

USB 3.0 as an Alternative to Camera Link – Key Factors When Switching Camera Interfaces

Since the introduction of USB 3.0 and its associated USB3 Vision standards, a growing number of users are deliberating switching from their old Camera Link cameras to new USB 3.0 cameras. The technology can be used for applications stretching across a broad range of industries, including print technology, food sorting, the pharmaceutical industry and classical inspection systems in the electronics industry.

This White Paper explores in detail the arguments for a switch from Camera Link to USB 3.0 and factors that demand consideration.

Content

1. Fundamental Issues	1
2. Detailed Comparison between Camera Link and USB 3.0	1
2.1 Cable	2
2.2 Bandwidth	2
2.3 Complexity of the setup.....	3
2.4 Bit Error	3
2.5 Real-Time Compatibility.....	3
2.6 Summary of the Comparison	4
3. What must be taken into consideration when switching?	4
3.1 Hardware adaption	4
3.2 Software adaption.....	6
4. Cost/Benefit Analysis: Where is the break-even point for switching?	7

- Significantly reduced complexity thanks to the plug and play compatibility of the USB 3.0 host controller, with no additional driver installation required
- Greater flexibility and simplicity in the cable solutions
- Higher bandwidth in single cable solutions
- Fault detection (such as using CRC checksums) and security against data loss already included in standard version
- Significant cost savings in overall system (sample calculation provided in chapter 4)

1. Fundamental Issues

Generally speaking, three types of digital interfaces dominate industrial image processing: Camera Link, GigE and, the most recent option, USB 3.0 (in new notation USB 3.1 Gen 1). The characteristics and benefits of the different interfaces are explored in Basler’s White Paper „Comparison of Current Digital Interface Technologies within Industrial Image Processing.“ Comparison of Current Digital Interface Technologies within Industrial Image Processing.“ It explores the USB3 Vision standard associated with the USB 3.0 interface and clearly defines data transmission from camera to PC, the characteristics of the cable, the drilling pattern and other central points. Basler helped spearhead and shape this standard and as such can ensure 100% compliance with the standard on all Basler USB 3.0 cameras. Thanks to its similar bandwidth and cable lengths, the interface represents an alternative to Camera Link systems.

A USB 3.0 camera system offers the following benefits over a Camera Link system, particularly in the Camera Link base or medium configuration:

2. Detailed Comparison between Camera Link and USB 3.0

The following provides a detailed exploration of the specific differences between Camera Link and USB 3.0 and compares the strengths of the individual interfaces.

2.1 Cable

Let’s start with a review of the different types of cable for the two interfaces:

	Camera Link	USB 3.0
Shielding	Double shielding	Double shielding
Connector	Industrial screw-down connector	Industrial screw-down connector
Cable pairs	4+7 twisted pairs (+4) (Fig. 1)	2+1 twisted pairs (+2) (Fig. 2)
Flexibility	0	+
Costs	-	++
Max. Length	10 m	8 m

Tab. 1: Comparison of Cabling

¹For simplicity’s sake, USB 3.1 Gen1 will simply be referred to as, USB 3.0’, as there is no difference in the two technologies.

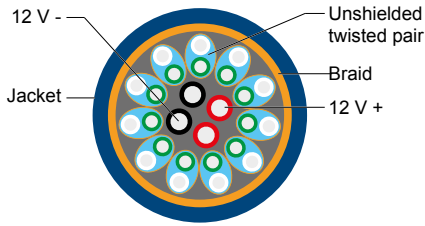


Fig. 1: Camera Link, 4+7 twisted pairs (+4)

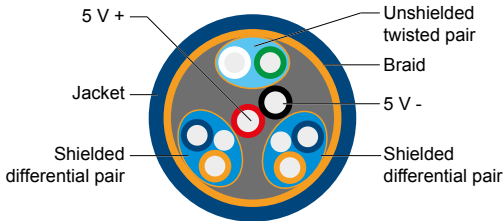


Fig. 2: USB 3.0, 2+1 twisted pairs (+2)

To summarize this initial comparison, it can be said that the USB 3.0 cable offers the same robustness as a Camera Link cable, with greater flexibility, lower complexity but also a slightly lower maximum length.

2.2 Bandwidth

In terms of bandwidth, Camera Link requires a variety of configuration steps.

Interface	Configuration	Maximum Bandwidth [MB/s]
Camera Link	Base (3 x 8 bit)	255
	Medium (6 x 8 bit) ¹	510
	Full (8 x 8 bit) ¹	680
	Full+ (10 x 8 bit) ¹	850
USB 3.0		640 (with overhead; real bandwidth 350 - 430)

Tab. 2: Comparison of Bandwidth

Compared with the base configuration, USB 3.0 uses a higher bandwidth than Camera Link. Beyond this, Camera Link offers significant advantages in this category.

2.3 Complexity of the setup

During the setup of a Camera Link system, several points must be taken into consideration: For starters, connecting the camera to a PC requires not just the correct cable but

also a frame grabber, which must also be configured to the camera. During cabling, it is important to note that – depending on the configuration – the cable is connected in the right direction and to the right port. Beyond this, the camera’s power supply must be established – such as through Power over Camera Link (PoCL).

USB 3.0, by contrast, takes full advantage of the interface’s plug and play compatibility. No additional configuration is needed and power is supplied via a simple single-cable solution.

It can thus be said with confidence that USB 3.0 offers significant benefits in terms of the simplicity of the system setup.

2.4 Bit Error

While the Camera Link interface offers no mechanism for detecting bit errors, the USB3 Vision standard dictates that each header and each data packet is controlled using a CRC checksum. A technology inherent to the USB 3.0 interface enables repeated sending of damaged data.

The USB3 Vision standard thus ensures more secure data transmission than Camera Link thanks to CRC checksums and packet resend mechanisms.

2.5 Real-Time Compatibility

Real-time compatibility in vision systems is defined by various points where latency and jitter can arise. Latency involves an absolute measurable time, whereas jitter refers to the variance of time between two sequential, identical process steps. The latter is the most important factor for a deterministic prediction of how a process step will unfold.

Figure 3 explains jitter and latency in systems:

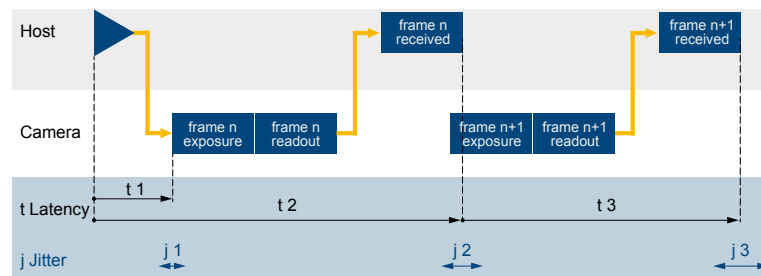


Fig. 3: Latency and Jitter in the System

What matters at this point are the trigger options offered by the interface, since different connections manifest different characteristics (see tab. 3).

¹With this configuration, you need two cables for each camera.

	Camera Link	USB 3.0
Trigger options	Hardware trigger directly on the camera or via frame grabber Software trigger and control command	Hardware trigger directly on the camera Software trigger and control command
Jitter	Almost no jitter thanks to the pure hardware interface	<1%

Tab. 3: Comparison of trigger options between Camera Link and USB 3.0

In terms of the stability of the interface and jitters, the inherent hardware basis of the Camera Link interface offers clear benefits over USB 3.0.

2.6 Summary of the Comparison

Based on the points above, it is clear that USB 3.0 offers significant benefits in terms of complexity and flexibility. The simple cable solution and lower integration costs with high bandwidth have positioned the interface well as an alternative for Camera Link, whose sole benefits come in terms of jitter and higher bandwidths in the Medium, Full and Full+ configurations.

3. What must be taken into consideration when switching?

This chapter describes the cost aspects involved with switching from the Camera Link to USB 3.0 interface. This should then deliver a rough indicator of the time and money costs involved with the switch. The observation goes in depth into the required hardware and software adaptations.

3.1 Hardware adaption

The following will take as its example a one-camera system for inspecting objects. The complete setup is oriented toward that object, with distances pre-calculated and a lens matching the specifications of the sensor. Furthermore, an illumination system is integrated into the setup and a suitable camera bracket is present.

During set-up of Camera Link - in this case the Base configuration - a frame grabber must also be built into the system. This unit is connected to the camera by cable and to the PC via a PCIe interface. A hardware trigger is used for accurate triggering of the camera.

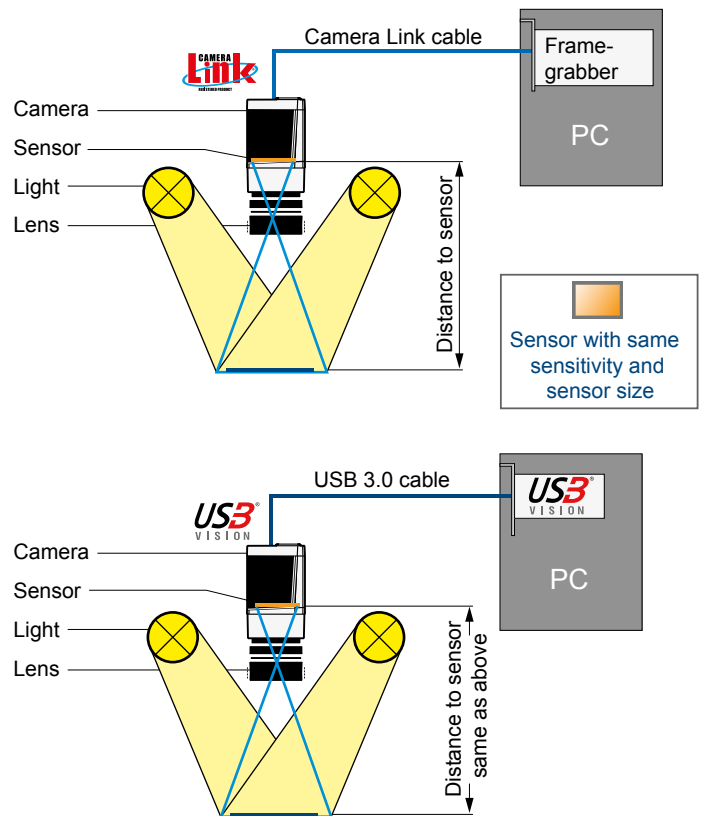


Fig. 4: Comparison of setup of a Camera Link system (above) vs. setup of a USB 3.0 system (below)

Only minimal effort is required to convert this setup into a USB 3.0 system, as in many cases the same sensor, and as such the same optical setup, can be used. If this is not possible, then newer sensors with similar optical values (such as sensor dimensions and pixel size) can be used.

The size of the housing for a USB 3.0 should be similar, but in no case bigger than the current camera, and if possible should use the same fastening pattern. On the PC side of the system, the cable and PCI cards at least – and potentially the entire PC – must be replaced, although the frame grabber unit is no longer needed.

On the whole, the one-off costs for the needed hardware are very manageable; a long-term analysis shows that the new acquisition of required PC hardware is potentially even more cost-efficient.

3.2 Software adaption

Compared with the hardware, software adaption can represent a significantly larger factor. The real scope depends strongly on how the camera has been configured to date and which read out method is being used. In most cases, this is handled via direct registry access, conducted either through a binary protocol or using the frame grabber manufacturer's SDK. Another widely found option is use of larger image libraries, which allows for the same thing.

Variante 1:

Applications whose previous software solution weren't based on the GenICam standard and which do not have any image processing libraries relevant for USB 3.0 will have to be completely rewritten to comply with the GenICam standard. The Basler pylon Camera Software Suite is a broad no-cost software package with a very powerful Software Development Kit (SDK) that even less experienced software developers can use to handle porting to GenICam easily. This porting only needs to be performed once, after which the user can also take advantage of other current and future machine vision software interfaces, since all interface technologies must comply with the GenICam standard.

Variante 2:

For applications where a GenICam-based software environment is being used, the costs are significantly lower. Nevertheless, the current GenICam version must be adapted for USB3 Vision to ensure that the software will function properly. Ideally the software environment contains the option of updating all drivers for USB3 Vision. The Basler pylon Camera Software Suite and many image library manufacturers offer precisely this.

Figure 5 illuminates the setup and contents of the pylon Camera Software Suite:

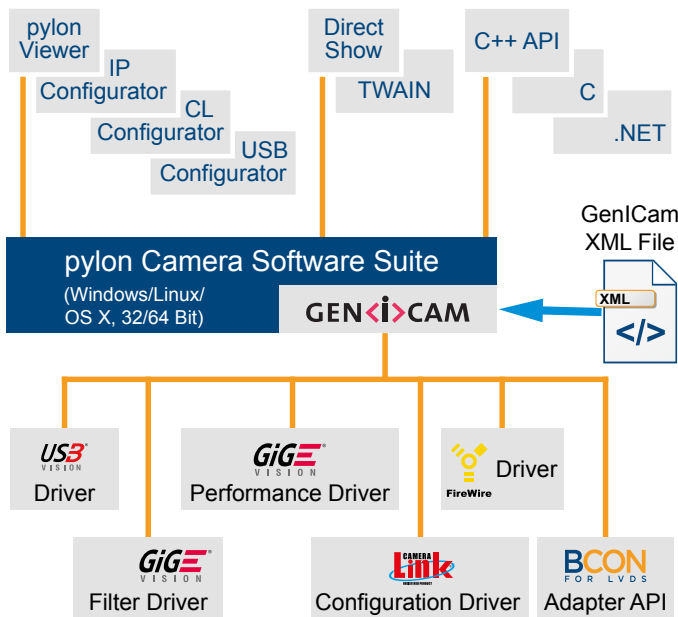


Fig. 5: Setup and contents of the Basler pylon Camera Software Suite

4. Cost/Benefit Analysis: Where is the break-even point for switching?

The following sample calculation (tab. 4) shows when the switch to USB 3.0 pays for itself from a financial standpoint. The cameras themselves are not part of the equation, since they usually can be replaced 1:1 within the Basler portfolio. The primary costs instead fall on the areas of software, installation and necessary accessories. Since the same sensor can be used, the optical setup and illumination requires no adjustment.

This comparison shows that the break-even point can be reached before a single year has passed. The comparison is based on a system with 100 cameras and a corresponding number of cables and necessary cards.

Sample calculation in €	Camera Link setup	USB 3.0 setup with same sensor (same price/camera)
One-time costs to adapt the software (4 man-months)	- €	€36,000
One-off costs for hardware adaption (4 man weeks)	- €	€9,000
One-off costs for logistics/parts list adjustments and misc	- €	€5,000
Cameras	100	100
List price for cable	€71	€18
List price for Framegrabber	€2,450	- €
List price for USB 3.0 PCIe card	- €	€28
Purchase costs for accessories, per year	€252,100	€4,600
Savings in year 1:	- €	€197,500
Savings in year 2:	- €	€247,500
Savings in year 3:	- €	€247,500

Tab 4: Sample calculation of system costs - Camera Link vs. USB 3.0

In summary, a USB 3.0 system can provide a better and at the same time cost-efficient alternative to a Camera Link system.



Autor

Dominik Lappenküper

Product Market Manager

Dominik Lappenküper is responsible for Basler's ace, Basler beat and racer cameras series, and oversees market launches for new camera models. He is also the first point of contact when new features are rolled out for these camera families. He is additionally responsible for liaising with the market to better understand its needs.

Dominik started at Basler in 2011 as part of a work/study program in industrial engineering, and successfully earned his Bachelor of Engineering. He has since completed a Master of Science at the Polytechnical University of Wedel alongside his work at Basler.

Contact

Dominik Lappenküper – Product Market Manager

Tel. +49 4102 463 409

Fax +49 4102 463 46409

Email: dominik.lappenkueper@baslerweb.com

Basler AG
An der Strusbek 60-62
22926 Ahrensburg
Germany

About Basler

Basler is a leading global manufacturer of digital cameras for industrial and retail applications, medical devices, and traffic systems. Product designs are driven by industry requirements and offer easy integration, compact size, excellent image quality, and a very strong price/performance ratio. Founded in 1988, Basler has more than 25 years of experience in vision technologies. The company employs 500 people at its headquarters in Ahrensburg, Germany, as well as in international subsidiaries and offices in Europe, Asia, and the Americas.