Computer vision for intralogistics: Deploying FPD-Link III and GMSL2
Demanding applications

Cameras for logistic vehicles such as Autonomous Guided Vehicles (AGVs), Automated Mobile Robots (AMRs), and forklifts are subject to space constraints and rough use. They not only have to be small, light and power efficient, but they must also operate reliably under harsh conditions.

Many intralogistics applications are designed with Computer Vision algorithms on an Embedded Vision system. Those systems benefit from small weight and size, low power consumption and stand out with minimal costs in hardware. The needed image data is often acquired by MIPI CSI-2 sensors and processed by highly effective SoCs. By leveraging the integrated image pipeline, the data can be transferred with low latency and high data rates into the system’s memory, without any interaction of the CPU. Although successfully deployed in many systems, the maximum cable length of around 0.5m between camera and processor has restricted the adoption of CSI-2 cameras.

Long cable solutions
Because many systems, such as automotive, require longer distance between processor and camera, FPD-Link III (Flat Panel Display Link) and GMSL2 (Gigabit Multimedia Serial Link) have seen widespread adoption. Due to their high-speed data transmission capabilities, low latency, and robustness in harsh environments, they are now also transitioning into vision systems for intralogistics applications. FPD-Link from Texas Instruments and GMSL from Maxim Integrated are the primary suppliers of this technology. This is often referred to as “range extender” technology. Both represent physical layer standards, where data can be transmitted transparently to the user via coax or shielded twisted pair cables by using integrated SerDes technology.

This paper will provide some guidance for selecting the best configuration of range extender hardware. This includes a deep explanation of the similarities and difference of FPD-Link and GMSL, as well as some details on the cable choices for the best performance in your system.
FPD-Link III and GMSL2

FPD-Link (Flat Panel Display Link) and GMSL (Gigabit Multimedia Serial Link) from Texas Instruments and Maxim Integrated Analog Devices respectively, are both suitable for intralogistics and offer different benefits depending on your needs.

FPD-Link III
FPD-Link III, an updated version of the Flat Panel Display Link protocol, is an industry-standard high-speed protocol developed by Texas Instruments. It uses LVDS (Low Voltage Differential Signaling) to transmit data at high speeds with low electromagnetic interference.

Key features and benefits
• High-speed data transmission: Supports high-resolution 4k video transmission at high speed.
• Forward error correction: Enhances reliability and robustness in the face of signal degradation.
• Electromagnetic interference reduction techniques: Spread spectrum and low swing reduces electromagnetic interference (EMI).

GMSL2
GMSL2 is a high-speed communication protocol developed by Maxim Integrated. GMSL2 can transmit high-definition video, audio, and control data over a single cable.

Key features and benefits
• High-Speed Data Transmission: Capable of transmitting 4K and 8K video data.
• Long-Range Transmission: Supports long cable lengths, providing a practical advantage in large-scale industrial setups.
• Robustness to noise: Features robust error detection and correction mechanisms.

Speed and Range
FPD-Link III and GMSL2 are designed to support high-speed data transmission, crucial for high-resolution industrial vision applications. While both support 4K data transmission, GMSL2 stands out by even supporting 8K resolution, potentially offering a higher degree of precision in vision tasks.

• FPD-Link III 3.2 Gbit/s
• GMSL2 6.0 Gbit/s

In terms of range, GMSL2 can support longer cable lengths, providing an advantage in large-scale industrial settings.

• FPD-Link III 10 - 15 m
• GMSL2 15 - 20 m

Reliability and Noise Resistance
FPD-Link III and GMSL2 include mechanisms for error detection and correction, a key function for maintaining data integrity in industrial environments. GMSL2 may give it an edge in the reliability.

What is the difference in the performance of the interface?

Which one fits better to the requirements of an application?
System Integration

In order to achieve cable lengths of up to 15 meters, the camera needs to be connected to a serializer that receives all the necessary signals as parallel input.

To realize the SerDes connection with either GMSL or FPD-Link, additional electronics are required: One PCB for the serializer close to the camera and another for the deserializer connected to the host.

As popular embedded platforms don’t have a deserializer and the necessary connectors on their boards, an additional interface board is required for the deserialization. This hardware, commonly called a carrier board, can be custom or can be provided by third-party vendors and have the required deserializer and connector on board.

If you are contemplating a custom design using GMSL, an NDA with Analog Devices is required to receive the required technical documentation and support.

Software

GenICam for CSI-2 Access controls the camera by GenICam features, using the Alvium CSI-2 driver and CSI-2 transport layer (TL) directly. Open-source CSI-2 drivers are available on GitHub for different boards and system on chips (SoCs).

Video4Linux2 Access allows to control the cameras via V4L2 API, Allied Vision V4L2 Viewer, Frameworks like GStreamer and OpenCV.

Conclusion

→ Both GMSL and FPD-Link provide an interesting alternative to overcome the cable length limitation of MIPI CSI-2, by keeping its characteristics and supporting distances up to 15 meters.

→ FPD-Link III and GMSL2 are potent technologies for high-speed data transmission in industrial vision applications.

→ GMSL2 stands out in integration robustness and EMI reduction, cable lengths, and data transmission capacity, while FPD-Link III offers potential benefits in system simplicity.

→ The choice between these two depends on the specific needs of the industrial vision application.

Especially factors like the required data resolution, transmission pace, and the existing physical setup determine the most appropriate solution.
Coaxial and STP cables

To connect an FPD-Link III or GMSL-2 camera to a system, either coaxial or STP (shielded twisted pair) cabling can be used. They provide power and a low speed control channel to the camera, as well as a highspeed downstream channel for the image data.

Both technologies come with rugged connectors that are not susceptible to vibrations and motions. Another advantage is that the connectors are also available as IP68 rated versions.

Connectors

<table>
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<tr>
<th>Coaxial cable</th>
<th>FAKRA Connector</th>
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<tr>
<td>STP cable</td>
<td>HSD Connector</td>
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Possible cable lengths

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<tbody>
<tr>
<td>Coaxial cable</td>
<td>10 - 15 m</td>
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<tr>
<td>STP cable</td>
<td>8 - 10 m</td>
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STP advantages over Coax

- Thinner and more flexible cables
- Can be bent to small bend radii

Cameras with STP cables are thus better suited for dynamic applications such as robots.

Since STP cables usually have more wires available, those can naturally be used to supply the camera with power.

Coax advantages over STP

- Cables are lighter, less expensive
- Better signal integrity enable longer cables
- Stiffer cables for harsh applications
- Coaxial-based FAKRA connector is widely supported resulting in a broader availability of carrier boards, cables, and connectors.

Coaxial connections enable single-cable solutions supported by Power over Coax (PoC).

Coax cameras are the ideal choice for outdoor applications.
Alvium FP3 cameras with FPD-Link III (Flat Panel Display Link) interface and Alvium GM2 Coax cameras with GMSL2 (Gigabit Multi-media Serial Link) have been designed to overcome the limitations of standard CSI-2 cameras.

Within the Alvium platform, Allied Vision is offering a large range of Alvium cameras with either FPD-Link III or GMSL2 interface. There are more than 30 high-quality image sensors to choose from.

The housed Alvium FP3 and Alvium GM2 cameras come with integrated serializer and rugged connectors: Either coaxial-based FAKRA connectors for coax cables or HSD STP connectors for thin shielded twisted pair cables.

For applications with static cables, Alvium FP3/GM2 cameras are available as Coax models with a FAKRA connector, supporting up to 15 m with FAKRA coaxial cables. For applications with moving cables, Alvium FP3/GM2 STP cameras with an HSD connector and STP (Shielded Twisted Pair) cables are better suited. The thin STP cables permit a tighter bend radius, are more flexible, and support up to 10 m for FP3 and up to 8 m for GM2 models.

The cameras are particularly suitable for use in demanding intralogistics applications because they address important requirements:

- Full Electromagnetic compatibility (EMC) compliance
- Resistance against shock and vibration
- Fast and low overhead image transmission on embedded systems
- 2 GPIOs (General Purpose Input/Output) on the camera that can be used either via the cable or the separate I/O connector.
- Multi camera friendly
- Deserializer boards available
- Support for single-cable solutions
- Support by Vimba X SDK
- Support for GenICam for CSI-2
- Easy set-up thanks to one driver for various embedded boards

**Software and driver**

The cameras are tested on NVIDIA® Jetson systems running NVIDIA Jetpack™ 5.1.2 with our open-source driver. The Alvium CSI-2 camera driver supports Jetson Xavier™ NX, AGX Xavier, Orin™ Nano, Orin NX, AGX Orin systems on module (SoMs) as well as NXP i.MX 8M Plus, AMD Xilinx Zynq UltraScale+ SoCs and Kria SoMs.

For more information and download links visit our website:
Alvium FP3 and Alvium GM2 cameras

One platform, infinite solutions

Alvium FP3 and Alvium GM2 cameras are part of the Alvium Camera Series. All Alvium cameras share the same platform. They are based on ALVIUM® Technology – a custom ASIC packed with unique features and 35 years of machine vision industry expertise. This offers tremendous flexibility for the development of any vision system and makes it very easy to adjust or upgrade during development or redesign.

Users benefit from long-term availability, easy migration between different series, fast prototype development and time-to-market, easy system integration, and identical 29 mm x 29 mm (H x W) form factor. Alvium also offers an extensive variety of housing configurations and optical mounts.

If you still have any questions about Alvium FP3 Coax/STP or Alvium GM2 Coax/STP cameras, the Allied Vision Team is happy to help:

→ info@alliedvision.com
→ www.alliedvision.com/contact