BALLUFF

USB3 VISION

GiGE VISION

BVS CA - Software Features

Functional description

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2 USER INSTRUCTIONS

2.1 Introduction

This functional description describes the "Smart Features" of the Balluff Vision Solutions BVS CA product families in the context of **GenICam** and shows the appropriate use with the help of use cases.

GenICam is a standard, which on the one hand decouples industrial camera interfaces technology from the user application programming interface and by this it standardizes the access to the camera features. On the other hand and according to the standard's **SFNC**, the camera features have the same name and behaviour without regard for the respective manufacturer. Additionally, it is possible to create specific features like the Smart Features of the Balluff *Camera*, which can be read, accessed and used with standard compliant third-party software. A standard compliant software is the GUI tool **wxPropView**, for example, which is part of the Balluff *Camera* driver package. wxPropView provides wizards, which ease the work with the Smart Features.

The Smart Features of the Balluff Vision Solutions BVS CA become possible by the interplay of the intergrated image memory and the FPGA, which

- simplify and optimize an overall system by eliminating cables, controllers as well as reducing the need of host PC load, and which
- furthermore improve the efficiency of the overall system and increase the flexibility.

All user's manuals are available on the Balluff Vision Solutions product families BVS CA via www.balluff.com.

2 USER INSTRUCTIONS

This functional description applies to the following variants of the Balluff *Camera*:

Order code	Product name	Description
BVS002H	BVS CA-M1456Z00-31-000	Balluff *Camera*, mono, 1.6 MPix, Gigabit Ethernet
BVS002J	BVS CA-C1456Z00-31-000	Balluff *Camera*, color, 1.6 MPix, Gigabit Ethernet
BVS002K	BVS CA-M2064Z00-31-000	Balluff *Camera*, mono, 3.2 MPix, Gigabit Ethernet
BVS002L	BVS CA-C2064Z00-31-000	Balluff *Camera*, color, 3.2 MPix, Gigabit Ethernet
BVS002M	BVS CA-M2464Z00-31-000	Balluff *Camera*, mono, 5.1 MPix, Gigabit Ethernet
BVS002N	BVS CA-C2464Z00-31-000	Balluff *Camera*, color, 5.1 MPix, Gigabit Ethernet
BVS002P	BVS CA-M4112Z00-31-000	Balluff *Camera*, mono, 12.1 MPix, Gigabit Ethernet
BVS002R	BVS CA-C4112Z00-31-000	Balluff *Camera*, color, 12.1 MPix, Gigabit Ethernet
BVS002T	BVS CA-M1456Z00-35-000	Balluff *Camera*, mono, 1.6 MPix, USB 3.0
BVS002U	BVS CA-C1456Z00-35-000	Balluff *Camera*, color, 1.6 MPix, USB 3.0
BVS002W	BVS CA-M2064Z00-35-000	Balluff *Camera*, mono, 3.2 MPix, USB 3.0
BVS002Y	BVS CA-C2064Z00-35-000	Balluff *Camera*, color, 3.2 MPix, USB 3.0
BVS002Z	BVS CA-M2464Z00-35-000	Balluff *Camera*, mono, 5.1 MPix, USB 3.0
BVS0030	BVS CA-C2464Z00-35-000	Balluff *Camera*, color, 5.1 MPix, USB 3.0
BVS0031	BVS CA-M4112Z00-35-000	Balluff *Camera*, mono, 12.1 MPix, USB 3.0
BVS0032	BVS CA-C4112Z00-35-000	Balluff *Camera*, color, 12.1 MPix, USB 3.0

2 USER INSTRUCTIONS

2.2 Typographical conventions

The following conventions are used in this manual:

2.2.1 Bulleted Lists

Enumerations are shown as a list with an en-dash.

- Entry1
- Entry 2

2.2.2 Actions

Action instructions are indicated by a preceding triangle. The result of an action is indicated by an arrow.

1. Action instruction 1
   a. Action result
2. Action instruction 2

2.2.3 Numbers

- Decimal numbers are shown without additional indicators (e.g. 123).
- Fixed-point numbers are shown with a period (e.g. 0.123).
- Hexadecimal numbers are shown with the additional indicator hex (e.g. 00_{hex}).

2.2.4 Parameters

Parameters are shown in italics (e.g. *CRC_16*).

2.2.5 Directory paths

Path information for saving data is shown with fixed font width (e.g. `Projekt:\Data Types\Benutzerdefiniert`).

2.2.6 ASCII code

Characters transmitted in ASCII code are set in apostrophes (e.g. 'L').

2.2.7 Symbols

NOTE

A **note** indicates important information that helps you optimize usage of the products.

WARNING

A **warning** indicates how to avoid either potential damage to hardware or loss of data.

ATTENTION

An **attention** indicates a potential for property damage, personal injury, or death.

2 USER INSTRUCTIONS

2.3 Abbreviations

ADC	Analog-to-digital converter
BVS	Balluff Vision Solutions
CA	Balluff *Camera*
CMOS	Complementary metal-oxide-semiconductor
EEPROM	Electrical Erasable and Programmable ROM
EMC	Electromagnetic compatibility
FCC	Federal Communications Commission
FPGA	Field Programmable Gate Array
GenICam	Generic Interface for Cameras
GigE Vision	Image processing standard for Gigabit Ethernet interfaces
GND	Ground
I/O-Port	Digital input / output port
IO	Input / Output
NC	Not connected
PC	Personal Computer
PLC	Programmable Logic Controller
PPS	Pulse-per-second
RGB	Red Green Blue
RX	Receiver
SNFC	Standard Feature Naming Convention
TX	Transmitter
USB3 Vision	Image processing standard for USB 3.0 interfaces
XML	eXtensible Markup Language

2.4 Copyright

2 USER INSTRUCTIONS

2.5 Legal requirements

The General Terms and Conditions of Balluff GmbH in their respective current version and the conditions in these operating instructions exclusively apply to all deliveries of products and to all other services of Balluff GmbH (henceforth referred to as “GTC”). The provisioning of the software is exclusively subject to the respective current GTC, the conditions in these operating instructions as well as the regulations of the “Balluff Enduser Licensing Agreement”. You may use the software only in compliance with these provisions. If they should not yet be available, Balluff GmbH will gladly provide the current GTC upon request.

The driver of the Balluff *Camera* uses a variety of freely available tools which were published under various open source licenses. Some licenses require that the source code and modifications be published. These sources are published on the Product homepage.

The license texts for all software products used can be downloaded from the web interface along with the manuals. They are available as ZIP files.

2.6 Updates and upgrades

Balluff GmbH is authorized – but not obligated – to make updates or upgrades of the firmware available via the website of Balluff GmbH or in any other form. In such a case, Balluff GmbH is authorized – but not obligated – to inform you about the updates or upgrades. The use of such upgrades or updates assumes that you accepted the validity of the current GTC as well as the additional conditions in the operating instructions.

2.7 Trademarks

The product, trade, company and technology designations used (e.g. Microsoft®, Windows 7®, Internet Explorer®, Google Chrome®, Mozilla Firefox® and HALCON®) are trademarks of the respective owners.

3 INTRODUCTION

Balluff *Cameras* are GenICam compliant devices. For these devices, the SNFC (Standard Features Naming Convention) defines,

- which general features there are at all,
- how they are named, and
- which behavior they have.

Which feature and behavior a device supports, is concretized by an XML file, which must be provided by every GenICam compliant device. Thus, it is guaranteed that a GenICam device can be used without regard for the respective manufacturer.

To obtain a better overview, the general features are categorized as so-called *Controls*. This chapter introduces the most important *Controls*.

NOTE

Further details we refer to the latest version of the SNFC, which is available on the EMVA (European Machine Vision Association) web-site:

http://www.emva.org/standards-technology/genicam/genicam-downloads/ → SFNC (Standard Features Naming Convention)

The GenICam standard allows to create specific features in addition to the SFNC, which can be used by GenICam compliant software. You can recognize Balluff features, which are not part of the GenICam standard, by the prefix "**mv**" (for machine vision).

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3.1 Device Control

Contains the features related to the device and its sensor. Some of them are:

Feature name (according to SFNC)	**Description**
DeviceType	Returns the device type.
DeviceScanType	Scan type of the sensor of the device.
DeviceVendorName	Name of the manufacturer of the device.
DeviceModelName	Name of the device model.
DeviceManufacturerInfo	Manufacturer information about the device.
DeviceVersion	Version of the device.
DeviceFirmwareVersion	Firmware version of the device.
DeviceSerialNumber	Serial number of the device.
DeviceLinkSpeed	Indicates the speed of transmission negotiated on the specified link.
DeviceTemperature	Device temperature.
etc.	

Furthermore, there are additional Balluff *Camera* properties for the parts listed:

- FPGA
  - **mvDeviceFPGAVersion**
- Image sensor
  - **mvDeviceSensorName**
  - **mvDeviceSensorColorMode**
- Standby
  - **mvDevicePowerMode**
- Timestamp using PPS signal
  - **mvTimestampPPSSync**

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3.2 Image Format Control

Contains the features related to the format of the transmitted image. Some of them are:

Feature name (according to SFNC)	**Description**
SensorWidth	Effective width of the sensor in pixels.
SensorHeight	Effective height of the sensor in pixels.
Width	Width of the image provided by the device (in pixels).
Height	Height of the image provided by the device (in pix-els).
PixelFormat	Format of the pixels provided by the device.
TestPattern	Selects the type of test image that is sent by the de-vice.
etc.	

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3.3 Acquisition Control

Contains the features related to the image acquisition, including the triggering mode. Some of them are:

Feature name (according to SFNC)	Description
AcquisitionMode	Sets the acquisition mode of the device. There are different modes available with GenICam and provides the opportunity that the camera sends • exactly **one** image (**"SingleFrame"**), • exactly the **set number** of frames (**"MultiFrame"**) or • it acquire live images (**"Continuous"**). and can be used for asynchronously grabbing and sending image(s). It works with internal and external hardware trigger where the edge is selectable. The external trigger uses **ImageRequestTimeout** (ms) to time out.
AcquisitionStart	Starts the acquisition of the device.
AcquisitionStop	Stops the acquisition of the device at the end of the current frame.
AcquisitionAbort	Aborts the acquisition immediately.
AcquisitionFrameRate	Controls the acquisition rate (in Hertz) at which the frames are captured.
TriggerSelector	Selects the type of trigger to configure. A possible option is **mvTimestampReset**.
ExposureMode	Sets the operation mode of the exposure (or shutter).
ExposureTime	Sets the exposure time (in microseconds) when *ExposureMode* is **Timed** and *ExposureAuto* is **Off**.
ExposureAuto	Sets the automatic exposure mode when *ExposureMode* is **Timed**.
etc.	

Furthermore, there are additional Balluff *Camera* properties for the parts listed:

- Image correction
  - **mvDefectivePixelEnable**
- Exposure
  - **mvExposureAutoAverageGrey**
    Common desired average grey value (in percent) used for Auto Gain Control (AGC) and Auto Exposure Control (AEC).
  - **mvExposureAutoAOIMode**
    Common AutoControl AOI used for Auto Gain Control (AGC), Auto Exposure Control (AEC) and Auto White Balance (AWB).
- Acquisition

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- **mvAcquisitionMemoryMode**
  There are three additional acquisition modes which use the internal memory Balluff *Camera*:
  - **mvRecord** which is used to store frames in memory.
  - **mvPlayback** which transfers stored frames.
  - **mvPretrigger** which stores frames in memory to be transferred after trigger.
    To define the number of frames to acquire before the occurrence of an *AcquisitionStart* or *AcquisitionActive* trigger, you can use **mvPretrig-gerFrameCount**.
- **mvAcquisitionMemoryFrameCount**
  The number of frames currently stored in the frame buffer.

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3.4 Counter And Timer Control

Contains the features related to the usage of programmable counters and timers.. Some of them are:

Feature name (according to SFNC)	**Description**
CounterSelector	Selects which counter to configure.
CounterEventSource[CounterSelector]	Selects the events that will be the source to in-crement the counter.
CounterEventActivation[CounterSelector]	Selects the activation mode event source sig-nal.
etc.	
TimerSelector	Selects which timer to configure.
TimerDuration[TimerSelector]	Sets the duration (in microseconds) of the timer pulse.
TimerDelay[TimerSelector]	Sets the duration (in microseconds) of the de-lay.
etc.	

Balluff *Cameras* provides

- four Counters for counting events or external signals and
- two Timers.

Counter and Timers can be used, for example,

- for pulse width modulation (PWM) and
- to generate output signals of variable length, depending on conditions in camera.

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3.5 Analog Control

Contains the features related to the video signal conditioning in the analog domain. Some of them are:

Feature name (according to SFNC)	**Description**
GainSelector	Selects which gain is controlled by the various gain features.
Gain[GainSelector]	Controls the selected gain as an absolute physical value [in dB].
GainAuto[GainSelector]	Sets the automatic gain control (AGC) mode.
GainAutoBalance	Sets the mode for automatic gain balancing between the sensor color channels or taps.
BlackLevelSelector	Selects which black level is controlled by the various black level features.
BalanceWhiteAuto	Controls the mode for automatic white balancing between the color channels.
Gamma	Controls the gamma correction of pixel intensity.
etc.	

Furthermore, there are additional Balluff *Camera* properties for the parts listed:

- Image optimization
  - **mvBalanceWhiteAuto**
  - **mvGainAuto**

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3.6 Chunk Data Control

Contains the features related to the Chunk Data Control. Chunk Data are additional information blocks, which are streamed with the image. Some of them are:

Feature name (according to SFNC)	**Description**
ChunkModeActive	Activates the inclusion of chunk data in the payload of the image.
ChunkSelector	Selects which chunk to enable or control.
ChunkEnable[ChunkSelector]	Enables the inclusion of the selected chunk data in the payload of the image.
ChunkImage	Returns the entire image data included in the payload.
ChunkOffsetX	Returns the offset x of the image included in the payload.
ChunkOffsetY	Returns the offset y of the image included in the payload.
ChunkWidth	Returns the width of the image included in the payload.
ChunkHeight	Returns the height of the image included in the payload.
ChunkPixelFormat	Returns the pixel format of the image included in the payload.
ChunkTimestamp	Returns the timestamp of the image included in the payload at the time of the *FrameStart* internal event.
etc.	

3.7 File Access Control

Contains the features related to the File Access Control that provides all the services necessary for generic file access of a device. Some of them are:

Feature name (according to SFNC)	**Description**
FileSelector	Selects the target file in the device.
FileOperationSelector[FileSelector]	Selects the target operation for the selected file in the device.
FileOperationExecute[FileSelector][FileOperationSelector]	Executes the operation selected by *FileOperationSelector* on the selected file.
FileOpenMode[FileSelector]	Selects the access mode in which a file is opened in the device.
etc.	

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3.8 Digital IO Control

Contains the features related to the control of the general input and output pins of the device. Some of them are:

Feature name (according to SFNC)	Description
LineSelector	Selects the physical line (or pin) of the external device connector to configure.
LineMode[LineSelector]	Controls if the physical Line is used to Input or Output a signal.
UserOutputSelector	Selects which bit of the User Output register will be set by *UserOutputValue*.
etc.	

Furthermore, there are additional Balluff *Camera* properties for the parts listed:

- Debouncing of signals
  - **mvLineDebounceTimeRisingEdge**
  - **mvLineDebounceTimeFallingEdge**

3.9 Sequencer Control

Contains the features related to the prgoamming of acquisition sequences. Some of them are:

Feature name (according to SFNC)	Description
SequencerMode	Controls if the sequencer mechanism is active.
SequencerConfigurationMode	Controls if the sequencer configuration mode is active.
SequencerFeatureSelector	Selects which sequencer features to control.
SequencerFeatureEnable[SequencerFeatureSelector]	Enables the selected feature and make it active in all the sequencer sets.
SequencerSetSelector	Selects the sequencer set to which further settings applies.
SequencerSetSave	Saves the current device state to the selected sequencer set selected by *SequencerSetSelector*.
SequencerSetLoad	Loads the sequencer set selected by *SequencerSetSelector* in the device. Even if *SequencerMode* is **Off**.
SequencerSetStart	Sets the initial/start sequencer set, which is the first set used within a sequencer.
SequencerPathSelector[SequencerSetSelector]	Selects to which branching path further path settings apply.
SequencerSetNext	Select the next sequencer set.
SequencerTriggerSource	Specifies the internal signal or physical input line to use as the sequencer trigger source. Value supported by Balluff *Cameras* are: • Off: Disables the sequencer trigger. • ExposureEnd: Starts with the reception of the *ExposureEnd*. • Counter1End: Starts with the reception of the *Counter1End*.
SequencerTriggerActivation	Specifies the activation mode of the sequencer trigger: • RisingEdge: Specifies that the trigger is considered valid on the rising edge of the source signal.

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	• FallingEdge: Specifies that the trigger is considered valid on the falling edge of the source signal. • AnyEdge: Specifies that the trigger is considered valid on the falling or rising edge of the source signal. • LevelHigh: Specifies that the trigger is considered valid as long as the level of the source signal is high. • LevelLow: Specifies that the trigger is considered valid as long as the level of the source signal is low.

The sequencer mode can be used to set a series of feature sets for image acquisition. The sets can consecutively be activated during the acquisition by the camera. The sequence is configured by a list of parameters sets.

The following features are available for using them inside the sequencer control:

- BinningHorizontal
- BinningVertical
- CounterDuration
- DecimationHorizontal
- DecimationVertical
- ExposureTime
- Gain
- Height
- OffsetX
- OffsetY
- Width
- mvUserOutput
- UserOutputValueAll
- UserOutputValueAllMask
- Multiple conditional sequencer paths

Configured sequencer programs are stored as part of the User Sets like any other feature. Actual settings of the camera are overwritten when a sequencer set is loaded.

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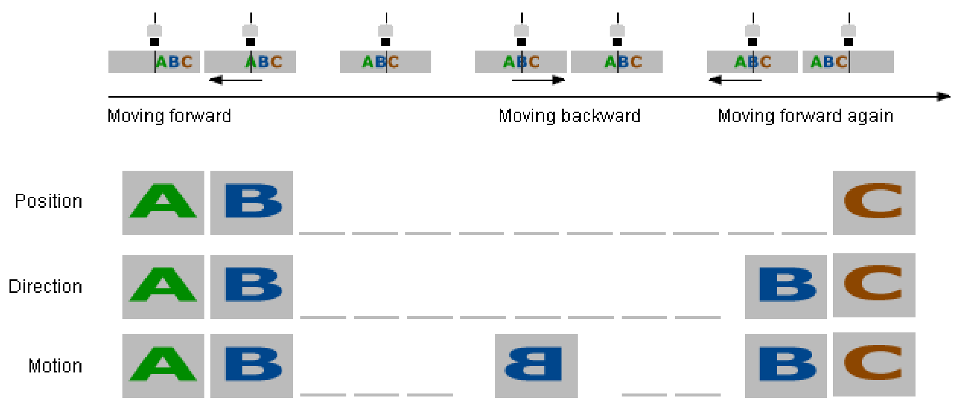
3.10 Encoder Control

Contains the features related to the usage if quadrature encoders. Some of them are:

Feature name (according to SFNC)	Description
EncoderSourceA	Selection of the A input line.
EncoderSourceB	Selection of the B input line.
EncoderMode [FourPhase]	The counter increments or decrements 1 for every full quadrature cycle.
EncoderDivider	Sets how many Encoder increment/decrements that are needed generate an encoder output signal.
EncoderOutputMode	Output sgnals are generated at all new positions in one direction (see figure)
EncoderValue	Reads or writes the current value of the position counter of the selected Encoder. Writing to EncoderValue is typically used to set the start value of the position counter.

The following figure explains the different **EncoderOutputModes**:



Additionally, the Encoder is also available as **TriggerSource** and as an **EventSource**.

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3.11 Color Transformation Control

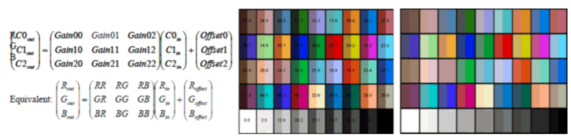
Contains the features related to the control of the color transformation. Some of them are:

Feature name (according to SFNC)	Description
ColorTransformationSelector	Activates the selected color transformation module.
ColorTransformationSelector	Selects which color transformation module is controlled by the various color transformation features.
ColorTransformationValue	Represents the value of the selected gain factor or offset inside the transformation matrix.
ColorTransformationValueSelector	Selects the gain factor or offset of the transformation matrix to access in the selected color transformation module.

This control offers an enhanced color processing for optimum color fidelity using a color correction matrix (CCM) and enables

- 9 coefficients values ($Gain_{00}$ .. $Gain_{22}$) and
- 3 offset values ($Offset_0$ .. $Offset_2$)

to be entered for $RGB_{IN} \rightarrow RGB_{OUT}$ Transformation zum Einsatz kommen.



Coefficients will be made available for sensor models and special requirements on demand.

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3.12 LUT Control

Contains the features related to the look-up table (LUT) control. Some of them are:

Feature name (according to SFNC)	Description
LUTSelector	Selects which LUT to control.
LUTEnable[LUTSelector]	Activates the selected LUT.
LUTIndex[LUTSelector]	Controls the index (offset) of the coefficient to access in the selected LUT.
LUTValue[LUTSelector][LUTIndex]	Returns the value at entry LUTIndex of the LUT selected by LUTSelector.
LUTValueAll[LUTSelector]	Allows access to all the LUT coefficients with a single read/write operation.

The look-up table (LUT) is a part of the signal path in the camera and maps data of the ADC into signal values. The LUT can be used e.g. for:

- High precision gamma
- Non linear enhancement (e.g. S-Shaped)
- Inversion (default)
- Negative offset
- Threshold
- Level windows
- Binarization

Furthermore, there are additional Balluff *Camera* properties for the parts listed:

- LUT itemization
    - **mvLUTType**
      Specifies the LUT type:
        - **Direct LUTs**
          Define a mapping for each possible input value.
          For example: a 12 → 10 bit "Direct LUT" has 2^{12} entries and each entry has 10 bit.
        - **Interpolated LUTs**
          The user defines an output value for equidistant nodes. In between the nodes linear interpolation is used to calculate the correct output value.
          For example: 10 → 10 bit "Interpolated LUT" with 256 nodes. The user defines a 10 bit output value for 256 equidistant nodes beginning at input value 0, 4, 8, 12, 16 and so on. For input values in between the nodes linear interpolation is used.
    - **mvLUTInputData**
      This register describes on which data the LUT is applied to:
        - **Bayer** means that the LUT is applied to raw bayer data, thus (depending on the debayer algorithm) a manipulation of one pixel may also affect other pixels in its neighborhood.
        - **Grau** means that the LUT is applied to gray data.

- **RGB** means that the LUT is applied to RGB data (i.e. after debayering).

- **mvLUTMapping**
  Describes the mapping of the currently selected LUT (e.g. 10 bit → 12 bit)
  - **map_10To10** means that a 10 bit input value is mapped to a 10 bit output values.
  - **map_12To10** means that a 12 bit input value is mapped to a 10 bit output value.
  - **...**

3.13 Action Control

Contains the features related to the action control features. Some of them are:

Feature name (according to SFNC)	**Description**
ActionDeviceKey	Provides the device key that allows the device to check the validity of action commands.
ActionSelector	Selects to which Action Signal further Action settings apply.
ActionGroupKey	Provides the key that the device will use to validate the action on reception of the action protocol message.
ActionGroupMask	Provides the mask that the device will use to validate the action on reception of the action protocol message.

3.14 Transport Layer Control

Contains the features related to the Transport Layer Control. Some of them are:

Feature name (according to SFNC)	**Description**
PayloadSize	Provides the number of bytes transferred for each image or chunk on the stream channel.
GevInterfaceSelector	Selects which physical network interface to control.
GevMACAddress[GevInterfaceSelector]	MAC address of the network interface.
GevStreamChannelSelector	Selects the stream channel to control.
etc.	

Furthermore, there are additional Balluff *Camera* properties for the parts listed:

- Bandwidth control
  - **mvGevSCBWControl**
    Selects the bandwidth control for the selected stream channel.
- USB 3.0 link performance
  - **mvU3V[...]**

3.15 Event Control

The **"Event Control"** contains features like

Contains the features related to the generation of event notifications by the device. Some of them are:

Feature name (according to SFNC)	**Description**
EventSelector	Selects which Event to signal to the host application.
EventNotification[EventSelector]	Activate or deactivate the notification to the host application of the occurrence of the selected event.
EventFrameTriggerData	Category that contains all the data features related to the *FrameTrigger* event.
EventFrameTrigger	Returns the unique Identifier of the *FrameTrigger* type of event.
EventFrameTriggerTimestamp	Returns the Timestamp of the *AcquisitionTrigger* event.
EventFrameTriggerFrameID	Returns the unique identifier of the frame (or image) that generated the *FrameTrigger* event.
EventExposureEndData	Category that contains all the data features related to the *ExposureEnd* event.
EventExposureEnd	Returns the unique identifier of the *ExposureEnd* type of event.
EventExposureEndTimestamp	Returns the timestamp of the *ExposureEnd* event.
EventExposureEndFrameID	Returns the unique identifier of the frame (or image) that generated the *ExposureEnd* event.
EventErrorData	Category that contains all the data features related to the error event.
EventError	Returns the unique identifier of the error type of event.
EventErrorTimestamp	Returns the timestamp of the error event.
EventErrorFrameID	If applicable, returns the unique identifier of the frame (or image) that generated the error event.
EventErrorCode	Returns an error code for the error(s) that happened.
etc.	

4 SMART FEATURES

4.1 Introduction

A Balluff *Camera* provides both a image memory and a FPGA and for this reason some kind of intelligence. Thus, Balluff *Camera* specific features, which are based on the interplay of image memory and FPGA, and are executed on the camera directly, are named "Smart Features". These features are presented below. Balluff features, which are not part of the GenICam standard, können Sie in Ihrer Software am Präfix "**mv**" (für Machine Vision) erkennen.

4.2 Overview of available

The following table gives an overview of the available Smart Features:

Device Name	Seq	Trig	Binning	Bits	FFC	Avg	RGB	CCM	Action	SFR	MultiAOI	DigIn	DigOut	Counter	Timer
BVS CA-C1456Z00-31	✓	✓[o]	16/16/16/16	12	✓[S]	-	-	-	4	-	2	4	4	4	2
BVS CA-C1456Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	✓	✓	0	✓	2	2	4	4	2
BVS CA-C2064Z00-31	✓	✓[o]	16/16/16/16	12	✓[R]	-	-	-	4	-	4	4	4	4	2
BVS CA-C2064Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	✓	✓	0	✓	8	2	4	4	2
BVS CA-C2464Z00-31	✓	✓[o]	16/16/16/16	12	✓[R]	-	-	-	4	-	4	4	4	4	2
BVS CA-C2464Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	✓	✓	0	✓	8	2	4	4	2
BVS CA-C4112Z00-31	✓	✓[o]	16/16/16/16	12	✓	-	-	-	4	-	4	4	4	4	2
BVS CA-C4112Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	✓	✓	0	✓	8	2	4	4	2
BVS CA-M1456Z00-31	✓	✓[o]	16/16/16/16	12	✓[S]	-	-	-	4	-	2	4	4	4	2
BVS CA-M1456Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	-	-	0	✓	2	2	4	4	2
BVS CA-M2064Z00-31	✓	✓[o]	16/16/16/16	12	✓[R]	-	-	-	4	-	4	4	4	4	2
BVS CA-M2064Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	-	-	0	✓	8	2	4	4	2
BVS CA-M2464Z00-31	✓	✓[o]	16/16/16/16	12	✓[R]	-	-	-	4	-	4	4	4	4	2
BVS CA-M2464Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	-	-	0	✓	8	2	4	4	2
BVS CA-M4112Z00-31	✓	✓[o]	16/16/16/16	12	✓	-	-	-	4	-	4	4	4	4	2
BVS CA-M4112Z00-35	✓	✓[o]	16/16/16/16	12	-	✓	-	-	0	✓	8	2	4	4	2

4 SMART FEATURES

Legend

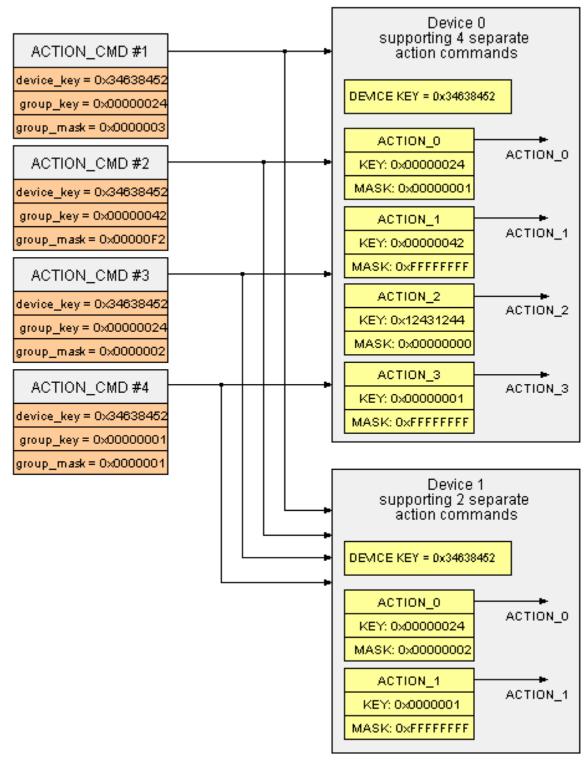
Sequencer(Seq): ✔:Sequencer supported, -:Sequencer not supported
Triggering(Trig): ✔:Hardware and Software Triggering supported, ✔[O]:Hardware and Software Triggering supported, plus Overlapped Triggering
Binning: Max. Binning Horizontal / Max. Binning Vertical / Max. Decimation Horizontal / Max. Decimation Vertical
FlatFieldCorrection(FFC): ✔:FlatField Correction supported, ✔[S]:FlatField Correction supported and saveable in flash memory, ✔[4.0]:FlatField Correction supported and saveable in flash memory dependent on hardware revision, ✔[L]:FlatField Correction supported and saveable in flash memory (Legacy mode), ✔[L 4.0]:FlatField Correction supported and saveable in flash memory (Legacy mode) dependent on hardware revision, -:FlatField Correction not supported
Frame Averaging(Avg): ✔:Frame Averaging supported, ✔[M]:Frame Averaging with Motion Compensation supported, -:Frame Averaging not supported
Color Formats(RGB): ✔:RGB Color Formats supported, -:RGB Color Formats not supported
Color Correction Matrix(CCM): ✔:Color Correction Matrix supported, -:Color Correction Matrix not supported
Action Commands(Action): Number of Action Commands supported by the device
Smart Frame Recall(SFR): ✔:mvSmartFrameRecall supported, -:mvSmartFrameRecall not supported
Multi AOI(MultiAOI): Number of AOIs supported by the device
Digital Inputs(DigIn): Number of Digital Inputs supported by the device, **(!)**No debouncing for Digital Inputs

4 SMART FEATURES

4.2.1 Action Commands

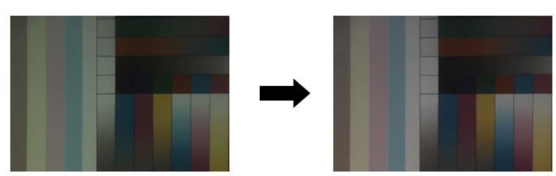
Description	**Action Commands** are commands that can be sent to devices in the same subnet via Unicast or Multicast. Depending on the setting, these have exclusive, write-only or read-only rights on the respective device. The Action Commands enable: • Trigger-over-Ethernet • The synchronization of multiple cameras, for example by ○ Increasing or resetting counters • Resetting timers • etc. **NOTE** Please note that Ethernet networks may experience delays. However, these are negligible for many applications.
Benefits & advantages	Action Commands • simplify the cabling of your application, • reduce the installation work required. As a result, you can • reduce your hardware costs.
SFNC Control	**Action Control**
Example	The conditions for an Action Command to be asserted by the device are: 1. Exclusive or write access has been established between the application and the device. 2. `device_key` has to match. 3. `group_key` has to match. 4. the logical AND-wise operation of `group_mask` must be non-zero. The following example shows the resulting behavior of four different Action Commands in a predefined environment: • The Action Command #1 asserts ACTION_0 in Device 0 and Device 1, • The Action Command #2 asserts nothing in Device 0 and Device 1, • The Action Command #3 asserts nothing in Device 0 and ACTION_0 in Device 1, • The Action Command #4 asserts ACTION_3 in Device 0 and ACTION_1 in Device 1.

4 SMART FEATURES



4 SMART FEATURES

4.2.2 Auto Functions

Description	With **Auto Functions**, the following features of the camera can be controlled automatically • the exposure time, • the gain, • the white balance.
Benefits & ad-vantages	Auto functions • mean that the camera automatically adapts to changing light conditions, • generate the maximum performance potential, • reduce the installation work required. As a result, you can • reduce your hardware costs, • reduce your software costs, • reduce your development expenses.
SFNC Control	**Image Format Control** → **mv Exposure Auto AOI Mode** **Analog Control** → **mv Gain Auto AOI Mode** → **mv Balance White Auto AOI Mode**
Example	Automatic white balance: 

4 SMART FEATURES

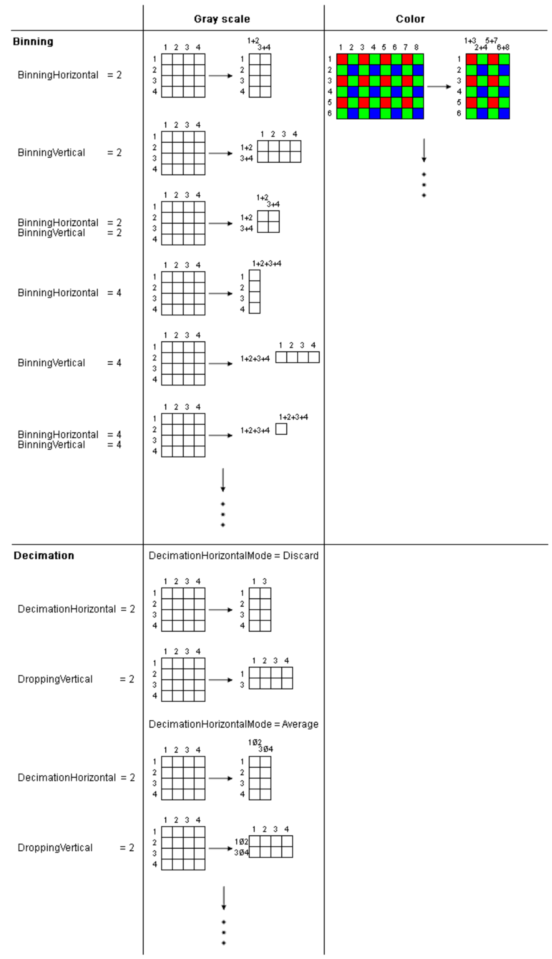
4.2.3 Binning / Decimation

Description	**Binning** combines a number of horizontal photo-sensitive cells together. **Decimation** represents a sub-sampling of the image either by discarding or averaging pixels.
	Adjustment options are:
	• BinningHorizontal
	• BinningVertical
	• DecimationHorizontalMode
	    o Discard
	    o Average
	• DecimationHorizontal
	• DecimationVerticalMode
	    o Discard
	    o Average
	• DecimationVertical

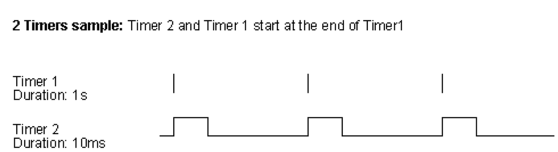
Benefits & advantages	With Binning or Decimation you can • reduce the amount of data, • increase the frame rate, • reduce the resolution, while keeping the field of view. Additionally by summing up the values, Binning will • increase the sensitivity of the image.
SFNC Control	**Image Format Control**

4 SMART FEATURES

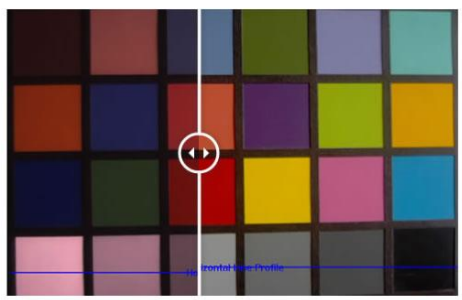
Example



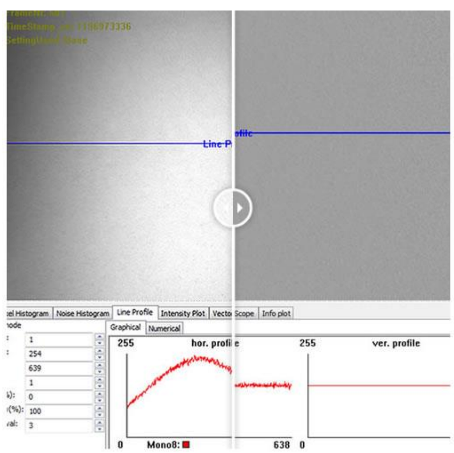
4.2.4 Counter/Timer (Micro PLC)

Description	**Counter/Timer** enable time-sensitive I/O and acquisition control, thereby replacing PLC control (hence the name Micro PLC). In total, four counters and two timers are available to our cameras, enabling the following: • The flexible generation of trigger signals. • The synchronization of multiple cameras. • The quick generation of image sequences with varying flash and lighting settings. • Dark and light images can be taken as reference image subtractions. • Lighting of images with various wavelengths (R/G/IR) can be controlled. • Disturbances can be removed by means of digital filtering circuits (inputs).
Benefits & advantages	Counter/Timer • replace flash controllers and other control components, • enable comfortable operation of these controllers/components via the camera software, • simplify the cabling of your application, • reduce the installation work required. As a result, you can • reduce your hardware costs • reduce your software costs • reduce your development expenses
SFNC Control	**Counter And Timer Control**
Example	Zwei Timer ermöglichen eine Pulsweitenmodulation. • *Timer1* gibt das Interval zwischen zwei Trigger vor (hier 1 s). • *Timer2* erzeugt einen Triggerpuls am Ende von *Timer1* (hier 10 ms). 

4.2.5 Color Correction Matrix (CCM)

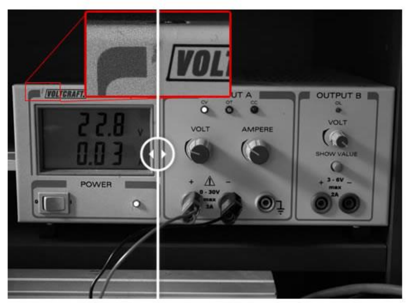
Description	With the **Color Correction Matrix (CCM)**, matrices are used to carry out colour corrections for colour optimisation. There is a matrix with sensor-specific correction coefficients, a matrix with parameters for colour saturation - effective for all image formats (RGB and YUV) - as well as a matrix for the choice of colour space of the display unit. This feature • enables a natural, colourfast reproduction or • adapts the display to application-specific circumstances (display).
Benefits & advantages	Color Correction Matrix (CCM) • optimizes image display quality and • generates the maximum performance potential. As a result, you can • reduce your software costs and • reduce your development expenses.
SFNC Control	**Color Transformation Control**
Example	Improved color fidelity of color cameras: 

4.2.6 Flat-Field Correction (FFC)

Description	With **Flat-Field Correction (FFC)**, every individual pixel of the sensor is corrected, so that when recording a homogeneous area, for example, it can be guaranteed that every pixel has the same output value. This feature can balance out • inhomogeneous lights, • vignetting of the image, and • sensor errors such as fixed pattern noise or photo response non uniformity.
Benefits & advantages	Flat-Field Correction (FFC) • prevents and corrects defective or unfavourable imaging characteristics, and • simplifies the hardware structure. As a result, you can • reduce your hardware costs, • reduce your software costs, and • reduce your development expenses.
SFNC Control	**mv FFC Control**
Example	The image before and after a flat-field correction. 

4 SMART FEATURES

4.2.7 Frame Averaging

Description	With **Frame Averaging** you can average the gray scale values of each pixel. As a result, in images with full bit depth • noise can be reduced, • movements can be compensated, and • an accumulation of lower intensity values can result.
Benefits & advantages	Frame Averaging • generates the maximum performance potential. As a result, you can • reduce your software costs and • reduce your development expenses.
SFNC Control	**mv Frame Average Control**
Example	The image is denoised with Frame Averaging. 

4 SMART FEATURES

4.2.8 Frame Buffering

Description	With **Frame Buffering** you can • look back at the past, for example in traffic or at traffic lights (pre-/post-trigger mode), • bridge bus bottlenecks, • record image sequences, and • achieve temporarily higher frequencies (burst mode).
Benefits & advantages	Frame Buffering • increases data security, • enables higher acquisition rates than the bus bandwidth actually permits, and • generates the maximum performance potential. As a result, you can • reduce your software costs and • reduce your development expenses.
SFNC Control	**Analog Control** → **mvAcquisitionFrameRateLimitMode** → **mvAcquisitionMemoryFrameCount**

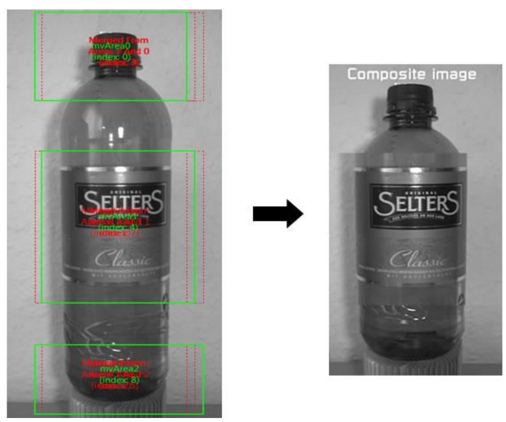
4 SMART FEATURES

4.2.9 Real-Time Gamma LUT

Description	The **Real-Time Gamma LUT** (Lookup-Tabelle) is a freely writeable RAM for any desired output characteristics. This feature enables • optimum use to be made of the camera's dynamic range, • the image to be changed in the Bayer or RGB path in the direction that the human eye perceives light and color, or generally • the image to be adapted to individual circumstances.
Benefits & ad-vantages	Real-Time Gamma LUT • optimizes image display quality and • generates the maximum performance potential As a result, you can • reduce your software costs and • reduce your development expenses.
SFNC Control	**LUT Control**
Example	The image before and after a Gamma correction. 

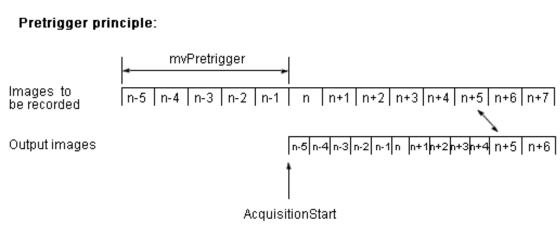
4 SMART FEATURES

4.2.10 Multi AOI

Description	Often, several areas in one image are of interest. With the **Multi AOI** feature, you can • select multiple image sections and • receive access to these.
Benefits & advantages	With the Multi AOI, you can define image sections that are relevant to you. As a result, • you obtain higher frame rates and • generate the maximum performance potential. As a result, you can • reduce your software costs and • reduce your development expenses.
SFNC Control	**Image Format Control → mv Multi Area Mode**
Example	Three AOIs procude a composite image. 

4 SMART **FEATURES**

4.2.11 Memory-based Acquisition Modes

Description	Three additional acquisition modes are possible with the internal image memory of the Balluff *Camera*: • **mvRecord** which is used to store frames in memory. • **mvPlayback** which transfers stored frames. • **mvPretrigger** which stores frames in memory to be transferred after trigger. . To define the number of frames to acquire before the occurrence of an *AcquisitionStart* or *AcquisitionActive* trigger, you can use *mvPretrigger-FrameCount*.
Benefits & ad-vantages	The memory-based acquisition • extends the functionality of the image memory and • allows a look back into the past. As a result, you can • reduce your hardware costs, • reduce your software costs, and • reduce your development expenses.
SFNC Control	**Acquisition Control → mv Acquisition Memory Mode**
Example	Five images are defined as pretrigger and after a trigger event they are streamed as fast as possible. 

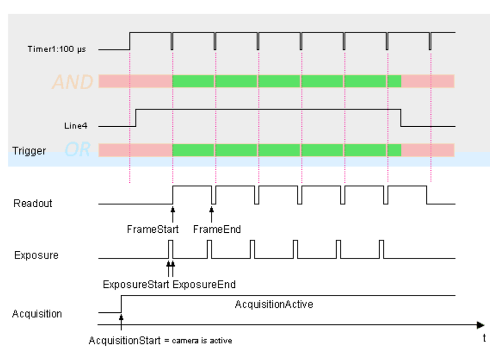
4 SMART FEATURES

4.2.12 Serial Interface

Description	The **Serial Interface** allows to control • motorizes lenses or • other peripherals based on RS232.
Benefits & advantages	The Serial Interface • generates the maximum performance potential, • simplifies the cabling of your application, and • reduces the installation work. As a result, you can • reduce your hardware costs, • reduce your software costs, and • reduce your development expenses.
SFNC Control	**mv Serial Interface Control**

4 SMART **FEATURES**

4.2.13 Logic Gates

<table>
<tr><td>Description</td><td>Logic Gates offers the possibility of logical operations on
• one logic input or
• more logic inputs
to produce a single logic output.</td></tr>
<tr><td>Benefits & advantages</td><td>Logic Gates
• generate the maximum performance potential,
• simplifie the cabling of your application, and
• reduce the installation work.
As a result, you can
• reduce your hardware costs,
• reduce your software costs, and
• reduce your development expenses.</td></tr>
<tr><td>SFNC Control</td><td>mv Logic Gate Control</td></tr>
<tr><td>Example</td><td>Triggered acquisition, but is not known, when the trigger (Line4) stops. However, an image should be acquired every 100 µs.
1. Connect Timer1 to the trigger input Line4 using a logical AND gate. Result will be true, if Timer1 and the trigger input are active.
2. The AND gate result is then connected as TriggerSource of the FrameStart trigger using a logical OR gate. As soon as the logical AND conjunction is true, the trigger source is true and the image acquisition will start.

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

4.2.14 Correction of Defective Pixels

Description	Due to random process deviations, not all pixels in an image sensor array will react in the same way to a given light condition. These variations are known as blemishes or defective pixels. With this feature, you can correct • leaky pixel (in the dark) and • cold pixel (in standard light conditions).
Benefits & advantages	The correction of defective pixels • generates the maximum performance potential.
SFNC Control	**mv Defective Pixel Correction Control**

4 SMART FEATURES

4.2.15 Sequencer

<table>
<tr><td>Description</td><td>With the Sequencer, you can simply define image sequences that

contain a certain set of parameters such as gain, binning, exposure time etc. and which
can be controlled via trigger input and signal.

Possible features for the set of parameters are:

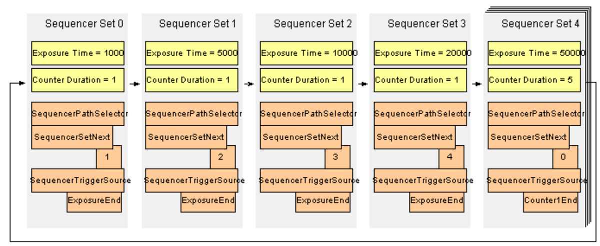
BinningHorizontal
BinningVertical
CounterDuration
DecimationHorizontal
DecimationVertical
ExposureTime
Gain
Height
OffsetX
OffsetY
Width
mvUserOutput
UserOutputValueAll
UserOutputValueAllMask
Multiple conditional sequencer paths
</td></tr>
<tr><td>Benefits & ad-vantages</td><td>The Sequencer

records information that would not be able to be achieved via a set-ting,
generates the maximum performance potential, and
simplifies the hardware structure.

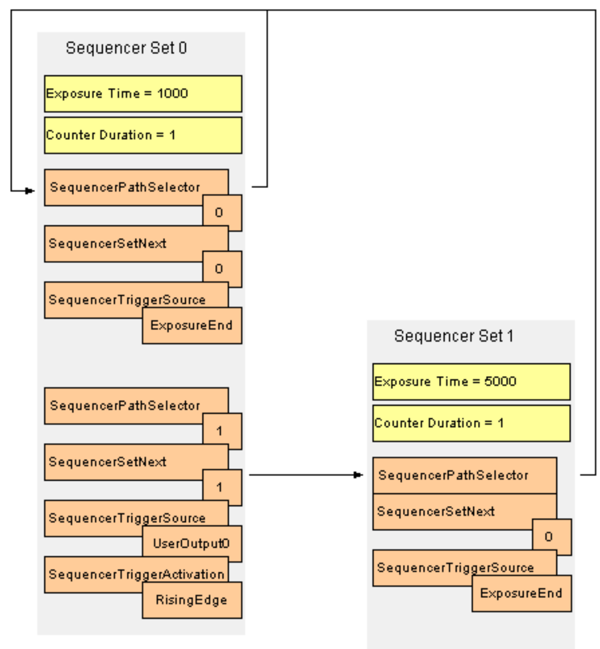
As a result, you can

reduce your hardware costs
reduce your software costs
reduce your development expenses.
</td></tr>
<tr><td>SFNC Control</td><td>Sequencer Control</td></tr>
<tr><td>Example</td><td>An acquisition sequence with five different exposure times on the device whereby the last step should be repeated five times.</td></tr>
</table>

4 SMART FEATURES

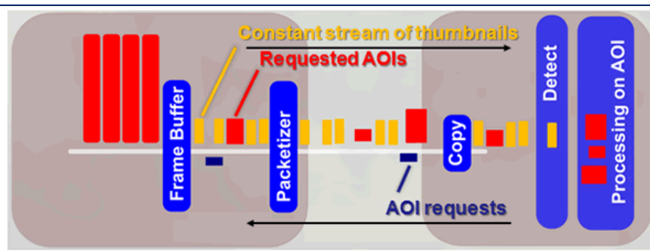


An external trigger via UserOutput0 activates an alternative sequence path with a longer exposure time:



4 SMART FEATURES

4.2.16 mvSmartFrameRecall

Description	The **mvSmartFrameRecall®** generates small preview images with reduced resolution (thumbnails), which are transferred to the host PC with IDs. At the same time, the corresponding image in full resolution is archived in the camera's image memory. If the image is required in full resolution, the application sends a request and the image is transferred in the same data stream as the preview image. The feature enables • Large sensors with high frame rates to also be fully exploited via Gigabit Ethernet and • to be used at full speed
Benefits & advantages	mvSmartFrameRecall® • Reduces the amount of data • Relieves the entire system • Generates the maximum performance potential • Simplifies the hardware structure • Reduces the installation work required As a result, you can • Reduce your hardware costs • Reduce your software costs • Reduce your development expenses
SFNC Control	**Acquisition Control → mv Smart Frame Recall Enable**
Example	

4 SMART FEATURES

4.2.17 mvBlockScan

Description	The **mvBlockscan** acquires an Area of Interest (AOI) block which consists of several lines. The user defines the amount of AOI blocks which are used to create one image. With this functionality the feature offers the possibility, • To realize a line scan application with Pregius global shutter area scan sensors from Sony and this • In connection with the standard interfaces USB3 and GigE Vision

Benefits & advantages	The mvBlockScan
	• Simplifies the handling of line scan applications (e.g. during focusing),
	• Increases the usability of area scan cameras,
	• Reduces the costs because
	    o A frame grabber is not needed and
	    o The area scan camera is less pricy than a line scan camera with the same line rate.
	As a result, you can
	• Reduce your hardware costs
	• Reduce your development efforts

SFNC Control	**Device Control → Device Scan Type → mv Block Scan**

4 SMART FEATURES

4.2.18 User Data in the Camera

Description	Every camera has a free non-volatile RAM that can be used for **User Data**. With this feature, you can • deposit customer-specific data such as serial numbers etc. (and thereby use the camera as a dongle), • secure configuration data.
Benefits & ad-vantages	The User Data feature • simplifies the hardware structure. As a result, you can • reduce your software costs. • reduce your development expenses.
SFNC Control	**File Access Control** **User Set Control → mv User Data**

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