technical info

pco.edge

Low Level Description

pco.
imaging

This document describes the **low-level command structure** of the pco.edge scientific CMOS (sCMOS) camera.

For SDK implementation please refer to the PCO **Software Development Kit** for pco.cameras (SW_PCOSDKWIN_xxx).

For a detailed description on the camera handling and operating please refer to the **user's manual** of the pco.edge camera.

This document replaces:

- pco.edge camera control commands
- pco.edge camera link packing modes

Target Audience: This camera is designed for use by technicians, engineers, and scientists.

In case of any questions or comments, please contact us at PCO.

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The cover photo shows an exemplary PCO camera system.
The lens is sold separately.

Updated March 2011 © PCO AG

The New Imaging Standard

The new pco.edge is a breakthrough in scientific imaging cameras, due to its distinctive ability to simultaneously deliver extremely low noise, fast frame rates, wide dynamic range, high quantum efficiency, high resolution and a large field of view - all in one image.

Live cell microscopy + Particle Imaging Velocimetry (PIV) + Single molecule detection + Super resolution microscopy + TIRF microscopy / waveguides + Spinning disk confocal microscopy + Spectral (hyperspectral) imaging + Lucky astronomy / imaging + Adaptive optics + Solar astronomy + Genome sequencing (2nd and 3rd gen) + Fluorescence spectroscopy + Bio- & Chemi - luminescence
High content screening + Photovoltaic inspection + X-ray tomography + Ophthalmology + Flow cytometry + Biochip reading + Machine vision + TV / Broadcasting + LIBS + FRAP + FRET + Live cell microscopy+ Biochip reading

	unit	setpoint	pco.edge
resolution (hor x ver)	pixel		2560 x 2160
pixel size (hor x ver)	µm²		6.5 x 6.5
quantum efficiency	%	@ 590 nm peak	57
dynamic range A/D	bit		16
readout noise	e- rms	@ 30 fps @ 100 fps	< 1.4 < 2
imaging frequency, frame rate	fps	@ full frame (ssc mode) @ full frame (fsc mode)	30 100
exposure time	s	@ rolling shutter @ global shutter	500 µs … 2 s 10 µs … 100 ms
region of interest			selectable
optical input			Nikon F-mount (std), C-mount (opt.)
data interface			full camera link

Table of Contents

1 General

Conventions

The following typographic conventions are used in this manual.

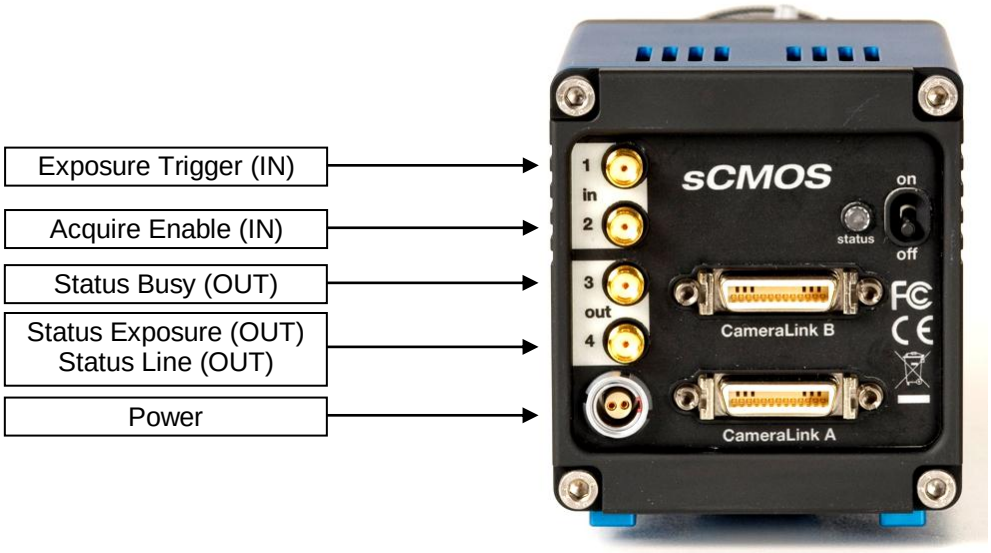
bold: e.g. get camera type
Functions, procedures, or modes that can be used

[words in brackets]: e.g. [run]
Possible values or “states” of the described functions

ALL CAPITAL WORDS: e.g. TRUE
Logical or Boolean values, e.g.:
TRUE, FALSE, ON, OFF, 0, 1, RISING, FALLING, HIGH, LOW

<words in arrows>: e.g. <acq enbl>
Names of hardware input / output signals

Hardware



For a detailed description of the hardware please refer to the user's manual.

2 Communication Layers

The application software running on the PC is able to send commands to the camera as well as requesting status information from the camera. There is also a channel for transmitting image data.

<table>
<tr><td colspan="2">camera status and command layer</td></tr>
<tr><td colspan="2">PC application</td></tr>
<tr><td colspan="2">PC DLL (interface to driver layer)</td></tr>
<tr><td colspan="2">PC driver layer</td></tr>
<tr><td colspan="2">hardware transmission layer</td></tr>
<tr><td colspan="2">camera communication port</td></tr>
<tr><td>camera microprocessor</td><td>camera FPGA</td></tr>
</table>

The DLL links the application software to the camera device driver layer. Commands sent to the driver are common for all versions of pco.camera models as well as for all types of interfaces (Camera Link, FireWire, USB etc.). Thus the driver converts the commands to the used hardware port.

3 Communication Basics

In normal operation the interfaces are used for establishing a point-to-point-connection. Command messages are sent asynchronous.

Each message, which has been sent, contains a checksum calculated over all bytes of the message (except the checksum). So if a message length is 4 byte without the checksum byte, the checksum byte is added and the complete message length is 5 byte. The microcontroller (µC) in the camera also calculates the checksum over the payload data and compares the result with the sent checksum. If the calculated checksum differs from the sent checksum, the command is ignored.

The messages are transferred binary in order to speed up the transfers as well as to minimize the transferred volume thus optimizing the overall system performance. Also “handshaking” is performed between communicating devices. Each message, which has been sent, will be responded by the receiving device. Basically three different cases have to be regarded:

- Transmission is ok - executed command was successful
- Transmission of the command failed - command was ignored
- Transmission is ok - but executed command failed

The transmitter has to wait a reasonable time due to the command and the status of the camera for the response message of the receiving device, as the receiving device has to execute the command and then send back the result in the response message. The timeout limit has to be specific for the command, as some commands as programming- or erase-flash-commands may take some time.

Commands for changing settings:

Basically all settings may be changed in any order. At last the **Arm Camera** command checks the settings for consistency and returns the PCO_NOERROR code, if the settings are consistent and a corresponding error code, if the settings are not consistent.

3.1 General message format

There is defined a general message format which facilitates the message handling for transmitter and receiver:

Command		Message Length		Payload Data					Chksum
0x01	0x01	0x0A	0x00	0x00	0xFF	0xFF	0x00	0x00	0x0A
Group Code	*Message Code*	*Low Byte*	*High Byte*	*Length of Payload data depends on the message. The data may be divided into blocks of different meaning again.*					*Sum of all bytes before*

Detailed description of the message:

- The group code defines the group to which the command belongs.
- The message code defines the command or message itself.
- The message length is the length of the complete message in bytes, including the checksum byte. Please note, that it is delivered in low byte – high byte order. Since the data bytes must not exceed 256 bytes, the maximum length is 261 bytes.
- The payload data is data e.g. needed for executing the command, e.g. parameter for settings, data byte for programming and update commands. However there may be messages with no data at all. The length of the data is simply calculated based on the message length minus 5. The maximum number of data byte is 256.
- The checksum is the sum over all preceding bytes of the message.

A corresponding C language structure representing a general command looks like this:

```
typdef struct      // C structure representing a general command
{
      WORD wCommand;    // Command of telegram
      WORD wLength;     // Length of telegram
      BYTE bData[256];  // Data
};
```

Note: The checksum is not regarded within the structure since its position is not constant for the complete set of messages. Please note also that low byte is sent before the high byte!

Because both transmitter and receiver know all commands, the receiver has to decide on the first two bytes which command is sent and then will fill the appropriate structure of the command.

3.2 Message Acknowledgement

Basically there are three possible cases for message handshaking or acknowledgement:

- Transmission is ok, executed command was successful.
- Transmission of the command failed, command was ignored.
- Transmission is ok, but executed command failed.

The response messages for these three cases sent are described below.

3.2.1 Regular Response Message

Each command has to be answered by the receiver. As sign of acknowledgement the responded message's group code is changed by adding 0x80 through a logical OR operation (setting bit 15 of the command word).

Command		Message Length		Data Returned (Status, command success etc.)					Chksum
0x81	0x01	0x0A	0x00	0x00	0xFF	0xFF	0x00	0x00	0x8A
Group Code **+ 0x80**	*Message Code*	*Low Byte*	*High Byte*	***Data returned has not to be the data sent, also the length of the response message may differ from the received message!***					*Sum of all bytes before*

Note:
The response message may not have the same length as the original message!

3.2.2 Failure / Warning Response Message

a.) Transmission Failure
However if the transmission of the message fails or the checksum is wrong then there is no responded message. The sender has to synchronize itself via timeouts!

Please note, that no message is sent only in case of transmission errors, i.e. the receiver gets a message with erroneous checksum or an undefined message code. If the command executed fails, this has to be handled via messages described below.

b.) Command Execution Failed
If the transmission is ok, but the command execution fails, the receiving device will indicate the failure with the following kind of message:

Command		Message Length		Data Returned				Chksum
0xC1	0x01	0x09	0x00	0xFF	0xFF	0xFF	0xFF	0xFF
Group Code **+ 0xC0**	*Message Code*	*Low Byte*	*High Byte*	***E.g. return status etc.***				*Sum of all bytes before*

The group code is changed by a logical OR operation with 0x80 to indicate, that it's a response message.
An additional change by a logical OR operation with 0x40 (thus resulting in an OR with 0xC0 = 0x80 + 0x40) indicates a failure or a warning of the requested command.

Note:
The response message may not have the same length as the original message!

4 Command Sections

Group codes:	
General Control/Status	0x10
Image Sensor Control	0x11
Timing Control	0x12
Storage Control	0x13
Recording Control	0x14
Image Read	0x15
Interface Specific	0x16

The total set of control commands is subdivided into five sections:

5.1 Camera (General Control/Status)
This section contains general instructions to control the camera and request information about the camera:

5.2 Image Sensor
This group contains all instructions to control the image sensor and to request information about the sensor.

5.3 Timing
This group contains all available commands for control of the timing of the imaging process.

5.4 Recording
This group contains all available commands for setting/requesting recording state, for preparing camera for recording command, and handling the acquire signal.

5.5 Image Read (Interface Specific Commands)
The camera has no internal memory. When recording, the image data is send directly over Camera Link.

4.1 General Control / Status

The group id code for General Control/Status Commands is 0x10. Thus the least significant byte of all command id codes is 0x10. The command id codes are 0x??10, the code of the response message 0x??90 or in case of a failed command 0x??D0.

Overview:

Command:	**Cmd.** Code	**Resp.** Code	**Error** Code
Get Camera Type	0x0110	0x0190	0x01D0
Get Camera Description	0x0111	0x0191	0x01D1
Get Camera Health Status	0x0210	0x0290	0x02D0
Get Temperature	0x0610	0x0690	0x06D0
Get Hardware Versions	0x0710	0x0790	0x07D0
Get Firmware Versions	0x0810	0x0890	0x08D0
Write Mailbox	0x0E10	0x0E90	0x0ED0
Read Mailbox	0x0F10	0x0F90	0x0FD0
Get Mailbox Status	0x1010	0x1090	0x10D0
Get Number of HW IO Signals	0x2511	0x2591	0x25D1
Get HW IO signal Description	0x2611	0x2691	0x0BD0
Get HW IO Signal	0x1912	0x1992	0x19D2
Set HW IO signal	0x1A12	0x1A92	0x1AD2

4.1.1 Get Camera Type

Request camera type, hardware/firmware version, serial number etc.

a.) Command Message:

Code	Length	Cks.
0x0110	0x0005	0x16

Parameter: None

b.) Response Message:

Code	Length	Cam. Type	Cam.Sub. Type	Ser. No.	HW Version	FW Version	Interf. Type	Cks.
0x0190	0x0017	0x0800	0x0000	0x########	0x########	0x########	0x0001	0x##

Return values:
camera type as word, see table below
camera sub type as word, currently 0x0000
serial no. as long word.
hardware version as long word, where the most significant word is the version no. and the lower significant word is the revision no. (ver.rev e.g. 2.01 = [0x00020001])
firmware version as long word, where the most significant word is the version no. and the lower significant word is the revision no. (ver.rev e.g. 2.01)
interface type as word, see table below

Camera Type codes:			
pco.1200 hs	0x0100	pco.4000	0x0260
pco.1300	0x0200	PCO.EDGE	0x1300
pco.1600	0x0220		
pco.2000	0x0240		

Interface Type codes:			
FireWire	0x0001	Ethernet	0x0004
Camera Link	0x0002	Serial Interface	0x0005
USB	0x0003	Reserved	0x0006

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x01D0	0x0009	0x#########	0x##

Return values:
error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.2 Get Camera Description

Request camera description (sensor type, horizontal / vertical / dynamic resolution/ binning/ delay/ exposure ...). The response message describes the sensor type, the readout hardware and its possible operating range and possible operating modes.
Important note: The camera description is a standard descriptor for the newer pco cameras like pco.camera series and pco OEM cameras. Therefore it may contain fields which might be not applicable. The existence of an descriptor will not indicate that a corresponding feature (e.g. binning) is intended to be realized in future versions.

a.) Command Message:

Code	Length	Cks.
0x0111	0x0005	0x17

Parameter: None

b.) Response Message:

Code	Length	Sensor Type	Sensor Sub Type	Hor. Res. standard	Vert. Res. standard	Hor. Res. extended
0x0191	0x007D	0x####	0x####	0x####	0x####	0x####
Vert. Res. extended	Dyn. Res.	Max Binn hor	Binn hor steps	Max Binn vert	Binn vert steps	ROI hor steps
0x####	0x####	0x####	0x####	0x####	0x####	0x####
ROI vert steps	ADC's	Pixelrate 1	Pixelrate 2	Pixelrate 3	Pixelrate 4	Convers. Factor 1
0x####	0x####	0x#### ####	0x#### ####	0x#### ####	0x#### ####	0x####
Convers. Factor 2	Convers. Factor 3	Convers. Factor 4	IR – Sens.	Min Del Time (nsec)	Max Del Time (msec)	Min Del Step (nsec)
0x####	0x####	0x####	0x####	0x#### ####	0x#### ####	0x#### ####
Min Exp Time (nsec)	Max Exp Time (msec)	Min Exp Step (nsec)	Min Del Time IR (nsec)	Max Del Time IR (msec)	Min Exp Time IR (nsec)	Max Exp Time IR (msec)
0x#### ####	0x#### ####	0x#### ####	0x#### ####	0x#### ####	0x#### ####	0x#### ####
Time Table	Min Cooling Setpoint	Max Cooling Setpoint	Default Cooling Setpoint	Power Down Mode	Offset Regu-lation	Color Pattern
0x####	0x####	0x####	0x####	0x####	0x####	0x####
Color Pattern Type	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
0x####	0x#### ####	0x#### ####	0x#### ####	0x#### ####	0x#### ####	0x#### ####
Reserved	Reserved	Reserved	Cks.			
0x#### ####	0x#### ####	0x#### ####	0x##			

Return values:
image sensor type as word, see table “Sensor Type codes” below.
image sensor sub type as word.
horizontal resolution standard in pixels (all effective pixels).
vertical resolution standard in pixels (all effective pixels).
horizontal resolution extended in pixels (all pixels; dummy + dark + eff.).
vertical resolution extended in pixels (all pixels; dummy + dark + eff.).
dynamic resolution in bits/pixel. (i.e. 12, 14 …)
max. binning value horizontal (allowed values from 1 to max. resolution)
binning steps horizontal
1 = linear step (binning from 1 to max i.e. 1,2,3…max is possible)
0 = binary step (binning from 1 to max i.e. 1,2,4,8,16…max is possible)
max. binning value vertical (allowed values from 1 to max. resolution)
binning steps vertical
1 = linear step (binning from 1 to max i.e. 1,2,3…max is possible)
0 = binary step (binning from 1 to max i.e. 1,2,4,8,16…max is possible)
ROI steps horizontal (e.g. 10, => ROI right = 1, 11, 21, 31 ...)
ROI steps vertical
ADC’s (number of ADC’s inside camera; i.e. 1..8)
pixelrate 1 (long word; frequency in Hz)
pixelrate 2 (long word; frequency in Hz; if not available, then value = 0)
pixelrate 3 (long word; fequency in Hz; if not available, then value = 0)
pixelrate 4 (long word; frequency in Hz; if not available, then value = 0)
conversion factor 1 (in electron / counts)
(the value 100 corresponds to 1; i.e. 610 = 6.1 electron/counts)
conversion factor 2 (in electron / counts; if not available, then value = 0)
(the value 100 corresponds to 1; i.e. 610 = 6.1 electron/counts)
conversion factor 3 (in electron / counts; if not available, then value = 0)
(the value 100 corresponds to 1; i.e. 610 = 6.1 electron/counts)
conversion factor 4 (in electron / counts; if not available, then value = 0)
(the value 100 corresponds to 1; i.e. 610 = 6.1 electron/counts)
IR-sensitivity; sensor can switch to improved IR sensitivity
(0 = function not supplied; 1 = possible)
min. delay time in nsec (long word; non IR-sensitivity mode)
max. delay time in msec (long word; non IR-sensitivity mode)
min. delay time step in nsec (long word)
Note: Applies both to non IR-sensitivity mode and IR-sensitivity mode
min. exposure time in nsec (long word; non IR-sensitivity mode)
max. exposure time in msec (long word; non IR-sensitivity mode)
min. exposure time step in nsec (long word)
Note: Applies both to non IR-sensitivity mode and IR-sensitivity mode
min. delay time in nsec (long word; IR-sensitivity mode)
max. delay time in msec (long word; IR-sensitivity mode)
min. exposure time in nsec (long word; IR-sensitivity mode)
max. exposure time in msec (long word; IR-sensitivity mode)
time table ; camera can perform a timetable with several delay/ exposures
(0 = function not supplied; 1 = possible)
double image mode; camera can perform a double image with short interleave
time between exposures (0 = function not supplied; 1 = possible)
min. cooling setpoint (in °C)
(if all setpoints are 0, then cooling is not available)
max. cooling setpoint (in °C)
(if all setpoints are 0, then cooling is not available)
default cooling setpoint (in °C)
(if all setpoints are 0, then cooling is not available)
power down mode; switch sensor into power down mode for reduced dark
current (0 = function not supplied; 1 = possible)
offset regulation; automatic offset regulation with reference Pixels
(0 = function not supplied; 1 = possible)

(Return values of command “Get Camera Description” continued)

color pattern (word), see detailed description below
color pattern type (word), where:
1 is bayer pattern
2 is bayer pattern CMY
reserved (9 long words; for future use)

Sensor Type codes: monochrome sensors:		color sensors:	
Fairchild CIS2051	0x2000	Fairchild CIS2051	0x2001

Note: This list will be updated with new entries and available on the www.pco.de web page.

4.1.3 Get Camera Health Status

Request the current camera health status: warnings, errors.

a.) Command Message:

Code	Length	Cks.
0x0210	0x0005	0x17

Parameter: None

b.) Response Message:

Code	Length	Warnings	Errors	Status	Cks.
0x0290	0x000D	0x########	0x########	0x########	0x##

Return values: Warnings encoded as bits of a longword. Bit set indicates warning, bit cleared indicates that the corresponding parameter is ok. See table on the next page.
System errors encoded as bits of a longword. Bit set indicates error, bit cleared indicates that the corresponding status is ok. See table on the next page.
System Status encoded as bits of a longword. For meaning of the bits see table on the next page.

The tables on the next page show the mask value (not the bit no.) for requesting the corresponding error / warning status:

```
// -- C/C++ example ---------------------------------
if (errorcode & 0x00000001)   //  power supply voltage range error
{
        // report error to user etc.
}
// -------------------------------------------------
```

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x02D0	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

d.) Warnings:

Warning mask codes:	
0x00000001	Power Supply Voltage Range
0x00000002	Power Supply Temperature
0x00000004	Camera temperature (board temperature / FPGA temperature)
0x00000008	Image Sensor temperature (for cooled camera versions only)

e.) Errors:

Error mask codes:	
0x00000001	Power Supply Voltage Range
0x00000002	Power Supply Temperature
0x00000004	Camera temperature (board temperature / FPGA temperature)
0x00000008	Image Sensor temperature (for cooled camera versions only)
0x00010000	Camera Interface failure
0x00020000	Camera RAM module failure
0x00040000	Camera Main Board failure
0x00080000	Camera Head Boards failure

f.) Status:

Status mask codes:	
0x00000001	Default State: Bit set: Settings were changed since powerup or reset. Bit cleared: No settings changed, camera is in default state.
0x00000002	Settings Valid: Bit set: Settings are valid (i.e. last “Arm Camera’ was successful and no settings were changed since ‘Arm camera’, except exposure time). Bit cleared: Settings were changed but not yet not checked and accepted by ‘Arm Camera’ command.
0x00000004	Recording State: Bit set: Recording state is on. Bit cleared: Recording state is off.

4.1.4 Get Temperature

Request the current camera operation status: warnings, errors.

a.) Command Message:

Code	Length	Cks.
0x0610	0x0005	0x1B

Parameter: None

b.) Response Message:

Code	Length	CCD temp.	Cam. temp.	PS temp.	Cks.
0x0690	0x000B	0x####	0x####	0x0000	0x##

Return values: CCD temperature as signed word in 1/10 of °C!
Camera temperature as signed word in °C.
Power Supply temperature as signed word in °C.

Note: CCD temperature: temperature at sensor
Camera temperature: temperature at electronics
Power Supply temperature: temperature hotspot close to FPGA

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x06D0	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.5 Get Hardware Versions

Request the current hardware version of the camera´s boards.

a.) Command Message:

Code	Length	Cks.
0x0710	0x0005	0x1C

Parameter: None

b.) Response Message:

Code	Length	Board Num.	...	Cks.
0x0790	0x####	0x####	...	0x##

Text Descriptor (16 byte)	RFU	Revision	Variant
e.g. “edge.main”	0x####	0x####	0x####
“Device 2”			
“Device 3”			
..			
“Device 9”			
“Device 10”			

Return values: Board Number: For these number of board a revision info will follow
10 entries with each:
Text descriptor for the board, limited by a null character. Field is alway 16 bytes long, the bytes after the null character may be undefined.
RFU: reserved for future use (WORD)
Revision: Revision no. from 0 to 99 (WORD)
Variant: Board variant, usually 1 (WORD)

There are always 10 entries, if the board number is less, the 10 – n fields at the end are not defined.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x07D0	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.6 Get Firmware Versions

Request the current firmware version of the camera's programmable devices.

a.) Command Message:

Code	Length	Cks.
0x0810	0x0005	0x1E

Parameter: None

b.) Response Message:

Code	Length	Dev. Num.	...	Cks.
0x0890	0x####	0x####	...	0x##

Text Descriptor (16 byte)	Minor Rev	Major Rev	Variant
e.g. “Main up”	0x##	0x##	0x####
“Device 2”			
..			
“Device 9”			
“Device 10”			

Return values:

Device number: For these number of programmable devices a revision info for the programmed firmware will follow
10 entries with each:
Text descriptor for the device, limited by a null character. Field is always 16 bytes long, the bytes after the null character may be undefined.
Minor revision: (byte)
Major revision (byte)
Variant: Firmware variant, usually 1 (WORD)

There are alway 10 entries, if the board number is less, the 10 – n fields at the end are not defined.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x08D0	0x0009	0x########	0x##

Return values:

error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.7 Write Mailbox

The mailboxes are useful for two control devices (connected to different interfaces at the camera) communicating via the camera. One control device writes data to the mailbox, the other one can read the message. There is a simple acknowledge mechanism for the writer of a message to see, if the message has been read by the receiving device. See also command “Get Mailbox Status”.

a.) Command Message:

Code	Length	Mailbox No.	Data[0]	..	Data[63]	Cks.
0x0E10	0x0047	0x####	0x##	..	0x##	0x##

Return values:
- No. (index) of mailbox to be read, from [0 to Number of Mailboxes – 1]
- 64 byte of data. If not all 64 byte shall contain valid data, the user must implement a size mechanism by himself, e.g. by defining the first byte or word as size parameter!

Notes:
- Writing to a mailbox will overwrite the old content of the mailbox. Please use the command “Get Mailbox Status” in order to check, if the old message has been already read.

b.) Response Message:

Code	Length	Mailbox No.	Cks.
0x0E90	0x0009	0x####	0x##

Parameter:
- No. (index) of mailbox, same as input parameter

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x0ED0	0x0009	0x########	0x##

Return values:
- PCO_ERROR_FIRMWARE_NOT_SUPPORTED or PCO_ERROR_FIRMWARE_UNKNOWN_COMMAND if the command is not supported by the camera.
- PCO_ERROR_FIRMWARE_VALUE_OUT_OF_RANGE
- error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.8 Read Mailbox

The mailboxes are useful for two control devices (connected to different interfaces at the camera) communicating via the camera. One control device writes data to the mailbox, the other one can read the message. There is a simple acknowledge mechanism for the writer of a message to see, if the message has been read by the receiving device. See also command “Get Mailbox Status”.

a.) Command Message:

Code	Length	Mailbox No.	Cks.
0x0F10	0x0007	0x####	0x..

Parameter: No. (index) of mailbox to be read, range from [0 to Number of Mailboxes – 1]

b.) Response Message:

Code	Length	Mailbox No.	Read Status	Data[0]	..	Data[63]	Cks.
0x0F90	0x0049	0x####	0x####	0x##	..	0x##	0x##

Return values:
- No. (index) of mailbox, same as input parameter
- Status of read operation, where:
  - 0x0000: No message available, content of the mailbox not valid
  - 0x0001: New message is ready, content of the mailbox is valid
  - 0x0003: Content of the mailbox is valid, but message was already read (by recipient)
- 64 byte of data. If not all 64 byte shall contain valid data, the user must implement a size mechanism by himself, e.g. by defining the first byte or word as size parameter!

Notes:
- A read mailbox will not clear or empty the mailbox, thus the content of the mailbox can be read many times. It can be evaluated by the read status (see above), if a message in the mailbox is new and unread.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x0FD0	0x0009	0x########	0x##

Return values:
- PCO_ERROR_FIRMWARE_NOT_SUPPORTED or PCO_ERROR_FIRMWARE_UNKNOWN_COMMAND if the command is not supported by the camera.
- PCO_ERROR_FIRMWARE_VALUE_OUT_OF_RANGE
- error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.9 Get Mailbox Status

The mailboxes are useful for two control devices (connected to different interfaces at the camera) communicating via the camera. One control device writes data to the mailbox, the other one can read the message.

The “Get Mailbox Status” command implements an acknowledge mechanism for the writer of a message to see, if the message has been read by the receiving device.

a.) Command Message:

Code	Length	Cks.
0x1010	0x0005	0x25

Parameter: No. (index) of mailbox to be read, range from [0 to Number of Mailboxes – 1]

b.) Response Message:

Code	Length	Mailbox Num.	Status[0]	..	Status[7]	Cks.
0x1090	0x0049	0x####	0x####	..	0x####	0x##

Return values:
- Total number of mailboxes which are available (max. 8)
- Status of the mailboxes 0 to 7:
  - 0x0000: No message available, content of the mailbox not valid
  - 0x0001: New message is ready, content of the mailbox is valid
  - 0x0003: Content of the mailbox is valid, but message was already read (by recipient)

Notes:
- A read mailbox will not clear or empty the mailbox, thus the content of the mailbox can be read many times. It can be evaluated by the read status (see above), if a message in the mailbox is new and unread.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x10D0	0x0009	0x########	0x##

Return values:
- PCO_ERROR_FIRMWARE_NOT_SUPPORTED or PCO_ERROR_FIRMWARE_UNKNOWN_COMMAND if the command is not supported by the camera.
- PCO_ERROR_FIRMWARE_VALUE_OUT_OF_RANGE
- error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.10 Get Number of HW IO Signals

Use this command in order to request the number of IO signals and ports which can be configured by the HW IO commands.

a.) Command Message:

Code	Length	Cks.
0x2511	0x0005	0x##

Parameter: None

b.) Response Message:

Code	Length	Number	Cks.
0x2591	0x0007	0x####	0x##

Return values: Number of signals/ports which can be configured.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x25D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.11 Get HW IO Signal Description

Get the description of the requested hardware IO signal. To get the number of available hardware IO signals, please call “Get HW IO SignalCount”. Repeat the command <num> times and increment the index from 0 to num – 1 to get all descriptors. To configure the signals use the command ”Set HW IO Signal”. To request the current configuration use “Get HW IO Signal”.

a.) Command Message:

Code	Length	Index	Cks.
0x2611	0x0005	0x####	0x##

Parameter: None

b.) Response Message:

Code	Length	SignalName	SignalDefs	SignalTypes	SignalPol	SignalFilter	Cks.
0x2691	0x009F	4 x 24 char	0x####	0x####	0x####	0x####	0x##

##
##
##
##

Return values: Signal name, 4 fields of 24 characters, null terminated. The signal names correspond to one physical port and will show which function can be connected to that physical port. If there is only one function, only the first field contains a name, the other fields are filled with null strings
Signal Def, bit mask:
0x0001: Signal can be enabled / disabled
0x0002: Signal is output
Signal Types, bit mask describing which signal standard can be configured:
0x0001: TTL
0x0002: High level TTL
0x0004: Contact
0x0008: RS485 (differential)
Signal Polarity, bit mask describing possible polarity settings:
0x0001: High level active
0x0002: Low level active
0x0004: Rising edge
0x0008: Falling edge
Signal Filter, bit mask describing possible filter settings:
0x0001: Filter off
0x0002: Medium filter (time constant in the range of 10 µs)
0x0004: High filter (time constant > 1 ms)

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x0BD0	0x0009	0x########	0x##

Return values: PCO_ERROR_FIRMWARE_NOT_SUPPORTED or PCO_ERROR_FIRMWARE_UNKNOWN_COMMAND if the command is not supported by the camera.
Other error code, less than 0 (see also section **5**. **Error / Warning Codes**)

4.1.12 Get HW IO Signal

Get the current configuration of the requested hardware IO signal.

a.) Command Message:

Code	Length	Index	Cks.
0x1912	0x0005	0x####	0x##

Parameter: Index of signal

b.) Response Message:

Code	Length	Enable	Type	Polarity	Filter	Select	Cks.
0x1992	0x000F	0x####	0x####	0x####	0x####	0x####	0x##

Return values:
Enable:
0x0000: Signal is disabled (not used)
0x0001: Signal is enabled
Type:
0x0001: TTL
0x0002: High level TTL
0x0004: Contact
0x0008: RS485 (differential)
Polarity:
0x0001: High level active
0x0002: Low level active
0x0004: Rising edge
0x0008: Falling edge
Filter: possible filter settings:
0x0001: Filter off
0x0002: Medium filter (time constant in the range of 10 µs)
0x0004: High filter (time constant > 1 ms)
Select: Shows which function of the port is selected, if there are several functions which can be connected. (See also command “Get HW IO Signal Description”).

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x19D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.1.13 Set HW IO Signal

Set the current configuration of the requested hardware IO signal.

a.) Command Message:

Code	Length	Index	Enable	Type	Polarity	Filter	Select	Cks.
0x1A12	0x0011	0x####	0x####	0x####	0x####	0x####	0x####	0x##

Parameter:
Index: Index of signal to configure (as provided by the command "Get HW IO Signal Description").
Enable:
0x0000: Signal is disabled (not used)
0x0001: Signal is enabled
Type:
0x0001: TTL
0x0002: High level TTL
0x0004: Contact
0x0008: RS485 (differential)
Polarity:
0x0001: High level active
0x0002: Low level active
0x0004: Rising edge
0x0008: Falling edge
Filter: possible filter settings:
0x0001: Filter off
0x0002: Medium filter (time constant in the range of 10 µs)
0x0004: High filter (time constant > 1 ms)
Select: Shows which function of the port is selected, if there are several functions which can be connected. (See also command "Get HW IO Signal Description").

b.) Response Message:

Code	Length	Index	Enable	Type	Polarity	Filter	Select	Cks.
0x1A92	0x0011	0x####	0x####	0x####	0x####	0x####	0x####	0x##

Return values: Same as input parameter (see above)

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x1AD2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2 Image Sensor

The group id code for image sensor control commands is 0x11. Thus the least significant byte of all command id codes is 0x11. The command id codes are 0x??11, the code of the response message 0x??91 or in case of a failed command 0x??D1.

Overview:

Command:	**Cmd.** Code	**Resp.** Code	**Error/ Warning** Code
Get Sensor Format	0x1411	0x1491	0x14D1
Fehler! Verweisquelle konnte nicht gefunden werden.	0x1511	0x1591	0x15D1
Get ROI	0x0211	0x0291	0x02D1
Set ROI	0x0311	0x0391	0x03D1
Get Binning	0x0411	0x0491	0x04D1
Set Binning	0x0511	0x0591	0x05D1
Get Pixelrate	0x0611	0x0691	0x06D1
Set Pixelrate	0x0711	0x0791	0x07D1
Get Cooling Setpoint Temperature	0x1011	0x1091	0x10D1
Set Cooling Setpoint Temperature	0x1111	0x1191	0x11D1
Get Hot Pixel Correction Mode	0x1E11	0x1E91	0x1ED1
Set Hot Pixel Correction Mode	0x1F11	0x1F91	0x1FD1
Set Correction Mode	0x2A11	0x2A91	0x2AD1
Get Correction Mode	0x2B11	0x2B91	0x2BD1
Get Lookuptable Info	0x3111	0x3191	0x31D1
Get Lookuptable	0x3211	0x3291	0x32D1
Set Lookuptable	0x3311	0x3391	0x33D1

4.2.1 Get Sensor Format

Get format of sensor. The [standard] format is full resolution of 2560 x 2160 pixels, the [extended] format is Full HD resolution of 1920 x 1080 pixels.

a.) Command Message:

Code	Length	Cks.
0x1411	0x0005	0x2A

Parameter: None

b.) Response Message:

Code	Length	Format	Cks.
0x1491	0x0007	0x####	0x##

Return values: x0000 = [standard]
x0001 = [extended]

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x14D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.2 Set Sensor Format

Set format of sensor. The [standard] format uses only effective pixels, while the [alternative] format shows all pixels inclusive effective, dark, reference and dummy.

a.) Command Message:

Code	Length	Format	Cks.
0x1511	0x0007	0x####	0x##

Parameter: x0000 = [standard]
x0001 = [alternative]

Note: This command will be rejected, if Recording State is [run].

b.) Response Message:

Code	Length	Format	Cks.
0x1591	0x0007	0x####	0x##

Return values: x0000 = [standard]
x0001 = [alternative]

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x15D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.3 Get ROI

Get ROI (region or area of interest) window. The ROI is equal to or smaller than the absolute image area which is defined by the settings of **format** and **binning**.

a.) Command Message:

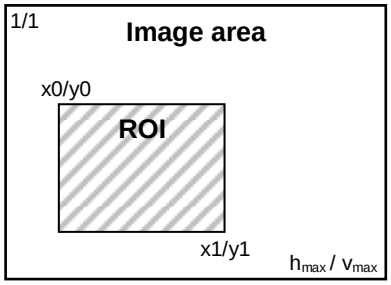
Code	Length	Cks.
0x0211	0x0005	0x18

Parameter: None

b.) Response Message:

Code	Length	ROI x0	ROI y0	ROI x1	ROI y1	Cks.
0x0291	0x000D	0x####	0x####	0x####	0x####	0x##

Return values: x0, x1, y0, y1: region of interest (in pixels) within the complete image of the sensor (see also figure below).



c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x02D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.4 Set ROI

Set ROI (region or area of interest) window. The ROI must be equal to or smaller than the absolute image area which is defined by the settings of **format** and **binning**.

a.) Command Message:

Code	Length	ROI x0	ROI y0	ROI x1	ROI y1	Cks.
0x0311	0x000D	0x####	0x####	0x####	0x####	0x##

Parameter: x0, x1, y0, y1: set region of interest (in pixels) within the complete image of the sensor.

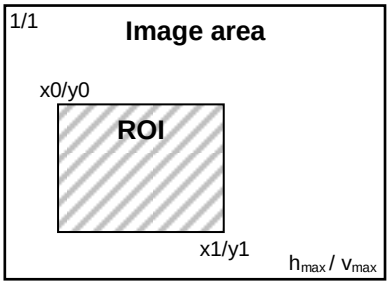
Notes:
- valid ROI settings range from 1/1 to h_{max}/v_{max} (h_{max}/v_{max} are dependent from the settings of **format** and **binning**)
- values out of range result in a failure response message
- the command will be rejected, if Recording State is [run]

b.) Response Message:

Code	Length	ROI x0	ROI y0	ROI x1	ROI y1	Cks.
0x0391	0x000D	0x####	0x####	0x####	0x####	0x##

Return values:
- x0, x1, y0, y1: configured region of interest (in pixels) within the complete image of the sensor (see also figure below).

Notes:
- valid ROI settings range from 1/1 to h_{max}/v_{max}



c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x03D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.5 Get Binning

Get binning information

a.) Command Message:

Code	Length	Cks.
0x0411	0x0005	0x1A

Parameter: None

b.) Response Message:

Code	Length	Binning x	Binning y	Cks.
0x0491	0x0009	0x####	0x####	0x##

Return values: current binning x (horizontal direction) and binning y (vertical direction).

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x04D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.6 Set Binning

Set binning

a.) Command Message:

Code	Length	Binning x	Binning y	Cks.
0x0511	0x0009	0x####	0x####	0x##

Parameter: set binning x (horizontal direction) and binning y (vertical direction)

Notes:
- valid binning settings generally are 1, 2, 4, 8, 16, 32, other values may be depending on the camera type
- values not valid result in a failure response message
- the command will be rejected, if Recording State is [run]

b.) Response Message:

Code	Length	Binning x	Binning y	Cks.
0x0591	0x0009	0x####	0x####	0x##

Return values: configured binning x (horizontal direction) and binning y (vertical direction)

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x05D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.7 Get Pixelrate

Get pixelrate for reading images from the image sensor.

a.) Command Message:

Code	Length	Cks.
0x0611	0x0005	0x1C

Parameter: None

b.) Response Message:

Code	Length	Pixelrate	Cks.
0x0691	0x0009	0x########	0x##

Return values: current pixelrate as long word in Hz.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x06D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.8 Set Pixelrate

Set pixelrate

a.) Command Message:

Code	Length	Pixelrate	Cks.
0x0711	0x0009	0x########	0x##

Parameter: pixelrate to be configured as long word in Hz.
Notes: valid values depend on camera type, the adjustable values are defined in the camera descriptor.
non valid values result in a failure response message
the command will be rejected, if Recording State is [run]

b.) Response Message:

Code	Length	Pixelrate	Cks.
0x0791	0x0009	0x########	0x##

Return values: configured pixelrate as long word in Hz.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x07D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.9 Get Cooling Setpoint Temperature

Get the temperature setpoint for cooling the image.

a.) Command Message:

Code	Length	Cks.
0x1011	0x0005	0x26

Parameter: None
Notes: the actual temperature of the sensor can be read with **get temperature** command (see 4.1.4)

b.) Response Message:

Code	Length	Temp.	Cks.
0x1091	0x0007	0x####	0x##

Return values: current cooling temperature setpoint as signed word in °C units

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x10D1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.10 Set Cooling Setpoint Temperature

Set the temperature setpoint for cooling the image sensor.

a.) Command Message:

Code	Length	Temp.	Cks.
0x1111	0x0007	0x####	0x##

Parameter:
cooling temperature setpoint to be adjusted as signed word in °C units

Notes:
valid range depends on camera type, non valid values result in a failure response message
the actual temperature of the sensor can be read with **get temperature** command (see 4.1.4)

b.) Response Message:

Code	Length	Mode	Cks.
0x1191	0x0007	0x####	0x##

Return values: configured cooling temperature setpoint as signed word in °C units

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x11D1	0x0009	0x#########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.2.11 Get Hot Pixel Correction Mode

Get the hot pixel correction mode.

a.) Command Message:

Code	Length	Cks.
0x1E11	0x0005	0x34

Parameter: None

b.) Response Message:

Code	Length	Mode	Cks.
0x1E91	0x0007	0x####	0x##

Return values: current mode:
0x0001 = hot pixel correction mode ON,
0x0000 = hot pixel correction mode OFF
0x0100 = hot pixel correction test mode, reserved for future use!

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x1ED1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)
PCO_ERROR_FIRMWARE_NOT_SUPPORTED = 0x80031020, if hot pixel correction is not supported.

4.2.12 Set Hot Pixel Correction Mode

Set the hot pixel correction mode.

a.) Command Message:

Code	Length	Mode	Cks.
0x1F11	0x0007	0x####	0x##

Parameter mode:
0x0001 = hot pixel correction mode ON,
0x0000 = hot pixel correction mode OFF
0x0100 = hot pixel correction test mode, reserved for future use!

Notes:
non valid values result in a failure response message
the command will be rejected, if Recording State is [run]

b.) Response Message:

Code	Length	Gain	Cks.
0x1F91	0x0007	0x####	0x##

Return values: configured mode:
0x0001 = hot pixel correction mode ON,
0x0000 = hot pixel correction mode OFF
0x0100 = hot pixel correction test mode, reserved for future use!

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x1FD1	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)
PCO_ERROR_FIRMWARE_NOT_SUPPORTED (0x80031020), if hot pixel correction is not supported.

4.2.13 Set Correction Mode

Set camera specific correction modes on or off

a.) Command Message:

Code	Length	Modes	Offset	Rsrvd1	Rsrvd2	Cks.
0x2A11	0x000D	0x####	0x####	0x0000	0x0000	0x##

Parameter: Modes
0x0000 = CORRMODE_COMPLETELY_OFF

b.) Response Message:

Code	Length	Modes	Offset	Rsrvd1	Rsrvd2	Cks.
0x2A91	0x000D	0x####	0x####	0x0000	0x0000	0x##

Return values: See command

4.2.14 Get Correction Mode

Get status of camera specific correction modes

a.) Command Message:

Code	Length	Cks.
0x2B11	0x0005	0x41

Parameter: None

b.) Response Message:

Code	Length	Modes	Offset	Rsrvd1	Rsrvd2	Cks.
0x2B91	0x000D	0x####	0x####	0x0000	0x0000	0x##

Return values: Modes
0x0000 = CORRMODE_COMPLETELY_OFF

4.2.15 Get Lookuptable Info

Get lookup table descriptor.

a.) Command Message:

Code	Length	Cks.
0x3111	0x0005	0x47

Parameter: None

b.) Response Message:

Code	Length	Number	…	Cks.
0x3391	0x010B	0x####	…	0x##

Text Descriptor (20 byte)	Identifier	Input Width	Output Width
e.g. “sqrt(256 * x)”	0x####	0x##	0x##
*“sqrt(32 * x)”*			
..			

Return values:

Number: For these number of lookup tables a description will follow
10 entries with each:
Text descriptor for the device, limited by a null character. Field is always 20 bytes long, the bytes after the null character may be undefined.
Identifier of the specific lookup table needed to activate with “Set Lookuptable” (byte)
Input width in bits of the lookup table (byte)
Output width in bits of the lookup table (byte)

There are alway 10 entries, if the number is less, the 10 – n fields at the end are not defined.

4.2.16 Get Lookuptable

Get actual selected lookup table.

a.) Command Message:

Code	Length	Cks.
0x3211	0x0005	0x48

Parameter: None

b.) Response Message:

Code	Length	Identifier	Parameter	Cks.
0x3291	0x0009	0x####	0x####	0x##

Return values: Identifier
0x0000 = lookup table disabled
0x#### = Identifier of the actual lookup table
Offset: 11 Bit value for fixed offset subtraction before lookup table

4.2.17 Set Lookuptable

Set lookup table or disable it.

a.) Command Message:

Code	Length	Identifier	Parameter	Cks.
0x3311	0x0009	0x####	0x####	0x##

Parameter: Identifier
0x0000 = disable lookup table
0x1612 = 16-bit to 12-bit compression

b.) Response Message:

Code	Length	Identifier	Parameter	Cks.
0x3391	0x0009	0x####	0x####	0x##

Return values: See command

4.3 Timing

The group id code for the Timing Control Commands is 0x12. Thus the least significant byte of all command id codes is 0x12. The command id codes are 0x??12, the code of the response message 0x??92 or in case of a failed command 0x??D2.

Overview:

Command:	**Cmd.** Code	**Resp.** Code	**Error/ Warning** Code
Get Timebase	0x0C12	0x0C92	0x0CD2
Set Timebase	0x0D12	0x0D92	0x0DD2
Get Delay / Exposure Time	0x0112	0x0192	0x01D2
Set Delay / Exposure Time	0x0212	0x0292	0x02D2
Get Framerate	0x1712	0x1792	0x17D2
Set Framerate	0x1812	0x1892	0x18D2
Get Trigger Mode	0x0312	0x0392	0x03D2
Set Trigger Mode	0x0412	0x0492	0x04D2
Force Trigger	0x0512	0x0592	0x05D2
Get Camera Busy status	0x0612	0x0692	0x06D2
Get COC Runtime	0x1012	0x1092	0x10D2
Get Image Timing	0x1E12	0x1E92	0x1ED2
Get Sensor Signal Status	0x2112	0x2192	0x21D2
Get HW IO Signal Timing	0x2612	0x2692	0x26D2
Set HW IO Signal Timing	0x2612	0x2692	0x26D2

For a detailed description of the timing and the different trigger modes please refer to the user's manual.

4.3.1 Get Timebase

Get timebase for delay and exposure times.

a.) Command Message:

Code	Length	Cks.
0x0112	0x0005	0x23

Parameter: None

b.) Response Message:

Code	Length	Timebase Delay	Timebase Exposure	Cks.
0x0192	0x0009	0x####	0x####	0x##

Return values: timebase for delay and exposure times
- 0x0000 => timebase = [ns] (10^{-9}s)
- 0x0001 => timebase = [µs] (10^{-6}s)
- 0x0002 => timebase = [ms] (10^{-3}s)

Note:
delay and exposure values are multiplied with the configured **timebase** unit values

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x0CD2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.2 Set Timebase

Set timebase for delay and exposure times.

a.) Command Message:

Code	Length	Timebase Delay	Timebase Exposure	Cks.
0x0D12	0x0009	0x####	0x####	0x##

Parameter:

timebase to be selected for delay and exposure times
- 0x0000 => timebase = [ns] (10^{-9}s)
- 0x0001 => timebase = [µs] (10^{-6}s)
- 0x0002 => timebase = [ms] (10^{-3}s)

b.) Response Message:

Code	Length	Timebase Delay	Timebase Exposure	Cks.
0x0D92	0x0009	0x####	0x####	0x##

Return values:

configured timebase for delay and exposure times
- 0x0000 => timebase = [ns] (10^{-9}s)
- 0x0001 => timebase = [µs] (10^{-6}s)
- 0x0002 => timebase = [ms] (10^{-3}s)

Note:
delay and exposure values are multiplied with the configured **timebase** unit values

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x0DD2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.3 Get Delay / Exposure Time

Get delay / exposure time

a.) Command Message:

Code	Length	Cks.
0x0112	0x0005	0x18

Parameter: None

b.) Response Message:

Code	Length	Delay	Exposure	Cks.
0x0192	0x000D	0x########	0x########	0x##

Return values: delay and exposure time as multiples of timebase units

Note:
delay and exposure values are multiplied with the configured **timebase** unit values

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x01D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.4 Set Delay / Exposure Time

Set delay / exposure time

a.) Command Message:

Code	Length	Delay	Exposure	Cks.
0x0212	0x000D	0x########	0x########	0x##

Parameter: delay and exposure time to be adjusted as multiples of timebase units

b.) Response Message:

Code	Length	Delay	Exposure	Cks.
0x0292	0x000D	0x########	0x########	0x##

Return values: configured delay and exposure time as multiples of timebase units

Note:
delay and exposure values are multiplied with the configured **timebase** unit values
If **exposure** is set to zero an error is generated

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x02D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.5 Get Framerate

Get framerate and exposure time. See also “Set Framerate”

a.) Command Message:

Code	Length	Cks.
0x1712	0x0005	0x2E

Parameter: None

b.) Response Message:

Code	Length	Status	Framerate	Exposure	Cks.
0x1792	0x000F	0x####	0x########	0x########	0x##

Return values: Status of last “Set Framerate command”
Framerate, or 0 if not configured, in mHz
Exposure time in ns

Note:
It is strongly recommend using either the “Set Framerate” or the “Set Delay/Exposure Time” command!

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x17D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.6 Set Framerate

Set framerate and exposure time. This command is intended to set directly the framerate and the exposure time of the camera. The framerate is limited by the readout time and the exposure time:

$$\text{Framerate} \leq \frac{1}{t_{readout}} \qquad \text{Framerate} \leq \frac{1}{t_{expos}}$$

Please note that there are some overhead times, therefore the real values can differ slightly, e.g. the maximum framerate will be a little bit less than 1 / exposure time. The mode parameter of the function call defines, how the function works if these conditions are not met.

a.) Command Message:

Code	Length	Mode	Framerate	Exposure	Cks.
0x1812	0x000F	0x####	0x########	0x########	0x##

Parameter: Mode, defines the way of operation when settings are inconsistent, where:
0x0000: auto mode (camera decides which parameter will be trimmed)
0x0001: Framerate has priority, (exposure time will be trimmed)
0x0002: Exposure time has priority, (framerate will be trimmed)
0x0003: Strict, function shall return with error if values are not possible.
Framerate in mHz (milli!), thus e.g. 1kHz = 1000000
Exposure time in ns

b.) Response Message:

Code	Length	Status	Framerate	Exposure	Cks.
0x1892	0x000F	0x####	0x########	0x########	0x##

Return values: Status, where:

0x0000: Settings consistent, all conditions met
0x0001: Framerate trimmed, framerate was limited by readout time
0x0002: Framerate trimmed, framerate was limited by exposure time
0x0004: Exposure time trimmed, exposure time cut to frame time

configured framerate and exposure time

Note:
Framerate and exposure time are also affected by the “Set Delay/Exposure Time” command. **It is strongly recommend to use either the “Set Framerate” or the “Set Delay/Exposure Time” command**!

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x18D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.7 Get Trigger Mode

Get image trigger mode (for further explanations see camera manual)

a.) Command Message:

Code	Length	Cks.
0x0312	0x0005	0x1A

Parameter: None

b.) Response Message:

Code	Length	Mode	Cks.
0x0392	0x0007	0x####	0x##

Return values: Current trigger mode:
0x0000 = [auto trigger]
An exposure of a new image is started automatically best possible compared to the readout of an image. If using a CCD and images are taken in a sequence, then exposures and readout of the sensor are started simultaneously. Signals at the trigger input (<exp trig>) are irrelevant.
0x0001 = [software trigger]:
An exposure can only be started by a **force trigger** command.
0x0002 = [extern exposure & software trigger]:
A delay / exposure sequence is started at the RISING or FALLING edge (depending on the polarity setting; HWIO) of the trigger input (<exp trig>).

Note: In mode [extern exposure & software trigger], it depends also on the selected acquire mode, if a trigger edge at the trigger input (<exp trig>) will be effective or not. A software trigger however will always be effective independent of the state of the <acq enbl> input (true for: [software trigger] and [extern exposure & software trigger].

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x03D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.8 Set Trigger Mode

Set image trigger mode

a.) Command Message:

Code	Length	Mode	Cks.
0x0412	0x0007	0x####	0x##

Parameters: trigger mode to be selected:
0x0000 = [auto trigger]
An exposure of a new image is started automatically best possible compared to the readout of an image. If using a CCD and images are taken in a sequence, then exposures and readout of the sensor are started simultaneously. Signals at the trigger input (<exp trig>) are irrelevant.
0x0001 = [software trigger]:
An exposure can only be started by a **force trigger** command.
0x0002 = [extern exposure & software trigger]:
A delay / exposure sequence is started at the RISING or FALLING edge (depending on the polarity setting; HWIO) of the trigger input (<exp trig>).

Notes: the command will be rejected, if Recording State is [run]
In mode [extern exposure & software trigger], it depends also on the selected acquire mode, if a trigger edge at the trigger input (<exp trig>) will be effective or not. A software trigger however will always be effective independent of the state of the <acq enbl> input (true for: [software trigger] and [extern exposure & software trigger].

b.) Response Message:

Code	Length	Mode	Cks.
0x0492	0x0007	0x####	0x##

Return values: Configured trigger modes:
0x0000 = [auto trigger]
0x0001 = [software trigger]
0x0002 = [extern exposure & software trigger]

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x04D2	0x0009	0x#########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.9 Force Trigger

This software command starts an exposure if the **trigger mode** is in the state [software trigger] (0x0001) or in the state [extern exposure & software trigger] (0x0002). If in state [extern exposure control] (0x0003), nothing happens. The camera has to be ready: (**recording** = [start]) and [not busy].

a.) Command Message:

Code	Length	Cks.
0x0512	0x0005	0x1C

Parameter: None

b.) Response Message:

Code	Length	Return	Cks.
0x0592	0x0007	0x####	0x##

Return values: result:
0x0000 = trigger command was not successful because of camera being busy
0x0001 = a new image exposure has been triggered by the command

Note:
Due to response and processing times e.g. caused by the interface and/or the operating system on the PC, the delay between command and actual trigger may be several 10ms up to 100ms.
A force trigger command will be effective independent of the selected acquire mode and independent of the state of the <acq enbl> input.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x05D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.10 Get Camera Busy status

Get camera busy status: a trigger is ignored, if the camera is still busy ([exposure] or [readout]). In case of **force trigger** command the user may request the camera busy status in order to be able to start a valid **force trigger** command.

a.) Command Message:

Code	Length	Cks.
0x0612	0x0005	0x1D

Parameter: none

b.) Response Message:

Code	Length	Status	Cks.
0x0692	0x0007	0x####	0x##

Return values: camera busy status:
0x0000 = camera is [not busy], ready for a new trigger command
0x0001 = camera is [busy], not ready for a new trigger command

Note:
The status is according to the hardware signal at the <status busy> SMA connector. Due to response and processing times e.g. caused by the interface and/or the operating system, the delay between the delivered status and the actual status may be several 10ms up to 100ms. If timing is critical it is strongly recommended to use the hardware signal (<status busy>).

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x06D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.11 Get COC Runtime

Requests the run time for one image. The run time is the time which is required before a new image can be started. Thus the runtime determines the frame rate.

a.) Command Message:

Code	Length	Cks.
0x1012	0x0005	0x27

Parameter: none

b.) Response Message:

Code	Length	Runtime [s]	Runtime [ns]	Cks.
0x1092	0x000F	0x########	0x########	0x##

Return values: Time for one image is: Runtime [s] + Runtime [ns]

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x10D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.12 Get Image Timing

Get the timing of the current recording settings.

a.) Command Message:

Code	Length	Cks.
0x1E12	0x0005	0x35

Parameter: none

b.) Response Message:

Code	Length	Frametime [s]	Frametime [s]	Exposuretime [ns]	Exposuretime [ns]
0x1E92	0x0025	0x########	0x########	0x########	0x########

Trigger System Delay [ns]	Trigger System Jitter [ns]	Trigger Delay [s]	Trigger Delay [ns]	Cks.
0x########	0x########	0x########	0x########	0x##

Return values:

- Time for one image is: Frametime [s] + Frametime [ns]
- Exposure Time for one image is: Time for one image is: Exposuretime [s] + Exposuretime [ns]
- Trigger System Delay [ns]
- Trigger System Jitter [ns]
- Trigger Delay for one image is: Triggerdelay [s] + Triggerdelay [ns]

Note:
If a specific timing is not available the value is set to IMAGE_TIMING_NOT_APPLICABLE (0xFFFFFFFF)

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x1ED2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.13 Get Sensor Signal Status

Get the current image counter value and the status of the recording statemachine.

a.) Command Message:

Code	Length	Cks.
0x2112	0x0005	0x38

Parameter:
- none

b.) Response Message:

Code	Length	Status	ImageCount	Rsvd.[0]	Rsvd.[1]	Cks.
0x2192	0x0015	0x########	0x########	0x########	0x########	0x##

Return values:
- Status
  SIGNAL_STATE_BUSY = 0x00000001
  SIGNAL_STATE_IDLE = 0x00000002
  SIGNAL_STATE_EXP = 0x00000004
  Busy and exposure state are the current states of the camera.
  The idle state is the inverted recording state.
- ImageCount
  actual image counter value
- Reserved
  for future use, set to 0x00000000

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x21D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.3.14 Get HW IO Signal Timing

Get the current signal timing of the requested hardware IO signal function.

a.) Command Message:

Code	Length	Index	Select	Cks.
0x2612	0x0009	0x####	0x####	0x##

Parameter:
- Index of signal
- Select: Shows which function of the port is selected (See also command “Get HW IO Signal Description”)

b.) Response Message:

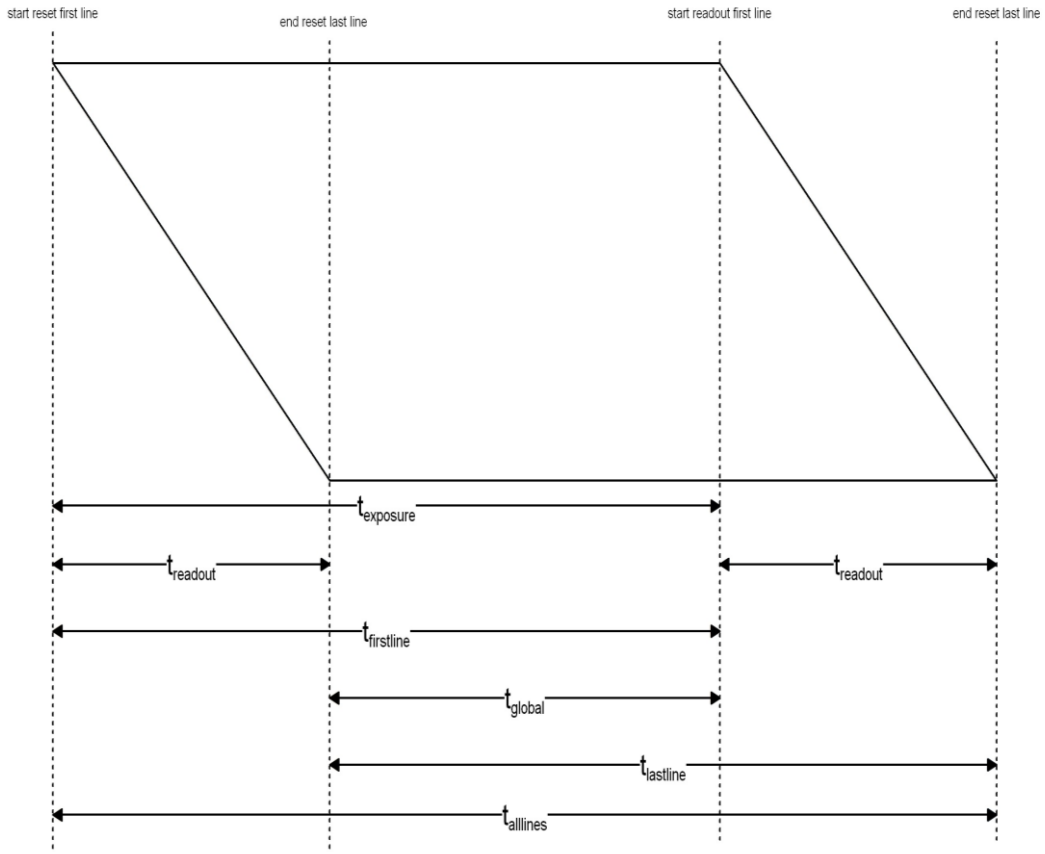
Code	Length	Index	Select	Type	Parameter	Reserved[0]	…	Reserved[3]	Cks.
0x2692	0x0021	0x####	0x####	0x########	0x########	0x########	…	0x########	0x##

Return values:
- Index of signal
- Select: Shows which function of the port is selected.
- Type of signal
  - 0x00000001: Trigger signal
  - 0x00000002: Acquire signal
  - 0x00000003: Busy signal
  - 0x00000004: Exposure signal
  - 0x00000005: Read signal
  - 0x00000006: Sync signal
  - 0x00000007: Exposure signal for rolling shutter
- Parameter of the current function, which depends on the type of signal
- reserved for future use (set to zero)

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x26D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)



Parameter for "rolling shutter exposure" signal type	
0x00000001	shows the exposure time of the first rolling shutter line ($t_{firstline}$)
0x00000002	shows when all sensor lines are integrating (t_{global})
0x00000003	shows the exposure time of the last rolling shutter line ($t_{lastlinel}$)
0x00000004	shows if any sensor line is integrating ($t_{alllines}$)

4.3.15 Set HW IO Signal Timing

Set the current signal timing of the requested hardware IO signal function.

a.) Command Message:

Code	Length	Index	Select	Parameter	Reserved[0]	…	Reserved[3]	Cks.
0x2792	0x001D	0x####	0x####	0x########	0x########	…	0x########	0x##

Parameter:
- Index of signal
- Select: Shows which function of the port is selected.
- Parameter of the current function, which depends on the type of signal
- reserved for future use (set to zero)

b.) Response Message:

Code	Length	Index	Select	Type	Parameter	Reserved[0]	…	Reserved[3]	Cks.
0x2792	0x0021	0x####	0x####	0x########	0x########	0x########	…	0x########	0x##

Return values:
- Index of signal
- Select: Shows which function of the port is selected.
- Type of signal
  - 0x00000001: Trigger signal
  - 0x00000002: Acquire signal
  - 0x00000003: Busy signal
  - 0x00000004: Exposure signal
  - 0x00000005: Read signal
  - 0x00000006: Sync signal
  - 0x00000007: Exposure signal for rolling shutter
- Parameter of the current function, which depends on the type of signal
- reserved for future use

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x27D2	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.4 Recording

The group id code for the Recording Control Commands is 0x14. Thus the least significant byte of all command id codes is 0x14. The command id codes are 0x??14, the code of the response message 0x??94 or in case of a failed command 0x??D4.

Overview:

Command:	**Cmd.** Code	**Resp.** Code	**Error/ Warning** Code
Get Recording Status	0x0514	0x0594	0x05D4
Set Recording State	0x0614	0x0694	0x06D4
Arm Camera	0x0A14	0x0A94	0x0AD4

4.4.1 Get Recording Status

Requests the current **recording status**.
The **recording status** controls the status of the camera. If the **recording status** is [run], images can be started by **exposure trigger** and <acq enbl>. If the **recording status** is [clear]'ed or [stop]'ped, all image readout or exposure sequences are stopped and the sensors are running in a special idle mode to prevent dark charge accumulation.
The **recording status** has the highest priority compared to functions like <acq enbl> or **exposure trigger**.
The **recording status** is controlled by:

- software command: **set recording status** = [run]

The **recording status** is cleared by:

- powering ON the camera
- software command: **set recording status** = [stop]
- software command: **reset** all settings to default values

a.) Command Message:

Code	Length	Cks.
0x0514	0x0005	0x1E

Parameter: None

b.) Response Message:

Code	Length	Status	Cks.
0x0594	0x0007	0x####	0x##

Return values: current recording status:
0x0001 = camera is running, in **recording status** = [run]
0x0000 = camera is idle or [stop]'ped, not ready to take images

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x05D4	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.4.2 Set Recording State

Sets the current **recording status**.
The **recording status** controls the status of the camera. If the **recording status** is [run], images can be started by **exposure trigger** and <acq enbl>. If the **recording status** is [clear]'ed or [stop]'ped, all image readout or exposure sequences are stopped and the sensors (CCD or CMOS) are running in a special idle mode to prevent dark charge accumulation.
The **recording status** has the highest priority compared to functions like <acq enbl> or **exposure trigger**.
The **recording status** is controlled by:
- software command: **set recording status** = [run]

The **recording status** is cleared by:
- powering ON the camera
- software command: **set recording status** = [stop]
- software command: **reset** all settings to default values

Notes:
- It is necessary to issue an **arm camera** command before every **set recording status** command in order to ensure that all settings are accepted correctly. Do not change settings between **arm camera** command and **set recording status** command.
- If a **set recording status** = [stop] command is sent and the current status is already stopped by [stop], nothing will happen (no warning/error message)
- If a **set recording status** = [run] command is sent and the current status is already [run], a warning message will be generated
- If a successful **set recording status** = [run] command is sent and recording is started, the images from a previous record to the active segment are lost!

a.) Command Message:

Code	Length	Status	Cks.
0x0614	0x0007	0x####	0x##

Parameter: recording status to be selected:
0x0001 = [run]
0x0000 = [stop], switch camera to idle mode

b.) Response Message:

Code	Length	PostLen	Cks.
0x0694	0x0007	0x####	0x##

Return values: Configured recording status:
0x0001 = [run], camera is in recording mode.
0x0000 = [stop] camera is idle, not ready to take images.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x06D4	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.4.3 Arm Camera

Arms, i.e. prepares the camera for a consecutive **set recording status** = [run] command. All configurations and settings made up to this moment are accepted and the internal settings of the camera are prepared. Thus the camera is able to start immediately when the **set recording status** = [run] command is performed.
Note: It is required to issue an **arm camera** command before every **set recording state** = [run] command in order to ensure that all settings are accepted correctly. Do not change settings between **arm camera** command and **set recording status** command.

a.) Command Message:

Code	Length	Cks.
0x0A14	0x0005	0x23

Parameter: None

b.) Response Message:

Code	Length	Cks.
0x0A94	0x0005	0xA3

Return values: None

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x0AD4	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

4.5 Interface Specific Commands

The group id code for the Interface Specific Commands is 0x16. Thus the least significant byte of all command id codes is 0x16. The command id codes are 0x??16, the code of the response message 0x??96 or in case of a failed command 0x??D6.

Overview:

Command:	**Cmd.** Code	**Resp.** Code	**Error/ Warning** Code
Set Interface Output Format	0x1016	0x1096	0x10D6
Get Interface Output Format	0x1116	0x1196	0x11D6

4.5.1 Set Interface Output Format

Set interface specific output format

a.) Command Message:

Code	Length	Dest IF	Format	Rsrvd1	Rsrvd2	Cks.
0x1016	0x000D	0x####	0x####	0x0000	0x0000	0x##

Parameter: Dest IF
0x0002 = SCMOS
Format, where:
0x0100= Chip readout direction from outside to inside
Rsrvd 1: Reserved for future use, set to 0x0000
Rsrvd 2: Reserved for future use, set to 0x0000

b.) Response Message:

Code	Length	Dest IF	Format	Rsrvd1	Rsrvd2	Cks.
0x1096	0x000D	0x####	0x####	0x0000	0x0000	0x##

Return values: See command

4.5.2 Get Interface Output Format

Get interface specific output format

a.) Command Message:

Code	Length	Dest IF	Cks.
0x1116	0x0007	0x####	0x##

Parameter: Dest IF
0x0002 = SCMOS

b.) Response Message:

Code	Length	Dest IF	Format	Rsrvd1	Rsrvd2	Cks.
0x1196	0x000D	0x####	0x####	0x0000	0x0000	0x##

Return values: Dest IF
0x0002 = SCMOS
Format, where:
0x0100= Chip readout direction from outside to inside
Rsrvd 1: Reserved for future use, set to 0x0000
Rsrvd 2: Reserved for future use, set to 0x0000

5 Error / Warning Codes

The error codes are standardized as far as possible. The error codes contain the information of the error source (microcontrollers, CPLDs, FPGAs) and an error code (error cause). Both values are compared by a logical OR operation. Error codes and warnings are always negative values, if read as signed integers, or if read as unsigned word, the MSB is set. Errors have the general format 0x80######, warnings have the format 0xC0######.

See header file pco_err.h for a complete list of error codes. It is included in the SDK. Please contact PCO if you need this file for developing your own Camera control software.

Command Implementation per Camera Link Interface
The following description requires some basic knowledge about the Camera Link interface. The referred standard is Camera Link Specification 1.0.

The camera uses the base configuration for data transfer. Data transfer must be started either by command or is continuous, if the camera is set to this mode. The clock frequency of the Camera Link channel and baudrate of the serial interface can be set with commands. The commands and responses are received resp. sent through the serial lines of the Camera Link interface.

6 Command Implementation per Camera Link Interface

The following description requires some basic knowledge about the Camera Link interface. The referred standard is Camera Link Specification 1.0.

The camera uses the base configuration for data transfer. Data transfer must be started either by command or is continuous, if the camera is set to this mode. The clock frequency of the Camera Link channel and baud rate of the serial interface can be set with commands. The commands and responses are received resp. sent through the serial lines of the Camera Link interface.

6.1 Communication between Camera and Master

Basically there are the following types of data to be exchanged between the camera and the Camera Link controller board:

- Commands sent by the controller board.
- Command responses sent by the camera.
- Image data sent by the camera.
- Control lines set by the controller board

Commands and command responses are sent through the serial lines of the Camera Link interface and should be done in one not interruptible sequence:

- Write command to the camera
- Read command response from the camera
- Check error conditions

Image data is sent as requested, according to the Camera Link specification.

6.1.1 Commands sent by the controller

As can be seen from the chapters above the master which controls the camera send telegrams to the camera. The telegrams are sent as a write to the serial interface of the Camera Link channel. The camera interprets all received data from the serial line (SerTC) as commands. Then it looks at the second word, which is the message length descriptor (see also “3.1 General message format”) calculates the checksum over the telegram and compares it to the checksum byte of the telegram. Then it decodes the command by reading the first word being the command ID. If the checksum is correct and the command is known, the camera will execute the command and send a response telegram.

6.1.2 Command responses sent by the camera

The camera does a write to the serial interface of the Camera Link channel containing a command specific response telegram. The controller receives the telegram at the serial line (SerTFG). The controller should read at first two WORDs from the serial interface, extract the size information of the telegram and then read the additional data of the telegram. Then error conditions should be checked. Timeout conditions should also be checked. For most of the commands a timeout of 200ms is sufficient. For the commands “Arm Camera” and “Get COC Runtime” the timeout should be set to 5000ms.

6.1.3 Image data sent by the camera

FVAL, LVAL, DVAL signals are sent as specified in the Camera Link manual. Only the pure image data is sent. There are no additional black lines or pixel. Therefore DVAL is the same as LVAL. Two sets of interval times can be programmed using the
"Set CL Configuration" command. Default mode is ShortGapMode other setting is LongGap (values in brackets).

- the interval between two following lines (LVAL - LVAL) is 4 Clks (16 Clks)
- the interval between framestart and the first line (FVAL - LVAL) is 8 Clks (16 Clks)
- the shortest interval between two frames (FVAL - FVAL) is 16 Clks (2560 Clks)

6.1.4 Control lines set by the controller

The four Camera Link control lines CC1, CC2, CC3, CC4 are assigned to specific functions of the camera. The functionality of the lines can be enabled or disabled using the “Set CL Configuration” command.

(not yet implemented)

6.2 Camera Link specific commands

Overview:

Command:	**Cmd.** Code	**Resp.** Code	**Error** Code
Set CL Configuration	0x3516	0x3596	0x35D6
Get CL Configuration	0x3416	0x3496	0x34D6
Set CL Baudrate	0x3316	0x3396	0x33D6
Get CL Baudrate	0x3216	0x3296	0x32D6

6.2.1 Set CL Configuration

Set the parameters required for the Camera Link Configuration.

a.) Command Message:

Code	Length	Pixelclock	CClines	Dataformat	Transmit continuous	Cks.
0x3516	0x000C	0x########	0x##	0x##	0x##	0x##

Parameter:

Pixelclock:
Clockfrequency of the Camera Link Datatransfer in Hz.
Possible values are 85 000 000

CClines:
(not yet implemented)

Dataformat:
CL_FORMAT_5x16 = 0x05: five 16bit pixels per clock
CL_FORMAT_5x12 = 0x07: compressed data stream 12 Bit per pixel
CL_FORMAT_5x12L = 0x09: compressed data stream 12 Bit per pixel
CL_FORMAT_5x12R = 0x0A: compressed data stream 12 Bit per pixel

Transmit :
Bit0 set: Enables continuous transmit of image data from the camera to the Camera Link interface when the camera is started (recording state: [run]). Every time a new image is grabbed from the camera, it is sent to the Camera Link interface.
Bit1 set: Enable LongGap mode.
Use longer intervals between Camera Link signals FVAL and LVAL

b.) Response Message:

Code	Length	Pixelclock	Cclines	Dataformat	Transmit continuous	Cks.
0x3596	0x000C	0x########	0x##	0x##	0x##	0x##

Return values: same as for the command message

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x35D6	0x0009	0x#########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

6.2.2 Get CL Configuration

Get the parameters required for the Camera Link Configuration.

a.) Command Message:

Code	Length	Cks.
0x3416	0x0005	0x4F

Parameter: None

b.) Response Message:

Code	Length	Pixelclock	Cclines	Dataformat	Transmit continuous	Cks.
0x3496	0x000C	0x########	0x##	0x##	0x##	0x##

Parameter:

Pixelclock:
Clockfrequency of the Camera Link Datatransfer in Hz.

CClines:
(not yet implemented)

Dataformat:
CL_FORMAT_5x16 = 0x05: five 16bit pixels per clock
CL_FORMAT_5x12 = 0x07: compressed data stream 12 Bit per pixel
CL_FORMAT_5x12L = 0x09: compressed data stream 12 Bit per pixel
CL_FORMAT_5x12R = 0x0A: compressed data stream 12 Bit per pixel

Transmit continuous:

Bit0 set: continuous transmit is enabled
Image date from the camera to the Camera Link interface is transmitted continuously, when the camera is started (recording state: [run]) . Every time a new image is grabbed from the camera, it is sent to the Camera Link interface.

Bit1 set: LongGap mode enabled
Longer intervals between Camera Link signals FVAL and LVAL are used.

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x34D6	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

6.2.3 Set CL Baudrate

Set the baudrate of the serial interface of the camera.

a.) Command Message:

Code	Length	Baudrate	Cks.
0x3316	0x0009	0x########	0x##

Parameter: Baudrate:
Possible values are 9 600, 19 200, 38 400, 57 600,115 200
Default setting is 9 600

b.) Response Message:

Code	Length	Baudrate	Cks.
0x3396	0x000C	0x########	0x##

Parameter: Baudrate to be set:

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x33D6	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

Important note:

Because the configuration of new baudrates must be done on the controller and the Camera, the setting **must** be done in the following manner:

Send the “Set CL Baudrate”, parameter = new baudrate, using the old baudrate
Get the response of camera also with the old baudrate
Wait 100 - 200 ms
Then set the new baudrate on the controller (using the controller specific commands)
Send the command “Get CL Baudrate” (now using the new baudrate)
Get the response of camera (using the new baudrate)
If no response or error response, switch back to standard baudrate 9600 and try again

6.2.4 Get CL Baudrate

Get the baudrate of the serial interface of the camera

a.) Command Message:

Code	Length	Cks.
0x3216	0x0005	0x4D

Parameter: None

b.) Response Message:

Code	Length	Baudrate	Cks.
0x3296	0x0009	0x########	0x##

Parameter: Currently configured baudrate of the camera

c.) Failure / Warning Response Message:

Code	Length	Message	Cks.
0x32D6	0x0009	0x########	0x##

Return values: error code, less than 0 (see also section 5. Error / Warning Codes)

PCO AG was founded in 1987. The company headquarters in Kelheim employs more than 50 specialists in the development and production of optimized, fast, sensitive camera systems for scientific applications. PCO's range of products includes digital camera systems featuring high dynamics, extremely high sensitivity, high resolution, high speed, and extremely low noise, which are sold in industrial and scientific markets all over the world.

Cameras for every point of view.

The systems produced by PCO AG are cameras and scientific measuring instruments at the same time. Our high-tech systems are mostly the result of manual labor: over 50 highly specialized employees handle development and production at the Kelheim site. We deliver roughly 4.000 cameras a year to customers all over the world. As in every cutting edge technology, dialogue with the user is the main focus of PCO's approach. Worldwide representatives, in cooperation with the in-house marketing division and technical support team, ensure that PCO camera systems are developed in step with the individual requirements of our customers.

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