HDMI:

WHAT YOU NEED TO KNOW

ROTEL

Making Life Simple? Hah!

Digital technology was supposed to enhance our entertainment options. Well, it's done that. Unfortunately, it – and a veritable legion of lawyers – has made things far more complicated, too.

Recently, the resulting confusion has reached near-epidemic proportions. It seems as though we're all drowning in an "alphabet soup" of new connection problems brought on by new formats, new data transfer protocols, even new connectors as we try to get our home theater systems to fulfill their ever-elusive promise.

So here's an overview we think you'll find useful. It'll detail some of the more obscure issues we all face today: What's the difference (or is there one?) between HDMI and HDCP? Which version of HDMI do I need? Is any of this stuff important?

Well, it's all important if we want to get the best sound and picture from your speakers and display device.

Video Basics

Note: Some of you may want to skip this section and go directly to ***HDMI and HDCP****.*

We're assuming that most of the readers of this piece understand video basics but for those who'd like a quick review, here they are.

Defining Resolution

Resolution tells us how finely detailed a picture is.

In the current transition from conventional analog (NTSC) TV to the new digital standards (ATSC), resolution is perhaps best defined by "pixel count" (or the number of "picture elements" in a complete image), and whether that image is "interlaced" or "progressive." All other things being equal, the more pixels, the better the resolution.

In the "good old days," we never really discussed pixels. Instead, we used the phrase *lines of resolution* to describe picture sharpness. In part, that was because *every* complete TV image (a frame) was formed by 480 scan lines. This is simply another way of saying that every image's vertical resolution (the number of individual elements from top to bottom) was 480.

With that in mind, the only way to differentiate a good picture from a less acceptable image was by describing how much detail each line could convey. That's where the confusing term "lines of resolution" came from.

Of course, higher resolution claims didn't necessarily mean you'd see any difference from one set to the next, particularly with over-the-air broadcasts.

Today, the pixel makes the whole concept of resolution or definition easier to deal with. A **pixel** is the *smallest element of a picture that we can individually address and modify to make a difference in what we see*. Thus, the pixel is one of the main things that distinguish between different resolution or definition levels.

In today's world, the pixel applies equally to both source and display. A digital image, whether from a disc, a broadcast, or a still camera, has an intrinsic pixel structure. A display also has an intrinsic pixel structure and the whole trick of digital imaging is to get both pixel structures to match up as closely as possible.

Let's take another – and closer – look at resolution to distinguish between horizontal and vertical resolution measurements. If you were very close to a conventional direct view TV set, you could see the individual scan lines. If you were able to count every pixel – every individual picture element – that made up one scan line, you'd know what the *horizontal resolution* of source/TV set combination was. (For the sake of our discussion, let's accept the figure of 640.)

Now, let's tackle *vertical resolution*. Starting at the top left hand corner of the screen and moving to the bottom, count the number of lines you can distinguish. If you're watching an NTSC source, you're going to end up somewhere around 480 *visible* scan lines.

So what's the total resolution of that conventional television? Simple! Just multiply the number of pixels per line by the number of lines to get an upper "resolution limit" of 307,200 pixels. (Well, we *might* end up with that number if everything was perfect. In reality, NTSC broadcasts never arrive at our sets with more than 330 lines of horizontal resolution.)

With digital television, the situation is complicated by the fact that the ATSC standards allow several resolutions: SDTV (*standard* definition digital TV), EDTV (*enhanced* definition) and HDTV (*high* definition.)

The pixel count for **standard definition digital television** ranges from the NTSC-like 480 x 640 to 480 x 704. That's a total pixel count of either 307,200 (as we've seen before) or 337,920. Remember that even though the numbers are similar to those for NTSC, the reality is that digital TV is nearly always better than NTSC. That's because a digital TV signal is *there* or it is *not* there. It is never "not quite as good as it should be."

Enhanced definition TV: As we move towards true "high definition," things improve. For one thing, all EDTVs and EDTV broadcasts process a 480 line *progressively*-scanned picture. (You'll read more about scanning methods shortly.) Although the pixel count is the same as SDTV, the progressive scan approach makes for a more enjoyable picture especially with fast moving action on the screen.

With true **High Definition** TV pictures, however, the difference can be striking. For one thing, the pixel count ranges from just over 921,000 (for a 720p signal) to more than 2,000,000 (for 1080p)! That's almost seven times NTSC's pixel count.) For another, high definition is synonymous with "widescreen" even though enhanced definition standards also allow for the more movie-like 16:9 aspect ratio.

Scanning For Differences

Video images appear on the screen in one of two ways. Either they're "drawn" in halves and then meshed together (interlaced) or scanned in their entirety at one time (progressive).

Interlaced scanning began with NTSC TV. Here, the TV scans 262.5 lines in 1/60th of a second to complete a **field** composed of odd numbered lines (called "field 1") and *then* scans the next (even-line) field called, naturally enough "field 2") in the subsequent 1/60th of a second. The two fields fit together to form a whole picture. Of course, this integration process was helped by our persistence of vision and the screen phosphors' decay time.

Progressive scanning is simply a different way to "paint" a picture on a TV screen. It scans *all* the lines in order from top to bottom without interruption and without dividing them into odd and even numbers. It's called "progressive" scanning simply because the electron beam progresses from one line to the next without any concern for whether a line is odd or even – it is simply *next*.

Despite the claims you'll hear from rabid partisans on both sides of the fence, there are few *intrinsic* advantages for either scanning strategy.

The broadcast industry has used interlaced scanning ever since the birth of television. Most TV cameras are interlaced. In fact, one of the arguments broadcasters made against progressive scanning when the ATSC standards were being set was that a progressive scan camera, if one could be made at all, would be ruinously expensive. (Then Polaroid made an affordable one and that argument was crushed.)

On the other hand, the computer industry (particularly gamers) used progressive scan technology almost exclusively as it lent itself more easily to quickly changing graphics.

The fact is that neither approach is flawless. All else being equal, interlaced pictures can convey more static detail. Progressive images are better at rendering fast moving events without the occasional vagueness caused by interlace's field-to-field changes.

Now that we've covered Video Basics, let's jump into the most complex topics first.

Those Pesky Natives

Let's open this section with a short discussion on *native resolution* and the impact it has on our viewing pleasure.

With "fixed pixel" displays like LCD and plasma flat screens and microdisplays such as DLP, the native resolution, or the number of horizontal and vertical pixels built into the active viewing device, has a profound impact on the final picture quality.

Digital display devices with a pixel matrix of 704 x 480, for example, will never be able to product an image formatted in 1080 (either i or p) clearly. These displays will downconvert an incoming signal to its own standard (or native) resolution.

Video "signal-to-noise" – or S/N – performance has a significant impact on picture quality. As the S/N measurement of an NTSC signal gets worse, so does the picture. Eventually, of course, the NTSC signal just disappears into a sea of "snow" and you can't distinguish anything at all. A digital TV signal, on the other hand, stays pretty much the same until the S/N measurement goes totally into the toilet (at about -15 dB) and the picture just goes away.

Native resolution	Commonly called	Meets definition of high-def?	Frequency	Typical TV types
1,920x1,080	1080p	Yes	Rare but getting more common especially in larger TVs	Flat-panel LCD; DLP, LCD, and LCoS projection; very high-end plasma
1,366x768	768p	Yes	Very common in all screen sizes	Flat-panel LCD; 50-inch plasma
1,280x720	720p	Yes	Common in rear-projection but not flat-panels	DLP, LCD, and LCoS projection
1,024x768	HDTV plasma	Yes	The most common plasma resolution	37- and 42-inch plasma
852x480	EDTV plasma	No	Increasingly rare	37- and 42-inch plasma
640x480	VGA	No	Increasingly rare	Small LCD TVs

To help you, here are some common native resolution specs from CNET (http://www.cnet.com/4520-7874_1-5137915-1.html).

This differs sharply from older CRT displays which are far less sensitive to these discrepancies. Oh, well – two steps forward and a half-step back seems to be the price of video progress these days.

The important note here is that you check digital display device specifications very carefully for optimal picture quality. For example, will that "1080" set accept a 1080p signal directly or will it downconvert and lose some picture quality in the process? These are things you need to know.

HDMI and HDCP

To begin with, HDMI and HDCP are very different technologies.

HDMI stands for "**H**igh **D**efinition **M**ultimedia **I**nterface." HDMI provides a way to get digital audio and video data from one home theater component to another. (Yes, HDMI is beginning to be used in the computer world too but we'll restrict our discussion to home entertainment for now.) **In short, HDMI is simply a new data pipeline.**

HDCP (**H**igh-bandwidth **D**igital **C**ontent **P**rotection), on the other hand, is the security patrol that makes sure no one makes unauthorized use of the data flowing through the HDMI pipeline. **So HDCP is the cop on the beat looking for burglars.**

Are HDMI and HDCP related? Yes, they certainly are – at least in a functional sense. Together, they provide a secure pathway for the high definition formats of today – and tomorrow.

So what benefits does this DDC/EDID link provide? When you turn your system on, the source component (a DVD player for instance) queries the display device and, in effect, asks it what kind of data it wants to see. The source component then automatically formats the HDMI output to conform to those preferences.

A Closer Look at HDMI

HDMI is both an electrical and a physical specification. On the electrical front, HDMI spells out exactly what data can be passed through the HDMI pipeline and how that data is formatted for transmission.

The technical key to HDMI is something called TMDS or **T**ransition **M**inimized **D**ifferential **S**ignaling. Obviously, this isn't going to become a household term in the near (or far . . .) future and we mention it here only for the sake of being complete. TMDS's advantage is that it allows very high speed data transmission over low cost "twisted pair" cables.

There are three TMDS channels in an HDMI link. Each one carries one of the color components of a video signal (red, green, or blue) along with audio data. A separate clock channel minimizes any errors long cables might introduce in the data flow.

In addition to the three TDMS channels and clock channel, there's another link called the DDC or **D**isplay **D**ata **C**hannel. This communication link reads an IC in the display device to tell the rest of the HDMI-linked system exactly what that display device is capable of. The IC is called EDID (**E**xtended **D**isplay **I**dentification **D**ata) and contains make, model and serial #, color depth, maximum resolution, audio capabilities, and the video formats the display can handle.

The technical points here have practical implications also. We'll see these further on in our explanation.

HDMI Cables

Next, we need to look at HDMI cables to see how they impact data transmission.

Physically, an HDMI cable is very different from the usual RCA-style or mini-DIN connectors we're used to.

The common HDMI flat connector (called "Type A") has 19 pins to accommodate the different data and power supply paths.

We'll soon see a smaller "Type C' connector on cameras and camcorders. (Yes, there is a "Type B" connector but it's not important in the consumer electronics world.)

To solve the frustration of having an HDMI cable fall out of an A/V component's rear panel socket, a locking Type A connector is also on the way.

Cable Length

The question of optimal cable length is difficult to address because it involves both cable quality and the signal you're transmitting. HDMI specs don't even mention distance *per se*. Instead, they specify the minimum electrical values the cable must maintain. When you consider that some HDMI cables use 28 gauge conductors while others use 26 gauge wire, and that the purity of a conductor is totally independent of the wire gauge, you begin to see how complicated this is.

Here are some general guidelines. For most high-def video signals (720p and 1080i), almost all HDMI cables are suitable for runs up to 5 meters (15 feet). Many work quite well up to 8 meters (24 feet) and some high quality cables do just fine at 10 meters (30 feet).

1080p signals, on the other hand, require better – or shorter – cables, usually 5 meters or less in length.

In an effort to make the cable length situation a bit less confusing, HDMI-authorized testing centers (ATCs) recently implemented tests that distinguish between "Category 1" and "Category 2" cables. Category 1 cables pass a 720p/1080i signal without a problem. Category 2 cables are certified with more demanding 1080p (and higher) signals. Note that this hierarchy was recently adapted and some older cable designs originally certified for "garden variety" HDMI use will pass today's more stringent Category 2 tests.

So what cable do you use for a particular application? The one that works! Again, a bit of caution – make sure you test the cable under actual conditions *with the components used in the system* before you run it behind drywall or bury it behind a rack-full of equipment.

For longer signal runs, particularly with 1080p signals, you'll probably need an active repeater device. There are two broad categories here. The first simply equalizes the signal to make up for cable losses. The second – and far more capable type – actually decodes, re-clocks, and re-encodes the signal on its way to a display device.

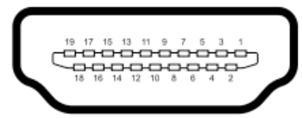
Although you might be tempted to use an inexpensive in-line passive enhancer that derives its power from the 5 volt supply carried by the HDMI cable itself, we strongly recommend that you don't. The device you finally choose should have an independent power supply that won't cause the cable-borne supply to "sag" and affect the performance of the HDMI receiver IC in the downstream component.

Finally, you need to know that the cable length suggestions we've presented here are also dependent on the quality of the HDMI transmitter and receiver ICs used in system components. Unfortunately, these crucial circuits come in different performance grades. All meet HDMI specs but some provide a more robust link than others. How do you know which is which? You don't. And most suppliers (particularly the domestic marketing arms of off-shore manufacturers) don't either.

HDMI Versions and What They Mean

With cable questions out of the way, it's time to address HDMI versions and dispel some myths that have built up in the last few years. Incidentally, the dates we've listed below indicate when the specs for a particular version were first published. Equipment conforming to that spec usually first appeared long after the spec was promulgated.

Type A HDMI connector



Pin configuration for Type A connector

Type A and Type C HDMI connectors

A Note on HDMI Cable Connectors

One of the reasons an HDMI connector is only 7/8" wide is so you can drill pass-through holes in 2x4 wall studs without violating building codes. A larger hole would weaken the stud enough to impact structural integrity.

HDMI's initial version (1.0, released in December 2002) had the following capabilities:

- 1080p digital video transmission: Yes, that's correct! Even HDMI 1.0 was perfectly capable of transmitting very high definition video information.
- Eight (8) channels of uncompressed 24-bit/192 kHz PCM digital audio data. In addition, HDMI 1.0 supports compressed bit-streams such as Dolby Digital, dts, Dolby Digital ES, and dts EX.

In May 2004, Version 1.1 appeared. It added DVD-Audio capability.

Version 1.2 arrived in August 2005 with the ability to transmit single-bit formats like Direct Stream Digital (DSD), the data structure behind SA-CD.

Four months later (December 2005), Version 1.2a eliminated remaining confusion about an optional bi-directional serial control protocol called CEC (Consumer Electronics Control). It also added the cable testing protocols mentioned above.

CEC's major benefit is simple operation. If all the components in a home theater system – even those from different manufacturers – used CEC control protocol, you could activate the entire system (turn on the DVD player, start playing a disc, turn on the A/V receiver/processor, switch the input, turn on the display device, etc.) just by pushing the DVD player's "play" control!

The latest version, 1.3, was published in June 2006. It supports much higher data rates (up to 340MHz or 10.2Gbps).

- The higher data rate allows video information even more detailed than 1080p (1449p being the most-often mentioned density). In addition, 1.3 allows something called Deep Color™, a high-bit color rendering format that provides finer gradations for more realistic visual images. Previous HDMI versions passed only 24-bit color data. 1.3's speed allows descriptions with 48-bit accuracy.
- In addition, Version 1.3's total color "space" is larger so it can convey more colors than older HDMI versions. Again, greater realism is the goal.
- Video frame rate capability is also higher.
- Lip sync, which compensates for the fact that video processing often takes longer than audio processing with the result that we sometimes hear dialog before a screen figure's mouth begins to move, is now automatic.
- Finally, Version 1.3 supports the new lossless-compression audio formats such as Dolby True HD, and dts-HD Master Audio.

Which Version Do I Need?

That's not as easy to answer as you might think. Although we're all tempted to insist on the "newest, greatest, whiz-bang," the fact is that we may not need it. A better approach than deciding by version number involves listing the capabilities we really need and making sure that the equipment we're considering supports those requirements.

If you're intrigued by the theoretically superior video capabilities of Version 1.3, for example, ask yourself if your source components and display devices are up to the task. Does your display device really handle 720p or 1080i? Are you satisfied with the image you see? Do you have any sources that produce a 1080p image? (If you don't have an HD-DVD or Blu-ray disc player, the answer is "No".) Can your display device actually handle a 1080p input? Don't be satisfied with "1080p capable" on the spec sheet either. Many of these so-called 1080p sets actually downconvert signals to 1080i or even 720p before upscaling internally to 1080p. As far as Deep Color goes, displays with this capability are in the planning stage but, as of this writing (2/07), are not yet available.

And there are similar questions on the audio side. Remember that any HDMI version handles 24-bit/192 kHz signals with ease. Will there be a discernable difference between sound quality conveyed by this high definition PCM format and a True HD data stream?

Don't read these questions as a put-down of new technology. If you think you want the most forward-looking capabilities, just be prepared to wait for components with 1.3 HDMI capability and to pay more when they arrive.

What About DVI?

DVI (**D**igital **V**ideo **I**nterface) is a precursor to HDMI. Just as newer versions of HDMI are backwards-compatible with older versions, HDMI in general is backwards compatible with DVI. Although it uses the same video transmission structure as HDMI versions 1.0 through 1.2, it sports a larger connector that is less installer-friendly. However, DVI does *not* transmit audio at all and has none of the control potential of HDMI version 1.3. A final caution: Most early DVI connections do not support HDCP and this might limit system resolution.

You can connect an HDMI-equipped source to a DVI-only display (and vice-versa) with adaptors. However, remember that you're still going to need to route audio separately.

HDCP: The 800 Pound Video Gorilla

Here's where things get *really* interesting! **HDCP** (**H**igh-bandwidth **D**igital **C**ontent **P**rotection, remember?), is the content producers' (and their lawyers') contribution to the joys of watching – or trying to watch – high-definition video sources.

You'll find Intel-developed HDCP on any device that outputs high-definition video data including upscaling DVD players, HD-capable cable and satellite STBs (**S**et-**T**op **B**oxes), and, of course, the new HD-DVD and Blu-ray disc players.

HDCP uses HDMI's DDC channel to establish a digital "handshake" between the source and downstream components (a display device or an intervening switcher like an A/V processor or receiver) to make sure they're authorized HDCP-enabled devices. After authentication, the video data is encrypted and sent downstream.

Authentication isn't a static process, however. The advanced algorithms used by HDCP change the encryption/decryption "keys" every two seconds on average to make sure all the devices in the signal path are still authorized and that an unauthorized component hasn't been suddenly substituted after the initial authorization process. If the system detects subsequent skullduggery, it either turns off the link or reduces resolution to non-hi-def levels.

HDCP comes into play only with protected content – movies, or pay-per-view programming. It is not engaged when playing DVDs through a DVD player's analog outputs at resolutions up to 480p or over-the-air broadcasts, even if those broadcasts are in hi-def.

HDCP Problems

We've had many real-world questions about HDMI/HDCP operation. Some are not easy to answer but we will give you a way of isolating the problems you may encounter.

First, some early implementations of HDMI are not compliant with the HDCP spec. This does not directly relate to the HDMI version running on your system components although the problem, naturally enough, comes into play more often with older HDMI versions than with newer. Contact the manufacturer of your system components to see if a firmware upgrade might help cure your specific interoperability issue.

Occasionally, inserting an HDMI-capable A/V processor or receiver between a previously-compatible source (DVD player or STB) and display will interfere with HDMI data transmission. Although the explanation for this problem is somewhat counter-intuitive, the problem most likely rests in the source component's failure to properly implement the HDCP "repeater" function than with the A/V processor. Again, a firmware upgrade will most likely cure the problem.

Another example: You may have two sources connected to a display – a DVD player via HDMI and an STB via a component video link. When you toggle to the STB, your picture is fine. Going back to the DVD player produces either a poor picture or no picture at all. Again, the cause is in the DVD player. It most likely does not support an HDMI mode called "authenticate forever" that makes data transmission immune to switching interruptions. The cure is a firmware upgrade from the source component's manufacturer.

What To Do

Although we haven't described all the possible problems, we've tried to focus on the most glaring issues that have come to our attention. For quick reference, the table on the next page identifies things that may interfere with your enjoyment of A/V over an HDMI/HDCP data link.

We hope this information was useful as you begin to pick your way through the HDMI/HDCP jungle and ask that you let us know if it was helpful.

Macrovision, *an older anti-copying technology, is also found in today's DVD players. However, it deals with the analog video outputs. If a player detects a Macrovision-encoded disc (and most commercial discs are now replicated with Macrovision encoding), the Macrovision circuit prevents the player from outputting an analog video signal with resolution greater than 480p. Note that Macrovision is* ***not*** *part of the HDMI spec – it's analog, remember? – as is HDCP.*

One practical implication of this strange state of affairs is that a scaling DVD player may well produce a better image via the HDMI link than via a component video link.

Symptom	Cause	Cure
Indistinct or non-existent picture, particularly with longer cable	Insufficient cable quality	• Use shorter cable • Use higher quality cable • Use repeater device with integral power supply
Same as above	Cable too long	Same as above
Same as above	Insufficient quality in HDMI transmitter/ receiver ICs for particular application	Difficult to isolate and resolve – choose different component
No high resolution video or no video at all	I have a DVI-HDMI connection in my system	• Most DVI platforms do not support HDCP. • Use a different signal path (component video, for example) • Replace the DVI component
No signal via HDMI	Adding A/V processor or receiver to system	Upgrade source component firmware (contact manufacturer for details).
No signal via HDMI	Switching inputs at processor or display device	Upgrade source component firmware to include "authenticate forever" function

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