WHITE PAPER

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CoaXPress 2.0 as an Alternative to Camera Link - More Performance and Lower System Costs When Changing the Camera Interface

CoaXPress is an established interface for high data rates in the market of industrial image processing. With the release of the new CoaXPress 2.0 (CXP 2.0) standard, this further development offers an interesting alternative to the proven Camera Link interface. Both interfaces require a similar system structure and special hardware in the host PC. Camera Link and CXP 2.0 need a frame grabber for data pre-processing. But what are the differences despite all the technical similarities? We compare both interfaces and ask the question: Is CXP 2.0 the ideal successor to Camera Link?

Content

Camera Link and CoaXPress: Two Interfaces for High Data Rates

In the field of industrial image processing, two interfaces that require a frame grabber dominate: Camera Link and CoaXPress. Both interfaces are used in applications where high speeds or resolutions are usually used. Both interfaces also offer advantages when data pre-processing on the frame grabber is required to reduce the data load in the host PC or to accelerate processes. These pre-processing operations can include debayering, color correction or deep learning processes. The applications in which frame grabbers are used are very diverse and therefore occur in very different industries, such as automation, electronics manufacturing, medical technology or classical automation processes.

Since the release of the new CoaXPress 2.0 vision standard, many users have been busy upgrading existing Camera Link systems with the new CoaXPress 2.0 standard. This is because the new standard offers convincing advantages, so that a change of interface is worthwhile in many cases. The most important reasons to change from the Camera Link system to a CoaXPress system are:

- The bandwidth in the Camera Link system is no longer sufficient to meet current and future requirements on the image processing system, such as higher frame rates or resolutions
- More flexible and simplified cable solution
- Significantly simplified integration and implementation effort
- Achievement of cost savings and therefore a much better price-performance ratio
- More precise triggering of the camera
- A better image quality is desired, which can only be achieved with the latest image processing sensors
- Larger cable lengths of up to 40 m, with maximum bandwidth

Detailed Comparison of Camera Link and CXP 2.0

But what are the main differences between the two interfaces in terms of bandwidth, cable, bit errors and real-time capability?

Bandwidth

When comparing the bandwidths, it is important to consider the different configuration options of the Camera Link interface. They differ in the number and nature of the data cables. For example, CXP 2.0 only requires a single cable to achieve a higher data rate than Camera Link (full+ configuration):

Interface	Configuration	Bandwidth (MB/s)	Number of cables
Camera Link	Base	255	1
	Medium	510	2
	Full	680	2
	full+	850	2
CXP 2.0	CXP-12	1200	1
	CXP-12	2400	2
	CXP-12	4800	4

CXP offers advantages over Camera Link even in the simplest configuration with only one cable. In addition, CXP also offers scalability, making it future-proven to increase bandwidth if required. This is a great advantage in many applications, for example, when sensors with higher resolutions or speeds are to be used and therefore a larger data volume must be handled. The higher data rates that can be transmitted over a smaller number of cables also result in an economic advantage and a simplification of the entire image processing system. This will be discussed in more detail in a later section of the White Paper.

Cable

Cables are an important cost factor in machine vision systems. The required cables and their specifications are therefore essential factors when comparing the Camera Link and CoaXPress interfaces

	Camera Link	CXP 2.0
Shielding	Double shielding	Double shielding
Connector	Industrial connector; MDR / SDR connector	Industrial connector with robust bayonet connector; Micro-BNC
Flexibility	0	++
Costs	-	++
Cable length at max. bandwidth	10 m	40 m

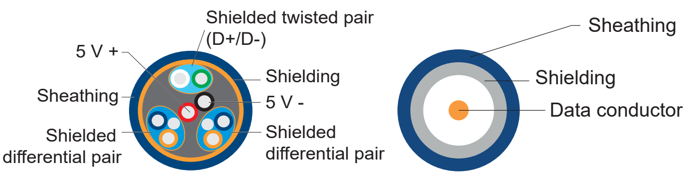

Figure 1: Comparison of the cable design of Camera Link cable with CXP cable

Figure 2: Camera Link cable (MDR), Camera Link cable (SDR), CXP cable (Micro-BNC)

Cable construction or individual cable types are shown in the illustrations. CXP cables have the following advantages over Camera Link cables:

- Greater cable length of up to 40 m (at maximum bandwidth)
- Standardization of connector type -> Micro-BNC (HD-BNC)
- Increased flexibility and thinner cable, making it easier to lay cables in the vision system
- Cost saving

Data Security

To ensure data integrity, CXP uses a CRC32 checksum for the image data. This ensures that the user can detect if, contrary to expectations, errors occur.

This checksum can be used - in contrast to Camera Link - to detect errors during data transmission and assign them to the images. However, in order to reduce complexity on the receiving side and to avoid having to install additional memory capacity in the camera, no mechanism is provided for resending the damaged packets at the frame grabber.

The CoaXPress Standard thus offers the user a secure and traceable quality in data transfer.

Real-time Capability

Real-time capability in vision systems is the ability to record and process image data without noticeable delay. The technical term for the delay or delays that occur in the system is the so-called latency time or latency periods. A real-time-capable system therefore has low latency times. Latencies can occur at different points in the image processing system. The latency time of the system is an absolutely measurable delay. If the latency time is not constant, but varies when tasks or process steps are repeatedly processed, there is a technical term for this property: "jitter" describes variance in the processing time of consecutive identical process steps. It is one of the most important variables when setting up deterministic process steps. The figure below illustrates both jitter and the latency of a system.

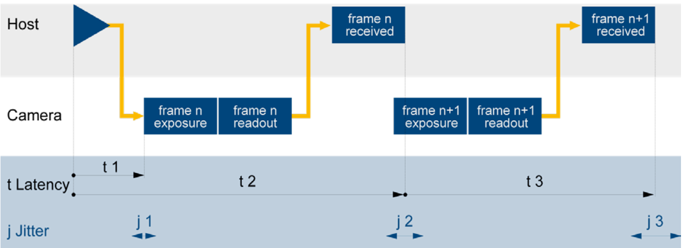

Figure 3: Latency times and jitter of a system

Important at this point are also the trigger possibilities of the interface.

	Camera Link	CXP 2.0
Trigger options	Hardware trigger directly on the camera or via the frame grabber	Hardware trigger directly on the camera or via the frame grabber
Jitter	Almost no jitter due to the pure hardware interface	Almost no jitter due to the new software interface

The table shows that both interfaces (Camera Link and CXP 2.0) have similar specifications with regard to triggers and jitter, respectively, as these two interfaces are technologically very similar.

Conclusion of the Technological Comparison

The two interfaces CameraLink and CoaXPress are technologically very similar. A change from Camera Link to CXP 2.0 is therefore possible without major problems. CoaXPress 2.0 even has significant advantages over Camera Link: thanks to the greater maximum cable lengths, applications can bridge greater distances and, thanks to the greater bandwidth, a higher resolution can be used or higher frame rates achieved. CXP 2.0 offers many possibilities and advantages to improve the existing image processing system based on frame grabber technology.

What Do I Have to Consider When Changing?

Let us look at the differences between two typical system setups - each with Camera Link and CXP 2.0 - to explain the differences and highlight relevant hardware components. We also look at the special features of the respective software architecture.

Different System Architectures

The following paragraph contains a typical system design, which can be used in electronics production, medical technology, or for various automation tasks. In this setup, the camera is focused on a specific test object, e.g. an individual part or workpiece, which is precisely aligned. Let‘s assume that the working distances have already been calculated and adjusted, and a suitable lens and illumination have been selected for the corresponding optical parameters (sensor size, working distance and field of view).

In the figure provided, an inspection task with the Camera Link interface is shown (in this example, the fastest Camera Link version, namely the CL Full+, is used). The camera is connected with two cables that lead to the frame grabber installed in the host PC. These two cables are necessary to achieve a bandwidth of 850 MB/s. The frame grabber is connected to the mainboard in the PC via a PCIexpress interface. In this case the software trigger is done via the Camera Link cable.

To convert this Camera Link system structure into a CXP

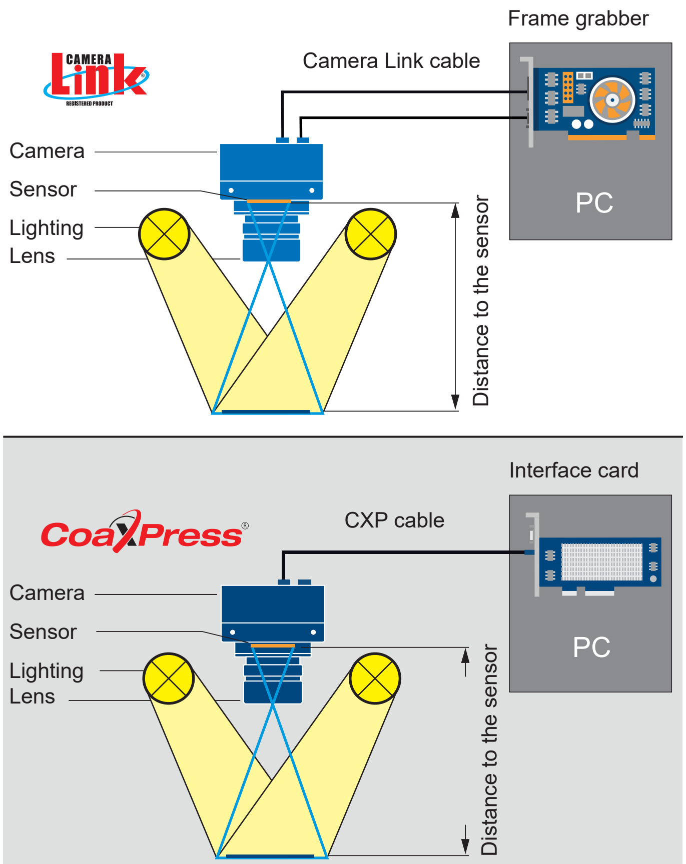

Figure 4: Inspection task with Camera Link system compared to an inspection task with CXP system

2.0 system, the hardware element requires only a very small effort, since a frame grabber is also used in a CXP system. It should be noted that a PCI Express 3.0 interface on the mainboard of the host PC is required for changing the frame grabber. In addition, older sensors are often used in Camera Link systems, so the lens may need to be adapted. Newer generations of sensors often have smaller pixels, which can change the optical conditions as compared with the old system while maintaining the same resolution. The sensors often offer higher speeds and better image quality. Thus, in many cases, faster throughput rates with higher inspection quality can be achieved in the application. Thus, small individual parts can be inspected at even higher speeds and a higher production quantity of different components is possible.

In addition to the increased quality through the use of new types of sensors, a major advantage in the hardware setup of CXP 2.0 is the use of better cable technology. Among other things, at least one cable can be saved in the new image processing system with the same or only minimally increased bandwidth requirements, which simplifies the entire system setup. Further advantages are:

- Higher bandwidth with up to 1200 MB/s per cable
- Standardized Micro-BNC (HD-BNC) connector
- Cable lengths of up to 40 m possible (with full bandwidth of 1200 MB/s)
- Thinner and more flexible cables, therefore smaller minimum bending radius
- Additional saving of one cable and thus cost saving

Adaptation of the Software

System changes that affect the software can be more extensive and require considerably more work. This effort depends on how the previous setup was configured and read out. With Camera Link technology, parameterization - among other things - is carried out via the serial interface of the frame grabber, which can be very time-consuming. In recent years, the introduction of the GenICam standard has led to a simplification.

We present two possible scenarios for a software migration:

Variant 1:

Users whose existing software solution does not follow the GenICam standard and who do not use an image processing library applicable to CoaXPress must adapt their software to comply with the GenICam standard. This includes communication with the camera and image acquisition. The Basler pylon Camera Software Suite offers a comprehensive free software package with a very powerful Software Development Kit (SDK) that allows less experienced software developers to easily port to GenICam. After the one-time porting, the user is also prepared for other current and future machine vision software interfaces, as all interface technologies must comply with the GenICam standard.

Variant 2:

For applications where a GenICam-based software environment is already in use, the effort required is significantly lower. Nevertheless, the current GenICam version for CoaXPress must be adapted to ensure the functionality of the software. This can include, among other things, the different naming of camera features. Ideally, the software environment should include the possibility of updating all drivers for CXP 2.0, which is offered by the Basler pylon Camera Software Suite and by many image library manufacturers.

The following figure illustrates the structure and content of the pylon Camera Software Suite:

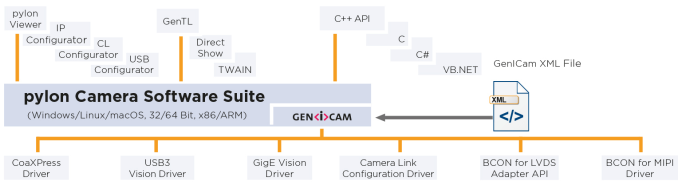

Figure 5: Structure and content of the pylon Camera Software Suite

A universally applicable software thus offers significant time and cost savings in software development for every migration project.

Example of a Cost Analysis - Comparison of Camera Link with CXP 2.0

In the following diagram, we would like to take a closer look at the cost benefits when switching to CXP 2.0.

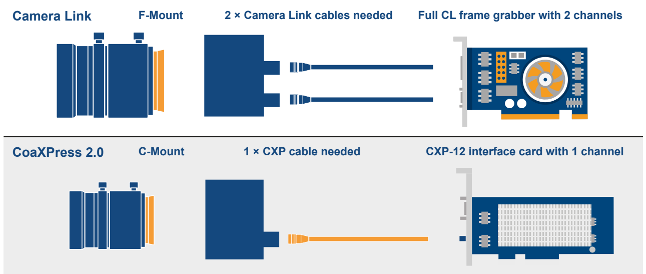

Figure 6: Camera Link system compared to a CXP 2.0 system

We look at the comparison between the configuration of Camera Link Full and CXP-12, which are typical industrial cameras with a resolution of 12 megapixels and a frame rate of about 60 fps. The Camera Link version has a frame grabber built into the system. CXP frame grabbers are now available in simple versions, which reduces complexity compared to Camera Link and also offers cost advantages.

The following table compares the costs of both setups:

	CameraLink - System Sensor CMV12000		CXP - System Sensor IMX 253	
Lens	F-Mount	600 EUR	C-Mount	300 EUR
Industrial camera	CameraLink Full+	2.800 EUR	CXP-12	3.000 EUR (bundle)
PC plug-in card	Frame grabber	1.200 EUR	Interface Card	
Cable	2 x 10 m	300 EUR	1 x 10 m	80 EUR
Total costs		**4.900 EUR**		**3.380 EUR**
Cost per megapixel	12 MP	408 EUR per megapixel	12 MP	281 EUR per megapixel
Cost per megabyte	850 MB/s	5.76 EUR per MB/s	1200 MB/s	2.80 EUR per MB/s

**We assume standard commercial list prices*

From the comparison of the costs, it can be seen very clearly that there is a great price advantage for a system with the new CXP 2.0 interface. This calculation example shows a cost advantage of approx. 1500 EUR or 45 % for an image processing system with all typical components required for image acquisition. If no pre-processing is required, a simple technical version of the frame grabber is completely sufficient. Also cheaper lenses can be used. This is due to the sensor size, in this example an IMX 253 with a 1.1“ sensor size (see also chapter „Different System Setups“). This sensor also offers advantages in terms of image quality and sensitivity. A further cost saving is in the cables. The unit price of the CXP 2.0 cable is significantly lower than that of its CameraLink counterpart. In addition, only one cable is used, which reduces the cost of cables to almost a quarter compared to the CameraLink system.

Summary

Camera Link, in combination with a frame grabber, has been a preferred interface in the field of industrial image processing for years, when high resolutions and speeds are required. Due to technological advancements and the existing cost pressure in the image processing market, CXP 2.0 is a perfect upgrade to use the latest state-of-the-art technology to improve its overall system and to be perfectly positioned for the future. Customers will benefit from the low integration time required for the new interface and will therefore be able to change interfaces at short notice. This new interface thus offers the opportunity to be prepared for changing market conditions in the long term and to meet increasing customer requirements. In the following diagram, the essential characteristics of both interfaces are finally compared:

	Camera Link	CXP 2.0
Bandwidth	Max. bandwidth 850 MB/s	Max. bandwidth 1200 MB/s
Higher bandwidth for applications with challenging image processing tasks		
Cable length	10 m	40 m
Four times the cable length, with greater bandwidth; less bulky and more flexible cables available		
Image Sensor	😐	🙂
Latest CMOS sensors available for optimal image quality and higher speed		
Cable Connector type	MDR / SDR	Micro-BNC
Standardized connector type simplifies the selection of frame grabbers and cables		
System costs	$$$	$
Through technological progress, cost savings are possible when changing hardware		

Author

Thomas Karow has worked as Product Market Manager at Basler AG since 2018 and is responsible for the Performance Segment product line. In this position he is in charge of the market launch of new camera models. In addition, he also continuously observes and evaluates trends and requirements in camera technology as part of market analyses, which gives him a good overview of customers' wishes.

Thomas Karow has a diploma in business management. Before joining Basler, he worked in international sales of industrial cameras for over eight years and thus contributes much experience and substantial market knowledge regarding industrial image processing.

About Basler

Basler is an internationally leading manufacturer of high-quality cameras and accessories for applications in factory automation, medicine, traffic and a variety of other markets.

The company's product portfolio encompasses line scan and area scan cameras in compact housing dimensions, camera modules in board-level variants for embedded vision solutions, and 3D cameras. The catalog is rounded off by the user-friendly pylon SDK and a broad spectrum of accessories, including a number developed specially for Basler and optimally designed for the Basler cameras. Basler has 30 years of experience in the area of computer vision. The Basler Group is home to approximately 800 employees at its headquarters in Ahrensburg, Germany, and its additional sites in Europe, Asia and North America.

Basler AG
Germany, Headquarters
Tel. +49 4102 463 500
Fax +49 4102 463 599
sales.europe@baslerweb.com
www.baslerweb.com

Basler, Inc.
USA
Tel. +1 610 280 0171
Fax +1 610 280 7608
sales.usa@baslerweb.com

Basler Asia Pte Ltd.
Singapore
Tel. +65 6367 1355
Fax +65 6367 1255
sales.asia@baslerweb.com

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