High-Definition Multimedia Interface

It's the interconnect that sorts out a lot of problems we thought we had and a few that we didn't; it's the High-Definition Multimedia Interface. NIGEL JOPSON discovers a new digital connector that has all sorts of implications for the future — including the forced deactivation of analogue outputs.

ON THE LAST DAY OF MARCH, Toshiba put on sale the world's very first HD-DVD player, the HD-XA1. HD-DVD and Blu-ray are the two new formats set to replace the DVD for high-definition home movie viewing and will vie with each other for consumer spending-money in the marketplace. The arrival of players has been eagerly anticipated and trailered by home-entertainment pundits and vendors for quite some time. However, new software included on both Blu-ray and HD-DVD releases will automatically slash the image quality, making it only marginally better than current DVDs, unless consumers have a new connector and cable called HDMI to hook up players to their screens.

Only one in 20 HD-TVs sold to early adopters has the appropriate version of this connector. Perhaps just 15% of new sets sold this year will include it and be able to deliver the full 1080 high resolution picture that these devices are being sold on. Unlike the disparate disc formats that have polarised manufacturers into two camps, the HDMI connector has cross-industry support. The founders include electronics manufacturers Hitachi, Matsushita Electric (Panasonic), Philips, Sony, Thomson (RCA), Toshiba, and Silicon Image. Digital Content Protection LLC (a subsidiary of Intel) is providing High-bandwidth Digital Content Protection (HDCP) for HDMI. In addition, HDMI has the very partisan support of major movie producers Fox, Universal, Warner Bros and Disney, and system operators DirecTV and EchoStar (Dish Network) as well as CableLabs and Samsung.

So HDMI is an industry-supported, uncompressed, all-digital audio/video interface. The small connector provides the interface between any compatible digital audio/video source, such as a set-top box, DVD player or AV receiver and a compatible digital audio and/or video monitor. It was conceived as a sort of digital SCART, primarily a point-to-point connector; HDMI grew out of DVI and the picture side is backwards compatible (providing that copy protection is implemented). HDMI adds support for component video, multichannel audio, the so-called universal CD control, and the concept of auto-configuration. The payload on the new cable includes 24-bit video pixels and sync, at a possible 4 different rates up to 165MHz (or 330MHz for type B), information frames for video that inform the receiving device about the resolution and aspect ratio of the picture, and colour information, such as gamma inventory, so the receiving device can do a good job of rendering.

HDMI is, coincidentally, the highest specification single-cable digital audio connection currently available, with v1.3 of the standard adding support for 8 channels of 192kHz audio, native DSD and all the Dolby True HD formats. It's streaming audio, a vast improvement over packet-based computer protocols, but even so the digital audio is likely to arrive with a lot of jitter in it. As might be expected of a standard designed with the TV metaphor in mind, video is the master clock and the audio clock is derived from it via PLLs (phase locked loops). To transmit audio, a

blank video screen must be output to maintain sync and for an audio manufacturer to acquire a 'license' to use the connector. From an audiophile point of view, putting all the very high speed digital silicon inside equipment seems slightly undesirable. However, the audio support in version 1.3 is probably good news for HD player manufacturers. Currently, player makers have no choice but to fit all the decoders and codecs for different protocols inside their machines. In future the consumer can anticipate cheaper and simpler players, with all the multichannel audio output as digital data.

On the actual HDMI wire there is one clock channel and 6 data channels (in the type B specification). The clock design is non-coherent: a 165MHz or 330MHz clock down a 15m twisted cable is hardly conducive to keeping in time, the twist of the cable means that internal cable lengths will differ quite significantly. So when the signal arrives at a destination the clock is retimed for each of the data wires, indeed the clock itself runs much slower than the pixel rate on the wire, which can be up to 10 times faster.

Digital audio is sent at the beginning of every horizontal video line, and there is additional descriptive audio data sent concerning how to recover the audio clock for the PLLs and the type of encoding. Other information frames sent to the receiving piece of equipment carry data explaining pixel encoding, colour, aspect ratio and whether the picture is over-scanned. Pixel encodings supported are RGB 4:4:4, YCbCr 4:4:4 (8 bits per component) and YCbCr 4:2:2 (12 bits per component). There is support for legacy-resolution VGA plus progressive formats 720 and HDTV 720p and 1089. Frame rates officially supported include 50, 59.94 and 60Hz, although backwards compatible 48 and 72 can also be used. The new interface supports interlaced and standard definition by using double clocking. Even quadruple clocking may be used as well — perhaps for situations where audio bandwidth is very high compared to the video — maybe a concert recording from some future Mobile Fidelity Sound Lab-type operation. The audio formats are the areas where there has been most change in upgrading the HDMI standard, as the 1.0 version only supported audio up to 48kHz and the compressed formats found on DVD.

But HDMI is far, far more than a neat little digital connector. It is a Compliance Program. HDMI mandates the use of AACS (Advanced Access Content System) via the HDCP license, which is a form of DRM (Digital Rights Management) and for which a fee is payable. HDMI devices have a special 5 volt signal wire that sends something known as a Hotplug event: think of it as similar to a computer USB port's plug-and-play behaviour. Every time a Hotplug event is detected, something called the EDID (Extended Display Identification Data) is read in each device and the format of information to be sent is agreed between the two devices.
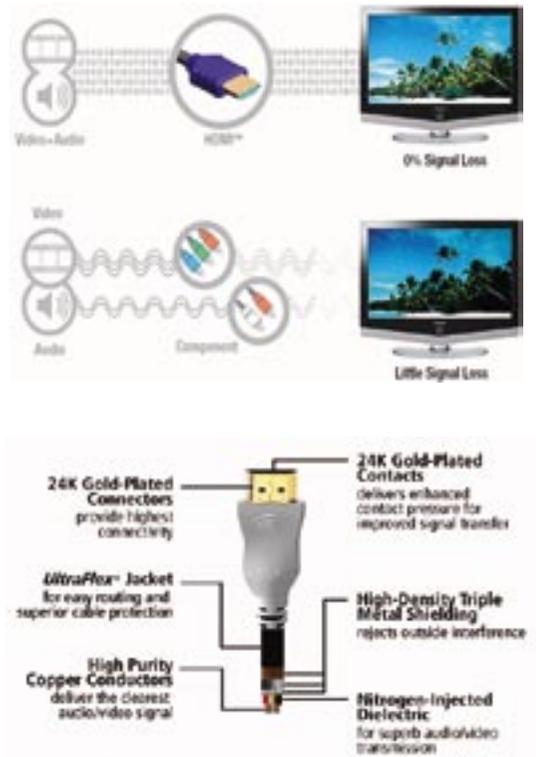
This has all sorts of potentially useful consequences, such as the display being able to adjust itself to match the format of an incoming picture and the audio reproduction chain being able to set itself for the correct sample rate and surround format. The HDMI link is copy protected based on an authorisation code, and the contents are encrypted on the cable. Each device has 40 56-bit keys, the source and the sync generate a shared secret that is changed every 4 seconds (just in case some mischievous consumer pulls the cable out and connects to a recording device), so as the content is travelling the key is changing. The HDCP protection has the goal of preventing transmission of non-encrypted content, with the key-changing data encryption preventing any form of eavesdropping on the digital content stream.

DVDs also benefited from software protection, the content-scrambling DeCSS system. *Resolution* readers may recall this protection was famously cracked in a very short time by Jon Lech Johansen (DVD Jon). His teenage success was not quite as dramatic as first believed, however, as it later turned out that Real Networks had 'forgotten' to encrypt a CSS key in one of its software players, and Jon was simply recovering content using the compromised key. Bearing this embarrassing snafu in mind, Intel has built a key revocation procedure into the new HDCP protection system, which means that devices manufactured by any vendors who violate the license agreement, or any spoof-keys used by future 'HD-Jons', can be easily blocked from retrieving HD content. How? Well, HD products (the disc bought by consumers,

for example, or possibly a live HD stream ... from a satellite ... from broadband) may contain a list of revoked keys. So your newly purchased piece of content will just switch off your expensive home

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If you want the audio and video to be rendered by different devices — for example the audio has to be returned to a separate device such as a 6-channel surround amplifier — then the audio sync has to read the video capability of the video sync, patch it into its EDID and make a new EDID, then the source can read the composite EDID, authenticate it and decide what picture and what audio to send. With the new Toshiba HD-XA1 taking over a minute to switch on, and 28 seconds for the 'loading' display to change to 'HD-DVD' after putting in a disc, it's not looking good for larger and more complex installations.

Part of the HDMI program includes signing up to the rather sadly named 'Analog Sunset' clauses. According to the AACS Interim Adopter Agreement of 15th February 2006 (Exhibit F - Compliance rules paragraph 1.7.1): '2010 Analog Sunset. Existing Models (as defined in Section 1.7.2) may be manufactured and sold by Adopter up until

theatre system if it thinks any part of it might have been too naughty.

The handshaking between HDMI devices, and the AACS/HDCP protection, has significant implications for system installers and facility designers. The 1080 picture can be sustained for runs of 10m, but to go 60m some form of equaliser is required. Clearly, 10m

is a pathetic length for an installer fitting cable into a wall chase. Extending the authentication process using repeater devices currently looks like a bit of a minefield for designers. With two syncs, audio and video, the authentication process can become quite complex. Every time you flip programmes there will be a Hotplug 'event'.

December 31st, 2011. For any Licensed Player (other than Existing Models) manufactured after December 31, 2010, analog outputs for Decrypted AACS Content shall be limited to SD Interlace Modes only (i.e., Composite, S-Video, 480i component.) 576i component will be addressed in the applicable Final Agreements.'

What price, then, the estimated 5 million non-HDMI compliant HDTV displays sold in the USA? If the analogue sunset is implemented on time, it will also mean that extremely expensive Digital Light Processing projectors — more than capable of displaying 720p and 1080i — will not work with the new players. Perhaps all consumers need to do is purchase a player before the sunset period? Only with the following proviso: that their keys are not revoked or downgraded by future content purchases. Their so-called 'Robust Inactive Product' will need to be 'activated through a Periodic Update.' A 'Periodic Update' is defined as ' ... provision of or replacement of a Device Key Set, via ... download of updated software.'

For those of us using HDMI screens in a professional setting there are some other concerns: so far, I've been unable to accurately determine if time-to-render will be correctly reported by the EDID handshaking. Any sort of motion compensation will clearly change the delay and will have to be reported back accurately in order for screens using this connector to be used in a situation where lip-sync is important.

For those who may be thinking 'they will just play it on their PCs', I'd like to point out that Microsoft and Hollywood's aim of a digital-rights-holy-grail moved a step closer when Intel embedded DRM into its latest dual-core Pentium D processor and accompanying 945 chipset last year. And there's another connection standard on the horizon: DisplayPort. DisplayPort is

a new digital display interface standard, approved this month, put forward by the Video Electronics Standards Association (VESA). It defines a new digital audio/video interconnect, intended to be used mainly between a computer and its display, or a computer and a home-theatre system. DisplayPort connections support 1 to 4 data pairs on a link that also carries audio and clock signals, with transfer rate of 1.62 or 2.7 gigabits per second. The video signal provides an 8- or 10-bit pixel format per colour channel.

DisplayPort includes DPCP (DisplayPort Content Protection) from Philips, which (surprise!) uses the 128-bit Advanced Encryption Standard with session key establishment plus authentication and an independent revocation system. Displayport is being driven by the silicon makers and computer companies, who would love to use one twisted pair between the lid and body of a laptop rather than the currently required 30-60 wires. One of the design hurdles with HDMI is the quantity of wires between chips.

I have yet to meet a consumer in possession of the equipment necessary to make a digital copy of a DVD, never mind an HD-DVD. End-to-end DRM has moral and possibly economic ramifications for our industry, as equipment manufacturers are required to push high-definition content through a progressively more tortuous and obtrusive path, just to prevent casual copying. But with the increasing practice of using consumer equipment — especially displays — in a professional environment, this policy of treating the consumer as a potential criminal also has the potential to create some very severe roadblocks in production facilities. ■