Zebra Rapixo CoF

Product Reference Guide

MN-005377-01EN Rev A

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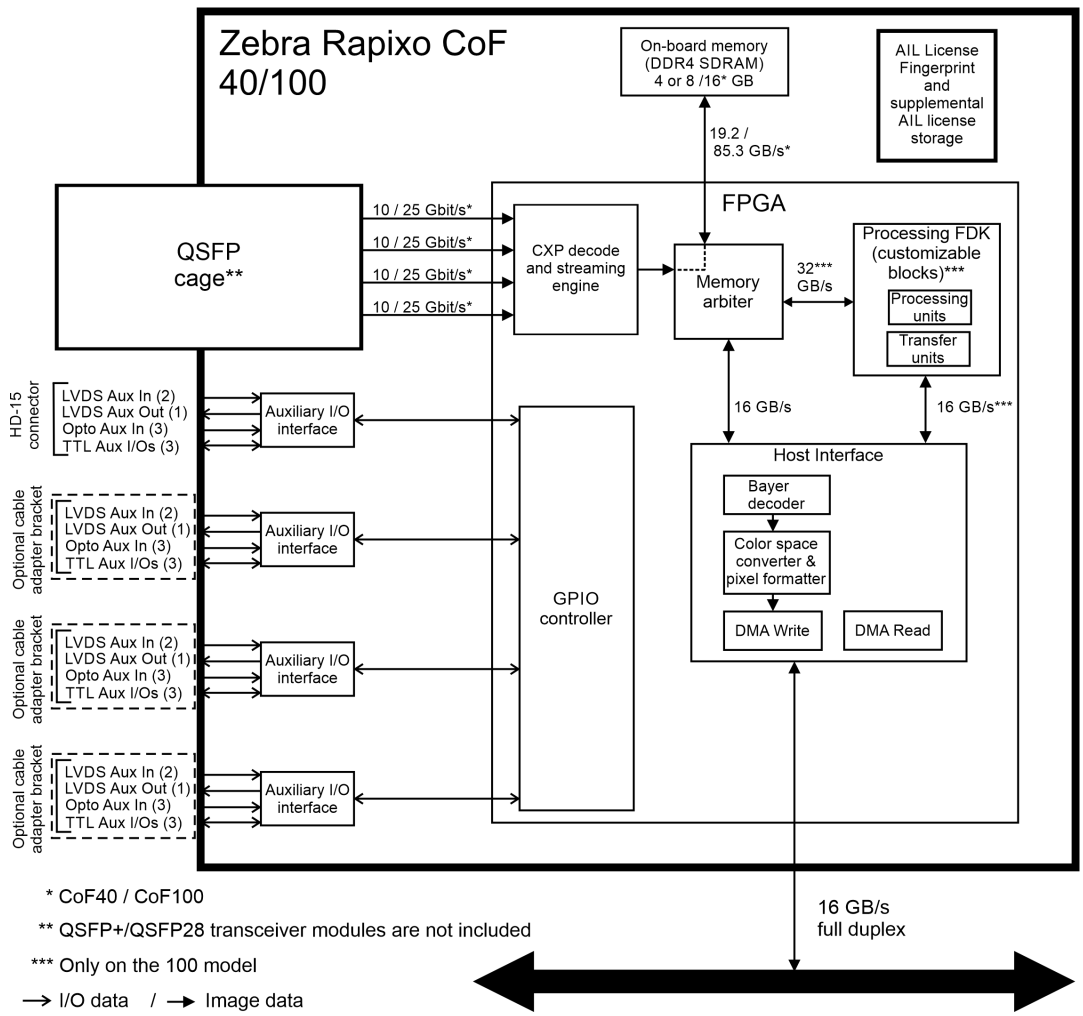
Before you start

Zebra Rapixo CoF is a family of high-performance PCIe frame grabbers that support image capture from high-resolution and high-speed video sources using CoaXPress-over-Fiber (CoF). There are two models of the Zebra Rapixo CoF: Zebra Rapixo CoF40 and Zebra Rapixo CoF100.

Figure 1 Rapixo CoF block diagram



Acquisition features of Zebra Rapixo CoF

Depending on the model, Zebra Rapixo CoF supports a total aggregate bandwidth of 40 Gbps (4 x 10 Gbits/sec) or 100 Gbps (4 x 25 Gbits/sec) for one or multiple standard CoaXPress links. A CoaXPress link contains all the connections and components needed to capture from one video source (camera). Zebra Rapixo CoF supports frame (area) and line-scan monochrome or color video sources. The color video sources can be RGB video sources or video sources with a Bayer color filter. Zebra Rapixo CoF can decode Bayer color-encoded images and perform color space conversions while transferring the image to the Host.

Frame burst technology Zebra Rapixo CoF supports frame burst technology. This technology allows you to grab a group of sequential frames into a multi-frame image buffer with one grab command; the defined number of frames are stored contiguously in the same buffer. The end-of-grab event only occurs once the entire group of frames has been grabbed, reducing the number of events that need to be handled. This is useful in cases where you have a high frame rate and need to ensure that no frames are missed.

Additional functionality

In addition to the core video capture capabilities, Zebra Rapixo CoF incorporates a variety of features to simplify overall system integration. These features include:

- **Color space converter and image formatter.** This can convert data as it is being transferred to the Host. It can convert 8- or 16-bit monochrome or 24- or 48-bit packed BGR data to monochrome, packed BGR, packed BGRa, planar RGB, or YUV (YUYV) format. In addition, it can flip or subsample data sent to the Host.
- **Bayer decoder.** This can convert Bayer-encoded data to RGB using an average demosaicing algorithm. The following Bayer patterns are supported: GRBG, GBRG, BGGR, and RGGB.
- **Auxiliary, multi-purpose signals (32 with the cable adapter bracket installed).** These are non-video signals that can support one or more functionalities (for example, trigger input, rotary/linear encoder input, or timer output), depending on the auxiliary signal. With cable adapter brackets connected to both of the internal 32-pin connector, the Rapixo CoF has 32 signals available.
- **Integrated quadrature decoders** These can decode input received from a rotary or linear encoder with quadrature output.
- **Programmable lookup tables (LUTs).** These allow Zebra Rapixo CoF to map data to precalculated values, before it is stored in on-board memory.
- **On-board peak extraction.** This allows the board to perform laser line (peak) extraction, needed for 3D profiling. When performing peak extraction, only the subpixel Y-coordinate and intensity of the peak(s) from each column are transmitted for each frame, lightening the load of the PCIe bus and Host CPU. Each frame is used to establish one row (Y-axis) in the uncorrected depth map and intensity map of the object in the scene. This feature is only available on the CoF100[1].
- **On-board flat-field correction.** This applies gain and offset correction, on a pixel basis, to correct uneven lighting that was present in the initial acquisition. This feature is only available on the CoF100[1].

On-board memory

Zebra Rapixo CoF is equipped with 4GB, 8GB, or 16GB of DDR4 SDRAM memory, depending on your model. This memory is accessed through the memory controller and is used to store acquired images and

1 Contact your Zebra representative for more information.

images for or resulting from processing. The memory controller has multiple input/output (I/O) ports, and it has a maximum data transfer rate of 19.2 Gbytes/sec (CoF40) or 85.3 Gbytes/sec (CoF100).

Data transfer

Zebra Rapixo CoF can send data to the Host at a maximum theoretical transfer rate of 16 Gbytes/sec, when using a PCIe 3.x slot with 16 lanes. The DMA write performance is chipset and computer dependent, and also slightly affected by the image size and alignment in Host memory (frame start address and line pitch).

Documentation conventions

This manual refers to all Zebra Rapixo CoF boards as Zebra Rapixo CoF. When necessary, this manual distinguishes between the boards using their full names (for example, Zebra Rapixo CoF40 or Zebra Rapixo CoF100), or their abbreviated forms (CoF40 or CoF100). Also be aware that, when the term Host is used in this manual, it refers to the host computer.

Software

To operate your Zebra Rapixo CoF you can use one or more Zebra software products that supports the board, such as Aurora Imaging Library and its derivatives (for example, Aurora Imaging Library-Lite, Zebra Design Assistant, and Zebra Capture Works). Zebra software is supported under Windows; Aurora Imaging Library is also supported under Linux when using Zebra Rapixo CoF. Consult your software manual for supported versions of these operating systems. Alternatively, you can operate your Zebra Rapixo CoF with third-party software that supports GenTL.

Aurora Imaging Library Aurora Imaging Library is a high-level programming library with an extensive set of optimized functions for image capture, processing, analysis, transfer, compression, display, and archiving. Image processing operations include point-to-point, statistical, spatial filtering, morphological, geometric transformation, and FFT operations. Analysis operations support camera calibration, are performed with sub-pixel accuracy, and include pattern recognition (normalized grayscale correlation and Geometric Model Finder), blob analysis, edge extraction and analysis, measurement, image registration, metrology, character recognition (template-based and for both normal and dot-matrix text, feature-based), code reading and verification (1D, 2D and composite code types), bead (continuous strips of material) inspection, 3D reconstruction, 3D processing, 3D analysis, classification, and color analysis. Aurora Imaging Library applications are easily ported to new Zebra hardware platforms and can be designed to take advantage of multi-processing and multi-threading environments.

Aurora Imaging Library applications are easily ported to new Zebra hardware platforms and can be designed to take advantage of multi-processing and multi-threading environments.

Aurora Imaging Library-Lite Aurora Imaging Library-Lite is a subset of Aurora Imaging Library. It includes all the Aurora Imaging Library functions for image acquisition, transfer, display control, and archiving. It also allows you to perform processing operations that are typically useful to pre-process grabbed images.

Aurora Design Assistant Aurora Design Assistant is a flowchart-based, integrated development environment (IDE). It allows you to create an imaging application without writing a single line of code. Application development is a step-by-step approach, where each step is taken from an existing toolbox and is configured through a series of dialog windows. An application developed with Aurora Design Assistant can be deployed locally (on the same computer as that used for application development) or remotely. Once the project is built and deployed, it can run without the Aurora Design Assistant interface being installed.

With Aurora Design Assistant, you can:

- Create your project as a series of steps using a flowchart.

- Test your project from your computer without any additional code editors or compilers and without deploying (copying and running) your project on the target computer.
- Design and layout a web page (operator view) to receive operator input and to display your project's output.
- Run, terminate, and re-run the project on your target computer from within Aurora Design Assistant.

Imaging projects can:

- Grab images from your camera using your Zebra Rapixo CoF.
- Analyze images using several industry-proven image analysis and measurement tools (for example, code and geometric model finder tools).
- Send and receive user-defined auxiliary I/O signals from the auxiliary I/O terminal-block connector of your Zebra Rapixo CoF.
- Send and receive information from the serial ports of your computer.
- Send and receive information and save images across the network using the TCP/IP protocol and communicate with external devices using the Modbus or EtherNet/IP industrial protocol.
- Communicate with industrial robots to offer an integrated machine vision solution.

Aurora Imaging Capture Works Aurora Imaging Capture Works is a utility that allows you to rapidly evaluate the performance and functionality of virtually any GenICam-compliant camera or 3D sensor (or other device). Aurora Imaging Capture Works will list all detected GenICam-compliant devices connected to your computer. It can start or stop capturing images, display acquired images, save the last grabbed image, send a software trigger, as well as browse and control the selected device's features. You can view network adapter information (such as, the IP address or packet size), view and change device information (such as, the user-defined name of your device), view and change acquisition properties, and view acquisition statistics. You can use it to configure the device and network adapter in static IP mode (or point-to-point connection mode) or DHCP mode (or corporate network mode). Aurora Imaging Capture Works uses the Zebra GigE Vision discovery service to automatically detect when GigE Vision-compliant devices are added to or removed from your network. Aurora Imaging Capture Works is distributed with Aurora Imaging Library and Aurora Design Assistant; it is also available with Aurora Imaging Library Lite.

GenTLA GenICam GenTL Producer is available for Zebra Rapixo CoF. This allows third-party software that supports a GenTL Consumer to communicate with and grab from a camera connected to Zebra Rapixo CoF.

NOTE: Some Aurora Imaging Library functionality is not accessible when using Zebra Rapixo CoF with GenTL (for example, peak extraction and flat-field correction are not available). The Zebra Rapixo CoF GenTL Producer (.cti file) can be found in your Aurora Imaging Library/Aurora Imaging Library-Lite installation folder.

Minimum requirements

To begin using your Zebra Rapixo CoF, you must have a computer with the following:

- An available PCIe slot with at least a Gen 3.x slot that supports 16 lanes, if you want to operate at the maximum available bandwidth.
- Processor with an Intel 64-bit architecture, or equivalent.
- Aurora Imaging Library or one of its derivatives. This software should be installed after you install your board.

Zebra does not guarantee compatibility with all computers that have the above specifications. Please consult with your local Zebra representative, local Zebra sales office, the Zebra website, or the Zebra Customer Support Group at headquarters before using a specific computer.

Consult your software package for other computer requirements (for example, operating system and memory requirements).

Inspecting your package

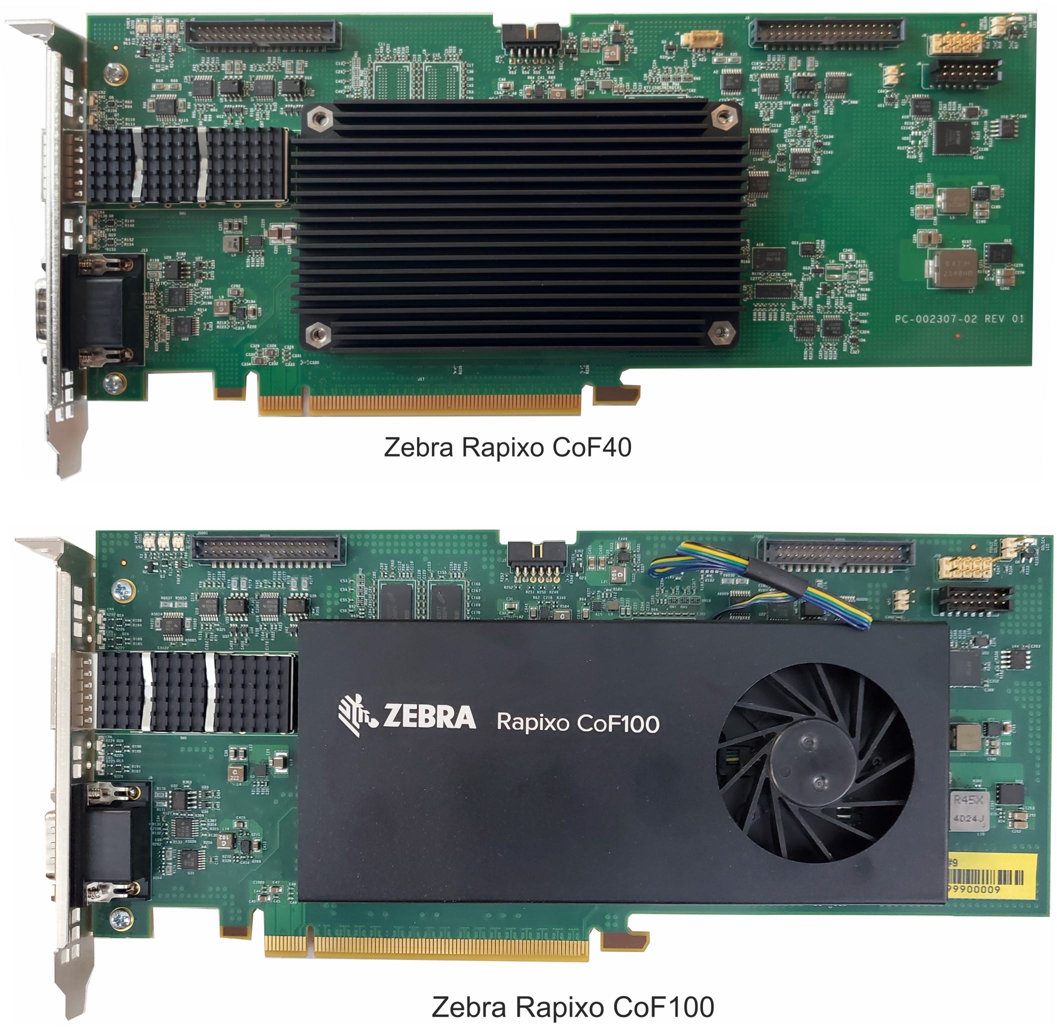
When you first open your Zebra Rapixo CoF package, inspect its contents carefully. If any items are missing or damaged, contact your Zebra representative immediately

Standard items

You should receive the following items:

- The Zebra Rapixo CoF board.

Figure 2 Rapixo CoF boards



Available separately

You might have also ordered one or more of the following:

- RAPACCKIT02. An accessory kit which includes one dual HD-15 I/O bracket with ribbon cable.

Figure 3 HD-15 I/O bracket with ribbon cable

- QSFP+/QSFP28 transceiver module.
- Aurora Imaging Library, Aurora Imaging Library-Lite, or Aurora Imaging Design Assistant. Aurora Imaging Capture Works and Aurora Intellicam are included with these software packages.

Handling components

The electronic circuits in your computer and the circuits on your Zebra Rapixo CoF are sensitive to static electricity and surges. Improper handling can seriously damage the circuits. Be sure to drain static electricity from your body by touching a metal fixture (or ground) before you touch any electronic component. In addition, do not let your clothing come in contact with the circuit boards or components.

WARNING: Before you add or remove devices from your computer, always turn off the power to your computer and all peripherals.

Installation basics

The installation procedure consists of the following steps:

- Complete the hardware installation procedure described in Chapter 2: Hardware installation.
- Complete the software installation procedure described in the documentation accompanying your software package.

More information For information on using multiple Zebra Rapixo CoF boards, refer to Chapter 3: Using multiple Zebra Rapixo CoF boards. For in-depth hardware information, refer to Chapter 4: Zebra Rapixo CoF hardware reference; whereas for a summary of this information, as well as environmental and electrical specifications, and connector pinout descriptions, see Appendix B: Technical information.

This manual occasionally makes reference to an Aurora Imaging Library-Lite function. However, anything that can be accomplished with Aurora Imaging Library-Lite can also be accomplished with Aurora Imaging Library.

Service Information

If you have a problem with your equipment, contact Zebra Global Customer Support for your region. Contact information is available at: zebra.com/support. When contacting support, please have the following information available:

- Serial number of the unit
- Model number or product name
- Software/firmware type and version number

Zebra responds to calls by email, telephone, or fax within the time limits set forth in support agreements.

If your problem cannot be solved by Zebra Customer Support, you may need to return your equipment for servicing and will be given specific directions. Zebra is not responsible for any damages incurred during shipment if the approved shipping container is not used. Shipping the units improperly can possibly void the warranty.

If you purchased your Zebra business product from a Zebra business partner, contact that business partner for support.

Hardware installation

This chapter explains how to install your Zebra Rapixo CoF board in your computer.

Installing your board

Before you install your Zebra Rapixo CoF board, some precautionary measures must be taken. Turn off the power to your computer and its peripherals, and drain static electricity from your body (by touching a metal part of the computer chassis).

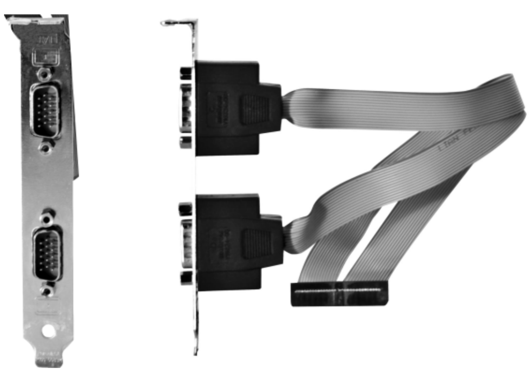
Proceed with the following steps to install your board:

1. Remove the cover from your computer; refer to your computer's documentation for instructions.
2. Check that you have an empty PCIe slot in which to install your board. For maximum available bandwidth, use a Gen 3 x16 PCIe slot.

NOTE: You can install Zebra Rapixo CoF in any mechanical PCIe slot that fits your board (for example, connecting to open-ended connectors). Be aware that if you install it in a PCIe slot that has less PCIe lanes or is of an earlier version than the capabilities of the board, then the maximum bandwidth transfer rate will be affected. Zebra Rapixo CoF might drop frames if the PCIe slot has less active lanes than the capabilities of the board.

If you need to install the HD-15 cable adapter bracket, you will need an additional slot. This slot does not need to be adjacent to the Zebra Rapixo CoF board. In addition, the cable adapter bracket does not plug into a slot's connector; it attaches only to the back of the computer's chassis.

Figure 4 Cable adapter bracket



3. If there is a metal plate at the back of the selected slots, remove it. Keep the screw from the top of the plate to anchor your board and cable adapter bracket once they are installed.

4. Position your Zebra Rapixo CoF board in the selected PCIe slot. Align the connectors of your board with the opening at the back of the slot, and move the board until the connectors pass through the opening.

NOTE: When installing your Zebra Rapixo CoF board in a PCIe x16 slot, special care must be taken to avoid damaging the board. Some PCIe x16 slots have a connector with a retainer. You should avoid touching the latch of this retainer with the board. Alternatively, you can remove the latch from the retainer.

5. Once the input connectors are in the opening of the chassis, press the board firmly but carefully straight down into the connector of the slot.
6. Anchor the board using the screw that you removed in step 3.
7. If required, install the cable adapter bracket, as described in the section Installing the cable adapter bracket, later in this chapter.
8. Attach your video sources.
9. Turn on your computer.

NOTE: When you boot your computer under Windows, Windows' Plug-and-Play system will detect a new Multimedia Video Device and you will be asked to assign it a driver. At this point, you should click on Cancel.

Under Windows and Linux, the driver will be installed during the installation of Zebra Rapixo CoF software.

10. Disable Active State Power Management (ASPM) for PCIe devices, to maximize the performance of Zebra Rapixo CoF. In the BIOS, disable all ASPM (or equivalent) settings (typically accessible from the Power management sub-menu of the Advanced Configurations menu). In addition, if the operating system has an ASPM for PCIe devices option, disable this option as well. For example, under Microsoft Windows 10, open the Power Options dialog box from the Windows Control Panel. For the currently selected power plan, click on Change Plan Settings and then click on Change Advanced Power Settings. In the presented dialog, expand PCI Express, and then expand Link State Power Management and set it to Off.
11. Under Microsoft Windows, set the power plan option to high performance to maximize the performance of Zebra Rapixo CoF and minimize the possibility of dropped frames. For example, under Microsoft Windows 10, open the Power Options dialog box from the Windows Control Panel and set the power plan option to High Performance.

Connecting video sources to your board

The Zebra Rapixo CoF board has the following connectors on its bracket:

- **QSFP connector.** Used to receive video streams from 10 or 25 GbE interfaces. These connectors are also used to transmit CoaXPress trigger signals, as well as transmit and receive control and acknowledgment messages.
- **HD15 connector.** This connector is used to transmit and receive auxiliary signals. To access the signals of internal auxiliary I/O connector 2/3, you can install the cable adapter bracket.
- **External auxiliary I/O connectors (panel mount HD-15).** Each used to transmit and receive auxiliary signals.

Connecting to the QSFP cage

Zebra CoF comes with one QSFP cage to which you must connect QSFP+ or QSFP28 transceiver. The QSFP+ and QSFP28 form factors are identical; however, QSFP+ supports 40 Gbits/sec speeds and QSFP28 supports 100 Gbits/sec speeds, across all lanes. Zebra CoF supports direct-attach copper, AOC, and single-mode/multi-mode fiber QSFP+/QSFP28 transceivers.

Zebra CoF QSFP cages support the following types of transceivers and cables. Be aware that this table only lists the compatible transceivers for 40 and 100 Gbits/sec rates and is only provided for reference and is liable to change:

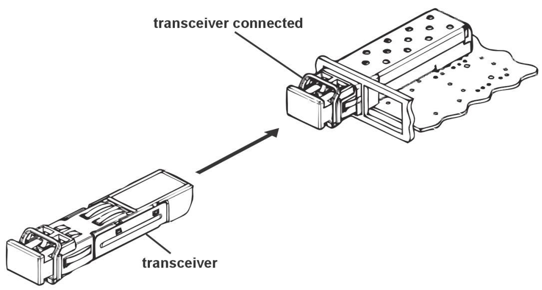
Standard	Description	Supported distance
40GBASE-SR	4 x 10 Gbits/sec Short Reach QSFP+ Transceiver	Up to 300 m over OM3 multi-mode fiber
40GBASE-LR	4 x 10 Gbits/sec Long Reach QSFP+ Transceiver	Up to 10 km over single-mode fiber
40GBASE-AOC	4 x 10 Gbits/sec QSFP+ Active Optical Cable (AOC)	Up to 30 m pre-terminated 40 Gbits/sec QSFP+ active optical cable
40GBASE-CR	4 x 10 Gbits/sec QSFP+ Direct Attach Twinax Copper Cable (DAC)	Up to 7 m pre-terminated 40 Gbits/sec QSFP+ twinax copper cable
100GBASE-SR	4 x 25 Gbits/sec Short Reach QSFP28 Transceiver	Up to 70 m over parallel OM3 multi-mode fiber and 100 m over parallel OM4 multi-mode fiber
100GBASE-LR	4 x 25 Gbits/sec Long Reach QSFP28 Transceiver	Up to 10 km over single-mode fiber
100GBASE-AOC	4 x 25 Gbits/sec QSFP28 Active Optical Cable (AOC)	Up to 30 m pre-terminated 100 Gbits/sec QSFP28 active optical cable
100GBASE-CR	4 x 25 Gbits/sec QSFP28 Direct Attach Twinax Copper Cable (DAC)	Up to 5 m pre-terminated 100 Gbits/sec QSFP28 twinax copper cable
100GBASE-CR-S	4 x 25 Gbits/sec QSFP28 Direct Attach Twinax Copper Cable (DAC)	Up to 3 m pre-terminated 100 Gbits/sec QSFP28 twinax copper cable

NOTE: The supported speed and the supported cable length vary by module manufacturer. Confirm with the manufacturer of the module whether it supports the speed and cable length that you expect to use.

Changing QSFP transceivers

If you need to change your transmission speed, you might also need to physically change your transceiver to one that supports your required speed. Each brand of QSFP transceiver will vary both in size and specific installation instructions, but as a general rule, you should hear a small click sound after the QSFP makes proper contact with the connector. Also, be aware of the orientation of the QSFP connector and ensure that you are installing it according to the instructions from the manufacturer. The QSFP transceiver is connected as follows:

Figure 5 Connecting QSFP transceiver



NOTE: To reduce unnecessary wear, only plug and unplug the QSFP+/QSFP28 transceivers when absolutely required. The QSFP cages are rated for a maximum of 250 module insertions.

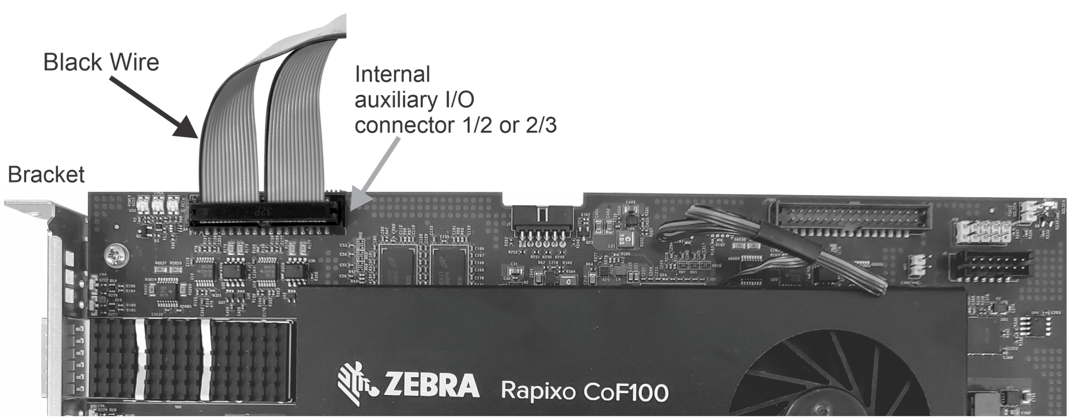
Once the transceiver is connected to the board, Link Speed Auto negotiation will automatically establish the speed of any newly connected transceiver. You can now also remove any dust cap that might be covering the connector and plug a cable into the connector like any other Ethernet port.

Installing the cable adapter

To install the cable adapter bracket, proceed with the following steps:

1. Make sure that your Zebra Rapixo CoF board is fastened to the computer chassis.
2. Attach the cable adapter bracket to internal auxiliary I/O connector 1/2 or 2/3 on the Zebra Rapixo CoF board. When attaching the flat ribbon cables of the adapter bracket, position the cable so that the black wire is on the same side as the bracket of the Zebra Rapixo CoF board.

NOTE: The internal auxiliary I/O connector that is closest to the panel (connector 1/2) supports 16 signals across both HD-15 connectors. The internal I/O connector that is further from the panel (connector 2/3) only supports 8 signals on the top HD-15 connector.

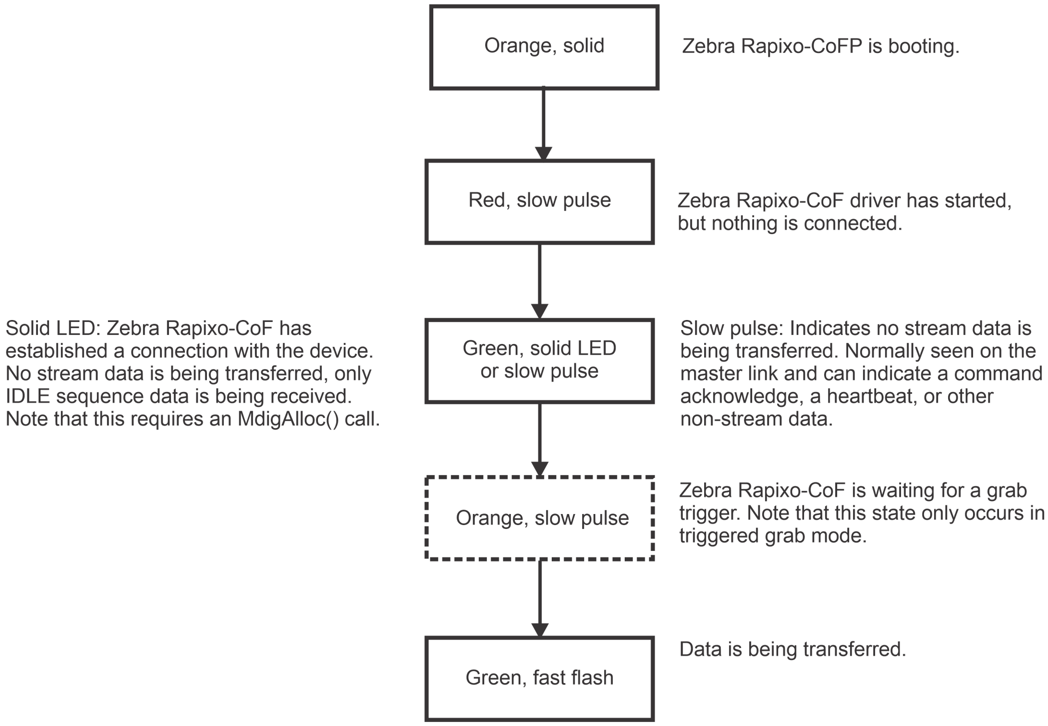


3. Slide the bracket of the cable adapter bracket into the opening at the back of the selected slot.
4. Anchor the bracket to the chassis using the screw that you removed in the previous section.

NOTE: The external auxiliary I/O connectors on the cable adapter bracket are panel mount connectors. If you don’t want to occupy an entire slot for the additional bracket, you can punch out two holes in the computer chassis, and then screw the connectors in the holes.

CoaXPress LEDs

The four CoaXPress LEDs on the main bracket identify the state and activity of each connection. The LEDs respect the JIIA CoaXPress Standard version 2.1 specification for connector indicator lamps. The typical sequence of LED states is as follows:



The following identifies the different timing used to define the LED flash or pulse states that can occur:

LED indication	HZ	Timing (+/- 20%)
Fast flash	12.5	20 msecs on, 60 msecs off
Slow flash	0.5	1 sec on, 1 sec off
Slow pulse	1	200 msecs on, 800 msecs off

Using multiple boards

You can install and use multiple Zebra Rapixo CoF boards in one computer. In addition, you can also simultaneously capture images from multiple videos sources across multiple Rapixo CoF boards. Follow the instructions in the following sections to acquire images across multiple video sources and boards.

Installation of multiple boards

Install each additional Zebra Rapixo CoF board the same way you installed the first board (refer to Chapter 2: Hardware installation). The number of Zebra Rapixo CoF boards that you can install is primarily dependent on the number of physical slots in your computer, and your BIOS; your BIOS establishes how many PCIe devices can be mapped to the PCIe memory space of your computer.

Using Aurora Imaging Library-Lite, you have to allocate an Aurora Imaging Library system for each board and allocate the resources of each Aurora Imaging Library system. For more information, see MsysAlloc() with M_SYSTEM_RAPIXOCOF in the Aurora Imaging Library Reference.

Simultaneous image capture from different boards

In addition to capturing images from multiple video sources with a single Zebra Rapixo CoF board, you can also simultaneously capture images from video sources attached to multiple Zebra Rapixo CoF boards.

NOTE: Be aware that the number of video sources from which you can simultaneously capture images is limited by the PCIe chipset on your computer.

A high performance PCIe chipset might be necessary to sustain PCIe transfers to Host memory. Ideally, you should use at least a PCIe 3.x chipset. Using the correct PCIe chipset will optimize the speed of data transmission and will minimize data loss.

To measure the effective available bandwidth of the PCIe slot in your computer with the Zebra Rapixo CoF board, you can use the Zebra Rapixo CoF Bench tool, accessible using the AILConfig utility. As a reference point, capturing from a 2K x 2K, 8-bit, 60 frames/sec video source will require a minimum bandwidth of 240 Mbytes/sec, plus an additional bandwidth margin of approximately 20%, for a bandwidth of 288 Mbytes/sec.

Hardware features

This chapter provides information on the Zebra Rapixo CoF hardware. It covers the architecture, features, and modes of the board's acquisition section. In addition, the chapter covers the Zebra Rapixo CoF hardware related to the formatting and transfer of data. A summary of the features of Zebra Rapixo CoF, as well as pin assignments for the various connectors, can be found in Chapter 5: Technical information.

Acquisition Path. This manual uses the term acquisition path to refer to a path that has the capability to, for example, capture a component or stream of the video input signal. The term independent acquisition path is used to refer to an acquisition path that can, if required, acquire data from a video source independently from another such path on the same frame grabber. On Zebra Rapixo CoF, each CoaXPress connection in a CoaXPress link uses the same acquisition path.

Digitizer. Aurora Imaging Library-Lite uses the concept of an Aurora Imaging Library digitizer to represent the acquisition path(s) with which to grab from one input source (one CoaXPress link on Zebra Rapixo CoF) of the specified type. When several Aurora Imaging Library digitizers are allocated, their device number along with their DCF identify if they represent the same path(s) (but perhaps for a different input format) or independent path(s) for simultaneous acquisition.

Digitizer configuration format. To program the acquisition section, allocate an Aurora Imaging Library digitizer using MdigAlloc() with an appropriate DCF (supplied or created) and digitizer device number. If you find a DCF file that is suitable for your video source, but you need to adjust some of the more common settings, you can do so directly, without adjusting the file, using the appropriate Aurora Imaging Library-Lite function. For more specialized adjustments, use the Zebra Imaging Capture Works program to adjust the DCF file.

Zebra Rapixo CoF Acquisition

Zebra Rapixo CoF can capture video from digital video sources compliant with the CoaXPress over Fiber Bridge version 1.1. When a video source is connected to Zebra Rapixo CoF, the board communicates with the video source to determine the rate at which data will be transferred.

For each video source connected to the board, Zebra Rapixo CoF supports a CoaXPress trigger output signal, which is used to communicate exclusively with the video source. To communicate with other third-party devices, Zebra Rapixo CoF provides 32 auxiliary signals (depending on the model). Auxiliary input signals can be rerouted to the CoaXPress trigger output signal and the CoaXPress trigger input signal can be rerouted to auxiliary output signals.

Zebra Rapixo CoF supports monochrome, RGB color, and Bayer color-encoded acquisition. The board can perform color-conversion, flipping, image subsampling, and also supports frame burst technology.

Performance

The maximum data transmission rate that you can achieve depends on the type of QFSP+ module you use (QFSP+ or QFSP28), your video source, as well as the type of PCIe slot in which you install your Zebra Rapixo CoF.

Number of pixels/line	64K
Number of lines/frame	64K
Data transfer bit rate from camera (per connection)	25 Gbits/sec
Data transfer bit rate to camera (per connection)	Up to 25 Gbits/sec for each master connection

Effect of the type of PCIe slot

Both the version and number of active lanes of your PCIe slot are important to consider. A PCIe 3.x slot supports a higher data transmission rate than a 2.x slot; furthermore, a PCIe x8 slot will double the data rate, when compared to a PCIe x4 slot of the same base specification (3.x or 2.x). While transferring data to the Host, these factors will reduce the maximum transmission rate as follows.

Acquisition

Zebra Rapixo CoF accepts 8-, 10-, 12-, and 16-bit video data. All data is transmitted in packets over a CoaXPress link.

The Zebra Rapixo CoF CoaXPress interface is responsible for decoding packets from the video sources, as well as buffering incoming data before it is written to memory. Video sources can be frame or line-scan video sources.

Frame burst technology

Zebra Rapixo CoF supports frame burst technology. This technology allows you to grab a group of sequential frames into a multi-frame image buffer with one grab command; the defined number of frames are stored contiguously in the same buffer. The end-of-grab event only occurs once the entire group of frames has been grabbed, reducing the number of events that need to be handled. This is useful in cases where you have a high frame rate and need to ensure that no frames are dropped.

Since Zebra Rapixo CoF will wait for the specified number of frames to complete before sending data to the Host, you could experience latency if the last frame has not reached the minimum frame count for a frame burst, or the acquisition of the last frame has stalled. To prevent frame-burst latency, you can use the state of an auxiliary I/O signal, adjust the frame count, or enable a frame burst timeout.

To grab a group of sequential frames with one grab command (MdigGrab(), or one grab of MdigProcess()), grab into a multi-frame image buffer. To create such a buffer, allocate an image buffer with a height that is the product of the Y-size of an individual frame and the number of frames that will be grabbed into the buffer on each grab command. Then, set the number of frames to grab in the image buffer using MdigControl() with M_GRAB_GRAME_BURST_SIZE before calling the grab command.

CoaXPress trigger signals and control messages

To communicate exclusively with the video source(s), Zebra Rapixo CoF supports CoaXPress trigger signals going to the camera and control messages. Trigger packets, which are sent to the camera, are virtually represented as trigger signals. Control messages constitute the basic communication mechanism between the video source(s) and the board.

For each video source connected to the board, Zebra Rapixo CoF supports a CoaXPress trigger output signal. A CoaXPress trigger output signal can be sent from the board to a video source to initiate image acquisition or to optionally control the exposure time.

To send a trigger output signal to the camera, you use the Aurora Imaging Library-Lite function MdigControl() with M_IO_SOURCE + M_TL_....For more information on how to use the auxiliary input and output signals, refer to the Auxiliary signals section, later in this chapter.

Auxiliary signals

This section describes the auxiliary signals available on Zebra Rapixo CoF. The auxiliary signals of Zebra Rapixo CoF are acquisition path independent and can be used to initiate on-board events (inputs) or can be transmitted to third-party devices (outputs). You can also reroute an auxiliary input signal to a video source via the CoaXPress trigger output signal.

The following tables summarize the auxiliary functionality that Zebra Rapixo CoF supports using its auxiliary I/O signals. The table also documents which Aurora Imaging Library constants to use.

Table 1 TTL Aux I/O functionality

	TTL Aux I/O connector 0			**TTL Aux I/O connector 1**			**TTL Aux I/O connector 2**			**TTL Aux I/O connector 3**		
M_AUX_IOn[a]	4	5	6	12	13	14	20	21	22	28	29	30
Functionality that can be routed or received	AUX(TRIG)_TTL_IO_n											
Timer (M_TIMERn[a])	1-8	1-8	1-8	1-8	1-8	1-8	1-8	1-8	1-8	1-8	1-8	1-8
User output. The bit for static-user-output register M_USER_BITn[a]	4	5	6	12	13	14	20	21	22	28	29	30

a Aurora Imaging Library constant, where n corresponds to the number in the row.

Table 2 OPTO Aux In functionality

	OPTO Aux In connector 0		**OPTO Aux In connector 1**		**OPTO Aux In connector 2**		**OPTO Aux In connector 3**	
M_AUX_IOn[†]	0	1	8	9	16	17	24	25
Functionality that can be routed or received	AUX(TRIG)_OPTO_INn							

Table 3 LVDS Aux In Functionality

		LVDS Aux In connector 0		**LVDS Aux In connector 1**		**LVDS Aux In connector 2**		**LVDS Aux In connector 3**	
M_AUX_IOn†		2	3	10	11	18	19	26	27
Functionality that can be routed or received		AUX(TRIG)_LVDS_INn							
Bit of rotary input	Decoder 0	0	1						
	Decoder 1			0	1				
	Decoder 2					0	1		
	Decoder 3							0	1

Table 4 LVDS Aux Out functionality

	LVDS Aux Out connector 0	**LVDS Aux Out connector 1**	**LVDS Aux Out connector 2**	**LVDS Aux Out connector 3**
M_AUX_IOn†	7	15	23	31
Functionality that can be routed or received	AUX(EXP)_LVDS_OUTn			
Timer (M_TIMERn†)	1-8	1-8	1-8	1-8
User output. The bit for static-user-output register M_USER_BITn†	7	15	23	31

Specifications of the auxiliary signals

Zebra Rapixo CoF has auxiliary signals in the following formats:

Singla format	**Total #of signals from each DB15 connector**	**Total #of signals from cable brackets**
TTL auxiliary input or output signals	3	6
Opto-isolated auxiliary input signals	2	4

Singla format	Total #of signals from each DB15 connector	Total #of signals from cable brackets
LVDS auxiliary input signals	2	4
LVDS auxiliary output signals	1	2
Total number of auxiliary signals	8	16

When you route an external signal to an auxiliary signal or vice versa, verify that the external signal meets the electrical specifications of the auxiliary signal.

When an auxiliary input signal is received in TTL format directly, it will be clamped at a maximum of 5.7 V and at a minimum of -0.7 V to protect the input buffer. Typically, the signal should have a maximum of 5 V and a minimum of 0 V. A signal over 2 V is considered high, while anything less than 0.8 V is considered low.

The opto-isolated auxiliary input signals pass through an opto-coupler, a device that protects the board from outside surges and different ground levels, and allows the frame grabber to be totally isolated. The voltage difference across the positive and negative components of the signal must be between 4.71 V and 9.165 V for logic high, and between 0 V (recommended) and 0.8 V for logic low.

You can set the direction of an auxiliary I/O signal using the Aurora Imaging Library-Lite function MdigControl() with M_AUX_SIGNAL_MODE.

You can set up the auxiliary signals in the DCF. Alternatively, for most commonly used functionalities, you can configure the auxiliary signals using the Aurora Imaging Library-Lite function MdigControl() (for example, with M_IO..., M_GRAB_TRIGGER..., M_TIMER..., or M_ROTARY_ENCODER...).

Timers

Zebra Rapixo CoF has 8 16-bit timers, which operate based on a specified clock source. Timer output signals allow you to control the exposure time and other external events related to the video source (such as a strobe). A timer output signal can be output on any of the auxiliary output signals or auxiliary I/O signals in output mode. A timer output can also be sent to a video source via the CoaXPress trigger output signal.

The timers can use one of the following as a clock source:

- A 125MHz internal clock source.
- A clock based on the output of another timer set in continuous mode.

To route a timer output on an auxiliary signal, use the Aurora Imaging Library-Lite function MdigControl() with M_IO_SOURCE + M_AUX_IOn set to M_TIMERn. To set up a timer, use MdigControl() with M_TIMER_....

Trigger

You can use as a trigger any of the auxiliary input signals (or auxiliary I/O signals in input mode), or the CoaXPress trigger input signal. A trigger signal can be used to initiate image acquisition or prompt an on-board event.

To enable grabbing upon a trigger, use the Aurora Imaging Library-Lite function MdigControl() with M_GRAB_TRIGGER_STATE. To set the signal used to trigger the grab, use MdigControl() with M_GRAB_TRIGGER_SOURCE. To start a timer upon a trigger, use MdigControl() with M_TIMER_TRIGGER_SOURCE.

Data latches

Zebra Rapixo CoF provides data latches that are used to latch counter values or timestamps and can be triggered using an auxiliary I/O signal, a timer active signal, the frame start signal, or the frame end signal. Data latches are available when using Aurora Imaging Library digitizer allocated using MdigAlloc() with M_DEV0 or M_DEV1. Each allocated digitizer has access to 16 data latches.

Quadrature decoder

Zebra Rapixo CoF features 4 quadrature decoders. They are used to decode quadrature input received from linear or rotary encoders with a quadrature output. A rotary encoder is a device that provides information about the position and direction of a rotating shaft (for example, that of a conveyor belt); a linear encoder is a device that provides information about the position and direction of a moving sensor along a scale. Encoders with quadrature output transmit a two-bit code (also known as Gray code) on two pairs of LVDS wires for each change in position of the rotating shaft, or of the sensor along the scale. For a given direction, the encoder outputs the code in a precise sequence (either 00 - 01 - 11 - 10 or 00 - 10 - 11 - 01, depending on how the encoder is attached. If the rotating shaft, or sensor moving along the scale, changes direction, the encoder transmits the Gray code in the reverse sequence (00 - 10 - 11 - 01 or 00 - 01- 11 - 10, respectively).

Upon decoding a Gray code, the rotary decoder increments or decrements its 32-bit internal counter, depending on the direction of movement. You can configure which Gray code sequence represents forward movement and increments the counter; the reverse Gray code sequence will then represent the backward direction and decrement the counter. You can specify the direction of movement occurring when the Gray code sequence is 00 - 01 - 11 - 10, using MdigControl() with M_ROTARY_ENCODER_DIRECTION.

The rotary decoder supports encoder frequencies of up to 50 MHz. The encoders can only be connected to our LVDS auxiliary input signals. The LVDS receivers on Zebra Rapixo CoF can support, under most circumstances, RS-422 signaling; refer to the electrical specification of the LVDS auxiliary input signals in Appendix B: Technical information for requirements.

NOTE: An external source must be used to power the rotary or linear encoder.

You can configure the rotary decoder's settings, using the Aurora Imaging Library-Lite function MdigControl() with M_ROTARY_ENCODER..., or by modifying the DCF file with Aurora Imaging Capture Works.

User signals

Auxiliary signals can also be used to transmit or receive application-specific user output and/or input.

If you want to start or stop an external event based on some calculation or analysis, you can manually set the state of any auxiliary output signal (or I/O signal set to output) to high or low. To do so, you set the state (on/off) of a bit in a user settable register (static-user-output register). When the bit is on, its associated auxiliary output signal will be high; when it is off, the auxiliary output signal will be low. This bit is referred to as a user-bit. To route the state of a user-bit to an auxiliary output signal, use MdigControl() with M_IO_SOURCE and M_USER_BITn; to set the state of a user-bit, use MdigControl() with M_USER_BIT_STATE.

Your application can also act upon and interpret the state of an auxiliary input signal (or I/O signal set to input). The state of an auxiliary input signal is not associated with a user-bit; you poll the state of the signal directly. To poll the state of an auxiliary input signal, use MdigInquire() with M_IO_STATUS. The state of an auxiliary input signal can also generate an interrupt; to do so, use MdigControl() with

M_IO_INTERRUPT_STATE and then use MdigHookFunction() with M_IO_CHANGE to hook a function to this event (that is, to set up an event handler).

On-board memory

Zebra Rapixo CoF is equipped with on-board memory that is model dependent. This memory is accessed through the memory controller and is used to store acquired images and images for or resulting from processing. The table below describes the memory and transfer rates available on different Zebra Rapixo CoF models.

Zebra Rapixo CoF model	On-board memory	Maximum theoretical transfer rate
Rapixo CoF40 4G	4 Gbytes DDR4 or 8 Gbytes DDR4	19.2 Gbytes/sec
Rapixo CoF100	16 Gbytes DDR4	85.3 Gbytes/sec

Zebra Rapixo CoF has a default of 128 Mbytes of on-board memory mapped onto the PCIe bus. You can use a Host pointer to access this memory, or you can access it directly from another PCIe bus master; this memory is referred to as shared memory. To allocate a buffer in shared memory, use the Aurora Imaging Library-Lite function MbufAlloc...() with M_ON_BOARD + M_SHARED.

Data conversion

Data can be modified both before it is saved to on-board memory and as it is being transferred to the Host.

Lookup tables

Zebra Rapixo CoF has on-board lookup tables (LUTs) that can precondition input data at acquisition time, before it is stored in on-board memory.

The on-board programmable lookup tables (LUTs) can map 8-bit, 10-bit, and 12-bit data (monochrome or color). When a link is receiving color data, all bands of the data use the same specified LUT mapping. As soon as one link is receiving 12-bit data, all links (CoaXPress connections) share the same specified LUT mapping. Data of other depths are mapped through transparent LUTs. The LUTs are programmed using the Aurora Imaging Library-Lite function MdigControl() with M_LUT_ID.

Bayer color decoder

As data from on-board memory is transmitted to the Host, it can pass through the Bayer color decoder. The Bayer color decoder converts Bayer color encoded images (GB, BG, GR, and RG pattern support) to multi-band RGB images using a 2x2 average demosaicing algorithm. The maximum line width for Bayer color conversion ranges from 16 Kbytes to 32 Kbytes, depending on the model.

Color space converter and image formatter

As data from on-board memory, processing, or the Bayer color **decoder** is transmitted to the Host, it passes through the color space converter and image formatter. The color space converter and image formatter can convert data in the following ways:

- **Subsampling.** Image data can be subsampled.

The color space converter and image formatter can subsample in the horizontal and vertical directions by integer factors of 1 to 16. The color space converter and image formatter uses nearest-neighbor interpolation.

You can use any of the following Aurora Imaging Library-Lite functions to subsample image data:

MdigControl() with M_GRAB_SCALE_X/Y and the subsampling factor.

MimResize() with ScaleFactorX and ScaleFactorY and the subsampling factor.

MbufTransfer() with M_COPY + M_SCALE and setting the destination buffer size smaller than the original image.

NOTE: Zebra Rapixo CoF does not support cropping in hardware. However, you can have image data cropped during transfer to Host using MdigControl() with M_SOURCE_SIZE_X/Y and M_SOURCE_OFFSET_X/Y.

- **Flipping.** Images can be flipped horizontally or vertically, using the Aurora Imaging Library-Lite function MdigControl() with M_GRAB_DIRECTION_X/Y or when calling MimFlip() from on-board buffer to Host.
- **Color space conversion.** The color space converter and image formatter formats an image based on its type and the bit-depth and color format of the destination buffer. You can set the bit depth and color format of the destination buffer when you allocate it using the Aurora Imaging Library-Lite function MbufAlloc...(). The format of the source image is established in the DCF.

Image data can be converted as follows:

Input format	8-bit mono chrome output format	16-bit mono chrome output format	24-bit packed BGR	32-bit packed BGRa	48-bit packed BGR	16-bit YUV (YUYV)	24-bit RGB planar	48-bit RGB planar
8-bit mono chrome	yes		yes	yes		yes	yes	
16-bit mono chrome	yes	yes	yes	yes	yes	yes	yes	yes
24-bit packed BGR	yes		yes	yes		yes	yes	
48-bit packed BGR	yes	yes	yes	yes	yes	yes	yes	yes

The equations for the YUV16 conversion are described in the following table. The value of depth is either 8 or 16 when converting BGR24 or BGR48 data, respectively.

NOTE: While performing BGR48-to-YUV color space conversion, the operations are carried out on 16-bit data; then, each resulting YUV component is bit-shifted right by 8 bits (>> (depth - 8) where the value of depth is 16).

Color space conversion	Equations
BGR-to-YUV	Y = (0.114B + 0.587G + 0.299R) >> (depth -8) U = (0.500B - 0.331G - 0.169R + 2 ^ (depth-1)) >> (depth -8) V = (0.081B - 0.419G - 0.500R + 2 ^ (depth-1)) >> (depth -8)

Flat-field correction

Zebra Rapixo CoF100 can perform flat-field correction, to help improve the quality of images taken in environments with uneven lighting, which can affect the quality of your processing. To correct this, an on-board flat-field correction can be applied to images so that the intensity across the image is even before processing begins. This operation essentially does a gain and offset correction on a pixel basis, where a different gain and offset can be applied to each pixel.

To use flat-field correction, you need to specify an on-board buffer that contains the gain values, and optionally another that contains the offset values, using MdigControl with M_SHADING_CORRECTION_GAIN_ID and M_SHADING_CORRECTION_OFFSET_ID, respectively. The buffers should be the same size as the grabbed image, and the gain values should be in the specified fixed point format (M_SHADING_CORRECTION_GAIN_FIXED_POINT). The aggregate bandwidth to read the gain buffer and offset buffer from on-board memory cannot be bigger than the internal maximum bandwidth of the DMA port (8 Gbytes/sec). There is a line limitation of 64 K pixels per line and 1M lines per frame. Once you have set the buffers, enable the correction using MdigControl with M_SHADING_CORRECTION.

Flat-field correction is applied to the images as they are being transferred from memory to the Host. This on-board correction is only available on the CoF100 model with the appropriated firmware installed. This functionality cannot be used simultaneously with peak extraction because this requires a separate firmware.

Peak extraction

Zebra Rapixo CoF100 can perform on-board laser line (peak) extraction, needed for 3D profiling. For 3D profiling, a laser plane (sheet of light) is projected on an object. By extracting the position of the laser line as it deforms when striking the object's surface, depth information can be established for that slice of the object. By grabbing a sequence of images as the object moves underneath the laser plane, and extracting the position of the laser line on the object, you can generate an uncorrected depth map of the exposed topography of the object.

To perform laser line extraction on-board, the laser line must appear horizontally in the image. The CoF100 can record the position and intensity of up to 3 peaks in each column. Extracting more than one peak is useful if the object (or background) is reflective or the image is noisy. Only the subpixel Y-coordinate and intensity of the peak(s) from each column are transmitted for each frame, lightening the load of the PCIe bus and Host CPU. Each frame is used to establish one row (Y-axis) in the uncorrected depth map and intensity map of the object in the scene.

To perform peak extraction on-board, you need to grab into an on-board buffer, and then call MimLocatePeak1d() with this buffer as the source and an image processing result buffer (MimAllocResult()) as the destination. MimLocatePeak1d() will perform that operation on-board without Host intervention if the specified buffer is an on-board 8-bit buffer. The buffer can be a single frame or a multi-frame on-board image buffer. Typically, when performing a laser line extraction for 3D profiling, many small frames are grabbed; to reduce the number of end-of-frame events sent to the Host, enable multi-burst technology and grab into a multi-frame buffer. Specify the Y-size of each individual frame using MimControl() with

M_FRAME_SIZE. For on-board laser line extraction, the maximum frame size is 8192 columns with 512 rows, and the minimum frame size is 128 columns with 16 rows.

Processing FPGA

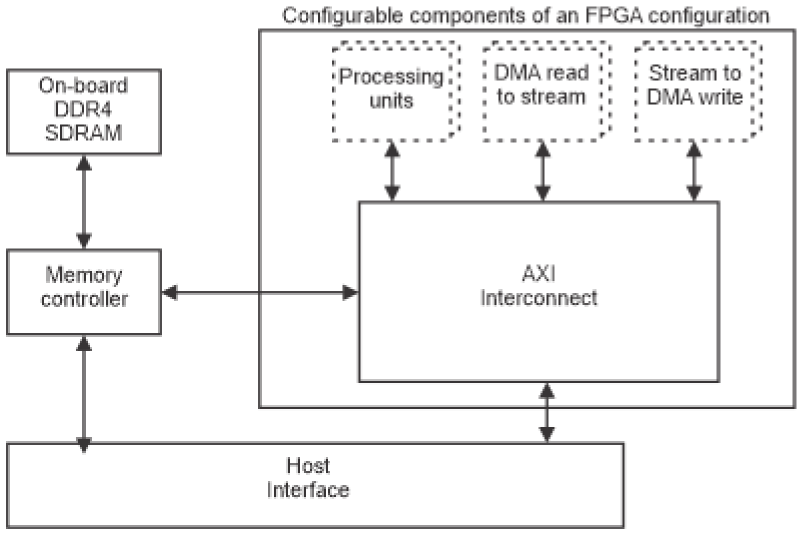
Zebra Rapixo CoF100 features an on-board real-time processing FPGA device (Processing FPGA), which can be configured to offload and even accelerate the most compute-intensive part of typical image processing applications, without generating additional data traffic within the host computer (Host). The Processing FPGA on the CoF100 is a highly customizable Xilinx Kintex UltraScale+ (KU15P).

Before the Processing FPGA can process grabbed images, they must be stored in on-board memory. If images stored in Host memory are required, they can be streamed directly to the Processing FPGA for processing. Images and other data resulting from processing can be stored in on-board memory or streamed to the Host.

The maximum peak bandwidth for images streamed directly to/from Host memory is 16Gbyte/sec, as well as for images streamed to/from on-board memory.

Possible processing operations

To use the Processing FPGA, you must configure it with an FPGA configuration that defines the appropriate functionality. An FPGA configuration is a code segment that is used to program an FPGA. The following diagram shows the configurable FPGA components in an FPGA configuration.



You would typically use standard Zebra FPGA configurations. You can also choose to implement processing on your own, using the Zebra FPGA Developers Toolkit (FDK) and C++. If required, Zebra's FPGA design services can be employed to develop an application-specific FPGA configuration.

Once the Processing FPGA is programmed, you can then make use of its functionality using Aurora Imaging Library. Refer to Using Aurora Imaging Library with a Processing FPGA chapter in the Aurora Imaging Library User Guide for more information.

Host interface

The Zebra Rapixo CoF PCIe Host interface is capable of high-speed DMA transfers to Host memory, or other memory mapped onto the PCIe bus. The DMA write engine of the Host interface is capable of performing the transfers without the help of the Host CPU.

DMA write performance is chipset and computer dependent, and is slightly affected by the image size and alignment in Host memory.

The Zebra Rapixo CoF Host interface has four DMA write contexts, which act independently, simulating four DMA write engines running in parallel. The presence of multiple DMA contexts does not change the maximum bandwidth, but can help reduce latency.

Technical reference

This chapter summarizes the hardware elements of Zebra Rapixo CoF. In addition, this chapter provides pinout descriptions for the external connectors of your Zebra Rapixo CoF.

The Zebra Rapixo CoF has the following minimum requirements:

- A free PCIe slot.

NOTE: For maximum bandwidth ensure that your PCIe slot supports at least x16 PCIe lanes.

- A relatively up-to-date PCIe chipset. A chipset that supports the PCIe 3.x standard is preferable.
- A proper power supply. Refer to the Electrical specifications section.
- Processor with an Intel 64-bit architecture, or equivalent.
- An operating system that supports the Zebra software you will use with your board. Consult your software manual for supported versions of Microsoft Windows and Linus.

Zebra does not guarantee compatibility with all computers that have the above specifications. Please consult with your local Zebra representative, local Zebra sales office, the Zebra website, or the Zebra Customer Support Group at headquarters before using a specific computer.

Board features

- Supports 1, 2, or 4 independent CoaXPress connections. Image data can be transmitted at up to 10 Gbits/sec (CoF40) or up to 25 Gbits/sec (CoF100) per connection.
- Supports frame-scan (area-scan) and line-scan video sources. The minimum and maximum number of pixels per line are 33 bytes and 16 Mbytes, respectively.
- Supports video sources with a Bayer color filter. Bayer color encoded images (GB, BG, GR, and RG pattern support) are converted to multi-band RGB images using a 2x2 average demosaicing algorithm. The maximum line width for Bayer color conversion ranges from 16 Kbytes to 32 Kbytes, depending on the model.
- Can convert 8- or 16-bit monochrome data or 24- or 48-bit packed BGR data to 8- or 16-bit monochrome, 24- or 48-bit packed/planar BGR, 32-bit packed BGRa, 16-bit YUV (YUYV), or 16-bit YCbCr format.
- Supports frame burst technology. This technology allows you to grab a group of sequential frames into a multi-frame image buffer with one grab command.
- Has 4 Gbytes (CoF40) , 8 Gbytes (CoF40) or 16 Gbytes (CoF100) of DDR4 SDRAM. Total memory bandwidth of up to 19.2 Gbytes/sec (CoF40), or 85.3 Gbytes/sec (CoF100).

- Has on-board programmable lookup tables (LUTs). These can map 8-bit, 10-bit, and 12-bit data (monochrome or color). When a link is receiving color data, all bands of the data use the same specified LUT mapping. As soon as one link is receiving 12-bit data, all links (CoaXPress connections) share the same specified LUT mapping. Data of greater depths are mapped through transparent LUTs.
- Can perform horizontal or vertical flipping.
- Can subsample image data using nearest neighbor integer subsampling factors of 1 to 16.
- Can perform on-board peak extraction. It can extract peaks from on-board 8-bit single frame or multi-frame image buffers. The maximum frame size is 8192 columns with 512 rows, and the minimum frame size is 128 columns with 16 rows. It can extract up to 3 peaks per column.
- Can perform on-board flat-field correction (only CoF100). There is a limitation of 64K pixels per line and 1M lines per frame.
- Has 32 auxiliary signals (with the cable adapter bracket installed) that are path independent. Each auxiliary I/O connector (HD-15) provides the following number of signals:

  - 3 TTL auxiliary I/O signals (trigger input or user input signals, or timer output, re-routing of the CoaXPress trigger input, or user output signals).

  - 1 LVDS auxiliary output signal (timer output, re-routing of the CoaXPress trigger input, or user output signals).

  - 2 LVDS auxiliary input signals (trigger input, rotary/linear encoder input, or user input signals).

  - 2 opto-isolated auxiliary input signals (trigger input signals).

  Auxiliary input signals (or auxiliary I/O signals set to input) can be rerouted to the CoaXPress trigger output signal and the auxiliary output signals.

  The auxiliary input signals have interrupt generation capabilities. In addition, when the LVDS auxiliary input signals are used for rotary/linear encoder input, they can be debounced.
- Has 4 quadrature decoders. Each supports external 5 V linear or rotary encoders with quadrature output, with a maximum differential swing of 3 V, and frequencies of up to 50MHz.
- Has 8 general timers. Each timer is a 16-bit timer that can count up to 65,535 clock ticks before resetting. Each timer uses 125 MHz internal clock source.
- Has a CoaXPress LEDs for the CoaXPress input connector, to identify the status and activity of each connection.
- Has 4 board status LEDs: board-power good, board configuration, PCIe speed/#lanes, and fallback board configuration.
- A fanless design for the CoF40 and a fansink for the CoF100.
- Support for Aurora Imaging Library license fingerprint and storage.

Electrical specifications

The following table describes electrical specifications for the Zebra Rapixo CoF.

Operating voltage and current for Zebra Rapixo CoF	
Rapixo CoF40	Total power dissipation (typical): 20W ([12V x 1.4A] + [3.3V x 0.33A] = 20W)[a]

Operating voltage and current for Zebra Rapixo CoF	
Rapixo CoF100	Total power dissipation (typical): 35W ([12V x 2.8A] + [3.3V x 0.43A] = 35W)[a][b]

[a] QSFP transceiver power consumption is specified at < 2W

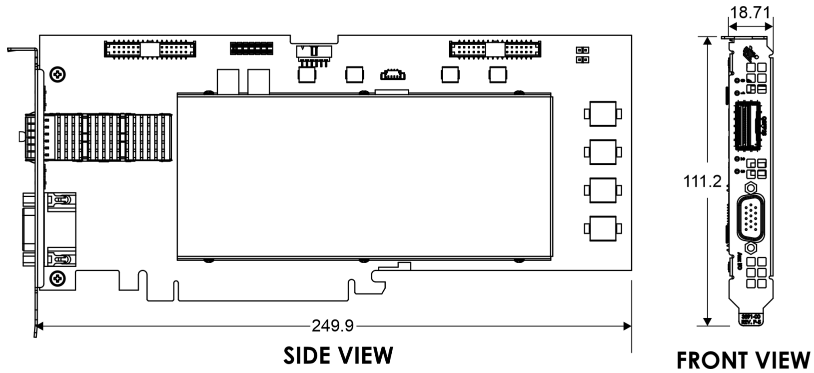
[b] CoF100 measurement conditions: grab only (without FDK algorithm)

The following table describes the specifications for the auxiliary I/O signals on Zebra Rapixo CoF.

I/O specification	
Minimum I/O jitter	+/- 8 ns, for any auxiliary input signal.
Input signals in LVDS format	100 Ohm differential termination. Input voltage on the (+) or (-) pin: -4 V (min) to +5 V (max). Maximum differential input: 3 V.
Output signals in LVDS format	Expecting a load of 100 Ohms. Differential output voltage (with load of 100 Ohm): 250 mV (min) to 450 mV (max). Offset voltage (common-mode): 1.125 V (min) to 1.375 V (max).
Input signals in TTL format	No series termination. Pulled up to 3.3 V with 4.7 KOhm. Clamped to -0.7 V to +5.7 V. Input voltage: low of 0.8 V (max); high of 2.0 V (min).
Output signals in TTL format	27 Ohm series termination. High-level output current: -32 mA (max). Low-level output current: +64 mA (max). High-level output voltage: 2.0 V (min). Low-level output voltage: 0.55 V (max).
Opto-couples input signals	511 Ohm series termination (connected on the anode inputs of the opto-coupler device). High-level Input current threshold: 5 mA (min) to 15 mA (max) (6.3 mA to 10 mA recommended). Input voltage: low (Vil) of 0.8 V (max); high (Vih) of 4.71 V (min) to 9.165 V (max). Input forward voltage (at 25 degrees C): 1.3 V (min), 1.8 V (max). Propagation delay (at 25 degrees C): 100 ns (max).

Dimensions and illustrations

Dimensions of all Zebra Rapixo CoF boards: 24.99 L x 11.15 H x 1.871 W cm (9.84" x 4.39" x 0.737") from bottom edge of goldfinger to top edge of board. These values respect the dimensions of a PCIe three-quarters length board.



Environmental Conditions

Parameter	Value
Ventilation	150 LFM over board(s) (through the heat sink) in a single board configuration. More ventilation might be required in multiple board configurations
Ambient operating temperature in the vicinity of the board (Minimum/Maximum)	0°C to 55°C (32°F to 131°F).
Storage temperature (Minimum/Maximum)	-40°C to 75°C (-40°F to 167°F).
Operating relative humidity	up to 95% relative humidity (non-condensing).
Storage humidity	up to 95% relative humidity (non-condensing).

Transceiver temperatures

As per SFF-8679, transceivers must operate within one or more of the following temperature ranges:

Transceiver class	Temperature range
Standard	0 to 70°C
Extended	-5 to 85°C
Industrial	-40 to 85°C

Connectors on the board

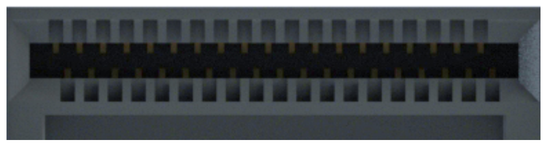
On the Zebra Rapixo CoF board, there are a number of connectors. On the bracket of the main board, there is an QSFP transceiver cage and an HD-15 connector. In addition, close to the top edge of the main board, there is an internal auxiliary I/O connector that can be used with an adapter bracket to access additional I/O.

The optional cable adapter bracket provides 2 additional external auxiliary I/O connectors (HD-15). Auxiliary I/O connectors 1, 2, and 3 are found on the cable adapter bracket. The cable adapter bracket attaches to this internal auxiliary I/O connector.

QFSP cage connector

One QSFP cage is available on Zebra CoF. The QSFP cage houses a 38-pin connector to which you must connect a transceiver. This connector supports Ethernet speeds of up to 10 Gbits/sec or 25 Gbits/sec, if using an QSFP28 transceiver.

Figure 6 QSFP 38-pin connector



NOTE: The QSFP cages are rated for a maximum of 250 module insertions.

External auxiliary I/O connectors

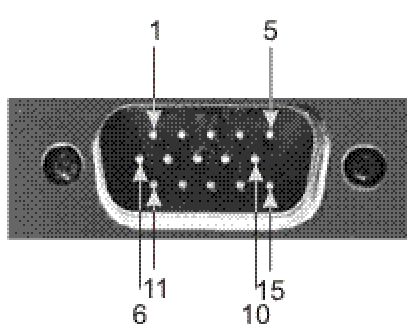
The external auxiliary I/O connectors on the HD15 adapter cable and the cable adapter bracket are high-density D-subminiature 15-pin (HD-15) male connectors. The external auxiliary I/O connectors are used to transmit and receive auxiliary signals.

NOTE: The auxiliary I/O connectors on Zebra Rapixo CoF are not compatible with display devices. Connecting one of the HD-15 connectors to a VGA monitor or any other display device might damage both the device and the Zebra Rapixo CoF board.

The auxiliary signals are path independent; regardless of the acquisition path that is being used to grab images, any of the auxiliary signals can be used.

The pinout for auxiliary I/O connector 0 is as follows. Auxiliary I/O connectors 1, 2, and 3 have the same pinout as auxiliary I/O connector 0, except you must add 8, 16, or 24, respectively, to the number at the end of their hardware signal name and Aurora Imaging Library constant. For example, AUX(TRIG)_TTL_IO_4 on connector 0 would be AUX(TRIG)_TTL_IO_12 on connector 1.

Figure 7 HD-15 connector



Pin	Hardware signal name	Aurora Imaging Library constant for auxiliary signal	description
1	AUX(TRIG)TTL_IO4	M_AUX_IO4	TTL auxiliary signal 4 (input/output), which supports: timer output (M_TIMER1/M_TIMER2/ M_TIMER3/M_TIMER4), trigger input, user input, or user output (M_USER_BIT4).
2	AUX(TRIG)TTL_IO5	M_AUX_IO5	TTL auxiliary signal 5 (input/output), which supports: timer output (M_TIMER1/M_TIMER2/ M_TIMER3/M_TIMER4), trigger input, user input, or user output (M_USER_BIT5).
3	AUX(TRIG)TTL_IO6	M_AUX_IO6	TTL auxiliary signal 6 (input/output), which supports: timer output (M_TIMER1/M_TIMER2/ M_TIMER3/M_TIMER4), trigger input, user input, or user output (M_USER_BIT6).
4+, 5-	AUX(TRIG)LVDS_IN2	M_AUX_IO2	LVDS auxiliary signal 2 (input), which supports: trigger input, user input, or rotary/linear encoder input bit 0.
6+, 8-	AUX(TRIG)LVDS_IN3	M_AUX_IO3	LVDS auxiliary signal 3 (input), which supports: trigger input, user input, or rotary/linear encoder input bit 1.
7	GND	N/A	Ground
10	GND	N/A	Ground
12+, 11-	AUX(TRIG)OPTO_IN1	M_AUX_IO1	Opto-isolated auxiliary signal 1 (input), which supports: trigger input or user input.

Pin	Hardware signal name	Aurora Imaging Library constant for auxiliary signal	description
13+, 14-	AUX(TRIG)LVDS_OUT7	M_AUX_IO7	LVDS auxiliary signal 7 (output), which supports: timer output (M_TIMER1/ M_TIMER2/M_TIMER3/ M_TIMER4) or user output (M_USER_BIT7).
15+, 9-	AUX(TRIG)OPTO_IN0	M_AUX_IO0	Opto-isolated auxiliary signal 0 (input), which supports: trigger input or user input.

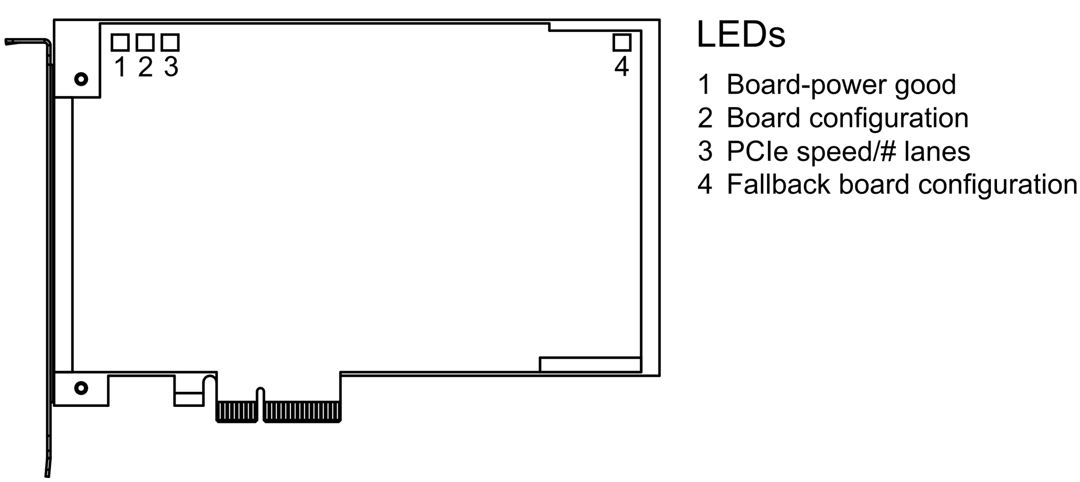
Status LEDs on Zebra Rapixo CoF

Zebra Rapixo CoF has LEDs to display the status of the CoaXPress connections and the board. The LEDs found on the bracket provide information about the status of the CoaXPress connections, and the LEDs found on the PCB of the board provide information about the status of the board.

Board status LEDs

Zebra Rapixo CoF has four board status LEDs to indicate the status of the board: board-power good, board configuration, PCIe speed/#lanes, and fallback board configuration.

Figure 8 LEDs found on the Rapixo CoF Board



The table below outlines the possible colors for each LED and their definitions.

LED	LED color and state	Description
1. Board-power good	Off/Red	One or more of the on-board voltage regulators did not start. If your computer is on and this LED state occurs, there is an issue with the voltage regulators on your Zebra Rapixo CoF. Contact Zebra technical support.
	Green	All of the on-board voltage regulators are working properly.
2. Board configuration	Red	The board is not configured.
	Green	The board is configured.
3. PCIe speed /# lanes	Off	The PCIe link is down.
	Blinking red	Slot is PCIe 1.x and not all lanes are active.
	Blinking orange	Slot is PCIe 2.x and not all lanes are active.
	Blinking green	Slot is PCIe 3.x and not all lanes are active.
	Solid red	Slot is PCIe 1.x and all lanes are active.
	Solid orange	Slot is PCIe 2.x and all lanes are active.
	Solid green	Slot is PCIe 3.x and all lanes are active.
4. fallback board configuration	Off	The normal board configuration is being used.
	On	The normal board configuration was corrupt. The fallback (golden) board configuration is being used.

CoaXPress LEDs

Zebra Rapixo CoF has one CoaXPress LED per connection. Each LED indicates the connection status between the device (camera) plugged into the LED's associated connector and the Host (frame grabber). Each LED also indicates whether the device is sending data, and whether Zebra Rapixo CoF is transmitting power to the device.

LED color and state	Description
Off	Zebra Rapixo CoF is not receiving power.
Orange, solid	Zebra Rapixo CoF is booting.

LED color and state	Description
Red, slow pulse	Zebra Rapixo CoF driver has started, but nothing is connected.
Green, solid	The device is compatible and Zebra Rapixo CoF has established a connection with the device (on the specified cable). **NOTE:** This requires an MdigAlloc() call. No data is being transferred.
Orange, slow pulse	Zebra Rapixo CoF is waiting for a grab trigger. **NOTE:** This state only occurs in triggered grab mode.
Green, fast flash	Zebra Rapixo CoF is receiving data from the connected device.
Red, 500 ms pulse	An error occurred during data transfer.
Red, fast flash	A CoaXPress system error occurred on the Zebra Rapixo CoF board. This type of error can prevent Zebra Rapixo CoF from receiving data.

Available Rapixo CoF boards

This chapter lists the available Rapixo CoF boards and the key feature changes to each SKU.

Key feature changes

SKU number	Version	Description
RAP16-4CF25-P15F	001	First shipping version of the Zebra Rapixo CoF100 with 16GB of on-board memory
RAP4G-4CF10-H	001	First shipping version of the Zebra Rapixo CoF40 with 4GB of on-board memory
RAP8G-4CF10-H	001	First shipping version of the Zebra Rapixo CoF40 with 8GB of on-board memory