

SONY



ES Series Receivers Technical Background

Version 3.0; May 30, 2003

Introduction

For 2003, Sony is introducing a completely new and dramatically different line of ES Series audio/video receivers. To create these remarkable components, Sony ES engineers have rethought, refreshed and redesigned just about every aspect:

- Digital power amplifier technology (STR-DA2000ES and higher)
- Redesigned internal chassis layout (STR-DA2000ES and higher)
- Pulse power supply (STR-DA2000ES, DA3000ES and DA5000ES)
- i.LINK® (IEEE 1394) 1-bit digital interface for Super Audio CD (STR-DA9000ES)
- Superior ergonomics with "silver cascade" front panel (STR-DA3000ES and higher)

While these design breakthroughs are exciting and fresh, the fact that they make their appearance in the Sony ES Series should come as no surprise at all. From the very beginning, ES receivers have benefited from Sony's comprehensive expertise in digital source components and Sony's thorough understanding of digital signals. Those insights led directly to significant Sony ES innovations:

- The world's first outboard D/A converter (DAS-702ES, 1985).
- The world's first Dolby® Surround decoder to operate in the digital domain (SDP-505ES, 1986).
- The world's first all-digital preamplifier (TA-E1000ESD, 1989).
- 24-bit Dolby Digital® decoding (SDP-EP9ES, 1997).
- Digital Cinema Sound™ processing (STR-DA90ESG, 1997).
- World's first floating-point 32-bit preamplifier (TA-E9000ES, 1998).

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

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S-Master Pro Technologies

Digital amplifiers have been around for decades, occupying a place outside the mainstream of home audio. But important trends in audio technology are creating significant reasons to prefer digital amplification.

First, digital signal-handling technology has improved, especially in the area of 1-bit digital signal processing. Modern circuitry can exercise amazingly precise control over 1-bit pulse lengths, pulse height and pulse timing, for jitter-free, distortion-free performance. Large Scale Integrated (LSI) technology continues to move forward, enabling manufacturers to build this sophisticated technology into consumer products. Today's faster output transistors do a better job at digital switching speeds. Finally, home entertainment continues to move inexorably into the digital domain, leaving analog processes behind.

Simultaneous with these advances, the function of the home audio receiver has been transformed. "High fidelity" or "AM/FM" receivers have long since given way to sophisticated A/V control centers that first handled composite video, then added component video, HD component video and now digital component video. Over the years, stereo receivers have been transformed into four, five, six and now seven-channel receivers. And the designs continue to grow in complexity. In this new context, digital amplification is becoming more and more compelling.

It was for this reason that Sony first developed the S-Master process back in 2001. The 2003 ES receivers, starting with the STR-DA2000ES, incorporate Sony's third generation of S-Master technology—and our most advanced by far.

Process	S-Master	"Digital Drive" S-Master	S-Master Pro
Generation	First	Second	Third
Introduction	2001	2002 AVD-C70ES AVD-S50ES	2003 STR-DA9000ES STR-DA5000ES STR-DA3000ES STR-DA2000ES
Technologies	<ul style="list-style-type: none"> • Clean Data Cycle • C-PLM • S-TACT 	<ul style="list-style-type: none"> • Clean Data Cycle • C-PLM • S-TACT • Pulse Height Volume Control 	<ul style="list-style-type: none"> • Clean Data Cycle • C-PLM • S-TACT • Pulse Height Volume Control • DC Phase Linearizer • Discrete Output Transistors • Toroidal Low Pass Filter • Two-Stage Pulse Power Supply

A look at analog amplifiers

Conventional, analog power amplifiers have awkward characteristics that are so familiar that receiver engineers automatically work around them. However, Sony's design program for the 2003 ES Series required more than the typical work-around. We sought to address these issues directly:

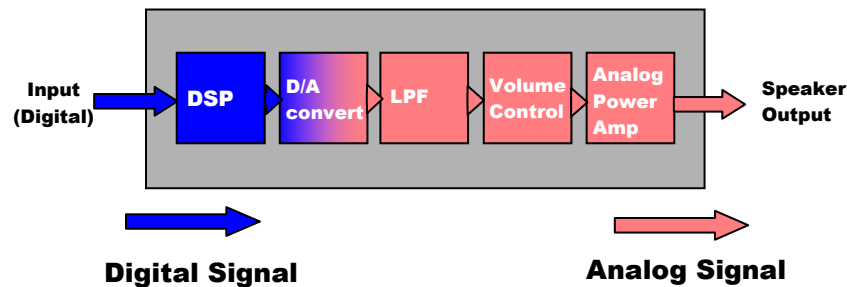
- **Circuit complexity.** In the context of today's home theater receivers, the analog power amplifier is out of place. You have digital source material processed through a digital preamplifier—only to be converted to analog prior to amplification.
- **Heat generation.** The heat thrown off by conventional power output transistors is a central fact of amplifier and receiver design. Conventional amplifiers and receivers often require heat sinks, fans, and chassis layouts that isolate the output transistors at the back or sides. Heat is always bad for electronics. Sony sought a more comprehensive solution for these ES receivers.
- **Crossover distortion.** Conventional power amplifiers use complementary pairs or sets of transistors to handle the top half and the bottom half of the waveform. This can create crossover distortion, the solution to which is amplifier bias—and that means more heat!
- **Thermal modulation distortion.** As the changing audio signal passes through the typical output transistors, it causes immediate changes in the transistors' temperature. Unfortunately, the temperature changes affect the transistors' handling of audio signal. This is thermal modulation distortion. Left unchecked, it can degrade sound quality.
- **Open-loop distortion.** Conventional amplifiers typically generate substantial distortion in "open-loop" mode. That's why amplifiers correct this distortion with Negative Feedback (NFB). However, NFB exposes the signal to Transient Intermodulation Distortion and other dynamic problems.

Sony's design program for the 2003 ES receiver line overcomes these fundamental constraints by applying digital technology.

S-Master Pro: simplicity of design

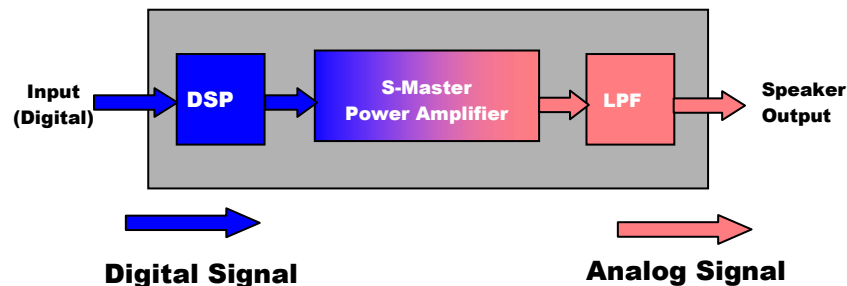
For years, it's been evident that digital power amplifiers can solve many of the intrinsic problems of analog amps. But now, digital amplifiers have the sound quality and technical performance to meet the stringent requirements of Sony ES engineers. The S-Master Pro design draws on 1-bit technologies that Sony originally developed for the Super Audio Compact Disc. The result is a breakthrough in home theater component design.

In high fidelity components, the simplest solution is usually the best because it subjects the signal to the fewest distortion-causing processes. Unfortunately, conventional A/V receivers are anything but simple. After Digital Signal Processing (DSP), every signal needs to be converted back to analog, run through a Low Pass Filter (LPF), sent through an analog volume control and then amplified.



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

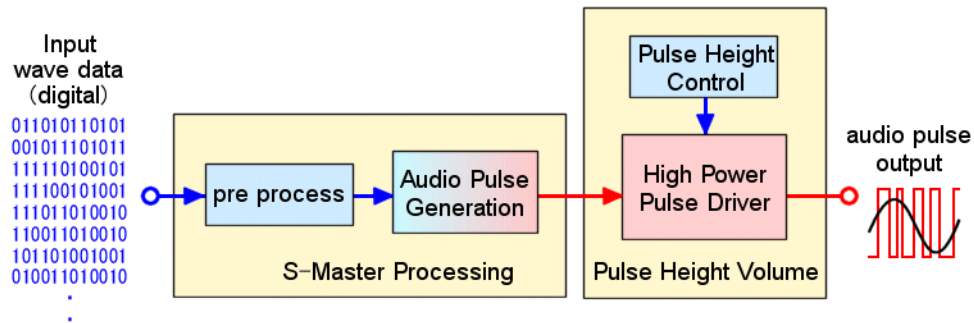
The Sony S-Master Pro amplifier is dramatically different. There is no Digital-to-Analog (D/A) converter. Instead, the amplifier accepts the digital output of the DSP stage *directly*. The output of the S-Master Pro amplifier provides the wattage that drives the speakers. In this way, the signal remains digital until the last possible instant.



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

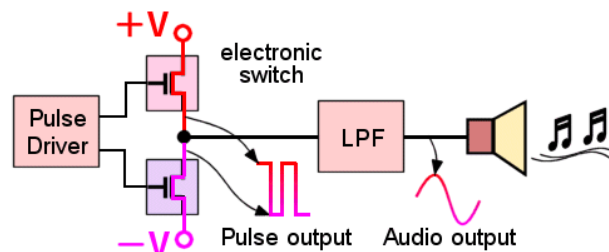
Principle of operation

The S-Master Pro amplifier accepts all digital signals directly, whether they're multi-bit Pulse Code Modulation (PCM) or 1-bit Direct Stream Digital™ pulses, in the case of the SCD-XA9000ES SA-CD player connected via i.LINK® interface to the STR-DA9000ES. Analog inputs undergo Analog-to-DSD (A/DSD) conversion.



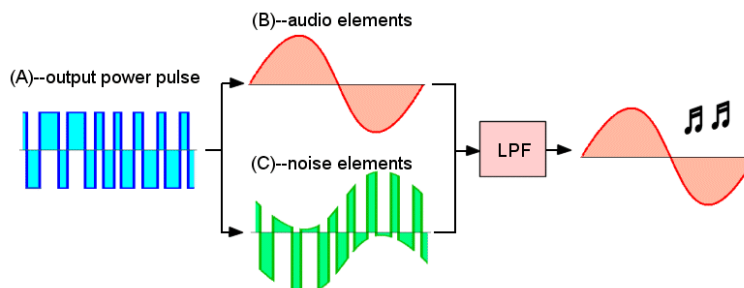
Block diagram of the S-Master Pro amplifier.

Sony generates a 1-bit pulse stream to switch a pair of FET power output transistors on and off. The resulting output has more than enough wattage to drive a loudspeaker.

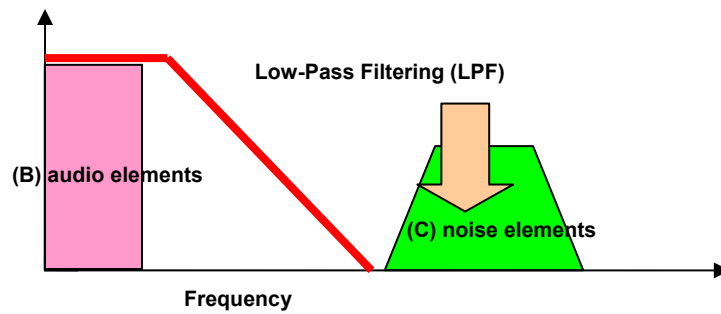


The output transistors act like an electronic on/off switch for the power supply voltage. The Low Pass Filter (LPF) converts the amplified pulses to a smooth, continuous analog waveform.

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.



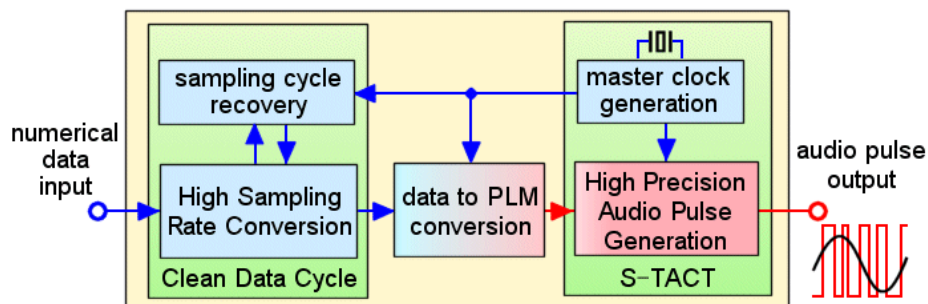
In the diagram above, (A) represents the output power pulse stream. This combines two components, the original audio signal (B) and a noise component (C). The audio signal (B) looks smooth and continuous because the frequencies are low. The noise component (C) looks abrupt and spiky because the frequencies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



The action of the LPF. The audio signal (B) consists of low frequencies, which pass. The red lines show the characteristic of the LPF, which suppresses the noise elements (C) on the right. These are high frequencies, which do not pass.

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 own CXD9730 Large Scale Integrated circuit (LSI) provides the S-Master Pro processing.

The S-Master Pro process converts the incoming signal to a one-bit Complementary Pulse Length Modulation (C-PLM) stream, after which the Pulse Height Volume control sets the volume level. The S-Master Pro process is performed by the Sony CXD9730, a proprietary Sony 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 the Sony CXD9730.

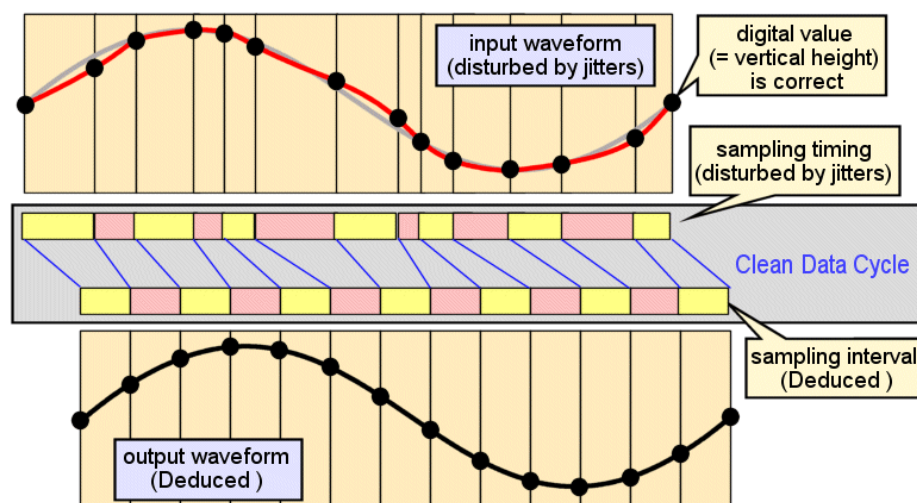
The S-Master Pro system involves eight important technologies:

- Clean Data Cycle
- Synchronous Time Accuracy Controller (S-TACT)
- Complementary Pulse Length Modulation (C-PLM)
- Pulse Height Volume Control
- DC Phase Linearizer
- Discrete Output Transistors
- Toroidal Low Pass Filter
- Two-Stage Pulse Power Supply

Clean Data Cycle

While digital signals are inherently resistant to noise and distortion, they are susceptible to time-base errors called jitter. Jitter can enter the signal during recording, playback or transfer. Precise pulse timing is crucial to the S-Master Pro circuit. For this reason, Sony uses powerful technology to suppress jitter.

The typical method of controlling jitter is Phase Locked Loop (PLL) clock regeneration. While the method does a good job of controlling high-frequency jitter, Sony also required excellent control at the low frequencies. That's why Sony engineers developed the Clean Data Cycle, the first stage of the S-Master process. Clean Data Cycle regenerates the digital signal with time-axis accuracy equivalent to the original A/D converter at the recording studio.



Even if the amplitude of every digital sample is 100% accurate, time-axis jitter can distort the analog result (top). Sony's Clean Data Cycle actually calculates the original sampling interval and applies the calculated timing to the signal (bottom).

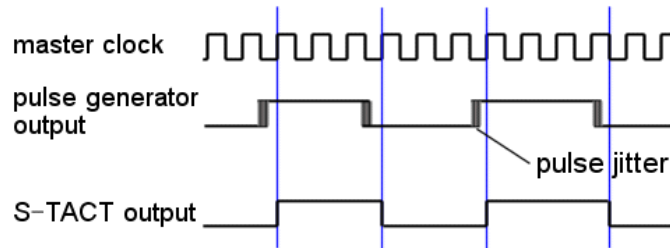
Using a supremely accurate clock, the Clean Data Cycle examines thousands of input pulses at a time, calculates the correct sampling interval and applies the clean interval to the output data. In this way, jitter is completely eliminated—and the integrity of the original musical signal is restored.

Low-distortion C-PLM

After the digital signal is stabilized by the Clean Data Cycle, S-Master Pro converts it to Complementary Pulse Length Modulation (C-PLM)—an original Sony technology. Previous digital amplifiers have used a 1-bit technology called Pulse Width Modulation or PWM. That is to say, 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)

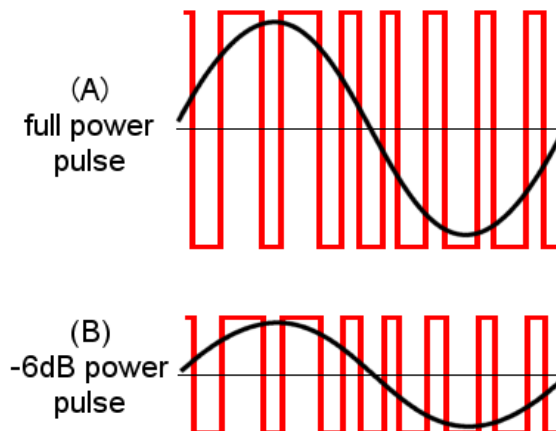
Because C-PLM conversion expresses the music in a different digital form, the signal requires another round of correction for time-base errors. For this purpose, Sony incorporates the Synchronous Time Accuracy Controller (S-TACT) circuitry we developed for the SCD-1 Super Audio CD player. S-TACT effectively clears pulse generator jitter by referencing the output directly to the master clock. This establishes extremely accurate pulse timing for amazingly low distortion.



The Synchronous Time Accuracy Controller (S-TACT) maintains accurate pulse timing at the output.

Pulse Height Volume Control

After S-TACT, the C-PLM signal passes to a Pulse Height volume control—the place at which user volume adjustments are executed. Most digital volume controls work by Digital Signal Processing. They adjust the sound by multiplying the samples by a coefficient between zero and one. For example, to achieve a volume setting 6 dB below maximum, you can multiply each sample by 0.5. This yields accurate results, but it does sacrifice some detail at the least significant bit. Sony demanded more.

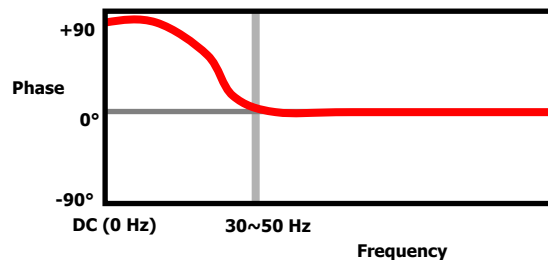


The full power pulse (A) represents the maximum setting of the volume control. To turn the volume down 6 dB, the receiver cuts the voltage to the power pulse generator in half (B).

In contrast, the 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 like -50 dB all the way to maximum.

DC Phase Linearizer

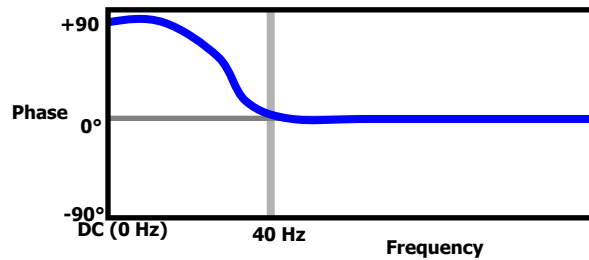
Digital amplifiers like the S-Master Pro design can be highly accurate—in some respects they can even be too accurate. Phase linearity is an issue with analog amplifiers and a contributor to analog sound. When you connect a real-world amplifier to a real-world loudspeaker, the interaction causes significant departure from phase linearity at frequencies below 30 or 50 Hz. Sony studies show a typical deviation from linear phase of about +90 degrees. While not making the bass any louder or softer, this shift does have a subtle effect, creating warmer and more accessible bass.



The low-frequency phase response of the typical analog amplifier departs from linearity at about 30 to 50 Hz. Because many audiophiles are accustomed to seeing frequency plotted against amplitude in decibels, this may look like a bass boost. It is not. It's a change in phase, which is much more subtle.

Because this phase shift is common across many brands of amplifiers at many price points, the shift has a broad effect on loudspeaker design. Consciously or not, loudspeaker designers take this phase shift into account when they fine-tune the sound of their products.

This raises an interesting dilemma. Should a new digital amplifier incorporate this phase shift or leave the sound in its original state? After extensive listening tests, Sony decided to give users the choice of applying an equivalent phase shift in the digital domain, using a dedicated Digital Signal Processor, the Sony CXD9776Q. This LSI adjusts low-frequency phase with internal accuracy equal to a 65-bit process. We call this circuit the DC Phase Linearizer, because it "restores" low-frequency phase, emulating the signal that the speaker would get from a top-quality analog amplifier.



The S-Master Pro circuit reproduces this phase response, with a shift beginning at 40 Hz.

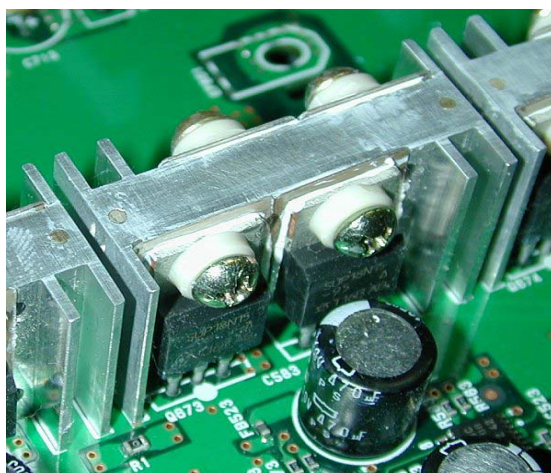
On the STR-DA2000ES, DA3000ES and DA5000ES, the DC Phase Linearizer provides four control positions: Off, Standard (factory preset), Mid and High. The STR-DA9000ES offers seven control positions: Off, Low-A, Standard-A (factory preset), High-A, Low-B, Standard-B and High-B. In this way, Sony accommodates the widest range of loudspeaker designs, which may someday include speakers based on the "flat" phase linearity of digital amplifiers like Sony's S-Master Pro design.



Sony's DC Phase Linearizer restores the low-frequency phase response that loudspeaker designers experience when speakers are developed.

Discrete Output Transistors

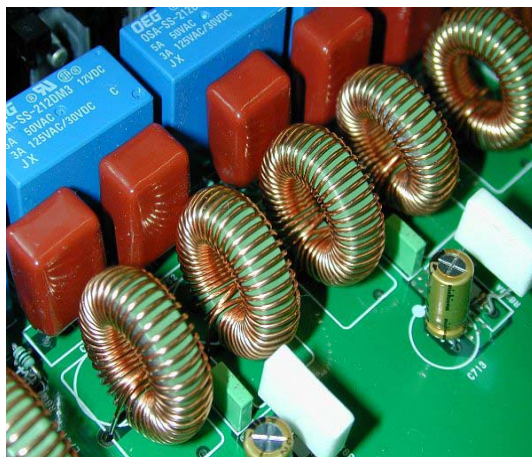
In analog amplifiers, the output transistors or ICs directly shape the analog waveform. For this reason, analog amplifiers are extremely sensitive to the selection, configuration, bias current and heat sinking of their output devices. By their design, digital amplifiers are inherently less sensitive 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 discrete output transistors for the entire ES line. The STR-DA2000ES, DA3000ES and DA5000ES use low-distortion Field Effect Transistors (FETs), while the STR-DA9000ES uses deluxe Metal Oxide Semiconductor FETs (MOS FETs). The result is another measure of signal integrity.



The discrete output FETs of the STR-DA2000ES.

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.

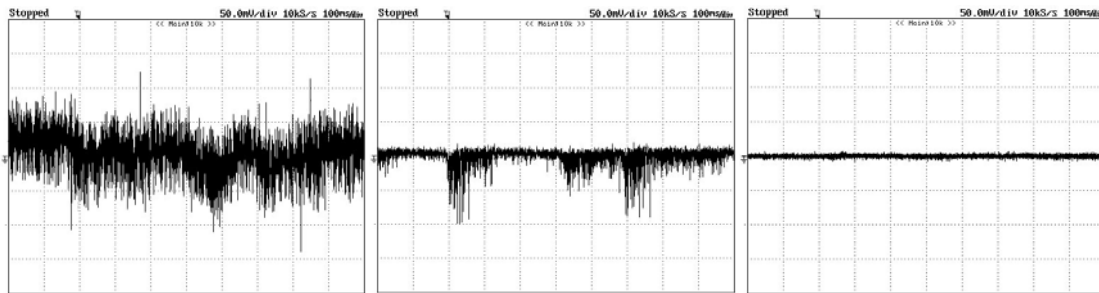


The toroidal coils of Sony's Low Pass Filters are more expensive. But their contribution to sound is more than worth the price.

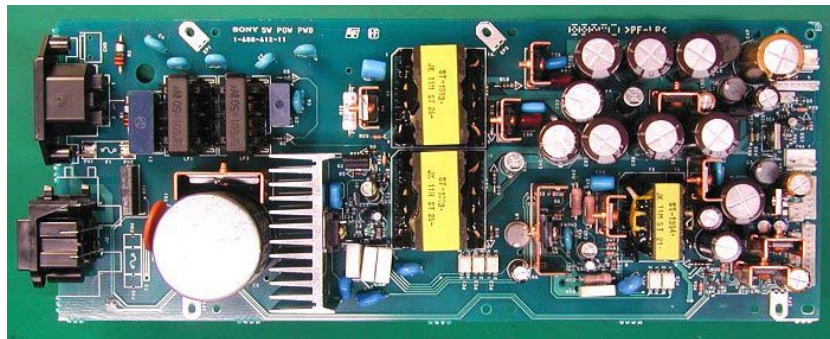
Two-Stage Pulse Power Supply

The power supply is always a critical component of amplifier sound quality. And this continues to be true of digital amplifiers. That's why Sony designed the S-Master Pro amplifiers with incredibly stable power supplies. The STR-DA2000ES, DA3000ES and DA5000ES take advantage of Sony's two-stage pulse power supply. At 200 watts per channel across seven channels (20—20,000 Hz, 8 ohms, 0.15% THD), the STR-DA9000ES required something even more robust, an absolutely massive Toroidal power supply, discussed later in this paper.

Simply stated, a receiver's power supply should output stable voltage no matter what the music is doing. Even during the most demanding musical peaks, the power supply output should be smooth and steady. Sony's Two-Stage Pulse Power Supply does a remarkable job in achieving exactly this result. The first stage is a switching or "pulse" power supply of high performance. The second stage is an analog constant voltage power supply, for an even higher degree of stability. The cumulative effect is remarkably stable performance, even when a rock band is playing all-out, or when a movie sound track includes car crashes and explosions.



On the left, these fluctuations, at the input of the Pulse Power Supply, are unacceptable for high fidelity audio reproduction. In the center, the output of the Pulse Power Supply is substantially better, but still not up to the standards of Sony ES. At right, after the analog constant voltage power supply, the power is ready for true high-resolution audio reproduction.

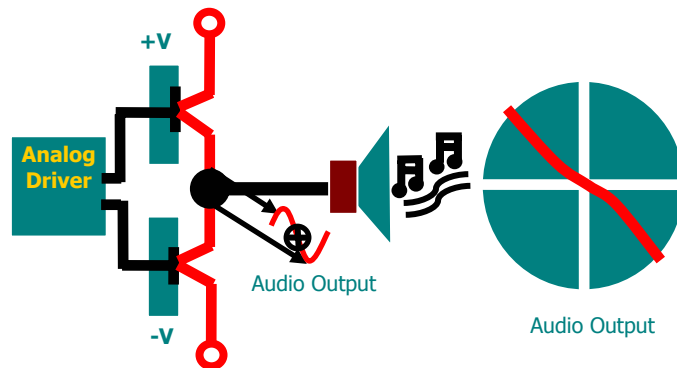


The pulse power supply of the STR-DA5000ES is remarkably compact and efficient.

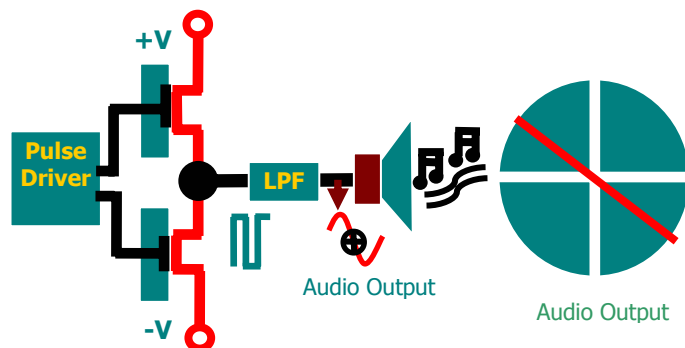
S-Master Pro Benefits

No crossover distortion

Conventional power amplifiers use separate transistors to reproduce the upper and lower halves of the waveform. Crossover distortion occurs when one power transistor switches off and the other switches on as the audio waveform "crosses over" the zero point between negative and positive. This distortion is particularly bothersome because it remains constant as the signal gets softer. This makes the distortion more audible during the quiet passages of music or movies. Conventional amplifiers combat crossover distortion with the output transistor bias current of Class A/B designs. Ironically, this bias current generates even more heat. So in fighting one problem, designers cause another.



Class B analog amplifiers introduce a "kink" in the audio waveform where the wave passes between positive and negative. Treating this crossover distortion is a major goal of conventional amplifier design.



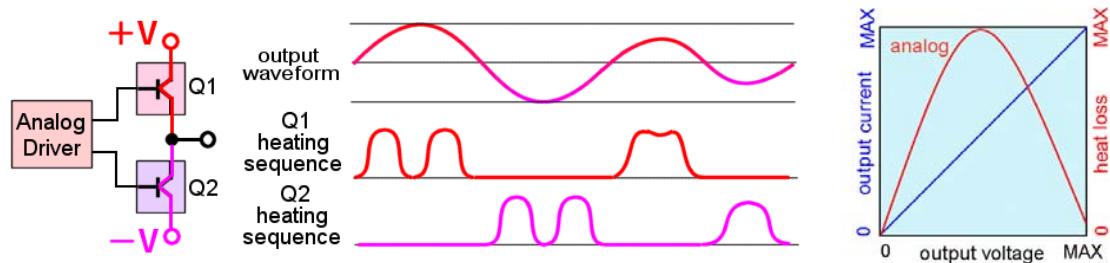
The S-Master Pro digital amplifier is immune from these issues because the output transistors do not shape the audio waveform directly.

Because the S-Master Pro amplifier uses pulse density, switching glitches get removed from the music by the low pass filter. The system is immune to

crossover distortion, even when the music or movie sound track is particularly soft.

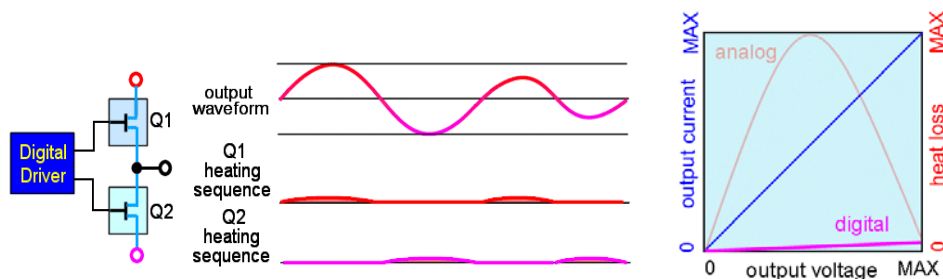
Reduced thermal modulation distortion

Analog power amp output transistors create the shape of the audio waveform directly. Unwanted variations in this waveform are heard directly as distortion. Unfortunately, changes in the output signal cause momentary heating or cooling in the transistors. These temperature changes actually alter the performance of the transistor, which distorts the sound. This is thermal modulation distortion.

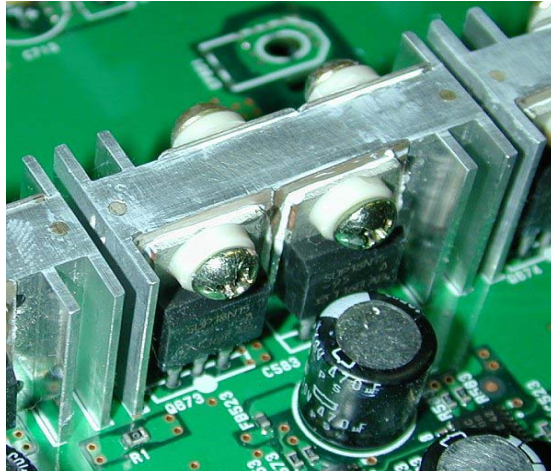


Analog power amplifier. On the left, the waveform can cause complex—and thoroughly unwanted—changes in the temperature and performance of the output transistors. The impact on sound is called thermal modulation distortion. On the right, the transistors perversely generate the most heat at moderate output levels—the levels you're most likely to experience most of the time. At full output, heat generation is near zero.

In dramatic contrast, the S-Master Pro amplifier does not generate substantial heat. So thermal effects are minimized at the source. What's more, any small thermal effects that might persist wash out of the signal because digital amplifier output transistors do not "shape" the output waveform in the way that analog output transistors must. With the S-Master Pro amplifier, thermal modulation distortion is no longer a concern.



S-Master Pro power amplifier. Here heating is low and the temperatures stay consistent over time. On the right, you can see why digital amplifiers can use much smaller heat sinks.

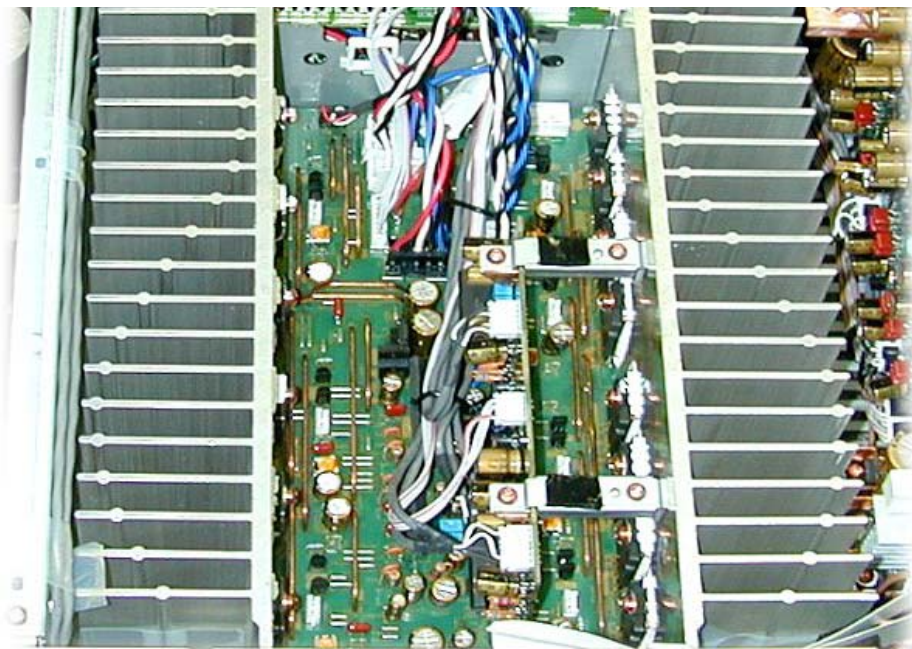


The STR-DA2000ES packs 120 watts per channel (20—20,000 Hz, 8 ohms, 0.8% THD). Yet the output transistors generate so little heat that they can be mounted directly onto the S-Master Pro circuit board and cooled by heat sinks less than one inch high!

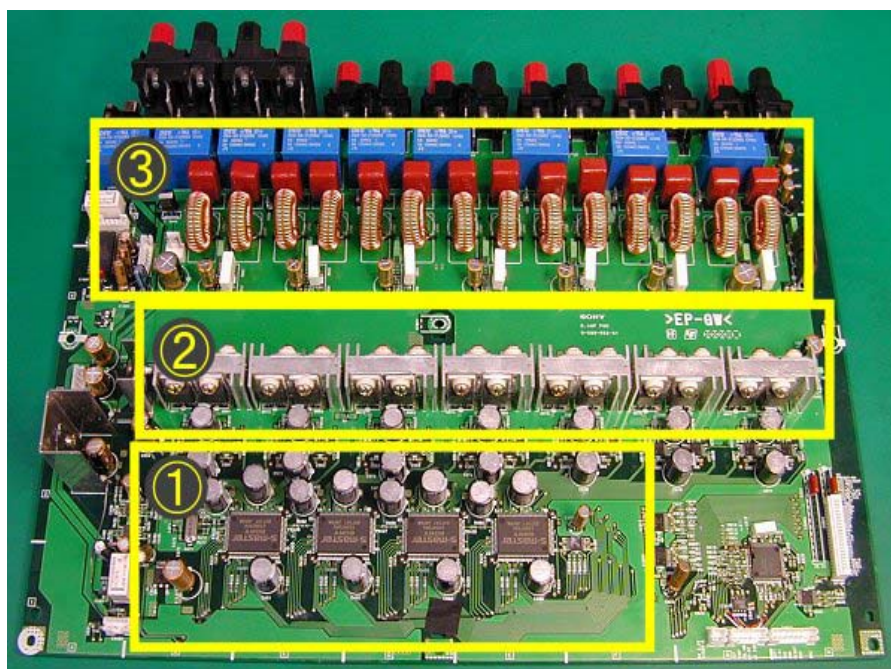
Simple and straight design

Heat is always bad for electronics. That's why the heat thrown off by conventional power output transistors is a crucial constraint in amplifier and receiver design. And that's why so many high-power amplifiers require massive internal heat sinks, cooling fans, and chassis layouts that isolate the output transistors at the back or sides. In contrast, the tremendous thermal efficiency of the S-Master Pro amplifier changes everything.

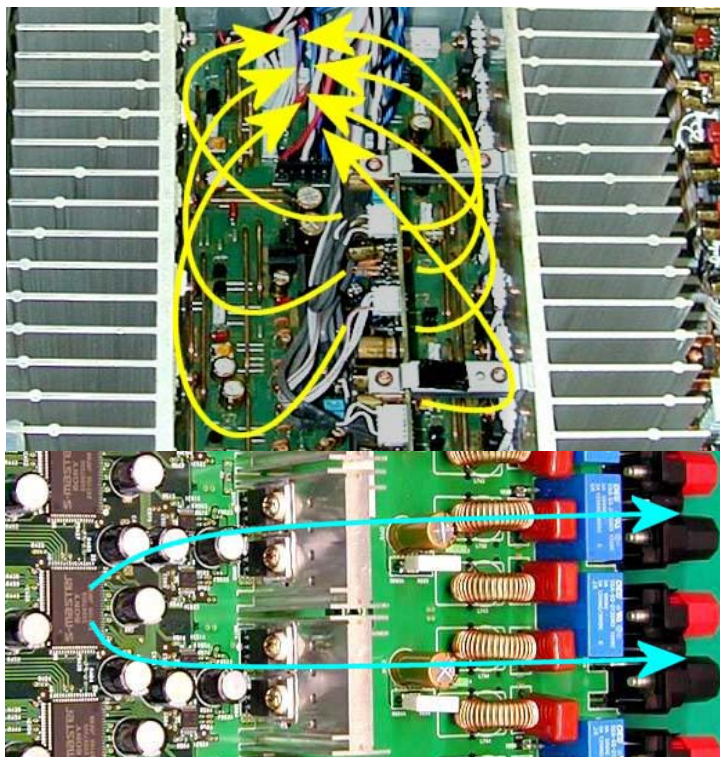
Instead of isolating the power output transistors, Sony can place them in the middle of a circuit board. Instead of massive aluminum heat sinks, the S-Master Pro heat sinks can be quite compact, especially on the STR-DA2000ES and DA3000ES. And instead of a complex, circuitous signal flow, driven by the need to hold the output transistors away at the periphery, the S-Master Pro signal flow can be refreshingly simple and straight.



The internal layout of the STR-DA4ES analog amplifier is driven by the issue of heat dissipation. The entire design is dominated by the output transistor heat sink fins.



In dramatic contrast, the power amplifier of the STR-DA2000ES is amazingly compact. The S-Master LSIs (1) convert the signal to a Pulse Length Modulation 1-bit stream. Thanks to low heat generation, the power output transistor heat sinks (2) can be quite small. Finally, the Low-Pass Filters (3) convert the power pulses to audio for the speaker terminals at the top of the picture.



In the STR-DA4ES (top), the signal flows from the center, to the sides and back to the center again for point-to-point wiring to the speaker output terminals. It's anything but straightforward. On the STR-DA2000ES (bottom), the signal flows in one direction only.

Superb open-loop performance

Conventional amplifiers typically generate substantial distortion in "open-loop" mode. That's why analog amps use Negative Feedback (NFB). NFB constantly compares the output with the input, identifying open-loop distortion and applying an equal-but-opposite correction signal at the input. NFB is a powerful tool for limiting distortion, and NFB explains the low distortion specifications common today. However, 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. And movie sound effects like car crashes and gunshots retain all their original impact.

Musicality and transparency

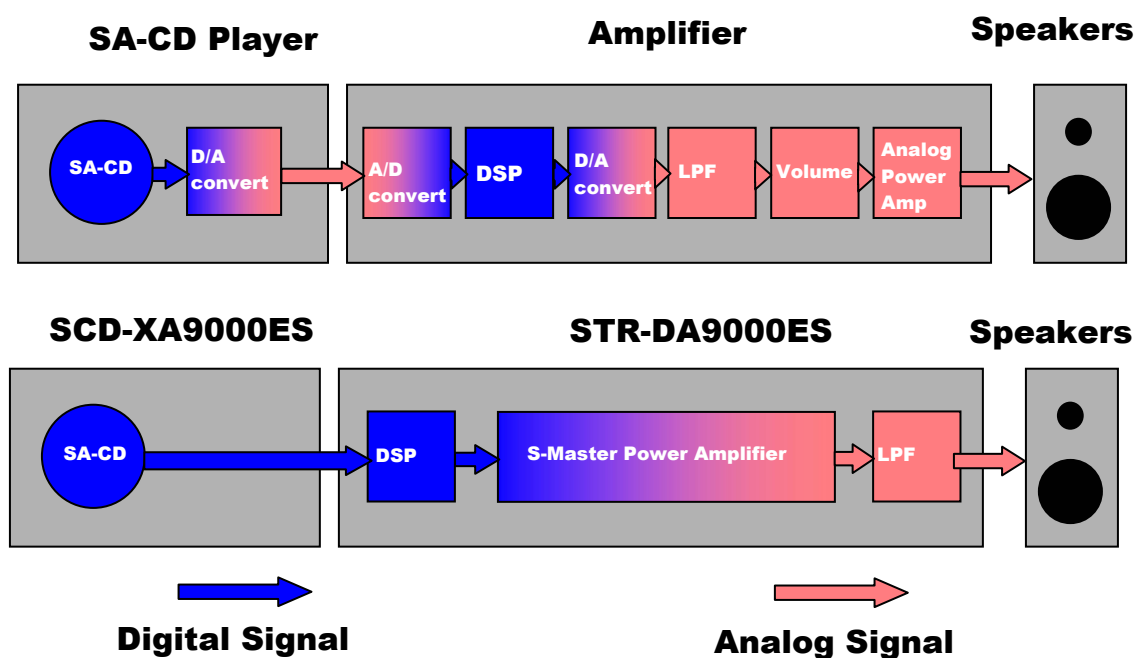
Armed with S-Master Pro amplifier technology, the latest ES Series receivers stand apart. They deliver high power output (up to 200 watts per

channel x7, 8 ohms, 20 to 20,000 Hz, 0.15%), and exceptional sound quality. Music is rendered in very high resolution, against a background of silky silence. Dynamics are powerful but not forced. Bass is vigorous but not boomy. These receivers are perfect for integration with the most difficult and power-hungry speakers. Use good speaker cables, a suitable disc player and a Super Audio Compact Disc that you know well. Then sit back and listen carefully. The results speak for themselves.

Other New Features

i.LINK® Digital Audio Interface (STR-DA9000ES)

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 is Sony's first SA-CD player to provide an i.LINK digital output for the 1-bit DSD signal. The STR-DA9000ES is Sony's first receiver to incorporate an i.LINK digital input. The i.LINK interface maintains the signal in the digital domain and can simplify the signal path considerably. The i.LINK interface also enables a single digital cable to take the place of six analog cables.



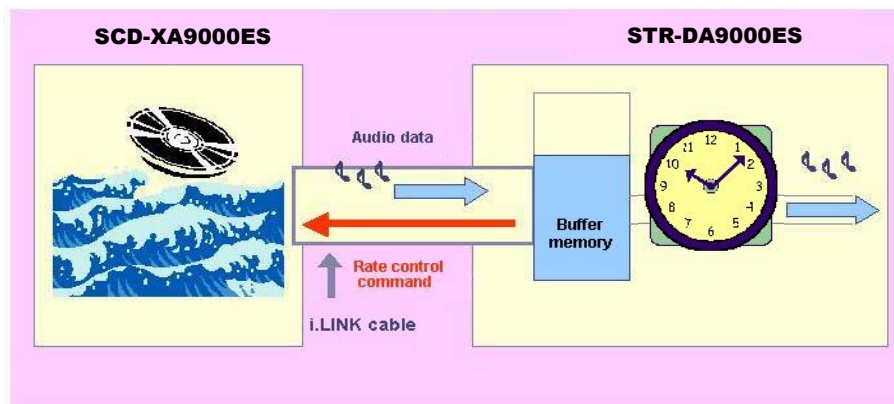
Typical SA-CD reproduction involves numerous D/A and A/D conversions. Connected to a compatible SA-CD player, the STR-DA9000ES maintains the signal in digital form.

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-DA9000ES i.LINK interface to a compatible digital audio output, such as that on the SCD-XA9000ES SA-CD player.

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. These errors translate 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.

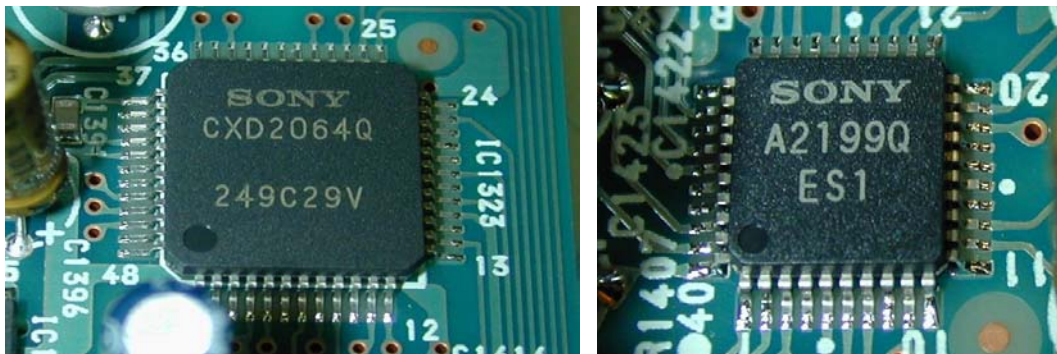
The receiver continually monitors the amount of audio data in its buffer memory. When the buffer memory reaches its lower limit, the receiver commands the player to increase data transmission speed. When the buffer memory reaches its upper limit, the receiver commands the player to decrease transmission 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 the exposing the signal to the potential for jitter-induced distortion.

Component Video Upconversion (STR-DA3000ES and higher)

As the nerve center of modern home entertainment, the A/V receiver needs to handle the full range of audio/video sources, including everything from HDTV receivers, digital satellite receivers and DVD recorders to VHS decks and videogames. Along with the range of sources comes a range of potential video input types: from the relatively low-grade composite video to S-Video, component video and HD component video. Ideally, all of these signals should be conveyed to the television with the highest possible quality. And for the sake of convenience alone, all of these signals should be conveyed to the same input of the television. That's why the STR-DA3000ES, DA5000ES and DA9000ES upconvert Composite Video to S-Video as well as upconverting S-Video to Component Video. Through these upconversions, Sony provides a high-quality connection to the television, while simultaneously reducing the need to switch input sources at the television.

These upconversions are made possible by two Sony large-scale integrated circuits (LSIs), which draw on years of Sony IC experience. Sony's CXD2064 digital LSI performs Composite to S-Video upconversion, while the analog CXA2199 upconverts S-Video to Component Video. Some previous upconversion circuits could not control the Hue, Contrast and Brightness of converted signals. But thanks to the CXA2199, Sony receivers give you these capabilities.



*On the left, Sony's CXD2064 upconverts Composite Video to S-Video.
On the right Sony's CXA2199, upconverts S-Video to Component Video.
Together, the circuits ensure high-quality connections to your
television—and simplify system operation.*

DVI Interface (STR-DA9000ES)

The STR-DA9000ES can accommodate the latest digital video sources with two digital inputs and one output. The Digital Visual Interface (DVI) enables spectacular, uncompressed digital-to-digital transport of a High Definition video

signal. The connection is also secured by HDCP technology to protect the signal from piracy.

Lip Sync (STR-DA5000ES and DA9000ES)

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 provided the STR-DA5000ES and DA9000ES with Lip Sync. This circuit enables you to correct time misalignments between the audio and video signals by up to 200 milliseconds, in 10 millisecond increments. This brings your television and your home theater speakers back into alignment. This Lip Sync is performed uniformly on stereo, 7.1-channel and even digital audio inputs.



The STR-DA5000ES performs Lip Sync with another Sony Large Scale Integrated circuit, the CXD9722.

9.1-Channel Operation (STR-DA9000ES)

The STR-DA9000ES offers an ingenious arrangement of the A and B speaker terminals. The speaker selector switch includes positions for A, B and A + B. In the A + B position, the receiver can drive two Surround Left and two Surround Right speakers, in addition to a Surround Back pair. Of course, this 9.1 configuration is closer to the array of surround speakers used in a commercial movie theater. It's also exactly the same as the 9.1-channel configuration of Hollywood dubbing theaters!

Toroidal Power Supply (STR-DA9000ES)

Like the STR-DA2000ES, DA3000ES and DA5000ES, the top-of-the-line DA9000ES operates the S-Master Pro amplifier from a two-stage power supply. And like these other receivers, in the DA9000ES, the second stage is an analog, constant voltage supply. But where the other receivers use a Pulse Power Supply, the DA9000ES uses an analog supply with a giant toroidal core power transformer. Sony made this choice for strictly practical reasons: we could not build a pulse power supply with the current capability for 200 watts per channel, for 7 simultaneous channels into 8 ohms (20—20,000 Hz, 0.15% THD).

For this reason, the first stage of STR-DA9000ES power supply wields an extremely massive toroidal-core power transformer. In fact, the unusual height of the DA9000ES chassis is determined in part by the size of the power transformer. Thanks to this transformer, the current delivery of the DA9000ES is an incredible 12 amps per channel. This is more than enough current to drive "difficult," low-impedance loudspeakers, including models rated at 4 ohms with impedance dips down to 2 ohms!

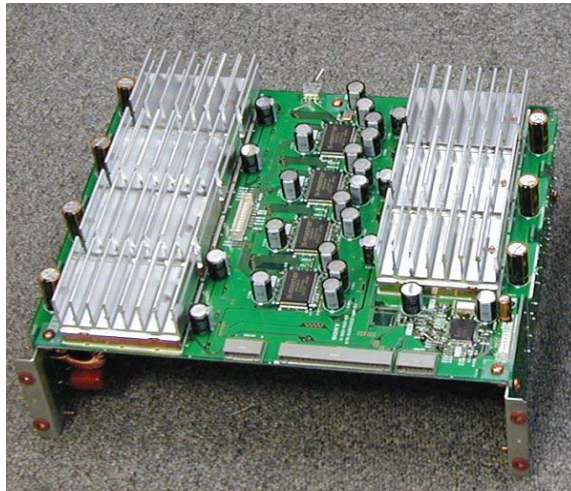
Power transformer cores and windings can vibrate and degrade the sound, radiating 60 Hz hum into nearby audio circuits. That's why Sony chose the toroidal core design, which enables the transformer windings to be wrapped without the voids or gaps that permit vibration. This results in far less radiation, far less radiated hum.



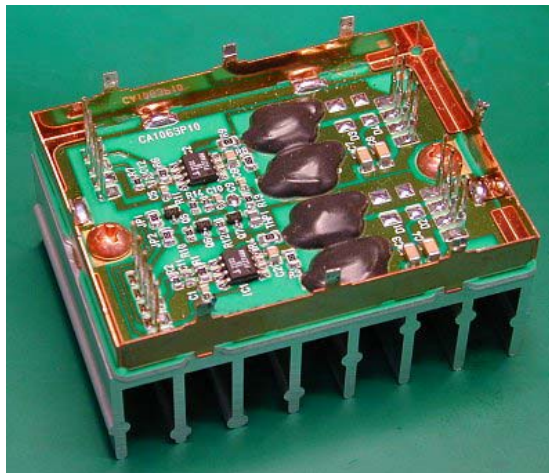
The extraordinary size and weight of the STR-DA9000ES receiver is explained in part by the size and weight of this toroidal-core power transformer.

MOS FET output transistors (STR-DA9000ES)

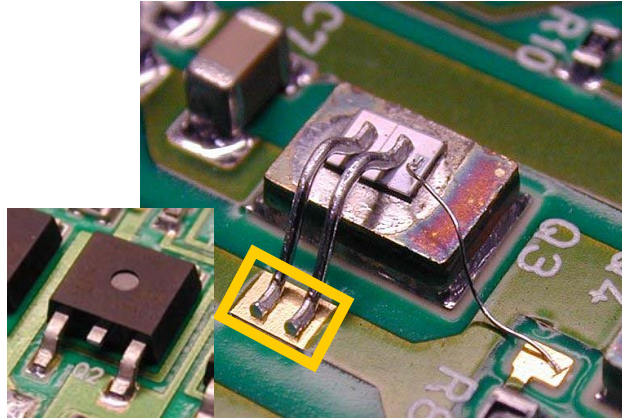
To achieve 200 watts x7 (20—20,000 Hz, 8 ohms, 0.15% THD), the STR-DA9000ES incorporates some unique power amplifier technology. For example, the power amplifier uses Metal Oxide Semiconductor Field Effect Transistors (MOS FETs), highly prized for their linearity. Four MOS FETs per channel are configured in modules that are direct-mounted to heat sinks in a "circuit-on-chassis" configuration.



The STR-DA9000ES power amp circuit board features seven heat sinks for the seven output channels.



The output stage is attached to the underside of each heat sink in a "circuit-on-chassis" configuration. The black capsules in this picture protect and insulate the four MOS FETs.



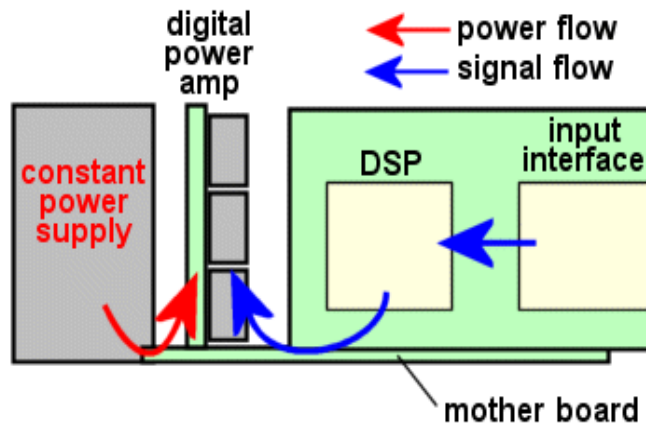
Conventional transistors are packaged in plastic with prefabricated leads (left). To achieve the shortest possible signal path, Sony uses bare MOS FETs and employs molecular bonding to connect each lead to the circuit board. The bare transistors and their connections are then encapsulated for protection.

Even the method of attaching the MOS FETs to the circuit board is remarkable. Instead of using conventional, packaged transistors, Sony uses "bare" transistors and molecular bonding. While expensive and time consuming, this approach makes for the shortest possible signal paths. Sony then protects the assembly with encapsulation in a protective compound.

Motherboard Topology (STR-DA9000ES)

To shorten the signal paths and optimize the circuit topology, the STR-DA9000ES uses an internal configuration that's rare in home audio, but common in computers. The receiver features a large motherboard that forms a "floor" and provides interconnections to daughterboards that process the signal. Input signals go directly into an input board, of which one edge is mounted to the back panel and one edge is mounted to the motherboard. Then the input board signal flows through the motherboard to the S-Master Pro power amplifier.

Power supply voltage travels a similar route, from the opposite side. In this way, Sony keeps signal leads to a minimum, protecting the music from the radiation of spurious hum and noise.



For efficient space utilization and minimum point-to-point wiring, the STR-DA9000ES uses a motherboard/daughterboard circuit topology.

Silver Cascade Design (STR-DA3000ES and up)

In addition to their remarkable technology, these receivers inaugurate 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 use them 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 components. But the design really comes into its own when the receivers are combined with other silver cascade components, such as the SCD-XA9000ES Super Audio CD player or the DVP-NC555ES DVD/CD/SA-CD 5-disc changer.



The DVP-NC555ES 5-disc DVD/CD/SA-CD changer shows how the Silver Cascade design extends to source components.

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

Continuing Features

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

- **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.
- **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
 - 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).** Using a proprietary Sony Large Scale Integrated circuit (LSI).
- **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-DA2000ES and higher).** ES receivers are destined to be used in custom installations where curtains, screens and lighting "scenes" may require 12-volt triggers.
- **Infrared repeater ports (STR-DA2000ES and higher).** To accommodate installations where the stack of electronics is hidden away, ES 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 (STR-DA2000ES and higher).** To communicate with third-party room automation systems, these receivers include RS-232C ports. The ports also enable future firmware upgrades to the STR-DA5000ES and DA9000ES.
- **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 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 ES 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 receivers represent another milestone in the digital technology. To appreciate the difference, just turn them on and listen.

Features and specifications

Feature	STR-DA9000ES	STR-DA5000ES	STR-DA3000ES	STR-DA2000ES	STR-DA1000ES
Power output, 8 ohms, 20 to 20,000 Hz at rated THD	200 watts x7	170 watts x7	150 watts x7	120 watts x7	100 watts x7
THD at rated power output	0.15%	0.8%	0.8%	0.8%	0.09%
S-Master Pro Amplifier	Yes	Yes	Yes	Yes	-
DC Phase Linearizer	6 positions + Off	3 positions + Off	3 positions + Off	3 positions + Off	-
Dolby Digital® EX decoding	Yes	Yes	Yes	Yes	Yes
dts® ES decoding	Yes	Yes	Yes	Yes	Yes
dts 96/24 decoding	Yes	Yes	Yes	Yes	Yes
Dolby® Pro Logic® II decoding	Yes	Yes	Yes	Yes	Yes
dts Neo:6 decoding	Yes	Yes	Yes	Yes	Yes
Digital Cinema Sound circuit	7.1-channel	7.1-channel	7.1-channel	7.1-channel	7.1-channel
32-bit Decoder	Yes	Yes	Yes	Yes	Yes
32-bit DSP	Yes (Two)	Yes (Two)	Yes (Two)	Yes	Yes
Lip Sync	Yes	Yes	-	-	-
OP Processing	-	-	-	-	Yes
Auto channel grouping	Yes	Yes	Yes	Yes	Yes
A/B speaker terminals	Yes	Yes	Yes	Yes	Yes
Multi-channel inputs	7.1 (x2)	7.1, 5.1	7.1, 5.1	7.1, 5.1	5.1
DVI inputs/outputs	2/1	-/-	-/-	-/-	-/-
HD Component video inputs/output	3/1	2/1	2/1	2/1	2/1
S-Video to Component upconverter	Yes	Yes	Yes	-	-
Composite to S-Video upconverter	Yes	Yes	Yes	Yes	Yes
S-Video inputs/outputs	7/3	4/2	4/2	3/1	3/1
Composite video inputs/outputs	7/3	4/2	4/2	4/1	4/1
i.LINK® digital audio input	Yes	-	-	-	-
Optical inputs/outputs	6/2	5/1	5/1	3/1	3/1
Coaxial inputs	5	2	2	1	1
Multi-channel preamp output	Yes, 7.1 channels	Yes, 7.1 channels	Yes, 7.1 channels	L, R, Subwoofer	Subwoofer
Front A/V input with optical digital audio	Yes	Yes	Yes	Yes	Yes
Infrared repeater input/outputs	1/2	1/2	1/2	1/1	-/-
RS-232C control/upgrade	Yes/Yes	Yes/Yes	Yes/-	Yes/-	-/-
12-volt trigger outputs	5	3	2	1	-
On screen display	Yes	Yes	Yes	Yes	Yes
Multi-Zone/Room Capability	3/3	3/3	2/2	2/2	-/-
2nd Room output	A/V out	A/V out	A/V out	Audio out	-
3rd Room output	Audio	Audio	-	-	-
Remote Features					
Preprogrammed LCD	Yes	Yes	Yes	Yes	Yes
Learning & Macro	Yes	Yes	Yes	Yes	Yes
2-way	Yes	Yes	-	-	-
Touch-screen	Yes	-	-	-	-
Second-room remote	Yes	Yes	Yes	-	-



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