Key digital The Experts in Digital Video Technology and Solutions™
521 East 3rd Street :: Mount Vernon :: NY 10553 Phone :: 914.667.9700 Fax :: 914.668.8666

For Immediate Release

PUBLIC RELATIONS CONTACT:
Masha Lakhter
Masha@keydigital.com
Phone: 914-667-9700 ext. 211
Cell: 917-701-3238
Fax: 914-668-8666

Key Digital® Continues Ongoing Efforts to Educate Commercial and Residential A/V Installers on the Successes and Shortcomings of HDMI with "Comparison of HDMI 1.0-1.3 and HDMI 1.4 Usages for the Commercial and Residential Markets" Article Written by Mike Tsinberg

Mount Vernon, NY – Key Digital Systems, Inc. the Experts in Digital Video Technology and Solutions have issued an informative article written by President and Company Founder, Mike Tsinberg. Mr. Tsinberg is the holder of 40 HDTV patents and founded Key Digital Systems in 1999 after a successful career with Phillips Research where he was in charge of the HDTV effort. Before making his contributions to DTV with Phillips, Mr. Tsinberg was the Head of Research and Development for Toshiba America and developed the world's first DVD authoring systems.

In addition to Mike Tsinberg's "How to Make HDMI Plug and Play Instead of Plug and Pray" article, you can go to the Key Digital Knowledge Center for more informative reading material.

www.keydigital.com/knowledgecenter.html

Comparison of HDMI 1.0-1.3 and HDMI 1.4 Usages for the Commercial and Residential Markets

Comparison of HDMI 1.0-1.3 and HDMI 1.4 Usages

History of HDMI Versions

Let's take a look at the history of the HDMI versions released up to this date, the features delivered in each version, and the use of these features in each

respective HDMI standard.

HDMI Version	1.0	1.1	1.2 1.2a	1.3	1.3a 1.3b 1.3b1 1.3c	1.4	**Usefulness/score. Score 1-5.** 1 –useless, 4- strong future potential, 5 – in constant use.
sRGB	Yes	Yes	Yes	Yes	Yes	Yes	Used for DVI. Legacy / 5
YCbCr	Yes	Yes	Yes	Yes	Yes	Yes	Used for HDMI / 5
8 channel LPCM/192 kHz/24-bit audio capability	Yes	Yes	Yes	Yes	Yes	Yes	Used for flat panels / 5
1080p video at full resolution	Yes	Yes	Yes	Yes	Yes	Yes	Misguided use with Blu Ray / 2
Consumer Electronic Control (CEC)	Yes	Yes	Yes	Yes	Yes	Yes	Not used on intra company basis / 1
DVD Audio support	No	Yes	Yes	Yes	Yes	Yes	Used by DVD/Blu Ray / 5
Super Audio CD (DSD) support	No	No	Yes	Yes	Yes	Yes	Rare use in DVD. No broadcast use / 1
Deep Color	No	No	No	Yes	Yes	Yes	No Blu Ray titles yet. No broadcast use / 2
xvYCC	No	No	No	Yes	Yes	Yes	No Blu Ray titles yet. No broadcast use / 4
Auto lip-sync	No	No	No	Yes	Yes	Yes	Not used yet. Lip Sync is taken care in DVD, Blu Ray and STB hardware / 1
Dolby TrueHD and DTS-HD bit stream capable	No	No	No	Yes	Yes	Yes	Some Blu Ray titles. No difference to AC3 to 99% of consumers / 3
Ethernet Channel	No	No	No	No	No	Yes	TV equipped with Internet access through WiFi or RJ45 jack / 1
Audio Return Channel	No	No	No	No	No	Yes	No equipment for this function. Currently done by A/V receivers / 1
3D Over HDMI – no standard not mandatory yet	No	No	No	No	No	Yes	No standard yet. Not mandatory / 1
4K x 2K/24 Resolution Support	No	No	No	No	No	Yes	Production application. No Consumer displays / 1

An interesting pattern emerges from looking at the new HDMI formats and their capabilities:
The later the release version of the HDMI standard, the less practical these added capabilities are. Let's look item by item.

HDMI 1.1

sRGB - A basic RGB format used by the HDMI predecessor, DVI. The compatibility with DVI is an important feature as it is used occasionally when PC's are connected to a consumer HDMI display through the use of a DVI to HDMI passive dongle. During the transition from DVI to HDMI the feature was very important because millions of cable Set Top Boxes were made with DVI outputs connected to HDMI equipped displays. The use of this feature will decrease in time when more and more computers will be equipped with HDMI output ports. At

present there is no Cable or Satellite Set Top Box that offers DVI connectivity.

YCrCb – A basic default HDMI format use by all HDMI sources today.

8 channel /192 kHz/24-bit audio capability - A basic Audio format, the 2CH stereo subset used for all HDMI source to flat panel TV connections today. Flat panels have two speakers and require this format for audio display.

1080p video at full resolution – This format received somewhat misguided use at the marketplace. There are two 1080p formats: 1080p/24 frames per second and 1080p/60 frames per second. All HDTV capable media today, such as Terrestrial ATSC, Satellite, Cable, and Blu Ray carry 1080p/24 among other HDTV formats such as1080i/60 and 720p/60. None of them carry 1080p/60. However, most of the larger and higher quality flat panel TV's do feature 1080p/60 format as the native resolution. Therefore, it is believed that 1080p/60 is a full resolution video. It is true, but 1080p/60 is not available as a native format. To create a 1080p/60 resolution, the Blue Ray, STB or TV itself must up-convert the incoming native video at 1080p/24, 1080i/60 or 720p/60 to 1080p/60 for display. Where is the better location to perform such up-conversion? If it is done at the source we encounter two problems: The quality of the up-conversion is dictated by a low cost scaler chip in the source device and the transmission line (HDMI or CAT5 cable) is weighed down with a 1080p/60 format that demands twice the bandwidth compared to1080p/24 or 1080i/720p and limits the connectivity to half distance. Therefore, using Blu Ray at 1080p/24 and Satellite or Cable Set Top Boxes at 1080i is most practical and provides the best quality connection. Nevertheless, 1080p at 60F/s or 24F/s is used today in Blu Ray to TV connectivity.

Consumer Electronic Control (CEC) - Extensively promoted as "the control bus" for interconnected consumer products, it is virtually never used…. It is not a surprise for most industry insiders because there were many "control bus" proposals over the past years: power line CE bus, Firewire 1394 and others. The basic problem is a business issue. The consumer products within one brand may have a chance to listen to each other over such a "control bus". Each brand is only interested in the customers buying more of their products to create a working system at home and may make an extra step for these components to interact properly. However, intra-company communication is not beneficial to the manufacturers because it encourages the consumer to buy different components from different brands… Therefore CEC remains a technological curiosity never promoted or used.

DVD Audio support - This is an important technology basically opening a de-facto surround sound encoding Dolby AC3 and other formats to be available over HDMI. This format is used extensively in any surround sound installation. It is successfully provided by Satellite, Cable, Terrestrial, DVD and Blu Ray HDMI sources.

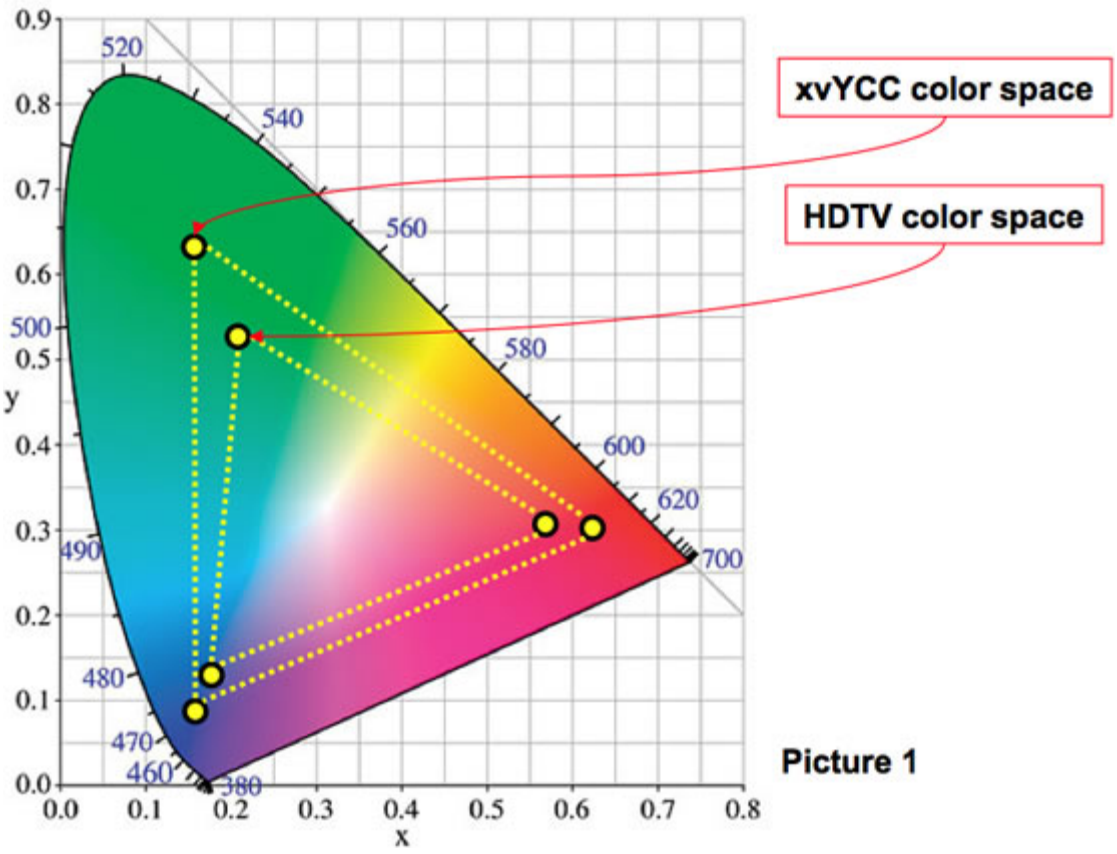
HDMI 1.2

Super Audio CD (DSD) support - The Super Audio CD format was introduced as a last high quality attempt to hang onto CD media. It has never been accepted by the mainstream market. CD's are quickly loosing the competition with downloaded audio. This format is available, but is probably never used in DVD or Blu Ray players.

HDMI 1.3

Deep Color - Deep color creates a more accurate image quantization from the usual 8 bits per color to 12 bits per color or more. Up to now, Deep Color is rarely used for actual TV displays outside the high-end workstations and other specialized production or post-production markets. It is difficult for the human eye to see any difference between 8 bits and 9 bits per color. There are special patterns that can be used to demonstrate the benefit of increased bit depth, but in regular HDTV images these effects are very hard to notice. Therefore, Deep Color is most likely a marketing feature that takes space and bandwidth costs and offers no perceivable benefit. In addition, the TV content production industry is geared for Terrestrial, Satellite and Cable distribution that is bound by 8 bit encoders and decoders. The reasons for extra production investments into Deep Color encoding systems are not clear because they will only benefit Blu Ray distribution.

xvYCC - Even though digital television currently uses 8 bit color (0 to 255 quantization levels) in most implementations, it is actually 16 to 236 or 220 quantization levels. The color gamut, or color representation, of each Red, Green and Blue is designed within BT.709 standard for 16 to 236 level systems. 16 to 236 is a legacy issue basically to be compatible with analog YPrPb interface. A fully digital interface, such as HDMI, is capable of a full 0 to 255 performance without increasing the 8 bits per color specification. The xvYCC is a new, more advanced, color gamut standard that uses the full range of values (from 0 to 255 in an 8-bit space) to represent colors. It is a great idea that does not take away bandwidth but can be demonstrated to the untrained eye quite easily with almost any TV content. The problem here is backwards compatibility. Both studio camera or film telecine and TV need to be xvYCC to use this feature. Some consumer TV's are starting to support xvYCC and this may in turn promote production to become xvYCC compatible as well. As you see from Picture 1 below there are more accurate and rich color representation in xvYCC color space compare to HDTV color space. Even though HDTV color space was considerable improvement compare to SDTV color space.



Picture 1

Auto Lip Sync - Auto Lip Sync is a capability of HDMI receiving chips to re-align Audio to be in sync with Video. Audio can run out of sync because video processing often involves frame memories that delay Video and make Audio run ahead. Recently, more and more content is digitally encoded and decoded via MPEG2 or more advanced MPEG4, H.264 and VC1 codec's. By Definition, all these systems create synchronized Audio and Video. In addition, one frame delay (16 milliseconds) is way below human sensitivity, which is about 30 milliseconds, to realize lip-sync issues. So, in principal we can have a Video/Audio time mismatch but in practice it is getting harder and harder to find with the digital delivery systems that are now in place for all TV delivery media. To take true advantage of auto lip-sync in HDMI1.3, all components in chain must cooperate: the HDMI source must be1.3 and include special time stamps on the video and audio bit streams and the HDMI receiver must be 1.3 and be able to read these time stamps and take action. Since conversion to 1.3 for consumer delivery sources is very slow and consumer sensitivity to lip-sync is very small – the implementation of this feature remains very questionable.

Dolby TrueHD and DTS-HD capability - The practical implementation of this feature follows the same basic trends we observed for Super Audio CD, Deep Color, xvYCC and Auto lip-sync. Both production and display must be implemented to use this feature. The problem is that it takes an extremely high quality Audio Home Theater system, well done content production, and a trained listening ear to actually hear the difference between Dolby AC3 and Dolby TrueHD/DTS-HD. In addition, the TV content production industry is geared for Terrestrial, Satellite and Cable distribution that is bound by AC3 as a compressed multichannel Audio format. Some Blu Ray discs began supporting this audio

format. Marketing efforts to promote this format may result in an increase in use. However, actual use will always be limited to only very high end audio display installations.

HDMI 1.4

Ethernet Channel - This is the latest installment of the ever increasing HDMI capabilities with ever decreasing usefulness in the marketplace… Let's assume that the TV is getting Internet access through a Blu Ray player using this input. What happens when you switch the HDMI input to a Satellite STB that may not have Internet access? What happens when you switch the input to a cable STB with Internet access? What happens to your internet session during the transition between input sources? Why would you rely on Internet access from HDMI if your TV may have uninterrupted Internet access through a wireless Wi-Fi signal or a simple RJ45 hardwired connection? Why should the HDMI source be your TVs gate to the Internet? There are many questions surrounding the wisdom of that connection.

Audio Return Channel - Once the TV switches to the desired HDMI input, this channel makes digital audio available for display on an external A/V receiver like product, but does not feature input switching capability. Of course, you can use a regular A/V receiver for input switching, but the receiver already switches HDMI inputs and already has an audio stream available for the display. So what is the advantage here? In theory, you can take away the input switching responsibilities from the A/V receiver, and system integration can be easier by needing to only control your TV. However, you still need to make adjustments to the A/V receiver's audio volume. Therefore, your TV remote would need to have IR codes for the Audio receiver or you would need to program a universal remote for control over the TV and the Audio receiver. I am not sure that we see any savings in programming. The cost reduction for an A/V receiver without switching capabilities is very small because most of the hardware in these products is responsible for audio decoding and amplification. The overall chance for future use is minimal in my opinion.

3D over HDMI - At this moment there is no 3D stereoscopic standard for TV displays yet. This feature is basically a place holder for such standards to emerge. It may or may not be compatible with what the industry will embrace as a 3D standard. Therefore, there are no displays or content yet developed. The structure of 3D will be embedded in TMDS (video/audio) portion of the HDMI stream. In principle, any HDMI cable should be able to pass this format. The discussion of implementing stereoscopic 3D for TV is ongoing and its future use in the HDMI cable is still pending the standardization process.

4Kx2K/24 display format - This format has 4 times the resolution of 1080p. It may be of interest to the content production community. Presently, only DVI digital interface offers this capability. However, the copy protection aspect of HDMI is of no use to the production community. It is not clear if HDMI will comp7ete with DVI or Display Port in this market. I think it will take a significant amount of time, if ever, for 1080p resolution to be "not enough" for use in the consumer and

commercial markets. An additional hurtle is that the camera, telecine, and the TV all need to be at this resolution to take advantage. It will take 4 times the encoded bandwidth data rate to transmit 4Kx2K/24 compare to 1080p/24. That means to transmit one 4Kx2K it will take the space of four current HDTV channels or 24 current SDTV channels. That is a big obstacle in bandwidth for the limited Cable, Satellite, and especially Internet delivery systems.

Conclusion

HDMI 1.1 remains the most practical and widely used interface today. There are some features of HDMI 1.3, such as xvYCC and Dolby TrueHD/DTS-HD, which have some potential for the residential and commercial marketplace. However, it remains to be seen if a global change and global investment in every aspect of video capture, production, and display will enable these features for wider use in the future.

Mike Tsinberg
Key Digital Systems

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About Key Digital, Inc.:

Mike Tsinberg,
President and Chief Engineer
Key Digital Systems.

The Emmy-award winning "Father of DVD" and SMPTE Fellow Mike Tsinberg is founder and President of Key Digital® Systems, an HDTV manufacturing company dedicated to researching and manufacturing innovative solutions for digital HDTV signal processing and distribution. For the past twenty-plus years, Mike has been a technological pioneer and an icon in the HDTV industry, defined by his ground-breaking work in the field of Digital HDTV broadcasting and in the development of the world's first DVD authoring systems. Mike has managed US and International technology developments efforts, with two leading consumer electronics manufacturers, Philips and Toshiba, where he amassed 40 US and foreign Patents, and industry praise. His own company, Key Digital, has already won 8 CES Video Innovation Awards for state-of-the-art home theater video processing products.