High-Definition Multimedia Interface

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(Redirected from Hdmi)

The **High-Definition Multimedia Interface** (**HDMI**) is a compact audio/video interface for transmitting uncompressed digital data.[1] It represents a digital alternative to consumer analog standards such as Radio Frequency (RF) coaxial cable, composite video, S-Video, SCART, component video, D-Terminal, and VGA. HDMI connects digital audio/video sources such as set-top boxes, Blu-ray Disc players, personal computers (PCs), video game consoles, and AV receivers to compatible digital audio devices, computer monitors, and digital televisions.[1]

HDMI supports, on a single cable, any TV or PC video format including standard, enhanced, and high-definition video along with up to 8 channels of digital audio.[2] It is independent of the various digital television standards 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).

HDMI products started shipping in autumn 2003.[3] Over 800 Consumer Electronics (CE) and PC companies have adopted the HDMI specification (HDMI Adopters).[4][5] In Europe, either DVI-HDCP or HDMI is included in the HD ready in-store labelling 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.[6][7][8][9][10] Shipments of HDMI are expected to exceed that of Digital Visual Interface (DVI) in 2008, driven primarily by the CE market.[11][12]

High-Definition Multimedia Interface

HDMI cable and HDMI official logo

Type	Digital audio/video connector	
	Production history	
Designer	HDMI Founders	
Designed	December 2002	
Manufacturer	HDMI Adopters	
Produced	2003-Present	
	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 TrueHD, DTS-HD Master Audio, MPCM	
Video signal	480i, 480p, 576i, 576p, 720p, 1080i, 1080p, 1440p, 1600p, etc.	
Data signal	Yes	
	Bandwidth	10.2 Gbit/s (340 MHz)
	Protocol	TMDS
Pins	19	

Pin out

Type A (Female) 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 (N.C. on device)
Pin 15	SCL
Pin 16	SDA
Pin 17	DDC/CEC Ground
Pin 18	+5 V Power (max 50 mA)
Pin 19	Hot Plug Detect

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Overview

HDMI supports, on a single cable, any TV or PC video format including standard, enhanced, and high-definition video along with up to 8 channels of digital audio.[2] HDMI encodes the video data into TMDS for uncompressed digital transmission over HDMI.

HDMI devices are manufactured to adhere to various versions of the specification, where each version is given a number such as 1.0, 1.2, or 1.3a.[13] 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.[13] For example the previous maximum pixel clock rate of HDMI interface was 165 MHz which was sufficient for supporting 1080p at 60 Hz and WUXGA (1920x1200) at 60 Hz. HDMI 1.3 increased that to 340 MHz which allows for higher resolution, such as WQXGA (2560x1600), across a single digital link.[14] 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]

HDMI 1.0 to HDMI 1.2a uses the CEA-861-B video standard and HDMI 1.3+ uses the CEA-861-D video standard.[13] The CEA-861-D document defines the video timing requirements, discovery structures, and data transfer structure.[15] The color spaces that can be used by HDMI are ITU-R BT.601, ITU-R BT.709-5, and IEC 61966-2-4.[16] HDMI can encode the video in xvYCC 4:4:4 (8–16 bits per component), sRGB 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).[16][17]

HDMI supports up to 8 channels of 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.[18][19] HDMI also supports any IEC61937-compliant compressed audio stream such as Dolby Digital and DTS and up to 8 channels of one-bit DSD audio, which is used on Super Audio CDs, at rates up to 4x that of Super Audio CD.[18] With version 1.3, HDMI supports lossless compressed audio streams Dolby TrueHD and DTS-HD Master Audio.[18]

In the U.S., HDCP
(High-bandwidth Digital Content Protection) support is a standard feature on digital TVs while in the PC industry it can depend on the specific model. The first computer monitors with HDCP support started being released in 2005 and by February 2006 a dozen different models had been released.[20][21]

History

The HDMI Founders are Hitachi, Matsushita Electric Industrial (Panasonic/National/Quasar), Philips, Silicon Image, Sony, Thomson (RCA), and Toshiba.[5] Digital Content Protection, LLC provides HDCP (which was developed by Intel) for HDMI.[22] 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 backward compatible with DVI.[23][24][25] At that time DVI-HDCP (DVI with HDCP) and DVI-HDTV (DVI-HDCP using the CEA-861-B video standard) were being used on HDTVs.[25][19][26] HDMI 1.0 was designed to improve on DVI-HDTV by using a smaller connector and adding support for audio, enhanced support for YCbCr, and CE control functions.[25][19][27][28]

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.[29][30][11] HDMI is becoming the de facto standard for HDTVs and according to In-Stat around 90% of digital televisions in 2007 included HDMI.[11][31][32][33][34][35] In-Stat has estimated that 229 million HDMI devices will sell in 2008.[36]

In 2008 PC Magazine awarded HDMI the 25th Annual Technical Excellence Awards in the Home Theater category for an innovation that has changed the world.[37] Ten companies will be given a Technology and Engineering Emmy Award for their development of HDMI by the National Academy of Television Arts and Sciences (NATAS) on January 7, 2009.[38][39]

Specifications

The HDMI specification defines the protocols, signals, electrical interfaces, and mechanical requirements of the standard.[40]

Connectors

HDMI Type A socket

There are three HDMI connector types with Type A and Type B defined since the HDMI 1.0 specification and Type C defined since the HDMI 1.3 specification.

The Type A connector has 19 pins with bandwidth to support all SDTV, EDTV, and HDTV modes.[2] The plug's outside dimensions are 13.9 mm wide by 4.45 mm high.[41] Type A is electrically compatible with single link DVI-D.[42]

The Type B connector has 29 pins (21.2 mm by 4.45 mm) and can carry double the video bandwidth of Type A for use with very high-resolution future displays such as WQUXGA (3840x2400).[43][42] Type B is electrically compatible with dual link DVI-D but has not yet been used in any products.[42][44]

The Type C mini-connector is intended for portable devices.[45] It is smaller than the Type A connector (10.42 mm by 2.42 mm) but has the same 19 pin configuration.[46][45] It can be connected to a Type A connector using a Type A-to-Type C connector cable.[45]

Cable

The HDMI cable can be used to carry video, audio, and device-controlling signals (CEC). HDMI cables are often more expensive than other video cables at retail stores.[47] However, many on-line retailers and auction sites offer HDMI cables at prices similar to coaxial and RCA cabling.[47]

Cable length

The HDMI specification does not define a maximum cable length, but because of signal attenuation there is an upper limit to how long HDMI cables can be made.[48] The length of the HDMI cable made depends on the construction quality and materials that were used.[48] The signal attenuation and intersymbol interference which is caused by long cables can be compensated by using adaptive equalization.

HDMI 1.3 has defined two categories of cables: Category 1 certified cables which have been tested at 74.5 MHz (1080i/720p) and Category 2 certified cables which have been tested at 340 MHz (1600p) to reduce the confusion about which cables support which video formats.[49] A Category 1 HDMI cable will be marketed as a "Standard

HDMI cable" and a Category 2 HDMI cable will be marketed as a "High Speed HDMI cable".[1] This labeling guideline for HDMI cables went into effect on October 17, 2008.[50][51]
Category 1 and 2 cables can either meet the required parameter specifications for inter-pair skew, far-end crosstalk, attenuation, and differential impedance or they can meet the required non-equalized/equalized eye diagram requirements.[49]
A cheaply made cable of about 5 meters (16 ft) can be manufactured to Category 1 specifications using 28 AWG conductors.[48] With better quality construction and materials (24 AWG conductors) an HDMI cable can reach lengths of up to 15 meters (49 ft).[48] The HDMI website has stated that many HDMI cables under 5 meters of length that were made before the HDMI 1.3 specification can work as a Category 2 cable but cautions that only Category 2 tested cables are guaranteed to work.[52] Long cable lengths can cause instability of HDCP and blinking on the screen due to the weakened DDC signal which 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.[53][54] 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).[55] HDMI extenders that are based on dual Category 5/Category 6 cable can extend HDMI to 50 meters (164 ft) while HDMI extenders based on optical fiber can extend HDMI to 100+ meters (328 ft).[48][55]

DDC

The Display Data Channel is a communication channel based on the I²C bus specification.[56][57] 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.[56][57][58] 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).[59] HDMI has 3 separate communication channels which are the DDC, TMDS, and the optional CEC.[58]

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.[60] During the Video Data Period, the pixels of an active video line are transmitted.[60] 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.[60] The Control Period occurs between Video and Data Island periods.[60]

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/auxiliary data using 4b/10b encoding for the Data Island Period.[60] 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.[61] 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.[62] Each Data Island Period can contain up to 18 Packets.[63] 7 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.[61] 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).[64][65] The Gamut Metadata Packet carries information on the color space being used for the current video stream and is required for xvYCC.[66][67][68]

Consumer Electronics Control

Consumer Electronics Control (CEC) wiring is mandatory although implementation of CEC in a product is optional.[69] CEC uses the industry standard AV Link protocol, is used for remote control functions, is a one-wire bidirectional serial
bus, and was defined in HDMI Specification 1.0 and updated in HDMI 1.2, HDMI 1.2a, and HDMI 1.3a (added timer and audio commands).[70][71][72][73] The CEC feature is used to allow the user to command and control multiple CEC-enabled boxes with one remote control and for individual CEC-enabled devices to command and control each other without user intervention.[71]

Alternative names for CEC are Anynet (Samsung), Aquos Link (Sharp), BRAVIA Theatre Sync (Sony), Kuro Link (Pioneer), CE-Link and Regza Link (Toshiba), RIHD (Remote Interactive over HDMI) (Onkyo), Simplink (LG), HDAVI Control, EZ-Sync and VIERA Link (Panasonic), EasyLink (Philips), and NetCommand for HDMI (Mitsubishi).[74][75][76][77][78][79][80][81][82][83][84][85]

Compatibility with DVI

DVI-HDMI Adapter

HDMI-DVI Adapter

A DVI signal is electrically compatible with an HDMI video signal; no signal conversion needs to take place when an adapter is used, and consequently no loss in video quality occurs.[86] As such HDMI is backward compatible with Digital Visual Interface digital video (DVI-D or DVI-I, but not DVI-A) as used on modern computer monitors and graphics cards. This means that a DVI-D source can drive an HDMI monitor, or vice versa, by means of a suitable adapter or cable. However, the audio and remote-control features of HDMI will not be available.[86] Additionally, not all devices with DVI input support High-bandwidth Digital Content Protection (HDCP). Without such support by the device, an HDCP-enabled signal source will suppress output and so prevent the device from receiving HDCP-protected content.[87]

HDCP

HDMI can use HDCP to encrypt the signal if required by the source device. CSS, CPPM, and AACS requires the use of HDCP on HDMI when playing back encrypted DVD-Video, DVD-Audio, 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 which implements HDCP must do so in a fully-compliant manner. HDCP testing which was previously only a requirement for optional tests such as the “Simplay HD” testing program is now part of the requirements for HDMI compliance.[88][89][90]
HDCP allows for up to 127 devices to be connected together with up to 7 levels using a combination of sources, sinks, and repeaters.[91] A simple example of this is several HDMI devices connected to an HDMI AV receiver that is connected to an HDMI display.[91]

There are devices called HDCP strippers which can remove the HDCP information from the video signal and allows the video to be playable on non-HDCP compliant displays.[92] An example of an HDCP stripper for HDMI is the HDfury2 which can convert the video to VGA or component video and the audio to stereo analog or digital TOSLINK.[93][94]

Versions

HDMI devices are manufactured to adhere to various versions of the specification, where each version is given a number such as 1.0, 1.2, or 1.3a.[13] 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.[13] 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").[95][96]

HDMI 1.0 was released December 9, 2002 and is a single cable digital audio/video connector interface with a maximum TMDS bandwidth of 4.9 Gbit/s. It supports up to 3.96 Gbit/s of video bandwidth (1080p60 Hz or UXGA) and 8 channel LPCM/192 kHz/24-bit audio.[13] HDMI 1.1 was released on May 20, 2004 and added support for DVD Audio.[13] 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 connector for PC sources, the ability for PC sources to use native 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.[13] HDMI 1.2a was released on December 14, 2005 and fully specifies Consumer Electronic Control (CEC) features, command sets, and CEC compliance tests.[13]

HDMI 1.3 was released June 22, 2006 and increased the single-link bandwidth to 340 MHz (10.2 Gbit/s).[13][14][97] 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 optionally supports output of Dolby TrueHD and DTS-HD Master Audio streams for external decoding by AV receivers.[98] 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 cable being tested up to 340 MHz. It also added the new Type C mini-connector for portable devices.[45][99]
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.[13] It also changed CEC capacitance limits, clarified sRGB video quantization range clarification, and CEC commands for timer control brought back in an altered form, audio control commands added.[13] HDMI 1.3b was released on March 26, 2007 and added HDMI compliance testing revisions.[100][90][101] HDMI 1.3b has no effect on HDMI features, functions, or performance since the testing is for products based on the HDMI 1.3a specification.[102]
HDMI 1.3b1 was released on November 9, 2007 and added HDMI compliance testing revisions which added testing requirements for HDMI Type C mini-connector.[100][90][101]
HDMI 1.3b1 has no effect on HDMI features, functions, or performance since the testing is for products based on the HDMI 1.3a specification.[102] HDMI 1.3c was released on August 25, 2008 and added HDMI compliance testing revisions which changed testing requirements for active HDMI cables.[103][55] HDMI 1.3c has no effect on HDMI features, functions, or performance since the testing is for products based on the HDMI 1.3a specification.[102]

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.[95]

HDMI version	1.0–1.2a	1.3+
Maximum signal bandwidth (MHz)	165	340
Maximum TMDS bandwidth (Gbit/s)	4.95	10.2
Maximum video bandwidth (Gbit/s)	3.96	8.16
Maximum audio bandwidth (Mbit/s)	36.86	36.86
Maximum Color Depth (bit/px)	24	48[A]
Maximum resolution over single link at 24-bit/px[B]	1920×1200p60	2560×1600p75
Maximum resolution over single link at 30-bit/px[C]	N/A	2560×1600p60
Maximum resolution over single link at 36-bit/px[D]	N/A	1920x1200p75
Maximum resolution over single link at 48-bit/px[E]	N/A	1920×1200p60

HDMI version	1.0	1.1	1.2 1.2a	1.3	1.3a 1.3b 1.3b1 1.3c
sRGB	✓	✓	✓	✓	✓
YCbCr	✓	✓	✓	✓	✓
8 channel LPCM/192 kHz/24-bit audio capability	✓	✓	✓	✓	✓
Blu-ray Disc video and audio at full resolution[F]	✓	✓	✓	✓	✓
Consumer Electronic Control (CEC)[G]	✓	✓	✓	✓	✓
DVD-Audio support	✗	✓	✓	✓	✓
Super Audio CD (DSD) support[H]	✗	✗	✓	✓	✓

Deep Color	✗	✗	✗	✓	✓
xvYCC	✗	✗	✗	✓	✓
Auto lip-sync	✗	✗	✗	✓	✓
Dolby TrueHD bitstream capable	✗	✗	✗	✓	✓
DTS-HD Master Audio bitstream capable	✗	✗	✗	✓	✓
Updated list of CEC commands[I]	✗	✗	✗	✗	✓

A 36-bit support is mandatory for Deep Color compatible CE devices with 48-bit support being optional.[104]
B Maximum resolution is based on CVT-RB blanking which is a VESA standard for non-CRT based displays.[105] Using CVT-RB blanking 1920x1200 would have a video bandwidth of 3.69 Gbit/s and 2560x1600 would have a video bandwidth of 8.12 Gbit/s.[106]
C Using CVT-RB blanking would have a video bandwidth of 8.12 Gbit/s.[106]
D Using CVT-RB blanking would have a video bandwidth of 7.91 Gbit/s.[106]
E Using CVT-RB blanking would have a video bandwidth of 7.39 Gbit/s.[106]
F Even for a compressed audio codec that a given HDMI version can not 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 CE products with HDMI version 1.3a.[107][108]
H Playback of SACD may be possible for older HDMI versions if the source device (such as the Oppo 970) converts to LPCM.[109]
I Large number of additions and clarifications for CEC commands. One addition is CEC command allowing for volume control of an AV receiver.[73]

Relationship with Blu-ray Disc players

Blu-ray Disc, introduced in 2006, offers new high-fidelity audio features that require HDMI for best results. Dolby Digital Plus, Dolby TrueHD, and DTS-HD Master Audio use bitrates exceeding S/PDIF's capacity.[110] HDMI 1.3 can transport Dolby Digital Plus, TrueHD, and DTS-HD bitstreams in compressed form.[18] This capability allows for an AV receiver with the necessary decoder to decode the compressed audio stream.

Blu-ray permits secondary audio decoding whereby the disc content can tell the player to mix multiple audio sources together before final output.[111] Some Blu-ray players can decode all of the audio codecs internally and can output LPCM audio over HDMI. Multi-channel LPCM can be transported over an HDMI connection and as long as the AV receiver supports multi-channel 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.[112][113]

Relationship with DisplayPort

Another audio/video interface is DisplayPort, which had version 1.0 approved in May 2006 and is supported in several computer monitors. The DisplayPort website states that DisplayPort is expected to complement HDMI.[114]

There are a few advantages that HDMI has over DisplayPort such as support for the xvYCC color space, Dolby TrueHD and DTS-HD Master Audio bitstream support, CE control signals, and compatibility with DVI.[115][116]
DisplayPort has an advantage that it is currently royalty free which might allow it to be cheaper to implement while the HDMI royalty is 4 cents per device and an annual fee for high volume manufacturers.[117] Most of the DisplayPort supporters
are computer companies such as Dell which has released several computer monitors that support both DisplayPort and HDMI.[118][119] Apple Inc. has announced a display and several laptops that support Mini DisplayPort which is also compatible with DVI and VGA.[120][121][122][123][124]

Relationship with personal computers

PCs with HDMI output using Windows Vista and Windows XP may be capable of HDMI audio output depending on specific hardware.[125] For example Intel's motherboard chipsets since the 945G have been capable of 8 channel LPCM output over HDMI as well as NVIDIA's GeForce 8200/8300 motherboard chipsets.[125][126] 8 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.[126][127][128][129][130] 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).[131] The ATI Radeon HD 4000 series supports ALSA.[131][132]

At WinHEC 2008 Microsoft announced that color depths of 30-bit and 48-bit would be supported in Windows 7 along with the wide color gamut scRGB (which can be converted and output as xvYCC). The video modes supported in Windows 7 are 16-bit sRGB, 24-bit sRGB, 30-bit sRGB, 30-bit with extended color gamut sRGB, and 48-bit scRGB.[133][134]

See also

- Deep Color
- Digital Visual Interface
- DisplayPort
- HD ready
- HDMI Extender
- List of display interfaces
- xvYCC

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