Introduction to HDCP 2.2

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white paper

Abstract

The availability of entertainment content is a key driver of growth for the emerging 4K video ecosystem. As in the early days of digital HD, HDCP will be the copy protection system used by content owners to encrypt 4K video. Most uncompressed 4K video entertainment content will be transported over HDMI 2.0, which is capable of 4K/UHD resolution, high color gamut, and high color bit depth. Keeping pace with advancements in digital video technology, HDCP has evolved to version 2.2, with stronger encryption, dedicated protection for high value 4K content, and new restrictions on the AV distribution system. AV professionals will need to understand HDCP 2.2 to integrate protected 4K content into AV systems successfully.

4K Video and HDMI 2.0

4K offers potential to deliver video signals that provide a more vivid, lifelike viewing experience, with features such as expanded color palettes, brighter, more detailed images, and high frame rates. The HDMI 2.0 standard gives the ability to support material with all of these elements combined. Subsequently, many AV equipment manufacturers are incorporating HDCP 2.2 into their products to protect high-value 4K content.

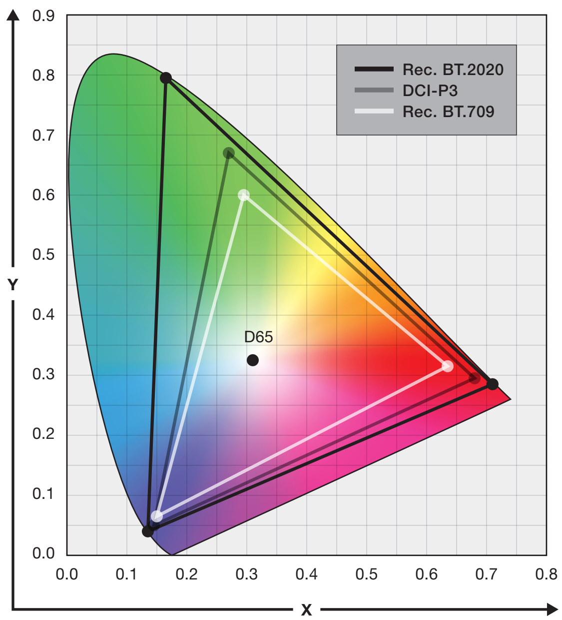


Figure 1: Color Gamut Comparison

Expanded Color Gamut – ITU-R BT.2020

With support for Rec. BT.2020, 4K content and displays have the potential to present imagery with dramatically wider color representation than traditional high-definition video, as shown in Figure 1. This will have just as much impact on the viewing experience as 4K's increased resolution, and potentially even more so on smaller screens where the advantages of increased resolution is less pronounced.

Bandwidth – Data Rate

Due to the high bandwidth requirements of 4K signals, video interfaces must support very high data rates. The HDMI 2.0 specification, released in September 2013, increases the maximum data rate to 18.0 Gbps for sending a 4K signal with a 60 Hz frame rate over a single HDMI cable at 8-bit color or up to 30 Hz with 10-bit color. HDMI 2.0 also supports 4:2:0 chroma subsampling. This enables a 4K signal with a 60 Hz frame rate, 8-bit color depth, and 4:2:0 chroma subsampling to be sent at the same data rate as a 4K 30 Hz signal with 8-bit color and 4:4:4 chroma sampling, as shown in Table 1.

High Dynamic Range

HDR is another integral part of the 4K format. The dynamic range of a video signal is the difference between the darkest black and brightest white that can be produced. Major manufacturers have announced that their upcoming displays will be capable of displaying HDR content. It is estimated that HDR encoded content will require 20% additional bandwidth compared to non-HDR content.

Data Rate Required for Video Signals					
Resolution	Frame Rate	Chroma Sampling	Pixel Clock	8-bit Color	10-bit Color
1080p/2K	60 Hz	4:4:4	148.5 MHz	4.46 Gbps	5.57 Gbps
4K/UHD	30 Hz	4:4:4	297.00 MHz	8.91 Gbps	11.14 Gbps
4K/UHD	60 Hz	4:2:0	594.00 MHz	8.91 Gbps	11.14 Gbps
4K/UHD	60 Hz	4:4:4	594.00 MHz	17.82 Gbps	22.28 Gbps

Table 1: Data Rate Requirements for Video Signals

HDCP Versions and What They Do

Since its introduction in 2000, HDCP copy protection for digital video interfaces, such as DVI, HDMI, and DisplayPort, has been universally adopted. It is used in consumer and commercial AV equipment such as flat panel displays, projectors, PCs, tablets, media players, switchers, distribution amplifiers, and many other product types. Besides adding references to DisplayPort in HDCP 1.3, there is very little operational difference between HDCP versions 1.0 to 1.4; so they will be referred to as HDCP 1.x henceforth.

Intended as copy protection for consumer-level entertainment content, HDCP 1.x imposes restrictions on the video distribution network, such that all equipment in the video signal chain from the source to the display must be HDCP-compliant for successful display of protected content. The source will only transmit video once it determines that all downstream sinks and repeaters are HDCP compliant, and that there are fewer than 128 total downstream sinks and less than 7 levels of repeaters. Any time there is a break in the video transmission, the entire authentication procedure needs to be repeated.

HDCP 2.0 was released in 2008 to strengthen encryption and be applicable to any digital interface, including Ethernet, wireless, or compressed formats. HDCP 2.0 employs a completely different encryption scheme from HDCP 1.x, replacing the specialized 56-bit HDCP 1.x encryption scheme with two standard algorithms from the data security industry: an RSA - Rivest-Shamir-Adleman cryptosystem with 1024 and 3072-bit keys for authentication and a 128-bit AES - Advanced Encryption System for content encryption. The maximum size of any HDCP 2.0 video distribution network is reduced to 32 sinks and 4 levels of repeaters. To block distribution of protected video over a wide area, HDCP 2.0 has a locality check mechanism where sinks must respond to cryptographic challenges from the video source within 7 ms.

HDCP 2.0 was not widely implemented in general HDMI products. Due to changes in encryption schemes and downstream distribution restrictions, HDCP 2.0 is not natively compatible with HDCP 1.x. To retain backward compatibility, the HDCP 2.0 specification describes the operation of HDCP 1.x converters. HDCP 2.0 found wide adoption in wireless video products, where the wireless interface is encrypted using HDCP 2.0, while the wired local video connectors retain HDCP 1.x.

With 4K content on the horizon, HDCP 2.1 was introduced in 2011 with all the enhanced security features of HDCP 2.0, while adding a mechanism called the Content Stream Type to restrict transmission of high value content. When video content is identified as high value using this mechanism, it is not allowed to be transmitted to any downstream sinks that support HDCP versions lower than 2.1.

HDCP 2.2 is the most recent release that was introduced in 2012 and strengthened some procedures in the HDCP 2.1 security protocol. A dedicated specification for mapping HDCP 2.2 to HDMI was released in 2013. Its high value content protection mechanism is well suited for the anticipated growth of the 4K video ecosystem. The sustained expansion of 4K video will require entertainment content to drive demand, and owners of 4K content rights will require enhanced copy protection. HDCP 2.2 will have opportunity for wide adoption in the new generation of 4K AV equipment such as 4K Blu-ray and media players, displays, and switching equipment.

Summary of Differences Between HDCP Versions

	HDCP 1.x	HDCP 2.0	HDCP 2.1/HDCP 2.2
Encryption Method	Specialized 56-bit symmetric system used for both authentication and video encryption	Authentication: Industry standard RSA 1024 and 3072-bit asymmetric system Video encryption: Industry standard AES symmetric 128-bit system	Authentication: Industry standard RSA 1024 and 3072-bit asymmetric system Video encryption: Industry standard AES symmetric 128-bit system
Applicable interfaces	DVI, HDMI, DisplayPort	Any 2-way digital interface	Any 2-way digital interface
Maximum downstream receivers for each transmitter	≤128	≤32	≤32
Maximum repeater levels for each transmitter	≤7	≤4	≤4
Backward Compatibility	All versions of HDCP 1.x are compatible with each other	Specification defines conversion mechanism for interfacing with HDCP 1.x	Specification defines conversion mechanism for interfacing with HDCP 1.x
Wireless/Network Support	Not specified	Explicitly specified with new locality check requirement	Explicitly specified with new locality check requirement
High Value Content Identification	N/A	N/A	Content flagged as high value (e.g. 4K movies) may be restricted for display only on connections protected by HDCP 2.1+

Table 2: Comparison of HDCP versions

Areas of Concern for Professional Video Integration

4K Is Not Necessarily HDCP 2.2

While HDCP 2.2 protects 4K video entertainment content from being illegally copied, 4K video formats existed before HDCP 2.2 was introduced. A wide range of video data rates is associated with 4K video. At high frame rates and color depths, the required video data rate can exceed the 18 Gbps of HDMI 2.0. At lower frame rates, color depths, or with 4:2:0 chroma sampling, the minimum data rate required to transport uncompressed 4K can fall below 10.2 Gbps data rate and within the capability of HDMI 1.4. Thus there is a generation of AV equipment with 10.2 Gbps data rate capability which can be used to transport 4K video that is unencrypted, or encrypted with HDCP 1.x, but will not be HDCP 2.2 compliant.

Release Date	HDMI Version	HDCP Version
Feb 2000		1.0
Dec 2002	1.0	
Jun 2003		1.1
May 2004	1.1	
Aug 2005	1.2	
Jun 2006	1.3	1.2
Dec 2006		1.3
Oct 2008		2.0
May 2009	1.4	
Jul 2009		1.4
Jul 2011		2.1
Feb 2013		2.2
Sep 2013	2.0	

Table 3: Timeline of HDMI and HDCP specification release dates

HDCP Versions and HDMI Versions

HDMI and HDCP have evolved over a similar time frame, as shown in Table 3. While initially applied to the DVI and HDMI video interfaces, HDCP became interface independent as of version 2.0. Meanwhile HDMI has grown in capability as it evolved, adding features and increasing data bandwidth to accommodate high color depth and video resolutions up to 4K.

Versions of the HDMI specification up to 1.4 required HDCP implementations to adhere to specific versions, whereas HDMI 2.0 breaks with the practice and does not mention any HDCP version, as shown in Table 4.

There is HDMI 2.0 equipment that supports HDCP 2.2, but with a maximum data rate of 10.2 Gbps instead of 18 Gbps. This is typical of HDMI equipment where many features such as maximum data rate, or 3D capability, are optional and not required to be implemented fully. It is also possible to encounter some HDMI 1.4 equipment, such as extenders, that support HDCP 2.2. Consequently, the level of HDCP support for a piece of video equipment should be determined separately from HDMI.

HDMI Version	Required HDCP Implementation
1.1	1.1
1.2	1.1
1.3	1.1
1.4	1.3
2.0	None Specified

Table 4: HDCP versions and the corresponding HDCP implementation requirements

Different Levels of HDCP Compliance within a Product

There can be varying levels of HDCP compliance in some products with multiple video connections. For example, many 4K displays may have a mix of HDCP 2.2/4K inputs and HDCP 1.x/HD inputs. Some early 4K displays even have HDCP 2.2 support on low bandwidth video inputs, but HDCP 1.4 support on high bandwidth inputs. When deploying such equipment it becomes important to specify the exact connection ports to use when designing the system, and to make sure that the correct connections are made when installing the system.

Unanticipated Equipment Behavior

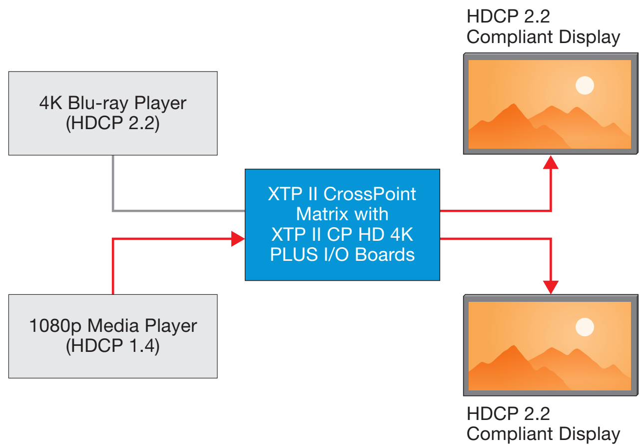
Since manufacturers have the prerogative to choose how their equipment supports HDCP 2.2, they may elect to encrypt the output using HDCP 2.2 at all times without regard to the actual setting of Content Stream Type value, thus always denying video to downstream HDCP 1.x equipment. Awareness of this possibility, investigating, and knowing the behavior of each system component will help the AV professional overcome the challenges of integrating 4K video protected by HDCP 2.2.

Backward Compatibility with HDCP 1.x

Transmitting HD content encrypted using HDCP 1.x, or unencrypted 4K video should be feasible in a system with mixed support for HDCP versions, but as noted above, some equipment may exhibit unanticipated behaviors due to the immature implementation of HDCP 2.2. Extron XTP II CrossPoint® matrix switchers equipped with XTP II CP HD 4K PLUS input/output boards have HDMI connections that are HDCP 2.2 compliant with full backward compatibility with HDCP 1.x. This solution will be used in the following examples to illustrate interoperability between HDCP 2.2 and HDCP 1.x.

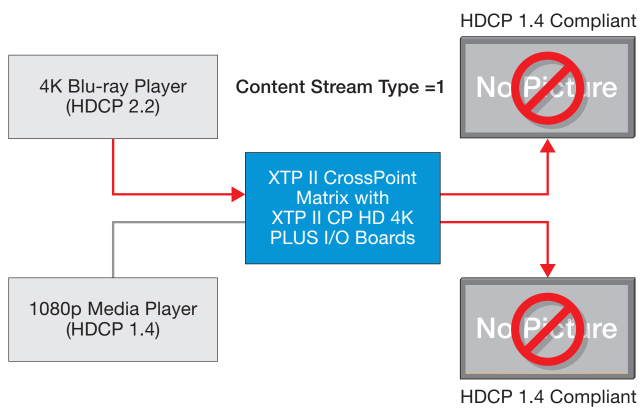
HDCP 1.x Source to HDCP 2.2 Displays

Displays equipped with HDCP 2.2-compliant inputs are generally capable of accepting unencrypted or HDCP 1.x-encrypted video.



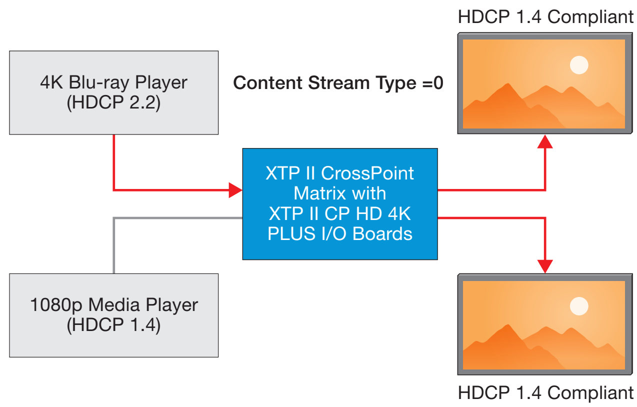
HDCP 2.2 Source to HDCP 1.x Displays – Content Marked High Value

An HDCP 2.2 compliant source, such as a 4K Blu-ray player, will not transmit high value protected content to HDCP 1.x displays.



HDCP 2.2 Source to HDCP 1.x Displays – Content Not Marked High Value

An HDCP 2.2 compliant source may transmit content not marked as high value to HDCP 1.x displays. This capability is described in the HDCP 2.2 specification, but implementation in actual products may be inconsistent. XTP II CrossPoint matrix switchers and XTP II CP HD 4K PLUS I/O boards support this capability.



Track Record of Integrator-Friendly Products

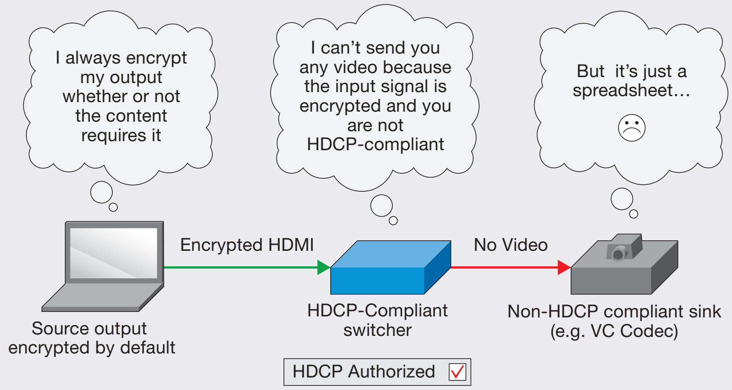
When HDCP was first introduced, integrating it into professional AV systems could be challenging. Switching a display between HDCP-encrypted sources could be slow due to the need for re-authentication. Troubleshooting HDCP issues could be difficult because there was no ready means to identify that the problem, usually just a blank screen, was caused by a failure in the HDCP handshake process.

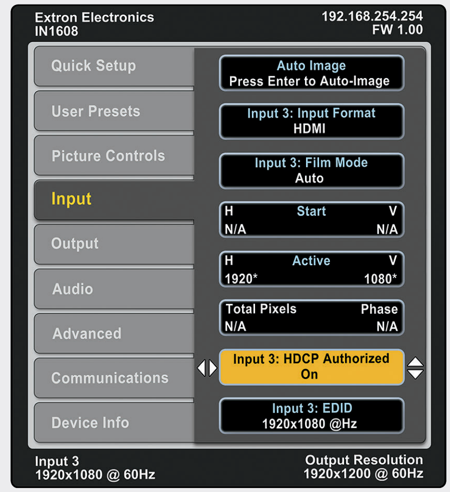
Some sink-type equipment found in professional AV systems, such as videoconferencing codecs or video capture devices, are never HDCP compliant. Particular video sources, such as some PCs and tablets, always encrypt with HDCP by default. If an HDCP-compliant switcher is connected between an always-encrypting PC and a non-compliant VC codec, the codec will receive no video, regardless of the nature of the content being sent from the source. In this situation, the source senses the HDCP-compliant switcher and encrypts the video as usual, whereas the switcher will not send video to the codec, since it is not HDCP compliant.

Over the years, Extron has introduced product features to address the abovementioned concerns and help to integrate HDCP equipment into professional AV systems:

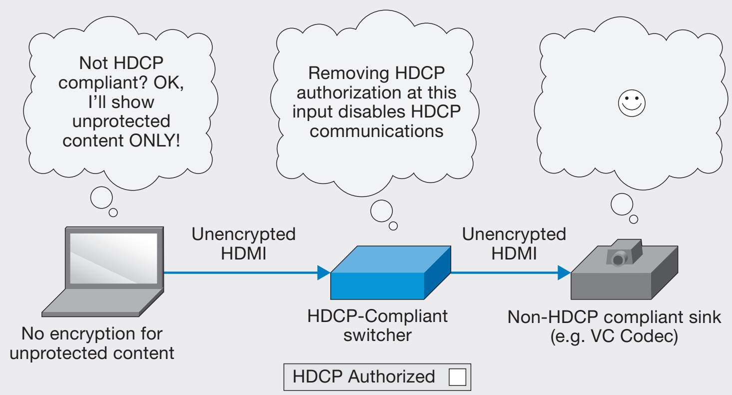
- **Key Minder** – An Extron product such as the IN1608 scaling presentation switcher maintains continuous HDCP encryption between its inputs and outputs so that switching does not require re-authentication and the associated lag time.
- **HDCP visual confirmation** – If a connected display is not HDCP compliant, an Extron product with this feature will generate a unique full screen green signal to give indication of the situation.

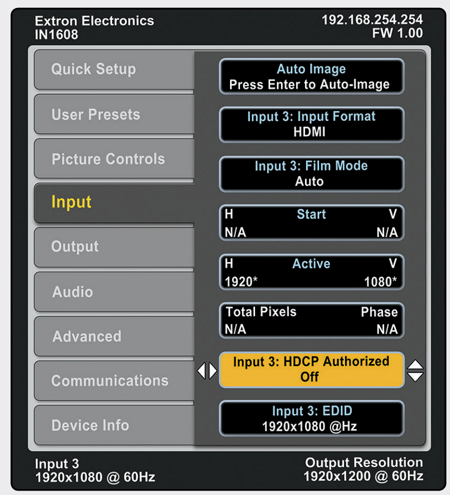
Some computers and tablets encrypt the video output by default as a general policy, even if the content to be displayed does not require HDCP encryption. Connecting such a source through an HDCP-compliant switcher to a non-HDCP capable sink device such as a VC codec or video capture equipment can result in no video.





Extron switching products such as the IN1608 are HDCP-compliant with selectable HDCP authorization at digital video inputs. By de-authorizing HDCP at the switcher, a connected video source that encrypts its output by default may send unencrypted video if the content does not actually require HDCP.





- **HDCP signal presence confirmation** – Many Extron products have dedicated front panel LEDs, internal Web pages, SIS™ – Simple Instruction Set commands and responses, as well as configuration software to indicate the HDCP status of input and output connections.

- **HDCP authorization** – An Extron product with this feature enables the user to designate any digital input as either HDCP compliant or non-compliant. Making an input non-compliant allows an otherwise always-encrypting source, such as an iPad, to send non-protected video so that non-HDCP sinks such as a VC codec can receive video. Protected content is not passed in non-compliant mode.

Based on our track record of commitment to Service, Support, and Solutions, Extron is well positioned to help you successfully design and deploy AV systems that require 4K, HDMI 2.0, HDCP 2.2, and other emerging video technologies.

Notes