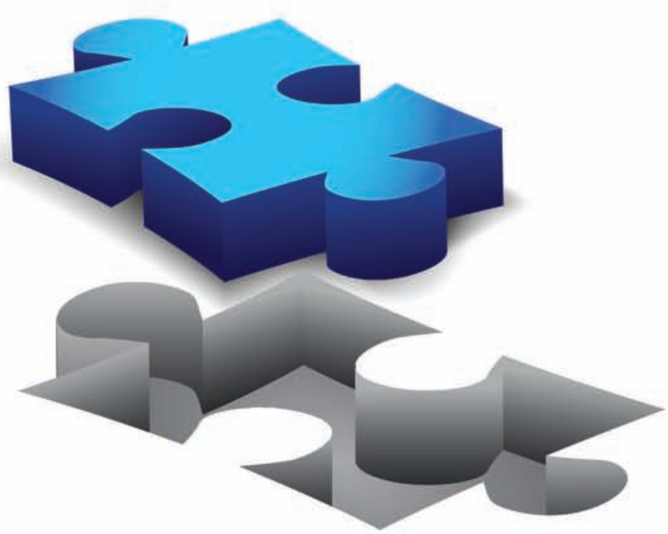
BLACK BOX®

Piecing Together the 4K Puzzle



Introduction

4K video, also called Ultra High Definition (UHD), delivers stunning beauty and resolution in digital signage and video extension applications. As with all disruptive innovation, it presents issues that can make deployment tricky.

Enormous bandwidth is required to deliver 4K video—10 Gbits/second. This places unprecedented demands on infrastructure. To be successful in real-world applications, 4K distribution systems must be designed and engineered to address the following puzzle pieces:

- Mismatched resolutions
- Bandwidth requirements
- Supporting 4K with multiple AV interfaces
- New cable lengths

Manufacturers of 4K sources and displays must take a holistic approach to testing their products to ensure that they are up to the challenges of an integrated 4K system, liberating system designers and integrators from having to take on this daunting challenge themselves.

Why 4K?

ProAV professionals should be aware of developments in 4K because, even though it is currently being adopted by a small group of technology enthusiasts, the larger mainstream market isn't far behind.

Display technology is evolving, and 4K screens are already available from most display manufacturers. The giant leaps in resolution quality coupled with declining prices make this technology very attractive to the consumer market.

4K Technology Overview

The term "4K" is used to refer to video signals with a horizontal resolution on the order of 4,000 pixels (generally, 3840 pixels). Previous generations of video resolutions were described by the vertical resolution (e.g., 1080p refers to a signal with 1080 vertical lines).

The increase in resolution presented by 4K is tremendous, as characterized in Figure 1.

An increasing number of displays show resolutions that fall between 1080p and 4K; these resolutions are referred to as "tweener resolutions." Even if a given system is not being designed for 4K content, hardware designed for 2K signals will not carry these higher resolutions. Therefore, the principles in this document must be applied in any system that might encounter resolutions such as those shown in Figure 2.

Figure 1: Video resolutions.

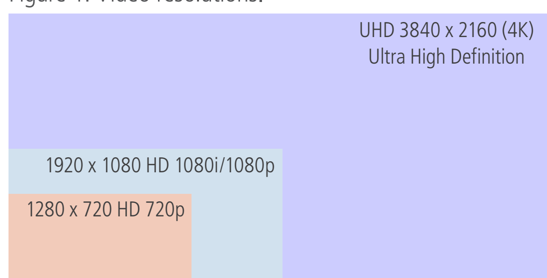
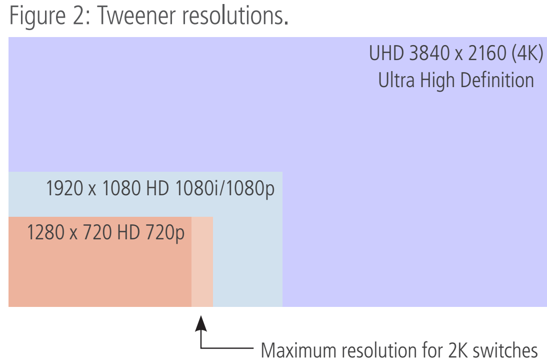


Figure 2: Tweener resolutions.



In some professional spheres, the terms 4K and Ultra HD (UHD) have become conflated; however they are not interchangeable. As far as a consumer is concerned, there is little practical difference, but they do mean different things.

Simply put, 4K is a professional production and cinema standard. UHD is the standard for consumer displays and broadcast. To get a better understanding of 4K technology, let's look at the pieces of the 4K puzzle.

Piece #1: Two Standard 4K Resolutions

720p, 1080i, and 1080p video all share the same aspect ratio, which is 1.78:1 (16:9). Since essentially all sources and displays have used this aspect ratio, we've seen an era of relative simplicity. No accommodations have been needed for various aspect ratios for a number of years. With 4K, all that is out the window because it presents the challenge of managing two different standard resolutions.

The resolution commonly referred to as UHD, 3840 x 2160, is precisely four times the resolution of 1080p, and results from doubling the horizontal and vertical pixel count of 1920 x 1080. Therefore, its aspect ratio is the same as high-definition (HD) video, that is, 16:9. Most 4K devices have a native resolution of 3840 x 2160. The second type of 4K resolution is 4096 x 2160, which has an aspect ratio of 19:10; this resolution is commonly referred to as 4K DCI. It is used in movie production and exhibition in commercial cineplexes. Some display devices have a native resolution of 4096 x 2160, but it's not as common as 3840 x 2160.

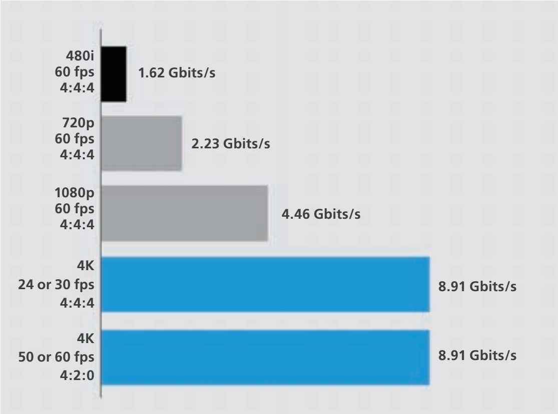
Many 4K cameras and source devices can be set to either of the two resolutions. Veteran AV professionals will recall the SXGA computer resolution of 1280 x 1024, which had a non-standard aspect ratio of 5:4 when nearly every other signal was 4:3. This led to similar issues that we may see with 4K. Displays and sources will have to be carefully matched and correctly configured in order to display all of the video information without cropping or stretching. Understanding the differences between conventional display resolutions and 4K resolutions will prevent difficulties in adopting this new technology.

Piece #2: 4K Resolution Requires 10Gbps Bandwidth

To deliver 1920 x 1080 video at 60 frames per seconds requires a data rate of 4.46 Gbits per second. Therefore, a four-times increase in pixels would increase the required data rate by a factor of four. However, HDMI supports a maximum data rate of 10.2 Gbits/s, including overhead.

Today's 4K devices are limited to 30 frames per second or less. For film, this doesn't represent a change, as the original source material is 24 frames per second. For video and computer applications, it's important to note that the frame rate is reduced by half. The key now is to design systems that may need to manage content at 24, 25, 30, 50, and 60 frames per second.

Figure 3: Required data rates, including HDMI overhead.



Chroma subsampling can enable the transmission of 4K video at 60 frames per second at under 9 Gbits/s by compressing color information to 4:2:0 — which is the chroma encoding used on Blu-ray® discs. Chroma subsampling transmits luminance information at full resolution and chrominance at a lower resolution (in this case 1920 x 1080). Because the human eye has a lower acuity for color differences than for luminance, this optimizes for the best perceived image from the available bandwidth.

Piece #3: 4K is Supported by Multiple AV Interfaces

HDMI is not the only way to extend 4K. Here are the typical video interfaces and frames rates they support.

DVI

DVI is used in professional AV and PC environments.

The DVI standard is based on transition-minimized differential sampling (TMDS). DVI comes in single-link and dual-link.

The DVI specification enables 1920 x 1200 pixels to be transmitted in single-link format or 2560 x 1600 (2048 x 2048) pixels in dual link. Typically single link is supported by 23/24" displays, commonly called Full HD panels. Dual-link resolutions require larger screen sizes of typically 27" (2560 x 1440), 30" (2560 x 1600), or square ATC displays of 2048 x 2048.

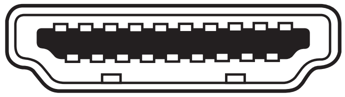


Figure 4: HDMI connector.

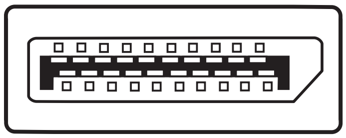


Figure 5: DisplayPort connector.

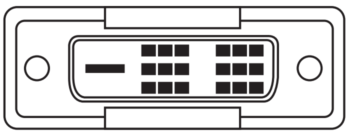


Figure 6: DVI-D, single-link connector.

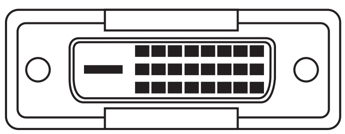


Figure 7: DVI-D, dual-link connector.

Full 4K resolutions of 3840 x 2160 or higher over dual-link DVI are possible, but only at less than 30 Hz due to bandwidth limitations.

Required bandwidth is up to 4.95 Gbps (165 Mhz) for single link or 9.9 Gbps (2x 165 Mhz) for dual link.

HDMI

Basically the same signal format as DVI, HDMI allows higher pixel-clock frequencies and by that, higher bandwidth of resolutions and deeper color. Details depend on the different evolution versions of HDMI.

Up to HDMI 1.2, it more or less reflects the DVI video specs 1.3. Furthermore, HDMI 1.4 exceeds the dual-link DVI specs, although it is using only a single link. HDMI 1.3/1.4 bandwidth is 10.2 GBps (single link 340 Mhz). All HDMI 4K appliances and displays currently on the market are limited to 30 Hz.

The recently released HDMI 2.0 standard increases the bandwidth to 18 Gbps (600 Mhz), effectively matching the bandwidth of DisplayPort for supporting 4K at up to 60 frames per second (fps). As of today, no display has been delivered with components supporting this full spec.

HDMI is most commonly used on almost all consumer and professional AV equipment.

DisplayPort 1.2

DisplayPort is a slightly different, micro-packet based video standard supporting a maximum. bandwidth of about 17 Gbps. By that standard, DisplayPort is currently only suitable as a single connect option for full UHD 3840 x 2160 at 60 fps.

DisplayPort is mainly used on graphic adapter cards of PCs.

Not all current graphic cards with DP support full spec of DP1.2a spec at 5.3 Gbps per lane and therefore only support 30 fps rather than 60 fps 4K resolutions.

Thunderbolt

Thunderbolt 1.0 is an Apple-only interface for multi-purpose use, including video. It is compatible with DP 1.1 and capable of natively outputting DisplayPort signals. Thunderbolt 2.0 is needed to support 4K at 60 Hz, and is compatible with DisplayPort 1.2.

Piece #4: 4K Requires New Cable Lengths

Even with the reduction in frame rate and possible gains from chroma subsampling, delivering 4K video requires massive bandwidth. In 4K applications, maximum twisted pair copper cable lengths (CATx STP) are significantly shorter than the industry is accustomed to with HD video, creating a new issue for system designers.

In analog systems, an overly long cable run can result in a degraded image. In a digital system, though, an overly long cable run can result in no picture at all (this is known as the cliff effect). Worse, incompatibilities between sources and displays are exacerbated by long cable runs. Just because some devices test okay with a longer cable run doesn't necessarily mean that every device introduced into the system later will, too. In practice, HDMI cable lengths may be more limited at the higher bandwidth required by 4K as well.

In order to combat these negative effects, high-speed HDMI cables are recommended for use in transmitting 4K. To reach farther, extenders can be used. HDBaseT™ is the most common standard for 4K.

Conclusion

The companies developing the first 4K sources and displays have a chicken-and-egg quandary on their hands: how do you test for inter-operability with other 4K devices when there are so few of them available during the infancy of this technology? 4K televisions won't be widely adopted until there is 4K content, and 4K content will not be widely available until there is a solid base of 4K displays. Compatibility issues can even exist between products from the same company in these early days of adoption.

4K is going to be an adjustment, and the video distribution industry faces some growing pains. However, companies will do their best to alleviate these difficulties. As a reference standard is developed, prices will drop, and adoption will increase significantly.

About Black Box

Black Box is a global provider of ProAV and networking solutions, and helps clients design and deploy mission-critical video processing and distribution infrastructure. Solutions include HDMI-over-IP, video switches and extenders, 4K splitters, scalers, and extenders, and HDBaseT recommended cables.

Black Box has been a leading technology partner since 1976. Black Box is a public company (NASDAQ:BBOX) with nearly $1 billion in annual revenue. Black Box services more than 175,000 clients in approximately 150 countries with approximately 200 offices throughout the world.