HDMI Demystified

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What is HDMI?

High-Definition Multimedia Interface, or HDMI, is a digital audio, video and control signal format defined by 7 of the largest consumer electronics manufacturers. HDMI specifications and compliance are enforced by an organization called HDMI LLC, which is controlled by representatives from the 7 founding companies. Released on 12/9/2002, it is supported by more than 300 companies. Since the beginning, HDMI has had several advantages over previous connection solutions:

- 1080p and higher resolution capability
- Multi channel high resolution uncompressed audio
- One cable for video, audio and control
- Two-way communication for easy system control
- Automatic display and source matching for resolution, format and aspect ratio
- PC compatibility

The Evolution of HDMI

Since HDMI's inception, the capabilities have changed as updates have been made to the specification. Version numbers, such as 1.2, 1.3, and most recently 1.4 have marked these updates. The majority of the changes involve an increased number of options for manufacturers to choose from. All new versions are compatible with electronics designed to meet previous standards, but will not add features that the existing products in your system do not have. For example, a Blu Ray player with 1080p, built to version 1.3 spec will work with a 1080i television built to version 1.2 spec, but will not give you 1080p.

The newest version of HDMI, version 1.4, added many new features, including audio return channel, 4k x 2k resolution, 3D video capability, as well as support for Ethernet.

Features and Data

Electronics manufacturers must carefully choose from these features. This is because the current HDMI specification limits the amount of data any piece of electronics can send and receive to 10.2 Gbps or less (Gigabytes per second). A good way to think of this is HDMI LLC has created a buffet of options and have given you a 10.2 Gbps plate. It is all you can eat, but it must fit on this 10.2 Gbps plate. Some features take up more room on this plate than others, so the electronics manufacturers must determine what features will be most desirable for their customers.

Video Options

- Resolution: Refers to the number of pixels in both the horizontal and vertical direction per frame. Although measured in both dimensions, it is usually referred to by only one of the dimensions. For example, 1080p is 1920x1080 pixels per frame. The current highest resolution is 4k (3840x1260). Increases in resolution dramatically affect the amount of data used.

- Interlaced/Progressive Scan: Progressive scan processes the video as a series of complete images or frames, while Interlaces divides these frames into two fields, one made of the even horizontal rows of pixels and the other of the odd rows. The most common interlaced format is 1080i, which uses half of the data of 1080p.

- Color Depth: This is the amount of color information per channel / per pixel (red, green, and blue). The amount of color information determines the number of colors the product is capable of reproducing, usually described as bits per channel such as 8bit, or total bits per pixel such as 24 bit. Increases in color depth dramatically affect the amount of data used.

- Color Space: Different types of devices use different ranges of colors. Color spaces act as a map to translate these different color ranges between devices. Having multiple color spaces available allows color to be more accurately reproduced from devices such as digital cameras. Additional color space options do not affect the amount of data used.

- 3D: A 3-dimensional effect is created using two images shot by separate cameras positioned to mimic the two perspectives given by human eyes. This new feature that will send up to 1080p in a dual stream configuration for a 3D effect. As 3D effectively doubles the amount of information sent, it dramatically affects the amount of data used.

- Refresh rate: Refresh rate refers to the number of times the image on the television is updated per second. It is described in Hz (hertz) or fps (fields per second). The most common refresh rate in the United States is 60 Hz. If the refresh rate is too low you may see image flickering or motion blurring. 24Hz is the minimum refresh rate that the human eye can perceive normal paced movement without flicker. Lower refresh rates are often used to manipulate product specifications so they can achieve higher resolutions with less data (for example - 1080p at 24 Hz is the same amount of data as 1080i at 60 Hz). This is the case for the new 4k resolution format - 4k and a higher refresh rate would exceed the 10.2 Gbps capacity. Refresh rates of 120 and even higher are possible, but currently they are done in the television and not in the source device, so they have no impact on the data used.

Audio Options

- Audio formats: Options range from PCM, Dolby Digital, and DTS which are standard, to newer formats such as Dolby TrueHD & DTS-HD Master that offer uncompressed digital surround. Audio formats have a minor impact on the data used.

- Lip sync: Synchronizes audio/video compensating for signal processing delays. There is no impact on the data used.

- Audio Return Channel: This is a new feature that allows a single HDMI cable, connected to a receiver, to not only send video from the receiver to the TV, but to also send audio from the TV back to the receiver. There is no impact on data used.

Additional Features

- Ethernet: A new feature that will allow enabled equipment to share a bi-directional 100 mbps Ethernet connection through the HDMI cable, as long as one piece in the system is connected to the Internet. This is the rare feature that requires a cable specified for Ethernet. The optional Ethernet feature does not impact the amount of data used.

- Control: Consumer Electronic Control (CEC) allows electronics to control one another without additional hardware or add-on control systems. Controls are somewhat limited, but often enable the customer to reduce the number of remotes needed. CEC does not impact the data used.

HDMI Cables:

All HDMI cables are made up of 19 individual wires. Many of these wires perform multiple tasks and transmit large amounts of data, so the quality of the conductors, precision of the geometry, and the quality of the termination all affect the ability for the cable to properly implement its tasks.

For the most part, unlike HDMI enabled components, HDMI cables do not have features, but they have capacity (often described as “speed” and measured in Gbps). The one exception to this is the new Ethernet feature, which requires a special cable. Other than this exception, the cable does not care what the resolution, color depth, or refresh rate of the

signal is, as long as the data that makes up the signal is not too large for the cable to pass. HDMI LLC has approved 2 different categories of cable.

High Speed: meets the maximum current data rate for HDMI of 10.2 Gbps. Nearly all short length cables meet or exceed this category. Very high quality cables will meet this standard on moderate lengths up to about 8m. Although great strides are being made in cable technology, long lengths such as 15 and 20m are not capable of high speed.

Standard Speed: meets the minimum HD data rate of a little over 2 Gbps, the amount needed to do 1080i or 720p. Many standard speed cables are capable of higher data rates that allow for features such as 1080p (which requires about 4 Gbps), but do not have the capacity to achieve the High Speed rating. Even the best long length HDMI cables are limited to a Standard Speed rating.

Since the ability for an HDMI cable to pass Ethernet requires a slightly different internal structure to the wire, HDMI has added two additional cable types. These are High Speed with Ethernet and Standard Speed with Ethernet.

To recap, there are four cable types approved for home use by HDMI LLC:

1. Standard Speed
2. High Speed
3. Standard Speed with Ethernet
4. High Speed with Ethernet

Other speed rating systems are on the market, but are not approved by HDMI LLC and are primarily for marketing purposes. Only the four cable types listed above are certified by HDMI LLC. Also be wary of cable manufacturers that tout incredibly high data rates on very long length cables. These manufacturers are usually labeling long length cables based on results found on testing shorter versions of the cable.

Cable Length, Data Rate, and the Cliff Effect:

In earlier sections, length is often mentioned as a concern for HDMI cables. The reason for this is that HDMI cables function differently than analog cables, like component video. When a component video cable is run longer, it will pick up noise and lose signal along the way in a very linear fashion. It is unrelated to the amount of signal being sent, and will result in visible noise and loss of detail and brightness. A better component video cable will lessen this effect and give you better performance by reducing the amount of distortion in the cable and shieldingthe signal from outside noise.

HDMI cables are transmitting pieces of digital data along twisted pairs of wire. While there is still noise and loss, as long as enough of the signal gets to the television, error correction inside the TV will fill in the missing pieces and give you a good clean picture that is difficult to distinguish from a picture with fewer errors. If loss is too great, the image will appear to “sparkle” or you will lose picture completely. This is called the cliff effect.

The primary factors that affect any given quality level of cable’s ability to provide a picture, is the amount of data being sent, and the length of the cable. Higher data rates in effect “strain” the capacity of the cable and reduce the effective length. A cable that may be capable of passing 1080i at 30m, may not be able to pass 1080p until it is as short as 15m, and will not be able to pass some of the upcoming formats like deep color or 4k unless it is much shorter.

The Premium Cable Argument:

More than any other cable category, premium HDMI cables are maligned for being “not worth it”. This is mostly due to a fundamental misunderstanding of how digital works as well as oversight of all the functions an HDMI cable is tasked

with. That said, there is an element of truth to what they say. Two short length (let's say 2m) cables of different qualities connected to identical systems will often be difficult to distinguish a difference in picture quality. This is because the error rate is very low on a short length cables and the television can easily correct for errors. Sharp eyes may see some differences in brightness, or errors when a lot of motion is present. These video differences can be more pronounced as lengths increase, but are rarely as clear as night and day. Premium cables are capable of reliably going longer distances at higher data rates. Because of this, most of the grumbling and pushback from naysayers is in regards to shorter cables.

It should be said though, that errors do still exist on shorter cables and error correction is never ideal. A premium cable even at short lengths will result in less error correction and a measurably better signal, even if the human eye is easily fooled.

While the human eye is easily fooled, the human ear is far more accurate. Think of this…if you are trying to really hear something, what is the first thing you do? Close your eyes! This is because vision can be so deceptive. Don't forget that HDMI is not just a video cable, but is also an audio cable. It is THE audio cable for our most sophisticated consumer level surround formats, but audio is rarely mentioned, leaving all of the focus on video. For many reasons, audio is far more complicated to reproduce, and error correction is rarely proven effective. This is partly due to the more freeform nature of audio verses video, as well as the ear's sensitivity to timing errors (also known as jitter in the digital world). The audio differences in cables can be heard even on the shortest lengths, and improvements in the cable materials make a marked difference in the sound quality from all HDMI enabled devices.

The AudioQuest Difference:

You may recall from previous modules, the Four Elements, the fundamental design elements in all AudioQuest cables. Given the complexity of HDMI, one can imagine that the Four Elements are integral to the design. Here is a refresher on these design elements and how they relate to AudioQuest HDMI cables

Solid Core: Unlike most HDMI cables on the market, all AudioQuest HDMI cables use only solid core conductors. This allows for reduced distortion (jitter in the digital world), which means lower error rates. In our testing, solid core conductors greatly improve the audio performance of the HDMI system, even when it is just a cable box and TV!

Metals: Great attention is paid to the quality of metals used in AudioQuest HDMI cables. The same quality LGC (Long-Grain Copper) used in our analog cables is used as our base metal, with increased amounts of silver plating added as the models improve. AudioQuest has even introduced a PSS (Perfect-Surface Silver) HDMI cable, called Diamond. Quality metals make large improvements in audio performance.

Geometry: Consistent reliable performance from an HDMI cable, particularly a long one, is reliant on very precise geometry with tight tolerances. This is why AudioQuest HDMI cables are constructed using the best precision twist machines available.

Dielectric: In HDMI cables, the proper dielectric can not only reduce jitter, but can also provide additional structure to help maintain the correct geometry. AudioQuest uses solid Polyethylene in all HDMI cables to ensure the geometry maintains its integrity.

Other technologies beyond the four elements:

Directionality: All audio cables are directional, including HDMI. Directionality is determined through careful listening. Arrows are clearly marked on the plugs to ensure you get the best sound quality.

Terminations: All AudioQuest HDMI cables are terminated using a wave solder machine, an automated process that allows for the greatest control of conductor placement, solder flow and temperature. This not only ensures reliable connection, but also further reduces signal loss and distortion.

AudioQuest High Speed with Ethernet:

All HDMI cables currently made by AudioQuest are High Speed with Ethernet up to and including 8m, regardless of price level. From 8m to 20m, AudioQuest HDMI cables are Standard Speed with Ethernet. Every cable is tested to ensure that it passes 1080p on a Bit Error Rate (BER) machine. 100% QC is unheard if in the cable industry, but AudioQuest feels that HDMI is complicated enough without having to worry about defective cables.

Troubleshooting HDMI Cables:

Despite rigorous QC, issues can arise in HDMI systems. It is rarely a defective cable, but it can sometimes seem that way. There is a lot going on in an system configured with HDMI and that means troubleshooting an issue may not be as simple as it is with analog cables. Not only does the video and audio need to be transmitted, but also data and copy protection (HDCP). These issues can be broken down into a couple of categories as they relate to cables.

Cliff Effect: Cliff effect typically affects only long length cables. If all the gear in the system is set up properly and capable of the desired resolution, but you are not getting a

picture or the image appears to “sparkle”, it is most likely cliff effect. You can test this by lowering the resolution on the source and seeing if the picture appears. You can have this problem even if a cable is rated to be capable of a certain resolution. Physical damage to the cable, low or noisy signal output from the source, or TV sensitivities can affect the ability for the signal work properly. The best solution is to go with the highest quality cable at the shortest length possible for the system. If incredibly long lengths are required, there are solutions on the market commonly called electronic extenders that send the signal over CAT5 or CAT6, or fiber. These solutions have a varying degree of success and cost.

Data and HDCP: While both Data and HDCP signals are weakened over distance, Data and HDCP issues can be a problem even in systems using short cables. A single wire inside the HDMI cable is used for two way communications, such as HDCP, format and resolution synchronization. Much like two-way traffic on a single lane road, the timing of the data transmissions is very important. Small variations in transmission voltages in the electronics, combined with variations in wire properties like capacitance, can result in poor timing and data crashes. While no particular product in the system is defective (for example you can put the HDMI cable on a different system and it works fine), the system as a whole fails. The solution is often to change the system slightly by using a different model HDMI cable, a different source or TV, or even adding a device into the system like an HDMI splitter.

In Conclusion:

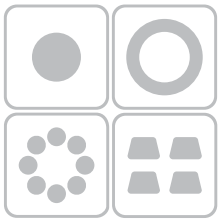
HDMI is the most advanced connection method available today, but its complexity can often be intimidating. Hopefully, this educational module answered some questions. AudioQuest believes the best marketing is an informed and inspired consumer, and that begins with you!

Take Aways:

1. HDMI is a 19 conductor cable that transmits High Definition audio, video, control, and now Ethernet.

2. AudioQuest HDMI cables are designed to maximize the audio and video experience through the best materials, design, and testing.

3. All AudioQuest HDMI cables up to and including 8 meters are rated High-Speed with Ethernet, the highest rating possible.



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