A Guide To HDMI Digital Video Connectivity

Joseph D. Cornwall, CTS-D, CTS-I

Technology Evangelist, Legrand N.A.

There are as many ways to connect AV devices as there are imaginations involved in the AV industry. We often think of DVI-D, HDMI and HDBaseT as mutually exclusive choices, but the truth is that all those connectivity solutions are transporting essentially identical content. Picking the right solution from the industry's menu of possible connections is challenging. Arriving at the right choice is a result of defining parameters surrounding a digital video link and then a solution that satisfies both current needs and future scalability. Instead of thinking about resolution and length, we should be analyzing connectivity choice in terms of meeting image-data payload demands, selecting physical connections that anticipate future compatibility and meet user expectations for convenience and ruggedness. Specifying those solutions while meeting budget limitations and bridging to legacy infrastructure is an issue in practical applied technology. In this article we will look at several digital video connectivity solutions and provide guidance on when and why you should select each.

Let's start our exploration with an overview of a few technical items, which may help narrow your search. Before beginning any project, you should understand your need for scalability and future compatibility with new devices. This analysis should include a survey of the possible source devices that will be attached to the system, their aspect ratio and potential image payload.

4K and color space

4K is A/V "shorthand" for video content that offers approximately an 8-million-pixel image and has the proper name UltraHD (UHDTV or UHD). Your current home HDTV is most likely a 1080p HDTV 16:9 display. This means that it delivers a picture by painting 1080 horizontal lines of picture elements (pixels) with each line under the previous, much like the text in this article. Each line consists of 1920 pixels presented side-by-side, like the letters of this sentence. Displays that use this format deliver 1080 lines of 1920 discrete pixels for a total of 2,073,600 pixels. You could correctly call this a "2K" display for its (approximate) 2,000 horizontal pixels, or you might think of this as a 2-megapixel image for its (approximate) 2-million-pixel total.

4K displays and content feature twice as much information along each axis, for a total of four times the total payload. A typical 4K LCD display delivers a picture by lighting 2160 (1080 x 2) horizontal lines of pixels. Each line consists of 3840 (1920 x 2) discrete pixels for a total of 8,294,400 pixels. The 4K moniker comes from the nearly 4,000 horizontal pixel count. As above, you might think of this as an 8-megapixel image for its 8-million-pixel total. Another way to look at this is to say that a 4K content requires four times the image payload of an otherwise identical a 2K image.

Note: there is another 4K "system" that uses 2160 scanning lines of 4096 pixels each. Naturally it is also called "4K." This format is primarily used in broadcast and content production and is quite specialized. There is no distinction made as regards the content of this article and both systems can be considered essentially interchangeable for connectivity purposes.

There is one more thing you need to know about digital video images and 4K before you can make a connectivity decision. Not all video content is the same. You must incorporate "color space" in your thinking to fully appreciate potential system payload demands. While the mathematical model of representing colors is challenging to understand, its effect is pretty easy to quantify.

Most video content uses a form of compression, known as chroma decimation or chroma subsampling, where-in an image displays significantly less color information than grayscale detail information. This is done to make the video signal smaller and easier to transport. Chroma subsampling has been in use since the very first color TV's in the 1950's for both analog and digital content.

Chroma decimation delivers about half as much information in color (chroma) content as it does black-and-white (luma or luminance) content. There is no real perceptual penalty to this technique because our vision can only perceive about half as much "color" detail as "B&W" detail in everything we see. This is a physiological limitation. You can identify chroma subsampled content by noting its color space specification, which is written as a ratio. The most common ratios you will see are 4:2:0, 4:4:4 and sometimes 4:2:2.

Computers graphics cards natively treat the RGB elements of the picture content equally. Therefore, most computer-originated content doesn't use chroma subsampling (in other words, it uses a 4:4:4 color space) and therefore has a much higher data payload than broadcast or Blu-ray content (which uses a 4:2:0 color space). A good example is thinking about high-definition video you recorded on your digital SLR camera and comparing it to the streaming video you might watch on Netflix. Both content payloads may be identified as 1080p, but the SLR camera image payload may require twice the bandwidth of the Netflix image or more!

Another way to understand this data payload comparison is this simple arithmetical trick. 4+2+0=6. 4+2+2=8. 4+4+4=12. 4+4+4+4 (for 4:4:4:4, sometimes called a 32-bit image) =16. A 4:2:0 color space (6) is half as big as a full RGB color space of 4:4:4 (12) and just under 40% the payload of content with an RGB signal using a transparency channel 4:4:4:4 (16).

HDMI interconnects rated as "High Speed" will support UltraHD 4K images delivered in a 4:2:0 color space, which technically has about the same data payload as 2K images in 4:4:4 color space. To support 4:4:4 full bandwidth UltraHD 4K signals, your installation will need an advanced connectivity solution. This is why it's so important to invest your effort in a comprehensive survey of the content and source devices you want to support, both now and over the course of the systems installed lifetime.

HDMI(e)

When selecting the right connectivity solution for your project you often run into the need to extend network connectivity to connected AV devices as well as the uncompressed digital video payload. HDMI standards anticipated this and define a category of connections to address the problem. You can deploy a special HDMI cable that offers Ethernet extension or an audio return channel. Both of these features are handled via a single conductor within the HDMI cable assembly, so you can support one or the other but not both simultaneously. HDMI(e) allows 100Mbps Fast Ethernet to piggyback on the digital video interconnect on devices designed to support this feature. The connection that supports both features is the same and there is no performance penalty for selecting a cable with HDMI(e) capability over one

that doesn't offer this feature. There is seldom a significant difference in cost. It's good practice to select an HDMI(e) enabled interconnect whenever possible.

Mini and micro HDMI connectors

In the past, some computers and other devices designed to a small form factor offered a mini-HDMI connector. These are about half the size of a standard HDMI connection. Additionally, some cell phones even used a micro-HDMI connector. Both of these formats have diminished in popularity, and they will likely be used less and less as the industry advances and new connectivity topologies take hold. There is nothing special about these smaller HDMI connectors other than the size. You can purchase mini-HDMI and micro-HDMI to standard HDMI connector cables, or use an adapter on any standard cable.

Economy interconnects

Commodity level lines of HDMI cables may be "high-speed" rated, particularly in shorter lengths below 15-feet. This category of performance is acceptable for simple source-to-display connectivity in non-critical home video and desktop applications. An HDMI LLC high-speed rating suggests these cables can support UHDTV 2160p in a 4:2:0 color space at low refresh rates, but are likely not "intended" for such demanding applications. Typically sporting a very small wire gauge (30AWG or smaller), it's definitely worth demanding a tested brand from an HDMI standards adopter to ensure product performance matches marketing claims.

High quality interconnects

A performance-optimized quality interconnect for commercial applications will display a UL CL2 rating for low-voltage in-wall deployment. A dependable, quality HDMI cable will support UltraHD 4:2:0 and will be HDMI high-speed rated and tested. Very few cables rated as "high speed" can actually deliver that performance at lengths over 25 feet. Look for interconnects that use a minimum 24AWG signal conductor to ensure performance at longer lengths.

Super flexible interconnects

Thin, flexible cables can be ideal for short distance temporary patches, short runs to table-top monitors and even component-to-component patching in an equipment rack. Often high-speed rated and capable of supporting UltraHD content in a 4:2:0 color space, a quality super flexible interconnect should also feature HDMI(e) capability for Ethernet or Audio Return Channel applications. When using super flexible HDMI patch cables it's important to understand bus power demands in the installation to prevent hardware handshake problems. Exercise caution if bus-powered signal sensitive selector switches or extenders are included in the link path.

Plenum HDMI interconnects

A plenum space is any enclosed space in a buildings used for airflow. Some wires can be run in a plenum space if they are properly rated in accordance with applicable electrical codes. The materials used in cables to be placed in plenum spaces are designed to meet rigorous fire safety test standards in accordance with NFPA 262 and outlined in NFPA 9. Many HDMI plenum-rated interconnects are standard speed rated and not intended to support UltraHD or 4K content, but some products at the premium end of the product spectrum may have a high speed rating. Plenum HDMI interconnects are often specified for use in projects in schools and public buildings.

HDMI cables with gripping connectors

Although the weight of an interconnect or patch cord should never be supported by the connector alone, there are times when the additional security of a "locking" connector comes in handy. Designs are available with proprietary locking, or gripping, connectors. The two are not the same. A gripping connector delivers about 3 times greater grip between the plug and the jack, but will disconnect if yanked. Keep in mind that if you trip over a "locked" connector its really easy to pull the jack out of the device and do permanent (and expensive!) damage. A gripping connector is a better choice as it prevents slippage while still allowing connector release in the event of a catastrophic jerk!

Digital video over Coax

Sometimes there is already wire in a building that's in good shape and can be repurposed during a retrofit renovation. Most boardrooms, educational facilities and houses of worship were wired a decade or more ago using quality RG6 quad-shield coaxial cable. Quite often there are five of them and they were used for RGBHV analog video connectivity. Wouldn't it be great if you could just run an HDMI signal over those wires that are already in place? You can.

HDMI and DVI-D solutions (and even some DisplayPort) devices that enable the distribution of uncompressed digital content to as many sixteen displays over a single coaxial cable are readily available. HDMI-over-coax solutions may be an ideal choice for a small scale digital signage system or an easy upgrade during a system renovation. Rarely designed to support UltraHD 4K or 3D video content, adapting HDMI to existing coaxial cable works well with standard high definition content from just about any device you can imagine, including workstations and laptop computers at distances up to 300-feet and more.

HDMI over Cat5

When an installation is taking place in commercial space we may decide to leverage the category cables that are typically associated with local area networks (LANs). In this scenario we use the same kind of twisted-pair (also known as a "category" cable) to carry digital video as would be used to connect a network switch to a device like a desktop workstation. Using Cat cables makes installing the system easier, and sometimes more cost effective, by leveraging the scale of economy associated with purchasing and installing large quantities of wire. Since tens of thousands of feet of Cat cable may be installed in a school, office building, or house of worship it's often less expensive and more efficient to pull more category cable for the A/V system, too. As with all things associated with digital video, there's more than one way to get from here to there. In fact, there are at least three.

IPTV is a method of encrypting video content into a format that can then be streamed over the actual network including wireless access points. There are significant benefits to using an IPTV design, such as freedom to access content anywhere in the network (and even beyond) and the number of end-points in the design can be very high. At the extreme end, this is how you enjoy YouTube videos – streaming video. But there is a corresponding downside – IPTV is resource intensive and can add a tremendous burden to the LAN. Most schools and universities, business and churches my find that their LAN simply can't support the additional payload. In the context of a new project, however, allowances can be made for a virtual LAN (VLAN) to support A/V connectivity.

Short range HDMI over Cat5 extenders don't leverage the LAN, but work by amplifying and equalizing the signal so it can move through the UTP category cable directly from source to sink. This simple technology is similar to the HDMI-over-coax solution above in that it provides a cost-effective method of delivering standard HD 1080p content up to 160 feet (50 meters) over a cabling infrastructure that is probably already there, or is being run during the project to support other systems.

The challenge with an HDMI extender that relies on equalization and amplification is that its effective length can change with varying content. For example, a device might support 1080p content up to 65 feet over Cat5e, or 130 feet over Cat6. That same device might support lower resolution content such as 720p even farther, as the carriage distance of this type of solution is inversely proportional to the size of the digital video payload. Understanding and living within the limitations of this type of technology demands a very good survey of system sources, sinks and anticipated evolution.

Short range extenders are less expensive than HDBaseT or IPTV solutions. The cost savings might make up for a slightly less-than-predictable performance in some installations where the content is well defined and the video payload is limited.

HDBaseT is the new IEEE 1911™ standard that enables the optimized delivery of uncompressed, UltraHD digital media. HDBaseT features its powerful 5Play™ feature set, including transport of ultra-high-definition digital video & audio, 100BaseT Ethernet, USB 2.0, up to 100W of Power (through POH, similar to 4-pair POE) and control signals all through a single 100m/328ft Cat6 cable. Generally speaking, most HDBaseT solutions don't support the uppermost level of 4:4:4:4 RGB 2160p 4K content (read 32 bit video). Like high speed rated HDMI cables, HDBaseT is best for 4:2:0 content.

HDBaseT doesn't travel over the LAN. Although it uses an Ethernet jack (RJ-45) and category cable, HDBaseT is based on a different protocol that standard Ethernet equipment can't work with.

HDBaseT solutions are also available in an **HDBaseT Lite** for projects that aren't limited by the Lite version's 50-meter length limitation or constrained feature set consisting of audio, HD video, and embedded control signals. Naturally the HDBaseT Lite solutions also come with a lighter price tag, all the better to fit into that stretched budget!

The one thing that should be considered for any HDBaseT installation is the use of a shielded or equivalent non-continuous shielded Cat6 or Cat6a cable. HDBaseT is very unforgiving of alien crosstalk distortions, so the signal must be very well protected from environmental RFI and EMI.

Active HDMI interconnects

It's been said by a number of industry experts that active cabling is the future of A/V electronics. In particular, if we want to limit the physical size, thickness, weight and stiffness of cables then we need to employ the power of a chipset. A silicon chip, powered by the source or sink devices themselves, can do a lot to limit attenuation, crosstalk and group velocity distortions that limit the effective length and physical size of passive copper links. In this way we can run a longer link over a lighter cable that might only support a run of a few meters in a passive application. The benefit of embedding chip technology in cables is the reduction of expensive copper used in production, reduced overall form factor, longer reach and lower power consumption than active solutions like HDBaseT.

Available in lengths up to 100feet, active HDMI cables are often CL3-rated for in-wall installation and will support content payloads up to 1080p, including 3D video. Active HDMI cables are a good choice when you need to get a longer run, but there isn't much room for big, thick cables in the cabinet or through the conduit. Active cables also mean that you can avoid having a physical device at each end, as would be the case with HDMI-over-Cat or HDMI-over-Coax solutions. Attention must be paid to bus power demands when deploying active cables or active optical cables, however.

Active Optical HDMI interconnects are a variation on the theme above. In this case, the actual digital video payload is converted from electrons to photons and sent over a set of fiber optic links, thereby delivering the very best performance. Often active optical HDMI cables are plenum rated for use where the standard copper active HDMI cable can't go. Like active copper cables, active optical HDMI cables are often rated to support 4:2:0 UltraHD resolution, including 3D and deep color payloads but not 4:4:4 32 bit payloads. This is a limitation of the chip set used in the cable.

RapidRun Optical Cables

This changes everything. RapidRun Optical isn't just using fiber optics to transport the signal. It's using VCSEL lasers to provide the absolute highest performance connectivity in the industry. Unlike an active optical HDMI cable, RapidRun Optical doesn't use a hybrid interconnect assembly. There is no copper between the source and the sink. This means perfect isolation, perfect immunity from RFI and EMI and perfect performance to the very limits of 4:4:4:4 32-bit RGB UltraHD video at lengths to an astounding 1,000 feet (330 meters)!

RapidRun Optical is a Plenum-rated solution that can support not only HDMI, but DisplayPort or DVI-D too. Its six channels of clear glass can deliver upwards of 20 Gbps of thru-put *per channel*, making this one of the most powerful point-to-point video connections on the market. Select RapidRun Optical when you need the best performance and the best scalability the industry has to offer!