# = HDMI =

HDMI ( High @-@ Definition Multimedia Interface ) is a proprietary audio / video interface for transferring uncompressed video data and compressed or uncompressed digital audio data from an HDMI @-@ compliant source device , such as a display controller , to a compatible computer monitor , video projector , digital television , or digital audio device . HDMI is a digital replacement for analog video standards .

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 . CEA @-@ 861 signals carried by HDMI are electrically compatible with the CEA @-@ 861 signals used by the 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 . The CEC ( Consumer Electronics Control ) capability allows HDMI devices to control each other when necessary and allows the user to operate multiple devices with one remote control handset .

Several versions of HDMI have been developed and deployed since initial release of the technology but all use the same cable and connector . Other than improved audio and video capacity , performance , resolution and color spaces , newer versions have optional advanced features such as 3D , Ethernet data connection , and CEC ( Consumer Electronics Control ) extensions .

Production of consumer HDMI products started in late 2003 . 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 . As of January 8 , 2013 ( ten years after the release of the first HDMI specification ) , over 3 billion HDMI devices have been sold .

## = = History = =

The HDMI founders are Hitachi , Panasonic , Philips , Silicon Image , Sony , Thomson , RCA and Toshiba . Digital Content Protection , LLC provides HDCP ( which was developed by Intel ) for HDMI . HDMI has the support of motion picture producers Fox , Universal , Warner Bros. and Disney , along with system operators DirecTV , EchoStar ( Dish Network ) and CableLabs .

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 . 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 . HDMI 1 @.@ 0 was designed to improve on DVI @-@ HDTV by using a smaller connector and adding audio capability and enhanced YCbCr capability and consumer electronics control functions .

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

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 . HDMI has become the de facto standard for HDTVs , and according to In @-@ Stat , around 90 % of digital televisions in 2007 included HDMI . In @-@ Stat has estimated that 229 million HDMI devices were sold in 2008 . On April 8 , 2008 there were over 850 consumer electronics and PC companies that had adopted the HDMI specification ( HDMI adopters ) . On January 7 , 2009 , HDMI Licensing , LLC announced that HDMI had reached an installed base of over 600 million HDMI devices . 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 .

On January 28 , 2008 , In @-@ Stat reported that shipments of HDMI were expected to exceed those of DVI in 2008 , driven primarily by the consumer electronics market .

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 . 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 .

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 . 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 . 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 . 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 . All future development of the HDMI specification will take place in the HDMI Forum and will be built upon the HDMI 1.4b specification . Also on the same day HDMI Licensing , LLC announced 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 . From October 25 , 2011 , all development of the HDMI specification became the responsibility of the newly created HDMI Forum .

On January 8 , 2013 , HDMI Licensing , LLC announced that there were over 1 @,@ 300 HDMI adopters and that over 3 billion HDMI devices had shipped since the launch of the HDMI standard . The day also marked the 10 @-@ year anniversary of the release of the first HDMI specification .

= = Specifications = =

The HDMI specification defines the protocols , signals , electrical interfaces and mechanical requirements of the standard . The maximum pixel clock rate for HDMI 1 @.@ 0 was 165 MHz , which was sufficient to allow 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 . An HDMI connection can either be single @-@ link ( type A / C / D ) 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 .

= = = 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 . 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 ) " . On July 15 , 2013 , the CEA announced the publication of CEA @-@ 861 @-@ F which is a standard that can be used by interfaces such as DVI , HDMI , and LVDS . CEA @-@ 861 @-@ F adds the ability to transmit several Ultra HD video formats and additional color spaces .

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 implement the sRGB color space at 8 bits per component . Ability to use the YCbCr color space and higher color depths ( " deep color " ) is optional . HDMI permits sRGB 4 : 4 : 4 chroma subsampling ( 8 ? 16 bits per component ) , xvYCC 4 : 4 : 4 chroma subsampling ( 8 ? 16 bits per component ) , YCbCr 4 : 4 : 4 chroma subsampling ( 8 ? 16 bits per component ) , or YCbCr 4 : 2 : 2 chroma subsampling ( 8 ? 12 bits per component ) . The color spaces that can be used by HDMI are ITU

@-@ R BT.601 , ITU @-@ R BT.709 @-@ 5 and IEC 61966 @-@ 2 @-@ 4 .

For digital audio , if an HDMI device has audio , it is required to implement 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 . HDMI also carries 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 . With version 1 @.@ 3 , HDMI allows lossless compressed audio streams Dolby TrueHD and DTS @-@ HD Master Audio . As with the YCbCr video , audio capability is optional . Audio return channel ( ARC ) is a feature introduced in the HDMI 1 @.@ 4 standard . " 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 . 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 .

The HDMI standard was not designed to pass closed caption data ( for example , subtitles ) to the television for decoding . 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 .

= = = Uncompressed video = = =

The HDMI specification specifies several modes of uncompressed digital video . Although often HD video capable cameras include an HDMI interface for playback or even live preview , the image processor and the video processor of cameras usable for uncompressed video must be able to deliver the full image resolution at the specified frame rate in realtime without any missing frames causing jitter . Therefore , usable uncompressed video out of HDMI is often called " Clean HDMI " .

= = = Communication channel protocols = = =

HDMI has three physically separate communication channels , which are the DDC , TMDS and the optional CEC . HDMI 1 @.@ 4 added ARC and HEC .

= = = = DDC = = = =

The Display Data Channel ( DDC ) is a communication channel based on the I ² C bus specification . HDMI specifically requires the device implement 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 can take . HDMI requires that the E @-@ DDC implement I ² C standard mode speed ( 100 kbit / s ) and allows it to optionally implement fast mode speed ( 400 kbit / s ) .
The DDC channel is actively used for High @-@ bandwidth Digital Content Protection .

= = = = TMDS = = = =

Transition Minimized Differential Signaling ( TMDS ) on HDMI interleaves video , audio and auxiliary data using three different packet types , called the Video Data Period , the Data Island Period and the Control Period . During the Video Data Period , the pixels of an active video line are transmitted . 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 . The Control Period occurs

between Video and Data Island periods .

 Both HDMI and DVI use TMDS to send 10 @-@ bit characters that are encoded using 8b / 10b encoding that differs from the original IBM form 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 . 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 . 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 . Each Data Island Period can contain up to 18 Packets . 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 . 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 ) . The Gamut Metadata Packet carries information on the color space being used for the current video stream and is required for xvYCC .

 = = = = CEC = = = =

 Consumer Electronics Control ( CEC ) is an HDMI feature designed to allow the user to command and control up to 15 CEC @-@ enabled devices , that are connected through HDMI , 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 ) . CEC also allows for individual CEC @-@ enabled devices to command and control each other without user intervention .

 It is a one @-@ wire bidirectional serial bus that is based on the CENELEC standard AV.link protocol to perform remote control functions . CEC wiring is mandatory , although implementation of CEC in a product is optional . 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 ) . USB to CEC adapters exist that allow a computer to control CEC @-@ enabled devices .

 = = = = ARC = = = =

 HDMI 1 @.@ 4 introduces a feature called ARC ( Audio Return Channel ) among other features . Like HEC , the ARC feature uses two pins from the connector : a previously unused pin and the hot plug detect pin .

 ARC is an audio link meant to replace other cables between the TV and the A / V receiver or speaker system . This direction is used when the TV is the one that generates or receives the video stream instead of the other equipment . A typical case is the running of an app on a smart TV such as Netflix , but reproduction of audio is handled by the other equipment . Without ARC , the audio output from the TV needs to be routed by another cable , typically TOS @-@ Link or coax , into the speaker system .

 = = = = HEC = = = =

 HDMI 1 @.@ 4 introduces a feature called HEC ( HDMI Ethernet Channel ) among other features . Like ARC , the HEC feature uses two pins from the connector : a previously unused pin and the hot plug detect pin .

 HDMI Ethernet Channel technology consolidates video , audio , and data streams into a single HDMI cable , and the HEC feature enables IP @-@ based applications over HDMI and provides a bidirectional Ethernet communication at 100 Mbit / s . The physical layer of the Ethernet implementation uses attenuated 100BASE @-@ TX type signals on a single twisted pair for both transmit and receive .

 HEC ( HDMI Ethernet Channel ) and ARC ( Audio Return Channel ) support combined by one port or cable is also sometimes referred to as " HEAC " ( HDMI Ethernet Audio Control ) .

### = = = 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 .

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 allowed 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 ) or the HDMI color encoding is in component color space YCbCr which is not possible in 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 . 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 .

Any DVI @-@ to @-@ HDMI adapter can function as an HDMI @-@ to @-@ DVI adapter ( and vice versa ) . Typically , the only limitation is the gender of the adapter 's connectors and the gender of the cables and sockets it is used with .

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 ) , and some multimedia displays may accept HDMI ( including audio ) over a DVI input . Exact capabilities beyond basic compatibility vary from product to product . Adapters are generally bi @-@ directional .

### = = = = Audio = = = =

Since the DVI specification does not include 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 capable 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 S / PDIF , which provide a baseline audio program ( such as stereo PCM ) . Likewise , when displaying video from an HDMI jack , an HDMI @-@ equipped display may allow alternative 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 were equipped for alternate @-@ audio input when sourcing video from an HDMI input .

Some single @-@ directional active converters exist that can decrypt HDCP and split off audio signal as S / PDIF and / or line @-@ level analog signal , allowing converting DVI @-@ only displays with a HDMI @-@ compatible resolution into a full HDMI display . Because these converters use pass a " clean " and unencrypted HDMI signal , the availability of these converters is usually limited to the professional media production industry .

### = = = Content protection ( HDCP ) = = =

High @-@ bandwidth Digital Content Protection ( HDCP ) is a newer form of digital rights management . Intel created the original technology to make sure that digital content followed the guidelines set by the Digital Content Protection group .

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 . HDCP allows for up to 127 devices to be connected , with up to 7 levels , using a combination of sources , sinks and repeaters . A simple example of this is several HDMI devices connected to an HDMI AV receiver that is connected to an HDMI display .

Devices called HDCP strippers can remove the HDCP information from the video signal so the video can play on non @-@ HDCP @-@ compliant displays , though a fair use and non @-@ disclosure form must usually be signed with a registering agency before use .

= = = 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 .
Type A
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 . There are 19 pins , with bandwidth to carry all SDTV , EDTV and HDTV modes . It is electrically compatible with single @-@ link DVI @-@ D.
Type B
This connector is 21 @.@ 2 mm × 4 @.@ 45 mm and has 29 pins , carrying six differential pairs instead of three , for use with very high @-@ resolution future displays such as WQUXGA ( 3 @,@ 840 × 2 @,@ 400 ) . It is electrically compatible with dual @-@ link DVI @-@ D , but has not yet been used in any products . However , the use of the extra three differential pairs is reserved as of 1 @.@ 3 specification . This sector of market is probably replaced by DisplayPort .
Type C
This Mini connector is smaller than the type A plug , measuring 10 @.@ 42 mm × 2 @.@ 42 mm but has the same 19 @-@ pin configuration . It is intended for portable devices . 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 . The type C Mini connector can be connected to a type A connector using a type A @-@ to @-@ type C cable .
Type D
This Micro connector shrinks the connector size to something resembling a micro @-@ USB connector , measuring only 6 @.@ 4 mm × 2 @.@ 8 mm For comparison , a micro @-@ USB connector is 6 @.@ 85 mm × 1 @.@ 8 mm and a USB Type @-@ A connector is 11 @.@ 5 mm × 4 @.@ 5 mm . It keeps the standard 19 pins of types A and C , but the pin assignment is different from both .
Type E
The Automotive Connection System has a locking tab to keep the cable from vibrating loose and a shell to help prevent moisture and dirt from interfering with the signals . A relay connector is available for connecting standard consumer cables to the automotive type .

= = = 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 . 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 ) . Category 1 HDMI cables are marketed as " Standard " and Category 2 HDMI cables as " High Speed " . This labeling guideline for HDMI cables went into effect on October 17 , 2008 . 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 . A cable of about 5 meters ( 16 feet ) can be manufactured to Category 1 specifications easily and inexpensively by using 28 AWG ( 0 @.@ 081 mm ² ) conductors . With better quality construction and materials , including 24 AWG ( 0 @.@ 205 mm ² ) conductors , an HDMI cable can reach lengths of up to 15 meters ( 49 feet ) . 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 for Category 2 purposes .

As of the HDMI 1 @.@ 4 specification , the following cable types are defined for HDMI in general :

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 ? , 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 . 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 . 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 feet ) ; those based on HDBaseT can extend to 100 meters ; HDMI extenders that are based on dual Category 5 / Category 6 cable can extend HDMI to 250 meters ( 820 feet ) ; while HDMI extenders based on optical fiber can extend HDMI to 300 meters ( 980 feet ) .

= = = Cost = = =

HDMI manufacturers pay an annual fee of US $ 10 @,@ 000 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 . An alternative fee for HDMI manufacturers making fewer than 10 @,@ 000 units per year is an annual fee of $ 5 @,@ 000 with a royalty rate of $ 1 per unit . 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 . For example , an HDMI cable sold directly to consumers is paid for by the cable manufacturer ; however , if the cable manufacturer sells the HDMI cable to a HDTV manufacturer ( who then includes the cable with an HDTV subject to the royalty ) then the HDTV manufacturer pays only the royalty on the HDTV .

= = 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. 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 . 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 " ) . 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 . 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 implements .

= = = Version 1 @.@ 0 = = =

 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 defines up to 3 @.@ 96 Gbit / s of video bandwidth ( 1080p / 60 Hz or UXGA ) and 8 channel LPCM / 192 kHz / 24 @-@ bit audio .

= = = Version 1 @.@ 1 = = =

 HDMI 1 @.@ 1 was released on May 20 , 2004 and added DVD @-@ Audio .

= = = Version 1 @.@ 2 = = =

 HDMI 1 @.@ 2 was released August 8 , 2005 and added the option of 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 implement only the sRGB color space while retaining the option to implement the YCbCr color space , and required HDMI 1 @.@ 2 and later displays to allow low @-@ voltage sources .
 HDMI 1.2a was released on December 14 , 2005 and fully specifies Consumer Electronic Control ( CEC ) features , command sets and CEC compliance tests .

= = = Version 1 @.@ 3 = = =

 HDMI 1 @.@ 3 was released June 22 , 2006 and increased the single @-@ link bandwidth to 340 MHz ( 10 @.@ 2 Gbit / s ) . It optionally allows 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 allows output of Dolby TrueHD and DTS @-@ HD Master Audio streams for external decoding by AV receivers . It incorporates automatic audio syncing ( audio video sync ) capability . 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 . It also added the new type C Mini connector for portable devices .
 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 . 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 . It also added the optional ability to stream SACD in its bitstream DST format rather than uncompressed raw DSD like from HDMI 1 @.@ 2 onwards .
 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 , but only describe testing for products based on the HDMI 1.3a specification regarding HDMI compliance ( 1.3b ) , the HDMI type C Mini connector ( 1.3b1 ) and active HDMI cables ( 1.3c ) .

= = = 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 . HDMI 1 @.@ 4 increases the maximum resolution to 4K × 2K , i.e. 4096 × 2160 at 24 Hz ( which is a resolution used with digital theaters ) or 3840 × 2160 ( Ultra HD ) at 24 Hz / 25 Hz / 30 Hz ; adds 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 ; and introduces an audio return channel ( ARC ) , 3D Over HDMI , a new Micro HDMI Connector , expanded set of color spaces , with the addition of sYCC601 , Adobe RGB and Adobe YCC601 ; and an Automotive Connection System . HDMI 1 @.@ 4 defines 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 ) , with additional top / bottom formats added in version 1.4a. HDMI 1 @.@ 4 requires that 3D displays implement the frame packing 3D format at either 720p50 and 1080p24 or 720p60 and 1080p24 . High Speed HDMI 1 @.@ 3 cables work with all HDMI 1 @.@ 4 features except for the HDMI Ethernet Channel .

 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 . HDMI 1.4a has defined mandatory 3D formats for broadcast , game , and movie content . HDMI 1.4a requires that 3D displays implement 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 .

 HDMI 1.4b was released on October 11 , 2011 . One of the new features is that it adds the ability to carry 3D 1080p video at 120 Hz ? allowing frame packing 3D format at 1080p60 per Eye ( 120 Hz total ) . All future versions of the HDMI specification will be made by the HDMI Forum that was created on October 25 , 2011 .

 = = = Version 2 @.@ 0 = = =

 HDMI 2 @.@ 0 , referred to by some manufacturers as HDMI UHD , was released on September 4 , 2013 .
 HDMI 2 @.@ 0 increases the maximum TMDS per channel throughput from 3 @.@ 4 Gbit / s to 6 Gbit / s which allows for a maximum total TMDS throughput of 18 Gbit / s . This enables HDMI 2 @.@ 0 to carry 4K resolution at 60 frames per second ( fps ) . Other features of HDMI 2 @.@ 0 include the options of the Rec . 2020 color space , Dual View , 4 : 2 : 0 chroma subsampling , 25 fps 3D formats , up to 4 audio streams , 21 : 9 aspect ratio , the HE @-@ AAC and DRA audio standards , dynamic auto lip @-@ sync , improved 3D capability , and additional CEC functions .
 HDMI 2.0a was released on April 8 , 2015 and added support for high dynamic range ( HDR ) video .
 Version 2 @.@ 1
 HDMI 2 @.@ 1 adds support for " dynamic metadata , " according to a white paper written by Philips .
 In short : " HDMI 2.0a covers HDR EOTF signaling and static metadata . Dynamic metadata is to be covered in HDMI 2 @.@ 1 . "
 There has yet to be an important feature that HDMI can support the teletext and closed captioning to extend their columns from 32 to 60 in order to mainstream the 21 : 9 aspect ratio in the future .

 = = = 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 are optional .

 = = 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 . This capability allows for an AV receiver with the necessary decoder to decode the compressed audio stream . The Blu @-@ ray specification does not include video encoded with either deep color or xvYCC ; thus , HDMI 1 @.@ 0 can transfer Blu @-@ ray discs at full video quality .
The HDMI 1 @.@ 4 specification ( released in 2009 ) added support for 3D video and is used by all Blu @-@ ray 3D compatible players .
The Blu @-@ ray Disc Association ( BDA ) spokespersons have stated ( Sept . 2014 at IFA show in Berlin , Germany ) that the Blu @-@ ray , 4K / Ultra HD players , and UHD discs are expected to be available starting in the second half to 2015 . It is anticipated that such Blu @-@ ray UHD players will be required to include a HDMI 2 @.@ 0 output supporting HDCP 2 @.@ 2 .
Blu @-@ ray permits secondary audio decoding , whereby the disc content can tell the player to mix multiple audio sources together before final output . 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 implements multichannel LPCM audio over HDMI and implements 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 allow audio processing over HDMI and are labelled as " HDMI pass through " devices . [ 10 / 2014 Update ] Virtually all modern AV Receivers now offer HDMI 1 @.@ 4 inputs and output ( s ) with processing for all of the audio formats offered by Blu @-@ ray Discs and other HD video sources . During 2014 several manufacturers introduced premium AV Receivers that include one , or multiple , HDMI 2 @.@ 0 inputs along with a HDMI 2 @.@ 0 output ( s ) . However , it was not until 2015 that most major manufacturers of AV receivers also included support for HDCP 2 @.@ 2 as will be needed to support certain high quality 4K / UHD video sources , such as the upcoming Blu @-@ ray 4K / UHD players .

### = = = 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 ) .
As of 2014 , some cameras also have 4K capability and 3D , even some cameras costing less than $ 900 . It needs at least a TV / monitor with HDMI 1.4a port .

### = = = Personal computers = = =

PCs with a DVI interface are capable of video output to an HDMI @-@ enabled monitor . Some PCs include an HDMI interface and may also be capable of HDMI audio output , depending on specific hardware . 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 . 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 implemented by other video cards in the ATI Radeon HD 4000 series . Linux can drive 8 @-@ channel LPCM audio over HDMI if the video card has the necessary hardware and implements the Advanced Linux Sound Architecture ( ALSA ) . The ATI Radeon HD 4000 series implements ALSA . Cyberlink announced in June 2008 that they would update their PowerDVD playback software to allow 192 kHz / 24 @-@ bit Blu @-@ ray Disc audio decoding in Q3 @-@ Q4 of 2008 . Corel 's WinDVD 9 Plus currently has 96 kHz / 24 @-@ bit Blu @-@ ray Disc audio decoding .
Even with an HDMI output , a computer may not be able to produce signals that implement HDCP , Microsoft 's Protected Video Path , or Microsoft 's Protected Audio Path . Several early graphic

cards were labelled as " HDCP @-@ enabled " but did not have the hardware needed for HDCP ; this included some graphic cards based on the ATI X1600 chipset and certain models of the NVIDIA Geforce 7900 series . The first computer monitors that could process HDCP were released in 2005 ; by February 2006 a dozen different models had been released . The Protected Video Path was enabled in graphic cards that had HDCP capability , since it was required for output of Blu @-@ ray Disc video . In comparison , the Protected Audio Path was required only if a lossless audio bitstream ( such as Dolby TrueHD or DTS @-@ HD MA ) was output . 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 . A limitation is that if the computer does not implement a Protected Audio Path , the audio must be downsampled to 16 @-@ bit 48 kHz but can still output at up to 8 channels . No graphic cards were released in 2008 that implemented the Protected Audio Path .

The Asus Xonar HDAV1.3 became the first HDMI sound card that implemented 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 . It has an HDMI 1 @.@ 3 input / output , and Asus says that it can work with most video cards on the market .

In September 2009 , AMD announced the ATI Radeon HD 5000 series video cards , which have HDMI 1 @.@ 3 output ( deep color , xvYCC wide gamut capability and high bit rate audio ) , 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 . The ATI Radeon HD 5870 released in September 2009 is the first video card that allows bitstream output over HDMI for Dolby TrueHD and DTS @-@ HD Master Audio . The AMD Radeon HD 6000 Series implements HDMI 1.4a. The AMD Radeon HD 7000 Series implements HDMI 1.4b.

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 ( actually , FPD @-@ Link ) from 2013 and legacy DVI and VGA connectors from 2015 , replacing them with DisplayPort and HDMI .

On August 27 , 2012 , Asus announced a new 27 in ( 69 cm ) monitor which can produce its native resolution of 2560 × 1440 via HDMI 1 @.@ 4 .

On September 18 , 2014 , Nvidia launched GeForce GTX 980 and GTX 970 ( with GM204 chip ) with HDMI 2 @.@ 0 support . On January 22 , 2015 , GeForce GTX 960 ( with GM206 chip ) launched with HDMI 2 @.@ 0 support . On March 17 , 2015 , GeForce GTX TITAN X ( GM200 ) launched with HDMI 2 @.@ 0 support . On June 1 , 2015 , GeForce GTX 980 Ti ( with GM200 chip ) launched with HDMI 2 @.@ 0 support . On August 20 , 2015 , GeForce GTX 950 ( with GM206 chip ) launched with HDMI 2 @.@ 0 support .

On May 6 , 2016 , Nvidia launched the GeForce GTX 1080 ( GP104 GPU ) with HDMI 2.0b support .

=== Tablet computers ===

Some Tablet computers , such as the Microsoft Surface , Motorola Xoom , BlackBerry PlayBook , Vizio Vtab 1008 and Acer Iconia Tab A500 , implement HDMI using Micro @-@ HDMI ( Type D ) ports . Others , such as the ASUS Eee Pad Transformer implement the standard using Mini @-@ HDMI ( Type C ) ports . All iPad models 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 provide HDMI output using a Mini @-@ HDMI ( Type C ) port . Most new laptops and desktops now have built in HDMI as well .

=== Mobile phones ===

Many recent mobile phones can produce output of HDMI video via either a micro @-@ HDMI connector or MHL output .

= = = Legacy compatibility = = =

HDMI can only be used with older analog @-@ only devices ( using connections such as SCART , VGA , RCA , etc . ) by means of a digital @-@ to @-@ analog converter or AV receiver , as the interface does not carry any analog signals ( unlike DVI , where devices with DVI @-@ I ports accept or provide either digital or analog signals ) . Cables are available that contain the necessary electronics , but it is important to distinguish these active converter cables from passive HDMI to VGA cables ( which are typically cheaper as they don 't include any electronics ) . The passive cables are only useful if you have a device that is generating or expecting HDMI signals on a VGA connector , or VGA signals on an HDMI connector ; this is a non @-@ standard feature , not implemented by most devices .

= = Relationship with DisplayPort = =

Another audio / video interface is DisplayPort , version 1 @.@ 0 , which was approved in May 2006 . Several models of display , computer , and video cards have DisplayPort ports . The DisplayPort website states that DisplayPort is expected to complement HDMI . Most of the companies producing equipment that uses DisplayPort are in the computer sector . DisplayPort uses a self @-@ clocking , micro @-@ packet @-@ based protocol that allows for a variable number of differential lanes as well as flexible allocation of bandwidth between audio and video , and allows encapsulating multichannel compressed audio formats in the audio stream . DisplayPort ports can be made so that they are compatible with single @-@ link DVI and HDMI 1 @.@ 4 . Compatibility is achieved with DisplayPort Dual @-@ mode ports , which are marked with the + + DP logo , using attached passive adapters ; powered active adapters allow signal conversion to dual @-@ link DVI and analog VGA .
DisplayPort has a royalty rate of $ 0 @.@ 20 per unit ( from patents licensed by MPEG LA ) while HDMI has an annual fee of $ 10 @,@ 000 and a per unit royalty rate of between $ 0 @.@ 15 and $ 0 @.@ 04 . 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 the ability to use 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 .
HDMI has a few advantages over DisplayPort , such as ability to carry Consumer Electronics Control ( CEC ) signals , and electrical compatibility with DVI ( though practically limited to single @-@ link DVI rates ) . More importantly , HDMI can sustain full bandwidth for up to 10 meters of cable length , while DisplayPort can carry full bandwidth for up to 3 meters only .

= = 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 developed by the MHL Consortium , a consortium of manufacturers of mobile electronics , several of which are also behind HDMI .
MHL features include :
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 @.@ 5 m long .
HDMI @-@ CEC capability .

Video resolution limited to 1080p uncompressed 4 : 2 : 2 HD video ( PacketVideo ) or 720p 4 : 4 : 4 HD video . MHL 2 @.@ 0 provides for 1080p at 60 Hz .

8 channel ( e.g. , 7 @.@ 1 surround sound ) uncompressed audio .

Allows 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 .

The superMHL specification was announced on January 6 , 2015 . SuperMHL supports higher video resolution and frame rates , additional audio formats and 40W of power charging , along with a new reversible connector .

Features of superMHL include :

Up to 8K 120fps video .

Up to 48 @-@ bit color depth .

Wider color gamut .

High @-@ Dynamic Range ( HDR ) support .

Support for Dolby Atmos ® , DTS : X , 3D audio , and an audio @-@ only mode .

Ability to link multiple MHL devices together ( TV , AVR , Blu @-@ ray player ) and control them via one remote .

Power charging up to 40W .

Ability to send content to multiple displays .

Reversible superMHL connector .

Support for the MHL Alt Mode for the USB Type @-@ C specification .