HDMI and HDCP: Setting new standards in video-to-display transference

Introduction
Video by nature contains large amounts of information that must be transferred quickly. This trandfer from source to display has been an engineering challenge since the advent of television. As computer displays were being introduced, new standards for transferring video to the display were also developed. Early computer display standards were not compatible with the television standards and vice versa. Most modern LCD, plasma, and DLP displays are more like computer displays than television displays. Because of the digital nature of the content used in DVD, digital cable and HDTV, the video transfer (signaling) standard used by television/video and the standards used by computers are starting to converge. This began with the DVI-D standard, which is the basis for the High-Definition Multimedia Interface (HDMI) standard.

HDMI
HDMI was developed by a group of companies that includes Hitachi, Philips, Matsushita and Sony, as a connection standard for HDTV and consumer electronics. HDMI is essentially a very fat pipe that can move massive amounts of digital information between two sources. HDMI cables have 5Gbps worth of bandwidth available. HDTV requires 3Gbps. HDMI also has up to eight channels of 24-bit high-quality audio, all of which are uncompressed. This means that there is no signal conversion (from digital to analog and then back again), and no compression, each of which can possibly affect video or sound quality. And it is all done through one cable.

HDMI supports every uncompressed standard as well as enhanced and high-definition video format including 480I to 480P, 720P, 1080I and 1080P in addition to existing PAL formats. HDMI also has the bandwidth to support compressed audio formats such as Dolby Digital, Dolby Digital EX, DTS, DTS EX and uncompressed formats (PCM audio) up to eight channels, up to 192kHz, up to 24-bits. HDMI also supports most standard PC monitor formats, such as VGA, XGA and SXGA—all in a single HDMI cable.

HDMI is based on the same technology as DVI-D Transition Minimized Differential Signaling (TMDS), so it is fully backwards compatible with DVI-D. TMDS signal advantages include:
- high speed with high reliability
- it is already a digital signal, requiring less processing of the signal enabling better image quality
- the bandwidth of the video can be doubled by using a second link in a single cable, allowing for higher-resolution PC displays
- less sensitive to electronic device interference, electrical noise, and external radio frequencies

Since the HDMI standard is based on DVI, the picture quality on both is similar. HDMI has some advantages over DVI-D, including:
- Audio capabilities
- HDMI cables can be made longer than DVI/HDMI can extend up to 15m in length
HDMI will increase its single-link bandwidth to support the demands required by future HD display devices, such as higher resolutions, deep color and high frame rates.

**HDCP**

With the advent of DVI (now HDMI) came HDCP, a standard “key” encoded into the HDMI/DVI signal to prevent video data from being pirated. HDCP was strongly endorsed by the entertainment industry. HDCP is not a strict requirement of the HDMI standard, though all HDMI implementations on the market feature HDCP. If a source device is HDCP-coded and is connected to an HDTV display or projector via DVI/HDMI without the proper HDCP decoding mechanism, the picture is relegated to “snow” or, in some cases, a very low (480P) resolution. In order to see HDTV with HDCP compliance, both the source and display devices must be equipped with HDMI/DVI connections that can enable HDCP using “software key” decoding.

The encryption is carried out in the HDMI transmitter found in the “source” (DVD player, set-top box) and decryption is carried out by the HDMI receiver (the HDTV display). The secret keys for encryption are exchanged between the source and display via the cable.

In addition to the encryption and decryption functions, HDCP implements authentication to verify that the receiving device (such as a display or television) is licensed to receive encrypted content. Re-authentication occurs approximately every two seconds to continuously confirm the security of the DVI or HDMI interface. If, at any time, re-authentication does not occur, for example by disconnecting a device and/or connecting an illegal recording.
device, the source device (such as a DVD player or set-top box) ends transmission of encrypted content.

In order to encrypt the information, HDCP-compatible units contain a set of 40 56-bit keys that make up the unit’s device private keys. Each set of these keys is associated with the device’s key selection vector (KSV), which is unique to that device. Each HDCP-compatible transmitter and receiver has a KSV all to itself. This KSV allows for transmitters and receivers to communicate their encryption to one another in order to ensure the validity of their content protection. Only after a two-part encryption process takes place will the transmitter begin to send information to the receiver via its digital output (i.e. DVI or HDMI). If the set of device keys is found to be invalid or corrupt, the digital picture information will not be sent from the transmitter. This process takes a fraction of a second to complete.

On units that have component, S-video or composite analog ports in addition to DVI-D or HDMI, all the standard analog ports will still operate with or without HDCP. However, in the future, these analog ports will only carry low resolution signals not exceeding 480p. If you want to enjoy the superior picture quality of full HDTV resolution, you must use the digital (DVI or HDMI) signal ports where HDCP is a key factor.

All devices in the signal chain must be HDCP-compliant. Even if the devices on either end of the application are compliant, all devices in the middle must be as well (repeaters, converters, switchers, etc.). Fortunately most cables and adapters simply pass through the HDCP information and hence are not a major concern. For example, if we are using a DVD player with an HDCP-encrypted DVI output and sending the signal to a monitor, the monitor must be equipped with HDCP. If we want to show this same content on two monitors simultaneously, the DVI distribution amplifier that we are using must also be equipped with HDCP. As the application becomes more complex, it becomes less likely that all the devices will be HDCP-compliant. Remember – if one device is not HDCP compliant, then no signal is passed and your screen goes black.

**PCs Equipped with HDCP**

Currently HDCP is not implemented in the operating systems and hardware of most personal computers. Part of the feature set of Microsoft’s upcoming Windows Vista (ne Longhorn) operating system is support for HD content, either through television signals, HD or Blu-Ray DVDs, or Internet video. Along with this support though, is a new set of restrictions designed to ensure the sanctity of HD content and to protect it from copying.

In 2003, more than 500 consumer electronics devices had DVI/HDMI-HDCP ports and approximately 80% of new DTVs shipped to the U.S. market had DVI/HDMI-HDCP inputs. In 2006, HDMI Licensing announced that more than 300 makers of consumer electronics and PC products worldwide have adopted HDMI. More than 17 million devices featuring HDMI were shipped during 2005 and 59 million more are expected to ship in 2006, according to market researcher In-Stat.

**References**

*HDMI: Gaining Momentum.* (Published in March 2005 issue of CompoTech Asia), Raj Karamchedu, Senior Product Marketing Manager, Consumer Electronics Products.

www.hDMI.org

http://www.digital-cp.com


This white paper was published in and based on information as of January 2007. Technical information is subject to change.