AVT Guppy PRO

Technical Manual

V2.0.3

08 April 2011

Allied Vision Technologies GmbH
Taschenweg 2a
D-07646 Stadtroda / Germany

ALLIED
Vision Technologies

Legal notice

For customers in the U.S.A.

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 when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However there is no guarantee that interferences will not occur in a particular installation. If the equipment does cause harmful interference to radio or television reception, 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 distance between the equipment and the receiver.
- Use a different line outlet for the receiver.
- Consult a radio or TV technician for help.

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment. The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart B of Part 15 of FCC Rules.

For customers in Canada

This apparatus complies with the Class B limits for radio noise emissions set out in the Radio Interference Regulations.

Pour utilisateurs au Canada

Cet appareil est conforme aux normes classe B pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

Life support applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Allied customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Allied for any damages resulting from such improper use or sale.

Trademarks

Microsoft, Windows, Windows 7, Windows Vista, and Windows XP are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.
FireWire is a registered trademark of Apple Computers for the IEEE 1394 standard.
IEEE 1394 standard is a trademark of the Institute of Electrical and Electronics Engineers, Inc. and licensed to the IEEE 1394 Standards Association.
Apple is a trademark of Apple Inc., registered in the U.S. and other countries.
Unless stated otherwise, all trademarks appearing in this document of Allied Vision Technologies are brands protected by law.

Warranty

The information provided by Allied Vision Technologies is supplied without any guarantees or warranty whatsoever, be it specific or implicit. Also excluded are all implicit warranties concerning the negotiability, the suitability for specific applications or the non-breaking of laws and patents. Even if we assume that the information supplied to us is accurate, errors and inaccuracy may still occur.

Copyright

Allied Vision Technologies GmbH 04/2011

Managing Director: Mr. Frank Grube
Tax ID: DE 184383113

Headquarters:

Taschenweg 2A
D-07646 Stadtroda, Germany
Tel.: +49 (0)36428 6770
Fax: +49 (0)36428 677-28
e-mail: info@alliedvisiontec.com

Contents

Contacting Allied Vision Technologies

Info

- **Technical information:**
  http://www.alliedvisiontec.com
- **Support:**
  support@alliedvisiontec.com

Allied Vision Technologies GmbH (Headquarters)
Taschenweg 2a
07646 Stadtroda, Germany
Tel.: +49 36428-677-0
Fax.: +49 36428-677-28
e-mail: info@alliedvisiontec.com

Allied Vision Technologies Canada Inc.
101-3750 North Fraser Way
Burnaby, BC, V5J 5E9, Canada
Tel: +1 604-875-8855
Fax: +1 604-875-8856
e-mail: info@alliedvisiontec.com

Allied Vision Technologies Inc.
38 Washington Street
Newburyport, MA 01950, USA
Toll Free number +1-877-USA-1394
Tel.: +1 978-225-2030
Fax: +1 978-225-2029
e-mail: info@alliedvisiontec.com

Allied Vision Technologies Asia Pte. Ltd.
82 Playfair Road
#07-02 D'Lithium
Singapore 368001
Tel: +65 6634-9027
Fax: +65 6634-902
e-mail: info@alliedvisiontec.com

Introduction

This **AVT Guppy PRO Technical Manual** describes in depth the technical specifications, dimensions, all camera features (IIDC standard and AVT smart features) and their registers, trigger features, all video and color formats, bandwidth and frame rate calculation.

For information on hardware installation, safety warnings, pin assignments on I/O connectors and 1394b connectors read the **Hardware Installation Guide**.

Note

Please read through this manual carefully.

We assume that you have read already the Hardware Installation Guide and that you have installed the hardware and software on your PC or laptop (FireWire card, cables).

Document history

Version	Date	Remarks
V2.0.1	30.11.10	New Manual — RELEASE status
to be continued on next page		

Table 1: Document history

Version	Date	Remarks
	continued from last page	
V2.0.2	05.04.11	• Revised video formats of Guppy PRO F-503 Table 76: Video Format_7 default modes Guppy PRO F-503B / F-503C on page 162 • Added exposure time offset for Guppy PRO F-503 Table 58: Camera-specific exposure time offset on page 141 • Added *On request: power out 6 W (HIROSE)* in all specification tables: see Chapter Specifications on page 35 to 46 • Revised advanced register: input control (only one input) in Table 20: Advanced register: Input control on page 64 • Revised IO_INP_CTRL: ID 0x3..0x1F is Reserved in Table 21: Input routing on page 65 • Revised advanced register: output control (3 outputs) in Table 26: Advanced register: Output control on page 70 • At register 0xF1000200 changed width and height: see Table 114: Advanced register: Maximum resolution inquiry on page 223 • YUV8: deleted description of data type *straight binary*: Figure 32: Data structure of YUV8; Source: IIDC V1.31 on page 80 • Y (Mono8/Raw8) are AVT own formats: see Table 33: Y (Mono8) format: Source: IIDC V1.31 / Y (Raw8) format: AVT on page 78
	to be continued on next page	

Table 1: Document history

Version	Date	Remarks
		continued from last page
[continued] V2.0.2	[continued] 05.04.11	• Video data formats now with subscript letters instead of underscore as wrongly used in IIDC, see Chapter Description of video data formats on page 77 • Revised spectral sensitivity for Guppy PRO F-031C: see Figure 10: Spectral sensitivity of Guppy PRO F-031C (without IR cut filter) on page 48 • Defect pixel correction: you don't need to set value for brightness to max. any more: see Figure 43: Defect pixel correction: build and store on page 102 and Chapter Grab an image with defect pixel data on page 103 • Max. resolution of Guppy PRO F-503B/C changed from 2592 x 1944 to 2588 x 1940: see Chapter Guppy PRO F-503B/C on page 45 and Chapter Video Format_7 default modes Guppy PRO F-503B / F-503C on page 162 • Added Guppy PRO F-503 frame rate and bandwidth: see Table 4: Bandwidth of Guppy PRO cameras on page 28 • Changed max. resolution of Guppy PRO F-503 from 2592 x 1944 to 2588 x 1940: see Chapter Guppy PRO F-503B/C on page 45 • Guppy PRO F-503: Mono8, YUV411 and YUV422 now in all F7 modes available: see Chapter Guppy PRO F-503B/C on page 45 • Guppy PRO F-503: added minimum exposure time in Table 59: Camera-specific minimum exposure time on page 142 • Guppy PRO F-503: added shutter speed at full resolution: see Chapter Guppy PRO F-503B/C on page 45 • Guppy PRO F-503: added shutter speed: see Chapter Guppy PRO F-503B/C on page 45 • Guppy PRO F-503: binning and sub-sampling in all F7 modes for b/w and color models: see Chapter Guppy PRO F-503B/C on page 45 • Guppy PRO F-503: added 800 Mbit/s: see Chapter Guppy PRO F-503B/C on page 45 • Guppy PRO F-503: added exposure time for long-term integration (extended shutter) up to 22 seconds: see Chapter Extended shutter on page 142 • Guppy PRO F-503: Revised chapter Chapter Mirror function (only Guppy PRO F-503) on page 96
		to be continued on next page

Table 1: Document history

Version	Date	Remarks
	continued from last page	
[continued] V2.0.2	[continued] 05.04.11	• Guppy PRO F-503: manual gain range now 8 … 48 (instead of 60): see Chapter Manual gain on page 94 • Guppy PRO F-503: manual gain range in db now 0 … 18 dB (instead of 26 dB): see Chapter Guppy PRO F-503B/C on page 45
V2.0.3	08.04.11	• Revised Chapter Binning (only b/w cameras; F-503: also color cameras) on page 105

Table 1: Document history

Manual overview

This **manual overview** describes each chapter of this manual shortly.

- Chapter Contacting Allied Vision Technologies on page 9 lists AVT contact data for both:
  - technical information / ordering
  - commercial information
- Chapter Introduction on page 10 (this chapter) gives you the document history, a manual overview and conventions used in this manual (styles and symbols). Furthermore you learn how to get more information on **how to install hardware (Hardware Installation Guide)**, available **AVT software** (incl. documentation) and where to get it.
- Chapter Guppy PRO cameras on page 17 gives you a short introduction to the Guppy PRO cameras with their FireWire technology. Links are provided to data sheets and brochures on AVT website.
- Chapter Conformity on page 18 gives you information about conformity of AVT cameras.
- Chapter FireWire on page 19 describes the FireWire standard in detail, explains the compatibility between 1394a and 1394b and explains bandwidth details (incl. Guppy PRO examples).
  - **Read and follow the FireWire hot-plug and screw-lock precautions in Chapter FireWire hot-plug and screw-lock precautions on page 29.**
  - **Read Chapter Operating system support on page 30.**
- Chapter Filter and lenses on page 31 describes the IR cut filter and suitable camera lenses.
- Chapter Specifications on page 35 lists camera details and spectral sensitivity diagrams for each camera type.
- Chapter Camera dimensions on page 54 provides CAD drawings of standard housing (copper and GOF) models, tripod adapter, available angled head models, cross sections of CS-Mount and C-Mount.

- Chapter Camera interfaces on page 58 describes in detail the inputs/outputs of the cameras (incl. Trigger features). For a general description of the interfaces (FireWire and I/O connector) see **Hardware Installation Guide**.
- Chapter Description of the data path on page 82 describes in detail IIDC conform as well as AVT-specific camera features.
- Chapter Controlling image capture on page 127 describes trigger modes, exposure time, one-shot/multi-shot/ISO_Enable features.
- Chapter Video formats, modes and bandwidth on page 150 lists all available fixed and Format_7 modes (incl. color modes, frame rates, binning/sub-sampling, AOI=area of interest).
- Chapter How does bandwidth affect the frame rate? on page 178 gives some considerations on bandwidth details.
- Chapter Configuration of the camera on page 182 lists standard and advanced register descriptions of all camera features.
- Chapter Firmware update on page 250 explains where to get information on firmware updates and explains the extended version number scheme of FPGA/µC.
- Chapter Appendix on page 251 lists the sensor position accuracy of AVT cameras.
- Chapter Index on page 252 gives you quick access to all relevant data in this manual.

Conventions used in this manual

To give this manual an easily understood layout and to emphasize important information, the following typographical styles and symbols are used:

Styles

Style	Function	Example
Bold	Programs, inputs or highlighting important things	**`bold`**
Courier	Code listings etc.	`Input`
Upper case	Register	REGISTER
Italics	Modes, fields	*Mode*
Parentheses and/or blue	Links	(Link)

Table 2: Styles

Symbols

Note

This symbol highlights important information.

Caution

This symbol highlights important instructions. You have to follow these instructions to avoid malfunctions.

www

This symbol highlights URLs for further information. The URL itself is shown in blue.

Example:

http://www.alliedvisiontec.com

More information

For more information on hardware and software read the following:

- **Hardware Installation Guide** describes the hardware installation procedures for all 1394 AVT cameras (Oscar, Marlin, Guppy, Pike, Stingray, Guppy PRO). Additionally you get safety instructions and information about camera interfaces (IEEE 1394a/b copper and GOF, I/O connectors, input and output).

www

For downloading the Hardware Installation Guide go to:

http://www.alliedvisiontec.com/emea/support/downloads/product-literature.html

There is no product CD.

www

All **software packages** (including **documentation** and **release notes**) provided by AVT can be downloaded at:

http://www.alliedvisiontec.com/emea/products/software.html

All software packages are also on AVT's product CD.

Before operation

We place the highest demands for quality on our cameras.

Target group This **Technical Manual** is the guide to detailed technical information of the camera and **is written for experts**.

Getting started For a quick guide how to get started read **Hardware Installation Guide** first.

Note

Please read through this manual carefully before operating the camera.

For information on **AVT accessories** and **AVT software** read **Hardware Installation Guide**.

Caution

Before operating any AVT camera read **safety instructions** and **ESD warnings** in **Hardware Installation Guide**.

www

To demonstrate the properties of the camera, you find some samples on **SmartView** which is part of **AVT FirePackage**. A free version is available for download at:

http://www.alliedvisiontec.com/emea/products/software.html

Note

The camera also works with all IIDC (formerly DCAM) compatible IEEE 1394 programs and image processing libraries.

Guppy PRO cameras

Guppy PRO With Guppy PRO cameras, entry into the world of digital image processing is simpler and more **cost-effective** than ever before. Guppy PRO cameras are the smallest 1394b cameras worldwide.

IEEE 1394b With the new Guppy PRO, Allied Vision Technologies presents a wide range of cameras with **IEEE 1394b interfaces**.

Image applications Allied Vision Technologies can provide users with a range of products that meet almost all the requirements of a very wide range of image applications.

FireWire The industry standard IEEE 1394 (FireWire or i.Link) facilitates the simplest computer compatibility and bidirectional data transfer. Further development of the IEEE 1394 standard has already made 800 Mbit/second possible. Investment in this standard is therefore secure for the future; each further development takes into account compatibility with the preceding standard, and vice versa, meaning that IEEE 1394b is backward-compatible with IEEE 1394a. Your applications will grow as technical progress advances.

Note

For further information on **FireWire** read Chapter FireWire on page 19.

www

For further information on the highlights of Guppy PRO **types**, the Guppy PRO **family** and the whole range of **AVT FireWire cameras** read the data sheets and brochures on the website of Allied Vision Technologies:

www.alliedvisiontec.com

Conformity

Allied Vision Technologies declares under its sole responsibility that all standard cameras of the **AVT Guppy PRO** family to which this declaration relates are in conformity with the following standard(s) or other normative document(s):

- CE, following the provisions of 2004/108/EG directive
- FCC Part 15 Class B
- RoHS (2002/95/EC)

CE

We declare, under our sole responsibility, that the previously described **AVT Guppy PRO** cameras conform to the directives of the CE.

FCC – Class B Device

Note: 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 environment. 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. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment.

FireWire

Overview

FireWire provides one of the most comprehensive, high-performance, cost-effective solutions platforms. **FireWire** offers very impressive throughput at very affordable prices.

Definition

FireWire (also known as **i.Link** or **IEEE 1394**) is a personal computer and digital video serial bus interface standard, offering high-speed communications and isochronous real-time data services. **FireWire** has low implementation costs and a simplified and adaptable cabling system.

Figure 1: FireWire Logo

IEEE 1394 standards

FireWire was developed by Apple Computer in the late 1990s, after work defining a slower version of the interface by the IEEE 1394 working committee in the 1980s. Apple's development was completed in 1995. It is defined in IEEE standard 1394 which is currently a composite of three documents:

- the original IEEE Std. 1394-1995
- the IEEE Std. 1394a-2000 amendment
- the IEEE Std. 1394b-2002 amendment

FireWire is used to connect digital cameras, especially in industrial systems for machine vision.

Why use FireWire?

Digital cameras with on-board **FireWire** (IEEE 1394a or 1394b) communications conforming to the IIDC standard (V1.3 or V1.31) have created cost-effective and powerful solutions options being used for thousands of different applications around the world. **FireWire** is currently the premier robust digital interface for industrial applications for many reasons, including:

- Guaranteed bandwidth features to ensure fail-safe communications
- Interoperability with multiple different camera types and vendors

- Diverse camera powering options, including single-cable solutions up to 45 W
- Effective multiple-camera solutions
- Large variety of **FireWire** accessories for industrial applications
- Availability of repeaters and optical fibre cabling
- Forwards and backward compatibility blending 1394a and 1394b
- Both real-time (isochronous) and demand-driven asynchronous data transmission capabilities

FireWire in detail

Serial bus

Briefly summarized, **FireWire** is a very effective way to utilize a low-cost serial bus, through a standardized communications protocol, that establishes packetized data transfer between two or more devices. FireWire offers real time isochronous bandwidth for image transfer with guaranteed low latency. It also offers asynchronous data transfer for controlling camera parameters, such as gain and shutter, on the fly. As illustrated in the diagram below, these two modes can co-exist by using priority time slots for video data transfer and the remaining time slots for control data transfer.

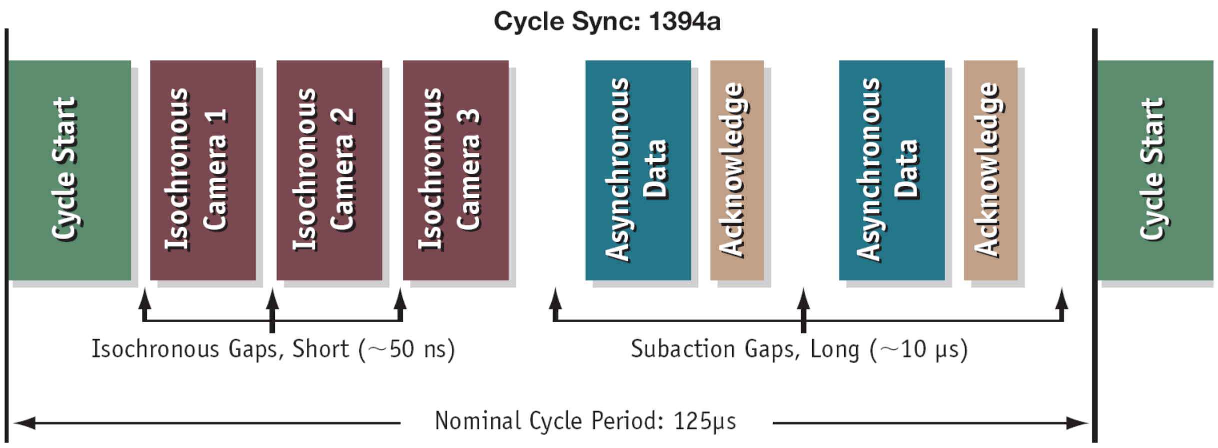


Figure 2: 1394a data transmission

In case of 1394b no gaps are needed due to parallel arbitration, handled by bus owner supervisor selector (BOSS) (see the following diagram). Whereas 1394a works in half duplex transmission, 1394 does full duplex transmission.

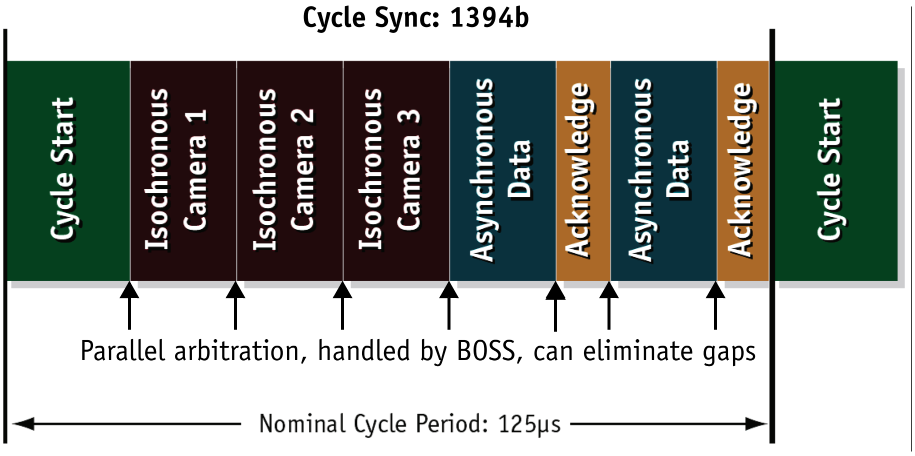


Figure 3: 1394b data transmission

Additional devices may be added up to the overall capacity of the bus, but throughput at guaranteed minimum service levels is maintained for all devices with an acknowledged claim on the bus. This deterministic feature is a huge advantage for many industrial applications where robust performance is required. Such is the case when it is not acceptable to drop images within a specific time interval.

Note

How to extend the size of an isochronous packet up to 11.000 byte at S800:

- see register 0xF1000048, ADV_INQ_3, Max IsoSize [1] in Table 112: Advanced register: Advanced feature inquiry on page 220
- see Chapter Maximum ISO packet size on page 239

FireWire connection capabilities

FireWire can connect together up to 63 peripherals in an acyclic network structure (hubs). It allows peer-to-peer device communication (between digital cameras), to take place without using system memory or the CPU.

But even more importantly, a **FireWire camera** can directly, via direct memory access (DMA), write into or read from the memory of the computer with almost no CPU load.

FireWire also supports multiple hosts per bus. **FireWire** requires only a cable with the correct number of pins on either end (normally 6 or 9). It is designed to support plug-and-play and hot swapping. It can supply up to 45 W of power per port at 30 V, allowing high consumption devices to operate without a separate power cord.

Caution

While supplying such an amount of bus power is clearly a beneficial feature, it is **very** important **not** to exceed the inrush current of 18 mJoule in 3 ms.

Higher inrush current may damage the Phy chip of the camera and/or the Phy chip in your PC.

Capabilities of 1394a (FireWire 400)

FireWire 400 (S400) is able to transfer data between devices at 100, 200 or 400 MBit/s data rates. Although USB 2.0 claims to be capable of higher speeds (480 Mbit/s), FireWire is, in practice, not slower than USB 2.0.

The 1394a capabilities in detail:

- 400 Mbit/s
- Hot-pluggable devices
- Peer-to-peer communications
- Direct Memory Access (DMA) to host memory
- Guaranteed bandwidth
- Multiple devices (up to 45 W) powered via FireWire bus

IIDC V1.3 camera control standards

IIDC V1.3 released a set of camera control standards via 1394a which established a common communications protocol on which most current FireWire cameras are based.

In addition to common standards shared across manufacturers, a special Format_7 mode also provided a means by which a manufacturer could offer special features (smart features), such as:

- higher resolutions
- higher frame rates
- diverse color modes

as extensions (advanced registers) to the prescribed common set.

Capabilities of 1394b (FireWire 800)

FireWire 800 (S800) was introduced commercially by Apple in 2003 and has a 9-pin FireWire 800 connector (see details in **Hardware Installation Guide** and in Chapter IEEE 1394b port pin assignment on page 58). This newer 1394b specification allows a transfer rate of 800 MBit/s with backward compatibilities to the slower rates and 6-pin connectors of FireWire 400.

The 1394b capabilities in detail:
- 800 Mbit/s
- All previous benefits of 1394a (see above)
- Interoperability with 1394a devices
- Longer communications distances (up to 500 m using GOF cables)

IIDC V1.31 camera control standards

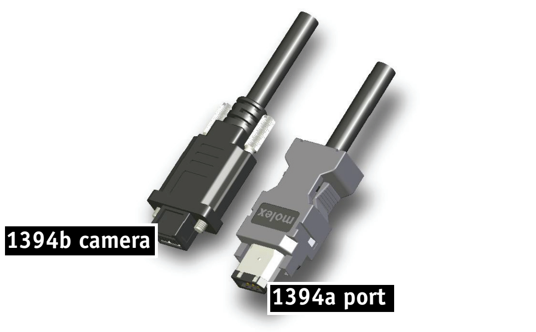
Twinned with 1394b, the IIDC V1.31 standard arrived in January 2004, evolving the industry standards for digital imaging communications to include I/O and RS232 handling, and adding further formats. At such high bandwidths it has become possible to transmit high-resolution images to the PC's memory at very high frame rates.

Compatibility between 1394a and 1394b

1394a camera connected to 1394b bus

The cable explains dual compatibility: This cable serves to connect an IEEE 1394a camera with its **six-pin** connector to a bilingual port (a port which can talk in a- or b-language) of a 1394b bus.

In this case the b-bus communicates in a-language and a-speed with the camera achieving a-performance



1394b camera connected to 1394a bus

The cable explains dual compatibility: In this case, the cable connects an IEEE 1394b camera with its **nine-pin** connector to a 1394a port.

In this case the b-camera communicates in a-language with the camera achieving a-performance

Figure 4: 1394a and 1394b cameras and compatibility

Compatibility example

It's possible to run a 1394a and a 1394b camera on the 1394b bus.

You can e.g. run a Guppy PRO F-032B and a Marlin F-033B on the same bus:
- Guppy PRO F-032B @ S800 and 60 fps (2560 bytes per cycle, 32% of the cycle slot)
- Marlin F-033B @ S400 and 30 fps (1280 bytes, 32% of the cycle slot)

Bus runs at 800 Mbit/s for all devices. Data from Marlin's port is up-converted from 400 Mbit/s to 800 Mbit/s by data doubling (padding), still needing 32% of the cycle slot time. This doubles the bandwidth requirement for this port, as if the camera were running at 60 fps. Total consumption is thus 2560+ 2560 = 5120 bytes per cycle.

Image transfer via 1394a and 1394b

Technical detail	1394a	1394b
Transmission mode	Half duplex (both pairs needed) 400 Mbit/s data rate aka: a-mode, data/strobe (D/S) mode, legacy mode	Full duplex (one pair needed) 1 Gbit/s signaling rate, 800 Mbit/s data rate 10b/8b coding (Ethernet), aka: b-mode (beta mode)
Devices	Up to 63 devices per network	
Number of cameras	Up to 16 cameras per network	
Number of DMAs	4 to 8 DMAs (parallel) cameras / bus	
Real time capability	Image has real time priority	
Available bandwidth acc. IIDC (per cycle 125 µs)	4096 bytes per cycle ~ 1000q @ 400 Mbit/s	8192 bytes per cycle ~ 2000q @ 800 Mbit/s (@1 GHz clock rate)
	For further detail read Chapter Frame rates on page 166.	
Max. image bandwidth	31.25 MByte/s	62.5 MByte/s
Max. total bandwidth	~45 MByte/s	~85 MByte/s
Number of busses	Multiple busses per PC limit: PCI bus	Multiple busses per PC limit: PCI (Express) bus
CPU load	Almost none for DMA image transfer	
Gaps	Gaps negatively affect asynchronous performance of widespread network (round trip delay), reducing efficiency	No gaps needed, BOSS mode for parallel arbitration

Table 3: Technical detail comparison: 1394a and 1394b

Note

The bandwidth values refer to the fact:

1 MByte = 1024 kByte

1394b bandwidths

According to the 1394b specification on isochronous transfer, the largest recommended data payload size is 8192 bytes per 125 µs cycle at a bandwidth of 800 Mbit/s.

Note

Certain cameras may offer, depending on their settings in combination with the use of AVT FirePackage higher packet sizes.

Consult your local dealer's support team, if you require additional information on this feature.

For further details read Chapter How does bandwidth affect the frame rate? on page 178.

Requirements for PC and 1394b

One Guppy PRO camera connected to a PC’s 1394b bus can saturate the standard PCI bus.

1394b also requires low latency for data transmission (due to small receive-FIFO). In order to get the most out of your camera-to-PC configuration, we recommend the following chipsets for your PC:

- For Intel-based desktops, chipset 945 (or higher)
- For non-Intel based desktops (e.g. AMD), PCI Express compatible chipset

www

For more information:

http://support.intel.com/support/chipsets/#desktop

For multi-camera applications one of the following bus cards is needed:

- PCI ExpressCard with potential 250 MByte/s per lane (up to 6 supported by chipset) or
- 64-bit PCI-X card (160 MByte/s)

Caution

As mentioned earlier, it is **very** important **not** to exceed an inrush current of 18 mJoule in 3 ms. (This means that a device, when powered via 12 V bus power must **never** draw more than 1.5 A, even not in the first 3 ms.)

Higher inrush current may damage the physical interface chip of the camera and/or the phy chip in your PC.

Whereas inrush current is not a problem for one 1394b camera, supplying bus power via (optional) HIROSE power out to circuitry with unknown inrush currents needs careful design considerations to be on the safe side.

Requirements for laptop and 1394b

As mentioned above, 1394b requires low latency for data transmission (small receive-FIFO). In order to get the most out of your camera-to-laptop configuration, we recommend the following chipset for your laptop:

- For Intel-based laptops, chipset 915 (or higher)
- For non-Intel based laptops (e.g. AMD), PCI Express compatible chipset

Because most laptops have (only) one PC-card interface, it is possible to connect one Guppy PRO camera to your laptop at full speed. Alternatively laptops with an additional 1394 ExpressCard interface can be used.

Note

Recent developments at Apple allow the INTEL based Apple computers (both laptops as well as desktops) to run a Windows operating system. This makes it possible to use AVT 1394 camera technology with the same AVT-SDKs.

The following cardbus adapter for laptops allows the connection of two industrial screw locking cables (obtainable at AVT).

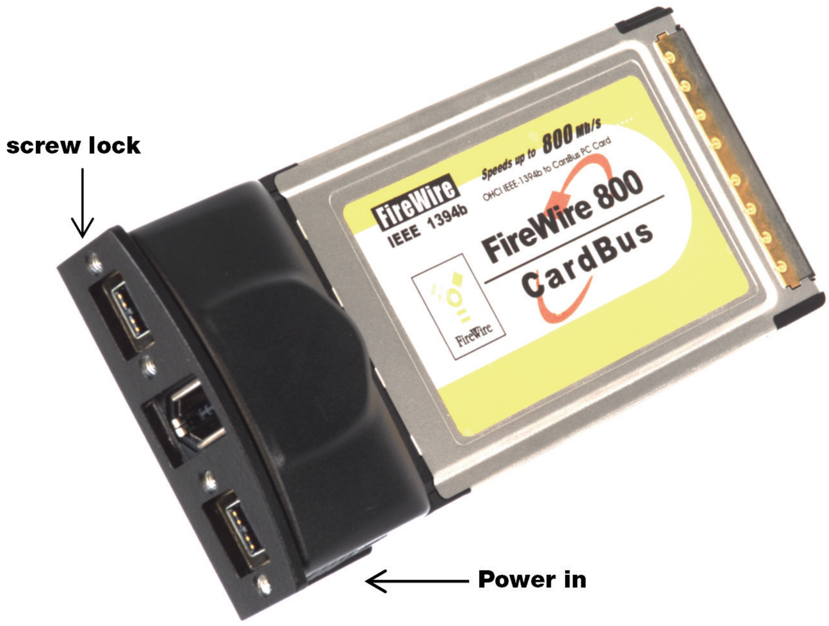


Figure 5: Cardbus adapter with two screw locks (AVT order number E3000104)

Figure 6: ExpressCard Logo, ExpressCard/54 (SIIG)

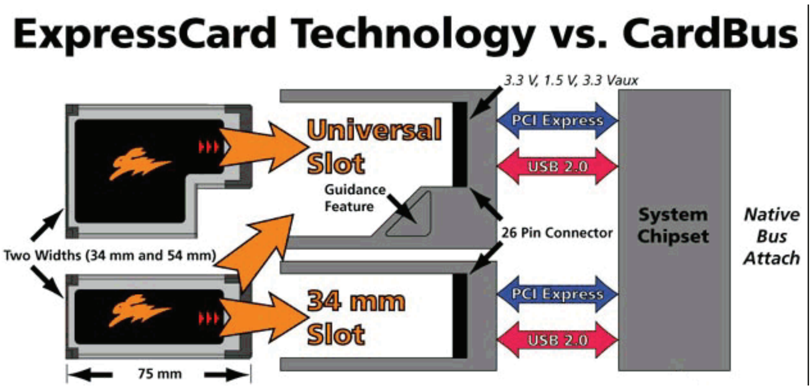


Figure 7: ExpressCard technology

www

ExpressCard is a new standard set by PCMCIA.

For more information visit:

http://www.expresscard.org/web/site/

Example 1: 1394b bandwidth of Guppy PRO cameras

Guppy PRO model	Resolution	Frame rate	Bandwidth
Guppy PRO F-031 B/C	0.3 megapixels	136 fps	38 MByte/s
Guppy PRO F-032 B/C	0.3 megapixels	80 fps	22 MByte/s
Guppy PRO F-125 B/C	1.2 megapixels	30 fps	37 MByte/s
Guppy PRO F-146 B/C	1.4 megapixels	16 fps	20 MByte/s
Guppy PRO F-201 B/C	2.0 megapixels	14 fps	28 MByte/s
Guppy PRO F-503 B/C	5.0 megapixels	13 fps	65 MByte/s

Table 4: Bandwidth of Guppy PRO cameras

Note

All data are calculated using Raw8 / Mono8 color mode. Higher bit depths or color modes will double or triple bandwidth requirements.

Example 2: More than one Guppy PRO camera at full speed

Due to the fact that one Guppy PRO camera can, depending on its settings, saturate a 32-bit PCI bus, you are advised to use either a PCI Express card and/or multiple 64-bit PCI bus cards, if you want to use 2 or more Guppy PRO cameras simultaneously (see the following table).

# cameras	PC hardware required
1 Guppy PRO camera at full speed	1 x 32-bit PCI bus card (85 MByte/s)
2 or more Guppy PRO cameras at full speed	PCI Express card and/or Multiple 64-bit PCI bus cards

Table 5: Required hardware for multiple camera applications

FireWire Plug & play capabilities

FireWire devices implement the ISO/IEC 13213 **configuration ROM** model for device configuration and identification, to provide plug & play capability. All FireWire devices are identified by an IEEE EUI-64 unique identifier (an extension of the 48-bit Ethernet MAC address format) in addition to well-known codes indicating the type of device and protocols it supports. For further details read Chapter Configuration of the camera on page 182.

FireWire hot-plug and screw-lock precautions

Caution

Hot-plug precautions

- Although FireWire devices can **theoretically** be hot-plugged without powering down equipment, **we strongly recommend turning the computer power off, before connecting a digital camera** to it via a FireWire cable.
- **Static electricity or slight plug misalignment during insertion may short-circuit and damage components.**
- The physical ports **may be damaged** by **excessive ESD** (electrostatic discharge), when connected under powered conditions. It is good practice to ensure proper grounding of computer case and camera case to the same ground potential, before plugging the camera cable into the port of the computer. This ensures that no excessive difference of electrical potential exists between computer and camera.
- As mentioned earlier, it is **very** important **not** to exceed the **inrush energy of 18 mJoule in 3 ms**. (This means that a device, when powered via 12 V bus power must NEVER draw more than 1.5 A, but only 0.5 A in the first 3 ms, assuming constant flow of current.)
- Higher inrush current over longer periods **may damage the physical interface chip of the camera and/or the phy chip in your PC**. Whereas inrush current is not a problem for one Guppy PRO camera, daisy chaining multiple cameras or supplying bus power via (optional) HIROSE power out to circuitry with unknown inrush currents needs careful design considerations to be on the safe side.

Screw-lock precautions

- Also, all AVT 1394b camera and cables have **industrial screw-lock fasteners**, to insure a tight electrical connection that is resistant to vibration and gravity.
- **We strongly recommend using only 1394b adapter cards with screw-locks.**

Operating system support

<table>
<tr><th>Operating system</th><th>1394a</th><th>1394b</th></tr>
<tr><td>Linux</td><td>Full support</td><td>Full support</td></tr>
<tr><td>Apple Mac OS X</td><td>Full support</td><td>Full support</td></tr>
<tr><td>Windows XP</td><td colspan="2">With SP2 / SP3 the default speed for 1394b is S100 (100 Mbit/s). A download and registry modification is available from Microsoft to restore performance to either S400 or S800.

http://support.microsoft.com/kb/885222

Alternatively use the drivers of SP1 instead: Microsoft Windows XP SP2 and XP SP3 do not correctly support IEEE 1394b FireWire adapters. Downgrading the Windows XP FireWire bus driver to the SP1 version is required for IEEE 1394a or 1394b FireWire cameras to work correctly on an IEEE 1394b adapter, or if you want to use a 1394b FireWire camera with an IEEE 1394a adapter.

Or: use either the driver of the AVT Universal Package/ AVT FirePackage or install the driver provided with the AVT 1394 Bus Driver Package. Both drivers replace the Microsoft OHCI IEEE 1394 driver, but the second is 100% compliant to the driver of Microsoft. This means, applications using the MS1394 driver will continue to work.</td></tr>
<tr><td>Windows Vista</td><td>Full support</td><td>Windows Vista incl. SP1/SP2 supports 1394b only with S400.

Use either the driver of the AVT Universal Package/ AVT FirePackage or install the driver provided with the AVT 1394 Bus Driver Package. Both drivers replace the Microsoft OHCI IEEE 1394 driver, but the second is 100% compliant to the driver of Microsoft. This means, applications using the MS1394 driver will continue to work.</td></tr>
<tr><td>Windows 7</td><td>Full support</td><td>Full support</td></tr>
</table>

Table 6: FireWire and operating systems

www

For more information see **AVT Software Selector Guide:**

http://www.alliedvisiontec.com/emea/support/downloads/software.html

Filter and lenses

IR cut filter: spectral transmission

The following illustration shows the spectral transmission of the IR cut filter:

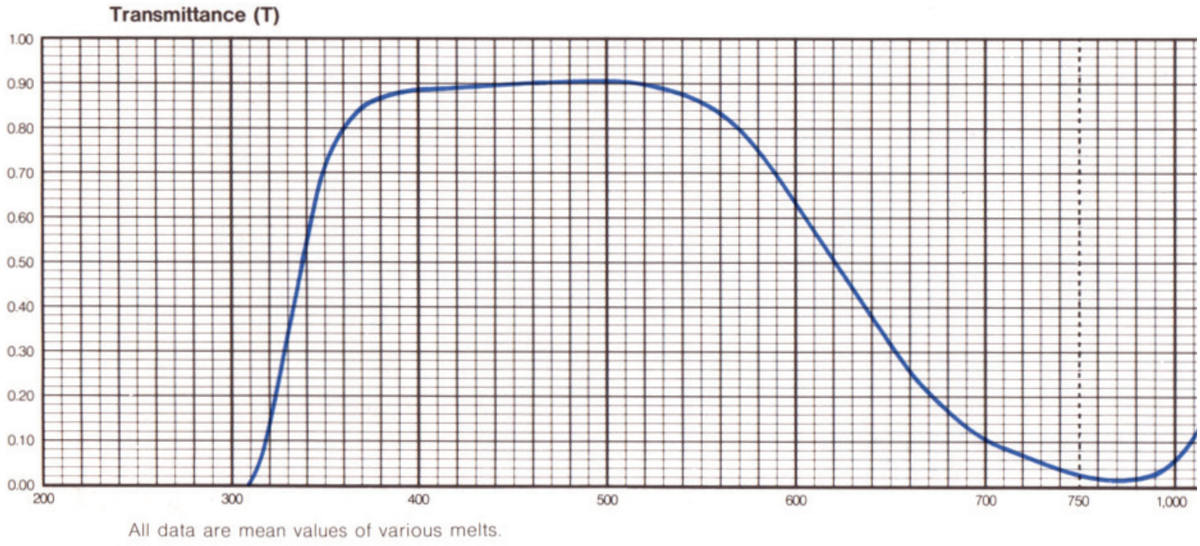


Figure 8: Spectral transmission of Hoya C5000

Camera lenses

AVT offers different lenses from a variety of manufacturers. The following table lists selected image formats in **width x height** depending on camera type, distance and the focal length of the lens.

Note

All calculations apply to the principle planes of the lenses: these are unknown (real lenses are not infinite thin).

All calculations are valid only for a distortion free optical image (among other things: not valid for fisheye lenses).

Focal length for type 1/4 sensors Guppy PRO F-031	Distance = 500 mm	Distance = 1000 mm
2.8 mm	652 mm x 492 mm	1307 mm x 987 mm
4 mm	455 mm x 343 mm	914 mm x 690 mm
4.2 mm	433 mm x 327 mm	870 mm x 657 mm
4.8 mm	379 mm x 286 mm	761 mm x 574 mm
6 mm	302 mm x 228 mm	608 mm x 459 mm
6.5 mm	279 mm x 210 mm	561 mm x 423 mm
8 mm	226 mm x 170 mm	455 mm x 343 mm
12 mm	149 mm x 113 mm	302 mm x 228 mm
16 mm	111 mm x 84 mm	226 mm x 170 mm
25 mm	70 mm x 53 mm	143 mm x 108 mm

Table 7: Focal length vs. field of view (Guppy PRO F-031)

Focal length for type 1/3 sensors Guppy PRO F-032	Distance = 500 mm	Distance = 1000 mm
2.8 mm	867 mm x 648 mm	1738 mm x 1300 mm
4 mm	605 mm x 453 mm	1215 mm x 909 mm
4.2 mm	576 mm x 431 mm	1157 mm x 865 mm
4.8 mm	503 mm x 377 mm	1012 mm x 757 mm
6 mm	402 mm x 301 mm	808 mm x 605 mm
6.5 mm	371 mm x 277 mm	746 mm x 558 mm

Table 8: Focal length vs. field of view (Guppy PRO F-032)

Focal length for type 1/3 sensors Guppy PRO F-032	Distance = 500 mm	Distance = 1000 mm
8 mm	300 mm x 224 mm	605 mm x 453 mm
12 mm	198 mm x 148 mm	402 mm x 301 mm
16 mm	148 mm x 110 mm	300 mm x 224 mm
25 mm	93 mm x 69 mm	190 mm x 142 mm

Table 8: Focal length vs. field of view (Guppy PRO F-032)

Focal Width for type 1/2.5 sensors Guppy PRO F-503	Distance = 0.5 m	Distance = 1 m
4.8 mm	0.44 m x 0.59 m	0.89 m x 1.18 m
8 mm	0.26 m x 0.35 m	0.53 m x 0.70 m
12 mm	0.17 m x 0.23 m	0.35 m x 0.47 m
16 mm	0.13 m x 0.17 m	0.26 m x 0.35 m
25 mm	0.08 m x 0.11 m	0.17 m x 0.22 m
35 mm	0.06 m x 0.08 m	0.12 m x 0.16 m
50 mm	0.04 m x 0.05 m	0.08 m x 0.11 m

Table 9: Focal width vs. field of view (Guppy PRO F-503)

Focal length for type 1/2 sensors Guppy PRO F-146	Distance = 500 mm	Distance = 1000 mm
4.8 mm	660 mm x 495 mm	1327 mm x 995 mm
8 mm	394 mm x 295 mm	794 mm x 595 mm
12 mm	260 mm x 195 mm	527 mm x 395 mm
16 mm	194 mm x 145 mm	394 mm x 295 mm
25 mm	122 mm x 91 mm	250 mm x 187 mm
35 mm	85 mm x 64 mm	176 mm x 132 mm
50 mm	58 mm x 43 mm	122 mm x 91 mm

Table 10: Focal length vs. field of view (Guppy PRO F-146)

Focal length for type 1/1.8 sensors Guppy PRO F-201	Distance = 500 mm	Distance = 1000 mm
4.8 mm	740 mm x 549 mm	1488 mm x 1103 mm
8 mm	441 mm x 327 mm	890 mm x 660 mm
12 mm	292 mm x 216 mm	591 mm x 438 mm
16 mm	217 mm x 161 mm	441 mm x 327 mm
25 mm	136 mm x 101 mm	280 mm x 207 mm
35 mm	95 mm x 71 mm	198 mm x 147 mm
50 mm	65 mm x 48 mm	136 mm x 101 mm

Table 11: Focal length vs. field of view (Guppy PRO F-201)

Note

Lenses with focal lengths < 8 mm may show shading in the edges of the image and due to micro lenses on the sensor's pixel.

Ask your dealer if you require non C-Mount lenses.

Specifications

Note

- For information on bit/pixel and byte/pixel for each color mode see Table 87: ByteDepth on page 179.
- **Maximum protrusion** means the **distance from lens flange to the glass filter in the camera**.

Guppy PRO F-031B/C

Feature	Specification
Image device	Type 1/4 (diag. 4.5 mm) progressive scan SONY IT CCD ICX618AL/AQA with EXview HAD microlens
Effective chip size	**3.6 mm x 2.7 mm**
Cell size	5.6 µm x 5.6 µm
Picture size (max.)	656 x 492 pixels (Format_7 Mode_0)
Lens mount	Adjustable C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) maximum protrusion: 10.1 mm (see Figure 23: Guppy PRO C-Mount dimensions on page 56) **Note** **Maximum protrusion** means the distance from lens flange to the glass filter in the camera.
ADC	14 bit
Color modes	**Only color:** Raw8, Raw12, Raw16, Mono8, YUV411, YUV422, RGB8
Frame rates	1.875 fps; 3.75 fps; 7.5 fps; 15 fps; 30 fps; 60 fps; 120 fps Up to 121 fps in Format_7
Gain control	Manual: 0-24.4 dB (0.0359 dB/step); auto gain (select. AOI)
Shutter speed	71 µs … 67,108,864 µs (~ 67 s); auto shutter (select. AOI)
External trigger shutter	Programmable, trigger level control, single trigger, bulk trigger, programmable trigger delay
Look-up tables	User programmable (12 bit → 10 bit); default gamma (0.45)

Table 12: Specification Guppy PRO F-031B/C

Feature	Specification
Smart functions	AGC (auto gain control), AEC (auto exposure control), autofunction AOI, LUT, binning (only b/w), sub-sampling (only b/w), color correction, hue, saturation, 1 storable user set **only color:** AWB (auto white balance)
I/Os	One configurable input (optocoupled), three configurable outputs (optocoupled)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s, 800 Mbit/s
Digital interface	IEEE 1394b (IIDC V1.31), 1 x copper connector
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Typical <3.5 watt (@ 12 V DC) (full resolution and maximal frame rates)
Dimensions	44.8 mm x 29 mm x 29 mm (L x W x H); incl. connectors, without tripod and lens
Mass	75 g (without lens) + 5 g filter ring
Operating temperature	+ 5 °C ... + 45 °C ambient temperature (non-condensing)
Storage temperature	- 10 °C ... + 70 °C ambient temperature (non-condensing)
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w:** protection glass **color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, power out 6 W (HIROSE)
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 12: Specification Guppy PRO F-031B/C

Note

The design and specifications for the products described above may change without notice.

Guppy PRO F-032B/C

Feature	Specification
Image device	Type 1/3 (diag. 6 mm) progressive scan SONY IT CCD ICX424AL/AQ with HAD microlens
Effective chip size	**4.9 mm x 3.7 mm**
Cell size	7.4 µm x 7.4 µm
Picture size (max.)	656 x 492 pixels (Format_7 Mode_0)
Lens mount	Adjustable C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) maximum protrusion: 10.1 mm (see Figure 23: Guppy PRO C-Mount dimensions on page 56) **Note** **Maximum protrusion** means the distance from lens flange to the glass filter in the camera.
ADC	12 bit
Color modes	**Only color:** Raw8, Raw12, Raw16, Mono8, YUV411, YUV422, RGB8
Frame rates	1.875 fps; 3.75 fps; 7.5 fps; 15 fps; 30 fps; 60 fps Up to 79 fps in Format_7
Gain control	Manual: 0-24.4 dB (0.0359 dB/step); auto gain (select. AOI)
Shutter speed	27 µs … 67,108,864 µs (~ 67 s); auto shutter (select. AOI)
External trigger shutter	Programmable, trigger level control, single trigger, bulk trigger, programmable trigger delay
Look-up tables	User programmable (12 bit → 10 bit); default gamma (0.45)
Smart functions	AGC (auto gain control), AEC (auto exposure control), autofunction AOI, LUT, binning (only b/w), sub-sampling (only b/w), color correction, hue, saturation, 1 storable user set **only color:** AWB (auto white balance)
I/Os	One configurable input (optocoupled), three configurable outputs (optocoupled)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s, 800 Mbit/s
Digital interface	IEEE 1394b (IIDC V1.31), 1 x copper connector
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Typical <3.5 watt (@ 12 V DC) (full resolution and maximal frame rates)
Dimensions	44.8 mm x 29 mm x 29 mm (L x W x H); incl. connectors, without tripod and lens

Table 13: Specification Guppy PRO F-032B/C

Feature	Specification
Mass	75 g (without lens) + 5 g filter ring
Operating temperature	+ 5 °C ... + 45 °C ambient temperature (non-condensing)
Storage temperature	- 10 °C ... + 70 °C ambient temperature (non-condensing)
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w:** protection glass **color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, power out 6 W (HIROSE)
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 13: Specification Guppy PRO F-032B/C

Note

The design and specifications for the products described above may change without notice.

Guppy PRO F-125B/C

Feature	Specification
Image device	Type 1/3 (diag. 6 mm) progressive scan SONY IT CCD ICX445ALA/AQA with EXview HAD microlens
Effective chip size	**4.8 mm x 3.6 mm**
Cell size	3.75 µm x 3.75 µm
Picture size (max.)	1292 x 964 pixels (Format_7 Mode_0)
Lens mount	Adjustable C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) maximum protrusion: 10.1 mm (see Figure 23: Guppy PRO C-Mount dimensions on page 56) **Note** **Maximum protrusion** means the distance from lens flange to the glass filter in the camera.
ADC	14 bit
Color modes	**Only color:** Raw8, Raw12, Raw16, Mono8, YUV411, YUV422, RGB8
Frame rates	1.875 fps; 3.75 fps; 7.5 fps; 15 fps; 30 fps; 60 fps Up to 30 fps in Format_7
Gain control	Manual: 0-24.4 dB (0.0359 dB/step); auto gain (select. AOI)
Shutter speed	35 µs … 67,108,864 µs (~ 67 s); auto shutter (select. AOI)
External trigger shutter	Programmable, trigger level control, single trigger, bulk trigger, programmable trigger delay
Look-up tables	User programmable (12 bit → 10 bit); default gamma (0.45)
Smart functions	AGC (auto gain control), AEC (auto exposure control), autofunction AOI, LUT, binning (only b/w), sub-sampling (only b/w), color correction, hue, saturation, 1 storable user set **only color:** AWB (auto white balance)
I/Os	One configurable input (optocoupled), three configurable outputs (optocoupled)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s, 800 Mbit/s
Digital interface	IEEE 1394b (IIDC V1.31), 1 x copper connector
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Typical <3.5 watt (@ 12 V DC) (full resolution and maximal frame rates)
Dimensions	44.8 mm x 29 mm x 29 mm (L x W x H); incl. connectors, without tripod and lens

Table 14: Specification Guppy PRO F-125B/C

Feature	Specification
Mass	75 g (without lens) + 5 g filter ring
Operating temperature	+ 5 °C ... + 45 °C ambient temperature (non-condensing)
Storage temperature	- 10 °C ... + 70 °C ambient temperature (non-condensing)
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w:** protection glass **color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, power out 6 W (HIROSE)
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 14: Specification Guppy PRO F-125B/C

Note

The design and specifications for the products described above may change without notice.

Guppy PRO F-146B/C

Feature	Specification
Image device	Type 1/2 (diag. 8 mm) progressive scan SONY IT CCD ICX267AL/AK with HAD microlens
Effective chip size	**6.5 mm x 4.8 mm**
Cell size	4.65 µm x 4.65 µm
Picture size (max.)	1388 x 1038 pixels (Format_7 Mode_0)
Lens mount	Adjustable C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) maximum protrusion: 10.1 mm (see Figure 23: Guppy PRO C-Mount dimensions on page 56) **Note** **Maximum protrusion** means the distance from lens flange to the glass filter in the camera.
ADC	12 bit
Color modes	**Only color:** Raw8, Raw12, Raw16, Mono8, YUV411, YUV422, RGB8
Frame rates	1.875 fps; 3.75 fps; 7.5 fps; 15 fps; 30 fps Up to 17 fps in Format_7
Gain control	Manual: 0-24.4 dB (0.0359 dB/step); auto gain (select. AOI)
Shutter speed	31 µs … 67,108,864 µs (~ 67 s); auto shutter (select. AOI)
External trigger shutter	Programmable, trigger level control, single trigger, bulk trigger, programmable trigger delay
Look-up tables	User programmable (12 bit → 10 bit); default gamma (0.45)
Smart functions	AGC (auto gain control), AEC (auto exposure control), autofunction AOI, LUT, binning (only b/w), sub-sampling (only b/w), color correction, hue, saturation, 1 storable user set **only color:** AWB (auto white balance)
I/Os	One configurable input (optocoupled), three configurable outputs (optocoupled)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s, 800 Mbit/s
Digital interface	IEEE 1394b (IIDC V1.31), 1 x copper connector
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Typical <3.5 watt (@ 12 V DC) (full resolution and maximal frame rates)
Dimensions	44.8 mm x 29 mm x 29 mm (L x W x H); incl. connectors, without tripod and lens

Table 15: Specification Guppy PRO F-146B/C

Feature	Specification
Mass	75 g (without lens) + 5 g filter ring
Operating temperature	+ 5 °C ... + 45 °C ambient temperature (non-condensing)
Storage temperature	- 10 °C ... + 70 °C ambient temperature (non-condensing)
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w:** protection glass **color:** IR cut filter
Accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, power out 6 W (HIROSE)
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 15: Specification Guppy PRO F-146B/C

Note

The design and specifications for the products described above may change without notice.

Guppy PRO F-201B/C

Feature	Specification
Image device	Type 1/1.8 (diag. 8.9 mm) progressive scan SONY IT CCD ICX274AL/AQ with Super HAD microlens
Effective chip size	**7.1 mm x 5.4 mm**
Cell size	4.40 µm x 4.40 µm
Picture size (max.)	1624 x 1234 pixels (Format_7 Mode_0)
Lens mount	Adjustable C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) maximum protrusion: 10.1 mm (see Figure 23: Guppy PRO C-Mount dimensions on page 56) **Note** **Maximum protrusion** means the distance from lens flange to the glass filter in the camera.
ADC	12 bit
Color modes	**Only color:** Raw8, Raw12, Raw16, Mono8, YUV411, YUV422, RGB8
Frame rates	1.875 fps; 3.75 fps; 7.5 fps; 30 fps Up to 14 fps in Format_7
Gain control	Manual: 0-24.4 dB (0.0359 dB/step); auto gain (select. AOI)
Shutter speed	45 µs … 67,108,864 µs (~ 67 s); auto shutter (select. AOI)
External trigger shutter	Programmable, trigger level control, single trigger, bulk trigger, programmable trigger delay
Look-up tables	User programmable (12 bit → 10 bit); default gamma (0.45)
Smart functions	AGC (auto gain control), AEC (auto exposure control), autofunction AOI, LUT, binning (only b/w), sub-sampling (only b/w), color correction, hue, saturation, 1 storable user set **only color:** AWB (auto white balance)
I/Os	One configurable input (optocoupled), three configurable outputs (optocoupled)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s, 800 Mbit/s
Digital interface	IEEE 1394b (IIDC V1.31), 1 x copper connector
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Typical <3.5 watt (@ 12 V DC) (full resolution and maximal frame rates)
Dimensions	44.8 mm x 29 mm x 29 mm (L x W x H); incl. connectors, without tripod and lens

Table 16: Specification Guppy PRO F-201B/C

Feature	Specification
Mass	75 g (without lens) + 5 g filter ring
Operating temperature	+ 5 °C ... + 45 °C ambient temperature (non-condensing)
Storage temperature	- 10 °C ... + 70 °C ambient temperature (non-condensing)
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w:** protection glass **color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, power out 6 W (HIROSE)
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 16: Specification Guppy PRO F-201B/C

Note

The design and specifications for the products described above may change without notice.

Guppy PRO F-503B/C

Feature	Specification
Image device	Type 1/2.5 (diag. 7.13 mm) Micron/Aptina CMOS MT9P031 with microlens • Electronic rolling shutter (ERS) • Global reset release shutter (GRR)
Effective chip size	5.7 mm x 4.3 mm
Cell size	2.2 µm x 2.2 µm
Lens mount	Adjustable C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) maximum protrusion: 10.1 mm (see Figure 23: Guppy PRO C-Mount dimensions on page 56) **Note** **Maximum protrusion** means the distance from lens flange to the glass filter in the camera.
Picture size (max.)	2588 x 1940 pixels (Format_7 Mode_0)
ADC	12 bit
Color modes	**Only color:** Raw8, Raw12, Raw16, Mono8/12/16 (all F7 modes), YUV411 (all F7 modes), YUV422 (all F7 modes)
Frame rates	1.875 fps; 3.75 fps; 7.5 fps; 15 fps; 30 fps; 60 fps; 120 fps variable frame rates in Format_7 up to 13 fps at full resolution (up to ~ 830 fps at 64x64)
Gain control	Manual: 0-18 dB (average 0.53 dB/step); auto gain (select. AOI)
Shutter speed	20 µs … ~ 22.37 s
External trigger shutter	Edge mode, programmable trigger delay
Look-up tables	User programmable (12 bit → 10 bit); default gamma (0.45)
Smart functions	AGC (auto gain control), AEC (auto exposure control), autofunction AOI, LUT, mirror, binning, low-noise binning mode, sub-sampling, defect pixel correction, color correction, hue, saturation, 1 storable user set **only color:** AWB (auto white balance)
I/Os	One configurable input (optocoupled), three configurable outputs (optocoupled)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s, 800 Mbit/s
Digital interface	IEEE 1394b (IIDC V1.31), 1 x copper connector
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 8-pin HIROSE

Table 17: Specification Guppy PRO F-503B/C

Feature	Specification
Power consumption	Typical <3.5 watt (@ 12 V DC) (full resolution and maximal frame rates)
Dimensions	44.8 mm x 29 mm x 29 mm (L x W x H); incl. connectors, without tripod and lens
Mass	75 g (without lens) + 5 g filter ring
Operating temperature	+ 5 °C ... + 45 °C ambient temperature (non-condensing)
Storage temperature	- 10 °C ... + 70 °C ambient temperature (non-condensing)
Regulations	FCC Class B, CE, RoHS (2002/95/EC)
Standard accessories	**b/w:** protection glass **color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, power out 6 W (HIROSE)
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 17: Specification Guppy PRO F-503B/C

Note

The design and specifications for the products described above may change without notice.

Spectral sensitivity

Note

All measurements were done without protection glass / without filter.

The uncertainty in measurement of the QE values is ±10%. (QE = Quantum Efficiency)

This is due to:

- Manufacturing tolerance of the sensor
- Uncertainties in the measuring apparatus itself (Ulbricht-Kugel/Ulbricht sphere, optometer, etc.)

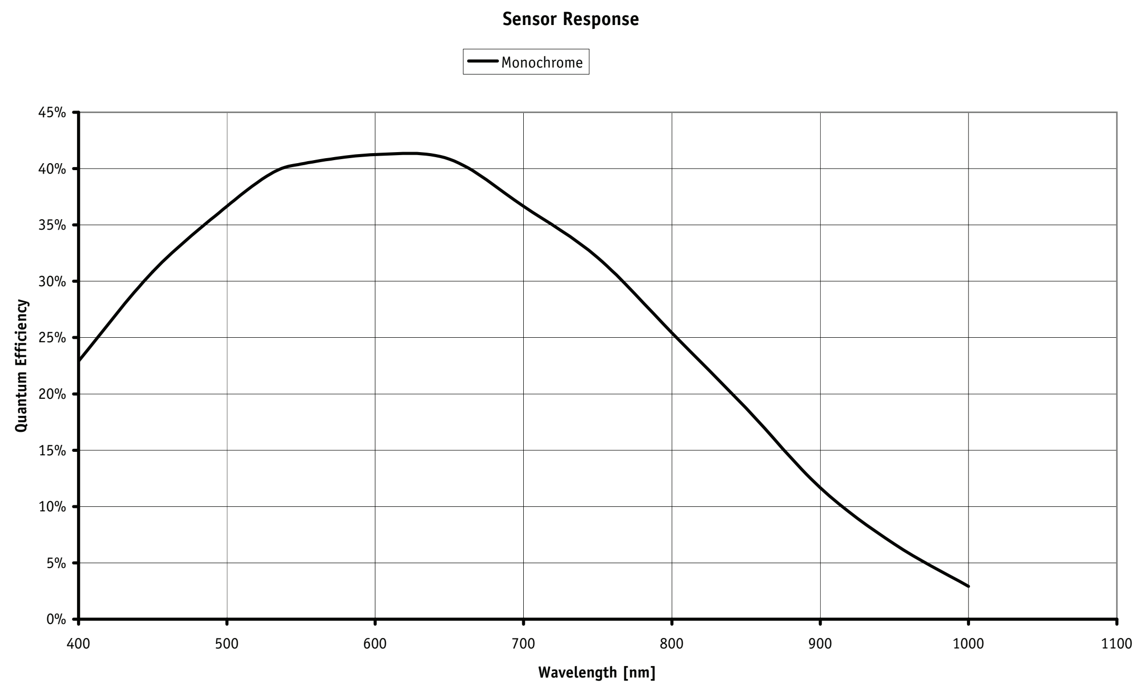


Figure 9: Spectral sensitivity of Guppy PRO F-031B

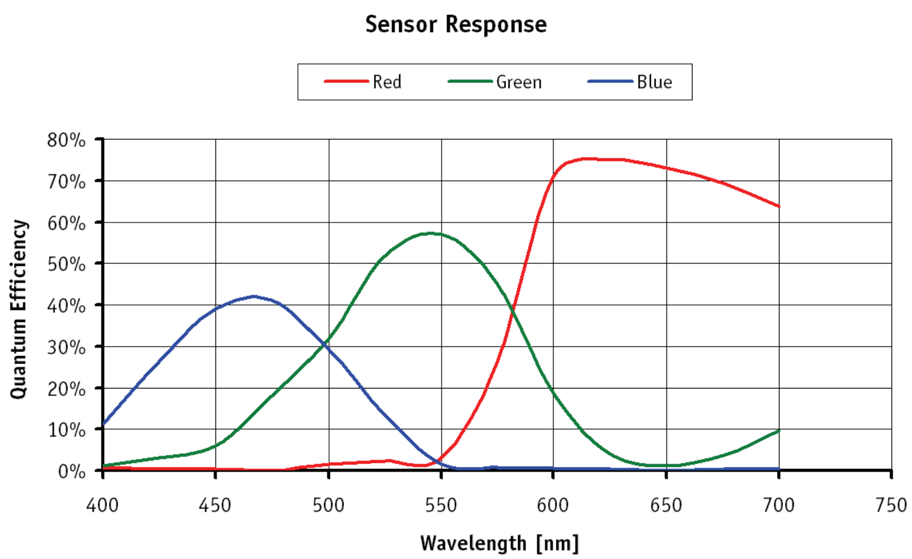


Figure 10: Spectral sensitivity of Guppy PRO F-031C (without IR cut filter)

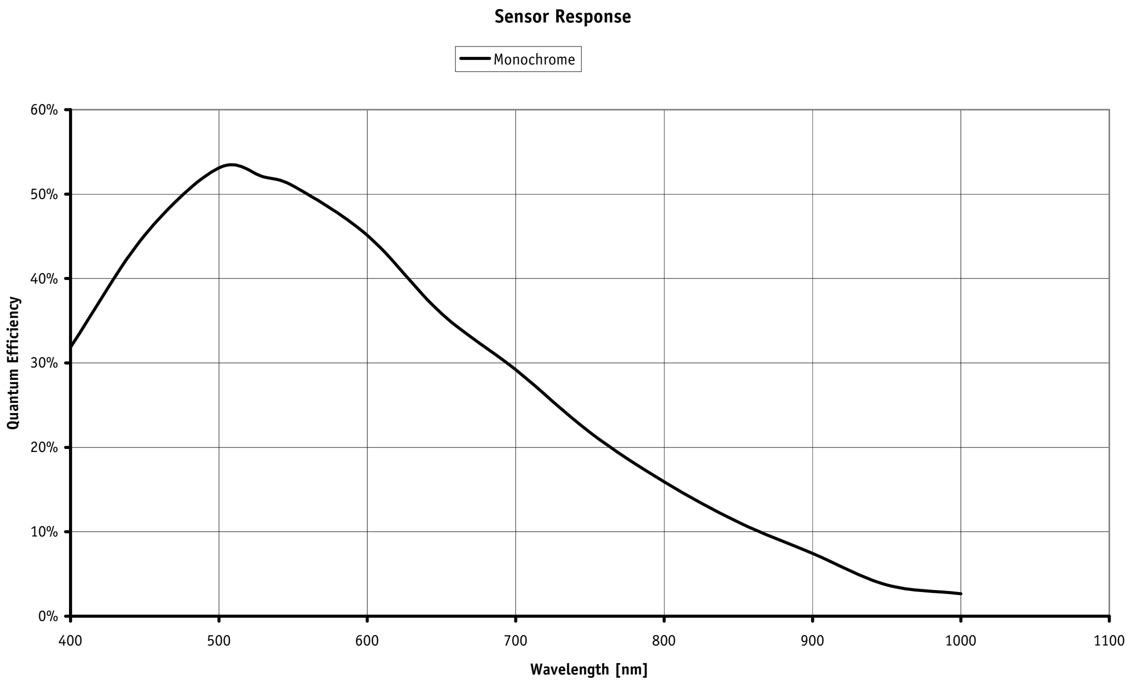


Figure 11: Spectral sensitivity of Guppy PRO F-032B

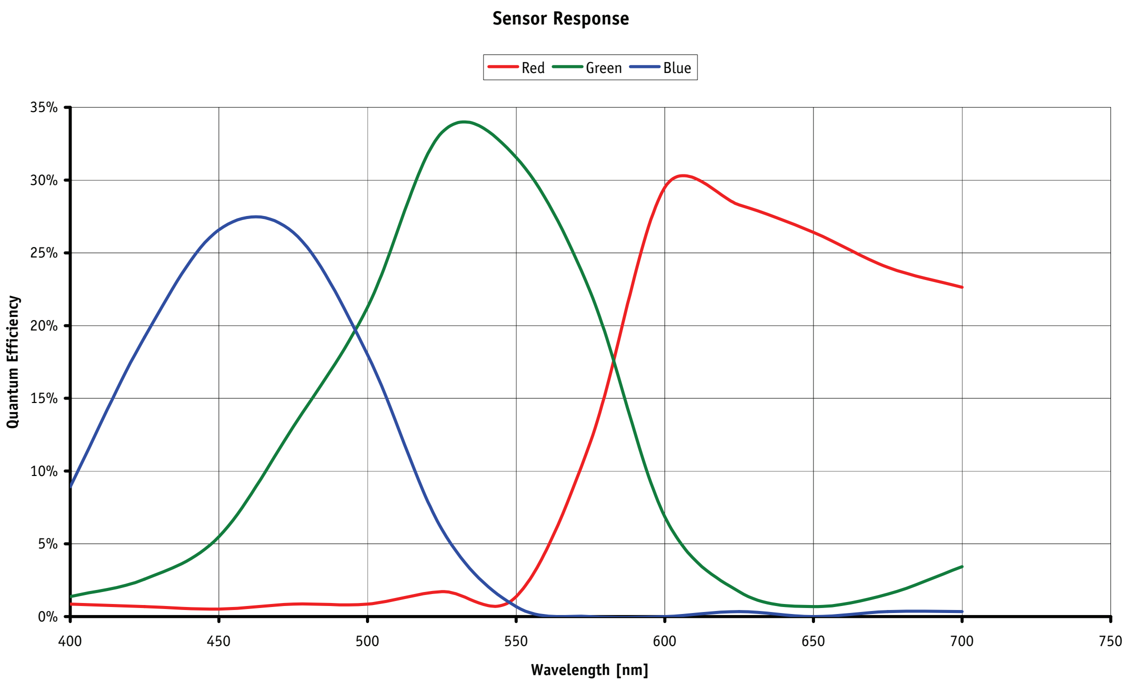


Figure 12: Spectral sensitivity of Guppy PRO F-032C (without IR cut filter)

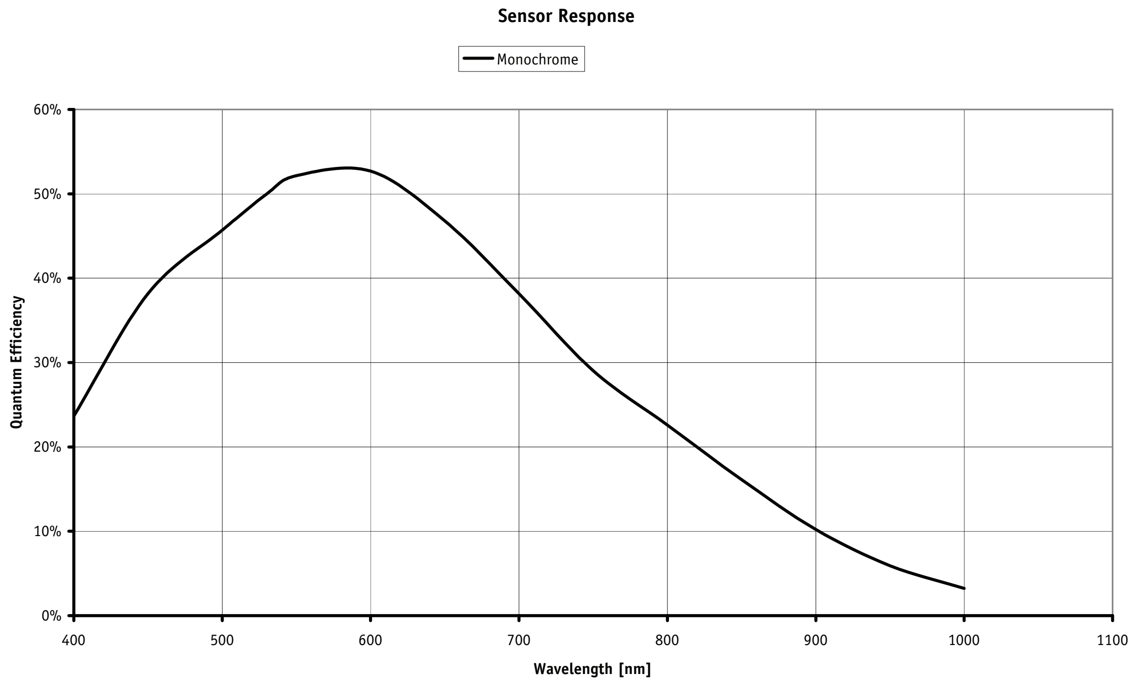


Figure 13: Spectral sensitivity of Guppy PRO F-125B

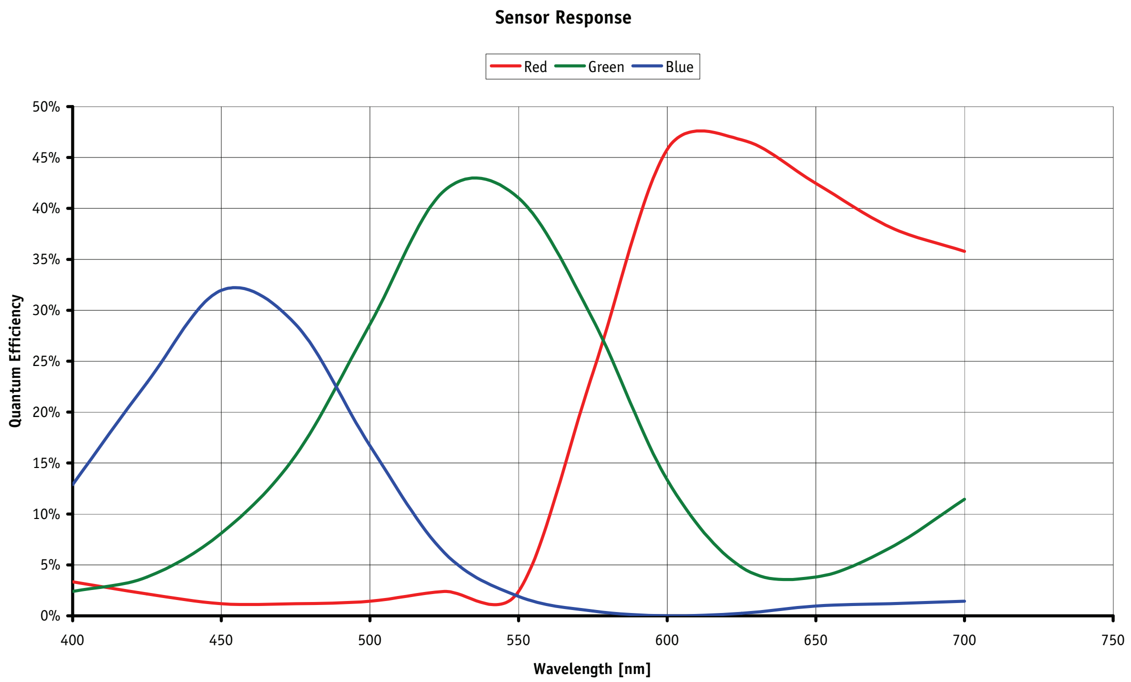


Figure 14: Spectral sensitivity of Guppy PRO F-125C (without IR cut filter)

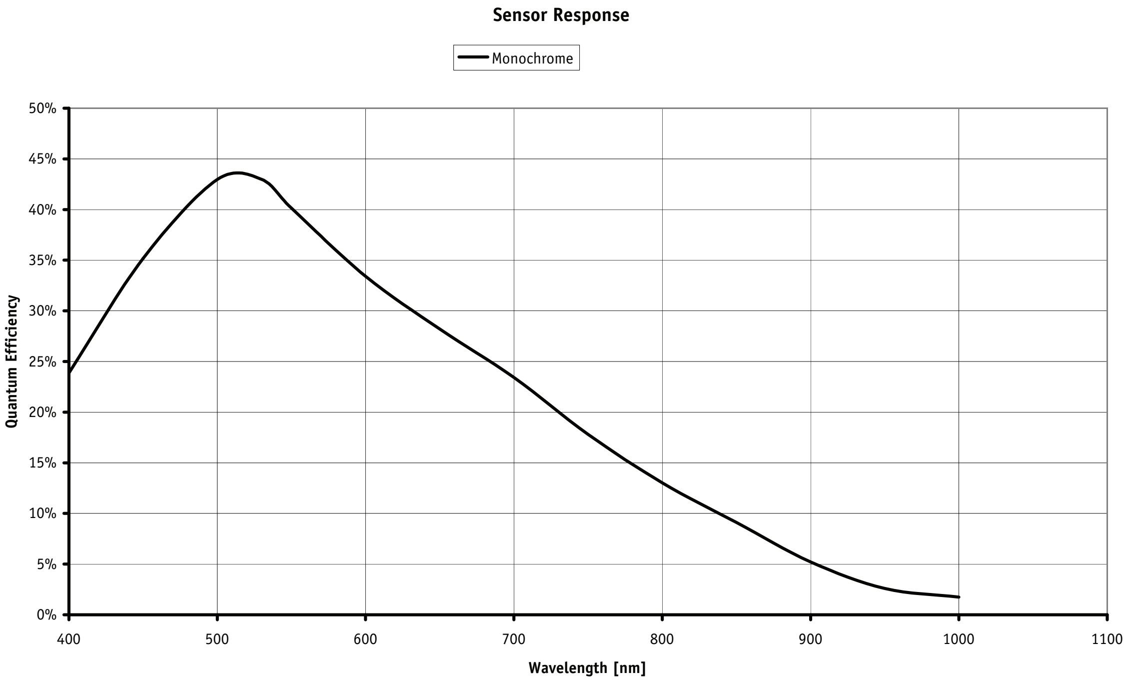


Figure 15: Spectral sensitivity of Guppy PRO F-146B

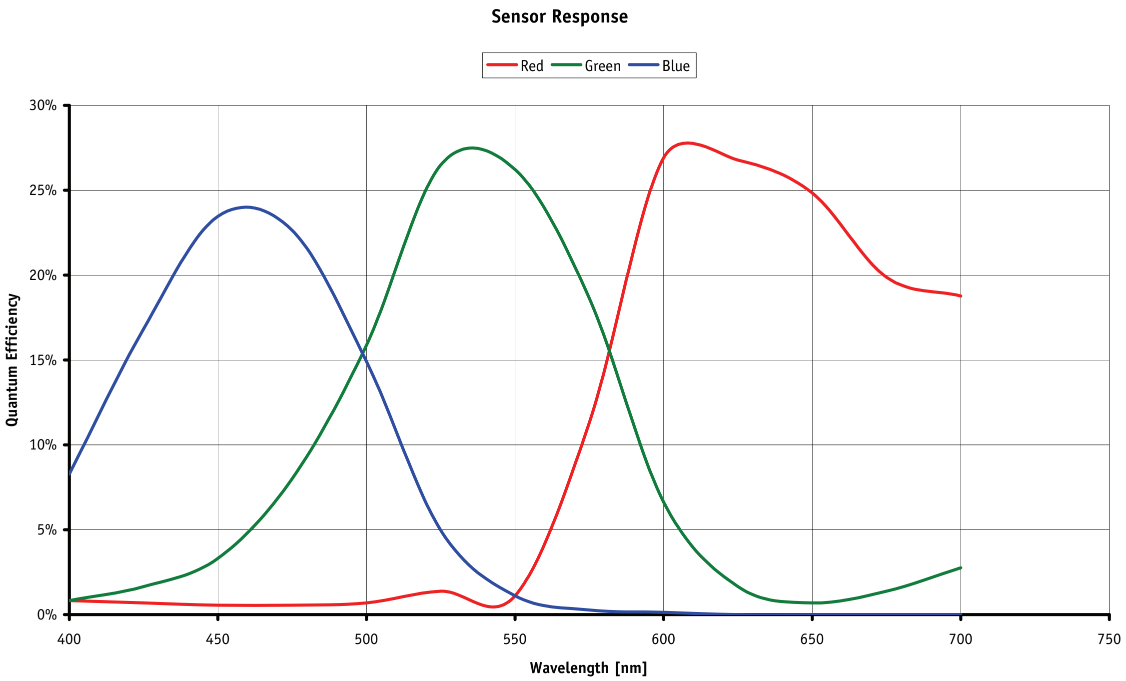


Figure 16: Spectral sensitivity of Guppy PRO F-146C (without IR cut filter)

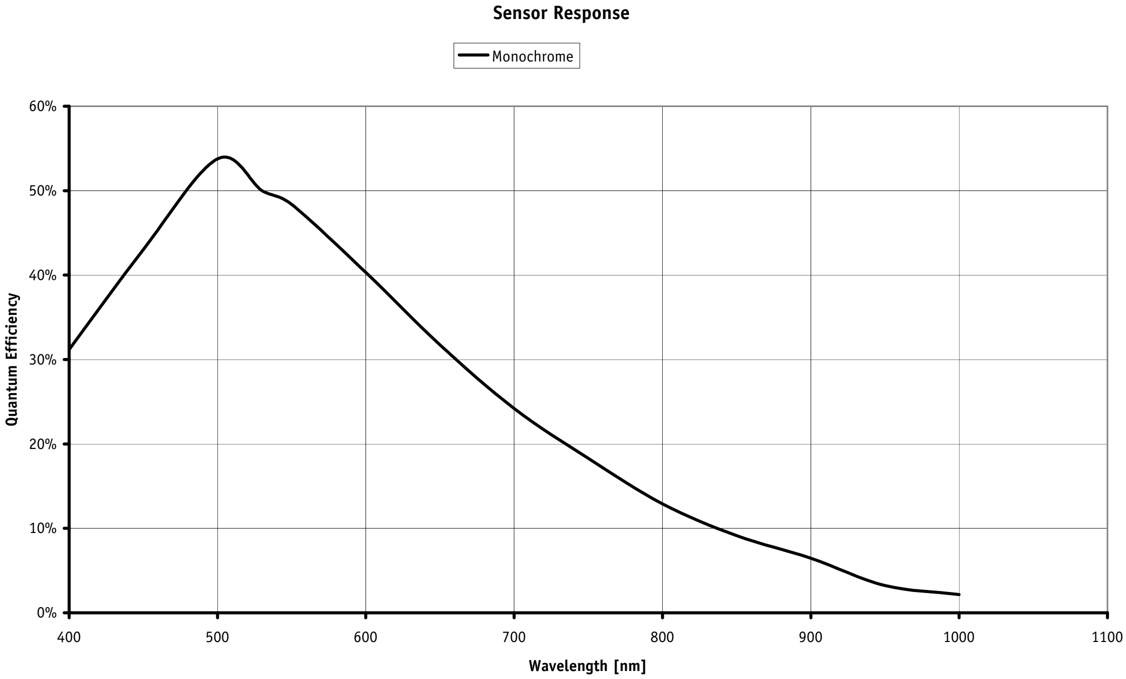


Figure 17: Spectral sensitivity of Guppy PRO F-201B

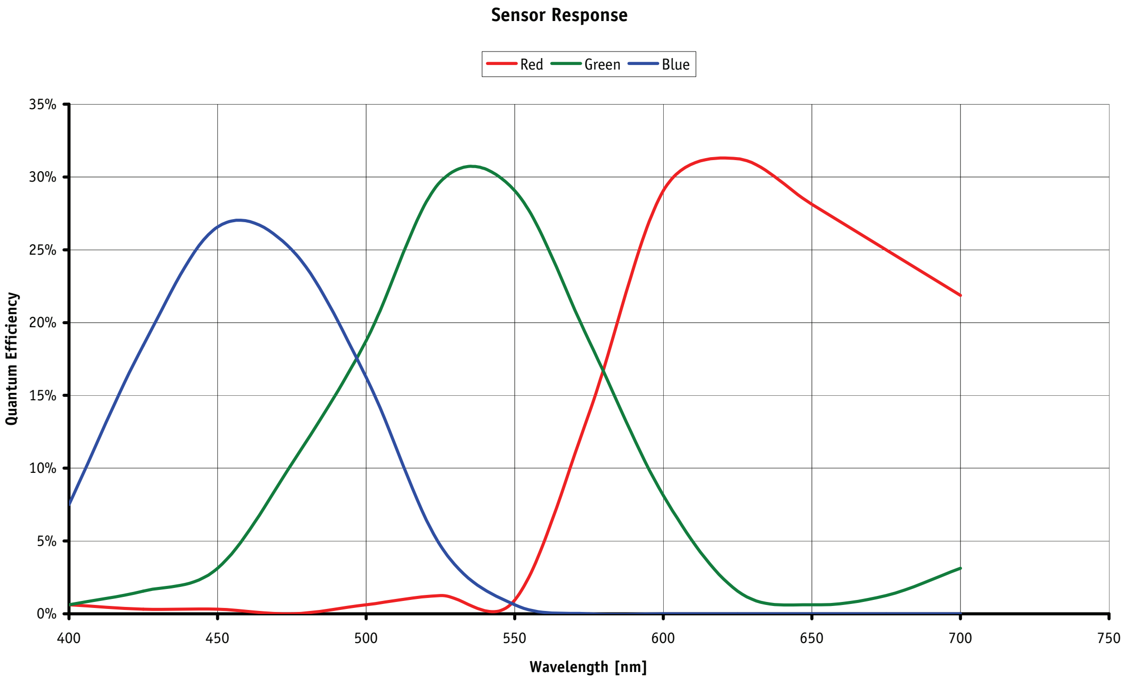


Figure 18: Spectral sensitivity of Guppy PRO F-201C (without IR cut filter)

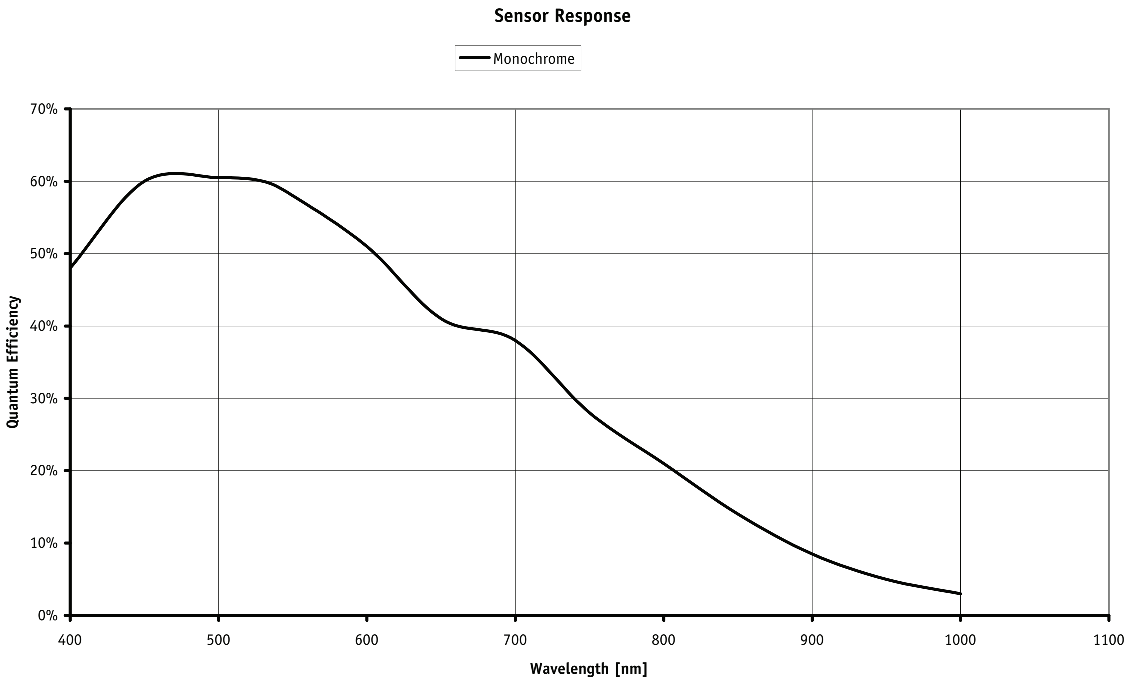


Figure 19: Spectral sensitivity of Guppy PRO F-503B

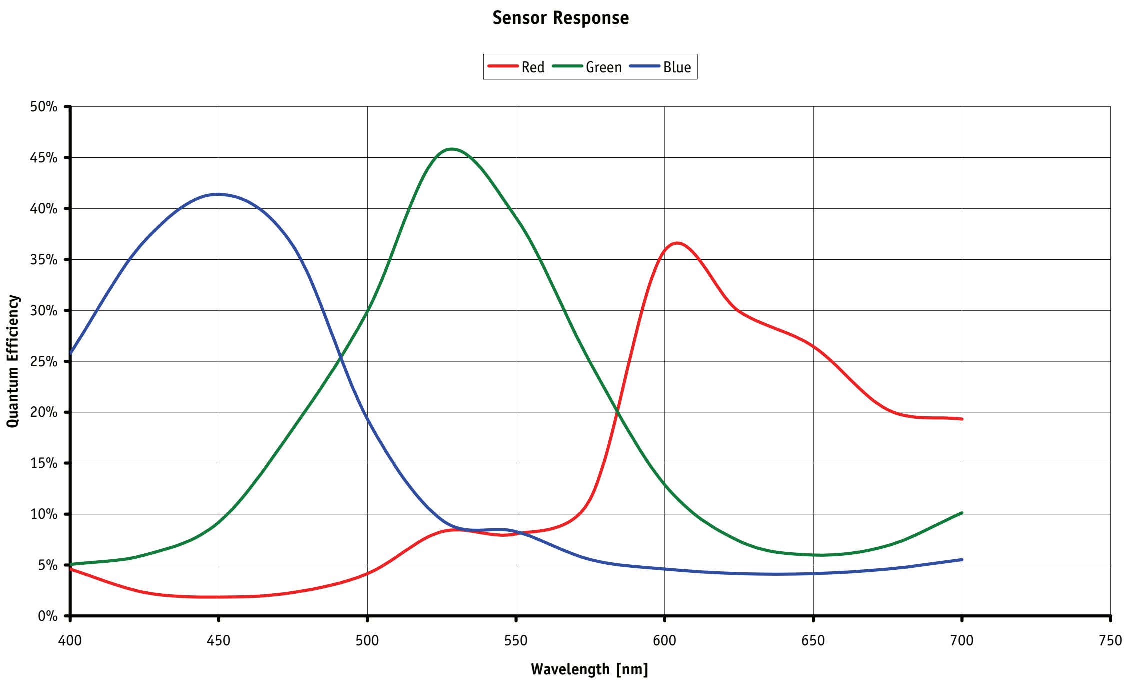


Figure 20: Spectral sensitivity of Guppy PRO F-503C (without IR cut filter)

Camera dimensions

Note

For information on **sensor position accuracy:**

(sensor shift x/y, optical back focal length z and sensor rotation α) see Chapter Sensor position accuracy of AVT Guppy PRO cameras on page 251.

Guppy PRO standard housing (1 x 1394b copper)

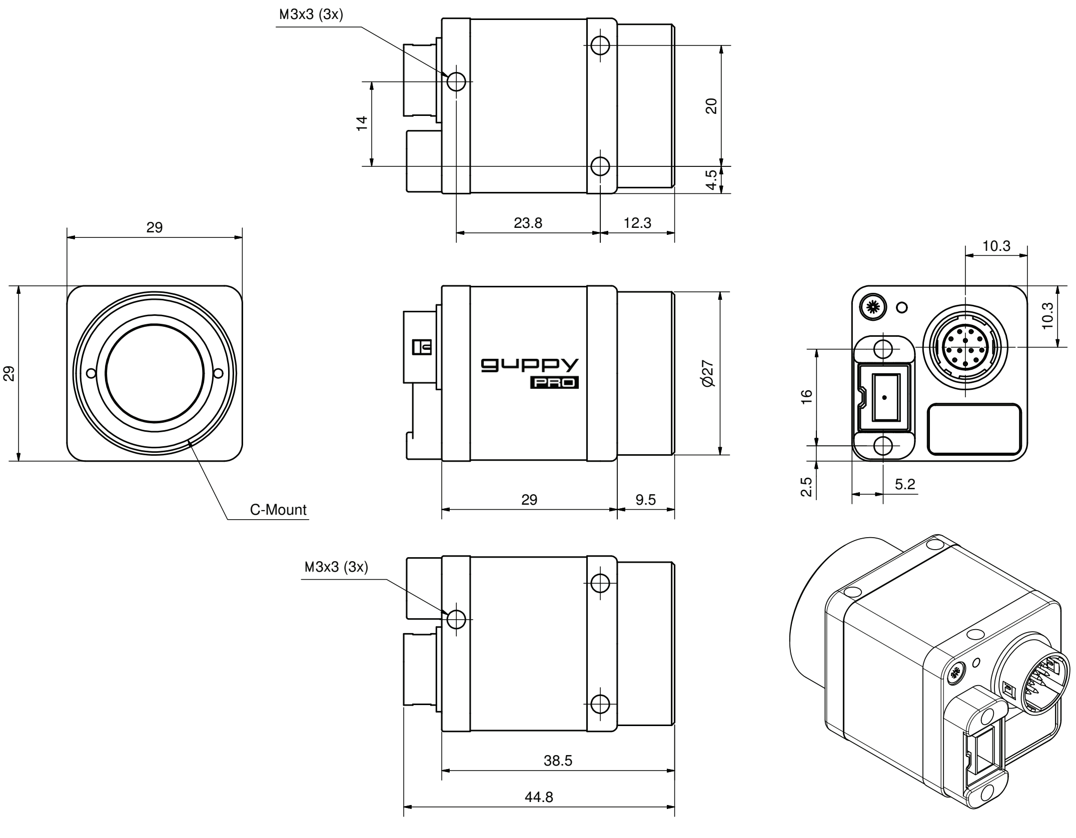
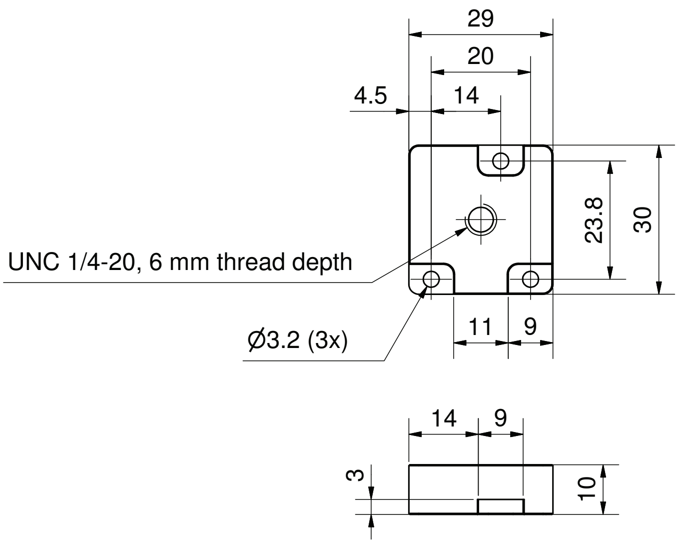


Figure 21: Camera dimensions (1 x 1394b copper)

Tripod adapter

This three hole tripod adapter (AVT order number 1216) ...

- ... can be used for Guppy PRO only.
- ... is only designed for standard housings.



Body size: 29 mm x 30 mm x 10 mm (L x W x H)

Figure 22: Tripod dimensions

Cross section: C-Mount

- All **monochrome** Guppy PRO cameras are equipped with the same model of protection glass.
- All **color** Guppy PRO cameras are equipped with the same model of IR cut filter.

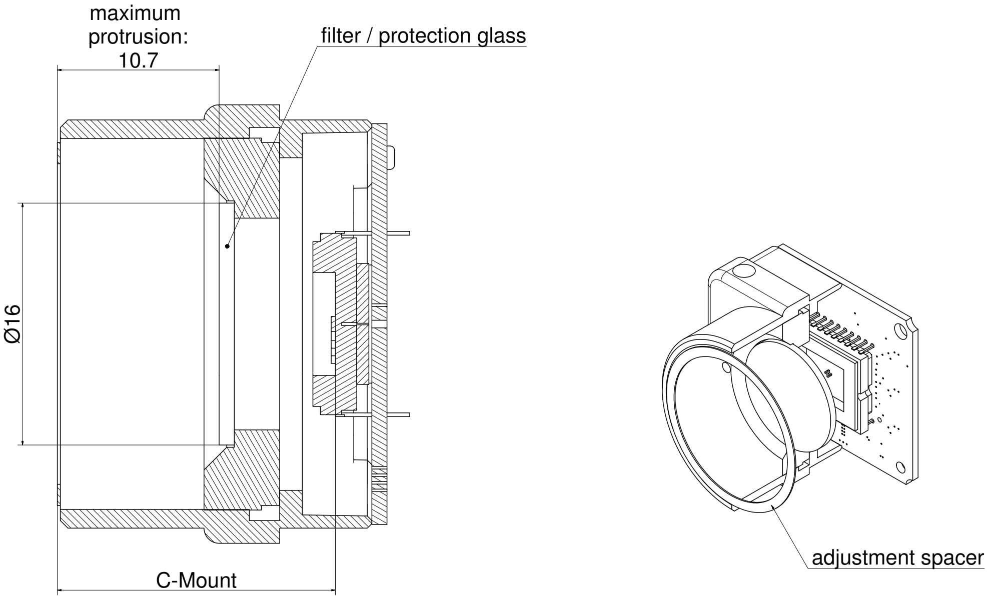


Figure 23: Guppy PRO C-Mount dimensions

Note

Adjustment is only done (via adjustment spacer between lens and front flange), if the customer needs accuracy below 100 µm.

For more information read Chapter Adjustment of C-Mount on page 57.

Adjustment of C-Mount

The dimensional adjustment cannot be done any more by the customer. All adjustments have to be done by the AVT factory.

Adjustment is only done (via adjustment spacer between lens and front flange), if the customer needs accuracy below 100 µm.

If you need any adjustments, please contact Customer Care: For phone numbers and e-mail: See Chapter Contacting Allied Vision Technologies on page 9.

Note

For all customers who know the C-Mount adjustment procedure from Pike and Oscar cameras:

The front flange of Guppy PRO cameras is a fixed part of the camera (and cannot be screwed).

As mentioned above: **adjustment** of C-Mount with **Guppy PRO** cameras **can only be done by the AVT factory.**

Camera interfaces

This chapter gives you detailed information on status LEDs, inputs and outputs, trigger features and transmission of data packets.

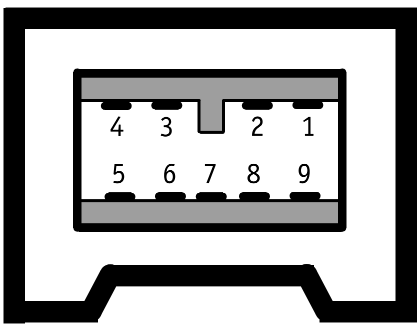
Note

For a detailed description of the **camera interfaces (FireWire, I/O connector), and operating instructions** see the **Hardware Installation Guide,** Chapter ***Camera interfaces***.

Read all **Notes** and **Cautions** in the **Hardware Installation Guide**, before using any interfaces.

IEEE 1394b port pin assignment

The IEEE 1394b connector is designed for industrial use and has the following pin assignment as per specification:



Pin	Signal
1	TPB-
2	TPB+
3	TPA-
4	TPA+
5	TPA (Reference ground)
6	VG (GND)
7	N.C.
8	VP (Power, VCC)
9	TPB (Reference ground)

Figure 24: IEEE 1394b connector

Note

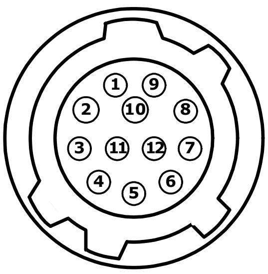
- Both IEEE 1394b connectors with **screw lock** mechanism provide access to the IEEE 1394 bus and thus makes it possible to control the camera and output frames. Connect the camera by using either of the connectors. The other connector can be used to daisy chain a second camera.
- Cables with latching connectors on one or both sides can be used.

www

For **more information on cables** and on **ordering cables online** (by clicking the article and sending an inquiry) go to:

http://www.alliedvisiontec.com/emea/products/accessories/firewire-accessories.html

Camera I/O connector pin assignment



Pin	Signal	Direction	Level	Description
1	External GND		GND for ext. power	External Ground for external power
2	External Power		+8...+36 V DC	Power supply
3	---	---	---	---
4	Camera In 1	In	U_{in}(high) = 3 V...24 V U_{in}(low) = 0 V...1.5 V	Camera Input 1 (GPIn1) default: Trigger
5	Camera Out 3	Out	Open emitter,	Camera Output 3 (GPOut3) default: Busy
6	Camera Out 1	Out	Open emitter	Camera Output 1 (GPOut1) default: IntEna
7	Camera In GND	In	Common GND for inputs	Camera Common Input Ground (In GND)
8	---	---	---	---
9	---	---	---	---
10	Camera Out Power	In	Common VCC for outputs max. 36 V DC	External Power for digital outputs (OutVCC)
11	---	---	---	---
12	Camera Out 2	Out	Open emitter	Camera Output 2 (GPOut2) default: Off

Figure 25: Camera I/O connector pin assignment

Note

GP = **G**eneral **P**urpose

For a detailed description of the **I/O connector and its operating instructions** see the **Hardware Installation Guide, Chapter *Guppy PRO input description***.

Read all **Notes** and **Cautions** in the **Hardware Installation Guide**, before using the I/O connector.

Status LEDs

Figure 26: Position of status LED (example showing green half of LED on)

There is one **bicolor** LED: showing green or orange (If half green and half red is on you see an orange color).

RED means: red half of LED permanent on

+RED pulsing means: red half of LED is switched on for a short time. If the red LED is already on, the LED will be switched off.

GREEN means: green half of LED permanent on

+GREEN pulsing means: green half of LED is switched on for a short time. If the green LED is already on, the LED will be switched off.

Normal conditions

Event	(GREEN)	(RED)
Camera startup	During startup all LEDs are switched on consecutively to show the startup progress: (GREEN + RED) long time then (GREEN + RED) short time then GREEN permanent on	
Power on	GREEN	
Bus reset	not available	
Asynchronous traffic	+GREEN pulsing	
Isochronous traffic	+GREEN pulsing	
Waiting for external trigger	GREEN	RED
External trigger event	GREEN	+RED pulsing

Table 18: LEDs showing normal conditions

Error conditions

Blink codes are used to signal warnings or error states (When S1 and S2 blink together, you see blinking orange):

- S1 means green half of LED
- S2 means red half of LED
- Example: LLC not ready ⇨ S1 (3 blinks) + S2 (5 blinks): 3 orange blinks and afterwards 2 red blinks

Error Code S1 → / Error Class S2 ↓	1 blink	2 blinks	3 blinks	4 blinks	5 blinks	6 blinks	7 blinks
1 blink	Video mode error	Format 7 error 1	Format 7 error 2				
2 blinks	Camera class object	Camera regconst object	Register mapping	Unknown FPGA type ID			
3 blinks	FLASH class object	Platform class object	Platform initialization	Platform firmware set	Platform LLC version		
4 blinks	FPGA boot S1 error	FPGA boot S2 error	FPGA boot S3 error	FPGA boot S4 error	FPGA boot S5 error		FPGA version not supported
5 blinks	Stack setup error	Stack start error	LLC not ready				
6 blinks							
7 blinks							
8 blinks	No valid firmware set available						

Table 19: Error codes

Video mode error: These are error modes according IIDC specification: Vmode_Error_Status register (wrong settings of video mode, format, frame rate and ISO settings).

Format 7 error: see Format 7 register description of IIDC specification.

Control and video data signals

The inputs and outputs of the camera can be configured by software. The different modes are described below.

Inputs

Note

For a general description of the **inputs** and **warnings** see the **Hardware Installation Guide,** Chapter **Guppy PRO input description.**

The optocoupler inverts all input signals. Inversion of the signal is controlled via the IO_INP_CTRL1..2 register (see Table 20: Advanced register: Input control on page 64).

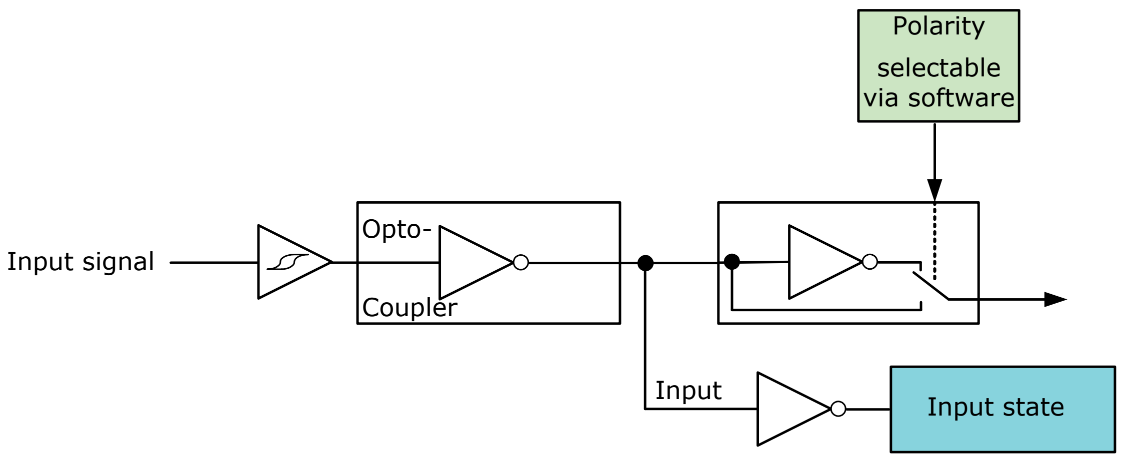


Figure 27: Input block diagram

Triggers

All inputs configured as triggers are linked by AND. If several inputs are being used as triggers, a high signal must be present on all inputs in order to generate a trigger signal. Each signal can be inverted. The camera must be set to **external triggering** to trigger image capture by the trigger signal.

Input/output pin control

All input and output signals running over the camera I/O connector are controlled by an advanced feature register.

Register	Name	Field	Bit	Description
0xF1000300	IO_INP_CTRL1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..6]	Reserved
		Polarity	[7]	0: Signal not inverted 1: Signal inverted
		---	[8..10]	Reserved
		InputMode	[11..15]	Mode see Table 21: Input routing on page 65
		---	[16..30]	Reserved
		PinState	[31]	RD: Current state of pin

Table 20: Advanced register: **Input control**

IO_INP_CTRL 1

The **Polarity** flag determines whether the input is low active (0) or high active (1). The **input mode** can be seen in the following table. The **PinState** flag is used to query the current status of the input.

The **PinState** bit reads the inverting optocoupler status after an internal negation. See Figure 27: Input block diagram on page 63.

This means that an open input sets the **PinState** bit to **0**. (This is different to AVT Marlin/Dolphin/Oscar, where an open input sets **PinState** bit to **1.**)

ID	Mode	Default
0x00	Off	
0x01	Reserved	
0x02	Trigger input	Input 1
0x03..0x1F	Reserved	

Table 21: Input routing

Note

If you set more than 1 input to function as a trigger input, all trigger inputs are ANDed.

Trigger delay

Guppy PRO cameras feature various ways to delay image capture based on external trigger.

With IIDC V1.31 there is a standard CSR at Register F0F00534/834h to control a delay up to FFFh x time base value.

The following table explains the inquiry register and the meaning of the various bits.

Register	Name	Field	Bit	Description
0xF0F00534	TRIGGER_DELAY_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		---	[2]	Reserved
		One_Push_Inq	[3]	One-push auto mode (controlled automatically by the camera once)
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto mode (controlled automatically by the camera)
		Manual_Inq	[7]	Manual mode (controlled by user)
		Min_Value	[8..19]	Minimum value for this feature
		Max_Value	[20..31]	Maximum value for this feature

Table 22: Trigger delay inquiry register

Register	Name	Field	Bit	Description
0xF0F00834	TRIGGER_DELAY	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR. If this bit=1 the value in the value field has to be ignored.
		---	[2..5]	Reserved
		ON_OFF	[6]	Write ON or OFF this feature Read: Status of the feature ON=1 OFF=0
		---	[7..19]	Reserved
		Value	[20..31]	Value

Table 23: Trigger Delay CSR

The cameras also have an advanced register which allows even more precise image capture delay after receiving a hardware trigger.

Trigger delay advanced register

Register	Name	Field	Bit	Description
0xF1000400	TRIGGER_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	Reserved
		DelayTime	[11..31]	Delay time in µs

Table 24: Trigger delay advanced CSR

The advanced register allows the start of the integration to be delayed by max. 2^{21} µs, which is max. 2.1 s after a trigger edge was detected.

Note

- Switching trigger delay to ON also switches external Trigger_Mode_0 to ON.
- This feature works with external Trigger_Mode_0 only.

Outputs

Note

For a general description of the **outputs** and **warnings** see the **Hardware Installation Guide**, Chapter **Guppy PRO output description.**

Output features are configured by software. Any signal can be placed on any output.

The main features of output signals are described below:

Signal	Description
IntEna (Integration Enable) signal	This signal displays the time in which exposure was made. By using a register this output can be delayed by up to 1.05 seconds.
Fval (Frame valid) signal	This feature signals readout from the sensor. This signal Fval follows IntEna.
Busy signal	This signal appears when: • the exposure is being made or • the sensor is being read out or • data transmission is active. The camera is busy.
PulseWidthMod (pulse-width modulation) signal	Each output has pulse-width modulation (PWM) capabilities, which can be used for motorized speed control or autofocus control. See Chapter Pulse-width modulation on page 73ff.
WaitingForTrigger signal	This signal is available and useful for the outputs in **Trigger Edge Mode**. (In level mode it is available but useless, because exposure time is unknown. (Signal always =0)) In edge mode it is useful to know if the camera can accept a new trigger (without overtriggering). See Table 27: Output routing on page 71 and Figure 29: Output impulse diagram on page 72

Table 25: Output signals

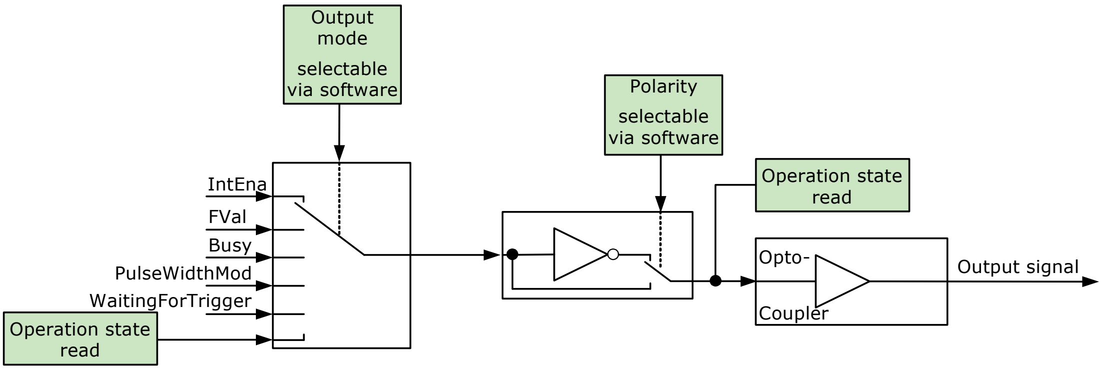


Figure 28: Output block diagram

IO_OUTP_CTRL 1-3

The outputs (Output mode, Polarity) are controlled via 3 advanced feature registers (see Table 26: Advanced register: Output control on page 70).

The **Polarity** field determines whether the output is inverted or not. The **output mode** can be viewed in the table below. The current status of the output can be queried and set via the **PinState**.

It is possible to read back the status of an output pin regardless of the output mode. This allows for example the host computer to determine if the camera is busy by simply polling the BUSY output.

Note

Outputs in **Direct** Mode:

For correct functionality the **Polarity should always be set to 0** (SmartView: Trig/IO tab, Invert=No).

Register	Name	Field	Bit	Description
0xF1000320	IO_OUTP_CTRL1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		PWMCapable	[1]	All Guppy PRO cameras: Indicates if an output pin supports the PWM feature. See Table 28: PWM configuration registers on page 73.
		---	[2..6]	Reserved
		Polarity	[7]	0: Signal not inverted 1: Signal inverted
		---	[8..10]	Reserved
		Output mode	[11..15]	Mode see Table 27: Output routing on page 71
		---	[16..30]	Reserved
		PinState	[31]	RD: Current state of pin WR: New state of pin
0xF1000324	IO_OUTP_CTRL2	Same as IO_OUTP_CTRL1		
0xF1000328	IO_OUTP_CTRL3	Same as IO_OUTP_CTRL1		

Table 26: Advanced register: **Output control**

Output modes

ID	Mode	Default / description
0x00	Off	
0x01	Output state follows **PinState** bit	Using this mode, the Polarity bit has to be set to 0 (not inverted). This is necessary for an error free display of the output status.
0x02	Integration enable	Output 1
0x03	Reserved	
0x04	Reserved	
0x05	Reserved	
0x06	FrameValid	
0x07	Busy	Output 2
0x08	Follow corresponding input (Inp1→ Out1, Inp2 → Out2)	
0x09	PWM (=pulse-width modulation)	Guppy PRO housing models
0x0A	**WaitingForTrigger**	Only in **Trigger Edge Mode**. All other Mode = 0 **WaitingForTrigger** is useful to know, if a new trigger will be accepted.
0x0B..0x1F	Reserved	

Table 27: Output routing

PinState 0 switches off the output transistor and produces a low level over the resistor connected from the output to ground.

The following diagram illustrates the dependencies of the various output signals.

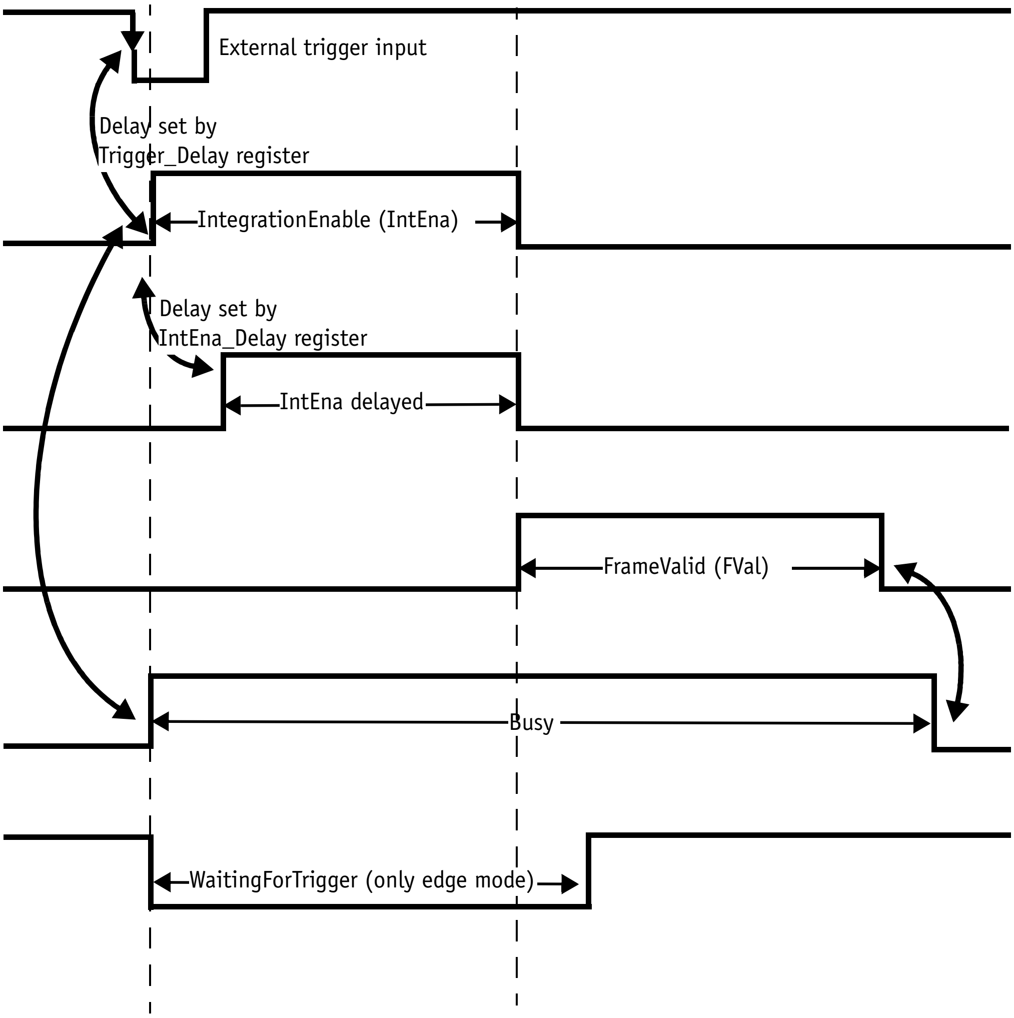


Figure 29: Output impulse diagram

Note

The signals can be inverted.

Caution

Firing a new trigger while **IntEna** is still active can result in **missing image.**

Note

- Note that **trigger delay** in fact delays the image capture whereas the **IntEna_Delay** only delays the leading edge of the IntEna output signal but does not delay the image capture.
- As mentioned before, it is possible to set the outputs by software. Doing so, the achievable maximum frequency is strongly dependent on individual software capabilities. As a rule of thumb, the camera itself will limit the toggle frequency to not more than 700 Hz.

Pulse-width modulation

The 2 inputs and 4 outputs are independent. Each output has pulse-width modulation (PWM) capabilities, which can be used (with additional external electronics) for motorized speed control or autofocus control.

Period (in µs) and pulse width (in µs) are adjustable via the following registers (see also examples in Chapter PWM: Examples in practice on page 75):

Register	Name	Field	Bit	Description
0xF1000800	IO_OUTP_PWM1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1]	Reserved
		---	[2..3]	Reserved
		MinPeriod	[4..19]	Minimum PWM period in µs (read only)
		---	[20..27]	Reserved
		---	[28..31]	Reserved
0xF1000804		PulseWidth	[0..15]	PWM pulse width in µs
		Period	[16..31]	PWM period in µs
0xF1000808	IO_OUTP_PWM2	Same as IO_OUTP_PWM1		
0xF100080C				
0xF1000810	IO_OUTP_PWM3	Same as IO_OUTP_PWM1		
0xF1000814				
0xF1000818	IO_OUTP_PWM4	Same as IO_OUTP_PWM1		
0xF100081C				

Table 28: PWM configuration registers

To enable the PWM feature select output mode 0x09. Control the signal state via the **PulseWidth** and **Period** fields (all times in microseconds (µs)).

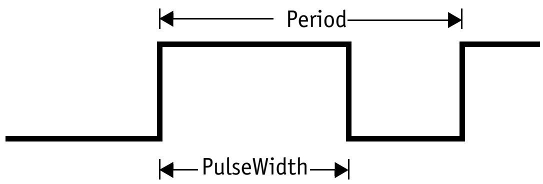


Figure 30: PulseWidth and Period definition

Note

Note the following conditions:

- PulseWidth < Period
- Period ≥ MinPeriod

PWM: minimal and maximal periods and frequencies

In the following formulas you find the minimal/maximal periods and frequencies for the pulse-width modulation (PWM).

$$period_{min} = 3\mu s$$

$$\Rightarrow \quad frequency_{max} = \frac{1}{period_{min}} = \frac{1}{3\mu s} = 333.33kHz$$

$$frequency_{min} = \frac{1}{2^{16} \times 10^{-6} s} = 15.26Hz$$

$$\Rightarrow \quad period_{max} = \frac{1}{frequency_{min}} = 2^{16}\mu s$$

Formula 1: Minimal/maximal period and frequency

PWM: Examples in practice

In this chapter we give you two examples, how to write values in the PWM registers. All values have to be written in microseconds (µs) in the PWM registers, therefore remember always the factor 10^{-6}s.

Example 1:

Set PWM with 1kHz at 30% pulse width.

$$\text{RegPeriod} = \frac{1}{\text{frequency} \times 10^{-6}\text{s}} = \frac{1}{1\text{kHz} \times 10^{-6}\text{s}} = 1000$$

$$\text{RegPulseWidth} = \text{RegPeriod} \times 30\% = 1000 \times 30\% = 300$$

Formula 2: PWM example 1

Example 2:

Set PWM with 250 Hz at 12% pulse width.

$$\text{RegPeriod} = \frac{1}{\text{frequency} \times 10^{-6}\text{s}} = \frac{1}{250\text{Hz} \times 10^{-6}\text{s}} = 4000$$

$$\text{RegPulseWidth} = \text{RegPeriod} \times 12\% = 4000 \times 12\% = 480$$

Formula 3: PWM example 2

Pixel data

Pixel data are transmitted as isochronous data packets in accordance with the 1394 interface described in IIDC V1.31. The first packet of a frame is identified by the **1** in the **sync bit** (sy) of the packet header.

sync bit

<table>
<tr><td>0-7</td><td>8-15</td><td colspan="2">16-23</td><td colspan="2">24-31</td></tr>
<tr><td colspan="2">data_length</td><td>tg</td><td>channel</td><td>tCode</td><td>sy</td></tr>
<tr><td colspan="6">header_CRC</td></tr>
<tr><td colspan="6">Video data payload</td></tr>
<tr><td colspan="6">data_CRC</td></tr>
</table>

Table 29: Isochronous data block packet format. Source: IIDC V1.31

<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td>data_length</td><td>Number of bytes in the data field</td></tr>
<tr><td>tg</td><td>Tag field
shall be set to zero</td></tr>
<tr><td>channel</td><td>Isochronous channel number, as programmed in the iso_channel field of the cam_sta_ctrl register</td></tr>
<tr><td>tCode</td><td>Transaction code
shall be set to the isochronous data block packet tCode</td></tr>
<tr><td>sy</td><td>Synchronization value (sync bit)
This is one single bit. It indicates the start of a new frame.
It shall be set to 0001h on the first isochronous data block of a frame, and shall be set to zero on all other isochronous blocks</td></tr>
<tr><td>Video data payload</td><td>Shall contain the digital video information</td></tr>
</table>

Table 30: Description of data block packet format

- The video data for each pixel are output in either 8-bit or 14-bit format (**Packed 12-Bit Mode:** 12-bit format).
- Each pixel has a range of 256 or 16384 (**Packed 12-Bit Mode**: 4096) shades of grey.
- The digital value 0 is black and 255 or 16383 (**Packed 12-Bit Mode**: 4095) is white. In 16-bit mode the data output is MSB aligned.

Description of video data formats

The following tables provide a description of the video data format for the different modes. (Source: IIDC V1.31; packed 12-bit mode: AVT)

<YUV8 (4:2:2) format>

Each component has 8-bit data.

<YUV8 (4:2:2) format>			
$U_{(K+0)}$	$Y_{(K+0)}$	$V_{(K+0)}$	$Y_{(K+1)}$
$U_{(K+2)}$	$Y_{(K+2)}$	$V_{(K+2)}$	$Y_{(K+3)}$
$U_{(K+4)}$	$Y_{(K+4)}$	$V_{(K+4)}$	$Y_{(K+5)}$
$U_{(K+Pn-6)}$	$Y_{(K+Pn-6)}$	$V_{(K+Pn-6)}$	$Y_{(K+Pn-5)}$
$U_{(K+Pn-4)}$	$Y_{(K+Pn-4)}$	$V_{(K+Pn-4)}$	$Y_{(K+Pn-3)}$
$U_{(K+Pn-2)}$	$Y_{(K+Pn-2)}$	$V_{(K+Pn-2)}$	$Y_{(K+Pn-1)}$

Table 31: YUV8 (4:2:2) format: Source: IIDC V1.31

<YUV8 (4:1:1 format)

Each component has 8-bit data.

<YUV8 (4:1:1) format>			
$U_{(K+0)}$	$Y_{(K+0)}$	$Y_{(K+1)}$	$V_{(K+0)}$
$Y_{(K+2)}$	$Y_{(K+3)}$	$U_{(K+4)}$	$Y_{(K+4)}$
$Y_{(K+5)}$	$V_{(K+4)}$	$Y_{(K+6)}$	$Y_{(K+7)}$
$U_{(K+Pn-8)}$	$Y_{(K+Pn-8)}$	$Y_{(K+Pn-7)}$	$V_{(K+Pn-8)}$
$Y_{(K+Pn-6)}$	$Y_{(K+Pn-5)}$	$U_{(K+Pn-4)}$	$Y_{(K+Pn-4)}$
$Y_{(K+Pn-3)}$	$V_{(K+Pn-4)}$	$Y_{(K+Pn-2)}$	$Y_{(K+Pn-1)}$

Table 32: YUV8 (4:1:1) format: Source: IIDC V1.31

<Y (Mono8/Raw8) format>

Y component has 8-bit data.

<Y (Mono8/Raw8) format>			
$Y_{(K+0)}$	$Y_{(K+1)}$	$Y_{(K+2)}$	$Y_{(K+3)}$
$Y_{(K+4)}$	$Y_{(K+5)}$	$Y_{(K+6)}$	$Y_{(K+7)}$
$Y_{(K+Pn-8)}$	$Y_{(K+Pn-7)}$	$Y_{(K+Pn-6)}$	$Y_{(K+Pn-5)}$
$Y_{(K+Pn-4)}$	$Y_{(K+Pn-3)}$	$Y_{(K+Pn-2)}$	$Y_{(K+Pn-1)}$

Table 33: Y (Mono8) format: Source: IIDC V1.31 / Y (Raw8) format: AVT

<Y (Mono16/Raw16) format>

Y component has 16-bit data.

<Y (Mono16) format>			
High byte	Low byte		
$Y_{(K+0)}$		$Y_{(K+1)}$	
$Y_{(K+2)}$		$Y_{(K+3)}$	
$Y_{(K+Pn-4)}$		$Y_{(K+Pn-3)}$	
$Y_{(K+Pn-2)}$		$Y_{(K+Pn-1)}$	

Table 34: Y (Mono16) format: Source: IIDC V1.31

<Y (Mono12/Raw12) format>

<Y (Mono12) format>			
$Y_{(K+0)}$ [11..4]	$Y_{(K+1)}$ [3..0] $Y_{(K+0)}$ [3..0]	$Y_{(K+1)}$ [11..4]	$Y_{(K+2)}$ [11..4]
$Y_{(K+3)}$ [3..0] $Y_{(K+2)}$ [3..0]	$Y_{(K+3)}$ [11..4]	$Y_{(K+4)}$ [11..4]	$Y_{(K+5)}$ [3..0] $Y_{(K+4)}$ [3..0]
$Y_{(K+5)}$ [11..4]	$Y_{(K+6)}$ [11..4]	$Y_{(K+7)}$ [3..0] $Y_{(K+6)}$ [3..0]	$Y_{(K+7)}$ [11..4]

Table 35: **Packed 12-Bit Mode** (mono and raw) Y12 format (AVT)

<Y(Mono8/Raw8), RGB8>

Each component (Y, R, G, B) has 8-bit data. The data type is *Unsigned Char*.

Y, R, G, B	Signal level (decimal)	Data (hexadecimal)
Highest	255	0xFF
	254	0xFE
	.	.
	.	.
	1	0x01
Lowest	0	0x00

Figure 31: Data structure of Mono8, RGB8; Source: IIDC V1.31 / Y(Mono8/Raw8) format: AVT

<YUV8>

Each component (Y, U, V) has 8-bit data. The Y component is the same as in the above table.

U, V	Signal level (decimal)	Data (hexadecimal)
Highest (+)	127	0xFF
	126	0xFE
	.	.
	.	.
	1	0x81
Lowest	0	0x80
	-1	0x7F
	-127	0x01
Highest (-)	-128	0x00

Figure 32: Data structure of YUV8; Source: IIDC V1.31

<Y(Mono16)>

Y component has 16-bit data. The data type is *Unsigned Short (big-endian)*.

Y	Signal level (decimal)	Data (hexadecimal)
Highest	65535	0xFFFF
	65534	0xFFFE
	.	.
	.	.
	1	0x0001
Lowest	0	0x0000

Figure 33: Data structure of Y(Mono16); Source: IIDC V1.31

<Y(Mono12)>

Y component has 12-bit data. The data type is *unsigned*.

Y	Signal level (decimal)	Data (hexadecimal)
Highest	4095	0x0FFF
	4094	0x0FFE
	.	.
	.	.
	1	0x0001
Lowest	0	0x0000

Table 36: Data structure of **Packed 12-Bit Mode** (mono and raw) (AVT)

Description of the data path

Block diagrams of the cameras

The following diagrams illustrate the data flow and the bit resolution of image data after being read from the CCD sensor chip in the camera. The individual blocks are described in more detail in the following paragraphs. For sensor data see Chapter Specifications on page 35.

Black and white cameras

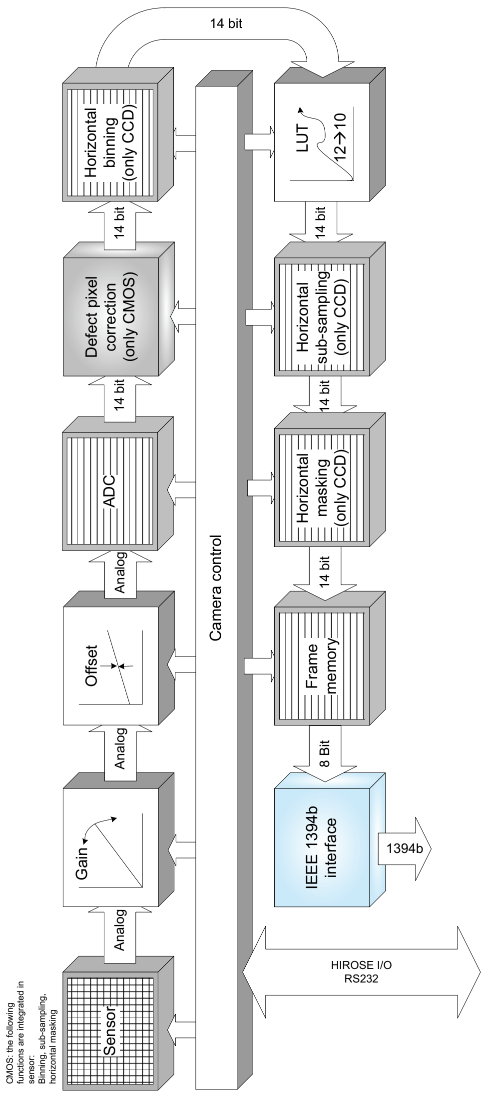


Figure 34: Block diagram b/w camera

Setting LUT = OFF effectively makes full use of the 14 bit by bypassing the LUT circuitry; setting LUT = ON means that the most significant 12 bit of the 14 bit are used and further down converted to 10 bit.

Color cameras

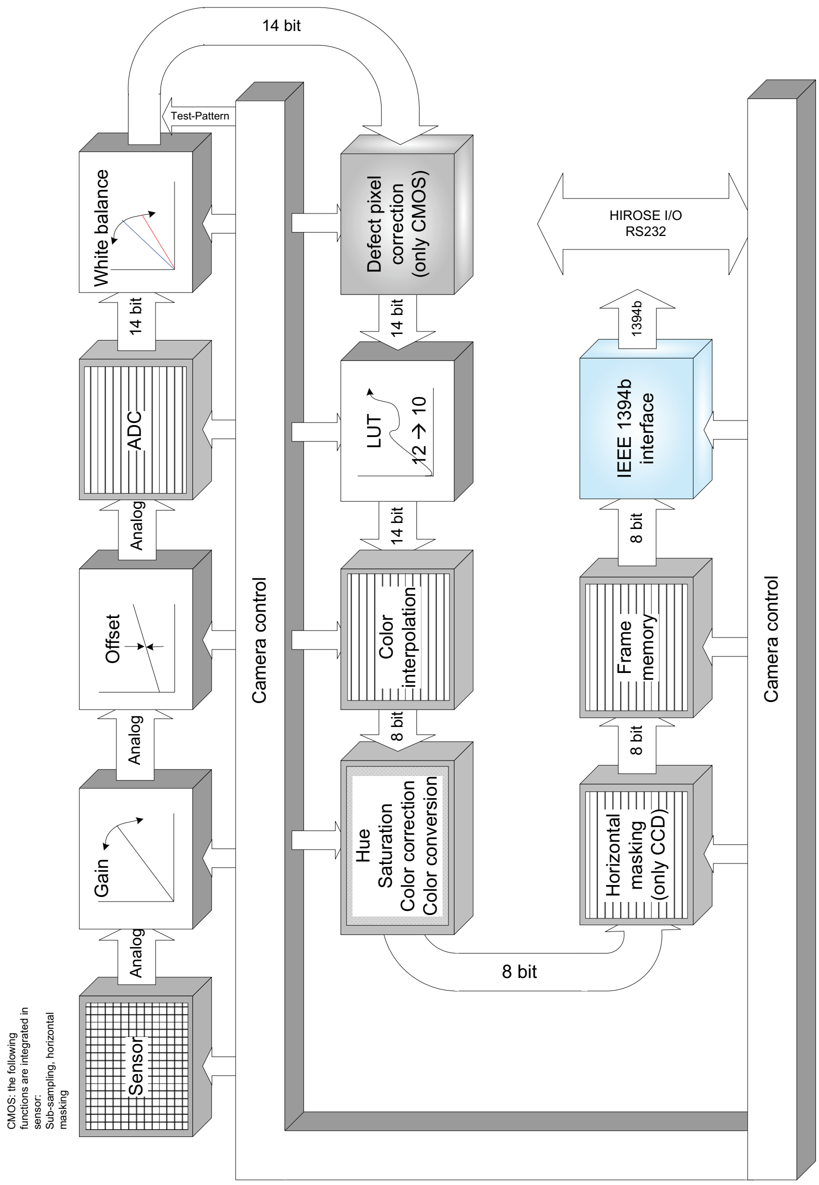


Figure 35: Block diagram color camera

Setting LUT = OFF effectively makes full use of the 14 bit by bypassing the LUT circuitry; setting LUT = ON means that the most significant 12 bit of the 14 bit are used and further down converted to 10 bit.

White balance

There are two types of white balance:

- **one-push white balance**: white balance is done only once (not continuously)
- **auto white balance** (AWB): continuously optimizes the color characteristics of the image

Guppy PRO color cameras have both **one-push white balance** and **auto white balance**.

White balance is applied so that non-colored image parts are displayed non-colored.

From the user's point, the white balance settings are made in register 80Ch of IIDC V1.31. This register is described in more detail below.

Register	Name	Field	Bit	Description
0xF0F0080C	WHITE_BALANCE	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the **Value** field 1: Control with value in the **Absolute** value CSR If this bit=1, the value in the **Value** field will be ignored.
		---	[2..4]	Reserved
		One_Push	[5]	Write 1: begin to work (self-cleared after operation) Read: 1: in operation 0: not in operation If A_M_Mode = 1, this bit will be ignored.
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current mode 0: MANUAL 1: AUTO
		U/B_Value	[8..19]	U/B value This field is ignored when writing the value in Auto or OFF mode. If readout capability is not available, reading this field has no meaning.
		V/R_Value	[20..31]	V/R value This field is ignored when writing the value in Auto or OFF mode. If readout capability is not available, reading this field has no meaning.

Table 37: White balance register

The values in the **U/B_Value** field produce changes from green to blue; the **V/R_Value** field from green to red as illustrated below.

Note

While lowering both U/B and V/R registers from 284 towards 0, the lower one of the two effectively controls the green gain.

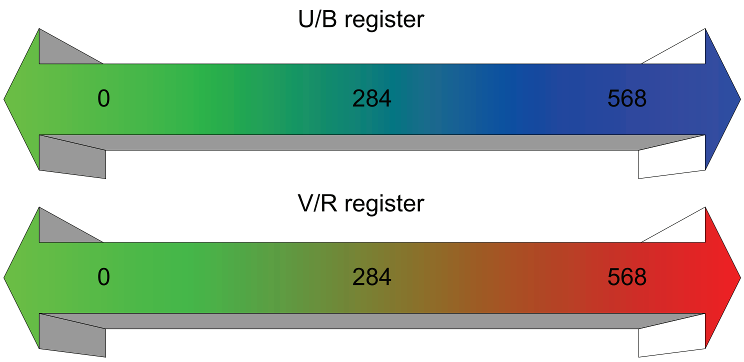


Figure 36: U/V slider range

Type	Range	Range in dB
Guppy PRO color cameras	0 ... 568	± 10 dB

Table 38: U/V slider range of the various Guppy PRO types

The increment length is ~0.0353 dB/step.

One-push white balance

Note

Configuration

To configure this feature in control and status register (CSR): See Table 37: White balance register on page 85.

The camera automatically generates frames, based on the current settings of all registers (GAIN, OFFSET, SHUTTER, etc.).

For white balance, in total **9** frames are processed. For the white balance algorithm the whole image or a subset of it is used. The R-G-B component values of the samples are added and are used as actual values for the **one-push white balance**.

This feature uses the assumption that the R-G-B component sums of the samples shall be equal; i.e., it assumes that the average of the sampled grid pixels is to be monochrome.

Note

The following ancillary conditions should be observed for successful white balance:

- There are no stringent or special requirements on the image content, it requires only the presence of monochrome pixels in the image.

If the image capture is active (e.g. **IsoEnable** set in register 614h), the frames used by the camera for white balance are also output on the 1394 bus. Any previously active image capture is restarted after the completion of white balance.

The following flow diagram illustrates the **one-push white balance** sequence.

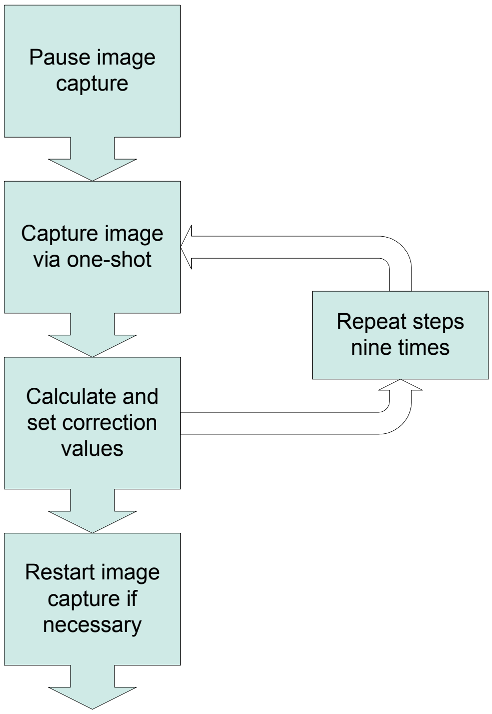


Figure 37: **One-push white balance** sequence

Finally, the calculated correction values can be read from the WHITE_BALANCE register 80Ch.

Auto white balance (AWB)

The **auto white balance** feature continuously optimizes the color characteristics of the image.

For the white balance algorithm the whole image or a subset of it is used.

Auto white balance can also be enabled by using an external trigger. However, if there is a pause of >10 seconds between capturing individual frames this process is aborted.

Note

The following ancillary conditions should be observed for successful white balance:

- There are no stringent or special requirements on the image content, it requires only the presence of equally weighted RGB pixels in the image.
- **Auto white balance** can be started both during active image capture and when the camera is in idle state.

Note

Configuration

To set position and size of the control area (Auto_Function_AOI) in an advanced register: see Table 124: Advanced register: Autofunction AOI on page 235.

AUTOFNC_AOI affects the auto shutter, auto gain and auto white balance features and is independent of the Format_7 AOI settings. If this feature is switched off the work area position and size will follow the current active image size.

Within this area, the R-G-B component values of the samples are added and used as actual values for the feedback.

The following drawing illustrates the AUTOFNC_AOI settings in greater detail.

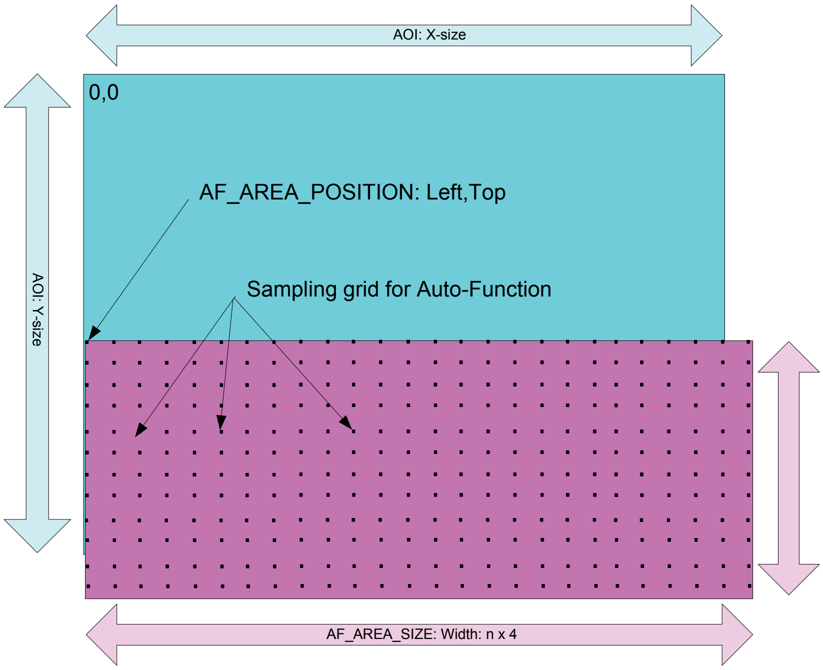


Figure 38: AUTOFNC_AOI positioning

The algorithm is based on the assumption that the R-G-B component sums of the samples are equal, i.e., it assumes that the mean of the sampled grid pixels is to be monochrome.

Auto shutter

In combination with auto white balance, Guppy PRO cameras are equipped with **auto shutter** feature.

When enabled, the auto shutter adjusts the shutter within the default shutter limits or within those set in advanced register F1000360h in order to reach the reference brightness set in auto exposure register.

Note

Target grey level parameter in **SmartView** corresponds to **Auto_exposure** register 0xF0F00804 (IIDC).

Increasing the auto exposure value increases the average brightness in the image and vice versa.

The applied algorithm uses a proportional plus integral controller (PI controller) to achieve minimum delay with zero overshot.

To configure this feature in control and status register (CSR):

Register	Name	Field	Bit	Description
0xF0F0081C	SHUTTER	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the **Value** field 1: Control with value in the **Absolute** value CSR If this bit=1, the value in the **Value** field will be ignored.
		---	[2..4]	Reserved
		One_Push	[5]	Write 1: begin to work (self-cleared after operation) Read: 1: in operation 0: not in operation If A_M_Mode = 1, this bit will be ignored.
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current mode 0: MANUAL 1: AUTO
		---	[8..19]	Reserved
		Value	[20..31]	Read/Write Value This field is ignored when writing the value in Auto or OFF mode. If readout capability is not available, reading this field has no meaning.

Table 39: CSR: **Shutter**

Note

Configuration

To configure this feature in an advanced register: See Table 122: Advanced register: Auto shutter control on page 233.

Auto gain

All Guppy PRO cameras are equipped with **auto gain** feature.

Note

Configuration

To configure this feature in an advanced register: See Table 123: Advanced register: Auto gain control on page 234.

When enabled auto gain adjusts the gain within the default gain limits or within the limits set in advanced register F1000370h in order to reach the brightness set in auto exposure register as reference.

Increasing the auto exposure value (aka **target grey value**) increases the average brightness in the image and vice versa.

The applied algorithm uses a proportional plus integral controller (PI controller) to achieve minimum delay with zero overshot.

The following tables show the gain and auto exposure CSR.

Register	Name	Field	Bit	Description
0xF0F00820	GAIN	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit=1 the value in the value field has to be ignored.
		---	[2..4]	Reserved
		One_Push	[5]	Write: Set bit high to start Read: Status of the feature: Bit high: WIP Bit low: Ready
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current mode 0: MANUAL 1: AUTO
		---	[8..19]	Reserved
		Value	[20..31]	Read/Write Value This field is ignored when writing the value in Auto or OFF mode. If readout capability is not available, reading this field has no meaning.

Table 40: CSR: **Gain**

Register	Name	Field	Bit	Description
0xF0F00804	AUTO_EXPOSURE	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit=1 the value in the value field has to be ignored.
		---	[2..4]	Reserved
		One_Push	[5]	Write: Set bit high to star Read: Status of the feature: Bit high: WIP Bit low: Ready
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current mode 0: MANUAL 1: AUTO
		---	[8..19]	Reserved
		Value	[20..31]	Read/Write Value This field is ignored when writing the value in Auto or OFF mode. If readout capability is not available, reading this field has no meaning.

Table 41: CSR: **Auto Exposure**

Note

Configuration

To configure this feature in an advanced register: See Table 123: Advanced register: Auto gain control on page 234.

Note

- Values can only be changed within the limits of gain CSR.
- Changes in auto exposure register only have an effect when auto gain is active.
- Auto exposure limits are 50..205. (**SmartView→Ctrl1 tab: Target grey level**)

Manual gain

Guppy PRO cameras are equipped with a gain setting, allowing the gain to be **manually** adjusted on the fly by means of a simple command register write.

The following ranges can be used when manually setting the gain for the analog video signal:

Type	Range	Range in dB	Increment length
Guppy PRO CCD cameras	0 … 680	0 … 24.4 dB	~0.0359 dB/step
Guppy PRO F-503 (CMOS camera)	8 … 32	0 … 12 dB	~0.5 dB/step
	33 … 48	12.56 … 18.06 dB	~0.56 dB/step

Table 42: Manual gain range of the various Guppy PRO types

Note

- Setting the gain does not change the offset (black value)
- A higher gain produces greater image noise. This reduces image quality. For this reason, try first to increase the brightness, using the aperture of the camera optics and/or longer shutter settings.

Brightness (black level or offset)

It is possible to set the black level in the camera within the following ranges:

0 … +16 grey values (@ 8 bit)

Increments are in 1/64 LSB (@ 8 bit)

Note

- Setting the gain does not change the offset (black value).

The IIDC register brightness at offset 800h is used for this purpose.

The following table shows the BRIGHTNESS register:

Register	Name	Field	Bit	Description
0xF0F00800	BRIGHTNESS	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		---	[2..4]	Reserved
		One_Push	[5]	Write: Set bit high to start Read: Status of the feature: Bit high: WIP Bit low: Ready
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current mode 0: MANUAL 1: AUTO
		---	[8..19]	Reserved
		Value	[20..31]	Read/Write Value; this field is ignored when writing the value in Auto or OFF mode; if readout capability is not available reading this field has no meaning.

Table 43: CSR: **Brightness**

Mirror function (only Guppy PRO F-503)

Guppy PRO F-503 cameras are equipped with a mirror function, which is built directly into the sensor. The mirror is centered to the current FOV center and can be combined with all image manipulation functions, like **binning**.

This function is especially useful when the camera is looking at objects with the help of a mirror or in certain microscopy applications.

- With Guppy PRO F-503B, **horizontal and vertical mirror** is possible.
- With Guppy PRO F-503C, only **horizontal mirror** is possible.

Note

Configuration

To configure this feature in an advanced register: See Table 127: Advanced register: Mirror on page 237.

Note

The use of the mirror function with color cameras and image output in RAW format has implications on the BAYER-ordering of the colors.

Mirror OFF: G-R-B-G (only F-503C)

Horizontal mirror ON: R-G-G-B (only F- 503C)

Figure 39: Mirror and Bayer order

Note

During switchover one image may be temporarily corrupted.

Look-up table (LUT) and gamma function

The AVT Guppy PRO camera provides **one** user-defined look-up table (LUT). The use of this LUT allows any function (in the form Output = F(Input)) to be stored in the camera's RAM and to be applied on the individual pixels of an image at run-time.

The address lines of the RAM are connected to the incoming digital data, these in turn point to the values of functions which are calculated offline, e.g. with a spreadsheet program.

This function needs to be loaded into the camera's RAM before use.

One example of using an LUT is the gamma LUT:

There is one gamma LUT (gamma= 0.45)

$\text{Output} = (\text{Input})^{0.45}$

or with normalized values:

$\text{Output}/1023 = (\text{Input}/4095)^{0.45}$

This gamma LUT is used with all Guppy PRO models.

Gamma is known as compensation for the nonlinear brightness response of many displays e.g. CRT monitors. The look-up table converts the incoming **12 bit** from the digitizer to outgoing **10 bit**.

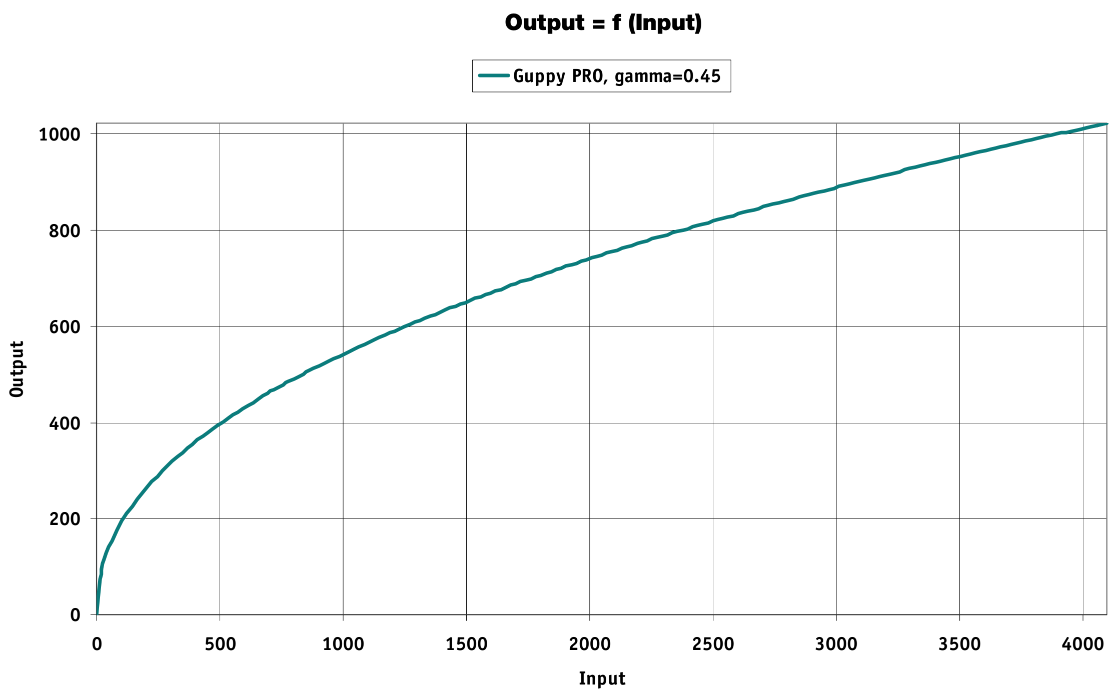


Figure 40: LUT with gamma= 0.45

Note

- The input value is the most significant **12-bit** value from the digitizer.
- Gamma 1 (gamma= 0.45) switches on the LUT. After overriding the LUT with a user defined content, gamma functionality is no longer available until the next full initialization of the camera.
- LUT content is volatile if you do not use the user profiles to save the LUT.

Loading an LUT into the camera

Loading the LUT is carried out through the data exchange buffer called GPDATA_BUFFER. As this buffer can hold a maximum of 2 kB, and a complete LUT at **4096 x 10 bit** is **5 kByte**, programming can not take place in a one block write step because the size of an LUT is larger than GPDATA_BUFFER. Therefore input must be handled in several steps. The flow diagram below shows the sequence required to load data into the camera.

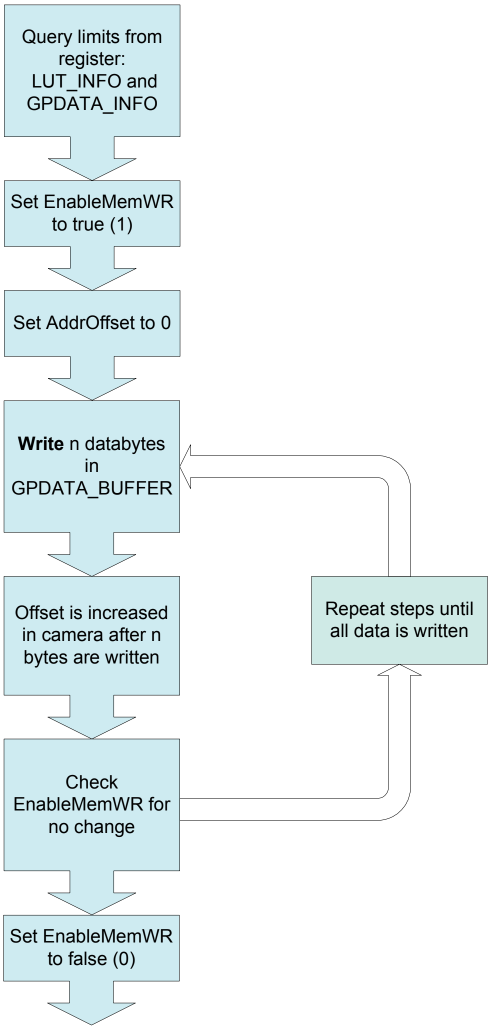


Figure 41: Loading an LUT

Note

Configuration

- To configure this feature in an advanced register: See *Table 119: Advanced register: LUT on page 227*.
- For information on GPDATA_BUFFER: See Chapter GPDATA_BUFFER on page 248.

Defect pixel correction (only Guppy PRO F-503B/C)

The mechanisms of defect pixel correction are explained in the following drawings. All examples are done in Format_7 Mode_0 (full resolution).

The first two examples are explained for b/w cameras, the third and fourth example are explained for color cameras.

The **X** marks a defect pixel.

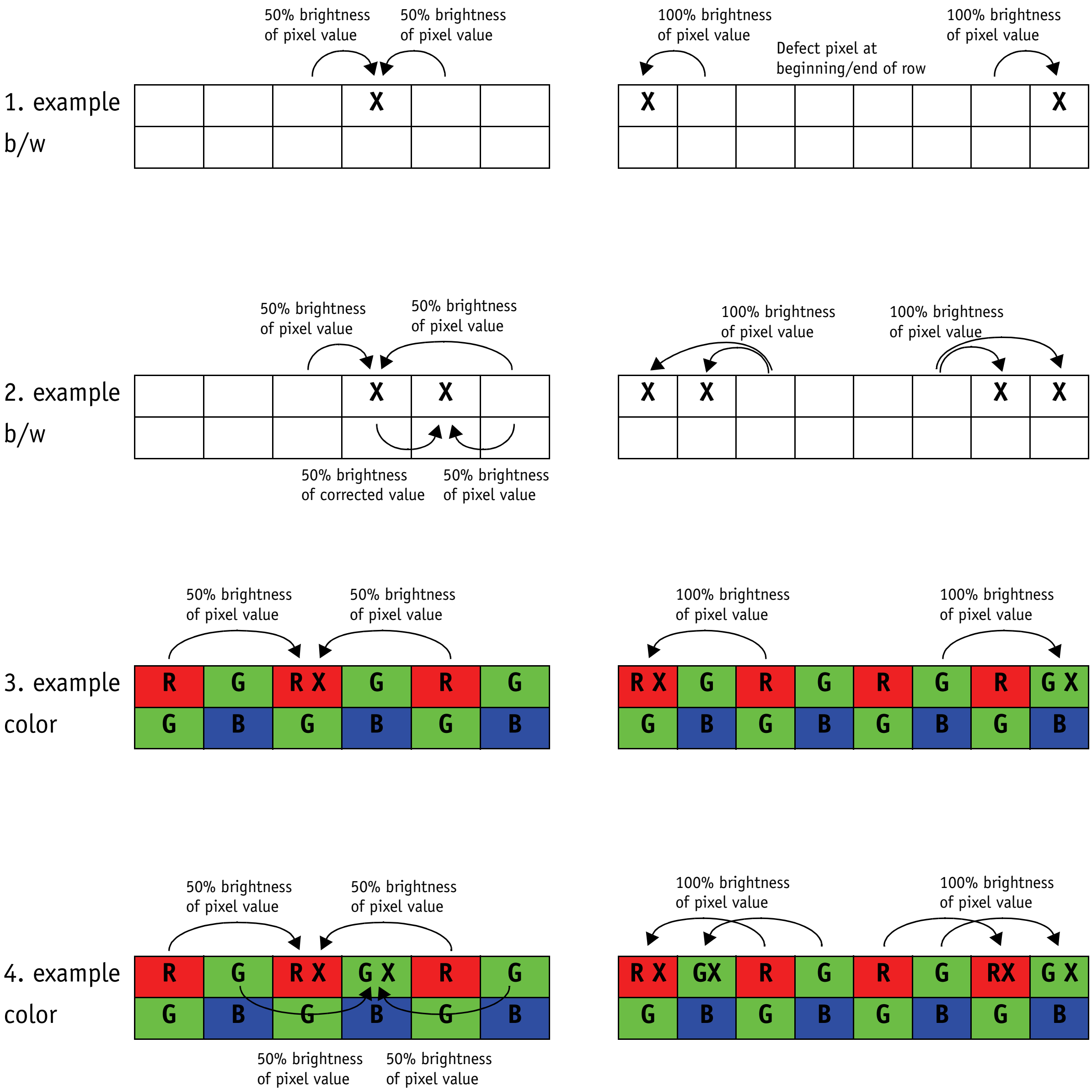


Figure 42: Mechanisms of defect pixel correction

Note

While building defect pixel correction data or uploading them from host, the defect pixel correction data are stored **volatile** in FPGA.

Optionally you can store the data in a **non-volatile** memory (Set MemSave to 1).

Note

Configuration

To configure this feature in an advanced register: See Table 120: Advanced register: Defect pixel correction on page 229.

Building defect pixel data

Note

- Defect pixel correction is **only possible in Mono8 modes for monochrome cameras** and **Raw8 modes for color cameras**.
- In all other modes you get an error message in advanced register 0xF1000298 bit [1] see Table 120: Advanced register: Defect pixel correction on page 229.
- Using Format_7 Mode_x: Defect pixel correction is done in **Format_7 Mode_x**.
- Using a fixed format (Format_0, Format_1 or Format_2): Defect pixel correction is done in **Format_7 Mode_0**.
- When using defect pixel correction with **binning** and **sub-sampling**: first switch to binning/sub-sampling mode and then apply defect pixel correction.

The following flow diagram illustrates the defect pixel correction:

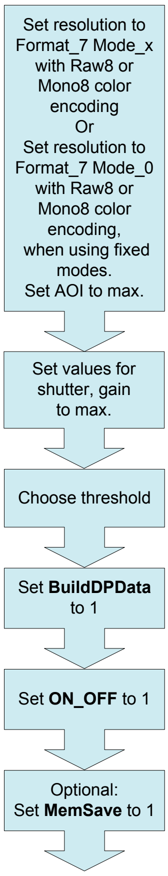


Figure 43: Defect pixel correction: build and store

To build defect pixel data perform the following steps:

Grab an image with defect pixel data

1. Take the camera, remove lens and put on lens cap.
2. Set image resolution to Format_7 Mode_x or Format_7 Mode_0 (when using fixed modes) with Raw8 or Mono8 color encoding, and set AOI to maximum.
3. Set values for shutter and gain to maximum.
4. Grab a single image (one-shot).

Calculate defect pixel coordinates

5. Accept default threshold from system or choose own threshold.

Note

A mean value is calculated over the entire image that was grabbed previously.

Definition: A defect pixel is every pixel value of this previously grabbed image that is:

- greater than (mean value + threshold)

or

- less than (mean value - threshold)

6. Set the **BuildDPData** flag to 1.

   In microcontroller the defect pixel calculation is started. The detected defect pixel coordinates are stored.

   Defect pixel coordinates are:

   – 16-bit y-coordinate and

   – 16-bit x-coordinate

   DPC data are organized like this:

31 … 16	15 … 0
y-coordinate	x-coordinate

   The calculated mean value is written in advanced register **Mean** field (0xF1000298 bit [18..24]).

   The number of defect pixels is written in advanced register **DPDataSize** (0xF100029C bit [4..17]). Due to 16-bit format: to get the number of defect pixels read out this value and divide through 4. For more information see Table 120: Advanced register: Defect pixel correction on page 229f.

Reset values (resolution, shutter, gain, brightness)

7. Take the camera, remove lens cap and thread the lens onto the camera.
8. Reset values for image resolution, shutter, gain and brightness (offset) to their previous values.

9. Grab a single image (one-shot).

Activate/deactivate defect pixel correction

Activate:

1. Set **ON_OFF** flag to **1**.

Deactivate:

1. Set **ON_OFF** flag to **0**.

Store defect pixel data non-volatile

1. Set the **MemSave** flag to **1**.

Load non-volatile stored defect pixel data

1. Set the **MemLoad** flag to 1.

   All non-volatile stored defect pixel coordinates are loaded.

Note

- Switch off camera and switch on again:
  ⇨ defect pixel data will get lost
- Initialize camera (start-up or soft reset):
  ⇨ non-volatile stored defect pixel data are loaded automatically

Send defect pixel data to the host

1. Set **EnaMemRD** flag to **1**.

   Defect pixel data is transferred from dual port RAM to host.
2. Read **DPDataSize**.

   This is the current defect pixel count from the camera.

Receive defect pixel data from the host

1. Set **EnaMemWR** flag to **1**.

Binning (only b/w cameras; F-503: also color cameras)

2 x binning (F-503 also 4 x)

Definition

Binning is the process of combining neighboring pixels while being read out from the sensor.

Note

- Binning does not change offset, brightness or black-level.

Binning is used primarily for 3 reasons:

- a reduction in the number of pixels and thus the amount of data while retaining the original image area angle
- an increase in the frame rate (CCD models: vertical binning only; CMOS models: also horizontal binning)
- a brighter image, also resulting in an improvement in the signal-to-noise ratio of the image

Signal-to-noise ratio (SNR) and **signal-to-noise separation** specify the quality of a signal with regard to its reproduction of intensities. The value signifies how high the ratio of noise is in regard to the maximum achievable signal intensity.

The higher this value, the better the signal quality. The unit of measurement used is generally known as the decibel (dB), a logarithmic power level. 6 dB is the signal level at approximately a factor of 2.

However, the advantages of increasing signal quality are accompanied by a reduction in resolution.

Only Format_7

Binning is possible only in video Format_7. The type of binning used depends on the video mode.

Types

In general, we distinguish between the following types of binning (H=horizontal, V=vertical):

- 2 x H-binning
- 2 x V-binning
- 4 x H-binning (only F-503)
- 4 x V-binning (only F-503)

and the full binning modes:

- 2 x full binning (a combination of 2 x H-binning and 2 x V-binning)
- 4 x full binning (a combination of 4 x H-binning and 4 x V-binning) (only F-503)

For Guppy F-503 there are also mixed modes via mode mapping available:

For example:

- 4 x H-binning 2 x V-binning (only F-503)
- 2 x H-binning 4 x V-binning (only F-503)

... and many other mixed modes. For more information see the mapping table of possible Format_7 modes (for F-503 only) on page 120.

Vertical binning

Light sensitivity

Vertical binning increases the light sensitivity of the camera by a factor of two (monochrome CCD models). Guppy PRO F-503B/C have only averaged binning (low-noise binning) without any increase in light sensitivity.

In the **CCD** sensors, this is done directly in the horizontal shift register of the monochrome sensor.

With the **CMOS** sensor of Guppy PRO F-503B/C, monochrome and color binning is possible. The monochrome CMOS sensor of Guppy PRO F-503B uses the same binning patterns as the color version.

Format_7 Mode_2

By default and without further remapping use **Format_7 Mode_2** for 2 x vertical binning.

This reduces vertical resolution, depending on the model.

Binning mode	CCD models (monochrome)	Guppy PRO F-503B/C
2 x vertical binning	2 pixel signals from 2 vertical **neighboring pixels** are combined and their signals are **added**.	2 pixel signals from 2 vertical **adjacent same-color pixels** are combined and their signals are always **averaged (low-noise binning)**
4 x vertical binning	not applicable	4 pixel signals from 4 vertical **adjacent same-color pixels** are combined and their signals are always **averaged (low-noise binning)**
Averaged? or Added?	Added	Averaged (low-noise binning)
When the signals are **averaged**, the image will **not be brighter** than without binning. When the signals are **added**, the image will be **brighter** than without binning.		

Table 44: Definition of 2 x and 4 x vertical binning

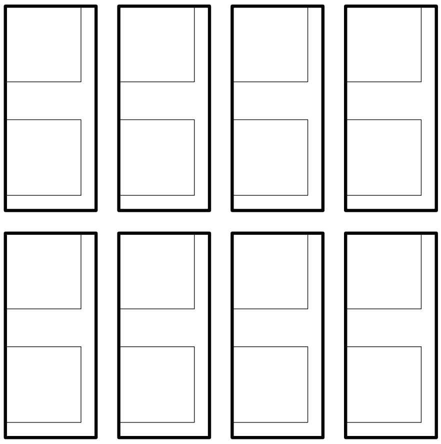


Figure 44: 2 x vertical binning (CCD models)

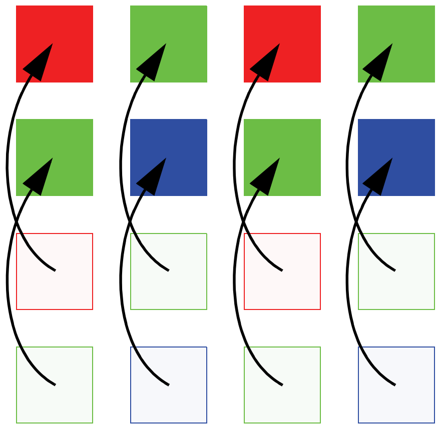


Figure 45: 2 x vertical binning (**Guppy PRO F-503B/C**)

Note

Vertical resolution is reduced, but **signal-to noise ratio** (SNR) is increased by about 3 or 6 dB (2 x or 4 x binning).

Note

The image appears **vertically** compressed in this mode and no longer exhibits a true aspect ratio.

If **vertical binning** is activated the image may appear to be over-exposed and may require correction.

Horizontal binning

Definition

(CCD cameras only) In **horizontal binning** adjacent pixels of a row are combined digitally in the FPGA of the camera without accumulating the black level. CMOS cameras: horizontal binning is done in the CMOS sensor.

With the CMOS sensor of Guppy PRO F-503C, color binning is possible. The monochrome CMOS sensor of Guppy PRO F-503B uses the same binning patterns as the color version. Using Guppy PRO F-503B/C you can choose between averaging and additive binning.

Light sensitivity

This means that in horizontal binning the **light sensitivity** of the camera is also increased by a factor of two (**6 dB**) or 4 (**12 dB**). This is only true for added binning but not for averaged binning (low-noise binning). Signal-to-noise separation improves by approx. 3 or 6 dB.

Horizontal resolution

Horizontal resolution is lowered, depending on the model.

Format_7 Mode_1

By default and without further remapping use **Format_7 Mode_1** for 2 x horizontal binning.

Low-noise binning

For Guppy PRO F-503, low-noise binning (averaged pixel signals) is available. To activate this mode see Chapter Low-noise binning mode (2 x and 4 x binning) (only Guppy PRO F-503) on page 242.

Binning mode	CCD models (monochrome)	Guppy PRO F-503B/C
2 x horizontal binning	2 pixel signals from 2 horizontal **neighboring pixels** are combined and their signals are **added.**	2 pixel signals from 2 horizontal **adjacent same-color pixels** are combined and their signals are **added** or **averaged (low-noise binning)**. Default: Added
4 x horizontal binning	not applicable	4 pixel signals from 4 horizontal **adjacent same-color pixels** are combined and their signals are **added** or **averaged (low-noise binning)**. Default: Added.
Averaged? or Added?	Only added	Added or averaged. Default: added
When the signals are **averaged**, the image will **not be brighter** than without binning. When the signals are **added**, the image will be **brighter** than without binning.		

Table 45: Definition of 2 x and 4 x horizontal binning

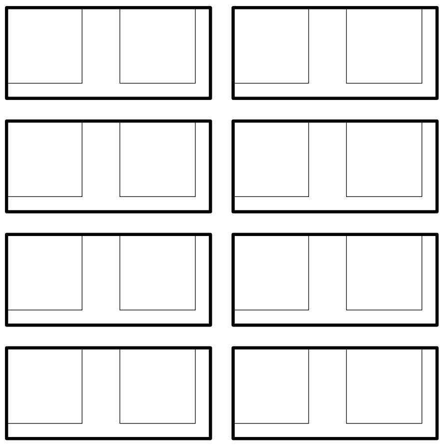


Figure 46: 2 x horizontal binning (CCD models)

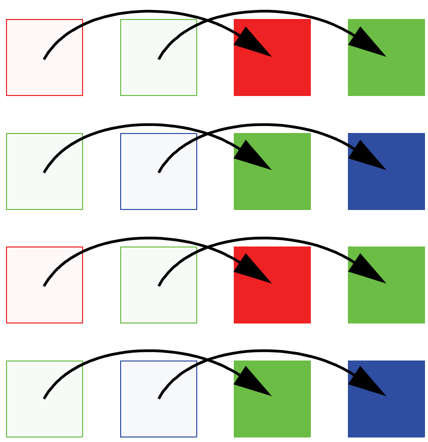


Figure 47: 2 x horizontal binning (**Guppy PRO F-503B/C**)

Note

The image appears **horizontally** compressed in this mode and does no longer show true aspect ratio.

If **horizontal binning** is activated the image may appear to be over-exposed and must be corrected, if necessary.

2 x full binning (F-503 also 4 x full binning)

If horizontal and vertical binning are combined, every 4 (16) pixels are consolidated into a single pixel. At first two (4) vertical pixels are put together and then combined horizontally. With the CMOS sensor of Guppy PRO F-503C, color binning is possible. The monochrome CMOS sensor of Guppy PRO F-503B uses the same binning patterns as the color version.

Light sensitivity This increases light sensitivity by a total of a factor of 4 (16) and at the same time signal-to-noise separation is improved by about 6 (12) dB (not low-noise binning).

Resolution Resolution is reduced, depending on the model.

Format_7 Mode_3 By default and without further remapping use **Format_7 Mode_3** for 2 x full binning.

Low-noise binning For Guppy PRO F-503, low-noise binning (averaged pixel signals) is available. To activate this mode see Chapter Low-noise binning mode (2 x and 4 x binning) (only Guppy PRO F-503) on page 242

Binning mode	CCD models (monochrome)	Guppy PRO F-503B/C
2 x full binning	4 pixel signals from 2 **neighboring rows and columns** are combined and their signals are **added.**	4 pixel signals from 2 **adjacent rows and columns (same-color pixels)** are combined and their signals are horizontally **added/averaged** and vertically **averaged.**
4 x full binning	not applicable	16 pixel signals from 4 **adjacent rows and columns (same-color pixels)** are combined and their signals are horizontally **added/averaged** and vertically **averaged.**
Averaged? or Added?	Added	Horizontal: added or averaged Vertical: averaged
When the signal is **averaged**, the image will **not be brighter** than without binning. When the signal is **added**, the image will **be brighter** than without binning.		

Table 46: Definition of 2 x and 4 x full binning

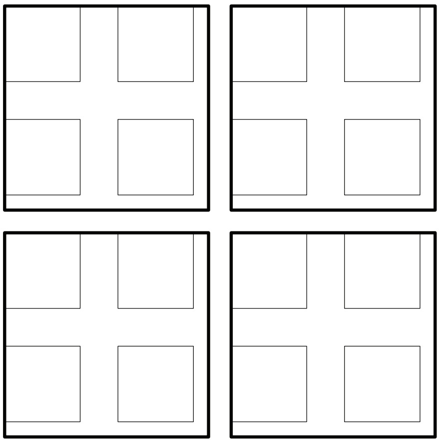


Figure 48: Full binning (CCD models)

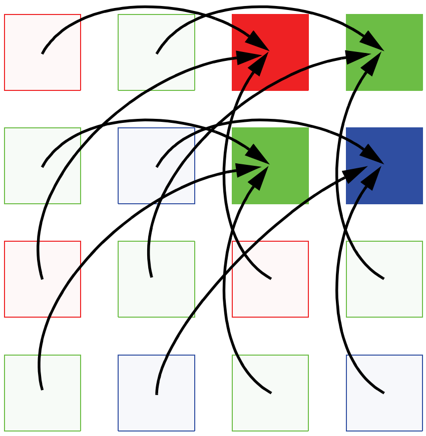


Figure 49: 2 x full binning (**Guppy PRO F-503**)

Note

If **full binning** is activated the image may appear to be over-exposed and must be corrected, if necessary.

Sub-sampling (only F-503B/C and CCD cameras b/w)

What is sub-sampling?

Definition Sub-sampling is the process of skipping neighboring pixels (with the same color) while being read out from the CCD chip.

Which Guppy PRO models have sub-sampling?

- **CMOS Guppy PRO** cameras (F-503B/C) (b/w and color cameras) have sub-sampling.
- **CCD** Guppy PRO cameras: only b/w cameras have sub-sampling (only 2x horizontal/vertical/H+V)

Description of sub-sampling

Sub-sampling is used primarily for the following reason:

- A reduction in the number of pixels and thus the amount of data while retaining the original image area angle and image brightness

Similar to binning mode the cameras support horizontal, vertical and h+v sub-sampling mode.

Format_7 Mode_4 By default and without further remapping use **Format_7 Mode_4** for

- Guppy PRO F-503B: 2 out of 4 horizontal sub-sampling
- Guppy PRO F-503C: 2 out of 4 horizontal sub-sampling

The different sub-sampling patterns are shown below.

2 out of 4

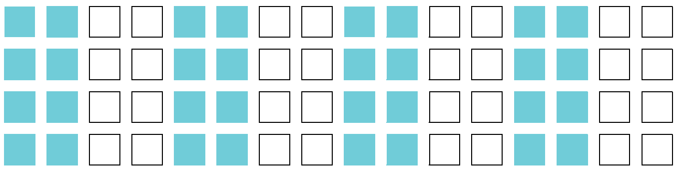


Figure 50: Horizontal sub-sampling 2 out of 4 (**b/w**)

2 out of 8

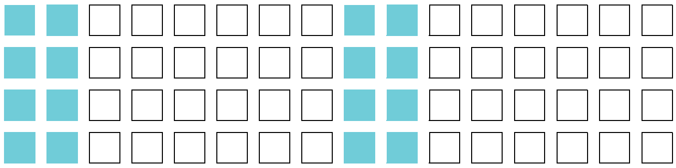


Figure 51: Horizontal sub-sampling 2 out of 8 (**b/w**)

2 out of 4

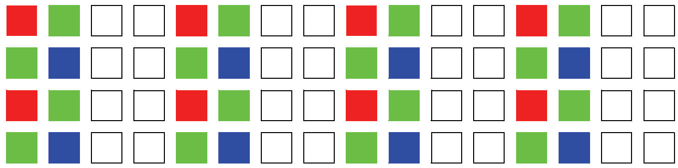


Figure 52: Horizontal sub-sampling 2 out of 4 (**color**)

2 out of 8

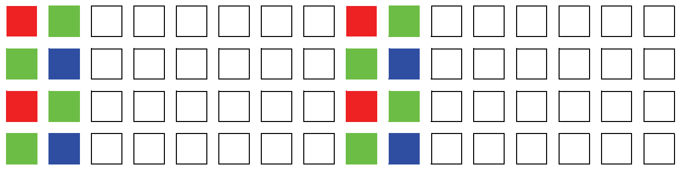


Figure 53: Horizontal sub-sampling 2 out of 8 (**color**)

Note

The image appears **horizontally compressed** in this mode and no longer exhibits a true aspect ratio.

Format_7 Mode_5 By default and without further remapping use **Format_7 Mode_5** for

- Guppy PRO F-503B: 2 out of 4 vertical sub-sampling
- Guppy PRO F-503C: 2 out of 4 vertical sub-sampling

The different sub-sampling patterns are shown below.

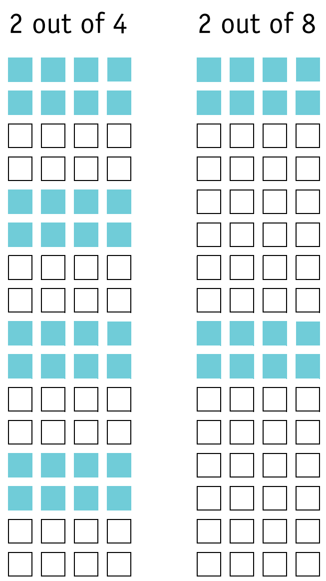


Figure 54: Vertical sub-sampling (**b/w**)

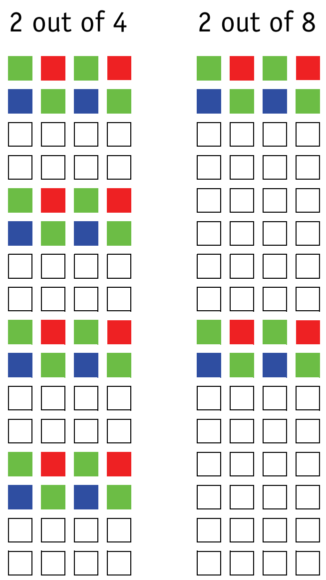


Figure 55: Vertical sub-sampling (**color**)

Note

The image appears vertically compressed in this mode and no longer exhibits a true aspect ratio.

Format_7 Mode_6

By default and without further remapping use **Format_7 Mode_6** for 2 out of 4 H+V sub-sampling

The different sub-sampling patterns are shown below.

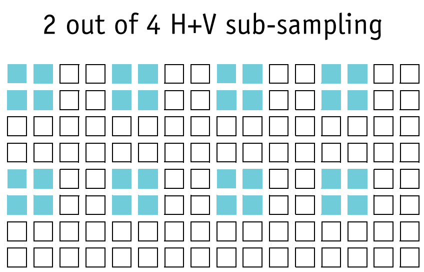


Figure 56: 2 out of 4 H+V sub-sampling (**b/w**)

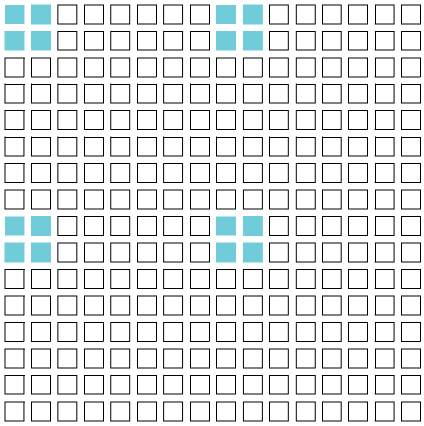


Figure 57: 2 out of 8 H+V sub-sampling (**b/w**)

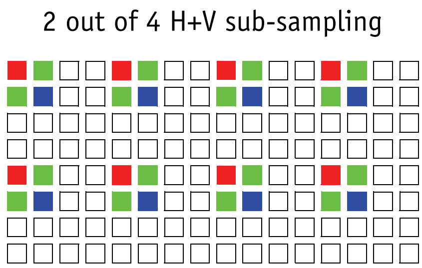


Figure 58: 2 out of 4 H+V sub-sampling (**color**)

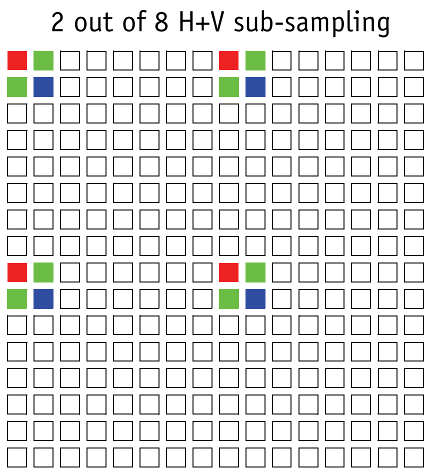


Figure 59: 2 out of 8 H+V sub-sampling (**color**)

Binning and sub-sampling access (F-503 only)

The binning and sub-sampling modes described in the last two chapters are only available as pure binning or pure sub-sampling modes. A combination of both is not possible.

As you can see there is a vast amount of possible combinations. But the number of available Format_7 modes is limited and lower than the possible combinations.

Thus access to the binning and sub-sampling modes is implemented in the following way:

- **Format_7 Mode_0** is fixed and cannot be changed
- A maximum of 7 individual AVT modes can be mapped to **Format_7 Mode_1** to **Mode_7**

(see *Figure 60: Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 on page 120*)

- Mappings can be stored via register (see Chapter Format_7 mode mapping (only Guppy PRO F-503) on page 241) and are uploaded automatically into the camera on camera reset.
- The **default settings** (per factory) in the Format_7 modes are listed in the following table

Format_7	Guppy PRO monochrome	Guppy PRO color
Mode_0	full resolution, no binning, no sub-sampling	full resolution, no sub-sampling, no binning
Mode_1	2 x **horizontal** binning	2 x **horizontal** binning
Mode_2	2 x **vertical** binning	2 x **vertical** binning
Mode_3	2 x **full** binning	2 x **full** binning
Mode_4	2 out of 4 **horizontal** sub-sampling	2 out of 4 **horizontal** sub-sampling
Mode_5	2 out of 4 **vertical** sub-sampling	2 out of 4 **vertical** sub-sampling
Mode_6	2 out of 4 **full** sub-sampling	2 out of 4 **full** sub-sampling

Table 47: Default Format_7 binning and sub-sampling modes (per factory)

Note

- A **combination** of binning and sub-sampling modes is **not possible.**
  Use either pure binning or pure sub-sampling modes.
- The Format_ID numbers 0...27 in the binning / sub-sampling list on page 120 do **not** correspond to any of the Format_7 modes.

F7 modes according to IIDC 1394

F7M0 (no change)
F7M1
F7M2
F7M3
F7M4
F7M5
F7M6
F7M7

mapping of each of 27 modes to F7M1..F7M7 possible

Format_ID (see p241) **AVT modes**

Format_ID	Horizontal	Vertical	
0	0 x horizontal	0 x vertical	binning (F-503 only) b/w and color cameras
1	2 x horizontal		
2	4 x horizontal		
3	---		
4	0 x horizontal	2 x vertical	
5	2 x horizontal		
6	4 x horizontal		
7	---		
8	0 x horizontal	4 x vertical	
9	2 x horizontal		
10	4 x horizontal		
11	---		
12	---		
13	---		
14	---		
15	---		
16	---	2 out of 2 vertical	sub-sampling (F-503 only) b/w and color camerass
17	2 out of 4 horizontal		
18	2 out of 8 horizontal		
19	---		
20	2 out of 2 horizontal	2 out of 4 vertical	
21	2 out of 4 horizontal		
22	2 out of 8 horizontal		
23	---		
24	2 out of 2 horizontal	2 out of 8 vertical	
25	2 out of 4 horizontal		
26	2 out of 8 horizontal		
27	---		

Figure 60: Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only)
For default mappings per factory see page 162

Note

Configuration

To configure this feature in an advanced register: See Table 131: Advanced register: Format_7 mode mapping on page 241.

Packed 12-Bit Mode

All Guppy PRO cameras have the so-called **Packed 12-Bit Mode**. This means: two 12-bit pixel values are packed into 3 bytes instead of 4 bytes.

B/w cameras	Color cameras
Packed 12-Bit MONO camera mode SmartView: MONO12	**Packed 12-Bit RAW** camera mode SmartView: RAW12
Mono and raw mode have the same implementation.	

Table 48: **Packed 12-Bit Mode**

Note

For data block packet format see Table 35: Packed 12-Bit Mode (mono and raw) Y12 format (AVT) on page 79.

For data structure see Table 36: Data structure of Packed 12-Bit Mode (mono and raw) (AVT) on page 81.

The color codings are implemented via Vendor Unique Color_Coding according to IIDC V1.31: COLOR_CODING_INQ @ 024h...033h, IDs=128-255)

See Table 108: Format_7 control and status register on page 213.

Mode	Color_Coding	ID
Packed 12-Bit MONO	ECCID_MONO12	ID=132
Packed 12-Bit RAW	ECCID_RAW12	ID=136

Table 49: **Packed 12-Bit Mode**: color coding

Color interpolation (BAYER demosaicing)

The color sensors capture the color information via so-called primary color (R-G-B) filters placed over the individual pixels in a **BAYER mosaic** layout. An effective BAYER → RGB color interpolation already takes place in all Guppy PRO color version cameras.

In color interpolation a red, green or blue value is determined for each pixel. An AVT proprietary BAYER demosaicing algorithm is used for this interpolation (2x2), optimized for both sharpness of contours as well as reduction of false edge coloring.

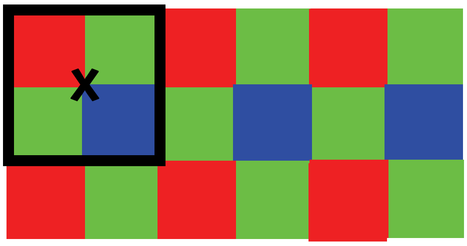


Figure 61: BAYER demosaicing (example of 2x2 matrix)

Color processing can be bypassed by using so-called RAW image transfer.

RAW mode is primarily used to

- save bandwidths on the IEEE 1394 bus
- achieve higher frame rates
- use different BAYER demosaicing algorithms on the PC (for all Guppy PRO models the first pixel of the sensor is RED).

Note

If the PC does not perform BAYER to RGB post-processing, the b/w image will be superimposed with a checkerboard pattern.

In color interpolation a red, green or blue value is determined for each pixel. Only two lines are needed for this interpolation:

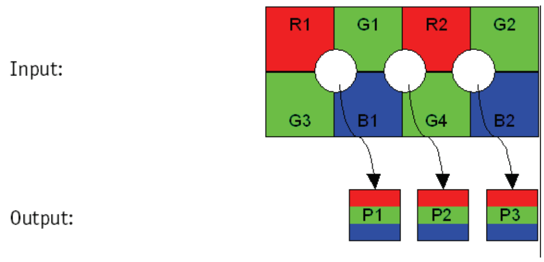


Figure 62: BAYER demosaicing (interpolation)

$$P1_{red} = R1 \qquad P2_{red} = R2 \qquad P3_{red} = R2$$

$$P1_{green} = \frac{G1 + G3}{2} \qquad P2_{green} = \frac{G1 + G4}{2} \qquad P3_{green} = \frac{G2 + G4}{2}$$

$$P1_{blue} = B1 \qquad P2_{blue} = B1 \qquad P3_{blue} = B2$$

Formula 4: BAYER demosaicing

Hue and saturation

Guppy PRO CCD and Guppy PRO F-503 color models are equipped with **hue** and **saturation** registers.

The **hue register** at offset 810h allows the color of objects to be changed without altering the white balance, by +/- 40 steps (+/- 10°) from the nominal perception. Use this setting to manipulate the color appearance after having carried out the white balance.

The **saturation register** at offset 814h allows the intensity of the colors to be changed between 0 and 200% in steps of 1/256.

This means a setting of zero changes the image to black and white and a setting of 511 doubles the color intensity compared to the nominal one at 256.

Note

Configuration

To configure this feature in feature control register:
See offset 810h on page 212 and 814h on page 212.

Note

Configuration

Hue and saturation do not show any effect on Guppy PRO color models in the Raw8 and Raw16 format, because color processing is switched off in all Raw formats.

Color correction

Why color correction?

The spectral response of a CCD is different of those of an output device or the human eye. This is the reason for the fact that perfect color reproduction is not possible. In each Guppy PRO camera there is a factory setting for the color correction coefficients, see Chapter GretagMacbeth ColorChecker on page 124.

Color correction is needed to eliminate the overlap in the color channels. This overlap is caused by the fact that:

- Blue light: is seen by the red and green pixels on the CCD
- Red light: is seen by the blue and green pixels on the CCD
- Green light: is seen by the red and blue pixels on the CCD

The color correction matrix subtracts out this overlap.

Color correction in AVT cameras

In AVT cameras the color correction is realized as an additional step in the process from the sensor data to color output.

Color correction is used to harmonize colors for the human eye.

Guppy PRO cameras have the so-called color correction matrix. This means: you are able to manipulate the color-correction coefficients yourself.

Color correction: formula

Before converting to the YUV format, color correction on all color models is carried out after BAYER demosaicing via a matrix as follows:

$$\begin{aligned} red^* &= Crr \times red + Cgr \times green + Cbr \times blue \\ green^* &= Crg \times red + Cgg \times green + Cbg \times blue \\ blue^* &= Crb \times red + Cgb \times green + Cbb \times blue \end{aligned}$$

Formula 5: Color correction

GretagMacbeth ColorChecker

Sensor-specific coefficients C_{xy} are scientifically generated to ensure that GretagMacbeth™ ColorChecker® colors are displayed with highest color fidelity and color balance.

These coefficients are stored in user set 0 and can not be overwritten (factory setting).

Changing color correction coefficients

You can change the color-correction coefficients according to your own needs. Changes are stored in the user settings.

Note

- A number of 1000 equals a color correction coefficient of 1.
- To obtain an identity matrix set values of 1000 for the diagonal elements an 0 for all others. As a result you get colors like in the RAW modes.
- The sums of all rows should be equal to each other. If not, you get tinted images.
- Color correction values range -1000 ... +2000 and are signed 32 bit.
- In order for white balance to work properly ensure that the row sum equals 1000.
- Each row should sum up to 1000. If not, images are less or more colorful.
- The maximum row sum is limited to 2000.

Note

Configuration

To configure the color-correction coefficients in an advanced register: See Table 125: Advanced register: Color correction on page 236.

To change the color-correction coefficients in **SmartView**, go to **Adv3** tab.

Switch color correction on/off

Color correction can also be switched off in YUV mode:

Note

Configuration

To configure this feature in an advanced register: See Table 125: Advanced register: Color correction on page 236.

Note

Color correction is deactivated in RAW mode.

Color conversion (RGB to YUV)

The conversion from RGB to YUV is made using the following formulae:

$$
\begin{aligned}
Y &= 0.3 \times R + 0.59 \times G + 0.11 \times B \\
U &= -0.169 \times R - 0.33 \times G + 0.498 \times B + 128 \text{ (@ 8 bit)} \\
V &= 0.498 \times R - 0.420 \times G - 0.082 \times B + 128 \text{ (@ 8 bit)}
\end{aligned}
$$

Formula 6: RGB to YUV conversion

Note

- As mentioned above: Color processing can be bypassed by using so-called RAW image transfer.
- RGB → YUV conversion can be bypassed by using RGB8 format and mode. This is advantageous for edge color definition but needs more bandwidth (300% instead of 200% relative to b/w or RAW consumption) for the transmission, so that the maximal frame frequency will drop.

Bulk Trigger

See Chapter Trigger modes on page 129 and the following pages.

Level Trigger

See Trigger Mode 1 in Chapter Trigger modes on page 129.

Controlling image capture

Global shutter (CCD cameras only)

Shutter modes The cameras support the SHUTTER_MODES specified in IIDC V1.31. For all models (except Guppy PRO F-503) this shutter is a **global shutter**; meaning that all pixels are exposed to the light at the same moment and for the same time span.

Pipelined Pipelined means that the shutter for a new image can already happen, while the preceding image is transmitted.

Continuous mode In continuous modes the shutter is opened shortly before the vertical reset happens, thus acting in a frame-synchronous way.

External trigger Combined with an external trigger, it becomes asynchronous in the sense that it occurs whenever the external trigger occurs. Individual images are recorded when an external trigger impulse is present. This ensures that even fast moving objects can be grabbed with no image lag and with minimal image blur.

Software trigger Guppy PRO cameras know also a trigger initiated by software (status and control register 62Ch on page 207 or in SmartView by **Trig/IO** tab, **Stop trigger** button).

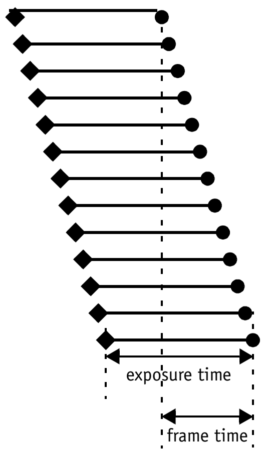
Camera I/O The external trigger is fed as a TTL signal through **Pin 4** of the camera I/O connector.

Electronic rolling shutter (ERS) and global reset release shutter (GRR) (only Guppy PRO F-503)

The CMOS Guppy PRO F-503 (Micron/Aptina CMOS sensor MT9P031) has an **electronic rolling shutter (ERS)** and **a global reset release shutter (GRR)** but no global shutter.

<table>
<tr><th>Shutter mode Guppy PRO F-503</th><th>Description</th></tr>
<tr><td>

Electronic rolling shutter (ERS)



</td><td>

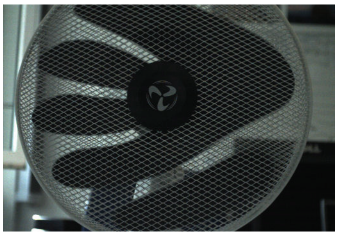
Advantage: designed for maximum frame rates

How it works:

- exposure time is the same for all rows
- start of exposure is different for each row

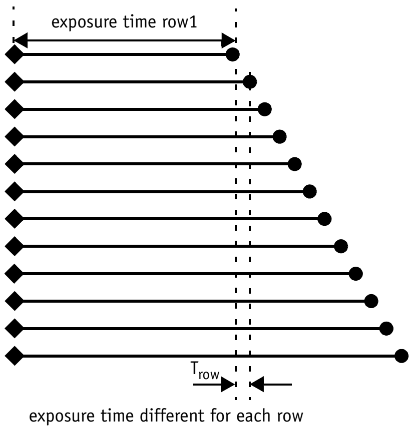
⇨ This can cause a shear in moving objects, see photo below.

Customer action: Use this mode only in situations with non-moving objects.



</td></tr>
<tr><td>

Global reset release shutter (GRR)



</td><td>

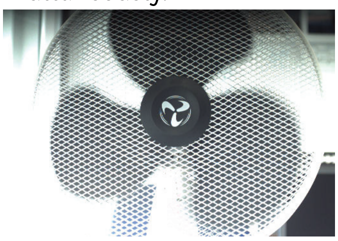
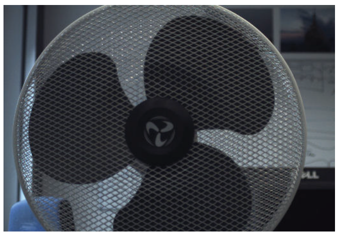
Advantage: designed for situations with moving objects; use this mode to avoid the problems with ERS described above

How it works: Image acquisition is done by starting all rows exposures at the same time.

⇨ So there is no shear in moving objects.

- exposure time is different for each row
- start of exposure is the same for each row

Customer action: Different exposure time for each row will result in images which get brighter with each row (see photo below left). In order to get an image with uniform illumination, use special lighting (flash) or mechanical/LCD extra shutter (see photo below right) which will stop the exposure of all rows simultaneously.

</td></tr>
</table>

Table 50: Guppy PRO F-503 shutter modes

Trigger modes

Guppy PRO cameras support IIDC conforming Trigger_Mode_0 and Trigger_Mode_1 and special Trigger_Mode_15 (bulk trigger).

Note

CMOS cameras Guppy PRO F-503 support only Trigger_Mode_0.

Trigger mode	also known as	Description
Trigger_Mode_0	Edge mode	Sets the shutter time according to the value set in the **shutter** (or extended shutter) **register**
Trigger_Mode_1	Level mode	Sets the shutter time according to the **active low time** of the pulse applied (or active high time in the case of an inverting input)
Trigger_Mode_15	Programmable mode	Is a **bulk trigger**, combining one external trigger event with continuous or one-shot or multi-shot internal trigger

Table 51: Trigger modes

Trigger_Mode_0 (edge mode) and Trigger_Mode_1 (level mode)

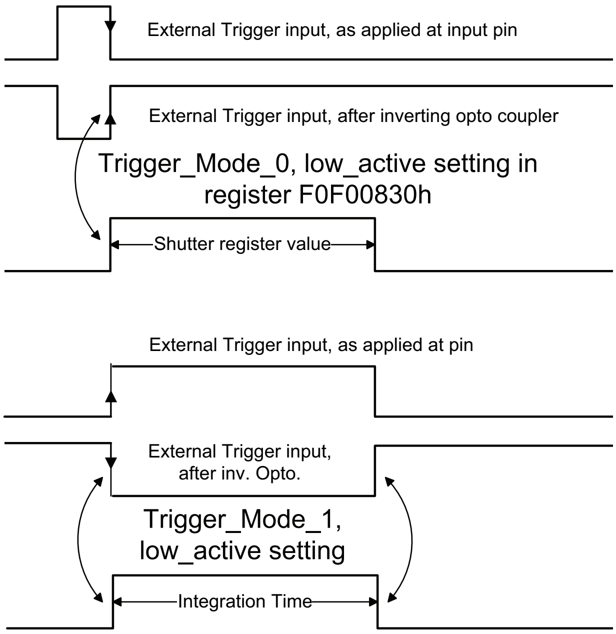


Figure 63: Trigger_Mode_0 and 1

The Guppy PRO F-503 has two shutter modes:

- electronic rolling shutter (ERS) and
- global reset release shutter (GRR)

Note

With this two shutter modes only Trigger_Mode_0 is possible. Details are explained in the following diagrams.

Guppy PRO F-503, Trigger_Mode_0, electronic rolling shutter

- IntEna is high, when all pixels are integrated simultaneously.
- IntEna starts with start of exposure of last row.
- IntEna ends with end of exposure of first row.

⇨ No IntEna if exposure of first row ends before the last row starts.

Long exposure time:

To get an IntEna signal the following condition must be true:

$$T_{exp\ eff.} = T_{exp} - T_{frame} > 0$$

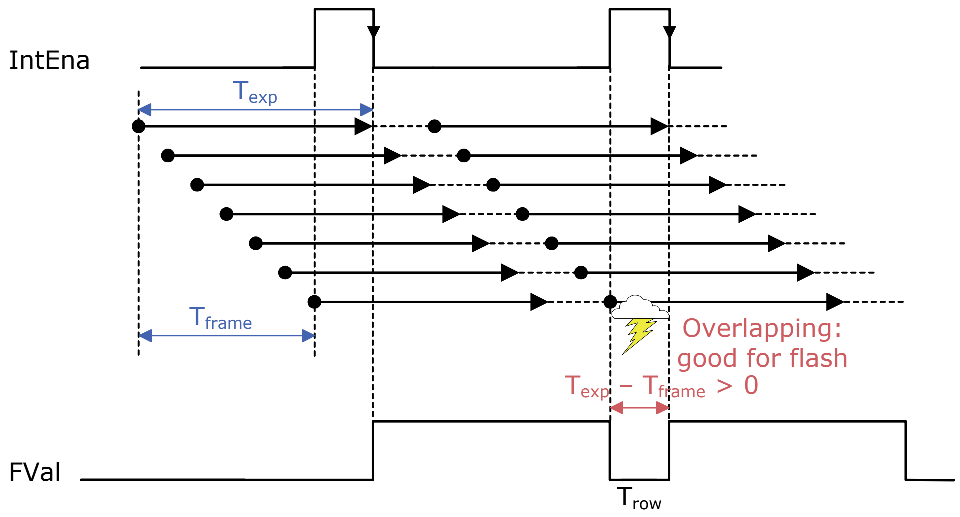


Figure 64: Trigger_Mode_0: Guppy PRO F-503 electronic rolling shutter (**long** exposure time)

Short exposure time:

If the following condition is true:

$T_{exp\ eff.} = T_{exp} - T_{frame} < 0$

then you don't get an IntEna signal and triggering is not possible.

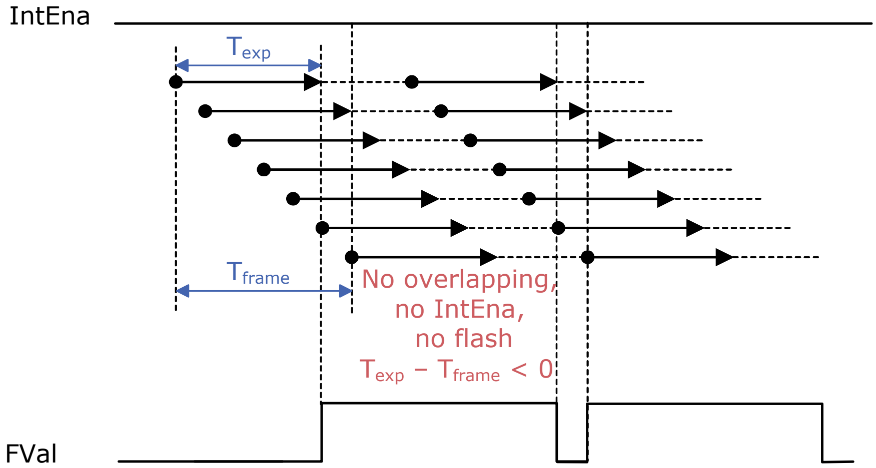


Figure 65: Trigger_Mode_0: Guppy PRO F-503 electronic rolling shutter (**short** exposure time)

Guppy PRO F-503, Trigger_Mode_0, global reset release shutter

Note

For activating **global reset release shutter** in an advanced register see Table 137: Advanced register: Global reset release shutter on page 247.

- IntEna is high, when all pixels are integrated simultaneously.
- Readout starts with end of exposure of first row.
- Readout ends with (end of exposure of last row) + (1x T_{row}).

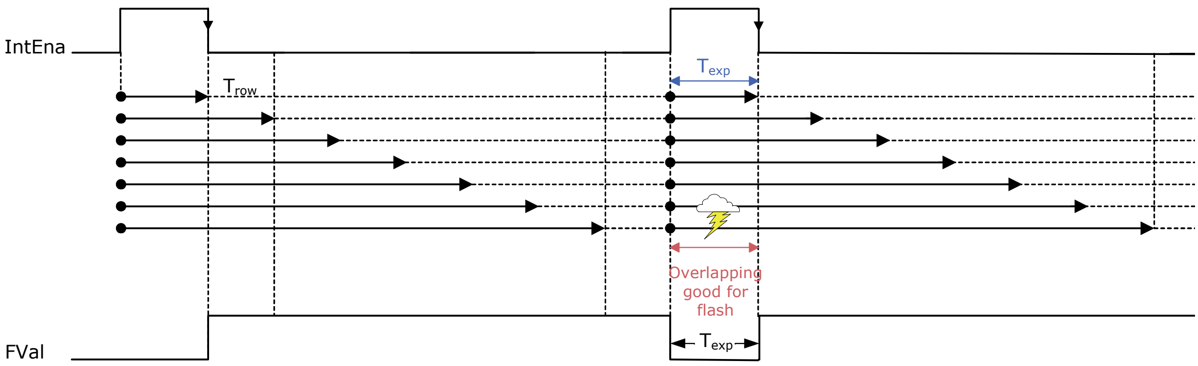


Figure 66: Trigger_Mode_0: Guppy PRO F-503: global reset release shutter

Exposure time of first row is:	T_{exp}
Exposure time of second row is:	$T_{exp} + T_{row}$
Exposure time of n-th row is:	$T_{exp} + (n-1) \times T_{row}$

Thus the image gets brighter with every row. To prevent this the customer should use:

- flash (when all rows are overlapping, see drawing above)
- or a mechanical/LCD shutter

Bulk trigger (Trigger_Mode_15)

Note

Trigger_Mode_15 is only available for Guppy PRO CCD cameras.

Trigger_Mode_15 is a bulk trigger, combining one external trigger event with continuous or one-shot or multi-shot internal trigger.

It is an extension to the IIDC trigger modes. One external trigger event can be used to trigger a multitude of internal image intakes.

This is especially useful for:

- Grabbing exactly one image based on the first external trigger.
- Filling the camera's internal image buffer with one external trigger without overriding images.
- Grabbing an unlimited amount of images after one external trigger (surveillance)

The figure below illustrates this mode.

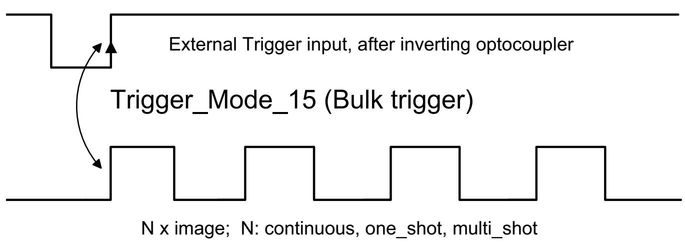


Figure 67: Trigger_Mode_15 (bulk trigger)

The functionality is controlled via bit [6] and bitgroup [12-15] of the following register:

Register	Name	Field	Bit	Description
0xF0F00830	TRIGGER_MODE	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the **Value** field 1: Control with value in the **Absolute** value CSR If this bit = 1 the value in the **Value** field has to be ignored.
		---	[2..5]	Reserved
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON If this bit = 0, other fields will be read only.
		Trigger_Polarity	[7]	Select trigger polarity If Polarity_Inq is 1: Write to change polarity of the trigger input. Read to get polarity of the trigger input. If Polarity_Inq is 0: Read only. 0: Low active input 1: High active input
		Trigger_Source	[8..10]	Select trigger source Set trigger source ID from trigger source ID_Inq.
		Trigger_Value	[11]	Trigger input raw signal value read only 0: Low 1: High
		Trigger_Mode	[12..15]	Trigger_Mode (Trigger_Mode_0..15)
		---	[16..19]	Reserved
		Parameter	[20..31]	Parameter for trigger function, if required (optional)

Table 52: Trigger_Mode_15 (Bulk trigger)

The screenshots below illustrate the use of Trigger_Mode_15 on a register level:

- Line #1switches continuous mode off, leaving viewer in listen mode.
- Line #2 prepares 830h register for external trigger and Mode_15.

Left = continuous	Middle = one-shot	Right = multi-shot
Line #3 switches camera back to **continuous** mode. Only one image is grabbed precisely with the first external trigger. To repeat rewrite line three.	Line #3 toggles **one-shot** bit [0] of the one-shot register 61C so that only one image is grabbed, based on the first external trigger. To repeat rewrite line three.	Line #3 toggles **multi-shot** bit [1] of the one-shot register 61C so that Ah images are grabbed, starting with the first external trigger. To repeat rewrite line three.

Table 53: Description: using Trigger_Mode_15: continuous, one-shot, multi-shot

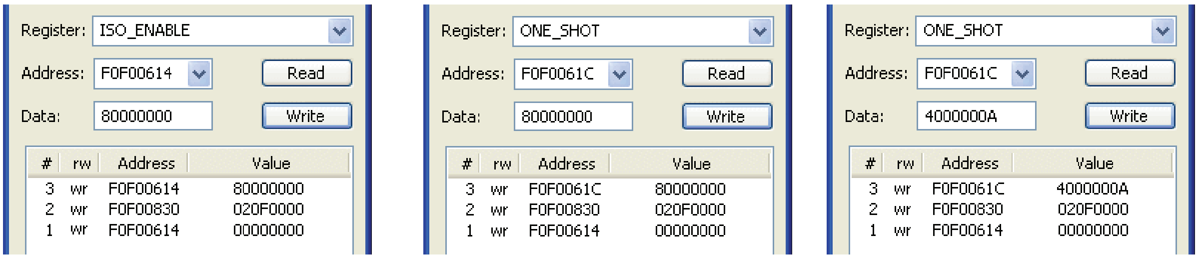


Figure 68: Using Trigger_Mode_15: continuous, one-shot, multi-shot

Note

Shutter for the images is controlled by shutter register.

Trigger delay

Guppy PRO cameras feature various ways to delay image capture based on external trigger.

With IIDC V1.31 there is a standard CSR at register F0F00534/834h to control a delay up to FFFh x time base value.

The following table explains the Inquiry register and the meaning of the various bits.

Register	Name	Field	Bit	Description
0xF0F00534	TRIGGER_DLY_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		---	[2]	Reserved
		One_Push_Inq	[3]	One-push auto mode (controlled automatically by the camera once)
		ReadOut_Inq	[4]	Capability of reading out the value of this feature
		On_Off_Inq	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto mode (controlled automatically by the camera)
		Manual_Inq	[7]	Manual mode (controlled by user)
		Min_Value	[8..19]	Minimum value for this feature
		Max_Value	[20..31]	Maximum value for this feature

Table 54: Trigger delay inquiry register

Register	Name	Field	Bit	Description
0xF0F00834	TRIGGER_DELAY	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the **Value** field 1: Control with value in the **Absolute** value CSR If this bit = 1, the value in the **Value** field has to be ignored
		---	[2..5]	Reserved
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON If this bit = 0, other fields will be read only.
		---	[7..19]	Reserved
		Value	[20..31]	Value If you write the value in OFF mode, this field will be ignored. If **ReadOut** capability is not available, then the read value will have no meaning.

Table 55: CSR: **trigger delay**

Trigger delay advanced register

In addition, the cameras have an advanced register which allows even more precise image capture delay after receiving a hardware trigger.

Register	Name	Field	Bit	Description
0xF1000400	TRIGGER_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	Reserved
		DelayTime	[11..31]	Delay time in µs

Table 56: Advanced CSR: **trigger delay**

The advanced register allows start of the integration to be delayed by max. 2^{21} µs, which is max. 2.1 s after a trigger edge was detected.

Note

- Switching trigger delay to ON also switches external Trigger_Mode_0 to ON.
- This feature works with external Trigger_Mode_0 only.

Software trigger

A software trigger is an external signal that is controlled via a status and control register: 62Ch on page 207: to activate software trigger set bit [0] to 1.

The behavior is different dependent on the trigger mode used:

- **Edge mode, programmable mode:** trigger is automatically reset (self cleared).
- **Level mode:** trigger is active until software trigger register is reset manually.
  - ➩ in advanced register 62Ch on page 207: set bit [0] to 0
  - ➩ in SmartView: **Trig/IO** tab, **Stop trigger** button

Debounce

Only for input ports:

There is an adjustable debounce time for trigger: separate for each input pin. The debounce time is a waiting period where no new trigger is allowed. This helps you to set exact one trigger.

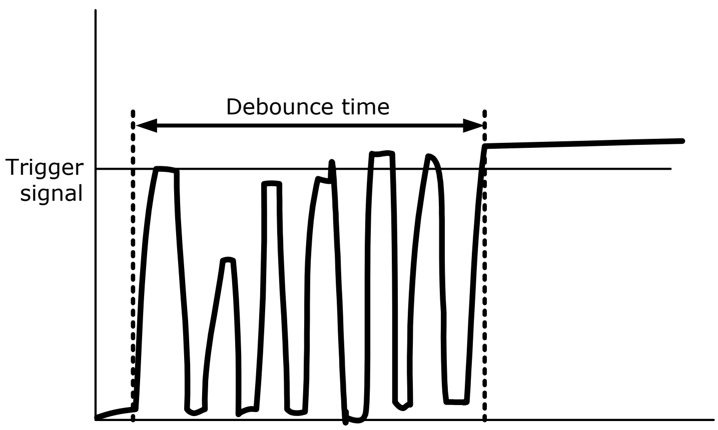


Figure 69: Example of debounce time for trigger

To set this feature in an advanced register: see Chapter Debounce time on page 140.

To set this feature in SmartView: **Trig/IO** tab, **Input pins** table, **Debounce** column.

Debounce time

This register controls the debounce feature of the cameras input pins. The debounce time can be set for each available input separately.

Increment is 500 ns

Debounce time is set in Time x 500 ns

Minimum debounce time is 1.5 µs ⇨ 3 x 500 ns

Maximum debounce time is ~16 ms ⇨ $(2^{15}-1)$ x 500 ns

Offset	Name	Field	Bit	Description
0xF1000840	IO_INP_DEBOUNCE_1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[2..7]	Reserved
		Time	[8..31]	Debounce time in steps of 500 ns (24 bit) see examples above
0xF1000844		MinValue	[0..31]	Minimum debounce time
0xF1000848		MaxValue	[0..31]	Maximum debounce time
0xF100084C		---	[0..31]	Reserved
0xF1000850	IO_INP_DEBOUNCE_2			same as IO_INP_DEBOUNCE_1
0xF1000860	IO_INP_DEBOUNCE_3			same as IO_INP_DEBOUNCE_1
0xF1000870	IO_INP_DEBOUNCE_4			same as IO_INP_DEBOUNCE_1
0xF1000880				Reserved
0xF1000890				Reserved
0xF10008A0				Reserved
0xF10008B0				Reserved

Table 57: Advanced register: **Debounce time for input ports**

Note

- The camera corrects invalid values automatically.
- This feature is not stored in the user settings.

Exposure time (shutter) and offset

The exposure (shutter) time for continuous mode and Trigger_Mode_0 is based on the following formula:

Shutter register value x time base + offset

The register value is the value set in the corresponding IIDC 1.31 register (SHUTTER [81Ch]). This number is in the range between 1 and 4095.

The shutter register value is multiplied by the time base register value (see Table 116: Time base ID on page 224). The default value here is set to 20 µs.

Exposure time of Guppy PRO F-503 (CMOS)

The exposure time of Guppy PRO F-503 can be set in row time increments.

The formula for the row time is:

$$t_{row} = 10.42\ \text{ns} \times \text{width} + 9.375\ \mu\text{s}$$

Formula 7: Row time for Guppy PRO F-503 (CMOS)

The minimum row time and the row time by maximum resolution are:

$$t_{row\ min} = 10.042\ \mu\text{s}$$
$$t_{row\ max\ res} = 36.375\ \mu\text{s}$$

Formula 8: Min. row time and row time at max. resolution for Guppy PRO F-503 (CMOS)

The shutter time of Guppy PRO F-503 can be extended via the advanced register: EXTENDED_SHUTTER

For more information see Chapter Extended shutter on page 225 and Table 117: Advanced register: Extended shutter on page 225.

Exposure time offset

A camera-specific offset is also added to this value. It is different for the camera models:

Camera model	Exposure time offset
Guppy PRO F-031	67 µs
Guppy PRO F-032	23 µs
Guppy PRO F-125	31 µs
Guppy PRO F-146	27 µs

Table 58: Camera-specific exposure time offset

Camera model	Exposure time offset
Guppy PRO F-201	41 µs
Guppy PRO F-503	see Chapter Exposure time of Guppy PRO F-503 (CMOS) on page 141

Table 58: Camera-specific exposure time offset

Minimum exposure time

Camera model	Minimum exposure time	Effective min. exp. time = Min. exp. time + offset
Guppy PRO F-031	4 µs	4 µs + 67 µs = 71 µs
Guppy PRO F-032	4 µs	4 µs + 23 µs = 27 µs
Guppy PRO F-125	4 µs	4 µs + 31 µs = 35 µs
Guppy PRO F-146	4 µs	4 µs + 27 µs = 31 µs
Guppy PRO F-201	4 µs	4 µs + 41 µs = 45 µs
Guppy PRO F-503	see Chapter Exposure time of Guppy PRO F-503 (CMOS) on page 141	

Table 59: Camera-specific minimum exposure time

Example: Guppy PRO F-031

Camera	Register value	Time base (default)
Guppy PRO F-031	100	20 µs

Table 60: Register value and time base for **Guppy PRO F-031**

register value x time base + exposure time offset = exposure time

100 x 20 µs + 27 µs = 2027 µs exposure time

The minimum adjustable exposure time set by register is 4 µs. → The real minimum exposure time of **Guppy PRO F-031** is then:
4 µs + 67 µs = 71 µs

Extended shutter

The exposure time for long-term integration of

- up to 67 seconds for the CCD models
- up to 22 seconds for the Guppy PRO F-503 (CMOS model)

can be extended via the advanced register: EXTENDED_SHUTTER

Register	Name	Field	Bit	Description
0xF100020C	EXTD_SHUTTER	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1.. 5]	Reserved
		ExpTime	[6..31]	Exposure time in µs

Table 61: Advanced register: **Extended shutter**

The longest exposure time, 3FFFFFFh, corresponds to 67.11 sec.

The lowest possible value of **ExpTime** is camera-specific (see Table 59: Camera-specific minimum exposure time on page 142).

Note

- Exposure times entered via the 81Ch register are mirrored in the extended register, but not vice versa.
- Longer integration times not only increase sensitivity, but may also increase some unwanted effects such as noise and pixel-to-pixel non-uniformity. Depending on the application, these effects may limit the longest usable integration time.
- Changes in this register have immediate effect, even when the camera is transmitting.
- Extended shutter becomes inactive after writing to a format/mode/frame rate register.

One-shot

Guppy PRO cameras can record an image by setting the **one-shot bit** in the 61Ch register. This bit is automatically cleared after the image is captured. If the camera is placed in ISO_Enable mode (see Chapter ISO_Enable / free-run on page 147), this flag is ignored.

If **one-shot mode** is combined with the external trigger, the **one-shot** command is used to arm it. The following screenshot shows the sequence of commands needed to put the camera into this mode. It enables the camera to grab exactly one image with an external trigger edge.

If there is no trigger impulse after the camera has been armed, **one-shot** can be cancelled by clearing the bit.

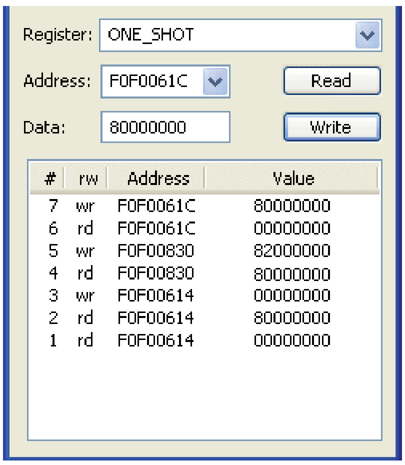


Figure 70: One-shot control (SmartView)

#	Read = rd Write = wr	Address	Value	Description
7	wr	F0F0061C	80000000	Do one-shot.
6	rd	F0F0061C	00000000	Read out one-shot register.
5	wr	F0F00830	82000000	Switch on external trigger mode 0.
4	rd	F0F00830	80000000	Check trigger status.
3	wr	F0F00614	00000000	Stop free-run.
2	rd	F0F00614	80000000	Check Iso_Enable mode (→free-run).
1	rd	F0F00614	00000000	This line is produced by SmartView.

Table 62: One-shot control: descriptions

One-shot command on the bus to start of exposure

The following sections describe the time response of the camera using a single frame (one-shot) command. As set out in the IIDC specification, this is a software command that causes the camera to record and transmit a single frame.

The following values apply only when the camera is idle and ready for use. Full resolution must also be set.

Feature	Value
One-shot → microcontroller sync	≤ 150 µs (processing time in the microcontroller)
µC-Sync/ExSync → integration start	8 µs

Table 63: Values for one-shot

Microcontroller sync is an internal signal. It is generated by the microcontroller to initiate a trigger. This can either be a direct trigger or a release for ExSync if the camera is externally triggered.

End of exposure to first packet on the bus

After the exposure, the CCD sensor is read out; some data is written into the FRAME_BUFFER before being transmitted to the bus.

The time from the end of exposure to the start of transport on the bus is:

710 µs ± 62.5 µs

This time *jitters* with the cycle time of the bus (125 µs).

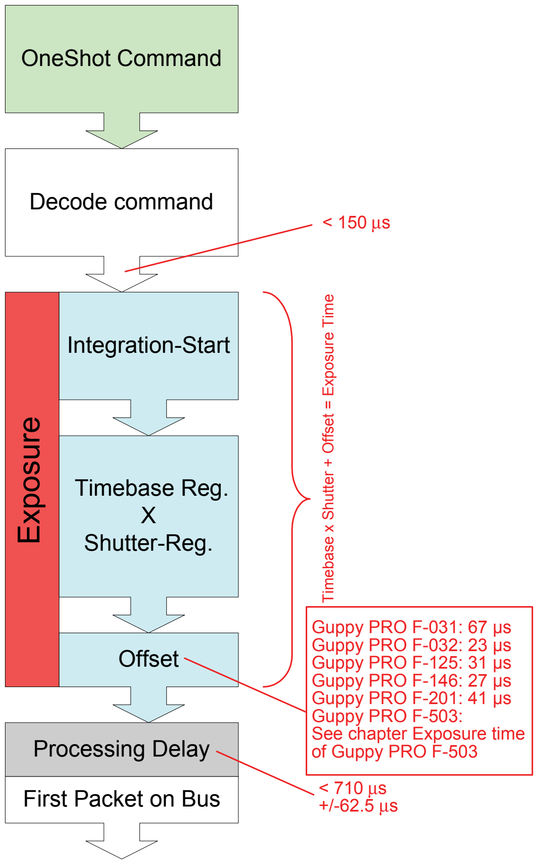


Figure 71: Data flow and timing after end of exposure

Multi-shot

Setting **multi-shot** and entering a quantity of images in **Count_Number** in the 61Ch register enables the camera to record a specified number of images.

The number is indicated in bits 16 to 31. If the camera is put into **ISO_Enable** mode (see Chapter ISO_Enable / free-run on page 147), this flag is ignored and deleted automatically once all the images have been recorded.

If **multi-shot** mode is activated and the images have not yet all been captured, it can be cancelled by resetting the flag. The same result can be achieved by setting the number of images to **0**.

Multi-shot can also be combined with the external trigger in order to grab a certain number of images based on an external trigger.

ISO_Enable / free-run

Setting the MSB (bit 0) in the 614h register (ISO_ENA) puts the camera into **ISO_Enable mode** or **Continuous_Shot (free-run)**. The camera captures an infinite series of images. This operation can be quit by deleting the **0** bit.

Asynchronous broadcast

The camera accepts asynchronous broadcasts. This involves asynchronous write requests that use node number 63 as the target node with no acknowledge.

This makes it possible for all cameras on a bus to be triggered by software simultaneously - e.g. by broadcasting a **one-shot**. All cameras receive the **one-shot** command in the same IEEE 1394 bus cycle. This creates uncertainty for all cameras in the range of 125 µs.

Inter-camera latency is described in Chapter Jitter at start of exposure on page 148.

The following screenshot shows an example of broadcast commands sent with the Firedemo example of FirePackage:

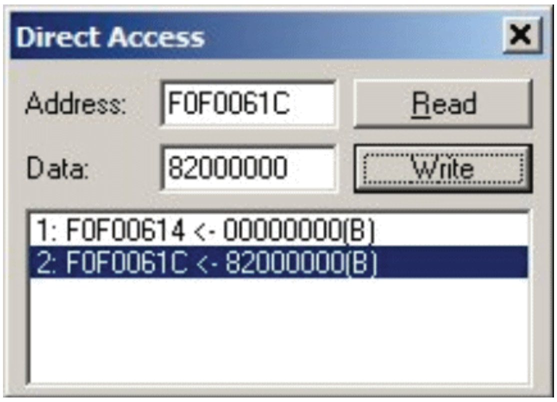


Figure 72: Broadcast one-shot

- Line 1 shows the broadcast command, which stops all cameras connected to the same IEEE 1394 bus. It is generated by holding the **Shift** key down while clicking on **Write**.
- Line 2 generates a **broadcast one_shot** in the same way, which forces all connected cameras to simultaneously grab one image.

Jitter at start of exposure

The following chapter discusses the latency time which exists for all Guppy PRO CCD models when a hardware trigger is generated, until the actual image exposure starts.

Owing to the well-known fact that an **Interline Transfer CCD** sensor has both a light sensitive area and a separate storage area, it is common to interleave image exposure of a new frame and output that of the previous one. It makes continuous image flow possible, even with an external trigger.

The uncertain time delay before the start of exposure depends on the state of the sensor. A distinction is made as follows:

FVal is active → the sensor is reading out, the camera is busy

In this case the camera must not change horizontal timing so that the trigger event is synchronized with the current horizontal clock. This introduces a maximum uncertainty which is equivalent to the line time. The line time depends on the sensor used and therefore can vary from model to model.

FVal is inactive → the sensor is ready, the camera is idle

In this case the camera can resynchronize the horizontal clock to the new trigger event, leaving only a very short uncertainty time of the master clock period.

Model	Exposure start jitter (while FVal)	Exposure start jitter (while camera idle)
Guppy PRO F-031	± 14.2 µs	± 2.9 µs
Guppy PRO F-032	± 24.3 µs	± 3 µs
Guppy PRO F-125	± 33.2 µs	± 5 µs
Guppy PRO F-146	± 56 µs	± 13.7 µs
Guppy PRO F-201	± 29.5 µs	± 10.3 µs
Guppy PRO F-503	not applicable	not applicable

Table 64: Jitter at exposure start (no binning, no sub-sampling)

Note

- Jitter at the beginning of an exposure has no effect on the length of exposure, i.e. it is always constant.

Video formats, modes and bandwidth

The different Guppy PRO models support different video formats, modes and frame rates.

These formats and modes are standardized in the IIDC (formerly DCAM) specification.

Resolutions smaller than the generic sensor resolution are generated from the center of the sensor and without binning.

Note

- The maximum frame rates can only be achieved with shutter settings lower than 1/framerate. This means that with default shutter time of 40 ms, a camera will not achieve frame rates higher than 25 frames/s. In order to achieve higher frame rates, please reduce the shutter time proportionally.
- **The following tables assume that bus speed is 800 Mbit/s.** With lower bus speeds (e.g. 400, 200 or 100 Mbit/s) not all frame rates may be achieved.
- For information on bit/pixel and byte/pixel for each color mode see Table 87: ByteDepth on page 179.

Note

The following Format_7 tables show **default Format_7 modes** without Format_7 mode mapping.

For information on Format_7 mode mapping ...

- ... see Chapter Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 on page 120
- ... see Chapter Format_7 mode mapping (only Guppy PRO F-503) on page 241

Note

H-binning means horizontal binning.

V-binning means vertical binning.

Full binning (H+V) means horizontal + vertical binning

2 x binning means: 2 neighboring pixels are combined.

4 x binning means: 4 neighboring pixels are combined.

- **Binning increases signal-to-noise ratio** (SNR), but decreases resolution.

Guppy PRO F-031B / Guppy PRO F-031C

Format	Mode	Resolution	Color mode	240 fps	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444								
	1	320 x 240	YUV422			x	x	x	x	x	x
	2	640 x 480	YUV411			x	x	x	x	x	x
	3	640 x 480	YUV422			x	x	x	x	x	x
	4	640 x 480	RGB8			x	x	x	x	x	x
	5	640 x 480	Mono8		x x*	x x*	x x*	x x*	x x*	x x*	x x*
	6	640 x 480	Mono16			x	x	x	x	x	x

Table 65: Video fixed formats Guppy PRO F-031B / Guppy PRO F-031C

*: Color camera outputs Mono8 interpolated image.

Only achievable with 1394b (S800).

Note

The following table shows **default Format_7 modes** without Format_7 mode mapping.

For information on Format_7 mode mapping ...

- ... see Chapter Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 on page 120
- ... see Chapter Format_7 mode mapping (only Guppy PRO F-503) on page 241

Format	Mode	Resolution	Color mode	Maximal S800 frame rates for Format_7 modes
7	0	656 x 492	Mono8 Mono12 Mono16	121 fps 121 fps 121 fps
		656 x 492	YUV411 YUV422,Raw16 Mono8,Raw8 RGB8 Raw12	121 fps 121 fps 121 fps 66 fps 121 fps
	1	328 x 492	Mono8 Mono12 Mono16	123 fps 2x H-binning 122 fps 2x H-binning 121 fps 2x H-binning
	2	656 x 246	Mono8 Mono12 Mono16	204 fps 2x V-binning 204 fps 2x V-binning 194 fps 2x V-binning
	3	328 x 246	Mono8 Mono12 Mono16	204 fps 2x H+V binning 205 fps 2x H+V binning 205 fps 2x H+V binning
	4	328 x 492	Mono8 Mono12 Mono16	123 fps 2 out of 4 H-sub-sampling 123 fps 2 out of 4 H-sub-sampling 121 fps 2 out of 4 H-sub-sampling
	5	656 x 246	Mono8 Mono12 Mono16	153 fps 2 out of 4 V-sub-sampling 153 fps 2 out of 4 V-sub-sampling 153 fps 2 out of 4 V-sub-sampling
	6	328 x 246	Mono8 Mono12 Mono16	153 fps 2 out of 4 H+V sub-sampling 153 fps 2 out of 4 H+V sub-sampling 153 fps 2 out of 4 H+V sub-sampling

Table 66: Video Format_7 default modes Guppy PRO F-031B / Guppy PRO F-031C

Guppy PRO F-032B / Guppy PRO F-032C

Format	Mode	Resolution	Color mode	240 fps	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444								
	1	320 x 240	YUV422			x	x	x	x	x	x
	2	640 x 480	YUV411			x	x	x	x	x	x
	3	640 x 480	YUV422			x	x	x	x	x	x
	4	640 x 480	RGB8			x	x	x	x	x	x
	5	640 x 480	Mono8			x x*	x x*	x x*	x x*	x x*	x x*
	6	640 x 480	Mono16			x	x	x	x	x	x

Table 67: Video fixed formats Guppy PRO F-032B / Guppy PRO F-032C

*: Color camera outputs Mono8 interpolated image.

Only achievable with 1394b (S800).

Note

The following table shows **default Format_7 modes** without Format_7 mode mapping.

For information on Format_7 mode mapping ...

- ... see Chapter Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 on page 120
- ... see Chapter Format_7 mode mapping (only Guppy PRO F-503) on page 241

Format	Mode	Resolution	Color mode	Maximal S800 frame rates for Format_7 modes
7	0	656 x 492	Mono8 Mono12 Mono16	79 fps 79 fps 79 fps
		656 x 492	YUV411 YUV422,Raw16 Mono8,Raw8 RGB8 Raw12	79 fps 79 fps 79 fps 66 fps 79 fps
	1	328 x 492	Mono8 Mono12 Mono16	79 fps 2x H-binning 79 fps 2x H-binning 79 fps 2x H-binning
	2	656 x 246	Mono8 Mono12 Mono16	135 fps 2x V-binning 135 fps 2x V-binning 135 fps 2x V-binning
	3	328 x 246	Mono8 Mono12 Mono16	135 fps 2x H+V binning 135 fps 2x H+V binning 135 fps 2x H+V binning
	4	328 x 492	Mono8 Mono12 Mono16	79 fps 2 out of 4 H-sub-sampling 79 fps 2 out of 4 H-sub-sampling 79 fps 2 out of 4 H-sub-sampling
	5	656 x 246	Mono8 Mono12 Mono16	99 fps 2 out of 4 V-sub-sampling 99 fps 2 out of 4 V-sub-sampling 99 fps 2 out of 4 V-sub-sampling
	6	328 x 246	Mono8 Mono12 Mono16	99 fps 2 out of 4 H+V sub-sampling 99 fps 2 out of 4 H+V sub-sampling 99 fps 2 out of 4 H+V sub-sampling

Table 68: Video Format_7 default modes Guppy PRO F-032B / Guppy PRO F-032C

Guppy PRO F-125B / Guppy PRO F-125C

Format	Mode	Resolution	Color mode	240 fps	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444								
	1	320 x 240	YUV422			x	x	x	x	x	x
	2	640 x 480	YUV411				x	x	x	x	x
	3	640 x 480	YUV422				x	x	x	x	x
	4	640 x 480	RGB8				x	x	x	x	x
	5	640 x 480	Mono8				x x*	x x*	x x*	x x*	x x*
	6	640 x 480	Mono16				x	x	x	x	x
1	0	800 x 600	YUV422				x	x	x	x	
	1	800 x 600	RGB8				x	x	x		
	2	800 x 600	Mono8				x x*	x x*	x x*		
	3	1024 x 768	YUV422				x	x	x	x	x
	4	1024 x 768	RGB8					x	x	x	x
	5	1024 x 768	Mono8				x x*	x x*	x x*	x x*	x x*
	6	800 x 600	Mono16				x	x	x	x	
	7	1024 x 768	Mono16				x	x	x	x	x
2	0	1280 x 960	YUV422					x	x	x	x
	1	1280 x 960	RGB8					x	x	x	x
	2	1280 x 960	Mono 8				x x*	x x*	x x*	x x*	x x*
	3	1600 x 1200	YUV422								
	4	1600 x 1200	RGB8								
	5	1600 x 1200	Mono8								
	6	1280 x 960	Mono16					x	x	x	x
	7	1600 x 1200	Mono16								

Table 69: Video fixed formats Guppy PRO F-125B / F-125C

*: Color camera outputs Mono8 interpolated image.

Frame rates with shading are only achievable with 1394b (S800).

Note

The following table shows **default Format_7 modes** without Format_7 mode mapping.

- see Chapter Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 on page 120
- see Chapter Format_7 mode mapping (only Guppy PRO F-503) on page 241

Format	Mode	Resolution	Color mode	Maximal S800 frame rates for Format_7 modes	
7	0	1292 x 964	Mono8 Mono12 Mono16	30 fps 30 fps 26 fps	
		1292 x 964	YUV411 YUV422,Raw16 Mono8,Raw8 RGB8 Raw12	30 fps 26 fps 30 fps 17 fps 30 fps	
	1	644 x 964	Mono8 Mono12 Mono16	30 fps 30 fps 30 fps	2x H-binning 2x H-binning 2x H-binning
	2	1292 x 482	Mono8 Mono12 Mono16	52 fps 52 fps 52 fps	2x V-binning 2x V-binning 2x V-binning
	3	644 x 482	Mono8 Mono12 Mono16	52 fps 52 fps 52 fps	2x H+V binning 2x H+V binning 2x H+V binning
	4	644 x 964	Mono8 Mono12 Mono16	30 fps 30 fps 30 fps	2 out of 4 H-sub-sampling 2 out of 4 H-sub-sampling 2 out of 4 H-sub-sampling
	5#	1292 x 482	Mono8 Mono12 Mono16	39 fps 39 fps 39 fps	2 out of 4 V-sub-sampling 2 out of 4 V-sub-sampling 2 out of 4 V-sub-sampling
	6#	644 x 482	Mono8 Mono12 Mono16	39 fps 39 fps 39 fps	2 out of 4 H+V-sub-sampling 2 out of 4 H+V-sub-sampling 2 out of 4 H+V-sub-sampling

Table 70: Video Format_7 default modes Guppy PRO F-125B / F-125C

#: Vertical sub-sampling is done via digitally concealing certain lines, so the frame rate is not
frame rate = f (AOI height)
but
frame rate = f (2 x AOI height)

Guppy PRO F-146B / Guppy PRO F-146C

Format	Mode	Resolution	Color mode	240 fps	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444								
	1	320 x 240	YUV422				x	x	x	x	x
	2	640 x 480	YUV411					x	x	x	x
	3	640 x 480	YUV422					x	x	x	x
	4	640 x 480	RGB8					x	x	x	x
	5	640 x 480	Mono8					x x*	x x*	x x*	x x*
	6	640 x 480	Mono16					x	x	x	x
1	0	800 x 600	YUV422					x	x	x	
	1	800 x 600	RGB8					x	x		
	2	800 x 600	Mono8					x x*	x x*		
	3	1024 x 768	YUV422					x	x	x	x
	4	1024 x 768	RGB8					x	x	x	x
	5	1024 x 768	Mono8					x x*	x x*	x x*	x x*
	6	800 x 600	Mono16					x	x	x	
	7	1024 x 768	Mono16					x	x	x	x
2	0	1280 x 960	YUV422					x	x	x	x
	1	1280 x 960	RGB8					x	x	x	x
	2	1280 x 960	Mono 8					x x*	x x*	x x*	x x*
	3	1600 x 1200	YUV422								
	4	1600 x 1200	RGB8								
	5	1600 x 1200	Mono8								
	6	1280 x 960	Mono16					x	x	x	x
	7	1600 x 1200	Mono16								

Table 71: Video fixed formats Guppy PRO F-146B / F-146C

*: Color camera outputs Mono8 interpolated image.

Only achievable with 1394b (S800). (pink-shaded cells: 15 fps of Format 1 Mode 4, Format 2 Modes 0, 1 and 6)

Note

The following table shows **default Format_7 modes** without Format_7 mode mapping.

- see Chapter Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 on page 120
- see Chapter Format_7 mode mapping (only Guppy PRO F-503) on page 241

Format	Mode	Resolution	Color mode	Maximal S800 frame rates for Format_7 modes	
7	0	1388 x 1038	Mono8 Mono12 Mono16	17 fps 17 fps 17 fps	
		1388 x 1038	YUV411 YUV422,Raw16 Mono8,Raw8 RGB8 Raw12	17 fps 17 fps 17 fps 17 fps 17 fps	
	1	692 x 1038	Mono8 Mono12 Mono16	17 fps 17 fps 17 fps	2x H-binning 2x H-binning 2x H-binning
	2	1388 x 518	Mono8 Mono12 Mono16	28 fps 28 fps 28 fps	2x V-binning 2x V-binning 2x V-binning
	3	692 x 518	Mono8 Mono12 Mono16	28 fps 28 fps 28 fps	2x H+V binning 2x H+V binning 2x H+V binning
	4	692 x 1038	Mono8 Mono12 Mono16	17 fps 17 fps 17 fps	2 out of 4 H-sub-sampling 2 out of 4 H-sub-sampling 2 out of 4 H-sub-sampling
	5#	1388 x 518	Mono8 Mono12 Mono16	21 fps 21 fps 21 fps	2 out of 4 V-sub-sampling 2 out of 4 V-sub-sampling 2 out of 4 V-sub-sampling
	6#	692 x 518	Mono8 Mono12 Mono16	21 fps 21 fps 21 fps	2 out of 4 H+V-sub-sampling 2 out of 4 H+V-sub-sampling 2 out of 4 H+V-sub-sampling

Table 72: Video Format_7 default modes Guppy PRO F-146B / F-146C

#: Vertical sub-sampling is done via digitally concealing certain lines, so the frame rate is not
frame rate = f (AOI height)
but
frame rate = f (2 x AOI height)

Guppy PRO F-201B / Guppy PRO F-201C

Format	Mode	Resolution	Color mode	240 fps	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444								
	1	320 x 240	YUV422				x	x	x	x	x
	2	640 x 480	YUV411				x	x	x	x	x
	3	640 x 480	YUV422				x	x	x	x	x
	4	640 x 480	RGB8				x	x	x	x	x
	5	640 x 480	Mono 8				x x*	x x*	x x*	x x*	x x*
	6	640 x 480	Mono 16				x	x	x	x	x
1	0	800 x 600	YUV422					x	x	x	
	1	800 x 600	RGB8					x	x		
	2	800 x 600	Mono8					x x*	x x*		
	3	1024 x 768	YUV422					x	x	x	x
	4	1024 x 768	RGB8					x	x	x	x
	5	1024 x 768	Mono 8					x x*	x x*	x x*	x x*
	6	800 x 600	Mono16					x	x	x	
	7	1024 x 768	Mono16					x	x	x	x
2	0	1280 x 960	YUV422					x	x	x	x
	1	1280 x 960	RGB8					x	x	x	x
	2	1280 x 960	Mono 8					x x*	x x*	x x*	x x*
	3	1600 x 1200	YUV422						x	x	x
	4	1600 x 1200	RGB8						x	x	x
	5	1600 x 1200	Mono8						x*	x x*	x x*
	6	1280 x 960	Mono16					x	x	x	x
	7	1600 x 1200	Mono16						x	x	x

Table 73: Video fixed formats Guppy PRO F-201B / F-201C

*: Color camera outputs Mono8 interpolated image.

Only achievable with 1394b (S800).

Note

The following table shows **default Format_7 modes** without Format_7 mode mapping.

- see Chapter Binning and sub-sampling access (F-503 only) on page 118
- see Table 47: Default Format_7 binning and sub-sampling modes (per factory) on page 119

Format	Mode	Resolution	Color mode	Maximal S800 frame rates for Format_7 modes
7	0	1624 x 1234	Mono8 Mono12 Mono16	14 fps 14 fps 14 fps
		1624 x 1234	YUV411 YUV422,Raw16 Mono8,Raw8 RGB8 Raw12	14 fps 14 fps 14 fps 10 fps 14 fps
	1	812 x 1234	Mono8 Mono12 Mono16	14 fps 2x H-binning 14 fps 2x H-binning 14 fps 2x H-binning
	2	1624 x 616	Mono8 Mono12 Mono16	24 fps 2x V-binning 24 fps 2x V-binning 24 fps 2x V-binning
	3	812 x 616	Mono8 Mono12 Mono16	24 fps 2x H+V binning 24 fps 2x H+V binning 24 fps 2x H+V binning
	4	812 x 1234	Mono8 Mono12 Mono16	14 fps 2 out of 4 H-sub-sampling 14 fps 2 out of 4 H-sub-sampling 14 fps 2 out of 4 H-sub-sampling
7	5#	1624 x 616	Mono8 Mono12 Mono16	17 fps 2 out of 4 V-sub-sampling 17 fps 2 out of 4 V-sub-sampling 17 fps 2 out of 4 V-sub-sampling
	6#	812 x 616	Mono8 Mono12 Mono16	17 fps 2 out of 4 H+V sub-sampling 17 fps 2 out of 4 H+V sub-sampling 17 fps 2 out of 4 H+V sub-sampling

Table 74: Video Format_7 default modes Guppy PRO F-201B / F-201C

#: Vertical sub-sampling is done via digitally concealing certain lines, so the frame rate is not

frame rate = f (AOI height)
but
frame rate = f (2 x AOI height)

Guppy PRO F-503B / Guppy PRO F-503C

Format	Mode	Resolution	Color mode	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444							
	1	320 x 240	YUV422	x	x	x	x	x	x	x
	2	640 x 480	YUV411	x	x	x	x	x	x	x
	3	640 x 480	YUV422		x	x	x	x	x	x
	4	640 x 480	RGB8							
	5	640 x 480	MONO8	x x*	x x*	x x*	x x*	x x*	x x*	x x*
	6	640 x 480	MONO16		x	x	x	x	x	x
1	0	800 x 600	YUV422		x	x	x	x	x	
	1	800 x 600	RGB8							
	2	800 x 600	MONO8		x x*	x x*	x x*	x x*		
	3	1024 x 768	YUV422			x	x	x	x	x
	4	1024 x 768	RGB8							
	5	1024 x 768	MONO8		x x*	x x*	x x*	x x*	x x*	x x*
	6	800 x 600	MONO16		x	x	x	x	x	
	7	1024 x 768	MONO16			x	x	x	x	x
2	0	1280 x 960	YUV422				x	x	x	x
	1	1280 x 960	RGB8							
	2	1280 x 960	Mono8			x x*	x x*	x x*	x x*	x x*
	3	1600 x1200	YUV422				x	x	x	x
	4	1600 x1200	RGB8							
	5	1600 x1200	Mono8				x x*	x x*	x x*	x x*
	6	1280 x 960	Mono16				x	x	x	x
	7	1600 x1200	Mono16				x	x	x	x

Table 75: Video formats Guppy PRO F-503B / Guppy PRO F-503C

*: Color camera outputs Mono8 interpolated image.

Only achievable with 1394b (S800).

Note

The following table shows **default Format_7 modes** without Format_7 mode mapping.

- see Chapter Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 on page 120
- see Chapter Format_7 mode mapping (only Guppy PRO F-503) on page 241

Format	Mode	Resolution	Color mode	Maximal S800 frame rates for Format_7 modes
7	0	2588 x 1940 2588 x 1940	Mono8 Mono12 Mono16 Mono8,Raw8 YUV411,Raw12 YUV422,Raw16	13.04 fps 8.69 fps 6.52 fps 13.04 fps 8.69 fps 6.52 fps
	1	1292 x 1940 1292 x 1944	Mono8 Mono12 Mono16 Mono8,Raw8 YUV411,Raw12 YUV422,Raw16	22.76 fps2x H-binning 17.41 fps2x H-binning 13.06 fps2x H-binning 22.76 fps2x H-binning 17.41 fps2x H-binning 13.06 fps2x H-binning
	2	2588 x 968 2588 x 968	Mono8 Mono12 Mono16 Mono8,Raw8 YUV411,Raw12 YUV422,Raw16	23.36 fps2x V-binning 17.41 fps2x V-binning 13.06 fps2x V-binning 23.36 fps2x V-binning 17.41 fps2x V-binning 13.06 fps2x V-binning
	3	1292 x 968 1292 x 968	Mono8 Mono12 Mono16 Mono8,Raw8 YUV411,Raw12 YUV422,Raw16	34.26 fps2x H+V binning 34.26 fps2x H+V binning 26.10 fps2x H+V binning 34.26 fps2x H+V binning 34.26 fps2x H+V binning 26.10 fps2x H+V binning
	4	1292 x 1940 1292 x 1940	Mono8 Mono12 Mono16 Mono8,Raw8 YUV411,Raw12 YUV422,Raw16	22.32 fps2x H-sub-sampling 17.41 fps2x H-sub-sampling 13.06 fps2x H-sub-sampling 22.32 fps2x H-sub-sampling 17.41 fps2x H-sub-sampling 13.06 fps2x H-sub-sampling
	5	2588 x 968 2588 x 968	Mono8 Mono12 Mono16 Mono8,Raw8 YUV411,Raw12 YUV422,Raw16	26.10 fps2x V-subsampling 17.41 fps2x V-subsampling 13.06 fps2x V-subsampling 26.10 fps2x V-subsampling 17.41 fps2x V-subsampling 13.06 fps2x V-subsampling
	6	1292 x 968 1292 x 968	Mono8 Mono12 Mono16 Mono8,Raw8 YUV411,Raw12 YUV422,Raw16	44.32 fps2x H+V sub-sampling 34.71 fps2x H+V sub-sampling 26.10 fps2x H+V sub-sampling 44.32 fps2x H+V sub-sampling 34.71 fps2x H+V sub-sampling 26.10 fps2x H+V sub-sampling

Table 76: Video Format_7 default modes Guppy PRO F-503B / F-503C

Area of interest (AOI)

The camera's image sensor has a defined resolution. This indicates the maximum number of lines and pixels per line that the recorded image may have.

However, often only a certain section of the entire image is of interest. The amount of data to be transferred can be decreased by limiting the image to a section when reading it out from the camera. At a lower vertical resolution the sensor can be read out faster and thus the frame rate is increased.

Note

The setting of AOIs is supported only in video Format_7.

While the size of the image read out for most other video formats and modes is fixed by the IIDC specification, thereby determining the highest possible frame rate, in Format_7 mode the user can set the **upper left corner** and **width and height** of the section (area of interest = AOI) he is interested in to determine the size and thus the highest possible frame rate.

Setting the AOI is done in the IMAGE_POSITION and IMAGE_SIZE registers.

Note

Pay attention to the increments entering in the UNIT_SIZE_INQ and UNIT_POSITION_INQ registers when configuring IMAGE_POSITION and IMAGE_SIZE.

AF_AREA_POSITION and AF_AREA_SIZE contain in the respective bits values for the column and line of the upper left corner and values for the width and height.

Note

For more information see Table 108: Format_7 control and status register on page 213.

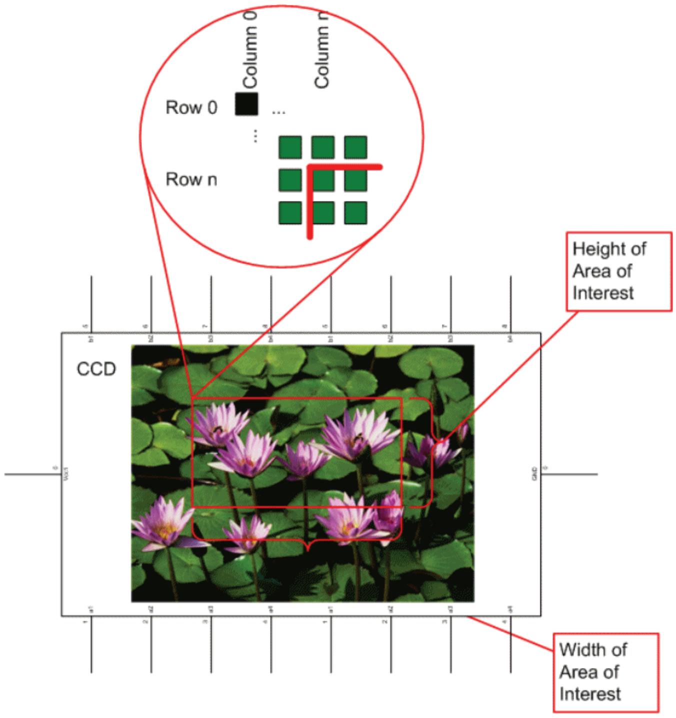


Figure 73: Area of interest (AOI)

Note

- The left position + width and the upper position + height may not exceed the maximum resolution of the sensor.
- The coordinates for width and height must be divisible by 4.

In addition to the area of interest (AOI), some other parameters have an effect on the maximum frame rate:

- The time for reading the image from the sensor and transporting it into the FRAME_BUFFER
- The time for transferring the image over the FireWire™ bus
- The length of the exposure time.

Autofunction AOI

Use this feature to select the image area (work area) on which the following autofunctions work:

- Auto shutter
- Auto gain
- Auto white balance

In the following screenshot you can see an example of the autofunction AOI:

Work area

Figure 74: Example of autofunction AOI (*Show work area* is on)

Note

Autofunction AOI is independent from Format_7 AOI settings.

If you switch off autofunction AOI, work area position and work area size follow the current active image size.

To switch off autofunctions, carry out following actions in the order shown:

1. Uncheck **Show AOI** check box (SmartView **Ctrl2** tab).
2. Uncheck **Enable** check box (SmartView **Ctrl2** tab).
Switch off Auto modes (e.g. **Shutter** and/or **Gain**) (SmartView **Ctrl2** tab).

As a reference it uses a grid of up to 65534 sample points equally spread over the AOI.

Note **Configuration**

To configure this feature in an advanced register see Chapter Autofunction AOI on page 235.

Frame rates

An IEEE 1394 camera requires bandwidth to transport images.

The IEEE 1394b bus has very large bandwidth of at least 62.5 MByte/s for transferring (isochronously) image data. Per cycle up to 8192 bytes (or around 2000 quadlets = 4 bytes@ 800 Mbit/s) can thus be transmitted.

Note

All bandwidth data is calculated with:

1 MByte = 1024 kByte

Depending on the video format settings and the configured frame rate, the camera requires a certain percentage of maximum available bandwidth. Clearly the bigger the image and the higher the frame rate, the more data is to be transmitted.

The following tables indicate the volume of data in various formats and modes to be sent within one cycle (125 µs) at 800 Mbit/s of bandwidth.

The tables are divided into three formats:

Format	Resolution	Max. video format
Format_0	up to VGA	640 x 480
Format_1	up to XGA	1024 x 768
Format_2	up to UXGA	1600 x 1200

Table 77: Overview fixed formats

They enable you to calculate the required bandwidth and to ascertain the number of cameras that can be operated independently on a bus and in which mode.

Format	Mode	Resolution	240 fps	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps
0	0	160 x 120 YUV (4:4:4) 24 bit/pixel	4H 640p 480q	2H 320p 240q	1H 160p 120q	1/2H 80p 60q	1/4H 40p 30q	1/8H 20p 15q	
	1	320 x 240 YUV (4:2:2) 16 bit/pixel	8H 2560p 1280q	4H 1280p 640q	2H 640p 320q	1H 320p 160q	1/2H 160p 80q	1/4H 80p 40q	1/8H 40p 20q
	2	640 x 480 YUV (4:1:1) 12 bit/pixel		8H 5120p 1920q	4H 2560p 960q	2H 1280p 480q	1H 640p 240q	1/2H 320p 120q	1/4H 160p 60q
	3	640 x 480 YUV (4:2:2) 16 bit/pixel			4H 2560p 1280q	2H 1280p 640q	1H 640p 320q	1/2H 320p 160q	1/4H 160p 80q
	4	640 x 480 RGB 24 bit/pixel			4H 2560p 1280q	2H 1280p 960q	1H 640p 480q	1/2H 320p 240q	1/4H 160p 120q
	5	640 x 480 (Mono8) 8 bit/pixel		8H 5120p 1280q	4H 2560p 640q	2H 1280p 320q	1H 640p 160q	1/2H 320p 80q	1/4H 160 p40q
	6	640 x 480 Y (Mono16) 16 bit/pixel			4H 2560p 1280q	2H 1280p 640q	1H 640p 320q	1/2H 320p 160q	1/4H 160p 80q
	7	Reserved							

Table 78: Format_0

As an example, VGA Mono8 @ 60 fps requires four lines (640 x 4 = 2560 pixels/byte) to transmit every 125 µs: this is a consequence of the sensor's line time of about 30 µs, so that no data needs to be stored temporarily.

It takes 120 cycles (120 x 125 µs = 15 ms) to transmit one frame, which arrives every 16.6 ms from the camera. Again no data need to be stored temporarily.

Thus around 64% of the available bandwidth (at S400) is used. Thus one camera can be connected to the bus at S400.

The same camera, run at S800 would require only 32% of the available bandwidth, due to the doubled speed. Thus up to three cameras can be connected to the bus at S800.

Format	Mode	Resolution	240 fps	120 fps	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
1	0	800 x 600 YUV (4:2:2) 16 bit/pixel			5H 4000p 2000q	5/2H 2000p 1000q	5/4H 1000p 500q	5/8H 500p 250q	6/16H 250p 125q	
	1	800 x 600 RGB 24 bit/pixel				5/2H 2000p 1500q	5/4H 1000p 750q	5/8H 500p 375q		
	2	800 x 600 Y (Mono8) 8 bit/pixel		10H 8000p 2000q	5H 4000p 1000q	5/2H 2000p 500q	5/4H 1000p 250q	5/8H 500p 125q		
	3	1024 x 768 YUV (4:2:2) 16 bit/pixel				3H 3072p 1536q	3/2H 1536p 768q	3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q
	4	1024 x 768 RGB 24 bit/pixel					3/2H 1536p 384q	3/4H 768p 576q	3/8H 384p 288q	3/16H 192p 144q
	5	1024 x 768 Y (Mono) 8 bit/pixel			6H 6144p 1536q	3H 3072p 768q	3/2H 1536p 384q	3/4H 768p 192q	3/8H 384p 96q	3/16H 192p 48q
	6	800 x 600 (Mono16) 16 bit/pixel			5H 4000p 2000q	5/2H 2000p 1000q	5/4H 1000p 500q	5/8H 500p 250q	5/16H 250p 125q	
	7	1024 x 768 Y (Mono16) 16 bit/pixel				3H 3072p 1536q	3/2H 1536p 768q	3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q

Table 79: Format_1

Format	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
2	0	1280 x 960 YUV (4:2:2) 16 bit/pixel			2H 2560p 1280q	1H 1280p 640q	1/2H 640p 320q	1/4H 320p 160q
	1	1280 x 960 RGB 24 bit/pixel			2H 2560p 1920q	1H 1280p 960q	1/2H 640p 480q	1/4H 320p 240q
	2	1280 x 960 Y (Mono8) 8 bit/pixel		4H 5120p 1280q	2H 2560p 640q	1H 1280p 320q	1/2H 640p 160q	1/4H 320p 80q
	3	1600 x 1200 YUV(4:2:2) 16 bit/pixel			5/2H 4000p 2000q	5/4H 2000p 1000q	5/8H 1000p 500q	5/16H 500p 250q
	4	1600 x 1200 RGB 24 bit/pixel				5/4H 2000p 1500q	5/8H 1000p 750q	5/16 500p 375q
	5	1600 x 1200 Y (Mono) 8 bit/pixel		5H 8000p 2000q	5/2H 4000p 1000q	5/4H 2000p 500q	5/8H 1000p 250q	5/16H 500p 125q
	6	1280 x 960 Y (Mono16) 16 bit/pixel			2H 2560p 1280q	1H 1280p 640q	1/2H 640p 320q	1/4H 320p 160q
	7	1600 x 1200Y(Mono16) 16 bit/pixel			5/2H 4000p 2000q	5/4H 2000p 1000q	5/8H 1000p 500q	5/16H 500p 250q

Table 80: Format_2

As already mentioned, the recommended limit for transferring isochronous image data is 2000q (quadlets) per cycle or 8192 bytes (with 800 Mbit/s of bandwidth).

Note

- If the cameras are operated with an external trigger the maximum trigger frequency may not exceed the highest continuous frame rate, so preventing frames from being dropped or corrupted.
- IEEE 1394 adapter cards with PCILynx™ chipsets (predecessor of OHCI) have a limit of 4000 bytes per cycle.

The frame rates in video modes 0 to 2 are specified and set fixed by IIDC V1.31.

Frame rates Format_7

In video Format_7 frame rates are no longer fixed.

Note

- Different values apply for the different sensors.
- Frame rates may be further limited by longer shutter times and/or bandwidth limitation from the IEEE 1394 bus.

Details are described in the next chapters:

- Max. frame rate of CCD (theoretical formula)
- Diagram of frame rates as function of AOI by constant width: the curves describe RAW8, RAW12/YUV411, RAW16/YUV422, RGB8 and max. frame rate of CCD
- Table with max. frame rates as function of AOI by constant width

Guppy PRO F-031: AOI frame rates

$$\text{max. frame rate of CCD} = \frac{1}{148.71\mu s + \text{AOI height} \times 16.05\mu s + (508 - \text{AOI height}) \times 3\mu s}$$

Formula 9: **Guppy PRO F-031**: theoretical max. frame rate of CCD

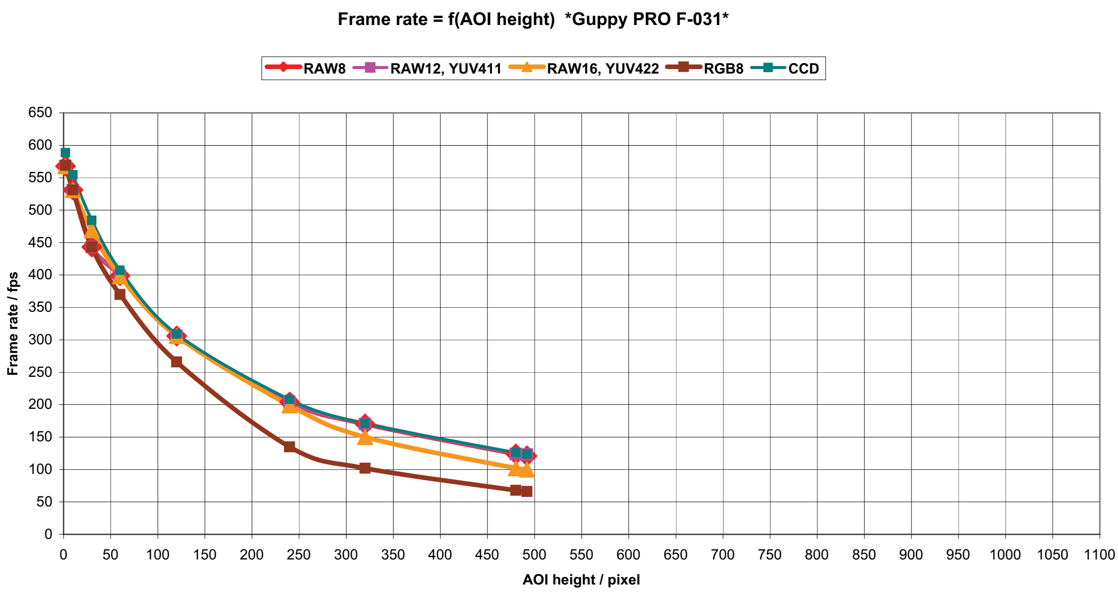


Figure 75: Frame rates **Guppy PRO F-031** as function of AOI height [**width=656**]

AOI height	CCD*	Raw8	Raw12	Raw16	YUV411	YUV422	RGB8
492	123.55	121	123	100	122	99	66
480	125.99	124	124	102	124	102	68
320	170.97	170	170	150	170	150	102
240	208.12	204	204	199	204	199	135
120	308.76	306	306	306	306	307	266
60	407.21	399	399	398	399	399	398
30	484.44	443	443	469	442	469	443
10	554.56	531	531	531	531	531	531
2	588.64	568	568	568	569	569	569

Table 81: Frame rates (fps) of **Guppy PRO F-031** as function of AOI height (pixel) [**width=658**]

* CCD = theoretical max. frame rate (in fps) of CCD according to given formula

Guppy PRO F-032: AOI frame rates

$$\text{max. frame rate of CCD} = \frac{1}{495.5\mu s + \text{AOI height} \times 24.4\mu s + (509 - \text{AOI height}) \times 3\mu s}$$

Formula 10: **Guppy PRO F-032**: theoretical max. frame rate of CCD

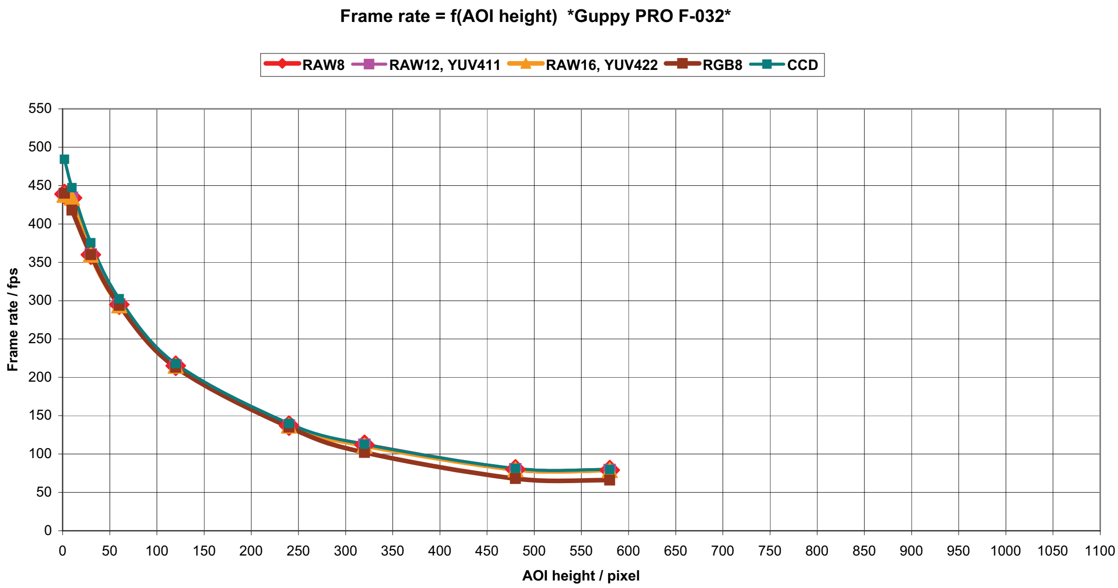


Figure 76: Frame rates **Guppy PRO F-032** as function of AOI height [**width=656**]

AOI height	CCD*	RAW8	RAW12	RAW16	YUV411	YUV422	RGB8
492	79.67	79	79	79	79	79	66
480	81.33	80	80	80	80	80	68
320	112.73	112	112	111	111	111	102
240	139.69	137	137	137	137	137	135
120	217.84	215	215	215	214	214	213
60	302.43	295	295	294	295	294	294
30	375.30	360	360	360	360	360	360
10	447.12	434	434	434	418	418	418
2	484.19	439	438	438	440	465	440

Table 82: Frame rates (fps) of **Guppy PRO F-032** as function of AOI height (pixel) [**width=656**]

* CCD = theoretical max. frame rate (in fps) of CCD according to given formula

Guppy PRO F-125: AOI frame rates

$$\text{max. frame rate of CCD} = \frac{1}{189.3\mu s + \text{AOI height} \times 33.2\mu s + (978 - \text{AOI height}) \times 5\mu s}$$

Formula 11: **Guppy PRO F-125**: theoretical max. frame rate of CCD

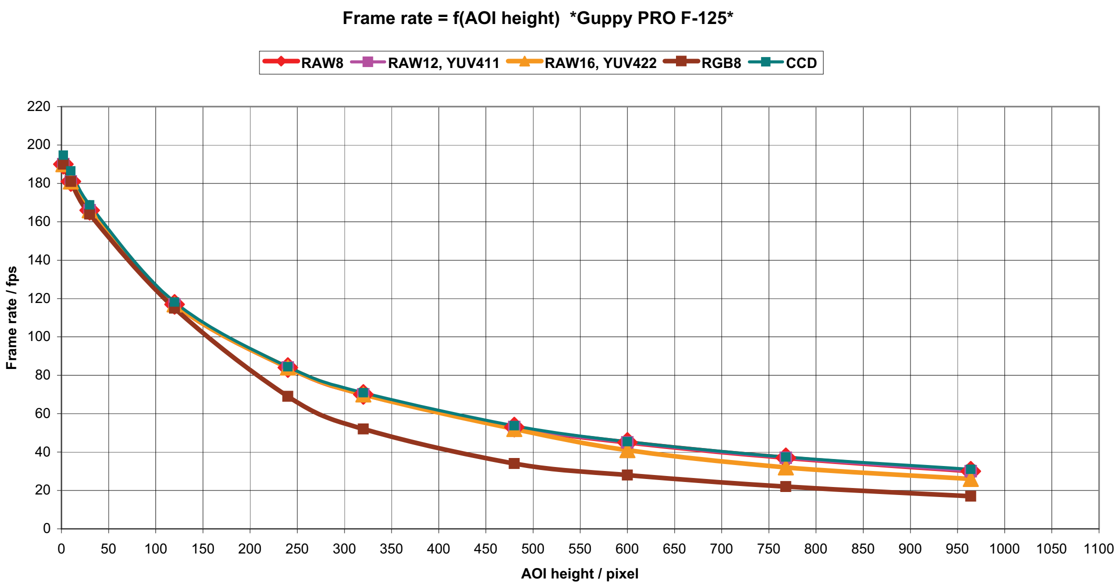


Figure 77: Frame rates **Guppy PRO F-125** as function of AOI height [**width=1292**]

AOI height	CCD*	RAW8	RAW12	RAW16	YUV411	YUV422	RGB8
964	30.99	30.0	30.9	26.0	30.9	26.0	17.5
768	37.40	37.4	37.4	32.8	37.0	32.7	22.0
600	45.45	45.0	45.0	41.9	45.0	41.9	28.0
480	53.71	53.0	53.0	52.0	53.0	52.0	34.9
320	70.90	70.6	70.9	70.7	70.0	70.0	52.0
240	84.40	84.2	84.2	84.2	83.0	83.0	69.6
120	118.15	117.7	117.5	117.5	115.8	115.8	115.9
30	168.76	166.4	166.6	166.7	166.5	166.6	164.0
10	186.52	181.6	181.7	181.0	181.7	181.7	181.7
2	194.71	190.3	190.3	190.3	190.4	190.3	190.4

Table 83: Frame rates (fps) **Guppy PRO F-125** as function of AOI height (pixel) [**width=1292**]

* CCD = theoretical max. frame rate (in fps) of CCD according to given formula (color modes: measured values)

Guppy PRO F-146: AOI frame rates

$$\text{max. frame rate of CCD} = \frac{1}{73.1\mu s + \text{AOI height} \times 56.1\mu s + (1051 - \text{AOI height}) \times 11.6\mu s}$$

Formula 12: **Guppy PRO F-146**: theoretical max. frame rate of CCD

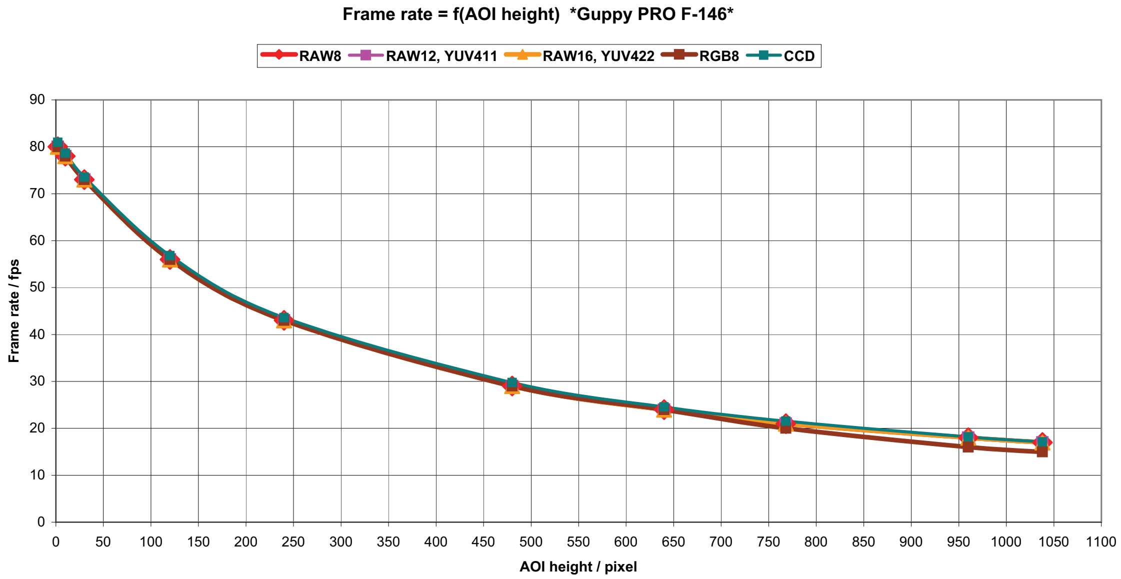


Figure 78: Frame rates **Guppy PRO F-146** as function of AOI height [**width=1388**]

AOI height	CCD*	RAW8	RAW12	RAW16	YUV411	YUV422	RGB8
1038	17.10	17	17	17	17	17	15
960	18.18	18	18	18	18	18	16
768	21.53	21	21	21	21	21	20
640	24.54	24	24	24	24	24	24
480	29.74	29	29	29	29	29	29
240	43.58	43	43	43	43	43	43
120	56.80	56	56	56	56	56	56
30	73.53	73	73	73	73	73	73
10	78.68	78	78	78	78	78	78
2	80.94	80	80	80	80	80	80

Table 84: Frame rates (fps) of **Guppy PRO F-146** as function of AOI height (pixel) [**width=1388**]

* CCD = theoretical max. frame rate (in fps) of CCD according to given formula (color modes: measured values)

Guppy PRO F-201: AOI frame rates

$$\text{max. frame rate of CCD} = \frac{1}{344.90\mu s + \text{AOI height} \times 57.50\mu s + (1238 - \text{AOI height}) \times 8.2\mu s}$$

Formula 13: **Guppy PRO F-201**: theoretical max. frame rate of CCD

Formula 14: Frame rates **Guppy PRO F-201** as function of AOI height [**width=1624**]

AOI height	CCD*	RAW8	RAW12	RAW16	YUV411	YUV422	RGB8
1234	14.01	14	14	14	14	14	10
1200	14.35	14	14	14	14	14	11
960	17.29	17	17	17	17	17	14
800	20.02	20	20	20	20	20	16
768	20.67	20	20	20	20	20	17
600	24.95	24	24	24	24	24	22
480	29.27	29	29	29	29	29	27
400	33.09	33	33	33	32	32	32
300	39.54	39	39	39	39	39	39
240	44.78	44	44	44	44	44	44
120	60.29	60	60	60	60	60	60
30	83.50	83	83	83	82	82	82
10	90.99	90	90	90	90	89	89
2	94.38	94	94	94	94	94	94

Table 85: Frame rates of **Guppy PRO F-201** as function of AOI height [**width=1624**]

* CCD = theoretical max. frame rate (in fps) of CCD according to given formula (color modes: measured values)

Guppy PRO F-503: AOI frame rates

$$\text{max. frame rate of CMOS} = \frac{1}{(\text{AOI height} + 9) \times t_{row}}$$

Formula 15: **Guppy PRO F-503**: theoretical max. frame rate of CMOS (min. shutter, no binning, no sub-sampling). For calculating $t_{row,}$ see Chapter Exposure time of Guppy PRO F-503 (CMOS) on page 141

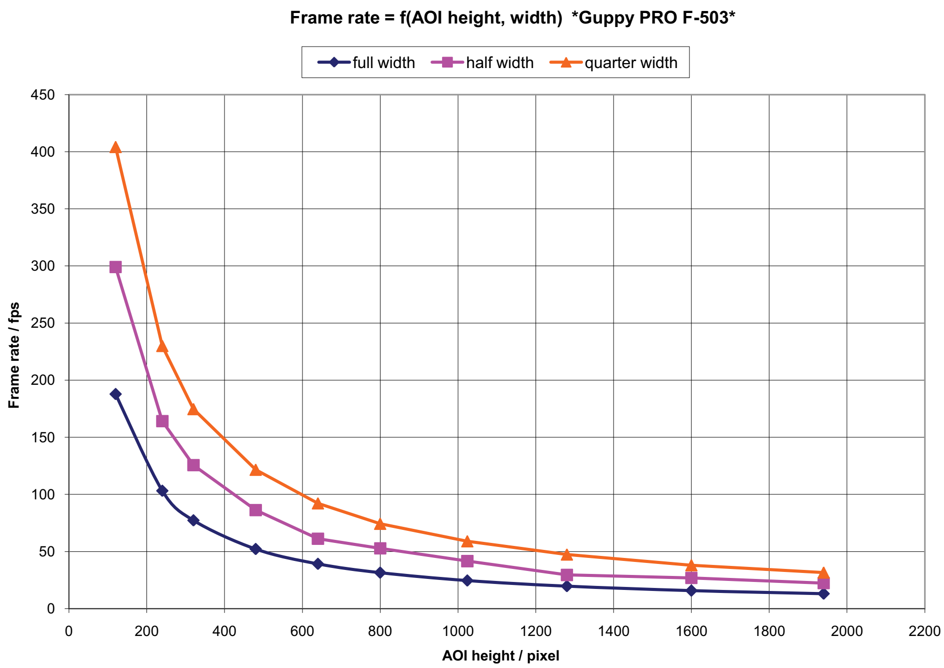


Figure 79: Frame rates Guppy PRO F-503 as function of AOI height and AOI width (full/half/quarter)

The frame rates in the following table are measured directly at the output of the camera (rolling shutter, Raw format). Compare with Chapter How does bandwidth affect the frame rate? on page 220.

AOI height / pixel	Frame rate / fps full width	Frame rate / fps half width	Frame rate / fps quarter width
1940	13.1	22.3	31.6
1600	15.8	26.9	38.0
1280	19.7	29.5	47.4
1024	24.6	41.6***	59.0

Table 86: Frame rates Guppy PRO F-503 as function of AOI height and AOI width (full/half/quarter)

AOI height / pixel	Frame rate / fps full width	Frame rate / fps half width	Frame rate / fps quarter width
800	31.5	52.8**	74.3
640	39.2	61.2	92.2
480	52.2	86.3	121.6
320	77.3	125.6	174.7
240	103.2	164.2	230.0
120	187.9*	299.1	404.2

Table 86: Frame rates Guppy PRO F-503 as function of AOI height and AOI width (full/half/quarter)

*: Max. packet size 7760

**: max. packet size 6980

***: max. packet size 6960

Note

The minimum AOI of GUPPY F-503 is 64 x 64 (AOI width x AOI height).

The readout time for one row is not constant. It varies with AOI width.

How does bandwidth affect the frame rate?

In some modes the IEEE 1394b bus limits the attainable frame rate. According to the 1394b specification on isochronous transfer, the largest data payload size of 8192 bytes per 125 µs cycle is possible with bandwidth of 800 Mbit/s. In addition, there is a limitation, only a maximum number of 65535 (2^{16} -1) packets per frame are allowed.

Note

Certain cameras may offer, depending on their settings in combination with the use of AVT FirePackage higher packet sizes.

Consult your local dealer's support team, if you require additional information on this feature.

The following formula establishes the relationship between the required Byte_Per_Packet size and certain variables for the image. It is valid only for Format_7.

$$\text{BYTE\_PER\_PACKET} = \text{frame rate} \times \text{AOI\_WIDTH} \times \text{AOI\_HEIGHT} \times \text{ByteDepth} \times 125\mu s$$

Formula 16: Byte_per_Packet calculation (only Format_7)

If the value for **BYTE_PER_PACKET** is greater than 8192 (the maximum data payload), the sought-after frame rate cannot be attained.

The attainable frame rate can be calculated using this formula:

(Provision: **BYTE_PER_PACKET** is divisible by 4):

$$\text{frame rate} \approx \frac{\text{BYTE\_PER\_PACKET}}{\text{AOI\_WIDTH} \times \text{AOI\_HEIGHT} \times \text{ByteDepth} \times 125\mu s}$$

Formula 17: Maximum frame rate calculation

ByteDepth is based on the following values:

Mode	bit/pixel	byte per pixel
Mono8, Raw8	8	1
Mono12, Raw12	12	1.5
Mono16, Raw16	14	2
YUV4:2:2	16	2
RGB8	24	3

Table 87: ByteDepth

Example formula for the b/w camera

Mono16, 1392 x 1040, 30 fps desired

$$\text{BYTE\_PER\_PACKET} = 30 \times 1392 \times 1040 \times 2 \times 125\mu s = 10856 > 8192$$

$$\Rightarrow \quad \text{frame rate}_{\text{reachable}} \approx \frac{8192}{1392 \times 1040 \times 2 \times 125\mu s} = 22.64$$

Formula 18: Example maximum frame rate calculation

Test images

Loading test images

FirePackage	Fire4Linux
1. Start **SmartView**. 2. Click the **Edit settings** button.  3. Click **Adv1** tab. 4. In combo box **Test images** choose **Image 1** or another test image.	1. Start **cc1394** viewer. 2. In **Adjustments** menu click on **Picture Control**. 3. Click **Main** tab. 4. Activate Test image check box **on**. 5. In combo box **Test images** choose **Image 1** or another test image.

Table 88: Loading test images in different viewers

Test images for b/w cameras

Guppy PRO b/w cameras have two test images that look the same. Both images show a grey bar running diagonally (mirrored at the middle axis).

- **Image 1** is static.
- **Image 2** moves upwards by 1 pixel/frame.

Figure 80: Grey bar test image

Test images for color cameras

The color cameras have 1 test image:

YUV4:2:2 mode

Figure 81: Color test image

Mono8 (raw data)

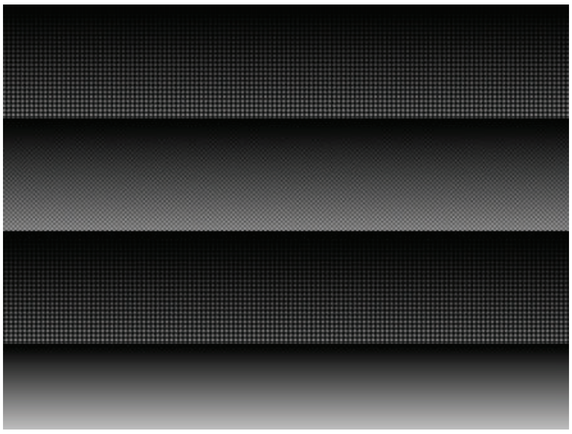


Figure 82: Bayer-coded test image

The color camera outputs Bayer-coded raw data in Mono8 instead of (as described in IIDC V1.31) a real Y signal.

Note

The first pixel of the image is always the **red** pixel from the sensor. (Mirror must be switched off.)

Configuration of the camera

All camera settings are made by writing specific values into the corresponding registers.

This applies to:

- values for general operating states such as video formats and modes, exposure times, etc.
- extended features of the camera that are turned on and off and controlled via corresponding registers (so-called advanced registers).

Camera_Status_Register

The interoperability of cameras from different manufacturers is ensured by IIDC, formerly DCAM (Digital Camera Specification), published by the IEEE 1394 Trade Association.

IIDC is primarily concerned with setting memory addresses (e.g. CSR: Camera_Status_Register) and their meaning.

In principle all addresses in IEEE 1394 networks are 64 bits long.

The first 10 bits describe the Bus_Id, the next 6 bits the Node_Id.

Of the subsequent 48 bit, the first 16 bit are always FFFFh, leaving the description for the Camera_Status_Register in the last 32 bit.

If a CSR F0F00600h is mentioned below this means in full:

Bus_Id, Node_Id, FFFF F0F00600h

Writing and reading to and from the register can be done with programs such as **FireView** or by other programs developed using an API library (e.g. **FirePackage**).10Every register is 32 bit (big endian) and implemented as follows (MSB = Most Significant Bit; LSB = Least Significant Bit):

Far left

Bit 0	Bit 1	Bit 2	...	Bit 30	Bit 31
MSB					LSB

Table 89: 32-bit register

Example

This requires, for example, that to enable **ISO_Enabled mode** (see Chapter ISO_Enable / free-run on page 147), (bit 0 in register 614h), the value 80000000 h must be written in the corresponding register.

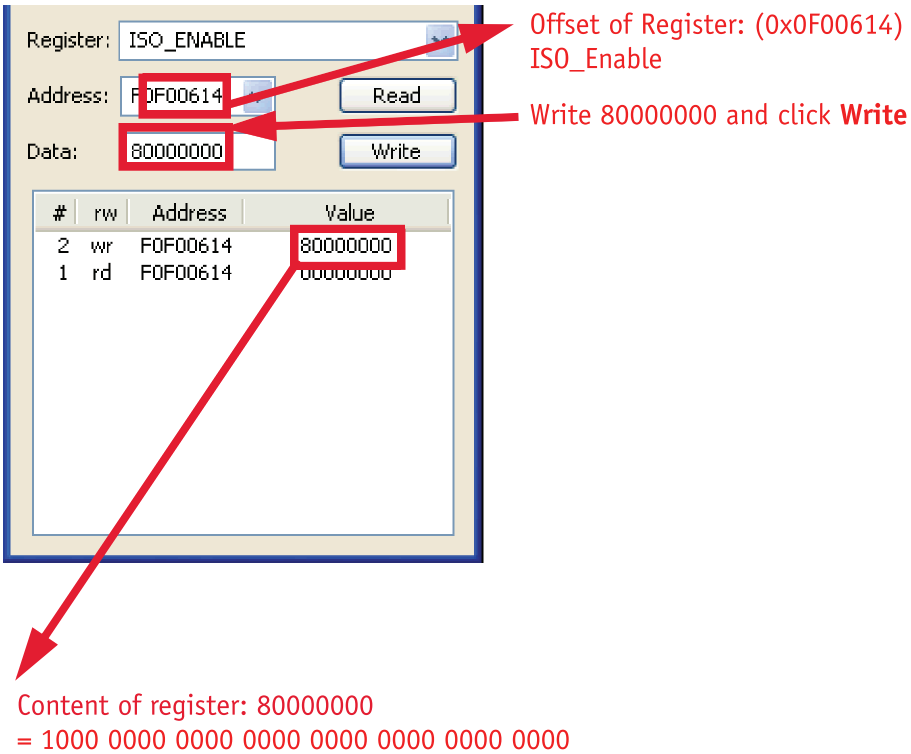
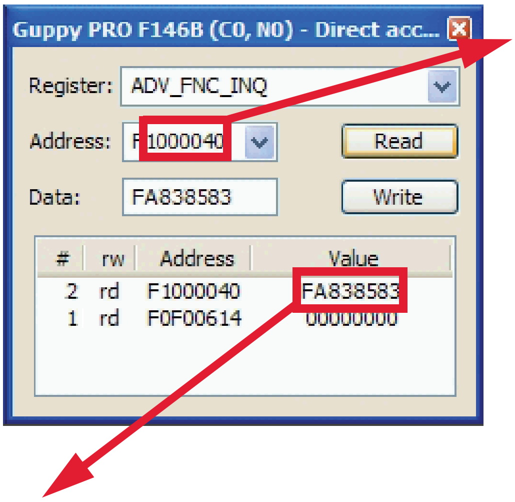


Figure 83: Enabling ISO_Enable



Offset of Register: (0xF1000040)
ADV_FNC_INQ

Content of register: FA838583
= 1111 1010 1000 0011 1000 0101 1000 0011

Table 90: Configuring the camera (Guppy PRO F-146B)

	MaxResolution	TimeBase	ExtdShutter	TestImage			VersionInfo		Look-up tables						Trigger Delay	Misc. features
Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	1	1	1	1	1	0	1	0	1	0	0	0	0	0	1	1

	SoftReset					UserProfiles										GP_Buffer
Bit	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	1

Table 91: Configuring the camera: registers

Sample program

The following sample code in C/C++ shows how the register is set for video mode/format, trigger mode etc. using the **FireGrab** and **FireStack API**.

Example FireGrab

```
…
// Set Videoformat
  if(Result==FCE_NOERROR)
  Result= Camera.SetParameter(FGP_IMAGEFORMAT,MAKEIMAGEFORMAT(RES_640_480,
CM_Y8, FR_15));

  // Set external Trigger
  if(Result==FCE_NOERROR)
  Result= Camera.SetParameter(FGP_TRIGGER,MAKETRIGGER(1,0,0,0,0));

  // Start DMA logic
  if(Result==FCE_NOERROR)
   Result=Camera.OpenCapture();

  // Start image device
  if(Result==FCE_NOERROR)
   Result=Camera.StartDevice();

…
```

Example FireStack API

```
…
// Set framerate

Result=WriteQuad(HIGHOFFSET,m_Props.CmdRegBase+CCR_FRAMERATE,(UINT32)m_Parms.F
rameRate<<29);

  // Set mode
  if(Result)

Result=WriteQuad(HIGHOFFSET,m_Props.CmdRegBase+CCR_VMODE,(UINT32)m_Parms.Video
Mode<<29);

  // Set format
  if(Result)

Result=WriteQuad(HIGHOFFSET,m_Props.CmdRegBase+CCR_VFORMAT,(UINT32)m_Parms.Vid
eoFormat<<29);

  // Set trigger
  if(Result)
  {
    Mode=0;
    if(m_Parms.TriggerMode==TM_EXTERN)
     Mode=0x82000000;
    if(m_Parms.TriggerMode==TM_MODE15)
     Mode=0x820F0000;
    WriteQuad(HIGHOFFSET,m_Props.CmdRegBase+CCR_TRGMODE,Mode);
  }

  // Start continous ISO if not oneshot triggermode
  if(Result && m_Parms.TriggerMode!=TM_ONESHOT)
   Result=WriteQuad(HIGHOFFSET,m_Props.CmdRegBase+CCR_ISOENABLE,0x80000000);


…
```

Configuration ROM

The information in the **configuration ROM** is needed to identify the node, its capabilities and which drivers are required.

The base address for the **configuration ROM** for all registers is FFFF F0000000h.

Note

If you want to use the **DirectControl** program to read or write to a register, enter the following value in the Address field:

F0F00000h + Offset

The **configuration ROM** is divided into

- Bus info block: providing critical information about the bus-related capabilities
- Root directory: specifying the rest of the content and organization, such as:
  - Node unique ID leaf
  - Unit directory
  - Unit dependant info

The base address of the camera control register is calculated as follows based on the camera-specific base address:

	Offset	0-7	8-15	16-23	24-31	
Bus info block	400h	04	29	0C	C0	
	404h	31	33	39	34	.... ASCII for 1394
	408h	20	00	B2	03	.... Bus capabilities
	40Ch	00	0A	47	01	.... Node_Vendor_Id, Chip_id_hi
	410h	Serial number				.... Chip_id_lo
Root directory	414h	00	04	B7	85	According to IEEE1212, the root directory may have another length. The keys (e.g. 8D) point to the offset factors rather than the offset (e.g. 420h) itself.
	418h	03	00	0A	47	
	41Ch	0C	00	83	C0	
	420h	8D	00	00	02	
	424h	D1	00	00	04	

Table 92: Configuration ROM

The entry with key 8D in the root directory (420h in this case) provides the offset for the Node unique ID leaf.

To compute the effective start address of the node unique ID leaf:

To compute the effective start address of the node unique ID leaf	
currAddr	= node unique ID leaf address
destAddr	= address of directory entry
addrOffset	= value of directory entry
destAddr	= currAddr + (4 x addrOffset)
	= 420h + (4 x 000002h)
	= 428h

Table 93: Computing effective start address

420h + 000002h x 4 = 428h

	Offset	0-7	8-15	16-23	24-31	
→	428h	00	02	5E	9E	....CRC
Node unique ID leaf	42Ch	00	0A	47	01	....Node_Vendor_Id,Chip_id_hi
	430h	00	00	Serial number		

Table 94: Configuration ROM

The entry with key D1 in the root directory (424h in this case) provides the offset for the unit directory as follows:

424h + 000004 x 4 = 434h

	Offset	0-7	8-15	16-23	24-31
→	434h	00	03	93	7D
Unit directory	438h	12	00	A0	2D
	43Ch	13	00	01	02
	440h	D4	00	00	01

Table 95: Configuration ROM

The entry with key D4 in the unit directory (440h in this case) provides the offset for unit dependent info:

440h + 0000xx * 4 = 444h

	Offset	0-7	8-15	16-23	24-31	
Unit dependent info →	444h	00	0B	A9	6E	....unit_dep_info_length, CRC
	448h	40	3C	00	00	....command_regs_base
	44Ch	81	00	00	02	....vender_name_leaf
	450h	82	00	00	06	....model_name_leaf
	454h	38	00	00	10	....unit_sub_sw_version
	458h	39	00	00	00	....Reserved
	45Ch	3A	00	00	00	....Reserved
	460h	3B	00	00	00	....Reserved
	464h	3C	00	01	00	....vendor_unique_info_0
	468h	3D	00	92	00	....vendor_unique_info_1
	46Ch	3E	00	00	65	....vendor_unique_info_2
	470h	3F	00	00	00	....vendor_unique_info_3

Table 96: Configuration ROM

And finally, the entry with key 40 (448h in this case) provides the offset for the camera control register:

FFFF F0000000h + 3C0000h x 4 = FFFF F0F00000h

The base address of the camera control register is thus:

FFFF F0F00000h

The offset entered in the table always refers to the base address of F0F00000h.

Implemented registers (IIDC V1.31)

The following tables show how standard registers from IIDC V1.31 are implemented in the camera:

- Base address is F0F00000h
- Differences and explanations can be found in the **Description** column.

Camera initialize register

Offset	Name	Description
000h	INITIALIZE	Assert MSB = 1 for Init.

Table 97: **Camera initialize** register

Inquiry register for video format

Offset	Name	Field	Bit	Description
100h	V_FORMAT_INQ	Format_0	[0]	Up to VGA (non compressed)
		Format_1	[1]	SVGA to XGA
		Format_2	[2]	SXGA to UXGA
		Format_3	[3..5]	Reserved
		Format_6	[6]	Still Image Format
		Format_7	[7]	Partial Image Format
		---	[8..31]	Reserved

Table 98: **Format** inquiry register

Inquiry register for video mode

Offset	Name	Field	Bit	Description	Color mode
180h	V_MODE_INQ (Format_0)	Mode_0	[0]	160 x 120	YUV 4:4:4
		Mode_1	[1]	320 x 240	YUV 4:2:2
		Mode_2	[2]	640 x 480	YUV 4:1:1
		Mode_3	[3]	640 x 480	YUV 4:2:2
		Mode_4	[4]	640 x 480	RGB
		Mode_5	[5]	640 x 480	MONO8
		Mode_6	[6]	640 x 480	MONO16
		Mode_X	[7]	Reserved	
		---	[8..31]	Reserved (zero)	
184h	V_MODE_INQ (Format_1)	Mode_0	[0]	800 x 600	YUV 4:2:2
		Mode_1	[1]	800 x 600	RGB
		Mode_2	[2]	800 x 600	MONO8
		Mode_3	[3]	1024 x 768	YUV 4:2:2
		Mode_4	[4]	1024 x 768	RGB
		Mode_5	[5]	1024 x 768	MONO8
		Mode_6	[6]	800 x 600	MONO16
		Mode_7	[7]	1024 x 768	MONO16
		---	[8..31]	Reserved (zero)	
188h	V_MODE_INQ (Format_2)	Mode_0	[0]	1280 x 960	YUV 4:2:2
		Mode_1	[1]	1280 x 960	RGB
		Mode_2	[2]	1280 x 960	MONO8
		Mode_3	[3]	1600 x 1200	YUV 4:2:2
		Mode_4	[4]	1600 x 1200	RGB
		Mode_5	[5]	1600 x 1200	MONO8
		Mode_6	[6]	1280 x 960	MONO16
		Mode_7	[7]	1600 x 1200	MONO16
		---	[8..31]	Reserved (zero)	
18Ch … 197h	Reserved for other V_MODE_INQ_x for Format_x.			Always 0	
198h	V_MODE_INQ_6 (Format_6)			Always 0	

Table 99: **Video mode** inquiry register

Offset	Name	Field	Bit	Description	Color mode
19Ch	V_MODE_INQ	Mode_0	[0]	Format_7 Mode_0	
	(Format_7)	Mode_1	[1]	Format_7 Mode_1	
		Mode_2	[2]	Format_7 Mode_2	
		Mode_3	[3]	Format_7 Mode_3	
		Mode_4	[4]	Format_7 Mode_4	
		Mode_5	[5]	Format_7 Mode_5	
		Mode_6	[6]	Format_7 Mode_6	
		Mode_7	[7]	Format_7 Mode_7	
		---	[8..31]	Reserved (zero)	

Table 99: **Video mode** inquiry register

Inquiry register for video frame rate and base address

Offset	Name	Field	Bit	Description
200h	V_RATE_INQ	FrameRate_0	[0]	Reserved
	(Format_0, Mode_0)	FrameRate_1	[1]	Reserved
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
204h	V_RATE_INQ	FrameRate_0	[0]	1.875 fps
	(Format_0, Mode_1)	FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
208h	V_RATE_INQ (Format_0, Mode_2)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
20Ch	V_RATE_INQ (Format_0, Mode_3)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
210h	V_RATE_INQ (Format_0, Mode_4)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
214h	V_RATE_INQ (Format_0, Mode_5)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
218h	V_RATE_INQ	(Format_0, Mode_6) FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
21Ch … 21Fh	Reserved V_RATE_INQ_0_x (for other Mode_x of Format_0)			Always 0
220h	V_RATE_INQ (Format_1, Mode_0)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
224h	V_RATE_INQ (Format_1, Mode_1)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	Reserved
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
228h	V_RATE_INQ (Format_1, Mode_2)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	Reserved
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
22Ch	V_RATE_INQ (Format_1, Mode_3)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
230h	V_RATE_INQ (Format_1, Mode_4)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
234h	V_RATE_INQ (Format_1, Mode_5)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)
238h	V_RATE_INQ (Format_1, Mode_6)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	240 fps (V1.31)
		---	[8..31]	Reserved (zero)

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
23Ch	V_RATE_INQ (Format_1, Mode_7)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)
240h	V_RATE_INQ (Format_2, Mode_0)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	Reserved
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)
244h	V_RATE_INQ (Format_2, Mode_1)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	Reserved
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
248h	V_RATE_INQ (Format_2, Mode_2)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (V1.31)
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)
24Ch	V_RATE_INQ (Format_2, Mode_3)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	Reserved
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)
250h	V_RATE_INQ (Format_2, Mode_4)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	Reserved
		FrameRate_6	[6]	Reserved
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
254h	V_RATE_INQ (Format_2, Mode_5)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	Reserved
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)
258h	V_RATE_INQ (Format_2, Mode_6)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	Reserved
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved (zero)
25Ch	V_RATE_INQ (Format_2, Mode_7)	FrameRate_0	[0]	1.875 fps
		FrameRate_1	[1]	3.75 fps
		FrameRate_2	[2]	7.5 fps
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	Reserved
		FrameRate_7	[7]	Reserved
		---	[8..31]	Reserved
260h … 2BFh	Reserved V_RATE_INQ_y_x (for other Format_y, Mode_x)			
2C0h	V_REV_INQ_6_0 (Format_6, Mode0)			Always 0
2C4h .. 2DFh	Reserved V_REV_INQ_6_x (for other Mode_x of Format_6)			Always 0

Table 100: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
2E0h		V-CSR_INQ_7_0	[0..31]	CSR_quadlet offset for Format_7 Mode_0
2E4h		V-CSR_INQ_7_1	[0..31]	CSR_quadlet offset for Format_7 Mode_1
2E8h		V-CSR_INQ_7_2	[0..31]	CSR_quadlet offset for Format_7 Mode_2
2ECh		V-CSR_INQ_7_3	[0..31]	CSR_quadlet offset for Format_7 Mode_3
2F0h		V-CSR_INQ_7_4	[0..31]	CSR_quadlet offset for Format_7 Mode_4
2F4h		V-CSR_INQ_7_5	[0..31]	CSR_quadlet offset for Format_7 Mode_5
2F8h		V-CSR_INQ_7_6	[0..31]	CSR_quadlet offset for Format_7 Mode_6
2FCh		V-CSR_INQ_7_7	[0..31]	CSR_quadlet offset for Format_7 Mode_7

Table 100: **Frame rate** inquiry register

Inquiry register for basic function

Offset	Name	Field	Bit	Description
400h	BASIC_FUNC_INQ	Advanced_Feature_Inq	[0]	Inquiry for advanced features (Vendor unique Features)
		Vmode_Error_Status_Inq	[1]	Inquiry for existence of Vmode_Error_Status register
		Feature_Control_Error_Status_Inq	[2]	Inquiry for existence of Feature_Control_Error_Status
		Opt_Func_CSR_Inq	[3]	Inquiry for Opt_Func_CSR
		---	[4..7]	Reserved
		1394b_mode_Capability	[8]	Inquiry for 1394b_mode_Capability
		---	[9..15]	Reserved
		Cam_Power_Cntl	[16]	Camera process power ON/OFF capability
		---	[17..18]	Reserved
		One_Shot_Inq	[19]	One-shot transmission capability
		Multi_Shot_Inq	[20]	Multi-shot transmission capability
		---	[21..27]	Reserved
		Memory_Channel	[28..31]	Maximum memory channel number (N) If 0000, no user memory available

Table 101: **Basic function** inquiry register

Inquiry register for feature presence

Offset	Name	Field	Bit	Description
404h	FEATURE_HI_INQ	Brightness	[0]	Brightness control
		Auto_Exposure	[1]	Auto_Exposure control
		---	[2]	Reserved
		White_Balance	[3]	White balance control
		Hue	[4]	Hue control
		Saturation	[5]	Saturation control
		Gamma	[6]	Gamma control
		Shutter	[7]	Shutter control
		Gain	[8]	Gain control
		Iris	[9]	Iris control
		Focus	[10]	Focus control
		Temperature	[11]	Temperature control
		Trigger	[12]	Trigger control
		Trigger_Delay	[13]	Trigger_Delay control
		---	[14]	Reserved
		Frame_Rate	[15]	Frame_Rate control
		---	[16..31]	Reserved
408h	FEATURE_LO_INQ	Zoom	[0]	Zoom control
		Pan	[1]	Pan control
		Tilt	[2]	Tilt control
		Optical_Filter	[3]	Optical_Filter control
		---	[4..15]	Reserved
		Capture_Size	[16]	Capture_Size for Format_6
		Capture_Quality	[17]	Capture_Quality for Format_6
		---	[16..31]	Reserved
40Ch	OPT_FUNCTION_INQ	---	[0]	Reserved
		PIO	[1]	Parallel Input/Output control
		SIO	[2]	Serial Input/Output control
		Strobe_out	[4..31]	Strobe signal output

Table 102: **Feature presence** inquiry register

Offset	Name	Field	Bit	Description
410h .. 47Fh	Reserved			Address error on access
480h	Advanced_Feature_Inq	Advanced_Feature_Quadlet_Offset	[0..31]	Quadlet offset of the advanced feature CSR's from the base address of initial register space (vendor unique) This register is the offset for the Access_Control_Register and thus the base address for Advanced Features. Access_Control_Register does not prevent access to advanced features. In some programs it should still always be activated first. **Advanced Feature Set Unique Value** is 7ACh and **CompanyID** is A47h.
484h	PIO_Control_CSR_Inq	PIO_Control_Quadlet_Offset	[0..31]	Quadlet offset of the PIO_Control CSR's from the base address of initial register space (Vendor unique)
488h	SIO_Control_CSR_Inq	SIO_Control_Quadlet_Offset	[0..31]	Quadlet offset of the SIO_Control CSR's from the base address of initial register space (vendor unique)
48Ch	Strobe_Output_CSR_Inq	Strobe_Output_Quadlet_Offset	[0..31]	Quadlet offset of the Strobe_Output signal CSR's from the base address of initial register space (vendor unique)

Table 102: **Feature presence** inquiry register

Inquiry register for feature elements

Register	Name	Field	Bit	Description
0xF0F00500	BRIGHTNESS_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		---	[2]	Reserved
		One_Push_Inq	[3]	One-push auto mode (controlled automatically by the camera once)
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto Mode (Controlled automatically by the camera)
		Manual_Inq	[7]	Manual Mode (Controlled by user)
		Min_Value	[8..19]	Minimum value for this feature
		Max_Value	[20..31]	Maximum value for this feature
504h	AUTO_EXPOSURE_INQ	Same definition as Brightness_inq.		
508h	SHARPNESS_INQ	Same definition as Brightness_inq.		
50Ch	WHITE_BAL_INQ	Same definition as Brightness_inq.		
510h	HUE_INQ	Same definition as Brightness_inq.		
514h	SATURATION_INQ	Same definition as Brightness_inq.		
518h	GAMMA_INQ	Same definition as Brightness_inq.		
51Ch	SHUTTER_INQ	Same definition as Brightness_inq.		
520h	GAIN_INQ	Same definition as Brightness_inq.		
524h	IRIS_INQ	Always 0		
528h	FOCUS_INQ	Always 0		
52Ch	TEMPERATURE_INQ	Same definition as Brightness_inq.		

Table 103: **Feature elements** inquiry register

Register	Name	Field	Bit	Description
530h	TRIGGER_INQ	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		---	[2..3	Reserved
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Polarity_Inq	[6]	Capability of changing the polarity of the trigger input
		Value_Read_Inq	[7]	Capability of reading raw trigger input Here you can read if trigger is active. In case of external trigger, you can read a combined signal.
		Trigger_Source0_Inq	[8]	Presence of Trigger Source 0 ID=0 Indicates usage of standard inputs.
		---	[9..31]	Reserved

Table 103: **Feature elements** inquiry register

Register	Name	Field	Bit	Description
534h	TRIGGER_DELAY_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		---	[2]	Reserved
		One_Push_Inq	[3]	One Push auto mode Controlled automatically by the camera once)
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto Mode (Controlled automatically by the camera)
		Manual_Inq	[7]	Manual Mode (Controlled by user)
		Min_Value	[8..19]	Minimum value for this feature
		Max_Value	[20..31]	Maximum value for this feature
538 .. 57Ch	Reserved for other FEATURE_HI_INQ			
580h	ZOOM_INQ	Always 0		
584h	PAN_INQ	Always 0		
588h	TILT_INQ	Always 0		
58Ch	OPTICAL_FILTER_INQ	Always 0		
590 .. 5BCh	Reserved for other FEATURE_LO_INQ	Always 0		
5C0h	CAPTURE_SIZE_INQ	Always 0		
5C4h	CAPTURE_QUALITY_INQ	Always 0		
5C8h .. 5FCh	Reserved for other FEATURE_LO_INQ	Always 0		

Table 103: **Feature elements** inquiry register

Status and control registers for camera

Register	Name	Field	Bit	Description
600h	CUR-V-Frm_RATE/Revision	Bit [0..2] for the frame rate		
604h	CUR-V-MODE	Bit [0..2] for the current video mode		
608h	CUR-V-FORMAT	Bit [0..2] for the current video format		
60Ch	ISO-Channel	Bit [0..3] for channel, [6..7] for ISO speed		
610h	Camera_Power	Always 0		
614h	ISO_EN/Continuous_Shot	Bit 0: 1 for start continuous shot; 0 for stop continuos shot		
618h	Memory_Save	Always 0		
61Ch	One_Shot, Multi_Shot, Count Number	See Chapter One-shot on page 144 See Chapter Multi-shot on page 147		
620h	Mem_Save_Ch	Always 0		
624	Cur_Mem_Ch	Always 0		
628h	Vmode_Error_Status	Error in combination of Format/Mode/ISO Speed: Bit(0): No error; Bit(0)=1: error		
62Ch	**Software_Trigger**	Software trigger Write: 0: Reset software trigger 1: Set software trigger (self cleared, when using edge mode; must be set back to 0 manually, when using level mode) Read: 0: Ready (meaning: it's possible to set a software trigger) 1: Busy (meaning: no trigger possible)		

Table 104: **Status and control** registers for camera

Inquiry register for absolute value CSR offset address

Offset	Name	Description
700h	ABS_CSR_HI_INQ_0	Always 0
704h	ABS_CSR_HI_INQ_1	Always 0
708h	ABS_CSR_HI_INQ_2	Always 0
70Ch	ABS_CSR_HI_INQ_3	Always 0
710h	ABS_CSR_HI_INQ_4	Always 0
714h	ABS_CSR_HI_INQ_5	Always 0
718h	ABS_CSR_HI_INQ_6	Always 0
71Ch	ABS_CSR_HI_INQ_7	Always 0
720h	ABS_CSR_HI_INQ_8	Always 0
724h	ABS_CSR_HI_INQ_9	Always 0
728h	ABS_CSR_HI_INQ_10	Always 0
72Ch	ABS_CSR_HI_INQ_11	Always 0
730h	ABS_CSR_HI_INQ_12	Always 0
734 .. 77Fh	Reserved	Always 0
780h	ABS_CSR_LO_INQ_0	Always 0
784h	ABS_CSR_LO_INQ_1	Always 0
788h	ABS_CSR_LO_INQ_2	Always 0
78Ch	ABS_CSR_LO_INQ_3	Always 0
790h .. 7BFh	Reserved	Always 0
7C0h	ABS_CSR_LO_INQ_16	Always 0
7C4h	ABS_CSR_LO_INQ_17	Always 0
7C8h .. 7FFh	Reserved	Always 0

Table 105: **Absolute value** inquiry register

Status and control register for one-push

The **OnePush** feature, WHITE_BALANCE, is currently implemented. If this flag is set, the feature becomes immediately active, even if no images are being input (see Chapter One-push white balance on page 86).

Offset	Name	Field	Bit	Description
800h	BRIGHTNESS	Presence_Inq	[0]	Presence of this feature 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the **Value** field 1: Control with value in the Absolute value CSR If this bit = 1, value in the **Value** field is ignored.
		---	[2-4]	Reserved
		One_Push	[5]	Write 1: begin to work (Self cleared after operation) Read: Value=1 in operation Value=0 not in operation If A_M_Mode =1, this bit is ignored.
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF, 1: ON If this bit =0, other fields will be read only.
		A_M_Mode	[7]	Write: set the mode Read: read a current mode 0: Manual 1: Auto
		---	[8-19]	Reserved
		Value	[20-31]	Value. Write the value in Auto mode, this field is ignored. If **ReadOut** capability is not available, read value has no meaning.

Table 106: **Feature** control register

Offset	Name	Field	Bit	Description
804h	AUTO-EXPOSURE			See above Note: **Target grey level** parameter in SmartView corresponds to Auto_exposure register 0xF0F00804 (IIDC).

Table 106: **Feature** control register

Offset	Name	Field	Bit	Description
80Ch	WHITE-BALANCE	Presence_Inq	[0]	Presence of this feature 0: N/A 1: Available Always 0 for Mono
		Abs_Control	[1]	Absolute value control 0: Control with value in the Value field 1: Control with value in the Absolute value CSR If this bit = 1, value in the Value field is ignored.
		---	[2-4]	Reserved
		One_Push	[5]	Write 1: begin to work (Self cleared after operation) Read: Value=1 in operation Value=0 not in operation If A_M_Mode =1, this bit is ignored.
		ON_OFF	[6]	Write: ON or OFF this feature, Read: read a status 0: OFF 1: ON If this bit =0, other fields will be read only.
		A_M_Mode	[7]	Write: set the mode Read: read a current mode 0: Manual 1: Auto
		U_Value / B_Value	[8-19]	U value / B value Write the value in AUTO mode, this field is ignored. If **ReadOut** capability is not available, read value has no meaning.
		V_Value / R_Value	[20-31]	V value / R value Write the value in AUTO mode, this field is ignored. If **ReadOut** capability is not available, read value has no meaning.

Table 106: **Feature** control register

Offset	Name	Field	Bit	Description
810h	HUE			See above Always 0 for Mono
814h	SATURATION			See above Always 0 for Mono
818h	GAMMA			See above
81Ch	SHUTTER			See Advanced Feature time base See Table 39: CSR: Shutter on page 90
820h	GAIN			See above
824h	IRIS			Always 0
828h	FOCUS			Always 0
830h	TRIGGER_MODE			Can be effected via advanced feature IO_INP_CTRLx.
834h .. 87C	Reserved for other FEATURE_HI			Always 0
880h	Zoom			Always 0
884h	PAN			Always 0
888h	TILT			Always 0
88Ch	OPTICAL_FILTER			Always 0
890 .. 8BCh	Reserved for other FEATURE_LO			Always 0
8C0h	CAPTURE-SIZE			Always 0
8C4h	CAPTURE-QUALITY			Always 0
8C8h .. 8FCh	Reserved for other FEATURE_LO			Always 0

Table 106: **Feature** control register

Feature control error status register

Offset	Name	Description
640h	Feature_Control_Error_Status_HI	Always 0
644h	Feature_Control_Error_Status_LO	Always 0

Table 107: **Feature control** error register

Video mode control and status registers for Format_7

Quadlet offset Format_7 Mode_0

The quadlet offset to the base address for **Format_7 Mode_0**, which can be read out at F0F002E0h (according to Table 100: Frame rate inquiry register on page 192) gives 003C2000h.

4 x 3C2000h = F08000h so that the base address for the latter (Table 108: Format_7 control and status register on page 213) equals F0000000h + F08000h = F0F08000h.

Quadlet offset Format_7 Mode_1

The quadlet offset to the base address for **Format_7 Mode_1**, which can be read out at F0F002E4h (according to Table 100: Frame rate inquiry register on page 192) gives 003C2400h.

4 x 003C2400h = F09000h so that the base address for the latter (Table 108: Format_7 control and status register on page 213) equals F0000000h + F09000h = F0F09000h.

Format_7 control and status register (CSR)

Offset	Name	Description
000h	MAX_IMAGE_SIZE_INQ	According to IIDC V1.31
004h	UNIT_SIZE_INQ	According to IIDC V1.31
008h	IMAGE_POSITION	According to IIDC V1.31
00Ch	IMAGE_SIZE	According to IIDC V1.31
010h	COLOR_CODING_ID	See note
014h	COLOR_CODING_INQ	According to IIDC V1.31
024h . . 033h	COLOR_CODING_INQ	Vendor Unique Color_Coding 0-127 (ID=128-255) **ID=132 ECCID_MONO12** **ID=136 ECCID_RAW12** ID=133 Reserved ID=134 Reserved ID=135 Reserved See Chapter Packed 12-Bit Mode on page 121.
034h	PIXEL_NUMER_INQ	According to IIDC V1.31
038h	TOTAL_BYTES_HI_INQ	According to IIDC V1.31
03Ch	TOTAL_BYTES_LO_INQ	According to IIDC V1.31

Table 108: **Format_7** control and status register

Offset	Name	Description
040h	PACKET_PARA_INQ	See note
044h	BYTE_PER_PACKET	According to IIDC V1.31

Table 108: **Format_7** control and status register

Note

- For all modes in Format_7, **ErrorFlag_1** and **ErrorFlag_2** are refreshed on each access to the Format_7 register.
- Contrary to IIDC V1.31, registers relevant to Format_7 are refreshed on each access. The **Setting_1** bit is automatically cleared after each access.
- When **ErrorFlag_1** or **ErrorFlag_2** are set and Format_7 is configured, no image capture is started.
- Contrary to IIDC V1.31, COLOR_CODING_ID is set to a default value after an INITIALIZE or **reset**.
- Contrary to IIDC V1.31, the **UnitBytePerPacket** field is already filled in with a fixed value in the PACKET_PARA_INQ register.

Advanced features (AVT-specific)

The camera has a variety of extended features going beyond the possibilities described in IIDC V1.31. The following chapter summarizes all available (AVT-specific) advanced features in ascending register order.

Note

This chapter is a **reference guide for advanced registers** and does not explain the advanced features itself.

For detailed description of the theoretical background see

- Chapter Description of the data path on page 82
- Links given in the table below

Advanced registers summary

The following table gives an overview of **all available advanced registers**:

Register	Register name	Description
0xF1000010	VERSION_INFO1	See Table 110: Advanced register: Extended version information on page 217
0xF1000014	VERSION_INFO1_EX	
0xF1000018	VERSION_INFO3	
0xF100001C	VERSION_INFO3_EX	
0xF1000040	ADV_INQ_1	See Table 112: Advanced register: Advanced feature inquiry on page 220 In ADV_INQ_3 there is a new field F7MODE_MAPPING [3] Low-noise Binning [9]
0xF1000044	ADV_INQ_2	
0xF1000048	ADV_INQ_3	
0xF100004C	ADV_INQ_4	
0xF1000100	CAMERA_STATUS	See Table 113: Advanced register: Camera status on page 222
0xF1000200	MAX_RESOLUTION	See Table 114: Advanced register: Maximum resolution inquiry on page 223
0xF1000208	TIMEBASE	See Table 115: Advanced register: Time base on page 223
0xF100020C	EXTD_SHUTTER	See Table 117: Advanced register: Extended shutter on page 225
0xF1000210	TEST_IMAGE	See Table 118: Advanced register: Test images on page 226
0xF1000240	LUT_CTRL	See Table 119: Advanced register: LUT on page 227
0xF1000244	LUT_MEM_CTRL	
0xF1000248	LUT_INFO	

Table 109: **Advanced registers** summary

Register	Register name	Description
0xF1000298	DEFECT_PIXEL_CORRECTION	Defect pixel correction (only Guppy PRO F-503 CMOS) See Table 120: Advanced register: Defect pixel correction on page 229
0xF100029C		
0xF10002A0		
0xF1000300	IO_INP_CTRL1	Guppy PRO housing See Table 20: Advanced register: Input control on page 64
0xF1000320	IO_OUTP_CTRL1	Guppy PRO housing See Table 26: Advanced register: Output control on page 70
0xF1000324	IO_OUTP_CTRL2	
0xF1000328	IO_OUTP_CTRL3	
0xF1000340	IO_INTENA_DELAY	See Table 121: Advanced register: Delayed Integration Enable (IntEna) on page 232
0xF1000360	AUTOSHUTTER_CTRL	See Table 122: Advanced register: Auto shutter control on page 233
0xF1000364	AUTOSHUTTER_LO	
0xF1000368	AUTOSHUTTER_HI	
0xF1000370	AUTOGAIN_CTRL	See Table 123: Advanced register: Auto gain control on page 234
0xF1000390	AUTOFNC_AOI	See Table 124: Advanced register: Autofunction AOI on page 235
0xF1000394	AF_AREA_POSITION	
0xF1000398	AF_AREA_SIZE	
0xF10003A0	COLOR_CORR	Guppy PRO color cameras only See Table 125: Advanced register: Color correction on page 236
0xF1000400	TRIGGER_DELAY	See Table 126: Advanced register: Trigger delay on page 237
0xF1000410	MIRROR_IMAGE	See Table 127: Advanced register: Mirror on page 237
0xF1000510	SOFT_RESET	See Table 128: Advanced register: Soft reset on page 238
0xF1000550	USER PROFILES	See Table 134: Advanced register: User profiles on page 244
0xF1000580	F7MODE_MAPPING	See Table 131: Advanced register: Format_7 mode mapping on page 241
0xF1000640	SWFEATURE_CTRL	See Table 133: Advanced register: Software feature control (disable LEDs) on page 243

Table 109: **Advanced registers** summary

Register	Register name	Description
0xF1000800 0xF1000804	IO_OUTP_PWM1	Guppy PRO housing See Table 28: PWM configuration registers on page 73
0xF1000808 0xF100080C	IO_OUTP_PWM2	
0xF1000810 0xF1000814	IO_OUTP_PWM3	
0xF1000840	IO_INP_DEBOUNCE_1	See Table 57: Advanced register: Debounce time for input ports on page 140
0xF1000850	IO_INP_DEBOUNCE_2	
0xF1000860	IO_INP_DEBOUNCE_3	
0xF1000870	IO_INP_DEBOUNCE_4	
0xF1000FFC	GPDATA_INFO	See Table 138: Advanced register: GPData buffer on page 248
0xF1001000 ... 0xF100nnnn	GPDATA_BUFFER	

Table 109: **Advanced registers** summary

Note

Advanced features should always be activated before accessing them.

Note

- Currently all registers can be written without being activated. This makes it easier to operate the camera using **Directcontrol**.
- AVT reserves the right to require activation in future versions of the software.

Extended version information register

The presence of each of the following features can be queried by the **0** bit of the corresponding register.

Register	Name	Field	Bit	Description
0xF1000010	VERSION_INFO1	µC type ID	[0..15]	Always 0
		µC version	[16..31]	Bcd-coded version number
0xF1000014	VERSION_INFO1_EX	µC version	[0..31]	Bcd-coded version number

Table 110: Advanced register: **Extended version** information

Register	Name	Field	Bit	Description
0xF1000018	VERSION_INFO3	Camera type ID	[0..15]	See Table 111: Camera type ID list on page 219.
		FPGA version	[16..31]	Bcd-coded version number
0xF100001C	VERSION_INFO3_EX	FPGA version	[0..31]	Bcd-coded version number
0xF1000020		---	[0..31]	Reserved
0xF1000024		---	[0..31]	Reserved
0xF1000028		---	[0..31]	Reserved
0xF100002C		---	[0..31]	Reserved
0xF1000030		OrderIDHigh	[0..31]	8 Byte ASCII Order ID
0xF1000034		OrderIDLow	[0..31]	

Table 110: Advanced register: **Extended version** information

The µC version and FPGA firmware version numbers are bcd-coded, which means that e.g. firmware version 0.85 is read as 0x0085 and version 1.10 is read as 0x0110.

The newly added **VERSION_INFOx_EX** registers contain extended bcd-coded version information formatted as *special.major.minor.patch*.

So reading the value **0x00223344** is decoded as:

- special: 0 (decimal)
- major: 22 (decimal)
- minor: 33 (decimal)
- patch: 44 (decimal)

This is decoded to the human readable version **22.33.44** (leading zeros are omitted).

Note

If a camera returns the register set to all zero, that particular camera does not support the extended version information.

The FPGA type ID (= camera type ID) identifies the camera type with the help of the following list:

ID	Camera type
501	Guppy PRO F-031B
502	Guppy PRO F-031C
503	Guppy PRO F-032B
504	Guppy PRO F-032C
---	---
---	---
511	Guppy PRO F-125B
512	Guppy PRO F-125C
---	---
---	---
515	Guppy PRO F-146B
516	Guppy PRO F-146C
517	Guppy PRO F-201B
518	Guppy PRO F-201C
519	Guppy PRO F-503B
520	Guppy PRO F-503C
---	---
---	---

Table 111: Camera type ID list

Advanced feature inquiry

This register indicates with a named bit if a feature is present or not. If a feature is marked as not present the associated register space might not be available and read/write errors may occur.

Note

Ignore unnamed bits in the following table: these bits might be set or not.

Register	Name	Field	Bit	Description
0xF1000040	ADV_INQ_1	MaxResolution	[0]	
		TimeBase	[1]	
		ExtdShutter	[2]	
		TestImage	[3]	
		---	[4]	Reserved
		Sequences	[5]	
		VersionInfo	[6]	
		---	[7]	Reserved
		Look-up tables	[8]	
		---	[9]	Reserved
		---	[10]	Reserved
		---	[11]	Reserved
		---	[12]	Reserved
		---	[13]	Reserved
		TriggerDelay	[14]	
		Mirror image	[15]	
		Soft Reset	[16]	
		---	[17]	Reserved
		---	[18]	Reserved
		---	[19..20]	Reserved
		User Sets	[21]	
		---	[22..29]	Reserved
		Paramlist_Info	[30]	
		GP_Buffer	[31]	

Table 112: Advanced register: **Advanced feature inquiry**

Register	Name	Field	Bit	Description
0xF1000044	ADV_INQ_2	Input_1	[0]	
		---	[1]	Reserved
		---	[2..7]	Reserved
		Output_1	[8]	
		Output_2	[9]	
		Output_3	[10]	
		---	[11]	Reserved
		---	[12..15]	Reserved
		IntEnaDelay	[16]	
		---	[17..23]	Reserved
		Output 1 PWM	[24]	Guppy PRO housing
		Output 2 PWM	[25]	
		Output 3 PWM	[26]	
		---	[27..31]	Reserved
0xF1000048	ADV_INQ_3	Camera Status	[0]	
		Max IsoSize	[1]	
		Paramupd_Timing	[2]	
		F7 mode mapping	[3]	
		Auto Shutter	[4]	
		Auto Gain	[5]	
		Auto FNC AOI	[6]	
		---	[7..11]	Reserved
		Defect Pixel Correction	[12]	
		---	[13..31]	Reserved
0xF100004C	ADV_INQ_4	---	[0]	
		---	[1]	
		---	[2]	
		---	[18..31]	Reserved

Table 112: Advanced register: **Advanced feature inquiry**

Camera status

This register allows to determine the current status of the camera. The most important flag is the **Idle** flag.

If the **Idle** flag is set the camera does not capture and does not send any images.

The **ExSyncArmed** flag indicates that the camera is set up for external triggering. Even if the camera is waiting for an external trigger event the **Idle** flag might get set.

Other bits in this register might be set or toggled: just ignore these bits.

Note

- Excessive polling of this register may slow down the operation of the camera. Therefore the time between two polls of the status register should not be less than 5 milliseconds. If the time between two read accesses is lower than 5 milliseconds the response will be delayed.
- Depending on shutter and isochronous settings the status flags might be set for a very short time and thus will not be recognized by your application.

Register	Name	Field	Bit	Description
0xF1000100	CAMERA_STATUS	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..23]	Reserved
		ID	[24..31]	Implementation ID = 0x01
0xF1000104		---	[0..14]	Reserved
		ExSyncArmed	[15]	External trigger enabled
		---	[16..27]	Reserved
		ISO	[28]	Isochronous transmission
		---	[29..30]	Reserved
		Idle	[31]	Camera idle

Table 113: Advanced register: **Camera status**

Maximum resolution

This register indicates the highest resolution for the sensor and is read-only.

Note

This register normally outputs the MAX_IMAGE_SIZE_INQ Format_7 Mode_0 value.

This is the value given in the specifications tables under **Picture size (max.)** in Chapter Specifications on page 35ff.

Register	Name	Field	Bit	Description
0xF1000200	MAX_RESOLUTION	MaxWidth	[0..15]	Sensor width (read only)
		MaxHeight	[16..31]	Sensor height (read only)

Table 114: Advanced register: **Maximum resolution** inquiry

Time base

Corresponding to IIDC, exposure time is set via a 12-bit value in the corresponding register (SHUTTER_INQ [51Ch] and SHUTTER [81Ch]).

This means that you can enter a value in the range of 1 to 4095.

Guppy PRO cameras use a time base which is multiplied by the shutter register value. This multiplier is configured as the time base via the TIMEBASE register.

Register	Name	Field	Bit	Description
0xF1000208	TIMEBASE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..7]	Reserved
		ExpOffset	[8..19]	Exposure offset in µs
		---	[20..27]	Reserved
		Timebase_ID	[28..31]	See Table 116: Time base ID on page 224.

Table 115: Advanced register: **Time base**

The time base IDs 0-9 are in bit [28] to [31]. See Table 116: Time base ID on page 224. Refer to the following table for code.

Default time base is 20 µs: This means that the integration time can be changed in 20 µs increments with the shutter control.

Note

Time base can only be changed when the camera is in idle state and becomes active only after setting the shutter value.

The **ExpOffset** field specifies the camera specific exposure time offset in microseconds (µs). This time (which should be equivalent to Table 58: Camera-specific exposure time offset on page 141) has to be added to the exposure time (set by any shutter register) to compute the real exposure time.

The **ExpOffset** field might be zero for some cameras: this has to be assumed as an unknown exposure time offset (according to former software versions).

ID	Time base in µs	
0	1	
1	2	
2	5	
3	10	
4	**20**	**Default value**
5	50	
6	100	
7	200	
8	500	
9	1000	

Table 116: Time base ID

Note

The ABSOLUTE VALUE CSR register, introduced in IIDC V1.3, is not implemented.

Extended shutter

The exposure time for long-term integration of up to 67 seconds can be entered with µs precision via the EXTENDED_SHUTTER register.

Register	Name	Field	Bit	Description
0xF100020C	EXTD_SHUTTER	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ExpTime	[6..31]	Exposure time in µs

Table 117: Advanced register: **Extended shutter**

The minimum allowed exposure time depends on the camera model. To determine this value write **1** to the **ExpTime** field and read back the minimum allowed exposure time.

The longest exposure time, 3FFFFFFh, corresponds to 67.11 seconds.

Note

- Exposure times entered via the 81Ch register are mirrored in the extended register, but not vice versa.
- Changes in this register have immediate effect, even when camera is transmitting.
- Extended shutter becomes inactive after writing to a format / mode / frame rate register.
- Extended shutter setting will thus be overwritten by the normal time base/shutter setting after Stop/Start of FireView or FireDemo.

Test images

Bit [8] to [14] indicate which test images are saved. Setting bit [28] to [31] activates or deactivates existing test images.

By activating any test image the following auto features are automatically disabled:

- auto gain
- auto shutter
- auto white balance

Register	Name	Field	Bit	Description
0xF1000210	TEST_IMAGE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..7]	Reserved
		Image_Inq_1	[8]	Presence of test image 1 0: N/A 1: Available
		Image_Inq_2	[9]	Presence of test image 2 0: N/A 1: Available
		Image_Inq_3	[10]	Presence of test image 3 0: N/A 1: Available
		Image_Inq_4	[11]	Presence of test image 4 0: N/A 1: Available
		Image_Inq_5	[12]	Presence of test image 5 0: N/A 1: Available
		Image_Inq_6	[13]	Presence of test image 6 0: N/A 1: Available
		Image_Inq_7	[14]	Presence of test image 7 0: N/A 1: Available
		---	[15..27]	Reserved
		TestImage_ID	[28..31]	0: No test image active 1: Image 1 active 2: Image 2 active …

Table 118: Advanced register: **Test image**s

Look-up tables (LUT)

Load the look-up tables to be used into the camera and choose the look-up table number via the **LutNo** field. Now you can activate the chosen LUT via the LUT_CTRL register.

The LUT_INFO register indicates how many LUTs the camera can store and shows the maximum size of the individual LUTs.

The possible values for **LutNo** are 0..n-1, whereas n can be determined by reading the field **NumOfLuts** of the LUT_INFO register.

Register	Name	Field	Bit	Description
0xF1000240	LUT_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Enable/disable this feature
		---	[7..25]	Reserved
		LutNo	[26..31]	Use look-up table with **LutNo** number
0xF1000244	LUT_MEM_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	Reserved
		EnableMemWR	[5]	Enable write access
		---	[6..7]	Reserved
		AccessLutNo	[8..15]	
		AddrOffset	[16..31]	byte
0xF1000248	LUT_INFO	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..2]	Reserved
		BitsPerValue	[3..7]	Bits used per table item
		NumOfLuts	[8..15]	Maximum number of look-up tables
		MaxLutSize	[16..31]	Maximum look-up table size (bytes)

Table 119: Advanced register: **LUT**

Note

The **BitsPerValue** field indicates how many bits are read from the LUT for any grey-value read from the sensor. To determine the number of bytes occupied for each grey-value round-up the **BitsPerValue** field to the next byte boundary.

Examples:

- BitsPerValue = 8 → 1 byte per grey-value
- BitsPerValue = 14 → 2 byte per grey-value

Divide **MaxLutSize** by the number of bytes per grey-value in order to get the number of LUT entries (grey levels): that is 2^n with n=number of bits read from sensor.

Note

Guppy PRO cameras have the gamma feature implemented via a built-in look-up table. Therefore you can not use gamma and your own look-up table at the same time. Nevertheless you may combine a gamma look-up table into your own look-up table.

Note

When using the LUT feature and the gamma feature pay attention to the following:

- gamma ON → look-up table is switched ON also
- gamma OFF → look-up table is switched OFF also
- look-up table OFF → gamma is switched OFF also
- look-up table ON → gamma is switched OFF

Loading a look-up table into the camera

Loading a look-up table into the camera is done through the GPDATA_BUFFER. Because the size of the GPDATA_BUFFER is smaller than a complete look-up table the data must be written in multiple steps.

To load a lookup table into the camera:

1. Query the limits and ranges by reading LUT_INFO and GPDATA_INFO.
2. Set **EnableMemWR** to true (1).
3. Set **AccessLutNo** to the desired number.
4. Set **AddrOffset** to 0.
5. Write n lookup table data bytes to GPDATA_BUFFER (n might be lower than the size of the GPDATA_BUFFER; AddrOffset is automatically adjusted inside the camera).
6. Repeat step 5 until all data is written into the camera.
7. Set **EnableMemWR** to false (0).

Defect pixel correction

Definition The defect pixel correction mode allows to correct an image with defect pixels. Via threshold you can define the defect pixels in an image. Defect pixel correction is done in the FPGA and defect pixel data can be stored inside the camera.

DPC = defect pixel correction

WR = write

RD = read

MEM, Mem = memory

Note

- Defect pixel correction is always done in **Format_7 Mode_0**.
- When using defect pixel correction with **binning** and **sub-sampling**: first switch to binning/sub-sampling modus and then apply defect pixel correction.

Register	Name	Field	Bit	Description
0xF1000298	DPC_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		BuildError	[1]	Build defect pixel data that reports an error, e.g. more than 2000 defect pixels, see DPDataSize.
		---	[2..4]	Reserved
		BuildDPData	[5]	Build defect pixel data now
		ON_OFF	[6]	Enable/disable this feature
		Busy	[7]	Build defect pixel data in progress
		MemSave	[8]	Save defect pixel data to storage
		MemLoad	[9]	Load defect pixel data from storage
		ZeroDPData	[10]	Zero defect pixel data
		---	[11..17]	Reserved
		Mean	[18..24]	Calculated mean value (7 bit)
		Threshold	[25..31]	Threshold for defect pixel correction

Table 120: Advanced register: **Defect pixel correction**

Register	Name	Field	Bit	Description
0xF100029C	DPC_MEM	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1]	Reserved
		EnaMemWR	[2]	Enable write access from host to RAM
		EnaMemRD	[3]	Enable read access from RAM to host
		DPDataSize	[4..17]	Size of defect pixel data to read from RAM to host. A maximum of 2000 defect pixels can be stored. To get the number of defect pixels read out this value and divide by 4. In case of more than 2000 defect pixels, DPDataSize is set to 2001 pixels (DPDatasize of 8004 divided by 4 equals 2001 pixels) and BuildError flag is set to 1. Defect pixel correction data is done with first 2000 defect pixels only.
		AddrOffset	[18..31]	Address offset to selected defect pixel data
0xF10002A0	DPC_INFO	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..3]	Reserved
		MinThreshold	[4..10]	Minimum value for threshold
		MaxThreshold	[11..17]	Maximum value for threshold
		MaxSize	[18..31]	Maximum size of defect pixel data

Table 120: Advanced register: **Defect pixel correction**

Input/output pin control

Note

- See Chapter Input/output pin control on page 64
- See Chapter IO_INP_CTRL 1 on page 65
- See Chapter IO_OUTP_CTRL 1-3 on page 70
- See Chapter Output modes on page 71

Delayed Integration Enable (IntEna)

A delay time between initiating exposure on the sensor and the activation edge of the **IntEna** signal can be set using this register. The **on/off** flag activates/deactivates integration delay. The time can be set in µs in **DelayTime**.

Note

- Only one edge is delayed.
- If **IntEna_Out** is used to control an exposure, it is possible to have a variation in brightness or to precisely time a flash.

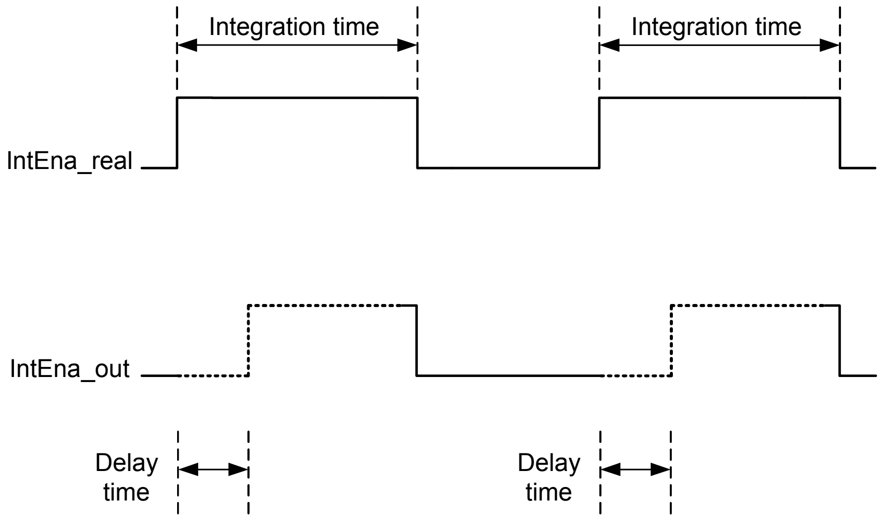


Figure 84: Delayed integration timing

Register	Name	Field	Bit	Description
0xF1000340	IO_INTENA_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Enable/disable integration enable delay
		---	[7..11]	Reserved
		DELAY_TIME	[12..31]	Delay time in µs

Table 121: Advanced register: **Delayed Integration Enable (IntEna)**

Auto shutter control

The table below illustrates the advanced register for **auto shutter control**. The purpose of this register is to limit the range within which auto shutter operates.

Register	Name	Field	Bit	Description
0xF1000360	AUTOSHUTTER_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..31]	Reserved
0xF1000364	AUTOSHUTTER_LO	---	[0..5]	Reserved
		MinValue	[6..31]	Minimum auto shutter value lowest possible value: 10 µs
0xF1000368	AUTOSHUTTER_HI	---	[0..5]	Reserved
		MaxValue	[6..31]	Maximum auto shutter value

Table 122: Advanced register: **Auto shutter control**

Note

- Values can only be changed within the limits of shutter CSR.
- Changes in auto exposure register only have an effect when auto shutter is enabled.
- Auto exposure limits are: 50..205 (**SmartView→Ctrl1 tab**: **Target grey level**)

When both **auto shutter** and **auto gain** are enabled, priority is given to increasing shutter when brightness decreases. This is done to achieve the best image quality with lowest noise.

For increasing brightness, priority is given to lowering gain first for the same purpose.

MinValue and **MaxValue** limits the range the auto shutter feature is allowed to use for the regulation process. Both values are initialized with the minimum and maximum value defined in the standard SHUTTER_INQ register (multiplied by the current active timebase).

If you change the **MinValue** and/or **MaxValue** and the new range exceeds the range defined by the SHUTTER_INQ register, the standard SHUTTER register will not show correct shutter values. In this case you should read the EXTENDED_SHUTTER register for the current active shutter time.

Changing the auto shutter range might not affect the regulation, if the regulation is in a stable condition and no other condition affecting the image brightness is changed.

If both **auto gain** and **auto shutter** are enabled and if the shutter is at its upper boundary and gain regulation is in progress, increasing the upper auto shutter boundary has no effect on auto gain/shutter regulation as long as auto gain regulation is active.

Note

As with the Extended Shutter the value of **MinValue** and **MaxValue** must not be set to a lower value than the minimum shutter time.

Auto gain control

The table below illustrates the advanced register for **auto gain control**.

Register	Name	Field	Bit	Description
0xF1000370	AUTOGAIN_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..3]	Reserved
		MaxValue	[4..15]	Maximum auto gain value
		---	[16..19]	Reserved
		MinValue	[20..31]	Minimum auto gain value

Table 123: Advanced register: **Auto gain control**

MinValue and **MaxValue** limits the range the auto gain feature is allowed to use for the regulation process. Both values are initialized with the minimum and maximum value defined in the standard GAIN_INQ register.

Changing the **auto gain range** might not affect the regulation, if the regulation is in a stable condition and no other condition affecting the image brightness is changed.

If both **auto gain** and **auto shutter** are enabled and if the gain is at its lower boundary and shutter regulation is in progress, decreasing the lower auto gain boundary has no effect on auto gain/shutter regulation as long as auto shutter regulation is active.

Both values can only be changed within the range defined by the standard GAIN_INQ register.

Autofunction AOI

The table below illustrates the advanced register for **autofunction AOI**.

Register	Name	Field	Bit	Description
0xF1000390	AUTOFNC_AOI	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..3]	Reserved
		ShowWorkArea	[4]	Show work area
		---	[5]	Reserved
		ON_OFF	[6]	Enable/disable AOI (see note above)
		---	[7]	Reserved
		YUNITS	[8..19]	Y units of work area/pos. beginning with 0 (read only)
		XUNITS	[20..31]	X units of work area/pos. beginning with 0 (read only)
0xF1000394	AF_AREA_POSITION	Left	[0..15]	Work area position (left coordinate)
		Top	[16..31]	Work area position (top coordinate)
0xF1000398	AF_AREA_SIZE	Width	[0..15]	Width of work area size
		Height	[16..31]	Height of work area size

Table 124: Advanced register: **Autofunction AOI**

The possible increment of the work area position and size is defined by the YUNITS and XUNITS fields. The camera automatically adjusts your settings to permitted values.

Note

If the adjustment fails and the work area size and/or work area position becomes invalid, then this feature is automatically switched off.

Read back the ON_OFF flag, if this feature does not work as expected.

Color correction

To switch off color correction in YUV mode: see bit [6]

Register	Name	Field	Bit	Description
0xF10003A0	COLOR_CORR	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Color correction on/off default: on Write: 02000000h to switch color correction **OFF** Write: 00000000h to switch color correction **ON**
		Reset	[7]	Reset to defaults
		---	[8..31]	Reserved
0xF10003A4	COLOR_CORR_COEFFIC11 = Crr		[0..31]	A number of 1000 equals a color correction coefficient of 1. Color correction values range -1000..+2000 and are **signed 32 bit.** In order for white balance to work properly ensure that the row sum equals to 1000. The maximum row sum is limited to 2000.
0xF10003A8	COLOR_CORR_COEFFIC12 = Cgr		[0..31]	
0xF10003AC	COLOR_CORR_COEFFIC13 = Cbr		[0..31]	
0xF10003B0	COLOR_CORR_COEFFIC21 = Crg		[0..31]	
0xF10003B4	COLOR_CORR_COEFFIC22 = Cgg		[0..31]	
0xF10003B8	COLOR_CORR_COEFFIC23 = Cbg		[0..31]	
0xF10003BC	COLOR_CORR_COEFFIC31 = Crb		[0..31]	
0xF10003C0	COLOR_CORR_COEFFIC32 = Cgb		[0..31]	
0xF10003C4	COLOR_CORR_COEFFIC33 = Cbb		[0..31]	
0xF10003A4 ... 0xF10003FC				Reserved for **testing purposes** **Don't touch!**

Table 125: Advanced register: **Color correction**

For an explanation of the color correction matrix and for further information read Chapter Color correction on page 124.

Trigger delay

Register	Name	Field	Bit	Description
0xF1000400	TRIGGER_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	Reserved
		DelayTime	[11..31]	Delay time in µs

Table 126: Advanced register: **Trigger delay**

The advanced register allows start of the integration to be delayed via **DelayTime** by max. 2^{21} µs, which is max. 2.1 s after a trigger edge was detected.

Note Trigger delay works with external trigger modes only.

Mirror image

The table below illustrates the advanced register for **Mirror image**. Mirror image is only possible with Guppy PRO F-503.

- With Guppy PRO F-503B, **horizontal and vertical mirror** is possible.
- With Guppy PRO F-503C, only **horizontal mirror** is possible.

Register	Name	Field	Bit	Description
0xF1000410	MIRROR_IMAGE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Mirror image on/off 1: on 0: off Default: off
		---	[7..31]	Reserved

Table 127: Advanced register: **Mirror**

Soft reset

Register	Name	Field	Bit	Description
0xF1000510	SOFT_RESET	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		Reset	[6]	Initiate reset
		---	[7..19]	Reserved
		Delay	[20..31]	Delay reset in 10 ms steps

Table 128: Advanced register: **Soft reset**

The **soft reset** feature is similar to the INITIALIZE register, with the following differences:

- 1 or more bus resets will occur
- The FPGA will be rebooted

The reset can be delayed by setting the **Delay** to a value unequal to 0.

The delay is defined in 10 ms steps.

Note

When SOFT_RESET has been defined, the camera will respond to further read or write requests but will not process them.

Maximum ISO packet size

Use this feature to increase the MaxBytePerPacket value of Format_7 modes. This overrides the maximum allowed isochronous packet size specified by IIDC V1.31.

Register	Name	Field	Bit	Description
0xF1000560	ISOSIZE_S400	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Enable/Disable S400 settings
		Set2Max	[7]	Set to maximum supported packet size
		---	[8..15]	Reserved
		MaxIsoSize	[16..31]	Maximum ISO packet size for S400
0xF1000564	ISOSIZE_S800	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Enable/Disable S800 settings
		Set2Max	[7]	Set to maximum supported packet size
		---	[8..15]	Reserved
		MaxIsoSize	[16..31]	Maximum ISO packet size for S800

Table 129: Advanced register: **Maximum ISO packet size**

Example For isochronous packets at a speed of S800 the maximum allowed packet size (IIDC V1.31) is 8192 byte. This feature allows you to extend the size of an isochronous packet up to 11.000 byte at S800. Thus the isochronous bandwidth is increased from 64 MByte/s to approximately 84 MByte/s. You need either PCI Express or PCI-X (64 bit).

The **Maximum ISO packet size** feature ...

- ... reduces the asynchronous bandwidth available for controlling cameras by approximately 75%
- ... may lead to slower responses on commands
- ... is not covered by the IEEE 1394 specification
- ... may not work with all available 1394 host adapters.

Note

We strongly recommend to use **PCI-X (64 bit)** or **PCI Express** adapter.

Restrictions Note the restrictions in the following table. When using software with an Isochronous Resource Manager (IRM): deactivate it.

Software	Restrictions
FireGrab	Deactivate Isochronous Resource Manager: SetParameter (FGP_USEIRMFORBW, 0)
FireStack/FireClass	No restrictions
SDKs using Microsoft driver (Active FirePackage, Direct FirePackage, ...)	n/a
Linux: libdc1394_1.x	No restrictions
Linux: libdc1394_2.x	Deactivate Isochronous Resource Manager: Set DC1394_CAPTURE_FLAGS_BANDWIDTH_ALLOC flag to 0
Third Party Software	Deactivate Isochronous Resource Manager

Table 130: Restrictions for feature: **Maximum ISO packet size**

Operation The maximum allowed isochronous packet size can be set separately for the ISO speeds S400 and S800. Check the associated **Presence_Inq** flag to see for which ISO speed this feature is available.

Setting the **Set2Max** flag to 1 sets the **MaxIsoSize** field to the maximum supported isochronous packet size. Use this flag to query the maximum supported size (may depend on the camera model).

Enable this feature by setting the **ON_OFF** flag to 1 and the **MaxIsoSize** field to a value greater than the default packet size.

The camera ensures:

- that the value of the **MaxIsoSize** field is a multiple of 4.
- that the value isn't lower than the value specified by the IEEE1394 specification.

The settings are stored in the user sets.

Note

Enabling this feature will not change the **MaxBytePerPacket** value automatically. The camera may not use the new isochronous packet size for the **MaxBytePerPacket** value until a write access to the desired Format_7 mode has been issued.

Format_7 mode mapping (only Guppy PRO F-503)

With Format_7 mode mapping it is possible to map special binning and sub-sampling modes to F7M1..F7M7. See *page 120*. For default mappings see Table 47: Default Format_7 binning and sub-sampling modes (per factory) on page 119

Register	Name	Field	Bit	Description
0xF1000580	F7MODE_MAPPING	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..31]	Reserved
0xF1000584	F7MODE_MAP_INQ	F7MODE_00_INQ	[0]	Format_7 Mode_0 presence
		F7MODE_01_INQ	[1]	Format_7 Mode_1 presence
		...	...	...
		F7MODE_31_INQ	[31]	Format_7 Mode_31 presence
0xF1000588	Reserved	---	---	---
0xF100058C	Reserved	---	---	---
0xF1000590	F7MODE_0	Format_ID	[0..31]	Format ID (read only)
0xF1000594	F7MODE_1	Format_ID	[0..31]	Format ID for Format_7 Mode_1
0xF1000598	F7MODE_2	Format_ID	[0..31]	Format ID for Format_7 Mode_2
0xF100059C	F7MODE_3	Format_ID	[0..31]	Format ID for Format_7 Mode_3
0xF10005A0	F7MODE_4	Format_ID	[0..31]	Format ID for Format_7 Mode_4
0xF10005A4	F7MODE_5	Format_ID	[0..31]	Format ID for Format_7 Mode_5
0xF10005A8	F7MODE_6	Format_ID	[0..31]	Format ID for Format_7 Mode_6
0xF10005AC	F7MODE_7	Format_ID	[0..31]	Format ID for Format_7 Mode_7

Table 131: Advanced register: **Format_7 mode mapping**

Additional Format_7 modes

With Format_7 mode mapping you can add some special Format_7 modes which aren't covered by the IIDC standard. These special modes implement **binning** and **sub-sampling**.

To stay as close as possible to the IIDC standard the Format_7 modes can be mapped into the register space of the standard Format_7 modes.

There are visible Format_7 modes and internal Format_7 modes:

- At any time only 8 Format_7 modes can be accessed by a host computer.
- Visible Format_7 modes are numbered from 0 to 7.
- Internal Format_7 modes are numbered from 0 to 27.

Format_7 Mode_0 represents the **mode with the maximum resolution** of the camera: this visible mode cannot be mapped to any other internal mode.

The remaining visible Format_7 Mode_1 ... Mode_7 can be mapped to any internal Format_7 mode.

Example

To map the internal Format_7 Mode_19 to the visible Format_7 Mode_1, write the decimal number 19 to the above listed F7MODE_1 register.

Note

For available Format_7 modes see Figure 60: Mapping of possible Format_7 modes to F7M1...F7M7 (F-503 only) For default mappings per factory see page 162 *on page 120*.

Setting the F7MODE_x register to:

- -1 forces the camera to use the factory defined mode
- -2 disables the respective Format_7 mode (no mapping is applied)

After setup of personal Format_7 mode mappings you have to reset the camera. The mapping is performed during the camera startup only.

Low-noise binning mode (2 x and 4 x binning) (only Guppy PRO F-503)

This register enables/disables **low-noise binning mode**.

This means: an average (and not a sum) of the luminance values is calculated within the FPGA.

The image is therefore darker than with the usual binning mode, but the signal to noise ratio is better (approximately a factor of $\sqrt{2}$).

Offset	Name	Field	Bit	Description
0xF10005B0	LOW_NOISE_BINNING	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Low-noise binning mode on/off
		---	[7..31]	Reserved

Table 132: Advanced register: **Low-noise binning mode**

Software feature control (disable LED)

The software feature control register allows to enable/disable some features of the camera (e.g. disable LED). The settings are stored permanently within the camera and do not depend on any user set.

Disable LEDs

- To disable LEDs set bit [17] to 1.
- To disable LEDs in SmartView:
  Adv3 tab, activate Disable LED functionality check box.

The camera does not show any more the status indicators during normal operation:

Examples:

- Power on is not shown
- Isochronous traffic is not shown
- Asynchronous traffic is not shown

Register	Name	Field	Bit	Description
0xF1000640	SWFEATURE_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		BlankLED_Inq	[1]	Indicates presence of *Disable LEDs* feature.
		---	[2..15]	Reserved
		---	[16]	Reserved
		BlankLED	[17]	0: Behavior as described in Chapter Status LEDs on page 60. 1: Disable LEDs. (Only error codes are shown.)
		---	[18..31]	Reserved

Table 133: Advanced register: Software feature control (disable LEDs)

Note

During the startup of the camera and if an error condition is present, the LEDs behave as described in Chapter Status LEDs on page 93ff.

User profiles

Definition

Within the IIDC specification **user profiles** are called **memory channels**. Often they are called **user sets**. In fact these are different expressions for the following: storing camera settings into a non-volatile memory inside the camera.

User profiles can be programmed with the following advanced feature register:

Offset	Name	Field	Bit	Description
0xF1000550	USER_PROFILE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Error	[1]	An error occurred
		---	[2..6]	Reserved
		Busy	[7]	Save/Load in progress
		Save	[8]	Save settings to profile
		Load	[9]	Load settings from profile
		SetDefaultID	[10]	Set Profile ID as default
		---	[11..19]	Reserved
		ErrorCode	[20..23]	Error code See Table 135: User profiles: Error codes on page 245.
		---	[24..27]	Reserved
		ProfileID	[28..31]	ProfileID (memory channel)

Table 134: Advanced register: **User profiles**

In general this advanced register is a wrapper around the standard memory channel registers with some extensions. In order to query the number of available user profiles please check the **Memory_Channel** field of the **BASIC_FUNC_INQ** register at offset **0x400** (see IIDC V1.31 for details).

The **ProfileID** is equivalent to the memory channel number and specifies the profile number to store settings to or to restore settings from. In any case profile #0 is the hard-coded factory profile and cannot be overwritten.

After an initialization command, startup or reset of the camera, the **ProfileID** also indicates which profile was loaded on startup, reset or initialization.

Note

- The default profile is the profile that is loaded on power-up or an INITIALIZE command.
- A save or load operation delays the response of the camera until the operation is completed. At a time only one operation can be performed.

Store To store the current camera settings into a profile:

1. Write the desired **ProfileID** with the **SaveProfile** flag set.
2. Read back the register and check the **ErrorCode** field.

Restore To restore the settings from a previous stored profile:

1. Write the desired **ProfileID** with the **RestoreProfile** flag set.
2. Read back the register and check the **ErrorCode** field.

Set default To set the default profile to be loaded on startup, reset or initialization:

1. Write the desired **ProfileID** with the **SetDefaultID** flag set.
2. Read back the register and check the **ErrorCode** field.

Error codes

ErrorCode #	Description
0x00	No error
0x01	Profile data corrupted
0x02	Camera not idle during restore operation
0x03	Feature not available (feature not present)
0x04	Profile does not exist
0x05	ProfileID out of range
0x06	Restoring the default profile failed
0x07	Loading LUT data failed
0x08	Storing LUT data failed

Table 135: User profiles: **Error codes**

Reset of error codes

The **ErrorCode** field is set to zero on the next write access.

You may also reset the **ErrorCode**

- by writing to the **USER_PROFILE** register with the **SaveProfile**, **RestoreProfile** and **SetDefaultID** flag not set.
- by writing 00000000h to the **USER_PROFILE** register.

Stored settings

The following table shows the settings stored inside a profile:

Standard registers	Standard registers (Format_7)	Advanced registers
Cur_V_Frm_Rate Cur_V_Mode Cur_V_Format ISO_Channel ISO_Speed BRIGHTNESS AUTO_EXPOSURE (Target grey level) WHITE_BALANCE (+ auto on/off) HUE (+ hue on) SATURATION (+ saturation on) GAMMA (+ gamma on) SHUTTER (+ auto on/off) GAIN TRIGGER_MODE TRIGGER_POLARITY TRIGGER_DELAY ABS_GAIN	IMAGE_POSITION (AOI) IMAGE_SIZE (AOI) COLOR_CODING_ID BYTES_PER_PACKET	TIMEBASE EXTD_SHUTTER IO_INP_CTRL IO_OUTP_CTRL IO_INTENA_DELAY AUTOSHUTTER_CTRL AUTOSHUTTER_LO AUTOSHUTTER_HI AUTOGAIN_CTRL AUTOFNC_AOI (+ on/off) TRIGGER_DELAY MIRROR_IMAGE LUT_CTRL (LutNo; ON_OFF is not saved)

Table 136: User profile: **stored settings**

The user can specify which user profile will be loaded upon startup of the camera.

This frees the user software from having to restore camera settings, that differ from default, after every startup. This can be especially helpful if third party software is used which may not give easy access to certain advanced features or may not provide efficient commands for quick writing of data blocks into the camera.

Note

- A profile save operation automatically disables capturing of images.
- A profile save or restore operation is an uninterruptable (atomic) operation. The write response (of the asynchronous write cycle) will be sent after completion of the operation.
- Restoring a profile will not overwrite other settings than listed above.
- If a restore operation fails or the specified profile does not exist, all registers will be overwritten with the hard-coded factory defaults (profile #0).
- Data written to this register will not be reflected in the standard memory channel registers.

Pulse-width modulation (PWM)

Note

See Table 28: PWM configuration registers on page 73.

Global reset release shutter (only Guppy PRO F-503)

Offset	Name	Field	Bit	Description
0xF10005C0	GLOBAL_RES_REL_SHUTTER	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Global reset release shutter on/off. If off, then electronic rolling shutter will be used.
		---	[7..31]	Reserved

Table 137: Advanced register: **Global reset release shutter**

GPDATA_BUFFER

GPDATA_BUFFER is a general purpose register that regulates the exchange of data between camera and host for:

- writing look-up tables (LUTs) into the camera
- uploading/downloading of shading image (not used) and defect pixel correction data (only CMOS cameras)

GPDATA_INFO Buffer size query

GPDATA_BUFFER indicates the actual storage range

Register	Name	Field	Bit	Description
0xF1000FFC	GPDATA_INFO	BufferSize	[0..31]	Size of GPDATA_BUFFER (byte) Bit 0 ... bit 254 is reserved for shading correction data (not used) Bit 255 is used for defect pixel correction (only CMOS cameras)
0xF1001000 ... 0xF10017FC	GPDATA_BUFFER			

Table 138: Advanced register: **GPData buff**er

Note

- Read the BufferSize before using.
- GPDATA_BUFFER can be used by only one function at a time.

Little endian vs. big endian byte order

- Read/WriteBlock accesses to GPDATA_BUFFER are recommended, to read or write more than 4 byte data. This increases the transfer speed compared to accessing every single quadlet.
- The big endian byte order of the 1394 bus is unlike the little endian byte order of common Intel PCs. Each quadlet of the local buffer, containing the LUT data for instance, has to be swapped bytewise from little endian byte order to big endian byte order before writing on the bus.

Bit depth	little endian ⇨	big endian	Description
8 bit	L0 L1 L2 L3 ⇨	L3 L2 L1 L0	L: low byte H: high byte
16 bit	L0 H0 L1 H1 ⇨	H1 L1 H0 L0	

Table 139: Swapped first quadlet at address offset 0

Firmware update

Firmware updates can be carried out via FireWire cable without opening the camera.

Note

For further information read the application note:
How to update Guppy/Guppy PRO/Pike/Stingray firmware.

This application note and the firmware itself is only accessible for distributors. End customers have to contact technical support.

Extended version number (FPGA/µC)

The new extended version number for microcontroller and FPGA firmware has the following format (4 parts separated by periods; each part consists of two digits):

Special.Major.Minor.Bugfix

or

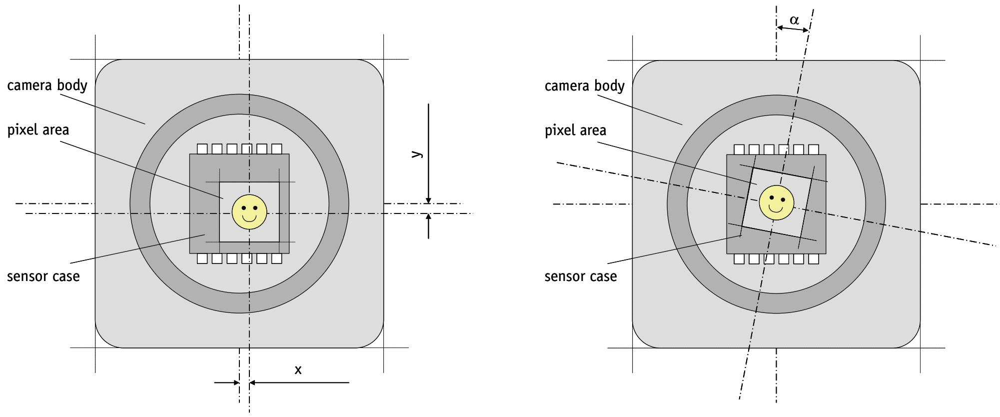
xx.xx.xx.xx

Digit	Description
1st part: Special	Omitted if zero Indicates customer specific versions (OEM variants). Each customer has its own number.
2nd part: Major	Indicates big changes Old: represented the number before the dot
3rd part: Minor	Indicates small changes Old: represented the number after the dot
4th part: Bugfix	Indicates bugfixing only (no changes of a feature) or build number

Table 140: New version number (microcontroller and FPGA)

Appendix

Sensor position accuracy of AVT Guppy PRO cameras



AVT Guppy PRO series

Method of positioning:	Optical alignment of photo sensitive sensor area into camera front module. (lens mount front flange)		
Reference points:	Sensor: Center of pixel area (photo sensitive cells). Camera: Center of camera front flange (outer case edges).		
Accuracy:	x/y:	+/- 150 µm	(Sensor shift)
	z:	+0 / -100 µm	(Optical back focal length)
	α:	+/- 0.5°	(Sensor rotation)

Note:

x/y - tolerances between C-Mount hole and pixel area may be higher.

Figure 85: AVT sensor position accuracy

Index

B

C

D

E

J

L

M

S

T

U

V

W