Smart Camera / Smart Sensor

Data sheet version: 1.07

1 Order data - General

Model number	Short description	Figure
	Smart Sensor	
VSS1x2xxx.xxxP-000	- Vision Smart Sensor (one active Vision Function) - ARM Cortex A9 CPU - Flash-Drive onboard - Standard size - FPGA image preprocessing - IP65 protection POWERLINK interface with integrated 2-port hub - Monochrome sensor - Lens with adjustable focus (lens optionally external) - Up to 4 LED segments with 4 multicolored LEDs each - LED optics - Lens cover	

Table 1: VSS1x2xxx.xxxP-000 - Order data

Model number	Short description	Figure
	Smart Sensor	
VSC122xxx.xxxP-000	- Vision Smart Camera (multiple Vision Functions simultaneously) - ARM Cortex A9 CPU - Flash-Drive onboard - Standard size - FPGA image preprocessing - IP65 protection POWERLINK interface with integrated 2-port hub - Monochrome sensor - Lens with adjustable focus (lens optionally external) - Up to 4 LED segments with 4 multicolored LEDs each - LED optics - Lens cover	

Table 2: VSC122xxx.xxxP-000 - Order data

2 Module description

Intelligent cameras (**Smart Sensor** and **Smart Camera**) are the core element of **Machine Vision**, B&R's machine vision technology with full machine control integration. Another key component of the system is the intelligent lighting, **Smart Light**. Lighting can either be integrated into the camera body or provided via an external device. Combinations of the two are also possible.

Depending on the selected hardware and software performance class, a wide range of camera models is available for a variety of applications. Options at the lower end replace simple machine vision sensors, while the top of the range provides the full potential of high-end smart cameras.

Camera modules are fully integrated real-time fieldbus devices. The camera integrated directly into the machine's real-time network via POWERLINK. The protocol is not only used for high-precision synchronization with control and drive technology, but also for transferring information for the HMI application. Image triggers from the camera and lighting control can be set in hard real-time directly from the controller or drive application. A synchronized exposure (flash) can therefore be implemented with the external light of a **Smart Light**.

Smart Sensor and **Smart Camera** have the same hardware options. Various integrated lenses and housing variants with a standard C mount are available. Other options include a variety of integrated lighting, FPGA image preprocessing and image sensors from 1.3 to 5.3 megapixels.

Internally, an individual Camera consists of a processor unit and a sensor unit, both of which can be selected from multiple options. It also includes various optics and a lighting unit that can be selected from multiple options. The individual product versions that can be ordered are dependent on how these units are combined.

Smart Sensor and **Smart Camera** differ in the number of vision functions that can be used simultaneously for an application.
Smart Sensor can be used for a single task (read code, measure, localize, ...). The function is defined in the application using simple parameterization instead of complex programming.
Smart Camera allows the simultaneous use of multiple functions to solve several tasks at once.

Functions:

- Integrated monochrome lighting
- Image acquisition
- Preprocessing (linear filters)
- Line sensor operation
- Vision functions

3 Smart Camera - Order number key

Product area																	
V																	Integrated machine vision
	Product group																
	S	S															Smart Sensor
	S	C															Smart Camera
			Placeholder for future options														
			1														Standard variant
				CPU (image processing power)													
				1													Cortex A9 i.MX6 dual core
				2													Cortex A9 i.MX6 quad core
					Placeholder for future options												
					2												Standard variant
						Integrated LED lighting											
						0											Without LED lighting (LED status indicator available)
						3											Blue
						8											Red
						A											UV
						D											IR
						F											White
						Q											R / G / B / Lime
						R											R / B / IR / White
							LED lens										
							0										Without LED lens (Only for variants without LED lighting)
							1										LED lens type 1, wide beam
							2										LED lens type 2, standard
							3										LED lens type 3, narrow beam
								Image sensor									
								1									1.3 MP - 90 fps - NOT suitable for line sensor
								2									1.3 MP - 165 fps - SUITABLE for line sensor
								4									3.5 MP - 43 fps - NOT suitable for line sensor
								5									5.3 MP - 43 fps - SUITABLE for line sensor
									.	**Lens**							
									.	0	0						C-mount (No lens installed)
									.	0	2						S-mount - 4.6MM, F3.5 1/1.8" (Only for 1.3 MP or 3.5 MP image sensor)
									.	0	3						S-mount - 6MM, F3.5 1/1.8" (Only for 1.3 MP or 3.5 MP image sensor)
									.	0	4						S-mount - 8MM, F4 1/1.8" (Only for 1.3 MP or 3.5 MP image sensor)
									.	M	5						S-mount - 12 mm, F4 1/1.8" macro lens (Only for 1.3 MP or 3.5 MP image sensor)
									.	0	5						S-mount - 12MM, F4 2/3"
									.	0	6						S-mount - 16MM, F4 2/3"
									.	0	7						S-mount - 25MM, F4 2/3"
												Front glass					
												0					No front glass (Only for C-mount variant)
												1					Glass with anti-reflective coating
												2					Glass with polarizing filter
												3					Glass diffuser
												B					Plastic with anti-reflective coating
												D					Plastic diffuser
													Variants				
													P	-	0	0	0	Standard variant
Examples																	
V	S	S	1	1	2	Q	2	1	.	0	3	1	P	-	0	0	0	Smart sensor (one active Vision Function), ARM Cortex-A9 2 cores, integrated FPGA image pre-processing, 4 LED segments with 4 multicolored LEDs each, 1.3 MP 2-channel sensor (NOT suitable for line sensor), S-mount - 6 mm, F3.5 1/1.8", glass cover with anti-reflective coating, POWERLINK interface with integrated 2-port hub
V	S	C	1	2	2	Q	2	2	.	0	4	2	P	-	0	0	0	Smart Camera (multiple Vision Functions simultaneously), ARM Cortex-A9 4 cores, integrated FPGA image pre-processing, 4 LED segments with 4 multicolored LEDs each, 1.3 MP 2-channel sensor (SUITABLE for line sensor), S-mount - 8 mm, F4 1/1.8", glass cover with polarizing filter, POWERLINK interface with integrated 2-port hub

Information:

The order key serves as an overview and should make it easier to distinguish the existing modules. Not every order key combination is technically feasible and is therefore not available as an orderable module variant.

4 Technical data

This section contains the technical data for the camera's individual configurable components. The product name (material number) and order key of a camera configuration can be used to determine the technical data of a specific Camera (**Smart Sensor** or **Smart Camera**.

General technical data

Order Number	VSS1x2xxx.xxxP-000	VSC1x2xxx.xxxP-000
Short description		
Camera	Vision Smart Sensor	Vision Smart Camera
General information		
System requirements		
Automation Studio	4.7.2 or later	
Automation Runtime	C4.7.2 or later	
mapp Technology Package	mapp Vision 5.10 or later: dual core, S mount, 1.3 megapixels sensor mapp Vision 5.13 or later: quad core, C mount, 3.5 and 5.3 megapixels sensor	mapp Vision 5.16 or later: one active Vision Function mapp Vision 5.19 or later: multiple active Vision Functions possible
Hardware module upgrade	Version 1.0.0.0 or later	Version 1.6.0.0 or later
Cooling	Passive	
Status indicators	Module status, Error, Link1, Link2	
Diagnostics	Yes, using LED "Status" and software	
Electrical isolation	No	
Undervoltage detection	Yes	
Short-circuit proof	Yes	
Reverse polarity protection	Yes	
Certification	CE	
Module power supply		
Connection	M12, 8-pin, Y-coded	
Nominal voltage	24 VDC -15% / +20%, SELV/PELV	
Max. input current	1.25 A (at 0.5 A at the digital output)	
Max. current consumption [1]	< 750 mA (image acquisition, image processing and network communication). 600 mA typical	< 800 mA (image acquisition, image processing and network communication). 600 mA typical
Max. output current	4 A / string (for forwarding)	
Interfaces		
Quantity	2	
Connection designation	IF1, IF2	
Fieldbus	POWERLINK	
Type	POWERLINK (V2) managing or controlled node	
Variant	M12, 8-pin, Y-coded (2-port hub, daisy-chain wiring possible)	
Cable length	Max. 20 m between 2 stations (segment length)	
Transfer rate	10/100 Mbit/s	
Transfer		
Physical layer	100BASE-TX	
Half-duplex	Yes	
Full-duplex	No	
Autonegotiation	Yes	
Auto-MDI/MDIX	Yes	
Min. cycle time	400 µs [2]	
Digital inputs		
Quantity	1	
Connection designation	X1	
Variant	M12, 5-pin, A-coded	
Input characteristics per EN 61131-2	Type 1	
Input voltage	24 VDC (-15% / +20%)	
Input current at 24 VDC	typ. 3.9 mA	
Input circuit	Sink/source	
Input resistance	typ. 6.1 kOhm	
Input delay	150 µs	
Switching threshold		
Low	< 5 VDC	
High	> 15 VDC	
Electrical isolation	Yes	
Digital outputs		
Quantity	1 (FET positive switching)	
Connection designation	X1	
Variant	M12, 5-pin, A-coded	
Nominal voltage	24 VDC	
Switching voltage	24 VDC -15% / +20%	
Output circuit	Source	

Order Number	VSS1x2xxx.xxxP-000	VSC1x2xxx.xxxP-000
Switching delay [3]		
0 → 1	< 80µs	
1 → 0	< 80µs	
Max. output current	500 mA	
Electrical isolation	No	
Protective measures		
Short-circuit proof	Yes	
Overtemperature shutdown	Yes	
Operating conditions		
Mounting orientation		
Horizontal	Yes	
Vertical	Yes	
Face-up	Yes	
Installation elevation above sea level		
0 to 2000 m	No limitation	
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m	
Pollution degree per EN 60664-1	2	
Overvoltage category per EN 60664-1	II	
Degree of protection per EN 60529	IP65/IP67	
Ambient conditions		
Temperature [4]		
Operation	-20 °C to +50 °C [5]	
Storage	-40 °C to +85 °C	
Transport	-40 °C to +85 °C	
Relative humidity		
Operation	5 to 100%, condensing	
Storage	5 to 100%, condensing	
Transport	5 to 100%, condensing	
Mechanical properties		
Material	Aluminum die casting	
Dimensions		
Width	116 mm	
Height	78 mm	
Depth	68 mm	
Weight	0.75 kg	

1) Without load on the digital output. The current consumption increases by a maximum of 0.5 A when using the digital output (depending on application).
2) The maximum cycle time should not exceed 10 ms
3) At loads <= 1kOhm
4) All mounting orientations
5) Operation below 0 °C: Condensation or icing can impair the camera function.

Processor (image pre-processing power)

Order number	VSS112xxx.xxxP-000	VSS122xxx.xxxP-000	VSC122xxx.xxxP-000
Controller			
Processor			
Type	Cortex A9 dual core	Cortex A9 quad core	
Clock frequency	800 MHz		
Number of cores	2	4	
L1 Cache			
Data code	32 kB (per core)		
Program code	32 kB (per core)		
L2 Cache	512 kB	1 MB	
Flash	Boot NOR-Flash; 4 MB; SPI		
Standardspeicher			
RAM	DDR3, 1 GB, 64-bit, 800 MT/s, 400 MHz	DDR3, 1 GB, 64-bit, 800 MT/s, 400 MHz	DDR3, 2 GB, 64-bit, 800 MT/s, 400 MHz
User memory			
Typ	eMMC NAND flash memory, 2 GB, 8-bit, ≤ 40 Mbit/s		
Image pre-processing			
Image memory	For saving 10 images		

Integrated LED lighting

Order number	VSx1x20xx.xxxP-000	VSx1x23xx.xxxP-000	VSx1x28xx.xxxP-000	VSx1x2Axx.xxxP-000	VSx1x2Dxx.xxxP-000	VSx1x2Fxx.xxxP-000	VSx1x2Qxx.xxxP-000	VSx1x2Rxx.xxxP-000
Integrated LED lighting								
Number of device status LED	1							
Number of LED lighting	Without LED lighting	16 (4 LED segments with 4 one-color LEDs each)					16 (4 LED segments with 4 multicolored LEDs each)	
Min. exposure time	-	1 µs						
Max. pulse length[1]	-	10 ms						

Order number	VSx1x20xx. xxxP-000	VSx1x23xx. xxxP-000	VSx1x28xx. xxxP-000	VSx1x2Axx. xxxP-000	VSx1x2Dxx. xxxP-000	VSx1x2Fxx. xxxP-000	VSx1x2Qxx. xxxP-000	VSx1x2Rxx. xxxP-000
Min. pause duration	-	9x pulse duration (with 10 ms pulse duration this means 90 ms pause duration)						
Max. duty cycle[2)]	-	10 %						
Peak wavelengths								
Blue	-	468 nm	-				468 nm	
Green	-						519 nm	-
Lime (neon green)	-						544 nm	-
Red	-		632 nm	-			632 nm	
Ultraviolet	-			385 nm	-			
Infrared	-				856 nm	-		856 nm
White	-					No (entire visible spectrum present)	-	No (entire visible spectrum present)
Risk group according to 62471:2008[3)]	RG0	RG1 (RG2 using LED lens 3)	RG0	RG1	RG0	RG1	RG0: Red, Green, lime RG1: Blue RG2: Blue (using LED lens 3)	RG0: Red, Infrared RG1: Blue, White RG2: Blue (using LED lens 3)

1) Reduced maximum pulse duration with infrared LED
- LED lens type 1 and 4.6 mm lens: Max. 1.25 ms
-LED lens type 1 and 6 mm lens: Max. 5 ms
- LED lens type 2 and 4.6 mm lens: Max. 5 ms
2) Pulse length in comparison to the sum of pulse length and pause duration (e.g. for flash operation)
3) For a working distance of 200 mm, pulse length of 10 ms, and a 10% duty cycle.

Image sensor

Order number	VSx1x2xx1.xxxP_000	VSx1x2xx2.xxxP_000	VSx1x2xx4.xxxP_000	VSx1x2xx5.xxxP_000
Image sensor				
Type	CMOS			
Number of pixels	1.3 megapixels		3.5 megapixels	5.3 megapixels
Sensor size	1/2”		1/1.8”	2/3”
Sensor pixel size	4.8 µm		3,2 µm	
Resolution	Width (X) x height (Y) pixels 1280 x 1024 pixels		Width (X) x height (Y) pixels 2112 x 1664 pixels	Width (X) x height (Y) pixels 2592 x 2048 pixels
Maximum frame rate	90 fps	165 fps	43 fps	
Can be used as a line sensor	No	Yes	No	Yes

Optics

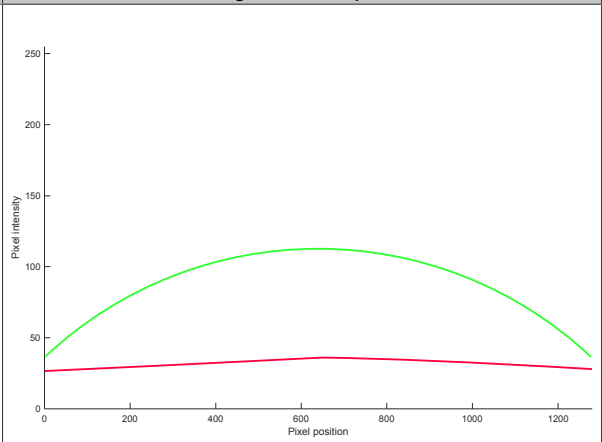
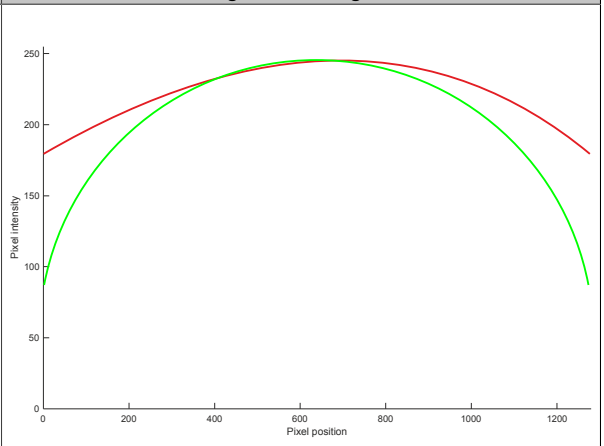
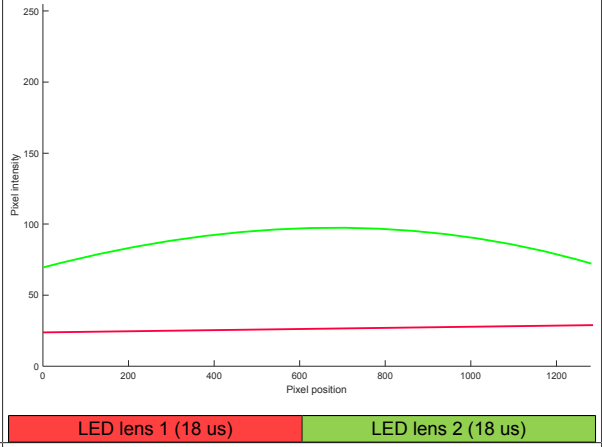
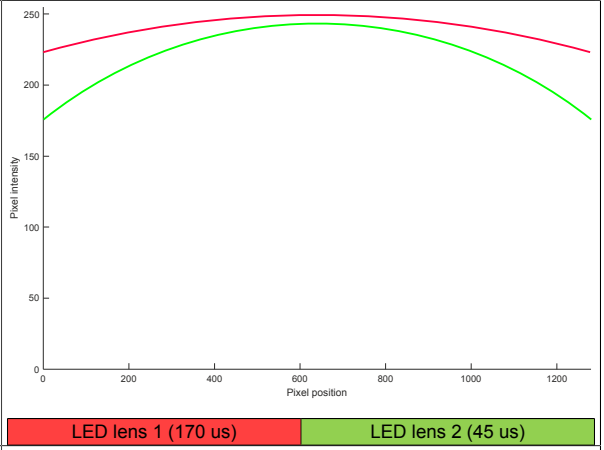
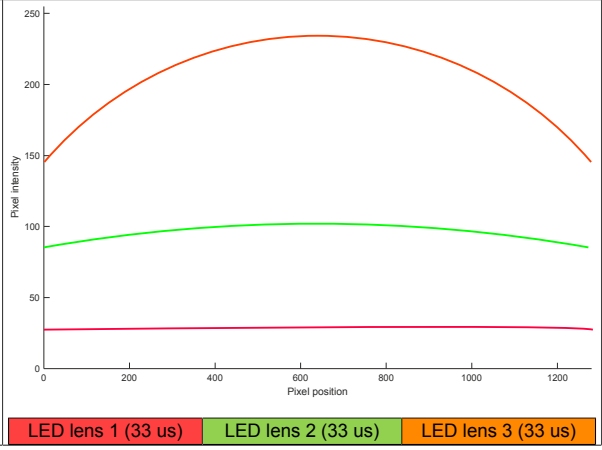
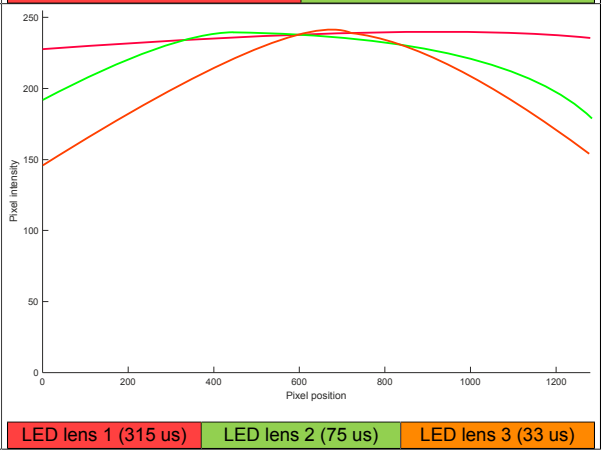
Order number	VSx1x2xxx. 00xP-000	VSx1x2xxx. 02xP-000	VSx1x2xxx. 03xP-000	VSx1x2xxx. 04xP-000	VSx1x2xxx. M5xP-000	VSx1x2xxx. 05xP-000	VSx1x2xxx. 06xP-000	VSx1x2xxx. 07xP-000
Lens								
Type	C mount, no internal lens	S mount						
Fixed focal length	-	4,6 mm	6 mm	8 mm	12 mm, macro	12 mm	16 mm	25 mm
Resolution	-	150 lp/mm						
Aperture	-	3,5			4			
Maximum aperture (light intensity)	-	1 /1,8"				2 /3"		
Minimum object distance [1) 2)]	-	25 mm	50 mm		35 mm	75 mm	100 mm	250 mm
Maximum object distance [1) 2)]	-	65500 mm			65 mm	5000 mm	1500 mm	
Optimum working distance	-	200 mm			-	200 mm		
Distortion	-	< -3.8 %	< -2.0 %	< -0.4 %	< -0.12 %	< -0.5 %	< -0.5 %	< 0.5 %
Front glass (cover)	No lens cover	Glass with AR coating Glass with polarizing filter Glass with diffuser Plastic with AR coating Plastic with diffuser						
LED lens[3)]								
Type 0 - Without LED lens	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Type 1 - Wide beam[4)]	-	Yes	Yes	Yes	-	-	-	-
Type 2 - Standard	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Type 3 - Narrow beam	-	-	-	Yes	-	Yes	Yes	Yes

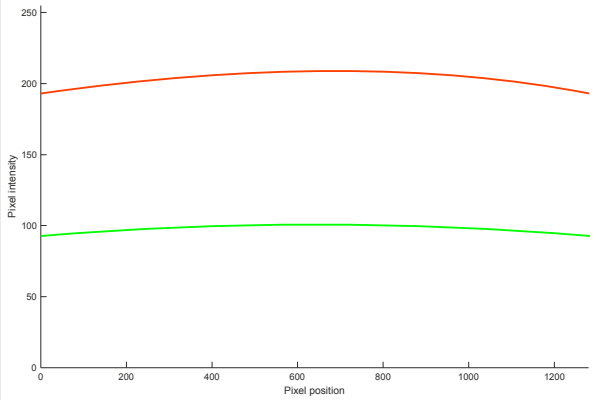
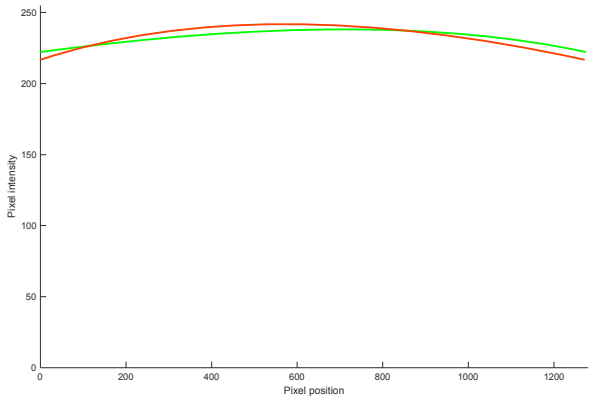
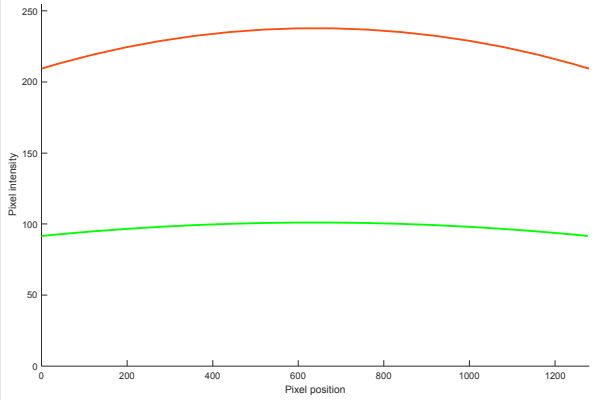
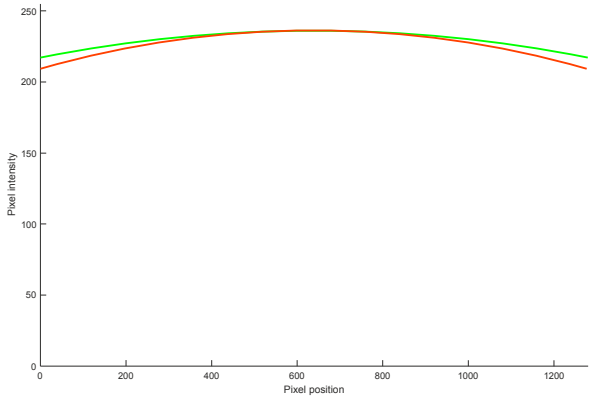
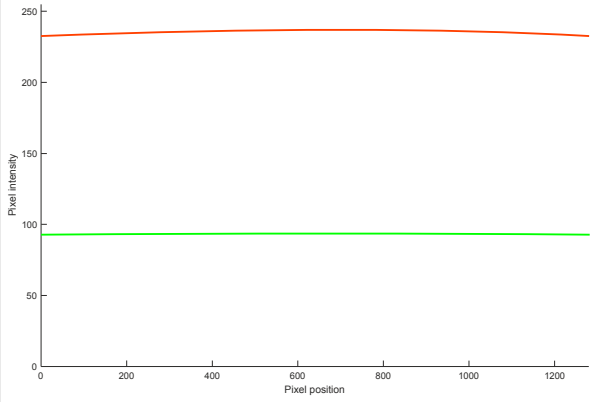
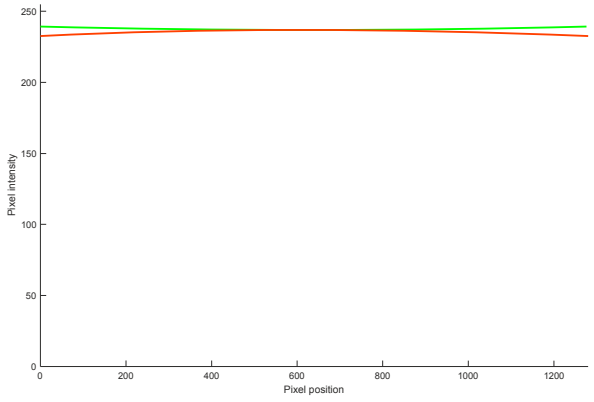
1) Object distances are based on the glass surface. The specified minimum and maximum object distances are guaranteed achievable distances (worst case values).
Individual cameras can reach values beyond that. However, since this distance cannot be guaranteed unrestrictedly across several cameras of a product variant or across the entire temperature range, the use of a camera outside of these distances is only permitted under certain circumstances (for example, if the object is within the depth-of-field range or if the resulting blur is allowed within the scope of the application).
2) Lenses are optimized for close range.
3) When using IR LED, the use of LED lens 2 is recommended for greater distances requiring a longer exposure time in the millisecond range.
At these focal lengths, LED lens 1 tends to reflect in the front glass (optic cover), which can influence the image acquisition.
4) When using polarizing filter, LED lens 1 tends to reflect in the front glass (optic cover), which can influence the image acquisition. In this case the use of LED lens 2 is recommended

Distribution of light intensity at the image sensor

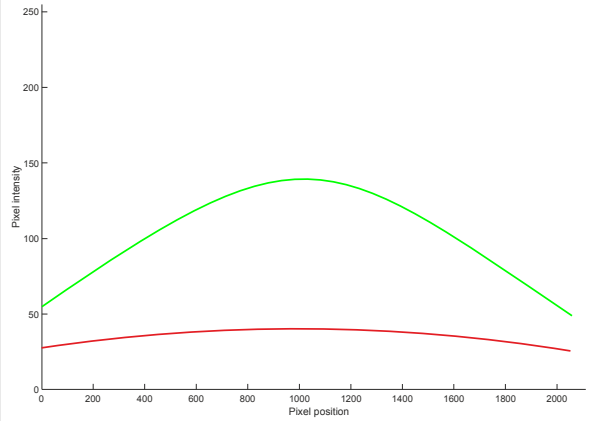
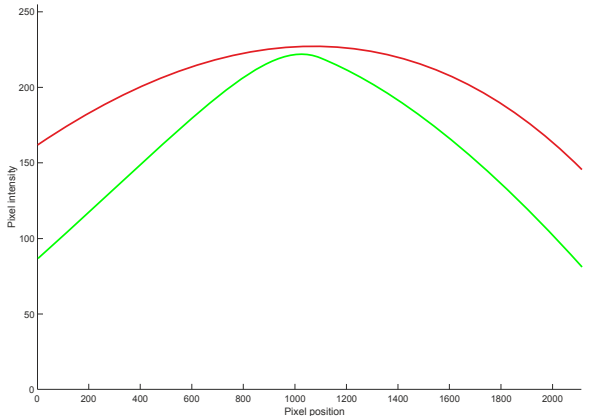
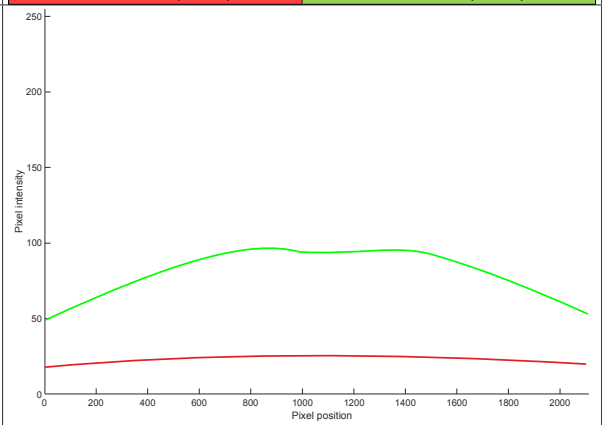
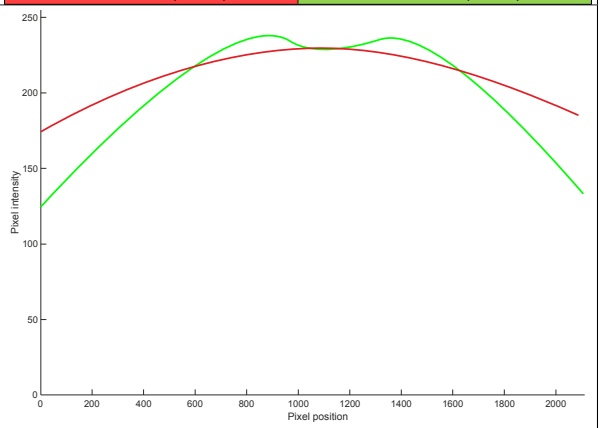
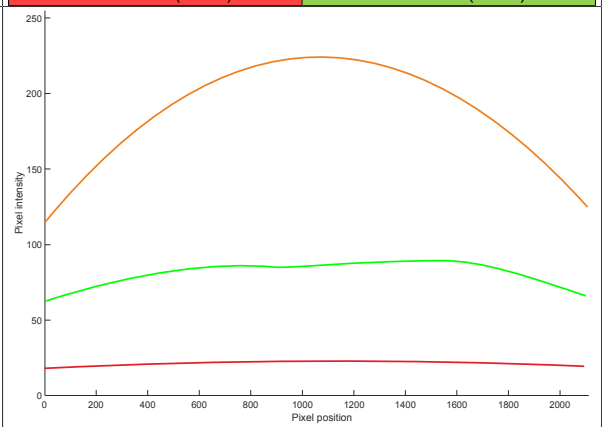
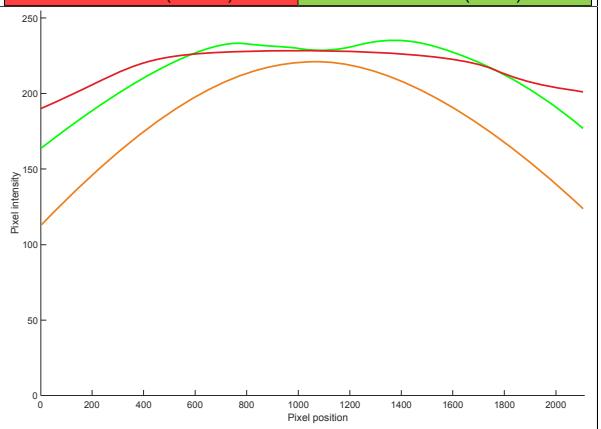
Distribution of light intensity at the image sensor for a given exposure time.
For S mount optics from 4.6 mm to 25 mm, in each case depending on the possible LED lenses.
Each for constant exposure and for constant brightness.

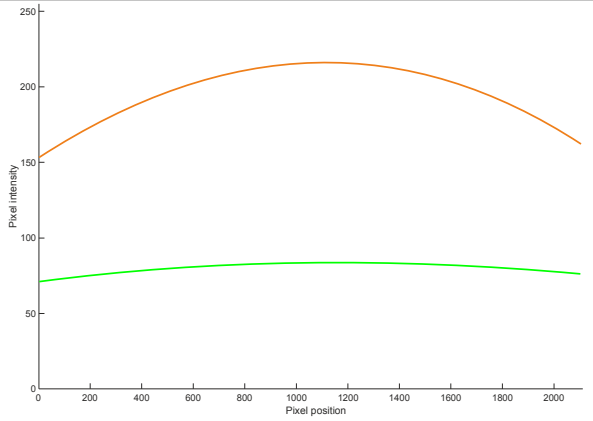
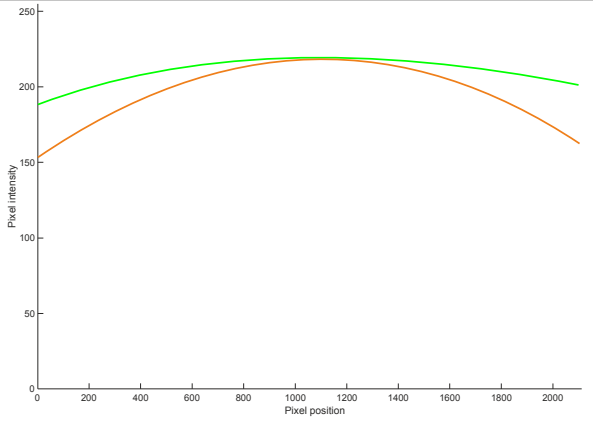
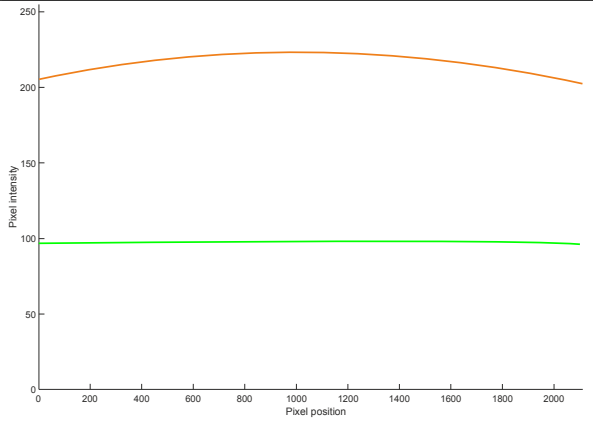
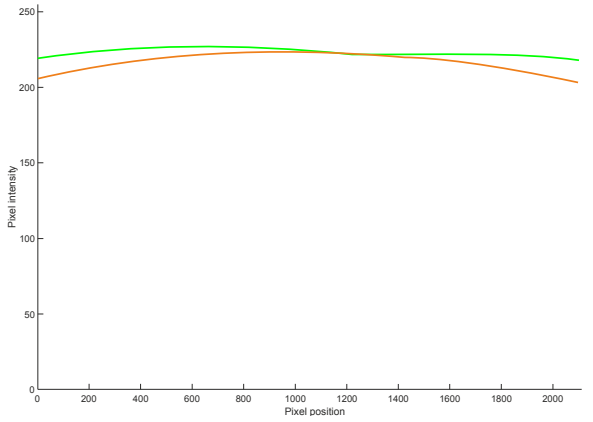
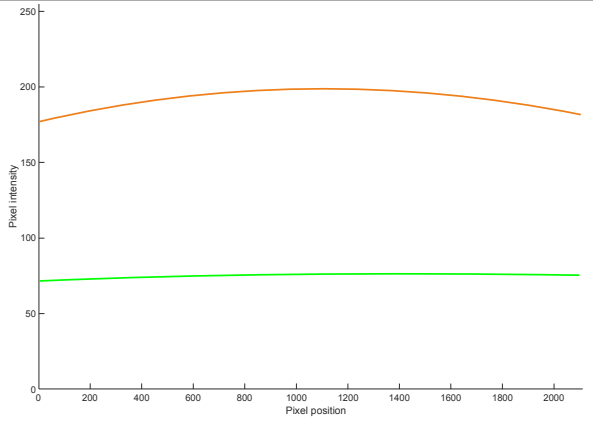
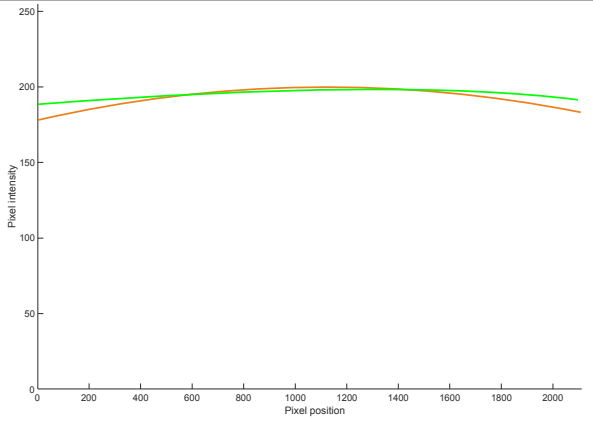
1.3 megapixels sensor

Optics	1.3 megapixels sensor	
	during constant exposure	during constant brightness
4.6 mm		
6 mm		
8 mm		

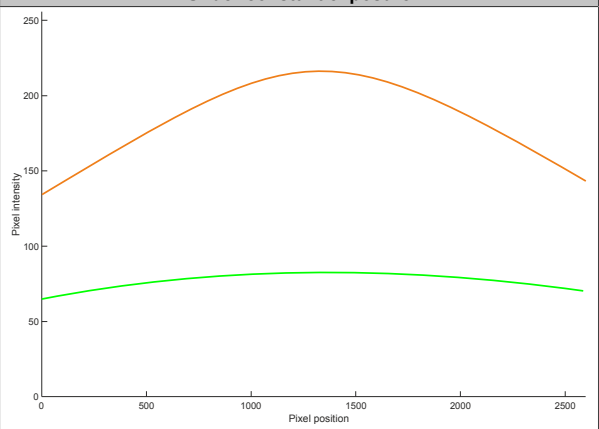
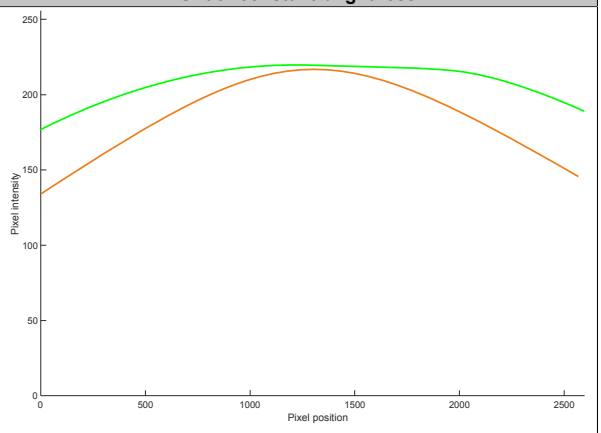
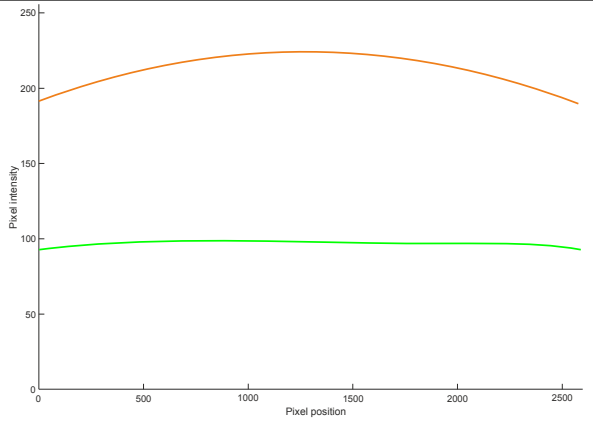
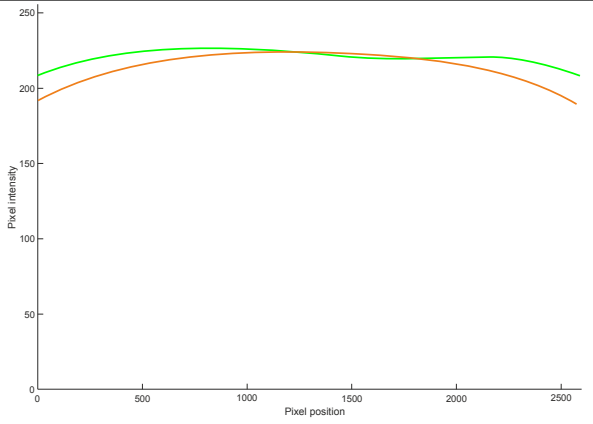
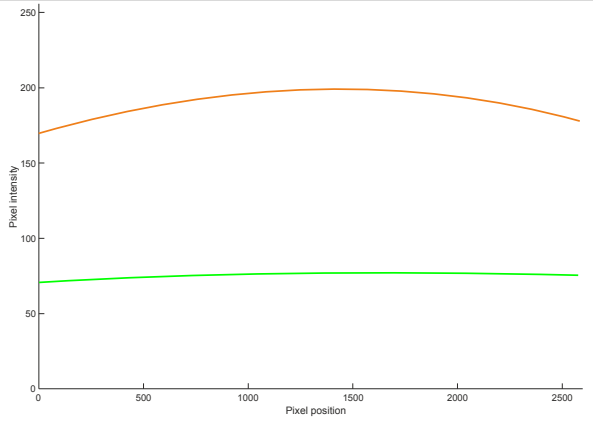
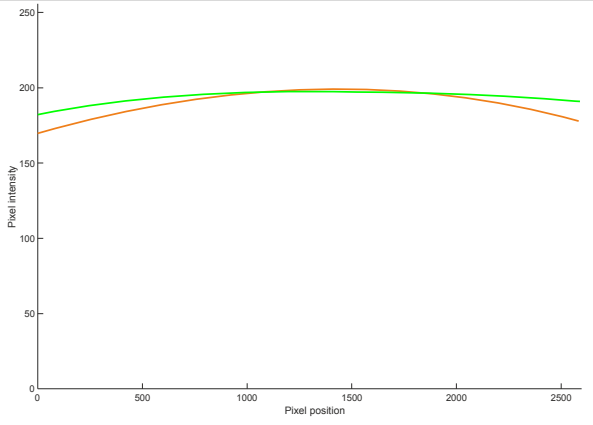
Optics	1.3 megapixels sensor	
	Under constant exposure	Under constant brightness
12 mm		
	LED lens 2 (19 us) / LED lens 3 (19 us)	LED lens 2 (46 us) / LED lens 3 (27 us)
16 mm		
	LED lens 2 (43 us) / LED lens 3 (43 us)	LED lens 2 (103 us) / LED lens 3 (43 us)
25 mm		
	LED lens 2 (119 us) / LED lens 3 (119 us)	LED lens 2 (317 us) / LED lens 3 (119 us)

3.5 megapixels sensor

Optics	3.5 megapixels sensor	
	during constant exposure	during constant brightness
4.6 mm	 LED lens 1 (14 us) LED lens 2 (14 us)	 LED lens 1 (80 us) LED lens 2 (22 us)
6 mm	 LED lens 1 (33 us) LED lens 2 (33 us)	 LED lens 1 (305 us) LED lens 2 (80 us)
8 mm	 LED lens 1 (63 us) LED lens 2 (63 us) LED lens 3 (63 us)	 LED lens 1 (637 us) LED lens 2 (167 us) LED lens 3 (63 us)

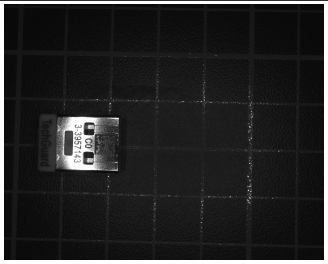
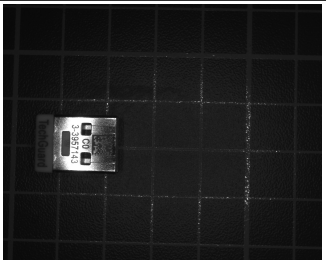
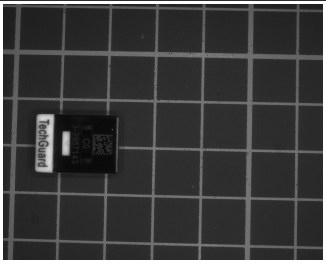
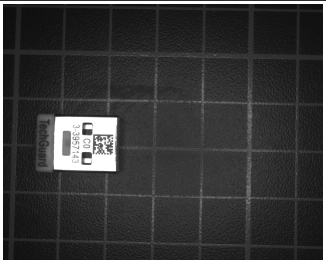
Optics	3.5 megapixels sensor	
	Under constant exposure	Under constant brightness
12 mm		
	LED lens 2 (124 us) / LED lens 3 (124 us)	LED lens 2 (331 us) / LED lens 3 (124 us)
16 mm		
	LED lens 2 (30 us) / LED lens 3 (30 us)	LED lens 2 (68 us) / LED lens 3 (30 us)
25 mm		
	LED lens 2 (471 us) / LED lens 3 (471 us)	LED lens 2 (1215 us) / LED lens 3 (471 us)

5.3 megapixels sensor

Optics	5.3 megapixels sensor	
	Under constant exposure	Under constant brightness
12 mm		
	LED lens 2 (124 us) / LED lens 3 (124 us)	LED lens 2 (331 us) / LED lens 3 (124 us)
16 mm		
	LED lens 2 (30 us) / LED lens 3 (30 us)	LED lens 2 (68 us) / LED lens 3 (30 us)
25 mm		
	LED lens 2 (471 us) / LED lens 3 (471 us)	LED lens 2 (1215 us) / LED lens 3 (471 us)

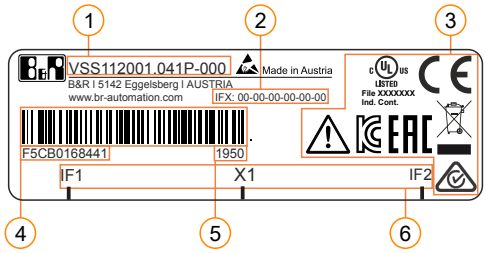
4.1 Influence of the front glasses (lens covers)

The following exemplary comparison shows the effects of different front glasses on an image acquisition.

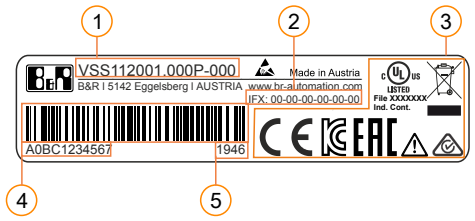
			
No glass (for C-Mount)	Glass with AR coating	Glass with polarizing filter	Glass with diffusor

4.2 Product label

S-mount



C-mount



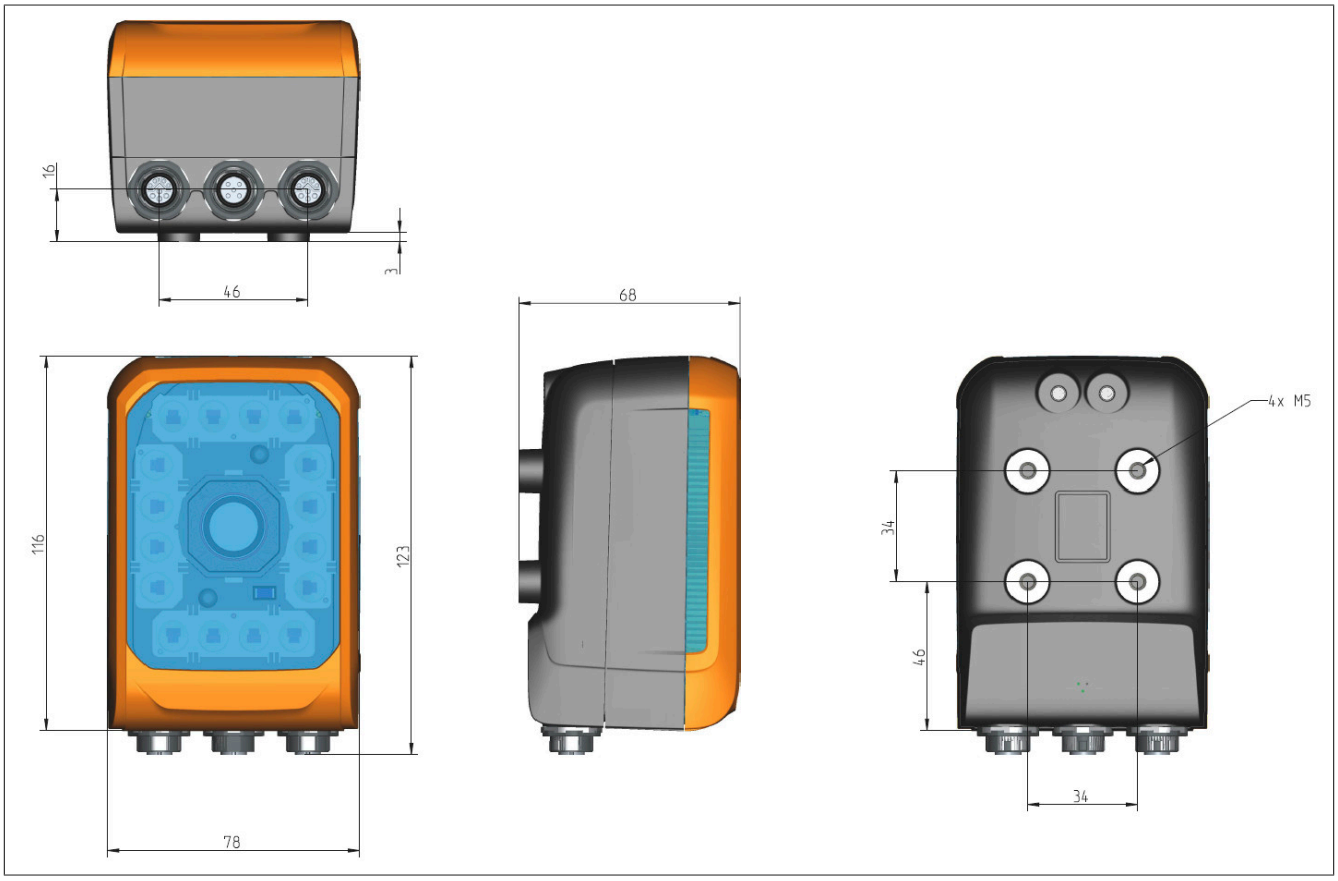
1	Smart Camera - Order number	**2**	MAC address
3	Certification marking	**4**	Serial number (barcode type 128 and hexadecimal)
5	Production date: Year and calendar week (yyww)	**6**	Interface name (only for S-mount variants)

5 Operating and connection elements

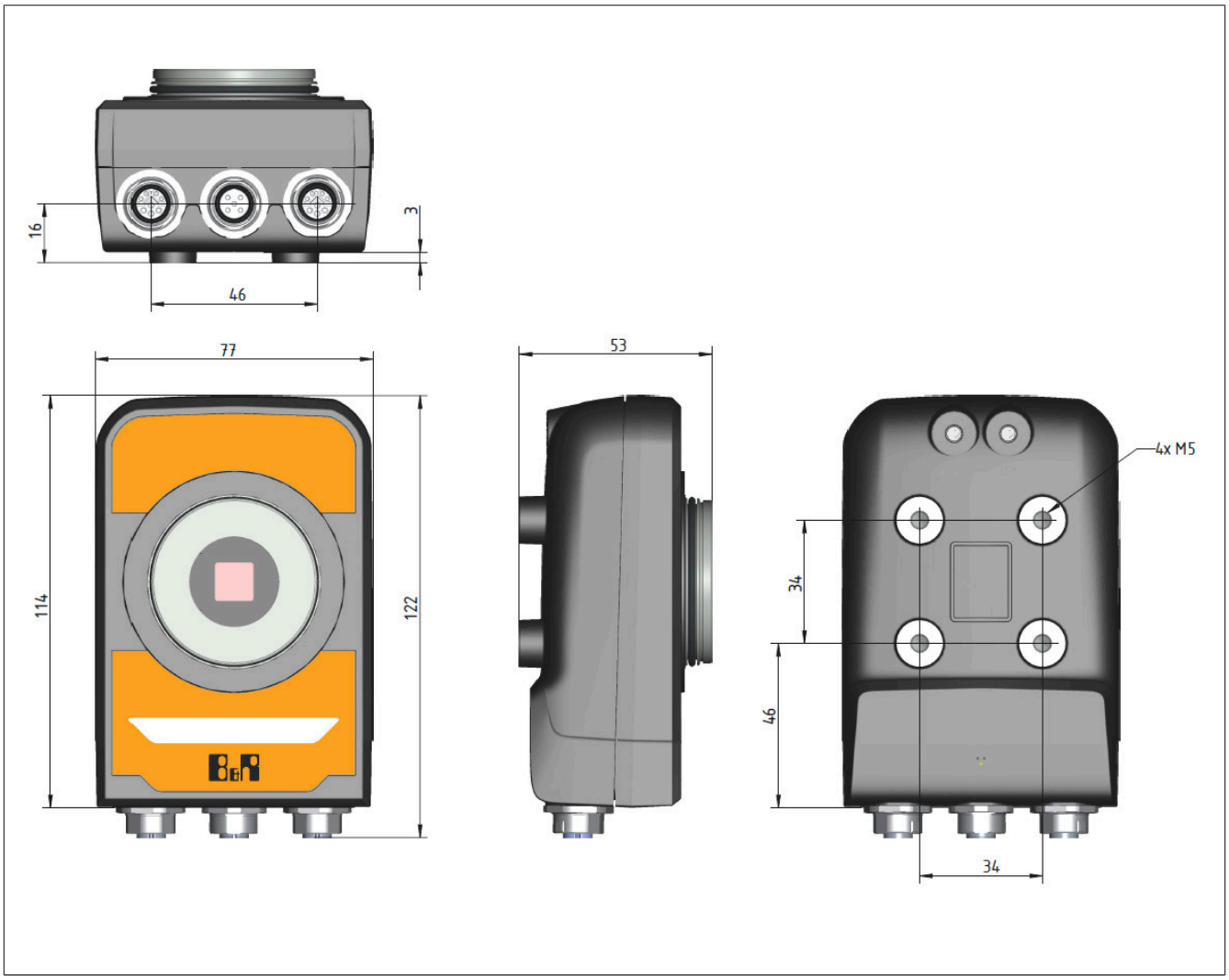
5.1 Dimensioned drawing

Dimensions in mm.

S-mount



C-mount



5.2 LED status indicators

The LED status indicator is the multicolor LED strip integrated into the housing frame by the front cover.

During camera startup, the LED behavior corresponds to the POWERLINK V2 mode described in the following section.

After the startup is complete, the status LED can be configured in Automation Studio via register.

Extended functionality of status LED indicator: firmware version 111 or later

If one of the bits of the parameter **CameraStatus** is set, which affects the parameter **ImageAcquisitionReady**, then the camera flashes in green double flash (like status PRE_OPERATIONAL_2 of the POWERLINK V2 mode).

If none of the bits affecting **ImageAcquisitionReady** is set and **ImageAcquisitionReady** is FALSE or the bit "MAPPVISION_HMI_ACTIVE" is set in **CameraStatus**, the LED status indicator is switched to blue.

If none of the above cases applies, the LED status indicator is green.

Information:

The parameters and registers mentioned in this section are part of the mapp Technology Package. For additional information, see the section of the corresponding mapp Technology Package in Automation Help.

5.2.1 POWERLINK V2 mode

Error message

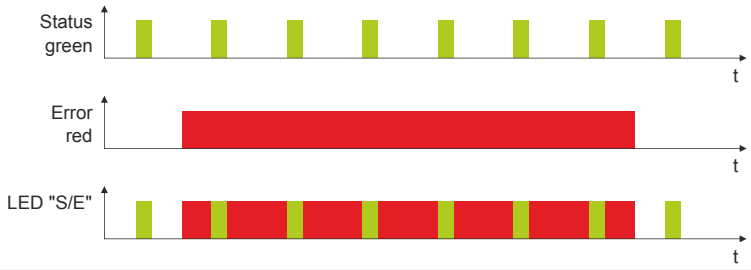
LED "S/E"		
Green	**Red**	**Description**
Off	On	The interface is in error mode (failed Ethernet frames, increased number of collisions on the network, etc.). Note: Several red blinking signals are displayed immediately after the device is switched on. These are not errors, however.
Blinking	On	If an error occurs in the following modes, then the green LED blinks over the red LED: • PRE_OPERATIONAL_1 • PRE_OPERATIONAL_2 • READY_TO_OPERATE 

Table: LED "S/E" - Error message (interface in POWERLINK mode)

Interface status

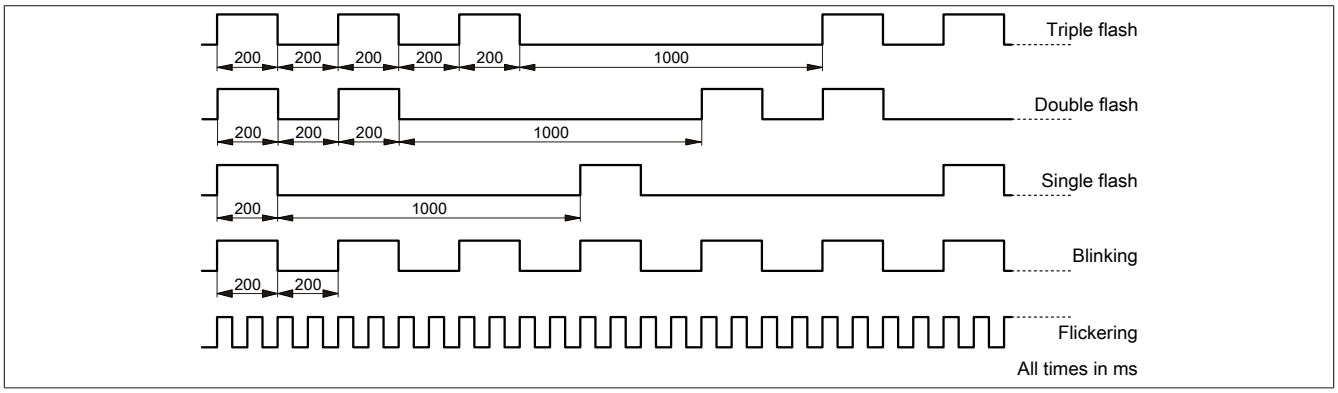
LED "S/E"		
Green	**Red**	**Description**
Off	Off	**Mode:** NOT_ACTIVE The interface is either in mode NOT_ACTIVE or one of the following modes or errors is present: • The device is switched off. • The LED status indicator is disabled. • The device is in the startup phase. • The interface or device is not configured correctly in Automation Studio. • The interface or device is defective. **Managing node (MN)** The network is monitored for POWERLINK frames. If a frame is not received within the configured time window (timeout), the interface immediately enters mode PRE_OPERATIONAL_1. If POWERLINK communication is detected before the time has elapsed, however, the MN is not started. **Controlled node (CN)** The network is monitored for POWERLINK frames. If a frame is not received within the configured time window (timeout), the interface immediately enters mode BASIC_ETHERNET. If POWERLINK communication is detected before this time expires, however, the interface immediately enters mode PRE_OPERATIONAL_1.
Flickering (approx. 10 Hz)	Off	**Mode:** BASIC_ETHERNET The interface is in mode BASIC_ETHERNET. The interface is operated in Ethernet mode. **Managing node (MN)** This mode can only be exited by resetting the controller. **Controlled node (CN)** If POWERLINK communication is detected during this mode, the interface enters mode PRE_OPERATIONAL_1.
Single flash (approx. 1 Hz)	Off	**Mode:** PRE_OPERATIONAL_1 The interface is in mode PRE_OPERATIONAL_1. **Managing node (MN)** The MN is in "reduced cycle" mode. The CNs are configured in this mode. Cyclic communication is not yet taking place. **Controlled node (CN)** The CN can be configured by the MN in this mode. The CN waits until it receives an SoC frame and then switches to mode PRE_OPERATIONAL_2.
	On	**Controlled node (CN)** If the red LED lights up in this mode, this means that the MN has failed.
Double flash (approx. 1 Hz)	Off	**Mode:** PRE_OPERATIONAL_2 The interface is in mode PRE_OPERATIONAL_2. **Managing node (MN)** The MN starts cyclic communication (cyclic input data is not yet evaluated). The CNs are configured in this mode. **Controlled node (CN)** The CN can be configured by the MN in this mode. A command then switches the mode to READY_TO_OPERATE.
	On	**Controlled node (CN)** If the red LED lights up in this mode, this means that the MN has failed.

Table: LED "S/E" - Interface state (interface in POWERLINK mode)

LED "S/E"		
Green	**Red**	**Description**
Triple flash (approx. 1 Hz)	Off	**Mode:** READY_TO_OPERATE The interface is in mode READY_TO_OPERATE. **Managing node (MN)** Cyclic and asynchronous communication. Received PDO data is ignored. **Controlled node (CN)** The configuration of the CN is completed. Normal cyclic and asynchronous communication. The transmitted PDO data corresponds to the PDO mapping. However, cyclic data is not yet evaluated.
	On	**Controlled node (CN)** If the red LED lights up in this mode, this means that the MN has failed.
On	Off	**Mode:** OPERATIONAL The interface is in mode OPERATIONAL. PDO mapping is active and cyclic data is evaluated.
Blinking (approx. 2.5 Hz)	Off	**Mode:** STOPPED The interface is in mode STOPPED. **Managing node (MN)** This mode does not occur for the MN. **Controlled node (CN)** Output data is not being output, and no input data is being provided. This mode can only be reached and exited by a corresponding command from the MN.

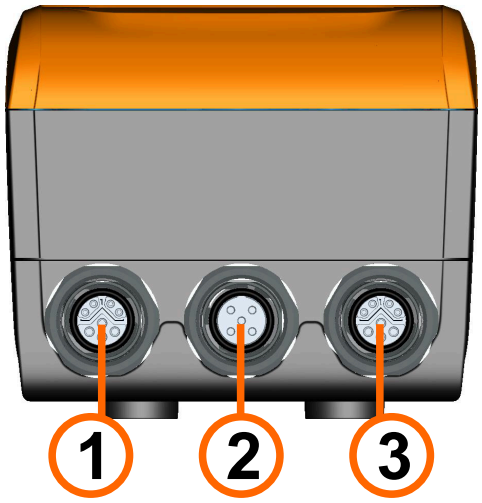
Table: LED "S/E" - Interface state (interface in POWERLINK mode)

Blink times

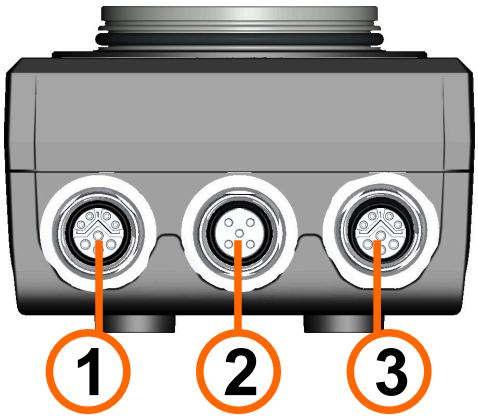


5.3 Connection elements

S-mount



C-mount



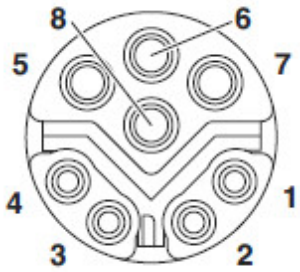
1	IF1: 24 VDC module power supply and POWERLINK 1	**2**	X1: Digital inputs/outputs, external sensor/actuator power supply
3	IF2: 24 VDC module power supply and POWERLINK 2	-	-

5.3.1 POWERLINK interface including 24 VDC module power supply

The POWERLINK interface with integrated 2-port hub connects to the fieldbus system for machine automation. The interface is designed for 100BASE-TX, and the two circular connectors also contain the 24 VDC module power supply.

The two hex address switches for setting the POWERLINK node number are located on the back of the device.

Pinout



Pin	Pinout	Explanation
1	TXD	PLK transmit signal
2	TXD\	PLK transmit signal inverted
3	RXD	PLK receive signal
4	RXD\	PLK receive signal inverted
5	GND	Supply line 1 (max. 3 A)
6	GND	Supply line 2 (max. 3 A)
7	+24 VDC	Supply line 2 (max. 3 A)
8	+24 VDC	Supply line 1 (max. 3 A)

POWERLINK node number

The node number for the POWERLINK node is set using the two number switches.

Switch position	Description
0x00	Only permitted when operating the POWERLINK node in DNA mode.
0x01 - 0xEF	Node number of the POWERLINK node. Operation as a controlled node (CN).
0xF0 - 0xFF	Reserved, switch position not permitted.

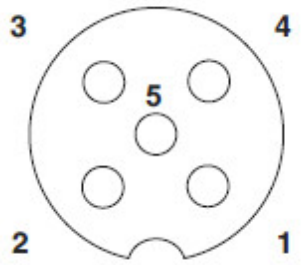
5.3.1.1 Dynamic node allocation (DNA)

Most POWERLINK bus controllers have the ability to dynamically assign node numbers. This has the following advantages:

- No setting of the node number switch
- Easier installation
- Reduced error sources

For information regarding configuration as well as an example, see Automation Help → Communication → POWERLINK → General information → Dynamic node allocation (DNA)

5.3.2 Input/Output interface



Pin	Pinout	Explanation
1	GND	
2	Digital output 24 VDC	Digital output. Switchable 24 VDC power supply for external sensor/actuator.
3	GND	
4	Input+	
5	Input-	

The device is equipped with a digital input (per IEC 61131-2 type 1). The input can operate in sink or source wiring and be used as a trigger input. The typical input delay is 150 µs.

The digital output is implemented with an integrated high-side driver and intended for controlling external lighting. Optionally, the output can also be used as a switchable 24 V sensor / actuator power supply. The output is permitted to be loaded with a maximum of 500 mA.
The output has reverse polarity protection, short-circuit protection and overtemperature shutdown.

6 Function description

Information:

The parameters and registers mentioned in this section are part of the mapp Technology Package. For additional information, see the section of the corresponding mapp Technology Package in Automation Help.

6.1 Startup and initialization

Information:

Camera startup and initialization may take a few seconds!

The first phase of startup is completed after successful initialization of the fieldbus connection. This is indicated by status bit "**ModuleOK**".

After the firmware has been started and the parameters initialized, camera startup is completed. This is indicated by status bit "**ImageAcquisitionReady**".

General error bits (e.g. "**UndervoltageError**") and vision function error registers (e.g. "**ImageProcessingError**") are operational from this point.

6.2 Integrated monochrome lighting

The use of colored lighting is of great importance in industrial image processing in connection with colored objects. Different light colors represent different wavelengths, regardless of whether it is the light from lighting or the reflected light of an object.

If the lighting color and the color of the object are approximately the same (i.e. their wavelengths are approximately the same), the object in the acquired image is displayed as very bright to completely white (since the object reflects this wavelength particularly well in incident light or absorbs it particularly badly in transmitted light). Conversely, with a complementary color (opposing color in the color circle), the object can be displayed very dark to completely black.

The right lighting color (in relation to the object color) can improve contrast and help highlight or hide structures.

Figure 1: Color circle per Johannes Itten, 1961, in the public domain

Photobiological safety

For information on photobiological safety see "Photobiological safety - User information" on page 32.

The exact risk groups of each LED color used are shown in the technical data section "Integrated LED lighting"!

Uniformity of lighting

For a vision application to produce consistent results, the object must be illuminated as uniformly as possible.

Each individual LED is therefore equipped with a lens that guarantees even emission of light. The lighting is already synchronized in the factory and thus does not require any manual synchronization. The lights also automatically compensate for the variations in light intensity that are typical of LEDs over the course of their service life and at different temperatures.

Information:

The parameters and registers mentioned in this section are part of the mapp Technology Package. For additional information, see the section of the corresponding mapp Technology Package in Automation Help.

6.3 Image acquisition

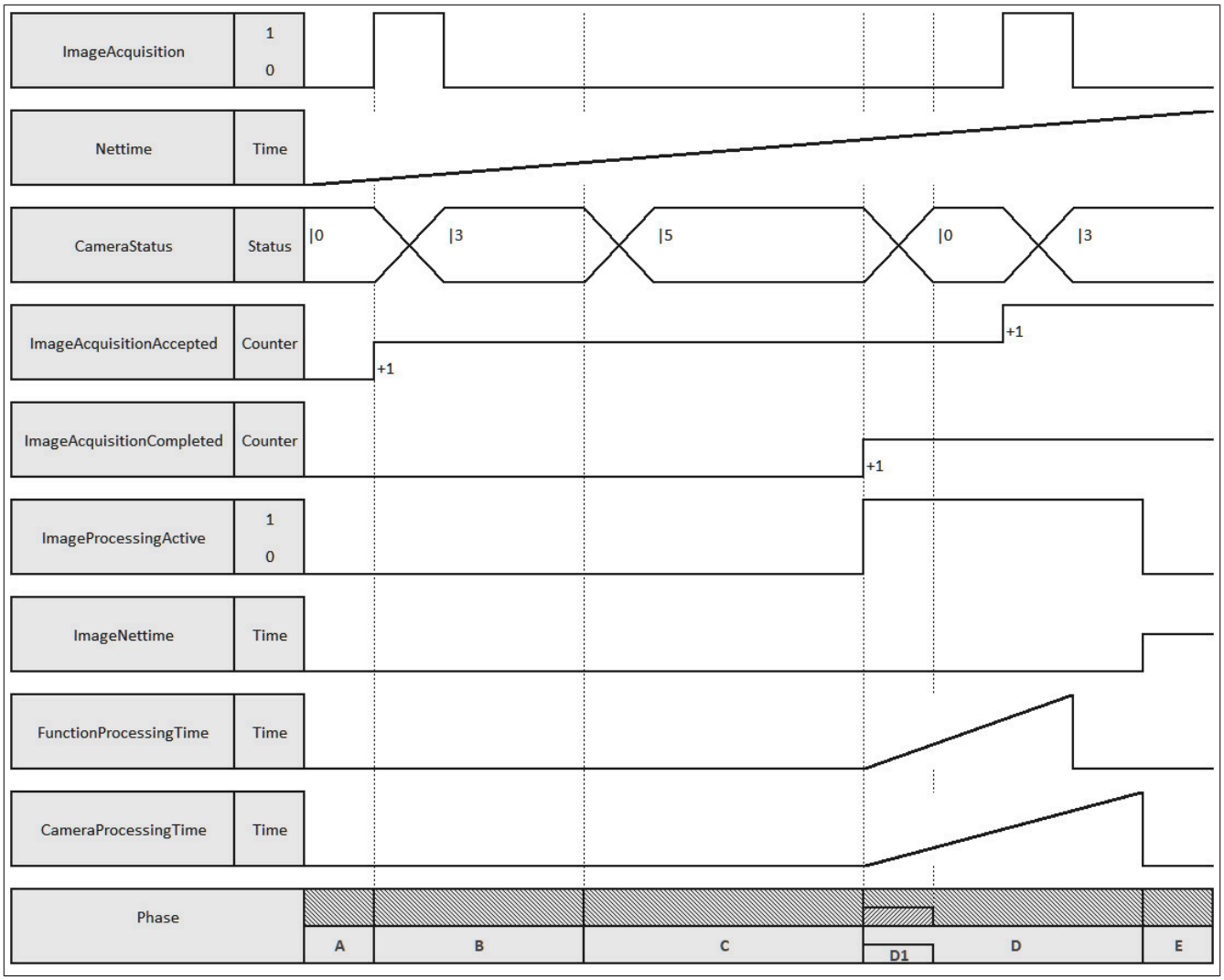
Image acquisition and its properties represent the basic function of a camera since good image acquisition always simplifies subsequent image processing or application of a vision function.
With machine vision, image acquisition is configured in the vision application via Automation Studio. The parameters are located in the I/O mapping of the camera.

The image acquisition settings include various trigger parameters (trigger source, trigger type, timing, etc.), settings for cycle and exposure times and for onboard LED illumination as well as the various acquired image counters and status bits.

Image acquisition also defines the focus, low-light amplifications, mirroring of the image in the x/y-direction, special CMOS sensor-side image readout configurations (binning, subsampling, etc.), as well as image cutouts and their position in the acquired image.

Image acquisition and subsequent image processing - Timing diagram

This timing diagram is a schematic diagram showing the course of selected image acquisition parameters over time. The lengths shown are not to scale with respect to the actual durations. It is also important to note that the times depend on the selected image processing task and image content.



A	Camera ready for operation. Waiting for trigger. An accepted image acquisition is recorded with a counter.	B	Time until the set NetTime trigger is reached.
C	Reading exposure time and sensor	D	The accepted image acquisition is recorded with a counter. The image processing is active. The processing time of the vision function and camera (operating system) is recorded. Changing ImageNettime.
D1	New image acquisition possible (CameraStatus = 0).	E	Image processing and processing time of the camera used to acquire the first image is completed.

Information:

As soon as the image processing and processing time of the camera of the first acquired image is finished (phase E in the previous diagram), this image is available. ImageNettime changes with each additional acquired image.

If several images are acquired in succession, ImageProcessingActive is constantly ready until all acquired images are processed. To get the correct results for the corresponding image, ImageNettime must be checked in the application as to whether it has changed or not.

Information:

CameraProcessingTime has low jitter. This is negligible for Smart Sensor variants, but for Smart Camera variants it adds up with every vision function!

Information:

The input data for image processing by the POWERLINK network is applied at the time of the actual (Nettime) trigger.

Coordinate system at the target object

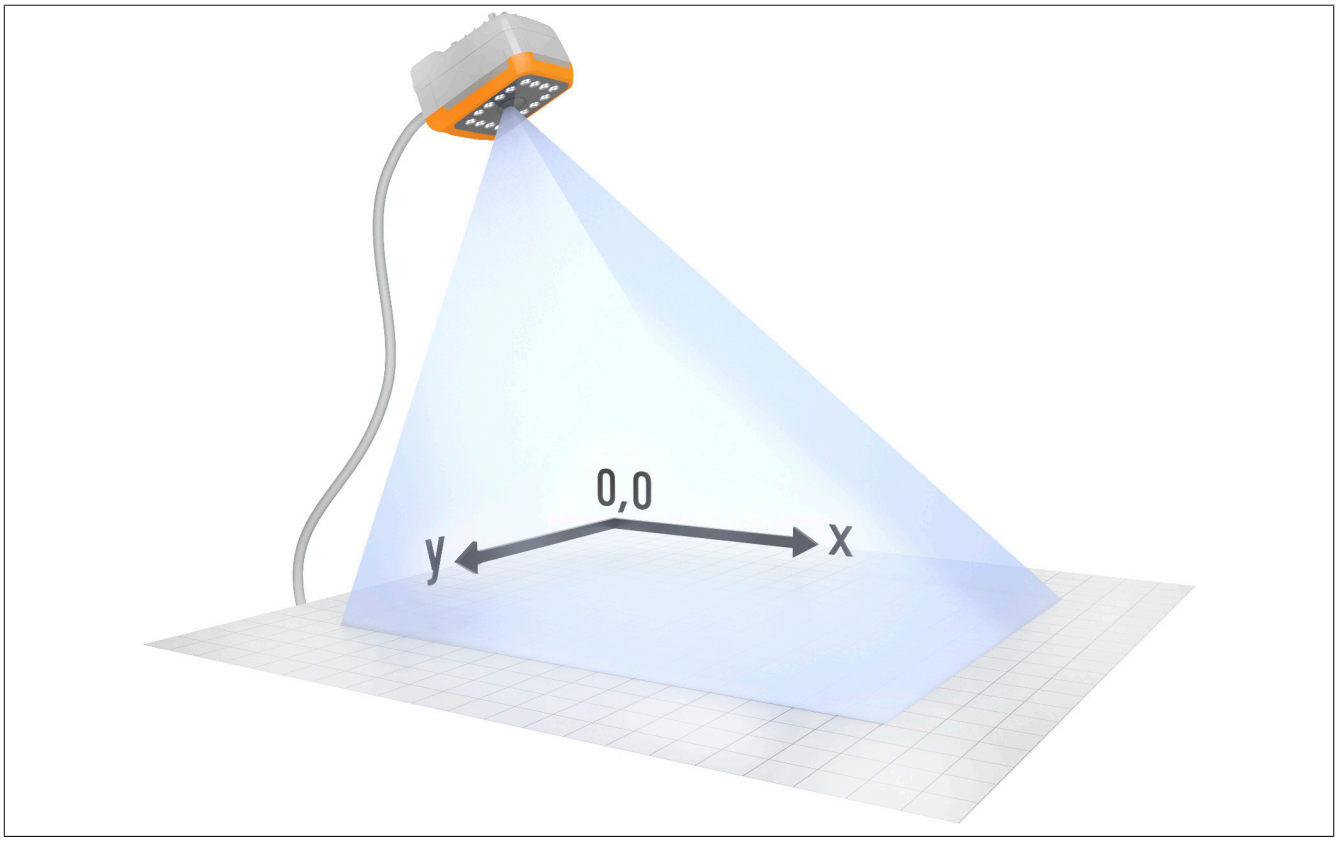
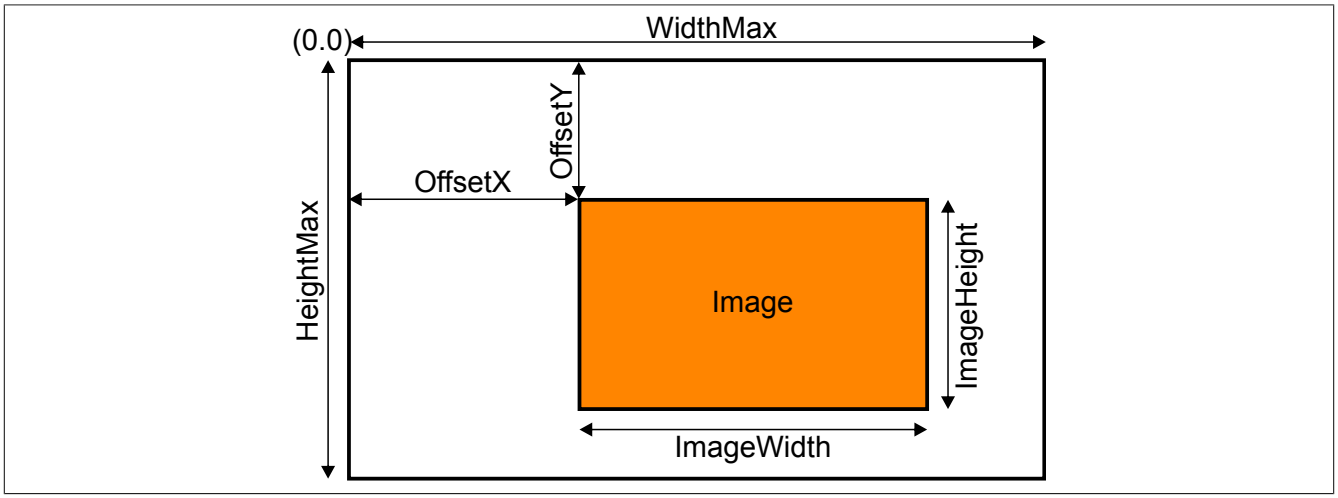
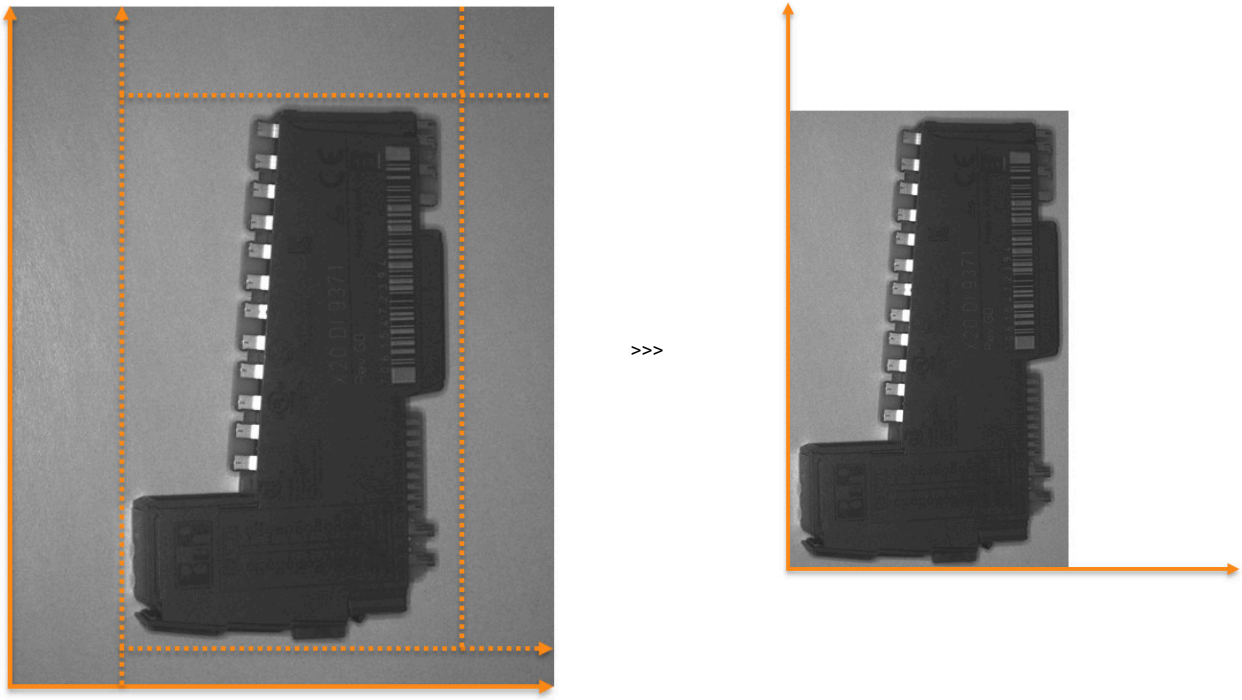


Image section - Parameters

The figure shows the relationship of the following image acquisition configuration parameters:

- Max. width of the image - ImageWidth
- Max. height of the image - ImageHeight
- Offset for the image on the x-axis - ImageOffsetX
- Offset for the image on the y-axis - ImageOffsetY
- Max. image width of the sensor used - WidthMax
- Max. image height of the sensor used - HeightMax





Information:

The parameters and registers mentioned in this section are part of the mapp Technology Package. For additional information, see the section of the corresponding mapp Technology Package in Automation Help.

6.4 Preprocessing (linear filters)

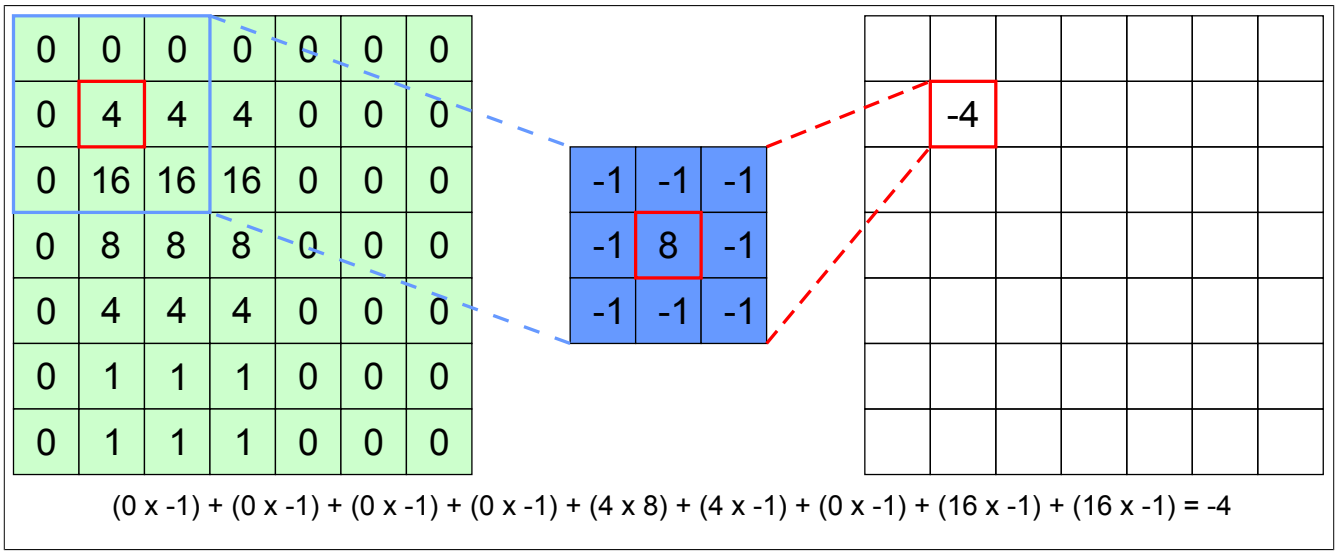
Preprocessing can already be carried out on the camera by selecting existing or user-defined filters. In this process, the grayscale values of the indented image are subjected to a computational correction. Objectives of preprocessing can be:

- Reduction of noise and individual image disturbances
- Smoothing (blurring) the image
- Edge detection (single or multi-directional)

Image preprocessing uses linear filters, which consist of a 3x3 matrix with definable coefficients in this case. Using these matrices, preprocessing is not always applied only to individual pixels; instead, the "neighborhood" of each pixel is also taken into account (the specific pixel to be filtered is detected with the center of the matrix).

I_{11}	I_{12}	I_{13}
I_{21}	**I_{22}**	I_{23}
I_{31}	I_{32}	I_{33}

The filtering is done mathematically via a convolution. The 3x3 matrix, the "filter core", is moved pixel by pixel over the image, and all covered pixels are multiplied by the respective coefficients of the filter core. All nine products are then added, and finally, the value of the original pixel is overwritten with the result. This means that the original pixel is replaced with a weighted sum of itself and its immediate neighboring pixels.
The convolution described above does not work readily for the pixels located on the edge since these have no neighboring pixels on one or two sides with whose values the associated filter coefficients can be multiplied. The margin lines and margin columns are therefore doubled and added to the outside of the actual image.



The results are shifted or scaled back into the range of values of the acquired image via subsequent offset and gain correction.
This is the result for the filtered image: Filter matrix x Original image x Gain + Offset.

Information:

The parameters and registers mentioned in this section are part of the mapp Technology Package. For additional information, see the section of the corresponding mapp Technology Package in Automation Help.

6.4.1 Common filter types

Keep

Default setting for user-defined filters. The resulting image is the same as the original image.

Gain = 1

0	0	0
0	1	0
0	0	0

Offset = 0

Smoothing filters

Smoothing filters reduce image noise but also all soften other structures, such as edges.

Average value filter: With the simple average filter value (also called box filter), all pixels are weighted equally, which also means that the filter is anisotropic, i.e. it does not smooth equally well in all directions (i.e. the corner pixels furthest away from the center pixel).

Gain = 1/9

1	1	1
1	1	1
1	1	1

Offset = 0

Binomial filter: In contrast to the simple average value filter, the binomial filter works equally well in all directions with regard to smoothing and noise reduction.

Gain = 1/16

1	2	1
2	4	2
1	2	1

Offset = 0

Edge filters

Edges represent large jumps in the gray value range of an image and provide basic information about the shape and contour of objects. Edge filters can be used to emphasize these rapid changes in gray value while also smoothing areas with more subtle changes in gray value.

Laplace: A common filter for edge detection is the Laplace filter. In simple terms, this filter subtracts a smoothed image from the original image.

Gain = 1/8

-1	-1	-1
-1	8	-1
-1	-1	-1

Offset = 127

Sobel filter: The Sobel filter, however, needs two internal filter masks to work in the horizontal and vertical direction. By following the coefficients of the binomial filter, noise is minimized and edges are emphasized.

SobelX

Gain = 1/4

1	0	-1
2	0	-2
1	0	-1

Offset = 0

SobelY

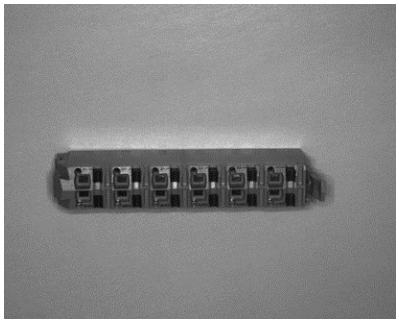
Gain = 1/4

1	2	1
0	0	0
-1	-2	-1

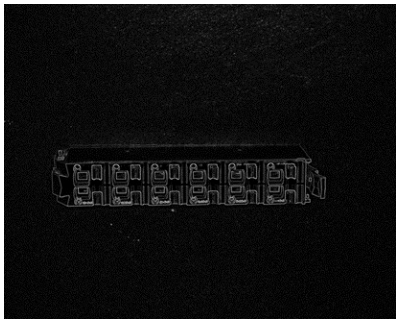
Offset = 0

Sobel = abs(SobelX) + abs(SobelY)

Example: Sobel filtering of a shot to emphasize the edges.



>>>



6.5 Line sensor operation

A B&R camera's surface sensor can also be operated as a line sensor and is equipped with dynamic and static operating modes.

The line length corresponds to the sensor width (e.g. 1280 pixels). The number of lines per acquired image is configurable.

The line sensor operation is suitable for the continuous generation of an image (line by line). An example of a possible application is scanning curved areas (e.g. a bottle label). In industrial image processing, the object is usually moved for this purpose and the sampling rate of the lines adjusts to the velocity of the object (e.g. with an encoder).

6.6 Vision functions

The **mapp Vision** Technology Package associated with machine vision products provides a range of vision functions. Each is a group of parameters that offer the corresponding range of functions for a particular purpose.

Information:

The HALCON machine vision library from MVTec was integrated into mapp Vision. The well proven algorithms enable robust, high-performance solutions for position detection, completeness inspection, quality evaluation, measuring and identification.

Depending on the camera hardware used, either one vision function (for a **Smart Sensor**) or several vision functions (for a **Smart Camera**) are used simultaneously for an application.

The default configuration of a camera and parameter settings for each vision function are set using the registers described for the individual vision functions. The registers can be accessed in Automation Studio as follows:

- Cyclic parameters and general data points are accessible via the I/O mapping of the camera. They can be modified at runtime.
- Acyclic camera parameters are accessible via the camera configuration. They cannot be modified at runtime.
- Acyclic vision function parameters are configured using the mapp Vision HMI application.

Cyclic parameters are also accessible in the mapp Vision HMI application as process variables of the vision function.

Acyclic parameters are divided into several subcategories:

- **Constants:** Help to determine the length of a POWERLINK frame and can only be modified during configuration in Automation Studio (i.e. acyclically).
- **Vision parameters:** Configuration parameters of the vision function.
- **Model parameters:** Configuration parameters of a model. These directly determine the size of the model and therefore the amount of data it contains.

Information:

Models of a vision function are always taught-in with a specific mapp Vision version and are not backward compatible!

Information:

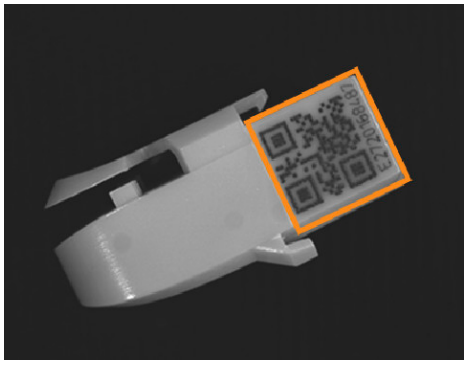
The parameters and registers mentioned in this section are part of the mapp Technology Package. For additional information, see the section of the corresponding mapp Technology Package in Automation Help.

6.6.1 Code reader

Vision function **Code Reader** is a generic data code reader. **Code Reader** reads and interprets all common one-dimensional (barcode) and two-dimensional codes (e.g. QR code).

Code quality is also graded according to as many as 23 different criteria based on ISO 15415, ISO 15416 and ISO TR 29158.

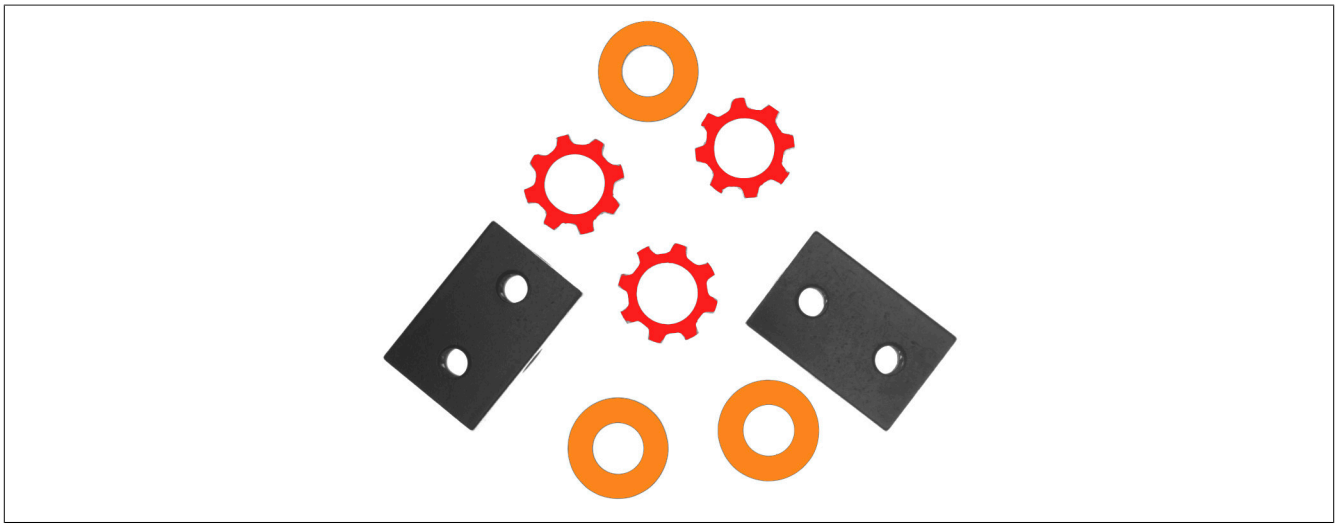
Automatic optimization of the predefined parameters at runtime can increase the detection speed.



6.6.2 Blob

A blob (Binary Large Object) is an area of contiguous pixels with the same defined grayscale value range.

Vision function **Blob** is a blob analysis function for detecting and segmenting blobs in an image using geometric and color parameters as well as for extracting features from them.



Blob makes it possible to teach-in blobs based on the following parameters (procedure for a blob analysis):

- Thresholds for grayscale values (MeanGrayValue)
- Blob shape (morphology)
- Thresholds for size (AreaMin/Max) (rough reduction)
- Selection according to shape and fitting
- Reduction to predefined maximum number
- Calculate the geometric features.

A blob analysis can be carried out in cyclic operation based on these determined parameters that can be used to count blobs, generally detect positions and colors or simply perform measurements of the blobs themselves.

6.6.3 Matching

Matching is used to locate contours or textures in images with subpixel accuracy, even if they are rotated or partially covered. This is done by creating a template in a reference image and deriving a model to be used for teach-in. The model is then used to search for matches in image acquisitions.

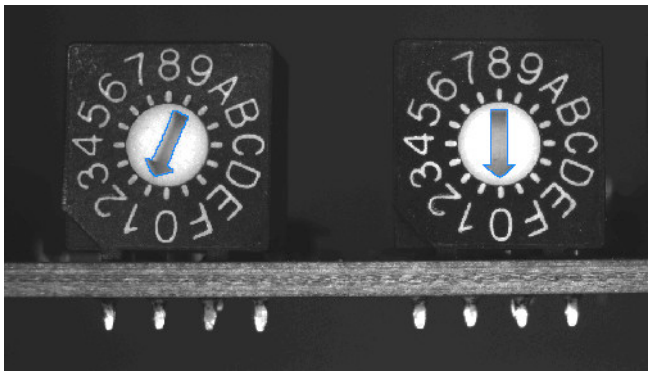
Vision function **Matching** can be performed using one of the following Matching methods:

Correlation-based Matching:

- Correlation-based Matching is based on grayscale values. Normalized cross-correlation (NCC) is used to grade how well the model matches the image being searched. The method can compensate for both additive and multiplicative lighting deviations.
- In contrast to shape-based Matching, is it possible to find objects with slightly different shapes or highly textured surfaces, as well as objects in blurred images.

Shape-based Matching:

- Shape-based Matching does not use grayscale values; it defines the shape of the contours instead.
- Shape-based Matching finds objects quickly, accurately and robustly. It even works if they are rotated, scaled, perspectively distorted, locally deformed, partially covered, outside of the image or subject to non-linear illumination fluctuations.



6.6.4 OCR

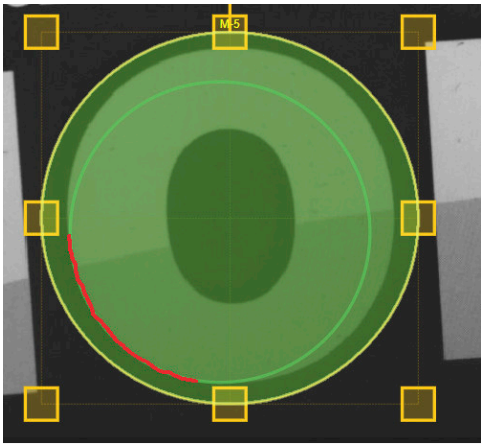
Optical character recognition (OCR) generally refers to automated alphanumeric character recognition within image acquisitions by comparing the pixel patterns of the text areas with familiar learned patterns, analogous to general object recognition (such as in Matching).

Vision function **OCR** reads and interprets texts on the basis of several pre-trained fonts suitable for different applications (dot matrix fonts, SEMI fonts, industrial fonts, handwriting, etc.) as well as a universal font of characters learned via "deep learning". It is therefore possible to achieve very high recognition rates without additional training.

In addition, all segmented characters in a line are graded in terms of the quality of recognition (GradingValue).

6.6.5 Measurement

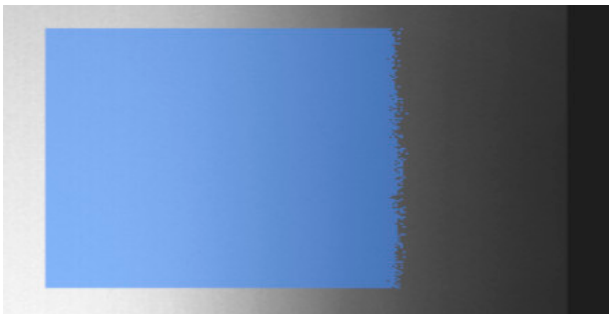
Vision function **Measurement** is a powerful and highly accurate instrument for measuring distances and object dimensions. Edges along lines or circle segments are measured with subpixel accuracy. This makes it possible to precisely determine distances and radii for quality control or for positioning and tracking tasks in mechanical gripping systems.

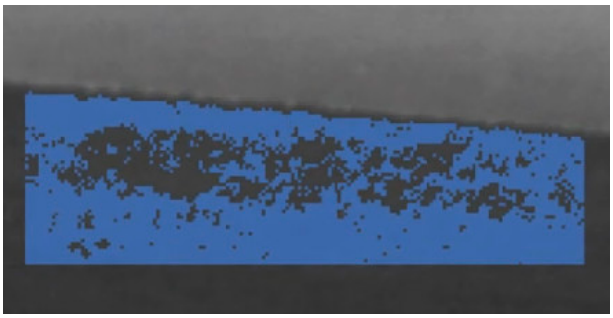


6.6.6 Pixel counter

Vision function **Pixel Counter** is a function for counting pixels and extracting features from them.

Pixel Counter allows, through simple operation, regions to be defined within which the pixels that correspond to a predefined grayscale value interval (ThresholdMin/Max) are counted.





Based on these defined parameters, counting and statistical analysis of the searched pixels can be performed in cyclic operation.

6.6.7 Subpixel Blob

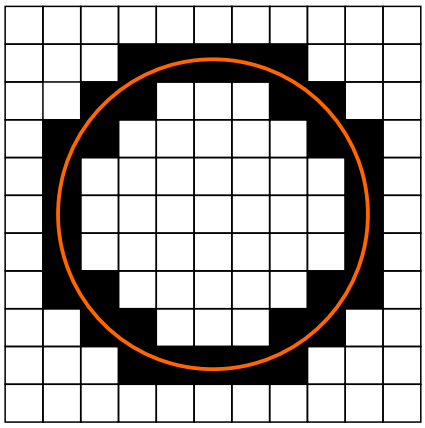
Information:

The function is not available when using a Smart Sensor (VSSxxxxxx.xxxx-000). At least one Smart Camera (VSC122xxx.xxxx-000) is required for execution.

A blob (Binary Large Object) is an area of contiguous pixels with the same defined grayscale value range.

A subpixel is a computational description of the internal structure of a pixel as opposed to the pixel itself, which is physically limited as an image of the area element from the image sensor. Calculated edge gradients within a pixel thus result in a higher resolution when using subpixels than would be possible with the actual pixels. For example, the subpixel-accurate calculation of the area of a circle.

Vision function **Subpixel Blob** is a blob analysis function with subpixel accuracy used for detecting and segmenting blobs in an image using geometric and color parameters as well as for extracting features from them.



Subpixel Blob makes it possible to teach-in blobs based on the following parameters (procedure for a subpixel blob analysis):

- Thresholds for grayscale values (MeanGrayValue)
- Blob shape (morphology)
- Thresholds for size (AreaMin/Max) (rough reduction)
- Selection according to shape and fitting
- Subpixel-accurate contour
- New area calculation
- Reduction to predefined maximum number
- Calculate the geometric features.

A blob analysis with subpixel accuracy can be carried out in cyclic operation based on these determined parameters that can be used to count blobs, generally detect positions and colors or simply perform measurements of the blobs themselves.

7 Commissioning

7.1 Camera factory alignment

Smart Camera products from B&R are aligned during production. This "factory alignment" includes the following aspects, which can be enabled in mapp Vision if required:

- Internal alignment of pixel errors (hot, dead and stuck pixels).
- Focus adjustment, see parameter FocusScale in mapp Vision.
  Available on the camera side starting with production date 1951 (year / calendar week).
- Adjustment of sensor vignetting, see parameter VignettingCorrection in mapp Vision.
  Available on the camera side starting with production data 2103 (year / calendar week) (exception: camera variants with UV LED).
- Adjustment of LED temperature drift, see parameter LEDTempDriftCorrection in mapp Vision.
  Available on the camera side starting with production data 2103 (year / calendar week) (exception: camera variants with UV LED).

The parameters for the adjustment can always be configured in **mapp Vision**, but they only have an effect on cameras from the specified production date. The respective function is only implemented in the cameras at the factory starting with this production date.

Information:

Cameras with an older production date sent in for repair will also be aligned!

7.2 Photobiological safety - User information

The standard EN 62471 "Photobiological safety of lamps and lamp systems" divides lighting sources into a series of risk groups:

- Risk group (RG) 0 = Harmless / no photobiological hazard, even with continuous, unrestricted use
- Risk group (RG) 1 = Low risk / no danger due to normal constraints of behaviour
- Risk group (RG) 2 = Moderate risk / does not present a hazard due to aversion reactions of bright light sources or thermal discomfort
- Risk group (RG) 3 = High risk / danger even for volatile or short-term irradiation

Caution!

Possible injuries to eyes and skin due to optical radiation!

The device corresponds to risk group 2 according to IEC 62471:2006 (at working distance 20 cm, pulse length 10 ms, duty cycle 10%).

- **Do not look directly into the lighting during operation.**
- **Workstations must maintain the minimum distance to the device specified in the standard.**
- **The risk related to the observer depends on the installation and use of the device**

Information:

Depending on the activated color of a multiple LED, different risk groups can arise with the same output power.

For further information on photobiological safety see "Photobiological safety" on page 66.

7.2.1 Protection measures

Technical protection measures

- Protection of adjacent workplaces against the light cone of an LED lighting
- Enclosures preventing access to the danger zone
- Reduction of the intensity (limitation of the duty cycle of the LEDs) Organisational protective measures

Organisational protective measures

- Limitation of the residence time in the vicinity of the LED illumination (compliance with the maximum exposure time)
- Hazard-related labelling of risk groups
- Marking of the danger area

Personal protection measures

- Avoid staring directly into an LED illumination, regardless of the light colour used and the duration of the light pulse.
- When staying in the immediate vicinity of LED lighting, appropriate safety goggles or protective clothing (UV) must be used!

7.3 Installation and wiring

7.3.1 Montage

When mounting machine vision modules, it must be ensured that the modules are mounted on a sufficiently large, thermally conductive, flat surface on the machine side that is free of contamination. The maximum operating temperature specified in the technical data and the protection class must be observed during installation (see "Technical data" on page 4).

The **Smart Camera** module must be attached using the 4 fixing points on the rear of the housing with a thermal and electrically conductive material, see "Dimensioned drawing" on page 13.

For mounting and heat dissipation, the mounting points specified in the dimensioned drawing must lie on the entire surface of the mounting surface! Fixing on uneven mounting surfaces can lead to impairment of the the heat dissipation of machine vision modules.

Furthermore, it is essential that a free space is provided above and below the machine vision modules to ensure sufficient heat dissipation through air circulation. The products must be protected against impermissible contamination.

The use of the installation accessories, that can be ordered, is strongly recommended for mounting, see "Installation accessories" on page 53.

7.3.2 Wiring

Only the available cables (see "Cables" on page 39) and the available cable accessories (see "Cable accessories" on page 49) are intended for wiring.

Calculation example for voltage loss on the cable

Setup

- Camera VSx1x2xxx.xxxP-000 (I_{max} = 0.8 A without load on the digital output)
- Hybrid cable VCA0Y01.0300 (cable length = 30 m) connected to hybrid distributor
- Supply voltage at input of hybrid distributor VAC0YC020 = 28.8 V

Question: Is the supply voltage of the camera sufficient?

$V_{DC,camera} = V_{DC,hybrid\ distributor} - (2 * R_{DC,max} * \text{cable length} * I_{max})$

$V_{DC,camera}$ =28.8 V − (2∗0.0284 Ω/m∗30 m∗0.8 A) = 27.44

27.44 > V_{min}(= 20.4 V)

Supply voltage is OK.

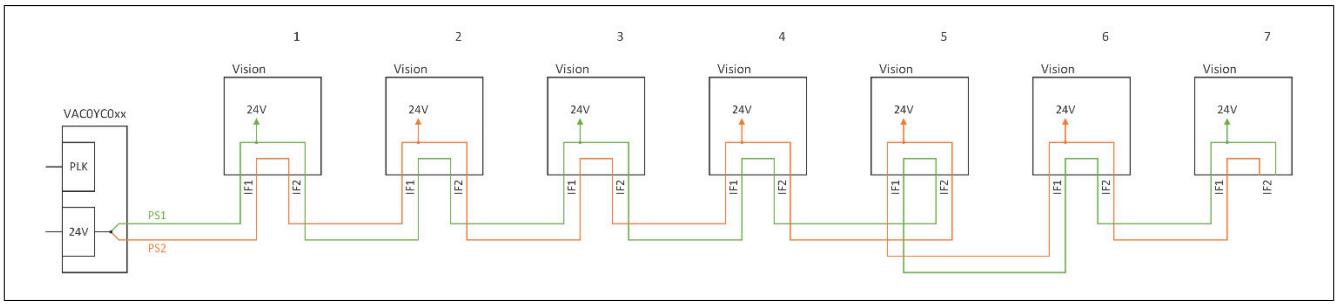
7.3.3 Vision modules supply concept

All vision modules (both **Smart Camera** and **Smart Light** modules) must be supplied with 24 V SELV / PELV. The voltage range at the input of 20.4 VDC to 28.8 VDC must be observed for correct function.

Power is supplied via the Vision POWERLINK hybrid cables. Each cable has 2 separate supply lines. The voltage is fed into the hybrid distributor and then split into the 2 supply lines PS1 and PS2. The energy for supplying the first vision module is taken from line PS1 from interface IF1. The line PS2 is only looped through. Both lines are crossed out on the circuit board. The maximum nominal current for the Smart Light is 4 A per line (2 supply lines per cable), so a section can be loaded with a maximum of 4 A.

Series connection example of vision modules:

As shown in the following illustration, the choice of the supply line (PS1 or PS2) for supplying the vision product depends on the position and the choice of the interface (IF1 or IF2) facing the hybrid distributor. With the vision module in position 5, IF2 was assigned to the hybrid distributor. So it is supplied with PS2. If IF1 were assigned to the hybrid distributor in position 5, as with the other positions, then the vision product in position 5 would be supplied with PS1.



Information:

Note the continuous current from the same line. Both lines are crossed out on the circuit board!

However, a POWERLINK line can not only consist of Vision modules, but can also be continued with a POWERLINK hybrid distributor. In principle, no separate power supply is required for this second POWERLINK hybrid distributor, since the power supply can be provided via the line. However, if a separate power supply is provided for the second POWERLINK hybrid distributor, the power supply source of the first distributor box must be used.

Information:

Both distribution boxes must therefore be supplied from a single voltage supply source (they must have the same reference potential)!

7.4 Overtemperature behavior

The module has an internal overtemperature shutoff that triggers at the internal temperature sensors at 85 °C and above (this is indicated in Automation Studio by a logger message) and switches off the module.
The hysteresis for the restart temperature is 5 °C.

Information:

The environmental conditions specified in the technical data must be adhered to independently of a temperature monitoring system.

Cooling measures

The corresponding requirements of mechanical assembly must be observed to ensure heat dissipation.

On the application side, the internal temperature sensors can be read out with the `SensorTemperature` data point in order to implement a user overtemperature shutdown. For example, if the internal temperature exceeds a specified threshold (e.g. 80 °C), the pulse-pause ratio can be increased to reduce the power consumption.

8 Maintenance

Notice!

Possible damage to the device due to improper handling!

- **Carry out maintenance work only when the power is switched off.**
- **Make sure that all modules and components are handled carefully.**

8.1 Cleaning the camera

The characteristics of the camera can be affected by dirt (reduced cooling power due to dust, poor image quality due to dirty lens, etc.) or condensation (e.g. water drops on the glass front). The camera must therefore be kept clean or cleaned regularly. To clean the device, proceed as follows:

- Use a soft cloth to clean the glass.
- Moisten the cloth only with screen cleaner, water with detergent or alcohol (ethanol).
- Do not spray the cleaning agent directly onto the camera, but first onto the cloth.

Notice!

Possible damage to the device due to incorrect cleaning!

Never use aggressive solvents, chemicals, abrasives, compressed air or steam jets.

8.2 Updating camera operating system

The camera operating system is updated via Automation Studio.

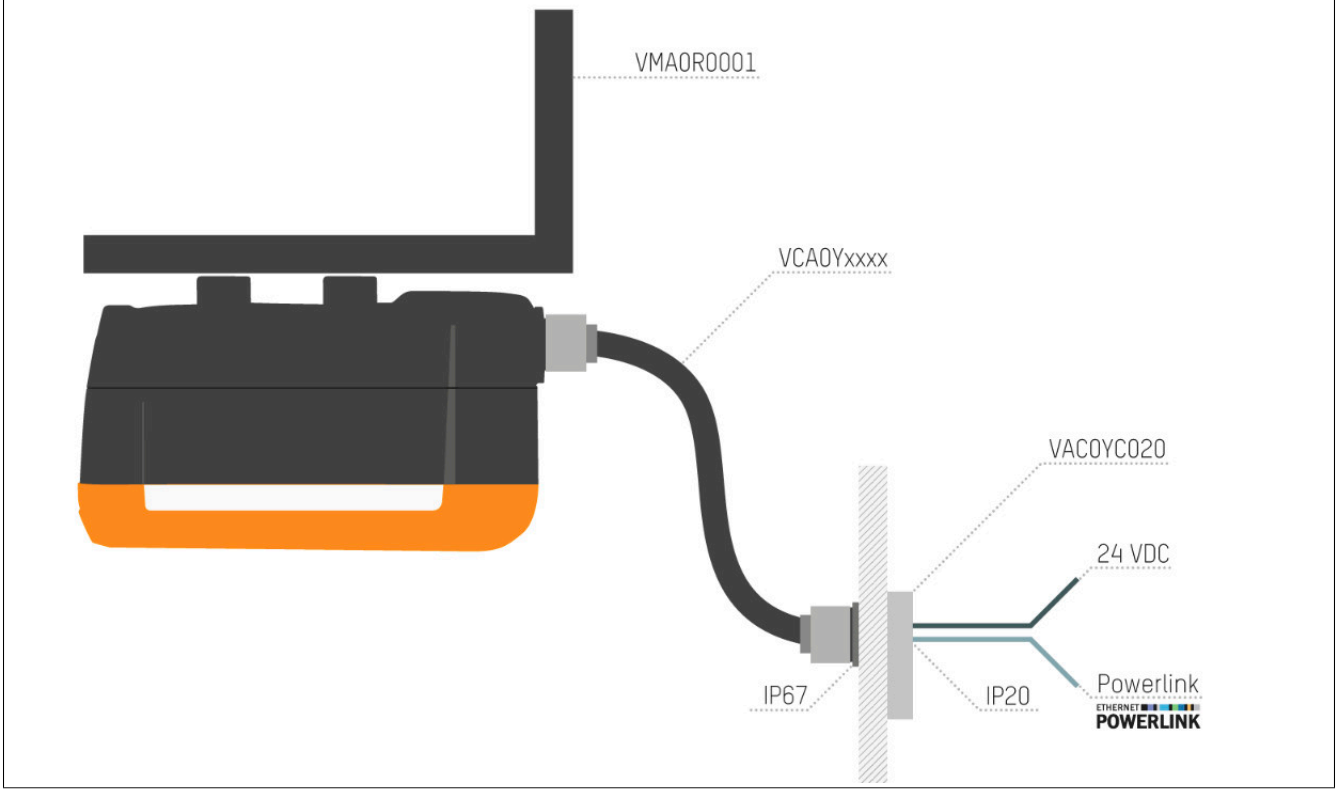
Up to and including production date 2040 (year/ww), the power supply must not be interrupted while a camera update is being performed. From production date 2041 (year/ww) on, additional measures are taken to ensure that a camera update can be continued unaffected even after a power interruption.

9 Machine vision accessories

Overview and use of B&R machine vision accessories for Smart Camera and Smart Light products:

- **VMA0R0001**: Vision mounting bracket 80 mm x 100 mm
- **VCA0Yxxxx**: POWERLINK M12 Y-coded hybrid cable, various lengths
- **VAC0YC020**: IP20 POWERLINK hybrid distributor for control cabinet installation
- **VLE0Cxxxx**: C mount lenses, various focal lengths

Smart Camera



Information:

Additionally to the exclusive Machine Vision accessories, a POWERLINK connection cable is required for operating machine vision hardware components.
A 3-pin terminal block is required for the machine-side connection of the POWERLINK hybrid distributor.
M12 sensor cables are available for optional connection of the input/output interface.

9.1 Accessories - Order number key

Cables

Product area											
V											Integrated machine vision
	Product group										
	C	A									Cables
			Variant								
			0								Standard variant
				Connector type							
				Y							Y-coded
					Length in 0.1 m steps						
					0	1	.	0	0	0	5	Y-hybrid cable 0.5 m M12 to M12, straight
					0	1	.	0	0	1	0	Y-hybrid cable 1.0 m M12 to M12, straight
					0	1	.	0	0	2	0	Y-hybrid cable 2.0 m M12 to M12, straight
					0	1	.	0	0	5	0	Y-hybrid cable 5.0 m M12 to M12, straight
					0	1	.	0	1	0	0	Y-hybrid cable 10.0 m M12 to M12, straight
					0	1	.	0	1	5	0	Y-hybrid cable 15.0 m M12 to M12, straight
					0	1	.	0	2	0	0	Y-hybrid cable 20.0 m M12 to M12, straight
					0	1	.	0	3	0	0	Y-hybrid cable 30.0 m M12 to M12, straight
					1	1	.	0	0	1	0	Y-hybrid cable 1.0 m M12 to M12, angled
					1	1	.	0	0	2	0	Y-hybrid cable 2.0 m M12 to M12, angled
					1	1	.	0	0	5	0	Y-hybrid cable 5.0 m M12 to M12, angled
					1	1	.	0	1	0	0	Y-hybrid cable 10.0 m M12 to M12, angled
					1	1	.	0	1	5	0	Y-hybrid cable 15.0 m M12 to M12, angled

Cable accessories

Product area								
V								Integrated machine vision
	Product group							
	A	C						Accessories for cables
			Variant					
			0					Standard variant
				Connector type				
				Y				Y-coded
					Accessory type			
					C	0	2	0	Y-distributor / IP20 power supply box, suitable for control cabinet installation

Installation accessories

Product area								
V								Integrated machine vision
	Product group							
	M	A						Installation accessories
			Variant					
			0					Standard variant
				Mounting type				
				R				Mounting bracket
					Accessory type			
					0	0	0	1	Type 1

9.2 Cables

The following cables are available for integrated machine vision.

9.2.1 VCA0Yxx.xxxx - POWERLINK hybrid cable M12, 8-pin, Y-coded

B&R offers hybrid cables with M12 screw connectors for connecting Smart Camera and Smart Light products to each other or to a POWERLINK hybrid distributor in the following lengths:

9.2.1.1 Order data

VCA0Y01.xxxx

Order number	Short description	Figure
	Cables	
VCA0Y01.0005	- POWERLINK hybrid cable - 0.5 m - Connector: Straight	
VCA0Y01.0010	- POWERLINK hybrid cable - 1.0 m - Connector: Straight	
VCA0Y01.0020	- POWERLINK hybrid cable - 2.0 m - Connector: Straight	
VCA0Y01.0050	- POWERLINK hybrid cable - 5.0 m - Connector: Straight	
VCA0Y01.0100	- POWERLINK hybrid cable - 10.0 m - Connector: Straight	
VCA0Y01.0150	- POWERLINK hybrid cable - 15.0 m - Connector: Straight	
VCA0Y01.0200	- POWERLINK hybrid cable - 20.0 m - Connector: Straight	
VCA0Y01.0300	- POWERLINK hybrid cable - 30.0 m - Connector: Straight	

Table 3: VCA0Y01.0005, VCA0Y01.0010, VCA0Y01.0020, VCA0Y01.0050, VCA0Y01.0100, VCA0Y01.0150, VCA0Y01.0200, VCA0Y01.0300 - Order data

VCA0Y11.xxxx

Order number	Short description	Figure
	Cables	
VCA0Y11.0010	- POWERLINK hybrid cable - 1.0 m - Connector: Angled	
VCA0Y11.0020	- POWERLINK hybrid cable - 2.0 m - Connector: Angled	
VCA0Y11.0050	- POWERLINK hybrid cable - 5.0 m - Connector: Angled	
VCA0Y11.0100	- POWERLINK hybrid cable - 10.0 m - Connector: Angled	
VCA0Y11.0150	- POWERLINK hybrid cable - 15.0 m - Connector: Angled	

Table 4: VCA0Y11.0010, VCA0Y11.0020, VCA0Y11.0050, VCA0Y11.0100, VCA0Y11.0150 - Order data

9.2.1.2 Technical data

VCA0Y01.xxxx

Order number	VCA0Y01. 0005	VCA0Y01. 0010	VCA0Y01. 0020	VCA0Y01. 0050	VCA0Y01. 0100	VCA0Y01. 0150	VCA0Y01. 0200	VCA0Y01. 0300
Short description								
Accessories	POWERLINK hybrid cable, M12, Y-coded, straight							
General information								
Durability	Flame-retardant per UL 1581, section 1060 / 1061 and UL 2556, section 9.3 Oil resistance per IEC 60811-2-1 and VDE 0282 part 10							
Certifications								
CE	Yes							

Table 5: VCA0Y01.0005, VCA0Y01.0010, VCA0Y01.0020, VCA0Y01.0050, VCA0Y01.0100, VCA0Y01.0150, VCA0Y01.0200, VCA0Y01.0300 - Technical data

Order number	VCA0Y01.0005	VCA0Y01.0010	VCA0Y01.0020	VCA0Y01.0050	VCA0Y01.0100	VCA0Y01.0150	VCA0Y01.0200	VCA0Y01.0300
Cable construction								
Supply lines								
Quantity	4							
Wire insulation	PP							
Variant	CuZn contact with Ni/Au contact surface							
Cross section	0.85 mm²							
Signal line								
Quantity	4							
Wire insulation	PP							
Variant	CuZn contact with Ni/Au contact surface							
Cross section	0.15 mm²							
Cable stranding	Yes							
Cable shield	Tinned copper wire braiding							
Outer jacket								
Material	PUR (halogen-free, low-adhesive)							
Color	Black RAL 9005							
Connector								
Type	2x M12 SPEEDCON, Y-coded, male, straight							
Mating cycles	At least 100							
Contacts	8 (4 power supply and 4 signal contacts)							
Electrical properties								
Nominal voltage	Max. 50 VDC (peak value)							
Nominal current	6 A power supply line 0.5 A signal line							
Test voltage								
Wire - Wire	2000 V (50 Hz, 1 min.)							
Wire - Shield	2000 V (50 Hz, 1 min.)							
Transfer properties	Ethernet hybrid Cat 5 (IEC 11801), 100 Mbit/s							
Transfer rate	100 Mbit/s							
Conductor resistance								
Supply lines	at 25 °C: <22.5 Ω/km at 90 °C: <28.4 Ω/km							
Signal line	Max. 280.0 Ω/km							
Insulation resistance	≥5 GΩ/km							
Operating conditions								
Degree of protection per EN 60529								
Cables	IP65/IP67							
Male M12 connector	IP65/IP67 (connected and screwed in)							
Ambient conditions								
Temperature								
Fixed installation	-25 to 90°C (male M12 connector) -40 to 80°C (cable)							
Flexible installation	-25 to 90°C (male M12 connector) -30 to 70°C (cable)							
Mechanical properties								
Dimensions								
Length	0.5 m	1.0 m	2.0 m	5.0 m	10.0 m	15.0 m	20.0 m	30.0 m
Diameter	8.8 ±0.2 mm							
Bend radius								
Fixed installation	Min. 4 outer diameter							
Flexible installation	Min. 8 outer diameter							
Drag chain data								
Acceleration	Max. 3 m/s²							
Flex cycles	Min. 2 million							
Velocity	Max. 3 m/s							
Weight	112 g	167 g	275 g	606 g	1159 g	1705 g	2267 g	3160 g

Table 5: VCA0Y01.0005, VCA0Y01.0010, VCA0Y01.0020, VCA0Y01.0050, VCA0Y01.0100, VCA0Y01.0150, VCA0Y01.0200, VCA0Y01.0300 - Technical data

VCA0Y11.xxxx

Order number	VCA0Y11.0010	VCA0Y11.0020	VCA0Y11.0050	VCA0Y11.0100	VCA0Y11.0150
Short description					
Accessories	POWERLINK hybrid cable, M12, Y-coded, angled				
General information					
Durability	Flame-retardant per UL 1581, section 1060 / 1061 and UL 2556, section 9.3 Oil resistance per IEC 60811-2-1 and VDE 0282 part 10				
Certifications					
CE	Yes				

Table 6: VCA0Y11.0010, VCA0Y11.0020, VCA0Y11.0050, VCA0Y11.0100, VCA0Y11.0150 - Technical data

Order number	VCA0Y11.0010	VCA0Y11.0020	VCA0Y11.0050	VCA0Y11.0100	VCA0Y11.0150
Cable construction					
Supply lines					
Quantity	4				
Wire insulation	PP				
Variant	CuZn contact with Ni/Au contact surface				
Cross section	0.85 mm²				
Signal line					
Quantity	4				
Wire insulation	PP				
Variant	CuZn contact with Ni/Au contact surface				
Cross section	0.15 mm²				
Cable stranding	Yes				
Cable shield	Tinned copper wire braiding				
Outer jacket					
Material	PUR (halogen-free, low-adhesive)				
Color	Black RAL 9005				
Connector					
Type	2x M12 SPEEDCON, Y-coded, male, angled				
Mating cycles	At least 100				
Contacts	8 (4 power supply and 4 signal contacts)				
Electrical properties					
Nominal voltage	Max. 50 VDC (peak value)				
Nominal current	6 A power supply line 0.5 A signal line				
Test voltage					
Wire - Wire	2000 V (50 Hz, 1 min.)				
Wire - Shield	2000 V (50 Hz, 1 min.)				
Transfer properties	Ethernet hybrid Cat 5 (IEC 11801), 100 Mbit/s				
Transfer rate	100 Mbit/s				
Conductor resistance					
Supply lines	At 25°C: <22.5 Ω/km At 90°C: <28.4 Ω/km				
Signal line	Max. 280.0 Ω/km				
Insulation resistance	≥5 GΩ/km				
Operating conditions					
Degree of protection per EN 60529					
Cables	IP65/IP67				
Male M12 connector	IP65/IP67 (connected and screwed in)				
Ambient conditions					
Temperature					
Fixed installation	-25 to 90°C (male M12 connector) -40 to 80°C (cable)				
Flexible installation	-25 to 90°C (male M12 connector) -30 to 70°C (cable)				
Mechanical properties					
Dimensions					
Length	1.0 m	2.0 m	5.0 m	10.0 m	15.0 m
Diameter	8.8 ±0.2 mm				
Bend radius					
Fixed installation	Min. 4 outer diameter				
Flexible installation	Min. 8 outer diameter				
Can be used in cable drag chains	Yes				
Drag chain data					
Acceleration	Max. 3 m/s²				
Flex cycles	Min. 2 million				
Velocity	Max. 3 m/s				
Weight	167 g	277 g	607 g	1165 g	1719 g

Table 6: VCA0Y11.0010, VCA0Y11.0020, VCA0Y11.0050, VCA0Y11.0100, VCA0Y11.0150 - Technical data

9.2.1.3 Wiring

<table>
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 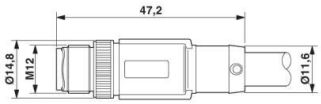
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 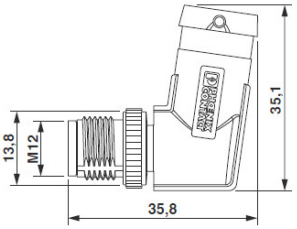
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</tr>
<tr><th colspan="3">Pinout</th></tr>
<tr><th>M12 connector</th><th></th><th>M12 connector</th></tr>
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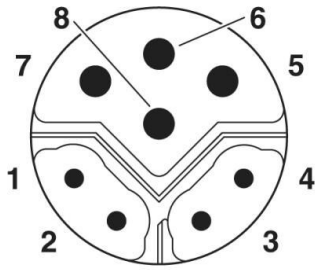
<td> 
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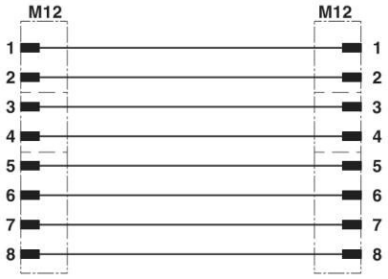
<td> 
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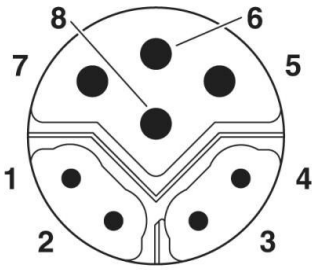
<td> 
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</tr>
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9.2.1.3.1 Pinout

Pin	Pinout	Explanation
1	TXD	PLK transmit signal
2	TXD\	PLK transmit signal inverted
3	RXD	PLK receive signal
4	RXD\	PLK receive signal inverted
5	GND	Supply line 1 (max. 4 A)
6	GND	Supply line 2 (max. 4 A)
7	+24 VDC	Supply line 2 (max. 4 A)
8	+24 VDC	Supply line 1 (max. 4 A)

9.2.2 X20CAxE61.xxxx(x) - POWERLINK connection cable RJ45

B&R offers POWERLINK connection cables with RJ45 connectors in the following lengths that can be used to connect a POWERLINK hybrid distributor to a POWERLINK network:

9.2.2.1 Order data overview

Length	X20CAxE61.xxxx	X20CA0E61.xxxxx
0.2 m		X20CA0E61.00020
0.25 m		X20CA0E61.00025
0.3 m		X20CA0E61.00030
0.35 m		X20CA0E61.00035
0.4 m		X20CA0E61.00040
0.5 m		X20CA0E61.00050
1 m		X20CA0E61.00100
1.5 m		X20CA0E61.00150
2 m		X20CA0E61.00200
3 m		X20CA0E61.00300
4 m		X20CA0E61.00400
5 m		X20CA0E61.00500
6 m		X20CA0E61.00600
8 m		X20CA0E61.00800
9 m		X20CA0E61.00900
10 m	X20CA3E61.0100	X20CA0E61.01000
11 m		X20CA0E61.01100
12 m		X20CA0E61.01200
13 m		X20CA0E61.01300
14 m		X20CA0E61.01400
15 m	X20CA3E61.0150	X20CA0E61.01500
16 m		X20CA0E61.01600
17 m		X20CA0E61.01700
19 m		X20CA0E61.01900
20 m	X20CA0E61.0200 X20CA3E61.0200	X20CA0E61.02000
25 m	X20CA0E61.0250	
30 m	X20CA0E61.0300	
35 m	X20CA0E61.0350	
40 m	X20CA0E61.0400	
50 m	X20CA0E61.0500	
60 m	X20CA0E61.0600	
100 m	X20CA0E61.1000	
		

Length	Tolerances for cable lengths
X20CAxE61.xxxx	
10 to 100 m	+2% of the length
X20CA0E61.xxxxx	
0.2 to 0.5 m	+0.01 m
1 to 5 m	+0.04 m
6 to 20 m	+1% of the length

9.2.2.2 Technical data

Product ID	X20CA0E61.xxxx	X20CA3E61.xxxx	X20CA0E61.xxxxx
General information			
Durability	Oil resistance per VED 0473 part 811-2-1 (EN 60811-2-1) Flame-retardant per IEC 60332-1-2 UV-resistant		Flame-retardant per IEC 60332-3-24 ROHS 2002/95/EC Can be used in industrial buildings and outdoors
Short description	POWERLINK connection cable RJ45 to RJ45		
Type	Connection cables		
Cable cross section			
AWG	4x 22 AWG		4x 2x 26 AWG
mm²	4x 0.34 mm²		4x 2x 0.14 mm²
Cable construction			
Inner jacket	-		Halogen-free, flame-retardant
Outer jacket			
Material	Polyurethane (PUR) GN		PVC
Properties	Halogen-free		-
Color	Green		Black (RAL 9005)
Labeling	B&R X67CA0Exx.xxxx and X20CA0Exx.xxxx	X20CA3E61.xxxx	B&R X20CA0E61.xxxxx
Wires			
Wire insulation	Polyethylene (PE)		
Wire colors	White, yellow, blue, orange	Red, white, yellow, blue	Blue-white, blue, orange-white, orange, green-white, green, brown-white, brown
Shield	Aluminum foil and braided wire shield composed of tinned copper wires	Overlapping aluminum-clad foil, tinned copper braiding, 85% coverage	Aluminum foil and braided wire shield composed of tinned copper wires
Type	Stranded wire 0.34 mm² (22 AWG), tinned	Tinned copper strand 22/7 AWG	Stranded wire 26 AWG, tinned 4x 2x 26 AWG
Stranding	4-wire twisted pair	Yellow with yellow, orange with orange, white with white, blue with blue	Blue-white with blue, orange-white with orange, green-white with green, brown-white with brown
Electrical properties			
Operating voltage	-		Max. 125 V
Test voltage			
Wire - Wire	-		1000 V
Conductor resistance	≤120 Ω/km at 20°C		≤145 Ω/km at 20°C
Transfer properties	Category 5 / Class D up to 100 MHz per ISO/IEC 11801 (EN 50173-1), ISO/IEC 24702 (EN 50173-3)		Category 5 per EN 50288-2-2 (2004) / IEC 61156-6 (2002)
Transfer rate	10/100 Mbit/s		
Insulation resistance	≥500 MΩ/km at 20°C		≥5 GΩ/km at 20°C
Operating conditions			
Degree of protection per EN 60529			
Cables	IP67		
RJ45 connector	IP20, only when properly connected		
Ambient conditions			
Temperature			
Transport	-50 to 70°C		-
Fixed installation	-25 to 60°C		-40 to 80°C
Flexible installation	-20 to 60°C		-10 to 60°C
Mechanical properties			
Dimensions			
Length	Various		
Diameter	6.5 mm ±0.2 mm		6.7 mm ±0.2 mm
Bend radius			
After installation	≥7x outer diameter		≥4x outer diameter
During installation	≥3x outer diameter		≥8x outer diameter
Drag chain data			
Acceleration	-	4 m/s²	-
Flex cycles	-	Min. 3 million	-
Velocity	-	4 m/s	-
Weight	0.061 kg/m		0.058 kg/m

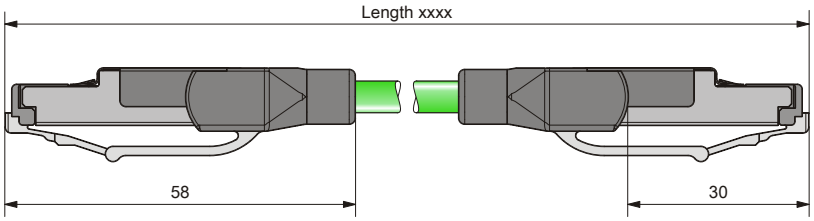
Table 7: X20CA0E61.xxxx, X20CA3E61.xxxx, X20CA0E61.xxxxx - Technical data

9.2.2.3 X20CA0E61.xxxx and X20CA3E61.xxxx

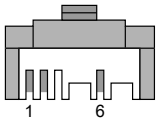
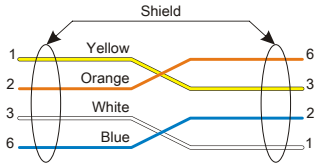
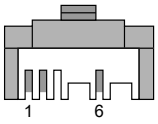
This cable is offered in 2 variants:

- X20CA0E61: Standard design
- X20CA3E61: Can be used in cable drag chains

Dimensions

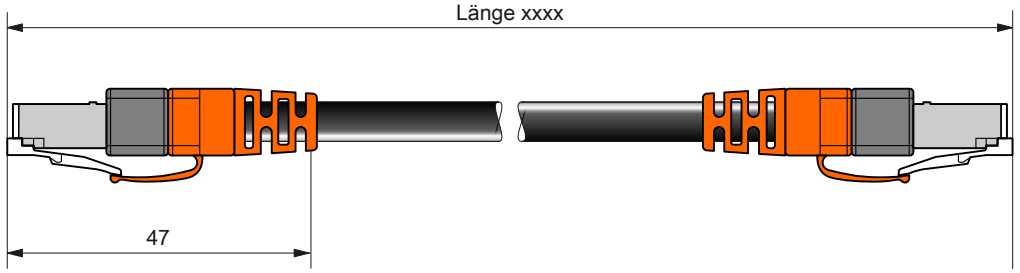


Pinout

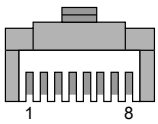
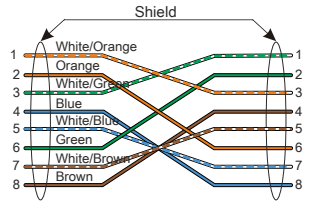
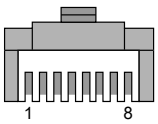
Male RJ45 connector	Pin	Name	Diagram	Male RJ45 connector
	1 - 3	TXD		
	2 - 6	TXD\		
	3 - 1	RXD		
	6 - 2	RXD\		

9.2.2.4 X20CA0E61.xxxxx

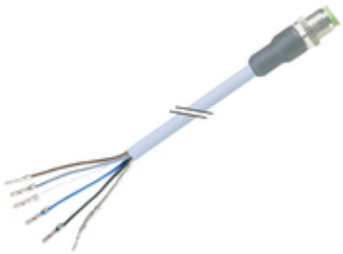
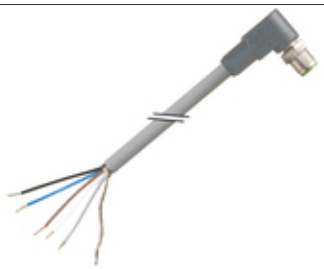
Dimensions



Pinout

Male RJ45 connector	Pin	Name	Diagram	Male RJ45 connector
	1 - 3	TXD		
	2 - 6	TXD\		
	4 - 8	RXD		
	6 - 2	RXD\		

9.2.3 M12 sensor cables

	Short description	
Length	M12 sensor cables	
2 m	X67CA0A41.0020	X67CA0A51.0020
5 m	X67CA0A41.0050	X67CA0A51.0050
10 m	X67CA0A41.0100	X67CA0A51.0100
15 m	X67CA0A41.0150	X67CA0A51.0150
20 m	X67CA0A41.0200	X67CA0A51.0200
		

Length	Tolerances for cable lengths
0 to <1 m	+2 cm
1 m to <10 m	+5 cm
10 m to xx m	+10 cm

9.2.3.1 Technical data

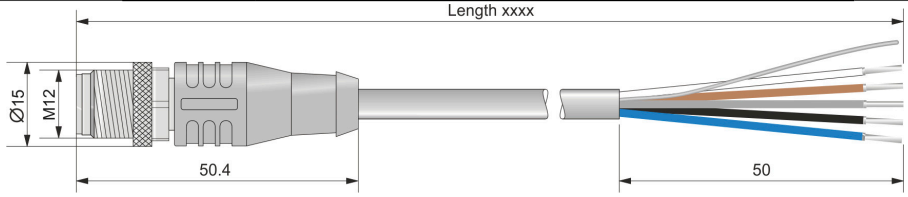
Product ID	X67CA0A41	X67CA0A51
General information		
Note	PVC- and silicone-free LABS- (PWIS-) and halogen-free	
Durability	Good chemical and oil resistance Flame resistant Good UV and ozone resistance	
Connection	M12, 5-pin, straight	M12, 5-pin, angled
Type	Attachment cables	
Cable cross section		
AWG	5x 22 AWG	
mm²	5x 0.34 mm²	
Cable construction		
Complete shielding	Tinned copper braiding, coverage 84%, 0.25 mm² with filler	
Outer sheathing		
Material	Polyurethane (PUR) UL	
Color	Gray	
Labeling	B&R X67CA0Axx.xxxx Rev. G0 ESCHA FC[1)]	
Lines		
Wire insulation	Polypropylene (PP) 9Y	
Wire colors	Brown, black, blue, white, gray	
Type	Uncoated copper ETP1 Fine stranded wire (42x 0.1 mm / 42x 38 AWG), class 5	
Stranding	5 wires stranded using filler	
Electrical characteristics		
Nominal current	Max. 4 A / contact at 40°C	
Operating voltage	Max. 60 V	
Degree of insulation	Category II in accordance with IEC 61076-2	
Conductor resistance	≤57 Ω/km	
Insulation resistance	≥100 MΩ	
Operating conditions		
EN 60529 protection		
Connector/Coupling	IP67, only when screwed in	
Environmental conditions		
Temperature		
Transport	-40 to 90°C	
Fixed installation	-30 to 90°C	
Flexible installation[2)]	-25 to 60°C	
Mechanical characteristics		
Dimensions		
Length	Various	
Diameter	5.6 mm ±0.2 mm	
Bend radius	≥12x outer diameter	
Drag chain data		
Acceleration	Max. 5m/s²	
Flex cycles	2 million	
Speed	Max. 1.6 m/s	

Table 8: X67CA0Axx - Technical data

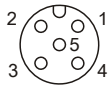
1) xx.xxxx: Group number and cable length.
2) In cable drag chain operation.

9.2.3.2 X67CA0A41.xxxx

Dimensions



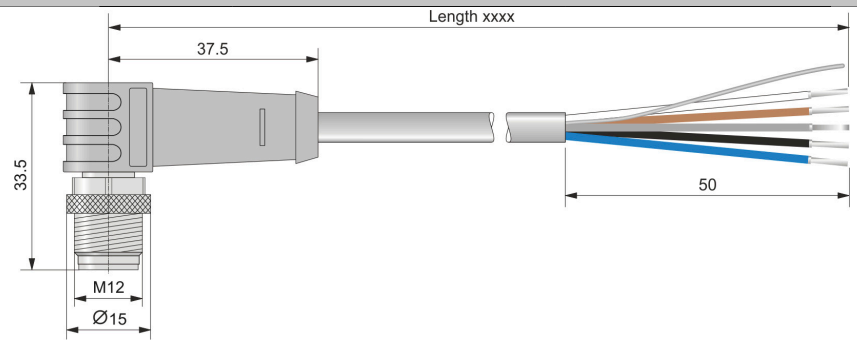
Pinout

Male connector	Pin	Name	Wire colors	Open
 A-keyed	1	Pinout, see module description	Brown	For custom wiring
	2		White	
	3		Blue	
	4		Black	
	5 [1)]		Gray	
	M12 [2)]	SHLD	-	

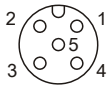
1) Do not use the gray connecting line in connection with X67 modules for which pin 5 is used as a shield connection. The cable shield for this cable is connected using a union nut.
2) Shield on M12 knurled-head screw in 360° design

9.2.3.3 X67CA0A51.xxxx

Dimensions



Pinout

Male connector	Pin	Name	Wire colors	Open
 A-keyed	1	Pinout, see module description	Brown	For custom wiring
	2		White	
	3		Blue	
	4		Black	
	5 [1]		Gray	
	M12 [2]	SHLD	-	

1) Do not use the gray connecting line in connection with X67 modules for which pin 5 is used as a shield connection. The cable shield for this cable is connected using a union nut.
2) Shield on M12 knurled-head screw in 360° design

9.3 Cable accessories

The following hybrid distributor boxes are available for integrated machine vision.

9.3.1 VAC0YC020 - POWERLINK hybrid distributor, M12, Y-coded

A POWERLINK hybrid distributor divides the lines (power supply and data) of a POWERLINK hybrid cable. For this purpose, the pins of the 8-pin M12 connector are divided between an RJ45 connector (POWERLINK data) and a 3-pin power connection.

In addition, an IP67 compliant connection to the control cabinet is possible.

9.3.1.1 Order data

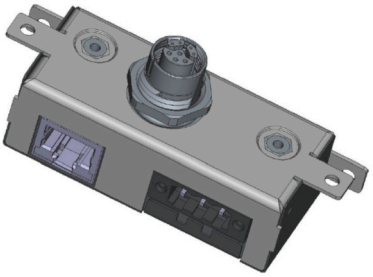
Order number	Short description	Figure
	Accessories	
VAC0YC020	IP20 POWERLINK M12 hybrid distributor	
	Optional accessories	
0TB103.9	Connector, 24 V, 5.08 3-pin screw clamp terminal block	
0TB103.91	Connector, 24 V, 5.08 3-pin cage clamp terminal block	
X20CAxE61.xxxx	PLK connection cable, RJ45-RJ45, drag chain	
X20CAxE61.xxxxx	PLK connection cable RJ45 to RJ45	

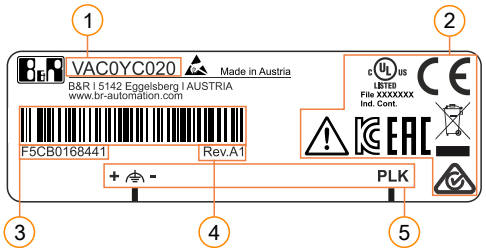
Table 9: VAC0YC020 - Order data

9.3.1.2 Technical data

Order number	VAC0YC020
Short description	
Accessories	IP20 POWERLINK M12 hybrid distributor
General information	
Certifications	
CE	Yes
Connector	
Type	1x M12, 8-pin, female 1x female RJ45 connector 1x 3-pin power supply
Internal connector	In the control cabinet: 1x female RJ45 connector and 1x 3-pin power supply
Additional connectors	Through the control cabinet panel: 1x M12, 8-pin, female
Electrical properties	
Nominal voltage	24 VDC -15% / +20%, SELV/PELV
Transfer properties	Category 5 / Class D up to 100 MHz per ISO/IEC 11801
Transfer rate	100 Mbit/s
Operating conditions	
Degree of protection per EN 60529	IP20 IP67 for M12 connector possible with compliant installation in the control cabinet
Ambient conditions	
Temperature	
Operation	-20°C to +45°C
Storage	-40°C to +85°C
Transport	-40°C to +85°C
Relative humidity	
Operation	5 to 100%, condensing
Storage	5 to 100%, condensing
Transport	5 to 100%, condensing
Mechanical properties	
Dimensions	
Width	88.0 mm
Length	38.6 mm
Height	30.0 mm
Weight	80 g

Table 10: VAC0YC020 - Technical data

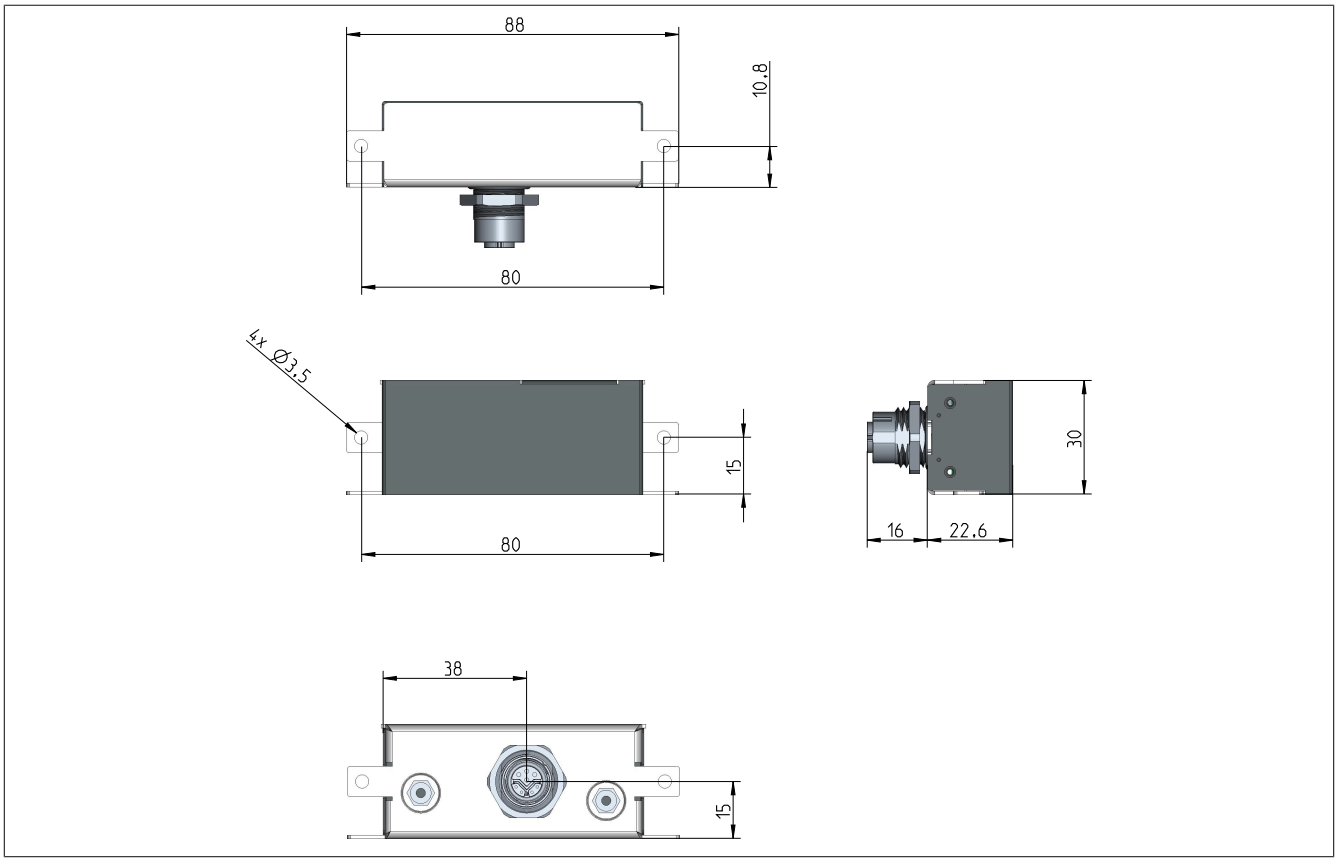
9.3.1.2.1 Product label



1	Distributor box - Order number	**2**	Certification mark and certifications
3	Serial number (barcode type 128 and hexadecimal)	**4**	Product revision
5	Interfaces: Product ID and pinout		

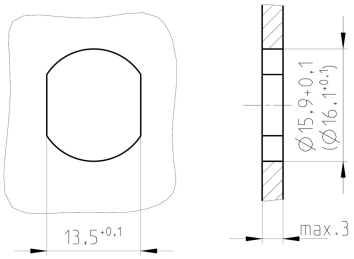
9.3.1.3 Installation

Dimensioned drawing / Drilling plan



IP67-compliant installation recommendation

1. Install the hybrid distributor with O-ring in the control cabinet.
2. Wall thickness of the control cabinet min. 2 mm and max. 3 mm.
3. Dimensions of the opening (cutout with anti-rotation protection, without chamfer):



4. Screw the M12 connector from the outside using the provided nut.
5. Tightening torque: 3 to 4 Nm.
6. The hybrid distributor can optionally be screwed to other points in the control cabinet using the side tabs.

Notice!

Failure to achieve the IP degree of protection can result in damage to the module!

- **IP67 protection of the M12 integral connector is only achieved with a correctly connected and locked male connector pair.**
- **For wall thicknesses < 2 mm, it may not be possible to achieve IP67 protection.**
- **The specified dimensions and tolerances of the opening must be strictly observed.**
- **Burrs and unevenness must be removed!**

9.3.1.4 Pinout

M12, 8-pin, Y-coded, female

Pin	Pinout	Explanation
1	TXD	PLK transmit signal
2	TXD\	PLK transmit signal inverted
3	RXD	PLK receive signal
4	RXD\	PLK receive signal inverted
5	GND	Supply line 1 (max. 4 A)
6	GND	Supply line 2 (max. 4 A)
7	+24 VDC	Supply line 2 (max. 4 A)
8	+24 VDC	Supply line 1 (max. 4 A)

Female RJ45 connector

Pin	Pinout	Explanation
1	RXD	Receive data
2	RXD\	Receive data inverted
3	TXD	Transmit data
4	Termination	-
5	Termination	-
6	TXD\	Transmit data inverted
7	Termination	-
8	Termination	-

3-pin power supply, pins

Pin	Pinout	Explanation
1	+	+24 VDC module power supply
2	Functional earth	Functional earth
3	-	Module power supply ground

9.4 Installation accessories

The following installation accessories are available for integrated machine vision.

9.4.1 VMA0Rxxxx - Mounting bracket

L-bracket with universal drill holes for direct installation of the Smart Camera and Smart Light.

9.4.1.1 Order data

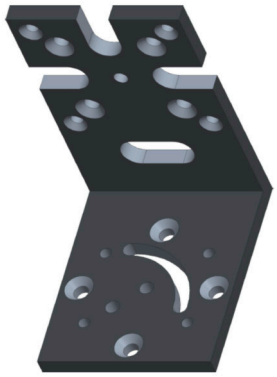
Order number	Short description	Figure
	Accessories	
VMA0R0001	Vision mounting bracket 80 mm x 100 mm 2x Torx countersunk screws DIN 965 M4x12 TORX 4.8 A2K T20 8x Torx countersunk screws DIN 965 M5x12 TORX 4.8 A2K T25 4x Torx flat-head screw ISO 14583 M5x12 70 A2 T25	

Table 11: VMA0R0001 - Order data

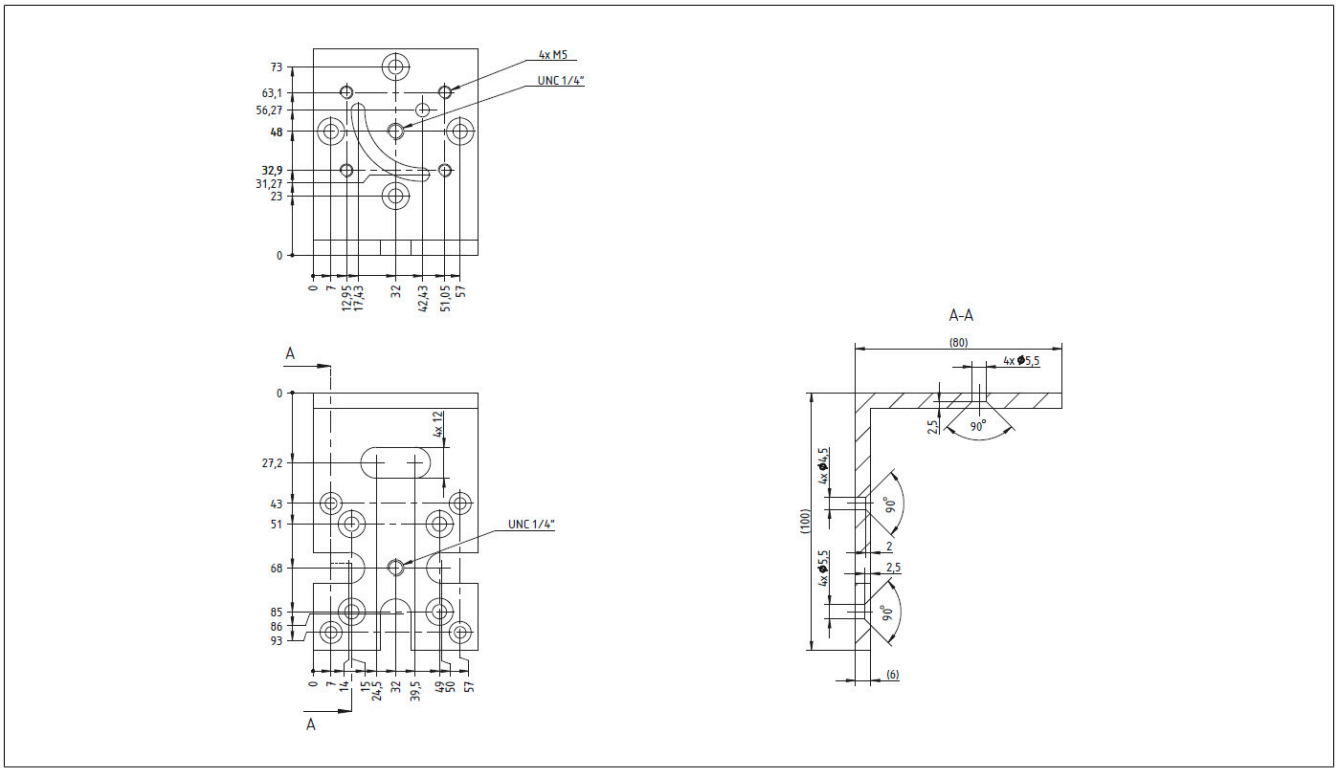
9.4.1.2 Technical data

Order number	VMA0R0001
Short description	
Accessories	Vision mounting bracket 80 mm x 100 mm
General information	
Certifications	CE
Mechanical properties	
Note	L - Bracket with universal drill holes
Material	EN AW-6060 (AlMgSi0.5)
Coating	Black, 25 µm, EPD-coated
Dimensions	
Width	64 mm
Height	100 mm
Depth	80 mm
Weight	180 g

Table 12: VMA0R0001 - Technical data

9.4.1.3 Installation

Dimensioned drawing / Drilling plan



Usage

The 100 mm long side of the mounting bracket is primarily intended for mounting a Smart Camera module or a Smart Light module. This side features 4 M5 cutouts for mounting a machine vision component, 4 additional M4 cutouts and a UNC 1/4" thread hole.

The 80 mm side of the mounting bracket is primarily intended for mounting the L-bracket on the machine. In addition to 4 M5 cutouts and a UNC 1/4" tapping hole, this side offers a curved oblong hole (90° arc) and a corresponding cutout for individual mounting.
Machine side installation can take place at any angle with two of the supplied flat-head screws.

The mounting bracket must be screwed to a thermally and electrically conductive mounting point on the machine side!

Grounding

The universal drill holes are uncoated. The mounting bracket can therefore be conductively connected to its mounting base on the machine with the mounting screws through the universal drill holes. The ground connection is thus provided if the mounting base is well connected to ground potential.

9.5 Lenses

The following lenses are available as accessories for the cameras of integrated machine vision.

9.5.1 Order data

Model number	Short description	Figure
	Accessories	
VLE0C0120	C-mount 12mm lens, 150 lp/mm, F1.8, 2/3"	
VLE0C0160	C-mount 16mm lens, 150 lp/mm, F1.8, 2/3"	
VLE0C0250	C-mount 25mm lens, 150 lp/mm, F1.8, 2/3"	
VLE0C0350	C-mount 35mm lens, 150 lp/mm, F1.8, 2/3"	
VLE0C0500	C-mount 50mm lens, 150 lp/mm, F1.8, 2/3"	

Table 13: VLE0C0120, VLE0C0160, VLE0C0250, VLE0C0350, VLE0C0500 - Order data

Additional accessories:

Model number	Short description
	Accessories
VLE0T0001	C-Mount lens tube Inner diameter: 42 mm Inner length: 55 mm

Table 14: VLE0T0001 - Order data

9.5.2 Technical data

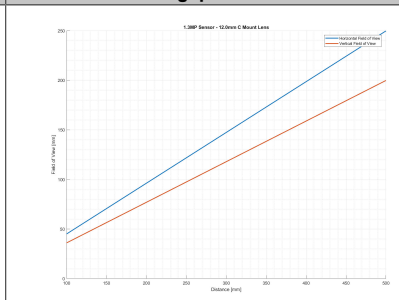
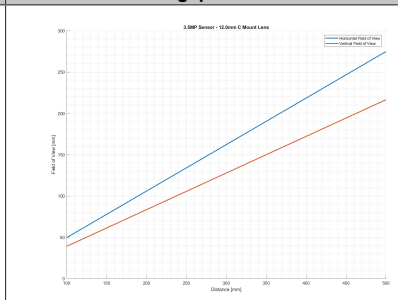
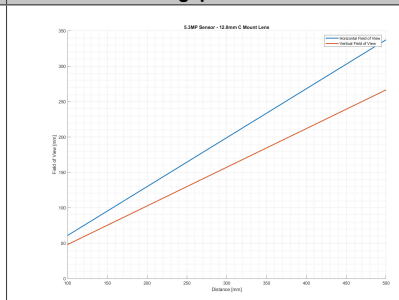
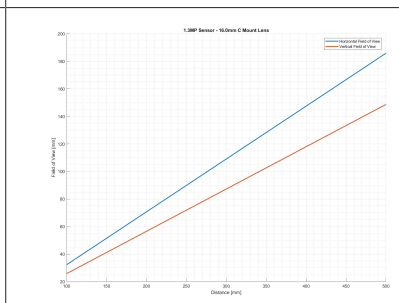
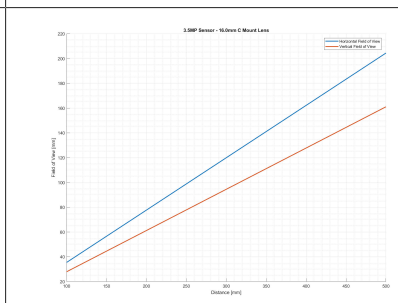
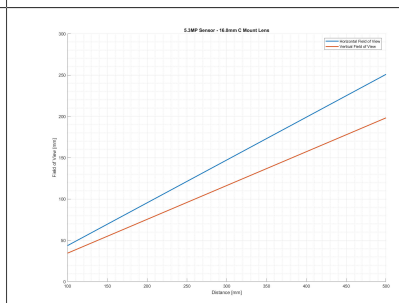
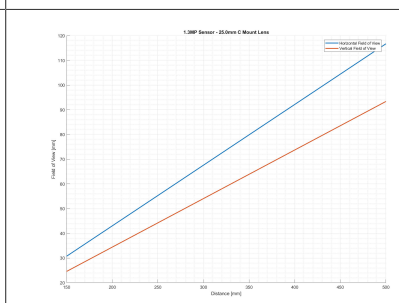
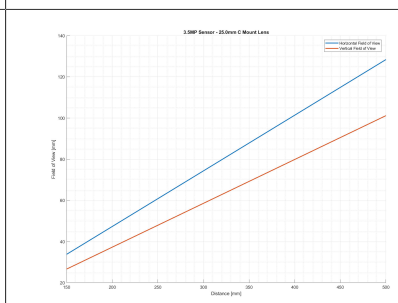
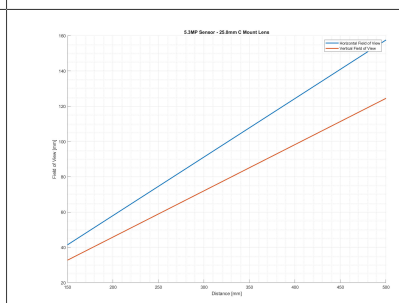
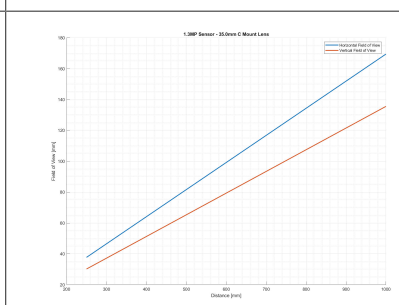
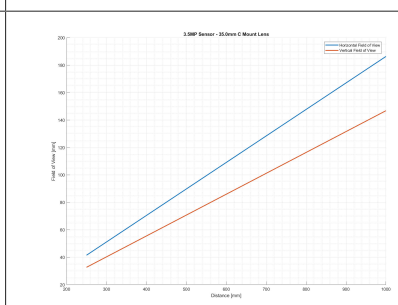
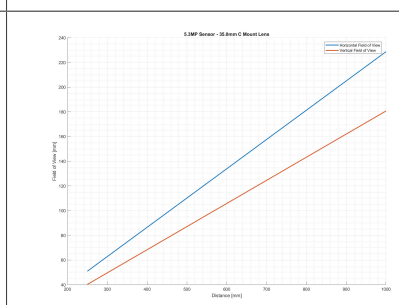
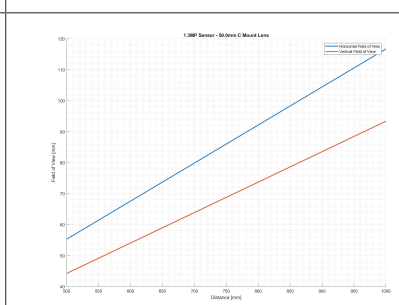
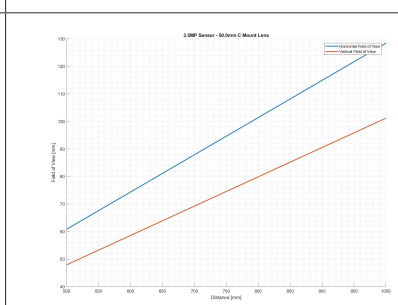
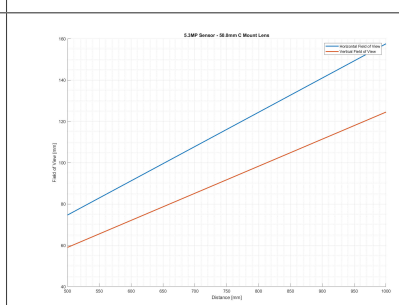
Order number	VLE0C0120	VLE0C0160	VLE0C0250	VLE0C0350	VLE0C0500
Short description					
Accessories	C mount lens				
General information					
Certification	Yes				
Lens					
Type	C mount, thread M27 x 0.5				
Fixed focal length	12 mm	16 mm	25 mm	35 mm	50 mm
Resolution	150 lp/mm				
Aperture	1.8 to 16				
Maximum aperture (light intensity)	2 /3"				
Minimum object distance [1]	100 mm		150 mm	250 mm	500 mm
Maximum object distance [1]	INF				
Optimum working distance	500 mm				
Total optical length in screwed lens	59.5 mm	59 mm	52.5 mm	55.7 mm	54 mm
Operating conditions					
Degree of protection per EN 60529	IP65				
Ambient conditions					
Temperature					
Operation	- 20 °C to 65 °C				
Storage	- 20 °C to 65 °C				
Mechanical properties					
Dimensions					
Length	42 mm (screwed)	41.5 mm (screwed)	35 mm (screwed)	38.2 mm (screwed)	36.4 mm (screwed)
Diameter	29 mm				
Weight	73 g	71 g	61 g	71 g	60 g

Table 15: VLE0C0120, VLE0C0160, VLE0C0250, VLE0C0350, VLE0C0500 - Technical data

1 Lenses are optimized for close range.

Field of View depending on the distance (lens - object)

Field of View depending on the distance (lens - object) from 100 mm to 500 mm.
For c mount lenses from 12 mm to 50 mm, each for the three CMOS sensor sizes 1.3, 3.5 as well as 5.3 megapixels.

mm	1.3 megapixels sensor	3.5 megapixels sensor	5.3 megapixels sensor
12			
16			
25			
35			
50			

9.5.3 Installation

C-mount lenses of the VLE0Cxxxx group are intended for mounting on C-mount variants of the Smart Camera product groups (Smart Sensor and Smart Camera).

Using the standardized C-mount threaded connection, a C-mount lens can be permanently and stably connected to a C-mount camera housing and can be used in an industrial environment.

10 International and national certifications

Machine vision devices meet the requirements of the listed certifications and their relevant standards. We are committed to ensuring the reliability of our products in industrial environments.

Information:

Certifications applicable to the respective module are available at the following locations:

- **Section "General information > Certifications in section "Technical data" in the data sheet**
- **On the website www.br-automation.com in section "Technical data" for the individual products (possible to search using model number).**
- **On the product label of the module.**

Changes and new certifications are promptly made available in electronic form on the B&R website at www.br-automation.com.

10.1 Overview of certifications

Mark	Explanation	Certificate authority	Region
CE	CE marking	Notified bodies	Europe (EU)

10.2 EU directives and standards (CE)

CE marking

The respective product complies with all applicable EU directives and relevant harmonized standards.

Certification of these products is performed in cooperation with accredited testing laboratories.

Validity: Europe (EU)

EMC Directive 2014/30/EU

Il devices satisfy the protection requirements of the "EMC Directive" and are designed for industrial use:

Applicable standards from this directive:

EN 61131-2	Programmable logic controllers - Part 2: Equipment requirements and tests
EN 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
EN 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emissions standard for industrial environments

The corresponding declaration of conformity is available for download from the B&R website.
For information about the versions of applicable standards, see the declaration of conformity.

Declaration of conformity

Declarations of conformity

10.2.1 Overview of standards

Standard	Description
EN 50581	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances
EN 55011 (CISPR 11)	Industrial, scientific and medical equipment - Radio frequency disturbance characteristics - Limits and methods of measurement
EN 55016-2-1 (CISPR 16-2-1)	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-1: Methods of measurement of disturbances and immunity - Conducted disturbance measurements
EN 55016-2-3 (CISPR 16-2-3)	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements
EN 55022 (CISPR 22)	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
EN 60068-2-6	Environmental testing - Part 2-6: Procedures - Test Fc: Vibration (sinusoidal)
EN 60068-2-27	Environmental testing - Part 2-27: Test procedure - Test Ea and guidance: Shock
EN 60068-2-31[1)]	Environmental testing - Part 2-31: Test procedure - Test Ec: Rough handling shocks, mainly for devices
EN 60529	Degrees of protection provided by enclosures (IP code)
EN 60664-1	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests
EN 60721-3-2	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 2: Transport and handling
EN 60721-3-3	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 3: Stationary use at weather-protected locations
EN 61000-4-2	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
EN 61000-4-3	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test
EN 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test
EN 61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measuring techniques - Surge immunity test
EN 61000-4-6	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields
EN 61000-4-8	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measuring techniques - Power frequency magnetic field immunity test
EN 61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measuring techniques - Voltage dips, short interruptions and voltage variations
EN 61000-4-29	Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests
EN 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
EN 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
EN 61131-2	Programmable logic controllers - Part 2: Guidance for inspection and routine testing
EN 62471	Photobiological safety of lamps and lamp systems

1) Replacement for EN 60068-2-32

10.2.2 Requirements for immunity to disturbances

Immunity	Testing performed per standard:	Requirements per standard:	
		EN 61131-2 [1]	EN 61000-6-2 [2]
Electrostatic discharge (ESD)	EN 61000-4-2	✓	✓
High-frequency electromagnetic fields (HF field)	EN 61000-4-3	✓	✓
High-speed transient electrical disturbances (Burst)	EN 61000-4-4	✓	✓
Surge voltages (Surge)	EN 61000-4-5	✓	✓
Conducted disturbances	EN 61000-4-6	✓	✓
Magnetic fields with electrical frequencies	EN 61000-4-8	✓	✓
Voltage dips (AC) Short-term interruptions (AC) Voltage fluctuations (AC)	EN 61000-4-11	✓	✓
Short-term interruptions (DC) Voltage fluctuations (DC)	EN 61000-4-29	✓	-

1) EN 61131-2: Product standard - Programmable logic controllers
2) EN 61000-6-2: Generic standard - Immunity for industrial environments

Criteria to prove the performance of a PLC system against EMC disturbances

Criteria	During test	After test
A	The PLC system shall continue to operate as intended. No loss of function or performance.	The PLC system shall continue to operate as intended.
B	Degradation of performance accepted. The operating mode is not permitted to change. Irreversible loss of stored data is not permitted.	The PLC system shall continue to operate as intended. Temporary degradation of performance must be self-recoverable.
C	Loss of functions accepted, but no destruction of hardware or software (program or data).	The PLC system shall continue to operate as intended automatically, after manual restart or power off / power on.
D	Degradation or failure of functionality that can no longer be restored.	PLC system permanently damaged or destroyed.

Electrostatic discharge (ESD)

Testing performed per standard: EN 61000-4-2	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
Contact discharge (CD) On conductive accessible parts	±4 kV Criteria B	
Air discharge (AD) On insulating accessible parts	±8 kV Criteria B	

High-frequency electromagnetic fields (HF field)

Testing performed per standard: EN 61000-4-3	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
Housing, completely wired	80 MHz to 1 GHz, 10 V/m 1.4 to 2 GHz, 3 V/m 2 to 2.7 GHz, 1 V/m Criteria A	

High-speed transient electrical disturbances (Burst)

Testing performed per standard: EN 61000-4-4	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
AC power inputs	±2 kV / 5 kHz Criteria B	
AC power outputs	±2 kV / 5 kHz [1] Criteria B	±2 kV / 5 kHz Criteria B
Other AC I/O	±2 kV / 5 kHz [1] Criteria B	-
DC mains inputs/outputs	±2 kV / 5 kHz [1] Criteria B	
Other I/Os and interfaces	±1 kV / 5 kHz [1] Criteria B	

1) Only for connections with a permitted cable length greater than 3 m.

Surge voltages (Surge)

Testing performed per standard: EN 61000-4-5	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
AC mains inputs/outputs Line / line	±1 kV Criteria B	
AC mains inputs/outputs Line / ground	±2 kV Criteria B	
DC mains inputs/outputs Line / line	±0.5 kV [1] Criteria B	±0.5 kV Criteria B
DC power inputs Line / ground	±0.5 kV [1] Criteria B	±0.5 kV Criteria B
DC power outputs Line / ground	±0.5 kV [1] Criteria B	±0.5 kV Criteria B
Signal connections, unshielded Line / ground	±1 kV [1] Criteria B	
All shielded cables Line / ground	±1 kV [1] Criteria B	-

1) Only for connections with a permitted cable length greater than 30 m.

Conducted disturbances

Testing performed per standard: EN 61000-4-6	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
AC mains inputs/outputs	10 V 150 kHz to 80 MHz 80% AM (1 kHz) Criteria A	
DC mains inputs/outputs	10 V 150 kHz to 80 MHz 80% AM (1 kHz) Criteria A	
Other I/Os and interfaces	10 V [1] 150 kHz to 80 MHz 80% AM (1 kHz) Criteria A	

1) Only for connections with a permitted cable length greater than 3 m.

Magnetic fields with electrical frequencies

Testing performed per standard: EN 61000-4-8	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
Housing, completely wired	30 A/m 3 axes (x, y, z) 50/60 Hz [1] Criteria A	

1) Mains frequency per manufacturer data

Voltage dips

Testing performed per standard: EN 61000-4-11	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
AC power inputs	0% residual voltage 250/300 periods (50/60 Hz) [1] 20 attempts Criteria C	
	40% residual voltage 10/12 periods (50/60 Hz) [1] 20 attempts Criteria C	
	70% residual voltage 25/30 periods (50/60 Hz) [1] 20 attempts Criteria C	

1) Mains frequency per manufacturer data

Short-term interruptions

Testing performed per standard: EN 61000-4-11 / EN 61000-4-29	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
AC power inputs	0% residual voltage 0.5 periods (50/60 Hz) [1] 20 attempts Criteria A	0% residual voltage 1 period (50/60 Hz) [1] 3 attempts Criteria B
DC power inputs	0% residual voltage ≥10 ms (PS2) [2] 20 attempts Criteria A	-

1) Mains frequency per manufacturer data
2) Use of a B&R power supply guarantees that these requirements are met.

Voltage fluctuations

Testing performed per standard: EN 61000-4-11 / EN 61000-4-29	Requirements per standard: EN 61131-2 / Zone B	Requirements per standard: EN 61000-6-2
AC power inputs	-15% / +10% Test duration per 30 minutes Criteria A	-
DC power inputs	-15% / +20% Test duration per 30 minutes Criteria A	-

10.2.3 Emission requirements

Phenomenon	Testing performed per standard:	Limit values per standard:	
		EN 61131-2 [1]	EN 61000-6-4 [2]
Emissions related to lines	EN 55011 / EN 55022 EN 55016-2-1	✓	✓
Radiated emissions	EN 55011 / EN 55022 EN 55016-2-3	✓	✓

1) EN 61131-2: Product standard - Programmable logic controllers
2) EN 61000-6-4: Generic standards - Emission standard for industrial environments

Emissions related to lines

Testing performed per standard: EN 55011 / EN 55022 / EN 55016-2-1	Limit values per standard: EN 61131-2 / Zone B	Limit values per standard: EN 61000-6-4
AC mains connection 150 kHz to 30 MHz	150 to 500 kHz 79 dB (µV) quasi-peak value 66 dB (µV) average value	
	500 kHz to 30 MHz 73 dB (µV) quasi-peak value 60 dB (µV) average value	
Telecommunications / network connection 150 kHz to 30 MHz	-	150 to 500 kHz 97 to 87 dB (µV) quasi-peak value 53 to 40 dB (µA) quasi-peak value 84 to 74 dB (µV) average value 40 to 30 dB (µA) average value
	-	500 kHz to 30 MHz 87 dB (µV) quasi-peak value 43 dB (µA) quasi-peak value 74 dB (µV) average value 30 dB (µA) average value

Radiated emissions

Testing performed per standard: EN 55011 / EN 55022 / EN 55016-2-3	Limit values per standard: EN 61131-2 / Zone B	Limit values per standard: EN 61000-6-4
Electric field / Measured from 10 m 30 MHz to 1 GHz	30 to 230 MHz 40 dB (µV/m) quasi-peak value	
	230 MHz to 1 GHz 47 dB (µV/m) quasi-peak value	
Electric field / Measured from 3 m 1 to 6 GHz [1]	-	1 to 3 GHz 76 dB (µV/m) peak value 56 dB (µV/m) average value
	-	3 to 6 GHz 80 dB (µV/m) peak value 60 dB (µV/m) average value

1) Depends on the highest internal frequency

10.2.4 Mechanical conditions

Testing	Testing performed per standard:	Requirements per standard:				
		EN 61131-2 [1]	EN 60721-3-2 Class 2M1	EN 60721-3-2 Class 2M2	EN 60721-3-2 Class 2M3	EN 60721-3-3 Class 3M4
Vibration (sinusoidal) / Operation	EN 60068-2-6	✓	-	-	-	✓
Shock / Operation	EN 60068-2-27	✓	-	-	-	✓
Vibration (sinusoidal) / Transport (packaged)	EN 60068-2-6	-	✓	✓	✓	-
Shock / Transport (packaged)	EN 60068-2-27	-	✓	✓	-	-
Free fall / Transport (packaged)	EN 60068-2-31 [2]	✓	✓	-	-	-
Toppling / Transport (packaged)	EN 60068-2-31	-	✓	✓	✓	-

1) EN 61131-2: Product standard - Programmable logic controllers
2) Replacement for EN 60068-2-32

Vibration (sinusoidal) / Operation

Testing performed per standard: EN 60068-2-6	Requirements per standard: EN 61131-2		Requirements per standard: EN 60721-3-3 / Class 3M4	
Vibration (sinusoidal) [1] Operation	Frequency	Amplitude	Frequency	Amplitude
	5 to 8.4 Hz	Deflection 3.5 mm	2 to 9 Hz	Deflection 3 mm
	8.4 to 150 Hz	Acceleration 1 g [2]	9 to 200 Hz	Acceleration 1 g [2]
	20 sweeps for each axis [3]			

1) Uninterrupted duty with movable frequency in all 3 axes (x, y, z); 1 octave per minute
2) 1 g = 10 m/s²
3) 2 sweeps = 1 frequency cycle ($f_{min} \rightarrow f_{max} \rightarrow f_{min}$)

Shock / Operation

Testing performed per standard: EN 60068-2-27	Requirements per standard: EN 61131-2	Requirements per standard: EN 60721-3-3 / Class 3M4
Shock [1] Operation	Acceleration 15 g Duration 11 ms 18 shocks	Acceleration 10 g Duration 11 ms 18 shocks

1) Pulse (half-sine) stress in all 3 axes (x, y, z), 1 octave per minute

Vibration (sinusoidal) / Transport (packaged)

Testing performed per standard: EN 60068-2-6	Requirements per standard: EN 60721-3-2 / Class 2M1		Requirements per standard: EN 60721-3-2 / Class 2M2		Requirements per standard: EN 60721-3-2 / Class 2M3	
Vibration (sinusoidal) [1] Transport (packaged)	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
	2 to 9 Hz	Deflection 3.5 mm	2 to 9 Hz	Deflection 3.5 mm	2 to 8 Hz	Deflection 7.5 mm
	9 to 200 Hz	Acceleration 1 g [2]	9 to 200 Hz	Acceleration 1 g [2]	8 to 200 Hz	Acceleration 2 g [2]
	200 to 500 Hz	Acceleration 1.5 g [2]	200 to 500 Hz	Acceleration 1.5 g [2]	200 to 500 Hz	Acceleration 4 g [2]
	20 sweeps for each axis [3]					

1) Uninterrupted duty with movable frequency in all 3 axes (x, y, z); 1 octave per minute
2) 1 g = 10 m/s²
3) 2 sweeps = 1 frequency cycle ($f_{min} \rightarrow f_{max} \rightarrow f_{min}$)

Shock / Transport (packaged)

Testing performed per standard: EN 60068-2-27	Requirements per standard: EN 60721-3-2 / Class 2M1	Requirements per standard: EN 60721-3-2 / Class 2M2
Shock [1] Transport (packaged)	Type I Acceleration 10 g Duration 11 ms 18 shocks	
	Type II -	Type II Acceleration 30 g Duration 6 ms 18 shocks

1) Pulse (half-sine) stress in all 3 axes (x, y, z)

Free fall / Transport (packaged)

Testing performed per standard: EN 60068-2-31 [1]	Requirements per standard: EN 61131-2 with shipping packaging		Requirements per standard: EN 61131-2 with product packaging		Requirements per standard: EN 60721-3-2 / Class 2M1	
Free fall Transport (packaged)	Weight	Height	Weight	Height	Weight	Height
	<10 kg	1.0 m	<10 kg	0.3 m	<20 kg	0.25 m
	10 to 40 kg	0.5 m	10 to 40 kg	0.3 m	20 to 100 kg	0.25 m
	>40 kg	0.25 m	>40 kg	0.25 m	>100 kg	0.1 m
	5 attempts					

1) Replacement for EN 60068-2-32

Toppling / Transport (packaged)

Testing performed per standard: EN 60068-2-31	Requirements per standard: EN 60721-3-2 / Class 2M1		Requirements per standard: EN 60721-3-2 / Class 2M2		Requirements per standard: EN 60721-3-2 / Class 2M3	
Toppling Transport (packaged)	**Weight**	**Required**	**Weight**	**Required**	**Weight**	**Required**
	<20 kg	Yes	<20 kg	Yes	<20 kg	Yes
	20 to 100 kg	-	20 to 100 kg	Yes	20 to 100 kg	Yes
	>100 kg	-	>100 kg	-	>100 kg	Yes
	Topple on all edges		Topple on all edges		Topple on all edges	

10.2.5 Electrical safety

Overvoltage category

Requirement per standard: EN 61131-2	Explanation per standard: EN 60664-1
Overvoltage category II	Equipment of "overvoltage category II" is energy-consuming equipment to be supplied from the fixed installation.

Pollution degree

Requirement per standard: EN 61131-2	Explanation per standard: EN 60664-1
Pollution degree 2	Only non-conductive pollution occurs. Temporary conductivity caused by condensation must occasionally be expected, however.

Protection rating provided by enclosure (IP code)

Requirement per EN 61131-2	Meaning of codes per EN 60529	Meaning for the protection of equipment	Meaning for the protection of personnel
≥IP20	First number IP**2**x	Protected against solid foreign bodies with a diameter ≥12.5 mm.	Protected against touching dangerous parts with fingers.
	Second number IPx**0**	Not protected.	-

Requirement per manufacturer	Meaning of codes per EN 60529	Meaning for the protection of equipment	Meaning for the protection of personnel
IP54	First number IP**5**x	Dust protected.	Protected against touching dangerous parts with conductor.
	Second number IPx**4**	Protected against splash water.	

Requirement per manufacturer	Meaning of codes per EN 60529	Meaning for the protection of equipment	Meaning for the protection of personnel
IP65	First number IP**6**x	Dust-proof	Protected against touching dangerous parts with conductor.
	Second number IPx**5**	Protected against water jets.	

10.2.6 Photobiological safety

10.2.6.1 Risk group classification

The following table shows the result of the risk group classification according to IEC 62471:2006 at a distance of 20 cm in front of the LEDs.

Smart Camera		LED colors						
		Red (1)	Green (2)	Blue (3)	Lime (4)	White (99)	Infrared (100)	UV (210)
LED lens	Lens 1	RG0	RG0	RG0	RG0	RG0	RG0	RG0
	Lens 2	RG0	RG0	RG1	RG0	RG0	RG0	RG0
	Lens 3	RG0	RG0	RG2	RG0	RG1	RG0	RG1

LED lens 2 – Color Blue (3)

Classification RG1 due to the blue light hazard.

LED lens 3 – Color Blue (3)

Classification RG2 due to the blue light hazard.

LED lens 3 – Color White (99)

Classification RG1 due to the blue light hazard.

LED lens 3 – Color UV (210)

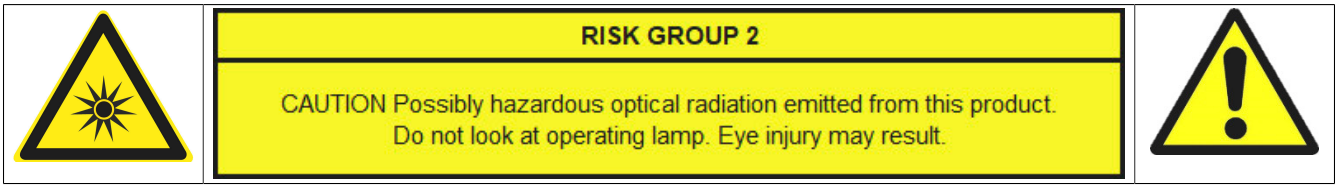
Classification RG1 based on the actinic ultraviolet hazard (skin and eye).
Classification RG1 due to the near UV hazard (eye).

10.2.6.2 Marking on plant/machine

According to the IEC TR 62471-2 standard and the risk group classification carried out, a hazard-related marking of the risk groups is required on the plant/machine.

The markings should be permanently attached, legible and clearly visible during normal operation and during maintenance and service work. Markings should be affixed in such a way that they can be read without the need to expose oneself to optical radiation exceeding the applicable exposure limit value (ELV). Text and borders should appear black on a yellow background.

Appropriate safety marking is shown in the following illustrations for each RG.



10.2.6.3 Exposure hazard value (EHV)

The hazard value of exposure (EHV) indicates the relationship between the actual measured value of exposure (exposure level) at a distance of 20 cm and the exposure limit value.

EHV = exposure level / exposure limit value

If the exposure level (measured value of exposure at a distance of 20 cm) exceeds the exposure limit value, EHV is greater than 1. A list of hazard values per risk group is given in the following tables.

Machine Vision	Photobiological safety	Exposure hazard value (EHV)		
		RG0	RG1	RG2
LED-lens 3 - Blue (3)	Blue light	7.3300	1.5398	0.0040

Machine Vision	Photobiological safety	Exposure hazard value (EHV)		
		RG0	RG1	RG2
LED-lens 2 - Blue (3)	Blue light	1.6400	0.7482	-

Machine Vision	Photobiological safety	Exposure hazard value (EHV)		
		RG0	RG1	RG2
LED-lens 3 - White (99)	Blue light	1.8100	0.2005	-

Machine Vision	Photobiological safety	Exposure hazard value (EHV)		
		RG0	RG1	RG2
LED-lens 3 - UV (210)	Actinic UV	1.3400	0.4467	-
	Near UV	2.9400	0.8909	-

10.2.6.4 Maximum permissible exposure time

The maximum duration of exposure that can be exposed without exceeding the exposure limit value. The duration of exposure thus has an influence on the limit value. The maximum exposure duration must be calculated over a whole day.

In worst case operation with 10 ms pulse length and 10% duty cycle, one can be exposed to the exposure at a distance of 20 cm for a total of 64.9 s per day without exceeding the limit value. In addition, the exposure limit value is exceeded.

The following tables show the maximum permissible exposure time (accumulated over one day) at a distance of 20 cm and operation with 10 ms pulse length and 10% duty cycle, where the exposure limit value is observed.

Machine Vision	Photobiological safety	Maximum permissible exposure time
LED-lens 3 - Blue (3)	Blue light	64.9 s

Machine Vision	Photobiological safety	Maximum permissible exposure time
LED-lens 2 - Blue (3)	Blue light	133.6 s

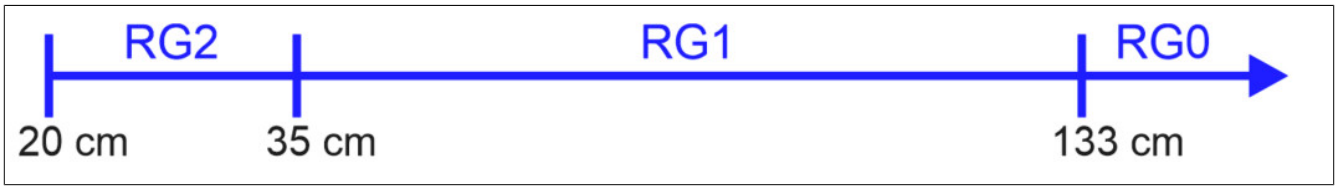
Machine Vision	Photobiological safety	Maximum permissible exposure time
LED-lens 3 - White (99)	Blue light	498.7 s

Machine Vision	Photobiological safety	Maximum permissible exposure time
LED-lens 3 – UV (210)	Actinic UV	22388 s
	Near UV	340 s

10.2.6.5 Hazard distances (HD)

The hazardous distance (HD) indicates the distance from the LEDs at which the exposure limit value is maintained when operating with 10 ms pulse length and 10% duty cycle. A list of the hazard distances per risk group is shown in the following tables.

Machine Vision	Photobiological safety	Hazard distances (HD)		
		RG0	RG1	RG2
LED-Lens 3 - Blue (3)	Blue light	1.33 m	0.35 m	0.20 m



Machine Vision	Photobiological safety	Hazard distances (HD)		
		RG0	RG1	RG2
LED-lens 2 - Blue (3)	Blue light	0.82 m	0.20 m	0.20 m

Machine Vision	Photobiological safety	Hazard distances (HD)		
		RG0	RG1	RG2
LED-lens 3 - White (99)	Blue light	0.82 m	0.20 m	0.20 m

Machine Vision	Photobiological safety	Hazard distances (HD)		
		RG0	RG1	RG2
LED-lens 3 - UV (210)	Actinic UV	0.24 m	0.20 m	0.20 m
	Near UV	0.35 m	0.20 m	0.20 m

10.2.6.6 Duty cycle LEDs

The duty cycle of the LEDs depends on the pulse duration and the pause duration:

Duty cycle = pulse duration / (pause duration + pulse duration)

For example, if a pulse duration of 1.4 ms and a pause duration of 98.6 ms is selected (resulting in a duty cycle of 1.4%), the limit value of RG0 is maintained at a distance of 20 cm.

In the following tables, the reduction in the intensity of the LEDs (duty cycle) is listed for which the limit value of the corresponding risk group is observed at a distance of 20 cm.

Machine Vision	Photobiological safety	Duty cycle LEDs		
		RG0	RG1	RG2
LED-lens 3 - Blue (3)	Blue light	1.4%	6.5%	10.0%

Machine Vision	Photobiological safety	Duty cycle LEDs		
		RG0	RG1	RG2
LED-lens 2 - Blue (3)	Blue light	6.1%	10.0%	10.0%

Machine Vision	Photobiological safety	Duty cycle LEDs		
		RG0	RG1	RG2
LED-lens 3 - White (99)	Blue light	5.5%	10.0%	10.0%

Machine Vision	Photobiological safety	Duty cycle LEDs		
		RG0	RG1	RG2
LED-lens 3 - UV (210)	Actinic UV	7.5%	10.0%	10.0%
	Near UV	3.4%	10.0%	10.0%

Publishing information

B&R Industrial Automation GmbH

B&R Strasse 1

5142 Eggelsberg

Austria

Telephone: +43 7748 6586-0

Fax: +43 7748 6586-26

office@br-automation.com