Comparison of Basler’s Camera Interfaces for Embedded Vision Technology: USB 3.0 vs BCON for LVDS

More and more customers develop applications based on embedded computing technology. Basler is the major manufacturer of digital industrial cameras used in such embedded systems. The choices of interfaces for cameras utilized in embedded vision include USB 3.0 and Basler’s BCON for LVDS. In this Product Insight, we would like to compare these interfaces and discuss their respective characteristics and benefits.

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For different companies and applications, the degree of ‘embedded’ for computing technology may vary a lot: Some prefer utilizing standard out-of-the-box equipment like the popular single-board computer. Others use Systems-on-Module (SoMs) which are adapted/integrated to their application. And other companies even prefer highly fitted, individually designed processing units which are specific to the matching application.

Likewise for the applied interfaces of the cameras: plug-and-play-solutions like USB 3.0 represent one approach, and Basler’s BCON for LVDS, which needs more adaptation to the specific application represents another. In this discussion we consider these different options and the respective advantages and drawbacks of each. But this analysis focuses on USB 3.0 and BCON only, because they are the most interesting interfaces and represent two very different solutions for this technology approach.

1. Easy vs. Slim Integration

First we consider the development of a system where a standard ready-to-use single board processing unit is used. For this kind of setup, a USB 3.0 connection is a logical choice. Most modern one-board computers provide a USB 3.0 connector, often even more than one, and if not, USB 2.0 connectors are an alternative with lowered bandwidth. Thus the camera can easily be linked. Also, Basler’s pylon Camera Software Suite can easily be installed on such x86 or ARM based computer units. With this SDK, the activation and configuration of the camera and the communication with it can be carried out directly ‘out of the box’ by an easy plug-and-play connection.

That simplifies the camera integration and the setup of the vision system. The only drawback of such a design-in approach is that predesigned processing boards typically provide more, in hardware and computing terms, than is needed for the application. This creates an unavoidable hardware overhead, which should be factored into the overall production costs.

The case is different with the Basler BCON interface, which incorporates many features for a true slim and lean system setup. However, this solution requires higher integration effort, because LVDS-based plug-and-play solutions do not exist, as LVDS-based Vision interface/protocol standards are rare and very specific. However, with BCON, Basler created an open documented, LVDS-based standard with a well-defined software protocol following existing market-adopted standards.

Enabling the image data transmission to the user application on the board requires compliant hardware. This hardware can be an FPGA or a proper SoC (System on Chip). If a compliant logic device of this type is not available, it is necessary to integrate an additional logic module. Furthermore, it requires appropriate, application-specific programming. The logic device must be programmed...
with a routine to manage the BCON signals for LVDS: It needs to thread in the single bytes which subsequently must be merged into an image that can be saved in RAM or transmitted to the application. Although this is a simple routine for handling the camera image data on board, it must still be created specifically for a given application/hardware specific adaptation.

However, this application-specific implementation is also an opportunity: It enables highly optimized and effective image data processing. And for applications that already need a specifically-designed processing board, an additional hardware component can be integrated easily and in an optimized manner, the additional cost and effort are manageable.

The advantage is that the hardware components of other interfaces like USB (or even network-based ones like GigE) can be reduced. This cuts down on space requirements, and on the cost of components like host controllers, connectors and so on. Furthermore, it saves the related software processing mechanisms, including drivers, memory allocation by CPU etc. For true lean embedded system architectures this is an unbeatable advantage, as CPU load can be minimized effectively.

2. Influence of Other Marginal Conditions

The considerations mentioned above focus mainly on system integration (development) costs and the final manufacturing bill of materials. But other factors may be more relevant for the intended application and lead to a solution driven by different needs. They are discussed as follows:

Size:
A striking difference between the two connectors is the space required. Where the USB connector has relatively large, standardized dimensions, the BCON interface requires far less space. In addition, the opportunities of an application specific board design can be fully used with the BCON interface. The connector can be positioned at the most optimal place and requires fewer changes to the boards. For applications where size is a major criterion, this factor may play an important role.

Speed:
With a maximum image data transfer rate of up to 350 MB/s, the USB connection is faster than the BCON interface which has a configured maximum of 252MB/s.

Latency:
BCON holds the advantage here: due to the direct connection of a BCON based camera to the processing unit,
the latency can be lowered to a minimum, although quantifications are difficult since latency depends strongly on setup and choice of hardware.

**Cabling:**
If long cable lengths are needed, USB 3.0 is the best choice. Lengths up to several meters can be used, and even longer when utilizing an active USB cable extension. Thus, the camera(s) can be operated with a longer distance to the processing unit. BCON connections are - depending on the flat flex cable quality - limited to 1 to 2 meters, making them best suited to applications with the camera and computer unit within one housing. Nevertheless, the cable is extremely flat and also very flexible which can lead to significant advantages regarding space requirements.

![Image](image.png)

*Fig. 5: Easy connection via flat flex cable*

**Energy consumption:**
The USB3 Vision protocol including the data packaging requires slightly more processing power than the direct signal input of BCON. So, considering the whole vision system's energy used for computation, the BCON interface uses less. This difference is presumably only a small percentage, though for energy-critical applications (e.g. mobile devices) this might be the key factor.

**Reusability of pre-product developments:**
Since USB 3.0 cameras apply the same technology for embedded as for non-embedded computer units, this interface offers the potential to re-use previous developments such as programs or integrations, and even product studies or certifications. As the SDK (Basler’s pylon Camera Software Suite) is equal on both systems, it enables engineers to do their work with less adjustment. USB 3.0 minimizes the effort required to change an existing product to a new design based on embedded technology.

Similarly, the BCON interface is compliant with Basler’s pylon Camera Software Suite for camera configuration. This allows for a partial re-use of existing program code. As regards the image data grabbing algorithms, the BCON interface software protocol is very comparable to the Camera Link protocol and is fully Channel Link compatible. Teams experienced with programming on this protocol will feel comfortable and programs can be adapted with minimal effort.
3. Properties Overview

<table>
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<tr>
<th>General properties</th>
<th>Integration/ installation aspects</th>
<th>System operation/ bill of material</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ standardized interface with standardized Vision Protocol</td>
<td>▪ plug &amp; play</td>
<td>▪ uses USB plug</td>
</tr>
<tr>
<td>▪ supports GenICam</td>
<td>▪ many out of box processing boards / SoMs available</td>
<td>▪ host controller needed</td>
</tr>
<tr>
<td>▪ high speed</td>
<td>▪ same machine vision equipment as for non-embedded set-up</td>
<td>▪ increased software routine (drivers, memory allocation, etc.)</td>
</tr>
<tr>
<td>▪ cable length up to several meters, more with active extensions</td>
<td>▪ SDK for camera control and grabbing</td>
<td></td>
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**USB Vision**

- Basler’s self-developed interface based on LVDS following de-facto-standards
- well-defined and open documented software protocol
- supports GenICam
- low latency
- lowest size and weight

<table>
<thead>
<tr>
<th>BCON</th>
<th>hardware specific programming of grabbing procedure on customer side</th>
<th>suitable SoC / FPGA necessary</th>
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<tr>
<td></td>
<td>SDK for camera control</td>
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<tr>
<th>System operation/ bill of material</th>
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<tr>
<td>uses 28-pin ZIF connector</td>
<td></td>
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<tr>
<td>direct connection to processing unit w/o hardware &amp; software overhead</td>
<td>leanest and most cost efficient set-up possible</td>
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4. Summary

BCON requires suitable SoCs or FPGAs on board in order to enable the image data transfer. Application-specific programming is necessary. Hence, the design-in process requires some effort. However, the final design allows for leaner and more effective hardware setup and lower production costs.

In contrast, USB 3.0 cameras with their plug-and-play attributes are easy to integrate and allow for an easy switch from conventional to embedded processing units. Furthermore, both interfaces have individual properties which might make one interface more suitable for a certain application than the other. These properties include size, weight, cabling, energy consumption, speed and others.

Both interfaces – USB 3.0 and BCON – have a high industrial quality standard and the GenICam compatibility in common. Therefore, they can be configured easily via Basler’s pylon Camera Software Suite.
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Product Manager

Dr. Thomas Rademacher has been a Product Manager at Basler since 2015. He is responsible for the new Basler dart cameras with LVDS-based BCON interfaces for embedded vision systems.

After completing his PhD in Physics at the University of Göttingen, he worked in product management for a leading company for industrial measurement technology in the semiconductor industry with focus on optical metrology and automated image processing and analysis.

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Basler is a leading manufacturer of high-quality digital cameras for applications in manufacturing, medicine, traffic and retail. Product development is led by the demands of industry. The cameras offer simple integration, compact sizes, excellent image quality, and an outstanding price/performance ratio. Basler has more than 25 years of experience in image processing. The company is home to more than 500 employees at its headquarters in Ahrensburg, Germany and its subsidiaries and sales offices in Europe, Asia and the USA.