands the player to transmit at normal speed.

In this way, HATS makes it unnecessary to synchronize a jitter-prone signal with the receiver master clock. Instead, the buffer memory outputs a jitter-free signal at the full quartz-crystal accuracy of the receiver's master clock. You

get all the benefits of digital transmission, without exposing the signal to the potential for jitter-induced distortion.

## Dual i.LINK interfaces

Where the STR-DA9000ES had one i.LINK interface, the STR-DA7100ES has two, in daisy chain configuration. However, source components should be connected in a one-to-one configuration.



*While it may be physically possible to daisy chain i.LINK interface source components as shown on the left, Sony cannot guarantee proper operation. The proper connection is shown on the right.*

The i.LINK processing of the STR-DA7100ES can also handle a variety of digital audio formats, including Dolby Digital® and dts® compressed streams and DVD-Audio. However, the performance depends on the connected players. At this time, Sony can only guarantee correct performance with the SCD-XA9000ES Super Audio CD/CD player and the DVP-NS9100ES DVD/SA-CD/CD player.

## Other New Features

### Analog Devices SHARC 32-bit decoding DSP

Back in 1998, Sony became the first consumer products company to adopt the Analog Devices SHARC processor to a home audio product. In this way, our TA-E9000ES preamplifier became the first home audio component with a 32-bit floating point processor that had previously been limited to professional equipment. The latest version of the SHARC processor is now back in the STR-DA7100ES and DA9100ES, where it performs a full range of Dolby Digital® and dts® decoding operations with awesome precision.

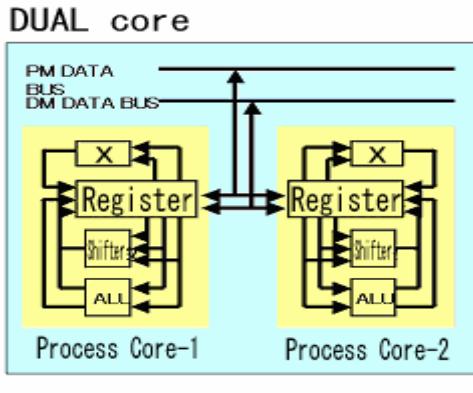


*The Analog Devices SHARC DSP achieves true 32-bit floating-point processing, for exceptional precision.*

Just as important as the choice of DSP chips is the way it's integrated into the overall system. To elicit the highest performance, Sony positions the SHARC processor on its own separate circuit board, in Sony's "DSP isolation" design. This prevents DSP noise from spreading into the main circuit board. To maintain superb sound quality, Sony carefully configured the DC power and Ground printed circuit traces leading into the SHARC chip.

### CB Programming

The SHARC chip operates at a 200 MHz clock speed, 67% faster than the decoding DSP used in Sony's previous best receiver, the STR-DA9000ES. But the chip is even faster than its clock speed suggests. Because it offers a dual processing core, it is effectively able to perform two operations at once. Theoretically, this makes the new DSP 230% faster than the previous one!



*Under ideal conditions, the SHARC DSP's dual core processing can double the operating speed.*

Unfortunately, most applications cannot take advantage of the full power of this dual core design. The issue is in the "compiler." Think of the DSP as a special-purpose computer. In order for the computer to perform meaningful task, software programs must first be loaded into the compiler. Using the C programming language and a conventional C compiler means sacrificing much of the performance advantage of the second processing core.

Thanks to our long experience programming DSPs, Sony engineers were able to develop the "CB compiling" technique. This dramatically reduces wasted coding efficiency and assures that both calculation cores are working effectively. The resulting system has 30% higher coding efficiency than conventional C compiling.

## A/DSD Conversion

The STR-DA7100ES converts all analog audio inputs into digital, using a proprietary Sony A/DSD converter, the CXD9856. The device integrates A/DSD conversion and a decimation filter, and makes it possible to change the operation mode based on the signal type and subsequent DSP processing.



*Sony converts analog sources to digital with our own CXD9856.*

**SONY**



**STR-DA3100ES**

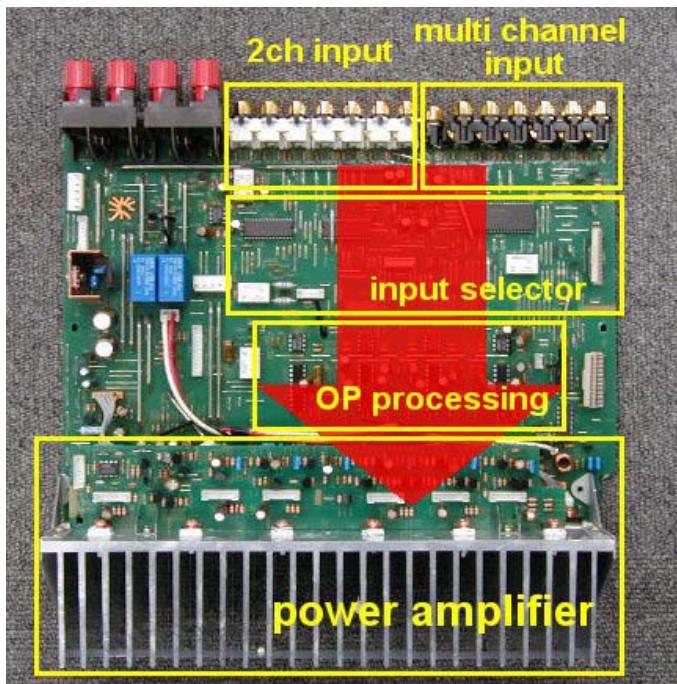


**STR-DA2100ES**

## **Audio/Video Performance Series Receivers**

## **Short, straight and simple chassis layout.**

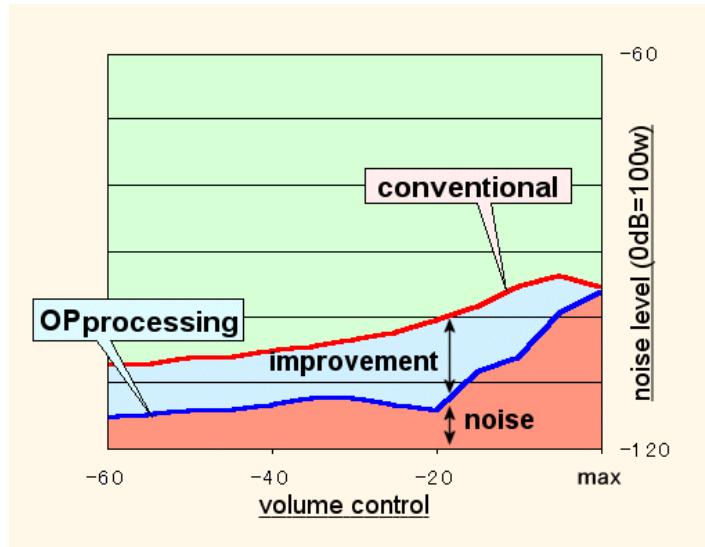
From Sony's early days in high fidelity, our engineers have understood that simpler is better. For this reason, they have aimed to keep internal point-to-point wiring to a minimum. The internal chassis layouts of the STR-DA3100ES and DA2100ES are outstanding examples of this "short, straight and simple " philosophy. Inputs pass directly from the back panel to the input selector, Optimum Preamplification (OP) processing and the power amplifier, in that sequence. It's a short, straight trip.



*Analog board of the STR-DA2100ES shows Sony's smart, simple and straight chassis layout.*

## **OP Processing with 0.5 dB steps**

Sony's Optimum Preamplification (OP) design is featured on the STR-DA3100ES, DA2100ES and DA1000ES. The system varies the preamp negative feedback according to the volume control setting. In this ways, Sony balances gain and volume control settings to achieve a 10-dB improvement in signal-to-noise ratio across most of the volume control operating range. So high-resolution audio is reproduced against a background of silky silence.



Sony's Optimum Preamplification (OP) circuit improves the signal-to-noise ratio across a broad range of volume control settings. The latest version of the OP design controls volume with twice the resolution of our previous design—0.5 dB steps instead of 1 dB.

In Sony's previous OP design, the volume control operated in precise 1 dB steps. However Sony found during critical listening at high volume levels that smaller steps are sometimes useful. That's why the STR-DA3100ES and DA2100ES incorporate a refined OP Processing system that enables you to vary the volume setting in precise, 0.5 dB steps!



Optimum Preamplification is made possible by Sony's proprietary CXD9725 integrated circuit.

## Oversized filter capacitors

Analog amplifiers depend heavily on the power supply filter capacitors. Because these devices filter out 60 Hz line frequency hum, they play a crucial role in protecting sound quality. That's why Sony's STR-DA3100ES and DA2100ES incorporate oversized filter capacitors carefully chosen for sound

quality. At the same time, they're environmentally friendly designs, entirely lead-free and PVC-free.



*Sometimes size does matter, as in the oversized filter capacitors of Sony's STR-DA3100ES.*

## **Spider Ground Plate**

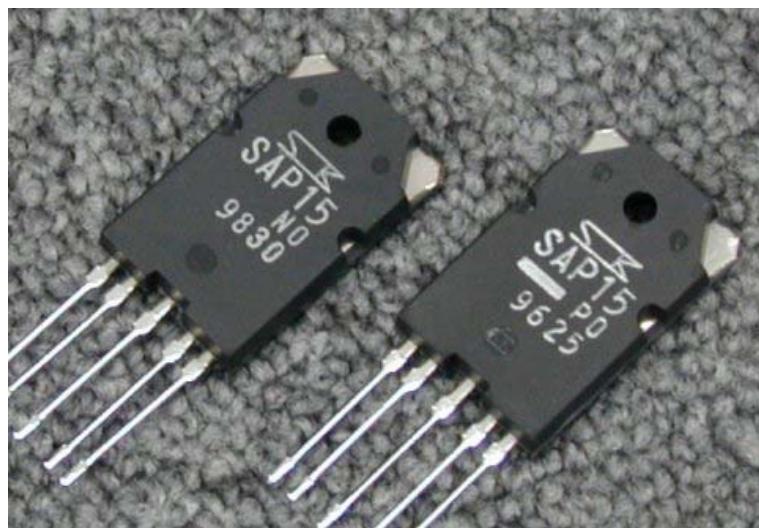
Amplifier designers often assume that the various circuits inside the chassis all "see" a common ground. Unfortunately, slight differences in grounding can have a subtle impact on the sound. That's why Sony created a Spider Grounding Plate for the STR-DA3100ES and DA2100ES. The plate establishes a "standard reference ground" for all circuits and reduces common impedance.



*Sony's Spider Grounding Plate uses ten points, plus substantially thicker connections to achieve a standard reference ground.*

## One-plate/dual-pellet output transistors

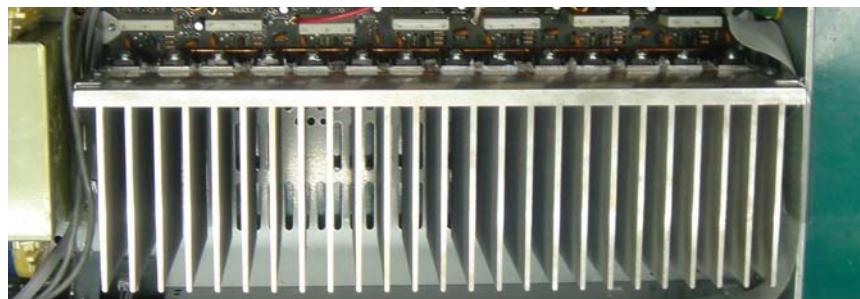
How do you combine the power of parallel output transistors with the "focus" of single-ended transistors? The STR-DA3100ES output transistors achieve this with a one-plate/dual-pellet design. Each of these is actually a pair of matched, high-speed transistors mounted to a common plate. In this way operating temperatures and current fluctuations remain perfectly balanced. It's another way that Sony fights thermal modulation distortion. As a further protection, Sony mounts these transistors on oversized extruded aluminum heat sinks.



*With one-plate/dual-pellet output transistors, the temperature and current fluctuations of one transistor are automatically corrected by the complementary transistor mounted on the same plate.*

## Master In-Line Design

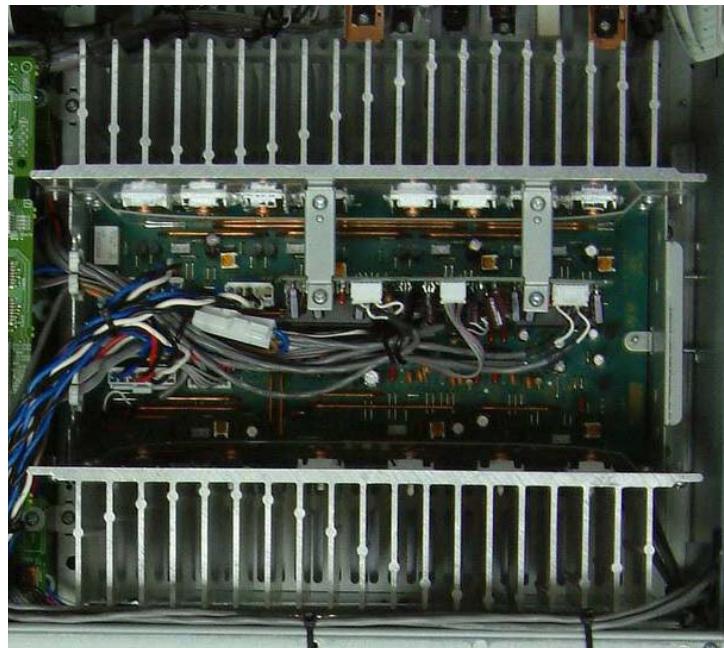
With seven channels of amplification, it's difficult to maintain uniformity. That's why Sony configured the STR-DA3100ES and DA2100ES power amplifiers with a master in-line design. This achieves uniformity in both electrical and mechanical characteristics, for superior richness and imaging.



*Lined up in a neat row, the output transistors of the STR-DA2100ES take advantage of Sony's Master In-Line design.*

## **sF Fin Heat Sinks**

Identical aluminum heat sink fins resonate at the same frequency, subtly degrading output transistor performance. That's why the STR-DA3100ES uses a series of vertical ribs, spaced at staggered intervals. This diffuses resonance to maintain sonic integrity. Because the ribs from the letter S, we call this design the "S-form" or "sF" Fin design.



*The inside of the STR-DA3100 ES, showing the two sets of massive aluminum heat sinks. At this angle, the s-Form ribs appear as circles on the white aluminum heat sink fins.*

## **Low-filler speaker terminals**

The engineers of Sony's ES Series try to look at everything that influences the sound quality, however subtle. Their examinations have prompted us to reconstitute the chemical composition of the speaker terminal lugs. We discovered that a resin with reduced fillers and pigments helps suppress resonance, especially when the audio program gets loud. You can actually see the result of this effort on the back panel, where the speaker terminals no longer have their customary bright red and deep black pigment!



*When Sony's engineers discovered that the speaker terminal pigments and filters actually compromised anti-resonant properties, we took the fillers out.*

## Continuing Features

Of course, the latest ES Series A/V receivers reflect the lessons learned in two decades of ES Series refinements and improvements. These models have the full complement of ES Series decoding, Digital Signal Processing, control and integration technologies.

- **Silver cascade design (DA3100ES and higher).** Sets the primary front panel controls at an angle, so that you can use them without uncomfortable bending and stooping to identify each one. Matches DVP-NS9100ES DVD player, DVP-NC555ES DVD changer, SCD-XA9000ES SA-CD player.
- **Seven channels of amplification (all models).** This configuration can drive separate Surround Back Left and Surround Back Right speakers, ideal for both 5.1- and 6.1-channel sources.
- **Amplifier relocation (DA2100ES and higher).** Enables you split the 7.1-channel amplifiers into 5.1 channel surround sound plus a stereo pair for a second room.
- **A/V Sync (DA2100 and up).** Corrects "lip sync" errors to bring your television and your home theater speakers back into alignment. Delays the audio by up to 200 milliseconds, in 10 millisecond increments.
- **Auto channel grouping (all models).** The feature adapts the reproduction to match a 7-speaker configuration. In reproducing 5.1-channel sources, the four Surround speakers are driven in two groups (SL and SR). In reproducing 6.1-channel sources, the Surround speakers are driven in three groups (SL, SB and SR).
- **Full complement of digital and analog surround decoding (all models).** Sony provides decoding for all of the following sources:
  - Dolby Digital® surround sound
  - Dolby Digital EX 6.1-channel sound
  - Dolby® Pro Logic® surround sound
  - Dolby Pro Logic II-movie and Pro Logic II-music
  - Dolby Pro Logic IIx surround sound (DA2100ES and higher only)
  - Dolby Dual Mono (DA2100ES and higher only)
  - dts® 5.1-channel surround sound
  - dts 96/24
  - dts ES discrete 6.1 and dts ES matrix 6.1
  - dts Neo6:cinema and dts Neo6:music
- **32-bit surround sound decoding (all models).**
- **6.0-channel Digital Cinema Sound™ concert hall modes (all models).** For the Amsterdam Concertgebouw and the Vienna Musikvereinsaal.

- **7.1-channel Cinema Studio EX modes (all models).** Recreate the acoustics of the Hollywood dubbing stages where directors go to audition and approve their final sound mixes.
- **7.1-channel Virtual Multi Dimension (all models).** Recreates the effect of a full array of Surround speakers.
- **12V triggers (STR-DA2100ES and higher).** ES Series receivers are destined to be used in custom installations where curtains, screens and lighting "scenes" may require 12-volt triggers.
- **Infrared repeater ports (STR-DA2100ES and higher).** To accommodate installations where the stack of electronics is hidden away, ES Series receivers offer one infrared repeater input and two outputs. This means you can place an inconspicuous IR "eye" in the home theater room and still control your components.
- **RS-232C interface for control and upgrade (STR-DA2100ES and higher).** To communicate with third-party room automation systems, these receivers include RS-232C ports. The ports also enable future firmware upgrades.
- **Front optical digital audio input (all models).** As part of the Video 3 input of the front panel, these receivers also accept optical digital audio, in addition to Left/Right analog audio.
- **Assignable digital input (all models).** An optical or coaxial digital input can be flexibly assigned to any video input, providing greater versatility when connecting a second DVD player, an HDTV tuner or other digital video source component.
- **A/B speaker terminals (all models).** Real estate on the back panel of modern A/V receivers is severely limited. At the request of ES Series dealers, Sony found a way to add a set of B speaker terminals.

## **Conclusion**

Beginning with the PCM-701ES digital processor in 1982, the engineers of Sony's ES Series have been extending the capabilities of digital audio. Breakthroughs like the S-Master® Pro amplifiers take audio reproduction to the next stage in sophistication, simplicity and sound quality. These ES Series receivers represent another milestone in the digital technology. To appreciate the difference, just turn them on and listen.

## Features and specifications

Feature	STR-DA7100ES	STR-DA3100ES	STR-DA2100ES	STR-DA1000ES
Power output, all channels driven into 8 ohms, 20 to 20,000 Hz	170 watts x7	120 watts x7	110 watts x7	100 watts x7
S-Master Pro Amplifier	Yes	-	-	-
32-bit S-Master Pro process	Yes	-	-	-
Power MOS FET output transistors, four per channel	Yes	-	-	-
DC Phase Linearizer	Yes	-	-	-
Dolby Digital® EX decoding	Yes	Yes	Yes	Yes
dts® ES decoding	Yes	Yes	Yes	Yes
dts 96/24 decoding	Yes	Yes	Yes	Yes
Dolby® Pro Logic® decoding	IIx	IIx	IIx	II
Dolby® Dual Mono decoding	Yes	Yes	Yes	-
dts Neo:6 decoding	Yes	Yes	Yes	Yes
Digital Cinema Sound™ circuit	7.1-channel	7.1-channel	7.1-channel	7.1-channel
32-bit Decoder	Yes	Yes	Yes	Yes
32-bit DSP	Yes (Two)	Yes (Two)	Yes	Yes
A/V Sync	Yes	Yes	Yes	-
OP Processing	-	Yes	Yes	Yes
Auto channel grouping	Yes	Yes	Yes	Yes
A/B speaker terminals	Yes	Yes	Yes	Yes
Multi-channel inputs	7.1	7.1	7.1	5.1
HDMI inputs/outputs	2/1	-/-	-/-	-/-
i.LINK® digital audio interfaces	2	-	-	-
HD Component video inputs/output	2/1	2/1	2/1	2/1
S-Video inputs/outputs	4/2	5/2	4/2	3/1
Composite video inputs/outputs	4/2	5/2	5/2	4/1
Video Upconversion (best)	to HDMI	To Component	To Component	???
Optical inputs/outputs	5/2	5/2	3/1	3/1
Coaxial inputs	3	2	2	1
Preamp output	7.1 channels	7.1 channels	Subwoofer	Subwoofer
Front A/V input with optical digital audio	Yes	Yes	Yes	Yes
Infrared repeater input/outputs	1/2	1/2	1/1	-/-
RS-232C control/upgrade	Yes/Yes	Yes/Yes	Yes/Yes	-/-
12-volt trigger outputs	3	3	1	-
Multi-Zone/Room Capability	3/3	3/3	2/2	-/-
2nd Room output	A/V out	A/V out	Audio out	-
3rd Room output	Audio	Audio	-	-
On screen display	Yes	Yes	Yes	Yes
Remote Features				
Preprogrammed LCD	Yes	Yes	Yes	Yes
Learning & Macro	Yes	Yes	Yes	Yes
2-way	Yes	-	-	-
Touch-screen	-	-	-	-
Second-room remote	Yes	Yes	-	-



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1. iLINK is a trademark of Sony used only to designate that product contains an IEEE 1394 connector. All products with an IEEE 1394 connector may not communicate with each other. Please refer to the documentation that comes with the device having an iLINK connector for information on compatibility, operating conditions and proper connection.
2. Multi-brand remote may not be compatible with some brands or models.