An Overview of Consumer Electronics Connectivity

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"For a list of all the ways technology has failed to improve the quality of life, please press three."
-- Alice Kahn

This quote is certainly applicable to consumer electronics. From the very first commercially produced radios to the latest in high-definition television technology, the manner in which the components used to deliver our news, music, movies and entertainment are interconnected seems to have escaped logic. For both the newcomer and the old hand alike, connecting equipment in the most efficient and effective manner can be a painful chore. It is hoped this article will improve your background knowledge concerning potential A/V system connection schemes and where each is most appropriate. The next time you find yourself in a "connectivity quandary" perhaps the ideas shared here will help you to quickly solve the riddle of which wire goes where and why!

HDMI™

HDMI (High Definition Multimedia Interface) is a trademark of HDMI Licensing LLC. Developed by Sony, Hitachi, Thomson (RCA), Philips, Matsushita (Panasonic), Toshiba and Silicon Image, HDMI was created as a digital interface standard for the consumer electronics market.

The HDMI protocol combines high-definition video, multi-channel audio, and inter-component control in a single digital interface. This lone interconnect has the ability to transmit uncompressed digital video and up to eight channels of audio from source to display. Even more, the HDMI connection enables audio/video components to share data and commands, thus unifying an oft-disjointed collection of "boxes" into a real, working system. Based on Silicon Image's TMDS® technology, HDMI is also fully compatible with PCs and display devices incorporating the Digital Visual Interface (DVI) standard.

For all of its amazing ability, the HDMI connector is surprisingly compact and robust. Based on copper cables (as opposed to optical fibers), HDMI makes few demands as to cable length and bend radius. Runs to 50 feet or more are easily accommodated. HDMI may well be the perfect way to transmit high definition images to a ceiling mounted projector or from multiple source components to a single control processor. HDMI is rapidly finding its way into many upscale home cinema products.

DVI™

DVI (Digital Video Interface) is a trademark of the Digital Display Working Group, an amalgam of corporations headed by Intel and including such powerhouses as Compaq, Fujitsu, Hewlett Packard, IBM, NEC and Silicon Image. The DVI connection was designed as a replacement for the P&D (Plug and Display) standard, itself an upgrade from the digital-only DFP format. Designed primarily to connect a computer to an LCD flat panel monitor, DVI has found applications in advanced consumer electronics image devices where it is used to deliver digital video from a source to a display. One drawback for DVI, that is not a major concern with HDMI, is the length of the connection. DVI is limited to about 20 feet. Beyond this length signal degradation quickly becomes evident.

There are three types of DVI connections: DVI-A, DVI-D, and DVI-I. Let's look at each in turn.

DVI-A

 The "A" in DVI-A stands for analog. DVI-A carries a DVI signal to an analog display such as a traditional computer CRT. DVI-A is seldom, if ever, encountered in the home theater realm. In the words of the immortal Forest Gump, "one less thing…"

DVI-D

 Digital video at last! DVI-D transfers uncompressed digital video in its native format between source and display or between components. DVD-D precludes the typical digital-to-analog/analog-to-digital conversions between a computer's video card and monitor and provides a higher quality and faster (wider bandwidth) interface. DVI-D is the interface used on the equipment of interest to the majority of readers of this site. Fortunately, DVI-D and the next iteration have much in common.

DVI-I

 Combine DVI-D and DVI-A on the same cable and you get DVI-I. "I" stands for "integrated". Please note, DVI-I does not convert a DVI-D to a DVI-A, nor does it work vice versa. It simply enables all 29 pins to conduct so the *interconnect* is dual use. It wouldn't be uncommon for a manufacturer to use a DVI-I connector, as this receptacle will allow for the use of both DVI-I and DVI-D cables even if the analog transmission ability is never accessed.

DVI Single Link or DVI Dual Link?

DVI uses a digital information format called Transition Minimized Differential Signaling (TMDS). Single link cables use one TMDS transmitter, while dual link cables use two. A single link DVI connection can support a 1920 x 1080 image at 60fps. A dual link connection supports up to a 2048 x 1536 image.

The digital interface uses 24 of the possible 29 pins found on a DVI-I interconnect. A single link DVI cable would enable 12 of those 24 digital pins. A dual link configuration enables all 24. For audio/video applications a single link interconnect is the correct choice. The dual link configuration, while not improving performance on a single link system, will not hinder performance and is interchangeable in that application.

IEEE 1394 (Firewire)

The IEEE 1394 interface is a true digital connection. It is much used on consumer a/v components, especially in computer applications. Known as i.LINK or Firewire, this connection has a typical data transfer rate of about 400 M bps; which is shy of the requirements demanded by progressive-scan high-definition video formats. Improved Firewire interface standards have increased this data transfer rate to a very fast 800 M bps. Almost all consumer Firewire video applications utilize an MPEG-2 compression algorithm. It is important to note that all high-definition display products do not necessarily have MPEG-2 decoders. Components featuring 8VSB terrestrial digital tuners universally incorporate MPEG-2, but this functionality is seldom incorporated into a projector or display device per se. Because of this, the use of the Firewire interface may be somewhat limited in the video domain to digital camcorders,

digital video recorders and other “creative use” audio/video components. Firewire is also used as a digital multi-channel audio interface for DVD and other digital audio sources.

RGBHV

The workhorse of commercial video production, this is analog video transmission at its finest. There are almost no limits to the practical installed length of an RGB interconnect. 100 feet is a wholly useable length! You’ve got to love analog for its robust nature.

There are two variations of Red/Green/Blue/Sync of which one should be aware:

RGBHV

A five-wire format using 75-ohm coaxial cable (often in the form of a “snake”), RGBHV sends the three primary color components on three of the conductors and sends a horizontal and a vertical negative TTL (transistor-to-transistor logic) sync signal on the remaining two conductors – hence the Red, Green, Blue, Horizontal and Vertical which make up the RGBHV moniker.

RGBS

A commercial-only format that is seldom seen in a crossover consumer product, RGBS is a four-wire variation of RGBHV. In this iteration, the three primary color components are sent as above on three conductors while the horizontal and vertical sync components are transmitted in a composite manner on the fourth conductor.

A great installation tip to keep in mind: when selecting your primary display interconnects always use an RGBHV snake or similar 75-ohm five-interconnect composite cable. With this infrastructure in place you can use three of the five conductors for component interface and the two remaining conductors make for a dandy s-video interface!

EIA 770.3 (YPbPr Component)

The component interface is the most common extended definition video interface in use on contemporary consumer products. Component connections send one luminance and two phase-opposite chrominance signals on three 75-ohm coaxial cables. Wholly analog, the 770.3 component interface boasts the same robust nature as RGBHV above. Regardless of other connection schemes, this is one you have to include if you want your system to be truly universal in nature.

S-Video

Super Video is an interface protocol first introduced by JVC with the very first S-VHS video decks about 18 to 20 years ago. S-Video sends an analog video signal on two 75-ohm coaxial cables. One conductor delivers a luminance signal, which is a black and white wide-bandwidth television signal. The other delivers a chrominance (color) signal which would normally be a composite signal riding “under” the luminance information at a frequency below the 3.58MHz ‘color burst’ frequency.

Many sources transmit a video signal using this two-part interface. Contrary to common belief, S-Video does not improve resolution. That is a function of the bandwidth of the connection, a commonly accepted “rule of thumb” being that you get approximately 90 lines of resolution for

each MHz of bandwidth. S-Video does, however, greatly improve *color* resolution allowing for a tighter and more refined image.

Composite Video

Granddaddy of all video connections, this simple single coax connection can be made via BNC or RCA connector. The RCA plug, as discussed elsewhere on the Audioholics web site, is not, by its very nature, a 75-ohm design. This little detail hasn't stopped it from becoming as ubiquitous as a dust-bunny and only slight more expensive. Older video formats such as analog C-Band satellite, laser disc, and VHS or Beta should be connected using a composite interface for maximum performance. It is HIGHLY likely that the comb filter function implemented in a modern performance-oriented projector or monitor is vastly better than any comb filter added to one of these video devices in order to provide an S-Video output.

AES EBU Digital Audio

AES/EBU (Audio Engineering Society/European Broadcasting Union) is a professional, balanced, digital audio transfer standard. This connection is found almost exclusively on esoteric high-end compact disc transports or professional digital recording components.

The AES/EBU digital interface is typically implemented using 3-pin XLR connectors. One cable carries both left- and right-channel audio data to the receiving device. AES/EBU is an alternative to the SPDIF standard.

SPDIF

SPDIF is an acronym for Sony Philips Digital Interface and is a CD "Red Book" standard digital audio transfer file format. A SPDIF interface can transport either stereo left-and-right channel information or multi-channel sound. It is typically found on audio and a/v equipment such as CD transports, Laser Disc players, DVD players, some digital satellite products and computer sound cards where it is implemented using an RCA connector. A SPDIF interface is a 75-ohm connection, identical to composite video in specification. Years ago many audiophiles felt that SPDIF offered better sound than the TOSLINK interface discussed below. Improvements in TOSLINK conductors have closed this performance gap and made concern over the interface a moot point.

TOSLINK

Short for Toshiba Link, TOSLINK is also a CD "Red Book" standard that allows for digital audio (both left and right channels or multi-channel sound) to be transported between components using an optical conductor and light as the carrier. Contrary to popular belief, TOSLINK does not use laser light but instead relies on the output of a simple LED. The Achilles heel of TOSLINK is the optical quality of the interface. The plastic conductors used in cheap cables can damage data and compromise performance.

TOSLINK connection performance is somewhat limited by the bend radius (bending a light conductor causes internal reflections and signal loss) of the conductor design. Additionally, the TOSLINK interface is length sensitive with maximum performance available only with runs of less than 20 feet.

XLR Audio Connections

Audio gear destined for the performance stage or recording studio almost always utilizes a three-pin XLR connector. This is because true pro-audio gear almost always utilizes a "balanced"

circuit. While an in-depth dissertation on balanced audio technology is beyond the scope of this article, suffice it to say that when properly implemented a balanced topology can render a piece of gear and its attendant interconnect infrastructure almost impervious to environmentally sourced noise. A balanced connection consists of two phase-opposite signals on discrete conductors and a third conductor that provides a ground reference. Noise (such as induced hum) will appear equally – but out of phase - on both conductors where it can then be easily cancelled. In essence this is the same technique used in the noise-canceling headphones so popular amongst frequent fliers!

Single-Ended (RCA) Audio Connections

There are those among us who refer to this as an "unbalanced" connection. For the sake of precision, we shall refer to this audio (and video or data) topology by its proper appellation. A single-ended audio interconnect, in this sense, is the traditional RCA- terminated cable with which we are all so familiar. The single-ended interconnect is also a primary source of snake oil - a topic of much interest to Audioholics readers! Simply put, a single ended connection is one where a signal is carried on one conductor and the ground reference is carried on another. Single ended interconnects are variously composed of coaxial, unshielded twisted pair (UTP), or shielded twisted pair topology.

Hopefully this article has provided you with a better understanding of the various acronyms used to describe the myriad ways audio and video components are connected. Familiarity with the options available on contemporary components will allow you to make an informed decision and, when all is said and done, end up with a home theater or music system that provides the level of performance and convenience you envisioned.