Dual-Link and 3G Overview

6/2011

There has been some confusion in the industry related to the terminology of Dual-Link and 3G. Below is an overview of the proper terminology as we use it in AJA documentation and also some examples of how these different standards are used.

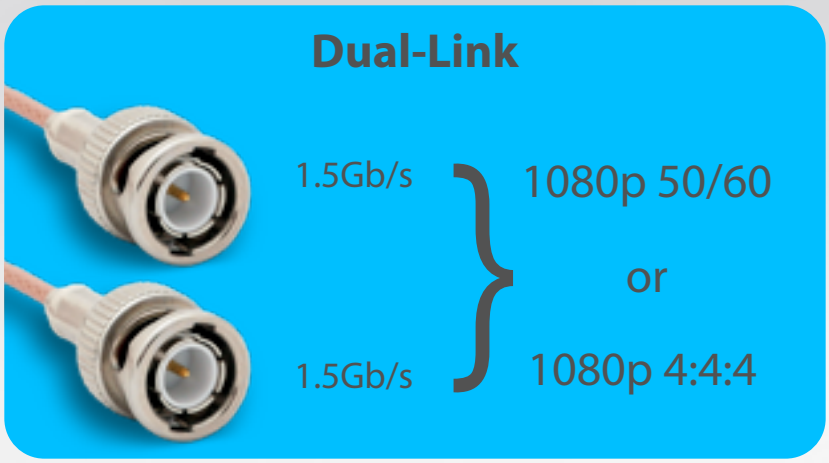
At the end is a more detailed explanation of the evolution of these standards.

Terminology

Standard HD-SDI Signal

Standard HD-SDI allows for a single 4:2:2 image to be carried on one cable at 1.5Gb/s.[1]

Dual-Link HD-SDI Signal



Dual-Link HD-SDI is simply two standard HD-SDI signals with a single image stream split between the two cables. This is most often used for 1080p video but may also be used for 2K and 4K implementations.

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[1] Technically 1.485Gb/s.

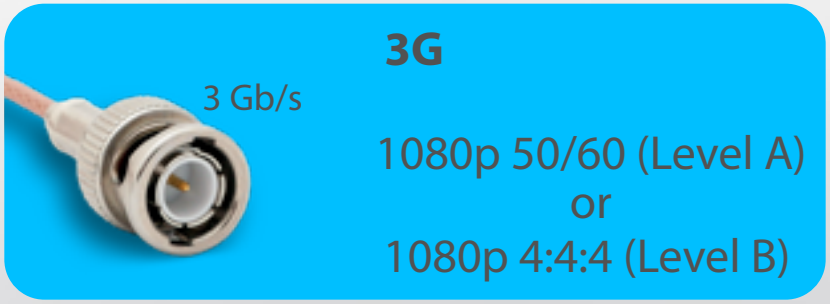
Dual-Link and 3G Overview

6/2011

In the case of 1080p 50/60, the higher frame rate is split between the two cables while with 1080p 4:4:4, the individual color channel information is carried across the two cables with the first cable carrying the standard 4:2:2 information while the second cable carries the remaining 0:2:2 information.

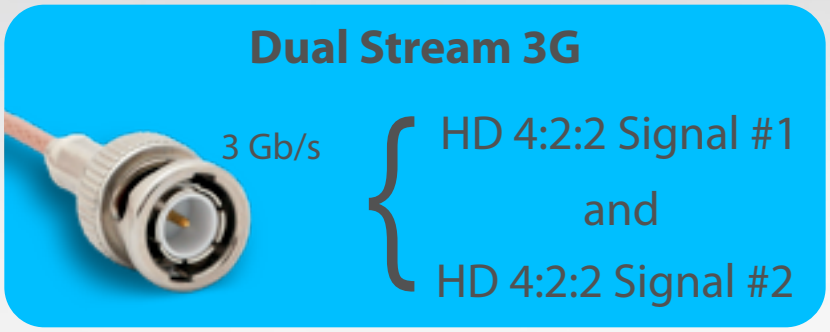
Note: The signal on the second cable is formatted as a complete 4:2:2 signal but only the second and third channels carry information useful to the final image.

3G HD-SDI Signal



3G HD-SDI uses a higher data rate to send more information per second. The capabilities are similar to Dual-Link but the confusion of two separate cables is removed. All information is carried on the single cable.

Dual Stream 3G HD-SDI Signal



Dual Stream 3G is a specific variant of the 3G signal which combines two completely separate 4:2:2 image streams into a single 3G signal. This can be used to minimize confusion in stereoscopic production by keeping left and right eye signals together.

Dual-Link and 3G Overview

Dual Stream vs. 3D Muxing

It's important to note that Dual Stream 3G when used for stereoscopic is not the same as a "muxed" stereoscopic image. Stereoscopic muxing squeezes the left and right eye images into a single, standard video frame, potentially sacrificing the quality of the images. Dual Stream 3G has the bandwidth to embed two complete 1.5 Gb image streams into a single 3G signal, which can then be extracted and used without compromise.

Examples

Dual Link 4:4:4

In this example, two SDI cables are connected between the source device and the receiver. The 4:4:4 data is split between the two cables such that the first cable carries a standard 4:2:2 signal and the second cable carries the remaining 0:2:2 signal.[2] In order to get the full 4:4:4 signal both cables must be used.

3G 4:4:4

With 3G 4:4:4, the entire signal is carried over a single 3G cable. In order for this to work, both the source and receiving device must support 3G.

Muxed 3G

In this case, two completely different 4:2:2 data streams are combined together and carried over a single 3G cable. Both the source and receiving device must not only support 3G but must also be able to combine or extract the two signals properly.

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[2] While the relevant information is 0:2:2, the actual signal on the cable is a standard 4:2:2 signal where the Y information is essentially null.

Dual-Link and 3G Overview

6/2011

How We Got Here

Initially, a standard HD-SDI signal had a data rate of 1.5Gb/s. Due to the data rate limitation this meant signals had to be at a frame rate of 24, 25 or 30 frames per second[3] and a bit depth of 4:2:2.

There was a need for higher frame rates and also higher bit-depth, but since the standard HD-SDI signal was maxed out, a new solution was needed. This lead to the creation of the Dual-Link specification[4], which links two standard HD-SDI signals together -- essentially doubling the bandwidth. Each signal carries a separate 1.5Gb/s 4:2:2 signal.

This can be used several ways. First, higher frame rates can be achieved by sending alternating video frames down each HD-SDI cable. This works similarly to interlacing within a video image. The alternating frames are chained together on the receiving end into a 50 or 60 fps signal.

Alternately, the two HD-SDI signals can carry higher bit depth information. By splitting the data between the two cables, more information per frame can be carried. This is usually referred to as Dual-Link 4:4:4 and can be either YUV or RGB. The advantage of YUV 4:4:4 is that the primary channel is carrying a standard YUV 4:2:2 signal, which can be plugged into a standard Single Link device.

Soon after, the ability to handle up to 3Gb/s on a single cable (called 3G) was introduced.[5] This made the need for two cables obsolete, since the higher frame rate and bit depth signals could now be carried on a single cable. When used to carry higher frame rates such as 1080p 50/60, the signal is referred to as Level A. When used to carry higher bit depth signals, it is referred to as Level B.

In addition, since 3G could carry twice the information it's also possible to combine two separate 1.5Gb/s 4:2:2 image streams into a single 3G stream. This is referred to as 'Dual Stream 3G'. Dual Stream 3G is particularly useful in stereoscopic production where separate left and right eye information is being captured.

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[3] We are ignoring the subtleties of 23.976 and 29.97 in the interest of brevity.

[4] SMPTE 372M

[5] SMPTE 424M

Typically, these two signals were captured to separate devices. This has two inherent problems. First, devices have to be synchronized properly in order to ensure the captured signals are aligned. Second, since the images are on separate devices it's possible for them to become separated from each other or to be played back out of sync.

By combining the two images into a Dual Stream 3G signal, they are locked together and can be recorded to a single device, ensuring that they are always associated and always in sync.

Conclusion

As the SDI signal has evolved, it's become necessary to practice proper use of terminology in order to avoid confusion when communicating. Often the term Dual-Link, for example, is used to describe a 3G signal. A customer asking if an AJA device supports Dual-Link may be expecting the two SDI connectors or they may be thinking of 3G, which would only require a single SDI connector. This could be a significant difference if miscommunicated.

For more specifics on the Serial Digital Interface (SDI), check out this Wikipedia article as a starting point:

http://en.wikipedia.org/wiki/Serial_Digital_Interface

There is also some good information in these two whitepapers from Altera:

http://www.altera.com/literature/wp/wp-01022.pdf

http://www.altera.com/literature/wp/wp-3gbps.pdf