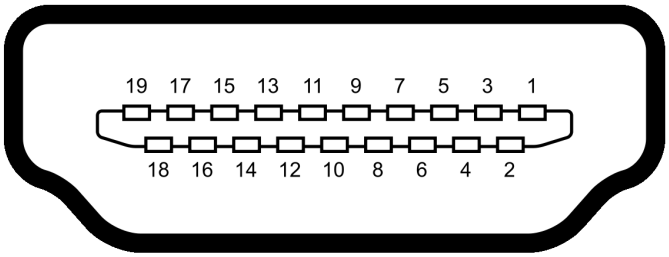
HDMI

HDMI (High-Definition Multimedia Interface)

HDMI official logo and standard connector

Type	Digital audio/video/data connector
Production history	
Designer	HDMI Founders (seven companies)
Designed	December 2002
Manufacturer	HDMI Adopters (over 1,100 companies)
Produced	2003–present
General specifications	
Width	Type A (13.9 mm), Type C (10.42 mm)
Height	Type A (4.45 mm), Type C (2.42 mm)
Hot pluggable	Yes
External	Yes
Audio signal	LPCM, Dolby Digital, DTS, DVD-Audio, Super Audio CD, Dolby Digital Plus, Dolby TrueHD, DTS-HD High Resolution Audio, DTS-HD Master Audio, MPCM, DSD, DST
Video signal	Maximum resolution limited by available bandwidth
Pins	19
Data	
Data signal	Yes
Bitrate	10.2 Gbit/s (340 MHz)
Protocol	TMDS
Pin out	



Type A receptacle HDMI

Pin 1	TMDS Data2+		
Pin 2	TMDS Data2 Shield		
Pin 3	TMDS Data2−		

Pin 4	TMDS Data1+		
Pin 5	TMDS Data1 Shield		
Pin 6	TMDS Data1−		
Pin 7	TMDS Data0+		
Pin 8	TMDS Data0 Shield		
Pin 9	TMDS Data0−		
Pin 10	TMDS Clock+		
Pin 11	TMDS Clock Shield		
Pin 12	TMDS Clock−		
Pin 13	CEC		
Pin 14	Reserved (HDMI 1.0−1.3c), HEC Data- (Optional, HDMI 1.4+ with Ethernet)		
Pin 15	SCL (I²C Serial Clock for DDC)		
Pin 16	SDA (I²C Serial Data Line for DDC)		
Pin 17	DDC/CEC/HEC Ground		
Pin 18	+5 V (max 50 mA)		
Pin 19	Hot Plug detect (all versions) and HEC Data+ (optional, HDMI 1.4+ with Ethernet)		

HDMI (**High-Definition Multimedia Interface**) is a compact audio/video interface for transferring uncompressed digital audio/video data from a HDMI-compliant device ("the source" or "input") to a compatible digital audio device, computer monitor, video projector, and digital television.[1] A digital audio/video source for HDMI can include a HDMI-compliant set-top box, DVD player, HD DVD player, Blu-ray Disc player, AVCHD camcorder, personal computer (PCs), video game console (such as the PlayStation 3, Xbox 360 and the Wii U), AV receiver, tablet computer, and mobile phone.[1] HDMI is a digital alternative to consumer analog standards, such as radio frequency (RF) coaxial cable, composite video, S-Video, SCART, component video, D-Terminal, or VGA (also called D-sub or DE-15F).

There are a number of HDMI-standard cable connectors available, each of which can be used for any uncompressed TV or PC video format, including standard, enhanced, high definition and 3D video signals; up to 8 channels of compressed or uncompressed digital audio; a CEC (Consumer Electronics Control) connection; and an Ethernet data connection. HDMI implements the EIA/CEA-861 standards, which define video formats and waveforms, transport of compressed, uncompressed, and LPCM audio, auxiliary data, and implementations of the VESA EDID.[2][3]

The CEC allows HDMI devices to control each other when necessary and allows the user to operate multiple devices with one remote control handset.[4] Because HDMI is electrically compatible with the CEA-861 signals used by digital visual interface (DVI), no signal conversion is necessary, nor is there a loss of video quality when a DVI-to-HDMI adapter is used.[5] As an uncompressed CEA-861 connection, HDMI is independent of the various digital television standards used by individual devices, such as ATSC and DVB, as these are encapsulations of compressed MPEG video streams (which can be decoded and output as an uncompressed video stream on HDMI).

Production of consumer HDMI products started in late 2003.[6] In Europe either DVI-HDCP or HDMI is included in the HD ready in-store labeling specification for TV sets for HDTV, formulated by EICTA with SES Astra in 2005. HDMI began to appear on consumer HDTV camcorders and digital still cameras in 2006.[7][8][9][10][11] Shipments of HDMI were expected to exceed those of DVI in 2008, driven primarily by the consumer electronics market.[12][13] HDMI Licensing, LLC announced on October 25, 2011 that there were over 1,100 HDMI Adopters and that over 2 billion HDMI-enabled products had shipped since the launch of the HDMI standard.[14][15] From October 25, 2011,

all development of the HDMI specification became the responsibility of the newly-created HDMI Forum.[15]

History

The HDMI Founders are Hitachi, Matsushita Electric Industrial (Panasonic/National/Quasar), Philips, Silicon Image, Sony, Thomson (RCA) and Toshiba.[14] Digital Content Protection, LLC provides HDCP (which was developed by Intel) for HDMI.[16] HDMI has the support of motion picture producers Fox, Universal, Warner Bros. and Disney, along with system operators DirecTV, EchoStar (Dish Network) and CableLabs.[1]

The HDMI Founders began development on HDMI 1.0 on April 16, 2002, with the goal of creating an AV connector that was backward-compatible with DVI.[17][18][19] At the time, DVI-HDCP (DVI with HDCP) and DVI-HDTV (DVI-HDCP using the CEA-861-B video standard) were being used on HDTVs.[19][20][21] HDMI 1.0 was designed to improve on DVI-HDTV by using a smaller connector and adding support for audio, and enhanced support for YCbCr and consumer electronics control functions.[19][20][22][23]

The first Authorized Testing Center (ATC), which tests HDMI products, was opened by Silicon Image on June 23, 2003, in California, United States.[24] The first ATC in Japan was opened by Panasonic on May 1, 2004, in Osaka.[25] The first ATC in Europe was opened by Philips on May 25, 2005, in Caen, France.[26] The first ATC in China was opened by Silicon Image on November 21, 2005, in Shenzhen.[27] The first ATC in India was opened by Philips on June 12, 2008, in Bangalore.[28] The HDMI website contains a list of all the ATCs.[29]

According to In-Stat, the number of HDMI devices sold was 5 million in 2004, 17.4 million in 2005, 63 million in 2006, and 143 million in 2007.[12][30][31] HDMI has become the de facto standard for HDTVs, and according to In-Stat, around 90% of digital televisions in 2007 included HDMI.[12][32][33][34][35] In-Stat has estimated that 229 million HDMI devices were sold in 2008.[36] On April 8, 2008 there were over 850 consumer electronics and PC companies that had adopted the HDMI specification (HDMI Adopters).[37][38] On January 7, 2009, HDMI Licensing, LLC announced that HDMI had reached an installed base of over 600 million HDMI devices.[38] In-Stat has estimated that 394 million HDMI devices will sell in 2009 and that all digital televisions by the end of 2009 would have at least one HDMI input.[38]

In 2008, PC Magazine awarded a Technical Excellence Award in the Home Theater category for an "innovation that has changed the world" to the CEC portion of the HDMI specification.[39] Ten companies were given a Technology and Engineering Emmy Award for their development of HDMI by the National Academy of Television Arts and Sciences on January 7, 2009.[40]

On October 25, 2011, the HDMI Forum was established by the HDMI Founders to create an open organization so that interested companies can participate in the development of the HDMI specification.[15][41] All members of the HDMI Forum have equal voting rights, may participate in the Technical Working Group, and if elected can be on the Board of Directors.[41] There is no limit to the number of companies allowed in the HDMI Forum though companies must pay an annual fee of $15,000 with an additional annual fee of $5,000 for those companies who serve on the Board of Directors.[41] The Board of Directors will be made up of 11 companies who are elected every 2 years by a general vote of HDMI Forum members.[41] All future development of the HDMI specification will take place in the HDMI Forum and will be built upon the HDMI 1.4b specification.[41]

Specifications

HDMI connector

The HDMI specification defines the protocols, signals, electrical interfaces and mechanical requirements of the standard.[42] The maximum pixel clock rate for HDMI 1.0 was 165 MHz, which was sufficient to support 1080p and WUXGA (1920×1200) at 60 Hz. HDMI 1.3 increased that to 340 MHz, which allows for higher resolution (such as WQXGA, 2560×1600) across a single digital link.[43] An HDMI connection can either be single-link (type A/C) or dual-link (type B) and can have a video pixel rate of 25 MHz to 340 MHz (for a single-link connection) or 25 MHz to 680 MHz (for a dual-link connection). Video formats with rates below 25 MHz (e.g., 13.5 MHz for 480i/NTSC) are transmitted using a pixel-repetition scheme.[1]

Audio/video

HDMI uses the Consumer Electronics Association/Electronic Industries Alliance 861 standards. HDMI 1.0 to HDMI 1.2a uses the EIA/CEA-861-B video standard, HDMI 1.3 uses the CEA-861-D video standard, and HDMI 1.4 uses the CEA-861-E video standard.[2][44][45][46] The CEA-861-E document defines "video formats and waveforms; colorimetry and quantization; transport of compressed and uncompressed, as well as Linear Pulse Code Modulation (LPCM), audio; carriage of auxiliary data; and implementations of the Video Electronics Standards Association (VESA) Enhanced Extended Display Identification Data Standard (E-EDID)".[47]

To ensure baseline compatibility between different HDMI sources and displays (as well as backward compatibility with the electrically compatible DVI standard) all HDMI devices must support the sRGB color space at 8 bits per component.[48] Support for the YCbCr color space and higher color depths ("deep color") is optional. HDMI permits sRGB 4:4:4 (8–16 bits per component), xvYCC 4:4:4 (8–16 bits per component), YCbCr 4:4:4 (8–16 bits per component), or YCbCr 4:2:2 (8–12 bits per component).[49][50] The color spaces that can be used by HDMI are ITU-R BT.601, ITU-R BT.709-5 and IEC 61966-2-4.[49]

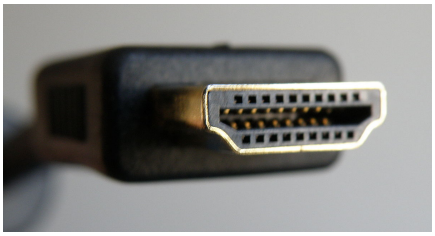
For digital audio, if an HDMI device supports audio, it is required to support the baseline format: stereo (uncompressed) PCM. Other formats are optional, with HDMI allowing up to 8 channels of uncompressed audio at sample sizes of 16-bit, 20-bit and 24-bit, with sample rates of 32 kHz, 44.1 kHz, 48 kHz, 88.2 kHz, 96 kHz, 176.4 kHz and 192 kHz.[20][51] HDMI also supports any IEC 61937-compliant compressed audio stream, such as Dolby Digital and DTS, and up to 8 channels of one-bit DSD audio (used on Super Audio CDs) at rates up to four times that of Super Audio CD.[51] With version 1.3, HDMI supports lossless compressed audio streams Dolby TrueHD and DTS-HD Master Audio.[51] As with the YCbCr video, device support for audio is optional. Audio Return Channel (ARC) is a feature introduced in the HDMI 1.4 standard.[52] "Return" refers to the case where the audio comes from the TV and can be sent "upstream" to the AV receiver using the HDMI cable connected to the AV receiver.[52] An example given on the HDMI website is that a TV that directly receives a terrestrial/satellite broadcast, or has a video source built in, sends the audio "upstream" to the AV receiver.[52]

The HDMI standard was not designed to pass closed caption data (for example, subtitles) to the television for decoding.[53] As such, any closed caption stream must be decoded and included as an image in the video stream(s) prior to transmission over an HDMI cable to be viewed on the DTV. This limits the caption style (even for digital captions) to only that decoded at the source prior to HDMI transmission. This also prevents closed captions when transmission over HDMI is required for upconversion. For example, a DVD player that sends an upscaled 720p/1080i format via HDMI to an HDTV has no way to pass Closed Captioning data so that the HDTV can decode it, as there is no line 21 VBI in that format.

Connectors

There are five HDMI connector types. Type A/B are defined in the HDMI 1.0 specification, type C is defined in the HDMI 1.3 specification, and type D/E are defined in the HDMI 1.4 specification.

HDMI type A receptacle connector


HDMI type A plug connector

Type A

Nineteen pins, with bandwidth to support all SDTV, EDTV and HDTV modes.[4] The plug (male) connector outside dimensions are 13.9 mm × 4.45 mm and the receptacle (female) connector inside dimensions are 14 mm × 4.55 mm.[54] Type A is electrically compatible with single-link DVI-D.[55]

Type B

This connector (21.2 mm × 4.45 mm) has 29 pins and can carry six differential pairs instead of three, for use with very high-resolution future displays such as WQUXGA (3,840×2,400).[55][56] Type B is electrically compatible with dual-link DVI-D, but has not yet been used in any products.[55][57] However, the use of the extra three differential pairs is reserved as of 1.3 specification.

Type C

A Mini connector defined in the HDMI 1.3 specification, it is intended for portable devices.[1][58][59] It is smaller than the type A plug connector (10.42 mm × 2.42 mm) but has the same 19-pin configuration.[58][60] The differences are that all positive signals of the differential pairs are swapped with their corresponding shield, the DDC/CEC Ground is assigned to pin 13 instead of pin 17, the CEC is assigned to pin 14 instead of pin 13, and the reserved pin is 17 instead of pin 14.[61] The type C Mini connector can be connected to a type A connector using a type A-to-type C cable.[58][59]

Type D

A Micro connector defined in the HDMI 1.4 specification[59][62] keeps the standard 19 pins of types A and C but shrinks the connector size to something resembling a micro-USB connector.[63] The type D connector is 2.8 mm × 6.4 mm, whereas the type C connector is 2.42 mm × 10.42 mm.[64] For comparison, a micro-USB connector is 1.8 mm × 6.85 mm and a USB Type A connector is 4.5 mm × 11.5 mm. The pin assignment is different from Type A or C.

Type E

Automotive Connection System defined in HDMI 1.4 specification.

Cables

Although no maximum length for an HDMI cable is specified, signal attenuation (dependent on the cable's construction quality and conducting materials) limits usable lengths in practice.[65] HDMI 1.3 defines two cable categories: Category 1-certified cables, which have been tested at 74.5 MHz (which would include resolutions such as 720p60 and 1080i60), and Category 2-certified cables, which have been tested at 340 MHz (which would include resolutions such as 1080p60 and 2160p30).[62][66][67] Category 1 HDMI cables are marketed as "Standard" and Category 2 HDMI cables as "High Speed".[1] This labeling guideline for HDMI cables went into effect on October 17, 2008.[68][69] Category 1 and 2 cables can either meet the required parameter specifications for interpair skew,

far-end crosstalk, attenuation and differential impedance, or they can meet the required nonequalized/equalized eye diagram requirements.[66] A cable of about 5 meters (16 ft) can be manufactured to Category 1 specifications easily and inexpensively by using 28 AWG (0.081 mm²) conductors.[65] With better quality construction and materials, including 24 AWG (0.205 mm²) conductors, an HDMI cable can reach lengths of up to 15 meters (49 ft).[65] Many HDMI cables under 5 meters of length that were made before the HDMI 1.3 specification can work as Category 2 cables, but only Category 2-tested cables are guaranteed to work.[70]

As of the HDMI 1.4 specification, these are the following cable types defined for HDMI in general:[71][72]

- Standard HDMI Cable – up to 1080i and 720p
- Standard HDMI Cable with Ethernet
- Automotive HDMI Cable
- High Speed HDMI Cable – 1080p, 4K, 3D and deep color
- High Speed HDMI Cable with Ethernet

An HDMI cable is usually composed of four shielded twisted pairs, with impedance of the order of 100 ohms, plus several separate conductors.

Extenders

An HDMI extender is a single device (or pair of devices) powered with an external power source or with the 5V DC from the HDMI source.[73][74][75] Long cables can cause instability of HDCP and blinking on the screen, due to the weakened DDC signal that HDCP requires. HDCP DDC signals must be multiplexed with TMDS video signals to be compliant with HDCP requirements for HDMI extenders based on a single Category 5/Category 6 cable.[76][77] Several companies offer amplifiers, equalizers and repeaters that can string several standard HDMI cables together. Active HDMI cables use electronics within the cable to boost the signal and allow for HDMI cables of up to 30 meters (98 ft).[73] HDMI extenders that are based on dual Category 5/Category 6 cable can extend HDMI to 250 meters (820 ft), while HDMI extenders based on optical fiber can extend HDMI to 300 meters (980 ft).[74][75]

Communication channel protocols

HDMI has three physically separate communication channels, which are the DDC, TMDS and the optional CEC.[78] HDMI 1.4 added ARC and HEC.[79][80]

DDC

The Display Data Channel (DDC) is a communication channel based on the I²C bus specification.[81][82] HDMI specifically requires support for the Enhanced Display Data Channel (E-DDC), which is used by the HDMI source device to read the E-EDID data from the HDMI sink device to learn what audio/video formats it supports.[78][81][82] HDMI requires that the E-DDC support I²C standard mode speed (100 kbit/s) and allows optional support for fast mode speed (400 kbit/s).[83]

The DDC channel is actively used for High Definition Content Protection.

TMDS

Transition Minimized Differential Signaling (TMDS) on HDMI carries video, audio and auxiliary data via one of three modes, called the Video Data Period, the Data Island Period and the Control Period.[84] During the Video Data Period, the pixels of an active video line are transmitted.[84] During the Data Island period (which occurs during the horizontal and vertical blanking intervals), audio and auxiliary data are transmitted within a series of packets.[84] The Control Period occurs between Video and Data Island periods.[84]

Both HDMI and DVI use TMDS to send 10-bit characters that are encoded using 8b/10b encoding for the Video Data Period and 2b/10b encoding for the Control Period. HDMI adds the ability to send audio and auxiliary data using 4b/10b encoding for the Data Island Period.[84] Each Data Island Period is 32 pixels in size and contains a

32-bit Packet Header, which includes 8 bits of BCH ECC parity data for error correction and describes the contents of the packet.[85] Each Packet contains four subpackets, and each subpacket is 64 bits in size, including 8 bits of BCH ECC parity data, allowing for each Packet to carry up to 224 bits of audio data.[86] Each Data Island Period can contain up to 18 Packets.[87] Seven of the 15 Packet types described in the HDMI 1.3a specifications deal with audio data, while the other 8 types deal with auxiliary data.[85] Among these are the General Control Packet and the Gamut Metadata Packet. The General Control Packet carries information on AVMUTE (which mutes the audio during changes that may cause audio noise) and Color Depth (which sends the bit depth of the current video stream and is required for deep color).[88][89] The Gamut Metadata Packet carries information on the color space being used for the current video stream and is required for xvYCC.[49][90][91]

CEC

Consumer Electronics Control (CEC) is an HDMI feature designed to allow the user to command and control up-to ten CEC-enabled devices, that are connected through HDMI,[92][93] by using only one of their remote controls (for example by controlling a television set, set-top box, and DVD player using only the remote control of the TV).[94] CEC also allows for individual CEC-enabled devices to command and control each other without user intervention.[94][95][96][97][98][99][100]

It is a one-wire bidirectional serial bus that uses the industry-standard AV.link protocol to perform remote control functions. CEC wiring is mandatory, although implementation of CEC in a product is optional.[78] It was defined in HDMI Specification 1.0 and updated in HDMI 1.2, HDMI 1.2a and HDMI 1.3a (which added timer and audio commands to the bus).[94][101][102][103][104] USB to CEC Adapters exist that allow a computer to control CEC enabled devices.[105][106][107][108]

Trade names for CEC are Anynet+ (Samsung); Aquos Link (Sharp); BRAVIA Link and BRAVIA Sync (Sony); HDMI-CEC (Hitachi); E-link (AOC); Kuro Link (Pioneer); CE-Link and Regza Link (Toshiba); RIHD (Remote Interactive over HDMI) (Onkyo); RuncoLink (Runco International); SimpLink (LG); HDAVI Control, EZ-Sync, VIERA Link (Panasonic); EasyLink (Philips); and NetCommand for HDMI (Mitsubishi).[109][110][111][112][113]

The following is a list of HDMI-CEC commands:

- **One Touch Play:** allows devices to switch the TV to use it as the active source when playback starts
- **System Standby** enables users to switch multiple devices to standby mode with the press of one button
- **Preset Transfer:** transfers the tuner channel setup to another TV set
- **One Touch Record** allows users to record whatever is currently being shown on the HDTV screen on a selected recording device
- **Timer Programming** allows users to use the electronic program guides (EPGs) that are built into many HDTVs and set-top-boxes to program the timer in recording devices like PVRs and DVRs
- **System Information:** checks all components for bus addresses and configuration
- **Deck Control** allows a component to interrogate and control the operation (play, pause, rewind etc.), of a playback component (Blu-ray or HD DVD player or a Camcorder, etc.)
- **Tuner Control** allows a component to control the tuner of another component
- **OSD Display:** use the OSD of the TV set to display text
- **Device Menu Control** allows a component to control the menu system of another component by passing through the user interface (UI) commands
- **Routing Control:** control the switching of signal sources
- **Remote Control Pass Through** allows remote control commands to be passed through to other devices within the system
- **Device OSD Name Transfer:** transfer the preferred device names to the TV set
- **System Audio Control** allows the volume of an AV receiver, integrated amplifier or pre-amplifier to be controlled using any remote control from a suitably-equipped device(s) in the system

ARC and HEC

HDMI 1.4 introduces two features called ARC (Audio Return Channel) and HEC (HDMI Ethernet Channel).[79][80][114] These features use two pins from the connector: a previously unused pin and the hot plug detect pin.[114]

ARC is an audio link meant to replace other cables between the TV and the A/V receiver or speaker system.[79] This direction is used when the TV is the one that generates or receives the video stream instead of the other equipment.[79] A typical case is the reception of ATSC or DVB signals by a TV, but reproduction of audio is handled by the other equipment.[79] Without ARC, the audio output from the TV needs to be routed by another cable, typically TOS-Link or coax, into the speaker system.[79]

HEC provides a bidirectional Ethernet communication at 100 Mbit/s.[80] It also goes by the name HEAC (HDMI, Ethernet, Audio, Control).[114]

Compatibility with DVI

HDMI is backward-compatible with single-link Digital Visual Interface digital video (DVI-D or DVI-I, but not DVI-A). No signal conversion is required when an adapter or asymmetric cable is used, so there is no loss of video quality.[5]

An HDMI to DVI adapter

From a user's perspective, an HDMI display can be driven by a single-link DVI-D source, since HDMI and DVI-D define an overlapping minimum set of supported resolutions and framebuffer formats to ensure a basic level of interoperability. In the reverse case a DVI-D monitor would have the same level of basic interoperability unless there are content protection issues with High-bandwidth Digital Content Protection (HDCP), not supported by DVI, or the HDMI color encoding is in component color space YCbCr which is not supported by DVI, instead of RGB. An HDMI source such as a Blu-ray player may demand HDCP-compliance of the display, and refuse to output HDCP-protected content to a non-compliant display.[115] A further complication is that there is a small amount of display equipment, such as some high-end home theater projectors, designed with HDMI inputs but not HDCP-compliant.

A DVI to HDMI adapter

Features specific to HDMI, such as remote-control and audio transport, are not available in devices that use legacy DVI-D signalling. However, many devices output HDMI over a DVI connector (e.g., ATI 3000-series and NVIDIA GTX 200-series video cards),[5] and some multimedia displays may accept HDMI (including audio) over a DVI input. Exact capabilities beyond basic compatibility vary from product to product.

Audio support

Since the DVI specification does not support audio transport, an interoperability problem arises when an HDMI-source drives a legacy DVI display (such as a PC monitor), or conversely, when a DVI source drives an HDMI display. While HDMI and DVI compliance rules ensure that a DVI video connection can be successfully negotiated and established (via a mutually supported display mode), the audio signal must still be transported through means outside of the DVI connection. Typically, an HDMI-equipped source will provide additional outputs for audio, such as line-level analog and SPDIF, which provide a baseline audio program (such as stereo PCM).

Likewise, when displaying video from an HDMI jack, an HDMI-equipped display may support alternate audio sourcing from a separate pair of analog-audio inputs. Provision for any of these compatibility mechanisms is down to the manufacturer; they are not specified by HDMI. By 2010, nearly all HDMI-equipped sources (set-top and media-extender boxes, Blu-ray and DVD players, and PCs) provided separate analog audio outputs, and many HDMI-equipped televisions supported alternate-audio input when sourcing video from an HDMI input.

There are consumer adapters available to place between a DVI source and HDMI device which can insert a separate audio signal into an HDMI TMDS data stream.[116] DVI connectors on PC video cards have also been increasingly able to take advantage of HDMI features such as audio output.

Content protection (HDCP)

HDMI can use HDCP to encrypt the signal if required by the source device. CSS, CPRM and AACS require the use of HDCP on HDMI when playing back encrypted DVD Video, DVD Audio, HD DVD and Blu-ray Disc. The HDCP Repeater bit controls the authentication and switching/distribution of an HDMI signal. According to HDCP Specification 1.2 (beginning with HDMI CTS 1.3a), any system that implements HDCP must do so in a fully compliant manner. HDCP testing that was previously only a requirement for optional tests such as the "Simplay HD" testing program is now part of the requirements for HDMI compliance.[117][118][119] HDCP allows for up to 127 devices to be connected together, with up to 7 levels, using a combination of sources, sinks and repeaters.[120] A simple example of this is several HDMI devices connected to an HDMI AV receiver that is connected to an HDMI display.[120]

Devices called HDCP strippers can remove the HDCP information from the video signal so the video can play on non-HDCP-compliant displays.[121]

Cost

HDMI manufacturers pay an annual fee of US$10,000 (less for HDMI manufacturers making less than 10,000 units per year) plus a royalty rate of $0.15 per unit, reduced to $0.05 if the HDMI logo is used, and further reduced to $0.04 if HDCP is also implemented. The royalty only applies to final products and does not apply to products that are included in, or with, a licensed HDMI product that is already subject to the royalty.[122] An example is that a HDMI cable sold directly to consumers is paid for by the cable manufacturer but if the cable manufacturer sells the HDMI cable to a HDTV manufacturer that includes it with an HDTV subject to the royalty then the HDTV manufacturer pays only the royalty on the HDTV.[122]

Versions

HDMI devices are manufactured to adhere to various versions of the specification, in which each version is given a number and/or letter, such as 1.0, 1.2, or 1.4b.[2] Each subsequent version of the specification uses the same kind of cable but increases the bandwidth and/or capabilities of what can be transmitted over the cable.[2] A product listed as having an HDMI version does not necessarily mean that it will have all of the features that are listed for that version, since some HDMI features are optional, such as deep color and xvYCC (which is branded by Sony as "x.v.Color").[123][124] Note that with the release of the version 1.4 cable, the HDMI Licensing LLC group (which oversees the HDMI standard) will require that any reference to version numbers be removed from all packaging and advertising for the cable.[125] Non-cable HDMI products starting on January 1, 2012 will no longer be allowed to reference the HDMI number and will be required to state which features of the HDMI specification the product supports.[126]

Version 1.0 to 1.2

HDMI 1.0 was released December 9, 2002 and is a single-cable digital audio/video connector interface with a maximum TMDS bandwidth of 4.95 Gbit/s. It supports up to 3.96 Gbit/s of video bandwidth (1080p/60 Hz or UXGA) and 8 channel LPCM/192 kHz/24-bit audio.[2] HDMI 1.1 was released on May 20, 2004 and added support for DVD-Audio.[2] HDMI 1.2 was released August 8, 2005 and added support for One Bit Audio, used on Super Audio CDs, at up to 8 channels. It also added the availability of HDMI type A connectors for PC sources, the ability for PC sources to only support the sRGB color space while retaining the option to support the YCbCr color space, and required HDMI 1.2 and later displays to support low-voltage sources.[2][48] HDMI 1.2a was released on December 14, 2005 and fully specifies Consumer Electronic Control (CEC) features, command sets and CEC compliance tests.[2]

Version 1.3

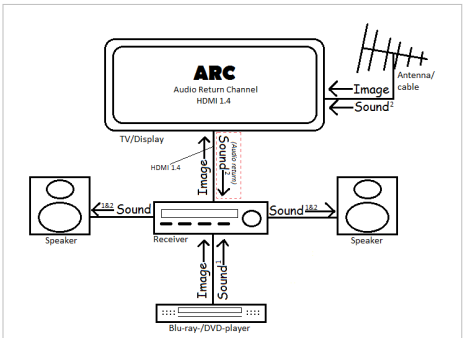
HDMI 1.3 was released June 22, 2006 and increased the single-link bandwidth to 340 MHz (10.2 Gbit/s).[2][43][127] It optionally supports deep color, with 30-bit, 36-bit and 48-bit xvYCC, sRGB, or YCbCr, compared to 24-bit sRGB or YCbCr in previous HDMI versions. It also optionally supports output of Dolby TrueHD and DTS-HD Master Audio streams for external decoding by AV receivers.[128] It incorporates automatic audio syncing (audio video sync) capability.[43] It defined cable Categories 1 and 2, with Category 1 cable being tested up to 74.25 MHz and Category 2 being tested up to 340 MHz.[66] It also added the new type C Mini connector for portable devices.[58][129]

HDMI 1.3a was released on November 10, 2006 and had Cable and Sink modifications for type C, source termination recommendations, and removed undershoot and maximum rise/fall time limits.[2] It also changed CEC capacitance limits, clarified sRGB video quantization range, and CEC commands for timer control were brought back in an altered form, with audio control commands added.[2] It also added support for optionally streaming SACD in its bitstream DST format rather than uncompressed raw DSD like from HDMI 1.2 onwards.[2]

HDMI 1.3b, 1.3b1 and 1.3c were released on March 26, 2007, November 9, 2007, and August 25, 2008 respectively. They do not introduce differences on HDMI features, functions, or performance,[130] but only describe testing for products based on the HDMI 1.3a specification regarding HDMI compliance (1.3b [119][131][132]), the HDMI type C Mini connector (1.3b1 [119][131][132]) and active HDMI cables (1.3c [73][133]).[130]

Version 1.4

HDMI 1.4 was released on May 28, 2009, and the first HDMI 1.4 products were available in the second half of 2009.[62][134] HDMI 1.4 increases the maximum resolution to 4K × 2K, i.e. 3840 × 2160p (Quad HD) at 24 Hz/25 Hz/30 Hz or 4096 × 2160p at 24 Hz (which is a resolution used with digital theaters); an HDMI Ethernet Channel (HEC), which allows for a 100 Mbit/s Ethernet connection between the two HDMI connected devices so they can share an Internet connection;[80] and introduces an Audio Return Channel (ARC),[79] 3D Over HDMI, a new Micro HDMI Connector, expanded support for color spaces, with the addition of sYCC601, Adobe RGB and Adobe YCC601; and an Automotive Connection System.[62][135][136][137][138]



HDMI 1.4 with Audio Return Channel

HDMI 1.4 supports several stereoscopic 3D formats including field alternative (interlaced), frame packing (a full resolution top-bottom format), line alternative full, side-by-side half, side-by-side full, 2D + depth, and 2D + depth + graphics + graphics depth (WOWvx),[59][139][140] with additional top/bottom formats added in version 1.4a . HDMI 1.4 requires that 3D displays support the frame packing 3D format at either 720p50 and 1080p24 or 720p60 and

1080p30.[140] High Speed HDMI 1.3 cables can support all HDMI 1.4 features except for the HDMI Ethernet Channel.[59][139][140]

HDMI 1.4a was released on March 4, 2010 and adds two additional mandatory 3D formats for broadcast content, which was deferred with HDMI 1.4 in order to see the direction of the 3D broadcast market.[141][142] HDMI 1.4a has defined mandatory 3D formats for broadcast, game, and movie content.[141] HDMI 1.4a requires that 3D displays support the frame packing 3D format at either 720p50 and 1080p24 or 720p60 and 1080p24, side-by-side horizontal at either 1080i50 or 1080i60, and top-and-bottom at either 720p50 and 1080p24 or 720p60 and 1080p24.[142]

HDMI 1.4b was released on October 11, 2011.[143] All future versions of the HDMI specification will be made by the HDMI Forum that was created on October 25, 2011.[15][144]

Version comparison

Note that a given product may choose to implement a subset of the given HDMI version. Certain features such as deep color and xvYCC support are optional.[123]

HDMI version	1.0–1.2a	1.3	1.4
Date initially released	December 29, 2002	June 22, 2006	May 28, 2009
Maximum clock rate (MHz)	165	340	340[59]
Maximum TMDS throughput per channel (Gbit/s) including 8b/10b overhead	1.65	3.40	3.40
Maximum total TMDS throughput (Gbit/s) including 8b/10b overhead	4.95	10.2	10.2
Maximum throughput (Gbit/s) with 8b/10b overhead removed	3.96	8.16	8.16
Maximum audio throughput (Mbit/s)	36.86	36.86	36.86
Maximum color depth (bit/px.)	24	48[A]	48
Maximum resolution over single link at 24-bit/px[B]	1920×1200p60	2560×1600p75	4096×2160p24
Maximum resolution over single link at 30-bit/px[C]	N/A	2560×1600p60	4096×2160p24
Maximum resolution over single link at 36-bit/px[D]	N/A	1920×1200p75	4096×2160p24
Maximum resolution over single link at 48-bit/px[E]	N/A	1920×1200p60	1920×1200p60

HDMI version	1.0	1.1	1.2 1.2a	1.3	1.3a 1.3b 1.3b1 1.3c	1.4 1.4a
sRGB	Yes	Yes	Yes	Yes	Yes	Yes
YCbCr	Yes	Yes	Yes	Yes	Yes	Yes
8 channel LPCM, 192 kHz, 24-bit audio capability	Yes	Yes	Yes	Yes	Yes	Yes
Blu-ray Disc and HD DVD video and audio at full resolution[F]	Yes	Yes	Yes	Yes	Yes	Yes
Consumer Electronic Control (CEC)[G]	Yes	Yes	Yes	Yes	Yes	Yes
DVD-Audio support	No	Yes	Yes	Yes	Yes	Yes
Super Audio CD (DSD) support[H]	No	No	Yes	Yes	Yes	Yes
Deep color	No	No	No	Yes	Yes	Yes
xvYCC	No	No	No	Yes	Yes	Yes
Auto lip-sync	No	No	No	Yes	Yes	Yes

Dolby TrueHD bitstream capable	No	No	No	Yes	Yes	Yes
DTS-HD Master Audio bitstream capable	No	No	No	Yes	Yes	Yes
Updated list of CEC commands[I]	No	No	No	Yes	Yes	Yes
3D over HDMI[136]	No	No	No	No	No	Yes
Ethernet channel	No	No	No	No	No	Yes
Audio return channel (ARC)	No	No	No	No	No	Yes
4K × 2K resolution support[137]	No	No	No	No	No	Yes

[A] 36-bit support is mandatory for deep-color-compatible consumer electronic devices, with 48-bit support being optional.[145]

[B] Maximum resolution is based on CVT-RB, which is a VESA standard for non-CRT-based displays.[146] Using CVT-RB 1920×1200 would have a video bandwidth of 3.69 Gbit/s, 2560×1600 would have a video bandwidth of 8.12 Gbit/s, and 4096×2160 would have a video bandwidth of 5.35 Gbit/s.[147]

[C] Using CVT-RB 2560×1600 would have a video bandwidth of 8.12 Gbit/s and 4096×2160 would have a video bandwidth of 6.69 Gbit/s.[147]

[D] Using CVT-RB 1920×1200 would have a video bandwidth of 7.91 Gbit/s and 4096×2160 would have a video bandwidth of 8.03 Gbit/s.[147]

[E] Using CVT-RB 1920×1200 would have a video bandwidth of 7.39 Gbit/s.[147]

[F] Even for a compressed audio codec that a given HDMI version cannot transport, the source device may be able to decode the audio codec and transmit the audio as uncompressed LPCM.

[G] CEC has been in the HDMI specification since version 1.0, but only began to be used in consumer electronics products with HDMI version 1.3a.[148][149]

[H] Playback of SACD may be possible for older HDMI versions if the source device (such as the Oppo 970) converts to LPCM.[150]

[I] Large number of additions and clarifications for CEC commands. One addition is CEC command, allowing for volume control of an AV receiver.[104]

Applications

Blu-ray Disc and HD DVD players

Blu-ray Disc and HD DVD, introduced in 2006, offer high-fidelity audio features that require HDMI for best results. HDMI 1.3 can transport Dolby Digital Plus, Dolby TrueHD, and DTS-HD Master Audio bitstreams in compressed form.[51] This capability allows for an AV receiver with the necessary decoder to decode the compressed audio stream. The Blu-ray specification does not support video encoded with either deep color or xvYCC; thus, HDMI 1.0 can transfer Blu-ray discs at full video quality.[151]

Blu-ray permits secondary audio decoding, whereby the disc content can tell the player to mix multiple audio sources together before final output.[152] Some Blu-ray and HD DVD players can decode all of the audio codecs internally and can output LPCM audio over HDMI. Multichannel LPCM can be transported over an HDMI connection, and as long as the AV receiver supports multichannel LPCM audio over HDMI and supports HDCP, the audio reproduction is equal in resolution to HDMI 1.3 bitstream output. Some low-cost AV receivers, such as the Onkyo TX-SR506, do not support audio processing over HDMI and are labelled as "HDMI pass through" devices.[153][154]

Digital cameras and camcorders

As of 2012, most consumer camcorders, as well as many digital cameras, are equipped with a mini-HDMI connector (type C connector).

Personal computers

PCs with a DVI interface are capable of video output to an HDMI-enabled monitor.[5] Some PCs include an HDMI interface and may also be capable of HDMI audio output, depending on specific hardware.[155] For example, Intel's motherboard chipsets since the 945G and NVIDIA's GeForce 8200/8300 motherboard chipsets are capable of 8-channel LPCM output over HDMI.[155][156] Eight-channel LPCM audio output over HDMI with a video card was first seen with the ATI Radeon HD 4850, which was released in June 2008 and is supported by other video cards in the ATI Radeon HD 4000 series.[156][157][158][159][160] Linux can support 8-channel LPCM audio over HDMI if the video card has the necessary hardware and supports the Advanced Linux Sound Architecture (ALSA).[161] The ATI Radeon HD 4000 series supports ALSA.[161][162] Cyberlink announced in June 2008 that they would update their PowerDVD playback software to support 192 kHz/24-bit Blu-ray Disc audio decoding in Q3-Q4 of 2008.[163] Corel's WinDVD 9 Plus currently supports 96 kHz/24-bit Blu-ray Disc audio decoding.[164]

Even with an HDMI output, a computer may not support HDCP, Microsoft's Protected Video Path, or Microsoft's Protected Audio Path.[156][165] Several early graphic cards were labelled as "HDCP-enabled" but did not have the hardware needed for HDCP;[166] this included some graphic cards based on the ATI X1600 chipset and certain models of the NVIDIA Geforce 7900 series.[166] The first computer monitors with HDCP support were released in 2005; by February 2006 a dozen different models had been released.[167][168] The Protected Video Path was enabled in graphic cards that supported HDCP, since it was required for output of Blu-ray Disc video.[156] In comparison, the Protected Audio Path was only required if a lossless audio bitstream (such as Dolby TrueHD or DTS-HD MA) was output.[156] Uncompressed LPCM audio, however, does not require a Protected Audio Path, and software programs such as PowerDVD and WinDVD can decode Dolby TrueHD and DTS-HD MA and output it as LPCM.[156][163][164] A limitation is that if the computer does not support a Protected Audio Path, the audio must be downsampled to 16-bit 48 kHz but can still output at up to 8 channels.[156] No graphic cards were released in 2008 that supported the Protected Audio Path.[156]

The Asus Xonar HDAV1.3 became the first HDMI sound card that supported the Protected Audio Path and could both bitstream and decode lossless audio (Dolby TrueHD and DTS-HD MA), although bitstreaming is only available if using the ArcSoft TotalMedia Theatre software.[169][170] It has an HDMI 1.3 input/output, and Asus says that it can work with most video cards on the market.[169][170][171]

> "Legacy interfaces such as VGA, DVI and LVDS have not kept pace, and newer standards such as DisplayPort and HDMI clearly provide the best connectivity options moving forward. In our opinion, DisplayPort 1.2 is the future interface for PC monitors, along with HDMI 1.4a for TV connectivity."

AMD, Dell, Intel Corporation, Lenovo, Samsung Electronics and LG. Dec 8, 2010. [172].

In September 2009, AMD announced the ATI Radeon HD 5000 series video cards, which support HDMI 1.3 output (deep color, xvYCC wide gamut support and high bit rate audio), support for 8-channel LPCM over HDMI, and an integrated HD audio controller with a Protected Audio Path that allows bitstream output over HDMI for AAC, Dolby AC-3, Dolby TrueHD and DTS Master Audio formats.[173][174][175] The ATI Radeon HD 5870 released in September 2009 is the first video card that supports bitstream output over HDMI for Dolby TrueHD and DTS-HD Master Audio.[175]

In December 2010, it was announced that several computer vendors and display makers including Intel, AMD, Dell, Lenovo, Samsung, and LG would stop using LVDS from 2013 and legacy DVI and VGA connectors from 2015, replacing them with DisplayPort and HDMI.[176][177]

Tablet Computers

Some Tablet computers, such as the Motorola Xoom, BlackBerry PlayBook, Vizio Vtab 1008 and Acer Iconia Tab A500, support HDMI using Micro-HDMI (Type D) ports. Others, such as the ASUS Eee Pad Transformer support the standard using Mini-HDMI (Type C) ports. The iPad and iPad 2 have a special A/V adapter that converts Apple's data line to a standard HDMI (Type A) port. Samsung has a similar proprietary thirty-pin port for their Galaxy Tab 10.1 that can adapt to HDMI as well as USB drives. The Dell Streak 5 smartphone/tablet hybrid is capable of outputting over HDMI. While the Streak uses a PDMI port, a separate cradle is available which adds HDMI compatibility. Most of the Chinese made tablets running Android OS support HDMI output using a Mini-HDMI (Type C) port.

Mobile Phones

Many recent mobile phones support output of HDMI video via either a mini-HDMI connector or MHL output.[178][179][180][181][182][183][184]

Compatibility with Older Televisions

HDMI can be used with older televisions that only use analog ports (SCART, VGA, RCA, etc.), using a scaler (digital-to-analog converter),[185] a relatively complex and expensive electronics device rather than a simple passive adapter.

Relationship with DisplayPort

Another audio/video interface is DisplayPort, version 1.0 of which was approved in May 2006. DisplayPort is supported in several computer monitors and video cards. The DisplayPort website states that DisplayPort is expected to complement HDMI.[186] Most of the companies producing equipment supporting DisplayPort are in the computer sector. DisplayPort uses a self-clocking micro-packet-based protocol that allows for a variable amount of differential lanes as well as flexible allocation of bandwidth between audio and video, and supports encapsulating multichannel compressed audio formats in the audio stream[187][188] DisplayPort ports can be made so that they are compatible with single-link DVI and HDMI.[189] Compatibility is achieved with dual-mode DisplayPort ports, which are marked with the ++DP logo, using attached passive adapters; active adapters allow signal conversion to dual-link DVI and analog VGA.[187][189]

For manufacturers DisplayPort has an advantage over HDMI in that it is royalty-free, while there is an annual charge and a royalty fee for HDMI. DisplayPort version 1.2 added the ability to transport multiple audio/video streams, doubled the maximum data rate from 10.8 Gbit/s to 21.6 Gbit/s, increased the "AUX" channel bandwidth from 1 Mbit/s to 720 Mbit/s, added support for multiple color spaces including xvYCC, scRGB and Adobe RGB 1998, added global time-code for audio synchronisation and the ability to transfer Ethernet, USB 2.0, DPMS, and other types of data over the "AUX" channel.[187][190][191] HDMI has a few advantages over DisplayPort, such as support for Consumer Electronics Control (CEC) signals, and electrical compatibility with DVI (though practically limited to single-link DVI rates).[191][192][193]

Relationship with MHL

Mobile High-definition Link (MHL) is an industry standard for a mobile audio/video interface for directly connecting mobile phones and other portable consumer electronics (CE) devices to high-definition televisions (HDTVs) and displays. MHL is being developed by the **MHL Consortium**, a consortium of developers of mobile devices. Many of the companies behind MHL are also the ones behind HDMI. MHL is an evolution of HDMI rather than a new standard.

MHL is basically an HDMI stream that has three logic channels multiplexed into a single physical one. Each logic channel represent a data channel in HDMI. Overall, an MHL cable only needs five wires instead of the nineteen ones used in HDMI.

MHL features:

- Power is transmitted through the cable. Typical cases include the TV charging the mobile device and the mobile device powering an active MHL to HDMI dongle.
- Uses a single, thin cable to connect the mobile device to the TV compared to HDMI. Typical MHL cables are 1.5m long.
- The HDTV remote will control the connected device with guaranteed mixed manufacturer interoperability (CEC).[194]
- Video resolution limited to 1080p uncompressed 4:2:2 HD video (PacketVideo) or 720p 4:4:4 HD video.
- 8 channel (e.g., 7.1 surround sound) uncompressed audio.
- Supports High-bandwidth Digital Content Protection (HDCP).
- Typical MHL connector is micro USB, a typical connector already found in many mobile devices. The same micro USB connector can be used to charge the device, to establish data communication with a computer and to transfer uncompressed video.

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- HDMI Forum, Inc. (http://www.hdmiforum.org/)
- Dolby Podcast Episode 60 – March 26, 2009 (http://www.dolby.com/uploadedFiles/en-US/Consumer/Home_Entertainment/Dolby_Podcast/Dolbycast_Episode_60.mp3) – Part one of a two-part discussion with Steve Venuti, President, and Jeff Park, Technology Evangelist, of HDMI Licensing.
- Dolby Podcast Episode 62 – April 23, 2009 (http://www.dolby.com/uploadedFiles/en-US/Consumer/Home_Entertainment/Dolby_Podcast/Dolbycast_Episode_62.mp3) – Part two of a two-part discussion with Steve Venuti, President, and Jeff Park, Technology Evangelist, of HDMI Licensing.

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