Operating and user manual

OPAL FAMILY
CAMERA LINK MODELS

Adimec

About Adimec

Adimec is the leading supplier of high-performance digital camera modules and camera-lens assemblies for use in three market segments: machine vision, medical imaging, and applications for government purposes such as traffic and defense systems. In developing our products as a partner to major OEMs around the world, we utilize the synergy between these segments to shine in terms of image quality, speed, dynamic range and reliability.

Adimec is the only company in the market that merges the specific needs of its highly demanding customers to its technological inventiveness, generating vision solutions of outstanding quality. The industry-leading standard products provide many times in customer specials, fulfilling the requirements of your application.

Thanks to this unique approach, Adimec's solutions add crucial competitive value to our customers' high-end systems and their applications, as they yield brilliant results to the users of those systems. The Netherlands-based Holding company has business offices in Europe, the United States, Japan, and Singapore. For more detailed information about Adimec and our products you can visit our website www.adimec.com or you can contact your local dealer or the business offices in your region:

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Contents

1. About this manual

This manual is intended for systems designers and engineers using the Adimec Machine Vision camera series. This manual provides the necessary information for setting-up, configure and maintaining the camera. We strongly recommend reading this manual, at least chapters three and four before you unpack or operate the camera.

1.1 Document applicability

This document applies to the cameras mentioned in Table 1.1. This information can be found on the camera ID label at the bottom of the camera (see figure 1.1 & 1.2) or via the ID? and BS? command. Elaborate information about camera identification can be found at chapter 6.

MODEL	ISSUE
OPAL-1000m/CL	1.0 - 1.2
OPAL-1000c/CL	1.0 - 1.2
OPAL-1600m/CL	1.1
OPAL-1600c/CL	1.2
OPAL-2000m/CL	1.1
OPAL-2000c/CL	1.0
OPAL-4000m/CL	1.0
OPAL-4000c/CL	1.0
OPAL-8000m/CL	1.0
OPAL-8000c/CL	1.0

Table 1.1: Applicable camera models

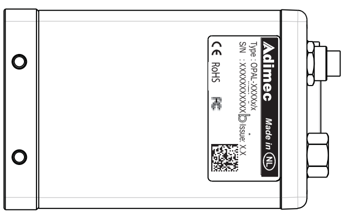

Figure 1.1: Bottom of the camera with Camera Link interface

1.2 How this guide is organized

First this guide focuses on the electrical and mechanical installation of the camera. This information should give enough information to properly design in the camera in the application. Follow up by an explaining of the different commandos for controlling and configuration the camera. Including the possibilities to control the camera and the commando structure followed by the explanation of every commando. At the end of this manual reference information is summarized for easy look up of timing issues and default camera settings.

In this manual we use the following standard symbols in the left margin to draw your attention:

WARNING	Indicates a hazard that can seriously impair operation. Do not proceed beyond any of the above notices until you have fully understood the implications.
	Command syntax
	Return message
NOTE	Practical tip or note
(OPTIONAL)	Function is not standard. For more information obtaining this function please contact your sales representative.

1.3 Liability

Every care has been taken in the preparation of this manual. Please inform your Adimec Business Office of any inaccuracies or omissions. Adimec Advanced Image Systems B.V. cannot be held responsible for any technical or typographical errors and reserves the right to make changes to the product and manuals without prior notice. Adimec Advanced Image Systems B.V. makes no warranty of any kind with regard to the material contained within this document, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Adimec Advanced Image Systems B.V. shall not be liable or responsible for incidental or consequential damages in connection with the furnishing, performance or use of this material.

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2. General introduction

Congratulations on the purchase of your OPAL camera. Your Adimec camera has been extensively tested in order to be sure that we delivered a high quality product.

The OPAL camera is designed for Industrial Machine Vision and measurement systems.

The Camera Link digital interface and the size of the camera make electrical and mechanical interfacing easy. All camera functions are remote controlled. This allows the camera to be optimized for an integrated application.

2.1 Product highlights

The Adimec Machine Vision camera series includes megapixel cameras with the following features:

- Platform based product line
- Interline Transfer CCD
- 14 bit ADC and channel matching down to sub LSB level
- Extremely low read noise
- Frame buffer for decoupling image acquisition and readout
- Selectable channel remapping in camera
- Horizontal and vertical image flip
- Tight tolerances combined with 100 % factory testing
- Ease of integration through Camera Link standard connection

2.2 Applications

Applications can be found in:

- Semiconductor manufacturing
- Electronics manufacturing
- Metrology
- Traffic

2.3 Camera models

The Adimec Machine Vision camera series are available in several models. Primary differences are the resolutions and frame speeds.

MODEL	RESOLUTION	FRAME RATE	MONO./COLOR	INTERFACE
OPAL-1000m	1024 x 1024	123,1 fps	Monochrome	Camera Link
OPAL-1000c	1024 x 1024	123,1 fps	Color	Camera Link
OPAL-1600m	1600 x 1200	69,8 fps	Monochrome	Camera Link
OPAL-1600c	1600 x 1200	69,8 fps	Color	Camera Link
OPAL-2000m	1920 x 1080	65,8 fps	Monochrome	Camera Link
OPAL-2000c	1920 x 1080	65,8 fps	Color	Camera Link
OPAL-4000m	2336 x 1752	33,5 fps	Monochrome	Camera Link
OPAL-4000c	2336 x 1752	33,5 fps	Color	Camera Link
OPAL-8000m	3296 x 2472	17,6 fps	Monochrome	Camera Link
OPAL-8000c	3296 x 2472	17,6 fps	Color	Camera Link

Table 2.1: Camera models and their main differences

2.4 RoHS

These products comply with the European RoHS directive, 2002/95/EC

2.5 Electromagnetic Compatibility (EMC)

This digital equipment fulfills the requirements for radiated emission according to limit B of EN61000-6-3, and the requirements for immunity according to EN61000-6-2 residential, commercial, and light industry.

3. Safety information

3.1 General

A CCD camera is a sensitive device. In order to ensure your warranty on this product, please read the following paragraphs scarefully before you continue to unpack and operate the camera.

- Read and follow the instructions – All the safety and operating instructions in this manual should be read before and be enforced while the camera is operated.
- Retain instructions – The safety and operating instructions should be retained for future reference.
- Perceive the warnings – All actions taken should be executed in compliance with the warnings.
- Do not remove the housing of the camera - There are no user-serviceable parts inside. The internal electronics may be damaged by touching the components.

3.2 Precautions

- It is advised to unpack and handle the camera in a clean, ESD protected work area.
- As long as the lens is not mounted, keep the lens cap in place to prevent dust or contamination from entering the CCD sensor or filter area.
- Remove the lens cap just before the lens is mounted on the camera. It is advised to perform this operation in a clean room or at least a clean bench.
- Never touch the CCD sensor surface. The cover glass is easily damaged, and the CCD sensor can be damaged by ESD (electrostatic discharge).

3.3 Safety symbols

The following safety symbols are applicable to and indicated on the camera.

CE Symbol for “Conformiteé European”

3.4 Handling

In order to prevent damage to the camera and to keep the CCD sensor clean, please pay attention to the following:

- Handle the camera with care. Do not abuse the camera. Avoid striking or shaking it. Improper handling or storage could damage the camera.
- Do not pull or damage the camera cable.
- During camera use, do not wrap the camera unit in any material. This will cause the internal temperature of the unit to increase.
- Do not operate camera beyond its maximum operating temperature, humidity and power source ratings.
- Do not expose the camera to the following environmental conditions:
  - Wet, moist and/or high humidity areas.
  - Direct sunlight.
  - High temperature areas.
  - In the vicinity of objects that release strong magnetic or electric fields.
  - In an electrostatic charged environment.
  - Strong vibration.
- Avoid touching the optical surface of the sensor with any object.
- If the optical surface of the sensor needs cleaning, please follow the directions in chapter 9.4; ‘Cleaning‘.
- The housing is susceptible for scratches. When cleaning the camera, use a soft cloth.

4. Installation

Camera Link at Base configuration is a universal way of connecting the CL series camera to a framegrabber and suitable for high speed applications.

The OPAL camera is also available with Coaxpress or GigE Vision interface. It goes beyond the scope of this manual to elaborate on this. Please contact your local sales representative for further information.

4.1 OPAL interface connections

The camera is equipped with several connectors for the following functions:

- Power
- I/O
- Video and Data

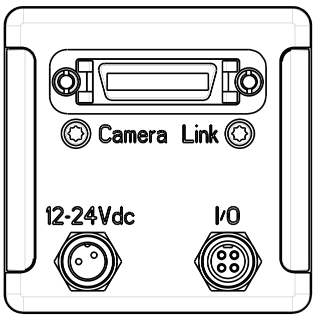


Figure 4.1: Backside of the camera

4.1.1. Power supply

The camera must be powered by a DC power supply.

All cameras adapt automatically to a wide range of input voltage. There is no galvanic isolation between input power lines and internal power lines.

For safety, peripheral equipment must be either double isolated or SELF qualified.

Power connector OPAL camera

Chassis part

- Binder series 712 type 09-0403-00-02

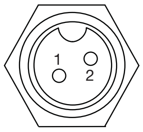


Figure 4.2: Camera male power connector

PIN	FUNCTION
1	10.2 to 27.6 Vdc
2	GND

Table 4.1: Power pin configuration for OPAL-1000.

CAMERA CL MODEL	POWER REQUIREMENT
OPAL-1000	< 5 Watt @12 Volt
OPAL-1600	< 6 Watt @12 Volt
OPAL-2000	< 6 Watt @12 Volt
OPAL-4000	< 6 Watt @12 Volt
OPAL-8000	< 6 Watt @12 Volt

Table 4.2: Power requirement Camera Link series cameras.

NOTE: The supply is reverse voltage protected. When applying power to the camera with the wrong polarity it will not operate, but will not be damaged also.

Mating cable connector:

- Binder series 711 type 99-0072-100-02 (straight)
- Binder series 712 type 99-0402-00-02 (straight)
- Binder series 712 type 99-0402-70-02 (90 degrees angle)

Power cable

All OPAL cameras can be delivered with a power cable (2 meter) as accessory. It is available as Adimec part no. 102830

WIRE	FUNCTION
White	Positive (12 - 24 Vdc)
Brown	Negative (return)
Shield	Mechanical ground

Table 4.3: Power pin configuration

All other wires are not used and should not be connected.

4.1.2. I/O Interface

I/O connection

An input for external triggering of the camera is available at the I/O connector.

Also a trigger output signal from the camera to control an external flash light is available at this connector. The input and output are fully programmable. For reference see par 7.8.

The input and output are galvanic isolated from the internal camera electronics by means of an optocoupler.

I/O connector

Chassis part:

- Binder series 711 type 09-0082-20-04

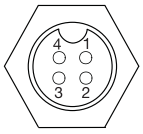


Figure 4.3: Camera female I/O connector

PIN NO.	SIGNAL NAME	DIRECTION	LEVEL	AT THE PIN
1	Flash strobe out	Output		Open collector of optocoupler
2	Trigger in	Input	10..20 mA	Anode of optocoupler(*)
3	Trigger return	Input	Isolated gnd	Cathode of optocoupler
4	Flash strobe return	Output	Isolated gnd	Emitter of optocoupler

Table 4.4: I/O pin configuration.

(*) serial resistors 2x 220 Ω inside Installationcamera.

Mating cable connector

- Binder series 711 type 99-0079-100-04 (straight)
- Binder series 712 type 99-0409-00-04 (straight)
- Binder series 712 type 99-0409-70-04 (90 degrees angle)

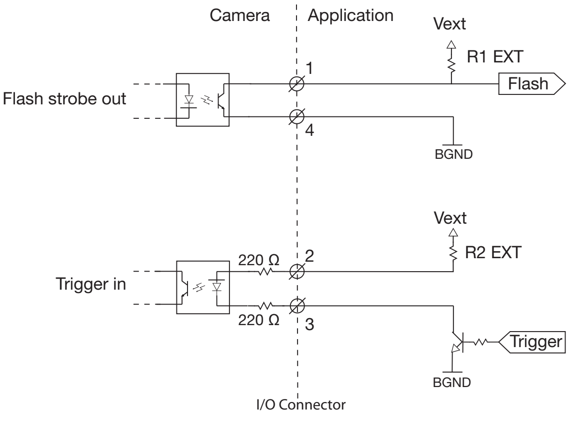


Figure 4.4: Circuit concept of I/O.

NOTE: The delay from non-conductive to conductive state of the phototransistor is less than 1.5 μs. The delay from conductive to non-conductive state of the phototransistor is less than 10 μs.

The recommended termination circuitry is drawn in Figure 4.4.

A current of 2.5 mA is recommended for the Flash output. For the trigger input a current of 10 mA is recommended. These current recommendations translate to the recommended resistor values in table 4.5.

VEXT [V]	R1 EXT [Ω]	R2 EXT [Ω]
3.3	1000	Do not apply
5.0	2000	0
12	4700	470

Table 4.5: Recommended series resistor for trigger input

4.1.3. Video and Data interface

Camera Link

The Camera Link output is designed to connect the camera to a Frame Grabber, in order to transmit the video and to control the camera settings. It is implemented according to the international Camera Link specification, described in the Camera Link Interface Standard for Digital Cameras and Frame Grabbers – Version 1.1 of January 2004.
The maximum theoretical cable length is 7 meter at the rated pixelclock frequency. However, the maximum attainable Camera Link data transmission distance is subject to cable performance, physical connection setup, balance, skew, and clock speed, therefore application dependent.

Camera Link Connector

Camera Link connector type: 3M MDR 26-pins.

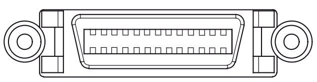


Figure 4.5: Female Camera Link connector at the camera.

Standard Camera Link cables can be ordered at Adimec.

WARNING: Avoid damage by preventing the entry of foreign objects or dirt to the connectors. The tightening torque for the retention screws may not exceed 0.29 Nm.

Camera Link ports

The two video outputs TAP-A and TAP-B of the camera are mapped to the Camera Link ports A, B and C as defined in the Camera Link specification. It is set up as a Camera Link Base configuration and therefore uses one Camera Link connector.

More information about Camera Link configuration can be found in par 10.1.

4.2 Mechanical

4.2.1. Outline dimensions Camera Link series camera

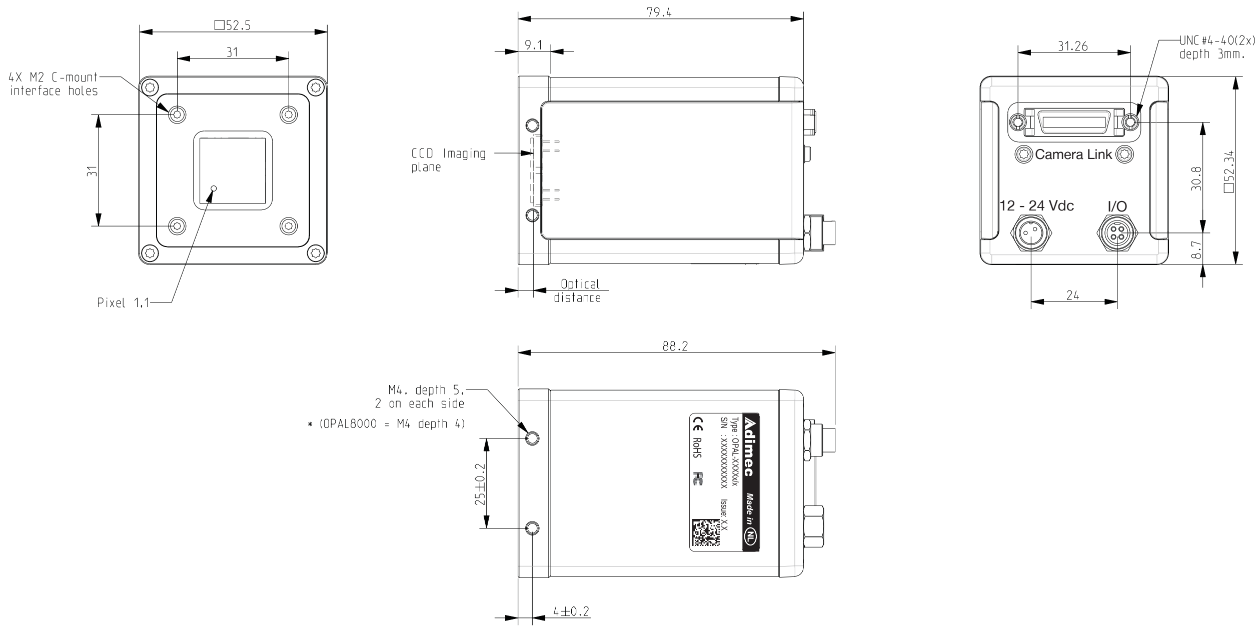


Figure 4.6: Camera outline drawing Camera Link camera.

4.2.2. Lensmount

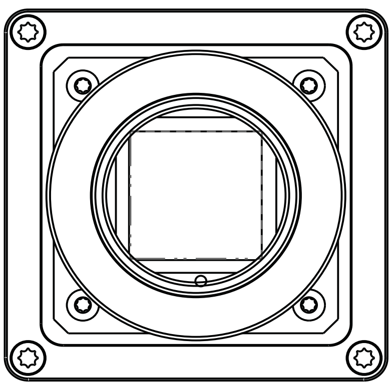


Figure 4.7: 4 Torx screws that hold the C-format lensmount (front view of the camera)

Upon delivery, the OPAL1000, 1600, 2000 and 4000 cameras are fitted with a C-format lensmount by means of four screws as indicated in figure 4.7. To prevent damage and contamination of the CCD a protective plastic cap is placed on the lensmount.

The OPAL8000 camera will be delivered without lensmount.
The OPAL-8000 camera has an 18.13mm (H) x 13.60mm (V) 22.66mm (diag) sized, 4/3” format CCD. Some applications may requires a lensmount and lens in accordance to the optical format listed.

Vignetting can be expected with F# values smaller than F4 when using a C-format lensmount.

NOTE: The protective cap may only be removed by pulling it off. Never try to unscrew the protective cap as this will dissasemble the C-format lensmount.

IN ORDER TO PREVENT DAMAGE TO THE CAMERA AND TO KEEP THE CCD CLEAN, PLEASE TAKE THE FOLLOWING PRECAUTIONS.

- Always keep the lens cap in place, as long as no lens is attached.
- Pull off the lens cap by just before the lens is screwed on the camera. It is advised to perform this operation in a clean room or clean bench.
- Never touch the CCD surface. The cover glass is easily damaged, and the CCD can be damaged by electrostatic discharge (ESD).

4.2.3. Mounting facilities for system integration

In order to provide the facility to integrate the camera into a system, the camera is provided with mounting holes in the top, bottom and left and right sides of the front. See figure 4.6 & 4.8 for more details.

WARNING: The length of the thread is 5 mm. The tightening torque for the retention screws may not exceed 1.9 Nm. To prevent damage, do not use bolts which will exceed the length of the tread. See figure 4.8 for more details

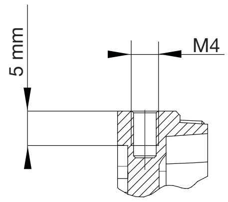


Figure 4.8: Maximum length of tread.

4.3 Environmental

4.3.1. EMC/EMI – ESD

The camera complies to the requirements of EN61000-6-2 and EN61000-6-3.

In order to obtain the best performance, the camera and the connected cables should be shielded from environmental noise sources.

Avoid possible ground loops when integrating in a system. Notice the following circuit diagram.

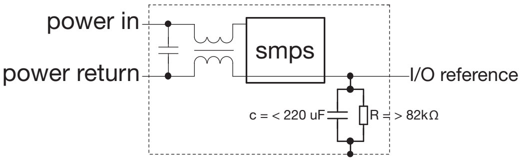


Figure 4.9: Simplified diagram of connections in the camera

Take appropriate precautions to prevent ESD:

The camera is shipped in a special bag designed to prevent ESD. For storage, keep the device in the bag.

- Never insert a metal tool or knife into the bag and rip it open, but open it by hand. It is advised to keep this bag; If it is ever needed to transport the device, the bag is the first line of protection from ESD.
- It is advised to wear an ESD wrist strap connected to the ground of the electrical system.
- If a wrist strap is unavailable, touch a grounded part of the system before handling the camera.
- Avoid touching the connector pins on the camera with bare fingers or tools.
- Protect the camera from high power electrical fields as generated in fans or high voltage power supplies.

4.4 Thermal management

Like any CCD sensor based camera, optimal performance is achieved by leading the heat away from the sensor. Keeping the sensor circuit relatively cool reduces the amount of dark current generated within the CCD sensor. Dark current is the major contributor to Fixed Pattern Noise, Dark Signal Non-Uniformity and other read noise effects. This harms the performance, especially when video is gained to a large extension. In general, the dark current is doubled with every 7°C increase in temperature of the sensor. Also the dark current increases linearly with the integration time. The camera is designed to operate at an ambient temperature between -10 °C and +50°C.

This camera is mechanically designed for optimal thermal conductance from the sensor to the solid front of the camera, in order to keep the sensor at the lowest temperature possible.

When integrating into a system and running at an ambient temperature up to 50°C, it is advised to take proper measures to dispose of the heat in order to gain optimal performance. Heat disposal from the front assembly can be improved by mounting the camera to a solid metal base. Also mounting heat sinks to the remaining sides of the front may contribute to the disposal of heat. Another method to carry away the heat is natural or forced convection.

5. Control of the camera

5.1 Introduction

The camera is fully software controlled via the Camera Link serial channel using a simple ASCII based protocol. It is possible to save settings as ‘power-up default settings’ in the camera.

Basically there are three ways to control the camera:

- By means of the Adimec easy-to-use Windows Control application
- By means of the Adimec Command Console application
- By means of your own dedicated software

In addition to an explanation on how to use the Adimec communication applications, you will also find a description of the command structure. This description should be read and understood when controlling the camera either with the Adimec Command Console application or with your own dedicated software.

Par 10.4 gives an overview of the camera commands and the possible ranges.

5.2 Controlling with the Windows Control application

The Windows Control application will run on W9x, NT, 2000 and XP (32 bit) operating systems and in 32 bit mode on Vista (64bit) systems.
It does not need installing, simply copy the files to a dedicated directory on the hard disk drive.

NOTE: The serial control signals of the camera needs to be mapped onto a communication channel, either by means of a hardware breakout circuit (to a hardware COM-port) or by mapping the control signals onto a serial communication channel supported by the Frame Grabber. In Figures 5.1 and 5.2 both possibilities are depicted in a simplified diagram. The camera in these pictures can either be a Camera Link version or a CoaXPress version (CL with additional CXP interfacebox or CXP Frame Grabber).

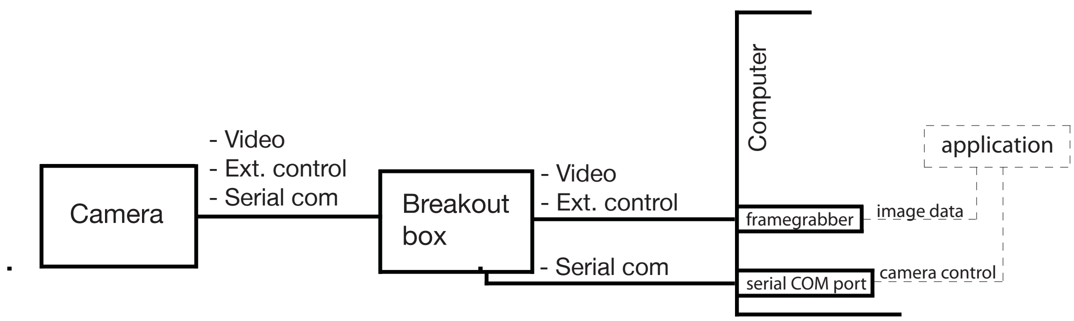


Figure 5.1: Camera Link mapped by means of a hardware breakout box

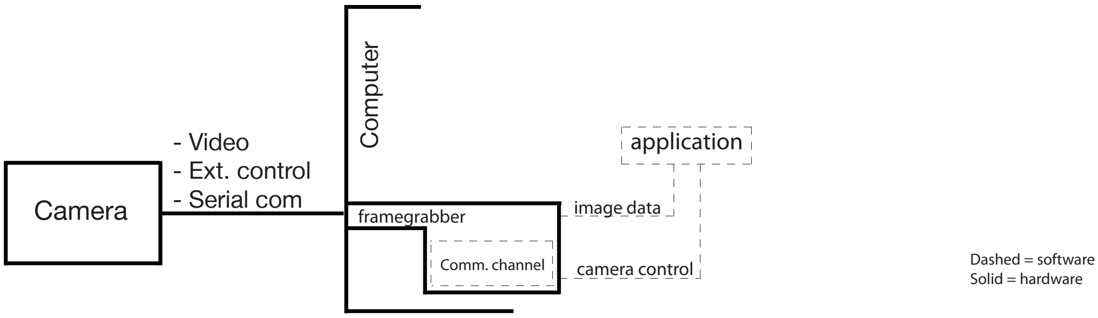


Figure 5.2: Camera Link mapped by means a virtual COM-port supported by the Frame Grabber

After launching the application it will autodetect the COM-port number or other communication channel. Make sure to select the correct COM-port.The application will then check communication and if OK, it will read the camera type and serial number from the camera and display the information in the status bar.

Figure 5.3: Example status bar

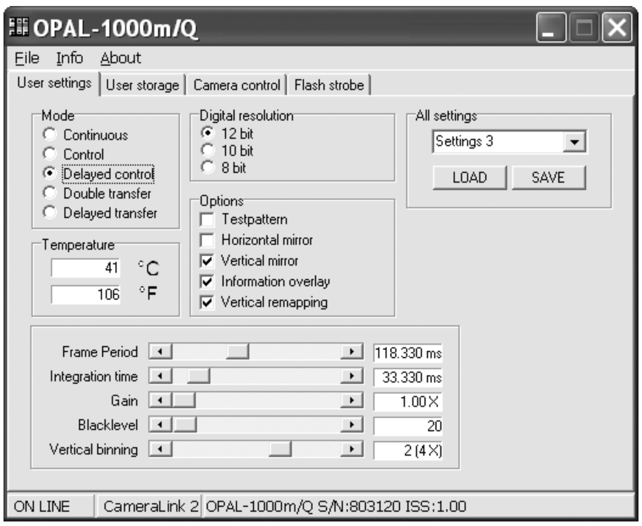


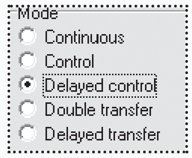
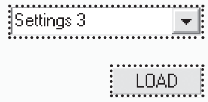
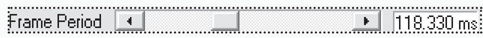
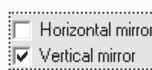
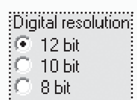
Figure 5.4: User interface example of windows control application

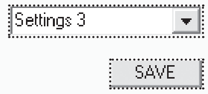
All basic functions of the camera can be controlled by an intuitive user interface. These functions are accessable via different tabs at the top of the application. The following tabs are available

- User settings tab
- User storage tab
- Additional settings tab (only available for color)
- Camera control tab
- Flash strobe tab

NOTE: Depending on camera model, available settings and options are shown.

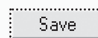
5.2.1. User settings tab

FUNCTION	CONTROL
Acquisition mode In the frame Mode, one of the different Image acquisition modes can be set. The Continuous and Control modes are standard. Delayed control, Double transfer, Delayed transfer are optional. More information regarding image acquisition can be found in chapter 7.	
Activate stored camera settings Up to nine user defined sets of power-up settings can be stored in the camera. These are power-up sets 1-9. Power-up set 0 is the factory default setting. Every power up set contains the values of every tab, except the values of the User storage. The user can choose from which power-up set the camera will power-up. Choose in the drop down box the desired power-up setting and press LOAD. The values of the desired settings are shown in the application and the camera is working according to the loaded settings	
Blacklevel, only for monochrome With slider Blacklevel, the offset can be set in order to enable all captured information to be displayed within the digital domain. More information can be found in chapter 8.	
Digital gain With slider Gain, the programmable amplifier can be set to apply gain in the signal path. More information can be found in chapter 8.	
Frame period With slider Frame Period, the frame period in units of 10 us can be set. More information about frame periods in the different image acquisition modes can be found in chapter 7. The setting is only valid when in continuous mode.	
Integration time With slider Integration time, the frame period in units of 10 us can be set. More information about integration times in the different image acquisition modes can be found in chapter 7 The setting is only valid when in continuous mode.	
Information overlay When enabled, the top left most active video pixels in the output image are replaced by 8 data pixels. The upper 8 bits of the data pixels carry information, lower bits (when applicable) are set 0.	
Mirroring With the checkboxes Vertical mirror and Horizontal mirror the output image can be vertical and/ or horizontal mirrored. More information can be found in chapter 8	
Output resolution In the frame Digital resolution, the bit depth of the camera output can be set by this parameter, Resolutions of 8, 10 and 12 bit are standard.	

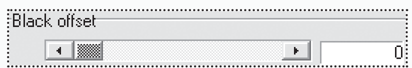
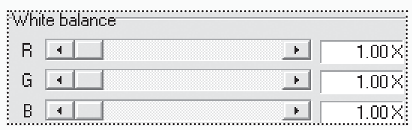
FUNCTION	CONTROL
Store camera settings The actual settings of every tab, except the settings of tab User storage, will be stored simultaneously. To store the current settings select the desired settings from 1 to 9 in the drop down box and press SAVE.	
Testpattern With checkbox Testpattern the testpattern on the output image can be set. More information about interpreting the testpattern can be foud in chapter 9	
Vertical binning With checkbox/ slider Vertical Binning, it is possible to combine two, four or eight lines of video on the CCD before reading out. When applying binning it is possible to achieve higher frame rates. The standard option can be selected by means of a checkbox. If the option extra binning is enabled the binning is set by means of a slider. More information can be found in chapter 8.	Standard  Optional 
Vertical remapping When enabled the data from the CCD will be re-arranged in order to provide normal left-to-right, top-to-bottom scanning. More information can be found in chapter 8.	

5.2.2. User storage tab

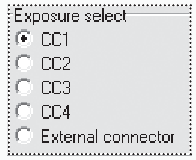
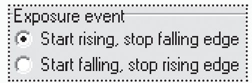
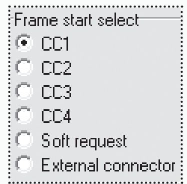
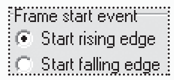
This tab can be used for storage of camera related values / labels, such as calibration data, specific settings, position in the application, etc. Data can be saved as a maximum of 15 integers and a maximum of 15 strings.

Function	CONTROL
Load camera related values To load every camera related value press Load	
Store camera related values Values are not automatically stored into the camera memory. To store the current values press Save.	

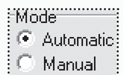
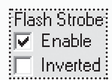
5.2.3. Additional settings tab (only available for color)

FUNCTION	CONTROL
Black offset With slider Black offset, the offset can be set in order to enable all captured information to be displayed within the digital domain. More information can be found in chapter 8	
White balance With the slides R(ed), G(reen) and B(lue) the additional gain per color channel can be programmed in order to correct for different illumination colors. More information can be found in chapter 8.	

5.2.4. Camera control tab

Function	CONTROL
Exposure select In the frame Exposure select, the method of controlling the exposure start trigger can be selected. This can be done by each and every one of the CC1..CC4 of the Camera Link connector or the external trigger input on the I/O-connector. More information can be found in chapter 7	
Exposure event Determines the activation of exposure on rising or falling edge.	
Frame start select In the frame Frame start select, the method of controlling the frame start trigger can be selected. This can be done by each and every one of the CC1..CC4 of the Camera Link connector, a soft request or the external trigger input on the I/O-connector. More information can be found in chapter 7.	
Frame start event Determines the start of read out on rising or falling edge.	

5.2.5. Flash strobe tab

Function	CONTROL
Mode of flash strobe operation In automatic mode the flash strobe output will be active during the integration of the image. When set to manual, the behaviour of the flash during exposure can be programmed.	
Flash strobe output The flash strobe output can be enabled if the option is selected. The output can reverse polarity when selected.	
Flash strobe delay If manual mode is selected, the start delay of the strobe output can be set by the slider.	
Flash strobe duration If manual mode is selected, the active duration of the strobe output can be set by the slider.	

5.3 Controlling the camera with the Command Console application

The Command Console application is a basic communication console. Commands entered at the prompt line are directly sent to the camera. The program will run on W9x, NT, 2000 and XP (32 bit) operating systems and in 32 bit mode on Vista (64 bit) systems.. It does not need installing, simply copy the files to your hard disk drive.

NOTE: The serial control signals of the camera needs to be mapped onto a communication channel, either by means of a hardware breakout circuit (to a hardware COM-port) or by mapping the control signals onto a serial communication channel supported by the Frame Grabber. In Figures 5.1 and 5.2 both possibilities are depicted in a simplified diagram. The camera in these pictures can either be a Camera Link version or a CoaXPress version (CL with additional CXP interfacebox).

Before launching the program the correct COM-port number must be entered by editing the console.ini file. Replace the line PORT=0 by PORT=x, where x = your COM-port number minus 1. In case of serial communication per Camera Link interface, set CLSELECT to 1.

5.4 Controlling the camera with your own dedicated software

The camera can also be controlled by a host system connected to the Camera Link interface using the serial communication link of the Camera Link. Commands and resulting data are transferred between the host system and the camera according to the communication protocol as defined in par 10.3. The camera will always act as slave in the communication link, the host system must be master. All actions are initiated by the host system, the camera only replies on messages received from the host system.

5.5 Command structure

5.5.1. Introduction

When the camera is controlled by means of the Console Application or with your own dedicated software, the following command structure is used.

5.5.2. Parameters

Most camera operation commands need one or more parameters. In general the command therefore consists of a command keyword and the required parameters for that specific command. If more parameters are required they should be separated by a semicolon (;).

Almost all parameters are signed integer values. Negative values must start with a minus sign character (-). A plus sign character (+) for positive values is allowed, but not required.

For some commands a parameter may consist of a string of characters rather than a number. In that case this string must be preceded by the double-quote sign character (“).

Commands accompanied by the wrong number of parameters are ignored.

<u>Command example:</u>

```
Command syntax: WB100;150;235
```

5.5.3. Request commands

Actual camera settings can be obtained via a request command. Commands with a question mark after the keyword are recognized as request commands.

Request command example:

```
Command syntax: BS?
```

The camera will reply with one or more parameters, separated by a semicolon (;) if necessary. Reply values are always preceded with minus sign character (-) when negative and a plus sign character (+) when positive.

If a reply is a string of characters rather than a number then this string is preceded by the double-quote sign character(“).

Reply message example:

```
Reply message: “1.0A;1.21;1.00
```

Where 1.0A;1.21;1.00 represents the camera information.

6. Managing Camera Settings

6.1 Introduction

Operation of the camera is defined by a number of settings, controlled by various commands. When the camera is powered initially, the camera will power-up in a defined mode, with all parameters in 'power-up default' setting. This is called power-up set 0. This default power-up set 0 is determined by Adimec can not be altered.

Instead, up to nine additional user defined sets of power-up settings can be stored. This way, user defined settings can be applied at powering up.

6.2 Load Power-up defaults and choose power-up set

At any moment all camera settings and parameters can be reverted back to one of the standard power-up settings by means of the load configuration command.

```
Command syntax: LCx
```

where x = power-up settings set number (see table 6.1).

SETTING (X)	FUNCTION
0	Factory default
1..9	User defined

Table 6.1: Possible power-up defaults

NOTE: The next time the camera is powered, it will start with the power-up settings set number x.

The number of the last selected power-up default can be read back from the camera:

```
Command syntax: LC?
Reply message: x
```

Where x = as in table 6.1

6.3 Change power-up defaults

To save the current camera configuration as a power-up settings set, the save configuration command must be used.

```
Command syntax: SCx
```

Where x = power-up settings set number

NOTE: x=0 is not allowed, because the factory default set cannot be altered

NOTE: An additional LCx command is needed to make the camera power-up in these settings.

6.4 Obtaining the camera identification string

For identification purposes the camera model and serial number can be requested by the identification command.

```
Command syntax: ID?
Reply message: a-bc/x[f] S/N:e
```

Where a is the family name OPAL

b is the detector type e.g. 1000, 2000, etc

c is c for color and m for monochrome

x is D or Q for Dual or Quad sensor output

[f] [optional] the customer special string

e is the camera serial number string

Example:

CAMERA MODEL	REPLY MESSAGE
OPAL-1000m/CL	OPAL-1000m/CL S/N:xxxxxxxxxxx
OPAL-1000c/CL	OPAL-1000c/CL S/N:xxxxxxxxxxx

Where xxxxxxxxxxx = serial number

Table 6.2: Example of the replied ID messages for monochrome and color cameras

6.5 Obtaining the camera model identification

The model identification (Adimec Part ID) can be obtained from the camera by means of the Model Identification command.

```
Command syntax: MID?
Reply message: “xxxxxx
```

Where xxxxxx = Adimec Part ID.

6.6 Obtaining the camera Serial Number

The serial number can be obtained from the camera by means of the Serial Number command.

```
Command syntax: SN?
Reply message: “xxxxxxxxxxx
```

Where xxxxxxxxxxx = serial number.

NOTE: When requesting support on some features of the camera, Adimec may request the serial number of the camera, in order to optimize support.

6.7 Obtaining the camera build state

The camera issue and firmware revisions can be obtained from the camera by means of the Build State command..

```
Command syntax: BS?
Reply message: "x.xx;y.yy;z.zz
```

Where x.xx stands for camera issue, y.yy indicates the microcontroller fimware version and z.zz indicates the FPGA firmware version.

NOTE: When requesting support on some features of the camera, Adimec may request the build state information, including firmware versions, in order to optimize support.

6.8 User storage

Up to 16 user-defined strings and 16 user-defined signed integers can be stored in the camera for user reference. These parameters do not have any effect on camera performance.

Setting one of the 16 user integers is done by means of the USI command

```
Command syntax: USIx;y
```

Where x = user integer index [0…15]
y = user integer value.

Reading back one of the 16 user integers is done by means of the USI? command

```
Command syntax:USI?x
Reply message: y
```

Where x = user integer index [0…15]
y = user integer value.

Setting one of the 16 user strings is done by means of the USS command

```
Command syntax: USSx;"y
```

Where x = user string index [0…15]
y = user string value (maximum length is 32 characters).

Reading back one of the 16 user strings is done by means of the USS? command

```
Command syntax for readback:USS?x
Reply message: y
```

Where x = user string index [0…15]
y = user string value.

7. Image capturing and video output

7.1 Introduction

Image acquisition is possible in several modes. In this chapter each mode is described in a separate paragraph.

Some general remarks:

- Image Acquisition takes some time, depending on camera settings. In either mode, if the user tries to capture frames at a higher frame rate than the acquisition time allows, the camera will not behave as expected.
- If images are captured continuously, an integration time larger than the frame period is not possible.
- To make use of the camera's maximum speed, it is in general necessary to start acquiring frame number n, while frame number (n-1) is still being read out through the Camera Link interface.

In general, as with all CCD cameras, sensor exposure time is controlled by performing an electronic shutter action. This action (in timing diagrams referred to as exposure) represents exposure duration or integration time.

NOTE: In the paragraphs describing the control modes, it is assumed that the trigger polarity is normal and that the trigger signals exposure and read-out are controlled by the CC1 input.

It is however also possible to choose one of the other camera control signals (CC2 - CC4) or the external trigger input on the I/O-connector for trigger input. It is even possible to use two different control signals; one for exposure control and another one to control the read-out timing.

The selection and behavior of the control signals are explained in detail in par. 7.10 and 7.11.

7.2 Selecting Image Acquisition Mode

Image acquisition mode is selected by the mode command

```
Command syntax: MOx
```

where x indicates acquisition mode, depending on camera model, according to table 7.1.

The actual mode can be read back from the camera:

```
Command syntax: MO?
Reply message: x
```

where x indicates acquisition mode, depending on camera model, according to table 7.1.

CAMERA MODEL	MO0	MO1	MO2*	MO3*	MO4*	MO5*
OPAL-1000 OPAL-1600 OPAL-2000 OPAL-4000 OPAL-8000	Continuous	Normal control	Delayed transfer	Double Transfer	Double Delayed Transfer	IT defined integration control

* optional

Table 7.1: Camera acquisition modes

7.3 Used parameters and timing table

The next paragraphs about the acquisition modes make use of timing diagrams. These diagrams list parameters that are gathered in table 7.2 below.

CAMERA MODEL	TD_IT_BGN	TD_IT_END	T_DTM_ GAPMIN	T FRAME-MIN @ NO BIN-NING	T FRAME MIN @ 2 LINES BINNING	T FRAME MIN @ 4 LINES BINNING*	T FRAME MIN @ 8 LINES BINNING*
OPAL-1000	2 µs	7.5 µs	26 µs	8,127 ms	4,637 ms	2,889 ms	2,029 ms
OPAL-1600	2 µs	7.5 µs	26 µs	14,332 ms	7,850 ms	4,612 ms	3,000 ms
OPAL-2000	2 µs	7.5 us	26 µs	15,189 ms	8,227 ms	4,749 ms	3,028 ms
OPAL-4000	2 µs	9 µs	26 µs	29,833 ms	16,791 ms	10,275 ms	7,045 ms
OPAL-8000	2 µs	10 µs	26 µs	56,917 ms	31,077 ms	18,163 ms	11,739 ms

* optional

Table 7.2: Timing details

A short explanation of the timing parameters in this table: There is some time needed to apply a shutter pulse to the CCD. The CCD will start integrating light (start of exposure) at a shutter action. Integration will start td_it_bgn after the rising edge of the shutter pulse.
During the time needed to transfer the image from the photo-sensitive area to the storage area, the CCD will continue to integrate during a short period of time being td_it_end. In other modes than continuous mode there is an additional demand in timing.

T_dtm_gapmin is only applicable in double transfer mode and double delayed transfer mode. T_dtm_gapmin lists the minimal time between 2 exposures.

Td_output is the figure for the delay between end of acquisition and start of output. The Vertical Remap function determines the method of transmitting the pixels at the output. For an extensive explanation of Vertical Remap refer to par 8.5. Enabling Vertical Remap influences the delay time to the output. The delay is listed in table 7.3 for the various models.

CAMERA MODEL	Td_output VR DISABLED	Td_output VR ENABLED
OPAL-1000	≤ 410 µs	≤ 4700 µs
OPAL-1600	≤ 720 µs	≤ 7900 µs
OPAL-2000	≤ 760 µs	≤ 8400 µs
OPAL-4000	≤ 1490 µs	≤ 16400 µs
OPAL-8000	≤ 2850 µs	≤ 31300 µs

Table 7.3: Vertical remap timing details - delay time to the output.

7.4 Exposure and image output overlap

Since acquisition and image output are related but independent processes within the camera, it is possible to integrate and output images the same time. Figure 7.1 show the sequence of processes when in normal control mode.

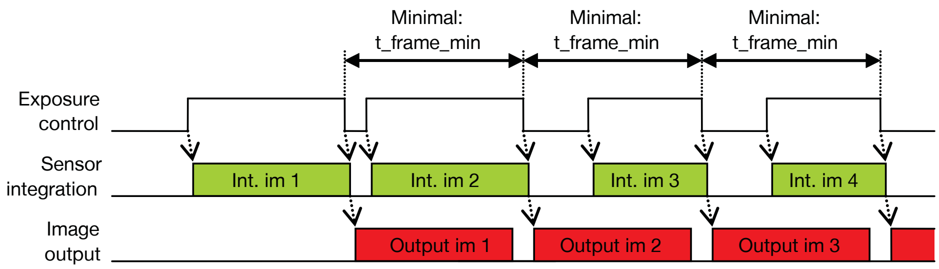


Figure 7.1: Timing details normal control mode showing integration and image output overlap.

After image 1 has been acquired, it is send to the output due to the falling edge of exposure control. While outputting image 1, image 2 can be acquired, started by the rising edge of exposure control. This sequence can run continuously when the exposure control pulse duration is in accordance with t_frame_min. (Texposure equal or greater than t_frame_min).

NOTE: in the simplified timing diagrams in par 7.5 up to and including par 7.9 integration and transmitting of only one image is presented. This is done in order to keep the diagrams simple. In practice however, timing might be a little different because integration time of a frame may start while the previous frame is still being output.

7.5 Image Aquisition in continuous mode

In continuous mode the camera is fully free-running. No external control signal is needed.

NOTE: When an external control signal is applied, it is ignored. Image acquisition and output timing is controlled by setting the parameters for integration time and frame period. Basically the camera integrates during a period as set by the integration time command and outputs the image data immediately after exposure time is expired.

Factory default the camera is set to this mode. Refer to figure 7.2 for a simplified basic timing diagram.

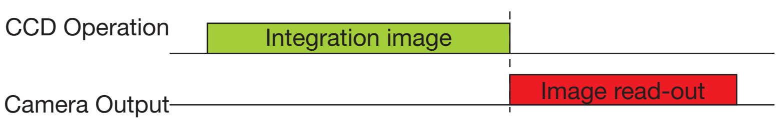


Figure 7.2: Simplified example continuous mode

By means of the MO0 command the camera will enter continuous mode. In this mode image acquistion cannot be influenced by means of hardware signals. The camera determines its own timing, conforming to the integration time and frame period parameters as set by the applicable commands:

`Command syntax: ITx`

Where x = integration time or exposure time in units of 10 µs.

`Command syntax: FPx`

Where x = frame period in units of 10 µs.

Both parameters can be read back from the camera

```
Command syntax: IT?
Reply message: x
```

Where x = integration time or exposure time in units of 10 μs.

```
Command syntax: FP?
Reply message: x
```

Where x = frame period in units of 10 μs.

If invalid parameter values are entered the camera will ignore these and react, depending on the parameter error according to tabel 7.4.

PARAMETER ERROR	CAMERA BEHAVIOR
frame period shorter than allowed (*)	frame period will be programmed as fast as possible
frame period out of range 0..32000	command will be ignored
integration time longer than allowed (**)	integration time will be programmed at its maximum
integration time period out of range 0..32000	command will be ignored

Table 7.4: Camera behavior in case of an invalid parameter

(*) The minimum frame period depends on camera model and on image format. See the paragraph about image format (chapter 8) for detailed information

(**) The maximum integration time is a little bit shorter than the frame period. The minimum integration time and maximum integration time in continuous mode can be found in table 7.5.

CAMERA MODEL	MINIMUM INTEGRATION TIME	MAXIMUM INTEGRATION TIME
OPAL-1000 OPAL-1600 OPAL-2000 OPAL-4000 OPAL-8000	10 μs	320000 μs

Table 7.5: Maximum integration time related to camera model

NOTE: The camera will not respond to external hardware trigger signals, the image acquiring system (frame grabber) must be able to act as slave.For timing details see figure below. See table 7.2 & 7.3 for the values of all timing parameters.

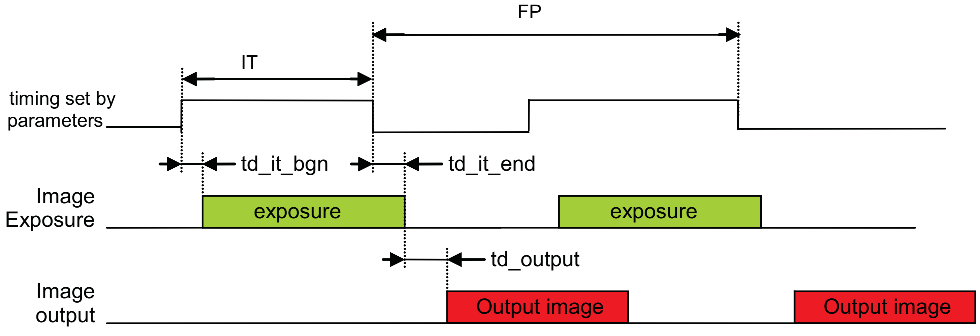


Figure 7.3: Timing details continuous mode.

7.6 Image Aquisition in normal control mode

In normal control mode camera timing is controlled by means of an external signal. The parameters for integration time and frame period can still be set and read-out but have no meaning. Refer to figure 7.4 for a simplified basic timing diagram.

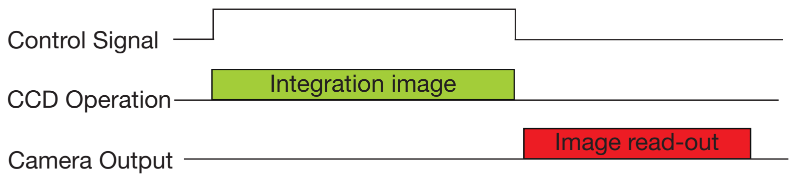


Figure 7.4: Simplified example normal control mode

The image integration starts at a rising edge of the trigger signal. Image integration stops at the falling edge. Image read-out starts at the falling edge of the same trigger control signal.

Controlling the camera timing by means of (an) external signal(s) is possible by means of several (combinations of) signals. The selection and behavior of the control signals are explained in detail in par. 7.10 and 7.11. To simplify explanations in this chapter we will assume that image integration and image read-out are controlled by only one external signal, i.e. the Camera Control signal #1 in the Camera Link interface, referred to as CC1.
The rising edge of CC1 is interpreted as a “start integrating” request; the falling edge is interpreted as both a “stop integrating” and a “start sending image data” request.

Taking into account the remarks and descriptions as mentioned in par 7.1, one can conclude the following restrictions on the trigger signal:

- The time between two falling edges of the read-out trigger signal must be equal or longer than the minimum frame period valid for the image format programmed.
  If a falling edge is detected too early, i.e. before the image is completely read out, then this event is ignored.
- To make use of the maximum speed possibilities of the camera it is generally necessary to generate a rising edge of the trigger signal before the previous image is completely read out.

If the integration time needs to be varied while grabbing images continuously, make sure that the control signal edge corresponding with start-of-integration is varied. In standard settings this is the rising edge of the control signal. The falling edges of this signal must remain at constant time-distances in order to prevent a too early “start sending image data” request. For timing details see figure 7.5. See table 7.2 & 7.3 for the values of all timing parameters.

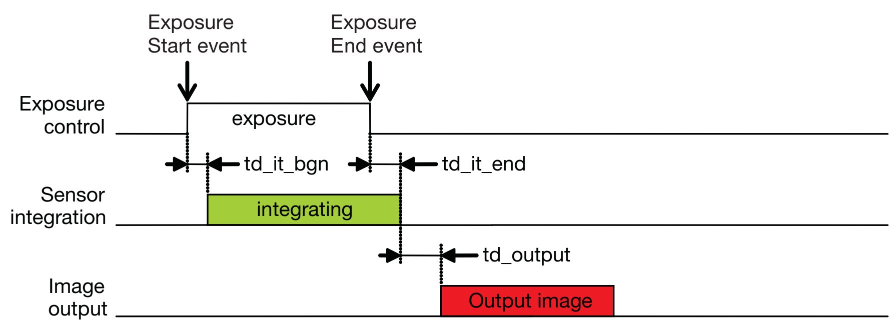


Figure 7.5: Timing details normal control mode.

NOTE: The selection and behavior of the control signals are explained in detail in par. 7.11 and 7.12.

7.7 Image Acquisition in delayed transfer mode (optional)

In delayed transfer mode camera timing is controlled by means of two external signals. The parameters for integration time and frame period can still be set and read-out but have no meaning. Refer to figure 7.6 for a simplified basic timing diagram.

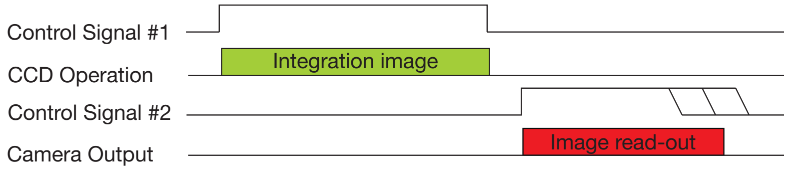


Figure 7.6: Delayed transfer mode

The image integration starts at a rising edge of the trigger signal. Image integration stops at the falling edge. Image read-out starts at the falling edge of another trigger control signal.

To simplify explanations in this chapter we will assume that image integration and image read-out are controlled by CC1. The rising edge of CC1 is interpreted as a “start integrating” request; the falling edge is interpreted as a “stop integrating” request. The rising edge of CC2 is interpreted as a “start sending image data” request. The behavior of CC1 and CC2 is determined by the settings explained in par. 7.11 and 7.12.

Taking into account the remarks and descriptions mentioned in par 7.1, one can conclude the following restrictions on the trigger signal:

- The time between two falling edges of the read-out trigger signal must be equal or longer than the minimum frame period valid for the image format programmed.
  If a falling edge is detected too early, i.e. before the image is completely read out, then this event is ignored.
- To make use of the maximum speed possibilities of the camera it is generally necessary to generate a rising edge of the trigger signal before the previous image is completely read out.

For timing details see figure 7.7. See table 7.2 & 7.3 for the values of all timing parameters.

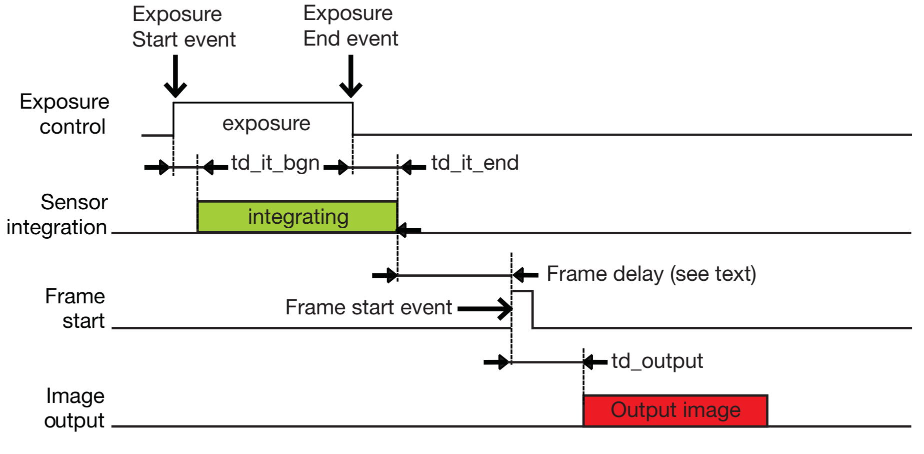


Figure 7.7: Timing details delayed transfer mode.

NOTE: The selection and behavior of the control signals are explained in detail in par. 7.11 and 7.12.

7.8 Image Acquisition in double transfer mode (optional)

Double transfer mode allows for the capture of two images shortly after each other. Image readout of both images is postponed until integration of the second image is completed. Refer to figure 7.8 for a simplified basic timing diagram.

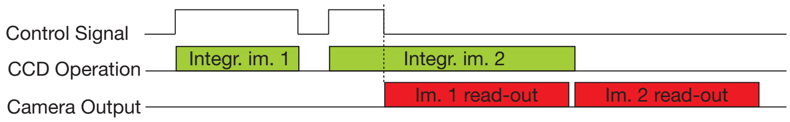


Figure 7.8: Simplified example doube transfer mode

In double transfer mode image acquisition is fully controlled by an external trigger input. Basically operation is the same as normal control mode, except for the important difference that a captured image will not always be output immediateley, thereby enabling the possibilitiy to capture a second image immediately after the first one.

This feature can be extremely useful if the average number of required frames per second is within normal camera capabilities, but when pairs of images must be captured on a much faster base.

General timing constraints are difficult to state, because they are completely dependent on the application.

In general the constraints applicable can be derived from the timing diagram shown in figure 7.9.

See table 7.2 & 7.3 for the values of all timing parameters.

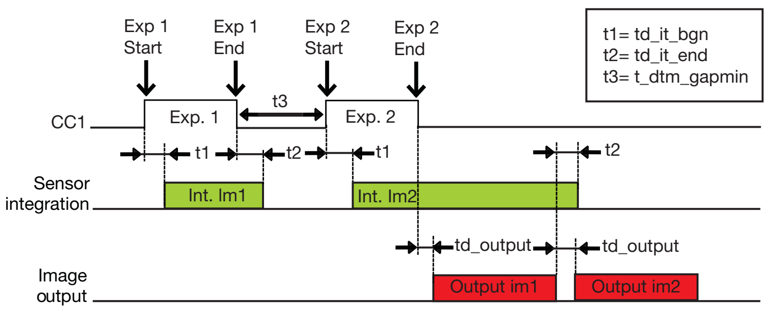


Figure 7.9: Timing details double transfer mode.

NOTE: The selection and behavior of the control signals are explained in detail in par. 7.11 and 7.12.

7.9 Image Acquisition in double delayed transfer mode (optional)

Double delayed transfer mode also allows for the capture of two images shortly after each other. Image readout of both images is postponed until integration of the second image is completed. Image readout of the second frame is controlled by a separate control signal. Refer to figure 7.5 for a simplified basic timing diagram.

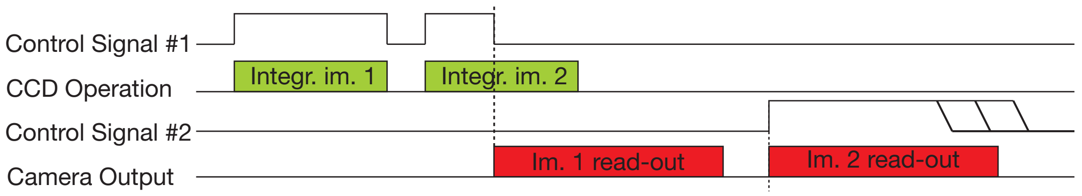


Figure 7.10: Simplified example double delayed transfer mode.

In double delayed transfer mode image acquisition is fully controlled by two external trigger inputs. Basically operation is the same as double transfer mode, except for the important difference that the frame readout of the 2nd image is controlled by an additional external control signal. Note that frame readout of the first images is still controlled by the same signal that controls the exposure.

This mode is useful at the same conditions as double transfer mode. In double transfer mode the second image is generated immediately after the first one. If the host system (frame-grabber) is not able to capture the second image directly after the first one, the double delayed transfer mode makes it possible to delay the second image. General timing constraints are difficult to state, because they are completely dependent on the application. In general the constraints applicable can be derived from the timing diagram shown in figure 7.11.

See table 7.2 & 7.3 for the values of all timing parameters.

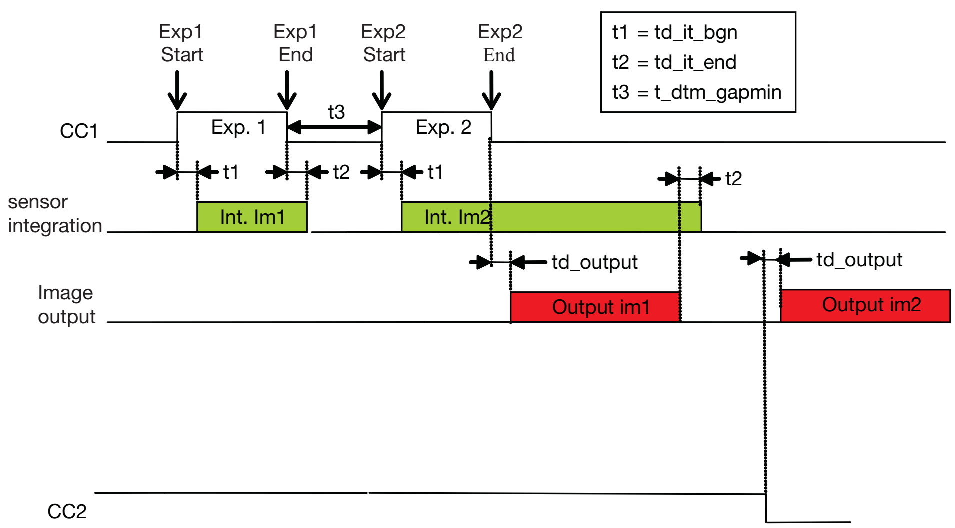


Figure 7.11: Timing details double delayed timing mode.

NOTE: The selection and behavior of the control signals are explained in detail in par. 7.11 and 7.12.

7.10 Image Aquisition in IT defined integration control mode (optional)

In IT defined integration control mode the start of integration is controlled by means of an external signal. The parameters for integration time IT can be set to determine the integration time. Refer to figure 7.11 for a simplified basic timing diagram.

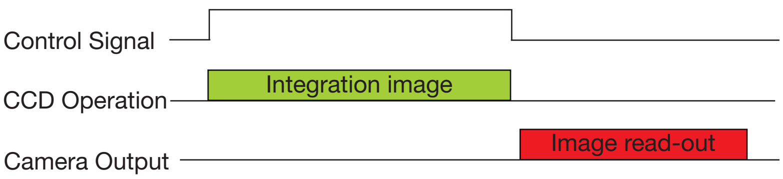


Figure 7.12: Simplified example normal control mode

The image integration starts at a rising edge of the trigger signal. Image integration stops after the set integration time has passed. Image read-out starts as soon as integration has finished..

Controlling the start of integration by means of an external signal is possible by choise of several control signals. The selection and behavior of the control signals are explained in detail in par. 7.11 and 7.12. To simplify explanations in this chapter we will assume that image integration start is controlled by only one external signal, i.e. the Camera Control signal #1 in the Camera Link interface, referred to as CC1.
The rising edge of CC1 is interpreted as a “start integrating” request; After the set integration time has passed, the image is transmitted at the output.

Taking into account the remarks and descriptions as mentioned in par 7.1, one can conclude the following restrictions on the trigger signal:

- The time between two rising edges of the ‘start aqcuisition’ trigger signal must be equal or longer than the minimum frame period and set integration time valid for the image format programmed. If a rising edge is detected too early, i.e. before the set integration time has passed, then this event is ignored.
- To make use of the maximum speed possibilities of the camera it is generally necessary to generate a rising edge of the trigger signal before the previous image is completely read out.

For timing details see figure 7.13. See table 7.2 & 7.3 for the values of all timing parameters.

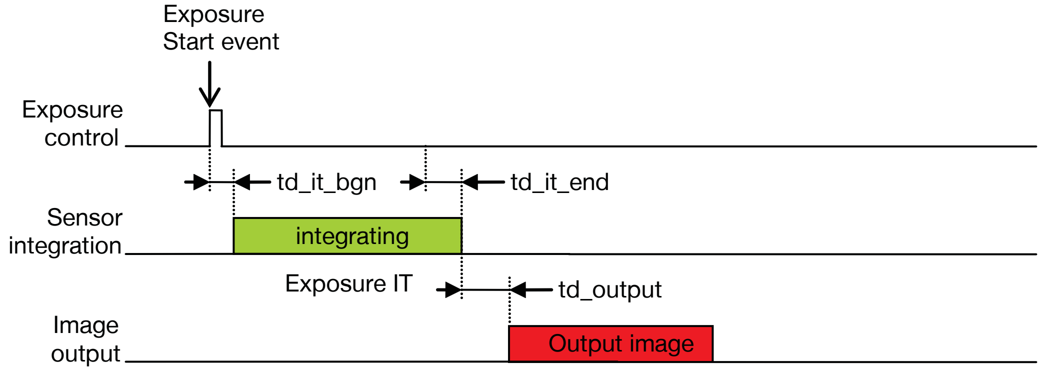


Figure 7.13: Normal control mode, IT defines integration time

7.11 Polarity and choice of external triggers

7.11.1. Introduction

Controlling integration and read-out in each one of the control inputs can be done by every one of the CC1..CC4 and/or the external trigger input on the I/O-connector. Which control signals control which event is fully programmable.

It is also possible to change the polarity of each one of the trigger signals.

7.11.2. Exposure control

Exposure control is done by means of the Camera Control Exposure command. This is applicable in the following modes:

- Normal control mode
- Delayed transfer control mode
- Double transfer control mode
- Double delayed transfer control mode

`Command structure: CCEe;f`

Where e and f are defined in the table below

The actual camera control event setting can be read back from the camera

`Command syntax: CCE?`
`Reply message: e;f`

Where e and f are defined in the table below

E	Trigger input signal source
0	CC1
1	CC2
2	CC3
3	CC4
4	I/O-connector

Table 7.6: Exposure control trigger source selection

F	RISING EDGE IS INTERPRETED AS	FALLING EDGE IS INTERPRETED AS
0	End of integration	Start of integration;
1	Start of integration	End of integration

Table 7.7: Polarity selection

7.12 Read-out control

Exposure control is done by means of the Camera Control Exposure and Camera Control Frame read-out.

Read-out control is done by means of the Camera Control Frame readout command. This is applicable in the following modes:

- Delayed transfer control mode
- Double delayed transfer control mode

NOTE: In Normal control mode and in Double transfer control mode image readout always starts at the end of exposure. There is no separate camera read-out trigger signal and the Camera Control Frame readout command is therefore not applicable.

Additional to starting read-out with an external trigger signal, it is also possible to start readout upon a 'soft request'. This is a request done by a separate command. This possibility is programmed by means of the same Camera Control Frame readout command.

```
Command structure: CCFSg;h
```

Where g and h are defined in the table below. The actual camera control event setting can be read back from the camera

```
Command syntax: CCFS?
Reply message: g;h
```

Where g and h are defined in the table below.

G	CORRESPONDING SOURCE
0	CC1
1	CC2
2	CC3
3	CC4
4	Trigger input signal on I/O-connector
5	Soft request

Table 7.8: frame readout trigger source selection

H	RISING EDGE IS INTERPRETED AS	FALLING EDGE IS INTERPRETED AS
0		Start of readout
1	Start of readout	

Table 7.9: Polarity selection

This command triggers the readout of the acquired image.

```
Command syntax: RQ
```

NOTE: On soft request, if frame read-out trigger source is set to Soft request, then the frame readout is not initiated by an external signal, but by the additional Camera Control Request frame command

7.13 Flash strobe

7.13.1. Flash strobe enable

The camera is equipped with strobe output signal on the I/O connector. The strobe can be switched on off by means of the FSE command.

`Command syntax: FSEx`

Where x is set to 0 to disable the strobe output and x is set to 1 to enable the strobe output. The definition of the active state depends on the strobe polarity.

The actual setting can be read back from the camera.

7.13.2. Flash strobe polarity

The active state of the strobe output can be inverted to adapt to the application requirements.

`Command syntax: FSPx`

Where x is set to 0 for the reverse polarity: in this polarity configuration the phototransistor at the camera output is non-conductive during the active state of the strobe.

And x is set to 1 for the normal polarity: in this polarity configuration the phototransistor at the camera output is conductive during the active state of the strobe.

The actual setting can be read back from the camera.

7.13.3. Flash strobe mode

The strobe output can be operated in two different modes, which are set through the FSM command.

`Command syntax: FSMx`

Where x is set to 0 for the automatic mode: The strobe will become active at the start of integration. The strobe will deactivate when the acquisition is completed.

If x is set to 1 the strobe will operate in programmed mode; both delay time after a sensor reset as well as the duration of the active state can be programmed. A new flash window can only start after the completion of the previous flash strobe window.

The actual setting can be read back from the camera.

7.13.4. Flash strobe Timing

The strobe output timing can be programmed through the FST command.

`Command syntax: FSTx;y`

Where x indicates the delay time between the sensor reset operation and the active state of the strobe.

Where y indicates the duration of the strobe if the camera is in programmed strobe timing mode. Note the parameters are ignored in automatic strobe mode.

Valid ranges for both x and y are 0 … 32000. Both x- and y-values are in units of 10 µs.

The actual settings can be read back from the camera.

8. Image and Data Formatting

8.1 Introduction

Although the CCD in the camera has a fixed format there are several possibilities to change the way the CCD is read-out. It is possible to limit the amount of lines read from the CCD (discussed in par 8.2); it is also possible to change the readout-direction (discussed in par. 8.7).

The video-processing, which converts the analog CCD-signal to the digital Camera Link output can also be changed. It is possible to choose the number of bits on the output (discussed in par. 8.6, it is possible to program a digital gain (discussed in par. 8.8) and there is a possibility to change the output offset. For color camera models it is possible to program additional gains for the R- G- and B-pixels in color camera models.

All cameras have a factory set defect pixel correction. Enabling / disabling this correction can be selected by the user. The user is able to add defect pixels to and remove defect pixels from the defect pixel table. A defect pixel mask can be made visible to the user.

8.2 Binning

8.2.1. Settings

In certain circumstances it might be preferable to sum 2 or more pixels. In CCD terms this process is called binning. If two or more pixels are binned the combination of those pixels can be regarded as one larger “bin-pixel”. In which circumstances this is preferable can be determined if the consequenses of binning are known.

A typical CCD implementation of this mechanism is to bin 2 pixels vertically. This is referred to as vertical binning and can be done on the CCD chip. This is the only binning feature that is available on a standard OPAL camera. Theoretically more pixels vertically can be binned and even horizontal binning is theoretically possible, the latter is discussed later.

One important property of on-chip binning is that it takes less time to read all the data out of the chip. As a consequence the maximum framespeed rises, this is regarded as the most important advantage. Another consequence is that there is less data on the CameraLink output to process.

Another consequense is that at N times binning the sensitivity of the camera increases with a factor of N at the cost of a decrease in resolution by a factor of N.

At the camera output Full Scale will always correspond with a Qmax of 18kel. Note that at 2x binning this corresponds with 18 kel in the “bin-pixel” or 9 kel per normal pixel.

OPTIONAL: Optionally 4 and 8 times vertical binning and horizontal binning is available. The following only refers to cameras with these non-standard options in place.

For 4x and 8x vertical binning goes that sensitivity increases with a factor of 4 and 8. The maximum possible framespeed also increases

Horizontal binning cannot be done on the CCD. This type of binning is done electronically, referred to as off-chip. This enables the possibility to correct for the increasing sensitivity. In the OPAL camera this is done automatically and can not be switched off. So when changing from no horizontal binning to 2x horizontal binning image brightness will not alter.

Horizontal binning gives no speed advantage; it does give the advantage of having less data on the CameraLink interface.

For a thorough understanding of the concept please find some properties of the possibilities (including optional binning modes) in the diagram below.
The standard OPAL camera only offers two binning modes: no binning (1x) and 2x vertical binning.

HBIN FAC-TOR	VBIN FAC-TOR	“BIN PIXEL” SIZE (H*V) [MICONS]	BIN PIXEL CHARGE CORRESPONDING WITH FULL SCALE CAMERA OUT-PUT [KEL]	PIXEL CHARGE CORRESPONDING WITH FULL SCALE CAMERA OUT-PUT [KEL]	SENSITIVITY, RELATIVE TO BINNING FAC-TOR
1	1	5.5 x 5.5	18	18	1 x
1	2	5.5 x 11	18	9	2 x
1	4 *	5.5 x 22	18	4.5	4 x
1	8 *	5.5 x 44	18	2.25	8 x
2 *	1 *	11 x 5.5	36	18	1 x
2 *	2*	11 x 11	36	9	2 x

Table 8.1: Theoretical charge values of camera in binning modes.
(*: optional only; not available on a standard camera)

NOTE: There are particular drawbacks in vertical binning. These will be discussed in par 8.2.3.

Vertical binning mode is set by means of the VBIN command.

```
Command syntax: VBINy
```

where
y=0 denotes no binning
y=1 denotes binning enabled; two vertical pixels are added
y=2 denotes binning enabled; four vertical pixels are added (OPTIONAL)
y=3 denotes binning enabled; eight vertical pixels are added (OPTIONAL)

The actual binning mode can be read back from the camera

```
Command syntax: VBIN?
Reply message: y
```

where
y = as above

Horizontal binning mode is set by means of the HBIN command.

```
Command syntax: HBINx (OPTIONAL)
```

where
x=0 denotes binning off
x=1 denotes binning on; two horizontal pixels are binned (not available on the standard camera)

The actual binning mode can be read back from the camera

```
Command syntax: HBIN? (OPTIONAL)
Reply message: x
```

where
x = as above

Binning is not available on a color camera because binning neighboring pixels would make the Bayer color pattern useless.

8.2.2. Frame rate consequences when vertical binning is used

If the vertical binning is used, the maximum possible frame rate will be higher than the standard frame rate. The camera will however not automatically increase frame rate when binning is enabled.

If the vertical binning is disabled or is switched to a lower binning factor, then the maximum possible frame rate decreases. If the camera is running in control mode, make sure to check if the external trigger signal complies with the new maximum frame rate.

If the camera is running in continuous mode, the frame rate is automatically decreased if necessary when vertical binning is disabled or switched to a lower binning factor.

When a higher binning factor is selected, the frame rate is not automatically increased! The maximum frame rate depends on the vertical resolution which is different for camera model, according to the table below.

CAMERA MODEL	NO BINNING		2X VBINNING		4 X VBINNING*		8X VBINNING*	
		OUTPUT FRAME H*V		OUTPUT FRAME H*V		OUTPUT FRAME H*V	FRAME RATE	OUTPUT FRAME H*V
OPAL-1000m	123 fps	1024x1024	215 fps	1024x512	346 fps	1024x256	492 fps	1024x128
OPAL-1600m	69 fps	1600x1200	127 fps	1600x600	216 fps	1600x300	333 fps	1600x150
OPAL-2000m	65 fps	1920x1080	121 fps	1920x540	210 fps	1920x270	330 fps	1920x135
OPAL-4000m	33 fps	2336x1752	59 fps	2336x876	97 fps	2336x438	142 fps	2336x219
OPAL-8000m	17 fps	3296x2472	32 fps	3296x1236	55 fps	3296x618	85 fps	3296x309

* optional

Table 8.2: Relation between vertical binning and maximum framerate.

8.2.3. Image quality considerations when binning is used

The electronics in the camera are optimized in order to detract as little as possible from any image artifact or image quality degradation when vertical binning is used. There are some principle drawbacks due to CCD properties.

The best way to illustrate this is to regard the binned CCD as a sensor with image pixels doubled in size in the vertical direction. The sensitivity of the camera will increase, due to the larger pixel. The capacity of the photo-pixel is also doubled. The capacity of the transfer register remains the same, but is large enough to transport the charge of two pixels. When binning more than two pixels (optional feature to the standard camera), transport capacity is not enough for the full load of saturated pixels. This may lead to excessive blooming when using binning, although the image was distortion-free in non-binning mode.

Also note that noise level will approximately remain the same. Because sensitivity, increases the signal-to-noise ratio seems to increase. But bear in mind that the signal will saturate at half the level that the camera would saturate in a non-binning format.

The output image resolution will decrease by the applied factor of binning.

Summarized: the dynamic range of the camera in binning format is approximately the same as in non-binning format. In fact the dynamic range is a little bit smaller, because noise does increase a small amount.

8.2.4. Binning without sensitivity consequences

OPTIONAL: A special non-standard feature is the Hi-Qmax option. If this option is ordered the electronic gain in the camera will be halved when two (or more when possible) lines are vertically binned. The following text only applies to Hi-Qmax cameras.

This option makes the sensitivity of the camera independent from the choice 1x or 2x vertical binning; the theoretical Qmax however does alter depending on binning settings.

Combining the Hi-Qmax option with the optional 4x and 8x vertical binning and horizontal binning leads to the following behaviour: All choices consisting of 1x or 2x horizontal binning and 1x or 2x vertical binning have the same sensitivity. Sensitivity does increase when 4x or 8x binning is selected; gain at these settings is not adapted, but fixed at the 2x binning value.

It is important to realize that the Hi-Qmax option does not solve any of the artifacts from par. 8.2.3. Excessive CCD charge will still lead to blooming effects, which tend to be more visible in a Hi-Qmax camera than in a standard camera. The Hi-Qmax option is therefore only deliverable on special request. The Hi-Qmax option is not swichable. A camera ordered with the Hi-Qmax option will always have the Hi-Qmax behaviour. The Hi-Qmax camera will not behave according to table 8.1, but to the following table. Note that the charge values are theoretical values. Charges much larger than twice the photo-pixel capacity of 18kel are in practise not transportable, so either not realizable or will result in excessive blooming.

HBIN FACTOR	VBIN FACTOR	“BIN PIXEL” SIZE (H*V) [MICONS]	BIN PIXEL CHARGE CORRESPONDING WITH FULL SCALE CAMERA OUTPUT [KEL]	PIXEL CHARGE CORRESPONDING WITH FULL SCALE CAMERA OUTPUT [KEL]	SENSITIVITY, RELATIVE TO NO BINNING
1	1	5 x 5	18	18	1 x
1	2	5 x 10	36	18	1 x
1	4*	5 x 20	36	9	2 x
1	8*	5 x 40	36	4.5	4 x
2*	1	10 x 5	36	18	1 x
2*	2	10 x 10	72	18	1 x

*optional

Table 8.3: Theoretical charge values of Hi-Qmax camera in binning modes

8.3 Region of Interest (optional)

A Region of Interest can be selected in order to reduce the amount of data transmitted over Camera Link; only the part of the image selected as ROI is output. Selecting a ROI does not increase the framerate. This is due to the fact that even with a selected ROI, the sensor has to be read out completely.

The Region of Interest can be set by the ROI command

```
Command syntax: ROIx;y;w;h
```

Where:
x = offset of the ROI relative to the left side of the image, range 0 to image width

y = offset of the ROI relative to the top of the image, range 0 to image height

w = width of the ROI, range 2 to image width

h = height of the ROI, range 2 to image height

NOTE: Only even values are expected to be entered at the ROI command.

The actual Region of Interest can be read back from the camera.

```
Command syntax: ROI?
Reply message: x;y;w;h
```

Where x, y, w and h are representing the values as described above

NOTE: Selecting a Region of Interest can be performed together with Burst Mode. In doing so, the amount of images stored im memory increases relative to full image Burst Mode.

NOTE: ROI0;0;max. image width;max. image height disables the selected ROI.

8.4 Burst mode (optional)

The camera can be equipped with a ringbuffer memory. This memory can be used to temporarily delay the output of the images when the camera is operated in control mode MO1. Acquisition and readout are decoupled and may take place asynchronously when using Burst Mode. Not that Burst mode does not increase the maximum framespeed, because the maximum frame speed is determined by sensor characteristics. A predefined number of images in the buffer will be released at request.

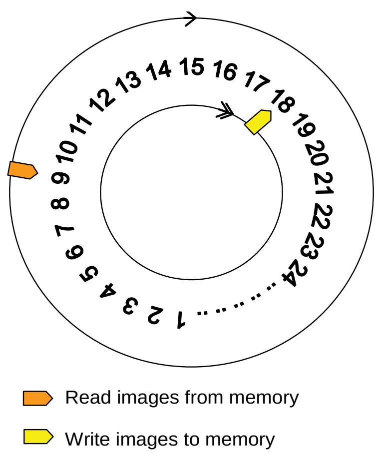


Figure 8.1: Circular representation of the ringbuffer memory

The memory size is limited. Table 8.4 shows an overview of the number of images that can be stored at full resolution. When using Region of Interest, the number of images increases, depending on the size of the ROI.

OPAL	# IMAGES @ 8 BIT OUTPUT RESOLUTION	# IMAGES @ 10 & 12 BIT OUTPUT RESOLUTION
1000	128	64
1600	69	34
2000	64	32
4000	32	16
8000	16	8

Table 8.4: Buffer capacity at full resolution

To enable the Burst Mode the BMO command is available

```
Command syntax: BMOx
```

Where:
x = 0 for normal operation, disabling Burst Mode
x = 1 for Burst Mode with automatic image release. An image is output as soon as one complete image is in the buffer memory.

x = 2 for Burst Mode with software triggered image release. On software request, a defined number of images are released from the memory.

The burst mode can be obtained from the camera using the BMO? command

```
Command syntax: BMO?
Reply message: x
```

Where: x is the status of the Burst Mode as indicated above.

To set the number of images to be released from memory per request the RQSIZE command can be used.

```
Command syntax: RQSIZEx
```

Where x = 0 to 255

To check the set number of imges released on request use Command RQSIZE?

```
Command syntax: RQSIZE?
Reply message: x
```

Where: x is the number of images released on request.

To generate a request use command RQ.

```
Command syntax: RQ
```

Interpretation of RQ? differs for the several image acquisition modes. If the camera is in Control Mode (MO1), RQ generates a soft event for Burst Mode, provided Burst Mode is set to 2. If the camera is in one of the optional image acquisition modes 2, 3 or 4 (not standard available), RQ generates a soft event for delay / double control mode. In all other combinations of image acquisition mode (MO) and Burst Mode (BMO, the RQ command does not have a function.

The number of images present in the burst memory can be obtained by the BCNT? command.

```
Command syntax: BCNT?
Reply message: x
```

Where x represents the number of images.

In the case that the number of image acquired exceeds the number of free memory locations, the Buffer Overrun flag is set and the BurstCount register is set to 0.

the Buffer overrun status can be obtained by the BO? command.

```
Command syntax: BO?
Reply message: x
```

Where x = 0 means no overrun and x = 1 Burst Mode memory overrun

NOTE: In practice, the memory locations that already have been read out during acquisition are available as free memory.

As an example; the OPAL-1000 has a memory capacity of 64 images of 12 bit resolution. Maximum acuisition speed is 120 frames per second. When reading out the memory at 60 frames per second during acquisition, the total number of 64 + 32 + 16 + 8 + 4 + 2 = 126 frames can be acquired before memory overrun occurs.

When memory overrun has occurred, the burst memory can be flushed and the BO flag can be cleared by the FB command.

`Command syntax: FB`

8.5 Vertical remap

The camera is equipped with a four-tap CCD. Data is read from the top and the bottom of the CCD simultaneously. For applications requiring minimum frame data delay, it might be advisable to operate the camera with vertical remapping disabled. In that case top and a bottom pixel will be output through the Camera Link Interface simultaneously. The top pixel will be at tap A and the bottom pixel at tap B, provided vertical mirror is disabled. This is illustrated in figure 8.2 & 8.3 by means of a 36 pixel CCD (6 x 6)..

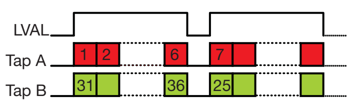


Figure 8.2: Output with vertical remap disabled

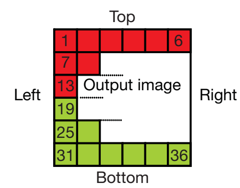


Figure 8.3: Example 36 pixel CCD

For a more intuitive camera output it is possible to enable the vertical remap function. The data from the CCD will be rearranged in order to provide normal left-to-right, top-to-bottom scanning. Note that the Camera Link data will be delayed half a frame when compared with the no-remapping situation. When remapping is enabled, neighboring odd and even pixels will be output simultaneously. The odd pixels will be at tap A and the even pixels at tap B, provided the horizontal mirror is switched off.

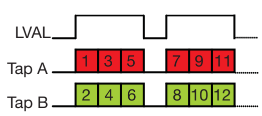


Figure 8.4: Output with vertical remap enabled.

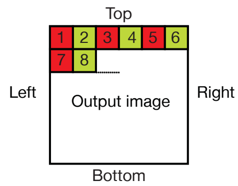


Figure 8.5: Example readout direction.

Enabling and disabling the vertical remap is done by means of the vertical remap command.

```
Command syntax: VRx
```

Where:
x=0 denotes no vertical remapping; simultaneous output of top and bottom pixel, no delay.
x=1 denotes vertical remapping active; simultaneous output of even and odd pixel, half frame delay.

The actual vertical remap setting can be read back from the camera.

```
Command syntax: VR?
Reply message: x
```

Where x = 0 or 1 as above.

8.6 Output resolution

The bit depth of the camera output can be set by the output resolution command.

```
Command syntax: ORx
```

Where x = 8, 10 or 12.

The actual output resolution can be read back from the camera.

```
Command syntax: OR?
Reply message: x
```

Where x = 8, 10 or 12.

8.7 Mirror

Depending on the application it can be necessary to have a horizontally or vertically mirrored output. Changing the horizontal and/or vertical readout direction is done by means of the mirror command.

```
Command syntax: MIx
```

Where x = value accoding the mode in table 8.5

The actual mirror setting can be read back from the camera.

```
Command syntax: MI?
Reply message: x
```

Where x = value accoding the mode in table 8.5

X	VERTICAL MIRROR	HORIZONTAL MIRROR	OUTPUT IMAGE
0	-	-	d
1	-	Yes	b
2	Yes	-	q
3	Yes	Yes	p

Table 8.5: Mirror settings

NOTE: When changing the vertical mirror setting, the camera needs initializing of the hardware and therefore will perform a soft-reboot. The camera will need up to 1 second to apply the new settings. A short interruption of camera operation takes place when switching the ReverseY parameter. Changing the vertical mirror on frame to frame base is not advised.

8.8 Digital gain

A programmable amplifier enables you to apply gain in the signal path. Note that this is an electronic gain, not influencing CCD operation. So sensitivity and noise are equally amplified, the saturation level remains the same in terms of camera output. Saturation level will decrease in terms of light level when gain increases.

```
Command syntax: GAx
```

Where x = 100..3200, representing a gain of 1.00x .. 32.00x

The actual gain setting can be read back from the camera.

```
Command syntax: GA?
Reply message: x
```

Where x = 100..3200, representing a gain of 1.00x .. 32.00x

8.9 White Balance (only for color)

To correct for different illumination colors it is possible to program additional gain per color channel.

```
Command syntax: WBr;g;b
```

Where r = 100..399, representing a gain in the red channel of 1.00x .. 3.99x
g = 100..399, representing a gain in the green channel of 1.00x .. 3.99x
b = 100..399, representing a gain in the blue channel of 1.00x .. 3.99x

The actual white balance setting can be read back from the camera.

```
Command syntax: WB?
Reply message: r;g;b
```

Where r = 100..399, representing a gain in the red channel of 1.00x .. 3.99x
g = 100..399, representing a gain in the green channel of 1.00x .. 3.99x
b = 100..399, representing a gain in the blue channel of 1.00x .. 3.99x

NOTE: The total gain per color can not be greater that 32x. So the product of digital gain (par 8.8) and white balance gain is clipped to 32x.

8.10 Offset (only for color)

In order to enable all captured information to be displayed within the digital domain an offset is applied on the camera output data. Black is not represented by 0, but by the value programmed with the offset command.

This ensures that all noise information, even when looking at absolute dark, is quantized and reproduced on the output

```
Command syntax: OFSx
```

Where x = 0..4096, the offset in greylevels on a 12 bit scale.

The actual offset setting can be read back from the camera.

```
Command syntax: OFS?
Reply message: x
```

Where x = 0..4096, the offset in greylevels on a 12 bit scale.Note: the offset is defined at the camera output on a 12 bit scale. That means that if the camera is switched to another output resolutions than 12 bit the actual offset seen on the output will be different.
Offset on Camera Output with an output resolution of 10 bit = x/4
Offset on Camera Output with an output resolution of 8 bit = x/16
See par 8.6 for information about output resolution and the the OR command

For monochrome cameras the offset command is not available. Use the blacklevel command instead to alter the output offset.

8.11 Blacklevel (only for monochrome)

In order to enable all captured information to be displayed within the digital domain an offset is applied on the camera output data. Black is not represented by 0, but by the value programmed with the offset command.

This ensures that all noise information, even when looking at absolute dark, is quantized and reproduced on the output.

```
Command syntax: BLx
```

Where x = 0..4096, the blacklevel in greylevels on a 12 bit scale, before the digital gain stage.

The actual blacklevel setting can be read back from the camera

```
Command syntax: BL?
Reply message: x
```

Where x = 0..4096, the black level in greylevels on a 12 bit scale before the digital gain stage.

NOTE: the black level is defined as the black level before digital gain. That means that if the camera is programmed to another gain than unity the actual offset seen on the output will be different. Assuming the camera is running in 12 bit mode, the gain value equals y and the black level equals x:
Offset on Camera Output with an output resolution of 12 bit = x.y

NOTE: the offset is defined at the camera output on a 12 bit scale. That means that if the camera is switched to another output resolutions than 12 bit the actual offset seen on the output will be different. Assuming the camera is running at a gain value equal to y and a black level equal to x:

Offset on Camera Output with an output resolution of 10 bit = x.y/4
Offset on Camera Output with an output resolution of 8 bit = x.y/16
See par 8.6 for information about output resolution and the the OR command.

For color cameras, the blacklevel command is not available. Use the offset command instead to alter the output offset.

8.12 Defect pixels

8.12.1. Introduction

The OPAL series camera do have a feature to correct for defect pixels real time.
This is done by interpolating the adjacent pixels according to the method illustrated in figures 8.6 and 8.7.

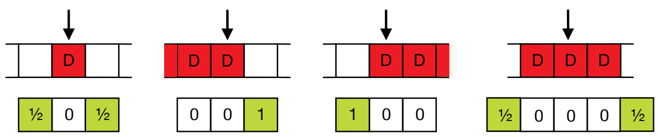


Figure 8.6: Defect pixel correction method on monochrome cameras.

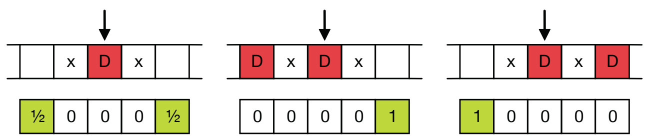


Figure 8.7: Defect pixel correction method on color cameras.

Up to 3 adjacent pixels can be corrected by the above method. More than 3 adjacent defect pixels can be user programmed, but may not result in a reliable correction.
Adimec does not release cameras with more than 3 adjacent defect pixels upon delivery.

8.12.2. Defect Pixel information

At manufacturing, a table is generated for each individual camera in order to correct for defect pixels. This table is stored in non volatile memory and can be read back from the camera. The number of defect pixels and the locations of each defect pixel can be obtained.

`Command syntax: DP?n`

Where the reply depends on the value of n.

If n = 0:

`Reply message: x`

where x = number of defect pixels.

If n> 0

Reply message: x;y

Where x, y are the coordinates of defect pixel number n.

NOTE: The left top pixel is referred to as 1;1**Adding a Defect Pixel to the table**

To add a defect pixel to the table, the DP command can be used

Command syntax: DPx;y

Where x, y are the coordinates of defect pixel number.

The DP0 (# of defect pixels) register will be updated accordingly.

NOTE: The left top pixel is referred to as 1;1

8.12.3. Removing a Defect Pixel to the table

To remove a defect pixel to the table, the DPR command can be used

Command syntax: DPRx;y

Where x, y are the coordinates of defect pixel number.

The DP?0 register will be updated accordingly.

NOTE: The left top pixel is referred to as 1;1

8.12.4. Defect Pixel Correction state

The camera corrects for defect pixels according to a defect pixel map, programmed at the factory. This correction can be enabled or disabled.

Command syntax: DPEx

Where x = 0 means disabled, 1 means enabled

The actual defect pixel correction setting can be read back from the camera.

Command syntax: DPE?
Reply message: x

Where x = 0 means disabled, 1 means enabled

8.12.5. Defect Pixel test mode.

For diagnostics purposes it is possible to visualize the defect pixel map on the video output by means of the Defect Pixels Test command.

Command syntax: DPTx

Where x = 0, 1, 2 or 3.

X	TEST MODE
0	disabled, normal image.
1	marks defect pixels white on video
2	marks defect pixels black on video
3	shows defect pixels as white on a black background

Table 8.6: Defect pixel test mode.

The actual setting can be read back from the camera.

```
Command syntax: DPT?
Reply message: x
```

Where x = 0, 1, 2 or 3 corresponding to the table 8.6.

8.13 Output LookUp Table.

8.13.1. Introduction

The camera has an Output LookUp Table. This table can be used to correct each pixel by a user specified value. It can be useful if, for instance, Gamma correction is desired.

In order to load the look-up table values, the camera should be prepared to receive the values.

This is done through the OLUTBGN command.

```
Command syntax: OLUTBGN
```

NOTE: When an OLUTBGN command is received if the LUT is already opened and/or the LUT is already (partly) filled, error 120 is issued and the LUT-status is reset.

8.13.2. Output LookUp Table content

The user look up table is loaded by command OLUT. Entries can be retrieved by OLUT?

```
Command syntax: OLUTx
```

Where $0 \leq x \leq 4095$

To fill the OLUT, it should first be opened through the OLUTBGN command.

The Output LookUp Table is based on the 12 bit output resolution. Therefore a total of 4096 values have to be entered, beginning with the entry replacing the input value 0 up to the input value 4095.

The LUT pointer is incremented at each LUT entry.

NOTE 1: If there is no preceeding OLUTBGN command there will be no action and error result is set to 121.

NOTE 2: If the number of OLUT commands exceeds the LUT size (4096) there will be no action and error result is set to 123.

Down scaling the output resolution to 8 or 10 bit is done after the LUT.

8.13.3. Output LookUp Table end.

After filling the output look-up table with 4096 vales, the table should be closed. This is done through the OLUTEND command.

`Command syntax: OLUTEND`

NOTE: If the camera did not receive exactly 4096 entries, the LUT definition is ended, but LUT data is not saved to non-volatile memory. The previous LUT is restored (if no valid LUT was found, a unity LUT function is used instead) and error result is set to 122.

8.13.4. Output LookUp Table enable.

The user look-up table can be enabled or disabled by means of the OLUTE command.

`Command syntax: OLUTEx`

Where x is set to 1 for enabling the LUT and 0 to disable the LUT.

The actual setting can be read back from the camera.

9. Service & Maintenance

9.1 Diagnostics

9.1.1. Error diagnosis by serial communication protocol

Within the communication protocol, the command and data are combined in a message.

After receiving a message the camera responds with an acknowledgement character. This can be an ACK character (positive acknowledgement) or a NAK character (negative acknowledgement).

The ACK response is given when the received message was understood (the content of the message is not considered).

The NAK response is given when the received message was not understood, which may be the case when invalid characters are received as message content, or the message overruns the camera receiver buffer capacity.

However, the communication protocol itself does not check the content and validity of a message. After each attempt to execute a command, the error register is set. To verify whether a command is succesfully executed or not, the result should be read back from the camera.

`Command syntax: ERR?`

The ERR command returns a single integer value.

A list of possible error codes and the cause are shown below:

Error code	Description
0	No error
1	Last received command: unknown command keyword
2	Last received command: missing parameter
3	Last received command: parameter syntax error
4	Last received command: too many parameters
5	Last received command: missing parameter(s)
7	Last received command: parameter(s) out of range
8	Last received command: internal Adimec error
100	Loading of settings configuration from non-volatile memory failed (CRC invalid)
101	Writing of settings configuration to non-volatile memory failed (CRC verify failed)
102	DP: adding a defect while the list is already full
103	DP: adding a defect that is already in the list
120	OLUTBGN operation error: LUT transactions already pending.
121	Adding OLUT element or OLUTEND while OLUT definition not opened by OLUTBGN.
122	OLUTEND while received not enough LUT entries.
123	Adding more LUT entries that allowed.

Table 9.1: Possible error codes

9.1.2. Built-In Test

After power up a number of built-in tests are performed to check on correct camera operation. The result of these tests can be obtained by the BIT command.

```
Command syntax: BIT?
Reply message : x;y
```

Where x;y = 0;0 indicates all tests passed.

NOTE: All other codes are of no meaning to the user. When requesting support on some features of the camera, Adimec may request the result of the BIT command, in order to optimize support.

9.1.3. Camera temperature

The temperature of the sensor pcb inside the camera can be obtained by means of the Temperature Measurement command..

```
Command syntax: TM?
Reply message : x;y
```

Where x = temperature in °Celsius and y = temperature in °Fahrenheit

9.1.4. Elapsed time

The amount of time the camera has been powered on after manufacturing can be obtained from the camera by means of the elapsed time command.

```
Command syntax: ET?
Reply message : x;y
```

Where the total elapsed time in hours is defined as x * 65536 + y.

9.1.5. Microcontroller firmware release time stamp

For diagnostic purposes on firmware issues the time stamp (date and time) of the internal microcontroller firmware can be obtained from the camera.

```
Command syntax: UFDT?
Reply message : “Mon dd YYYY;hh:mm:ss
```

Where Mon dd YYYY represent the date and hh:mm:ss the time.

NOTE: This command gives no practical user information. When requesting support on some features of the camera, Adimec may request the microcontroller timestamp, in order to optimize support.

9.2 Internal test pattern generator

In order to check the camera and datapath in the system, a test pattern is available. This test pattern generator produces a static, defined picture according to the settings for output resolution, gain and the mode the camera is currently working in. Binning and mirror settings are not functional. The output values of the test pattern are subject to the applied gain. The test pattern is developed with gain = 1 and therefore hereafter described as if gain were set to 1.

The following command switches the test pattern on or off.

```
Command syntax: TPx
```

Where x = 0 for off, 1 for on

The current setting can also be read back from the camera.

```
Command syntax: TP?
```

9.2.1. Test pattern definition

The test pattern image is specified in 12 bit digital values. When an output resolution m < 12 bit is selected the camera will output the upper m bits of the specified values discarding non-used lower bits.

For 8 and 10 bit output the values truncates as follows:

RELATIVE VALUE	12 BIT DOMAIN	10 BIT DOMAIN	8 BIT DOMAIN
Black 0 %	0	0	0
	1	0	0
	2	0	0
	3	0	0
	15	3	0
(G)ray / 50 % .	2047 ..	511 ..	127 ..
(W)hite / 100 %	4095	1023	255

Table 9.2: Test pattern mapping 8 to 12 bit domain.

9.2.2. Global layout

The test pattern has a size equal to the maximum active video area size. The size is defined by the parameters W and H according to the table below:

CAMERA TYPE	W	H
OPAL-1000	1024	1024
OPAL-1600	1600	1200
OPAL-2000	1920	1080
OPAL-4000	2336	1752
OPAL-8000	3296	2472

Table 9.3: Test pattern size.

The test pattern is composed of a black (digital 0) background with superimposed sub-patterns according to the layout shown below:

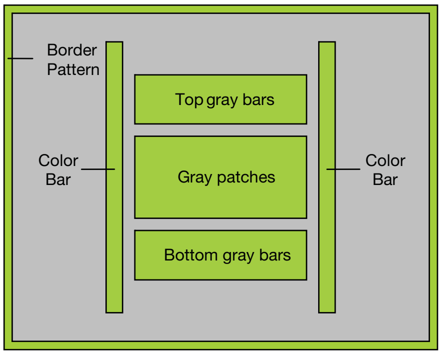
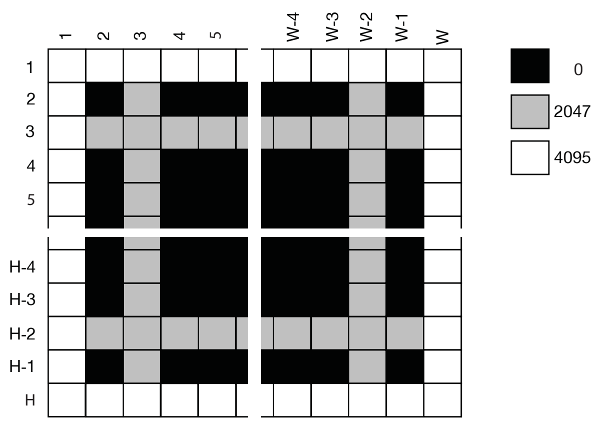


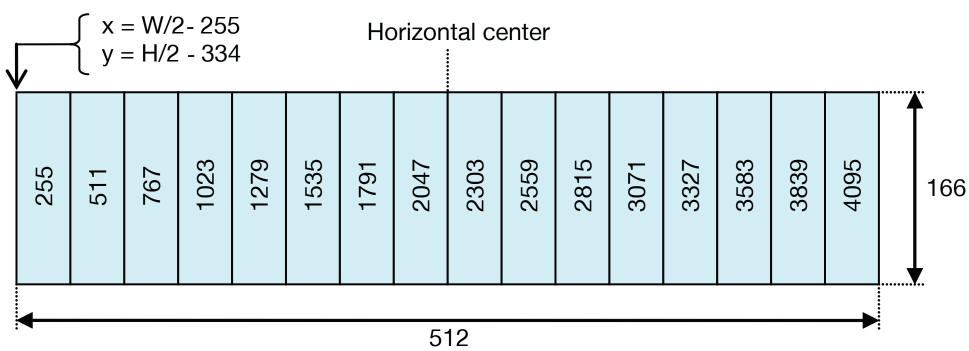
Figure 9.1: Test pattern layout.

The Color bar patterns only apply to color cameras. Monochrome cameras have these areas blanked.

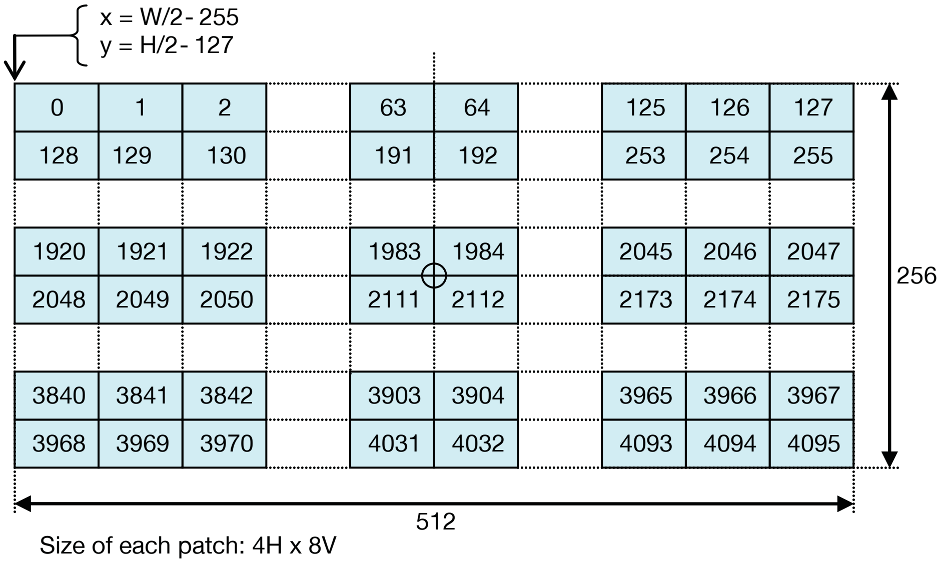
9.2.3. Border pattern



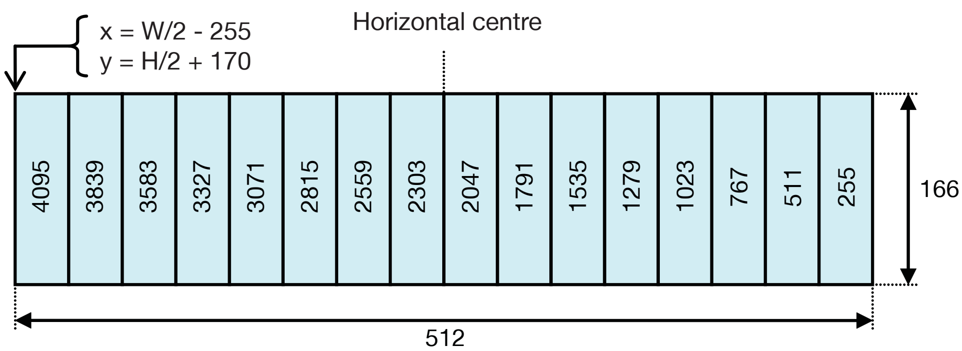
9.2.4. Top gray bars



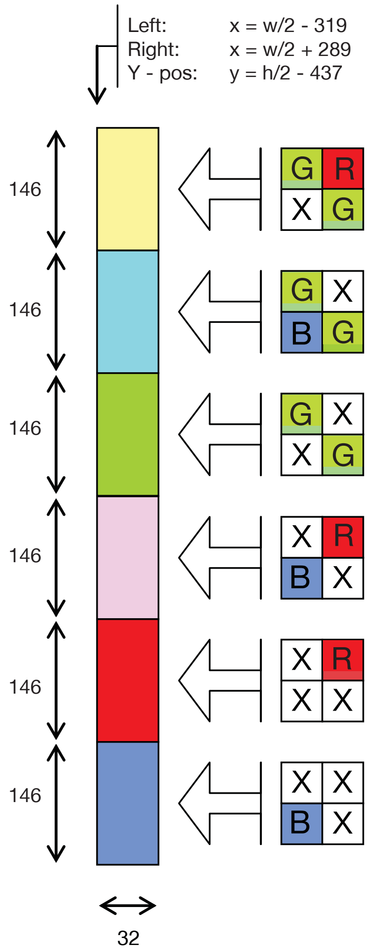
9.2.5. Gray patches



9.2.6. Bottom gray bars



9.2.7. Color bar



NOTE: The colored pixels indicated "On" have a value of 4095. Pixels indicated "X" have a value of 0.

9.3 Information Overlay data format

When enabled, the top left most active video pixels in the output image are replaced by 8 data pixels. The upper 8 bits of the data pixels carry information, lower bits (when applicable) are set 0.

`Command syntax: OVLx`

Where x = 0 disables the overlay function and x = 1 enables the overlay function.

The overlay data contains two 32 bit values:

- The current frame counter
- The actual integration time used for the current image. The integration time value is supplied in units of 1 pixel clock interval (25 ns).

The actual setting can be read back from the camera.

The data pixel layout is shown below:

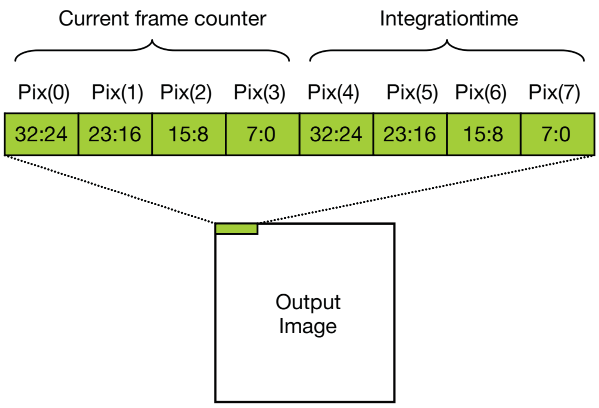


Figure 9.2: Graphic representation of overlay data layout.

9.4 Cleaning

9.4.1. Cleaning of the camera.

The camera must never be immersed in water or any other fluid. For cleaning, only use a light moist cotton tissue.

9.4.2. Cleaning of the CCD sensor

Cleaning of a CCD sensor is a rather difficult task. Due to the possibility of creating scratches on the cover glass or damaging the CCD by ESD, Adimec does not recommend cleaning the optical surface of the sensor, unless by necessity.

- Depending on the aperture of the lens used, any dust particles with a size of 7 μm and larger can show up in your image.
- All cameras are checked to be clean in the factory before shipment.
- Proper handling instructions during system assembly and integration can prevent the CCD sensor from becoming contaminated.
- Should cleaning of the CCD sensor be unavoidably necessary, follow the lprecaution below.

The correct work environment for cleaning is essential in order to ease cleaning and to prevent damage of the CCD sensor.

Precautions:

- Take general precautions to prevent ESD that can damage the CCD sensor
- Cleaning of the CCD sensor, and assembly of the lens is preferably performed in a clean room or at least at a clean bench.
- Never try to clean the CCD sensor at a relative humidity lower than 30 %. A relative humidity of 40 % or higher is preferred in order to minimize the chance of damage due to ESD.
- It is advisable to use an ionizer, in order to minimize the built-up of electrostatic charges.
- Use non-fluffing cotton swab and Alcohol (or Hexane) for cleaning. De-ionized water may be necessary to remove ionic contaminants like salts.
- A cotton swab should be used only once - you will otherwise move dirt from one place to another.
- Never rub the window dry. This may cause static charges or scratches that can destroy the CCD sensor.

Cleaning directions:

1. First try to remove the contamination by using clean, dry air. Use an ultra-filtered, non-residue dust remover spraycan. Dry air can cause an electrostatic charge. Take appropriate environmental measurements to avoid the build-up of electrostatic charges. Prevent blowing air in the thread of the lensmount, because this may cause contamination on the CCD sensor due to loose particles and traces of oil or grease.
2. If this step does not result in an acceptable result, continue with step 3.
3. Remove the lens mount by removing the 4 crosshead screws that hold the lensmount. Clean the inner side thread of the lens mount using Alcohol or Hexane and a cotton swab.
4. Clean the CCD cover glass using Alcohol or Hexane and a cotton swab. Gently and carefully rub the window always in the same direction, e.g. top to bottom.
5. Install the lensmount back onto the camera.

Check the results of the cleaning operation.

6. Install a lens and power up the camera. Adjust the lens at a small aperture (f.i. F16) and point the lens at a bright lightsource. Adjust gain and integration time if necessary.
7. Check the image on the monitor for dark spots and stripes caused by contamination on the CCD sensor cover glass. (Note that the image on the monitor should not saturate due to over exposure - if necessary close the iris even further).
8. If the CCD sensor is not clean, repeat steps 3 - 7 using a new cotton swab. After three unsuccessful tries, it is advised to wait a few minutes before a new attempt is made to clean the CCD sensor. (This allows the electric charge that has been built up during cleaning to neutralize).

If the cleaning operation is not successful, it is recommended that you contact your business office service department to get the appropriate support.

9.5 Maintenance

No specific maintenance other than cleaning is applicable.

9.6 Repair and modification

Repair, modification and replacement of parts shall be done only by Adimec to maintain compliance with the directive 89/336/EEC electromagnetic compatibility

10. Option: AEC/VEM

10.1 Introduction

The AEC option is available on all OPAL family members. This application note describes the functionality of the option.

AEC stands for Automatic Exposure Control. In the OPAL camera series this breaks down into two basic functionalities:

- Automatic Gain Control
- Automatic Integration time Control

The VEM option is available on the monochrome OPAL family members only.

VEM stands for Video Enhancement Module. This function optimizes contrast for the whole image based on real-time measurements made on a predefined window within the image.

The camera can be operated as any standard OPAL camera for setting the parameters described in this Application Note.

In this Application Note the following abbreviations will be used:

AGC: Automatic Gain Control

AIC: Automatic Integration time Control

AEC: Automatic Exposure Control: the combination of both AIC and AGC

10.2 Performance

10.2.1. AEC

The Automatic Exposure Control is fully configurable. The measurement window can be set; the auto exposure setpoint is adjustable. These parameters are common for both Automatic Gain Control and Automatic Integration time Control.

Both AIC and AGC can be enabled separately. The AIC will control in discrete steps. Therefore it is advised to always have both AGC and AIC enabled; in this configuration the AGC will act as a fine-tuning mechanism for the AIC. If the AIC is enabled and AGC is disabled, gain will be set to last gain set by the automatic gain control or manual gain.

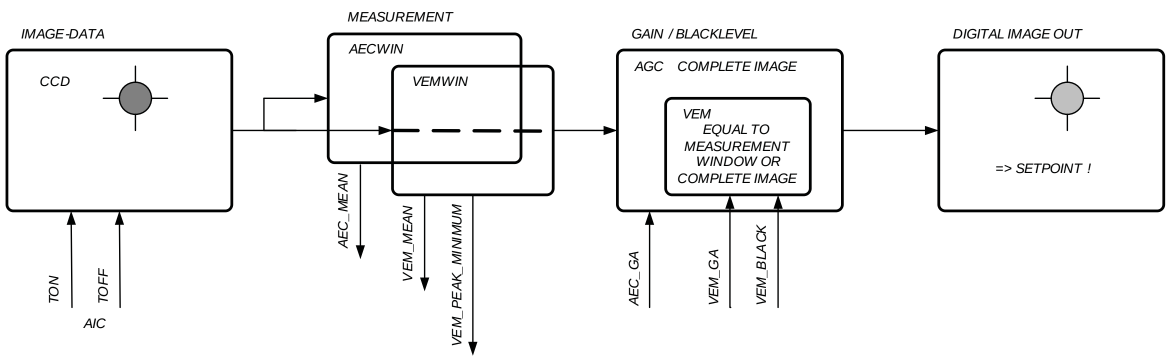


Figure 10.1: This figure indicates the control loop of AEC.

The detection value of the AEC mechanisms is the weighted average within a defined window of the grey value (monochrome cameras, default the weighing factor is 1) or the weighted average of the red, green and blue information (red + green + blue = 1).

AIC acts at sensor level. Ton and Toff in figure 1 are internal timing signals which determine the integration period of the sensor. This timing is the result of the algorithm using the Frame Period (FP), the measured average video level from sensor (AEC_mean) and the Auto Exposure Setpoint.

AGC will act if the Auto Exposure Setpoint cannot be matched by the AIC due to low light conditions. In this case, the integration time is at maximum with regards to AICmax and FP.

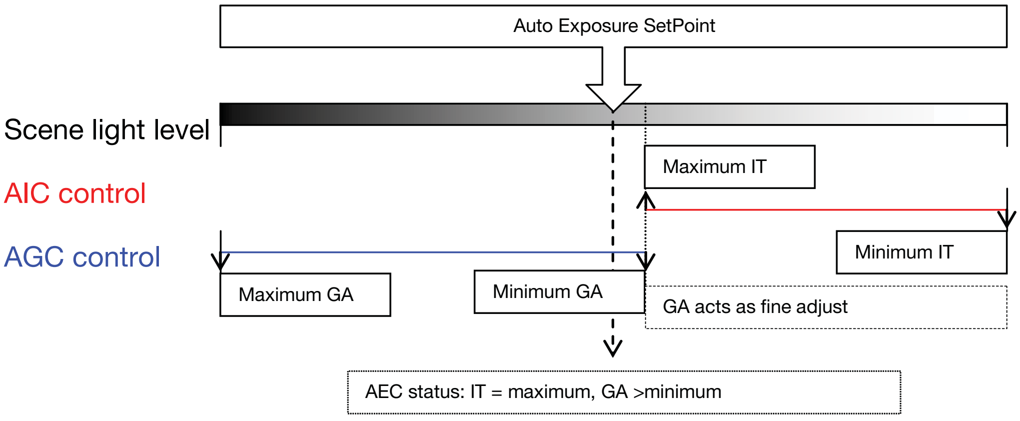


Figure 10.2: This figure indicates the operation of the AEC control loop

The speed factor of both AIC and AGC controls can be set by user command.

10.2.2. VEM

This function optimizes contrast for the whole image based on real-time measurements made on a predefined part of the image, referred to as detector window or Area Of Interest (AOI). Contrast optimization is done by applying gain and offset in order to have pre-defined maximum and minimum video levels in the AOI. The part of the image that is outside the AOI will also be optimized but will not contribute to the real time measurements. These parts may therefore remain over- or underexposed.

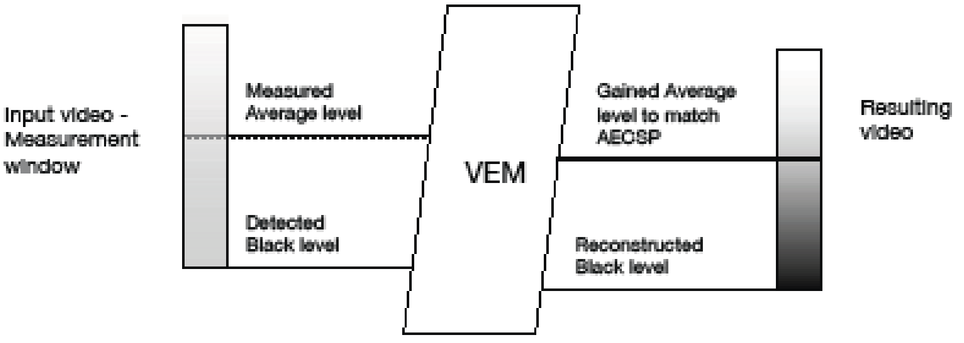


Figure 10.3: This figure indicates the operation of the VEM control loop

VEM allows for contrast enhancement by video level measurements within a defined window. The operation and its limits can be configured by commands.

The default values for VEM operation are selected as best trade-off between applied enhancement and noise. It is best to keep this default setting.

If noise becomes an issue, than parameter VEM maximum AGC gain might be decreased in order to have less overall gain.

10.3 AEC commands

All parameters in which the camera differs from the standard camera will be discussed in this chapter. For all parameters goes: where applicable the default setting is underlined.

10.3.1. Auto exposure control commands

All commands with a question mark are query commands, obtaining information from the camera. All other commands are commands with which a certain parameter is set. For all parameters goes: where applicable the default setting is underlined.

10.3.2. Enabling AEC (AIC & AGC)

Automatic gain control (AGC) and automatic integration time control (AIC) can be enabled independently.

`Command syntax:    AGCx`

Where x=0: AGC disabled

x=1: AGC enabled

`Command syntax:    AGC?`
`Reply: x`

Where x: as above

`Command syntax:    AICx`

Where x=0: AIC disabled

x=1: AIC enabled

`Command syntax:    AIC?`
`Reply: x`

Where x: as above

10.3.3. Controlling AEC setpoint and measurement window

Setpoint and window are common for AGC and AIC and can be altered with the AECSP (setpoint) and AECWIN (window) commands respectively.

`Command syntax:    AECSPx`

Where x= 0 .. 4095

NOTE: x= 0 : setpoint at absolute black

x= 1024: setpoint at 1/4 x Full Scale

x= 4095: setpoint at Full Scale

`Command syntax:    AECSP?`
`Reply: x`

Where x: as above

`Command syntax:    AECWINx;y;w;h`

Where x = 0 .. left side of window/HBIN factor

y = 0 .. top of window/VBIN factor

w= 2 .. width of window/HBIN factor

h= 2 .. height of window/VBIN factor

`Command syntax:    AECWIN?`
`Reply: x;y;w;h`

Where x, y, w and h as above

NOTE:

1) Values are automatically adjusted if needed to correct values. All values are rounded to even values.

2) After an ROI command, the AEC window will automatically be changed to the ROI-values.

3) The AEC setpoint is also the setpoint for VEM.

10.3.4. Controlling AEC Peak / Average balance

the balance between peak and average can be set by the AECPAB command.

`Command syntax:    AECPABx`

Where x= 0 .. 256

NOTE: x= 0 : completely average

x= 256 : completely peak

Command syntax: `AEPAB?`

Reply: `x`

Where x: as above

10.3.5. Weight of the R, G and B values for AEC (color only)

To determine the luminance value that is to be compared to the setpoint value each primary color has its own weight. In general this is considered necessary because the human eye has different sensitivities for the three primary colors. The optimum settings however do very much depend on the scene illumination and the application in which the camera is used.

Therefore the default settings are equal for each of the colors.

Command syntax: `AECLUMr;g;b`

Where r = 0 .. 100 = relative weight of red info in units of 0.01

g = 0 .. 100 = relative weight of green info in units of 0.01

b = 0 .. 100 = relative weight of blue info in units of 0.01

NOTE: r + g + b = 100, Values added together must not exceed 100 (1 time gain) in total, otherwise parameter range error.

Command syntax: `AECLUM?`

Reply: `r;g;b`

Where r, g and b as above

10.3.6. Defining AEC behavior

Four advanced parameters, defining AEC behavior can be set and read back by means of the AECP command. Refer to table below for a description of these parameters and their default values.

```
Command syntax:    AECPx;y
```

Where x = AEC parameter

y = parameter value

```
Command syntax:    AECP?x
Reply: y
```

Where x and y as above

x	range of the setting	parameter value description
0	1 .. 255	AGC Speed factor. High factor is fast response
1	100 .. 12799	AGC maximum gain in units of 0.01 times
2	1 .. 32000	AIC minimum time in units of 10 us
3	1 .. 32000	AIC maximum time in units of 10 us
6*	-	Current mean detection value
7*	-	Current peak detection value
8*	-	Current peak / mean ratio value
9	0 .. 9	Softness factor peak detector

* read only

Table 10.1: Range of the AEC settings

10.4 VEM commands (Monochrome only)

All commands with a question mark are query commands, obtaining information from the camera. All other commands are commands with which a certain parameter is set. For all parameters goes: where applicable the default setting is underlined.

10.4.1. Enabling the VEM

Although VEM can be enabled independent from AGC and AIC, it is recommended that at least AIC is enabled. This allows the camera to auto select the integration time necessary for nominal video.

```
Command syntax:    VEMx
```

Where x=0: VEM disabled

x=1: VEM enabled

```
Command syntax:    VEM?
Reply: x
```

Where x: as above

10.5 Controlling the AEC setpoint and VEM measurement window

Setpoint and window can be altered with the AECSP (setpoint) and ARCWIN (window) commands respectively

`Command syntax:    AECSPx`

Where x= 0 .. 4095

NOTE: x= 0 : setpoint at absolute black

x= 1024: setpoint at 1/4 x Full Scale

x= 4095: setpoint at Full Scale

`Command syntax:    AECSP?`
`Reply: x`

Where x: as above

`Command syntax:    VEMWINx;y;w;h`

Where x = 0 .. left side of window/HBIN factor

y = 0 .. top of window/VBIN factor

w= 2 .. width of window/HBIN factor

h= 2 .. height of window/VBIN factor

`Command syntax:    VEMWIN?`
`Reply: x;y;w;h`

Where x, y, w and h as above

10.5.1. Defining VEM behavior

Six advanced parameters, defining VEM behavior can be set and read back by means of the VEMP command. Refer to table below for a description of these parameters and their default values.

`Command syntax:    VEMPx;y`

Where x = advanced parameter

y = advanced parameter value

`Command syntax:    VEMP?x`
`Reply: y`

Where x and y as above

x	range of the setting	parameter value description
0	1 .. 255	Control Speed factor. High factor is fast response
1	0, 1	0 VEM active on complete window (ROI) 1 VEM active on VEM window only
2	1 .. 12799	VEM maximum AGC gain in units of 0.01
3	1 .. 12799	VEM maximum contrast gain budget in units of 0.01
4	1 .. 12799	VEM maximum contrast Gain in units of 0.01
5	0 .. 9	VEM softness factor minimum detection
6*	0 ..4095	The current mean detection value used by the VEM in 12 bit video resolution
7*	0 ..4095	The current minimum detection value used by the VEM in 12 bit video resolution.
8*	0 ..4095	The current gain value used by the VEM
9*	-4095 .. 0	The current black level value used by the VEM

*read only

Table 10.2: Range of the VEM settings

11. Reference

11.1 Camera Link port configuration

The two video outputs TAP-A and TAP-B of the camera are mapped to the Camera Link ports A, B and C according to the base configuration described in the Camera Link specification.

The mapping for 8,10 and 12 bit output resolution is shown in the tables below. All unused Port A/B/C signals are set to logic 0.

The DVAL signal is fixed to logic 1.

The mapping for 8 bit output resolution is shown below:

CAMERA OUTPUT	PHYSICAL CAMERA LINK PORT MAPPING
TAP-A (bit 7..0)	Port A (7..0)
TAP-B (bit 7..0)	Port B (7..0)

Table 11.1: Mapping for 8 bit output resolution

The mapping for 10 bit output resolution is shown below:

CAMERA OUTPUT	PHYSICAL CAMERA LINK PORT MAPPING
TAP-A (bit 9..8) TAP-A (bit 7..0)	Port B (1..0) Port A (7..0)
TAP-B (bit 9..8) TAP-B (bit 7..0)	Port B (5..4) Port C (7..0)

Table 11.2: Mapping for 10 bit output resolution

The mapping for 12 bit output resolution is shown below:

CAMERA OUTPUT	PHYSICAL CAMERA LINK PORT MAPPING
TAP-A (bit 11..8) TAP-A (bit 7..0)	Port B (3..0) Port A (7..0)
TAP-B (bit 11..8) TAP-B (bit 7..0)	Port B (7..4) Port C (7..0)

Table 11.3: Mapping for 12 bit output resolution

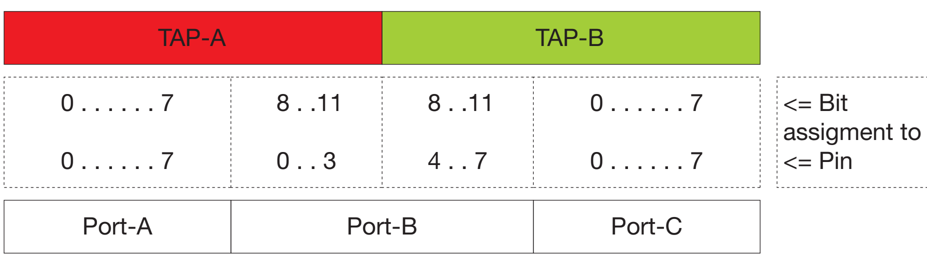


Figure 11.1: Figurative representation of two tap Camera Link 12-bits bit mapping in 12-bits.

11.2 Camera Link video output

11.2.1. Vertical Remap enabled:

If vertical remap is enabled the camera has the tap stream format as shown in fig. 10.2.

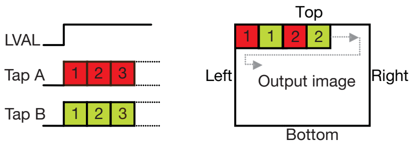


Figure 11.2: Camera Link video timing Vertical remap enabled.

The latency with vertical remap enabled is about 52% of the minimum frame period.

11.2.2. Vertical Remap disabled:

If vertical remap is disabled the camera has a tap stream format as shown in fig. 10.3.

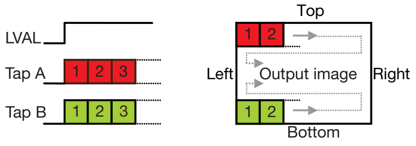


Figure 11.3: Camera Link video timing Vertical remap disabled.

The latency with vertical remap disabled is about 2% of the minimum frame period.

NOTE: Latency is defined as the time between the end of the camera integration period and the start of image output on the camera output.

11.2.3. Camera Link video timing caracteristics

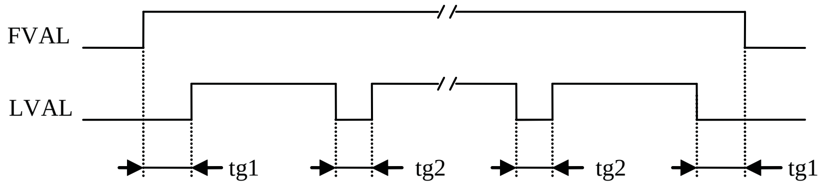


Figure 11.4: Camera Link video timing

- Time between FVAL rising edge and first LVAL rising edge tg1 ≥ 16 Tp.
- LVAL inactive period tg2 ≥ 4 Tp
- Time between last LVAL falling edge and FVAL falling edge tg1 ≥ 16 Tp ,

where Tp = interface clock period

Note that the LVAL signal is not a continuous signal and that the time between successive LVAL periods (tg2 in the timing diagram) is not fixed but depends on the image format and possibly inserted shutter operation. For details on shutter operations during image readout please refer to chapter 7.

11.2.4. Pixelclock

MODEL	PIXELCLOCK	CLOCK PERIOD (TP)
For all OPAL models	80 MHz	1.25 ns

Table 11.4: Pixelclock speed

11.2.5. Bayer pattern color cameras

The OPAL cameras use the following Bayer pattern for color encoding:

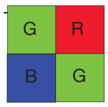


Figure 11.5: Bayer pattern.

The first pixel on the first line is basically the first pixel of a frame that is output by the camera is the pixel on left-top in fig. 10.4. This pixel is a so-called “Green Pixel On a Red Line.”

When using the horizontal and/or vertical flip functions, the Bayer pattern will also be mirrored.

11.3 Basic serial communication parameters of the camera

11.3.1. Control of the camera by serial communication

The OPAL camera is fully software controlled via the Camera Link cable using a ASCII based protocol.

Delivered with the camera is a command line based console application that can be used to interactively control the camera. It can also load and save power-up default settings.

Although this is an easy option of changing camera settings it is also possible to communicate with the camera using your own dedicated software.

11.3.2. Data link settings

The data link settings that shall be used for communication with the camera are:

DESCRIPTION	PARAMETER
Baudrate	57600 baud
Stop bit	1
Data bit	8
Parity	none
Handshaking	none

Table 11.5: port settings

11.3.3. Data flow characters

The communication protocol uses data flow control characters to identify a message and for acknowledgement.

The following data flow characters are defined:

CHAR	DEC	DESCRIPTION
NUL	0	NUL character, is ignored
STX	64	start of message identifier
ETX	13	end of message identifier
ACK	6	positive acknowledgement
NAK	21	negative acknowledgement

Table 11.6: Used ASCII control characters

11.3.4. Message Format

Command and data are combined in a message. A message starts with the STX character followed by the message content. The message ends with an ETX character. The characters allowed in the message content range from decimal 32 to 255.

Format: STX <message content> ETX

11.3.5. Message acknowledgement

After receiving a message, the camera responds with an acknowledgement character. This can be an ACK character (positive acknowledgement) or a NAK character (negative acknowledgement).

The ACK response is given when the received message was understood (the content of the message is not considered).

The NAK response is given when the received message was not understood, which may be the case when invalid characters are received as message content, or the message overruns the camera receiver buffer capacity.

11.3.6. Reply messages

When a message is sent to the camera that requires data to be transmitted back to the host system this data is packed in a message and is sent to the host system after the positive acknowledgement (ACK) character. When the camera responds with a NAK character no data is sent back to the host system.

11.3.7. Communication timing

The time between the successive characters making up a message is not limited. The camera however, when transmitting a message to host system, has a time interval between successive characters of less than the time required for a single character to be transmitted.

11.3.8. Host system requirements

- After transmitting a message to the camera, the host system must wait for the camera to reply with an ACK or NAK character. To prevent lock-up, the wait time for the response must be limited by a time-out period. If the host systems has not received an ACK or NAK character after the time-out period has elapsed, the host system must consider the transmitted message as not being received.
- The time-out time to be used for the camera should be at least 200 ms.
- Under normal conditions a NAK or no response from the camera results from damage of the transmitted characters due to noise or communication link hardware problems. In such case, the host system should transmit the message again. The number of repeated transmissions after a NAK response or no response must be limited by a retry count to prevent lock-up.
- After the maximum number of retries of the transmitted message, if the camera is still responding with a NAK character, the communications channel should be considered malfunctioning or too noisy.
- After the maximum number of retries of the transmitted message if the camera is still not responding, the communication channel should be considered disconnected or the camera not being powered or malfunctioning.

11.4 Camera Link interface standard

11.4.1. Introduction

Without getting into detail on the Camera Link standard, this section discusses the mechanics of the serial communication channel.

Available Camera Link serial software enhancements in the form of Dynamic Link Library files will greatly simplify the setup of a communication channel.

Both camera manufacturers and frame grabber vendors have issued these DLL files which will provide standard C, API and native Visual Basic support, so that applications written in C or Visual Basic can communicate serially with Camera Link cameras.

11.4.2. Overview

The user application calls into the generic clserial.dll, which dynamically loads the.dll file(s) specific to the frame grabber(s) referred to by the application. It then routes all calls to that .dll file. The following diagram illustrates this sequence:

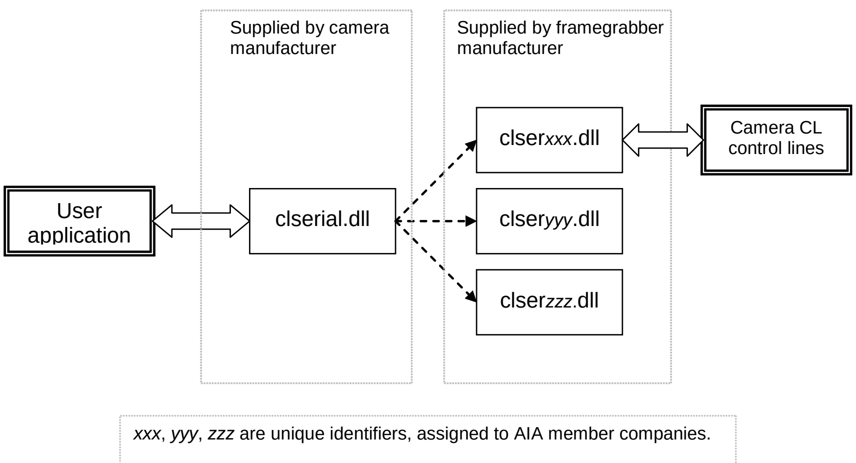


Figure 11.6: Mechanics of communication per Camera link serial channel

Features Provided by clserial.dll

- Simultaneous, multi-port (including cross vendor) support
- Support for binary or text based data transfers
- Common API across vendors
- Common error codes across vendors
- Common error text across vendors
- Strict, well defined behavior of all functions in specification
- Openness to vendor specific error codes and text
- Ability to enumerate ports on sytem
- Inquireable/adjustable baud rate for ports
- Win 32 support (open source for port to other platforms)
- C/C++ support through import library
- VisualBasic support through type library
- Backwards compatibility with recommended specification of October 2000
- Standard default communication settings for serial port

11.4.3. Mechanics of clserial.dll

When clserial.dll loads, it searches the operating system's system directory (for example, C:\windows\system or c:\winnt\system) for all files that use the naming convention clserxxx.dll (xxx is uniquely assigned to AIA member companies). Clserial.dll then dynamically loads those .dll files and queries each one for its manufacturer name and port names. This action produces a list of all possible ports.

The application can then select which port or ports it would like to communicate through. The required manufacturer specific .dll files will be loaded and clserial.dll will manage passing the application calls to
the appropriate .dll for the application specified port.

Further details can be found in the Camera Link – Specification of Camera Link Interface Standard for Digital Cameras and Frame Grabbers – Version 1.1 - January 2004.

11.5 Camera command set overview

COMMAND	DESCRIPTION
BIT?	Gets Built-In Test result (like FPGA boot status, LUT status) in 16 bits
BL	Sets the black level. (B/W only)
BL?	Gets the black level. (B/W only)
BCNT?	Gets the number of images present in the burst memory
BMO	Sets the mode to receive images from the burst memory
BMO?	Gets the mode to receive images from the burst memory
BO?	Gets the burst buffer memory overrun status
BS?	Gets the build state of the camera.
CCE	Selects the exposure control source and event selection
CCE?	Gets the exposure control source and event selection
CCFS	Selects the frame start control source and event selection
CCFS?	Gets the frame start control source and event selection
DP	Add a defect pixel to the Defect Pixel table
DP?n	Gets coordinates of pixel defect number n

COMMAND	DESCRIPTION
DPE	Enables or disables the defect pixel correction.
DPE?	Gets the current status of the defect pixel correction.
DPR	Remove a defect pixel from the table
DPT	Sets defect pixel testmode
DPT?	Gets defect pixel testmode
ERR?	Gets the last known error after executing a command.
FB	Flushes the burst memory and clears the overrun flag
FP	Sets the frame period.
FP?	Gets the current frame period.
FSE	Sets flash strobe output enable
FSE?	Gets flash strobe output enable
FSM	Sets the flash strobe output mode
FSM?	Gets the flash strobe output mode
FSP	Sets the flash strobe output polarity
FSP?	Gets the flash strobe output polarity
FST	Configures the flash strobe timing
FST?	Gets the configuration of the flash strobe timing
GA	Sets the digital gain of the camera.
GA?	Gets the current digital gain.
HBIN	Sets the horizontal binning (option)
HBIN?	Gets the horizontal binning (option)
ID?	Gets the ID-string of the camera, including serial number.
IT	Sets the integration time.
IT?	Gets the current integration time.
LC	Loads the saved configuration.
LC?	Returns current loaded configuration.
MI	Enables or disables the mirror function.
MI?	Gets the current status of the mirror function.
MID?	Gets the Model ID (Adimec Part No)
MO	Sets the operating mode of the camera.
MO?	Gets the current operating mode of the camera.
OFS	Sets the output offset in GL at 12 bit internal resolution (Color only)
OFS?	Gets the output offset at 12 bit internal resolution (Color only)
OLUT	Defines Output LookUp Table (OLUT) entry
OLUT?n	Gets the n-th OLUT entry
OLUTBGN	Begins OLUT definition
OLUTE	Sets OLUT enabled
OLUTE?	Gets status of OLUT enable
OLUTEND	Ends OLUT definition
OR	Sets the output resolution of the camera.
OR?	Gets the current output resolution of the camera.
OVL	Sets information overlay enable
OVL?	Gets information overlay enable
ROI	Sets the region of interest
ROI	Gets the region of interest

COMMAND	DESCRIPTION
RQ	Generates soft request event
RQSIZE	Sets the number of images to release from burst memory
RQSIZE?	Gets the number of images to release from burst memory
SC	Saves the current configuration, settings 0 cannot be saved by an user.
SN?	Gets the camera serial number.
TM?	Gets the actual temperature of the sensor.
TP	Selects display of the test pattern
TP?	Gets the current test pattern display status
USI	Stores an integer in the camera.
USI?	Retrieves an integer from the camera.
USS	Stores a string in the camera.
USS?	Retrieves a string from the camera.
VBIN	Sets the vertical binning
VBIN?	Retrieves the image output binning
VR?	Sets vertical remap function for camera link
VS?	Gets current sensor substrate voltages
WB	Sets the gain for the Red, Green and Blue channel (Color only)
WB?	Gets the gain for the Red, Green and Blue channel (Color only)

Table 11.7: Command set table

11.6 Factory Default settings (power-up set 0)

COMMAND	RANGE	DEFAULT
BL	0..4095	20
CCE	0..4;0..1	0;0
CCFS	0..5;0..1	0;0
DPE	0..1	1
FP	0..32000	different for each camera model.
FSE	0..1	0
FSM	0..1	0
FSP	0..1	0
FST	0..32000; 1..32000	0;1
GA	100..3200	100
IT	1..32000	different for each camera model.
MI	0..3	0
MO	0..3	0
OFS	0..4095	20
OR	8, 10, 12	12
OVL	0..1	0
TP	0..1	0
VBIN	0..1 (0..3 optional)	0
VR	0..1	0
WB	100..399; 100..399; 100..399	100; 100; 100
VR	0..1	0

12. Revision History

REVISION	DESCRIPTION
1.0	Initial revision
1.1	Changed: 5.2.1: Cell **Integration time**; Frame period => Integration Time 5.2.4: Picture Exposure event is replaced Start <=> End 5.2.2: Save Button <=> Load Button 7.8.2: Table 7.7; Start <=> End
	Add OPAL-4000 and OPAL-8000 relevant data Changed: timing table 7.5 and 7.6 Add user defect pixels @ 8.12 and chapter 10
1.5	Add Camera Link serial communication chapter Change to OPAL CL only manual