# Teledyne DALSA
# Rad-icon 1520

## Detector User Manual

## GigE models

October 3, 2014
www.TeledyneDALSA.com

TELEDYNE DALSA
Everywhereyoulook™

## About Teledyne DALSA

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

Please feel free to contact the global Teledyne DALSA sales office for ordering, to obtain more detailed information or in case you encounter any problem operating the detector:

**Teledyne DALSA – Rad-icon Imaging**
3400 Garrett Drive
Santa Clara, CA 95054
USA
Tel: +1 408 736 6000
Fax: +1 408 736 6001
E-mail: sales.rad-icon@teledynedalsa.com
Website: http://www.teledynedalsa.com/ndt

# Contents

# 1

# System Precautions and Safety

## 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.

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 or Patients.**

The system has been designed to minimize the amount of interference it may generate in a medical 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, CsI 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 1520 Detector.

### 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.

### 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<br>- Operating<br>- Transport & Storage | <br>+10..+50 °C<br>-10..+55 °C |
| Humidity (non-condensing)<br>- Operating<br>- Transport & Storage | <br>10%..80%<br>10%..80% |
| Shock | 25G (6ms) |
| Vibration | 1G (10-150Hz) |
| IP Class | IP40 |

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, or whenever 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 pixel calibration map at least once 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, flatfield reference, saturation dose and MTF performance.

# 2

# The Rad-icon Detector

A full description of the features and functional specification of the Rad-icon 1520 detector can be found in the latest product specification or datasheet. Please contact sales.rad-icon@TeledyneDALSA.com or visit www.TeledyneDALSA.com/ndt/ 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
- Unmatched image quality at low doses, best-in-class DQE at all doses
- 1548 x 2064 pixel resolution, 99 um pixel pitch, active area 153 mm x 204 mm
- 14-bit A/D conversion
- No measureable image lag
- Up to 16.4 frames per second at full resolution, 14 bit pixel depth
- GigE data interface
- Gadox scintillator

### Programmability

- Exposure time
- Read-out mode
- Trigger modes

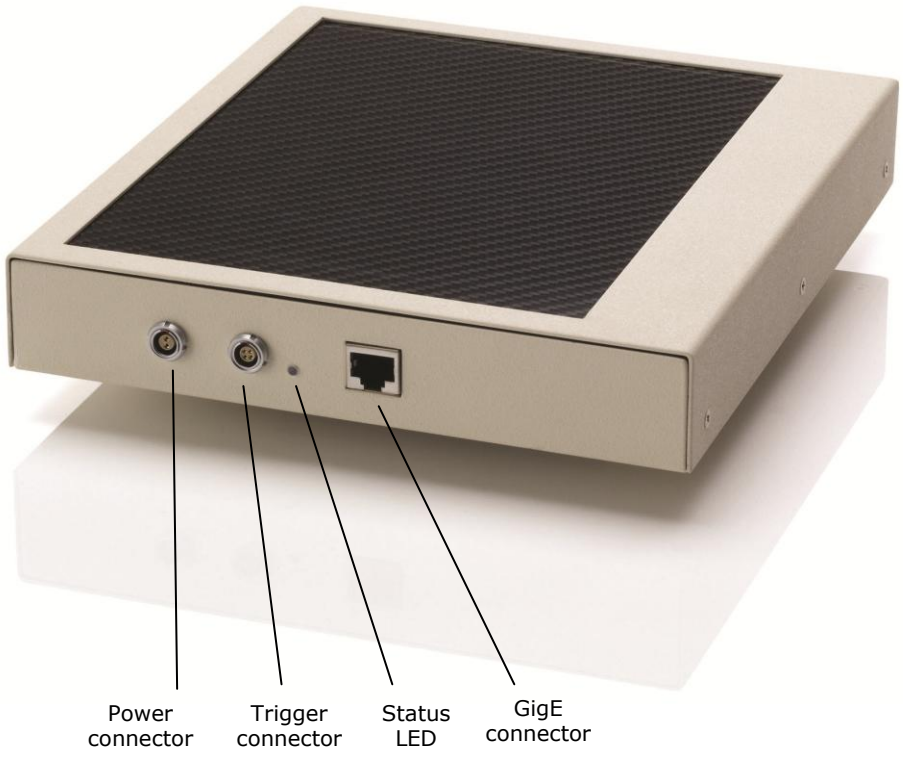
# 3

# 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 Ethernet cable
- One 2-pin Lemo connector for power
    - Lemo EXG.0B.302.HLN
    - Mating connector:
        straight type: FGG.0B.302.CLAD52
- One 4-pin Lemo connector for triggering
    - Lemo EXG.0B.304.HLN
    - Mating connectors:
        straight type: FGG.0B.304.CLAD52



# Ethernet Connector

### Ethernet Connection LED

Steady orange indicates that an Ethernet connection is successfully established.

### Data Transmission LED

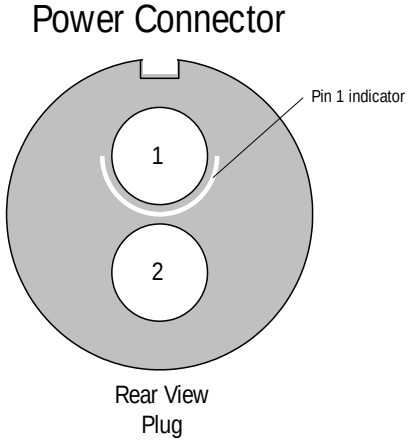
Flashing green indicates that the detector is transmitting or receiving data.

# 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 (+10-27V / 10W) |
| 2 | Ground |
| | Shielding (chassis) |

The detector requires a single voltage input (+10-27V / 10W). 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).

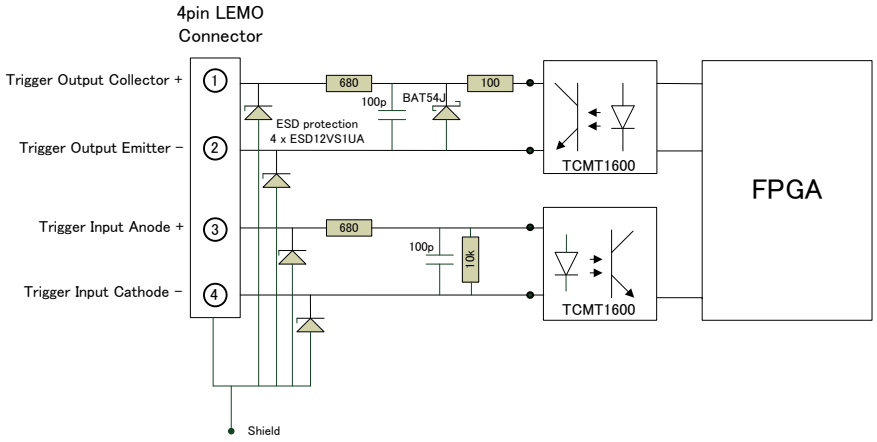
WARNING: When setting up the detector power supplies follow these guidelines:

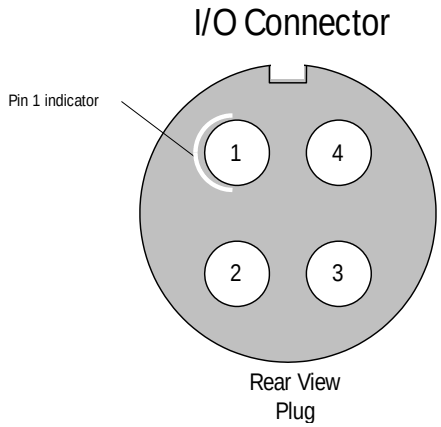
- Apply the appropriate voltages.
- Keep leads as short as possible in order to reduce voltage drop. The voltage level at the product power connector should be within the range mentioned in the datasheet.
- Use high-quality linear supplies of SELV type and/or EN 60601-1 compliant.

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 series resistor (note 1) |
| 2 | Out | optocoupler emitter |
| 3 | In | optocoupler anode with 680R 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.

# Setting up the Detector

## Network Interface Card

A Network Interface Card (NIC) is required to acquire images and control the Rad-icon 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 a 64-bit operating systems as the NIC driver are better maintained.

Due to the high bandwidth used by the detector we strongly advise 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 Trigger or Snapshot.

## Connect Ethernet Cable

Connect the CAT-6 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 10-27V and capable of delivery 10W.

## 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 approximately 30 to 60 seconds.

# Software installation

## Operating Systems Support

The current released GigE Vision framework supports up to Windows 7.

For Windows 8.0 a Beta framework is available.
Windows 8.1 is currently not supported.

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

For Windows 8 and Linux support please contact our support team for the software and the latest status.

## Obtain software

**Website**

Visit the Rad-icon product page to download the latest documentation and software for your specific operating system.

**FTP-server**

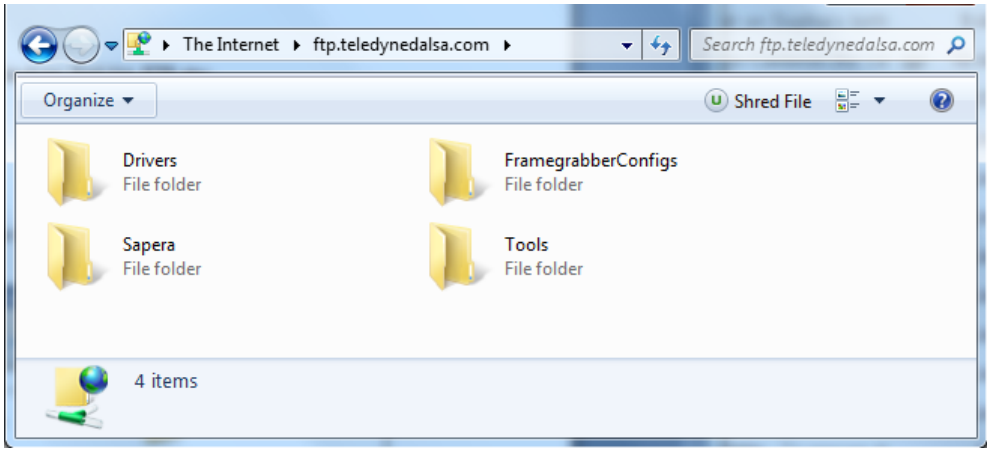
The software required for the Rad-icon detector is available at the following ftp-server:

ftp.teledynedalsa.com

username: xineosuser

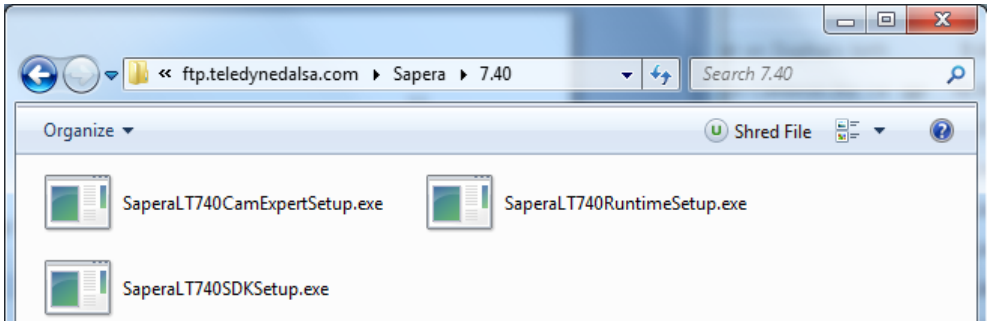
password: xray03

If you log in correctly you should see the following:



# Sapera LT and CamExpert Installation

Open the *Sapera* folder, and then open the folder with the latest version (e.g. *7.40*):




If you are evaluating the Product, you should download and run the installation file "SaperaLT7xxCamExpertSetup.exe". This will install a free copy of CamExpert.

If you are evaluating and developing your own software for the Product you should download "SaperaLT7xxSDKSetup.exe". This will install a 60-day evaluation copy of the Sapera LT SDK, including CamExpert. Purchase of a license is required to continue using the Sapera LT SDK beyond the 60-day free trial period.

CamExpert is evaluation software. The Sapera 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.

# GigE Vision framework for Sapera LT installation

Download and install the latest GigE Vision driver located in the *Drivers* folder. The GigE Vision framework installs the GigE Vision Module for Sapera and includes the Network Imaging package which is required to access a GigE Vision detector.

Refer to the "GigE Vision Module for Sapera" user manual and "Network Imaging Module for Sapera LT" user manual which are included in the installation.

# Optimizing Settings

**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.

**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.

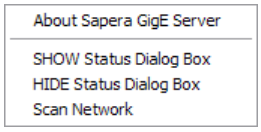
# Connecting

1. After the install is complete, plug in the detectors communication cable.
2. Power up the detector.
3. After powering up the detector, the application automatically detects the detector. This may take 30 to 60 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.

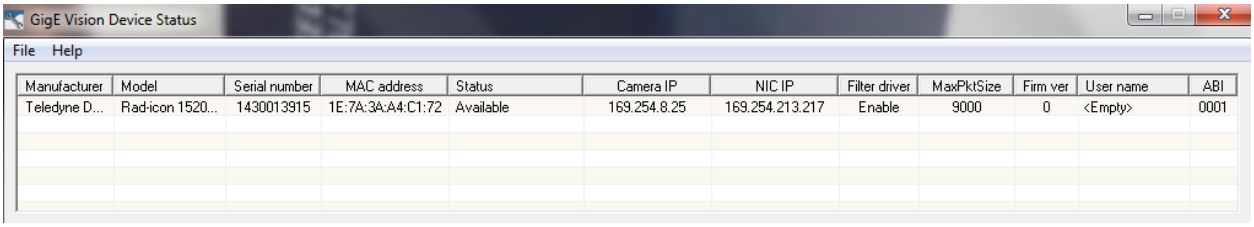



Selecting the "*SHOW Status Dialog Box*" will open the device status window, which displays the basic information of the detector

- Serial Number
- Model Name
- MAC Address
- Packet size, which should be 9000
- Firmware version (build number)
- IP addresses of
    - Detector

- Network Interface Card on host system to which the detector is connected

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




# Quick Test with CamExpert

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

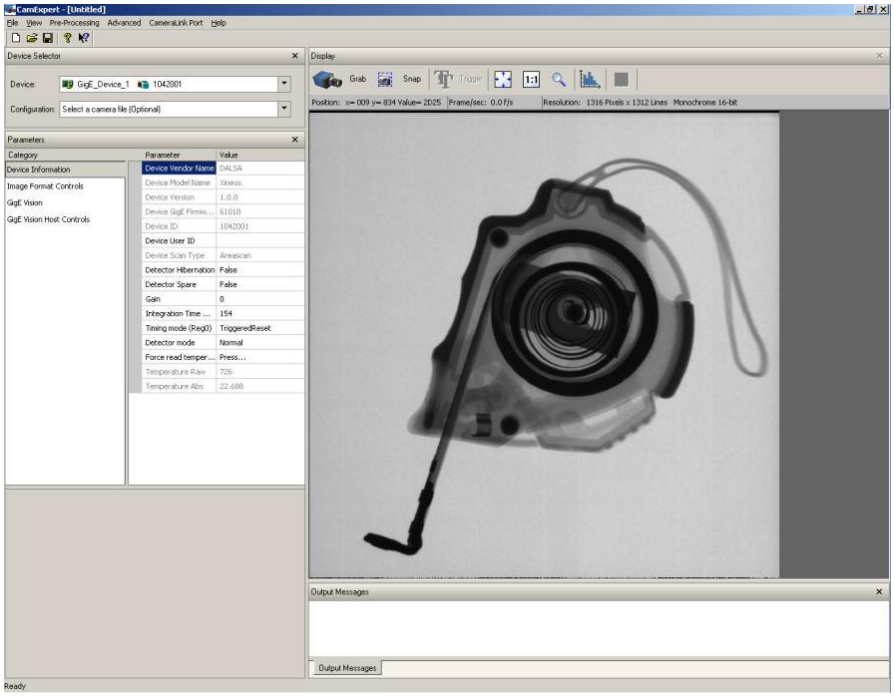
- Start Sapera CamExpert by double clicking the desktop icon created during the Sapera LT software installation.
- CamExpert will search for installed Sapera devices. In the Device list area on the left side, the connected detector is shown or will be listed in a few seconds after CamExpert completes the automatic device search (device discovery).
- Select the Rad-icon detector device by clicking on the camera user defined name. By default the Rad-icon detector is identified by its serial number.
- Click on the Grab button for live acquisition (the Rad-icon detector factory default is Free Running mode).
- See "Operational Reference" for information on CamExpert parameters with the Rad-icon 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.
- Refer to the Teledyne DALSA Network Imaging package manual if error messages are shown in the Output Messages pane. But 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.

# 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 detector.




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.

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# Operational reference

## Using CamExpert with the Rad-icon Detector

The Sapera CamExpert tool is the interfacing tool for GigE Vision detectors and cameras, and is supported by the Sapera 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).

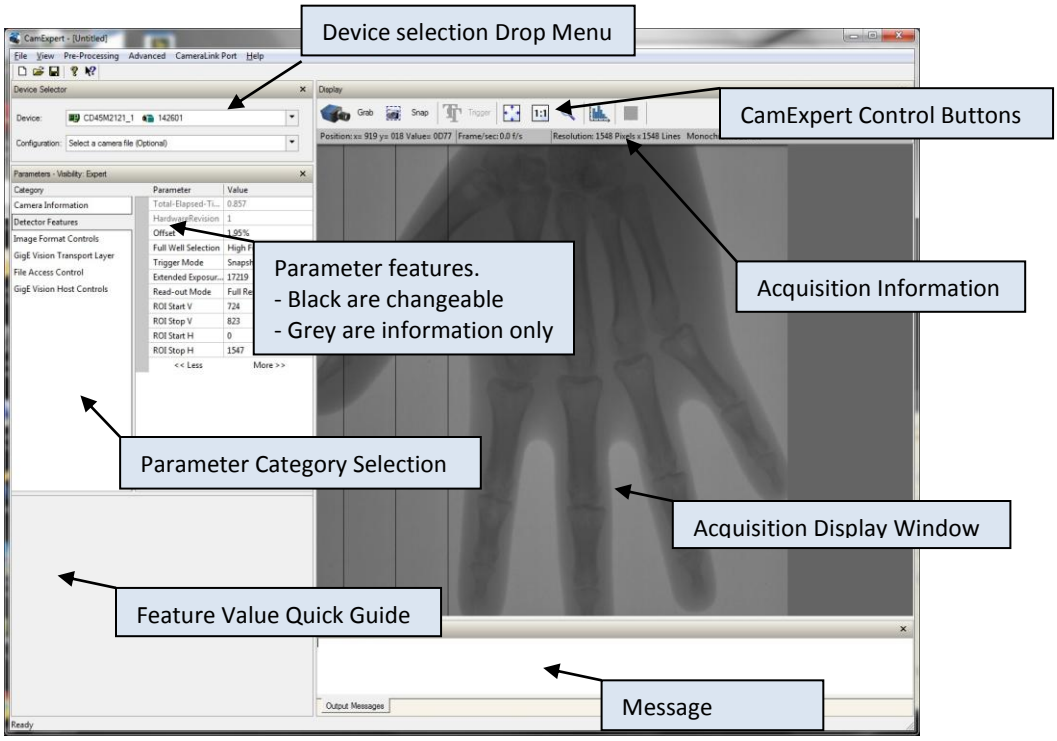
An important component of CamExpert is its live acquisition display window which allows immediate verification of timing or control parameters without the need to run a separate acquisition program.

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.

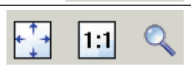
**CamExpert Panes**

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 Sapera 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:

| | |
|---|---|
|   | **Acquisition control button:**<br>Click once to start live grab, click again to stop. |
|   | **Single frame grab:**<br>Click to acquire one frame from device. |
|   | **Software trigger button:**<br>With the I/O control parameters set to Trigger Enabled / Software Trigger type, click to send a single software trigger command. |
|   | **CamExpert display controls:**<br>(these do not modify the frame buffer data)<br>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. |
|  | **Histogram / Profile tool:**<br>Select to view a histogram or line/column profile during live acquisition. |

- **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.

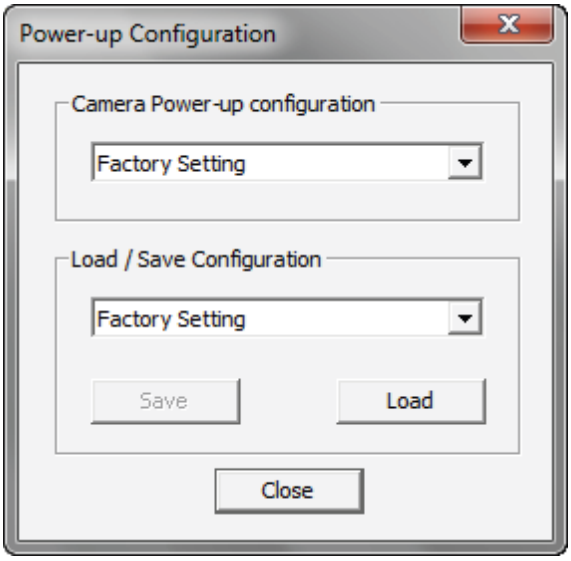
# Camera Information

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. |
| Device Product ID and Build number | DeviceProductIDBuild | RO | Provides the hardware Product ID and software Build Number |
| 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. |
| 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 are stored in camera non-volatile memory. (RW) |
| *Factory Setting* | *FactorySetting* | | *Load factory default feature settings.* |
| *UserSet1* | *UserSet1* | | *Select the user defined configuration UserSet 1 as the Power-up Configuration.* |
| *UserSet2* | *UserSet2* | | *Select the user defined configuration UserSet 2 as the Power-up Configuration.* |

| Display Name | Feature | Acc | Description |
|---|---|---|---|
| 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. |
| *Factory Setting* | *FactorySetting* | | *Select the default camera feature settings saved by the factory.* |
| *UserSet1* | *UserSet1* | | *Select the User Defined Configuration space UserSet1 to save to or load from features settings previously saved by the user.* |
| *UserSet2* | *UserSet2* | | *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 |
| Temperature | DeviceTemperature | RO | The temperature on the processing board in degrees Celcius |

# 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 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.

Note: A firmware reboot (power cycling) may be required after resetting the user set configuration to the Factory Setting.

# 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 |
|---|---|---|---|
| Read-Out Mode | ReadOutMode | RW | Select the way the sensor is read-out |
| *Full Resolution* | *FullResolution* | | *Read the full array of the image sensor* |
| *Binning 2x2* | *Binning* | | *Bins in sensor vertically and digital in FPGA for horizontally direction* |
| *Region of Interest* | *ROI* | | *Select a region in the full image array* |
| Trigger Mode | Trigger Mode | RW | Controls by what source initiate and how the sensor read-out |
| *Free Running* | *FreeRunning* | | *Detector uses internal timing* |
| *Triggered* | *ExtTrigger* | | *Read-out of sensor occurs on falling-edge of trigger input* |
| *Snapshot* | *Snapshot* | | *Sensor reset occurs on rising edge and sensor read-out occurs on falling-edge of trigger input* |
| Extended Exposure (us) | ExtendedExposure | RW | Time in microseconds between two successive read-outs in FreeRunning Trigger Mode |
| Offset | Offset | RW | Sensor dark ADC offset level; based on full scale of sensor |
| *0%* | *Offset0pct* | | *0* |
| *1.95%* | *Offset1pct95* | | *1,95% of 16384* |
| *3.9%* | *Offset3pct9* | | *3.9% of 16384* |
| *6.25%* | *Offset6pct25* | | *6.25% of 16384* |
| Full Well Selection | FullWell | RW | Selects the full well of the pixels in the sensor array |
| ~~*High Full Well*~~ | ~~*HighFullWell*~~ | | ~~*Large full well capacitor (future models)*~~ |
| *Low Full Well* | *LowFullWell* | | *Small full well capacitor (default)* |
| ROI Start V | ROIStartV | RW | Vertical start position for ROI mode; min 0, max 1516, multiple of 2 |
| ROI Stop V | ROIStopV | RW | Vertical stop position for ROI mode; min 31, max 1547, multiple of 2 |
| ROI Start H | ROIStartH | RW | Horizontal start position for ROI mode; min 0, max 1516, multiple of 4 |
| ROI Stop H | ROIStopH | RW | Horizontal stop position for ROI mode; min 31, max 1547, multiple of 4 |

# Read-Out Mode

When the TriggerMode is set to FreeRunning the frame period can be calculated for all Read-Out Modes by adding the Extended Exposure to the frame read-out time. The Extended Exposure value must be chosen high enough that the throughput bandwidth of the GigE link is below 100MByte/second.

**Full Resolution**

In this Read-Out Mode the 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 0.

Due to the injection of the butting gap in the image the number of pixels is 2065 pixels. However the GigE Vision interface requires a multiple of 4 pixels, for this reason the last column (2064) is discarded.

The table below indicates the pixels in one line and where the butting gap is located (pixel 1032) and that the last pixel is discarded:

| | Pixel | 0 | 1 | 2 | 3 | | 1030 | 1031 | ***1032*** | 1033 | 1034 | 1035 | | 2062 | 2063 | 2064 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full Resolution** | Value | A | B | C | D | | L | M | ***0*** | N | O | P | | X | Y | Z |

The minimum frame period of a full-resolution frame is 61 milliseconds. Note that the minimum "Extended Exposure" setting for full resolution mode is 21000.

**Binning 2x2**

The detector supports 2x2 pixel binning.

The butting gap appears as the mean value of an actual pixel value and the pixel value of the butting gap (0). The resolution in 2x2 binning mode is 1032 pixels by 774 lines.

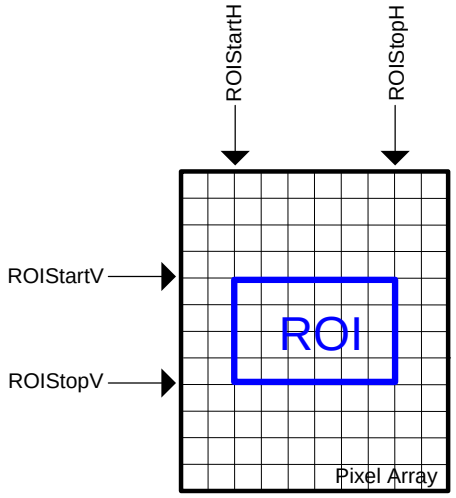
The table below indicates the pixels in one line, and how butting gap pixel is binned:

| | Pixel | 0 | 1 | | 515 | 516 | 517 | | 1031 |
|---|---|---|---|---|---|---|---|---|---|
| **Binning** | Value | (A+B)/2 | (C+D)/2 | | (L+M)/2 | N/2 | (O+P)/2 | | (X+Y)/2 |

The minimum frame period of a 2x2 binned frame is 30 milliseconds. Note that the minimum "Extended Exposure" setting for 2x2 binned mode is 12500.

**Region of Interest**

With Region of Interest (ROI) a region in the pixel array can be selected to read-out from the pixel array from the sensor and transferred to the host system as shown in the figure below.




Selecting fewer lines in vertical direction gives the possibility to increase the frame rate as fewer lines need to be read out from the pixel array.

Selecting fewer pixels in horizontal direction does not increase the frame rate from the image sensor but can be helpful if the bandwidth of GigE is limiting the frame rate.

Due to sensor architecture and restrictions of the GigE Vision interface the following requirements apply:

- ROIStartV must be multiple 2 with a maximum value of 1516
- ROIStopV must be multiple 2 with a minimum of 31
- ROIStartH must be multiple 4 with a maximum value of 2032
- ROIStopH must be multiple 4 with a minimum of 31

# Trigger Mode

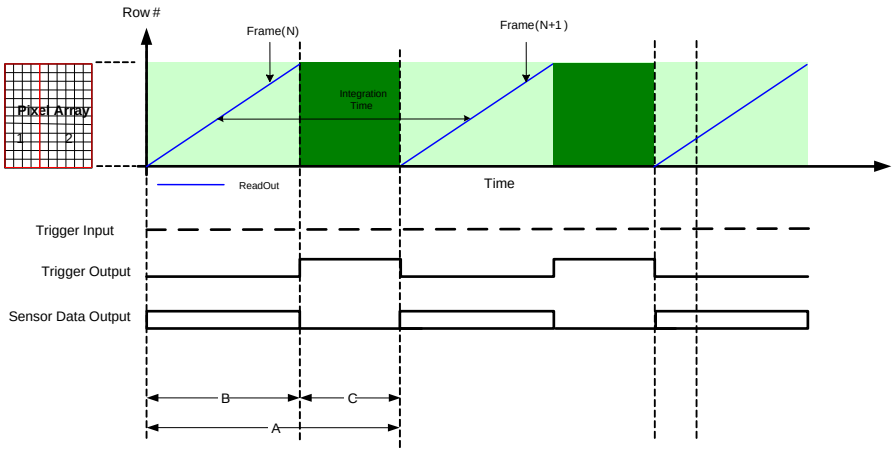
**FreeRunning Mode**

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 that the bandwidth of the GigE is below 100MByte/second.

In FreeRunning mode the sensor will integrate and read-out continuously even when the host does not acquire any images. However the trigger output is suppressed when no images are acquired, this is useful to see at what moment an integration period will be acquired and streamed to the host system.

When a grab is started the next integration period will be acquired and sent 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).



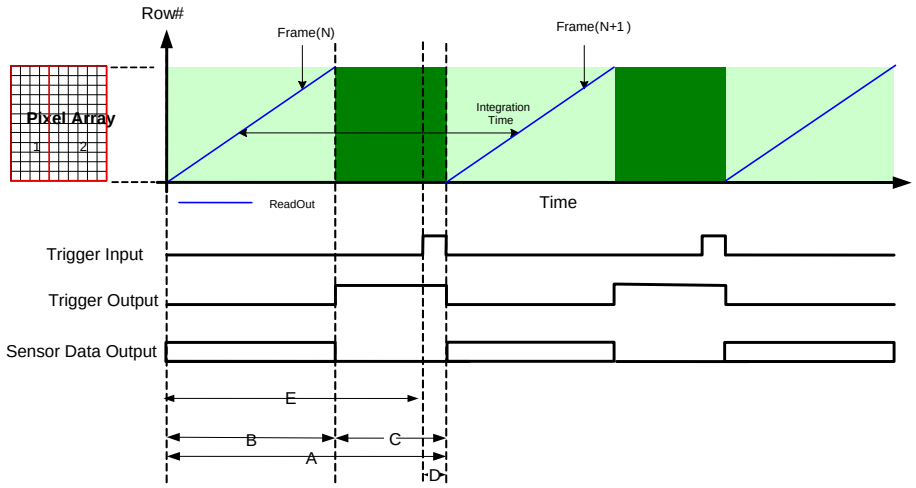

| | Full Resolution | Binning 2x2 | ROI |
|---|---|---|---|
| A: Integration Time | B + C | B + C | B + C |
| B: Read-out Time | 40 ms | 17.5 ms | varies |
| C: Extended Exposure | 21 ms – 65 sec | 12.5ms – 65sec | 0 ms – 65 sec |

**Triggered (External) Mode**

In this mode the detector will take a single image 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.

When using pulsed X-rays, the X-ray exposure including X-ray rise- and fall-times have to be within the "Exposure Time" window (C).

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




| | Full Resolution | Binning 2x2 | ROI |
|---|---|---|---|
| A: Integration Time | Trigger input period | | |
| B: Read-out Time | 40 ms | 17.5 ms | varies |
| C: Exposure Time | > 21 ms | > 12.5 ms | A - B |
| D: Minimal Trigger In high | > 1 ms | | |
| E: Minimal Trigger In low | > 61ms - E | > 30ms - E | B + C - E |

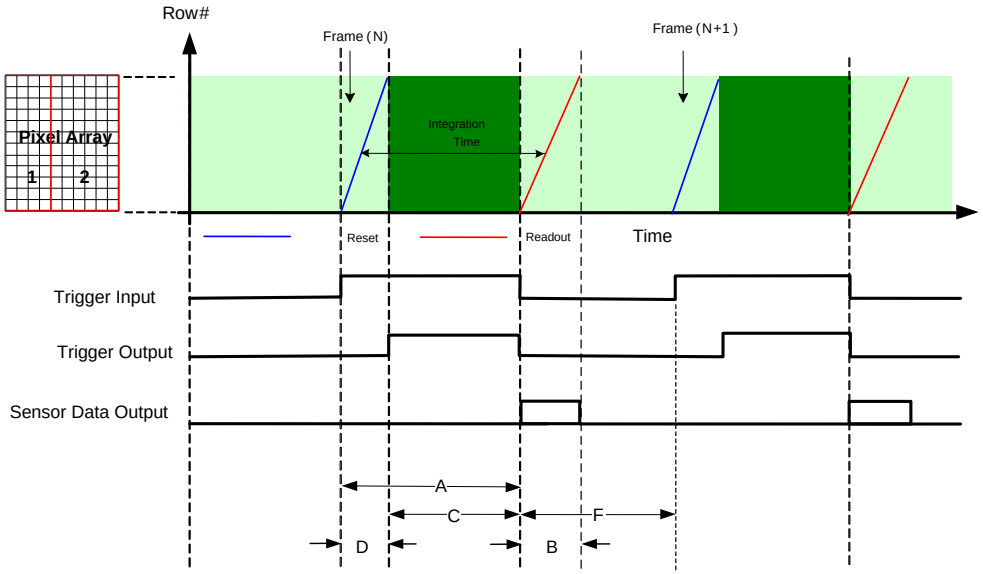
**Snapshot Mode**

In this mode the detector will initiate a sensor reset at the 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 time of the sensor (D).




| | Full Resolution | Binning 2x2 | ROI |
|---|---|---|---|
| A: Integration Time | Trigger input high | | |
| B: Read-out Time | 40 ms | 17.5 ms | varies |
| C: Exposure Time = Trigger Output | A - D | | |
| D: Reset Time | B | | |
| E: Minimal Trigger In high | > D | | |
| F: Minimal Trigger In low | > B | | |

# Image Format Control

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

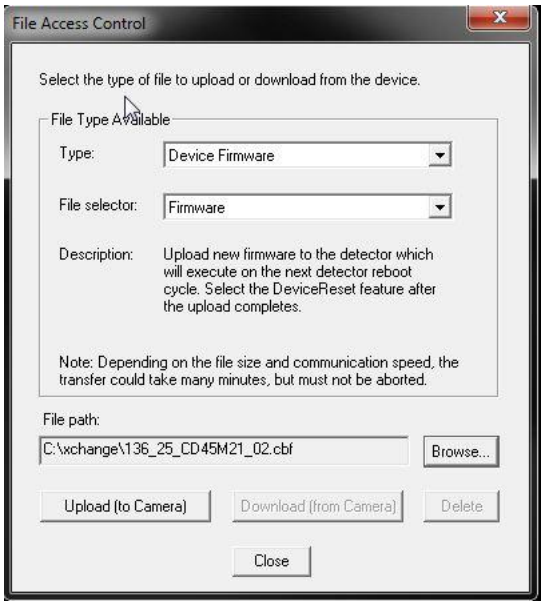
| Display Name | Feature | Acc | Description |
|---|---|---|---|
| PixelFormat | PixelFormat | RO | Format of the pixel provided by the device. Contains all information as provided by PixelCoding, PixelSize combined in one single value |
| *Monochrome 12-Bit Packed* | *Mono12Packed* | | *12 bit packed on 1.5 byte(0 bit loss for each pixel)* |
| *Monochrome 14-Bit* | *Mono14* | | *14 bit packed on 2 bytes (2 bit loss for each pixel)* |
| Pixel Size | PixelSize | RO | *Total Size in bits of an image pixel* |
| *Mono* | *Mono* | | *Pixel is monochrom* |
| *MonoPacked* | *MonoPacked* | | *Pixel is monochrome and packed* |
| 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) |

# File Access Control

Trough the file access control a 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.

# Shuttering

The Rad-icon Detector does not have a shuttering mechanism built into the detector. The detector can be operated quite normally with a continuous beam x-ray source, however there can be motion blur associated with continuous beam imaging. In the case that pulsed x-ray operation is required, the X-ray pulse must be carefully timed so that x-ray from the pulse are not incident on the detector during readout. This will cause imaging artifacts that show up as very uneven illumination within the images.

# 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 after standby.

# 6

# Mechanical Interface

## Mechanical Dimensions