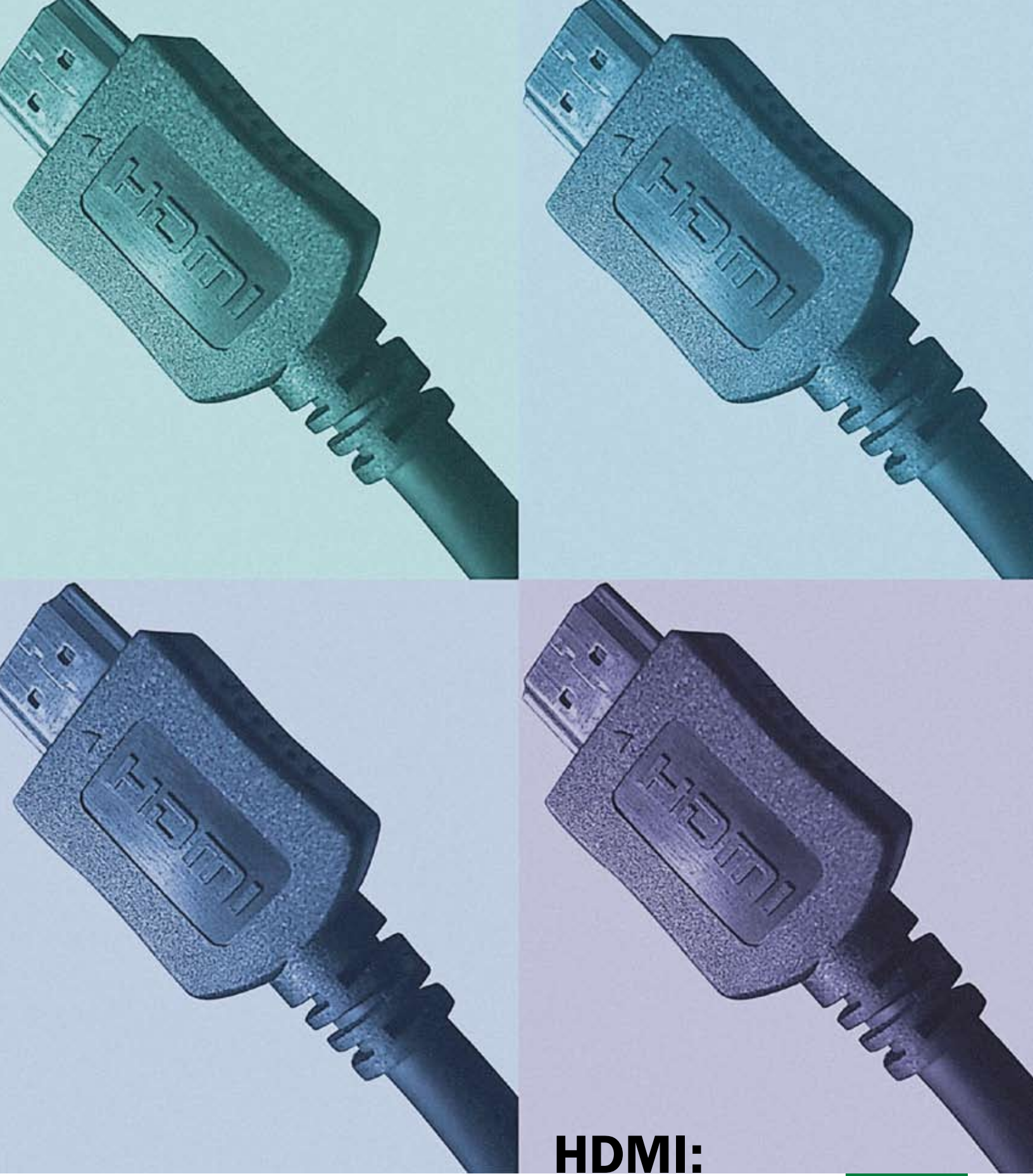

HDMI:

WHAT YOU NEED TO KNOW

ROTEL®

HDMI Questions

Rotel's Technical Support department is fielding many questions regarding HDMI (High Definition Multimedia Interface) version 1.3. We hope this technical paper will answer these inquiries and provide some background so you can better understand the real issues driving these questions.

Techno-Confusion

When any new standard appears in the market, technologically aware people (called "early adopters") want the promised benefits immediately. Although this reaction is fully understandable – and even commendable in many ways – some new standards actually deliver little more than was previously available. From many points of view, HDMI 1.3 is just such a standard.

Rotel has always emphasized real value and, for that reason, has used only technologies that provide easily discernable benefits to our customers. That is why we use HDMI 1.1 in our current product line. Although we know that it is easier to tell customers that the "latest and greatest" version of anything is superior to what went before, *the simple fact is that HDMI 1.3 does not provide better benefits for customers today than does HDMI 1.1.*

That's a challenging statement. Before we detail what we mean, let's look briefly at HDMI's history too see what's included in its various versions.

HDMI Version	Standard Introduced	Bandwidth/ Data Transfer Rate	Maximum Video Resolution (Single link, 24 bits/pixel)	Important Features/Additions
1.0	12/02	165 MHz/ 4.95 Gbps	1920 x 1080 (60 frames/sec)	1080p digital video transmission; 8 channels of uncompressed 24-bit/192 kHz PCM digital audio; Dolby Digital, DTS, Dolby Digital EX, DTS ES (lossy compression formats)
1.1	5/04	"	"	DVD-A with MLP lossless compression (up to 8 channels); content protection metadata
1.2	8/05	"	"	SACD (up to 8 channels of DSD single-bit format); PC compatibility
1.2a	12/05	"	"	CEC (Consumer Electronics Control), a bi-directional serial control format
1.3	6/06	340 MHz/ 10.2 Gbps	2560 x 1600 (60 frames/sec)	Deep Color™ (high bit) color format (*optional*); larger color space (*optional*); higher frame rate (*optional*); Lip Sync (optional); Dolby True HD and DTS-HD Master Audio lossless compression audio formats (*optional*); mini-connector for camcorders, etc. Higher bandwidth generally righer bequires special cable.
1.3a	11/06	"	"	General technical "housekeeping" – specs more carefully defined
1.3b	3/07	"	"	Includes testing protocols and corrects earlier mistakes in HDMI literature.

Let's look at some of the "real world" benefits customers are asking for and what HDMI version they'll need to enjoy them:

1080p video	*HDMI 1.0*
Fully uncompressed PCM audio	*HDMI 1.0*
Dolby Digital & EX (5.1 and 6.1 audio)	*HDMI 1.0*
DTS & ES (5.1 and 6.1 audio)	*HDMI 1.0*

This is not quite the picture you might get from reading press releases and other marketing materials. As you can see, *every version of HDMI, including 1.0, provides your customers with the connectivity and bandwidth they need to enjoy all of today's most important audio and video technologies.*

Rotel has gone one step past HDMI 1.0 to select 1.1 because it also supports DVD-A(udio) and, even more importantly, is a proven and robust method of getting digital audio and video from source to processor/receiver to display device quickly and easily.

HDMI 1.3 – A Different Perspective

When you look at 1.3's history closely, you'll see that it has gone through two revisions in less than 2 years. That's not what you should legitimately expect of carefully designed, mature technology. In this light, you could say that HDMI 1.3 and 1.3a were simply beta (test) versions perhaps best left unreleased.

Some engineers, in fact, cynical refer to HDMI as standing for "half-developed, mostly intermittent," Nowhere is this sentiment more obvious than at industry-wide "plug fests" where HDMI-certified components are tested under real world conditions and often don't function as expected. Although many of these functional incompatibilities result from "handshake" problems with a different technology called HDCP (**h**igh **d**efinition **c**ontent **p**rotection), HDMI itself was often blamed to the extent that many cable TV suppliers companies now advise consumers to avoid HDMI connections from cable box to receiver/processor to video display device entirely.

Video Standards and HDMI 1.3

Perhaps the most misrepresented aspect of HDMI 1.3 lies in its video capabilities. Given the enormous interest in high definition TV and the emergence of Blu-ray and HD DVD discs, we need to examine these aspects more closely.

Resolution

If you look at the best video display devices today, you'll see 1080p mentioned prominently as a must-have feature. This simply means that the device is capable of displaying 1080 progressively scanned lines of vertical resolution. That's as high as current video standards allow.

If fact, 1080p doesn't even exist in the broadcast world. The highest resolution covered in the HDTV standard is 1080i or 1080 *interlaced* lines of resolution. (Although 1080i provides excellent picture quality, it suffers in comparison with 1080p in its ability to portray quick movement without artifacts that some people find distracting.) The point here is that broadcast video will most likely never exceed the 1080i standard. If it does, count on a substantial gestation period – perhaps as long as 20 - 30 years at a minimum.

In the disc-based world, things are different. Here, 1080p is the *de facto* resolution standard for both Blu-ray and HD DVD.

This does not mean that all video information on all Blu-ray or HD DVD discs began its journey to a home theater system in 1080p format. In fact, much legacy content is scaled to 1080p either in disc authoring or by a player's internal circuitry prior to output.

Of note here is the fact that there is no provision whatsoever for higher resolutions in either the Blu-ray or HD DVD specification. Although some gurus forecast a "super Blu-ray" or "super HD DVD" with resolutions of 1440 lines (or higher), we see little chance of this emerging soon, particularly in light of new technologies that allow relatively easy downloads of today's high definition video sources.

The only exception to this, if it comes at all, will probably arise from the perceived needs of the gaming community where computer-based standards might evolve more quickly than they will in the consumer electronics field. Even then, you'll need a truly large screen (80"+) to begin to see the benefits. And you'll need entirely new sources to take advantage of these "someday" super high resolution formats.

The Color Palette

Deep Color: HDMI 1.3's increased bandwidth does support higher bit structures for color data transmission. Instead of the 24-bit/pixel limit in HDMI 1.1, 1.3 supports up to 48-bit color depth. (Color depth refers to the number of bits carrying color information for one pixel of a fixed-pixel display – LCD, plasma, DLP, etc.)[1]

The theoretical advantages are attractive. 24-bit color depth allows "only" 17 million colors while 48-bit depth allows 2.9 *billion* colors. This can

[1] Some sources quote an improvement from 8- to 16-bit color depth while others specify a 24- to 48-bit jump. The 8-16 camp counts intensity levels for only one of the three primary colors (red, green, and blue) that dictate a pixel's final output. Those who specify a 24- to 48-bit improvement potential count the increased color depth for all three primary colors simultaneously.

translate into smoother color transitions with no "color banding", more accurate rendition of various shades of gray for better image detail, etc.

But remember the phrase "theoretical advantages". When you review Blu-ray and HD DVD standards, you find that, although neither format is *necessarily* limited to 8-bit color depth, all disc content derived from materials originally encoded according to the MPEG-2 standards is.[2]

The more advanced MPEG-4 video compression standard allowed by both Blu-ray and HD DVD is not necessarily limited to 8-bit color depth. However, any MPEG-2 limitations still apply so movies originally compressed with MPEG-2 will be read as 8-bit sources.[3]

Again, HDMI 1.3's theoretical advantages may show at some indefinite point in the future but they won't be realized anytime soon. In fact, HDMI 1.3's increased bandwidth will most likely allow more current-format data streams over a single connecting cable rather than an undefined single source that takes advantage of the increased bandwidth.

xvYCC ("broader") color space: HDMI 1.3 supports something called xvYCC, an abbreviation for "Extended YCC colorimetry for Video Applications", the consumer description for the IEC 61966-2-4 xvYCC color standard. In effect, xvYCC allows the display of any color recognizable by the human eye, a 1.8x improvement over current high definition video standards.

The difference between Deep Color and xvYCC Color Space may seem somewhat obscure at first glance. In audio terms, think of Deep Color as wider dynamic range and xvYCC as wider frequency response.

xvYCC expands the total number of colors beyond what video engineers call the "RGB triangle." xvYCC includes all the colors perceived by the human eye and is, consequently, a more comprehensive color gamut than allowed by conventional RGB limitations.

Deep Color allows each of those colors, both those within the original RGB space and the "new" ones outside that space, to be rendered in many more shades or degrees of brightness. Together, Deep Color and xvYCC produce a wider range of colors.

At this point, it is important to note that *no current video source* (HDTV, DVD, Blu-ray, and HD DVD) *supports Deep Color or xvYCC Color Space.* Will some future developments take advantage of these potential performance advantages? Quite possibly. How soon might this happen? Don't hold your breath.

Where Video Meets Audio

Lip Sync: Processing digital video and audio signals today is increasingly complex. One of the effects we all have to deal with is something called "latency" or delay in signal throughput.

If this latency period is different for the audio and video portions of an A/V signal, you'll end up with a disparity between, for example, seeing someone say something and hearing that same something – sort of like a poorly dubbed kung-fu movie.

Today's A/V processors and receivers often include a manual "LipSync" adjustment that delays the audio portion of the total signal until the video portion, which usually undergoes more processing, "catches up" with the audio segment. The result is often hit-or-miss accompanied by constant fiddling with the delay adjustment.

In contrast, HDMI 1.3 supports automatic syncing with total accuracy. The problem is that both source and processor need this capability to function properly and, to the best of our knowledge, this source/processor implementation has not yet appeared in consumer products.

Audio Formats and HDMI 1.3

If HDMI 1.3's video capabilities are the most misrepresented, HDMI 1.3's support of high-resolution audio formats is the most confusing. Exactly what this means is somewhat obscured by complexity – or by artifice – by those who promote *new* at the expense of *user benefits.* Let's take a closer look.

New HD lossless audio formats: HDMI 1.3 supports new Dolby True HD and DTS-HD Master Audio lossless digital audio formats. That's in addition to conventional high-bandwidth uncompressed digital audio (PCM or Pulse Code Modulation) and all current compressed formats such as Dolby Digital and DTS, something that every HDMI version since 1.0 has been perfectly capable of.

Without a doubt, the new high definition audio formats are exciting and will provide an opportunity to introduce even more consumers to be audible benefits of better performance. However, we need some background in order to understand the real benefits more fully. To do this, we'll first examine data compression itself. Then we'll differentiate between lossy and lossless compression.

Compression

In the digital world, data travels as a series of bits. In most cases, we can remove some of those bits and not lose core information. That's called "compression". The computer world has used compression for years as programs like WinZip make sending files from one computer to another much easier by making those files smaller – so they take up less room on a disk or take less time to travel over the Internet.

[2] MPEG-2 is the standard compression format used for all DVDs.

[3] Even with MPEG-2 encoded sources, "scaling" performed after a disc is read may create new data points more accurately described with higher-bit processors. This may be a benefit of HDMI 1.3 if and only if the display device and all other links in the chain support the higher color depth. Although MPEG-4's "higher profiles" allow color depth up to 14-bit (42-bit RGB), there is no accurate prediction of when or even if this will ever happen.

Broadly speaking, there are two kinds of compression – lossy and lossless.

Lossy Compression

Lossy compression occurs when some of the data is intentionally stripped from the original bit stream. Exactly which bits are lost depends on the algorithm (an analytical equation) that's at the heart of any compression format. Generally speaking, these algorithms eliminate redundant, unnecessary, or irrelevant information. Different algorithms treat information differently. Some are relatively benign, some more predatory. In general, the greater the compression ratio, the fewer bits survive the compression process and, at some point, the effects become distinctly audible.

Examples of lossy compression for audio include Dolby Digital, DTS, MP3, WMA, and the AAC format used by iTunes.

Lossless Compression

In comparison, lossless compression reduces the size of a file without removing any information that can't be subsequently recovered or degrading original quality. Here's a crude example:

Uncompressed original:
If we remove all the spaces from a sentence, we can make it shorter without losing our ability to understand it.

Lossless compression:
Ifweremoveallthespacesfromasentence,wecan makeitshorterwithoutloosingourabilitytounderstandit.

Notice that we haven't lost any core information. The algorithm will restore the spaces when we decompress the file so that it's an exact duplicate of the original. And that's *exact* as in bit-for-bit.

True, lossless compression isn't as efficient as lossy compression – it can't shrink file sizes as well – but the huge storage capacity of HD discs and the increasing capacity of broadband internet connections makes this a very small issue indeed.

MLP (Meridian Lossless Packing) is an example of lossless compression used on some DVD-A discs.

PCM: The Real World Pipeline to Better Audio

PCM (Pulse Code Modulation) has been with us for decades. It's the format used for CDs, DVD-As and many other purposes. Because each sample (whether 16- or 24-bits long at rates from 44.1 kHz to 192 kHz) completely describes an analog voltage level, it's very difficult to compress data in PCM format. (Because it's so common and supported by every HDMI version, many HD discs offer an uncompressed PCM audio option.)

In addition, Dolby True HD and DTS Master HD sound tracks decoded in a Blu-ray or HD DVD player may well make the player-to-processor journey in PCM format via an HDMI link. Here are the possible pathways:

Source	Receiver/ Processor	Comments
HDMI 1.3 capable	HDMI 1.3 capable	Undecoded Dolby True HD or DTS Master Audio bitstream may travel from player to receiver/processor via HDMI link to be decoded in receiver/ processor, then converted to PCM. All subsequent data manipulation done in PCM format. (See additional comments under Where to Decode? below.)
HDMI 1.3 capable	HDMI 1.0/1.1/1.2 capable	Source senses receiver/processor capability. Decodes Dolby TrueHD or DTS-HD Master Audio internally. Sends PCM data via HDMI link for further processing (channel separation, etc.)
HDMI 1.0/1.1/1.2 capable	HDMI 1.0/1.1/1.2/1.3 capable	No Dolby True HD or DTS-HD Master Audio available from disc. Dolby Digital, DTS, PCM all transmitted via HDMI and available for further processing.

This table makes an important point**: Decoding an audio format (**whether "plain ol' Dolby Digital" or the newest DTS-HD Master Audio) **can take place in *either* the source component or the receiver/processor.**

So if your receiver or processor is not HDMI 1.3 capable, you'll still be able to enjoy the audible benefits of these high definition audio formats as all the necessary decoders, panners, and mixers are built into the players themselves.

Even if your receiver or processor lacks HDMI inputs (or provides HDMI switching only), you still have the option of decoding in the player itself and sending a multi-channel analog signal to your receiver or processor. So even here, you're not locked out of these new audio formats.

Where To Decode?

You might well ask if there's a benefit to decoding a high definition bitstream (either Dolby TrueHD or DTS Master Audio) in a receiver/processor as opposed to the player. From a pure performance standpoint, there's absolutely no difference.

From a feature standpoint, decoding a high definition audio bitstream in a receiver/processor actually deprives you of possible options. That's because the internet-sourced interactive audio features available as supplements to some HD DVD or Blu-ray discs are accessible only as long as that player is connected to the web and only when the disc-based high definition audio bitstream is mixed with supplemental web material and decoded *inside* the player.

This is in contrast to the DVD world where alternative languages, director's commentaries, etc., exist as completely separate audio tracks contained *only on the disc itself.*

The Problem With "Optional Support"

If you read the table under "Techno-Confusion" at the beginning of this paper closely, you saw the word "optional" many times in relation to HDMI 1.3. That's because there was no requirement to identify exactly what enhancements were included in any machine claiming 1.3 compliance.

The only real requirement was that the unit include the wideband circuitry necessary to support the benefits that *might* result.

On October 17, 2007, HDMI Licensing LLC, a subsidiary of Silicon Image, Inc. and the company responsible for overseeing HDMI specifications and trademark usage, took the rather unusual step of issuing a press release to address the increased confusion between HDMI 1.3's potential and actual benefits.

As of that date, HDMI Licensing began requiring manufacturers to *specify both the HDMI version number and exactly what features a particular piece of equipment supported.*

In part, the press release said "To ensure that consumers are given the product information that they want and need, manufacturers are now required to include specific HDMI features enabled in their product along with the HDMI version number (e.g. as "HDMI 1.3"). This enhancement is necessary because an HDMI version number does not require functionality, but specifies a list of optional features for manufacturers to select depending on their target market."

If you read that closely, you saw these phrases: "an HDMI version number does not require functionality" and "optional features for manufacturers to select."
With specific reference to HDMI 1.3, no current or soon-to-be-expected video source will provide Deep Color, enhanced Color Space, higher frame rates, or any of the new high definition audio formats.

In Conclusion

After all this, what does the consumer truly gain from HDMI 1.3 that previous versions can not provide? The answer is, quite simply, "Not much".

- HDMI 1.3 does offer the ability to transmit extended color ranges that do not currently exist on any video source at this time – nor are expected in the near future. Although extended color capability *may* be a benefit at some indefinite time in the future, it is of no practical use now.
- HDMI allows delivery of audio bitstreams that are better off decoded inside of the player to begin with. After that decoding, the audio information (in PCM form) can be (and currently is with great success) transmitted by any version of HDMI.
- The only real innovation that HDMI 1.3 allows is the enhanced lip sync correction feature. However, there is no indication of when or how that might be implemented.

For all *practical* applications, any version of HDMI that supports PCM audio is perfectly capable of transmitting the best that DVD, HD DVD, Blu-ray, or HDTV has to offer. When Rotel introduces HDMI 1.3-equipped products, it will be as a function of a stable supply of the quality ICs required to handle 1.3's wider bandwidth, and not because of some inadequacy of our current 1.1 models.

Thank you.

Appendix

Today's Confusing Array of Audio Formats

This following doesn't necessarily add to your understanding of HDMI's complexities. However, it may increase your knowledge of the plethora of new audio formats coming to market now.

We've put critical information in both table and outline form so you can approach this from whatever angle you're more comfortable with. In either case, you'll find valuable tips on understanding these new formats.

Format Name	Compression Type	Data Rate	Application	Comments
Dolby Pro Logic II and IIx	Not applicable	Not applicable	Early video sources (VHS tape), surround-encoded TV broadcasts, some DVDs, two channel analog sources	Both based on Dolby Pro Logic. PL II provides 5.1 decoding; PLIIx provides 7.1 channel decoding.
Dolby Digital	Lossy	Variable up to 640 Kbps; normally from 384 to 448 Kbps	DVD, HDTV, games, etc.	Supports up to 6 channels (5.1 format). Mandatory for DVD and HDTV.
Dolby Digital EX	Lossy	Variable up to 640 Kbps	DVD, HDTV, games, etc.	Supports up to 7 channels (6.1 format).
Dolby Digital Plus	Lossy	Variable from 96 kbps to 6.144 Mbps HD DVD: 3 Mbps Blu-ray: 1.7 Mbps	Eventual replacement for Dolby Digital Mandatory audio format for HD DVD; Optional audio format for Blu-ray.	Can support up to 14 channels (13.1 format). Advanced algorithm provides higher quality sound than Dolby Digital. Includes "dialog normalization" for better intelligibility.
Dolby TrueHD	Lossless	Variable up to 18 Mbps Both HD DVD and Blu-ray discs utilize maximum data rate.	Mandatory audio format for HD DVD; Optional audio format for Blu-ray.	Supports up to 14 channels (13.1 format). Not all channels used in current sources. Includes "dialog normalization" for better intelligibility.
DTS Neo:6	Not applicable	Not applicable	Surround effects from 2 channel sources	Supports up to six surround channels from matrix-encoded sources.
DTS	Lossy	Variable from 768 kpbs to 1.5 Mbps	DVD, games, etc.	Supports up to 6 channels (5.1 format)
DTS ES	Lossy	Variable from 768 kpbs to 1.5 Mbps	DVD, games, etc.	Supports up to 7 channels (6.1 format)
DTS 96/24	Lossy	NA	Some DVD-V and DVD-A discs	
DTS-HD High Resolution Audio	Lossy	Variable from 1.5 – 6 Mbps HD DVD: up to 3 Mbps Blu-ray: up to 6 Mbps	Eventual replacement for DTS and DTS ES. Optional audio format for HD DVD and Blu-ray discs	Supports 8 channels of 24-bit/96 kHz resolution. Will be used where disc capacity does not allow DTS-HD Master Audio.
DTS-HD Master Audio	Lossless	Variable to 24.5 Mbps; Constant at 1.5 Mbps HD DVD: up to 18 Mbps Blu-ray: up to 24.5 Mbps	Mandatory audio format for HD DVD and Blu-ray discs	Supports 8 channels of 24-bit/192 kHz resolution

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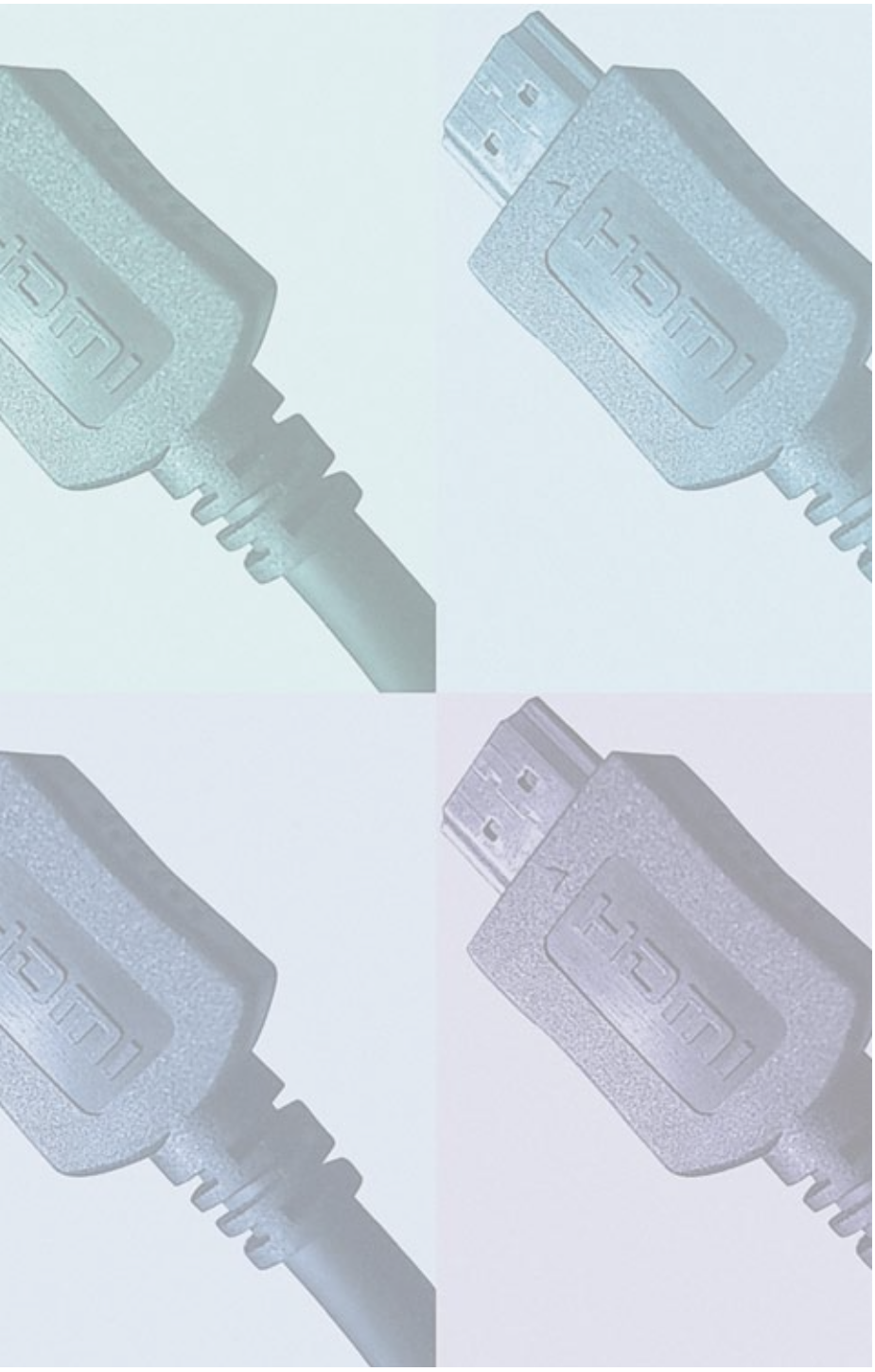

For those of you who are not comfortable with tables, here are important highlights for your information:

Dolby Pro Logic II and Pro Logic IIx

- Primary purpose: Provides up to six channels of surround effects from older two-channel analog sources or two-channel Dolby Surround encoded sources

Dolby Digital

- The principal surround format for DVD

Dolby Digital Plus

- Will eventually replace Dolby Digital
- Supports up to 14 channels although current content formats (HD DVD, Blu-ray) limit number of channels to 8.
- Currently used in European satellite video delivery
- Expected use in streaming applications (at lower end of data rate).

Dolby TrueHD

- Supports up to 14 channels although current content formats (HD DVD, Blu-ray) limit number of channels to 8.
- Future applications may include height information or other configurations beyond today's 7.1 formats.
- Data rate is more than *40 times* the maximum rate of Dolby Digital.

DTS and DTS ES

- When you see *DTS Encore* in the future, know that it is a re-labeling of DTS, ES, and 96/24 formats using only core data. Newer formats add extension data to encode more information.

DTS-HD High Resolution Audio

- Will be used primarily when source capacity does not allow DTS-HD Master Audio. Note the lower sampling frequency.

DTS-HD Master Audio

- Falls between DTS 5.1 and DTS-HD Master Audio

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