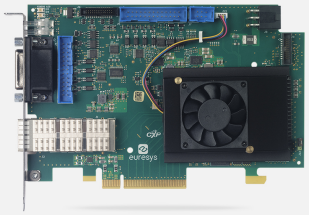
euresys
Empowering Computer Vision

Coaxlink QSFP+

Four-connection CoaXPress-over-Fiber frame grabber



At a Glance

- One QSFP+ port compliant with 40 Gbps optical modules
- 5,000 MB/s camera bandwidth
- PCIe 3.0 (Gen 3) x8 bus: 6,700 MB/s bus bandwidth
- Feature-rich set of 20 digital I/O lines
- Extensive camera control functions
- Memento Event Logging Tool
- Compatible with CustomLogic: Your own FPGA logic

Benefits

What is CoaXPress-over-Fiber?

CoaXPress-over-Fiber is a light but significant extension of the existing CoaXPress specification to support transport over fiber optics.

CoaXPress (CXP) is the de-facto standard for high-bandwidth computer vision applications. CoaXPress2.1, the latest version of the specification, specifies the CXP-12 speed, a 12.5 Gbps (Gigabit per second) connection over a coaxial copper cable. As link aggregation is common with CoaXPress, bandwidths of 50 Gbps (12.5 x 4) are easily achievable with four CXP-12 connections. CoaXPress-over-Fiber has been designed as an add-on to the CoaXPress specification. It provides a way to run the CoaXPress protocol, as it is, unmodified, over a standard Ethernet connection, including fiber optics. As such, CoaXPress-over-Fiber uses standard electronics, connectors and cables designed for Ethernet, but the protocol is CoaXPress, not Ethernet, not GigE Vision.

Read more about CoaXPress-over-Fiber on our technology page.

PCIe 3.0 (Gen 3) x8 bus

- 7,800 MB/s peak bus bandwidth
- 6,700 MB/s sustained bus bandwidth

Acquire images from the fastest and highest resolution cameras

- Highest data acquisition rate in the industry
- Up to 5,000 MB/s bandwidth from camera to host PC memory

What are the pros and cons of using fiber optics?

Pros

- First and foremost, cable length is not an issue anymore as fiber connectivity is basically not limited in length.

- Fiber optics provide more bandwidth, as connectivity at 10 and 25 Gbps per fiber is standard today and widely used in data centers.
- Fiber optics are immune to electrical noise, which will be a significant advantage on the production floor and in some medical applications.
- Fiber optics are lighter and smaller in size than the equivalent copper cabling, making it appropriate for applications where this characteristic is essential, like in aircrafts or vehicles.

Cons

- There is no "power over fiber". As signals in fiber optics are transmitted using light, there is no way to transfer power over fiber optics and devices such as cameras must be powered separately.

What are the cable options for CoaXPress-over-Fiber?

One of the most important benefits of CoaXPress-over-Fiber is the wide variety of connectivity options already available from multiple companies. The initial connectivity options for CoaXPress-over-Fiber and the Coaxlink QSFP+ at 10 Gbps are SFP+ and QSFP+ (Quad, or four times SFP+) modules.

The advantage of using modules compared to fixed interfaces is that ports can be equipped with any suitable type of transceiver as required by the application. A variety of transmitter and receiver types is available, allowing users to select the appropriate transceiver to provide the required optical reach over multi-mode or single-mode fiber.

What are the benefits of using CoaXPress-over-Fiber for my application?

- Available as CXP to nGMII (device) or nGMII to CXP (host) Bridge IP Cores
- Ultra-high data/frame rates
- Many accessory and cabling options to cover any length requirement
- Low CPU overhead, low latency, low jitter image acquisition
- Highest camera count per PC performance
- Very competitive cost/performance ratio
- Wide industry acceptance due to JIIA standardization
- Ready for CXP25

What are the jitter and latency of CoaXPress-over-Fiber? How do they compare to "traditional" CoaXPress?

CoaXPress-over-Fiber is based on the CoaXPress protocol and it exhibits the same high performance as CoaXPress in terms of jitter and latency. In addition, as CoaXPress-over-Fiber supports higher transmission speed compared to CoaXPress, the jitter and latency will be further improved in these versions.

What is the maximum cable length with multi-mode fibers?

With a standard 40GBASE-SR4 QSFP+ Optical Transceiver Module and an MTP/MPO multi-mode fiber cable, the maximum cable length is 150 meters. This solution is suitable for machine vision applications.

What is the maximum cable length with single-mode fibers?

With a standard 40GBASE-ER4 QSFP+ LC DOM Optical Transceiver Module and an LC-Duplex single-mode fiber cable, the maximum cable length is 40 kilometers. This solution is suitable, for example, for video transmission applications.

Memento Event Logging Tool

- Memento is an advanced development and debugging tool available for Coaxlink and Grablink cards.
- Memento records an accurate log of all the events related to the camera, the frame grabber and its driver as well as the application.
- It provides the developer with a precise timeline of time-stamped events, along with context information and logic analyzer view.
- It provides valuable assistance during application development and debugging, as well as during machine operation.

CustomLogic: Your own FPGA logic!

- CustomLogic is an FPGA design kit enabling the design and upload of FPGA code to a Coaxlink board
- It is compatible with the Coaxlink Octo, Coaxlink Quad CXP-12 and Coaxlink QSFP+ for which up to 70% of their AMD Kintex Ultrascale XCKU035 FPGA resources are available.

- The design phase uses the Xilinx Vivado development tools (not provided)
- Using CustomLogic does not require any additional hardware

Direct GPU transfer

- Sample programs for AMD DirectGMA and NVIDIA (CUDA) available.
- Direct GPU transfer eliminates unnecessary system memory copies, lowers CPU overhead, and reduces latency, resulting in significant performance improvements in data transfer times for applications.
- Direct capture of image data to GPU memory is available using AMD's DirectGMA. Compatible with AMD FirePro W5x00 and above and all AMD FirePro S series products.

General purpose I/O lines compatible with a wide range of sensors and motion encoders

High-performance DMA (Direct Memory Access)

- Direct transfer into user-allocated memory
- Hardware scatter-gather support

Area-scan triggering capabilities

- A trigger is used to start the acquisition when the part is in position. Hardware triggers come from the Coaxlink's I/O lines. Software triggers come from the application.
- An optional trigger delay is available to postpone the acquisition for a programmable time.
- A trigger decimation function allows to skip some of the triggers.
- Camera exposure control allows the application to control the exposure time of the camera.
- When the acquisition starts, at the appropriate timing, the Coaxlink board generates a signal to control an illumination device connected to one of its output lines.

Line-scan triggering capabilities 1/2

Coaxlink supports continuous web scanning (to inspect infinite, continuously moving surfaces without losing a single line) and discrete object scanning (to acquire the image of objects moving in front of the camera).

- A trigger is used to start the acquisition when the part is in position. Hardware triggers come from the board's I/O lines. Software triggers come from the application.
- After it is started, the acquisition either:
  - Continues indefinitely (for web inspection applications)
  - Continues for a programmable number of lines (to acquire the image of objects of a known length)
  - Continues until an end trigger is received (to acquire the image of objects of a variable length)
- An optional trigger delay is available to postpone the beginning of the acquisition for a programmable number of lines.

Line-scan triggering capabilities 2/2

- The Coaxlink frame grabber controls the camera scanning rate based on the signals received from a motion encoder. When the parts move faster, the acquisition line rate of the camera increases. When the parts move slower, the acquisition line rate of the camera decreases.
- The Coaxlink boards interpret A/B signals from quadrature motion encoders to know in which direction (forward or backward) the part is moving.
- Optionally, the Coaxlink board can be instructed to acquire lines only when the object is moving forward or only when the object is moving backward.
- A feature called Backward Motion Cancellation stops the acquisition when a backward motion is detected. The line acquisition automatically resumes when the motion is again in the forward direction, at the exact place where the acquisition was interrupted.
- A Rate Converter allows the camera to acquire lines at any programmable resolution lower or higher than the resolution of the motion encoder. This gives the designer incredible freedom and flexibility during the development of the application.
- A Rate Divider allows the camera to acquire lines at a resolution lower than the resolution of the motion encoder. It divides the frequency of the incoming encoder signal by a programmable integer.

Line-scan Metadata insertion

When activated, this feature records metadata beside image data. Line metadata are captured every acquired image line. Buffer metadata are only captured when the first image line of a buffer is acquired.

The metadata are composed with a configurable set of general purpose event counters, quadrature encoder position counters and/or I/O line status.

This feature allows line-scan applications to correlate image data with system events including motion encoder positions.

Flexible line-scan camera operation with the rate converter

- The rate converter is a smart, programmable frequency multiplier/divider.
- Used with motion encoders and line-scan cameras, it allows the user to choose the aspect ratio of the pixels in the image.
- It provides a way to calibrate the acquisition chain to easily reach square (1:1 aspect ratio) pixels.

C2C-Link camera synchronization

Allows to accurately synchronize multiple area-scan or line-scan cameras connected

- to the same card
- to different cards in the same PC
- to different cards in different PCs

Windows, Linux and macOS drivers available

- Including support for Intel 64-bit platforms as well as ARM 64-bit platforms

Compliant with GenICam

Including support for

- GenApi
- The Standard Feature Naming Convention (SFNC)
- GenTL

Compatible with eGrabber

- eGrabber Studio: eGrabber's new interactive evaluation and demonstration application
- GenICam Browser: An application giving access to the GenICam features exposed by the GenTL Producer(s)
- GenTL Console: A command-line tool giving access to the functions and commands exposed by the Euresys GenTL Producer

Specifications

Mechanical

Format	Standard profile, half length, 8-lane PCI Express card
Cooling method	Air cooling, fan-cooled heatsink
Mounting	For insertion in a standard height, 8-lane or higher, PCI Express card slot

Connectors	• 'QSFP+' on bracket: – Enhanced Quad Small Form-factor Pluggable port – CoaXPress-over-Fiber host interface • 'EXTERNAL I/O' on bracket: – 26-pin 3-row high-density female sub-D connector – I/O lines and power output • 'INTERNAL I/O 1' and 'INTERNAL I/O 2' on PCB: – 2x 26-pin 2-row 0.1" pitch pin header with shrouding – I/O lines and power output • 'I/O EXTENSION' on PCB: – 26-pin 2-row 0.05" pitch pin header with shrouding – I/O extension lines and power output • 'AUXILIARY POWER INPUT' on module: – 6-pin PEG power socket – 12 VDC power input for I/O power • 'C2C-LINK' on module: – 6-pin 2-row 0.1" header – Card to card link
LED indicators	• 'A', 'B', 'C', 'D' on bracket: – Bi-color red/green LEDs – CoaXPress Host connector indicator • 'FPGA STATUS LAMP' on PCB: – Bi-color red/green LED – FPGA status indicator • 'BOARD STATUS LAMP' on PCB: – Bi-color red/green LED – Board status indicator
Switches	'RECOVERY' on PCB: • 3-pin 1-row 0.1" header or 2-way DIP switch • Firmware emergency recovery
Dimensions	PCB L X H: 167.65 mm x 111.15 mm, 6.6 in x 4.38 in
Weight	176 g, 6.21 oz (without transceiver)

Host bus

Standard	PCI Express 3.0
Link width	• 8 lanes • 1 lane, 2 lanes or 4 lanes with reduced performance
Link speed	• 8.0 GT/s (PCIe 3.0) • 5.0 GT/s (PCIe 2.0) with reduced performance
Maximum payload size	512 bytes
DMA	32- and 64-bit
Peak delivery bandwidth	7,800 MB/s
Effective (sustained) delivery bandwidth	6,700 MB/s (Host PC motherboard dependent)
Power consumption	Typ. 16.5 W (3.0 W @ +3.3V, 12.5 W @ +12V), excluding I/O power output and optical transceiver module

Camera / video inputs

Interface standard(s)	CoaXPress 1.0, 1.1, 1.1.1 and 2.0, CoaXPress-over-Fiber Bridge Protocol 1.0
Connectors	• Enhanced Quad Small Form-factor Pluggable (QSFP+) port • Compliant with SFF-8436 (4 x10 Gbit/s Pluggable Transceiver) specification • Compliant with CoaXPress over Fiber • Available power for the module: 3.5 W (SFF-8436 Power Level 4)
Status LEDs	One CoaXPress Host connection status LED per connection
Number of cameras	• Area-scan cameras: – One 1- or 2- or 4-connection camera • Line-scan cameras: – One 1- or 2- or 4-connection camera
Maximum aggregated camera data transfer rate	5,000 MB/s
Supported CXP down-connection speeds	1.25 GT/s (CXP-1), 2.5 GT/s (CXP-2), 3.125 GT/s (CXP-3), 5 GT/s (CXP-5), 6.25 GT/s (CXP-6), 10.0 GT/s (CXP-10), and 12.5 GT/s (CXP-12)
Supported CXP up-connection speeds	• Low-speed 20.83... Mbps (CXP-1 to CXP-6) • Low-speed 41.66... Mbps (CXP-10, CXP-12)
Number of CXP data streams (per camera)	1 data stream per camera
Maximum CXP stream packet size	16,384 bytes
Camera types	• Area-scan cameras: – Grayscale and color (YCbCr, YUV, RGB and Bayer CFA) – Single-tap (1X-1Y) progressive-scan • Line-scan cameras and contact imaging sensors: – Grayscale and color RGB
Camera pixel formats supported	• Mono8, Mono10, Mono12, Mono14, Mono16 • BayerXX8, BayerXX10, BayerXX12, BayerXX14, BayerXX16 where XX = GR, RG, GB, or BG • RGB8, RGB10, RGB12, RGB14, RGB16 • RGBA8, RGBA10, RGBA12, RGBA14, RGBA16 • YCbCr601_422_8, YCbCr601_422_10 • YCbCr709_422_8, YCbCr709_422_10 • YUV422_8, YUV422_10 • Raw

Area-scan camera control

Trigger	• Precise control of asynchronous reset cameras, with exposure control. • Support of camera exposure/readout overlap. • Support of external hardware trigger, with optional delay and trigger decimation.
Strobe	• Accurate control of the strobe position for strobed light sources. • Support of early and late strobe pulses.

Line-scan camera control

Scan/page trigger	• Precise control of start-of-scan and end-of-scan triggers. • Support of external hardware trigger, with optional delay. • Support of infinite acquisition, without missing line, for web inspection applications.

Line trigger	• Support for quadrature motion encoders, with programmable noise filters, selection of acquisition direction and backward motion compensation. • Rate Converter tool for fine control of the pixel aspect ratio: Rate Conversion Ratio in the range 0.001 to 1000 with an accuracy better than 0.1%. • Rate Divider tool
Line strobe	• Accurate control of the strobe position for strobed light sources.

On-board processing

On-board memory	4 GB
Image data stream processing	• Unpacking of 10-/12-/14-bit to 16-bit with selectable justification to LSb or MSb • Optional swap of R and B components • Little endian conversion
Input LUT (Lookup Table)	• Monochrome 8-bit to 8-bit transformation • Monochrome 10-bit to 8-, 10- or 16-bit transformations • Monochrome 12-bit to 8-, 12- or 16-bit transformations
Bayer CFA to RGB decoder	'1-camera' firmware variant: • 3x3 linear interpolation method • 3x3 median-based interpolation method
Data stream statistics	• Measurement of: – Frame rate (Area-scan only) – Line rate – Data rate • Configurable averaging interval
Event signaling and counting	• The application software can be notified of the occurrence of various events: – Standard event: the EVENT_NEW_BUFFER event notifies the application of newly filled buffers – A large set of custom events • Custom events sources: – I/O Toolbox events – Camera and Illumination control events – CoaXPress data stream events – CoaXPress host interface events • Each custom event is associated with a 32-bit counter that counts the number of occurrences • The last three 32-bit context data words of the event context data can be configured with event-specific context data: – Event-specific data – State of all System I/O lines sampled at the event occurrence time – Value of any event counter
Metadata Insertion	Recording of metadata beside image data. • The metadata are composed with a configurable set of general purpose event counters, quadrature encoder position counters and/or I/O line status. • Line metadata are captured every acquired image line. • Buffer metadata are only captured when the first image line of a buffer is acquired. • Allows line-scan applications to correlate image data with system events including motion encoder positions. NOTE: Only available on selected line-scan firmware variants. Refer to release notes.

General Purpose Inputs and Outputs

Number of lines	20 I/O lines: • 4 differential inputs (DIN) • 4 singled-ended TTL inputs/outputs (TTLIO) • 8 isolated inputs (IIN) • 4 isolated outputs (IOUT) NOTE: The number of I/O lines can be extended using I/O modules attached to the I/O EXTENSION connector.
Usage	• Any I/O input lines can be used by any LIN tool of the I/O Toolbox • Selected pairs of I/O input lines can be used by any QDC tool of the I/O toolbox to decode A/B signals of a motion encoder
Electrical specifications	• DIN: High-speed differential inputs, up to 5 MHz, compatible with ANSI/EIA/TIA-422/485 differential line drivers and complementary TTL drivers • TTLIO: High-speed 5V-compliant TTL inputs or LVTTL outputs, compatible with totem-pole LVTTL, TTL, 5V CMOS drivers or LVTTL, TTL, 3V CMOS receivers • IIN: 200 kHz isolated current-sense input with wide voltage input range up to 30V, compatible with totem-pole (push-pull) HTL drivers, 5V TTL/RS-422 differential line drivers, 5V CMOS drivers, potential free contacts, solid-state relays and opto-couplers • IOUT: Isolated contact outputs compatible with 30V / 100mA loads NOTE: IIN and IOUT lines provide a functional isolation grade for the circuit technical protection. It does not provide an isolation that can protect a human being from electrical shock!
Filter control	• Glitch removal filter available on all System I/O input lines • Configurable filter time constants: – for DIN and TTLIO lines: 50 ns, 100 ns, 200 ns, 500 ns, 1 µs – for IIN lines: 500 ns, 1 µs, 2 µs, 5 µs, 10 µs
Polarity control	Yes
Power output	Non-isolated, +12V, 1A, with electronic fuse protection

I/O Toolbox tools	The I/O Toolbox is a configurable interconnection of tools that generates events (usually triggers): • Line Input tool (LIN): edge detector delivering events on rising or falling edges of any selected input line. • Quadrature Decoder tool (QDC): a composite tool including: – A quadrature edge detector delivering events on selected transitions of selected pairs of input lines. – An optional backward motion compensator for clean line-scan image acquisition when the motion is unstable. – A 32-bit up/down counter for delivering a position value. • Device Link Trigger tool (DLT): delivers an event on reception of a valid high-speed CoaXPress 2.0 connection trigger packet message from the remote device. • User Actions Scheduler tool (UAS): to delegate the execution of 'User Actions' at a scheduled time or encoder position. Possible user actions include setting low/high/toggle any bit of the User Output Register or generation of any User Events. • Delay tool (DEL): to delay up to 16 events from one or two I/O toolbox event sources, by a programmable time or number of motion encoder ticks (any QDC events). • Divider tool (DIV): to generate an event every nth input events from any I/O toolbox event source. • Multiplier/divider tool (MDV): to generate m events every d input events from any I/O toolbox event source. • The 'Input Tools' (LIN, QDC, DLT and UAS) can be further processed by the 'Event Tools' (DEL, DIV and MDV) to generate any of the following "trigger" events: – The "cycle trigger" of the Camera and Illumination controller – The "cycle sequence trigger" of the Camera and Illumination controller – The "start-of-scan trigger" of the Acquisition Controller (line-scan only) – The "end-of-scan trigger" of the Acquisition Controller (line-scan only)
I/O Toolbox composition	Determined by the selected firmware variant: • '1-camera': 8 LIN, 1 QDC, 2 DLT,1 UAS, 2 DEL, 1 DIV, 1 MDV, 2 C2C • '1-camera, line-scan': 8 LIN, 1 QDC, 2 DLT, 1 UAS, 2 DEL, 1 DIV, 1 MDV, 3 C2C

C2C-Link

Description	• Accurate synchronization of the trigger and the start-of-exposure of multiple grabber-controlled area-scan cameras. • Accurate synchronization of the start-of-cycle, start-of-scan and end-of-scan of multiple grabber-controlled line-scan cameras.

Specification	• C2C-Link synchronizes cameras connected to: – the same card – to different cards in the same PC (requires an accessory cable such as the "3303 C2C-Link Ribbon Cable" or a custom-made C2C-Link cable) – to different cards in different PCs (requires one "1636 InterPC C2C-Link Adapter" for each PC and one RJ 45 CAT 5 STP straight LAN cable for each adapter but the last one) • Maximum distance: – 60 cm inside a PC – 1200 m cumulated adapter to adapter cable length • Maximum trigger rate: – 2.5 MHz for configurations using a single PC, or up to 10 PCs and 100 m total C2C-Link cable length – 200 kHz for configurations up to 32 PCs and 1200m total C2C-Link cable length • Trigger propagation delay from master to slave devices: – Less than 10 ns for cameras on the same card or on different cards in the same PC – Less than 265 ns for cameras on different cards in different PCs (3 PCs and 40m total C2C-Link cable length)

Software

Host PC Operating System	• Microsoft Windows 11, 10, 8.1, 7 for x86-64 (64-bit) processor architecture • Linux for x86-64 (64-bit) and AArch64 (64-bit) processor architectures • macOS for x86-64 (64-bit) and AArch64 (64-bit) processor architectures
APIs	• EGrabber class, with C++ and .NET APIs: .NET assembly designed to be used with development environments compatible with .NET frameworks version 4.0 or higher • GenICam GenTL producer libraries compatible with C/C++ compilers: – 'x86_64' dynamic library designed to be used with ISO-compliant C/C++ compilers for the development of x86-64 (64-bit) applications – 'aarch64' dynamic library designed to be used with ISO-compliant C/C++ compilers for the development of AArch64 (64-bit) applications

Environmental conditions

Operating ambient air temperature	0 °C to +55 °C / +32 °F to +131 °F
Operating ambient air humidity	10% to 90% RH non-condensing
Storage ambient air temperature	-20 °C to +70 °C/ -4 °F to +158 °F
Storage ambient air humidity	10% to 90% RH non-condensing

Certifications

Electromagnetic - EMC standards	• European Council EMC Directive 2014/30/EU • United States FCC rule 47 CFR 15
EMC - Emission	• EN 55032:2015 / CISPR 32:2012 Class B • FCC 47 Part 15 Class B
EMC - Immunity	• EN 55035:2017 / CISPR 35:2016 • EN 61000-6-2:2005 / IEC 61000-6-2:2016 • EN 61000-4-2:2009 • EN 61000-4-3:2006 • EN 61000-4-4:2004 • EN 61000-4-6:2014
KC Certification	Korean Radio Waves Act, Article 58-2, Clause 3
Flammability	PCB compliant with UL 94 V-0

RoHS	European Union Directive 2015/863 (ROHS3)
REACH	European Union Regulation 1907/2006
WEEE	Must be disposed of separately from normal household waste and must be recycled according to local regulations

Ordering Information

Product code - Description	• 3625 - Coaxlink QSFP+
Optional accessories	• 1625 - DB25F I/O Adapter Cable • 1636 - InterPC C2C-Link Adapter • 3303 - C2C-Link Ribbon Cable • 3304 - HD26F I/O Adapter Cable • 3610 - HD26F I/O Extension Module - TTL-RS422 • 3612 - HD26F I/O Extension Module - TTL-CMOS5V-RS422

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