inneos

Real4K™ Optical Cable

Real4K™ Optical Adapter & Cables

## Getting the Full Ultra-High Definition 4K Experience
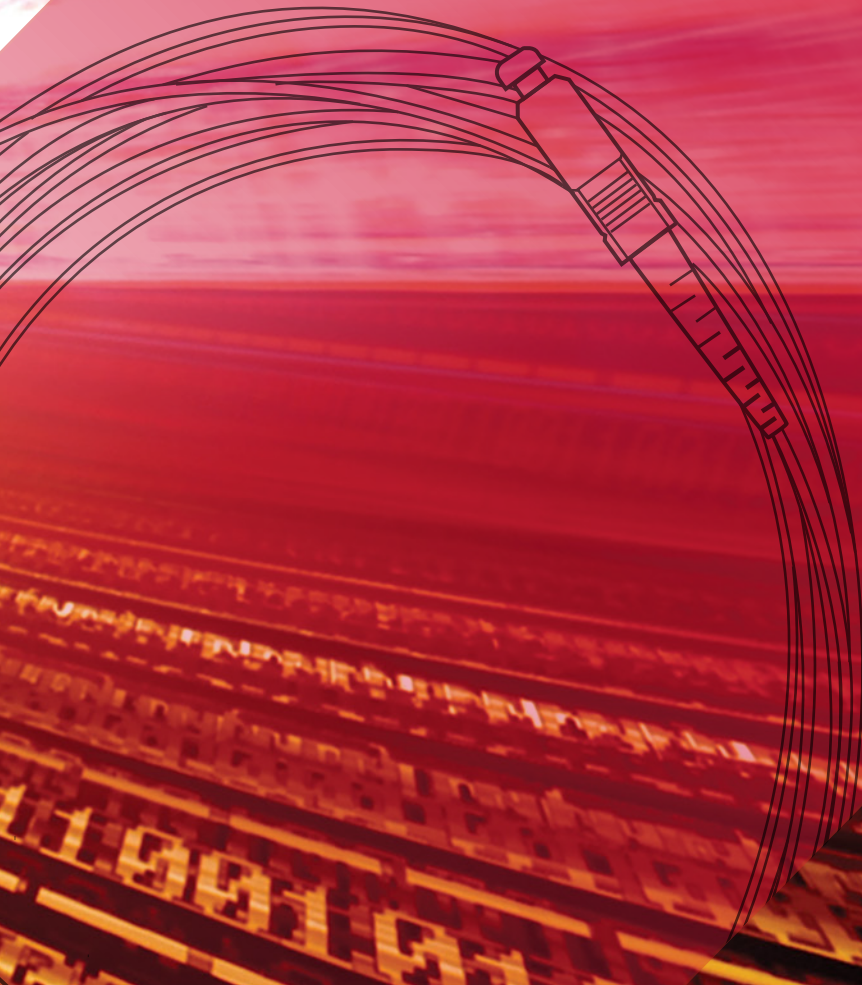
What is Real 4K?

The video market is rapidly moving toward 4K resolution as consumers demand higher pixel density and better image quality than the standard 1920x1080 HD resolution. However, the term 4K does not necessarily reflect the full details of the standard, which has resulted in market confusion, particularly for HDMI cables, as some products claim 4K, yet do not support the full scale of the 4K resolution. Inneos offers a **Real4K™HDMI** cable solution that supports the full specification in order to achieve truly enhanced pixel resolution and depth of color.

The 4K Ultra-High-Definition (UHD) resolution, as defined by the International Telecommunications Union (ITU) supports 3840x2160 pixel density and the 4K format defined by the Digital Cinema Initiatives (DCI) is a 4096x2160 pixel density. The frame rate of the video signal is also important to providing a high-quality video signal, with a 60 Hz (or 60 frames per second) rate being required for rendering fast-motion video content, such as sports and action scenes. With the UHD definition, the pixel density is four times that of 1080p resulting in a greatly improved picture quality if that resolution is maintained throughout the full system link. The final key aspect of UHD 4K resolution is the color depth. For a full color 8-bit resolution, data is required to be transmitted for each of the three colors. This leads to a bandwidth requirement of 17.9 Gbps for the UHD 4K video at 60 Hz. Because this is well above the 10.2 Gbps supported by High Speed HDMI cables and HDBaseT connectivity implementations, chromatic sampling is implemented to reduce the bandwidth required.

Figure 1
Effects of pixels displayed
due to color sampling
(Image courtesy of www.hdnumerique.com)
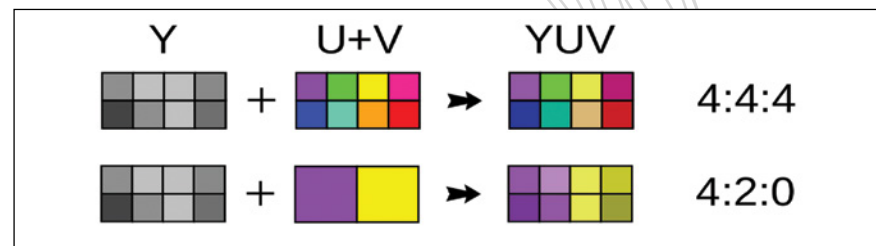
The most common implementation for HDMI is a reduction from full 4:4:4 chromatic intensity and color to the sub-sampled 4:2:0 color. The 4:2:0 color sampling, illustrated in Figure 1 above has full intensity information but reduces the color data with the nearest pixels in order to reduce the bandwidth at the expense of providing the full color information for each pixel.

The HDMI standard also includes support for deep color and high dynamic range, in which the color and intensity are expressed as 10 bits or 12 bits rather than the standard 8 bits, resulting in a broader range and depth of color when displayed, leading to a more realistic image when viewed on the display. Supporting the bandwidth required for the full UHD 4K pixel density, frame rate and color resolution with copper cables leads to severe limitations on the length of cable that can be used without compromising signal integrity. While the length depends on the cable construction and connectors used, it will generally support only a few meters for Premium High Speed HDMI cables, which severely limits installation capabilities. Integrating features such as deep color and high dynamic range will only make matters worse for standard copper cables. Even more data compression and image processing will be required to transport the signals from the video source to the video sink, defeating the benefits of the improvements in the video quality unless a real 4K transport media supporting the high bandwidths is used.

Figure 2
Signal integrity, data compression and loss of functionality, such as HDR, can degrade the viewing experience simply due to cable limitations
(Image courtesy of www.reviews.org)

Active copper solutions are being marketed that can provide modest improvements in cable transmission distances without significantly compromising signal integrity, though this comes at the expense of a heavy, bulky copper cable and still limits the distance to about 50 feet. Active optical cable solutions offer a potential seamless solution when implemented with the necessary high-bandwidth optical components without the need to compromise on resolution, chromatic data or frame rate in order to provide cables 100's of meters in length that deliver a real 4K experience.

Active Optical Cable Solutions for High Bandwidth and Long Distance

Active fiber optic cables (AOCs) can overcome the distance limitation of copper cables, allowing for transmission distances of 100's of meters without compromising image resolution or quality. There are a few different product offerings on the market today implementing optical transmission of 4K HDMI in a range of configurations. However, many of the products offered do not actually perform to the standards expected to provide a true 4K experience so it is important to evaluate how these optical cables perform in real-world applications.
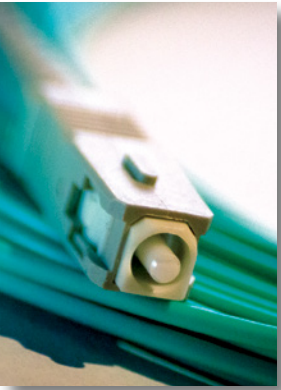
In addition to the distance benefit versus copper, optical fiber is also lightweight, flexible and immune to electromagnetic interference, so optical fiber solutions can reduce installation challenges. Most of the active optical HDMI cables available on the market today have the media converter permanently attached to the cable, which can eliminate the benefit of routing small-diameter flexible fiber, as the large housing can be difficult to route through conduit and around bends. The **Inneos Real4K™ AOC** has a connectorized fiber interface, so the fiber can be pulled with only the tiny SC fiber connectors and fiber lengths can be specific for each installation allowing for faster, more flexible setup and installation.

While most of the active fiber solutions do require power at the received video end of the cable, installations generally have power readily available for displays that can also be used for the active fiber receiver solution. **Inneos's** module easily integrates power through USB so the system simply requires plugging in the HDMI and USB connectors to the display ports, and no additional power source is required. Additionally, the **Inneos HDMI AOC** has external LEDs to provide a link status on the source and sink ends so that the installer immediately knows if the link is up and running through the active optical cable, which provides very fast troubleshooting, even compared to copper cables.

How Do Active Optical HDMI Cables Measure Up?

In order to achieve the true benefits of 4K video, the entire system must maintain performance from the video source all the way to the video display, including all

cables. The active fiber cable should be agnostic to both the video source and video sink as well as fully support any mode of high-bandwidth digital content protection (HDCP) delivered from the source, from no HDCP through HDCP 2.2. A sample of active cables were tested to determine how well they performed compared with the product claims. The table below shows the products tested. A Quantum Data 980 HDMI generator video source was used for error rate testing.

Table 1 • HDMI Active Optical Cables Evaluated

Brand	Model	Length	Maximum Specifications				Power Needed at Sink?
			Resolution	Frame Rate	Color Sampling	Deep Color?	
Celerity	DFO-100P	30m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Celerity	DFO-300P	100m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Celerity	DFO-1000P	300m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Inneos	BJK-30	30m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Inneos	BJK-100	100m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Inneos	BJK-300	300m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Kramer	CLS–AOCH–98	30m	UHD 4k	60 Hz	4:2:0	Unclear	No
Kramer	CLS–AOCH–328	100m	UHD 4k	60 Hz	4:2:0	Unclear	No
Metra	EHV-HDAOC30	30m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Metra	EHV-HDAOC100	100m	UHD 4k	60 Hz	4:4:4	Yes	Yes
Savlink	SDHC-8700	100m	UHD 4k	60 Hz	4:4:4	Unclear	No

This UHD 4K HDMI test system allows for specific settings to the resolution, frame rate and color sampling of the data stream to evaluate the error rates for each channel, HDCP and EDID interactions and viewing image test patterns. Four different video sinks were tested: Samsung JU7100 65" 4K UHD TV, Sony X830C 43" 4K UHD TV, LG UH6100 43" 4K UHD Smart LED TV, and Hisense K300UW 43" UHD 4K Smart LED TV. The data was gathered over 10 minutes for each configuration. This allowed a comparison of the HDMI cable functionality over various resolutions and color samplings in order to validate the performance of the cables with respect to their product specifications.

As Table 2 through Table 4 show, there are significant error rates for many of the cables for the full resolution, frame rate and color sampling data stream, which corresponds to the highest bandwidth of the cables, even the 30m active optical cables. Additionally, the test images also showed compromise in many of the cases, which would render viewing unappealing or even non-existent for a UHD 4K experience. This highlights that while many active optical cables may claim to support

the full rate, full color HDMI to 18Gbps, in reality they fall short of this goal and degrade the UHD 4K viewing experience.

Table 2 • Error Rate Test Results for 30m Active Optical Cables

Cable	Video Sink	Errors			Video Effects
		D0	D1	D2	
Celerity DFO-100P	Samsung JU7100	103	8062	0	Dropouts, black screen at 4 minutes
	Sony X830C	inf	inf	inf	Blank
	LG UH6100	inf	nf	0	
	Hisense K300UW	inf	inf	inf	
Inneos Real4K™	Samsung JU7100	0	0	0	
	Sony X830C	0	0	0	
	LG UH6100	0	0	0	
	Hisense K300UW	0	0	0	
Kramer CLS-AOCH-98	Samsung JU7100	0	10249	0	Sparkles visible
	Sony X830C	0	inf	0	
	LG UH6100	0	inf	0	
	Hisense K300UW	0	inf	0	
Metra EHV-HDAOC30	Samsung JU7100	0	0	0	
	Sony X830C	0	0	0	
	LG UH6100	0	0	0	
	Hisense K300UW	0	0	0	

Table 3 • Error Rate Test Results for 100m Active Optical Cables

Cable	Video Sink	Errors			Video Effects
		D0	D1	D2	
Celerity DFO-300P	Samsung JU7100				Had to replace AOC end
	Sony X830C	0	0	0	Video Dropouts
	LG UH6100	0	0	0	
	Hisense K300UW	0	0	0	Had to replace Rx AOC end
Inneos Real4K™	Samsung JU7100	0	0	0	
	Sony X830C	0	0	0	
	LG UH6100	0	0	0	
	Hisense K300UW	0	0	0	
Kramer CLS-AOCH-328	Samsung JU7100	0	90	0	
	Sony X830C	0	19	0	Video Dropouts
	LG UH6100	0	62	0	
	Hisense K300UW	1	27	0	
Metra EHV-HDAOC100	Samsung JU7100	0	0	0	Invalid bits from SCDC registers
	Sony X830C	0	0	0	Video Dropouts
	LG UH6100	0	0	0	
	Hisense K300UW	0	0	0	
Savlink SDHC-8700	Samsung JU7100	0	0	0	
	Sony X830C	488	257	338	Snow image at 3 minutes
	LG UH6100	inf	inf	inf	Dropouts down to 3G/Ch
	Hisense K300UW	inf	inf	inf	Did not work; no SCDC, EDID, or HDCP

These results highlight that the HDMI cable is critical to maintaining the system performance from the video source to the sink for UHD 4K systems. The **Inneos Real4K™** solution offers an active optical cable with a pluggable fiber that can support any length of HDMI cable installation up to 1000m or greater while still providing the full true UHD 4K experience.

Table 4 • Error Rate Test Results for 300m Active Optical Cables

Cable	Sink	Errors			Video Effects
		D0	D1	D2	
Celerity DFO-1000P	Samsung KU7000	0	inf	0	No signal visible due to D1 errors
	Sony X830C	0	0	0	Video dropout
	LG UH6100	inf	inf	0	
	Hisense K300UW	inf	inf	inf	
Inneos Real4K™	Samsung KU7000	0	0	0	
	Sony X830C	0	0	0	
	LG UH6100	0	0	0	
	Hisense K300UW	0	0	0	

HDMI Active Optical Cable Interoperability

The HDMI cable specification was developed so that any HDMI cable could be plugged into any source/sink pair and work, as long as the cable was rated to the bandwidth needed for the resolution, frame rate and color sampling implemented. For full speed UHD 4K video, this requires a Premium High Speed HDMI cable, which will be rated to 18Gbps and support HDCP 2.2. We also tested a number of different manufacturer's active optical cables on a range of video source and video sink combinations to evaluate interoperability of the cables, as the conversion from electrical to optical and back again should work with any source/sink pair. The performance is driven by how the media conversion is implemented in the cable end hardware and firmware by the manufacturer so cables with varying lengths from the same manufacturer will perform similarly. The key aspects of the source evaluated included the source resolution at UHD 4K at 60 Hz with 4:4:4 color sampling and resolution swapping from UHD 4K to 1080p as well as functional evaluation of power and plug situations, including power cycling both the video source and video sink, and hot-plugging the HDMI connector on each end, as all of these would be situations that would be expected to be encountered during normal operation.

The testing evaluated four different source to four different sink combinations. The sources were a Pioneer BDP-LX58, Nvidia Shield, Samsung UBD-K8500 and Murideo Fresco Six-G. The sinks were a Sharp LC-60UD27U, LG 55UH8500-UA, Sony XBR-43X830C and Insignia

NS-43DR710NA17. Also, if a cable failed the 4k full rate video resolution, the power cycling and hot plug interoperability tests were performed at the next lower supported resolution.

Our testing has shown that while active cable products claim 4K UHD support, they do not necessarily measure up to these claims with the hardware implemented. As the figures below show for cables from four different manufactures, all of the cables except the **Inneos Real4K™** cable fail for some interoperability case.
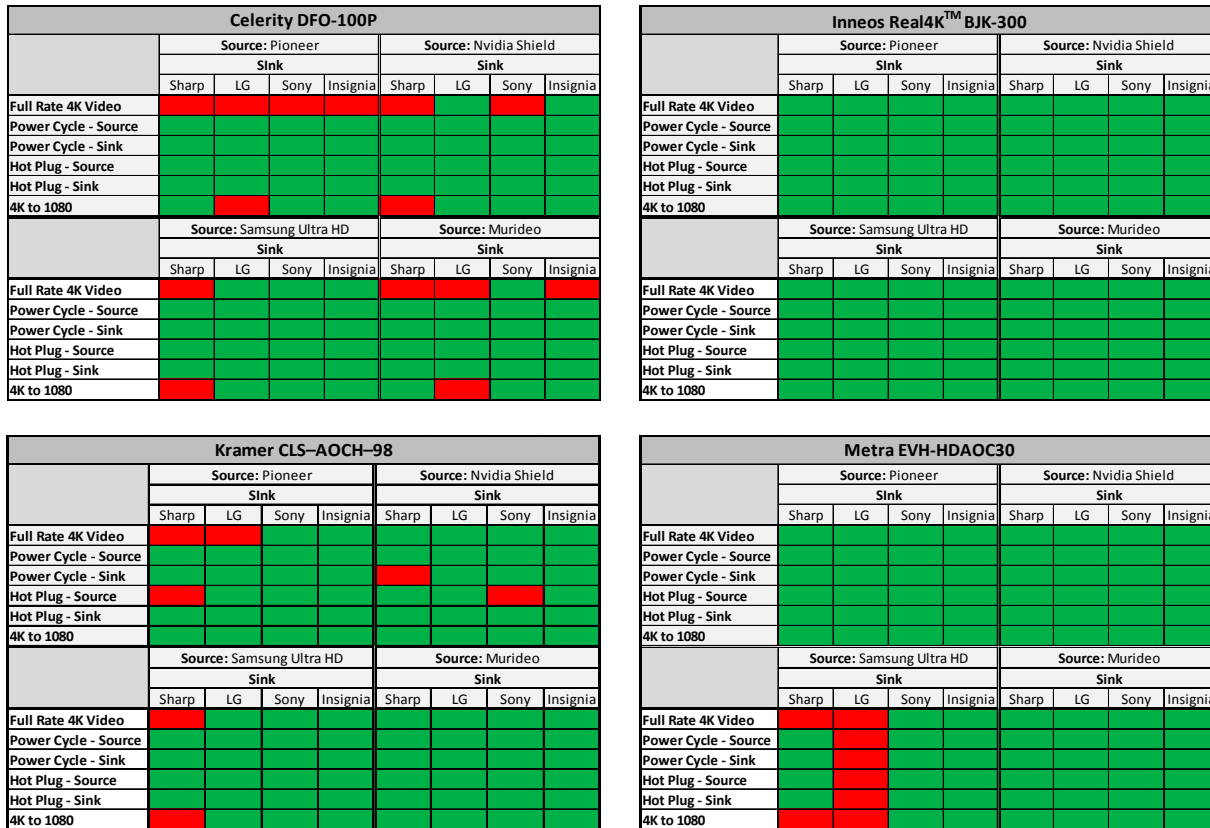
Celerity DFO-100P

	Source: Pioneer				Source: Nvidia Shield			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video	✗		✗		✗		✗	
Power Cycle - Source								
Power Cycle - Sink								
Hot Plug - Source								
Hot Plug - Sink								
4K to 1080		✗			✗			

	Source: Samsung Ultra HD				Source: Murideo			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video	✗				✗	✗	✗	
Power Cycle - Source								
Power Cycle - Sink								
Hot Plug - Source								
Hot Plug - Sink								
4K to 1080	✗					✗		

Inneos Real4K™ BJK-300

	Source: Pioneer				Source: Nvidia Shield			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video								
Power Cycle - Source								
Power Cycle - Sink								
Hot Plug - Source								
Hot Plug - Sink								
4K to 1080								

	Source: Samsung Ultra HD				Source: Murideo			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video								
Power Cycle - Source								
Power Cycle - Sink								
Hot Plug - Source								
Hot Plug - Sink								
4K to 1080								

Figure 3
Interoperability Test Results for Active Optical Cables from Different Manufacturers

Kramer CLS–AOCH–98

	Source: Pioneer				Source: Nvidia Shield			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video	✗	✗						
Power Cycle - Source								
Power Cycle - Sink					✗			
Hot Plug - Source	✗						✗	
Hot Plug - Sink								
4K to 1080								

	Source: Samsung Ultra HD				Source: Murideo			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video	✗							
Power Cycle - Source								
Power Cycle - Sink								
Hot Plug - Source								
Hot Plug - Sink								
4K to 1080	✗							

Metra EVH-HDAOC30

	Source: Pioneer				Source: Nvidia Shield			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video								
Power Cycle - Source								
Power Cycle - Sink								
Hot Plug - Source								
Hot Plug - Sink								
4K to 1080								

	Source: Samsung Ultra HD				Source: Murideo			
	Sink				Sink			
	Sharp	LG	Sony	Insignia	Sharp	LG	Sony	Insignia
Full Rate 4K Video	✗							
Power Cycle - Source		✗						
Power Cycle - Sink		✗						
Hot Plug - Source		✗						
Hot Plug - Sink		✗						
4K to 1080	✗	✗						

Conclusion

The HDMI active optical cable products on the market today offer a range of performances that can potentially degrade the UHD 4K experience and lead to significant installation and operational challenges. The HDMI cable should be something that is installed once and then maintains the end-to-end system performance to provide a full resolution UHD 4K image. The **Inneos Real4K™ Optical Adapter and Cables** provides this functionality in a small form factor with a pluggable fiber cable from 1m to over 1000m so that the high-quality, full resolution 4K video is maintained all the way to the display providing a **"Real 4K"** experience.

For more information on **Real4K™** solutions and **Inneos** products and services, please contact us at **contact@inneos.com** or visit **www.inneos.com**.