

Teledyne DALSA RAD-ICON 2329

Detector User Manual
GigE model



November 20, 2018

www.teledynedalsa.com/ndt

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Teledyne DALSA is an international high performance semiconductor and electronics company that designs, develops, manufactures, and markets digital imaging products and solutions, in addition to providing semiconductor products and services. Teledyne DALSA's core competencies are in specialized integrated circuit and electronics technology, software, and highly engineered semiconductor wafer processing. Products and services include image sensor components; electronic digital cameras; X-ray detectors; vision processors; image processing software; and semiconductor wafer foundry services for use in MEMS, high-voltage semiconductors, image sensors and mixed-signal CMOS circuits.

Contact Information

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1

Safety and System Information

Safety Information

Definitions

User of the products as described in this manual is the Original Equipment Manufacturer (OEM) that is developing and producing an X-ray imaging device (or 'modality'), using the product as an component to capture image information;

End-User of the products as described in this manual is the professional operating the OEM equipment to perform a diagnostic imaging routine;

Intended Use

The products as described in this manual are components that are used enclosed inside a User's system to capture images in X-ray modalities. Typical applications include, but are not limited to, Non-Destructive Testing, Electronics Inspection and Computed Tomography (CT).

Installation Warning

The User is responsible for the safe and prudent installation of the detector in their system. All X-ray sources and controls, shielding, personnel safety monitoring devices, and personnel safety precautions and training involved in the use of this equipment are the responsibility of the User and/or the End-User.

Safety Statement

The general safety precautions that follow must be observed during all phases of installation, operation, service, repair and disposal of this system. Failure to comply with these precautions, or with specific warnings noted in this manual, violates the safety standards of design, manufacture and the intended used of this system. Teledyne DALSA assumes no responsibility for the user's failure to comply with these requirements.



Warning: The product, when installed, is subject to exposure from X-rays during operation.

To ensure personnel safety, it is necessary that a radiation meter will be used to check for radiation leakage after installation of the digital camera in the end users system.

For safety reasons, the on-time of the X-ray source should never be controlled directly by the detector synchronization output. Control of the X-ray source remains a system/host responsibility.

Teledyne DALSA assumes no responsibility for proper installation of the detector, installation of X-ray shielding, X-ray shield enclosure testing, or safe and prudent

operation of the camera system in the End-user's installation. It is the Users and End-users responsibility to ensure that local and federal guidelines regarding the installation and operation of X-ray sources are followed.

The power requirements of the product, especially the voltage specifications, must be strictly adhered to or warranty will be void.

No User Serviceable Components

There are no components in this system which need to be replaced, modified, or adjusted by the end user. Please contact Teledyne DALSA Support for assistance if needed.



Safety Warning: Tampering with this product voids the warranty and may degrade the detectors image quality, resulting in a possibly unsafe condition for (End-) Users.

The system has been designed to minimize the amount of interference it may generate in an installation. This equipment generates and can radiate radio frequency energy and, if not installed and operated in accordance with the instructions, may cause harmful interference to other devices in the area.

Stacking

Teledyne DALSA does not recommend that the user stack the product or use it in adjacent to other equipment. If this arrangement is unavoidable, then the (End-)user must ensure that there is adequate airflow around the detector and that normal operation conditions are maintained.

Disposal of Product

The detector contains lead and no batteries. Dispose the unit in accordance with local regulatory guidelines.



EMC compliance

To ensure EMC compliance, follow these specific guidelines:

- Ensure that all cable shields have a 360° electrical connection to the connector.
- Tightly fasten and secure all connectors.

Warning

- The detector can influence the performance of very sensitive equipment.
- Strong EMC disturbances can influence the detectors performance.

System precautions

The following are precautions that must be taken in order to prevent possible damage to your Teledyne DALSA Detector system:

Warning:

The use of accessories, power supplies and cables other than those specified, with the exception of cables sold by Teledyne DALSA as replacement parts, may result in increased emission or decreased immunity of the Rad-icon Detector.

X-ray exposure should be limited only to the active image area (see chapter 5 mechanical drawing) in order not to cause damage to the electronic components of the device.

Static precautions

Observe proper ESD/static control procedures when handling system components. The use of properly grounded wrist strap is highly recommended.



Installation Precautions

Never connect or disconnect cables while power to the detector is on. Damage to the detector electronics might occur if the cables are connected and/or disconnected while the detectors power is on.

Enclosed Use

This equipment is designed for use in enclosed systems, with the enclosure sufficiently shielding the equipment against the influence of visible light. If used without enclosure and in bright environments, ambient light entering the detector may impact image quality or the effectiveness of calibrations. It is the customer’s responsibility to take measures in the application to avoid ambient light entering the detector.

Service by Qualified Personnel Only

This equipment is to be installed by a qualified technician only. The system can only be used in conjunction with a properly installed X-ray source with the appropriate shielding and a properly configured computer workstation that meets the minimum system requirements discussed later in this manual.

Environmental Specifications

Temperature	
- Operating	+10..+40 °C
- Transport & Storage	0..+50 °C
Humidity (non-condensing)	
- Operating	20%..80%
- Transport & Storage	20%..80%
Shock	25G (6ms)
Vibration	1G (10-150Hz)

Note: For transport and storage, the standard product packaging is assumed to be in place which includes a sealed anti-static shield bag.

Detector Maintenance

Before performing any of the following operations, make sure that the power to the detector is switched OFF.

Protecting the Detector Front Cover

The front cover of the detector and should be treated with care, as scratches or debris in this area may produce artifacts in the X-ray image.

Cleaning the Detector Body and Front Cover

The detector body and front cover can be cleaned with a mild, non-abrasive cleanser such as isopropyl alcohol. Place a small amount of cleanser on a soft cloth and rub gently over the detector body surface. Wipe off with a clean soft cloth. Do not use any harsh cleansers or solvents that may damage the paint or other finishes on the detector.

In the event of detector exposure to bio-hazardous materials, proper cleaning procedures should be undertaken prior to removal or maintenance of the detector.

Calibration

To have the best image performance, the raw image data generated by the detector should be corrected at the host by using a flat field (offset and gain) correction. As the offset (dark) calibration signal depends (amongst others) on ambient temperature conditions of the detector, it is commonly accepted good practice to generate these calibration images frequently at times that the X-ray source is switched off. It is recommended to re-calibrate the gain correction image at least once per year, at least when e.g. the X-ray tube is exchanged or anything changes in the X-ray imaging geometry (e.g. the distance between the X-ray source and the detector).

The detector can contain deviating pixels. To have the best possible image quality it is advised to perform a defect pixel correction in the host system. It is recommended to create a defect pixels calibration image at least every year, or more frequently in case of heavy use.

To verify if the detector still operates according specification it is advised to measure on regular base the following performance parameters of the detector: dark reference, noise performance, flat field reference, saturation dose and MTF performance.

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The Rad-icon 2329 Detector

A full description of the features and functional specification of the Rad-icon 2329 detector can be found in the latest product specification or datasheet.

Contact sales.sensors@teledyne.com or visit

<http://www.teledynedalsa.com/imaging/products/x-ray/> for information on how to obtain the latest datasheet or other product documentation.

Detector Highlights

Key Features

- Latest generation CMOS technology (6th generation) enables even lower noise and power consumption
- Highest sensitivity AND highest dynamic range over an extended dose range
- Unmatched image quality at low dose levels
- 4608 x 5890 pixel resolution, 49.5um pixel pitch, active area 228x291 mm²
- 14-bit A/D conversion
- No measurable image lag
- Up to 2 frames per second at full resolution, 16 bit pixel data
- GigE data interface
- GdOS scintillator

Programmability

- Read out modes
- Trigger modes
- Integration time
- 1x2 or 2x2 pixel binning

Typical Applications

- Non Destructive Testing
- Electronics Inspection
- Computed Tomography (CT)
- X-ray Crystallography

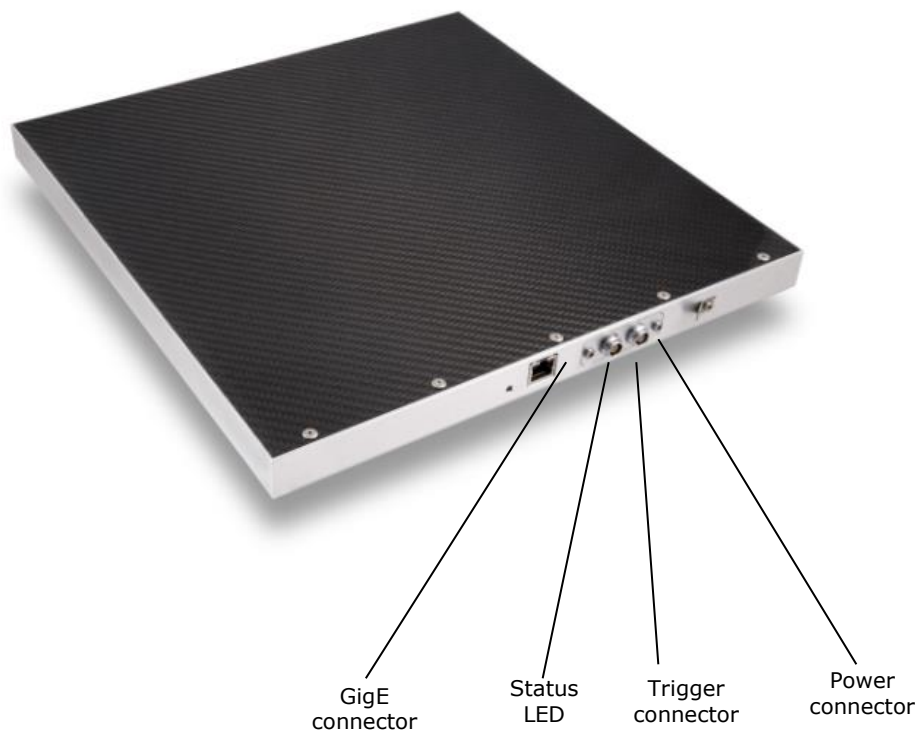
3

Setting up the Detector

Detector Connectors and Cables

This detector uses the following connectors.

- An RJ-45 connector for Gigabit Ethernet signals, data signals
 - CAT6 shielded Ethernet cable (STP)
- One 2-pin Lemo connector for power
 - Lemo EEG.0B.302.HLN
 - Mating connector:
 - straight type: FGG.0B.302.CLAD52
 - elbow type: FHG.0B.302.CLAD52
- One 4-pin Lemo connector for triggering
 - Lemo EEG.0B.304.HLN
 - Mating connectors:
 - straight type: FGG.0B.304.CLAD52
 - elbow type: FPG.0B.304.CLAD52



Ethernet Connector

Ethernet Connection LED

Steady orange indicates that an Ethernet connection is successfully established.

Data Transmission LED

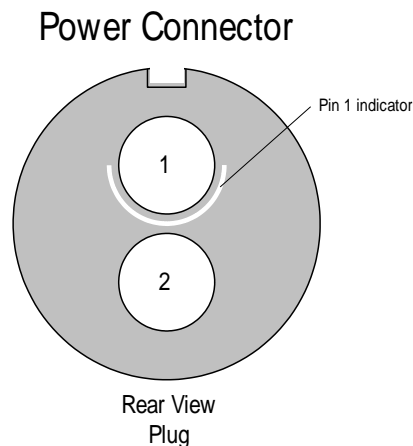
Flashing green indicates that the detector is transmitting or receiving data.

Detector Status LED

The detector is equipped with an orange/green LED used to display the status of the detector's operation. The table below summarizes the operating states of the detector and the corresponding LED states.

	Color Of Status LED	Meaning
1	Orange	Power applied, Standby mode
2	Green	Detector is operational
3	Off	No power

Power Connector



	Description
1	Supply voltage (+12- 28V / 20W)
2	Ground Shielding (chassis)

The detector requires a single voltage input (+12-28V / 20W). There is a protection for misconnection, via a resettable fuse. When the fuse has been activated (isolating), power cycling will return it to conductive state again thus restoring normal operation (assuming power has been properly applied).

WARNING: When setting up the detector power supplies follow these guidelines:

Apply the appropriate voltages.

The power supply must be able to deliver higher peak current of 3A during start up.



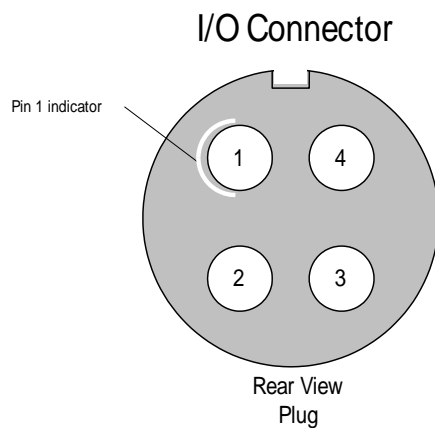
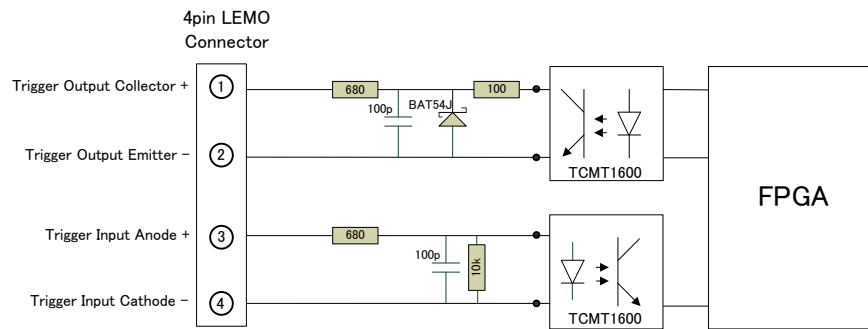
Keep leads as short as possible in order to reduce voltage drop. The voltage level at the product power connector should be within the range mentioned in the datasheet.

Use high-quality linear supplies of SELV type and EN 60601-1 compliant.

Note: If your power supply does not meet these requirements, the detector performance specifications cannot be guaranteed.

Trigger Connector

The trigger circuitry inside the detector is shown in the figure below.



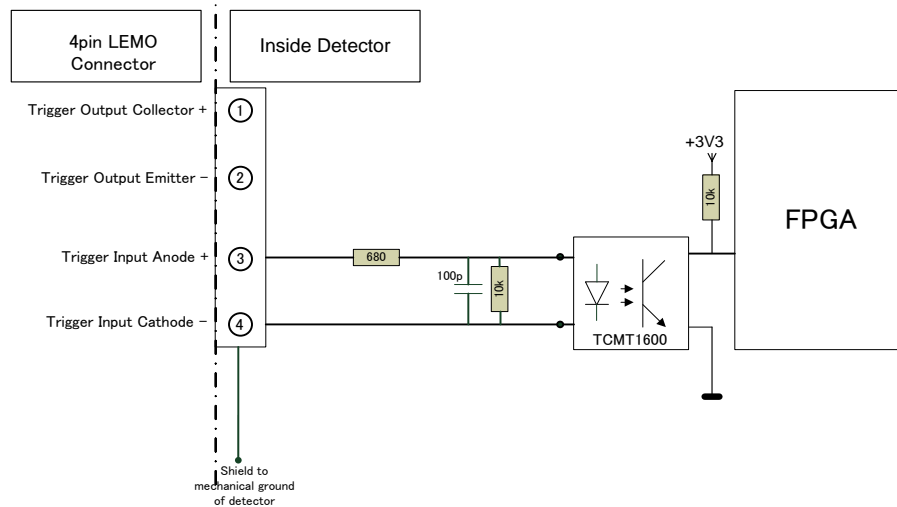
		Description
1	Out	Optocoupler collector with 680R +100R (+/- 2%) series resistor (note 1)
2	Out	Optocoupler emitter
3	In	Optocoupler anode with 680R (+/- 2%) series resistor (note 2)
4	In	Optocoupler cathode Shielding (chassis)

Note 1: maximum voltage across collector and emitter is 70V. Maximum reverse voltage (between emitter and collector) is 6V

Note 2: maximum reverse voltage across cathode and anode is 6V.

Description Input circuitry Trigger In

Inside the detector the connection for the input is as in below drawing:



Depending of the connection, the trigger input can be active high or active low:

For normal input operation:

“Trigger Input Anode +” is used as driving source and

“Trigger Input Cathode -” is connected to ground.

Then “Trigger in” is active high.

This is the situation which is referred to in this document.

For inversed input operation:

“Trigger Input Anode +” is connected to VCC and

“Trigger Input Cathode -” is used as driving source and then “Trigger in” is active low.

Voltage range of trigger input:

Active State:

The recommended photodiode forward current is 5mA. Absolute maximum input voltage is 10.0V. Do not apply an input voltage with reversed polarity. In the detector there is a series resistor of 680 Ohm. The maximum forward voltage of the photodiode is 1.35V.

Minimum voltage input:

When 2.4V input voltage is applied then the trigger will be active.

Forward voltage of optocoupler is maximum 1.35V.

The forward current will be $(2 - 1.35V)/680 \text{ Ohm} = 1.5\text{mA}$.

The optocoupler shall response correctly.

Maximum voltage input:

When 10V input voltage is applied then the trigger will be active.

Typical forward voltage of optocoupler is 1.35V.

The forward current will be $(10 - 1.35V)/680 \text{ Ohm} = 13\text{mA}$.

The maximum voltage is limited by internal dissipation of internal series resistor (which is 125mW). In this case the dissipation is 110mW.

By adding external series resistor the external voltage can be increased.

The forward current for the trigger input to the detector may not exceed 13mA.

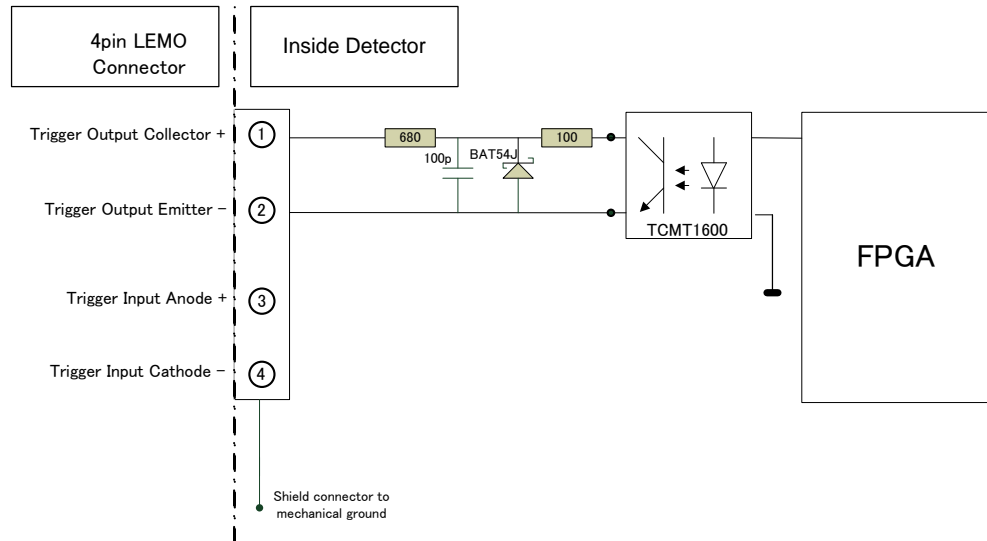
Then the optocoupler will respond correctly.

Voltage range active state: 2.4 ... 10V (with a corresponding current of 1,5 ... 13mA)

Passive state: Voltage range: <0.5V (with a corresponding current of < 0.1mA)

Description circuitry Trigger Out

Inside the detector the connection for the input is as in below drawing:



The optocoupler transistor output is able to sink 10mA current in non-saturated condition. Absolute maximum voltage is 24V. Do not apply a voltage with reversed polarity.

Depending of the connection the trigger output can be active high or active low.

When “**optocoupler collector connection**” is used:

“Trigger Output Collector” is pulled up with a resistor (of 10k) and

“Trigger Output Emitter” is connected to ground

Then “Trigger out” is active low (= integration state of detector).

When “**optocoupler emitter connection**” is used:

“Trigger Output Collector” is connected to VCC (supply) and

“Trigger Output Emitter” is pulled down with a resistor (of 10k)

Then “Trigger out” is active high (= integration state of detector).

In this document the state of “Trigger Out” is “active” (integrating) or “not active” (reading/reset of pixels).

Passive trigger output levels: 0...0.1mA@0..20V

Active trigger output levels:

Saturation voltage: <0.4V@ <10mA

Maximum allowed current: 10mA

Setting up the Detector

Network Interface Card

A Network Interface Card (NIC) is required to acquire images and control the Rad-
icon 2329 detector. A NIC with Jumbo packet support up to 9014 bytes is required to
receive streaming video, preferably with a PCI Express slot.

Teledyne DALSA advises to use the Intel Gigabit CT adapter Network Interface Card
(NIC) which is a low cost but high performance and reliable adapter with a PCI
Express slot.

Make sure that the latest driver of the NIC manufacturer is installed. We advise to use
64-bit operating systems as the NIC drivers are better maintained.

Due to the high bandwidth used by the detector it is strongly advised to have a direct
connection from the NIC to the detector.

Connect Trigger Cable

Connect the trigger cable to the detector when the trigger mode of the detector is set
to Triggered, Snapshot, Snapshot Extended Exposure and Triggered Sequence modes.

Connect Ethernet Cable

Connect the CAT-6 STP Ethernet cable from the detector to the computer Ethernet
jack. Secure the RJ-45 connector to the detector.

Connect Power Cable

Connect a power cable from the detector to a power supply with a supply voltage
between 12-28V and capable of delivering at least 20W.

Status Light

In normal operation the status light is green.

The status light is orange when the detector is in standby.

When the detector is connected to a host system it will be recognized in 30 to 65
seconds.

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Software installation

Operating Systems Support

The current released GigE Vision framework supports up to Windows 10.

For Linux the Teledyne DALSA GigE Vision Application Programmers Interface (API) for Linux is available.

For additional support please contact our support team for the software and the latest status.

Obtain software

CD

Check the CD that shipped with your detector for installation files for CamExpert, the GigE driver and/or the ShadoCam software. To obtain the latest versions, or software for a newer operation system, it may be necessary to go to the Teledyne DALSA website for the latest updates.

Website

Visit the Teledyne DALSA website to download the latest free version of the Spera LT SDK, including the CamExpert image viewer:

<http://www.teledynedalsa.com/imaging/products/software/spera/lt/download/>

The download is free after filling out the on-line registration form. Make sure to select "Full SDK" as your download option.

Spera LT and CamExpert Installation

A link to download the software will be emailed to you after submitting the application. Complete the download process and run the installation file (e.g. "SperaLT80xSDKSetup.exe").

CamExpert is an image viewer designed to evaluate your detector. The Spera SDK is a set of development tools and documentation for creating your own software for interfacing to the product. Please download the appropriate materials and follow the instructions that are part of that download.

The Spera SDK installation also contains a large number of helpful example projects to help you get started with integration the detector into your own application software. For additional examples specific to the Rad-ikon 1520 detector please contact our support team at the contact info listed on page 2 of this manual.

GigE Vision framework for Sopera LT installation

The GigE Vision framework installs the GigE Vision Module for Sopera and includes the Network Imaging package which is required to access a GigE Vision detector.

Refer to the “GigE Vision Module for Sopera” user manual and “Network Imaging Module for Sopera LT” user manual which are included in the installation.

Optimizing Settings

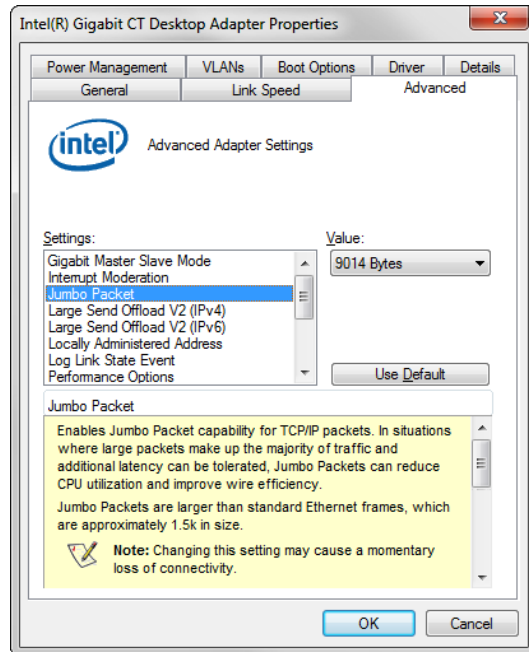
The performance of the gigabit Ethernet connection on the host computer generally can be improved by adjusting some settings in the NIC. The below advices refer to the Intel Gigabit CT desktop adaptor. For a more detailed explanation please refer to “Network Optimization Guide (PDF)” and “Network Imaging User’s Manual (PDF)” which is part of the Sopera LT software package.

To reduce the interrupt overhead in the host the following settings in the NIC are advised.

Packet Size

For a good Gigabit Ethernet connection with minimal packet resend conditions, host computer performance can generally be improved by increasing the data packet size. Each streaming video packet causes an interrupt in the host computer. Therefore increasing the packet size reduces the CPU overhead required to handle video data from the GigE Vision detectors.

A standard packet can have a size up to 1500 bytes. Many network cards support a jumbo packet mode that can extend that size up to 16Kbytes. In theory, a packet could be as large as 16 KB, but the CRC (cycle redundancy check) containing the checksum of each packet is not as efficient when the packet size grows larger than 9000 bytes. For this reason **we advise to set the packet size to 9014 bytes** (jumbo packet enabled).



Interrupt Moderation

Normally, each time a packet is received by the network card, the associated driver will receive an interrupt. Obviously, when the packet rate is very high (that is, at high transfer rate which is common for GigE Vision systems), this represents significant overhead. Most network cards have introduced an interrupt moderation mode where

the card waits to have received a certain number of packets over a maximum period of time before issuing the interrupt. This helps reduce the burden on the CPU as it can process multiple packets during the same interruption.

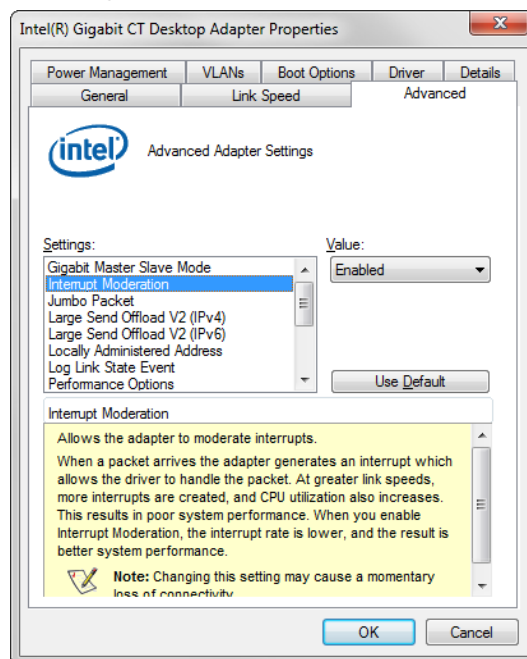
The Intel Gigabit CT Network adapter provides a configuration parameter to manually adjust the NIC interrupt moderation rate. By default the NIC driver sets this to Adaptive where the interrupt rate automatically balances packet transmission interrupts and host CPU performance. In most cases no manual optimization of the Interrupt Moderation Rate parameter is required.

In some conditions, video frames from the GigE Vision detector may be transferred to the host display or memory buffer as data bursts instead of a smooth continuous stream. The NIC may be over-moderating acquisition interrupts to avoid over-loading the host CPU with interrupts. If priority is required for acquisition transfers (i.e. a more real-time system response to the detector transfer) then the moderation rate should be set to “maximum” by manually adjusting the NIC parameter.

In the end, this is a compromise:

1. Enable interrupt moderation to minimize CPU usage, at the expense of a slight increase in latency (**recommended**).
2. Disable interrupt moderation to favor responsiveness of real-time system with a drawback in CPU usage.

In most situations, extra latency introduced by interrupt moderation is very low and thus the gain on CPU performance becomes more beneficial.

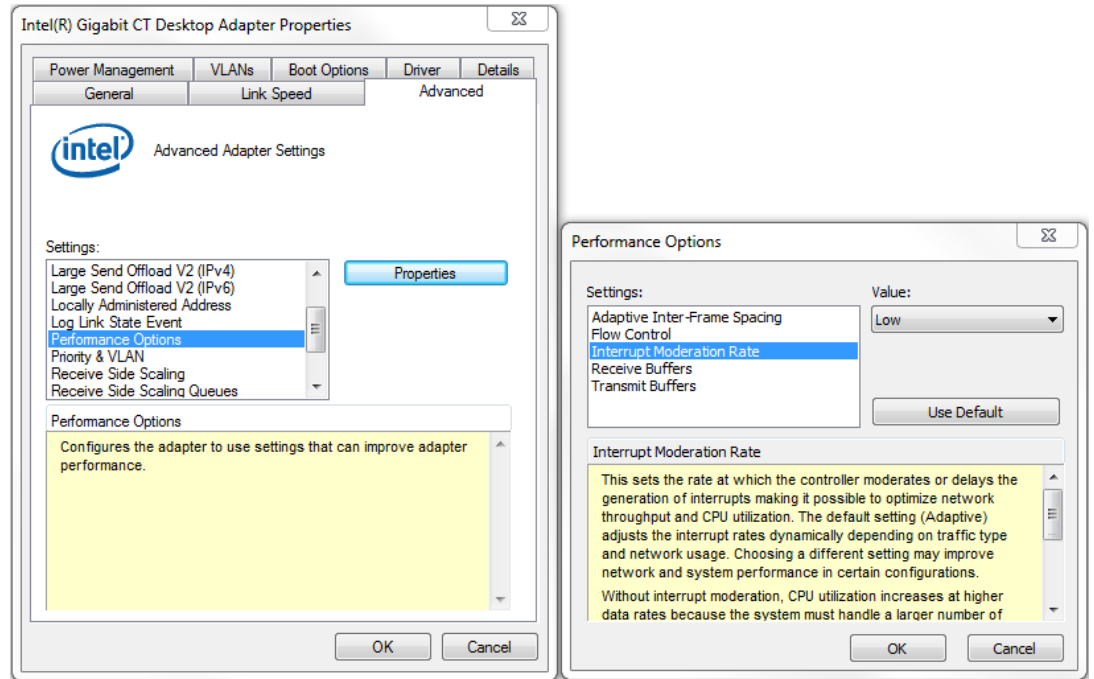


Receive Buffers

Under certain conditions the host PC system CPU may be busy with tasks other than the imaging application. Incoming image packets remain in the PC memory allocated to store packets instead of immediately being copied into the image buffer. By increasing the number of NIC (network interface card) receive buffers, more incoming image packets can be stored by the NIC before it must start discarding them. This provides more time for the PC to switch tasks and move image packets to the image buffer.

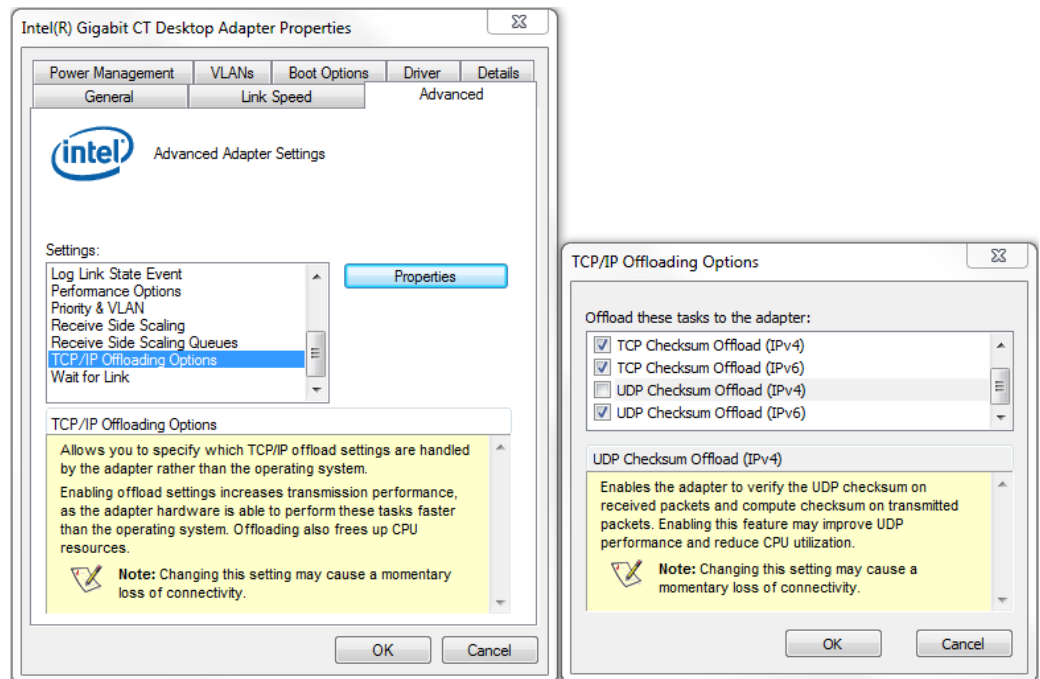
Not all network boards allow increases to their receive buffer count. Among those that do, different versions will have different maximum receive descriptor values.

We recommend **increasing the receive buffer size to the maximum permitted** by the network card, in order to provide more buffering capacity when needed.



UDP Checksum Offload (IPv4)

Disable UDP Checksum Offload (IPv4).



Flow Control

The GigE Vision standard defines an inter-packet delay that can be used to manage flow control (i.e. the speed at which stream packet can be output to the network). This is useful when connecting multiple detectors to the same port of the network card, or when the network card/Ethernet switch (if used) is simply too slow to process those packets. A careful selection of equipment will ensure that the network equipment is fast enough to handle data transmitted to the wire-speed of 1 Gigabit per second. Therefore, inter-packet delay is typically only used when multiple detectors are connected to the same port of the network card, through an Ethernet switch.

It is important to consider that inter-packet delay inserts a minimum delay between image packets to spread packet transmission over a longer period of time. This can directly impact system latency as more time than could be necessary is put in between those packets. The best approach for real-time imaging is to dedicate a different network port to each detector. This way, the inter-packet delay can be eliminated in many cases.

Some network equipment also supports the optional IEEE802.3 PAUSE mechanism. This is a low-level handshake to ensure the receiver of the packets is not overwhelmed by the amount of data. It can propagate a pause signal back to the transmitter, asking to momentarily stop the data transmission (with a possible impact on the overall system latency). Again, by combining network equipment that can operate at wire-speed and allocating a different network interface port for each detector in the system, we can ensure these pause requests will not be used.

Connecting

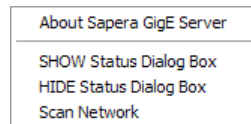
1. After the installation is complete, plug in the detector's communication cable.
2. Power up the detector.
3. After powering up the detector, the application automatically detects the detector. This may take 30 to 65 seconds. Wait until the detector connected indicator in the task bar (shown below) has confirmed that a connection has been established (the red cross over the camera icon disappears).



Checking detector status and information in Gigabit Ethernet

After the detector connection has been established, the status of the connection can be displayed by right clicking on the camera icon in the task bar and selecting "SHOW Status Dialog Box."

When you add or remove a detector from the network, it is automatically detected by the GigE server. A manual network scan can also be launched from this menu by selecting "Scan Network." This action will refresh the information of the device connected to the network. The "About Sapera GigE Server" option will display the version of the installed GigE driver.



Selecting the "SHOW Status Dialog Box" will open the device status window, which displays the basic information of the detector:

- Serial Number
- Model Name
- MAC Address
- Packet size, which should be 9000
- Firmware version which only indicates a build number
Refer to the "DeviceVersion" to see the actual firmware version (this can be seen in CamExpert)
- IP addresses of
 - o Detector
 - o Network Interface Card on host system to which the detector is connected

These settings can be changed by the Network Configuration which is included in the GigE Vision framework

The user can also view the detector and the host system IP addresses in this window.

Manufacturer	Model	Serial number	MAC address	Status	Camera IP	NIC IP	Filter driver	MaxPktSize	Firm ver	User name	ABI
Teledyne D...	2329	Change Me	00:11:22:33:44:55	Connected	169.254.4.168	169.254.83.83	Enable	9000	2	<Empty>	0001

The default assigned detector IP address and other network settings can be modified using the Teledyne DALSA Network Configuration Tool, which is part of the installation package.

The detector is default set to DHCP/LLA mode. This mode does not need any adjustment in the detector. However, as DHCP service is default not available on the detector network, this will cause some initialization delay during power on or reconnect of the detector. If initialization time is critical one may choose to enable Teledyne Dalsa DHCP Server on the NIC the detector is connected to or choose for Persistent IP on the detector. This will shorten the initialization time with approx. 15 sec. For further details please refer to Teledyne DALSA/Sapera Network Imaging Package/Network Imaging User's Manual.

Quick Test with CamExpert

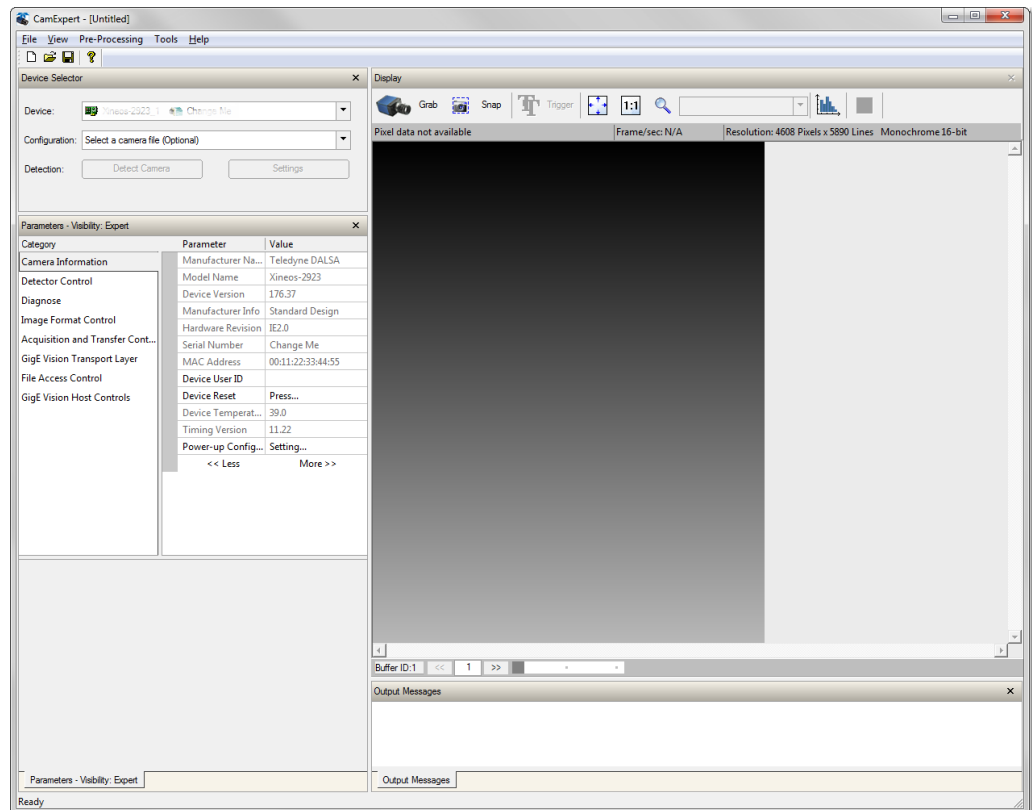
When a Rad-ikon detector is connected to a Gigabit network adapter on a host computer, testing the installation with CamExpert is a straightforward procedure.

- Start Sapera CamExpert by double clicking the desktop icon created during the Sapera LT software installation.
- CamExpert will search for installed Sapera devices. In the Device list area on the left side, the connected Rad-ikon detector is shown or will be listed in a few seconds after CamExpert completes the automatic device search (device discovery).
- Select the Rad-ikon detector device by clicking on the camera user defined name. By default the Rad-ikon detector is identified by its serial number.
- Click on the Grab button for live acquisition (the Rad-ikon detector factory default is Free Running mode).
- See "Operational Reference" for information on CamExpert parameters with the Rad-ikon detector.
- The Snap or Grab function of CamExpert can be used to acquire live image. By default this will be dark signal from the sensor from the parameters pane a digital test pattern can be selected for testing network/computer bandwidth issues.
- If error messages are shown in the Output Messages pane, first increase the value of the Interpacket Delay feature available from the GigE Vision TransportLayer Category group in CamExpert. An increase from default may correct errors with NIC interfaces that do not have adequate performance.
- Warning: If the detector is grabbing images, the ethernet cable to the detector should not be disconnected. When this is done by accident, the detector must be repowered before it becomes operational again after the ethernet has been reconnected.
- If error messages still remain, refer to the Teledyne DALSA Network Imaging package manual.

Acquiring Images

The CamExpert software can be started to acquire images. Select the correct device from the Device Selection Menu.

The software will display all available device parameters of the specific detector type.



The user has the option to either snap an image or to grab continuously. Snapping an image produces a single frame, whereas the grabbing process generates multiple frames by operating in a continuous mode.

To snap an image:

Click the *Snap* button. The Detector has now snapped a single frame. The image appears in the GUI window.

To grab continuously:

Click the *Grab* button. The detector is now armed and ready to acquire images in continuous mode.

To stop a *Grab* process the user must press the *Freeze* button. After the *Freeze* button is pressed the detector ignores any additional triggers and no additional images are acquired.

5



Operational reference

Using CamExpert with Rad-icon 2329 Detector

The Spera CamExpert tool is the interfacing tool for GigE Vision detectors and cameras, and is supported by the Spera library and hardware. When used with a Rad-icon detector, CamExpert allows a user to test most of the operating modes. Additionally CamExpert saves the Rad-icon user settings configuration to the detector or saves multiple configurations as individual detector parameter files on the host system (*.ccf).

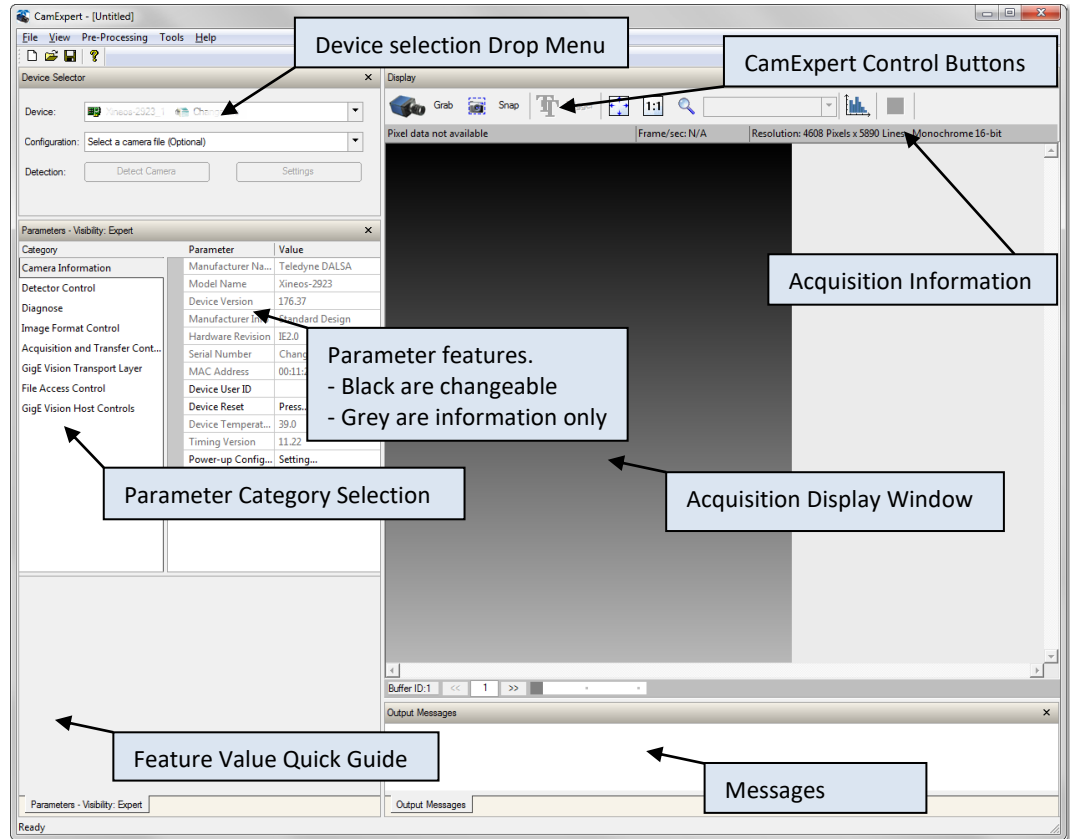
An important component of CamExpert is its live acquisition display window which allows immediate verification of timing or control parameters without the need to run a separate acquisition program.

Click on any parameter and a short description is displayed below the Category pane.

The same context sensitive help is available by clicking on the  button then click on a detector configuration parameter. Click on the  button to open the help file for more descriptive information on CamExpert.




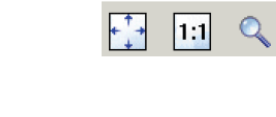

CamExpert Panes

The various areas of the CamExpert tool are described in the summary figure below. GigE Vision device Categories and Parameter features are displayed as per the device's XML description file. The number of parameters shown is dependent on the View mode selected (Beginner, Expert, Guru – see description below).



- **Device pane:** View and select from any installed GigE Vision or Sopera acquisition device. After a device is selected CamExpert will only present parameters applicable to that device.
- **Parameters pane:** Allows viewing or changing all acquisition parameters supported by the acquisition device. CamExpert displays parameters only if those parameters are supported by the installed device. This avoids confusion by eliminating parameter choices when they do not apply to the hardware in use.
- **Display pane:** Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.

- **Control Buttons:** The Display pane includes CamExpert control buttons. These are:

	<p>Acquisition control button: Click once to start live grab, click again to stop.</p>
	<p>Single frame grab: Click to acquire one frame from device.</p>
	<p>Software trigger button: With the I/O control parameters set to Trigger Enabled / Software Trigger type, click to send a single software trigger command.</p>
	<p>CamExpert display controls: (these do not modify the frame buffer data) Stretch (or shrink) image to fit, set image display to original size, or zoom the image to any size and ratio. Note that under certain combinations of image resolution, acquisition frame rate, and host computer speed, the CamExpert screen display may not update completely due to the host CPU running at near 100%. This does not affect the acquisition.</p>
	<p>Histogram / Profile tool: Select to view a histogram or line/column profile during live acquisition.</p>

- **Output pane:** Displays messages from CamExpert or the GigE Vision driver.

CamExpert View Parameters Option

All detector features have a Visibility attribute which defines its requirement or complexity. The states vary from Beginner features required for basic operation of the device) to Guru (optional features required only for complex operations).

CamExpert presents detector features based on their visibility attribute. CamExpert provides quick Visibility level selection (Beginner/Expert/Guru) via controls below each Category Parameter list [<< Less More >>].

The user can also choose the Visibility level (Beginner/Expert/Guru) from the View - Parameters Options menu.

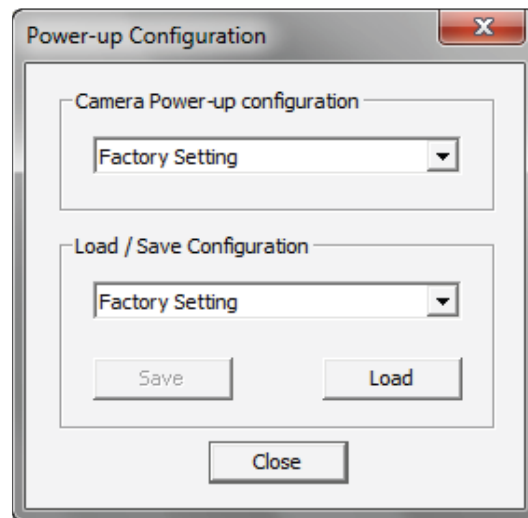
Camera Information

The following table describes the parameters Display Name as shown in CamExpert and their feature name, accessibility (RO=ReadOnly, RW=Read/Write, WO=WriteOnly) and description.

Display Name	Feature	Acc	Description
Manufacturer Name	DeviceVendorName	RO	Displays the device vendor name
ModelName	DeviceModelName	RO	Displays the device model name
Device Version	DeviceVersion	RO	Displays the device firmware version. This tag will also highlight if the firmware is a beta or custom design
Manufacturer Info		RO	Displays the type of the design
Hardware Revision	HardwareRevision	RO	Processing board hardware revision
Serial Number	DeviceID	RO	Displays the device's factory set camera serial number
MAC Address	deviceMacAddress	RO	Displays the unique MAC (Media Access Control) address
Device User ID	DeviceUserID	RW	Feature to store a user-programmable identifier of up to 15 characters. The default factory settings is empty
Device Reset	DeviceReset	WO	Resets the device to its power up state.
Device Temperature	Detector Temperature	RO	The temperature on the processing board in degrees Celcius
Timing Version	Sensor timing settings version	RO	Displays the sensor timing settings version on the detector
Power-up Configuration Selector	UserSetDefaultSelector	RW	Selects the camera configuration set to load and make active on camera power-up or reset. The camera configuration set is stored in camera non-volatile memory (RW)
<i>Factory Setting</i>	<i>FactorySetting</i>		<i>Load the factory default feature settings</i>
<i>UserSet1</i>	<i>UserSet1</i>		<i>Select the user defined configuration UserSet1 as the Power-up Configuration</i>
<i>UserSet2</i>	<i>UserSet2</i>		<i>Select the user defined configuration UserSet2 as the Power-up Configuration</i>
User Set Selector	UserSetSelector	RW	Selects the camera configuration set to load feature settings from or save current feature settings to. The Factory set contains default camera feature settings

<i>Factory Setting</i>	<i>FactorySetting</i>		Select the default camera feature settings saved by the factory
<i>UserSet1</i>	<i>UserSet1</i>		Select the User Defined Configuration space UserSet1 to save to or load from features settings previously saved by the user
<i>UserSet2</i>	<i>UserSet2</i>		Select the User Defined Configuration space UserSet2 to save to or load from features settings previously saved by the user
Load Configuration	UserSetLoad	WO	Loads the camera configuration set specified by the User Set Selector feature, to the camera and makes it active
Save Configuration	UserSetSave	WO	Saves the current camera configuration to the user set specified by the User Set Selector feature. The user sets are located on the camera in non-volatile memory

Camera Configuration Selection Dialog



CamExpert provides a dialog box which combines the features to select the detector power-up state and for the user to save or load a detector state from Rad-icon memory.

Camera (Detector) Power-up Configuration

The first drop list selects the detector configuration state to load on power-up (see feature UserSetDefaultSelector). The user chooses from one factory data set or one of two possible user saved states.

User Set Configuration

The second drop list allows the user to change the detector configuration anytime after a power-up (see feature UserSetSelector). To reset the detector to the factory configuration, select Factory Setting and click Load. To save a current detector configuration, select User Set 1 or 2 and click Save. Select a saved user set and click Load to restore a saved configuration.

Detector Control

The Rad-icon Detector controls, as shown by CamExpert, groups the detector specific parameters.

The features which are underlined link to the paragraph which describes these features in more detail.

Display Name	Feature	Acc	Description
Settings Revision	SettingsRevision	RO	Displays the current version of the power settings for driving the Sensor.
Standby	Standby	RW	Enables or Disables the Standby. A few seconds needed after coming out of the standby. Please consult Teledyne Dalsa for more details on image behavior after standby.
Linearity Equalizer	LinearityEqualizer	RW	Enables or Disables the linearization
Read out Mode	ReadOutMode	RW	Select the way the sensor is read out
<i>FullFOV 1x1</i>	<i>Full active pixel area</i>		<i>Full Field-of-View image (14-bit/pixel)</i>
<i>FullFOV 2x2</i>	<i>Binned full active area</i>		<i>Full Field-of-View image, 2x2 pixel binning (15-bit/pixel)</i>
<i>FullFOV 1x2</i>	<i>Vertical binned full active area</i>		<i>Full Field-of-View image, 2x vertical pixel binning (14-bit/pixel)</i>
Trigger Mode	Trigger Mode	RW	Controls by what source initiate and how the sensor is read out
<i>Free Running</i>	<i>FreeRunning</i>		<i>Detector uses internal timing</i>
<i>Triggered</i>	<i>ExtTrigger</i>		<i>Read out of sensor occurs on falling edge of trigger input</i>
<i>Snapshot</i>	<i>Snapshot</i>		<i>Sensor reset occurs on rising edge and sensor read out occurs on falling-edge of trigger input</i>
<i>Snapshot Extended Exposure</i>	<i>Timed Snapshot</i>		<i>Sensor reset occurs on rising edge of trigger and sensor read out occurs after extended exposure counter reaches its counter value</i>
<i>Triggered Sequence</i>	<i>Sequence of images</i>		<i>Sensor reset occurs on rising edge of trigger and then records a number of exposed frames and offset frames (trigger out is indicating the exposed frames).</i>
Software Trigger	Trigger activated by command		Sensor will start read out/reset depending on synchronization mode
Trigger out	Control of trigger output		When disabled trigger out is suppressed
Extended Exposure	ExtendedExposure	RW	Time (milliseconds) in between two successive read outs in Free Running Trigger Mode. Extended exposure setting should not be changed when the detector is making a transaction. 377ms, 188ms and 63ms should be used as minimum exposure time for FullFOV 1x1, FullFOV 1x2, FullFOV 2x2 modes subsequently when the summing mode is 1x1 Please contact us for more information.
Offset	Offset	RW	Sensor dark ADC offset level; based on full scale of sensor
<i>0%</i>	<i>Offset0pct</i>		<i>0</i>
<i>0.75%</i>	<i>Offset0pct75</i>		<i>0,75% of 16384 ADC full scale.</i>
<i>1.5%</i>	<i>Offset1pct5</i>		<i>1.5% of 16384 ADC full scale.</i>
<i>2.35%</i>	<i>Offset2pct35</i>		<i>2.35% of 16384 ADC full scale.</i>

Nr Exp Frames	The number of exposed frames.	RW	Controls the Trigger output. To be used with Trigger Mode "Triggered Sequence"
Nr Offset Frames	The number of offset frames	RW	This will output a sequence of offset images. After this number, the read out of the detector is stopped. Should be used with Trigger Mode "Triggered Sequence"
Summing Scheme	This register programs the summing scheme	RW	The summing scheme number indicates the summing algorithm for the output image. The left digit indicates the number of summed frames for the first output image and the right digit indicates the number of summed frames for the next output images. For instance 24: first two frames are summed for the first output image, after that 4 frames are summed per output image.

Changing Modes and Settings



Changing modes and settings via commands or CamExpert software should not be done when the detector is busy. There should be enough pause for the detector to process the last frame from the previous operation. The pause duration required could be up to 500ms during summing modes. Please consult Teledyne Dalsa for more details on read out and trigger mode changing on the fly.

First image after Standby or Switching Modes



Images acquired after a long period in standby mode or after switching trigger or read out modes might contain unwanted data from dark current accumulation or reset behavior. It is required to read and discard at least 2 images after such extended standby period.

Read out Modes

When the Trigger Mode is set to Free Running, the frame period can be calculated for all read out modes by adding the Extended Exposure with the read out time. The Extended Exposure value must be chosen high enough that the bandwidth of the GigE is below 100MByte/second.

Full Resolution

In Full Field-of-View, full resolution of the sensor is read out and streamed to the host system. A butting gap is injected in vertical direction in the image to indicate at what position the two separate sensors are butted to each other, the pixel value of this butting gap is 1. Refer to chapter "Mechanical Interface" for the exact location.

The table below indicates the pixel values in one line and where the butting gap is located (shaded) in the columns in different modes.

Pixel	0	1	2	3...	2302	2303	2304	2305	2306	2307	2308			
Value	A	B	C	D	1	1	M	0	N	O	P			

The position of the vertical and horizontal butting gap locations for different modes is shown in the table below. The first pixel position is defined as (0,0).

MODE	Image Resolution	Vertical Butting Gap Locations	Horizontal Butting Gap Location
FullFOV 1x1	4608 x 5890	2302, 2303	2944, 2945
FullFOV 2x2	2304 x 2945	1151	1472
FullFOV 1x2	4608 x 2945	2302, 2303	1472

Binning 2x2

The detector supports 2x2 pixel binning. The butting gap appears as a pixel with zero value.

Trigger Mode

Free Running Mode

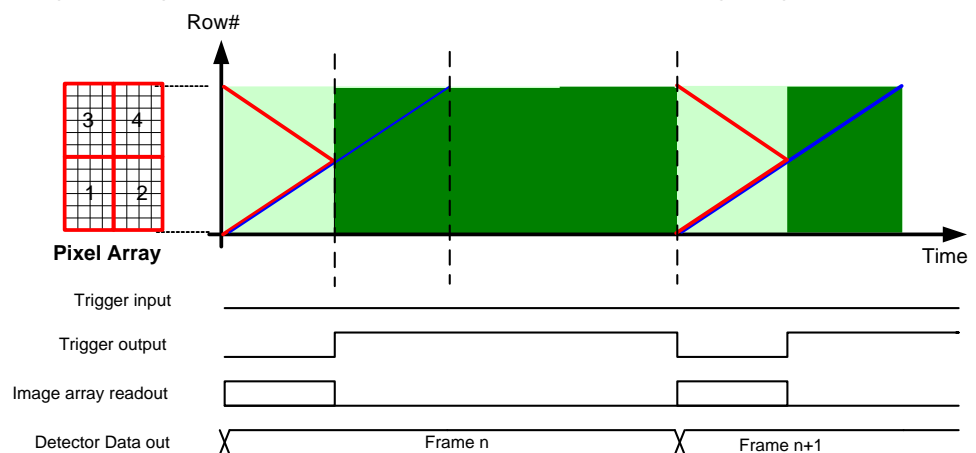
The detector is in Master mode. In this mode the detector will run continuously on internal timing, no trigger input is required to initiate a frame read out. The frame rate is determined by the time between successive frame read outs which can be set by the “Extended Exposure” feature.

The Extended Exposure value must be chosen high enough to comply with the bandwidth of the GigE which is around 100MByte/second.

The maximum frame rate is in Full FOV (1x1) mode 2 FPS. In Full FOV (2x2) mode the maximum frame rate is 8 FPS. In Full FOV (1x2) mode the maximum frame rate is 4 FPS.

The frame rate is depending on GigE Bandwidth.

The trigger output indicates the X-ray active time. When a grab is started, the next integration period will be acquired and send to the host system. If a grab is started but the sensor is still in the integration period, this frame will be dropped and the following frame will be send to the host system; this to avoid changes to the sensor during the integration period (which can happen before acquiring images).



Timing diagram in Free Running mode

The sensors are read simultaneously from top/bottom to centre. This read out method is called “butterfly read out”.

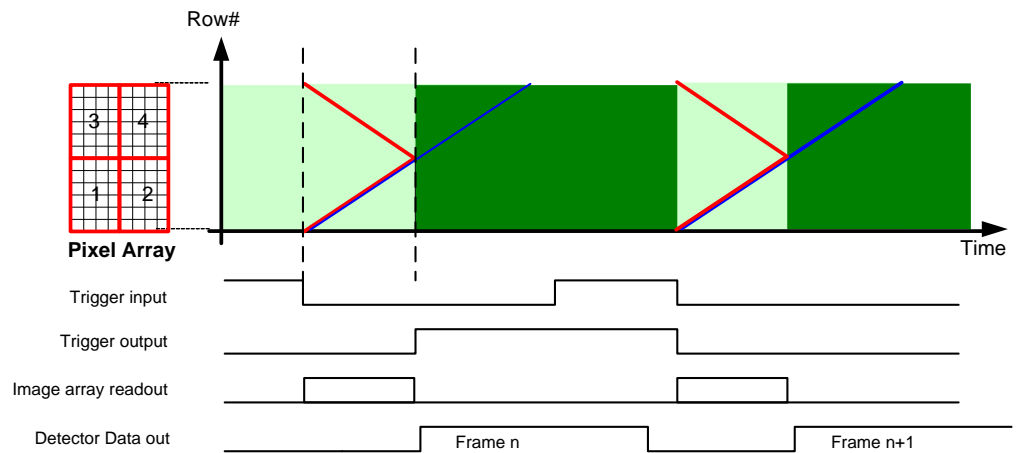
The read out time in full resolution is 125msec.

In 2x2 binning mode and 1x2 binning mode the read out time is reduced by a factor of 2, thus 62.5msec.

Triggered (External) mode

The detector is in Slave mode. In this mode the detector will take a single image (or multiple) at the moment a trigger signal is applied to the detector. This mode is equal to the Snapshot mode but no reset is needed before integration can start.

The trigger output indicates the Exposure Time when no read out of the sensor occurs.



Timing diagram in Triggered mode

Some notes about the external trigger mode.

Sensor array read out starts at falling edge of external trigger input. The duty cycle of external trigger is not critical.

When no external trigger signal is applied, the detector is accumulating dark signal. When an external trigger (sequence) is applied, it is recommended to discard the first image frame. Trigger pulse width $\geq 1\text{ms}$.

The trigger frequency is limited by the maximum frame rate.

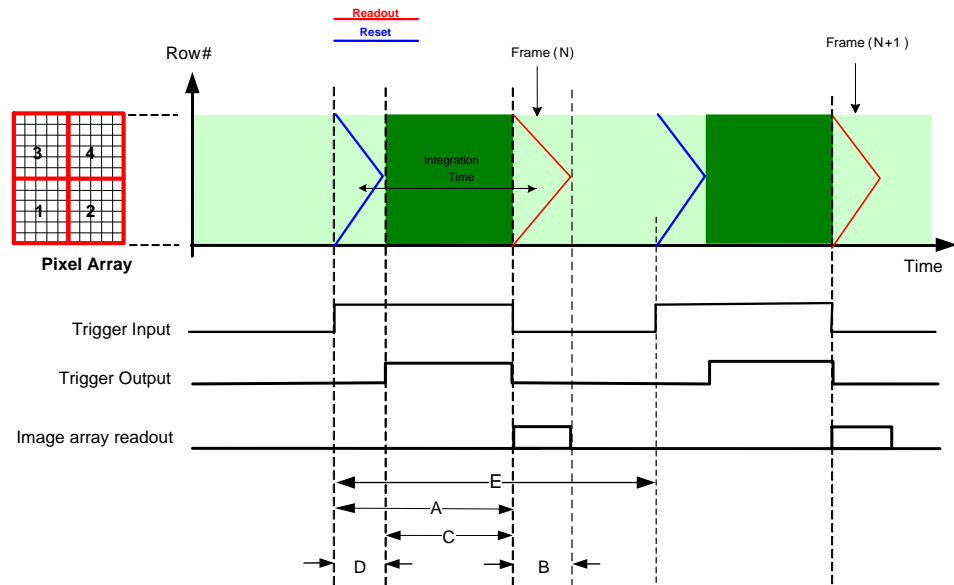
Snapshot mode

In this mode the detector will initiate a sensor reset at rising edge of the trigger input and succeeding to this it will read out the sensor at the falling edge.

The sensor reset is actually a normal read out of the sensor but the data is discarded.

The trigger output indicates the Exposure Time when no reset or read out of the sensor occurs.

To allow sufficient time for the sensor reset, the delay between rising edge of the trigger input and when the detector is exposed to x-ray should equal or higher to the reset or read out time (125ms) of the sensor.



		Full FOV 1x1	Full FOV 2x2	Full FOV 1x2
A	Trigger input active			
B	Detector read out	125ms	62.5ms	62.5ms
C	X-ray active	Trigger input - D	Trigger input - D	Trigger input - D
D	Dummy read (reset)	= B	= B	= B
E	Minimum period time	500ms	125ms	250ms

Timing diagram in Snapshot mode

Snapshot Extended Mode.

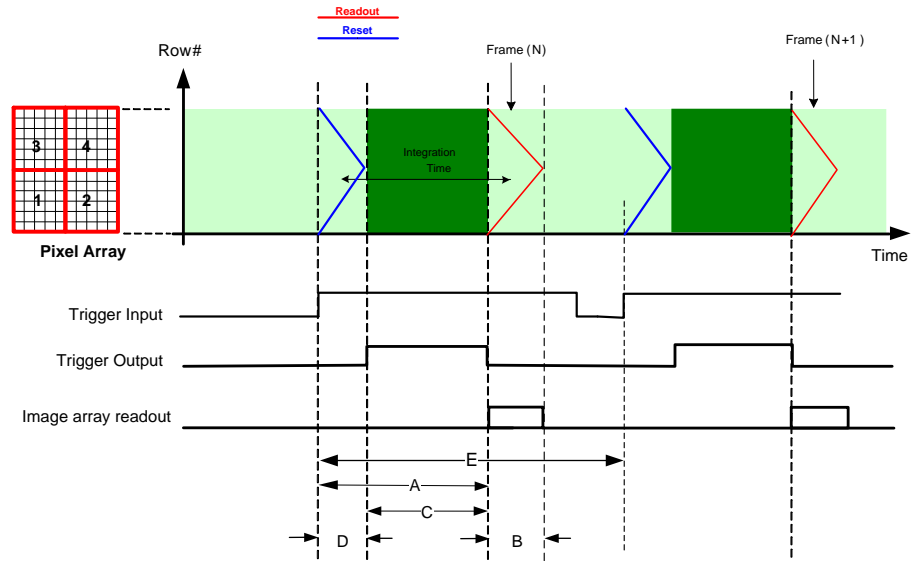
In snapshot mode an image is taken, including a reset before integration.

Before X-ray is active the detector is read out to clear the pixels.

The detector is in slave mode. At rising edge of the trigger input signal a dummy read (reset) is initiated. When the dummy read is finished, trigger out will be active.

The integration time is programmed by the Extended Exposure setting.

When the integration-timer is finished, trigger out will become inactive and the detector read out starts. See figure below.



		Full FOV 1x1	Full FOV 2x2	Full FOV 1x2
A	Trigger input active			
B	Detector read out	125ms	62.5ms	62.5ms
C	X-ray active	Extended Exposure setting	Extended Exposure setting	Extended Exposure setting
D	Dummy read (reset)	= B	= B	= B
E	Minimum period time	500ms	125ms	250ms

Timing diagram in Snapshot Extended mode

Offset images can be acquired by putting the detector in to free running mode with the same Extended Exposure settings.

Summing process

In FullFOV 1x1 and FullFOV 2x1 mode the summing scheme is maximal 4.

This means after 4 frames are summed one output image is streamed out. Original data is 14 bits from the detector. After summing the result will be 16 bit.

In FullFOV 2x2 the summing scheme is maximum 2.

This means after 2 frames are summed one output image is streamed out. Original data is 15 bits (in binning mode) from the detector. After summing the result will be 16 bit.

Frame rates

In **FullFOV 1x1** mode the maximum frame rate is 2 FPS. User should take care that this frame rate is not exceeded. When the frame rate is exceeded, frames will be lost or result in an incorrect image.

To reach 2 FPS at:

4 frames summing: the internal frame rate is 8 FPS (125 msec). The detector read out time takes 123 msec. The extended exposure time setting must be set to 2 msec.

3 frames summing: the internal frame rate is 6 FPS (166 msec). The detector read out time takes 123 msec. The extended exposure time setting must be set to 43 msec.

2 frames summing: the internal frame rate is 4 FPS (250 msec). The detector read out time takes 123 msec. The extended exposure time setting must be set to 127 msec.

1 frame: the internal frame rate is 2FPS (500 msec). The detector read out time takes 123 msec. The extended exposure time setting must be set to 377 msec.

In **FullFOV 1x2** mode the maximum frame rate is 4 FPS. User should take care that this framerate is not exceeded. When the frame rate is exceeded, frames will be lost or result in an incorrect image.

To reach 4 FPS at:

4 frames summing: the internal frame rate is 16 FPS (62.5 msec). The detector read out time takes 61 msec. The extended exposure time setting must be set to 1 msec.

3 frames summing: the internal frame rate is 12 FPS (83 msec). The detector read out time takes 61.5 msec. The extended exposure time setting must be set to 22 msec.

2 frames summing: the internal frame rate is 8 FPS (125 msec). The detector read out time takes 61.5 msec. The extended exposure time setting must be set to 63 msec.

1 frame: the internal detector frame rate is 4 FPS (250 msec). The detector read out time takes 61.5 msec. The extended exposure time setting must be set to 188 msec.

In **FullFOV 2x2** mode the maximum frame rate is 8 FPS. User should take care that this frame rate is not exceeded. When the frame rate is exceeded, frames will be lost or result in an incorrect image.

To reach 8 FPS at:

2 frames summing: the internal frame rate is 16 FPS (62.5 msec). The detector read out time takes 61.5 msec. The extended exposure time setting must be set to 1msec.

1 frame: the internal frame rate is 8 FPS (125 msec). The detector read out time takes 61.5 msec. The extended exposure time setting must be set to 63 msec.

Image Format Control

The Rad-ikon Image Format controls, as shown by CamExpert, groups parameters that give information about the resolution and pixel format.

Display Name	Feature	Acc	Description
PixelFormat	PixelFormat	RO	Format of the pixel provided by the device. Contains all information as provided by PixelCoding and PixelSize combined in one single value
<i>Monochrome 16-Bit</i>	<i>Mono16</i>		<i>16 bit packed on 2 bytes (no image data loss)</i>
Pixel Size	PixelSize	RO	Total Size in bits of an image pixel

<i>Mono</i>	<i>Mono</i>		<i>Pixel is monochrome</i>
Width	Width	RO	Width of the image provided by the device (in pixels)
Height	Height	RO	Height of the image provided by the device (in pixels)

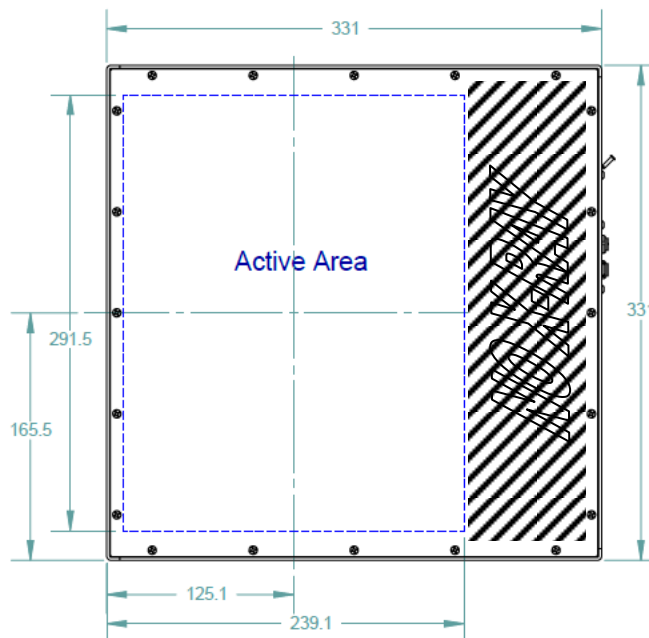
X-Ray Beam Collimation



WARNING: Rad-icon 2329 X-ray detectors require appropriate X-ray beam collimation. This is necessary to avoid the incidence of X-rays, either scattered or direct, on areas of the detector outside the scintillator + FOP stack. Inadequate collimation can lead to damaging the detector when X-rays hit sensitive detector electronics.

Although the sensor assembly of the Rad-icon 2329 detector is a fully closed housing, the incident X-ray beam needs to be collimated just above the sensor in such a way that only the active area of the detector as depicted in the figure below incident to the x-ray beam.

The material used for the collimator needs to be X-ray opaque, meaning it should completely absorb all energies of the X-ray beam. X-ray collimators are typically constructed of highly absorbing dense metals such as copper, tungsten or lead.



Position of the active area of the detector

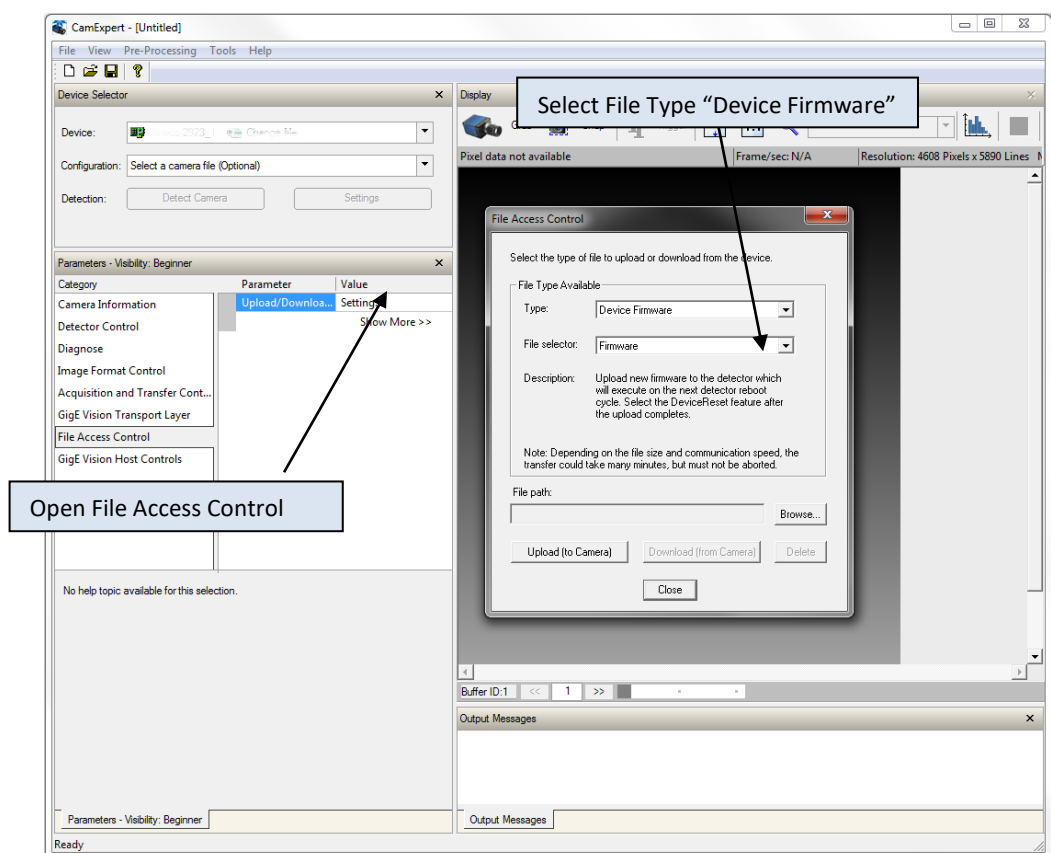
File Access Control

Uploading Firmware

Through the file access control firmware update can be performed. Use the browse button to select a firmware file which has the extension CBF. The filename has the following format:

- MAJORFWVER_ MINORFWVER_MODELNAME

The major firmware version (MAJORFWVER) and MODELNAME should be identical as the detector.



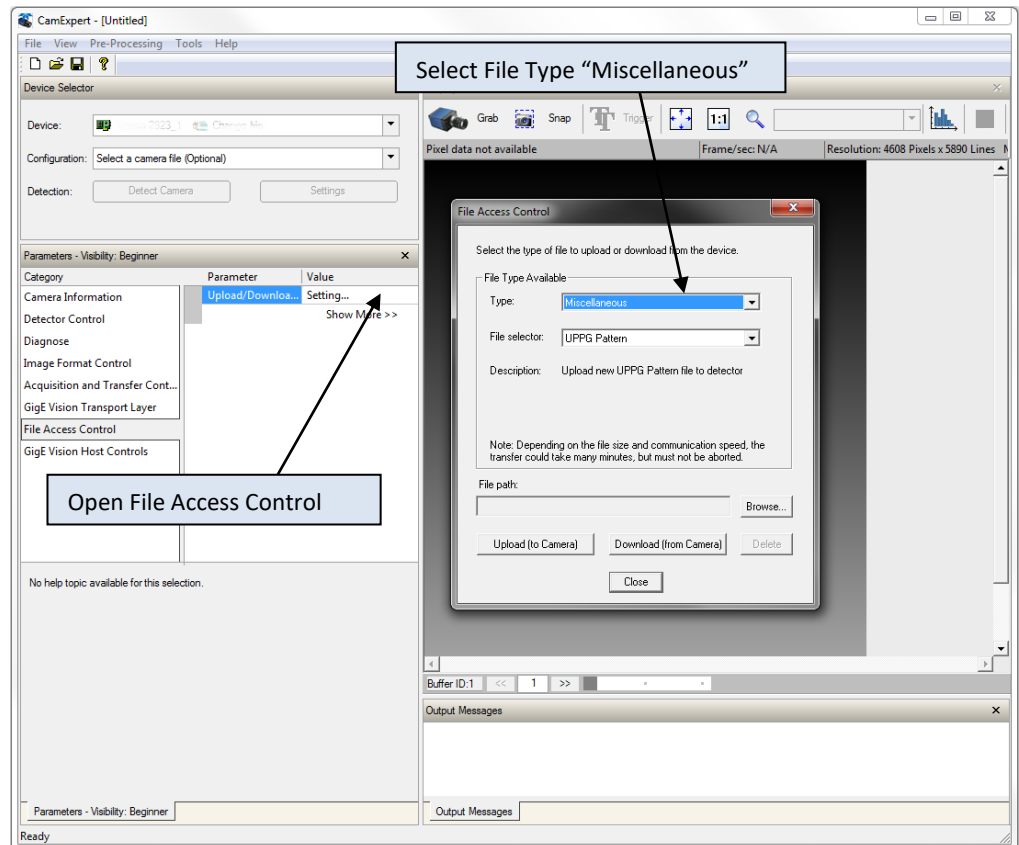
After uploading the file to the detector, CamExpert will request for a restart of the detector which is required to reboot with the new firmware.

Uploading Sensor Timing Settings

In order to update the sensor timing settings, a binary file called UPPG Pattern can be uploaded to the camera through file access feature as shown in the screenshot below.

For the correct UPPG pattern file contact us. Be sure to upload the correct “pattern.bin” file to the detector.

Uploading corrupt, changed and/or renamed files to the detector might result in a non-functional detector.



After uploading the new UPPG pattern file to the detector, a restart of the detector is required.

Shuttering

The detector does not have a shuttering mechanism built into the detector. The detector can be operated with a continuous beam X-ray source, however there can be motion blur associated with continuous beam imaging. If pulsed X-ray operation is required, the X-ray source should not be active during read out. This might cause unwanted imaging artifacts.

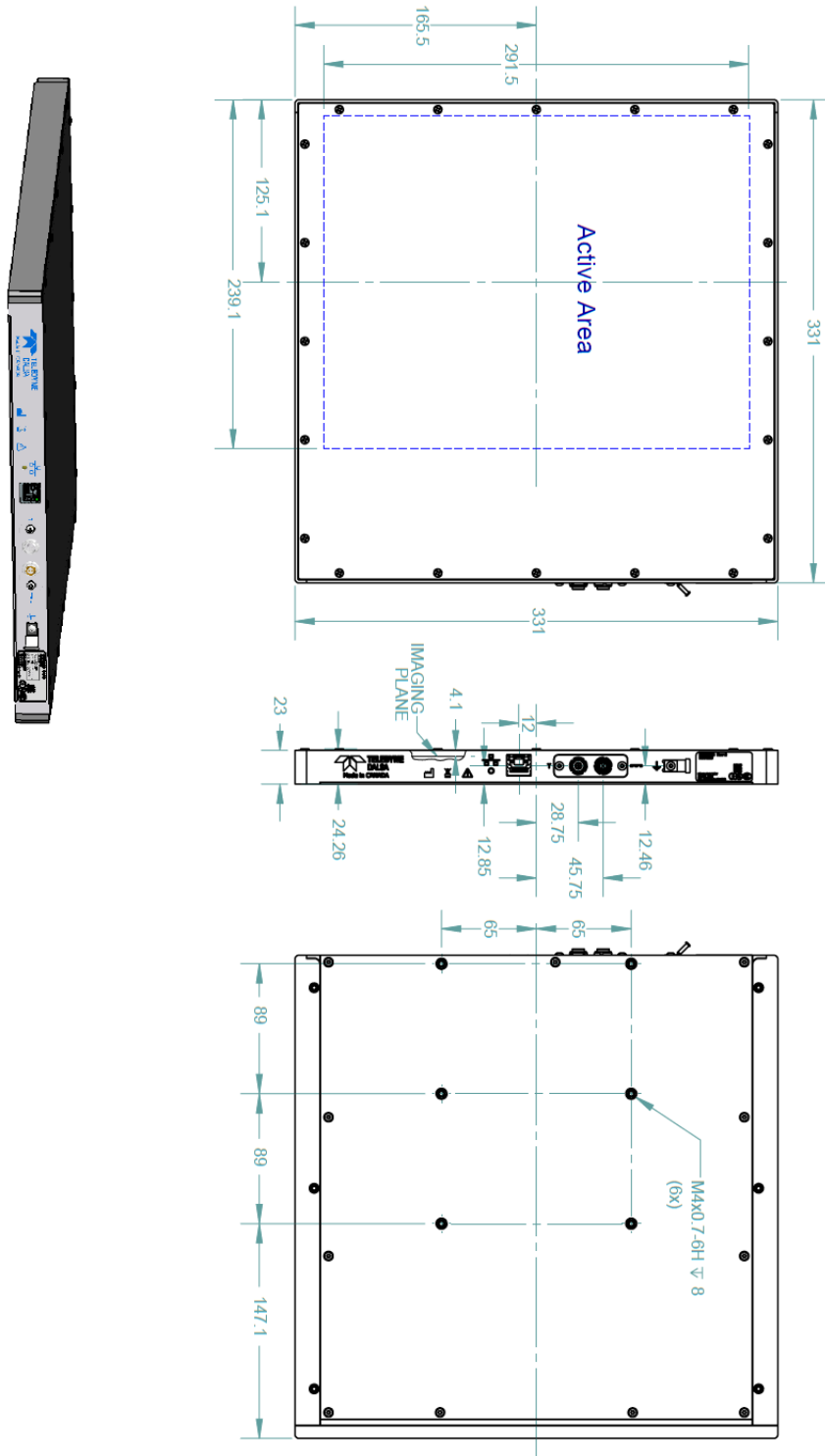
Dark Current after Standby

A first image acquired after long time in standby mode might contain unwanted signal. It is recommended to read and discard at least 2 images captured after standby.

6

Mechanical Interface

Mechanical Dimensions:



Appendix A

Revision History

Revision Number	Change Description	Revision Date
01	First release	2018-11-20