INSTRUCTION MANUAL

ITALA G SERIES

GigE Vision Cameras

CAMERAS

v1.17 - eng

Contents

1 GENERAL INFORMATION

1.1 Disclaimer

Always use and store Opto Engineering® products in the prescribed conditions in order to ensure they function properly. Failing to comply with the following conditions may shorten the product lifetime and/or result in malfunctioning, performance degradation or failure.

Be aware that incorrect functioning of this equipment may cause dangerous situations or significant financial losses. It is essential that the users ensure that the operation of the camera is suitable for their applications.

All trademarks mentioned herein belong to their respective owners.
Except where prohibited by law:

- All hardware, software and documentation are provided on an "as is" basis.
- Opto Engineering® accepts no liability for consequential loss, of any kind.

Upon receiving your Opto Engineering® product, visually examine it for any damage during shipping. If the product is damaged upon receipt, please notify Opto Engineering® immediately.

1.2 Intended use

This product is a **machine vision camera** for the detection, inspection and / or measurement of physical properties of items / objects. It provides a stream of images to a host device over a high-speed connection. Its operation can be synchronized with other devices using various types of electrical signals.
Please note that this product is not intended to be used as a CCTV camera in a video surveillance system.

1.3 Forbidden use

Please read the following notes before using this camera.
Contact your distributor or dealer for any doubts or further advice.

- Do not disassemble, modify or repair the product yourself. It may cause permanent malfunctioning or even fire or electric shock, possibly resulting in serious injury;
- Do not place the product in dusty, humid or hot places or near flames. These conditions may cause malfunctioning and damage or even fire or electric shock, possibly resulting in serious injury;
- Do not spray insecticide or apply other volatile chemicals on or around the product;

- This device must not be used in an application where its failure could cause a hazard to human health or damage to other equipment. Keep in mind that if the device is used in a manner not foreseen by the manufacturer, the protection provided by its circuits and by its enclosure may be impaired;
- This is a low voltage power supplied device. As such, the potential difference between any combination of applied signals must not exceed the supply voltage at any time;
- Higher voltages may cause a fault and can be dangerous to human health;
- This device has limited protection against transients caused by inductive loads. If necessary, use external protection devices like fast diodes or better still, specific transient protectors;
- Do not allow foreign objects to enter the unit or drop into holes, terminals and other openings or gaps. This may cause fire or electric shock, possibly resulting in serious injury;
- Disconnect the power cable before moving the product. Failure to comply with this precaution may damage the power cable, cause fire or electric shock, possibly resulting in serious injury;
- Do not scratch, cut, open or twist the power cables. It may cause malfunctioning, fire or electric shock, possibly resulting in serious injury;
- If the power cable is damaged or cracked, please contact our technical support and do not use the product. Damaged cables may cause malfunctioning, fire or electric shock, possibly resulting in serious injury;
- Do not insert or remove the plug of the power cable with wet hands. It may cause electric shock, possibly resulting in serious injury;
- Do not use the product in presence of inflammable gas. It may cause outbreaks and flames, possibly resulting in serious injury;
- If you notice any abnormality such as smell, smoke or overheating, turn off the power and disconnect the power cables. Continuing to use the product in these conditions may cause fire or electric shock, possibly resulting in serious injury;
- If you have dropped the product or damaged the product case, turn off the power and disconnect the power cables. Continuing to use the product in these conditions may cause fire or electric shock, possibly resulting in serious injury.

1.4 Revisions

In Table 1 are listed all the user manual revisions.
In the column *Description* are listed all the relevant differences between different revisions.

Rev.	Date	Description	FW ver.
1.0	22/09/2021	First manual release	1.0.0 - 1.1.2
1.1	14/06/2022	- Added references to new camera features - Added SDK installation section - Added Driver installation section - Added Itala View quick start section - Added Itala View wizards sections	1.1.3 - 1.1.5
1.2	10/02/2023	- Added CCM calibration procedure - Added TimerDelay feature - Added references to SDK documentation - Added PTP documentation - Updated storage and operating conditions - Updated sensor ADC resolution - Added references to GigE mechanical specifications - Added new part numbers in "Ordering code" section - Added use case in section 7.2	1.2.0 - 1.2.2
1.3	07/03/2023	- Added TriggerDelay feature - Added Action Commands feature - Added Serial interface configuration - Added Serial protocol (ASCII, Modbus, Binary) - Added PTP offset from UTC feature	1.3.0 - 1.3.2
1.4	04/05/2023	- Added DualExposure feature - Added new part numbers in "Ordering code" section - Added Variant in "Ordering code" section - Updated trigger input delay in "Electrical Specifications"	1.4.0
1.5	30/05/2023	- Added TestControl feature - Updated bandwidth limit formula - Updated access attribute of some features - Added Action Command section - Correction of Dual Exposure timings	1.4.1 - 1.5.3
1.6	04/08/2023	- Added "Streaming bandwidth management" use case - Added a caution note in the Liquid lens hardware installation section - Added Shock and vibration data	1.4.1 - 1.5.3
1.7	23/08/2023	- Added FCC Declaration section	1.4.1 - 1.5.3

1.8	27/09/2023	- Added Cognex Vision Pro compatibility test procedure - Updated Encoder output mode section - Added Encoder mode section - Updated Dual Exposure timings	1.5.3 - 2.0.0
1.9	07/11/2023	- Updated the firmware update procedure - Added note to TriggerWidth Exposure feature	2.0.0 - 2.0.2
1.10	20/11/2023	- Added note to DualExposure feature - Added note to TriggerWidth Exposure feature	2.0.0 - 2.0.2
1.11	16/01/2024	- Correction of the monochrome test pattern sequence - Update of the sensors optical responses plots - Revision of all the feature names cited in the document - Added Sequencer Control section - Added Sequencer configuration use case	2.1.0 - 2.1.2
1.12	30/05/2024	- Added Dual Use classification info for IMX990 cameras - Added ChunkSequencerSetActive features - Added a note for Sequencer paths priority - Improved sequencer multi-path example - Added IMX249 support (ordering code, dual exposure, QE plots) - Correction of Dual Exposure timings - Correction of random vibration test PSD - Added sensor centering data - Updated Dual Exposure timings - Updated ordering code information - Added section 6.3.1 - Added section 6.10.4	2.2.0 - 2.2.2
1.13	31/07/2024	- Added Autofocus section - Added Image compression section - Added Encoder and Counter chunk data - Added Polarized pixel formats	2.3.0
1.14	20/12/2024	- Added Device Pressure information - Added YUV411 pixel format - Added Linux driver installation section - Added Itala IP67 specifications - Added AutofocusDone event - Added oeLiquidLensAutofocusTriggerSource feature - Added oeFramesInBuffer feature - Added torque specification for mounting screws - Removed F-mount option - Added maximum current available on digital outputs - Added power supply requirements to satisfy 62368-1	2.4.0 - 2.5.1

1.15	26/08/2025	- Increased the number of sequencer sets - Added section 4.3.5 - Updated Ubuntu versions compatibility - Updated LED color coding	≥ 3.0.0
1.16	26/09/2025	- Added support for Ubuntu arm64	≥ 3.0.0
1.17	19/02/2026	- Added tested HW for arm64 platform - Added IP configuration for Ubuntu - Added Jumbo frames configuration for Ubuntu - Added NIC power management for Ubuntu - Added SDK installation instructions for Ubuntu - Added GigE Vision connector specifications - Updated the camera cleaning instructions - Added Corning Liquid Lenses features - Added Sensor Temperature Status section - Added Events descriptions - Added Debounce and Deglitch section - Added Bit Depth and Pixel Format section - Added Debayering section - Added Chunk Data section - Added Image Processing Pipeline section - Added OE AutoAOI section	≥ 3.2.0

Table 1: Manual revisions

1.5 Ordering code

The camera part number is composed as follow:

ITA000-WX-00Y-ZZ

The ordering code is explained in Table 2.
Refer to Opto Engineering website to check the availability of the desired part number.

> ***NOTE**: ITA13-GM-10C-SWIR product is subject to statutory export control regulations and may require written information on intended end use and final destination.*
> *Dual Use classification: 6A003.B.4.A.*

Code	Description	Options	Value
ITA	Series Name		
000	Sensor resolution	04	IMX287 - 0.40 Mpixels
		13	IMX990 - 1.34 Mpixels
		16	IMX273 - 1.58 Mpixels
		23	IMX249 - 2.35 Mpixels
		24	IMX392 - 2.35 Mpixels
		32	IMX265 - 3.19 Mpixels
		50	IMX264 - 5.07 Mpixels
		51	IMX547 - 5.10 Mpixels
		81	IMX546 - 8.13 Mpixels
		89	IMX267 - 8.95 Mpixels
		120	IMX304 - 12.37 Mpixels
			IMX253 - 12.37 Mpixels
		124	IMX545 - 12.41 Mpixels
		162	IMX542 - 16.19 Mpixels
		168	IMX387 - 16.88 Mpixels
		196	IMX367 - 19.66 Mpixels
		204	IMX541 - 20.35 Mpixels
		246	IMX540 - 24.55 Mpixels
		315	IMX342 - 31.49 Mpixels
W	Interface	G	Ethernet
X	Mono/Color sensor	M	Monochrome
		C	Color
00	Variant	1X	Sony IMX Pregius™ 1st/2nd gen sensor
		2X	Sony IMX Pregius S™ 4th gen sensor
Y	Mount	C	C-mount
		J	J-mount (M42x1 FD 12)
ZZ	Optional features	–	Standard version
		EL	With liquid lens controller
		PL	Polarized Polarsens™ sensor
		SWIR	VIS-SWIR SenSWIR™ sensor

Table 2: Ordering code

2 WARRANTY AND CERTIFICATIONS

2.1 Warranty

The device warranty is 5 years from the effective delivery date with reference to the device serial number.
Warranty covers the replacement or the repair of the defective part (components, device or part of it) with the exclusion of dismantling and shipping costs.
The replacement of one or more components does not renew the warranty period of the entire device.
The electronics and parts subjected to normal use or deterioration due to atmospheric agents and external environment are excluded from the warranty. Also, all failure caused by the lack of, insufficient or incorrect maintenance performed by unskilled or unauthorized personnel or due to unintended use or unauthorized replacements, alterations or repairs is excluded from the warranty.
The general validity of the warranty depends on:

- Maintenance being performed correctly as described in the device manual;
- The intended use of the device as specified in this manual.

2.2 CE Declaration

Itala cameras are conformal to the EMC directive 2014/30/EU and therefore comply with the following standards:

Standard	Description
EN 61000-6-2	Generic standards - Immunity standard for industrial environments
EN 61000-6-4	Generic standards - Emission standard for industrial environments

Table 3: EMC standards

2.3 FCC Declaration

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

2.4 KC Certification

Electrical and electronic equipment imported into South Korea is subject to KC certification. This is a mandatory certification system that ensures that only products certified by recognized bodies can enter the South Korean market. In particular, the certification checks the requirements for electromagnetic compatibility (EMC).
Itala cameras available for the South Korean market are identified by the KC mark and the KC registration number.
For more information about the KC identification data, please scan the QR code on the product or its packaging.

2.5 Shock and vibrations

Itala cameras have been tested for shocks and vibrations according to the following standards and limits:

2.5.1 ITALA G - G.EL

Standard	Date of issue	Test	Parameters
EN 60068-2-27	2009	Shock	x/y/z axis, 20g, 11ms, 10 pos. / 10 neg. shocks
EN 60068-2-6	2008	Sine vibration	x/y/z axis, 10g, 50-500 Hz, 10 sweep
EN 60068-2-64	2008+A1:2019	Random vibration	x/y/z axis, 5g RMS, 0.056g^2/Hz PSD, 30 min for each axis

Table 4: Shock and vibrations standards and limits

2.5.2 ITALA G.IP

Standard	Date of issue	Test	Parameters
EN 60068-2-27	2009	Shock	x/y/z axis, 50g, 11ms, 10 pos. / 10 neg. shocks
EN 60068-2-6	2008	Sine vibration	x/y/z axis, 10g, 50-500 Hz, 10 sweep
EN 60068-2-64	2008+A1:2019	Random vibration	x/y/z axis, 5g RMS, 0.056g^2/Hz PSD, 30 min for each axis

2.6 RoHS, REACH and WEEE

Itala cameras are conformal to the following directives and standards:

- RoHS 2011/65/EU
- REACH 1907/2006/EC
- WEEE 2012/19/EU

3 INTRODUCTION

3.1 Manual and conventions

Opto Engineering® SpA, with its registered office in Strada Circonvallazione Sud 15, 46100 Mantova (Mn) - Italy, hereinafter the manufacturer, provides all the necessary information in this installation, use and maintenance manual in a clear and simple way to install, use and service the product Itala.

The recipients of this manual are all those who have the knowledge, experience and capability of understanding the standards, prescriptions and safety measures indicated in this manual. Such people will be later identified as qualified personnel who are authorized to transport, install, use and service the products described in this manual.

This material can only be used by the customer whom this manual has been delivered to, in order to install, use and service the product.

The manufacturer will retain the right to modify or improve the manual and/or the product referred to in this manual without any prior notice.

The following typographical conventions are used in this document:

***NOTE**: notes contain important information. Highlighted outside the text to whom they refer*

***CAUTION**: these indications highlight procedures that, if not observed in their entirety or in part, can cause damage to the machine or to the appliances*

***HAZARD**: these indications highlight procedures that, if not observed in their entirety or in part, can cause injuries or affect the health of the operator*

3.2 Product identification data

Itala cameras are identified with a label placed on the lateral side of the packaging box. A compact version of the label is also placed on the back side of the camera, near the connectors.

This label is used to identify the part number, serial number and MAC address of each device. A label example is shown in Figure 1.

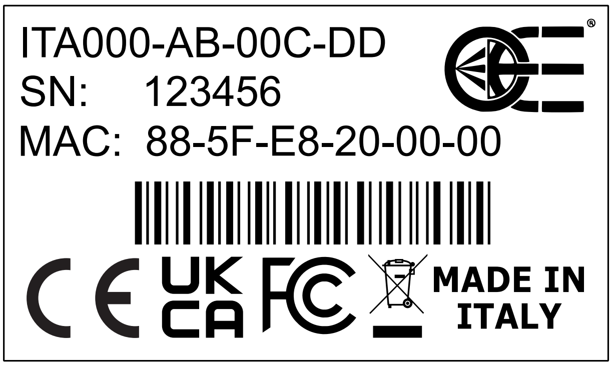


Figure 1: Example of camera label.

3.3 Storage and use conditions

3.3.1 Storage conditions

Storage environment between -10°C and 60°C.
Avoid thermal shock by not exposing the product to sudden changes in temperature.
Store the product in a dry place: storage environment with relative humidity (RH) less than 80% (no condensation).

3.3.2 Operating conditions

Extreme temperatures affect the product functionality, especially the electronic components.
Avoid thermal shock by not exposing the product to sudden changes in temperature.
Since the product includes electronic components, it may generate heat when functioning: it's very important to dissipate an appropriate amount of heat (if necessary, operate the device with a forced air cooling system).
Use the product in a dry place: operating environment with relative humidity (RH) less than 80% (no condensation).

In general, avoid to store and use the camera in the following environments:

- Environments with strong electric/magnetic fields.
- Places exposed to direct sunlight, rain or snow.
- Environments exposed to particular gas and dangerous substances.
- In extremely vibrating systems.
- Dusty places.
- Extremely humid places.
- Excessive hot/cold environments.

Itala cameras have been tested in climatic chamber in order to prove the temperature capabilities.

***CAUTION**: Image sensor quality easily degradates when its temperature exceedes range -10°C ÷ +60°C (junction temperature).*
In any case never exceed sensor absolute maximum temperature of 100°C.
*Please read the **Device Temperature** → **Sensor** GenIcam feature in order to monitor sensor temperature and not to exceed the absolute maximum ratings.*
Opto Engineering will not be responsible in case of overheating faults.

CAUTION**: **Case temperature must not exceed the range -25°C ÷ 65°C.
Case temperature has been measured on the external part of the aluminum case, near the mount of the camera.

***CAUTION**: Ambient and case temperatures can highly differ in case of poor heat dissipation.*
In this scenario, monitoring ambient temperature could be not sufficient.
User must monitor Itala case temperature and, if necessary, adopt suitable dissipation strategy in order not to exceed 65°C.
Opto Engineering will not be responsible in case of overheating faults and damage to the device.

3.4 Cleaning and maintenance

Even if the camera is equipped with a rugged mechanical case, some measures must be followed in order not to damage the camera itself.

***CAUTION**: **do not attempt to disassemble the camera for cleaning.** Internal components are highly sensitive and improper handling can cause permanent damage or void the warranty. All cleaning should be performed externally following the recommended procedures.*

Housing

***CAUTION**: avoid the use of inappropriate cleaning chemicals like benzene, acetone, thinner, spray-like cleaners.*

To clean the camera housing, use a small amount of neutral detergent applied with a soft cloth or brush, then wipe it dry.

Sensor protection glass / filter

CAUTION*: avoid the use of inappropriate cleaning chemicals like benzene, acetone, thinner, spray-like cleaners.*

CAUTION*: do not use high-pressure compressed air, as it can force dust particles into the camera assembly. If absolutely necessary, use only very low-pressure air delivered through a fine nozzle and regulated by an appropriate pressure regulator.*

Clean the protective glass or optical filter located in front of the sensor using a lint-free cotton swab lightly moistened with isopropyl alcohol.

4 GETTING STARTED

4.1 Overview

Itala is an industrial **Gigabit Ethernet camera** compliant with the *GigE Vision* and *GenICam* specifications.
This camera is capable of transferring image data at high frame rates and over long distances, up to hundreds of meters.
Specifically designed for harsh industrial environments, Itala cameras guarantee reliable operation and top notch performances in their class. The *GigE Vision* and *GenICam* compliance allow easy camera integration and replacement. With flexible powering options (12-24 Vdc and **Power over Ethernet**), Itala cameras are compatible with most vision systems, allowing simple and flexible wiring configurations.

4.2 Hardware installation

4.2.1 Camera installation

The camera is provided with 4 x M3 threaded holes on each side, allowing for flexible and robust mounting. It is recommended to mount the camera to a metal object using a metal bracket in order to facilitate the heat dissipation. Before installing the camera make sure to align it correctly, as requested by your application. Keep in mind that you can also exploit **ReverseX** and **ReverseY** camera features to flip the image on X and Y axis directly in camera, without performance loss.
Room should be provided to ensure a good cables setting on the back of the camera.

> ***NOTE**: tighten the screws to a torque of 1.2-1.4 Nm. Use a thread-locking fluid if the device is subject to high levels of vibrations.*

4.2.2 Lens

ITALA G - G.EL

Cameras which come in **TYPE 1** enclosure are equipped with a standard **C-mount** (1 inch diameter, 32 threads per inch), with a flange distance of 17.526 mm.
Cameras which come in **TYPE 2** enclosure are equipped with an **M42x1** threaded mount, with a flange distance of 12 mm.
See section 5.5 for the cameras dimensional drawings.

Before installing the lens, make sure that the lens and the camera protection glass are perfectly clean. Refer to section 3.4 for cleaning instructions.

> ***NOTE***: *for heavy lenses, consider to directly mount the lens with an appropriate clamping system instead of relying on the camera mounting holes. If the lens allows you to adjust the phase of the mount, this operation is straightforward. Otherwise, you need to ensure that the camera orientation will be correct after screwing it in final position.*

ITALA G.IP

Cameras which come in **IP67** enclosure are equipped with a standard **C-mount** (1 inch diameter, 32 threads per inch), with a flange distance of 17.526 mm.
See section 5.5 for the cameras dimensional drawings.

Before installing the lens, make sure that the lens and the camera protection glass are perfectly clean. Refer to section 3.4 for cleaning instructions.

> ***CAUTION***: *a proper lens enclosure is required to achieve full IP67 protection.*

IP67 Lens Enclosure

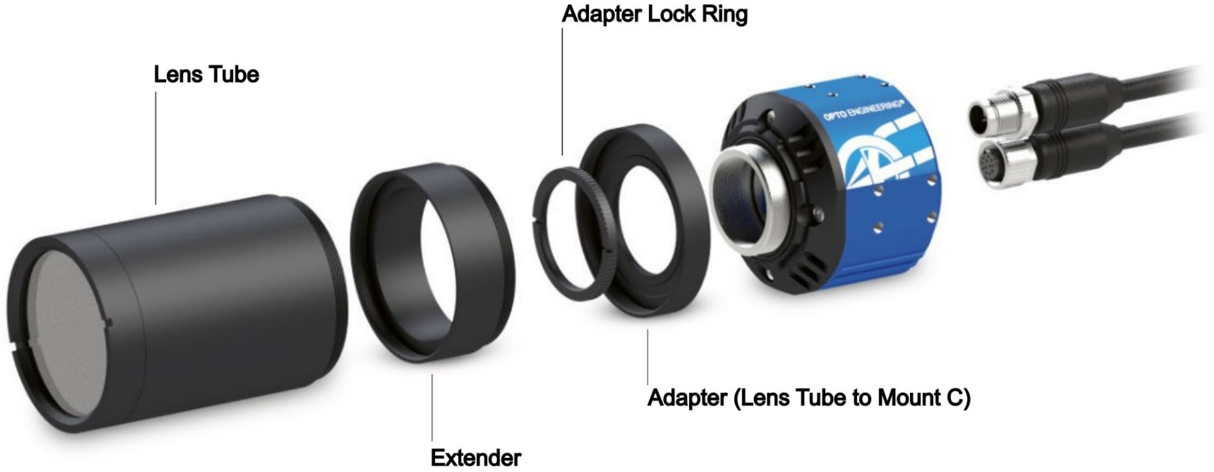


Figure 2: IP67 lens enclosure installation.

The **Adapter** should be properly tightened onto the C-mount to achieve a good seal. The **Adapter Lock Ring** is designed to lock the **Adapter** in place and prevent it from moving. The **Extender** is optional and its installation depends on the lens size. The **Lens Tube** should also be tightened to ensure a good seal.

***CAUTION**: do not overtighten the lens enclosure parts as this may cause damage to the camera and lens enclosure parts.*

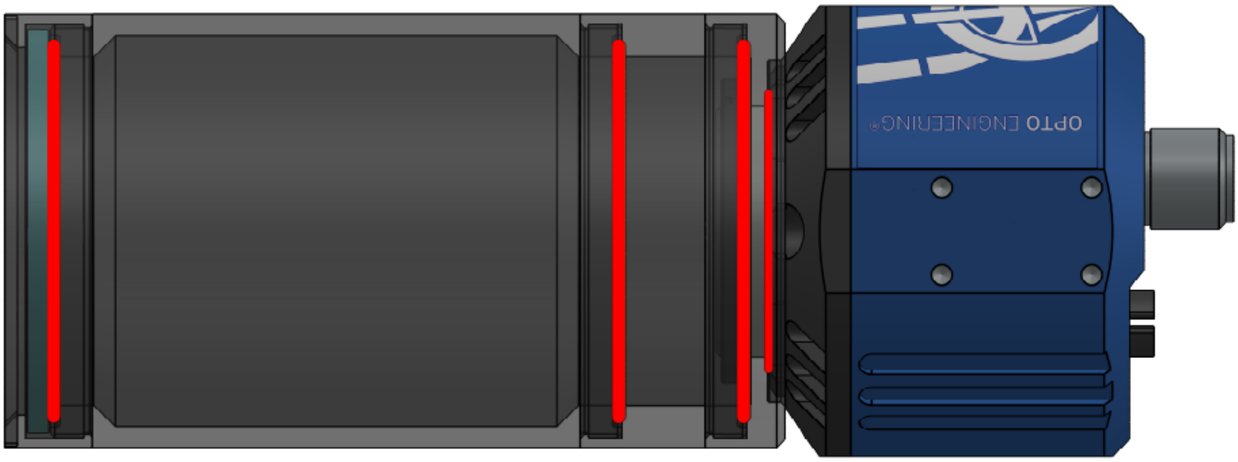


Figure 3: O-Ring placement for IP67 lens enclosure.

***HAZARD**: make sure that all the O-rings required by the mechanical parts of the lens enclosure are in place to ensure a good seal. Failing to do so may result in damage to the camera.*

4.2.3 Ethernet cable

Connect the camera to the host device with a suitable Cat 5e Ethernet cable or better, compliant with *ANSI/TIA-568* standard, with a maximum length of 100m.
A shielded cable should be used to improve the system EMI immunity, especially in harsh industrial environments.
If you intend to power the camera with PoE (Power over Ethernet), connect the cable to a suitable PoE injector or NIC (network interface card).

***CAUTION**: always use certified IEEE 802.3af PoE power supplies, injectors and NICs. Failing to do so may result in damaging the camera.*

CAUTION: *do not use Power over Ethernet (PoE) and the dedicated +24V power supply at the same time. Doing so may cause the camera to operate outside its guaranteed specifications.*

HAZARD: *cables should be arranged carefully, avoiding pinching, sharp corners and excessive tension. Failing to do so can lead to short circuits, damage to the appliances or even fire.*

ITALA G - G.EL

Itala G - G.EL cameras come with 2 x M2 threaded holes for use with screw lock RJ45 connectors. For moving applications (e.g. camera mounted on a robotic arm) use screw lock connectors and cable strain reliefs to ensure a reliable connection. A high-flexibility cable specifically designed for a high number of bending cycles is also recommended.
See section 5.5 for the cameras dimensional drawings.

ITALA G.IP

Itala G.IP cameras are equipped with an M12 X-Coded female Ethernet connector rated IP67. Additional strain relief is not required for dynamic or moving applications.

CAUTION: *to ensure proper sealing, the connector must be securely tightened. Typical tightening torque ranges from 0.4 to 0.6 Nm; however, always refer to the cable manufacturer's specifications for the recommended torque.*

For moving applications (e.g. camera mounted on a robotic arm) use screw lock connectors and cable strain reliefs to ensure a reliable connection. A high-flexibility cable specifically designed for a high number of bending cycles is also recommended.
See section 5.5 for the cameras dimensional drawings.

4.2.4 GPIO cable

The camera can also be powered through the GPIO (General-Purpose Input/Output) port using a GPIO cable up to 30m in length and a suitable power supply. To ensure optimal performance and EMI immunity in particularly disturbed environments, use shielded cables. For more information on the GPIO connector pinout and a complete list of Itala cameras' electrical specifications, see sections 5.6 and 5.2, respectively.

CAUTION: *do not use Power over Ethernet (PoE) and the dedicated +24V power supply at the same time. Doing so may cause the camera to operate outside its guaranteed specifications.*

HAZARD: *maximum power to be used to supply product PS2 per 62368-1 and LPS per Annex Q.1 less than 100W.*

HAZARD: *always use suitable cables and power supplies that satisfy all the device specifications. Failing to do so may result in damaging the camera, fire or injury to the operator.*

HAZARD: *cables should be arranged carefully, avoiding pinching, sharp corners and excessive tension. Failing to do so can lead to short circuits, damage to the appliances or even fire.*

ITALA G - G.EL

Plug the push-pull connector in firmly, paying attention to the correct orientation. For moving applications (e.g. camera mounted on a robotic arm) a high-flexibility cable specifically designed for a high number of bending cycles is recommended.

CAUTION: *don't force the connector if you encounter too much resistance. Check the connector orientation and try again.*

ITALA G.IP

Itala G.IP cameras are equipped with an M12 A-Coded male GPIO connector rated IP67. Additional strain relief is not required for dynamic or moving applications.

CAUTION: *to ensure proper sealing, the connector must be securely tightened. Typical tightening torque ranges from 0.4 to 0.6 Nm; however, always refer to the cable manufacturer's specifications for the recommended torque.*

For moving applications (e.g. camera mounted on a robotic arm) a high-flexibility cable specifically designed for a high number of bending cycles is recommended. See section 5.5 for the cameras dimensional drawings.

4.2.5 Liquid lens

If the camera comes with the **Liquid Lens Controller** option, use a specific cable to connect the camera GPIO port to an Opto Engineering® product integrating an electrically tunable lens. There are two possible configurations:

- A dedicated **point-to-point cable** allows for a simple connection of the liquid lens when the camera is powered via PoE.
- A dedicated **Y-cable** allows for simultaneous connection of liquid lens, power supply and synchronization devices.

See section 6.17.1 for more information about the liquid lens connection and operation.

***CAUTION**: when using the **Y-cable** be sure to **first connect the camera**, then the lens and finally the power supply. Never connect/disconnect the camera connector while the lens and/or the power supply are connected. Failing to do so may result in damaging the liquid lens integrated EEPROM.*

***CAUTION**: always use the specific cable provided by Opto Engineering® to connect the liquid lens to the camera. Failing to do so may result in damaging the camera or the liquid lens.*

***NOTE**: if the lens allows you to adjust the phase of the mount, choose an orientation that will reduce the strain on the cable.*

The orientation of the lens mounting can affect the image quality. Read the lens specifications before the final installation of the vision system.

4.3 System configuration

NOTE**: the camera firmware is updated frequently to add new features and improve the existing ones. Regularly check on Opto Engineering website for the availability of a new firmware version and **update the camera before installation.

4.3.1 System requirements

The Itala SDK can be installed in a system working with one of the following OS:

- Microsoft Windows 10 / 11 (x64)
- Ubuntu 18.04 (x64) or higher
- Ubuntu 18.04 (arm64) or higher
  (tested on NVIDIA Jetson AGX Orin, Jetson Orin Nano and Jetson TX2)

Proper functioning of the camera has not been tested with other operating systems and platforms. Contact your Opto Engineering representative for further information.

Be careful to use a NIC (network interface card) which supports Gigabit Ethernet communication: in particular, choose a NIC with jumbo frame packets capability.

The Itala camera is a high performance device which streams images with high data throughput. In order to guarantee optimal performances, the host system should be sufficiently powerful to handle the large amount of data sent by the camera. Consider choosing a high performance CPU and enough amount of RAM for the image acquisition and processing of your specific application.

4.3.2 Camera Driver

To better handle the image streaming high throughput, it's recommended to use the **Itala filter driver**. The filter driver intercepts *GigE Vision* streaming protocol packets, reassembles the whole payload and sends it directly to the application image buffer. This allows to skip the standard network protocol stack that would increase latency and CPU usage on the host machine (Fig.4). The result is a low level packet handling offload which optimizes the host system resources consumption.

Install Driver on Windows

The Itala SDK installer takes care of the necessary filter drivers which are automatically installed on the host computer.
You can check for successful installation of the filter driver on your Ethernet connection property window. Go to *Control Panel* > *Network and Sharing Center* > *Change adapter settings*, right-click on your Ethernet connection and select *Properties*. In the *Networking* tab you should see the filter driver entry with a selected checkbox, as shown in Fig.5.

> ***NOTE**: in order to avoid conflicts, it's recommended to disable filter drivers from other camera vendors that you may have installed on your system.*

If you need to re-install the drivers after an unwanted removal, follow this procedure:

1. Go to the Itala SDK installation directory.

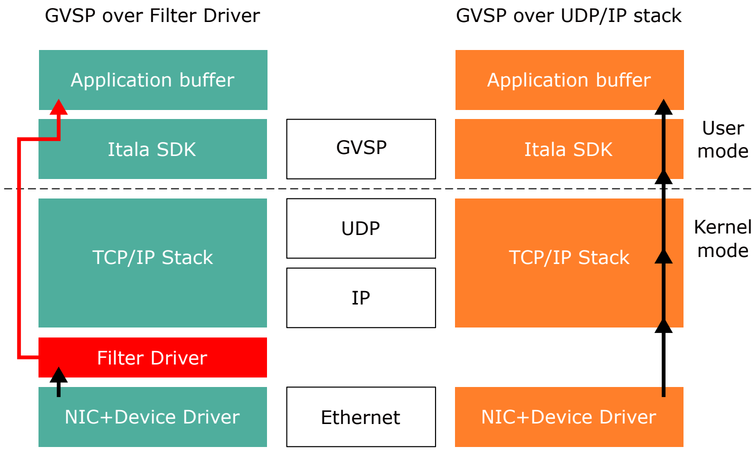


Figure 4: GigEVision Streaming (GVSP) with and without the Filter Driver

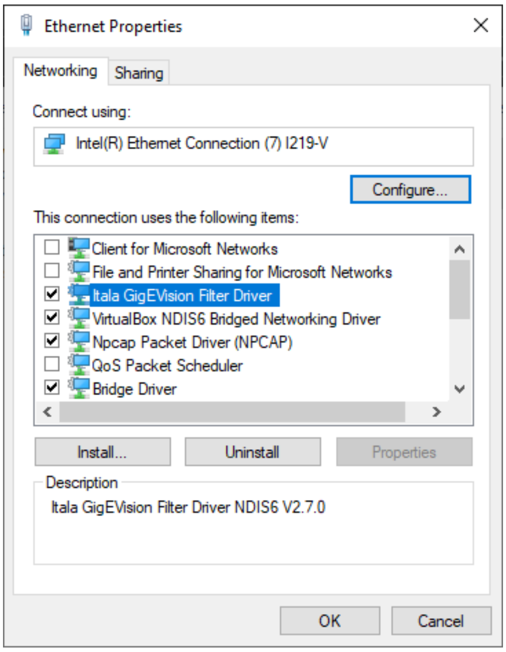


Figure 5: Successfully installed filter driver.

2. Open the Filterdriver folder.
3. Launch *install_driver_win10.bat* in case of Windows 10 OS. Please be careful to choose the correct batch depending on the operating system.
4. At the end of the installation, the filter driver will appear in the NIC property window (Fig.5).

Install Driver on Ubuntu

Ubuntu GEV module is not mandatory for 1G cameras but is strongly recommended for higher speed cameras, especially if you are experiencing problems with incomplete or lost packets. There are two ways to install the GEV driver in ubuntu (*oegevmodule*).

The first one is executing the script */opt/itala-sdk/scripts/oegevmodule/install_oegevmodule.sh* with administrator privilege. It will try to download and install the correct module version in your system.

The second way is to download and install GEV module manually from the Opto Engineering website (https://www.opto-e.com/en/resources/itala-drivers). To choose the correct version you need to know:

- the driver version supported by your Itala SDK version: check the file */opt/itala-sdk/changelog.md*
- your kernel version: open a terminal and type `uname -r`.

The file you are looking for follow the format *oegevmodule-<driver-version>-<kernel-version>.tar.gz*, e.g. *oegevmodule-24.04.0-5-15-119-generic.tar.gz*. Once the package is downloaded, you can unzip the archive and follow the *README* instructions in the unzipped folder.

Each time the kernel is upgraded, i.e. for a system upgrade, you need to install again the driver.

Each time you upgrade the Itala SDK you may need to upgrade the GEV module too. Check */opt/itala-sdk/changelog.md* or the official Opto Engineering website to verify if the GEV module version installed is supported by your Itala SDK version.

You can check if the installation complete correctly by executing `lsmod | grep oegevmodule` from a terminal. If the command return nothing, *oegevmodule* is not installed correctly otherwise it is. You can also evaluate the oegevmodule activity in the kernel logs (by executing `dmesg` linux utility).

Please refer to Opto Engineering Tech Support if you are experiencing an installation problem or if your target kernel version is not supported yet.

4.3.3 Network and configuration

The camera is factory configured to automatically obtain an IP address in DHCP / LLA mode (dynamic IP). This ensures the highest compatibility with different network configurations. For the first connection, it's recommended to configure your network settings in order to use DHCP.

If the camera is not accessible you can force it to adopt an **IP configuration** which is compatible with the current NIC settings. To do so, refer to section 4.7.2.

After the first connection, it is recommended to set a static IP address for both NIC and device whenever possible. This ensures a faster discovery process and IP negotiation.

It is recommended that the connection be as simple as possible. For optimal performance, use a direct connection with the NIC, or connect the camera and the host computer to the same Ethernet switch without routing any other heavy traffic through it.

Dynamic IP settings on Windows

Go to *Control Panel* > *Network and Sharing Center* > *Change adapter settings*, right-click on your Ethernet connection and select *Properties*. In the *Networking* tab select *Internet Protocol Version 4 (TCP/IPv4)* from the list and then click *Properties*.
Select *Obtain an IP address automatically* and click *OK*. Finally, click *OK* on the previous window.

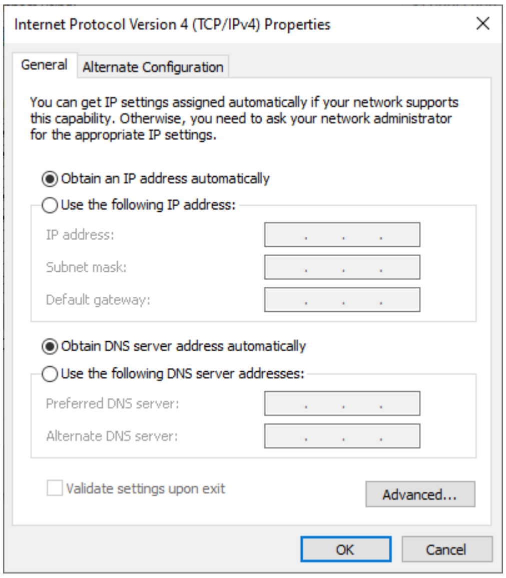


Figure 6: Dynamic IP configuration of the network connection on Windows.

Dynamic IP settings on Ubuntu

Go to *Settings* > *Network* and create or edit a *Connection Profile*. Go to *IPv4* tab, set *Automatic (DHCP)* and click *Apply*.

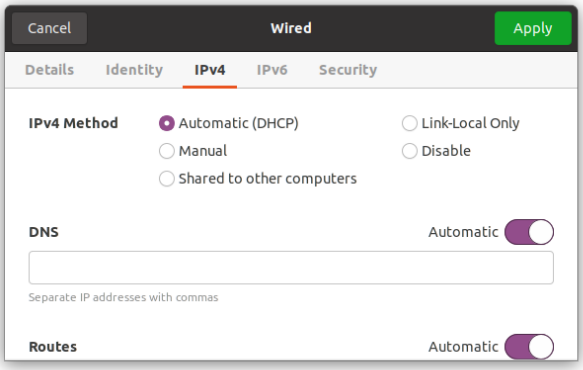


Figure 7: Dynamic IP configuration of the network connection on Ubuntu.

4.3.4 Bandwidth management

To achieve the best streaming performances, connection reliability and to reduce CPU consumption, it's recommended to configure the NIC (network interface card) to use **Jumbo** frames. Jumbo frames are Ethernet frames which are larger than 1500 bytes and allow to increase the connection efficiency, reducing the amount of protocol overhead. Opto Engineering® recommends to use a NIC which supports Jumbo frames of at least 9000 bytes.

When connecting **multiple cameras** to a single computer, it is recommended to connect all devices directly using multiple gigabit NICs.
If you're connecting the camera through an Ethernet switch, make sure it also supports jumbo frames. Keep in mind that if multiple devices are connected to the same Ethernet switch, they will share the available bandwidth.
For more information about bandwidth management and multi-camera system configuration, refer to section 6.1.2.

Jumbo frames settings on Windows

Jumbo frames are usually turned off by default. To enable them, go to *Control Panel* > *Network and Sharing Center* > *Change adapter settings*, right-click on your Ethernet connection and select *Properties*.
In the *Networking* tab click on *Configure*. The NIC settings window will appear.
In the *Advanced* tab locate the *Jumbo frame* or similar entry and enable it (Fig.8). The value to set may differ depending on the specific NIC model and manufcturer.

If you still experience issues with the camera connection you can try:

- Installing the latest NIC drivers.
- Increase the *receive buffer size* of your NIC.

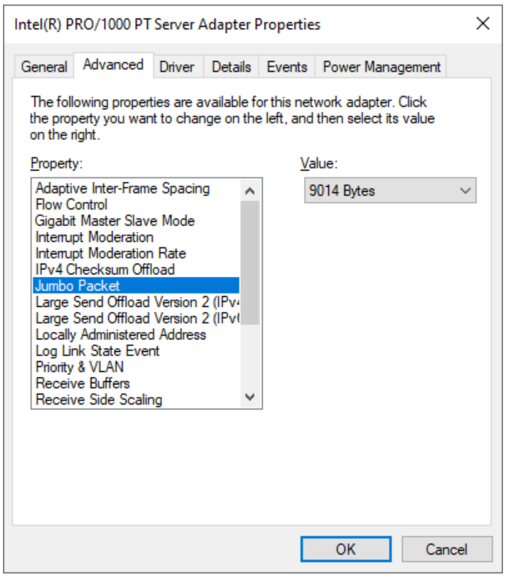


Figure 8: NIC advanced settings with Jumbo frames enabled on Windows.

Jumbo frames settings on Ubuntu

Jumbo frames are usually turned off by default. To enable them, go to *Settings* > *Network* and edit a *Connection Profile*. Go to *Identity* tab, set *MTU* to a value of 9000 (or greater) and click *Apply* (Fig.9). Please note that you need to check if the MTU value has been effectively set on your NIC. To do so, connect a device to your NIC card, open the *Terminal* and use the `ip a` or `ifconfig` commands. This will output something similar to Fig.10.

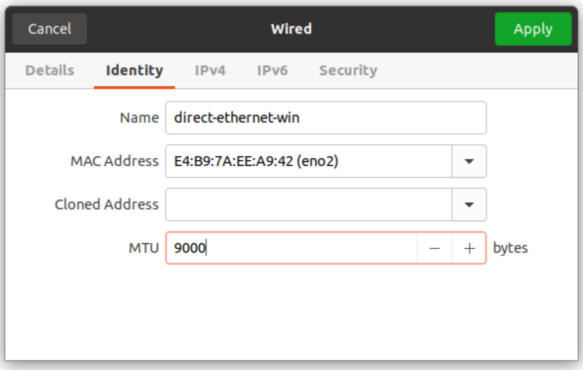


Figure 9: Jumbo frames settings on Ubuntu.

If you still experience issues with the camera connection you can try:

- Installing the latest NIC drivers.
- Increase the *receive buffer size* of your NIC.

```
eno2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 9000
        inet6 fe80::b9dc:9a85:3020:f0cc  prefixlen 64  scopeid 0x20<link>
        ether e4:b9:7a:ee:a9:42  txqueuelen 1000  (Ethernet)
        RX packets 3  bytes 894 (894.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 8  bytes 1452 (1.4 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
        device interrupt 16  memory 0xd1200000-d1220000
```

Figure 10: Check of jumbo frames settings on Ubuntu (`ifconfig` output).

One way to check the maximum available receive and transmit buffer size is by using the `ethtool -g eth0` command, if the target NIC is `eth0`. This will output something similar to Fig.11.

```
Ring parameters for eno2:
Pre-set maximums:
RX:             4096
RX Mini:        0
RX Jumbo:       0
TX:             4096
Current hardware settings:
RX:             256
RX Mini:        0
RX Jumbo:       0
TX:             256
```

Figure 11: Check of maximum RX and TX buffer size on Ubuntu.

Then, the maximum size can be set using `sudo ethtool -g eth0 rx 4096 tx 4096`.

On Ubuntu and, more generally, on Linux operating systems, there are different ways to set network parameters, especially advanced ones. To set network parameters from the *Terminal*, it's possible to use `ip`, `ifconfig` and `ethtool` commands. However, be aware that these settings are temporary and not persistent across reboots. To make persistent changes, use *Netplan*, the *NetworkManager* (*nmcli* / *nmtui*), or configure the */etc/network/interfaces* file.

4.3.5 NIC power management

Windows

Power Management panel is accessible in a dedicated tab of the NIC's Properties window (see Fig.12).
By default, Network Interface Cards could be configured for energy saving.
However, this setting could reduce the overall performances of the system, leading unexpected behaviours, especially at high bandwidth.
The **Allow the computer to turn off this device to save power** setting controls how the network card is handled when the computer enters sleep mode.
It's strongly recommended to leave this checkbox unmarked, in order to prevent OS power optimizations and possible performances losses.

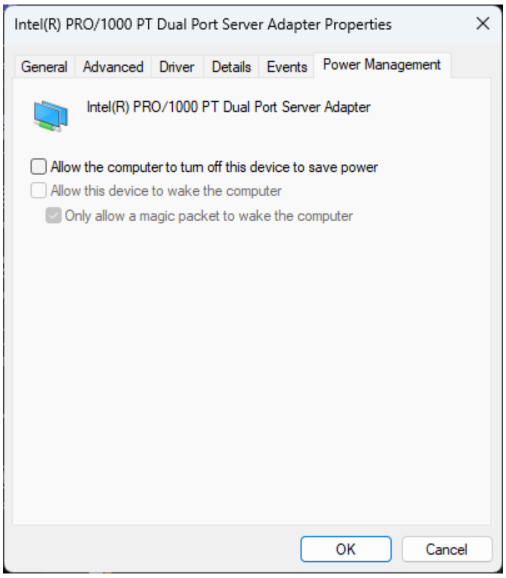


Figure 12: NIC power management settings: device turn-off should be disabled.

Ubuntu

If you experience issues related to power-saving features, consider disabling them. Start by checking whether *Wake-on* functionality or *Energy Efficient Ethernet (EEE)* settings are causing the problem, as these can sometimes interfere with network stability.
For a more performance-oriented configuration, you can try disabling *PCIe ASPM (Active-State Power Management)* if you suspect that system-wide power-saving mechanisms are impacting network performance. Disabling *ASPM* will turn off this feature for all PCIe devices, which may help reduce latency and improve stability at the cost of slightly higher power consumption.

4.4 Itala SDK

Itala cameras comes with a complete Software Development Kit, Itala SDK, which takes full advantage of the latest standards and technologies in machine vision industry.
The SDK includes:

- Itala API
- Itala View
- GenTL producer (.cti)
- Filter driver
- Documentation with code examples

Itala SDK installation on Windows

In order to install the Itala SDK correctly, do the following steps:

1. Download the Itala SDK from Opto Engineering website and run the installer.
2. The Itala SDK setup window is displayed: make sure to follow the instructions listed (Fig.13).

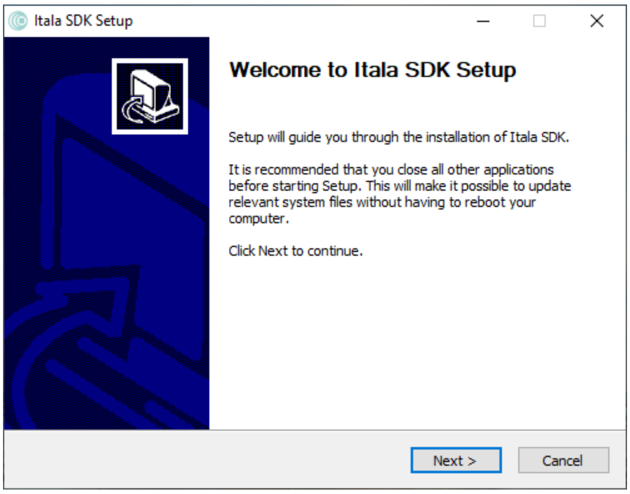


Figure 13: Itala SDK setup window.

3. Check the licence terms before installing Itala SDK (Fig.14).

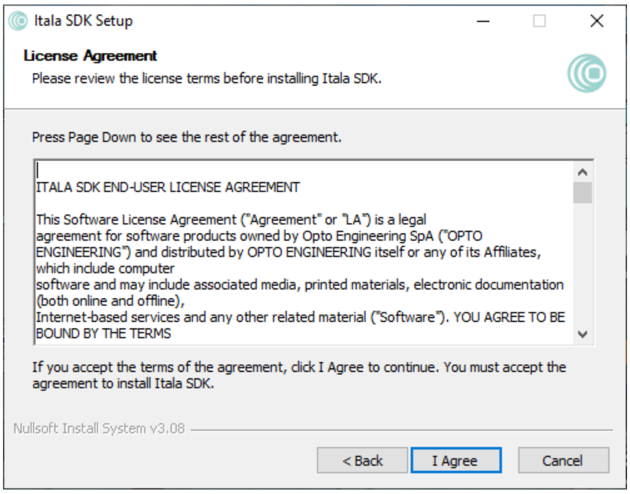


Figure 14: Itala SDK licence agreement window.

4. Choose the destination folder (Fig.15).
5. Select the components which need to be installed (Fig.16). In case of installation of the filter driver only, step 6 can be skipped.
6. (Optional) In case the .NET runtime needs to be installed, click *Install* in the .NET runtime installation window (Fig.17). In case of successful installation, the window shown in Fig.18 will appear.

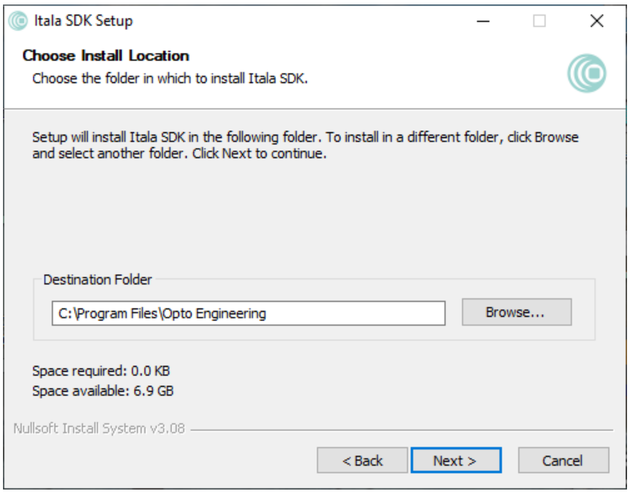


Figure 15: Itala SDK destination folder window.

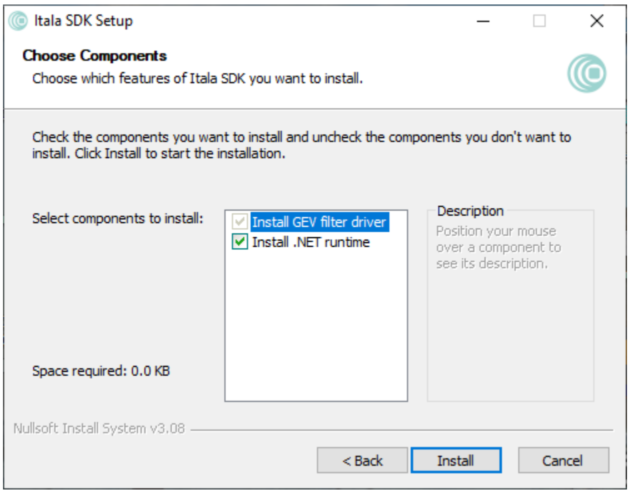


Figure 16: Components selection window.

7. The Itala SDK installation will be performed automatically. The progress bar can be monitored to check the installation status. At the end of the installation, a confirmation window will be displayed (Fig.19).

Itala SDK installation on Ubuntu

Itala SDK is provided as a .deb package, allowing easy installation using apt or dpkg. The package has no dependencies other than standard system libraries. **Administrator (root) privileges are required.**

Use the following commands to install or remove the package:

`dpkg -i itala-sdk_v2025.05.21_amd64.deb # install`

`dpkg -r itala-sdk # uninstall` (package name, not filename!)

All files are located in the */opt/itala-sdk* directory. When building software using Itala API, the linker

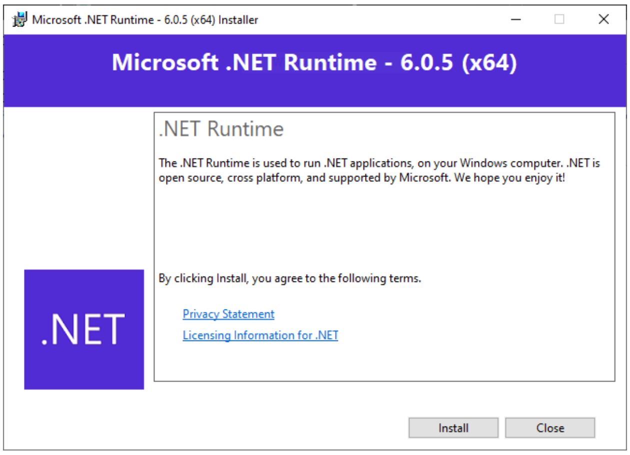


Figure 17: .NET runtime installation window.

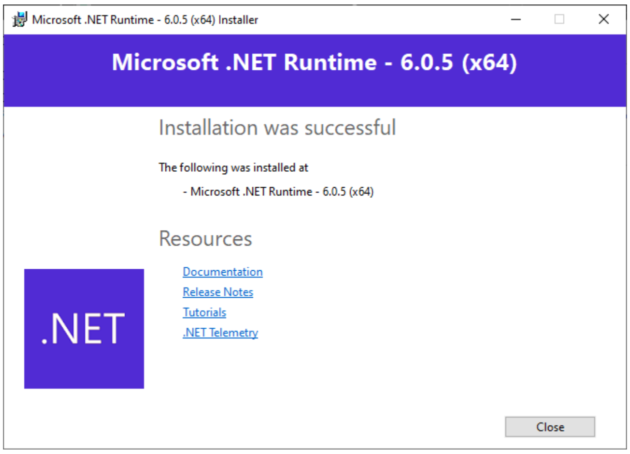


Figure 18: .NET runtime successful installation window.

will automatically detect the Itala API shared libraries. This is enabled by the *itala-sdk.conf* file, which is placed in the */etc/ld.so.conf.d* directory during installation. This directory contains configuration snippets that are included in the main linker configuration.

> ***NOTE***: *A reboot/logout may be necessary to apply the changes made to the linker and environment variables (i.e. GenTL variables).*

> ***NOTE***: *When installing via* `apt`*, the package size may appear as 115 GB. This value is incorrect and does not represent the actual installation size.*

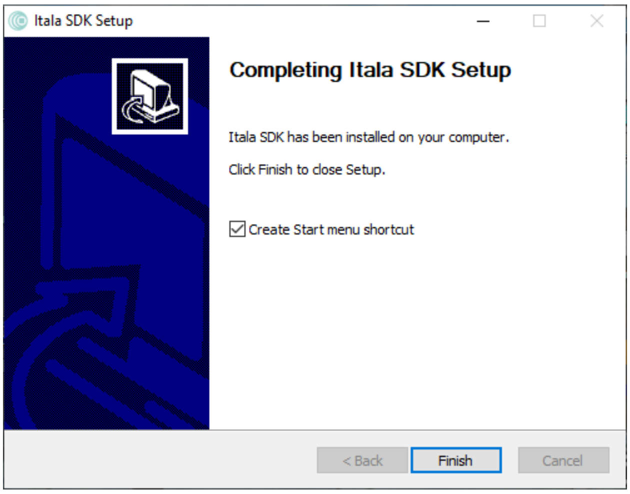


Figure 19: Itala SDK installation finished successfully.

4.5 Using the camera with Itala API

With Itala API it's easy to integrate Itala devices in custom applications, thanks to an extensive set of examples and complete documentation. For more information about the use of the library, refer to Itala API documentation in the SDK installation folder.

4.5.1 Itala SDK documentation

SDK documentation can be found in the installation directory (*Itala SDK* > *Development* > *doc* > *html*).

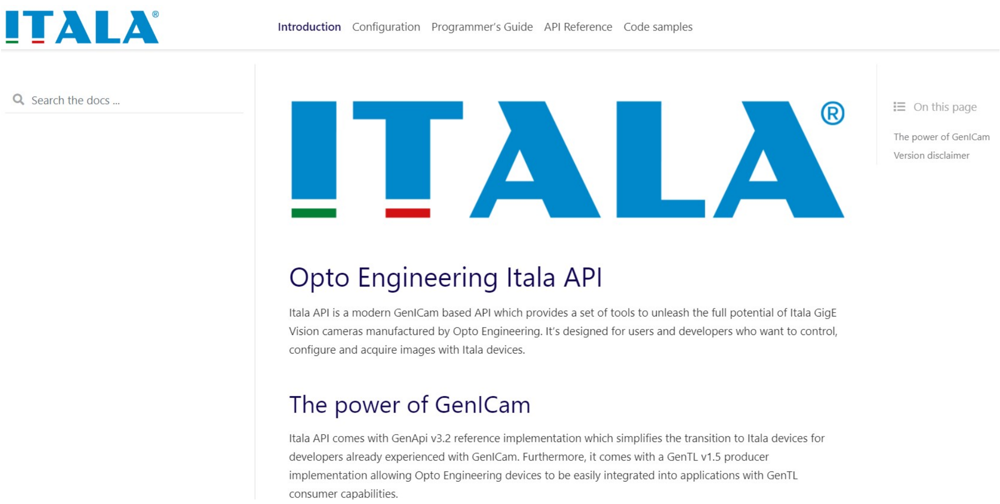


Figure 20: Home page of Itala SDK documentation.

Figure 20 depicts the home page of Itala SDK documentation.

4.6 Using the camera with third party software

Itala cameras are compliant to **GigEVision** and **GenICam** standards, allowing easy integration with third party vision software. In addition, the SDK includes a **GenTL producer** (.cti file) compliant with the GenTL specifications hosted by EMVA. This further enhances the interoperability with other compliant devices and software.

4.7 Using the camera with Itala View

Itala View is a GUI tool which allows the evaluation, configuration and troubleshooting of Itala cameras. With a comprehensive set of utilities and wizards, Itala View speeds up the evaluation and deployment of a vision system built around Itala cameras.
To facilitate the first use of the application, a brief overview is given in the following sections.

4.7.1 Tabs and panels

With reference to Fig.21, the main window of Itala View can be divided in different functional areas:

1. Menu bar
2. Device discovery
3. Device information and control
4. Video streaming
5. Image data analysis and logging
6. GenICam feature tree

The **menu bar** gives you access to the settings, tools and wizards of the application.

The **device discovery** panel lists the NICs of your computer and the cameras connected to them. A refresh button on the top allows you to perform a discovery and enumeration of the GigEVision devices connected to your network.
Each device has a status icon which signals if it's reachable or not. An unreachable device can be symptom of a wrong IP configuration or that the same device is currently in use by another client application.
Next to each device there's a connect/disconnect button used to gain access to it.

In the **device info** tab is shown some essential information about the device currently selected in the discovery panel. This includes the device model, serial number, MAC address and current IP address.
In the **device control** tab you can select the desired access mode and the number of buffers you want to allocate for image grabbing.

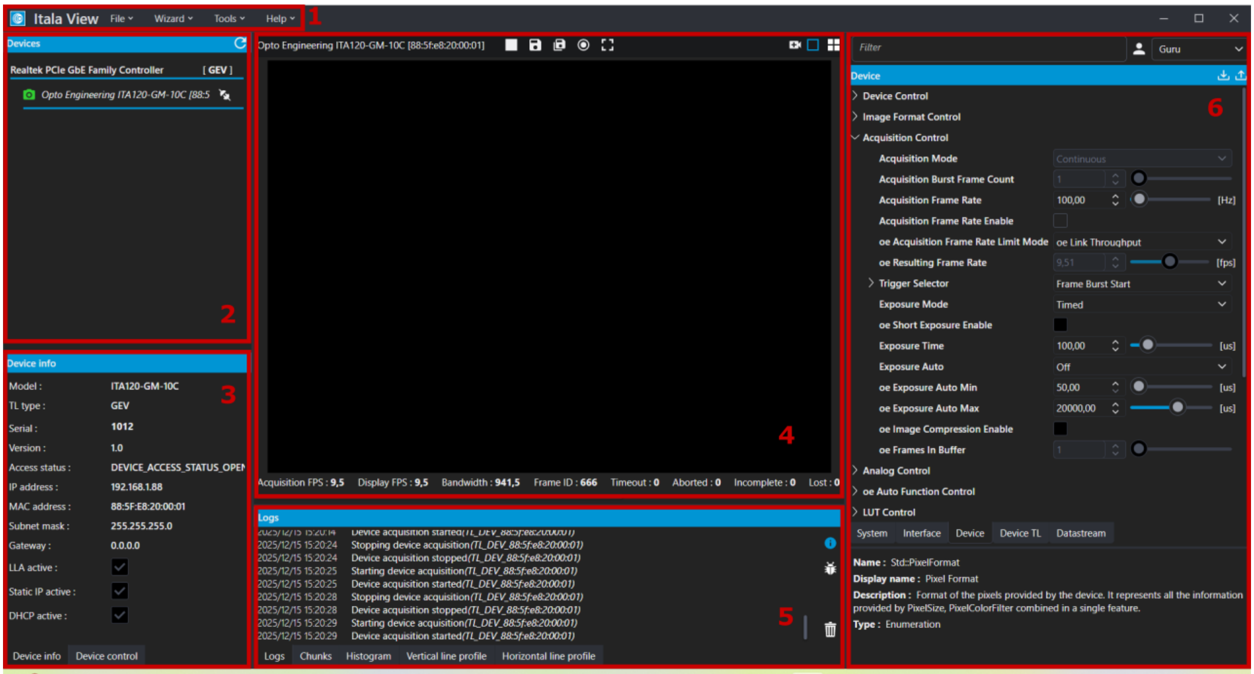


Figure 21: Viewer main window.

The **video streaming** view allows you to control the acquisition process and see the actual images grabbed by the camera.
On the top of the panel there are some quick access buttons to start/stop the acquisition, save images and toggle the full-screen mode.
On the bottom there's a status bar with statistics about the acquisition and useful information about the current image.

Using the **image data analysis and logging** tabs you can see the application log, current image chunk data and perform different types of analysis on the acquired image.

Through the **GenICam feature tree** you can access the camera parameters. The features are grouped by functions in a hierarchical manner and allow to configure the camera peripherals and/or read their status. These include basic functions, like the exposure time, gain or trigger settings and more advanced ones, like the encoder or the liquid lens controller.
You can use the tabs below the tree view to switch between the node maps of both GenTL modules and the connected device (selected by default).

4.7.2 IP configurator

From the *Tools* menu you can access the *IP Configurator* utility. The IP configurator has been designed to efficiently address network configuration issues of Itala cameras, including but not restricted to:

- Camera and NIC set with persistent IPs but different subnets

- Camera and NIC set with persistent IPs but different subnet masks
- Camera set in DHCP mode and NIC set with a persistent IP
- Camera set with a persistent IP and NIC set in DHCP mode

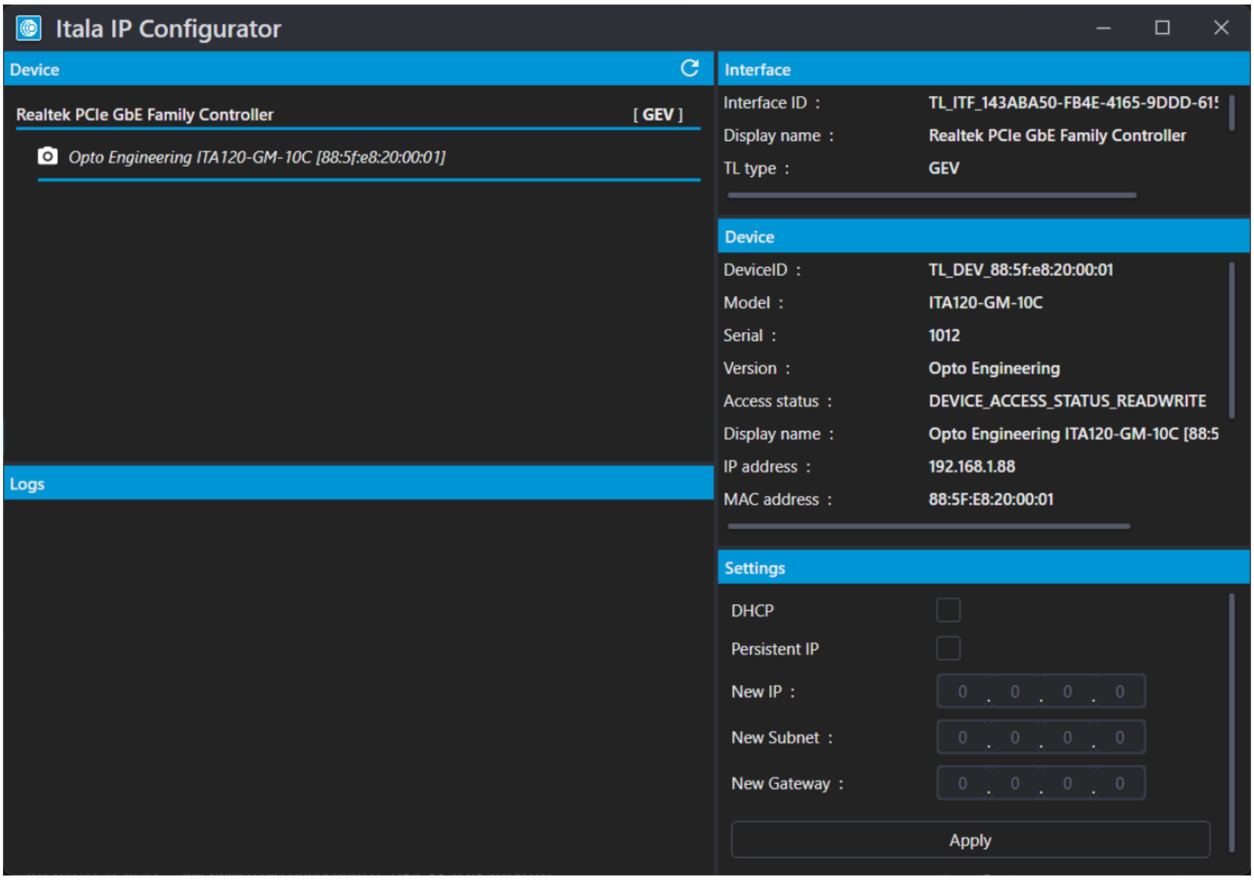


Figure 22: IP configurator window.

As can be seen in Fig.22, the IP configurator presents a panel for device discovery and enumeration similar to the one of the viewer main window. On the right relevant NIC and camera information related to the currently selected device in the aformentioned discovery panel can be seen.
IP configuration issues can be solved from the **settings** panel in the lower right corner. For example camera can be forces to adopt a persistent IP coherent with the current NIC IP settings. Just input the correct data and click the *Apply* button. In the log panel the configuration progress and check that the settings has been correctly applied can be seen.
As in the viewer main window, the icon next to each enumerated device show potential issues with a red warning sign.
For more information about the IP configuration of the camera refer to section 4.3.3.

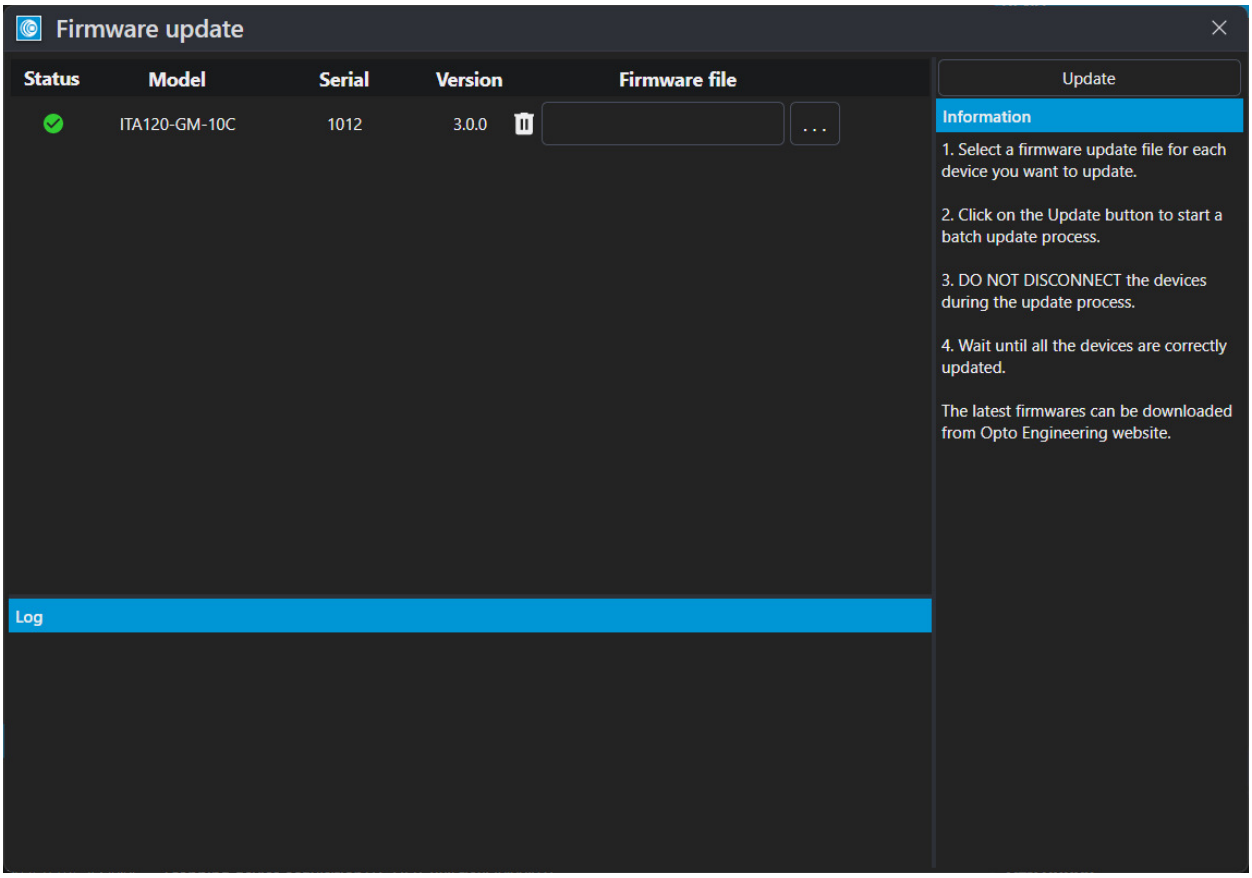


Figure 23: FW updater window.

4.7.3 Firmware update

From the *Tools* menu you can access to the *Firmware Update* utility (Fig.23). You can now select a firmware file for each device that has been enumerated. The latest firmware for Itala cameras can be downloaded from Opto Engineering website.
Follow this steps to update one or more devices:

1. Select a firmware update file for each device you want to update.
2. Click on the *Update* button to start a batch update process.
3. **Do not disconnect or power down** the devices during the update process (Fig.24). The LED blink signals that the camera is writing to the flash memory.
4. Wait until all the devices are correctly updated.

> ***NOTE**: **do not disconnect or power down** the device during the update process. Failing to do so could lead to a condition where the device is no longer bootable and it should be returned to Opto Engineering for a factory reset.*

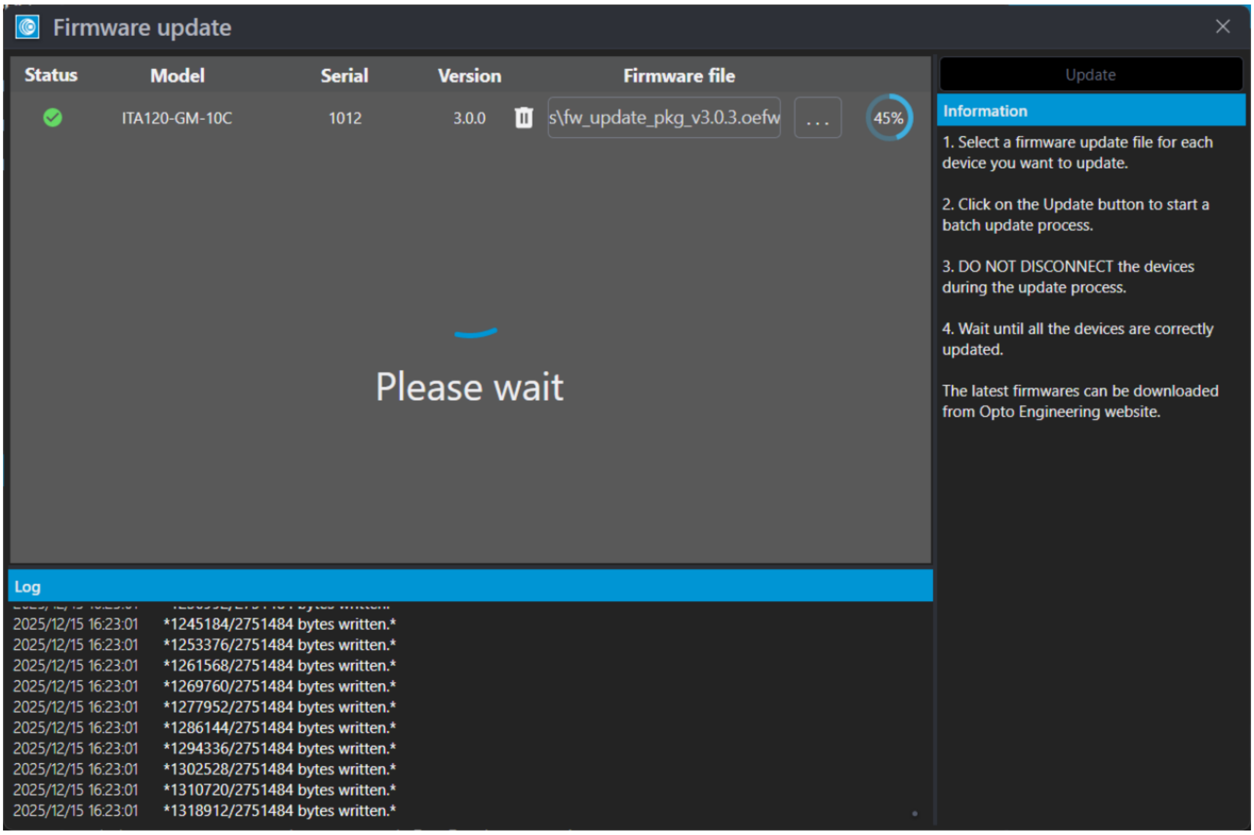


Figure 24: FW update in progress.

4.7.4 LUT wizard

From the *Wizard* menu you can access to the *LUT* wizard. This allows to view and edit the LUT of the selected camera.
Click on *Import from camera* to read the LUT from the camera registers and display it in the *Chart* tab (Fig.25). You can now edit each value the LUT in the *Table* tab (Fig.26). A better way to set a specific LUT is to load a CSV file previously generated with a spreadsheet editor or similar software. You can also write the current LUT on a CSV file, edit it and then read it back.
When you're satisfied with the resulting LUT, click on *Apply* to save it in the camera memory. For more information about the LUT feature refer to section 6.6.1.

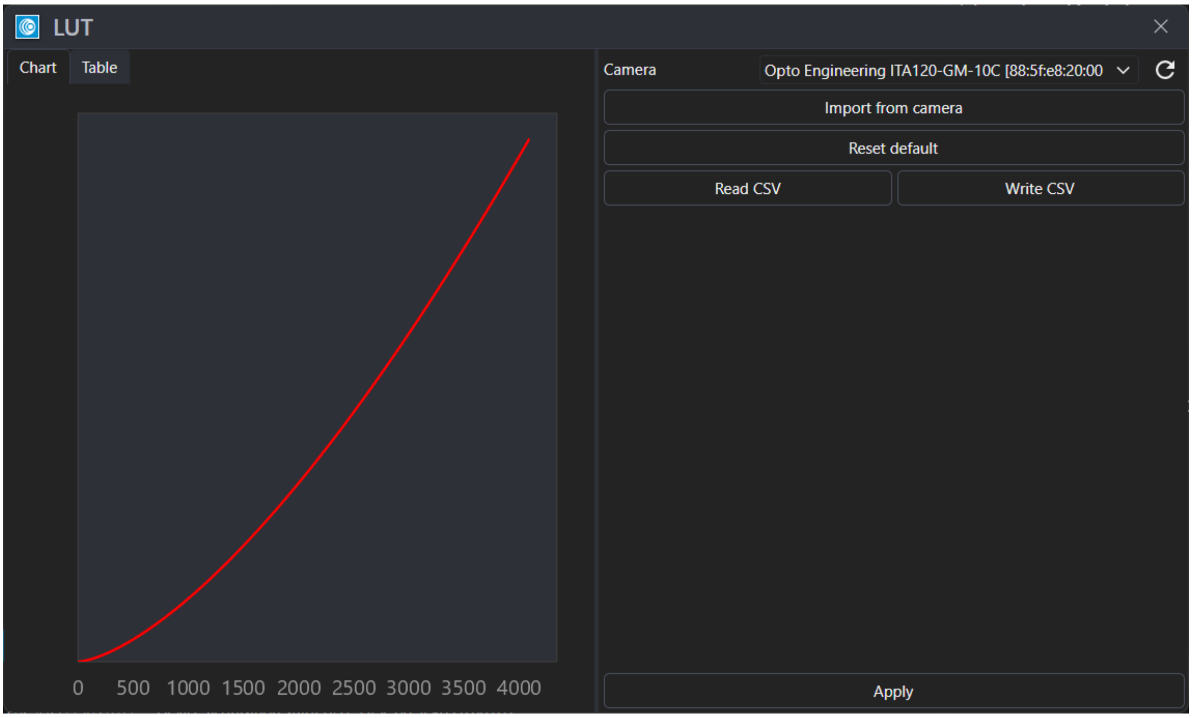


Figure 25: LUT wizard.

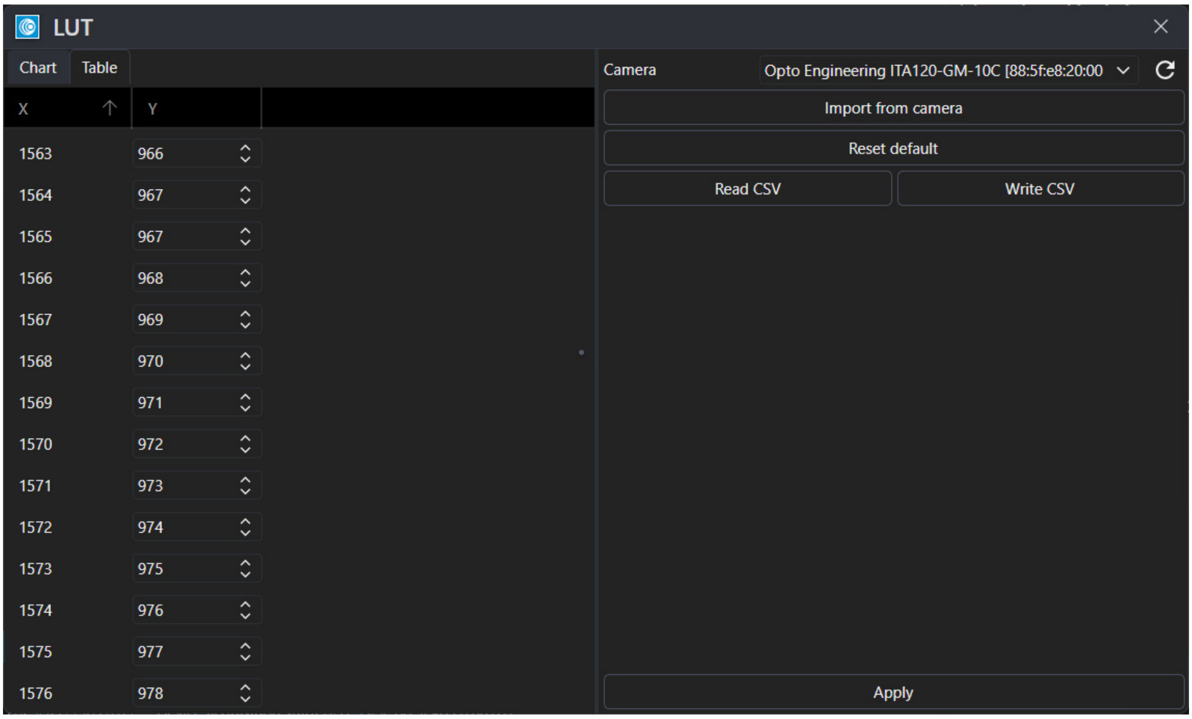


Figure 26: LUT wizard.

4.7.5 Defective pixels correction wizard

The image sensor defective pixels are mapped during Itala cameras production and testing procedures, since most of them are related to the sensor silicon production process. Their values are then corrected real-time in the camera acquisition pipeline. For more information about the defective pixel correction refer to section 6.18.
Anyway, there are other environmental factors which can increase the amount of defective pixels during the camera life. For this reason, Itala cameras enable the user to perform a custom pixel correction that takes into account these defects.
In order to enable the user defined defective pixel correction, the result of this operation must be saved in one of the available user set. The default user set, in fact, will correct only the defective pixels detected in factory.

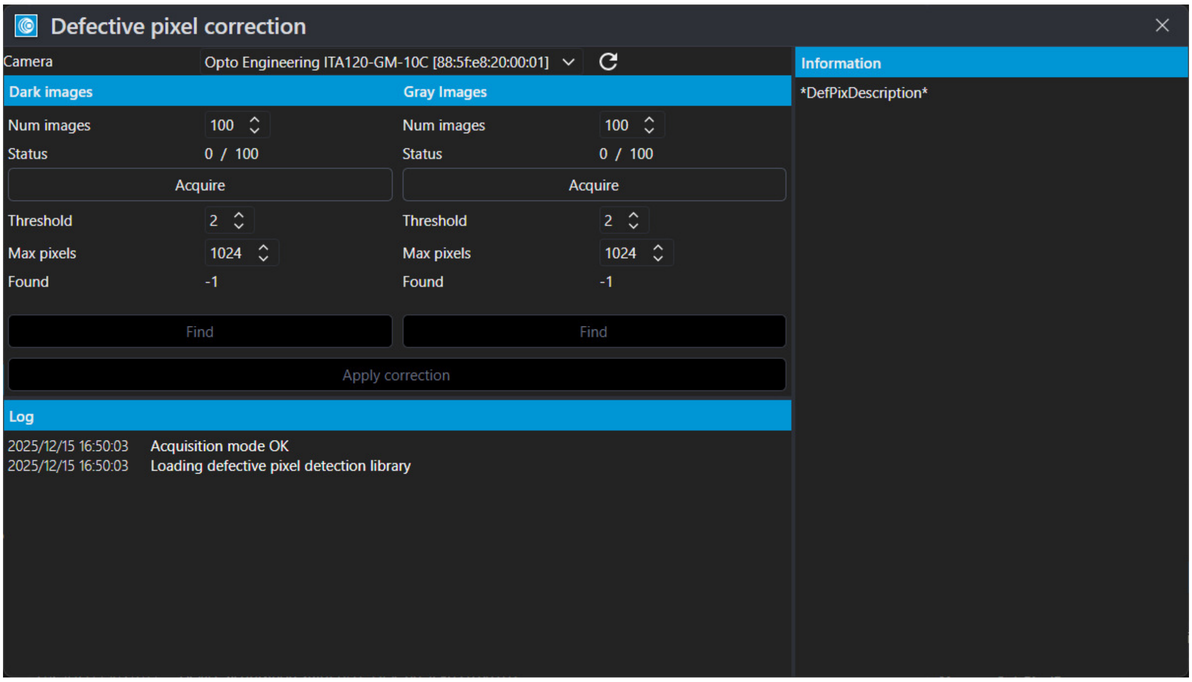


Figure 27: Defective pixels correction wizard.

From the *Wizard* menu you can access the *Defective Pixel Correction* wizard (Fig.27).

1. Put the camera in freerun acquisition or make sure there is a continuous stream of incoming trigger pulses.
2. For best results, consider using a raw pixel format with a bit depth of 12 bits, for example *Mono12p* or *BayerRG12*.
3. Start the image acquisition.
4. Cover the camera sensor.
5. Click on the *Acquire* button in the *Dark images* panel to acquire a first batch of dark images.

6. Click on the *Find* button on the same panel to detect the *leaky* pixels.
7. Expose the sensor to a uniform light source (suggested uniformity: >97%) in order to obtain an image with an average brightness of 50% of the maximum saturation level. You can adjust the exposure time to reach the desired level. **Keep in mind that the same exposure time should be used to acquire the dark images.**
8. Click on the *Acquire* button in the *Gray images* panel to acquire a second batch of gray images.
9. Click on the *Find* button on the same panel to detect the hot and cold pixels.
10. Click on *Apply correction* to upload the data to the camera.

In order to make this change permanent, you should save the current user set. Loading the default user set will restore the factory defective pixel correction.

4.7.6 Color correction wizard

From the *Wizard* menu you can access the *Color correction* wizard (Fig.28). With a reference color checker (Fig.29) is possible to calibrate the camera in specific light conditions and obtain an optimal color rendering. For more information about the color correction matrix refer to section 6.7.1.

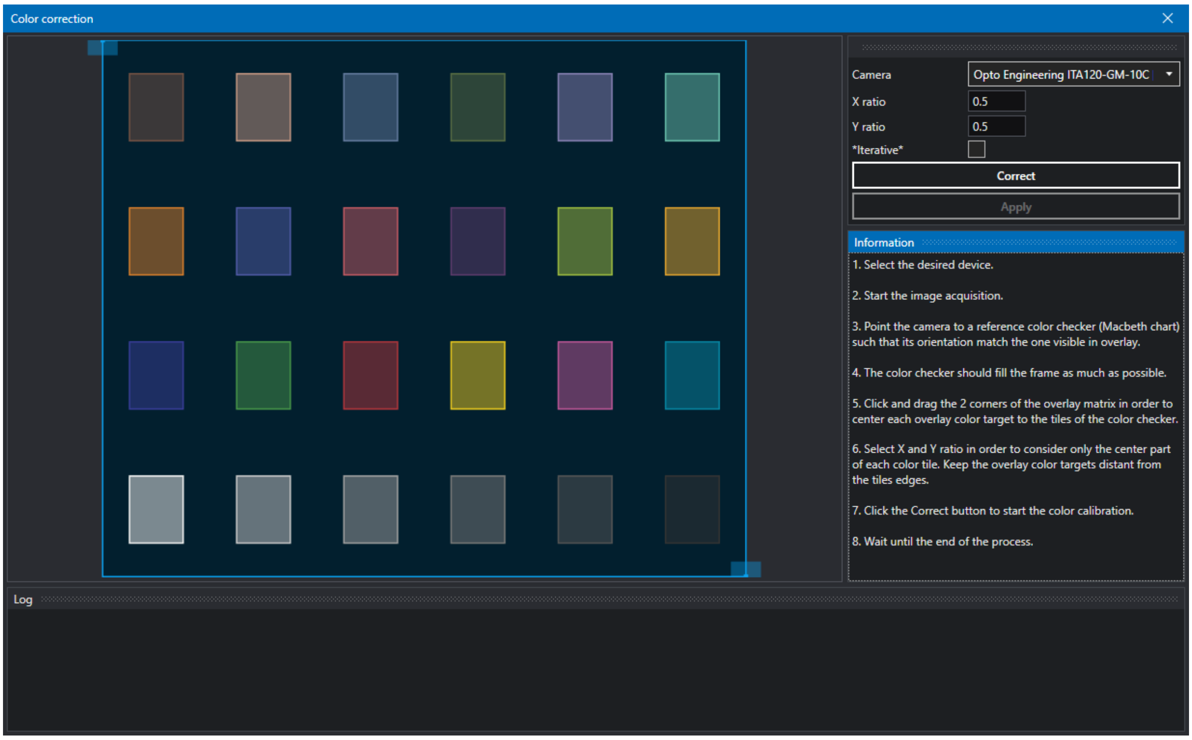


Figure 28: Color correction wizard.

Follow these steps to achieve a correct calibration:

1. Select the desired device.

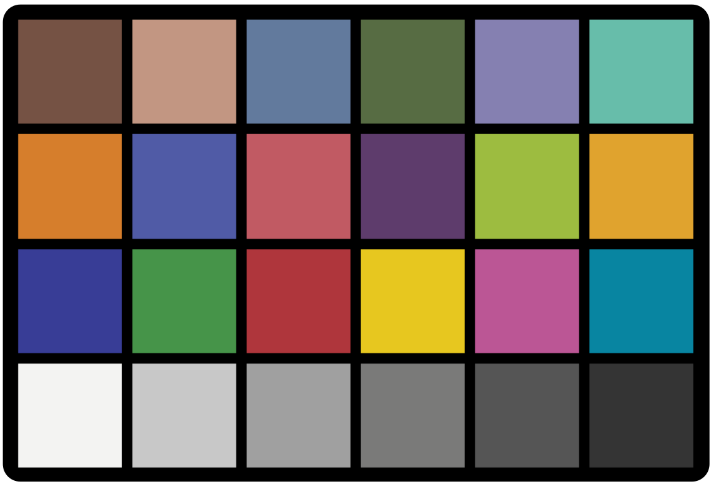


Figure 29: Reference color checker.

2. Start the image acquisition.
3. Open the Color Correction Wizard (*Wizard* > *Color correction*) (Fig.30).
4. Point the camera to a reference color checker (Macbeth chart) such that its orientation match the one visible in overlay.
5. The color checker should fill the frame as much as possible (Fig.31).
6. Click and drag the 2 corners of the overlay matrix in order to center each overlay color target to the tiles of the color checker.
7. Select X and Y ratio in order to consider only the center part of each color tile. Keep the overlay color targets distant from the tiles edges.
8. Click the *Correct* button to start the color calibration.
9. Wait until the end of the process.

In order to make this change permanent, you should save the current user set. Loading the default user set will restore the factory color correction matrix.

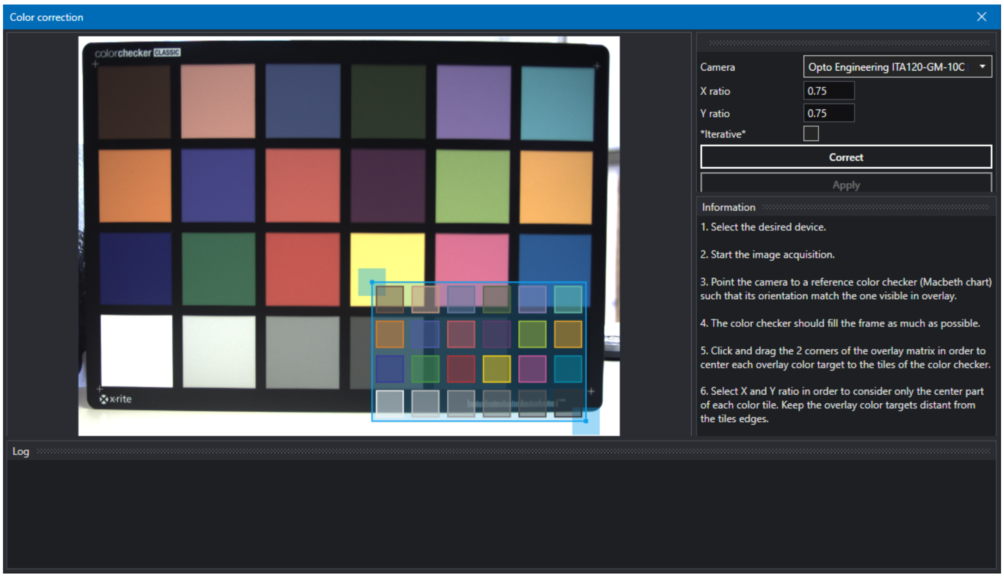


Figure 30: Window of the color correction wizard.

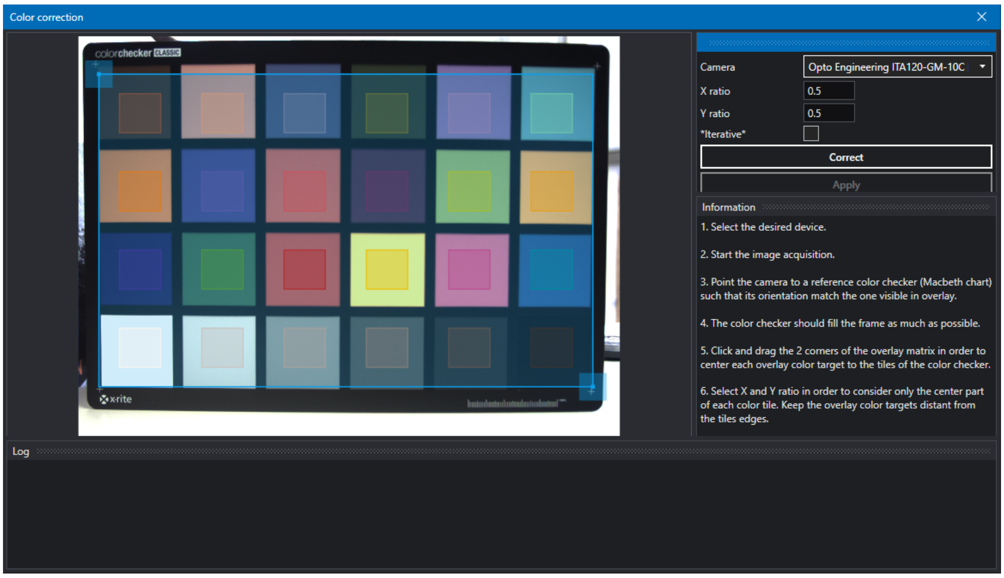


Figure 31: For optimal results, make sure to align the wizard color mask to the Macbeth color chart tiles.

OPTO ENGINEERING

5 TECHNICAL SPECIFICATIONS

5.1 Technical specifications

In Table 5.1 are summarized the main camera features.
Further explanations will be given in the following chapters.

Features	Standard version	Liquid Lens version	Ref. page
IMAGE FEATURES			
ADC resolution	10/12bit [1]	10/12bit [1]	-
Image buffer size	384MB	384MB	-
Image mirror (X/Y)	✓	✓	p.73
ROI mode	✓	✓	p.71
Decimation/binning	✓	✓	p.72
Pixel format	Mono8, Mono10Packed, Mono10p, Mono12Packed, Mono12p, RGB8, YUV422, YUV411, BayerRG8, BayerRG10p, BayerRG10Packed, BayerRG12p, BayerRG12Packed, Polarized [2]	Mono8, Mono10Packed, Mono10p, Mono12Packed, Mono12p, RGB8, YUV422, YUV411, BayerRG8, BayerRG10p, BayerRG10Packed, BayerRG12p, BayerRG12Packed, Polarized [2]	-
LUT/Gamma correction	✓	✓	p.106
Test pattern	✓	✓	p.93
Gain	✓	✓	p.104
Black level	✓	✓	p.107
Autoexposure	✓	✓	p.110
Autogain	✓	✓	p.110
Defective pixel correction	✓	✓	p.153
Debayering	✓[3]	✓[3]	p.90
White balance	✓[3]	✓[3]	p.104
Color correction matrix	✓[3]	✓[3]	p.114
Chunk data	✓	✓	p.141
CAMERA FEATURES			
Status LED indicator	✓	✓	p.63

OS compatibility	Windows 10, 11 (64 bit)	Windows 10, 11 (64 bit)	p.21
PoE (Power over Ethernet)	✓	✓	-
Gigabit ethernet	✓	✓	-
Packet resend option	✓	✓	-
Static IP/DHCP	✓	✓	-
IEEE 1588 (PTP)	✓	✓	-
Opto-isolated inputs	2	2	p.62
Opto-isolated outputs	4	1	p.62
Temperature sensor	Image sensor, FPGA	Image sensor, FPGA	-
User sets	Factory + 2 user sets	Factory + 2 user sets	-
Remote FW update	✓	✓	p.36
Burst acquisition	✓	✓	-
Trigger hardware	✓	✓	-
Trigger software	✓	✓	-
Timers	2	2	p.125
Counters	4	4	p.125
Encoder control	1 [4]	1 [4]	p.126
Logic blocks	4	4	p.129
Logic functions	OR, AND, LUT	OR, AND, LUT	p.129
Serial communication	RS232/485		p.145
Liquid Lens controller		✓	p.148
CERTIFICATIONS AND COMPLIANCES			
GigEVision compliance	✓	✓	-
GenICam compliance	✓	✓	-
CE certificate	✓	✓	p.8
Shock and Vibrations	✓	✓	p.9
RoHS	✓	✓	p.10
REACH	✓	✓	p.10
WEEE	✓	✓	p.10
ENVIRONMENTAL			
Storage temperature	-10°C - 60°C	-10°C - 60°C	p.12
Storage Humidity	RH < 80%	RH < 80%	p.12
Operating case temperature [5]	-25°C - 65°C	-25°C - 65°C	p.12
Operating ambient temperature [6]	-25°C - 50°C	-25°C - 50°C	p.12
Operating Humidity	RH < 80%	RH < 80%	p.12

[1] Sensor specific data.
[2] With BayerRG pixel format, also BayerGR, BayerGB, BayerBG are included in the available pixel formats. Polarized pixel format includes both Mono and Color, 8, 10p, 10Packed, 12p and 12Packed variants.
[3] Not available for monochrome sensors.
[4] Refer to paragraph 6.10 for the compatible encoder interfaces.
[5] Case temperature, measured on the front part of the camera body.
[6] Maximum ambient temperature without lens and without heat dissipation. Higher operating temperature can be achieved with proper heat dissipation (i.e., mounting the camera through a metal plate).

5.2 Electrical specifications

Electrical specifications of Itala cameras are summarized in Table 7.
Explanations about the I/O circuitry can be found in the section 5.7.

Parameter	MIN	TYP	MAX	UNIT
GENERAL				
Supply Voltage	12	-	24	[V]
Power consumption[1]	-	-	5	[W]
OPTO-ISOLATED INPUT				
Input voltage	0	-	30	[V]
Input HIGH voltage threshold	2.2	-	-	[V]
Input LOW voltage threshold	-	-	1.9	[V]
OPTO-ISOLATED OUTPUT				
Output voltage	0	-	+Vcc [2]	[V]
Output current	-	-	50 [3]	[mA]

[1] Maximum power to be used to supply product PS2 per 62368-1 and LPS per Annex Q.1 less than 100W.
[2] External power supply connected to the digital output + pin. Maximum power to be used to supply product PS2 per 62368-1 and LPS per Annex Q.1 less than 100W.
[3] Output current must be limited by the external load or an appropriate external resistor.

Table 7: Electrical specifications

5.2.1 Electrical input specifications

Figure 32 shows how the internal circuitry samples the input signals on Line0/Line1. Input voltages in the range 0–1.9 V are interpreted as a logic LOW, while voltages between 2.2–30 V are interpreted as a logic HIGH. Voltages above 30 V must not be applied.

Figure 33 highlights min/max input delay for both rising-edge and falling-edge logic.
Digital input represents the signal supplied to opto-isolated input of Itala camera.
Processed signal represents the signal after the processing performed by the input circuitry and after being sampled by the internal logic.
Processed signal is characterized by an average delay time and a jitter due to fluctuations of opto-isolated propagation delay and to the sampling performed by the internal logic (since digital input is asynchronous with respect to the internal clock). This jitter is depicted in figure 33 with a grey area. Minimum and maximum delay times represents the boudaries of this area.
Minimum/maximum input delays (when Itala camera is triggered by an external device) are shown in Table 8: column *Input voltage* defines the voltage level of the input triggering-signal.
Columns *MIN rise delay* and *MAX rise delay* show the signal propagation delay time from the input pin of the I/O connector to the image sensor trigger pin. In case of active low input signal, columns *MIN fall delay* and *MAX fall delay* should be considered.

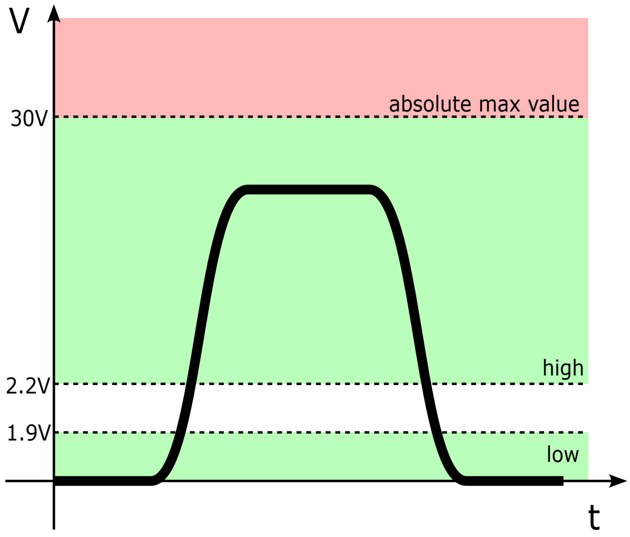


Figure 32: Input triggers between 0V-1.9V and 2.2V-30V are sampled as LOW and HIGH, respectively. Maximum input voltage threshold must not be exceeded.

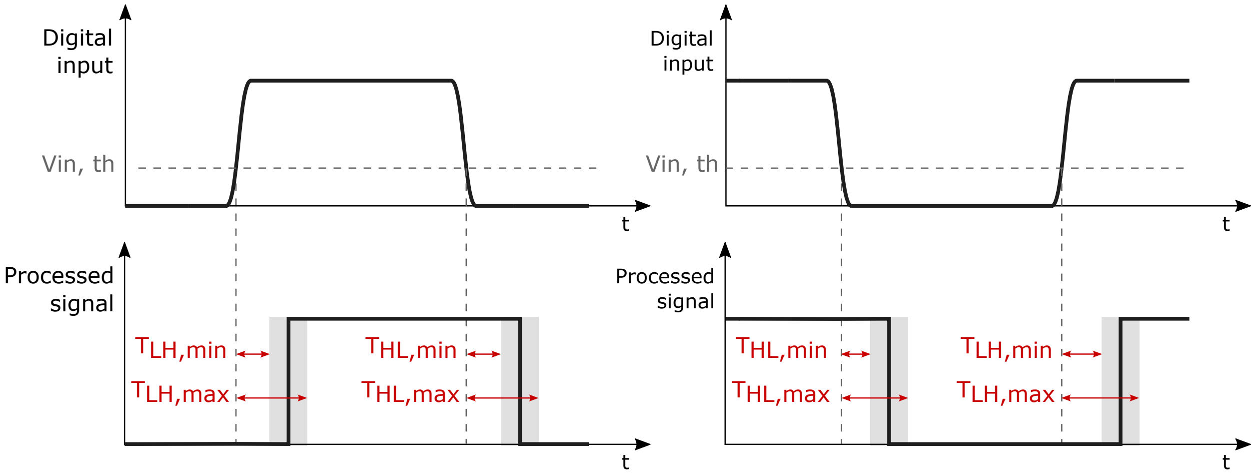


Figure 33: On the left: input trigger signal and processed signal (by input circuitry) in rising-edge logic. On the right: input trigger signal and processed signal (by input circuitry) in falling-edge logic.

Finally, column *MIN Input pulse* defines the minimum time of the input signal so that it's considered as a valid triggering signal (i.e. signal whose duration is lower than MIN Input pulse could not be correctly sampled by input circuitry).

> ***NOTE****: The difference between the minimum and maximum delays is the jitter due to the sampling of the input trigger signal.*

> ***NOTE***: *In Itala cameras a high performance opto-isolator is integrated in order to handle input trigger signals with minimum delay. This opto-isolated is also symmetrical (i.e. MIN/MAX rise delay are equal to MIN/MAX fall delays), so rising-edge triggering performances are equal to falling-edge ones.*

Input voltage [V]	MIN rise delay ($t_{LH,min}$) [us]	MAX rise delay ($t_{LH,max}$) [us]	MAX fall delay ($t_{HL,max}$) [us]	MIN fall delay ($t_{HL,min}$) [us]	MIN Input Pulse ($t_{pulse,min}$) [us]
3.3	1.5	2.5	1.5	2.5	2
5	1.5	2.5	1.5	2.5	2
12	1.5	2.5	1.5	2.5	2
24	1.5	2.5	1.5	2.5	2

Table 8: Minimum and Maximum input delays when Itala cameras are triggered by an external device

5.2.2 Electrical output specifications

Table 9 shows the electrical specifications of Itala opto-isolated outputs.
Columns *Supply Voltage* and *Load Res* define respectively the supply voltage connected to the *OPTO REF V+* pin and the load resistance connected to the opto-isolated output pin.
Column *Meas Output Current* shows the measured current flowing through the opto-isolator, while *Meas Output Voltage* shows the measured voltage on the opto-isolator output pin, considering the working condition of supply voltage and load resistance. Column *MAX Output delay* defines the maximum propagation delay from the input to the output of the opto-isolator.

Figure 34 highlights max output delay for both rising-edge and falling-edge logic.
Internal strobe signal represents the internal signal which the user wants to output to one of the opto-isolated output pins (e.g. exposure signal).
Digital output represents the signal after the processing performed by the output opto-isolated circuitry.
Digital output is characterized by an output delay due to the response time of the opto-isolator: this delay, represented by a grey area in Figure 34, can fluctuate over time due to changing in the operation conditions: supplied voltage oscillations, temperature changing, variations in the output load resistance. Table 9 specifies the maximum output delay, in order to deal with the worst case scenario.

> ***NOTE***: *Output opto-isolators don't show symmetrical behaviour, i.e. rising-edge logic and falling-edge logic differ in terms of current and output delay.*

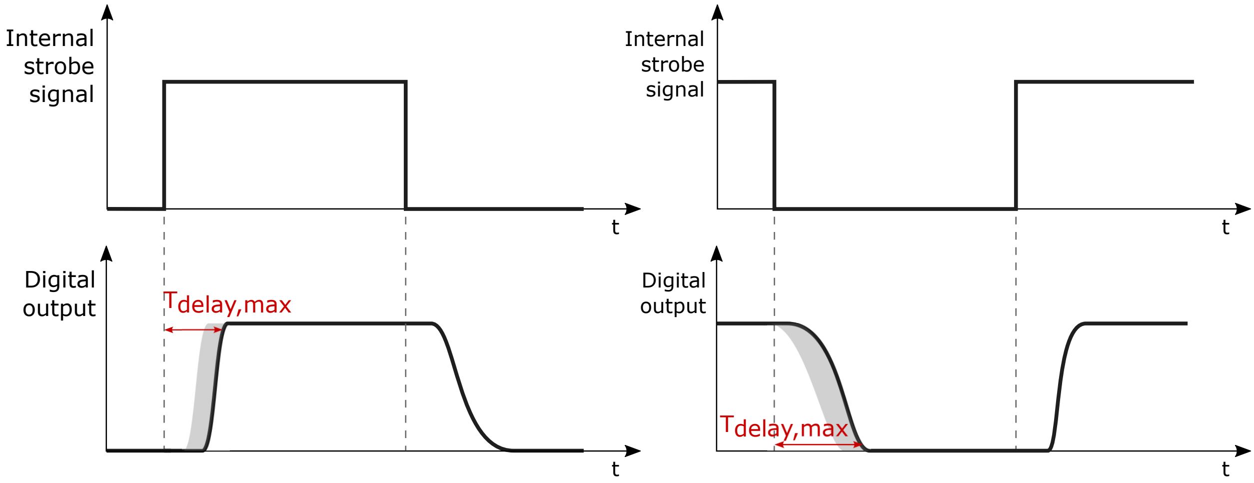


Figure 34: On the left: internal strobe signal and digital output in rising-edge logic. On the right: internal strobe signal and digital output in falling-edge logic.

Supply Voltage [V]	Load Res [ohm]	MAX Output delay [μs]	Meas Output Voltage [V]	Meas Output Current [mA]
RISING-EDGE LOGIC				
3.3	150	3.5	2.1	14.0
	330	3.5	3.0	8.8
	560	3.4	3.2	5.6
	1000	3.3	3.2	3.2
5	330	3.5	4	12.1
	560	3.5	4.5	8.0
	1000	3.5	4.7	4.7
	2200	3.4	4.8	2.2
12	330	3.8	8.5	25.6
	560	3.8	10.2	18.2
	1000	3.7	11.4	11.3
	2200	3.6	12.0	5.4
24	560	4.0	16.5	29.5
	1000	4.0	21.0	21.0
	2200	3.9	23.2	10.6
	4700	3.8	23.7	5.1
FALLING-EDGE LOGIC				
3.3	150	6.6	2.1	14.2
	330	17.3	3.0	9.1
	560	27.3	3.1	5.6

	1000	34.8	3.2	3.2
5	330	9.6	4.0	12.2
	560	20.6	4.6	8.2
	1000	30.7	4.7	4.7
	2200	42.2	4.8	2.2
12	330	1.8	8.4	25.6
	560	4.7	10.2	18.2
	1000	12.0	11.4	11.4
	2200	31.3	12.0	5.4
24	560	1.5	17.0	30.3
	1000	4.0	21.2	21.2
	2200	15.8	23.3	10.6
	4700	36.9	23.8	5.1

Table 9: Maximum output delays and electrical measurements for Itala cameras output signals

5.3 Sensor optical response

Typically all the 1st generation Sony IMX sensors exhibit the same optical response.
The relative transmittance for monochrome and color sensors is shown in Fig.35 and Fig.36.
Please refer to section 1.5 to retrieve the information about the image sensor family.

Typically all the 2nd generation Sony IMX sensors exhibit the same optical response.
The relative transmittance for monochrome and color sensors is shown in Fig.37 and Fig.38.
Please refer to section 1.5 to retrieve the information about the image sensor family.

Typically all the 4th generation Sony IMX sensors exhibit, on average, the same optical response.
The relative transmittance for monochrome and color sensors is shown in Fig.39 and Fig.40.
Please refer to section 1.5 to retrieve the information about the image sensor family.

The relative transmittance for Sony IMX990 SenSWIR™ sensor is shown in Fig.41.
Please refer to section 1.5 to retrieve the information about the image sensor family.

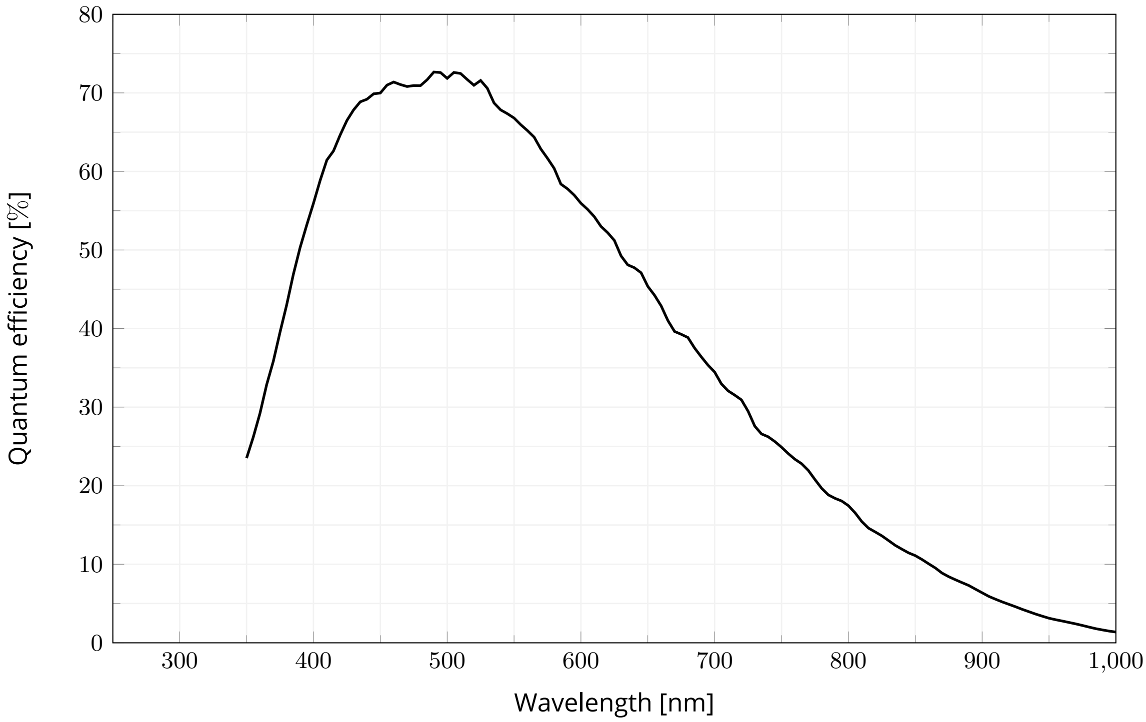


Figure 35: 1st gen Sony IMX monochrome sensors.

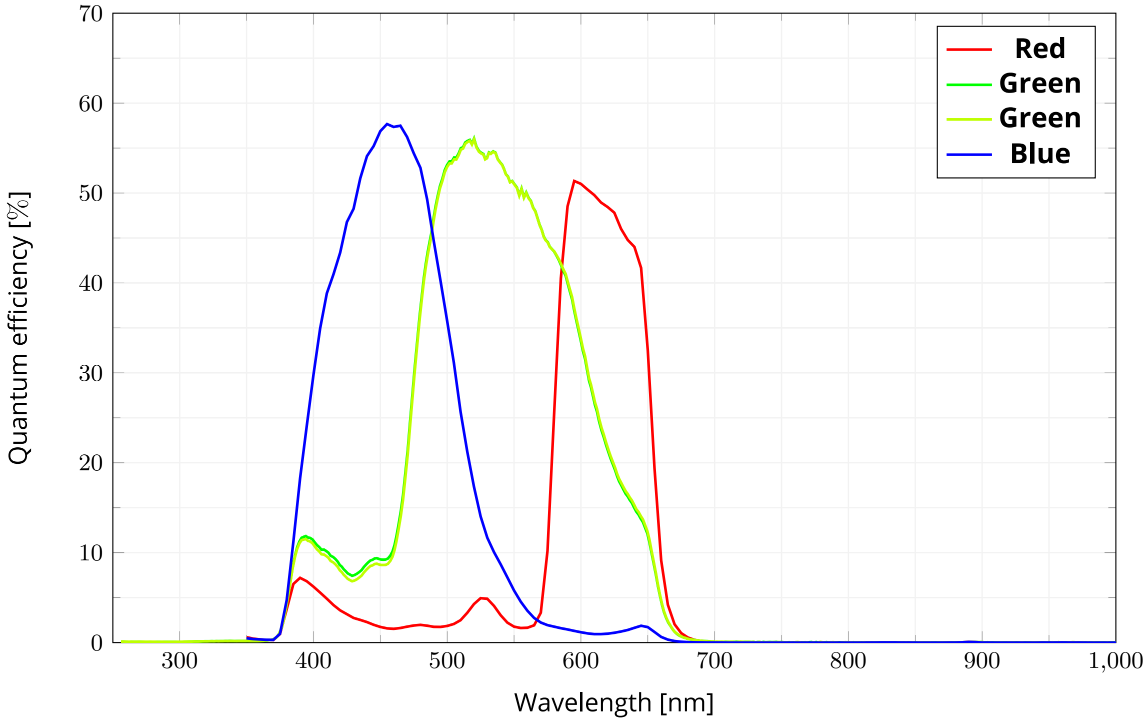


Figure 36: 1st gen Sony IMX color sensors.

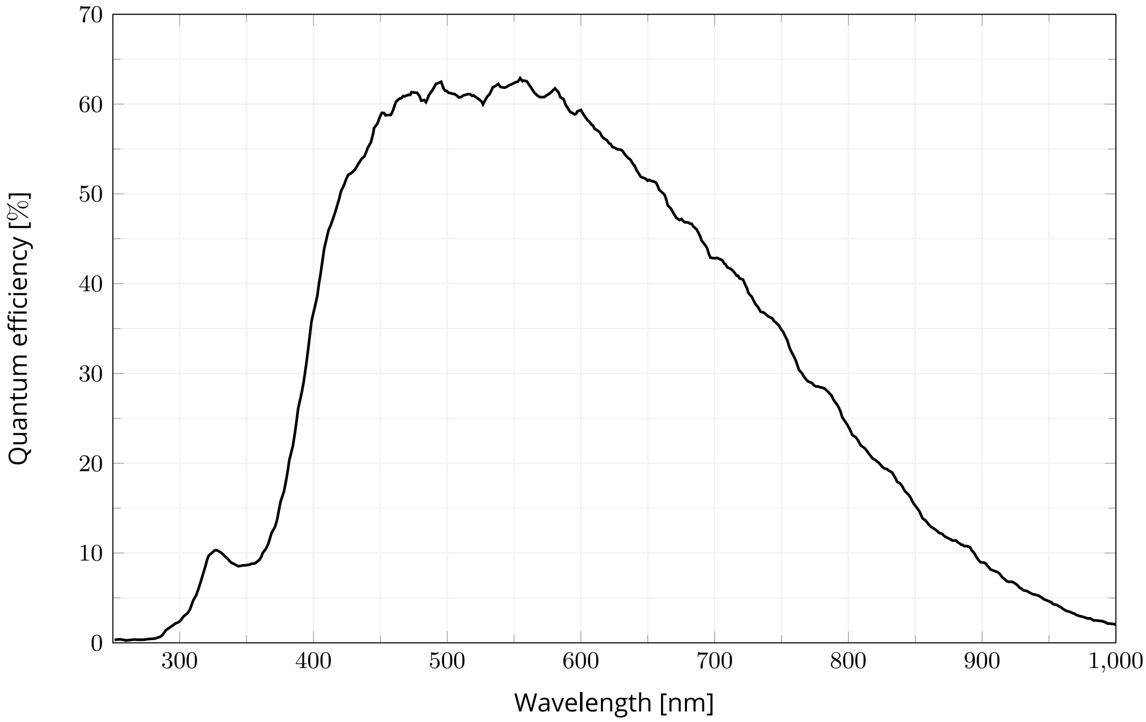


Figure 37: 2nd gen Sony IMX monochrome sensors.

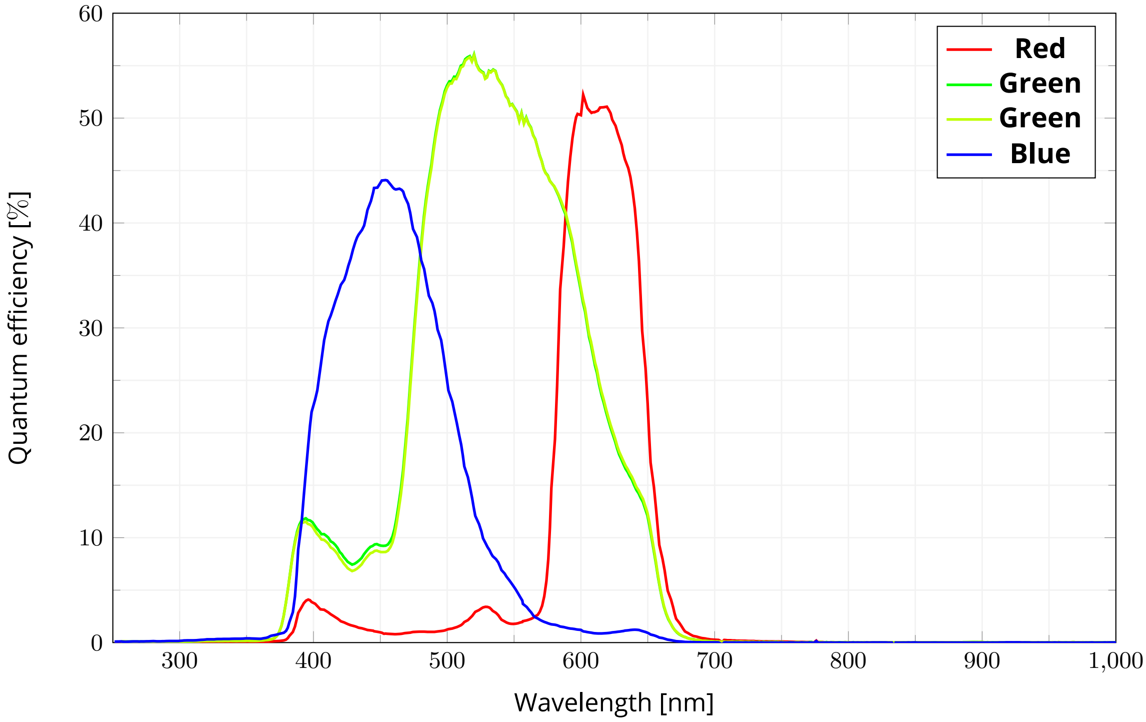


Figure 38: 2nd gen Sony IMX color sensors.

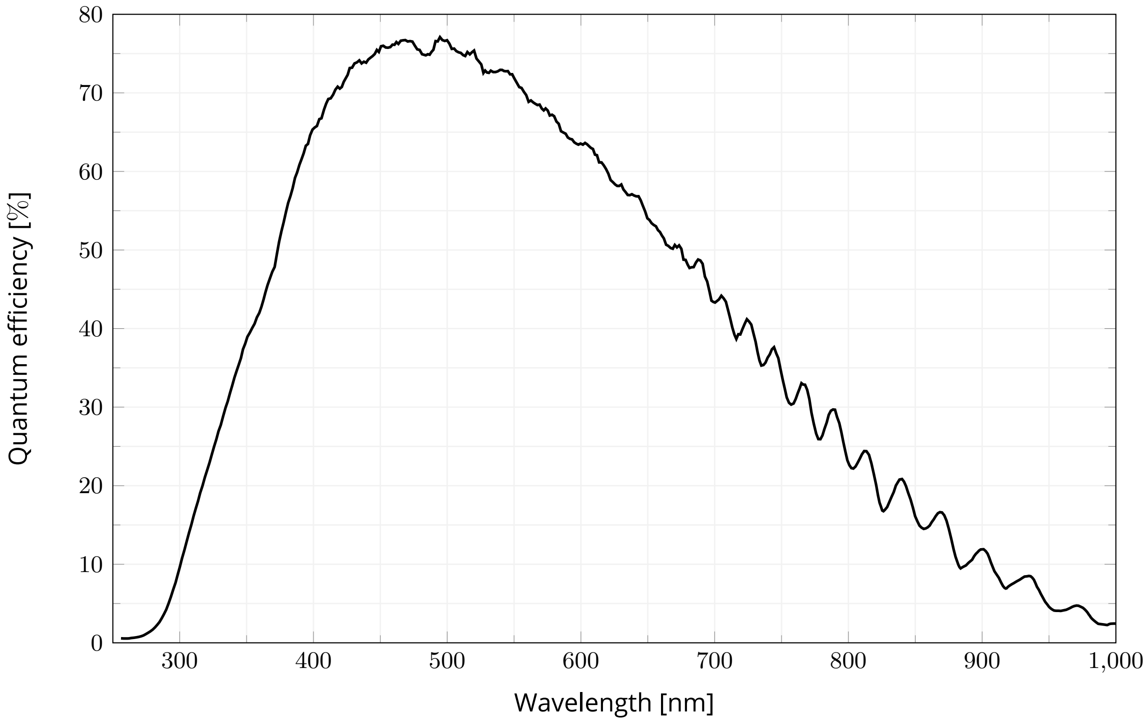


Figure 39: 4th gen Sony IMX monochrome sensors.

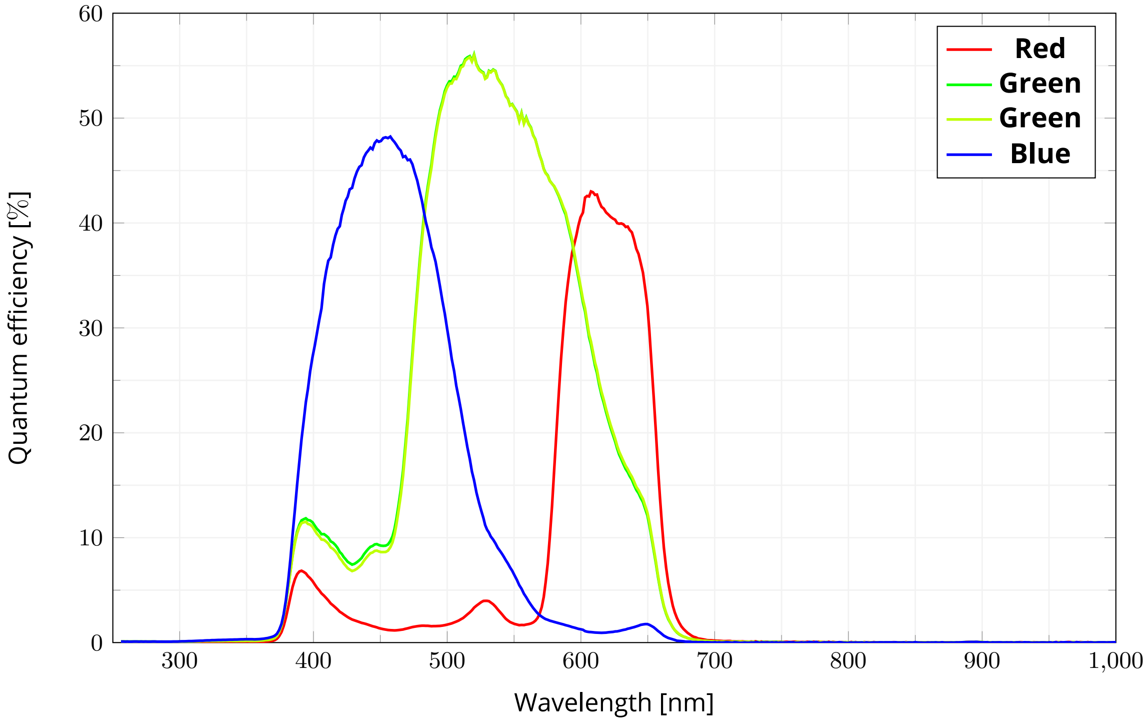


Figure 40: 4th gen Sony IMX color sensors.

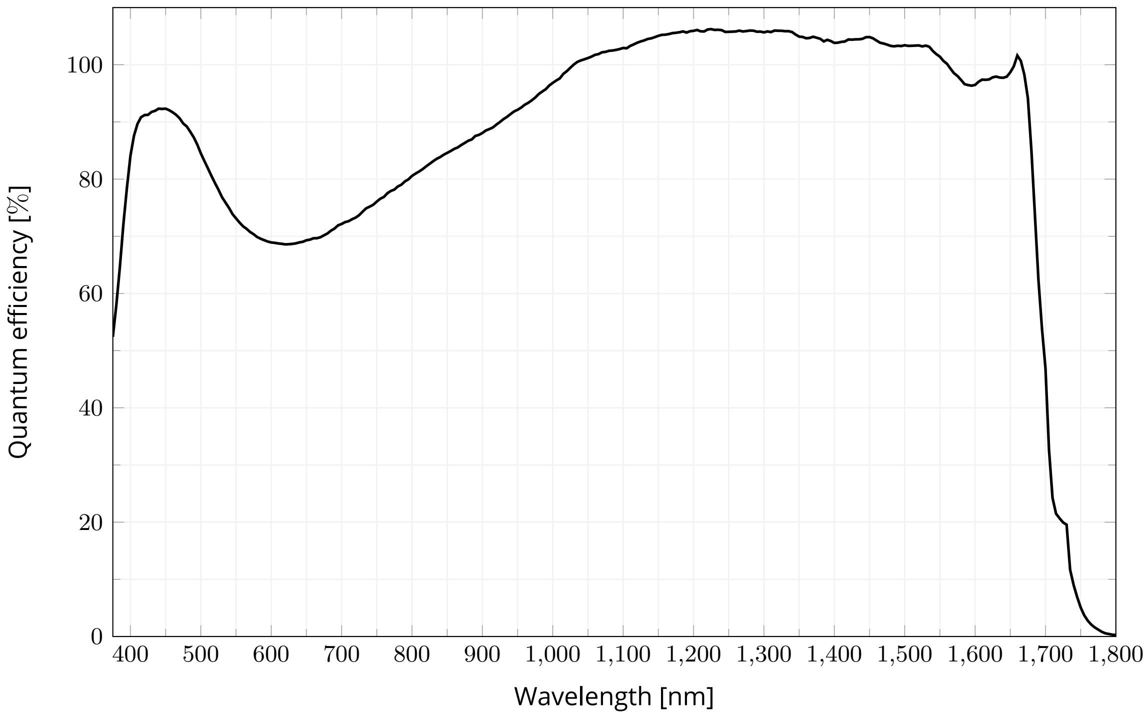
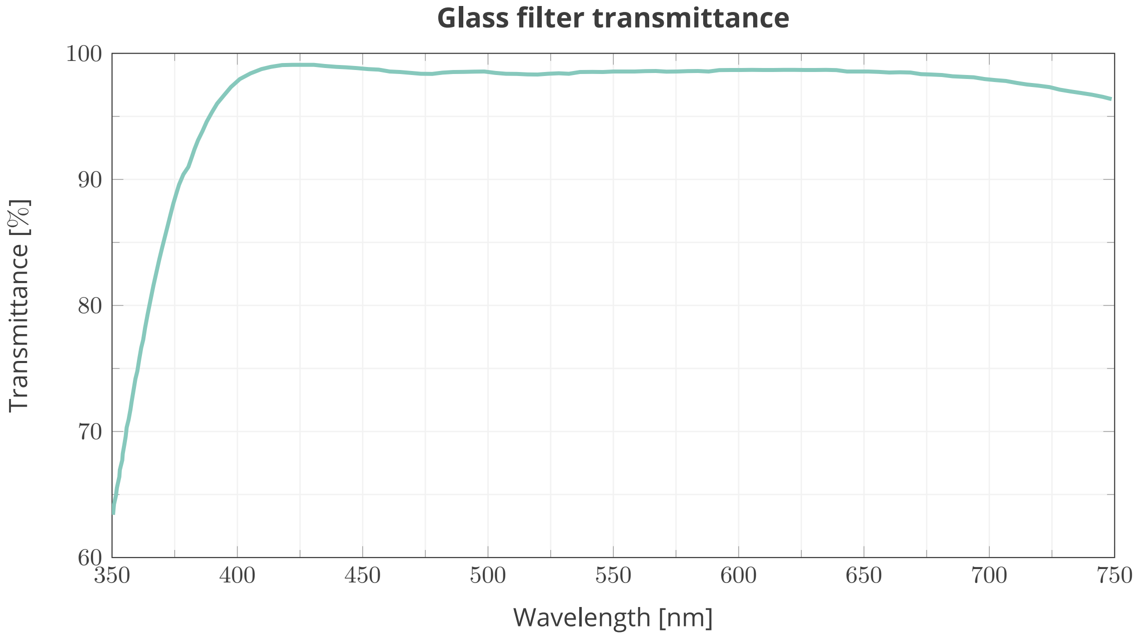


Figure 41: Sony IMX990 SenSWIR™ monochrome sensor.

5.4 Optical filters

The following figures show the transmittance characteristics of the available optical filters for the Itala camera series.



5.5 Mechanical specifications

5.5.1 Dimensional drawings

ITALA G - G.EL

The **TYPE 1** drawings (Figure 42) refers to all cameras with sensors up to 1.2" image format. These are equipped with a standard **C mount** (1 inch diameter, 32 threads per inch), with a flange distance of **17.526 mm**.

The **TYPE 2** drawings (Figure 43) refers to all cameras with sensors from 4/3" to APS-C image format. These are equipped with an **M42x1** threaded mount, with a flange distance of **12 mm**.

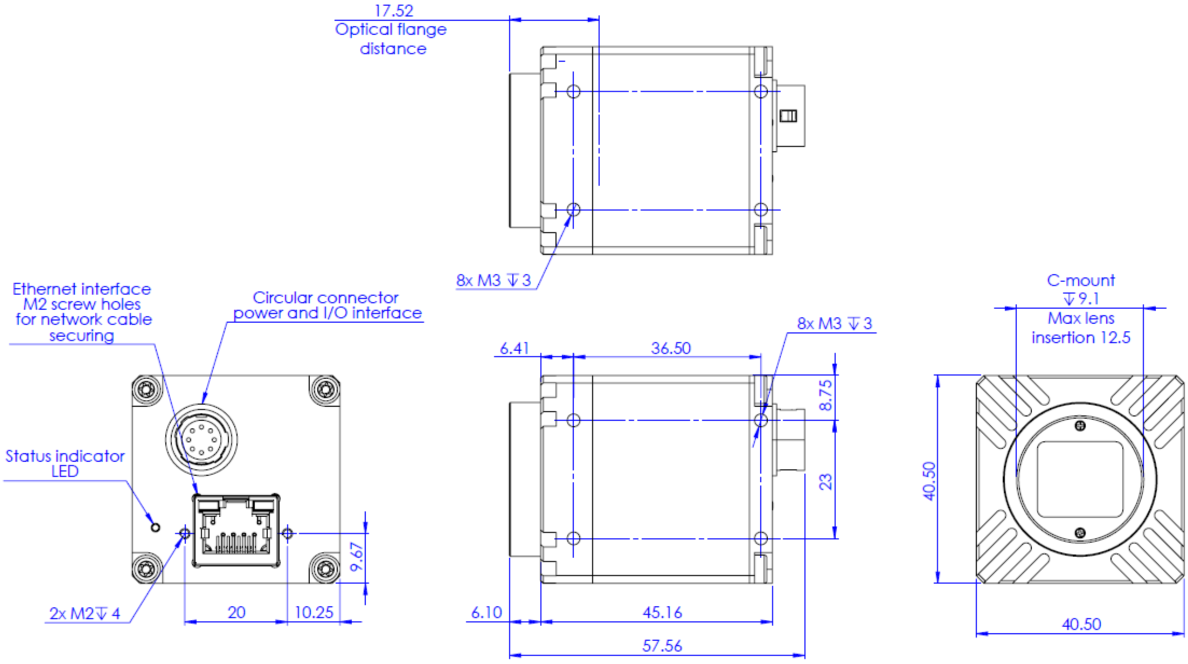


Figure 42: TYPE 1 dimensional drawings.

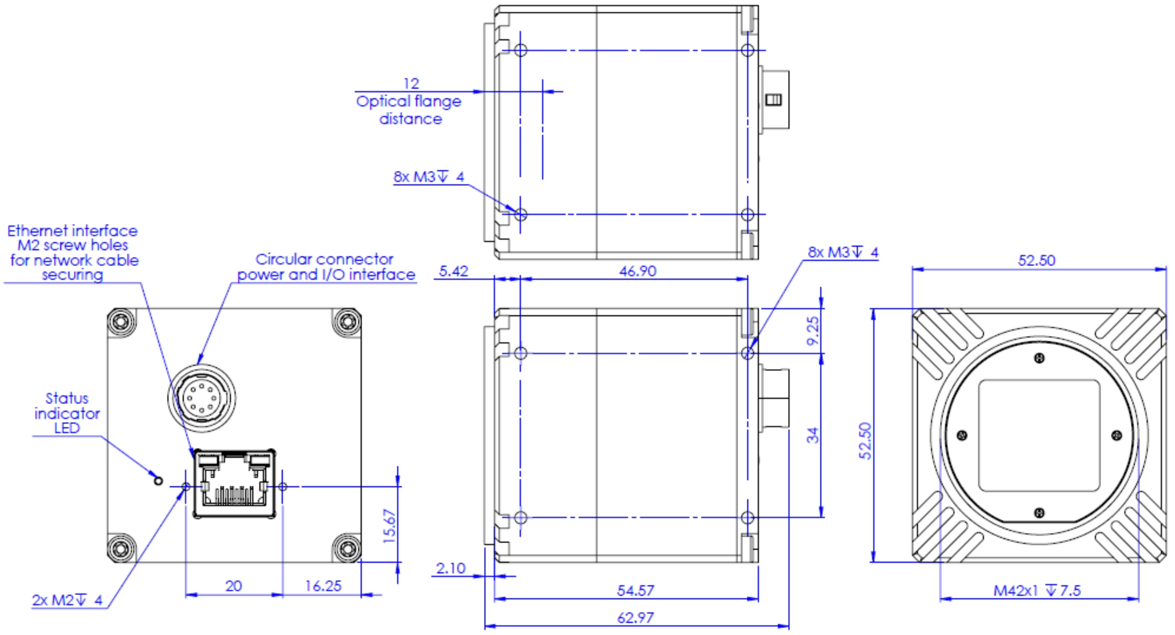


Figure 43: TYPE 2 dimensional drawings.

ITALA G.IP

The drawings in Figure 44 refers to all the IP67 cameras. These are equipped with a standard **C mount** (1 inch diameter, 32 threads per inch), with a flange distance of **17.526 mm**.

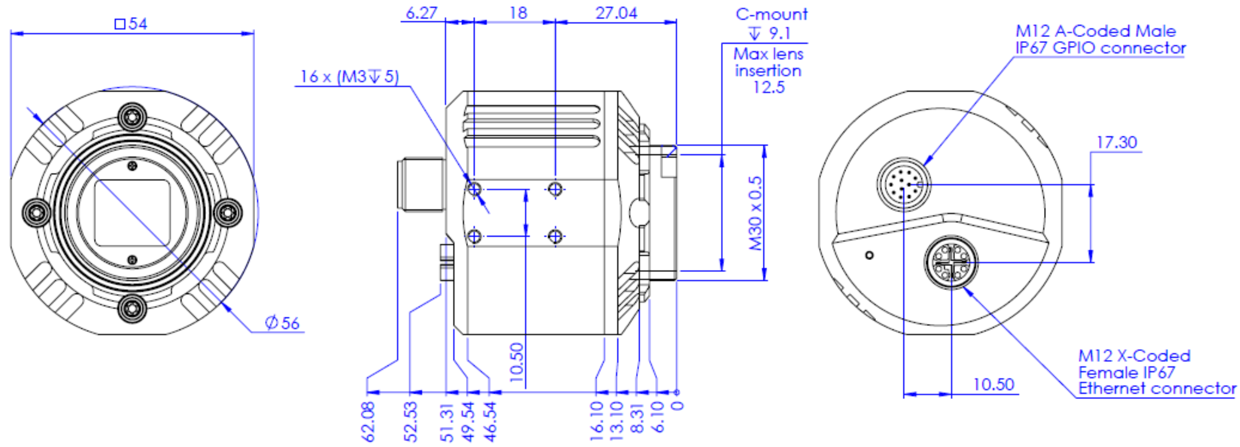
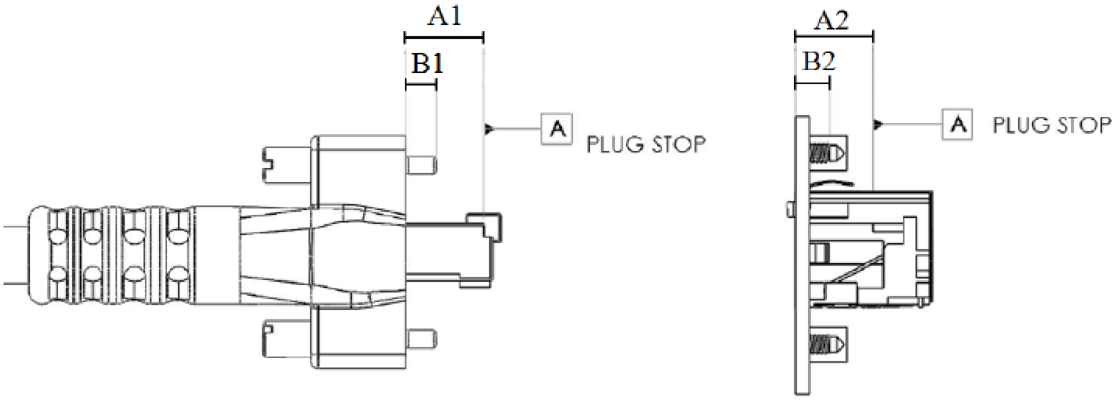


Figure 44: ITALA G.IP dimensional drawings.

5.5.2 GigE Vision mechanical requirements

Itala cameras are designed in full compliance with the GigE Vision mechanical specifications. The implemented configuration corresponds to the **TYPE090** standard as defined in the *GigE Vision Mechanical Supplement* (Figure 45).



Dimension – Free connector	TYPE090	TYPE110
From overmold to plug stop (A1)	9.0 mm (-0.47, +0.00)	11.0 mm (-0.47, +0.00)
From overmold to tip of thumbscrews (B1)	4.25 mm (-1.00, +0.25)	4.25 mm (-1.00, +0.25)
Dimension – Fixed Connector	**TYPE090**	**TYPE110**
From contact point to plug stop (A2)	9.0 mm (-0.00, +1.00)	11.0 mm (-0.00, +1.00)
From contact point to bottom of thumbscrew thread (B2)	4.5 mm (-0.00, +1)	4.5 mm (-0.00, +1.00)

Figure 45: GigE Vision connector specifications

5.5.3 Sensor centering data

All cameras are tested after assembly to make sure the sensor is correctly centered. Measurements are taken in all six degrees of freedom relative to the lens mount to ensure optimal imaging performance. In Table 10 and 11 are reported tipical production values for the sensor centering relative to Figure 46.

Axis	Nominal	3σ
Roll	0°	0.4°
Yaw	0°	0.3°
Pitch	0°	0.5°
Horizontal shift (x)	0 mm	0.2 mm
Vertical shift (y)	0 mm	0.2 mm
FD (z)	17.53 mm	0.11 mm

Table 10: Sensor centering for C-mount cameras

Axis	Nominal	$3\,\sigma$
Roll	0°	0.6°
Yaw	0°	0.3°
Pitch	0°	0.5°
Horizontal shift (x)	0 mm	0.2 mm
Vertical shift (y)	0 mm	0.2 mm
FD (z)	12 mm	0.2 mm

Table 11: Sensor centering for J-mount cameras

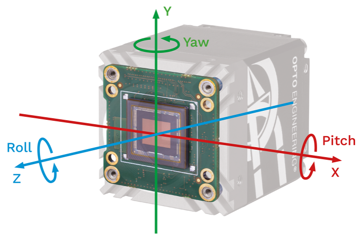


Figure 46: Sensor degrees of freedom.

5.6 Connectors and pinout

ITALA G - G.EL

The camera has two connectors:

- **Standard RJ45 connector with screw locks**
  Connection for image streaming and (optionally) for camera powering via PoE.

- **12-pin circular connector (P/N: HR10G-10R-12PB(71))**
  This connector has multi-purpose pins: power supply, trigger, synchronism, serial communication, liquid lens driver. The pinout is not fixed and depends on the camera model (standard or with liquid lens controller). Refer to Table 12 to see the pinout for both the camera models.

> ***NOTE***: *If a CBGPIO001 cable is used, check Opto Engineering® website to get the "color vs function" association.*

PIN	Standard	Liquid lens
1	GND	GND
2	+VIN	+VIN
3	Opto OUT 3	Lens -
4	Opto IN 0	Opto IN 0
5	Opto OUT 2	Lens +
6	Opto OUT 0	Opto OUT 0
7	Opto REF GND	Opto REF GND
8	RS232 RX	Lens SCL
9	RS232 TX	Lens SDA
10	Opto REF V+	Opto REF V+
11	Opto IN 1	Opto IN 1
12	Opto OUT 1	Lens +3.3V

Table 12: Itala pinout for both standard and liquid lens controller version.

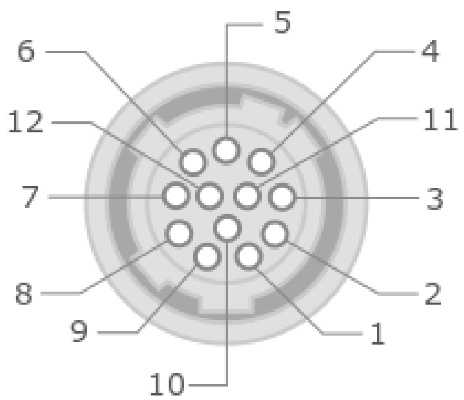


Figure 47: 12 pin circular connector pinout (camera front view)

ITALA G.IP

The camera has two connectors:

- **M12 X-Coded Female IP67 Ethernet connector (P/N: 394811-E)**
  Connection for image streaming and (optionally) for camera powering via PoE.

- **M12 A-Coded Male IP67 GPIO connector (P/N: 494518-E)**
  This connector has multi-purpose pins: power supply, trigger, synchronism, serial communication.

> ***NOTE**: If a RT-MSAS-12BFFM-SL8Dxx cable is used, check Opto Engineering® website to get the "color vs function" association.*

PIN	Standard
1	GND
2	+VIN
3	Opto OUT 3
4	Opto IN 0
5	Opto OUT 2
6	Opto OUT 0
7	Opto REF GND
8	RS232 RX
9	RS232 TX
10	Opto REF V+
11	Opto IN 1
12	Opto OUT 1

Table 13: Itala pinout for IP67 version.

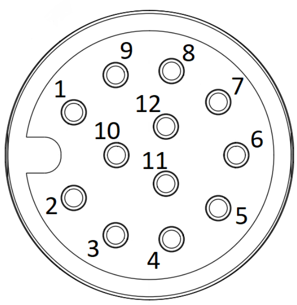


Figure 48: IP67 12-pin circular connector pinout (camera front view).

5.7 I/O circuitry

All input and output pins of the I/O connector are galvanically isolated.
All the electrical specifications and the maximum voltage/current ratings are listed in Table 7.

5.7.1 Opto Isolated Input

The opto-isolated input topology is schematically shown in Figure 49.

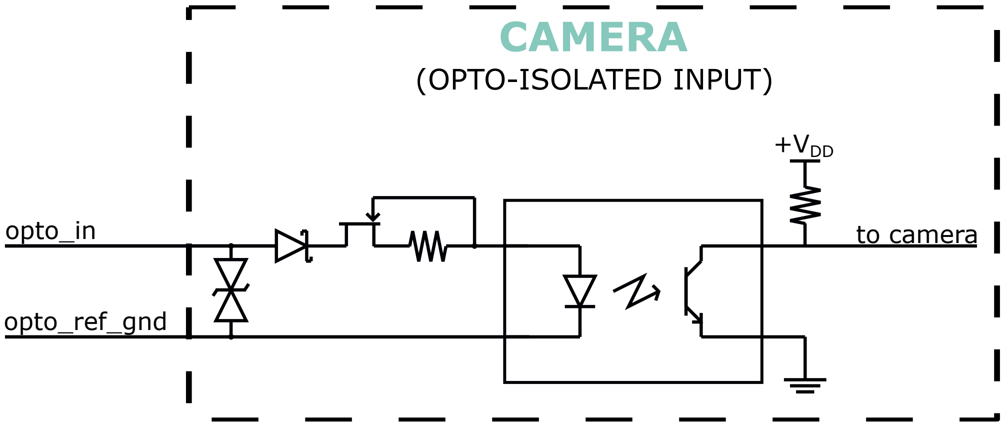


Figure 49: Opto isolated input topology.

A high-speed input isolator is used in the design to handle the input trigger signal with minimum propagation delay. A TVS diode is used as countermeasure against high voltage spikes, while a series diode prevents input polarity inversion. In addition, a current limiter circuit is also included in order to automatically adjust the input current.

> ***NOTE**: Be careful that any damage to opto-isolated input circuitry makes it not usable anymore.*

Some wiring diagram examples (both for opto-isolated and not-isolated systems) are shown in the "Wiring connection examples" chapter (7.1).

5.7.2 Opto Isolated Output

The opto-isolated output topology is schematically shown in Figure 50.

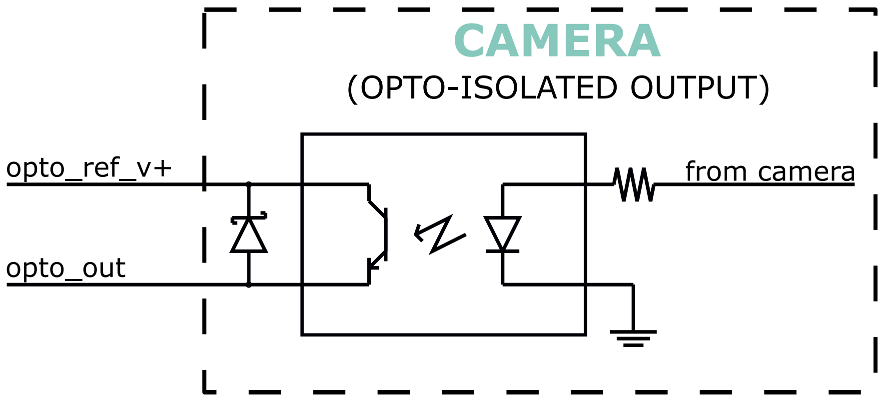


Figure 50: Opto isolated output topology.

In case of accidental connection on the output pins a bypass diode protects the transistor providing an alternate path for the current. The reference voltage for the opto-isolated output pins can be different from the power supply voltage, however the maximum specifications listed in Table 7 must not be exceeded.

5.8 LED indicators

All Itala cameras are equipped with an LED indicator on the back side of the housing, next to the connectors (see Figures 42, 43 and 44).
This LED provides a visual indication of the camera current operating status.
The color codes are listed in Table 14.

In addition, all Itala cameras except for the IP67 models have with two Ethernet status LED indicators on the back side of the housing, on the RJ45 connector (see Figures 42 and 43).
These LEDs provide a visual indication of the camera current Ethernet connection status.
The color codes are listed in Table 15.

Color	Camera status
Condition: camera working	
Yellow flashing	Camera start-up boot (at startup)
Yellow fixed	Camera ready
Green	Camera triggered
Condition: camera during firmware update	
Purple	Camera in boot mode
Purple/Cyan flashing	Camera is updating
Condition: fault	
Red fixed	Hardware fault - FPGA error
Red flashing fast - period: 500ms	Hardware fault - RAM error
Red flashing slow - period: 4s	Hardware fault - Image sensor error

Table 14: LED color codes indicating the camera status

Color	Ethernet status
Amber led - Network activity	
Yellow flashing	Data is actively being transferred
Off	No network activity
Green led - Connection status	
Green	1000 Mbps link
Off	100 Mbps link or absent link

Table 15: LEDs color codes for Ethernet status

6 CAMERA FEATURES

This chapter provides a summary of the standard and custom features of the Itala camera series. Features are defined following the *Standard Feature Naming Convention (SFNC)* and *GenICam* nomenclature. The following sections provide more detailed explanation of each feature.

6.1 Device Control

This section contains the features related to the control and information of the device.
This is mainly used to identify the device during the enumeration process and to obtain information about the device itself.
In Table 16 are listed all the Device Control parameters.

Feature	Description	Interface	Access
DeviceType	Returns the device type	IEnumeration	R
DeviceScanType	Scan type of the sensor of the device	IEnumeration	R
DeviceVendorName	Name of the manufacturer of the device	IString	R
DeviceModelName	Model of the device	IString	R
DeviceManufacturerInfo	Manufacturer information about the device	IString	R
DeviceVersion	Version of the device	IString	R
DeviceFirmwareVersion	Version of the firmware in the device	IString	R
DeviceSerialNumber	Device serial number	IString	R
DeviceUserID	User-programmable device identifier	IString	RW
DeviceTLType	Transport Layer type of the device	IEnumeration	R
DeviceTLVersionMajor	Major version of the Transport Layer of the device	IInteger	R
DeviceTLVersionMinor	Minor version of the Transport Layer of the device	IInteger	R
DeviceLinkSelector	Selects which Link of the device to control	IInteger	RW
DeviceLinkSpeed	Indicates the speed of transmission negotiated on the specified Link	IInteger	R

DeviceLinkThroughputLimitMode	Controls if the DeviceLinkThroughputLimit is active	IEnumeration	RW
DeviceLinkThroughputLimit	Limits the maximum bandwidth of the data that will be streamed out by the device on the selected Link	IInteger	RW
DeviceLinkHeartbeatMode	Activate or deactivate the Link's heartbeat	IEnumeration	RW
DeviceLinkHeartbeatTimeout	Controls the current heartbeat timeout of the specific Link	IFloat	RW
DeviceLinkCommandTimeout	Indicates the command timeout of the specified Link. This corresponds to the maximum response time of the device for a command sent on that Link	IFloat	RW
DeviceReset	Resets the device to its power up state. After reset, the device must be rediscovered. Note that some Transport Layers require the acknowledgement of the DeviceReset command before starting the actual reset of the device	ICommand	W
DeviceFeaturePersistenceStart	Indicate to the device and GenICam XML to get ready for persisting of all streamable features	ICommand	W
DeviceFeaturePersistenceEnd	Indicate to the device the end of feature persistence	ICommand	W
DeviceRegistersStreamingStart	Prepare the device for registers streaming without checking for consistency	ICommand	W
DeviceRegistersStreamingEnd	Announce the end of registers streaming	ICommand	W
DeviceTemperatureSelector	Selects the location within the device, where the temperature will be measured	IEnumeration	RW
DeviceTemperature	Device temperature in degrees Celsius (°C)	IFloat	R

oeSensorTemperatureNormal	Image sensor normal temperature limit in degrees Celsius (°C)	IFloat	R
oeSensorTemperatureHigh	Image sensor high temperature limit in degrees Celsius (°C)	IFloat	R
oeSensorTemperatureStatus	Shows the image sensor temperature status	IEnumeration	R
oeDevicePressure	Device internal pressure in hPa	IFloat	R

Table 16: Device Control features

6.1.1 Sensor Temperature Status

The temperature status of the sensor can be checked using the **oeSensorTemperatureStatus** feature. There are three possible statuses: **Normal**, **High** and **Overheat**, defined by the parameters **oeSensorTemperatureNormal** (editable) and **oeSensorTemperatureHigh** (fixed). Depending on the temperature status, intervention may be necessary: in Normal status, no intervention is required; in High status, cooling is recommended; in Overheat status, cooling is mandatory, otherwise the sensor may be damaged.
The **SensorTemperature** event is available in the Event Control section. By enabling it, you can receive an event every time there is a change in the **oeSensorTemperatureStatus** state. See the chapter on events for more information.

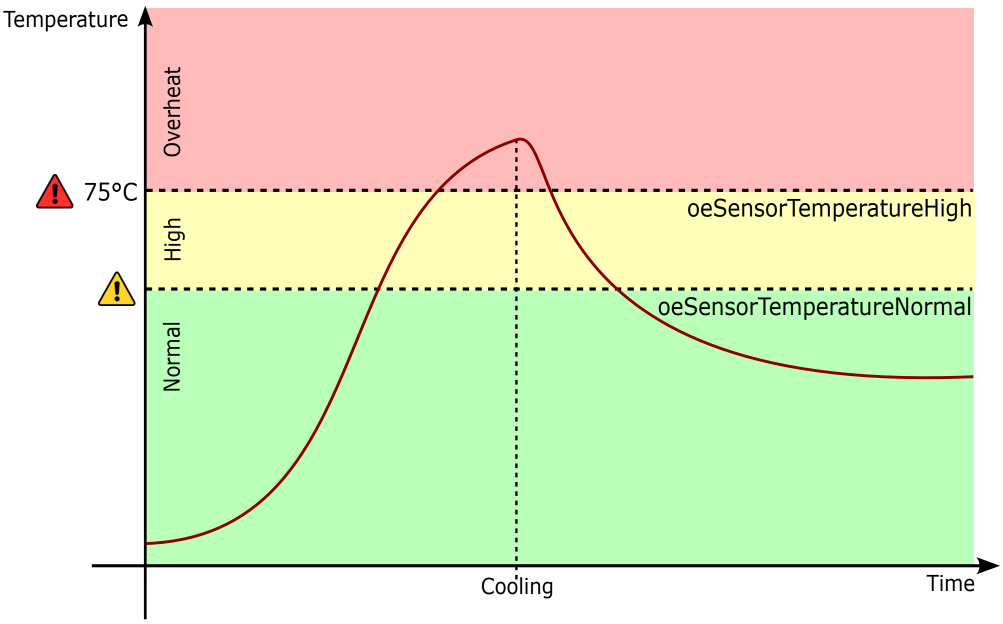


Figure 51: Example of a device temperature curve (Sensor) and states representation.

6.1.2 Bandwidth limit

The **DeviceLinkThroughputLimit** feature allows to limit the bandwidth available for the camera data streaming. Delays will be uniformly inserted between transport layer packets in order to control the peak bandwidth. This is equivalent to directly set the inter-packet delay value through the **GevSCPD** feature in the **Transport Layer Control** section. A suitable delay in data transfer will prevent the camera from "overrunning" the transfer interface limit.

The bandwidth limit is especially useful when setting up a multi-camera system with an installed bandwidth lower than the sum of the bandwidth of the single device. Setting a proper limit on each device ensures the lowest amount of collisions on the network, maximizing performances and improving overall stability.

6.2 Image Format Control

The Image Format Control section describes how to configure image size and format.

Feature	Description	Interface	Access
SensorWidth	Effective width of the sensor in pixels	IInteger	R
SensorHeight	Effective height of the sensor in pixels	IInteger	R
SensorPixelWidth	Physical size (pitch) in the x direction of a photo sensitive pixel unit	IFloat	R
SensorPixelHeight	Physical size (pitch) in the y direction of a photo sensitive pixel unit	IFloat	R
SensorName	Product name of the imaging Sensor	IString	R
WidthMax	Maximum width of the image (in pixels)	IInteger	R
HeightMax	Maximum height of the image (in pixels)	IInteger	R
Width	Width of the image provided by the device (in pixels)	IInteger	RW
Height	Height of the image provided by the device (in pixels)	IInteger	RW

OffsetX	Horizontal offset from the origin to the region of interest (in pixels)	IInteger	RW
OffsetY	Vertical offset from the origin to the region of interest (in pixels)	IInteger	RW
BinningHorizontalMode	Sets the mode to use to combine horizontal photo-sensitive cells together when BinningHorizontal is used	IEnumeration	RW
BinningHorizontal	Number of horizontal photo-sensitive cells to combine together	IInteger	RW
BinningVerticalMode	Sets the mode to use to combine vertical photo-sensitive cells together when BinningVertical is used	IEnumeration	RW
BinningVertical	Number of vertical photo-sensitive cells to combine together	IInteger	RW
DecimationHorizontalMode	Sets the mode used to reduce the horizontal resolution when DecimationHorizontal is used	IEnumeration	RW
DecimationHorizontal	Horizontal sub-sampling of the image	IInteger	RW
DecimationVerticalMode	Sets the mode used to reduce the vertical resolution when DecimationVertical is used	IEnumeration	RW
DecimationVertical	Vertical sub-sampling of the image	IInteger	RW
ReverseX	Flip horizontally the image sent by the device	IBoolean	RW
ReverseY	Flip vertically the image sent by the device	IBoolean	RW
PixelFormat	Format of the pixels provided by the device	IEnumeration	RW
TestPattern	Selects the type of test pattern that is generated by the device as image source	IEnumeration	RW

Table 17: Image Format Control features

6.2.1 Image processing pipeline

Figure 52 illustrates the onboard image-processing pipeline implemented in Itala cameras. The pipeline is composed of a sequence of processing stages that convert raw sensor data into usable information for analysis and further image elaboration.
The main processing blocks are listed below:

- **ROI**: defines the Region of Interest, i.e., the portion of the sensor that will be acquired.
- **Defective pixel correction**: compensates for defective pixels.
- **Decimation**: reduces the number of pixels to acquire and process.
- **Binning**: combines adjacent pixels to increase sensitivity.
- **AOI**: defines the Area of Interest used by the auto-functions.
- **Autofocus**: automatically determines the optimal focus setting.
- **Autoexposure**: automatically adjusts exposure time to reach a target brightness.
- **Autogain**: automatically adjusts the gain to reach a target signal level.
- **White balance**: equalizes the three color channels (R, G, B).
- **LUT**: Look-Up Table used to apply pixel-level transformations (e.g., gamma correction).
- **Debayering**: interpolates raw data to reconstruct a full-color R, G, B image.
- **Color Correction Matrix (CCM)**: adjusts color channels to achieve accurate color reproduction.

> ***NOTE**: Some processing stages are available only on specific Itala camera models. For example, white balance, debayering, and CCM are available exclusively on color cameras, while autofocus is supported only on Itala variants equipped with an integrated liquid-lens controller.*

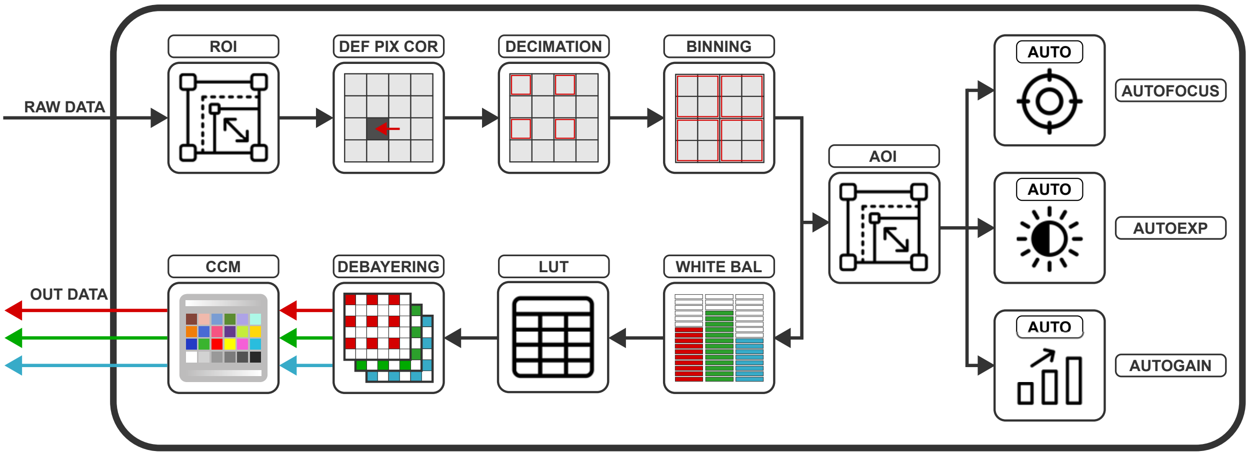


Figure 52: Image processing pipeline.

6.2.2 Image ROI

The **Width**, **Height**, **OffsetX**, **OffsetY** parameters are used to change the image format and to stream only a part of the full resolution image: in particular, the offsets set the displacement of the ROI (region of interest), while the width and height parameters set the effective dimensions of the image.
The sum of **OffsetX** and **Width** cannot exceed the **WidthMax** value and the sum of **OffsetY** and **Height** cannot exceed the **HeightMax**.
WidthMax and **HeightMax** are sensor specific and cannot be set by the user.
In Fig.53 is shown a graphical explanation of these parameters.

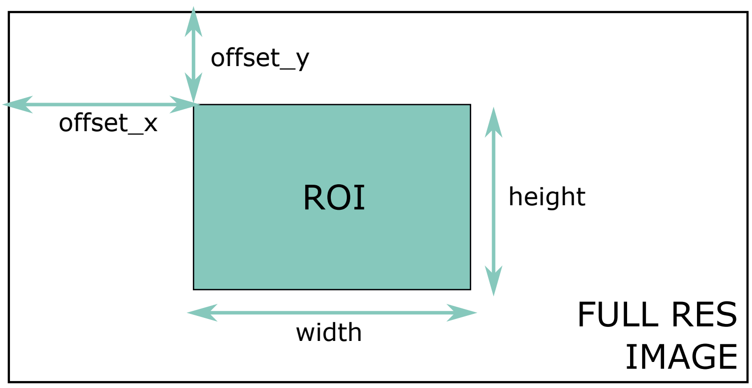


Figure 53: Image ROI paramenters.

6.2.3 Binning

Binning mode increases camera sensitivity by summing the charge values of adjacent pixels, at the cost of reducing the effective spatial resolution.
As shown in Fig.54, a **2x1 binning** operation reduces the image resolution by half along the x-axis while doubling the overall image brightness, since the signal from two adjacent pixels is combined. With a **2x2 binning** configuration, the resulting image resolution is one quarter of the original, and the brightness increases by a factor of four.

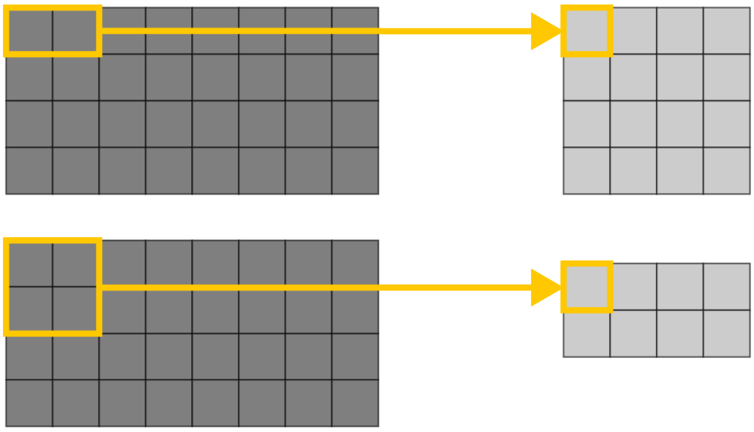


Figure 54: Examples of binning for monochrome sensors: in the figure above a 2x1 binning is performed, while in the figure below a 2x2 binning is applied.

For color sensors, the Bayer filter pattern must be considered. Because adjacent pixels correspond to different color channels, binning is applied only to pixels with the same chromatic component, as illustrated in Fig.55. This approach prevents chroma distortion and avoids artifacts introduced by mixing different color information.

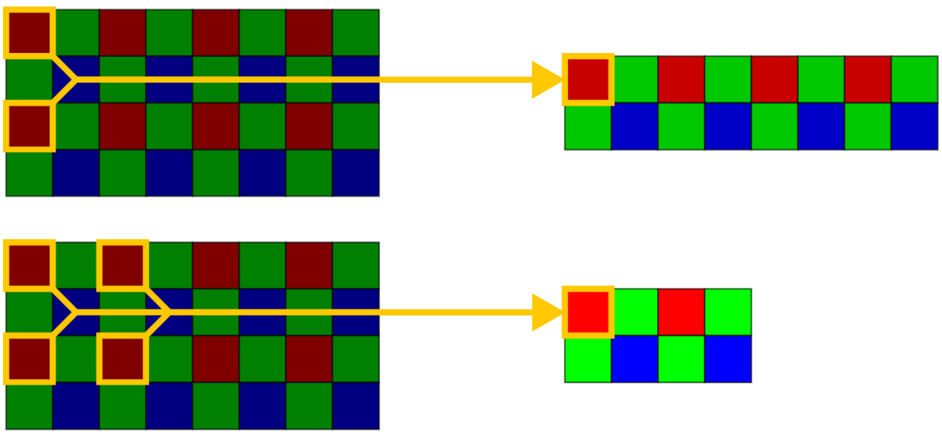


Figure 55: Examples of binning for color sensors: in the figure above a 1x2 binning is performed, while in the figure below a 2x2 binning is applied.

6.2.4 Decimation

Decimation mode is used to discard pixels in order to obtain a sub-sampled image.
Decimation mode has some advantages, e.g. the increasing of the frame rate of the camera.
In Fig.56 are shown two examples of decimation: in the figure above a **2x1 decimation** is performed: only one pixel over two is considered, thus the resulting image has half of the initial horizontal resolution; in the figure below a **4x1 decimation** has been applied, so only one pixel over four is acquired. Also in this case the resulting horizontal resolution has been reduced (by a factor 4).

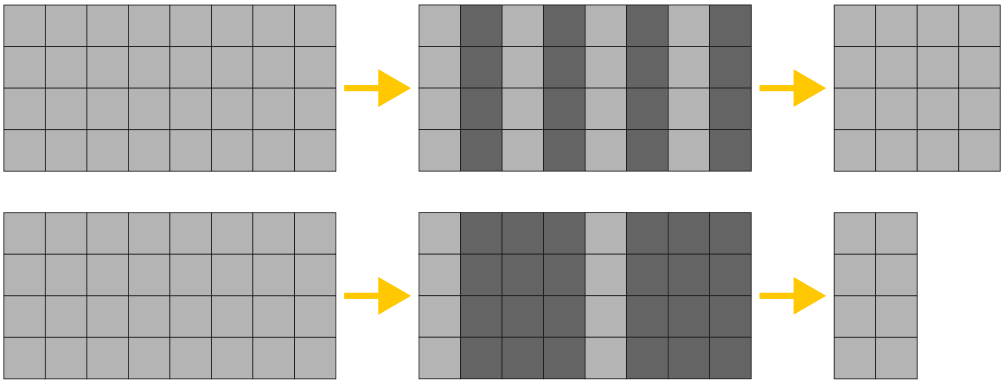


Figure 56: Examples of decimation: in the figure above a 2x1 decimation is performed, while in the figure below a 4x1 decimation is applied.

In case of color sensors, Bayer filter must be taken into account: since adiacent pixels have different chroma information, decimation is performed grouping pixels with alternate colors, as depicted in Fig.57. In this way, chroma information is not affected by algorithm artifacts.

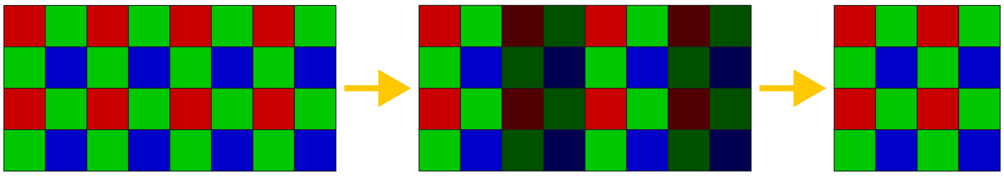


Figure 57: Examples of decimation for color sensors: in the figure above a 2x1 decimation is performed.

6.2.5 Readout direction

The camera supports image mirroring in both horizontal and vertical directions in order to make the integration of the camera insestitive to the mounting position.
In Fig.58 is shown an example of the **ReverseX** and **ReverseY** features.

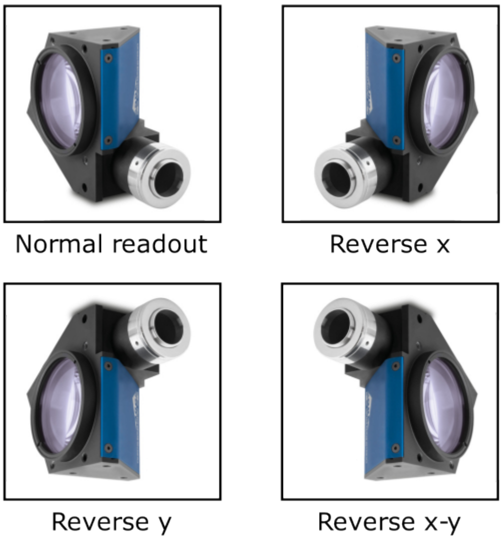


Figure 58: Representation of all the four possible readout modes.

6.2.6 Bit depth and pixel format

Bit depth refers to the number of bits used to represent the intensity value of each pixel captured by the sensor. It defines the number of available gray levels and contributes directly to the achievable dynamic range.
Figure 59 illustrates how bit depth affects pixel quantization: lower bit depths provide fewer discrete levels to encode the image, potentially limiting detail in low-contrast regions. Conversely, higher bit depths allow finer quantization steps, improving the effective image resolution.
However, increasing bit depth comes with a bandwidth trade-off: more bits per pixel increase the total payload to be transmitted. For a fixed interface bandwidth, higher payloads reduce the maximum achievable frame rate.
In machine-vision applications, a bit depth between 8 and 12 bits is commonly used, offering a good compromise between image quality and throughput.

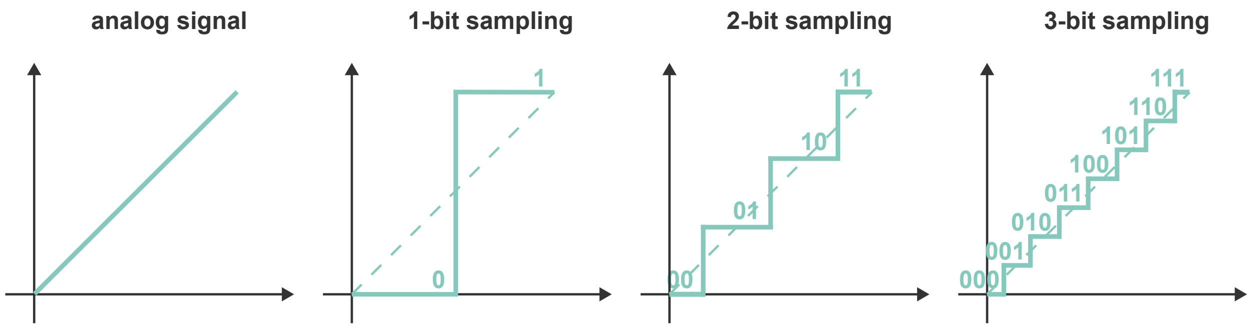


Figure 59: Example of pixel quantization: as bit depth increases (left to right), the number of representable intensity levels grows, allowing finer resolution in the captured image.

Pixel format defines how pixel data is encoded, specifying the type of information contained in

each pixel (e.g., monochrome or color channels, color space, channel ordering) and the number of bits used to represent it.
Although bit depth and pixel format are closely related, they refer to different concepts. For example, the pixel format *Mono10Packed* uses a 10-bit sampling resolution per pixel, but the data is stored in a 12-bit structure (10 bits of meaningful data plus 2 bits of padding).

The pixel formats supported by Itala are listed in Table 18:

Pixel Format	Bit/pixel	Data Information
MONOCHROME SENSORS		
Mono8	8	Grey level data (8-bit)
Mono10p	10	Grey level data (10-bit)
Mono12p	12	Grey level data (12-bit)
Mono10Packed	12	Grey level data (10-bit)
Mono12Packed	12	Grey level data (12-bit)
COLOR SENSORS		
Mono8	8	Luminance data (8-bit)
BayerXX8	8	Un-debayered raw data (8-bit)
BayerXX10p	10	Un-debayered raw data (10-bit)
BayerXX12p	12	Un-debayered raw data (12-bit)
BayerXX10Packed	12	Un-debayered raw data (10-bit)
BayerXX12Packed	12	Un-debayered raw data (12-bit)
YUV411_8_UYYVYY	12	Luminance (Y, 8-bit) and Croma (U-V, 4-bit) data
YUV422_8	16	Luminance (Y, 8-bit) and Croma (U-V, 8-bit) data
RGB8	24	Red (8-bit), Green (8-bit) and Blue (8-bit) data
MONOCHROME POLARIZED SENSORS		
Mono8	8	Grey level raw data (8-bit)
Mono10p	10	Grey level raw data (10-bit)
Mono12p	12	Grey level raw data (12-bit)
Mono10Packed	12	Grey level raw data (10-bit)
Mono12Packed	12	Grey level raw data (12-bit)
PolarizedYYMono8	8	Un-depolarized raw data (8-bit)
PolarizedYYMono10p	10	Un-depolarized raw data (10-bit)
PolarizedYYMono12p	12	Un-depolarized raw data (12-bit)
PolarizedYYMono10Packed	12	Un-depolarized raw data (10-bit)
PolarizedYYMono12Packed	12	Un-depolarized raw data (12-bit)
COLOR POLARIZED SENSORS		
BayerXX8	8	Un-debayered raw data (8-bit)
BayerXX10p	10	Un-debayered raw data (10-bit)

BayerXX12p	12	Un-debayered raw data (12-bit)
BayerXX10Packed	12	Un-debayered raw data (10-bit)
BayerXX12Packed	12	Un-debayered raw data (12-bit)
PolarizedYYBayerXX8	8	Un-depolarized raw data (8-bit)
PolarizedYYBayerXX10p	10	Un-depolarized raw data (10-bit)
PolarizedYYBayerXX12p	12	Un-depolarized raw data (12-bit)
PolarizedYYBayerXX10Packed	12	Un-depolarized raw data (10-bit)
PolarizedYYBayerXX12Packed	12	Un-depolarized raw data (12-bit)

Table 18: Pixel format in Itala cameras.

Figures 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72 illustrate how pixel data are packed and encoded, depending on the selected pixel format.

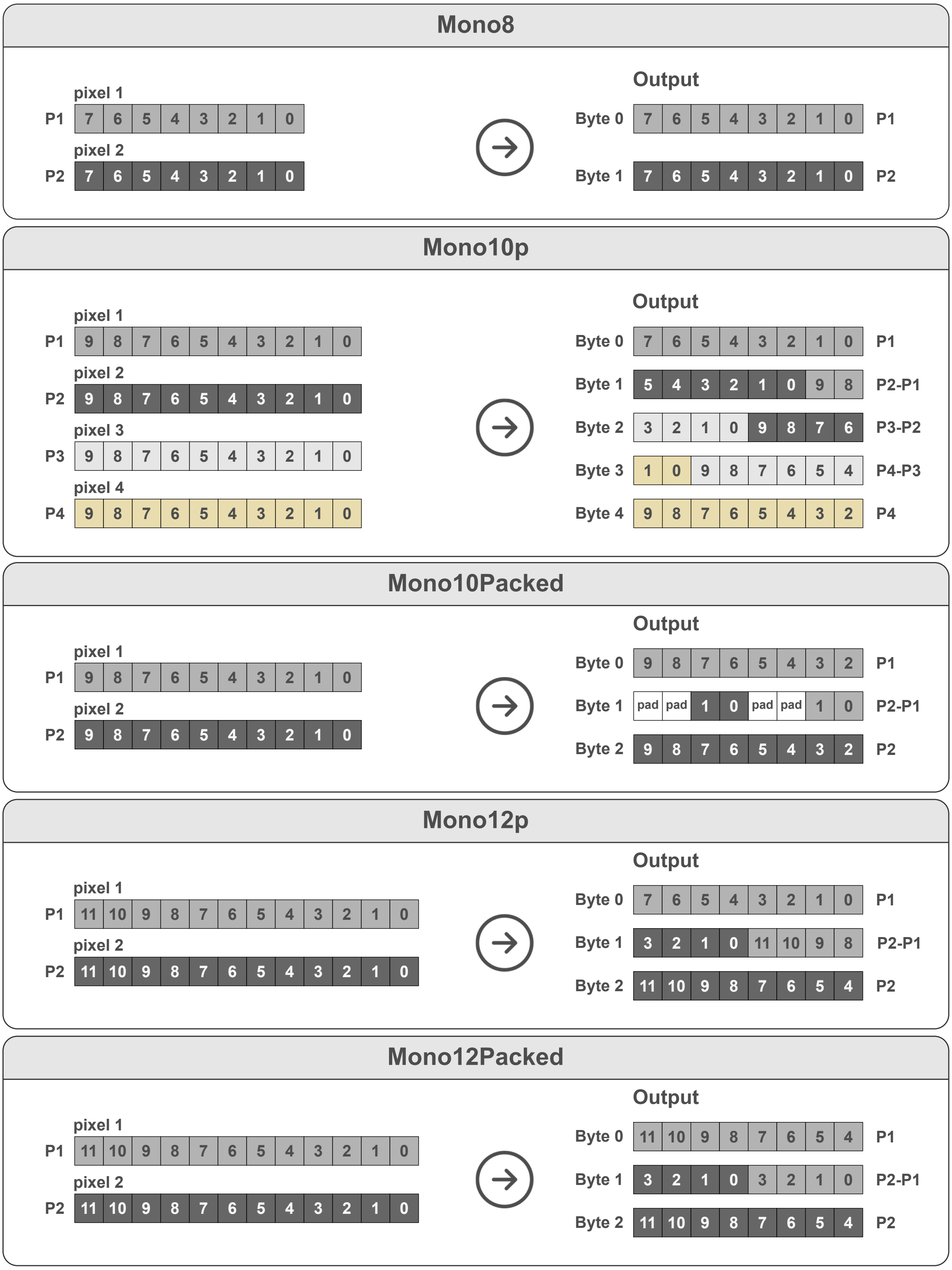


Figure 60: Pixel format encoding.

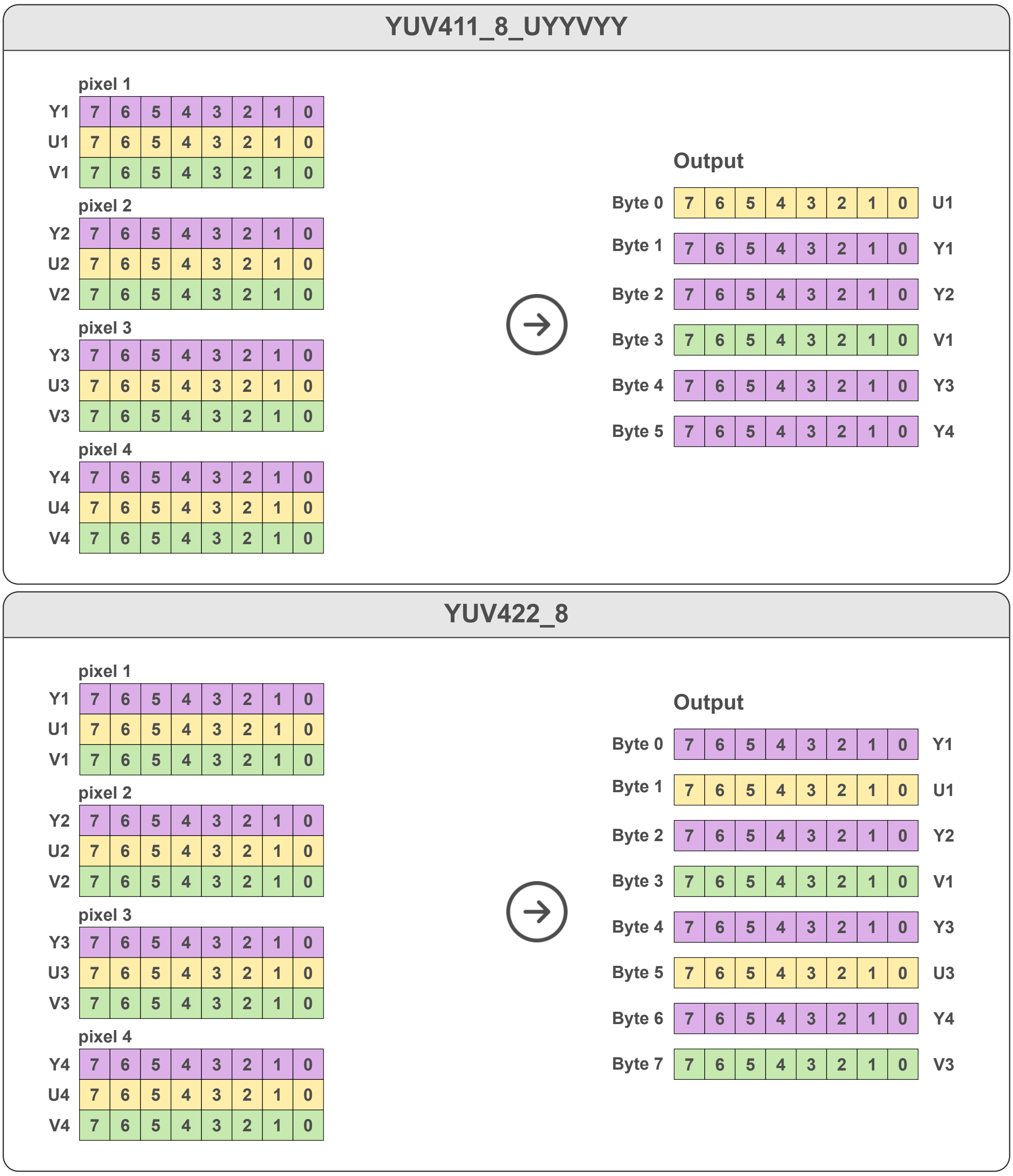


Figure 61: Pixel format encoding.

Figure 62: Pixel format encoding.

Figure 63: Pixel format encoding.

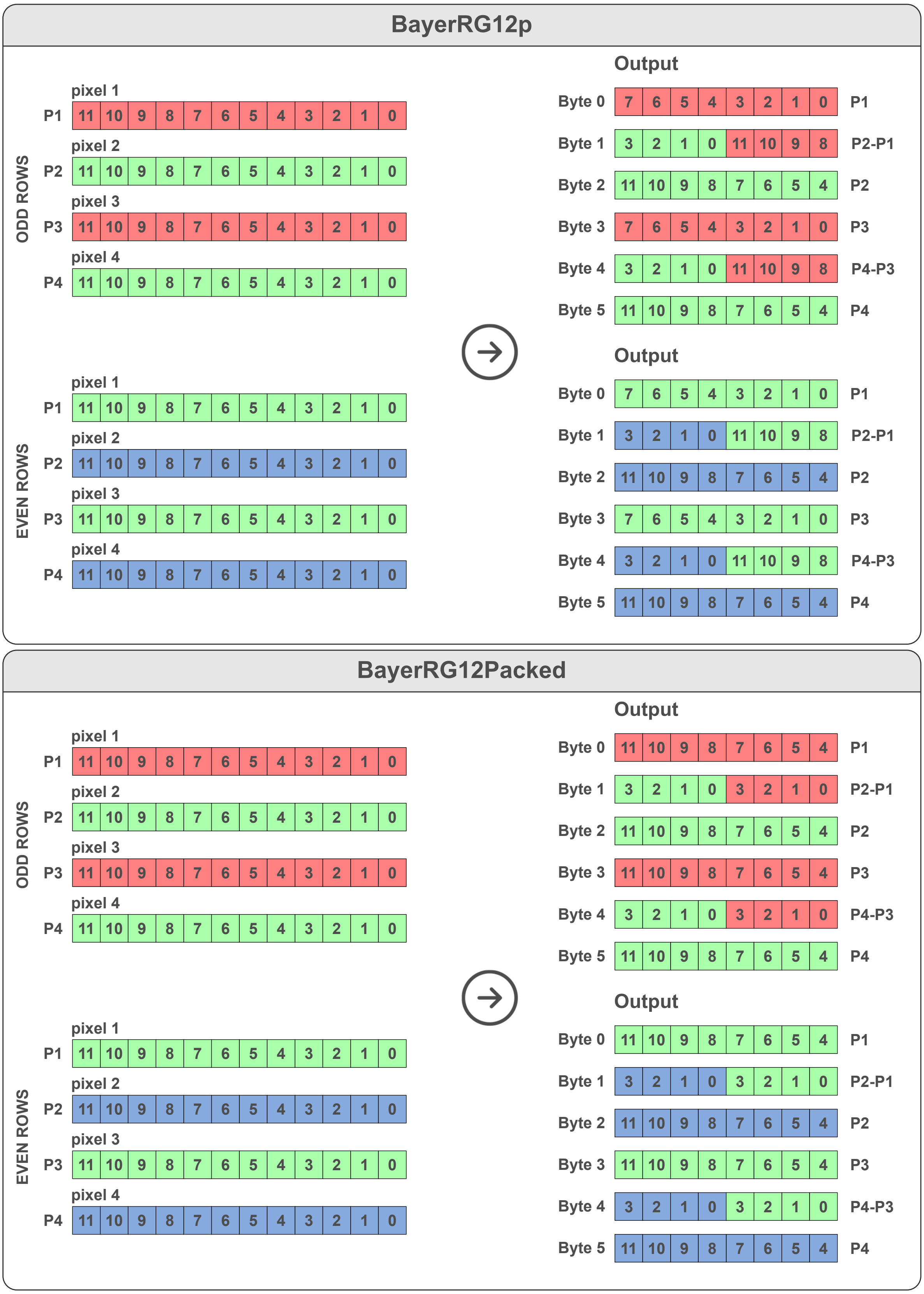


Figure 64: Pixel format encoding.

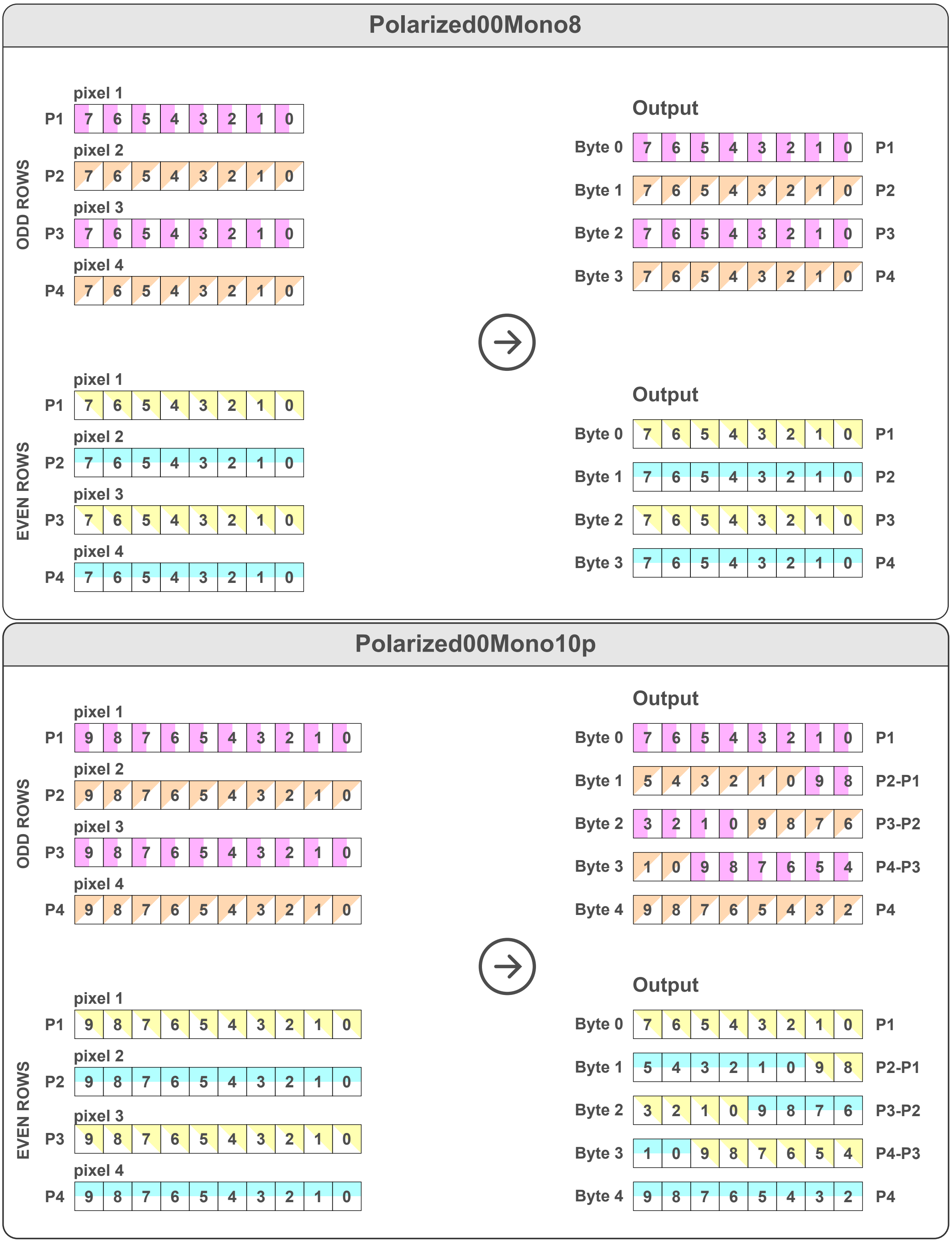


Figure 65: Pixel format encoding.

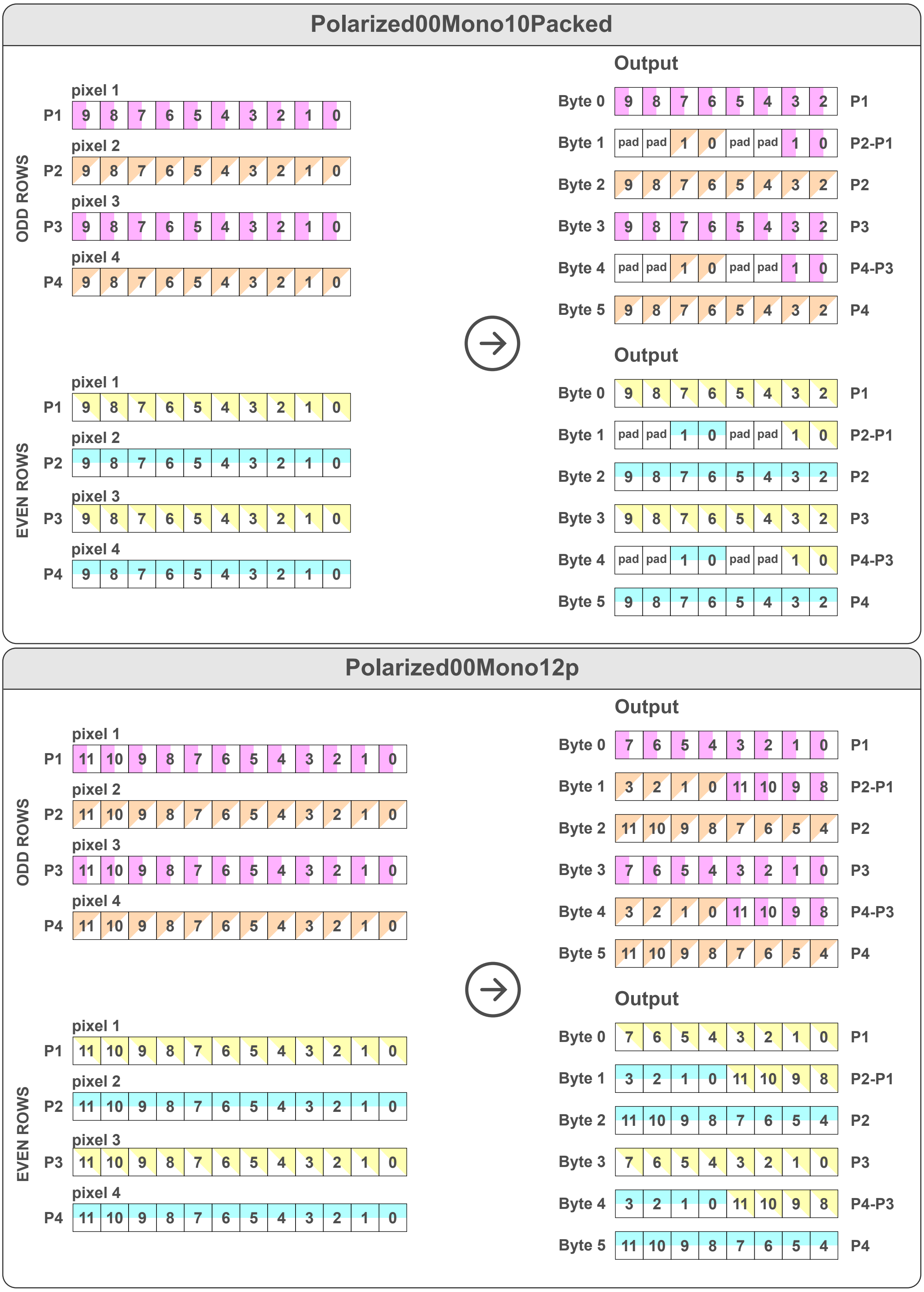


Figure 66: Pixel format encoding.

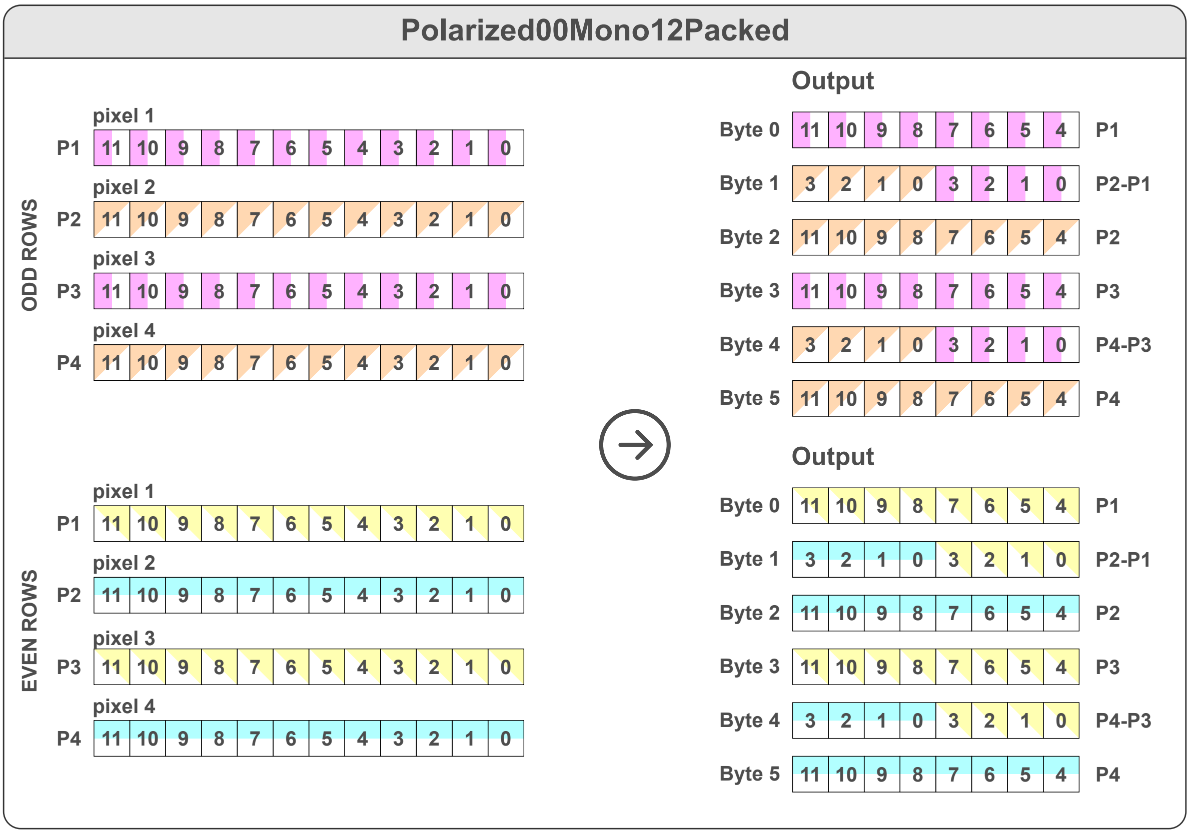


Figure 67: Pixel format encoding.

Figure 68: Pixel format encoding.

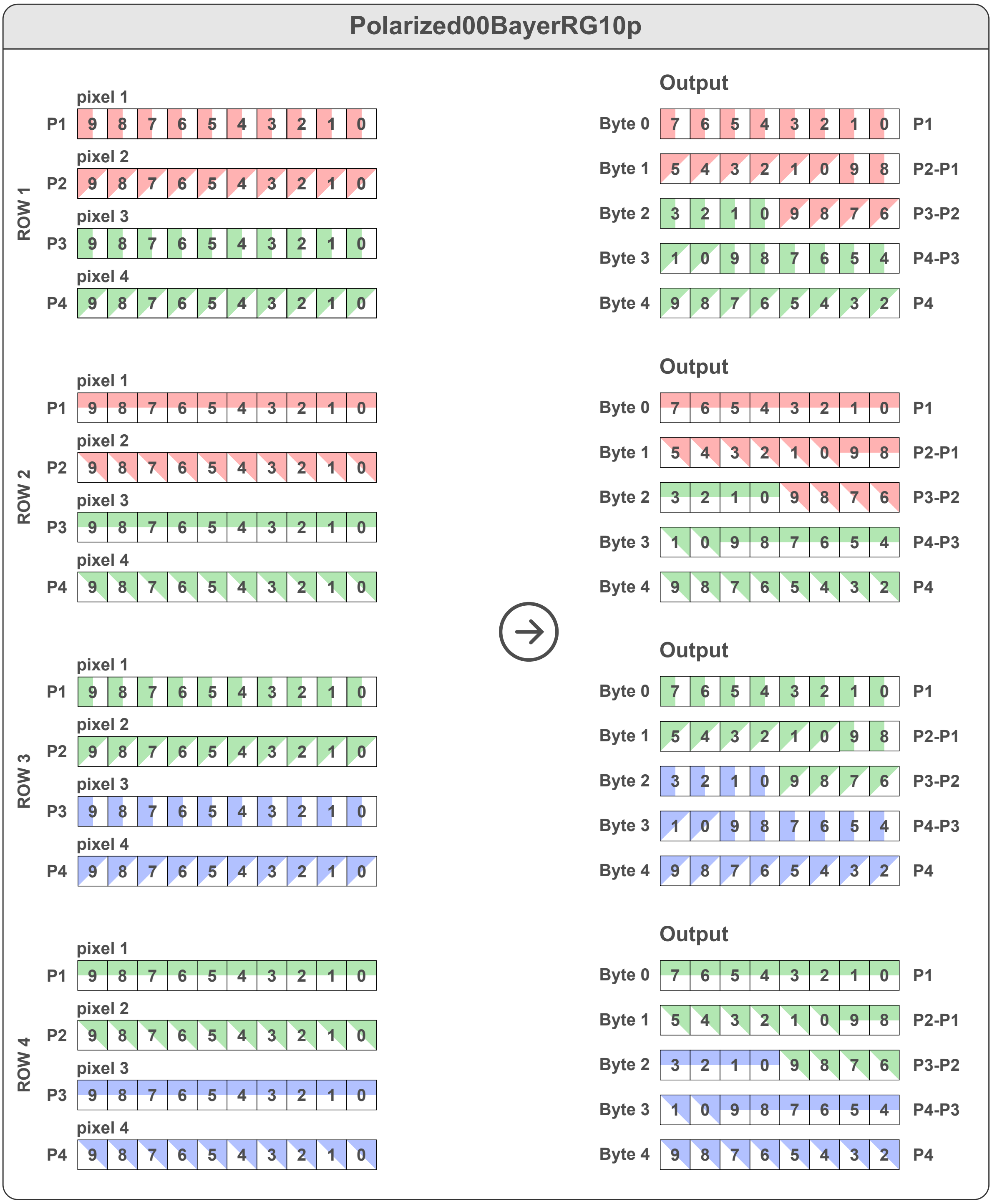


Figure 69: Pixel format encoding.

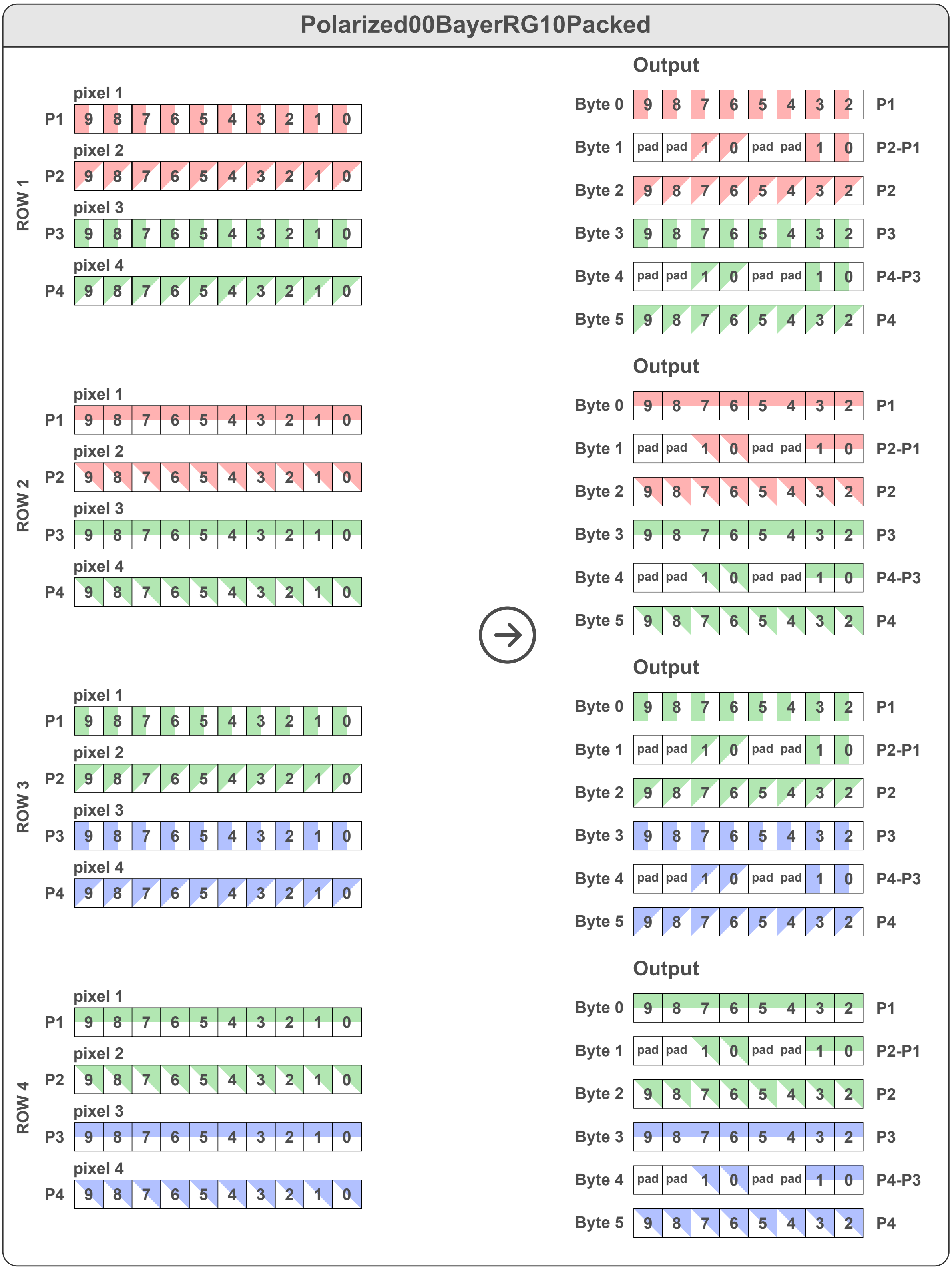


Figure 70: Pixel format encoding.

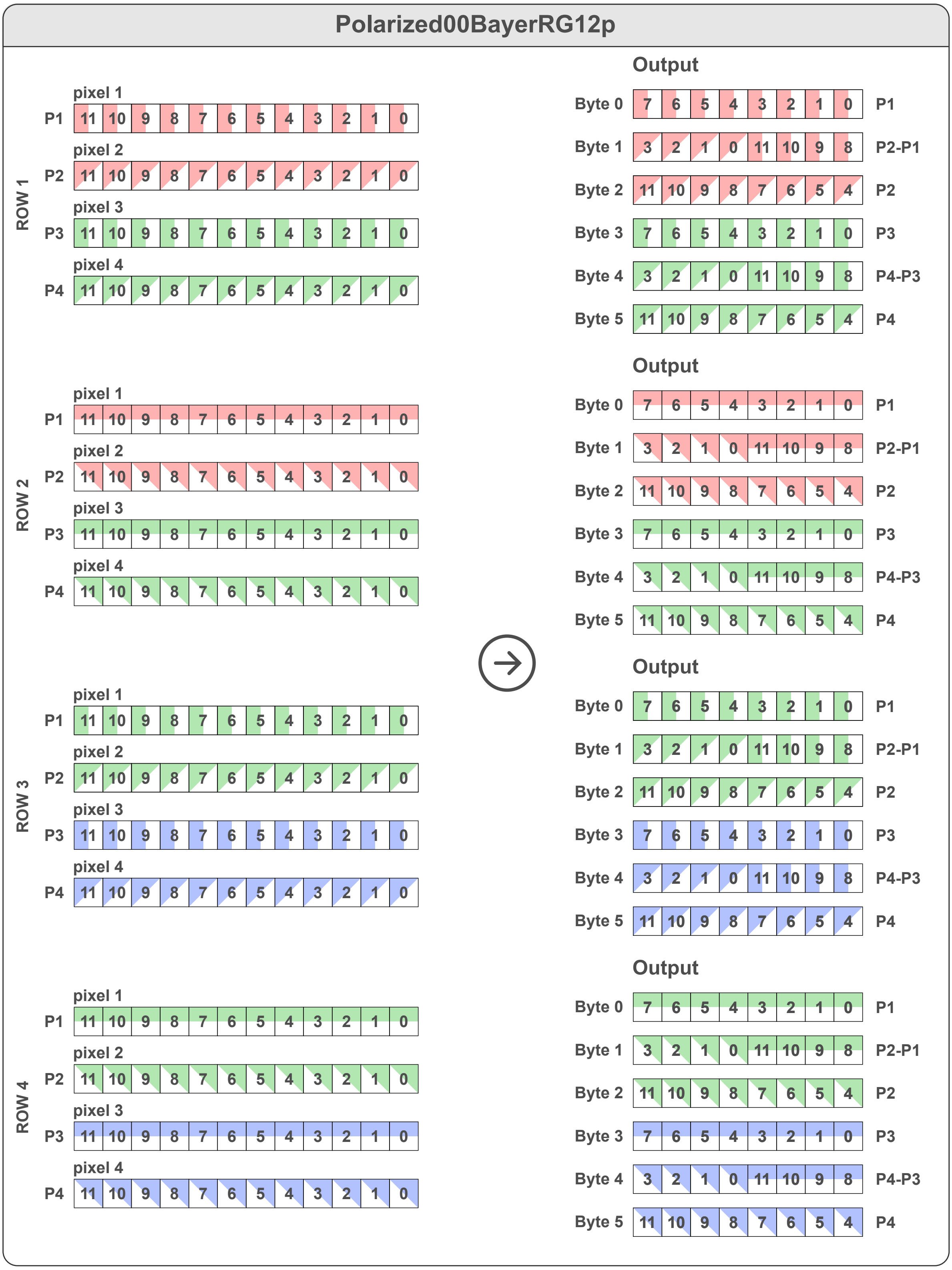


Figure 71: Pixel format encoding.

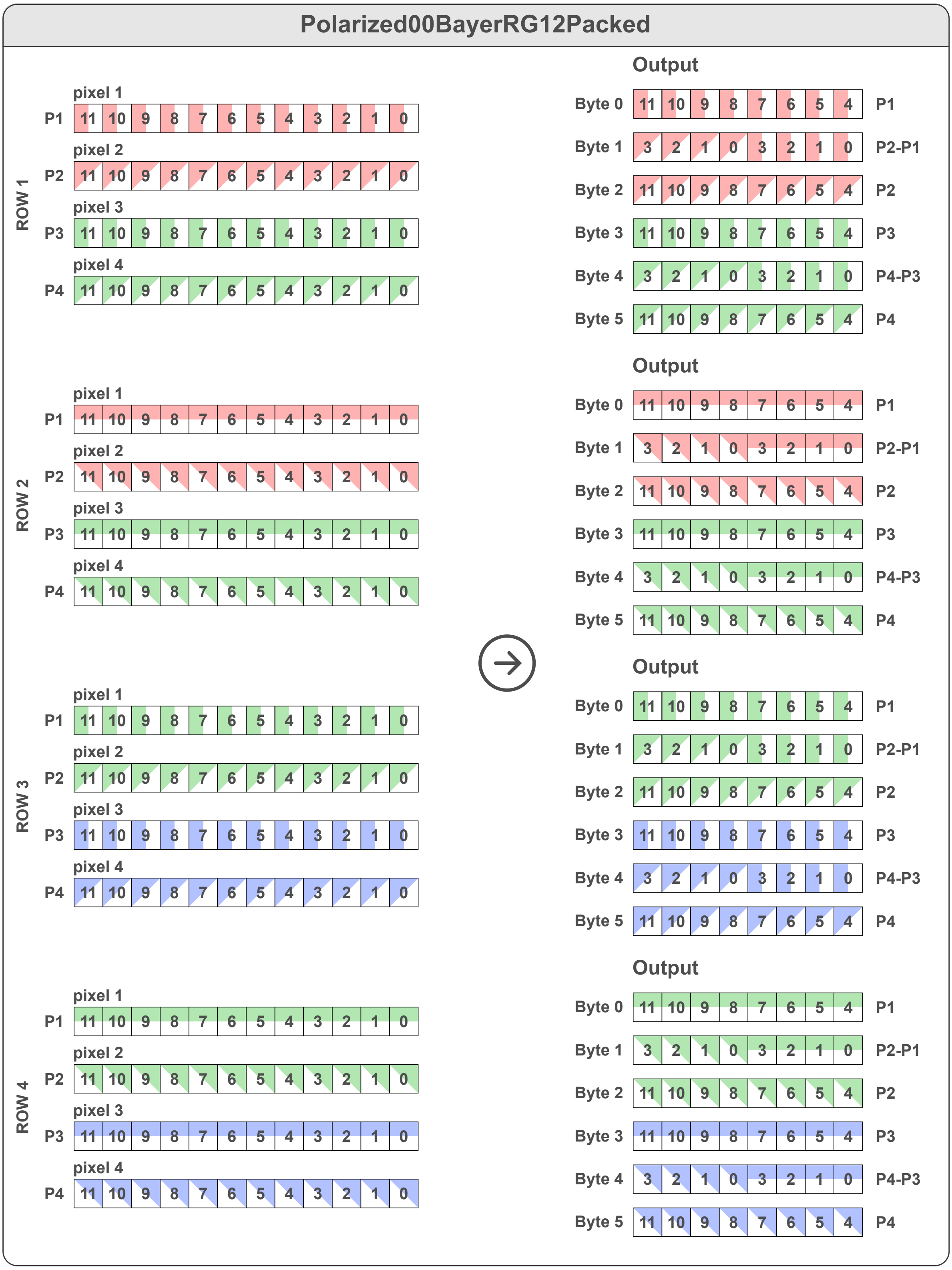


Figure 72: Pixel format encoding.

6.2.7 Debayering

Debayering (or demosaicing) is the process of generating a full-color image from the raw data acquired by an image sensor equipped with a Bayer filter.
Image sensors do not measure color directly: each pixel records only one primary component (red, green, or blue) due to the Bayer filter array positioned above the sensor surface.
As shown in Figure 73, the purpose of debayering is to reconstruct all three color channels for each pixel by interpolating the color information from neighboring pixels.

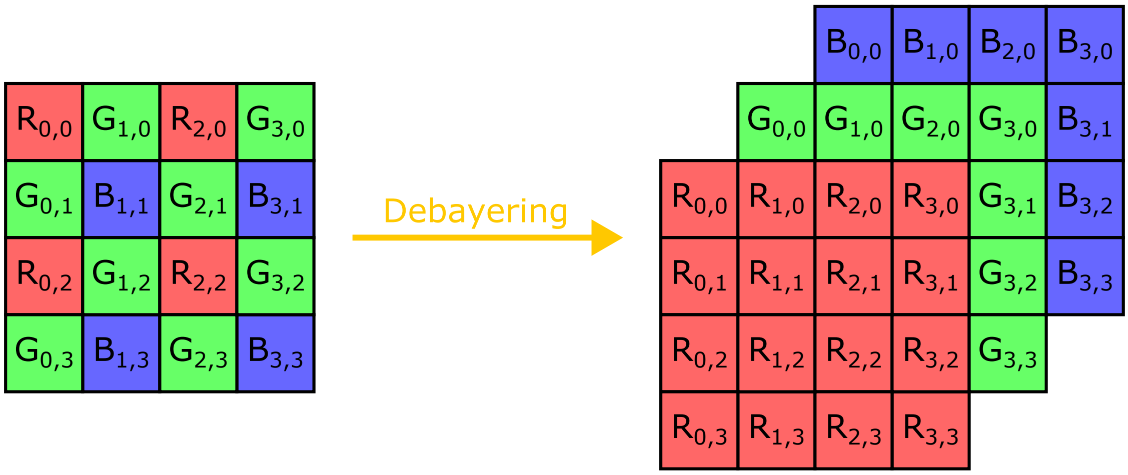
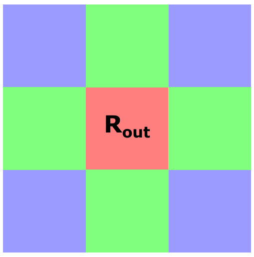


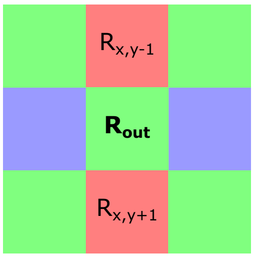
Figure 73: Color information of the image, pre and post debayering operations.

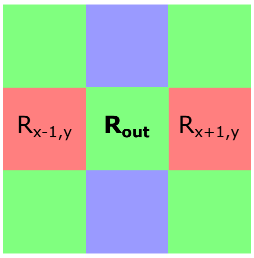
The color accuracy of the resulting image depends on the effectiveness of the debayering algorithm.
Because of the trade-off between algorithmic complexity and available hardware resources, industrial cameras typically employ linear interpolation algorithms, which are computationally simple yet effective for color reconstruction.
The algorithms implemented in Itala cameras are designed to prevent reconstruction artifacts, such as *zipper artifacts*.

The interpolation schemes used to recover the red, green, and blue components for every pixel type in the Bayer array are detailed in Tables 19, 20, and 21.



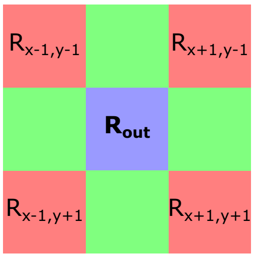
$$R_{out} = R_{x,y}$$





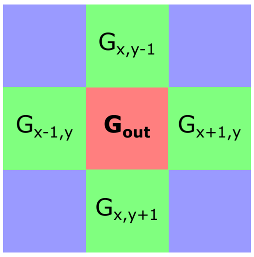
$$R_{out} = \frac{R_{x,y-1} + R_{x,y+1}}{2}$$

$$R_{out} = \frac{R_{x-1,y} + R_{x+1,y}}{2}$$

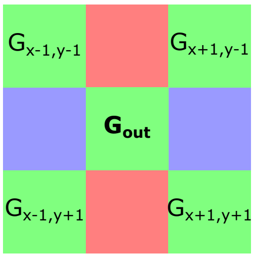


$$R_{out} = \frac{R_{x-1,y-1} + R_{x+1,y-1} + R_{x-1,y+1} + R_{x+1,y+1}}{4}$$

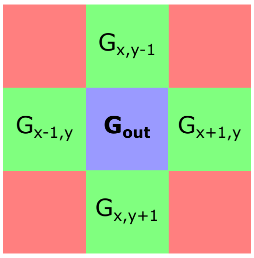
Table 19: Red color reconstruction on red (top), green (center) and blue (bottom) pixels respectively.



$$G_{out} = \frac{G_{x,y-1} + G_{x-1,y} + G_{x+1,y} + G_{x,y+1}}{4}$$

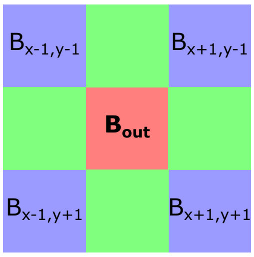


$$G_{out} = \frac{4 * G_{x,y} + G_{x-1,y-1} + G_{x+1,y-1} + G_{x-1,y+1} + G_{x+1,y+1}}{8}$$

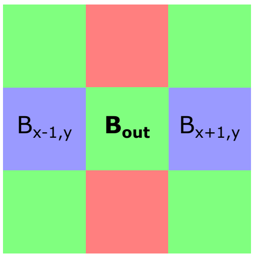


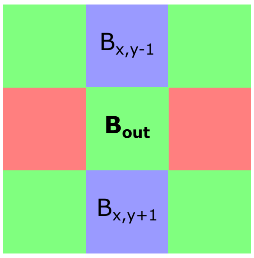
$$G_{out} = \frac{G_{x,y-1} + G_{x-1,y} + G_{x+1,y} + G_{x,y+1}}{4}$$

Table 20: Green color reconstruction on red (top), green (center) and blue (bottom) pixels respectively.

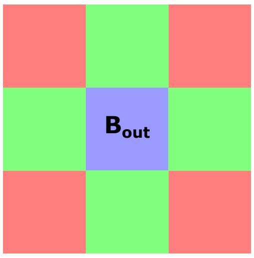


$$B_{out} = \frac{B_{x-1,y-1} + B_{x+1,y-1} + B_{x-1,y+1} + B_{x+1,y+1}}{4}$$





$$B_{out} = \frac{B_{x-1,y} + B_{x+1,y}}{2} \quad or \quad \frac{B_{x,y-1} + B_{x,y+1}}{2}$$



$$B_{out} = B_{x,y}$$

Table 21: Blue color reconstruction on red (top), green (center) and blue (bottom) pixels respectively.

6.2.8 Test pattern

Itala cameras support two different test patterns, one monochrome and one color.
The two different test patterns are represented in Fig. 74 and 75.

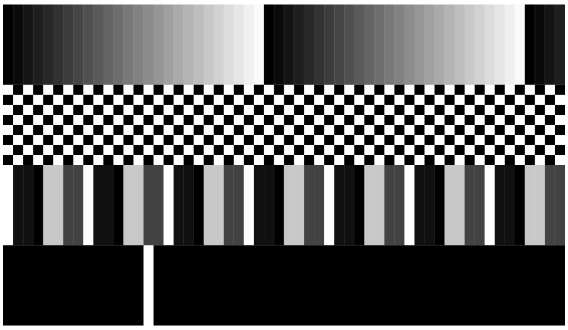


Figure 74: Monochrome test pattern

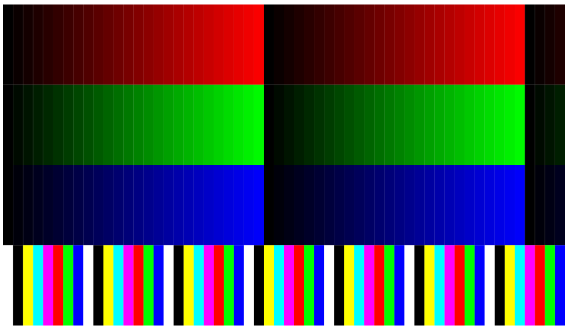


Figure 75: Color test pattern

The **monochrome pattern** is characterized by 4 different section:

- a fixed gradient pattern, from black to white;

- a fixed chess pattern;
- a fixed asymmetrical bars pattern (values: 0xC8, 0x10, 0x10, 0x42);
- a white moving line on a black background.

The **color pattern** is characterized by 4 different section:

- a fixed red gradient pattern, from black to red;
- a fixed green gradient pattern, from black to green;
- a fixed blue gradient pattern, from black to blue;
- a fixed color bars pattern (all the possible combinations of R, G and B coordinates).

6.3 Acquisition Control

The Acquisition Control section describes all features related to image acquisition, including the trigger and exposure control. It describes the basic model for acquisition and the typical behavior of the device.

Feature	Description	Interface	Access
AcquisitionMode	Sets the acquisition mode of the device. It defines mainly the number of frames to capture during an acquisition and the way the acquisition stops	IEnumeration	RW
AcquisitionStart	Starts the Acquisition of the device	ICommand	RW
AcquisitionStop	Stops the Acquisition of the device at the end of the current Frame	ICommand	RW
AcquisitionBurstFrameCount	Number of frames to acquire for each FrameBurstStart trigger	IInteger	RW
AcquisitionFrameRate	Controls the acquisition rate (in Hertz) at which the frames are captured	IFloat	RW

AcquisitionFrameRateEnable	Controls if the AcquisitionFrameRate feature is writable and used to control the acquisition rate. Otherwise, the acquisition rate is implicitly controlled by the combination of other features like ExposureTime, etc..	IBoolean	RW
oeAcquisitionFrameRateLimitMode	Select what limits the acquisition frame rate	IEnumeration	RW
oeResultingFrameRate	Shows the resulting acquisition frame rate	IFloat	RO
oeMaxFrameRate	Shows the maximum acquisition frame rate reachable when the image compression is enabled	IFloat	RO
TriggerSelector	Selects the type of trigger to configure	IEnumeration	RW
TriggerMode	Controls if the selected trigger is active	IEnumeration	RW
TriggerSoftware	Generates an internal trigger	ICommand	RW
TriggerSource	Specifies the internal signal or physical input Line to use as the trigger source	IEnumeration	RW
TriggerOverlap	Specifies the type trigger overlap permitted with the previous frame or line. This defines when a valid trigger will be accepted (or latched) for a new frame or a new line	IEnumeration	RW
TriggerDelay	Specifies the delay in microseconds (us) to apply after the trigger reception before activating it	IFloat	RW
ExposureMode	Sets the operation mode of the Exposure	IEnumeration	RW
oeShortExposureEnable	Enable the short exposure mode	IBoolean	RW
oeDualExposureEnable	Enable the dual exposure mode	IBoolean	RW

ExposureTime	Sets the Exposure time when ExposureMode is Timed and ExposureAuto is Off	IFloat	RW
oeWaitTime1	Time delay between the first and second exposure in Dual Exposure mode.	IFloat	RO
oeExposureTime2	Second Exposure Time in Dual Exposure mode.	IFloat	RO
oeWaitTime2	Time to wait before a new acquisition after the second exposure in Dual Exposure mode.	IFloat	RO
ExposureAuto	Sets the automatic exposure mode when ExposureMode is Timed	IEnumeration	RW
oeExposureAutoMin	Set the lower limit for the auto exposure algorithm	IFloat	RW
oeExposureAutoMax	Set the upper limit for the auto exposure algorithm	IFloat	RW
oeImageCompressionEnable	Enable the image compression algorithm	IBoolean	RW
oeFramesInBuffer	Displays the number of frames currently stored in the onboard memory	IInteger	RO

Table 22: Acquisition Control Features

6.3.1 Trigger overlap

Exposure Time and Frame Readout relationship

By default, the feature **TriggerOverlap** is set to OFF: in this case, as shown in Fig.76, the following exposure time period is not allowed until the end of the current frame transfer, i.e. exposure time and frame transfer cannot be overlapped. In this configuration, however, latency between exposure time and frame transfer is highly repeatable.
In conclusion, a higher determinism can be achieved at the cost of a lower effective camera frame rate.
When **TriggerOverlap** is configured to Readout, the latency between the end of the exposure and the beginning of the frame transfer exhibits higher variability. However, a new exposure can start while the previous frame is still being transferred from the sensor to the memory buffer. As illustrated in Fig.77, the only constraint in this mode is the avoidance of overlap between consecutive transfer intervals. Consequently, a higher camera frame rate can be achieved (subject to Ethernet bandwidth limitations), at the expense of reduced determinism in the frame-transfer timing.

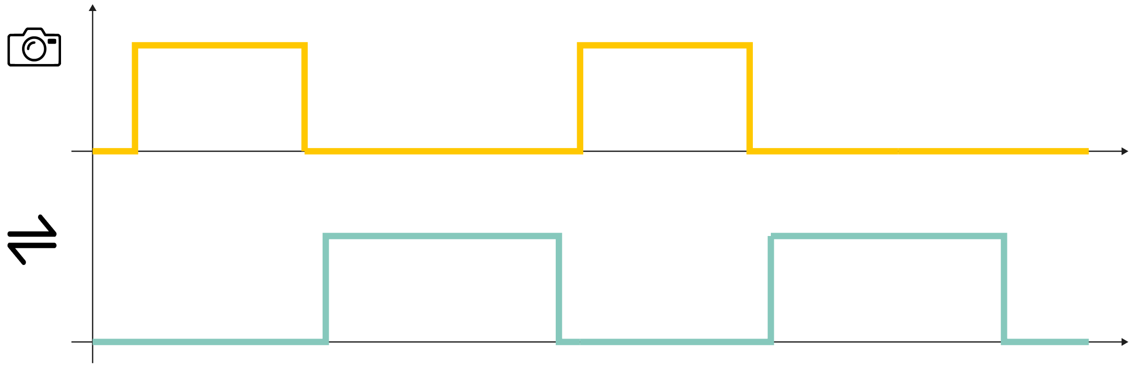


Figure 76: When TriggerOverlap is set to OFF, the latency is highly repeatable, but the following exposure time cannot be accepted until the current frame has been transfered to the internal memory. From top to bottom, the sensor exposure and readout signals are depicted.

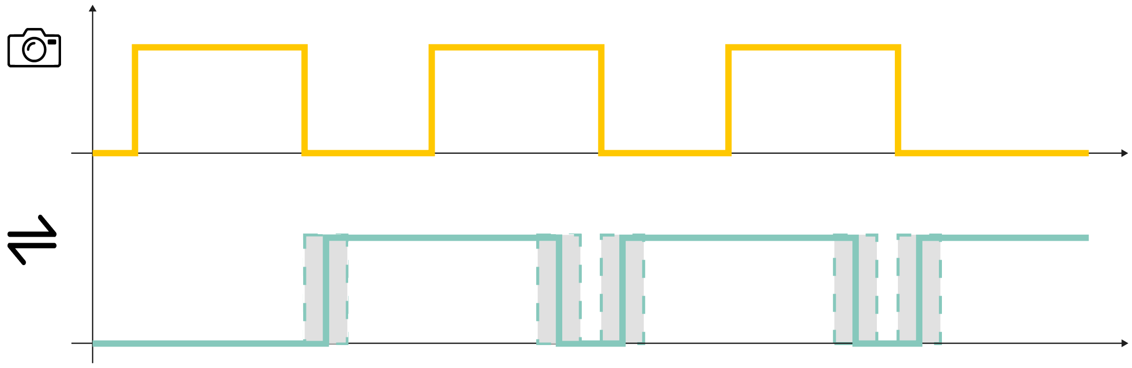


Figure 77: When TriggerOverlap is set to Readout, the following exposure time can be accepted when the current frame is being transfered to the internal memory, but the latency is affected by a higher uncertainty. From top to bottom, the sensor exposure and readout signals are depicted.

How Readout mode affects Exposure Time

ExposureTime value is bounded by:

- **ExposureTimeMin**: minimum exposure time that can be set by the user.
- **ExposureTimeMax**: maximum exposure time that can be set by the user.
- **ExposureTimeInc**: value of the discrete step for increasing/decreasing exposure time.

ExposureTimeMax is constant for both *TriggerOverlap* configurations (*Off* and *Readout*).

ExposureTimeMin differences between *TriggerOverlap = Off* and *TriggerOverlap = Readout* depend on sensor model, but are usually negligible.

TriggerOverlap mainly impacts on **ExposureTimeInc** value.

- When *TriggerOverlap = Off*, Exposure Time granularity is quite fine, in the order of tens of nanoseconds.
- When *TriggerOverlap = Readout*, Exposure Time granularity is strongly related to sensor line period, i.e. time needed by the image sensor to read a single line. In this configuration, the exposure time increment depends on sensor model, but usually is in the order of tens on microseconds.

Anyway, the **ExposureTime** set by the user is automatically adjusted by the device, depending on current camera configuration.

6.3.2 Dual Exposure

The Dual Exposure feature allows to acquire two frames as close as possible, making it easier inspecting fast moving objects or involving different sources of light. This can be achieved overlapping the first sensor readout with the second sensor exposure, as shown in Figure 78.

By default, the feature **oeDualExposureEnable** is not available. Dual Exposure is available only when **TriggerMode** is set to ON and **TriggerOverlap** is set to Readout. When **oeDualExposureEnable** is ON the **AcquisitionBurstFrameCount** disappears and it is automatically set to 2.

Dual Exposure is only available when a valid **TriggerSource** is set. The trigger starts the process explained below:

- The first exposure time *EXPOSURE TIME 1* follows **ExposureMode** settings: its duration can be Timed or TriggerWidth, as explained in subsection 6.3.4.
- Once the first exposure is completed a *WAIT TIME 1* is needed for sensor operation. This time represents the minimum achievable time span between two frames. This time is fixed.
- When it comes to *EXPOSURE TIME 2*, here takes place the trigger overlapping since the camera starts the second exposure during the first sensor readout. The *EXPOSURE TIME 2* lasts as long as the *SENSOR READOUT 1*. This time is fixed.
- After the second exposure the *WAIT TIME 2* occurs, allowing sensor operation and the sensor readout of the second frame. This time is fixed.

All fixed times are sensor dependent and are needed for the correct camera operation in dual exposure mode. These values depends on the sensor configuration (ROI, Pixel Format, Binning and Decimation) and can be read from **oeWaitTime1**, **oeExposureTime2** and **oeWaitTime2** features.

> ***NOTE***: *bear in mind that a second hardware trigger can occur only after the entire process is completed, which means after the WAIT TIME 2. All triggering signals which occur during WAIT TIME 1 or EXPOSURE TIME 2 or WAIT TIME 2 will be ignored.*

> ***NOTE***: *WAIT TIME 1 should be considered when designing your machine vision system to properly select the camera model, depending on the application requirements.*

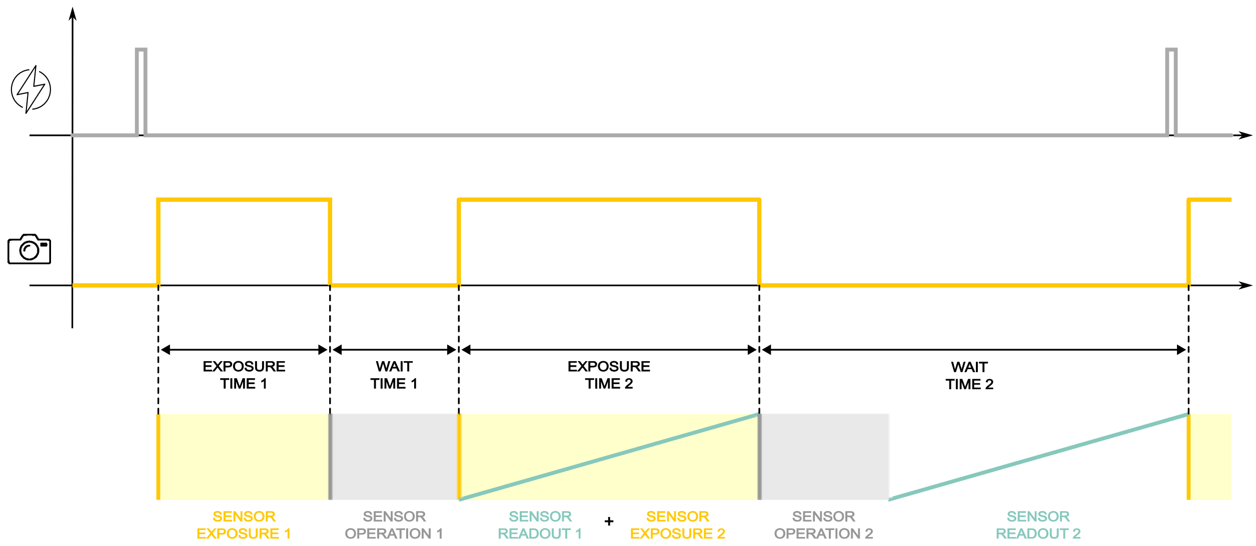


Figure 78: Dual Exposure timings and operation. From top to bottom, the trigger signal, the sensor exposure signal and the camera operation and are depicted.

> ***NOTE**: When **Dual Exposure** is enabled, **ChunkExposureTime** shows only the value set for EXPOSURE TIME 1 (i.e. the value set in **Exposure Time** field).*

6.3.3 Trigger delay

Since synchronization between illumination and exposure can be challenging, the **TriggerDelay** feature can be used to properly align the exposure period of the sensor with the external illumination.

For example, consider the situation of a triggering device which enables both illumination and camera exposure. In case of bad alignment, not all the light is collected by sensor (see Figure 79), leading to an inefficient illumination.
The **TriggerDelay** feature can be used to shift the exposure time of Itala cameras in order to fully cover the illuminator on-time (see Figure 80).

> ***NOTE**: Multiple trigger events received during the active delay period are queued internally and executed after the programmed delay. The camera's buffer can store up to 64 trigger signals, ensuring no trigger is lost during high-rate operation.*

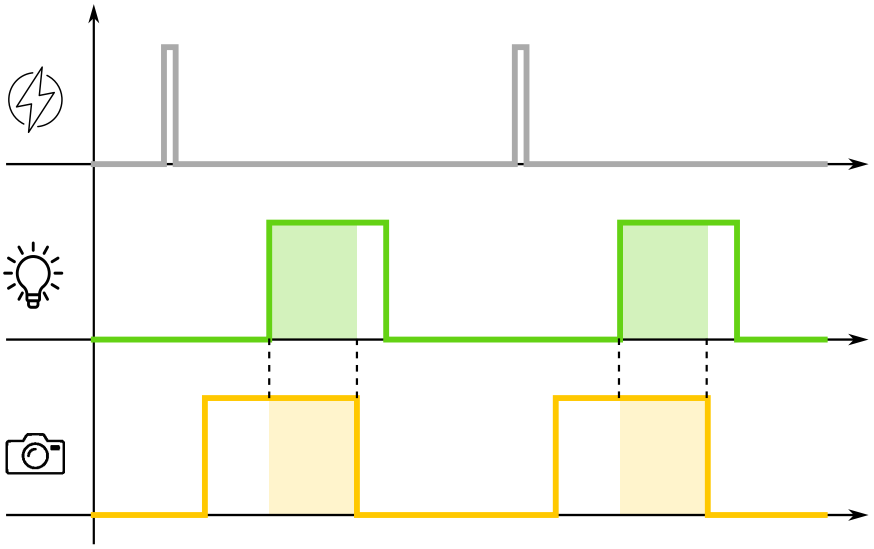


Figure 79: Incorrect alignment between illumination and camera exposure time. From top to bottom, the trigger signal, the illumination period and the camera exposure time are depicted.

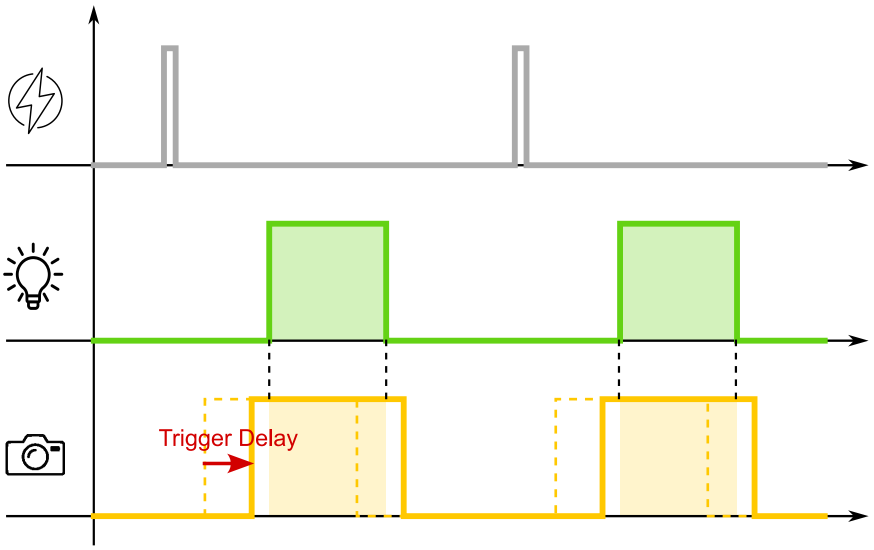


Figure 80: Correct alignment between illumination and camera exposure time. From top to bottom, the trigger signal, the illumination period and the camera exposure time are depicted.

6.3.4 *Timed* vs *TriggerWidth Exposure Mode*

Exposure mode can be either **Timed** or **TriggerWidth**.

When **Timed Exposure** is selected, the sensor exposure time is set using the *ExposureTime* or *ExposureAuto* features.
In this case the exposure time can be expressed as follows:

$$SensorExposureTime = ExposureTime \tag{1}$$

For example, if $ExposureTime = 500\mu s$, the image sensor is exposed for $500\mu s$.

When **TriggerWidth Exposure** is selected, the exposure duration is equal to the width of the current trigger signal pulse.
Actually, for some image sensors, the real exposure time can be computed as follows:

$$SensorExposureTime = TriggerPulse + ExposureOffset \tag{2}$$

where:

- *SensorExposureTime* is the overall exposure time of the image sensor.
- *TriggerPulse* is equal to the external trigger signal.
- *ExposureOffset* is an additional intrinsic period in which the image sensor is collecting light.

In this case, if the trigger pulse supplied to the camera is equal to $500\mu s$, also the intrinsic contribution of the sensor exposure offset must be taken into account, leading to an overall exposure time higher than $500\mu s$.
In general, the exposure offset depends on the image sensor and it's in the order of units/tens of microseconds.

> ***NOTE**: When **TriggerWidth Exposure** is selected, the **ExposureTime** field acts as the maximum allowed pulse width. Providing a trigger signal with a larger pulse width results in a captured frame with an exposure time clamped to the **ExposureTime** field.*

> ***NOTE**: When **TriggerWidth Exposure** is selected, **ChunkExposureTime** shows the value set in **ExposureTime** field.*

6.3.5 Image Compression

The **image compression** function allows the captured frame to be compressed with a lossless algorithm.

The compression ratio of the algorithm doesn't have a constant value, but is variable and depends on the image captured. In particular, the ratio is inversely proportional to the entropy of the pixels that make up the image. Therefore, the compression ratio is affected by image noise, which is why it is recommended to use low gain levels. The typical compression ratio is between 1.5 and 2.

If the **image compression** is enabled, the image payload size can be reduced and thus the frame rate can be increased for the same bandwidth. This is because the image payload size (along with exposure time, acquisition mode and other image processing functions such as binning and decimation) controls the frame rate of the camera, assuming the link bandwidth is fixed (see DeviceLinkThroughputLimit function in the section 6.1.2).

To enable the **image compression**, set the **oeImageCompressionEnable** parameter. When compression is activated, the camera automatically compresses the frame, calculates the new image payload size and adjusts the frame rate with the new size value to occupy all available bandwidth (DeviceLinkThroughputLimit). The result is that the algorithm increases the speed of the camera as much as possible.
All these operations are performed automatically by the camera only with compression enabled; all that is left for the user to do is to configure the other camera parameters.

The maximum frame rate, achievable by the camera only when image compression is on, is shown by **oeMaxFrameRate** parameter, while the absolute maximum frame rate is defined by the speed of the image sensor.

> ***NOTE**: The **image compression** supports only pixel formats with a size of 8bit: Mono8, BayerRG8, BayerGR8, BayerGB8, BayerBG8, Polarized00Mono8, Polarized00BayerRG8, Polarized00BayerGR8, Polarized00BayerGB8 and Polarized00BayerBG8.*

> ***NOTE**: The **image compression** is supported if **oeAcquisitionFrameRateLimitMode** is set to **oeLinkThroughput**.*

> ***NOTE**: Chunk data are not supported if **image compression** is enabled.*

The **decompression algorithm** is implemented in the Opto Engineering® GenTL producer (.cti), so decompression is not available with third party software that does not rely on Opto Engineering® GenTL producer (.cti).

The Fig.81 shows an example of implementation: two cameras share a bandwidth of 1 Gbps and each camera has 0.5 Gbps of bandwidth available (DeviceLinkThroughputLimit = 62500000). If compression can achieve a speed of x2, the two cameras can achieve the same frame rate even though they have half the bandwidth.

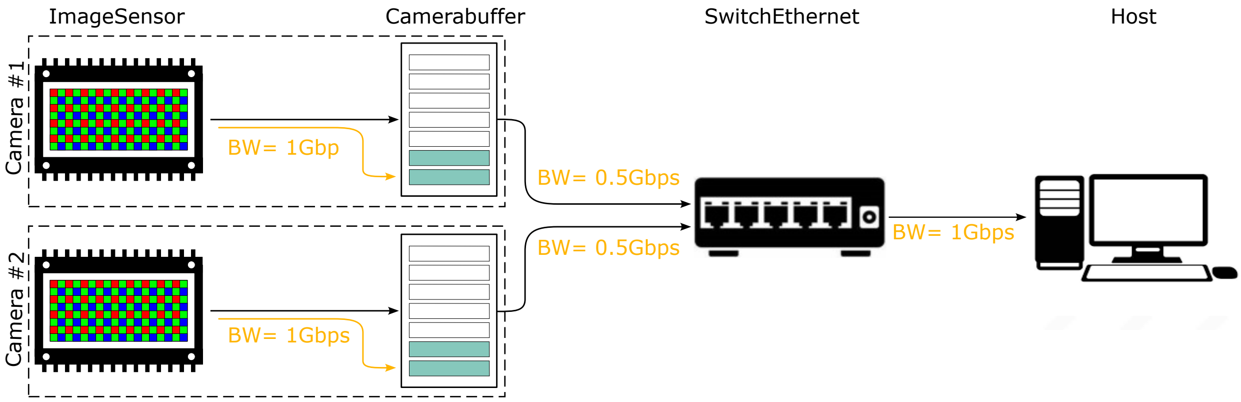


Figure 81: Example of multi-camera system with image compression enabled.

6.4 Analog Control

This sections describes how to influence the analog features of an image, such as gain, black level and gamma.

Feature	Description	Interface	Access
Gain	Controls the selected gain as an absolute physical value	IFloat	RW
GainAuto	Sets the automatic gain control (AGC) mode	IEnumeration	RW
oeGainAutoMin	Set the lower limit for the auto gain algorithm	IFloat	RW
oeGainAutoMax	Set the upper limit for the auto gain algorithm	IFloat	RW
BlackLevel	Controls the analog black level as an absolute physical value	IFloat	RW
BalanceRatioSelector	Selects the balance ratio to control	IEnumeration	RW
BalanceRatio	Controls the ratio of the selected color component	IFloat	RW
BalanceWhiteAuto	Controls the mode for automatic white balancing between the color channels. The white balancing ratios are automatically adjusted	IEnumeration	RW
oeGammaEnable	Enable the gamma correction. The LUT functions will be disabled	IBoolean	RW

Gamma	Controls the gamma correction of pixel intensity	IFloat	RW

Table 23: Analog Control Features

6.4.1 Gain

Gain is a multiplying factor applied to pixel values in order to increase the image brightness also in low-light conditions.
Sensor gain, however, affects indiscriminately useful signal and undesired noise: as can be seen in Fig.82, image brightness increases proportionally to the gain, however image quality can decrease in case of high gain values due to excessive noise.

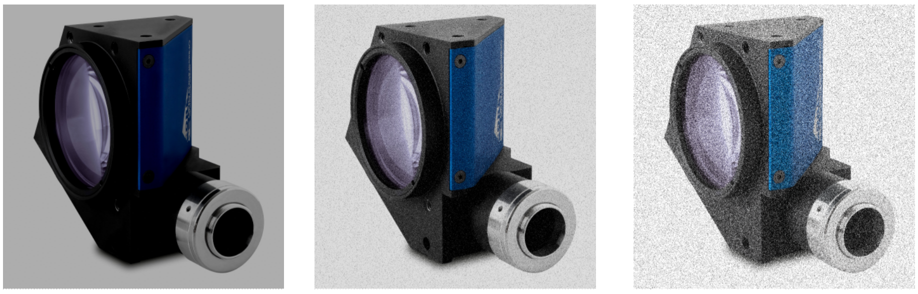


Figure 82: Different gain images

6.4.2 White balance

The **white balance** feature allows the adjustment of the response of the three color channels (R, G, B) of color cameras.
Typically color sensors have different sensitivities for the three color coordinates: this is mainly due to the different response of the Bayer filter present on top of the image sensor.
In Fig.83 (left figure) is shown a typical characteristic of a color sensor: even in case of perfectly uniform external light (i.e. flat spectrum), the pixel responses are not uniform (different mean values of gray levels), therefore green pixels will result brighter than red and blue ones.

To solve this inhomogeneity a scaling factor can be applied to the three color channels:

$$R_{out} = K_{red} * R_{in} \tag{3}$$

$$G_{out} = K_{green} * G_{in} \tag{4}$$

$$B_{out} = K_{blue} * B_{in} \tag{5}$$

To further simplify this operation a color channel may be kept constant (typically the green one, since it's the dominant Bayer tile color). The white balance coefficient for the red and blue channels can be therefore written as:

$$R_{out} = K_{red} * R_{in} \tag{6}$$

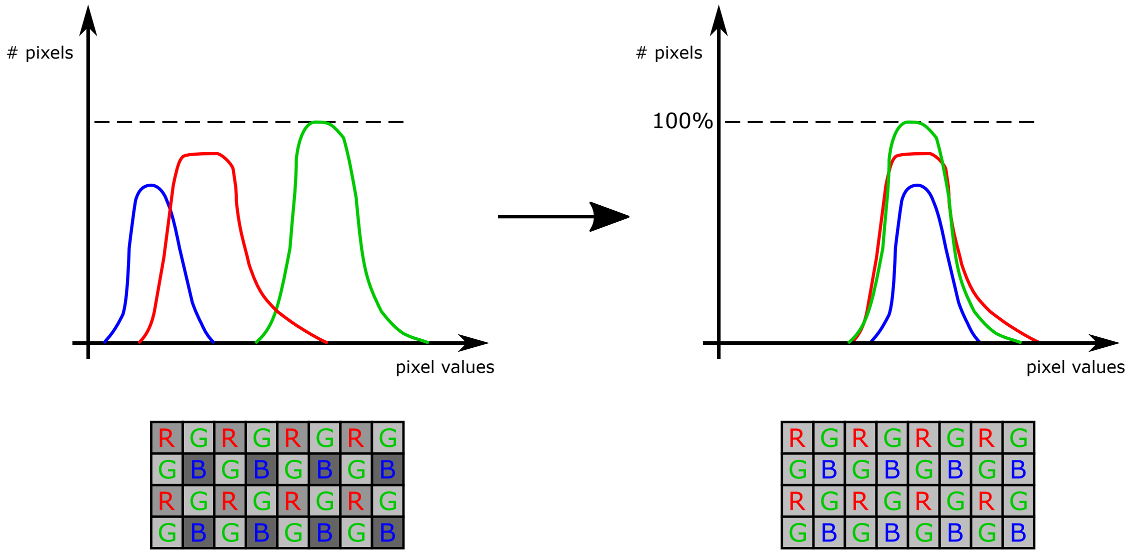


Figure 83: On the left, the histogram of a typical spectral sensitivity of a color sensor. On the right the histogram of a white balanced camera.

$$G_{out} = G_{in} \tag{7}$$

$$B_{out} = K_{blue} * B_{in} \tag{8}$$

where:

$$K_{red} = G_{in}/R_{in} \tag{9}$$

$$K_{blue} = G_{in}/B_{in} \tag{10}$$

Like in the last equations, **BalanceRatio** allows to set K_{red} and K_{blue} coefficients while K_{green} is fixed to 1.
The effect of the white balance procedure is depicted in Fig.83 (right figure): the three channels are equalized and show the same mean gray level.

Itala cameras offer the possibility to automatically balance the three color coordinates: in order to do this, the **BalanceWhiteAuto** feature must be enabled.
The BalanceWhiteAuto algorithms relies on the gray world approximation: the premise behind this assumption is that in a well balanced color image the average of all the color present is a neutral gray.
Consequently, in order to obtain a perfect white balance, perform the following steps:

- Start a free-run acquisition;
- Make sure to insert a uniform sample (for example a white neutral background) which cover all the ROI (region of interest) of the image;
- Enable the BalanceWhiteAuto (*Continuous mode* or *Once mode*);
- In case of *Continuous mode* auto white balance, after the correction is performed, disable the BalanceWhiteAuto;

- Remove the uniform neutral background;
- The camera is now balanced and ready to be used.

An example of auto white balance procedure is shown in Fig.84: on the left side an uncorrected image is displayed; on the right side a white balance corrected picture is shown.

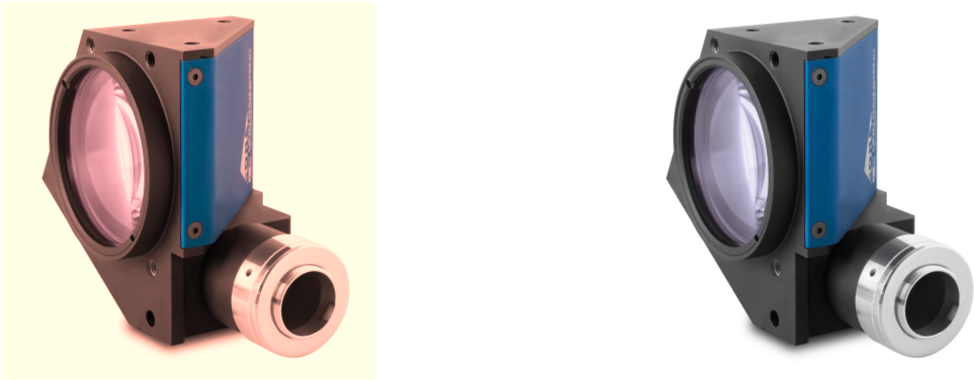


Figure 84: On the left side an uncorrected image is displayed; on the right side a white balance corrected picture is shown.

6.4.3 Gamma correction

Gamma correction is a non-linear operation which follows the formula 11:

$$V_{out} = V_{in}^{\gamma} \tag{11}$$

where V_{out} is the gray level of the pixel *n* after the gamma correction, V_{in} is the gray level of the pixel *n* and γ is the coefficient used for the non-linear transformation, set with the **Gamma** feature.

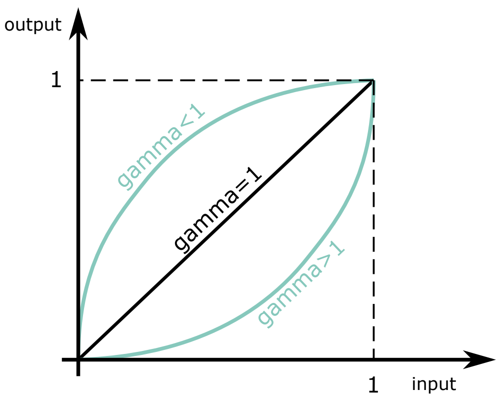


Figure 85: Gamma correction curves for $\gamma = 1$, $\gamma < 1$ and $\gamma > 1$. X-axis and Y-axis are normalized.

This operation is clearly shown in Fig.85: while "black" and "white" pixels remain the same after the correction, the different gray pixels are re-mapped on a non-linear curve, which enhances dark or bright features, depending on γ value.

In Fig.86 is shown an example of application of gamma correction.
A $\gamma < 1$ expands the range of values of dark regions and compresses the bright ones, so it's useful when looking at features in dark parts of the image. Viceversa, a $\gamma > 1$ compresses the range of values of the dark regions and expands the bright ones, so it's useful when looking at features in bright parts of the image.

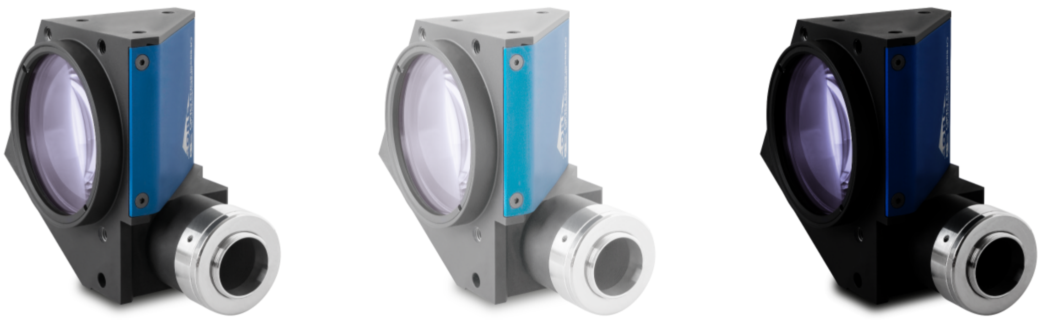


Figure 86: Images taken with different γ values: on the left $\gamma = 1$, in the center $\gamma < 1$ and on the right $\gamma > 1$

Please note that the Gamma correction can't be used if the LUT feature is enabled (see section 6.6.1).

6.4.4 Black level

The **BlackLevel** is an offset value, expressed in gray levels, that can be added to all the pixels of the image.
The effect of adding a black level value to an image is to move the pixels histogram towards the saturation level (as depicted in Fig.87).

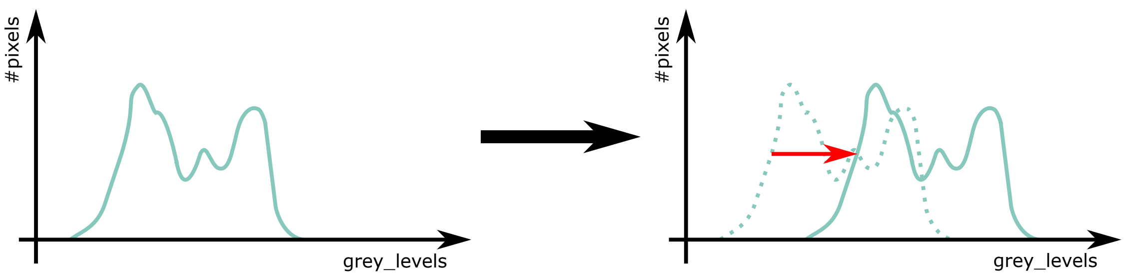


Figure 87: The black level moves the pixel histogram towards higher pixel values.

6.5 OE Auto Functions Control

This sections includes all the features related to auto exposure and auto gain control.

Feature	Description	Interface	Access
oeAutoTargetBrightness	Desired brightness level (in %) of the image used by auto gain and auto exposure functions	IInteger	RW
oeResultingBrightness	Actual brightness level (in %) of the image	IInteger	R
oeAutoDampingFactor	Control value (in %) used by auto gain and auto exposure features to reduce algorithm oscillations	IInteger	RW
oeAutoConfidence	Hysteresis around the target value used by auto gain and auto exposure features. Larger values improve image stability but increase the brightness error	IInteger	RW
oeAutoAOIWidth	Width of the area used for auto functions calculations (in pixels)	IInteger	RW
oeAutoAOIHeight	Height of the area used for auto functions calculations (in pixels)	IInteger	RW
oeAutoAOIOffsetX	Horizontal offset from the origin to the area used for auto functions calculations (in pixels)	IInteger	RW
oeAutoAOIOffsetY	Vertical offset from the origin to the area used for auto functions calculations (in pixels)	IInteger	RW

Table 24: OE Auto Functions Control Features

6.5.1 OE AutoAOI

ExposureAuto and **GainAuto** can operate either on the full-frame image or on a dedicated Area of Interest (AOI).
In the first case, the auto-functions are computed over the entire active frame, i.e., the region defined by the **Width** and **Height** parameters.
In the second case, the acquisition region and the auto-function region can be decoupled, as shown in Figure 88. The gray area represents all active pixels transmitted by the device, while the blue area defines the region used for **ExposureAuto** and **GainAuto** calculations.

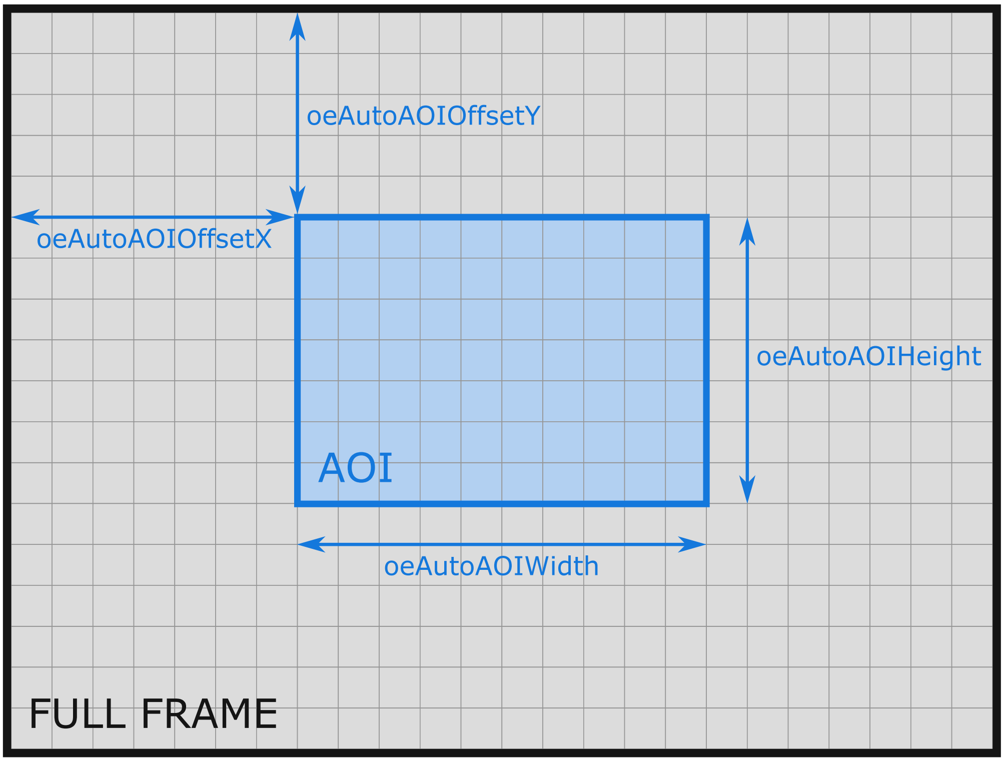


Figure 88: The gray region includes all active pixels transmitted during acquisition. The blue region defines the area used for AutoExposure/AutoGain computation; pixels outside this area (gray region) are ignored by the auto-functions.

The AOI for auto-functions can be configured in the **oeAutoFunctionControl** category.
With reference to Figure 88, the following nodes are available:

- **oeAutoAOIWidth**: width (in pixels) of the region on which auto-functions operate.
- **oeAutoAOIHeight**: height (in pixels) of the region on which auto-functions operate.
- **oeAutoAOIOffsetX**: horizontal offset (in pixels) of the region on which auto-functions operate.
- **oeAutoAOIOffsetY**: vertical offset (in pixels) of the region on which auto-functions operate.

In addition, when a reduced ROI is configured (e.g., to limit sensor area and reduce payload size), a separate AOI for AutoExposure/AutoGain may be defined, as shown in Figure 89.
In Figure 89, the AOI (blue) defines the region used for AutoExposure/AutoGain computation, the ROI (red) defines the active pixel area transmitted by the device, while the remaining pixels (gray) are excluded from both acquisition and auto-function processing.

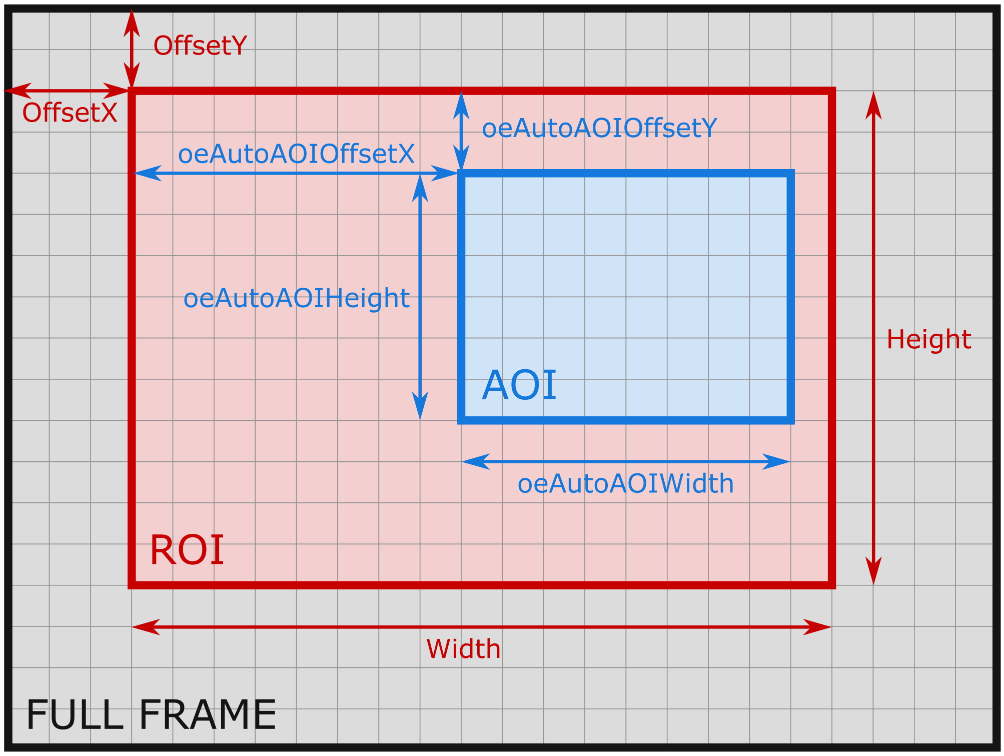


Figure 89: The AOI (blue) defines the region for AutoExposure/AutoGain computation; the ROI (red) defines the active acquisition area; all gray pixels are ignored for both acquisition and auto-functions.

6.5.2 OE Autoexposure/Autogain

When the correct amount of exposure time needed to have a sufficient level of brightness is not known a priori, or when the illumination of the target changes during time, the **autoexposure** and **autogain** features can be used to obtain a stable brightness level even if the external light conditions are not constant.

For example, consider Fig.90: at the beginning of the acquisition (i.e. the first capture), the resulting average gray level value of the image is equal to 50. Usually, a good exposure is centered at half of the full scale range (about 127 in case of 8-bit image), so an average gray level value of 50% of the full dynamic can be set in the **oeAutoTargetBrightness** feature. Thus, as it can be seen in Fig.90, the average gray level value automatically adjusts in order to achieve the desired brightness of 127.

In order to avoid the continuously adjustment of the exposure time, a certain threshold can be set with the **oeAutoConfidence** feature: in this way the algorithm becomes more insensitive to little external light fluctuations and becomes active only in case of a consistent gray level variations (see Fig.91).

The behaviour of the autogain/autoexposure algorithm can be tuned through the **oeAutoDampingFactor** node: low values of this parameter give higher stability but slower response; on the contrary, high values can speed up the algorithm but can lead to unstable behaviours (see Fig.92).

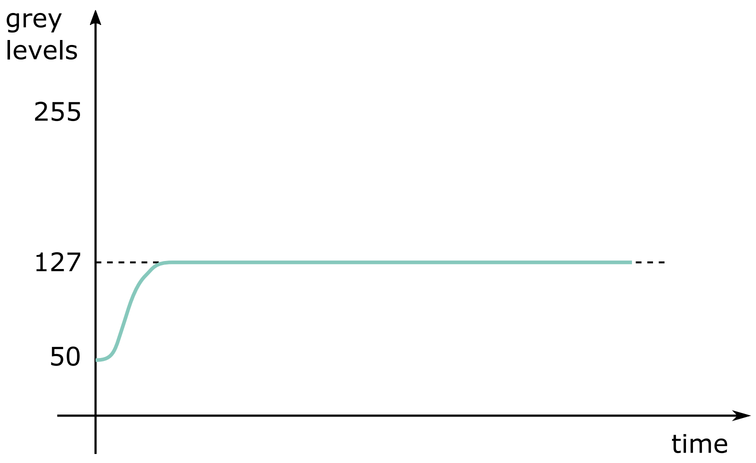


Figure 90: Evolution of the average gray level value over time when autoexposure is active.

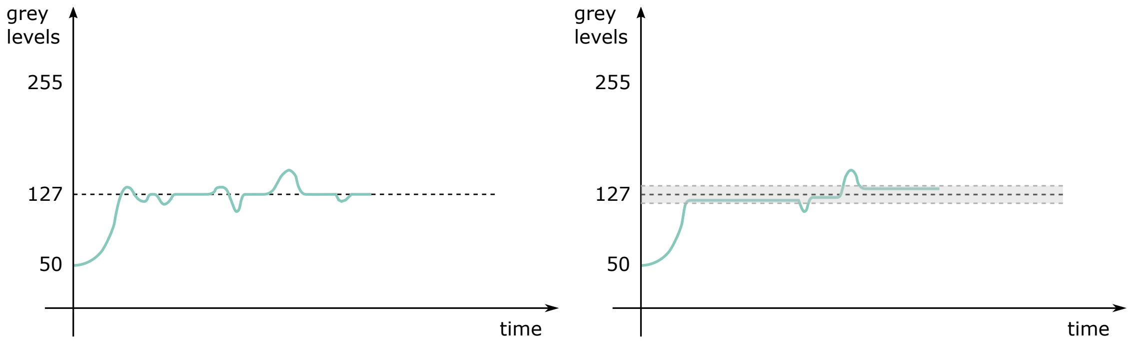


Figure 91: The continuous adjustment of the exposure time due to variations of the external light (figure on the left) can be slowed down by adding a confidence value around the target brightness (figure on the right).

If the light conditions are poor, a long exposure time is needed to achieved the desired brightness level: in some cases, this situation can lead to an undesired reduction of the camera frame rate. In order to avoid this condition, it's possible to set a minimum and maximum exposure time which can clamp and limit the exposure time computed by the autoexposure algorithm (i.e. **oeExposureAutoMin** and **oeExposureAutoMax** respectively): for example, as shown in Fig.93, in case the exposure time needed for having the desired brightness is greater than the oeExposureAutoMax value, the target gray level cannot be reached but the resulting frame rate won't be affected by an excessively long exposure time.

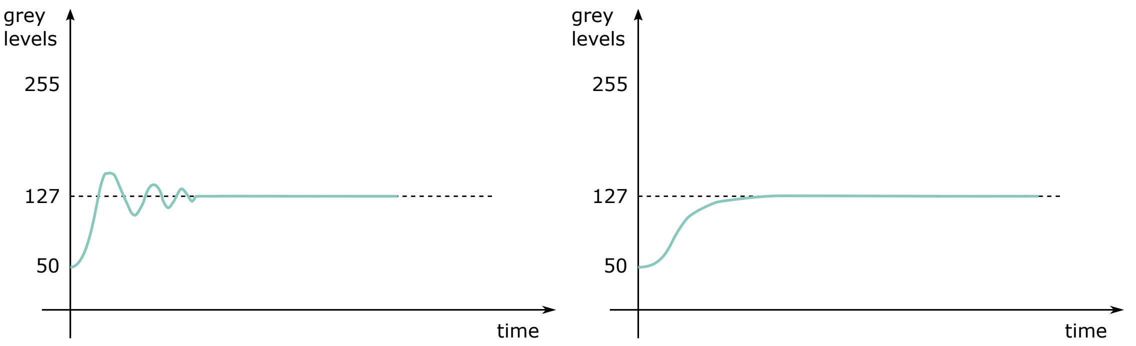


Figure 92: In case of low damping factor (figure on the left) the algorithm has a fast response but oscillations may rise; in case of high damping factor(figure on the right) the algorithm is stable but it can require long time to converge.

Figure 93: When an oeExposureAutoMax is set, the target brightness may not be achieved, but long exposures are avoided, thus preventing the reduction of the camera frame rate.

6.6 LUT Control

Features in this chapter describe the Look-up table (LUT) related features.

Feature	Description	Interface	Access
LUTSelector	Selects which LUT to control	IEnumeration	RW
LUTEnable	Activates the selected LUT	IBoolean	RW
LUTIndex	Control the index (offset) of the coefficient to access in the selected LUT	IInteger	RW

LUTValue	Returns the Value at entry LUTIndex of the LUT selected by LUTSelector	IInteger	RW

Table 25: LUT Control Features

6.6.1 LUT

The **LUT** (Look-up-table) feature allows the user to set a transformation at pixel level: a specific gray level at the input of the LUT can be replaced by a new gray level value. All the pixels with the same gray level value are processed in the same way.

Consider the graphs shown in Fig.94: in the first graph no LUT is applied, so the output gray level is equal to the input one (e.g. gray level 127 remains 127 at the output of the LUT); in the second graph, a binary thresholding is applied: all pixels with gray level values below 127 (in case of 8-bit image) are set equal to 0 (black), the others are set to 255 (white).

In Fig.95 are shown the results of the two previous transformations.

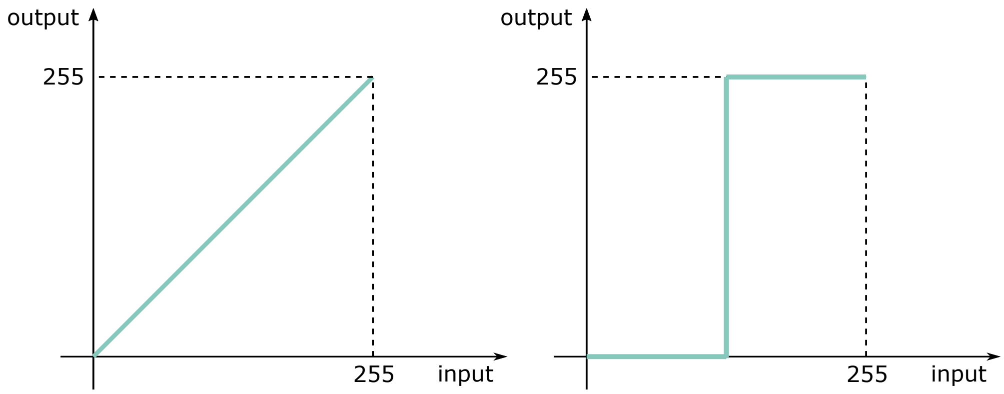


Figure 94: Two typical in-to-out transfer function: on the left no LUT is applied, on the right a binary thresholding is adopted.

Please note that the LUT can't be used if the Gamma feature is enabled (see section 6.4.3). For more information about the LUT wizard of Itala View refer to section 4.7.4.

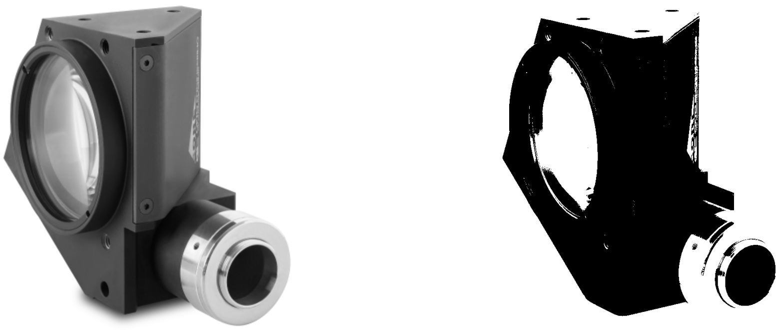


Figure 95: On the left no LUT is applied, on the right a binary thresholding is adopted.

6.7 Color transformation control

The Color Transformation section describes all features related to color transformations in the device.

Feature	Description	Interface	Access
ColorTransformationSelector	Selects which Color Transformation module is controlled by the various Color Transformation features	IEnumeration	RW
ColorTransformationEnable	Activates the selected Color Transformation module	IBoolean	RW
ColorTransformationValueSelector	Selects the Gain factor or Offset of the Transformation matrix to access in the selected Color Transformation module	IEnumeration	RW
ColorTransformationValue	Represents the value of the selected Gain factor or Offset inside the Transformation matrix	IFloat	RW

Table 26: Color Transformation Control Features

6.7.1 Color Correction Matrix (CCM)

Obtaining a good color fidelity can be challenging, this because the colors of an image depend on the camera color filter and, above all, on illumination.
Since illumination is application specific, sometimes colors need to be corrected in order to obtain a suitable color fidelity.
The **Color Correction Matrix (CCM)** allows the adjustment of the output colors of an image by

acting on gains/offset as follow:

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} Gain00 & Gain01 & Gain02 \\ Gain10 & Gain11 & Gain12 \\ Gain20 & Gain21 & Gain22 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} Offset_0 \\ Offset_1 \\ Offset_2 \end{bmatrix}$$

where *R'*, *G'* and *B'* are the corrected color coordinates, while *R*, *G* and *B* are the uncorrected ones. Gains and Offsets can be freely edited by the user but, in order to obtain an excellent calibration, a wizard has been already developed and available in Itala View. Please refer to Paragraph 4.7.6 to see the steps of this calibration procedure.

The color correction matrix is also use to make conversions between color spaces: for example, if a YUV pixel format is selected, the camera automatically load the right coefficients to switch from RGB to YUV color space:

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix}$$

For the proper adjustment of the CCM coefficients refer to section 4.7.6.

6.7.2 How to perform a correct color calibration

In order to perform a correct color calibration with Itala cameras, Itala View can be used and the following steps can be performed:

1. Given a proper lighting, select the *Horizontal line profile* tab (central lower panel) and draw a ROI which includes only the grayscale values on the bottom of the color checker (Figure 96).

2. Each grayscale tile of the displayed image should match the reference value imposed by the color checker.
   Therefore it's necessary to adjuct *ExposureTime* and *Gamma* values in order to achieve this perfect match (Figure 97). For now, consider only the green channel (current pixel values are displayed at the bottom right of the image display panel).

3. After the green channel has been properly adjusted, use the *BalanceRatioSelector* and the *BalanceRatio* features to do the same operation for the red and blue color channels.
   Avoid the *Balance white auto* feature for this step and keep monitored the *Horizontal line profile* tab. When the R, G and B curves are superimposed, the white balance is optimal (Figure 98).

4. Now the color calibration can be performed by using the dedicated wizard in the *Tool* panel of Itala View: the instructions for the proper use of the *Color Correction Wizard* are listed in Paragraph 4.7.6 (Figure 99).
   Once the calibration is complete, the result will be similar to the following one depicted in Figure 100.

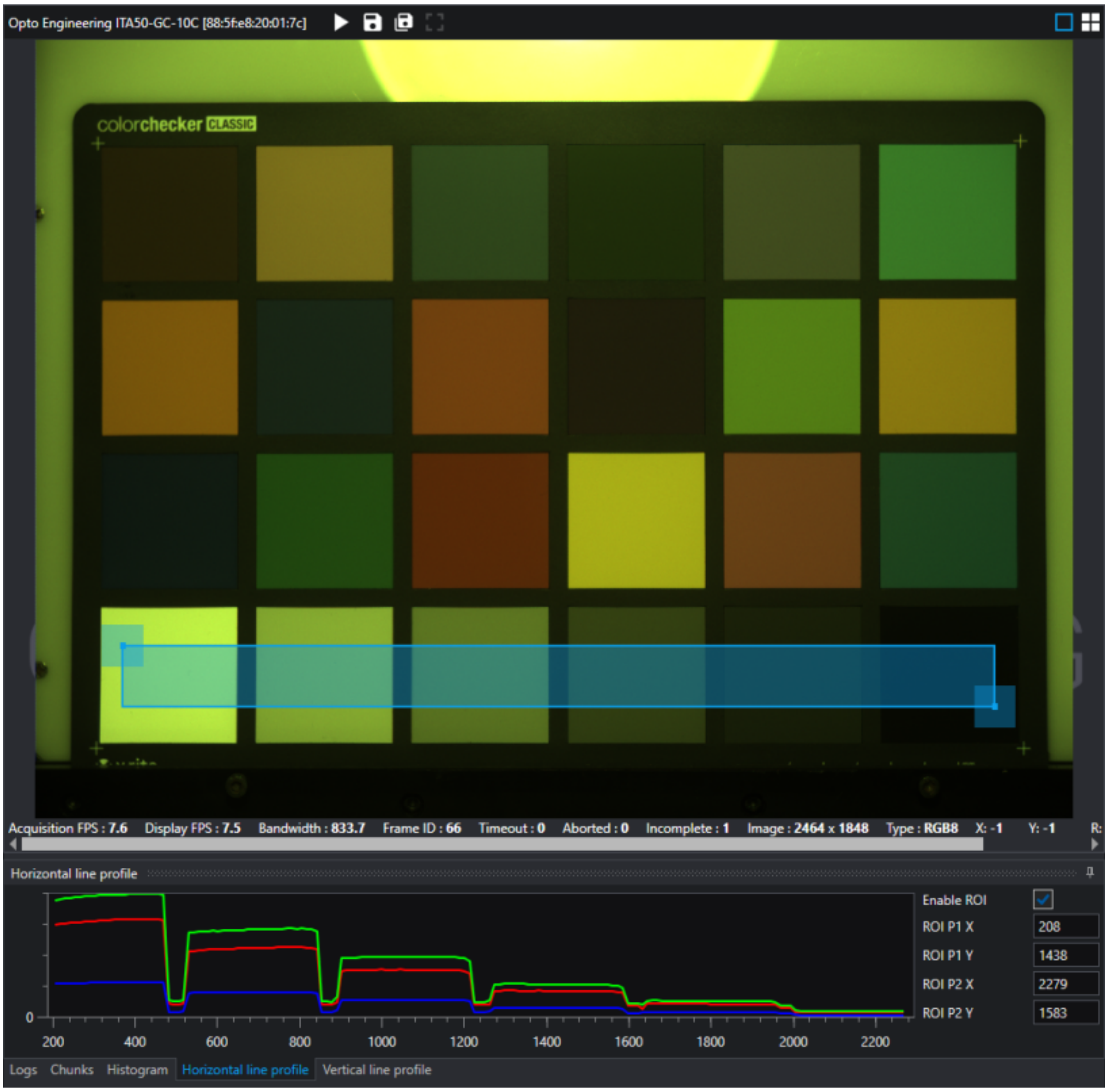


Figure 96: First steps of the color calibration procedure: setting of a proper ROI (including only the grayscale tiles of the color checker) and displaying the results on the horizontal line profiler.

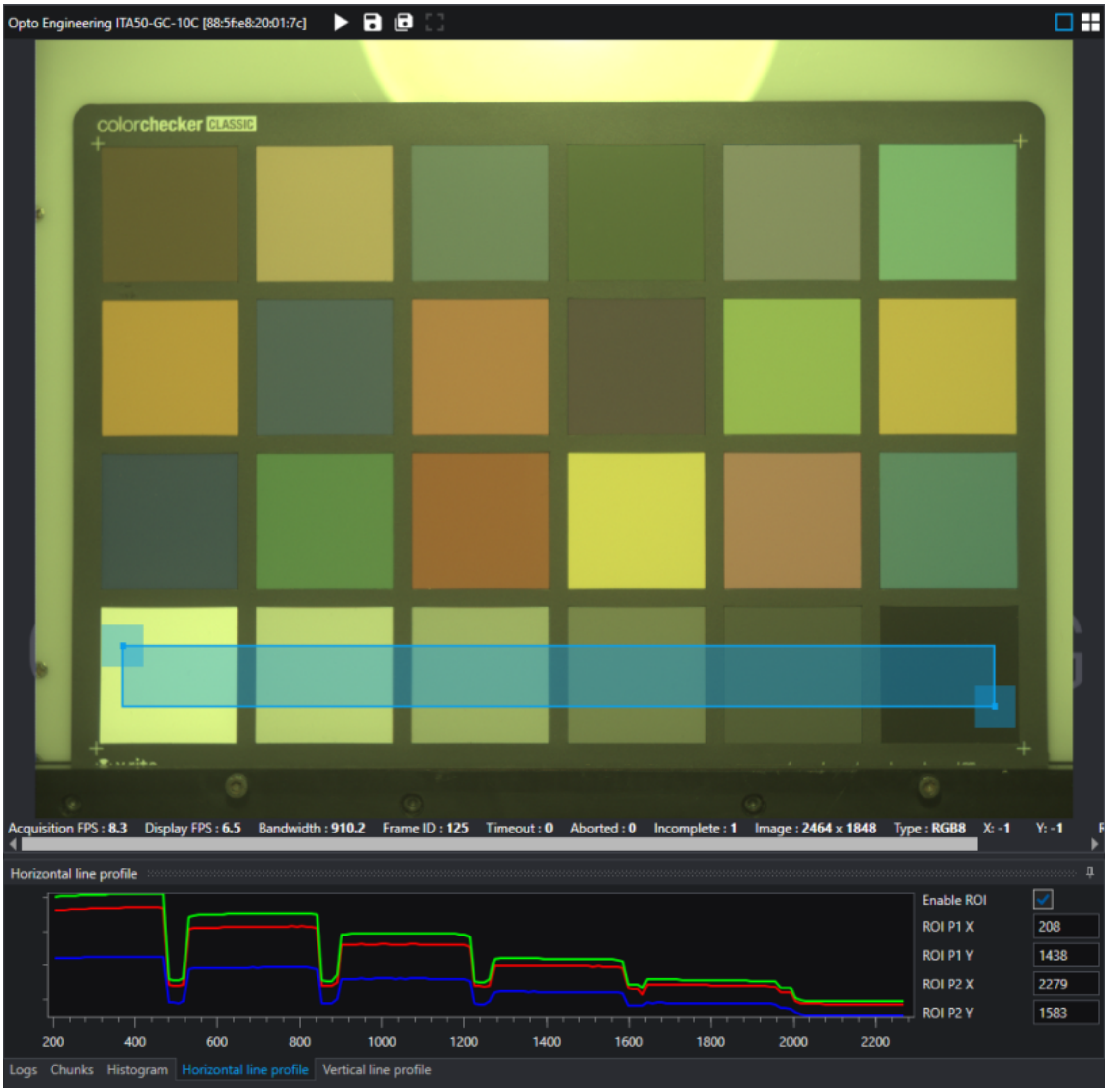


Figure 97: Second step of the color calibration procedure: *Exposure Time* and *Gamma* adjustment so that the green channel matches the value imposed by the color checker.

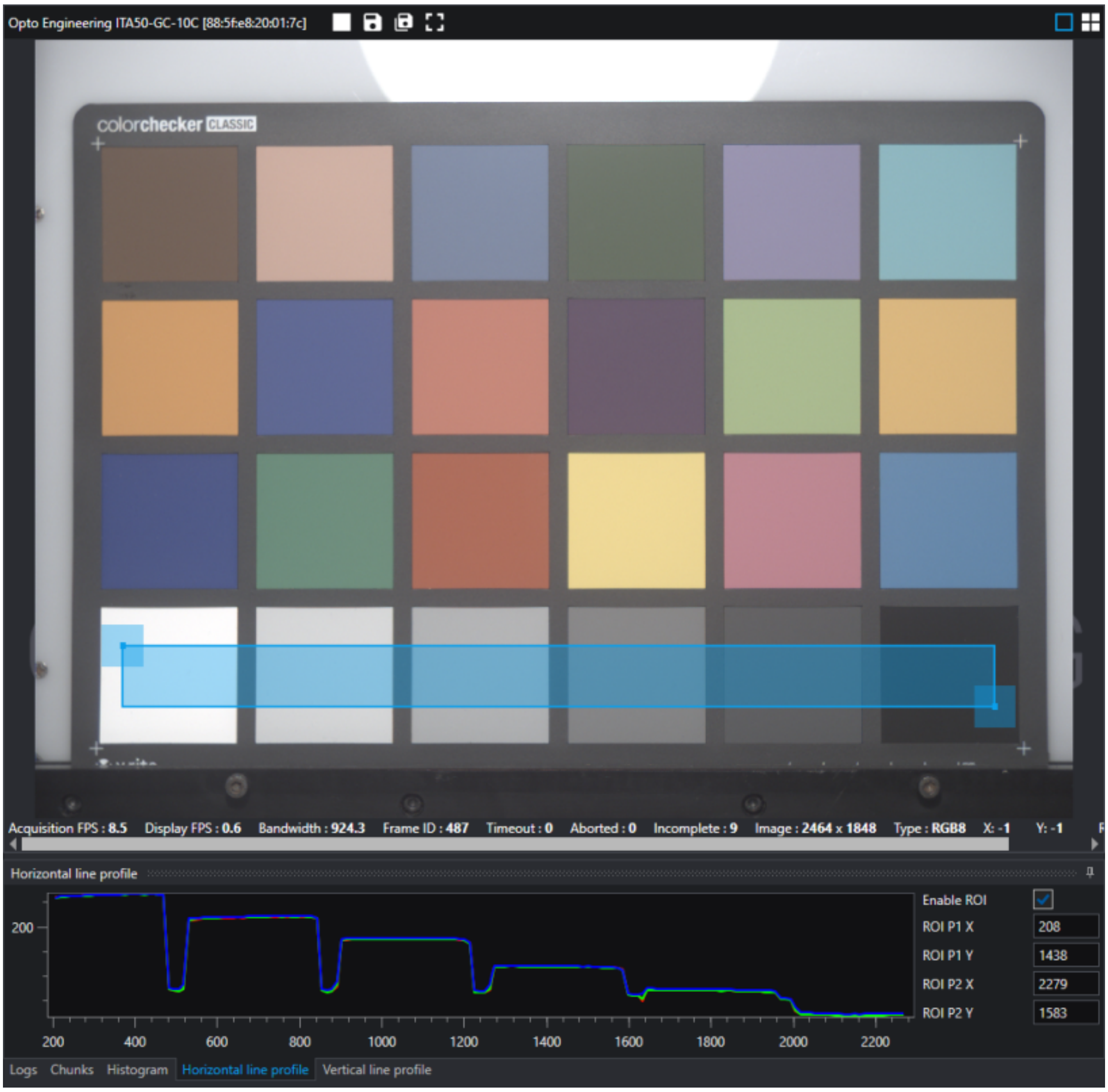


Figure 98: Third step of the color calibration procedure: using the *BalanceRatio* feature, adjust the red and blue channels in order to have all the three color curves superimposed in the horizontal line profile tab.

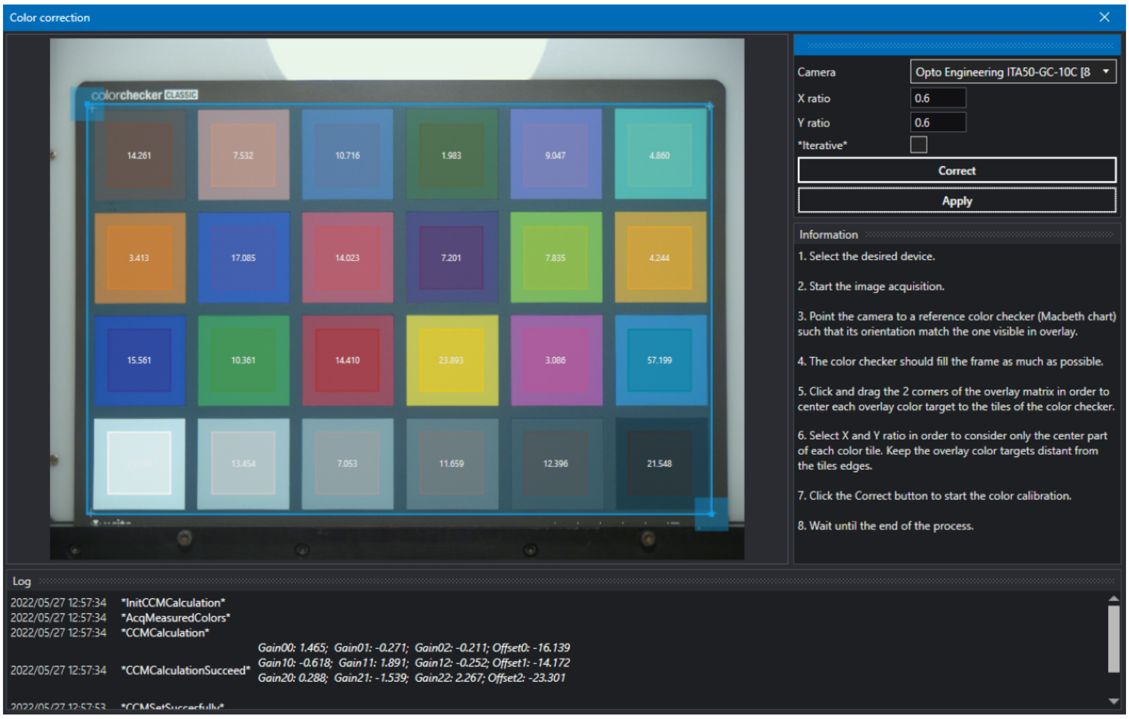


Figure 99: Fourth step of the color calibration procedure: using the *Color Correction Wizard* of Itala View, perform the color calibration following the tips of the wizard.

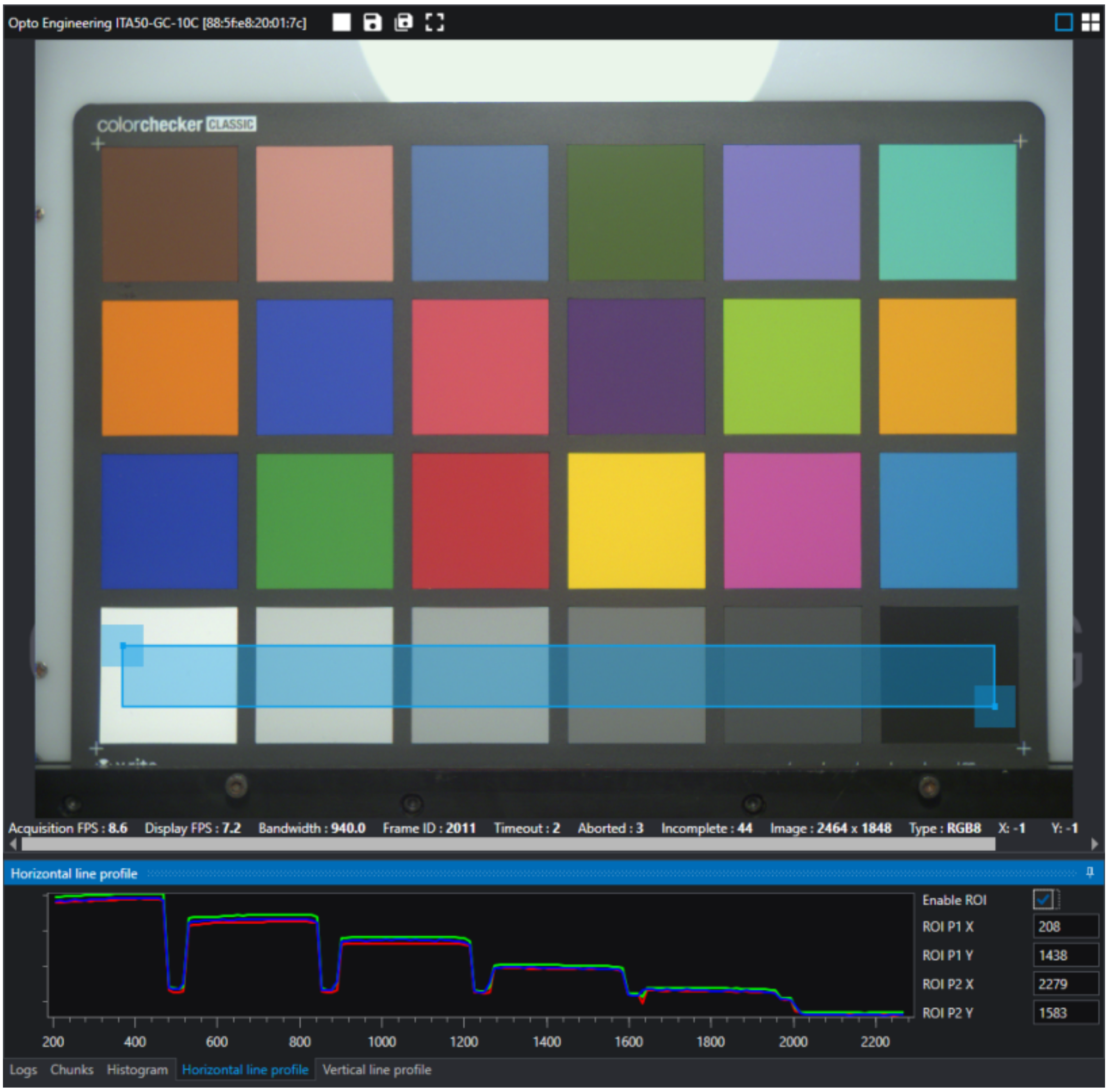


Figure 100: Color checker after Color Calibration procedure.

6.8 Digital I/O Control

The Digital I/O chapter covers the features required to control the general Input and Output signals of the device. These include input and output control signals for triggering timers, counters and also static signals such as user configurable input or output bits.

Feature	Description	Interface	Access
LineSelector	Selects the physical line (or pin) of the external device connector or the virtual line of the Transport Layer to configure	IEnumeration	RW
LineMode	Controls if the physical Line is used to Input or Output a signal	IEnumeration	RW
LineInverter	Controls the inversion of the signal of the selected input or output Line	IBoolean	RW
LineStatus	Returns the current status of the selected input or output Line	IBoolean	R
LineStatusAll	Returns the current status of all available Line signals at time of polling in a single bit field	IInteger	R
LineSource	Selects which internal acquisition or I/O source signal to output on the selected Line	IEnumeration	RW
oeDebounceEnable	Enable the input debounce circuitry. This allows to filter the input signal and ignore spurious commutations.	IBoolean	RW
oeDebounceAmount	Amount of time for which the input signal need to stay constant in order to be recognized as a valid input	IFloat	RW
oePulseGeneratorEnable	Override the output signal with a pulse generated at the rising edge of the signal specified by LineSource	IBoolean	RW
oePulseGeneratorPeriod	Sets the duration of the output signal pulse	IFloat	RW
UserOutputSelector	Selects which bit of the User Output register will be set by UserOutputValue	IEnumeration	RW

UserOutputValue	Sets the value of the bit selected by UserOutputSelector	IBoolean	RW
UserOutputValueAll	Sets the value of all the bits of the User Output register	IInteger	RW
UserOutputValueAllMask	Sets the write mask to apply to the value specified by UserOutputValueAll before writing it in the User Output register	IInteger	RW

Table 27: Digital I/O Control Features

6.8.1 Input Stage

The digital I/O block includes an onboard processing stage for input trigger signals and synchronization outputs.

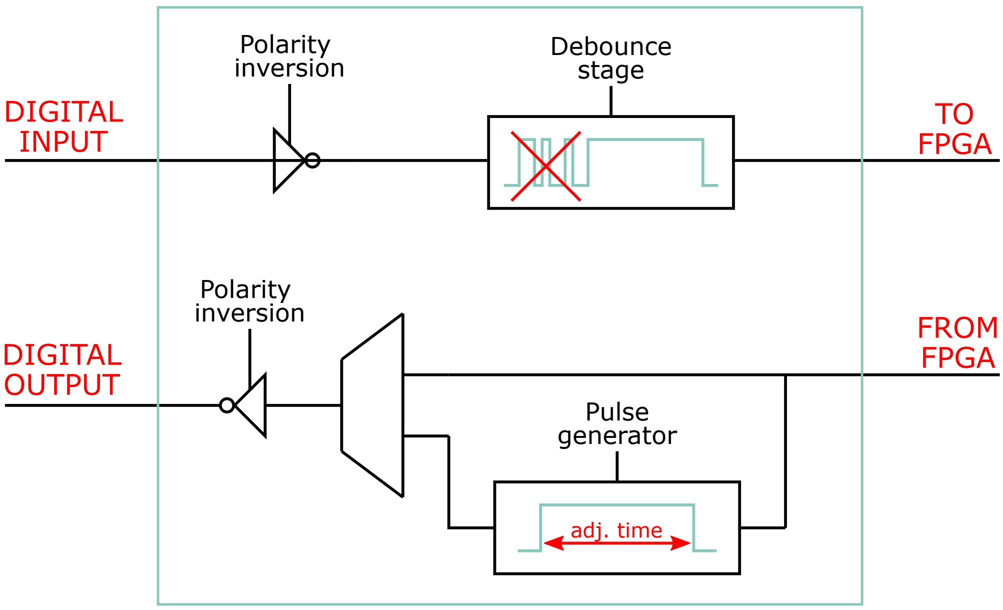


Figure 101: Digital I/O stage representation.

The **LineInverter** feature must be activated when the input trigger works with an *active-low* logic, i.e. when a falling edge must be detected. This feature applies also for synchronization outputs.

6.8.2 Debouncer

The debouncer is a feature designed to suppress noise, spikes, and oscillations on input trigger signals.
It is typically used in systems where such disturbances may cause unintended triggering events.

Figure 102 illustrates the operating principle of the debouncer logic.
Input pulses shorter than $T_{DEBOUNCE}$ (exposed as **oeDebounceAmount** in the GenICam tree) are classified as spurious and therefore rejected, while pulses exceeding this duration are considered valid.
Naturally, this stage introduces an intrinsic processing delay, since a time interval equal to oeDebounceAmount must elapse before determining whether an input pulse is genuine or not.

> ***NOTE**: To enable the debouncer, the boolean feature **oeDebounceEnable** must be set to ON.*

> ***NOTE**: A default intrinsic debounce period of $1\ \mu s$ is always present to suppress high-frequency oscillations on opto-isolated inputs.*

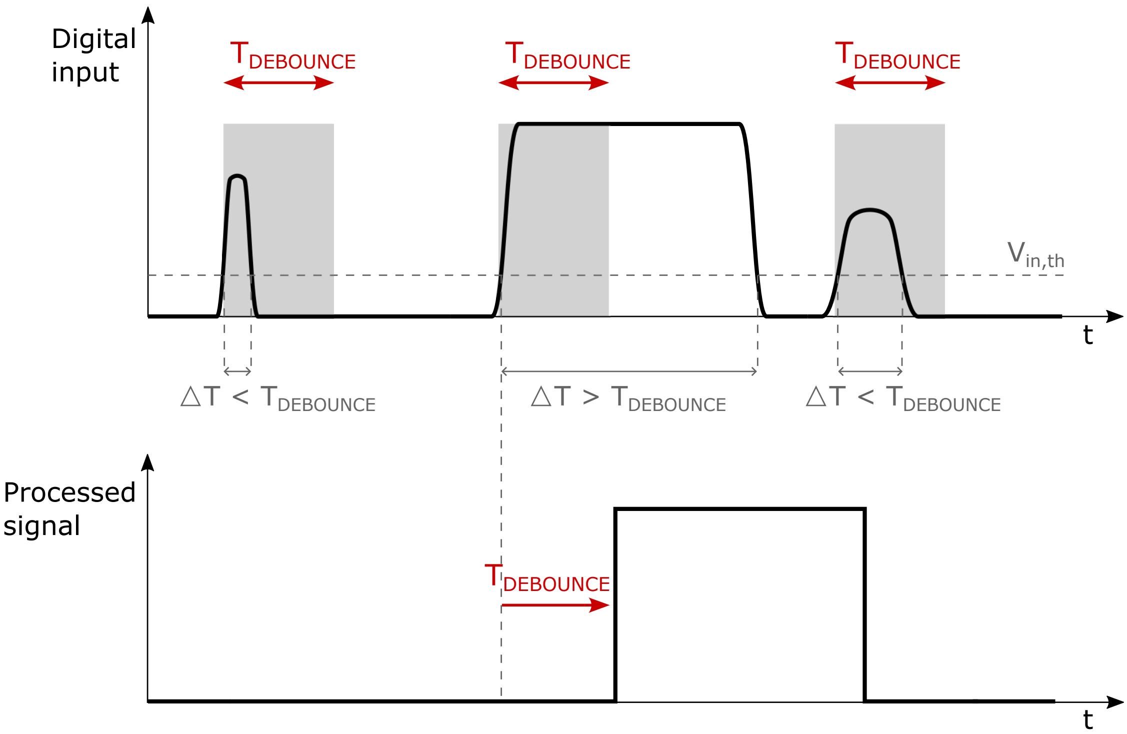


Figure 102: Debouncer operating principle. Pulses shorter than oeDebounceAmount are rejected as unwanted spikes, while longer pulses are accepted as valid trigger signals.

Additionally, an extra protection mechanism can be enabled to further increase input trigger robustness against noise and disturbances.
When the feature **oeDeglitchEnable** is activated, the input deglitch circuitry filters negative-going pulses whose duration is shorter than oeDebounceAmount. The deglitch stage operates only when the debouncer (oeDebounceEnable) is enabled.
Figure 103 shows the functional principle of the deglitch logic.

NOTE: *The deglitch period always matches the debounce period.*

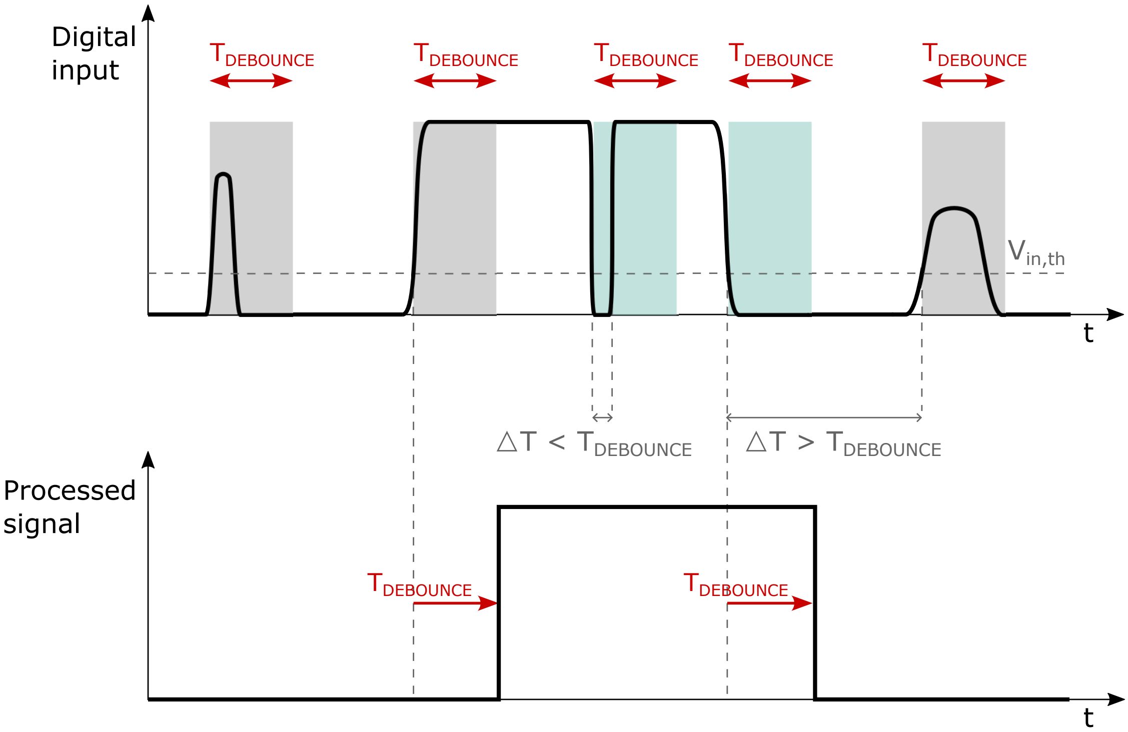


Figure 103: Deglitcher operating principle. Negative-going input pulses shorter than oeDebounceAmount are rejected, as they are considered unwanted glitches. When the logic LOW state persists for a duration longer than oeDebounceAmount, the falling edge is treated as valid, and the processed signal switches to LOW accordingly.

6.8.3 Output stage

The output synchronization signal can be chosen between an internally generated pulse which asserts when conditions are met (e.g. TimerEnd, CounterEnd, EncoderOut, ...) and a dedicated pulse generator: the advantage of using the second approach relies in the possibility of choosing the duration of the pulse, while in the first case the generated signals may last only one clock period and may be too fast to be detected by the slave device.
The **oePulseGeneratorEnable** feature allows the triggering of the pulse generator when **LineSource** condition is met, while the **oePulseGeneratorPeriod** feature sets its on-time.

6.9 Counter and Timer Control

This section lists all features related to control and monitor Counters and Timers.

Feature	Description	Interface	Access
CounterSelector	Selects which Counter to configure	IEnumeration	RW
CounterEventSource	Select the events that will be the source to increment the Counter	IEnumeration	RW
CounterResetSource	Selects the signals that will be the source to reset the Counter	IEnumeration	RW
CounterDuration	Sets the duration (or number of events) before the CounterEnd event is generated	IInteger	RW
CounterValue	Reads or writes the current value of the selected Counter	IInteger	RW
CounterReset	Does a software reset of the selected Counter and starts it	ICommand	RW
TimerSelector	Selects which Timer to configure	IEnumeration	RW
TimerTriggerSource	Selects the source of the trigger to start the Timer	IEnumeration	RW
TimerDuration	Sets the duration (in microseconds) of the Timer pulse	IFloat	RW
TimerDelay	Sets the duration (in microseconds) of the delay to apply at the reception of a trigger before starting the Timer	IFloat	RW
TimerValue	Reads or writes the current value (in microseconds) of the selected Timer	IFloat	RW
TimerReset	Does a software reset of the selected timer and starts it	ICommand	RW

Table 28: Counter and Timer Control Features

6.10 Encoder Control

This section lists all features for the control and the monitoring of quadrature encoders.
Quadrature encoders are also known as incremental, rotary and shaft encoders.

Feature	Description	Interface	Access
EncoderSelector	Selects which Encoder to configure	IEnumeration	RW
EncoderSourceA	Selects the signal which will be the source of the A input of the Encoder	IEnumeration	RW
EncoderSourceB	Selects the signal which will be the source of the B input of the Encoder	IEnumeration	RW
EncoderMode	Selects if the count of encoder uses FourPhase mode with jitter filtering or the HighResolution mode without jitter filtering	IEnumeration	RW
EncoderDivider	Sets how many Encoder increment/decrements are needed to generate an Encoder output pulse signal	IInteger	RW
EncoderOutputMode	Selects the conditions for the Encoder interface to generate a valid Encoder output signal	IEnumeration	RW
EncoderValue	Reads or writes the current value of the position counter of the selected Encoder	IInteger	RW
EncoderResetSource	Selects the signals that will be the source to reset the Encoder	IEnumeration	RW
EncoderReset	Does a software reset of the selected Encoder and starts it	ICommand	RW

Table 29: Encoder Control Features

6.10.1 Encoder interface

Itala can be used to monitor incremental encoders.
A-B pins of quadrature encoders can be connected to the opto-isolated input pins of Itala cameras.
The electrical specifications are listed in Table 7 and Table 5.1.

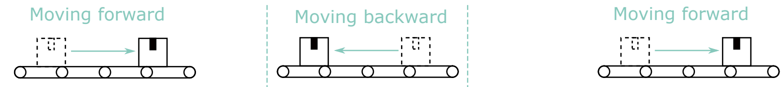
The maximum input frequency of Itala encoder interface is approximately 30KHz.
This is mainly due to the response times of the opto-isolated circuitry.

> ***NOTE***: *In case the input frequency is higher than the nominal specifications, sampling errors may occur and, consequently, errors may arise during the encoder monitoring.*

6.10.2 Encoder output mode

The **EncoderOutputMode** feature selects one of two following driving modes (see Fig.104):

- **direction mode**: encoder position is incremented only in one direction.
  When moving direction changes, the encoder counter stops counting until the moving direction changes again.
  In this configuration, motion reverse is not considered.
- **position mode**: encoder position is incremented only in one direction.
  When moving direction changes, the encoder counter starts decrementing until the moving direction changes again.
  In this configuration, motion reverse is therefore considered.



Object position	0	1	2	3	4	5	6	7	6	5	4	3	2	3	4	5	6	7	8	9	10	11	12	13
Encoder Value (direction mode)	0	1	2	3	4	5	6	7	7	7	7	7	7	8	9	10	11	12	13	14	15	16	17	18
Encoder Value (position mode)	0	1	2	3	4	5	6	7	6	5	4	3	2	3	4	5	6	7	8	9	10	11	12	13

Figure 104: The two different driving modes of the encoder block: (figure above) **direction mode** and (figure below) **position mode**.

6.10.3 Encoder mode

The encoder counter can be incremented/decremented with two different approaches:

- **High resolution mode**: encoder counter is updated (incremented or decremented) for every commutation of *Encoder A* or *Encoder B* signal.
- **4-phase mode**: encoder counter is updated (incremented or decremented) for every full cycle (i.e. for every sequence 00 - 10 - 11 - 01)

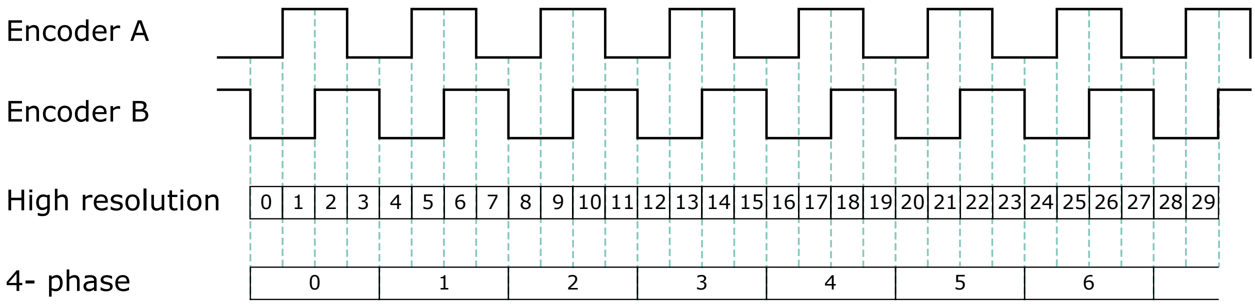


Figure 105: Encoder modes: High resolution (above) vs 4-phase (below).

6.10.4 EncoderValue wrapping management

EncoderValue is a positive value, ranging from 0 to 65535.
When encoder output mode is set to **position mode**, reverse motion is considered in **EncoderValue** computation: since this value cannot be negative, backward movements cause the encoder to reverse count, from 65535 to 0, as depicted in Fig.106.
In this scenario, if reverse motion is not correctly managed, spurious pulses could arise.

Consider the following exemple, where **EncoderDivider** is set equal to 20000.
Consider also a number of backward steps that lead **EncoderValue** to be equal 15000, i.e. a value smaller than **EncoderDivider**. When forward motion restarts, a spurious encoder pulse arises when **EncoderValue** equals **EncoderDivider** (i.e. 20000).

In order to avoid unwanted encoder pulses, the following condition must be satisfied:

$$Maximum\ backward\ steps < (2^{16} - 1) - EncoderDivider \tag{12}$$

In case Eq.11 could not be guaranteed, spurious encoder pulses must be managed by user application.

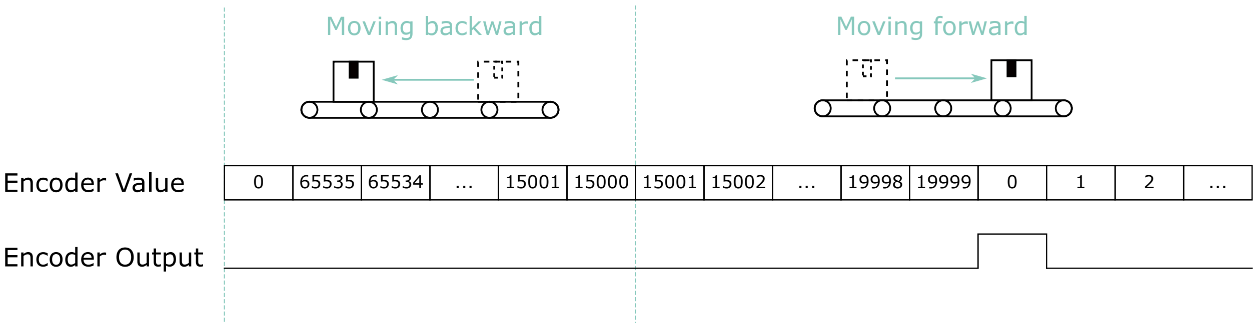


Figure 106: Example of spurious pulse generation: first, reverse motion is applied so that **EncoderValue** indicator goes lower than **EncoderDivider**. Then, when forward motion is restored, a spurious pulse is generated when **EncoderValue** equals **EncoderDivider**

6.11 Logic Block Control

The Logic Block Control section describes the model and features related to the control and the generation of signals by Logic Block elements.

Feature	Description	Interface	Access
LogicBlockSelector	Specifies the Logic Block to configure	IEnumeration	RW
LogicBlockFunction	Selects the combinational logic Function of the Logic Block to configure	IEnumeration	RW
LogicBlockInputNumber	Specifies the number of active signal inputs of the Logic Block	IInteger	R
LogicBlockInputSelector	Selects the Logic Block's input to configure	IInteger	RW
LogicBlockInputSource	Selects the source signal for the input into the Logic Block	IEnumeration	RW
LogicBlockInputInverter	Selects if the selected Logic Block Input source signal is inverted	IBoolean	RW
LogicBlockLUTIndex	Controls the index of the truth table to access in the selected LUT	IInteger	RW
LogicBlockLUTValue	Read or Write the Value associated with the entry at index LogicBlockLUTIndex of the selected LUT	IBoolean	RW
LogicBlockLUTValueAll	Sets the values of all the output bits of the selected LUT in one access ignoring LogicBlockLUTIndex	IInteger	RW

Table 30: Logic Block Control Features

6.11.1 Logic block module

The **logic block module** is mainly used to generate an output signal depending on two input conditions.
This block is characterized by three different logic functions (see Fig.107):

- **AND**: the output of logic block is HIGH if both the inputs are HIGH;
- **OR**: the output of logic block is HIGH if at least one the inputs is HIGH;
- **LUT**: the user can freely compile the truth table of the lut:

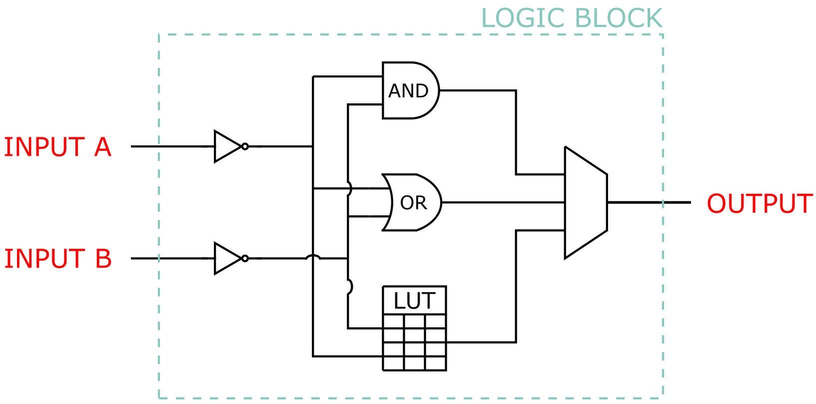


Figure 107: Simplified scheme of the logic block cell.

LogicBlockLUTIndex	Input A	Input B	LogicBlockLUTValue
0	0	0	LogicBlockLUTValue[0]
1	0	1	LogicBlockLUTValue[1]
2	1	0	LogicBlockLUTValue[2]
3	1	1	LogicBlockLUTValue[3]

Table 31: Example of LUT compilation.

In order to have the maximum flexibility, also an **inverting stage** has been included at the input of this block.

6.12 Action Control

The Action chapter describes all features related to Action Signals in the device.

Feature	Description	Interface	Access
ActionUnconditionalMode	Enables the unconditional action command mode where action commands are processed even when the primary control channel is closed.	IEnumeration	RW
ActionDeviceKey	Provides the device key that allows the device to check the validity of action commands	IInteger	W
ActionQueueSize	Indicates the size of the scheduled action commands queue. This number represents the maximum number of scheduled action commands that can be pending at a given point in time.	IEnumeration	R
ActionSelector	Selects to which Action Signal further Action settings apply	IInteger	RW
ActionGroupKey	Provides the key that the device will use to validate the action on reception of the action protocol message	IInteger	RW
ActionGroupMask	Provides the mask that the device will use to validate the action on reception of the action protocol message	IInteger	RW

Table 32: Action command Control Features

6.12.1 Action Command

Action Command allows the user to trigger actions on one or more GigE cameras at roughly the same time on the ethernet network. Action signals are not synchronous on all devices like hardware triggers because the system is affected by ethernet network latencies, therefore the signal does not reach the devices at the same time. Anyway, using the action command the user can avoid other hardware connections to trigger the camera and use only the ethernet line. Also, action command trigger is better than software trigger on multiple cameras, because only one command is forwarded to all of them.
The Itala camera support one action command, so the user can configure an ActionDeviceKey, an ActionGroupKey and an ActionGroupMask. The camera checks that the command information

matches the configured action command and then generates the trigger. Commands can be sent in unicast or broadcast mode, depending on whether one or more devices should be triggered.
To improve the synchronism of the trigger on camera the **Scheduled Action Commands** must be used (6.12.2).

6.12.2 Scheduled Action Command

Scheduled Action Commands allows a trigger action to be generated on one or more devices at a specific time in the future, with nanosecond granularity. The only two requirements are enabling of **PTP** feature and synchronizing the camera with PTP master clock (see 6.20.1), otherwise the scheduled action request is not processed.
The block diagram to explain the architecture of the scheduled action control is shown in Fig.108 and it is discussed in detail below.
When the user sends a scheduled action, the camera checks via hardware that the command information matches the configured action command. Then, if the scheduled action has a time tag in the past, the action is processed immediately, otherwise is added into the hardware action time queue; the queue has a depth of 4, so up to 4 scheduled actions can be handled. If the queue is full, additional commands will be ignored. When the action timestamp becomes less than or equal to the reference time, it is removed from the queue and an hardware trigger toward the Exposure Control is asserted.

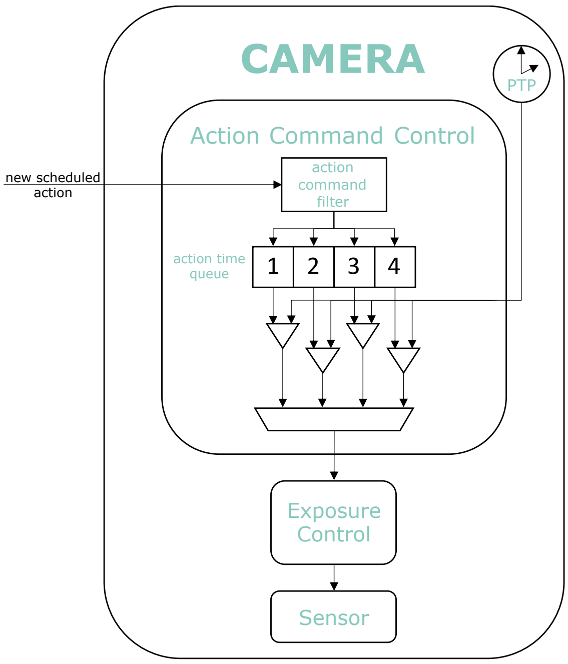


Figure 108: Scheduled Action Command block diagram.

If the ACK message is requested, the possible status codes are:

- **GEV_STATUS_NO_REF_TIME**:
the camera does not have a reference time synchronized to any master clock; the scheduled action request is not processed.
- **GEV_STATUS_ACTION_LATE**:
the camera received a scheduled action command with a time tag in the past (relative to the device timestamp).
- **GEV_STATUS_OVERFLOW**:
the timestamp queue is full and the device receives an action command that cannot be queued.

A hardware delay, measured when the scheduled action is configured to trigger a sensor exposure and caused by hardware processing, is removed in the timestamp in order to compensate for it and improve the accuracy of the trigger time.

If TriggerOverlap is ON, the latency between exposure time and frame transfer is affected by a higher uncertainty, therefore the jitter on frame acquisition is higher than when TriggerOverlap is OFF, even if Scheduled Action is used.

6.13 Event Control

This section describes how to control the generation of Events to the host application. An Event is a message that is sent to the host application to notify it of the occurrence of an internal event. Events are generally used to ensure the host application is synchronised with external events on the device. In machine vision, a typical use case is a host application that waits to be notified of the sensor's exposure end to move the inspected part on a conveyor belt.

EventSelector selects which particular Event to control. There are a number of sources of events, such as acquisition, temperature and I/O lines.

EventNotification is used to enable or disable the notification of the occurrence of the internal event selected by **EventSelector**. If **EventNotification** is set to **Off**, no event of the selected type will be generated.

For each of the events listed in the **EventSelector** enumeration, there is a corresponding event identifier feature with a standard name (e.g. **EventExposureEnd**). The controlling application can rely on this feature to register a callback function that will notify it when the event occurs. This integer event feature returns the unique identifier value that identifies the event on the transport layer.

Feature	Description	Interface	Access
EventSelector	Selects which Event to signal to the host application	IEnumeration	RW
EventNotification	Activate or deactivate the notification to the host application of the occurrence of the selected Event	IEnumeration	RW
EventExposureEndData	Category which contains all the attibutes related to the ExposureEnd event	ICategory	-
EventFrameTriggerMissedData	Category which contains all the attibutes related to the FrameTriggerMissed event	ICategory	-
EventFrameTriggerReadyData	Category which contains all the attibutes related to the FrameTriggerReady event	ICategory	-

EventLine0RisingEdgeData	Category which contains all the attibutes related to the Line0RisingEdge event	ICategory	-
EventLine1RisingEdgeData	Category which contains all the attibutes related to the Line1RisingEdge event	ICategory	-
EventTestData	Category which contains all the attibutes related to the Test event	ICategory	-
EventAutofocusDoneData	Category which contains all the attibutes related to the AutofocusDone event	ICategory	-
EventSensorTemperatureData	Category which contains all the attibutes related to the SensorTemperatureData event	ICategory	-
EventEventLostData	Category which contains all the attibutes related to the EventLost event	ICategory	-
oeEventLostCounter	Shows the count of events that have been lost	IInteger	-
oeEventLostCounterClear	Clears the Event Lost Counter	ICommand	-
EventBufferFullData	Category which contains all the attibutes related to the BufferFull event	ICategory	-
EventBufferReadyData	Category which contains all the attibutes related to the BufferReady event	ICategory	-
EventTransferSkippedData	Category which contains all the attibutes related to the TransferSkipped event	ICategory	-

Table 33: Event Control Features

6.13.1 Exposure End Event

This event is generated when the device has completed the exposure of one Frame (or Line).

Feature	Description	Interface	Access
EventExposureEnd	Returns the unique Identifier of the Exposure End type of Event	IInteger	R

EventExposureEndTimestamp	Returns the Timestamp of the ExposureEnd Event	IInteger	R
EventExposureEndFrameID	Returns the unique Identifier of the Frame (or image) that generated the ExposureEnd Event	IInteger	R

Table 34: Event Exposure End Data features

6.13.2 Frame Trigger Missed Event

This event is generated when the camera is unable to process incoming trigger signals, resulting in missed triggers. The cause may be too many triggers occurring within a prohibited interval.

Feature	Description	Interface	Access
EventFrameTriggerMissed	Returns the unique Identifier of the Frame Trigger Missed type of Event	IInteger	R
EventFrameTriggerMissedTimes-tamp	Returns the Timestamp of the Frame Trigger Missed Event	IInteger	R
EventFrameTriggerMissed-FrameID	Returns the unique Identifier of the Frame (or image) that generated the Frame Trigger Missed Event	IInteger	R

Table 35: Event Frame Trigger Missed Data features

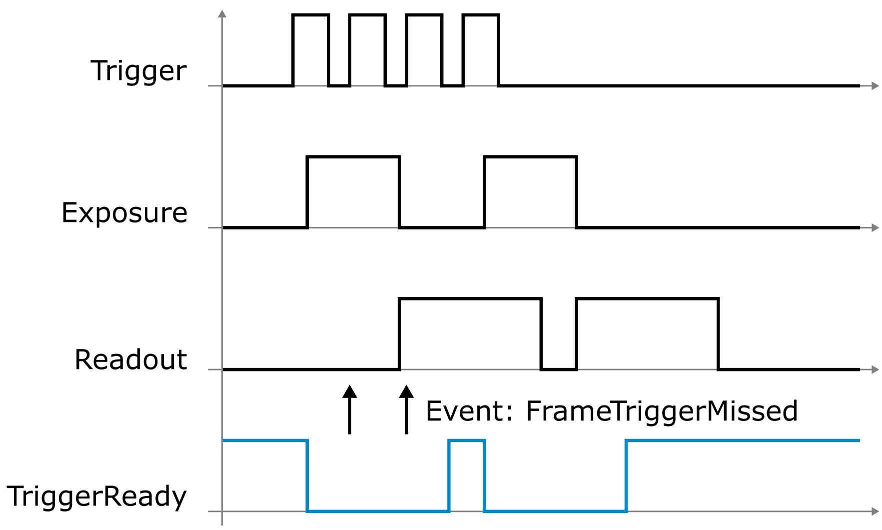


Figure 109: FrameTriggerMissedEvent

6.13.3 Frame Trigger Ready Event

The event is generated when the device is ready to receive a trigger to start the capture of a Frame.

Feature	Description	Interface	Access
EventFrameTriggerReady	Returns the unique Identifier of the Frame Trigger Ready type of Event	IInteger	R
EventFrameTriggerReadyTimestamp	Returns the Timestamp of the Frame Trigger Ready Event	IInteger	R

Table 36: Event Frame Trigger Ready Data features

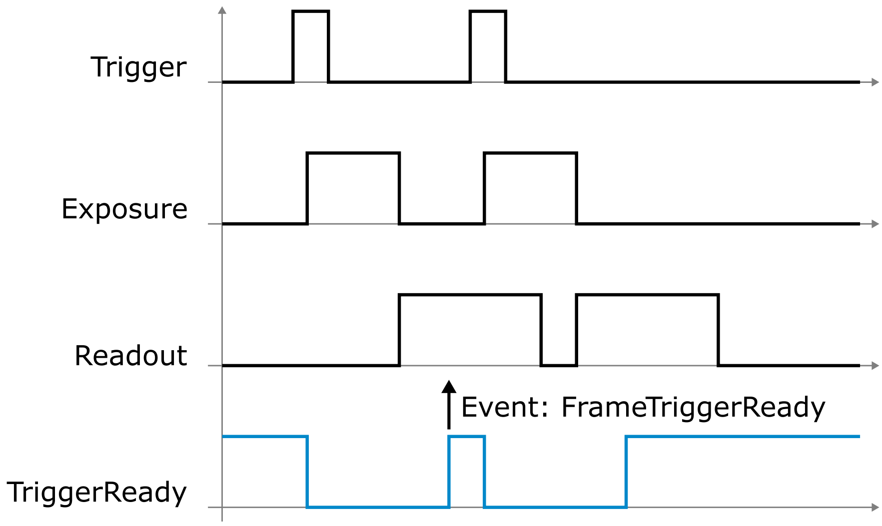


Figure 110: FrameTriggerMissedReady

6.13.4 Line 0 Rising Edge Event

The event will be generated when a Rising Edge is detected on the Line 0.

Feature	Description	Interface	Access
EventLine0RisingEdge	Returns the unique Identifier of the Line 0 Rising Edge type of Event	IInteger	R
EventLine0RisingEdgeTimestamp	Returns the Timestamp of the Line 0 Rising Edge Event	IInteger	R

EventLine0RisingEdgeFrameID	Returns the unique Identifier of the Frame (or image) that generated the Line 0 Rising Edge Event	IInteger	R

Table 37: Event Line 0 Rising Edge Data features

6.13.5 Line 1 Rising Edge Event

The event will be generated when a Rising Edge is detected on the Line 1.

Feature	Description	Interface	Access
EventLine1RisingEdge	Returns the unique Identifier of the Line 1 Rising Edge type of Event	IInteger	R
EventLine1RisingEdgeTimestamp	Returns the Timestamp of the Line 1 Rising Edge Event	IInteger	R
EventLine1RisingEdgeFrameID	Returns the unique Identifier of the Frame (or image) that generated the Line 1 Rising Edge Event	IInteger	R

Table 38: Event Line 1 Rising Edge Data features

6.13.6 Test Event

The test event will be generated when the device receives the **TestEventGenerate** command.

Feature	Description	Interface	Access
EventTest	Returns the unique Identifier of the Test type of event generated using the TestEventGenerate command	IInteger	R
EventTestTimestamp	Returns the Timestamp of the Test Event	IInteger	R

Table 39: Event Test Data features

6.13.7 Autofocus Done Event

This event is generated whenever the device has completed the autofocus process.

Feature	Description	Interface	Access
EventAutofocusDone	Returns the unique Identifier of the Event Autofocus type of Event	IInteger	R
EventAutofocusDoneTimestamp	Returns the Timestamp of the Autofocus Done Event	IInteger	R

Table 40: Event Autofocus Done Data features

6.13.8 Sensor Temperature Event

This event will be generated when the sensor changes operating temperature range.

Feature	Description	Interface	Access
EventSensorTemperature	Returns the unique identifier of the Event Sensor Temperature type of event generated by a change of image sensor temperature range	IInteger	R
EventSensorTemperatureTimestamp	Returns the Timestamp of the Event Sensor Temperature Event	IInteger	R

Table 41: Event Sensor Temperature Data features

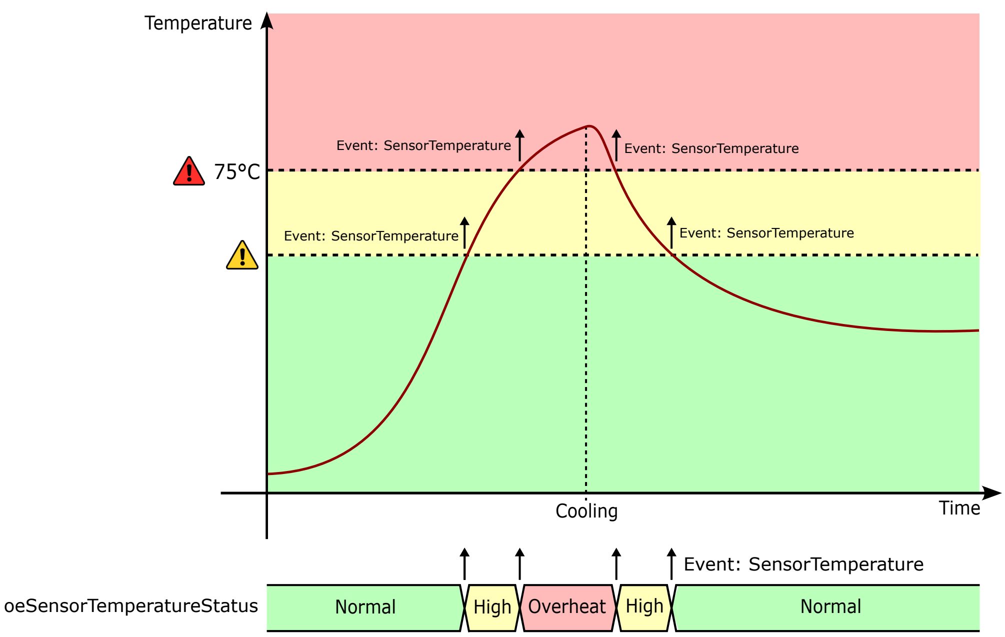


Figure 111: SensorTemperatureEvent

6.13.9 Event Lost Event

This event is generated when a selected event is lost. The loss may be caused by an excessive number of events occurring.

Feature	Description	Interface	Access
EventEventLost	Returns the unique Identifier of the Event Lost type of Event	IInteger	R
EventEventLostTimestamp	Returns the Timestamp of the Event Lost Event	IInteger	R

Table 42: Event Event Lost Data features

6.13.10 Buffer Full Event

This event is generated when the device image buffer is full.

Feature	Description	Interface	Access
EventBufferFull	Returns the unique Identifier of the Buffer Full type of Event	IInteger	R
EventBufferFullTimestamp	Returns the Timestamp of the Buffer Full Event	IInteger	R

Table 43: Event Buffer Full Data features

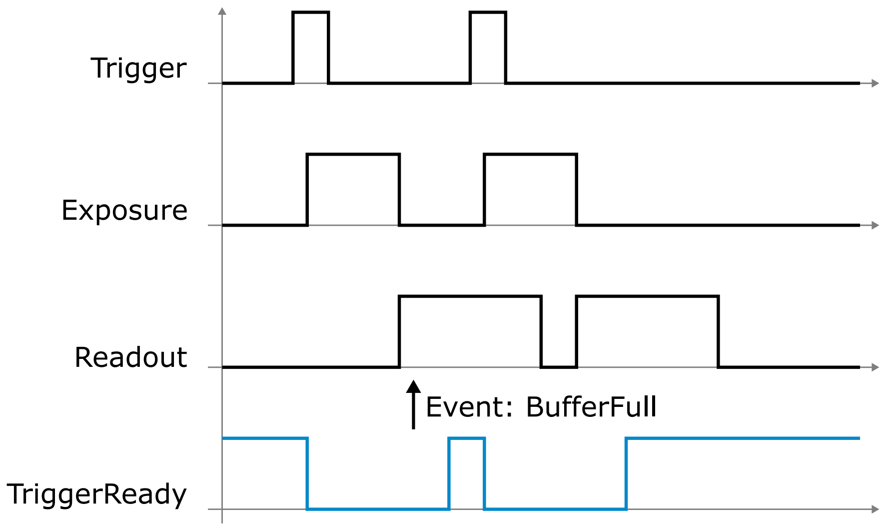


Figure 112: BufferFullEvent

6.13.11 Buffer Ready Event

This event is generated when the device image buffer is ready for a new frame.

Feature	Description	Interface	Access
EventBufferReady	Returns the unique Identifier of the Buffer Ready type of Event	IInteger	R
EventBufferReadyTimestamp	Returns the Timestamp of the Buffer Ready Event	IInteger	R

Table 44: Event Buffer Ready Data features

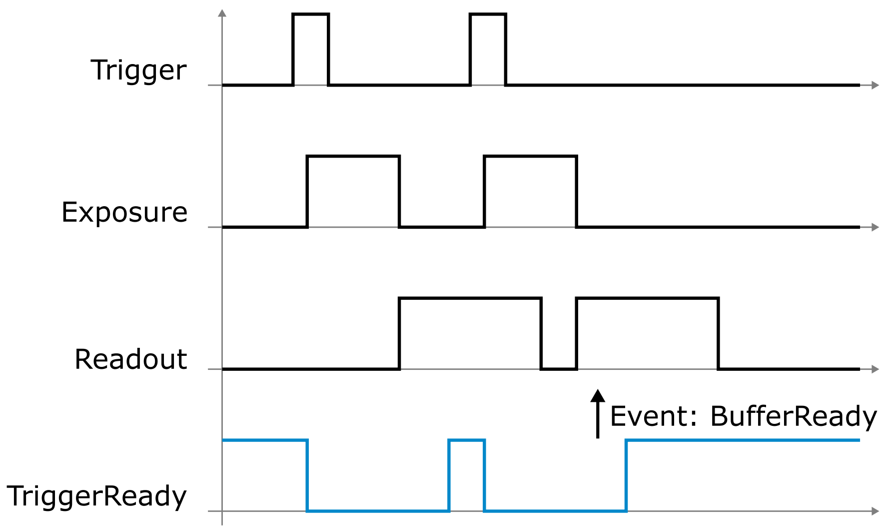


Figure 113: BufferReadyEvent

6.13.12 Transfer Skipped Event

This event is generated when the device skips the current frame transfer because the buffer is full.

Feature	Description	Interface	Access
EventTransferSkipped	Returns the unique Identifier of the Transfer Skipped type of Event	IInteger	R
EventTransferSkippedTimestamp	Returns the Timestamp of the Transfer Skipped Event	IInteger	R

Table 45: Event Transfer Skipped Data features

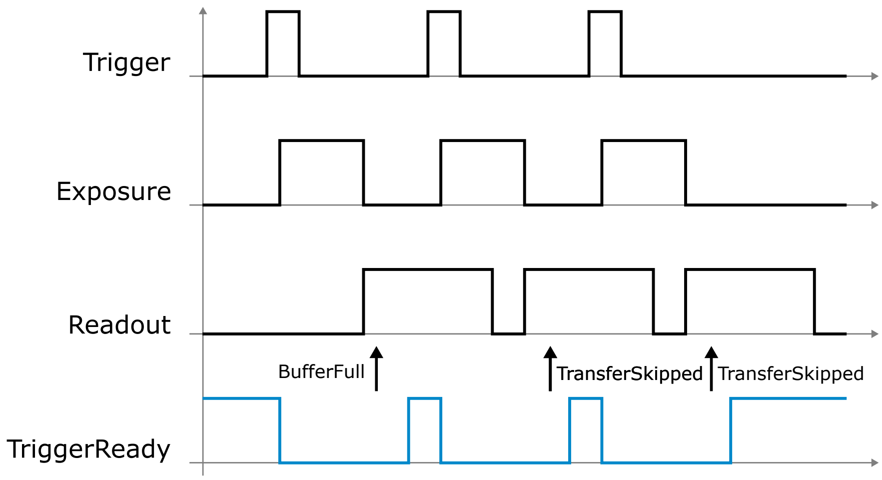


Figure 114: TransferSkippedEvent

6.14 User Set Control

This section describes the features for global control of the device settings. It allows loading or saving factory or user-defined settings.
Loading the factory default User Set guarantees a state where a continuous acquisition can be started using only the mandatory features.

Feature	Description	Interface	Access
UserSetSelector	Selects the feature User Set to load, save or configure	IInteger	RW
UserSetLoad	Loads the User Set specified by UserSetSelector to the device and makes it active	ICommand	RW
UserSetSave	Save the User Set specified by UserSetSelector to the non-volatile memory of the device	ICommand	RW
UserSetDefault	Selects the feature User Set to load and make active by default when the device is reset	IEnumeration	RW

Table 46: User Set Control Features

6.15 Chunk Data Control

This section describes all the features related to the chunk data.

Feature	Description	Interface	Access
ChunkModeActive	Activates the inclusion of Chunk data in the payload of the image	IBoolean	RW
ChunkSelector	Selects which Chunk to enable or control	IEnumeration	RW
ChunkEnable	Enables the inclusion of the selected Chunk data in the payload of the image	IBoolean	RW
ChunkWidth	Returns the Width of the image included in the payload	IInteger	R
ChunkHeight	Returns the Height of the image included in the payload	IInteger	R
ChunkOffsetX	Returns the OffsetX of the image included in the payload	IInteger	R
ChunkOffsetY	Returns the OffsetY of the image included in the payload	IInteger	R
ChunkPixelFormat	Returns the PixelFormat of the image included in the payload	IEnumeration	R
ChunkExposureTime	Returns the exposure time used to capture the image	IFloat	R
ChunkGain	Returns the gain used to capture the image	IFloat	R
ChunkBlackLevel	Returns the black level used to capture the image included in the payload	IFloat	R
ChunkTimestamp	Returns the Timestamp of the image included in the payload at the time of the FrameStart internal event	IInteger	R
ChunkFrameID	Returns the unique Identifier of the frame (or image) included in the payload	IInteger	R
ChunkSequencerSetActive	Returns the index of the active set of the running sequencer included in the payload	IInteger	R
ChunkEncoderValue	Returns the value of the Encoder 0 at the time of the FrameStart event	IInteger	R
ChunkCounterValue	Returns the value of the Counter 0 at the time of the FrameStart event	IInteger	R

Table 47: Chunk mode Control Features

6.15.1 Chunk Data

In machine-vision cameras, **chunk data** refers to metadata embedded directly into the image stream alongside the pixel payload.
This metadata provides additional information about the image or about the camera state at the time of acquisition. Chunk data is particularly valuable in industrial and vision-guided applications for:

- **Synchronization**: enabling alignment between acquired images and external sensors or events.
- **Dynamic analysis**: allowing applications to access real-time camera parameters.
- **Reduced overhead**: eliminating separate device queries to retrieve metadata.

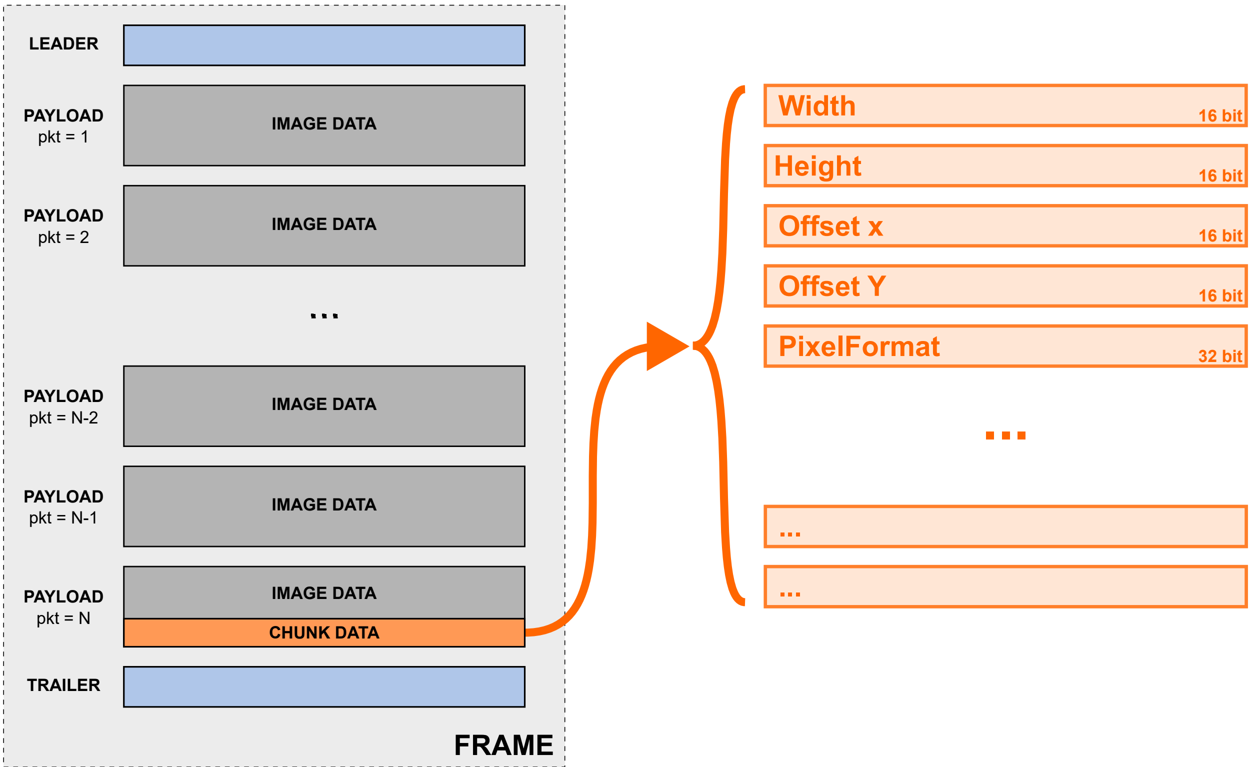


Figure 115: Left: representation of the GigE Vision packets output by the camera. Right: structure of the chunk data appended at the end of the frame transmission.

Figure 115 shows the structure of a *GigE Vision* frame: the leader packet opens the transmission, followed by a sequence of payload packets containing image data. The trailer packet closes the

transmission.
When chunk data is enabled, metadata is appended to the pixel stream in the final payload packet.
To enable chunk data, the **ChunkModeActive** feature must be set to ON and at least one chunk type must be enabled through **ChunkSelector**.

> ***NOTE**: When chunk mode is active, **all** chunk data types are transmitted by the camera. Selecting only a subset is not possible.*

A potential drawback is that chunk data may reduce the maximum achievable frame rate, particularly when the metadata size is comparable to the payload size.
Conversely, when image payload is significantly larger than the chunk data block, the impact on frame rate is negligible.

6.15.2 Chunk Data: application example

Consider the following example: an encoder is connected to the camera to trigger an acquisition every 1000 steps (Figure 116).
By enabling chunk data and using *ChunkEncoderValue*, each acquired image can be associated with the precise position of the moving sample.
Additionally, *ChunkFrameID* can be used to reconstruct the exact sequence of acquired images, even if the sample moves alternately forward and backward (i.e., *ChunkEncoderValue* may both increase and decrease).

> ***NOTE**: ChunkFrameID differs from GigE Vision FrameID. The former starts at 0, while the latter starts at 1.*

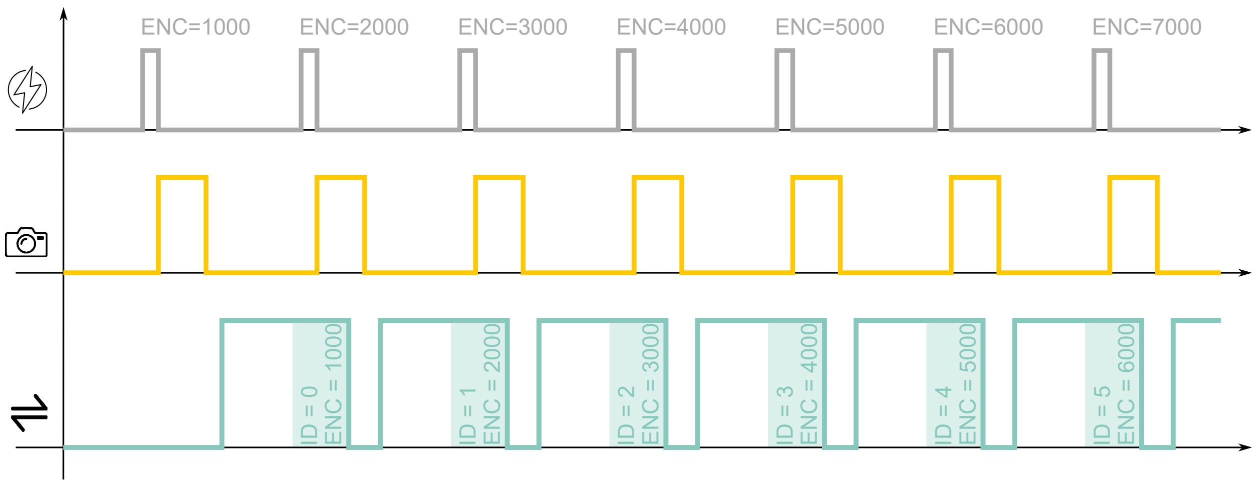


Figure 116: Example of chunk data application. Every 1000 encoder steps, an exposure and therefore a frame acquisition are triggered. With chunk data enabled, each frame is tagged with relevant metadata such as *ChunkFrameID* and *ChunkEncoderValue*.

6.15.3 OE Serial Interface Control

This section deals with the serial communication features.

Feature	Description	Interface	Access
oeSerialEnable	Enable the serial interface	IBoolean	RW
oeSerialBaudRate	Select the serial interface baud rate	IEnumeration	RW
oeSerialMode	Select the serial interface mode of operation	IEnumeration	RW
oeSerialProtocol	Select the protocol to use on the serial interface	IEnumeration	RW
oeSerialSlewRate	Select the slew rate of the serial interface data	IEnumeration	RW
oeSerialASCIIWriteBuffer	Character write buffer of the serial interface	IString	RW
oeSerialASCIIWrite	Start a write operation on the serial interface	ICommand	RW
oeSerialASCIIReadCount	Number of bytes to read from serial input buffer	IInteger	RW
oeSerialASCIIReadBuffer	Character read buffer of the serial interface	IString	R
oeSerialASCIIRead	Read the serial input buffer	ICommand	RW
oeSerialModbusSlaveID	Modbus Slave ID of target device	IInteger	RW

oeSerialModbusAddress	Slave Register Address for read/write requests	IInteger	RW
oeSerialModbusWriteValue	Value to write in Slave Register Address	IInteger	RW
oeSerialModbusWrite	Send a "Write Single Register" request (0x06)	ICommand	RW
oeSerialModbusReadValue	Value to read from Slave Register Address	IInteger	R
oeSerialModbusRead	Send a "Read Holding Register" request (0x03)	ICommand	RW
oeSerialBinaryWriteBuffer	Binary data buffer to write over the serial interface	IRegister	RW
oeSerialBinaryWriteCount	Length of data to write	IInteger	RW
oeSerialBinaryWrite	Command to write data to the serial interface	ICommand	RW
oeSerialBinaryReadBuffer	Binary data read from the serial interface	IRegister	R
oeSerialBinaryReadCount	Number of serial bytes to read	IInteger	RW
oeSerialBinaryRead	Command to read data from the serial interface	ICommand	RW

Table 48: OE Serial Interface Control Features

6.16 Serial interface

The **serial interface** allows to communicate with an external device through a serial connection. This is a dual-mode peripheral which can be configured as a **RS232** or **RS485** transceiver via the **oeSerialMode** feature, as shown in Fig.117. Select the appropriate mode of operation according to the external device you want to connect to the camera. The communication channel in RS232 mode is full-duplex while in RS485 mode is half-duplex.

The serial interface is configured as follows:

- **Baud Rate**: from 9600 to 115200;
- **Data Bits**: 8 bit;
- **Stop Bits**: 1 bit;
- **Parity**: none.

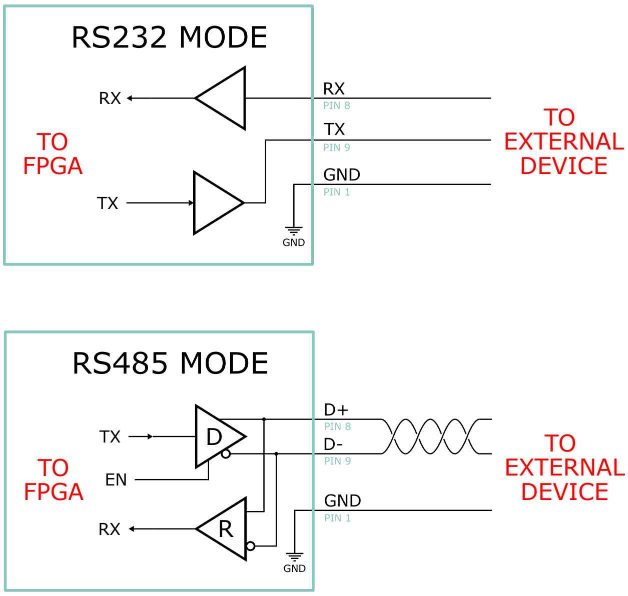


Figure 117: Equivalent circuit of the serial interface in RS232 and RS485 mode of operation.

> ***CAUTION**: always check the external device specification **before** connecting it to the camera and set the serial mode accordingly. Failing to do so may result in damaging the camera or the external device.*

The **slew rate** control affect the shape of the output signal waveform. The **slow** setting yields smooth transitions and may reduce EMI radiation. The **fast** setting yields steep transitions, enabling the use of the highest baud rates. This feature is only available for **RS485** mode.

ASCII Protocol:

The ASCII Protocol allows to send and receive ASCII characters (NULL terminated) over the serial interface. Available both for RS232 and RS485 mode.

Modbus RTU Protocol:

Modbus RTU is a request/reply protocol which provides client/server communication between devices connected on a serial bus. The camera acts like a client and implements a subset of the Modbus RTU function codes such as **Read Holding Registers** and **Write Single Register**. Only available for RS485 mode.

Binary Protocol:

The Binary Protocol allows to send and receive plain binary data over the serial interface. Available both for RS232 and RS485 mode.

6.17 OE Liquid Lens Control

This section describes all the features related to the liquid lens control.

Feature	Description	Interface	Access
oeLiquidLensEnable	Enable the liquid lens controller	IBoolean	RW
oeLiquidLensConfigurationData(1)	Get the configuration for the liquid lens	IEnumeration	R
oeLiquidLensManufacturer	Shows the lens manufacturer	IEnumeration	R
oeLiquidLensSerialNumber	Liquid lens serial number. This string is a unique identifier of the liquid lens	IString	R
oeLiquidLensFWVersion(2)	Liquid lens FW version for Corning liquid lenses	IInteger	R
oeLiquidLensFocalLenght(2)	Lens focal lenght	IInteger	R
oeLiquidLensTemperatureSensorStatus	Shows the liquid lens temperature sensor status	IEnumeration	R
oeLiquidLensTemperature	Temperature read by the sensor integrated in the liquid lens (available on specific models only)	IFloat	R
oeLiquidLensMode(1)	Select the lens control mode	IEnumeration	RW
oeLiquidLensMaxPositiveCurrent(1)	Maximum positive current which can be applied to the lens	IFloat	RW
oeLiquidLensMaxNegativeCurrent(1)	Maximum negative current which can be applied to the lens	IFloat	RW
oeLiquidLensCurrent(1)	Set the liquid lens coil current	IFloat	RW
oeLiquidLensPower(1)	Set the liquid lens focal power	IFloat	RW
oeLiquidLensVoltage(2)	Set the liquid lens voltage	IFloat	RW
oeLiquidLensResultingCurrent(1)	Resulting liquid lens coil current	IFloat	R
oeLiquidLensResultingPower(1)	Resulting liquid lens focal power	IFloat	R
oeLiquidLensAutofocusEnable(1)	Enable the autofocus controller	IBoolean	RW

oeLiquidLensAutofocusAOISize(1)	Select the autofocus area size	IEnumeration	RW
oeLiquidLensAutofocusAOIOffsetX(1)	Horizontal offset from the origin to the area used for autofocus calculations (in pixels)	IInteger	RW
oeLiquidLensAutofocusAOIOffsetY(1)	Vertical offset from the origin to the area used for autofocus calculations (in pixels)	IInteger	RW
oeLiquidLensAutofocusStartCurrent(1)	Start current value for autofocus	IFloat	RW
oeLiquidLensAutofocusStopCurrent(1)	Stop current value for autofocus	IFloat	RW
oeLiquidLensAutofocusStartPower(1)	Start power value for autofocus	IFloat	RW
oeLiquidLensAutofocusStopPower(1)	Stop power value for autofocus	IFloat	RW
oeLiquidLensAutofocusFrameCount(1)	Number of frames to acquire for autofocus	IInteger	RW
oeLiquidLensAutofocusStart(1)	Start autofocus	ICommand	RW
oeLiquidLensAutofocusTriggerSource(1)	Specifies the internal signal or physical input Line to use as the autofocus trigger source	IEnumeration	RW
oeLiquidLensAutofocusStatus(1)	Returns the autofocus status	IEnumeration	R

Table 49: OE Liquid Lens Control Features

(1) Feature available only with Optotune Lenses (2) Feature available only with Corning Lenses

6.17.1 Liquid Lens interface

The **liquid lens interface** allows to control an Opto Engineering® product with liquid lens technology directly from the camera device. This ensure maximum integration with the camera SDK and compatibility with third party software thanks to *GigE Vision* and *GenTL* standards.
The interface can operate in two different modes:

- EEPROM mode;
- manual mode;

In **EEPROM mode** the camera automatically detects the connected lens and read the calibration data from the embedded EEPROM. Through the *GenICam* feature tree is possible to read the lens attributes and directly set the lens focal power. The EEPROM also includes a temperature sensor used by the controller for thermal compensation of the lens current. This ensures a constant focal power across a wide range of operating temperature. It's also possible to directly control the lens current and check for the actual resulting focal power, which depends on the lens temperature. This mode is automatically selected when a compatible lens is connected.

In **manual mode** is possible to control a lens without an embedded EEPROM, directly setting the current of the actuation coil. In this case the user is responsible to set the correct values and to not exceed the limits reported in the lens specifications.

oeLiquidLensConfigurationData shows if the lens is equipped with a calibration EEPROM or if the peripheral is running in manual mode.

> ***CAUTION**: always check the lens specification before connecting it to the camera. If the lens is not equipped with a calbration EEPROM, check and set current limits **before** connecting the lens. Failing to do so may result in damaging the camera or the liquid lens.*

6.17.2 Autofocus

The autofocus is a completely in-camera feature that allows to automatically find the best focus controlling an Opto Engineering® product with liquid lens technology directly from the camera device.

The autofocus algorithm is not applied to the entire frame; therefore, a dedicated AOI must be defined via the **oeLiquidLensAutofocusAOISize** selector together with the **oeLiquidLensAutofocusAOIOffsetX** and **oeLiquidLensAutofocusAOIOffsetY** parameters:

- **oeLiquidLensAutofocusAOISize**: width and height (in pixels) of the region on which the autofocus algorithm operates.
- **oeLiquidLensAutofocusAOIOffsetX**: horizontal offset (in pixels) of the autofocus region.
- **oeLiquidLensAutofocusAOIOffsetY**: vertical offset (in pixels) of the autofocus region.

If a Region-of-interest (ROI) is currently applied (e.g. to select only a specific area of the full frame image), **oeLiquidLensAutofocusAOISize** and **oeLiquidLensAutofocusAOIOffsetX/oeLiquidLensAutofocusAO** are specified taking into account the *Width*, *Height*, *OffsetX*, and *OffsetY* GenICam features, as shown in Figure 119.

Depending on the **oeLiquidLensMode** feature, a current or power range must be set.
Finally, with the **oeLiquidLensAutofocusFrameCount** feature, a number of frame must be set.

> ***NOTE**: Once the **oeLiquidLensAutofocusStart** command is triggered, the camera waits for the last frame to be transferred. Then the autofocus starts.*

To determine if autofocus is complete, check **oeLiquidLensAutofocusStatus**.

The autofocus performance is affected by its configuration:

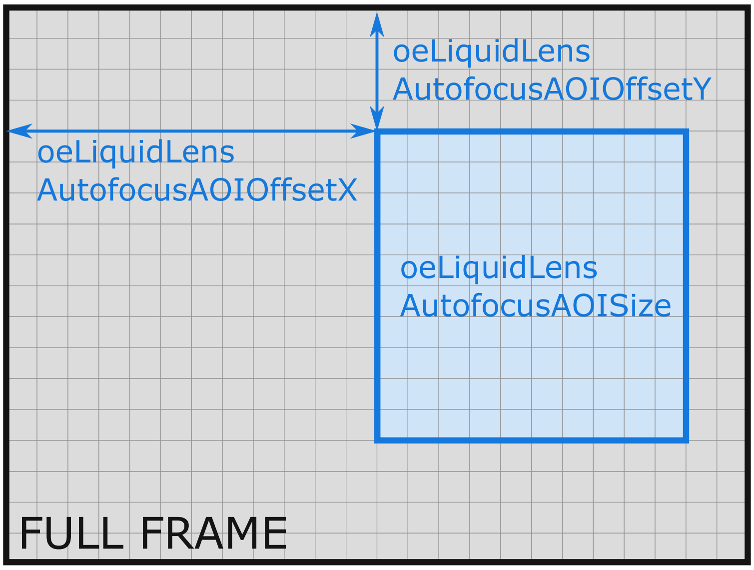


Figure 118: Definition of the autofocus Area of Interest (AOI): the autofocus algorithm evaluates only the pixels enclosed within the AOI boundaries.

1. The lower the current/power range, the better the accuracy.
2. The smaller the AOI, the faster the focusing time.
3. The shorter the exposure time, the better the accuracy and the faster the focusing time.
4. The higher the number of frames, the better the accuracy but the slower the focusing time.

The following formula determines the expected minimum focusing time:

$$MinAutofocusTime[ms] = 1000 \cdot \frac{N_{frame} - 1}{FPS[s^{-1}]} + t_{exp}[ms] \tag{13}$$

where, the FPS value must be evaluated setting a sensor ROI equal to the **oeLiquidLensAutofocusAOISize** and setting the **oeAcquisitionFrameRateLimitMode** to **oe Sensor Throughput**.

The **defocus** parameter is a figure of merit that helps determine whether the current autofocus configuration will produce an accurate result. The higher the defocus value, the worst the focusing accuracy:

$$defocus[dpt] = slope[dpt/ms] \cdot t_{exp}[ms] \tag{14}$$

where,

$$slope[dpt/ms] = \frac{PowerRange[dpt]}{MinAutofocusTime[ms]} \tag{15}$$

> ***NOTE**: The focusing time is variable and always greater than the Min Autofocus Time. It depends on the camera settings and the time it takes to download the last frame before the autofocus starts.*

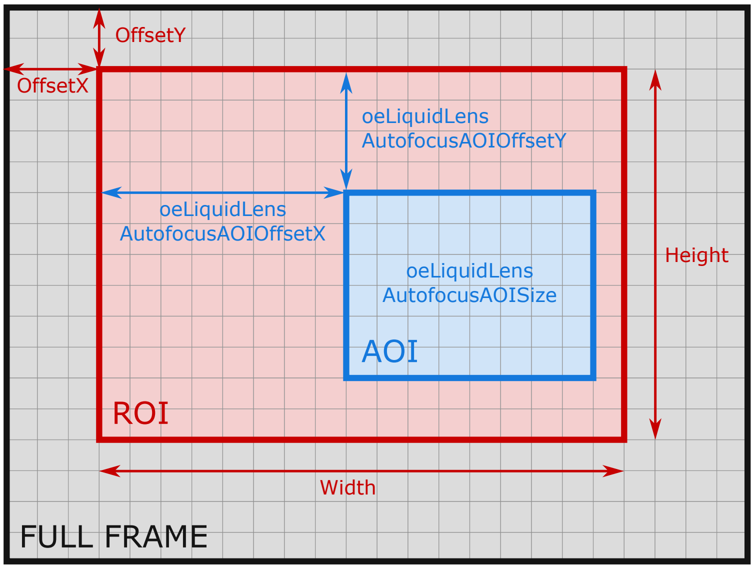


Figure 119: Definition of the area of interest (AOI) for the autofocus feature when a ROI is already applied: the autofocus algorithm is performed only in the pixels delimited by the AOI boundaries.

> ***NOTE***: *Focusing accuracy may be affected by exposure start jitter when* ***TriggerOverlap*** *is set to* ***ReadOut****.*

> ***NOTE***: *For higher accuracy, a* ***dual-pass*** *behavior can be implemented via the SDK. First, a coarse pass helps determine the region of best focus, then a fine pass provides a more accurate result. This can be accomplished by acting on the current/power range.*

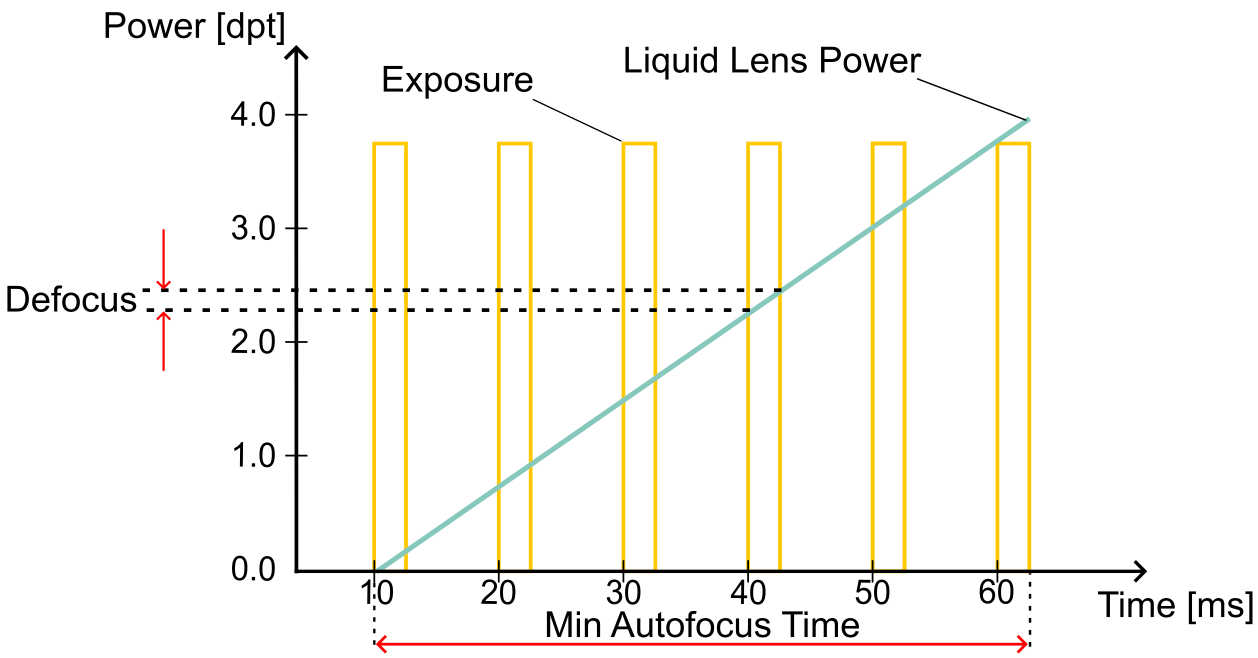


Figure 120: Autofocus working principle: exposure time and liquid lens behavior are depicted. The liquid lens performs a sweep across the current/power range.

6.18 OE Defective Pixel Correction Control

This section describes all the features related to the correction of the defective pixels.

Feature	Description	Interface	Access
oeDefectivePixelCount	Shows the number of the defective pixels	IInteger	RW
oeDefectivePixelSelector	Represents the index of the defective pixel inside the defective pixel map	IInteger	RW
oeDefectivePixelXCoordinate	Represents the horizontal coordinate of the actual defective pixel	IInteger	RW
oeDefectivePixelYCoordinate	Represents the vertical coordinate of the actual defective pixel	IInteger	RW
oeDefectivePixelWriteMap	Write the defective pixel map in the camera non-volatile memory	ICommand	RW

Table 50: OE Defective Pixel Correction Control Features

6.18.1 Defective Pixel Correction

Image sensors can be affected of pixel degradation for multiple causes (temperature, aging, cosmic rays, ionizing radiation and so on..).
A possible way to overcome these effects is to adopt a defective pixel correction strategy. This consists in replacing the defective pixel value with the one of a near good pixel. This algorithm is executed real-time in the camera acquisition pipeline and rely on a defective pixel coordinates table.

> ***NOTE***: *The automatic procedure for the pixels defects detection and correction is explained in section 4.7.5. Here there is the explanation of the single defective pixel correction only.*

oeDefectivePixelCount is the indicator of the actual defective pixels corrected in camera.
The defective pixels coordinates can be displayed on the nodes **oeDefectivePixelXCoordinate** and **oeDefectivePixelYCoordinate** after selecting the pixel index (**oeDefectivePixelSelector**).

The following example shows how to manually add a new defective pixel to the defective pixels list. Let's consider a defective pixel at coordinates (4,2) (see Fig.121). To correct this pixel:

1. Increase by 1 the number of **oeDefectivePixelCount**;
2. Select the first available index in **oeDefectivePixelSelector** node: the correct index is the one with the un-initialized **oeDefectivePixelXCoordinate** and **oeDefectivePixelYCoordinate** values (be aware that pixel enumeration starts from 0);
3. Insert the coordinates of the defective pixel in the **oeDefectivePixelXCoordinate** and **oeDefectivePixelYCoordinate** fields;
4. Save the new map in the onboard-memory with **oeDefectivePixelWriteMap** command;

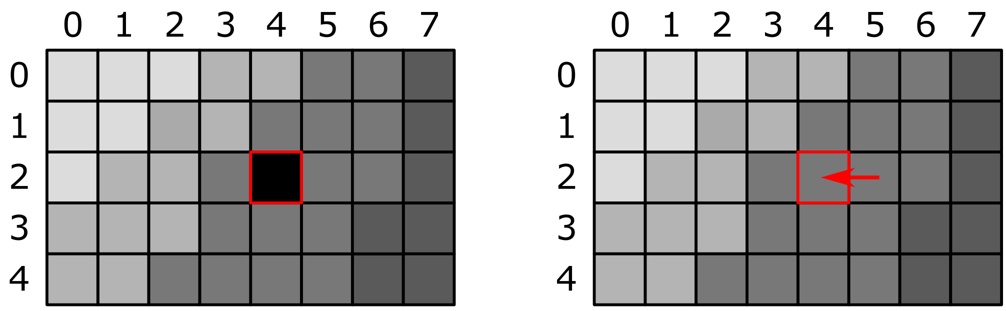


Figure 121: (On the left) Presence of a dead pixel at coordinates (4,2). (On the right) Error correction through the nearest neighbor algorithm.

In case of color cameras, the color correction algorithm takes into account that the adiacent pixel has a different chroma information, therefore the correction is performed with the following pixel value, ad depicted in Fig.122.

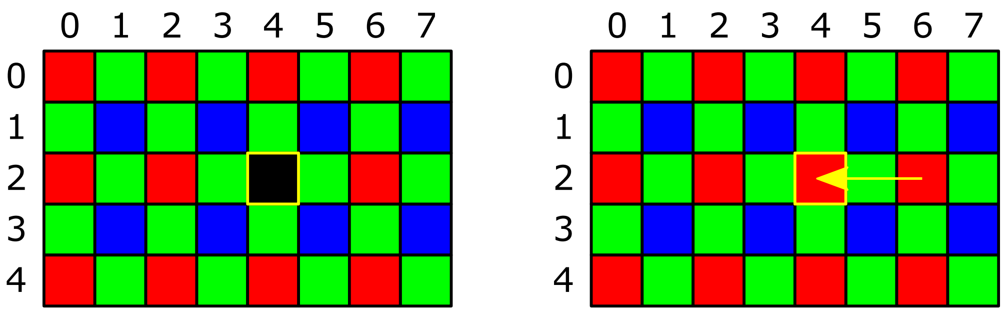


Figure 122: (On the left) Presence of a dead pixel at coordinates (4,2). (On the right) Error correction through the nearest neighbor (but with the same chroma info) algorithm.

6.19 Test Control

Contains the features related to the control of the test features.

Feature	Description	Interface	Access
TestEventGenerate	Generates a Test Event	ICommand	W

Table 51: Test Control Features

6.20 Transport Layer Control

This section provides the Transport Layer control features.

Feature	Description	Interface	Access
PayloadSize	Provides the number of bytes transferred for each image or chunk on the stream channel	IInteger	R
PtpEnable	Enables the Precision Time Protocol (PTP)	IBoolean	RW
oePtpOffsetFromUtc	Enables applying current IEEE 1588 UTC offset to the output time	IBoolean	RW
PtpDataSetLatch	Latches the current values from the device's PTP clock data set	ICommand	W
PtpStatus	Returns the latched state of the PTP clock	IEnumeration	R
PtpServoStatus	Returns the latched state of the clock servo	IEnumeration	R

PtpOffsetFromMaster	Returns the latched offset from the PTP master clock in nanoseconds	IInteger	R
PtpClockID	Returns the latched clock ID of the PTP device	IInteger	R
PtpParentClockID	Returns the latched parent clock ID of the PTP device	IInteger	R
PtpGrandmasterClockID	Returns the latched grandmaster clock ID of the PTP device	IInteger	R
GevSupportedOptionSelector	Selects the GEV option to interrogate for existing support	IEnumeration	RW
GevSupportedOption	Returns if the selected GEV option is supported	IBoolean	R
GevInterfaceSelector	Selects which logical link to control	IInteger	RW
GevMACAddress	MAC address of the logical link	IInteger	R
GevCurrentIPConfigurationLLA	Controls whether the Link Local Address IP configuration scheme is activated on the given logical link	IBoolean	RW
GevCurrentIPConfigurationDHCP	Controls whether the DHCP IP configuration scheme is activated on the given logical link	IBoolean	RW
GevCurrentIPConfigurationPer-sistentIP	Controls whether the PersistentIP configuration scheme is activated on the given logical link	IBoolean	RW
GevCurrentIPAddress	Reports the IP address for the given logical link	IInteger	R
GevCurrentSubnetMask	Reports the subnet mask of the given logical link	IInteger	R
GevCurrentDefaultGateway	Reports the default gateway IP address of the given logical link	IInteger	R
GevPersistentIPAddress	Controls the Persistent IP address for this logical link	IInteger	RW
GevPersistentSubnetMask	Controls the Persistent subnet mask associated with the Persistent IP address on this logical link	IInteger	RW
GevPersistentDefaultGateway	Controls the persistent default gateway for this logical link	IInteger	RW

GevDiscoveryAckDelay	Indicates the maximum randomized delay the device will wait to acknowledge a discovery command	IInteger	R
GevMCPHostPort	Controls the port to which the device must send messages	IInteger	R
GevMCDA	Controls the destination IP address for the message channel	IInteger	RW
GevMCTT	Provides the transmission timeout value in milliseconds	IInteger	RW
GevMCRC	Controls the number of retransmissions allowed when a message channel message times out	IInteger	RW
GevMCSP	This feature indicates the source port for the message channel	IInteger	R
GevStreamChannelSelector	Selects the stream channel to control	IInteger	RW
GevSCPInterfaceIndex	Index of the logical link to use	IInteger	RW
GevSCPHostPort	Controls the port of the selected channel to which a GVSP transmitter must send data stream or the port from which a GVSP receiver may receive data stream	IInteger	R
GevSCPSFireTestPacket	Sends a test packet. When this feature is set, the device will fire one test packet	IBoolean	RW
GevSCPSDoNotFragment	The state of this feature is copied into the "do not fragment" bit of IP header of each stream packet. It can be used by the application to prevent IP fragmentation of packets on the stream channel	IBoolean	RW
GevSCPSPacketSize	This GigE Vision specific feature corresponds to DeviceStreamChannelPacketSize and should be kept in sync with it	IInteger	RW
GevSCPD	Controls the delay (in GEV timestamp counter unit) to insert between each packet for this stream channel	IInteger	R

GevSCDA	Controls the destination IP address of the selected stream channel to which a GVSP transmitter must send data stream or the destination IP address from which a GVSP receiver may receive data stream	IInteger	RW
GevSCSP	Indicates the source port of the stream channel	IInteger	R

Table 52: Transport Layer Control Features

6.20.1 Precision Time Protocol (PTP)

PTP (Precision Time Protocol) is a clock synchronization protocol of IEEE 1588 standard. It allows to precisely synchronize clocks of multiple GigE cameras on an ethernet network. PTP procedure establishes that the device with the most accurate clock in the network is elected as grandmaster clock and other devices becomes slaves. Slaves periodically and automatically synchronize their clock directly with the master's clock. The result is that the timestamp values are aligned with the master over the entire network. This protocol is closely described in the IEEE standard document.

> ***NOTE**: Itala cameras can become only slave (master mode is not implemented).*

The PTP feature must be enabled if the **scheduled action commands** are used (6.12.2).

6.21 Sequencer Control

This section describes all the features related to the Sequencer Control.

Feature	Description	Interface	Access
SequencerMode	Controls if the sequencer mechanism is active	IEnumeration	RW
SequencerConfigurationMode	Controls if the sequencer configuration mode is active	IEnumeration	RW
SequencerFeatureSelector	Selects which sequencer features to control	IEnumeration	RW
SequencerFeatureEnable	Enables the selected feature and make it active in all the sequencer	IBoolean	RW

SequencerSetSelector	Selects the sequencer set to which further feature settings applies	IInteger	RW
SequencerSetSave	Saves the current device state to the sequencer set selected by the SequencerSetSelector	ICommand	W
SequencerSetLoad	Loads the sequencer set selected by SequencerSetSelector in the device	ICommand	W
SequencerSetActive	Contains the currently active sequencer set	IInteger	R
SequencerSetStart	Sets the initial/start sequencer set, which is the first set used within a sequencer	IInteger	RW
SequencerPathSelector	Selects to which branching path further path settings applies	IInteger	RW
SequencerSetNext	Specifies the next sequencer set	IInteger	RW
SequencerTriggerSource	Specifies the internal signal or physical input line to use as the sequencer trigger source	IEnumeration	RW
SequencerTriggerActivation	Specifies the activation mode of the sequencer trigger	IEnumeration	RW

Table 53: Sequencer Control Features

6.21.1 Sequencer overview

The purpose of the Sequencer Control is to allow the user to define a series of feature sets which can consecutively be activated during the acquisition. Each *sequencer set* change is triggered by an event configured by the user.
The execution of the sequencer is completely controlled by the device.

6.21.2 Configuration of a Sequencer set

The index of the *sequencer set* is given by the **SequencerSetSelector**. Up to 64 sequencer sets can be configured.

The features which are actually part of a *sequencer set* are defined in Table 54. These features can be selected by **SequencerFeatureSelector** and activated by **SequencerFeatureEnable**. If a feature is enabled it is for all *sequencer sets*.

To configure a *sequencer set* the camera has to be switched into configuration mode by **Sequencer-ConfigurationMode**. Then the user has to select the desired *sequencer set* he wants to modify with the **SequencerSetSelector**. After the user has changed all the needed camera settings it is possible to store all these settings within a selected *sequencer set* by **SequencerSetSave**. The user can also read back this settings by **SequencerSetLoad**.

To permit a flexible usage, up to two paths are available to go from one *sequencer set* to another. Such a path is selected by **SequencerPathSelector**. Each path and therefore the transition between different *sequencer sets* is based on a defined trigger and an upcoming targeted *sequencer set* which is selectable by **SequencerSetNext**. After the trigger occurs the settings of the next set become active.

The trigger is defined by the features **SequencerTriggerSource** (Table 55) and **SequencerTriggerActivation**.

> ***NOTE*: *SequencerTriggerActivation* is set to "RisingEdge" by default and cannot be changed.**

A *sequencer set* should contain the following values:

- Camera data which should be controlled by the device
- **SequencerPathSelector** with at least one path
- **SequencerSetNext**, **SequencerTriggerSource** and **SequencerTriggerActivation** for every path which is selectable by the **SequencerPathSelector**.

> ***NOTE***: *If two paths are configured,* ***Path 0*** *has a higher priority than* ***Path 1***. *If two different* ***SequencerTriggerSource*** *occur at the same time, the trigger source associated with* ***Path 0*** *wins.*

The features available in the Sequencer Control are summarized in Table 54, whereas Table 55 details the **SequencerTriggerSource** options supported by Itala cameras:

Feature	Note
ExposureTime	
CounterDuration	Only Counter0 is configured
OffsetX	A proper ROI must be pre-configured
OffsetY	A proper ROI must be pre-configured
Gain	
oeLiquidLensCurrent	oeLiquidLensMode must be set in CurrentMode
oeLiquidLensPower	oeLiquidLensMode must be set in PowerMode

Table 54: Available features for Sequencer Control operations

Feature	Note
Off	Disables the sequencer trigger
ExposureEnd	Starts with the reception of the ExposureEnd
Counter0End	Starts with the reception of the Counter0End
Timer0End	Starts with the reception of the Timer0End
Encoder0	Starts with the reception of the Encoder output signal

Table 55: Available trigger sources for Sequencer Control operations

> ***NOTE***: *Configured sequencer programs are stored as part of the UserSets like any other feature.*

> ***NOTE***: *Actual settings of the camera are overwritten when a sequencer set is loaded.*

7 USE CASES

7.1 Wiring connection examples

7.1.1 Triggering the camera by an external device

To trigger Itala cameras in a machine vision system, suitable connections must be performed. Considering the circuitry of the opto-isolated input pin (section 5.7), possible connections are the depicted in Figure 123.

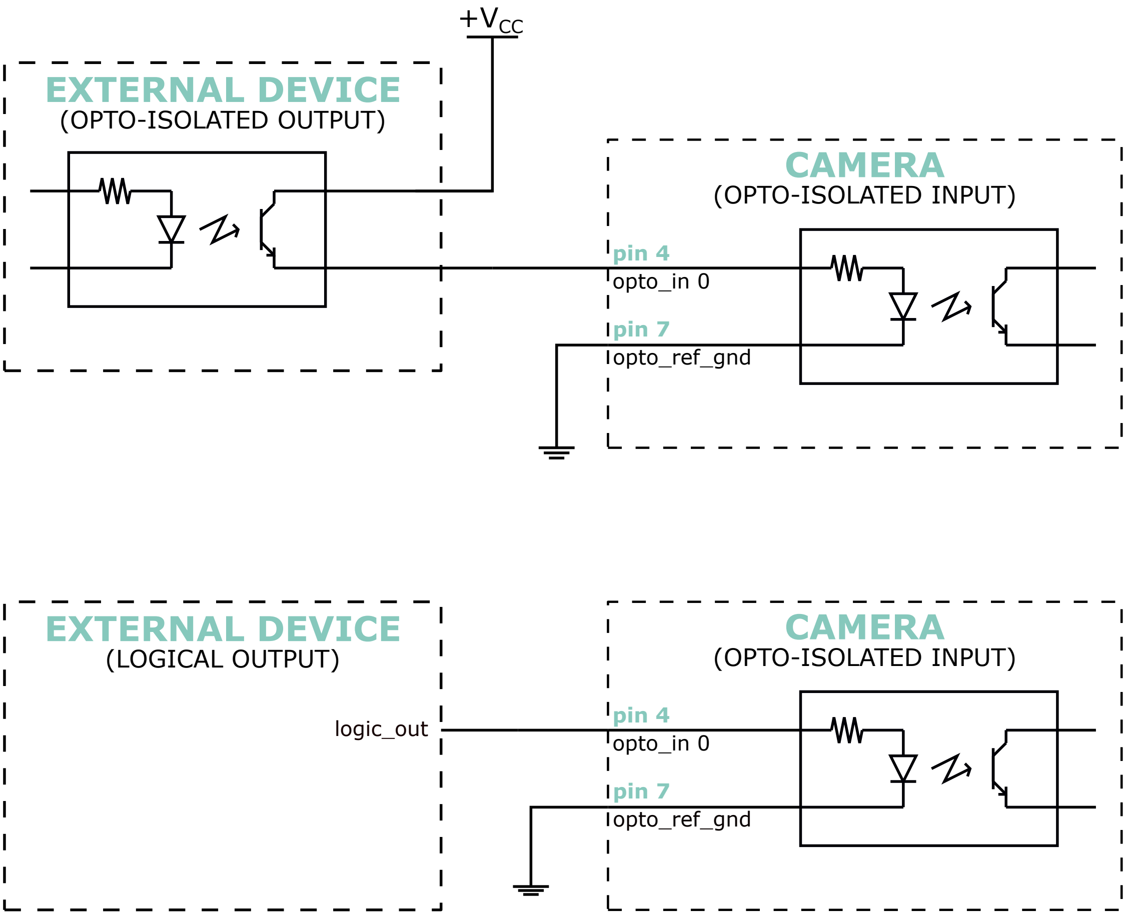


Figure 123: Figure above: camera is triggered by an opto-isolated external device. Figure below: camera is triggered by a logic output pin.

When Itala camera is triggered by an external **opto-isolated** device, the input pin of the camera can be directly wired to the source output pin of the triggering device.
In this case the triggering output stage acts as a switch: when the synchronization signal is generated, the switch closes and the external power supply ($+V_{CC}$) is delivered to the camera input pin, toggling the actual state and therefore triggering the camera.

> ***CAUTION***: *Please be careful not to exceed the maximum voltage specification of the opto-isolated input pins.*
> *As mentioned in section 5.2, $+V_{CC}$ must not exceed 30V.*

When Itala camera is triggered by an external **logic** pin (e.g. TTL), the output pin can still be wired to the opto-isolated input pin of the camera: in this case the logic output pin must be capable of triggering the opto-isolated input stage, i.e. the high logic level must be greater than the threshold voltage of the opto-coupler (see section 5.2).
Morevoer, the output pin must have a suitable drive strenght in order to toggle the opto-isolated input stage.

7.1.2 Synchronizing an external device with Itala cameras

When Itala camera is used to trigger external devices, suitable connections must be performed. Considering the circuitry of the opto-isolated output pin (section 5.7), possible connections are the depicted in Figure 124.
When Itala camera triggers an external **opto-isolated** device, the output pin of the camera can be directly wired to the input pin of the triggered device.
In this case the output stage acts as a switch: when the synchronization signal is generated, the switch closes and the external power supply ($+V_{CC}$) is delivered to the external device, toggling the actual state and therefore triggering the device.

> ***CAUTION***: *Please be careful not to exceed the maximum voltage specification of the opto-isolated input pins.*
> *As mentioned in section 5.2, $+V_{CC}$ must not exceed 30V.*

On the opposite, when Itala camera triggers an external **logic** pin (e.g. TTL), the output pin can still be wired to the opto-isolated input pin of the camera with some cautions: an external resistor is required in order to tie the input pin to ground when the opto-isolated output is not active.

> ***CAUTION***: *Please be careful not to exceed the maximum voltage specification of the opto-isolated input pins.*
> *As mentioned in section 5.2, $+V_{CC}$ must not exceed 30V.*

> ***CAUTION***: *Always check the compatibility between $+V_{CC}$ and the logic pin maximum voltage ratings.*

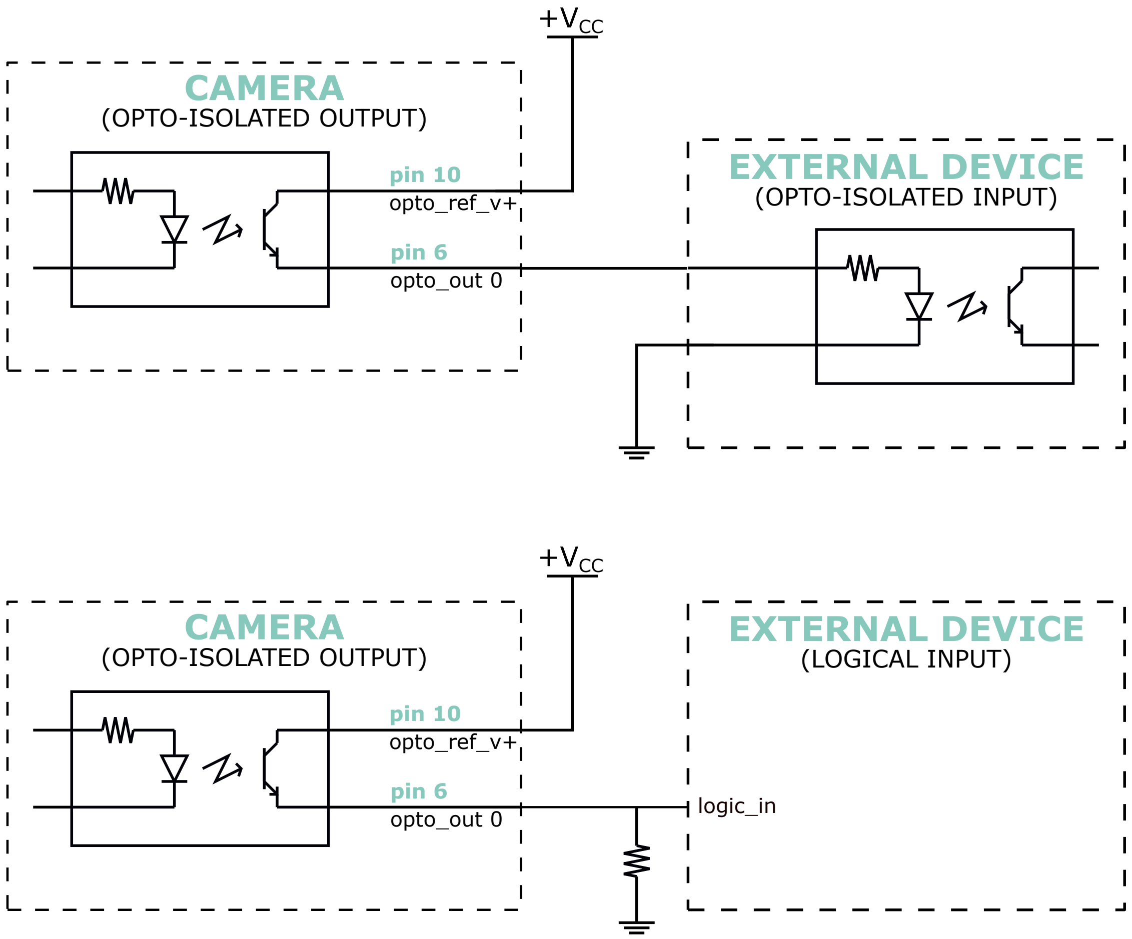


Figure 124: Figure above: camera triggers an opto-isolated external device. Figure below: camera triggers a logic input pin.

7.2 How to add a delay on the Output Lines of the camera

In this section is shown how to add a user defined delay for Itala output lines.

For example, let's consider to generate an output pulse on **Line2**, whose duration is equal to $1ms$ and delayed by $100\mu s$, and triggered by the *Exposure End* feature.
This scenario is depicted in Figure 125.

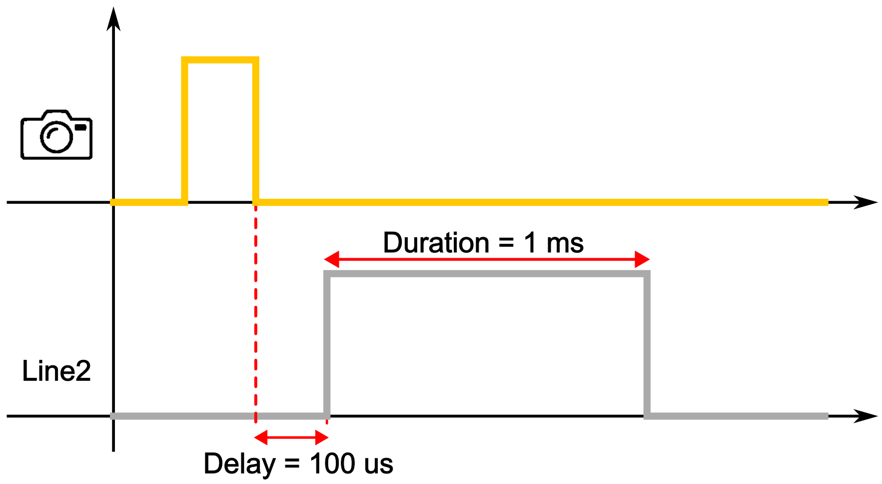


Figure 125: Example scenario: a $1ms$ output pulse (with $100\mu s$ delay) is generated after the exposure time.

In order to obtain this waveform on **Line2**, the following settings can be adopted:

1. **Timer configuration**
    - Select one of the timers using the *Timer Selector* feature (i.e. *Timer 0*).
    - Select the *Exposure End* entry for the *Timer Trigger Source* feature.
    - Set the desired pulse delay in the *Timer Delay* field (i.e. $100\mu s$).
    - Set the desired pulse duration in the *Timer Duration* field (i.e. $1000\mu s$).
2. **Digital IO configuration**
    - Select one of the output lines using the *Line Selector* feature (i.e. *Line 2*).
    - Select the *Timer 0 Active* entry for the *Line Source* feature.

If Itala View is used, the mentioned configuration is shown in Figure 126.
In particular, the Timer configuration is highlighted by green boxes, while the Digital IO configuration by the yellow ones.

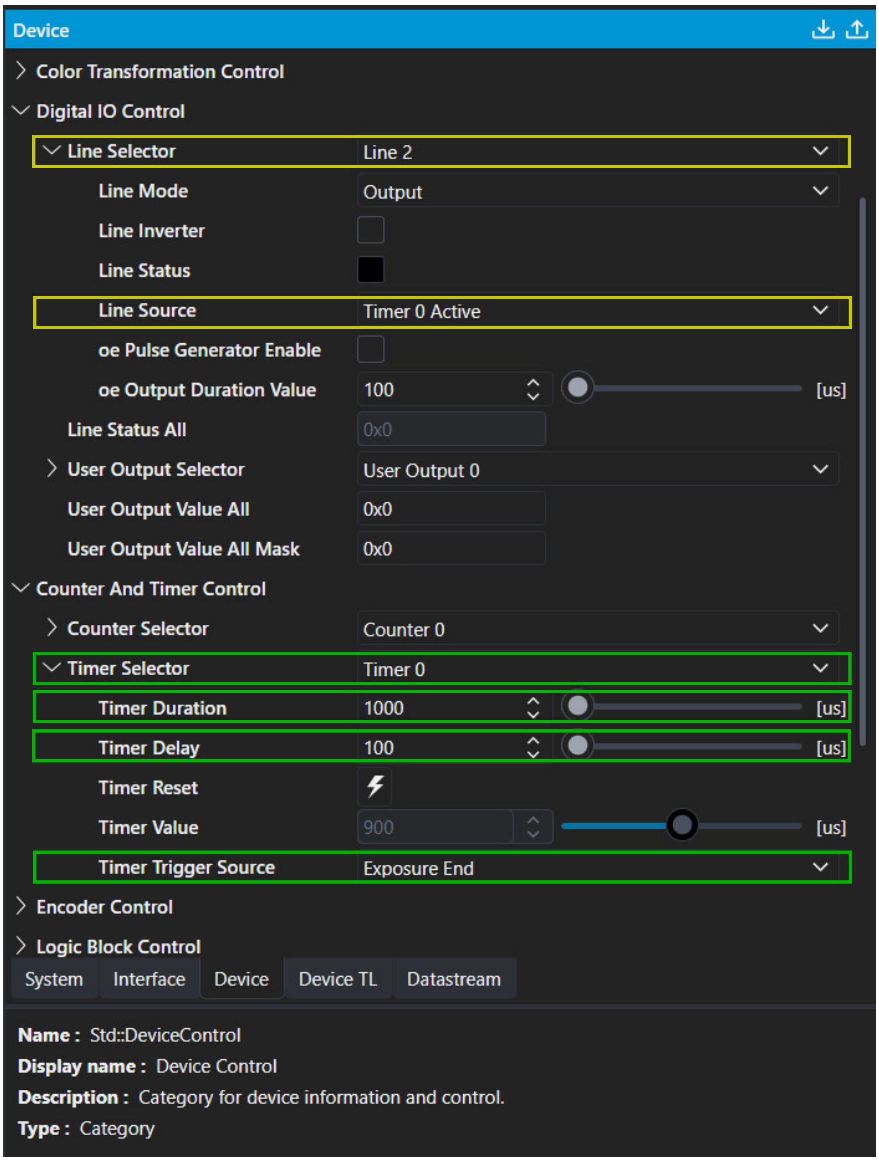


Figure 126: Implementation of an output delayed pulse using Itala View

7.3 Streaming bandwidth management

Itala has the possibility to select (and to adjust) the overall acquisition frame rate from the image sensor: in particular, the GenICam custom feature involved in the sensor throughput settings is **oeAcquisitionFrameRateLimitMode**.

By default, **oeAcquisitionFrameRateLimitMode** is set to **oeLinkThroughput**.

In this configuration, the acquisition frame rate is limited by the gigabit link bandwidth.

Sensors settings (like triggering logic, blanking periods and so on...) are automatically computed in order to match the throughput of the gigabit connection, i.e. 1 Gbps.

This scenario is depicted in Figure 127: frames, represented by turquoise blocks, are captured from the image sensor and stored in the internal camera buffer; then are read by the user application. Figure 127 also shows the behaviour of the on-board image buffer: since *read* data rate is always equal to *write* data rate, there isn't the possibility for the internal memory to be completely full.

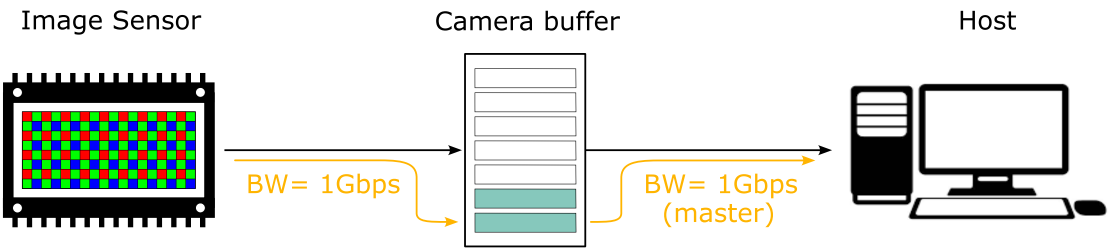


Figure 127: When *oeAcquisitionFrameRateLimitMode* = *oeLinkThroughput*, sensor throughput is automatically adjusted in order to match the gigabit bandwidth.

On the other hand, when *oeAcquisitionFrameRateLimitMode* is set to **oeSensorThroughput**, the driver of the acquisition bandwidth becomes the image sensor, as depicted in Fig 128.

In this case, the overall bandwidth between camera and host is still limited by the ethernet interface, however, acquisition data rate is no more related to the link bandwidth and its value can be higher or lower than the 1 gigabit link speed, depending on the image sensor model and its mode of operation.

Since *write* data rate can be higher than *read* data rate, the internal image buffer of the camera can saturate, as depicted in Fig 129. When this condition is met, a lagging effect can arise during the visualization of the captured frames.
This scenario is almost always present when Itala is in free-run acquisition mode and *oeAcquisition-FrameRateLimitMode* is set to *oeSensorThroughput*.

oeSensorThroughput configuration really shows its benefits when used in conjunction with trigger mode and burst acquisitions, i.e. when **TriggerMode** is set to ON and **AcquisitionBurstFrame-**

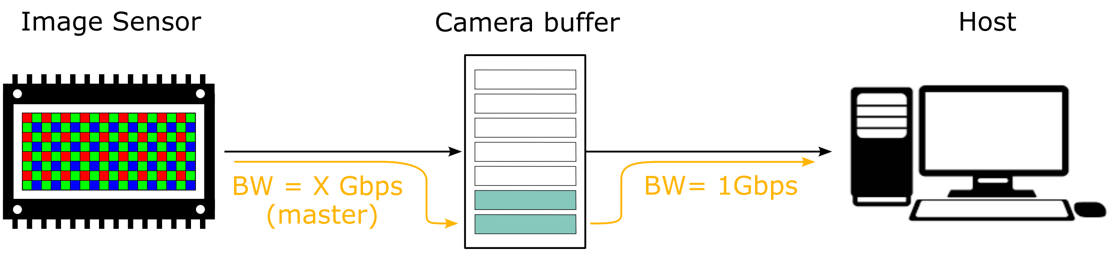


Figure 128: When *oeAcquisitionFrameRateLimitMode* = *oeSensorThroughput*, acquisition bandwidth is completely unrelated to the link bandwidth.

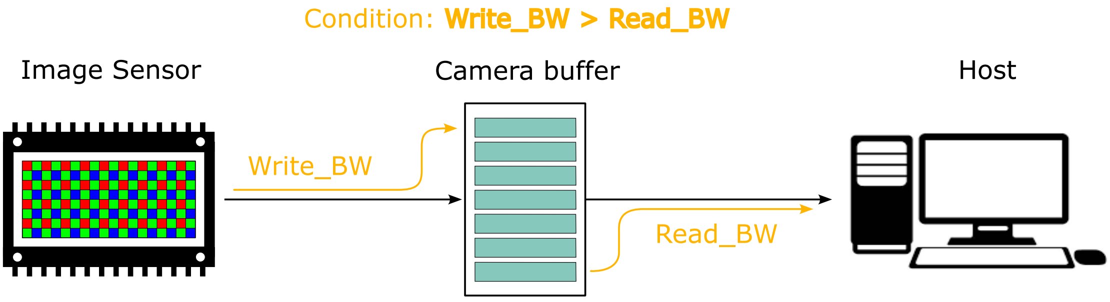


Figure 129: When *oeAcquisitionFrameRateLimitMode* = *oeSensorThroughput*, the *buffer-full* condition can occur if the write bandwidth is higher than read bandwidth.

Count is higher than 1.

In this case, it's possible to grab images from the image sensor at very high frame rate and to store them in the internal memory buffer (Fig 130a), while the readout can happen subsequently, with the lower gigabit bandwidth (Fig 130b).

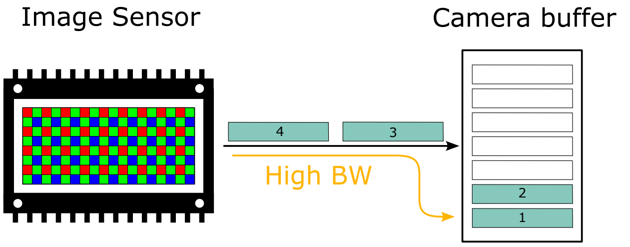
An important factor to consider is the finite size of the internal buffer: the number of frames which can be stored in memory are strictly related and dependent on two parameters: *image resolution* and *pixel format*.

The maximum number of frames which can be captured before buffer saturation is expressed by the following formula:

$$MaxBurstSize = \frac{BufferSize[Mbit]}{Resolution[Mpixel] * BitPerPixel} \tag{16}$$

where:

- *Buffer Size* is the internal memory buffer size (see section 5.1 for buffer size info).
- *Resolution* is the sensor resolution (width x height), expressed in Megapixels.
- *Bit Per Pixel* is the number of bit associated to each single pixel of the image.



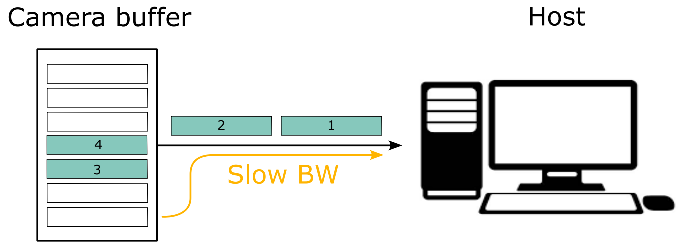


Figure 130: (a) First, burst acquisition is enabled in order to grab multiple frames with only one input trigger signal. (b) Second, images can be transferred from the camera to the host with a slower frame rate.

Table 56 briefly summarize the *Bit per Pixel* value for each pixel format supported by Itala cameras.

Pixel Format	Bit per Pixel
Mono8	8
BayerRG8	8
PolarizedXXMono8	8
PolarizedXXBayerRG8	8
Mono10p	10
BayerRG10p	10
PolarizedXXMono10p	10
PolarizedXXBayerRG10p	10
Mono10Packed	12
BayerRG10Packed	12
PolarizedXXMono10Packed	12
PolarizedXXBayerRG10Packed	12
Mono12p	12
BayerRG12p	12
PolarizedXXMono12p	12
PolarizedXXBayerRG12p	12
Mono12Packed	12
BayerRG12Packed	12

PolarizedXXMono12Packed	12
PolarizedXXBayerRG12Packed	12
YUV411	12
YUV422	16
RGB8	24

Table 56: Recap of the Bit per Pixel value for each pixel format supported by Itala cameras

The following example will show a rough computation of a maximum burst size estimation without buffer saturation.

> ***NOTE***: *In the following example the worst case scenario is considered, in which the download of the frames to the host application starts **after** the end of the burst acquisition.*

> ***NOTE***: *In the following example a buffer size equal to 384 Mb is considered (i.e. 3072 Mbit). Actual buffer size can be found in section 5.1.*

Considering a **12Mpixel** image sensor and a pixel format set to **Mono8**, the maximum number of frames which can be acquired before saturation will be equal to:

$$MaxBurstSize = \frac{3072Mbit}{12Mpixel * 8} = 32frames \quad (17)$$

A camera with the same sensor, set to work with **RGB8** pixel format, will have a maximum burst size equal to:

$$MaxBurstSize = \frac{3072Mbit}{12Mpixel * 24} = 10frames \quad (18)$$

7.4 Cognex Vision Pro compatibility

This is a small technical guide to briefly explain how to setup Cognex Vision Pro with Itala. Please follow these steps:

1. Connect the camera..
2. Ensure IPv4 configuration and camera IP mode is correct.
3. Open *Cognex GigE Vision Configuration*.
4. Ensure that the *Performance driver* is installed.

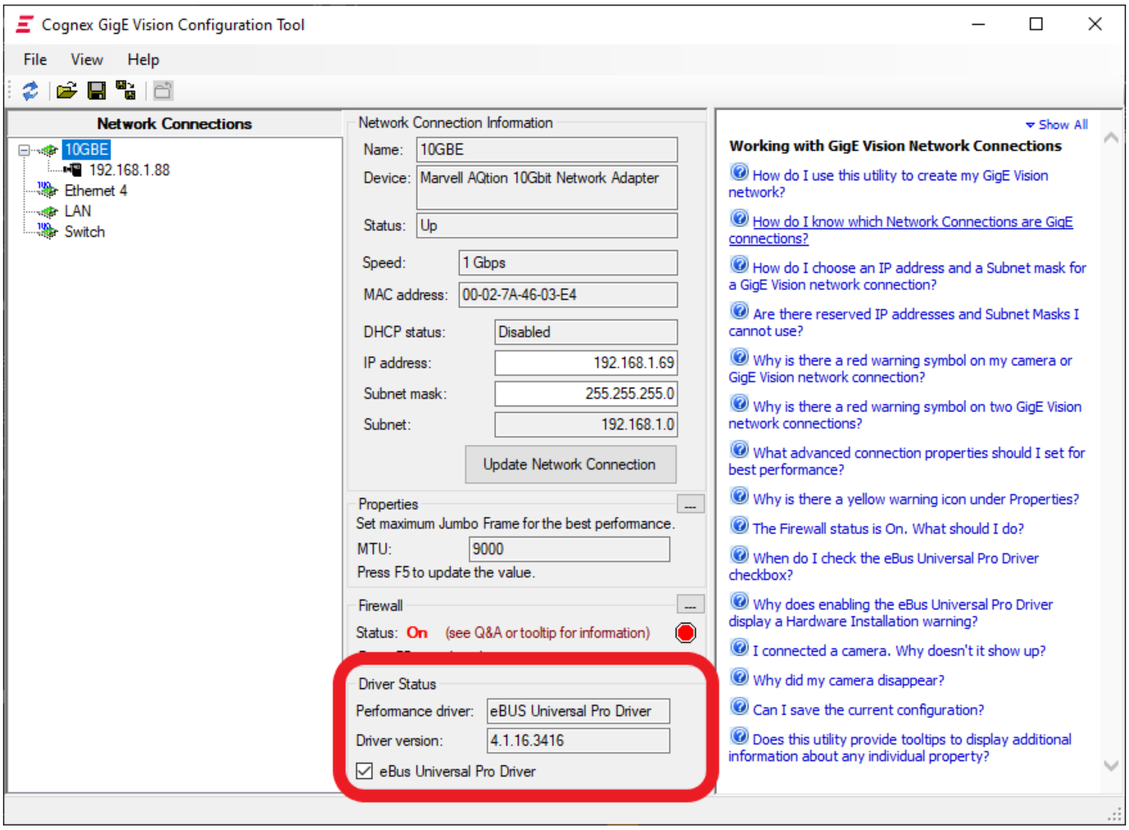


Figure 131: STEP 4 - *Cognex GigE Vision Configuration Tool* window.

5. Open *VisionPro QuickBuild*.

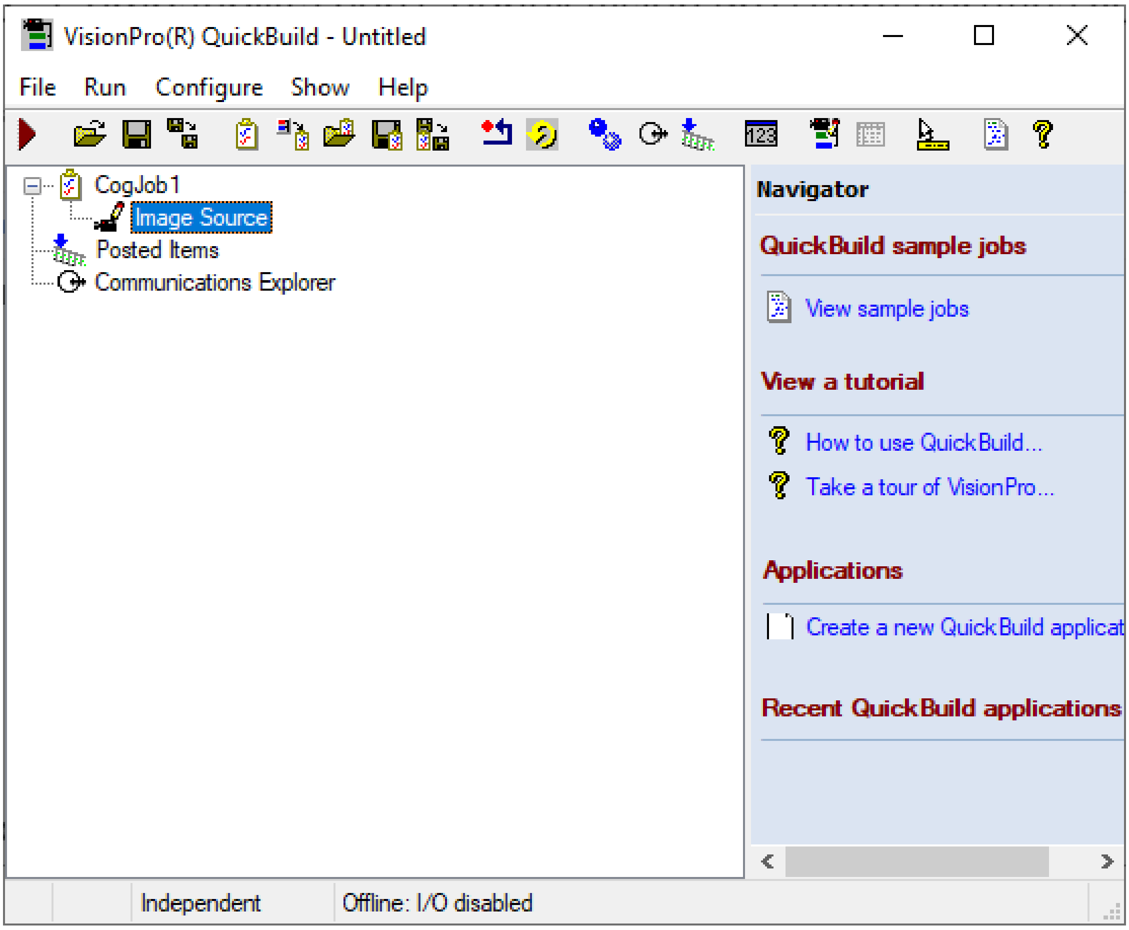


Figure 132: STEP 5 - *VisionPro QuickBuild* window.

6. Double click on *Image Source*.
7. Two windows will open up. On the *Image Source* window, click on the *Camera* button.

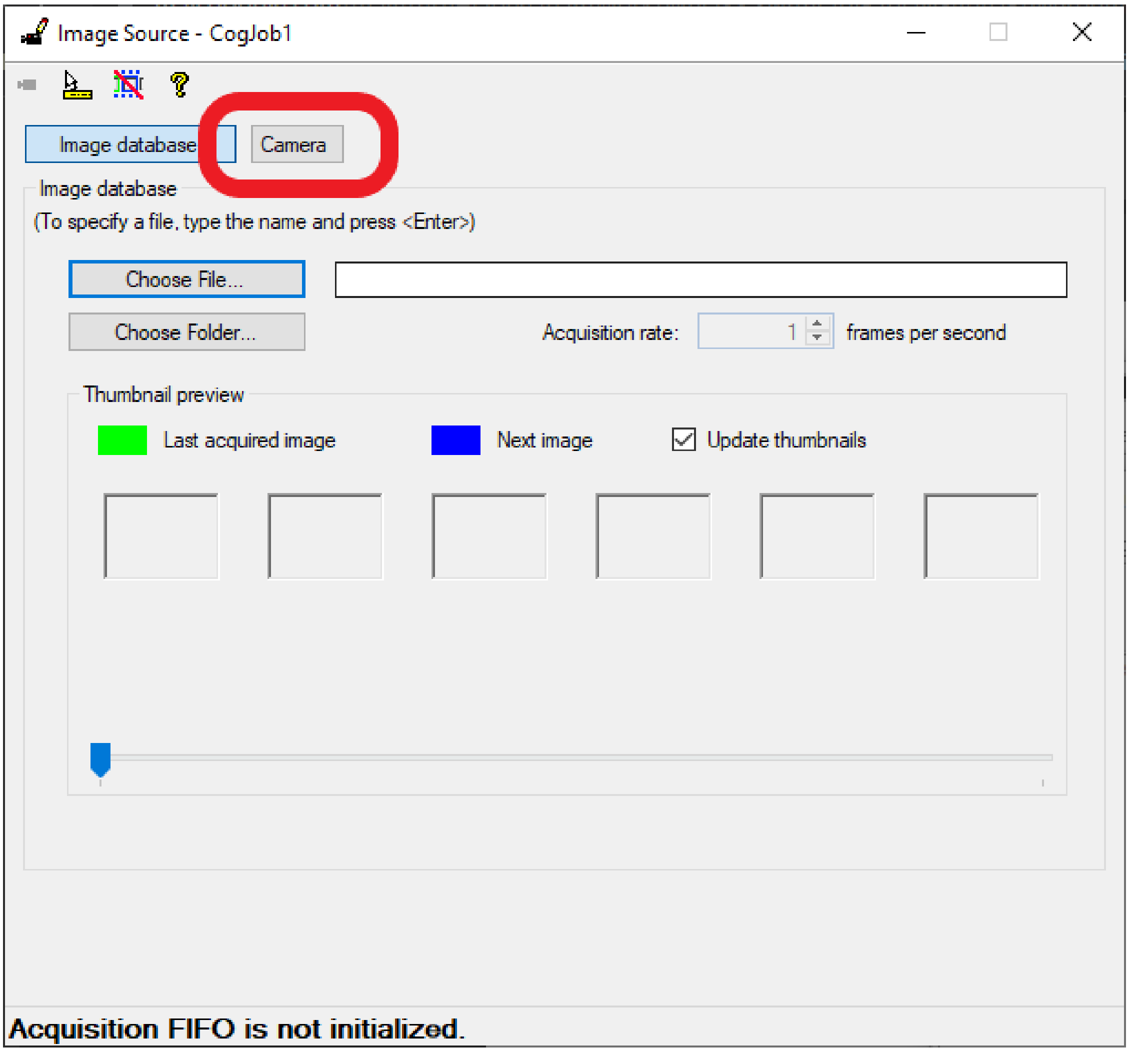


Figure 133: STEP 7 - *Image Source* window.

8. From the combo box select the entry that starts with *GigEVision*.

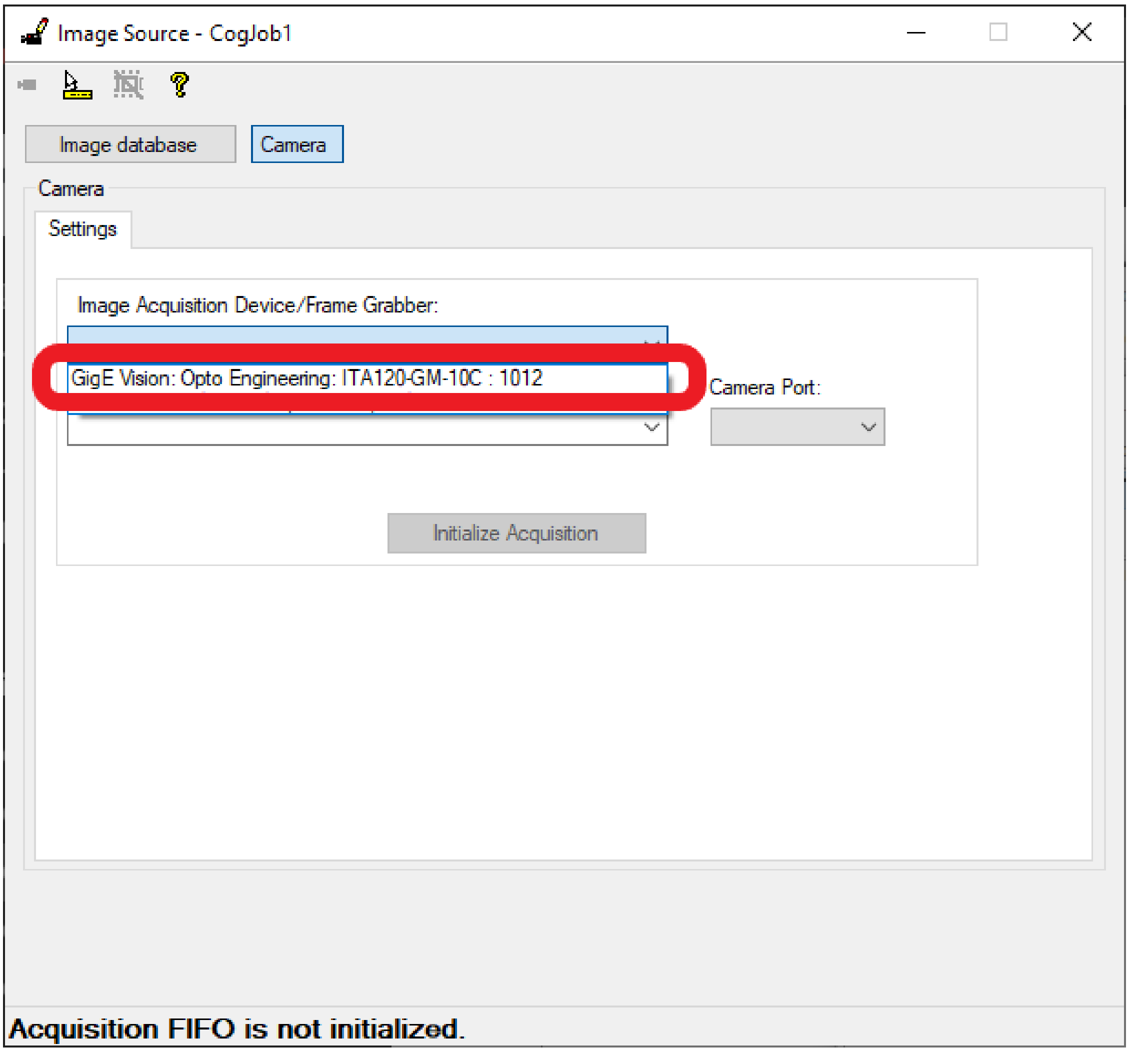


Figure 134: STEP 8 - *Image Source* window, *Image Acquisition Device* selection.

9. Click on the descending arrow on the *Video Formats* field and select the desired pixel format.

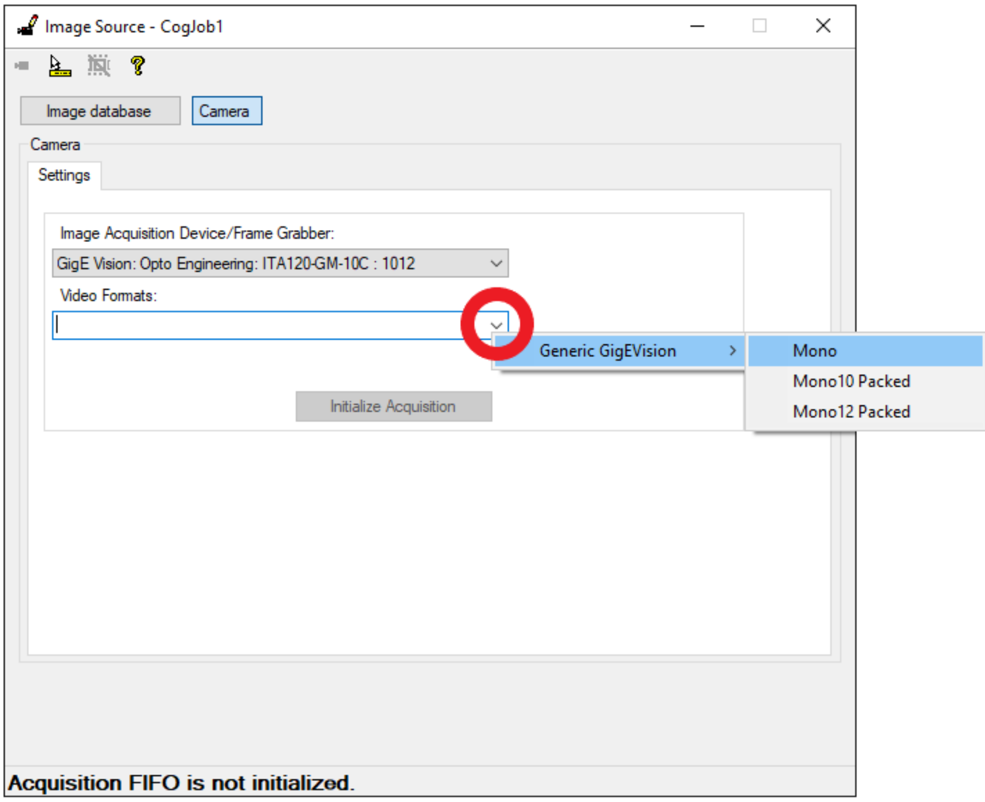


Figure 135: STEP 9 - *Image Source* window, *Video Formats* selection.

10. Click on *Initialize Acquisition*.

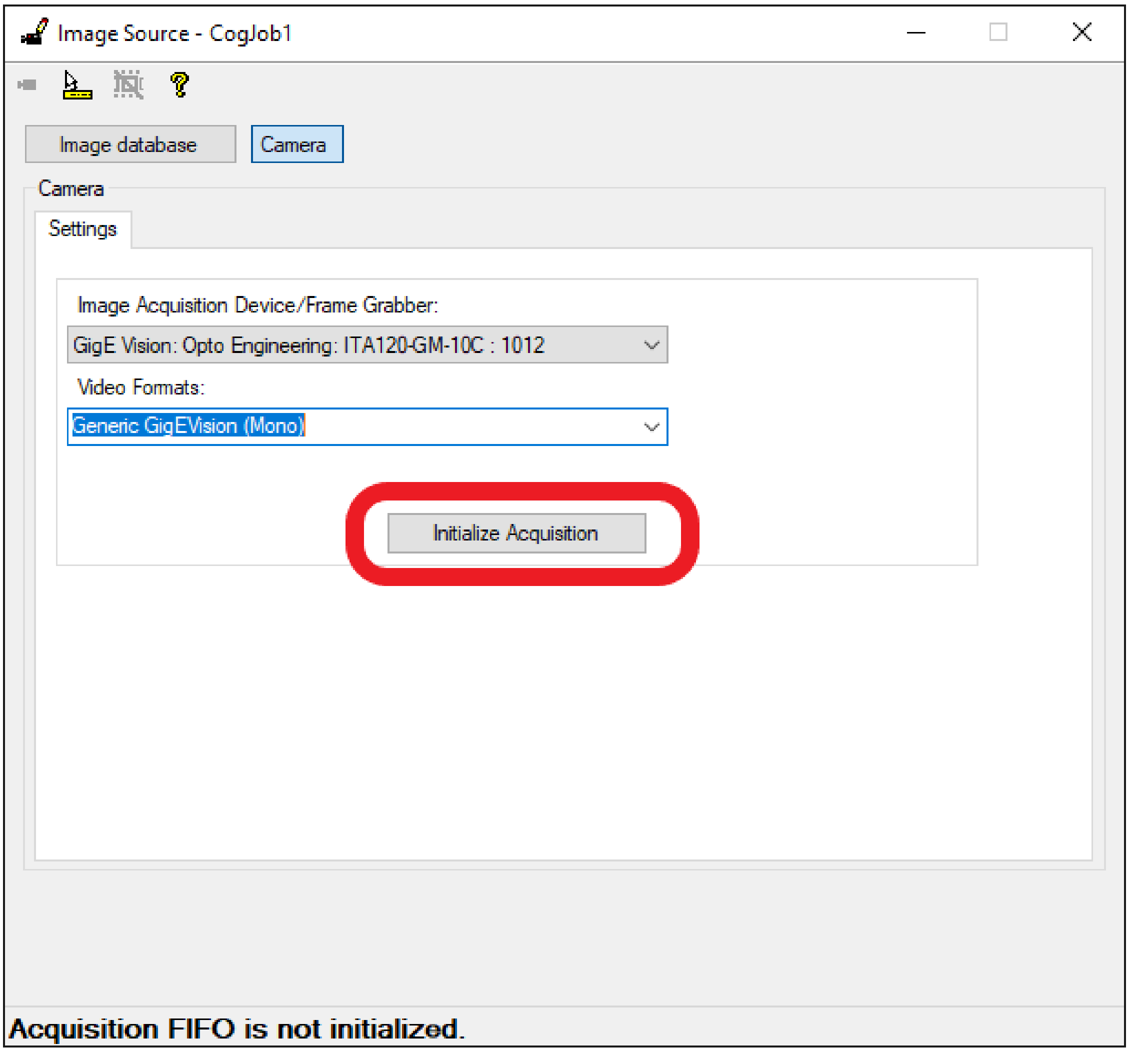


Figure 136: STEP 10 - *Image Source* window, *Initialize Acquisition*.

11. For a live preview click on the camera icon on the top left corner of the window. It is possible to set also the exposure time, trigger mode and other settings such as ROIs.

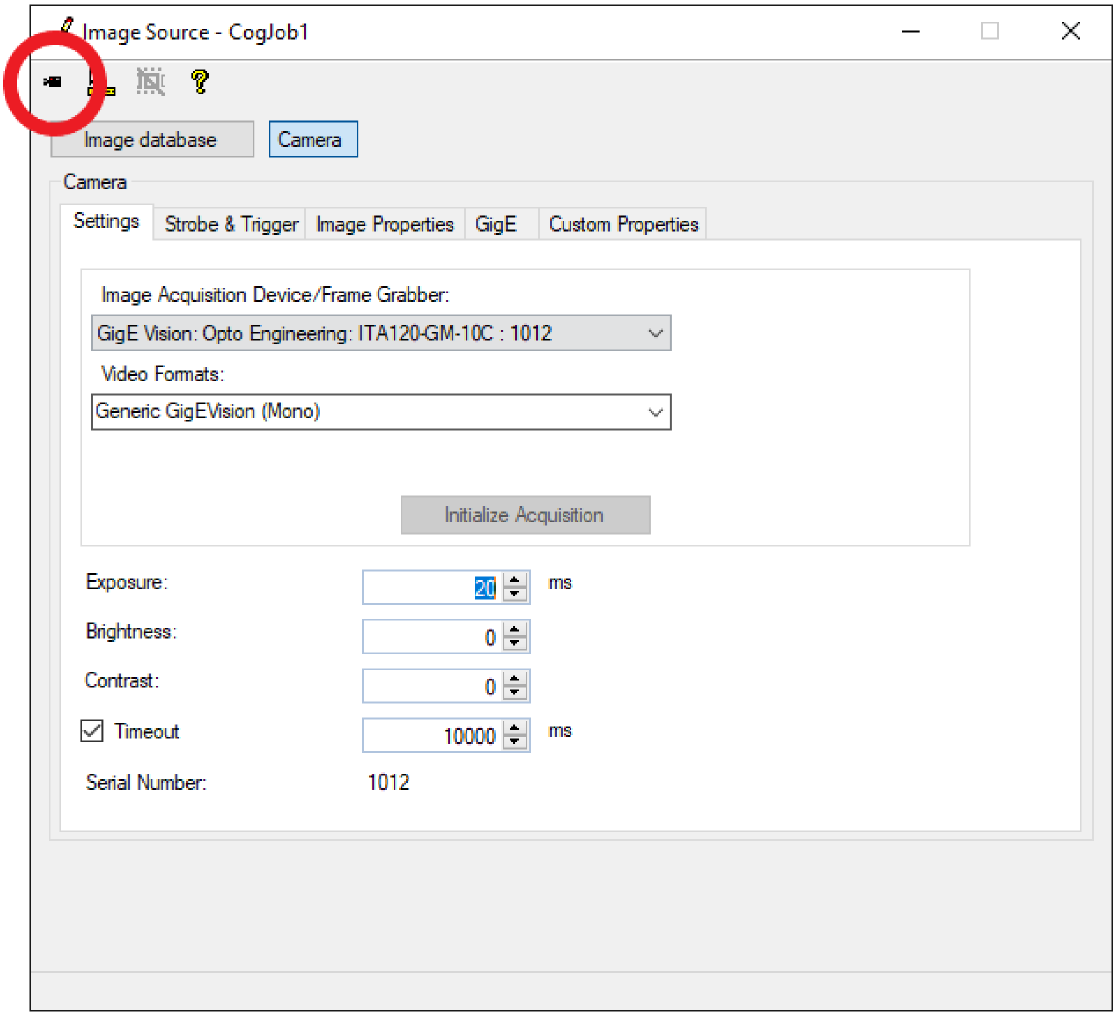


Figure 137: STEP 11 - *Image Source* window, *Live Preview*.

7.5 Sequencer Control configuration example

In this example, we define an acquisition sequence with four different exposure times on the device, in which the last step is repeated five times.

All configuration is done on the device itself, so after configuration is complete and acquisition is started, the device itself will apply the parameter changes if necessary. The host application then only needs to acquire the images. This results in a much faster overall frame rate than if these changes were applied frame by frame by the host application.

This will result in the following flow diagram:

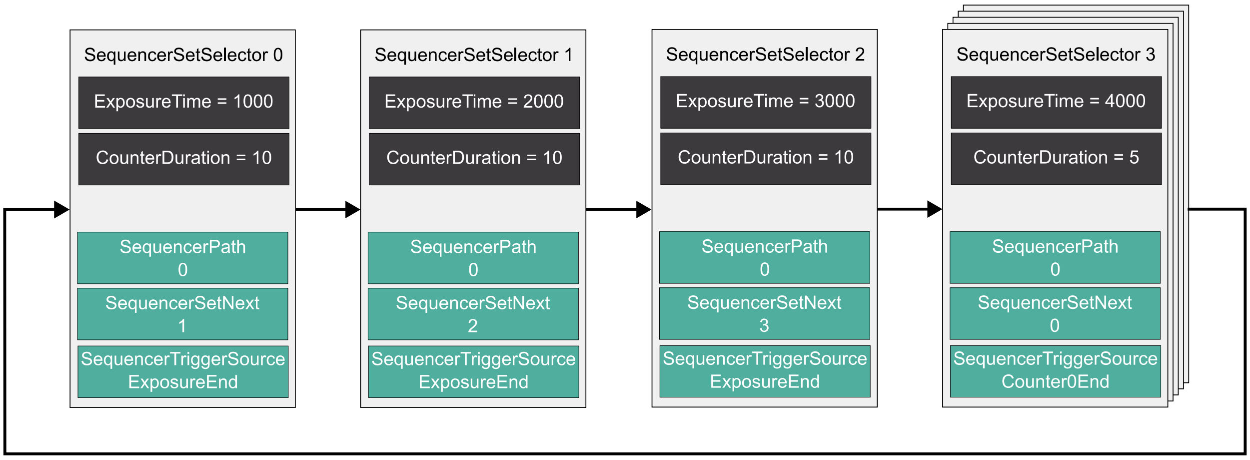


Figure 138: Sequencer Control example flow diagram.

There are some specifications concerning the sequencer path feature:

- A path is inactive as soon as the **SequencerTriggerSource** is Off.
- If both paths are inactive or none of the **SequencerTriggerSource** is triggered, the sequencer will remain in the current set.
- If the **SequencerTriggerSource** of both paths is triggered, the path with the trigger that occurred first will be followed.

7.5.1 Working with Sequencer Paths

It is possible to define sets with a maximum of two active paths. The following diagram shows an example using the **ExposureTime** and **oeLiquidLensPower** features, where two paths are defined in "Set 0" and "Set 1":

- "Set 0" and "Set 1" loops at each "ExposureEnd" following Path 0. When Timer0 ends, the next set is "Set 2", following Path 1.
- "Set 2" returns to "Set 0" after "ExposureEnd"

Additional settings:

- **TimerDuration** (Timer 0) = $2000000\mu s$
- **oeLiquidLensMode** = Power Mode

This will result in the following flow diagram:

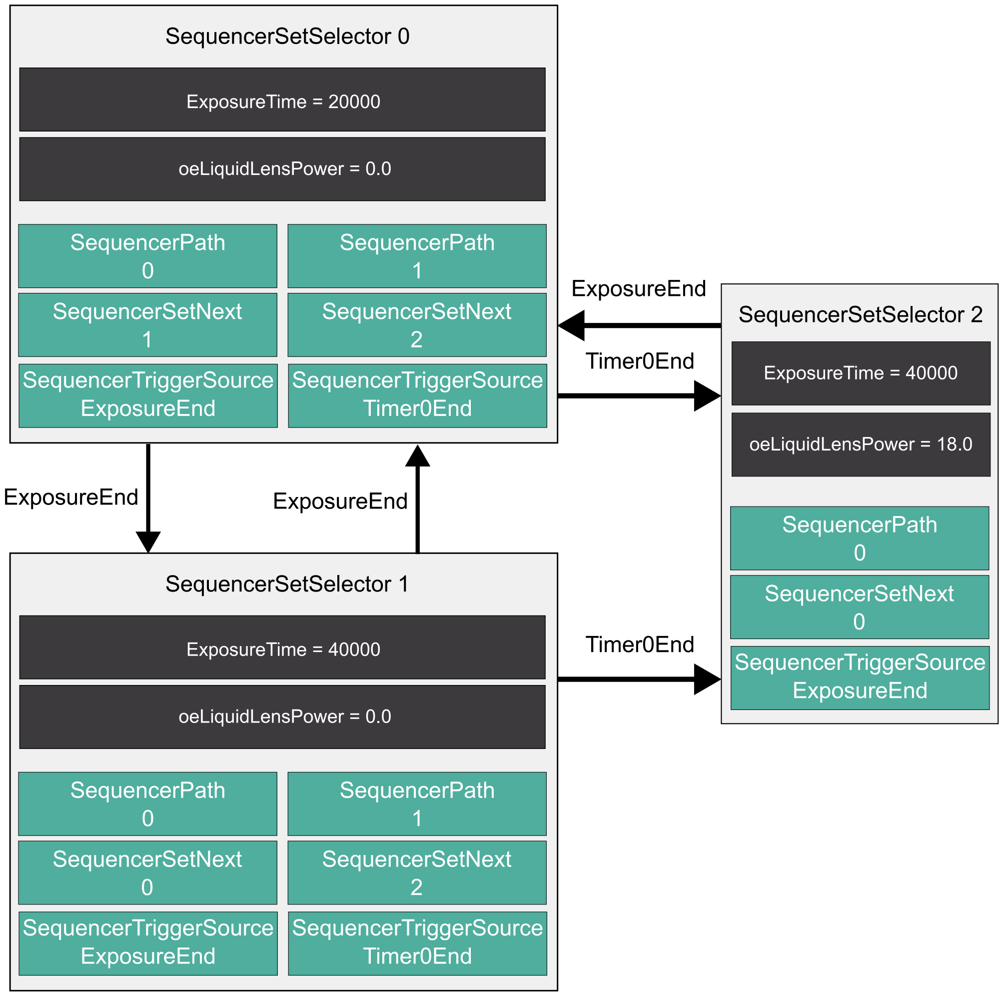


Figure 139: Sequencer Control paths example flow diagram.

8 TROUBLESHOOTING

8.1 The camera cannot be found in the available device list

When the camera is not detected and it's not available in the device list, check the following steps:

1. Check that the camera is correctly powered. When the camera is turned on, the status LED becomes yellow after few seconds.
2. Check if a firewall is currently blocking the communication between the host and the device.
3. Check the configuration of the NIC (network interface controller).
   By default, the camera is configured to have an IP address assigned by a DHCP server.
   The user, however, can assign a static IP address to the camera: in this case check that the interface card has a suited IP address, compatible to the camera one.
   As alternative, use the *IP Configurator tool* to properly configure the IP of the camera.
4. Check that network card's drivers are correctly installed (and updated to the last version).
5. If the camera is currently used by another application, the camera results unavailable for the actual process. In this case, disconnect the camera from the other application and connect the camera to the desired application again.
6. Check that the cable is not damaged.

8.2 Why some features are not present in the GenICam tree of the camera viewer?

When some feature are missing check the following points:

1. Check that the feature is actually available for the selected camera model.
   For example, typical color features (like RGB pixel formats) are not available for monochrome cameras.
2. Check the visibility mode of the viewer.
   Some features are not visible in *Beginner mode*, but can be displayed only in *Expert mode* or *Guru mode*.
3. Some new features may be added in following firmware releases: check that the camera FW is always up to date.

8.3 Why does the camera give frame losses?

When the camera and/or the network card are not properly configured, some frames may be lost. When this is happening, check the following potential causes:

1. Check the the GigE Vision capture driver is correctly installed.
2. Check the network interface drivers are currently up to date.
3. Check that the *jumbo packet* option of the network interface card is enabled.
   Jumbo packets support frames larger than 1500 bytes and give optimal performance on high-bandwidth cameras.
4. Check that the network interface card receive buffer is correctly dimensioned. In case of frame losses, try to increase the receive buffer size.
5. Check that the PC is not in *power saving mode*. In this working regime, CPU performances are strongly reduced and may cause frame losses.
6. Check that the current bandwidth doesn't exceed the supported rate of the link bandwidth.
   As a rule of thumb, BW can be approximated quite well by the equation 19:

   $$BW[Mbps] = Resolution[Mpixel] * BitPerPixel[bit/pixel] * FrameRate[fps] \tag{19}$$

   Along with this check, the *DeviceLinkThroughputLimit* feature may be used to control the amount of bandwidth used by the camera. The maximum available frame rate may decrease when this value is lowered since less bandwidth is available for transmission.

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