IMAGO TECHNOLOGIES

Hardware Manual

Vision Cam XM2
Vision Cam LM2

Version 1.5 – March 2025

1 Handling and Safety Instructions

Depending on the operating conditions, the housing temperature can exceed 60 °C. There is a risk of injury!

Electrical installation should be executed without power applied to the device and connected devices.

EMC conformity according to EN/IEC 61000-6-2:2005 is qualified for cable lengths ≤ 30 m.

Only open the housing if advised by IMAGO!

➔ Warranty void if product is opened without authorization by IMAGO.

Please take special note of the voltage range which may be applied to the device. Otherwise, permanent damage to the device may result!

Due to the characteristics and physical principles of flash memories, **SSDs have a finite lifetime** depending on the number of write operations. Therefore, take care of regular write operations to prevent early flash wear out.

2 Introduction

The heart of the *Vision Cam XM2* is the powerful NVIDIA Jetson Orin NX or Nano. It comes with up to 8 Arm cores and 1024 CUDA cores. The *Vision Cam XM2* incorporates different image sensors. We deliver the Vision Cam with an Ubuntu based Linux OS, which gives the customer the ability to use the popular Linux programs, libraries, and development tools.

The integrated Real-Time Communication Controller (*RTCC*) ensures proper timing for trigger signals, independently from the operating system. The IMAGO SDK provides a consistent C++ and Python programming interface for controlling the *RTCC*.

Due to its small size, powered by 24 V_{DC} and without fan, the Vision Cam can be mounted into nearly every machine. All components are available for several years for continuous delivery without changes. For series production, IMAGO delivers the Vision Cam ready-to-run, including a customer-specific Linux root filesystem and functional test. A PREEMPT_RT kernel is also available.

2.1 Main features

- NVIDIA Orin NX / Nano
  - 6 or 8-core Arm® Cortex®-A78AE v8.2 64-bit CPU
  - NVIDIA Ampere architecture with up to 1024 NVIDIA® CUDA® cores and 32 Tensor Cores
  - Up to 16 GB RAM
- Image sensors:
  - Lince 5M: 5.2 M pixels
  - Sony IMX 565: 12.4 M pixels
  - Sony IMX 567: 5.1 M pixels
  - Gpixel GL7004: 4096 x 4
- Real-Time Communication Controller
  - Controls vision- & automation-specific interfaces
    - Digital inputs and outputs
    - Encoder
    - Camera Trigger
  - Contains functional units for controlling I/Os in real time:
    - *Trigger unit*: creation of trigger signals, derived from other inputs (e.g. encoder)
    - *I/O Scheduler*: applies values stored in a FIFO to outputs in real time (based on trigger event, encoder position, or timer value)
    - *Multiplexer*: flexible connection of functional units with each other
  - Operates independently from Arm processor and OS
  - Easy-to-use high-level API for C++ and Python
- Interfaces
  - 1× Gigabit Ethernet
  - 4× digital output
  - 4× digital input
  - 1× RS-232, 2× optionally
  - 1× USB 2.0
  - RS-422 encoder input for *Vision Cam LM2* and *XM2* model “Line Scan”
- Storage
  - NVMe SSD ≥ 60 GB
- Housing
  - Passive cooling without heat sink
  - IP65 versions available
  - Lens mount: C-mount

2.2 Block Diagram

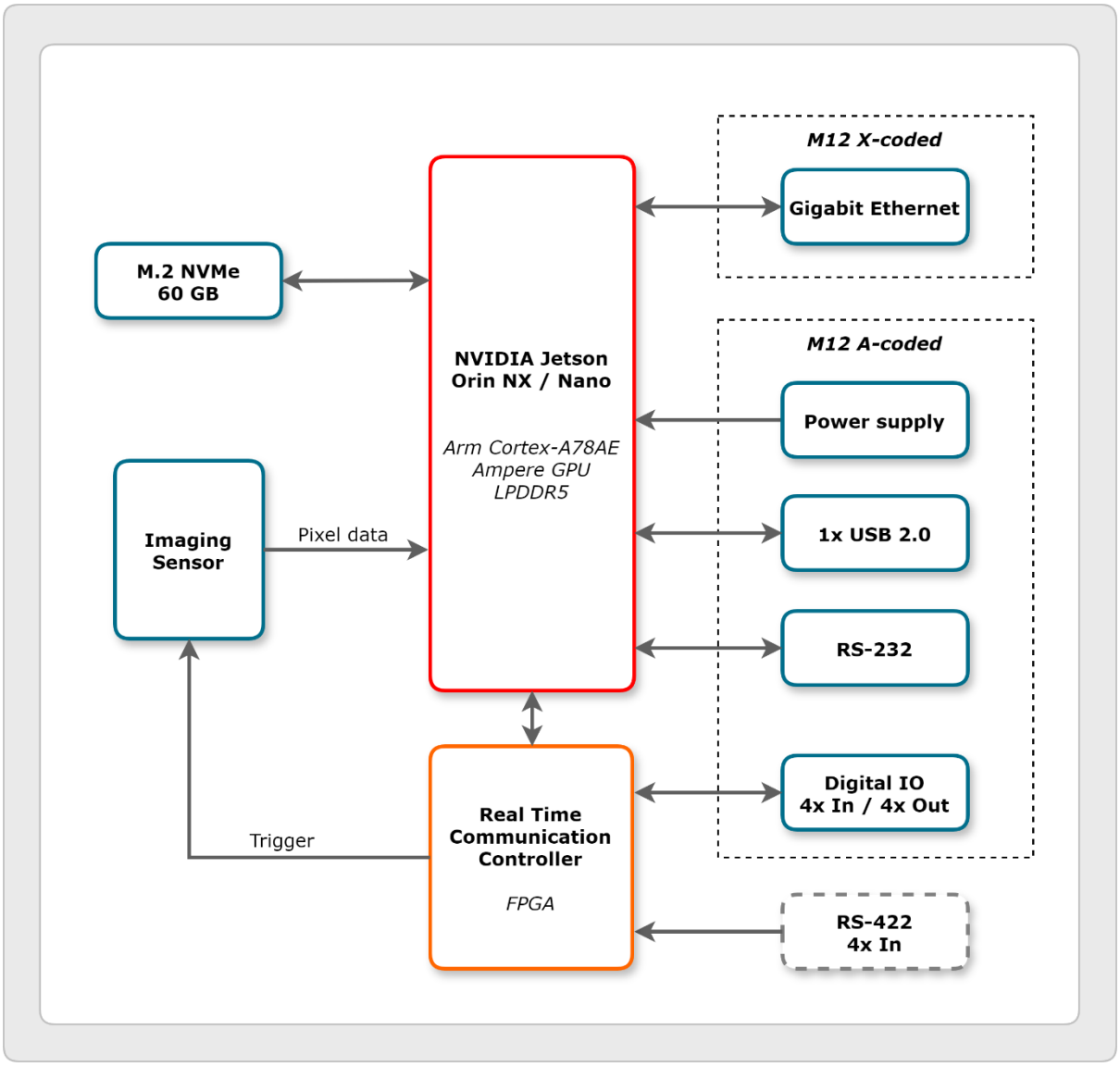


Figure 1: Block diagram

3 Technical Data

3.1 Configurations

	Vision Cam XM2		*Vision Cam LM2*
	Standard	*Line Scan*	
Sensor	IMX56x	Lince5M	Gpixel GL7004
Lens mount	C-mount		F-mount
Ethernet	1000BASE-T – M12		
Digital I/O	4 × IN / 4 × OUT		
RS-422	-	4 × IN	
RS-232	1 ×, optional 2 ×	1 ×	
USB	1 × USB 2.0		

3.2 Jetson Orin NX / Nano

The following Jetson Orin models are available for the *Vision Cam XM2 / LM2*:

	Jetson Orin Nano		*Jetson Orin NX*	
	4GB	*8GB*	*8GB*	*16GB*
CPU	6 cores, 1.5 GHz		6 cores, 2 GHz	8 cores, 2 GHz
GPU	512 NVIDIA® CUDA® cores, 16 Tensor Cores, 625 MHz	1024 NVIDIA® CUDA® cores, 32 Tensor Cores, 625 MHz	1024 NVIDIA® CUDA® cores, 32 Tensor Cores, 765 MHz	1024 NVIDIA® CUDA® cores, 32 Tensor Cores, 918 MHz
DL Accelerator	-	-	1x NVDLA v2.0, 614 MHz	2x NVDLA v2.0, 614 MHz
Vision Accelerator	PVA v2.0			
Memory	4 GB 64-bit LPDDR5, 34 GB/s	8 GB 128-bit LPDDR5, 68 GB/s	8 GB 128-bit LPDDR5, 102.4 GB/s	16 GB 128-bit LPDDR5, 102.4 GB/s
Storage	60 GB NVMe			
Module power limit	7…10 W	7…15 W	10…20 W	10…25 W

Table 1: Jetson Orin models

Note: The actual number of active cores and the frequency and power limits depend on the configured Power Mode for each Orin model.

3.3 Operating Conditions

Power Supply:

Parameter		Value	Unit
Supply voltage		18 … 30	V
Power supply current rating (values for 24 V)	Orin power limit: 7 W	0.8	A
	Orin power limit: 10 W	1	A
	Orin power limit: 15 W	1.3	A
	Orin power limit: 20 W	1.9	A
	Orin power limit: 25 W	2.2	A

Environment:

Parameter		Value	Unit
Operating temperature		0 … (see below)	°C
Storage temperature		-10 … +70	°C
Storage humidity, relative, non-condensing		5 … 95	%
Device weight	*Vision Cam XM2* without lens / tube	≈0.34	kg
	Vision Cam LM2 without lens	≈0.65	kg

Operating temperature:

The maximum operating temperature depends on many parameters like the configured power mode, system workload, mounting situation, and environment. Adequate cooling must be provided to maintain nominal performance. The temperature requirements should be verified for each application.

See also section *Thermal Considerations*.

RS-232:

Parameter	Min	Typ.	Max	Unit
RX signal input range	- 15		15	V
TX output voltage swing (R_L = 3 kΩ)	± 4.25	± 4.7		V
Data rate, R_L = 3 kOhm, C_L = 500 pF			1000	kbps

Digital Input:

Parameter	Min.	Typ.	Max.	Unit
Input voltage range	0		25	V
Rising edge threshold voltage	7.4		9.4	V
Falling edge threshold voltage	4.7		6.3	V
Input resistance		15.5		kΩ

Digital Output:

Parameter	Min.	Typ.	Max.	Unit
Output current			50	mA
Output high voltage		V_{Supply} - 0.2		V

RS-422:

Parameter	Min.	Typ.	Max.	Unit
Receiver differential input threshold	-200		200	mV
Receiver input hysteresis		45		mV
Receiver data rate			10	Mbps
5 V encoder supply output current			500	mA
12 V encoder supply output current			250	mA

3.4 Mass storage

The *Vision Cam* uses an integrated NVMe as mass storage device. It contains the Linux root file system and the user data.

3.5 Real-Time Clock

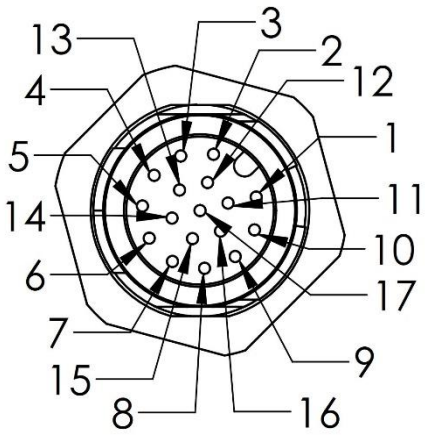
The *Vision Cam* provides a Real-Time Clock which is buffered by a supercapacitor. After powering the camera for one hour, it can maintain the time for about four weeks.

The time can be adjusted with Linux either manually, by an NTP server on the internet, or by a local NTP server.

4 Interfaces

4.1 Power and I/O connector

A 17-pin M12 A-coded male connector is used for power supply and I/O signals.



Pin Number	Function
1	GND (supply and I/O)
2	Power supply (+24 V)
3	RS-232 TX
4	RS-232 RX
5	Digital IN0
6	Digital IN1
7	Digital IN2
8	Digital OUT0
9	Digital OUT1
10	Digital OUT2
11	Digital OUT3
12	Digital IN3
13	USB D+
14	USB D-
15	UART_SEL[1]
16	RECOVERY[2]
17	VBUS (+5 V output)

We recommend shielded cables, for example:

Length	Product	IMAGO order code
1.5 m	Phoenix contact 1430284 “SAC-17P- 1,5-35T/FS SH SCO”	10004440
3 m	Phoenix contact 1430297 “SAC-17P- 3,0-35T/FS SH SCO”	10004441
5 m	Phoenix contact 1430307 “SAC-17P- 5,0-35T/FS SH SCO”	10004442

There are also angled and solder versions available.

[1] Pin 15 *UART_SEL:* controls UART routing, see section *RS-232* (not available for Lince5M models).

[2] Pin 16 must be left open for normal operation. Connecting pin 16 to GND during power-on will put the device into USB recovery mode, see section USB.

4.1.1 Digital I/O

The following illustration shows the electrical equivalent circuit for the digital input and output signals:

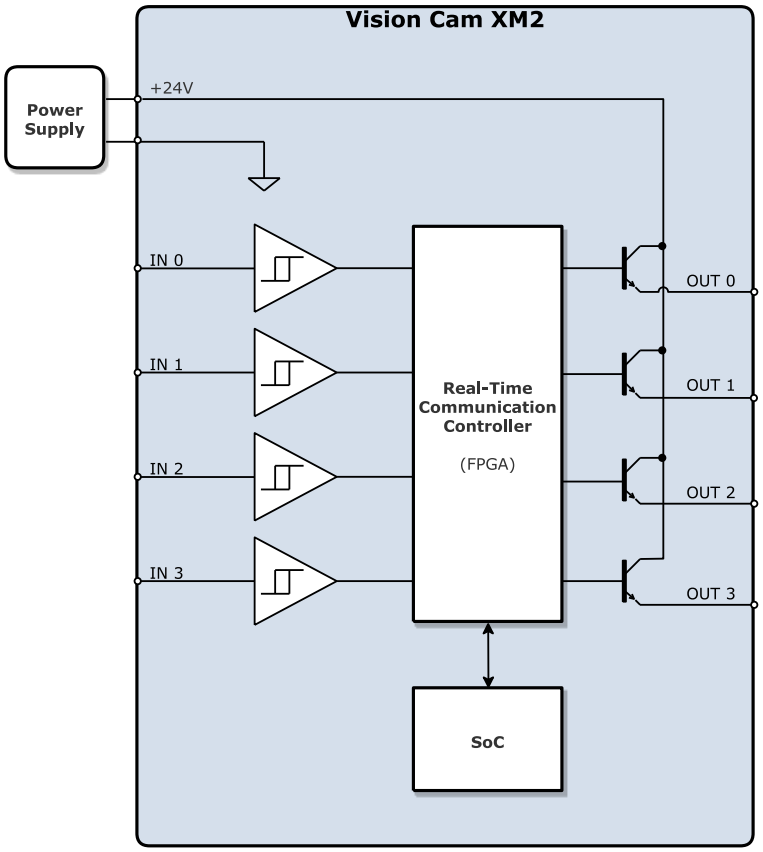


Figure 2: Simplified digital I/O circuit

The input signals use a Schmitt trigger circuit with the power supply GND as voltage reference.

The digital output circuit uses open-emitter configuration. All outputs are internally supplied by the 24 V power input.

4.1.2 RS-232

The TX and RX signals use the power supply GND pin 1 as reference potential. Make sure that the remote device is connected to the same GND reference.

After power on, the RS-232 interface transmits debug information about the boot process. The Linux kernel then uses it as the system console. After Linux has booted, it can also be used by custom applications (*/dev/ttyTCU0*).

Please note that the UART settings for */dev/ttyTCU0* can't be changed, because the device internally uses the *Tegra Combined UART* (TCU), which multiplexes information from different processors in the system:

Setting	Value
Baud rate	115200 bps
Parity	None
Data bits	8
Stop bits	1
Flow control	None

Pin 15 *UART_SEL* controls the routing between UART and the RS-232 connectors. This feature is not available for Lince5M models:

I/O Pin 15	I/O Pin 3/4	D-SUB RS-232 (if present)
Open (default)	*/dev/ttyTCU0*	*/dev/ttyTHS1*
GND	*/dev/ttyTHS1*	*/dev/ttyTCU0*

4.1.3 USB

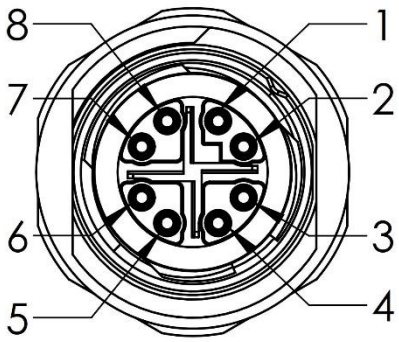
A USB device can be connected to pins 13 (D+) and 14 (D-). The interfaces support High-Speed signal rate of 480 Mbit/s. Pin 17 provides +5 V power supply to the device (max. 900 mA). Long cables > 3 m should be avoided if the USB interface is used.

USB recovery mode:
Connecting pin 16 to GND during power-on will put the device into USB recovery mode. This is indicated by a green blinking power LED.

Only use this mode if advised by IMAGO. Do not try to flash the Jetson OS image provided by NVIDIA!

4.2 Gigabit Ethernet / M12

The *Vision Cam* uses an 8-pin M12 X-coded female connector for Ethernet.

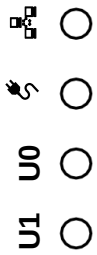


Pin Number	Function
1	D1+
2	D1-
3	D2+
4	D2-
5	D4+
6	D4-
7	D3-
8	D3+

Shielded cables are recommended, for example:

Length	Product	IMAGO order code
1 m	Phoenix contact 1407471 “NBC-MSX/ 1,0-94F/R4AC SCO”	10007049
2 m	Phoenix contact 1407472 “NBC-MSX/ 2,0-94F/R4AC SCO”	10007050
5 m	Phoenix contact 1407473 “NBC-MSX/ 5,0-94F/R4AC SCO”	10008076

4.3 Status LEDs



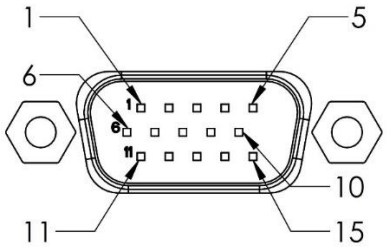
LED	Color	Function
	Green	Ethernet link is up
	Red	Ethernet activity
	Green	Power On
	Green blinking	USB recovery mode
	Red	Power off
U0	Green	User LED 0
U1	Green	User LED 1

4.4 RS-422 / D-Sub 15HD

A D-Sub 15HD male connector providing four RS-422 inputs is available for the following models:

- *VisionCam XM2* “Line Scan”
- *VisionCam LM2*

The inputs are typically used with a rotary encoder.



Pin	Function
1	IN1-
2	IN2-
3	IN3-
4	Reserved
5	5V DC output
6	GND
7	IN1+
8	IN2+
9	IN3+
10	Reserved
11	IN0+
12	IN0-
13	Reserved
14	Reserved
15	12V DC output

Connector pins 5 and 15 provide a 5 V / 12 V power supply for RS-422 encoders. See chapter 3 for current limits.

Do not insert a plug while the device is powered. There is a risk of making a short circuit on the supply output pins with the connector shield.

4.5 RS-232 / D-Sub 9 (option)

The optional male 9-pin D-Sub connector for the *Vision Cam XM* provides an additional RS-232 interface without flow control.

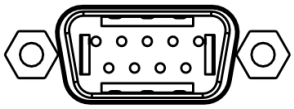


Figure 3: RS-232 D-Sub connector

Pin	Function
1	N/C
2	RX
3	TX
4	N/C
5	GND
6	N/C
7	N/C
8	N/C
9	N/C

The TX and RX signals use the GND pin as reference potential. Make sure that the remote device uses the same GND reference. A null modem cable is required to connect the *Vision Cam* to another PC.

Pin 15 *UART_SEL* on the I/O connector can be used to change the UART routing, see section *RS-232*.

5 Image Sensors

The following sensors are available for the *Vision Cam XM2 / LM2*:

	Teledyne Anafocus Lince5M	Sony IMX565	Sony IMX567	Gpixel GL7004
Type	Monochrome or Bayer pattern			Quad color line sensor (RGBW)
Optical format	1”	1/1.1”	1/1.8”	APS-C
Resolution	2560 × 2048	4096 x 3008	2432 x 2064	4096 x 4
Frame rate / Line rate	165 Hz	42 Hz	96 Hz	Single line (W): 211 kHz Tripple line (RGB): 70 kHz Quad line (RGBW): 53 kHz
Lens mount	C-Mount			F-Mount

5.1 Teledyne Anafocus Lince5M

Overview:

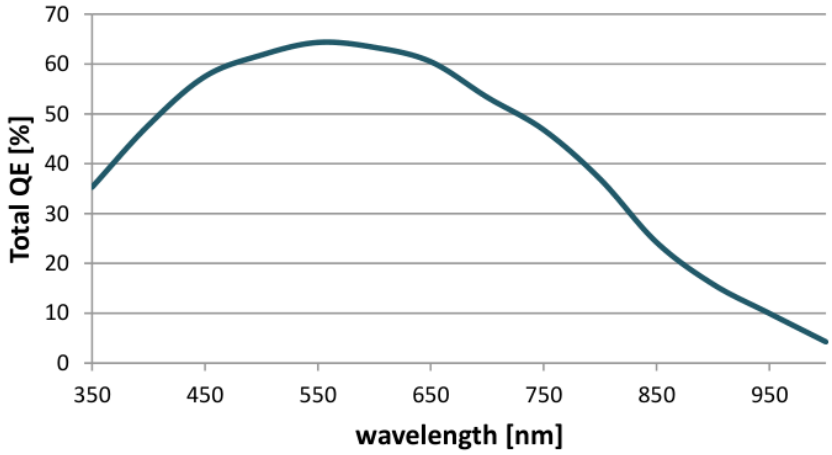
- Full resolution: 2560 × 2048
- Global Shutter
- Monochrome or RGB Bayer pattern
- Partial scan function (AOI) to increase the frame rate, e.g.:
  - 1216 × 680 @ 1000 fps
  - 2048 × 2 @ 32600 fps ➔ suitable for line scan applications

Sensor	Technology	CMOS
	Optical Format	1"
	Resolution	2560 × 2048 pixels
	Framerate (full resolution)	165 fps
	Partial Scan	Yes
	Color	Monochrome or Bayer pattern
	Pixel Size	5.0 µm × 5.0 µm
	A/D Converter	12-bit
	Exposure	1 µs …
	Digital Gain	0 … 8

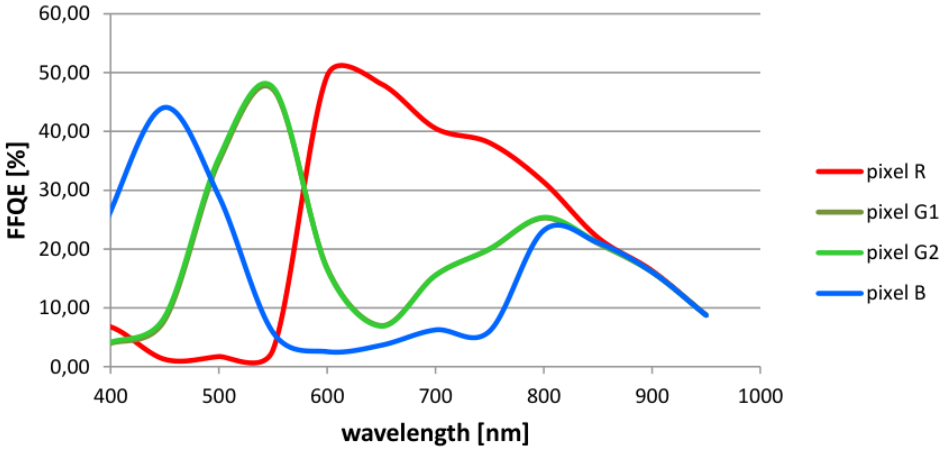
Characteristics	Sensitivity	6 V / lux-s
	DSNU	50 e-/sec, 10 DN12/sec
	PRNU	0.5 %
	Dynamic Range	58 dB
	SNR	42 dB

Trigger	Trigger Modes	Free Run, SW-Trigger, HW-Trigger via *RTCC*
	Exposure Indicator output	Yes

Total Quantum Efficiency – Monochrome sensor



Color Filter Response – Color sensor



Note:

The use of an IR cut-off filter in the optical path is necessary to obtain good color separation when using light with an NIR component.

5.2 Sony IMX56x

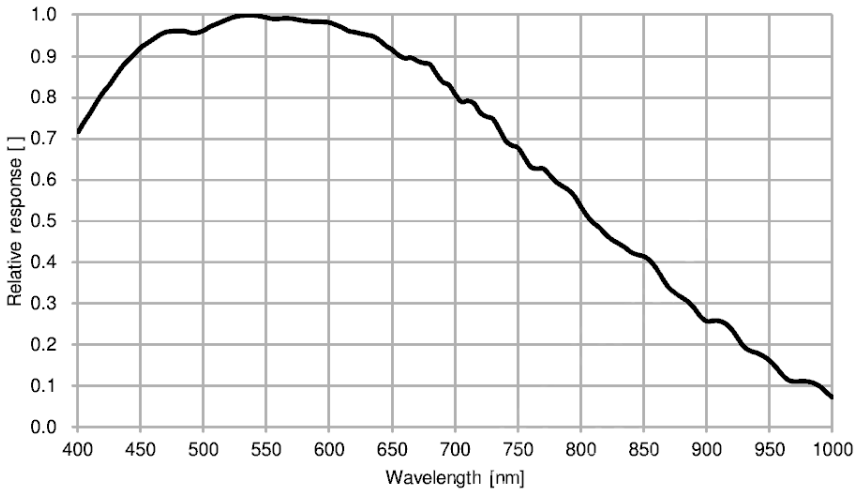
Overview:

- IMX565: 12.4 M pixel
- IMX567: 5.1 M pixel
- Global Shutter
- Monochrome or RGB Bayer pattern
- Partial scan function (AOI) to increase the frame rate

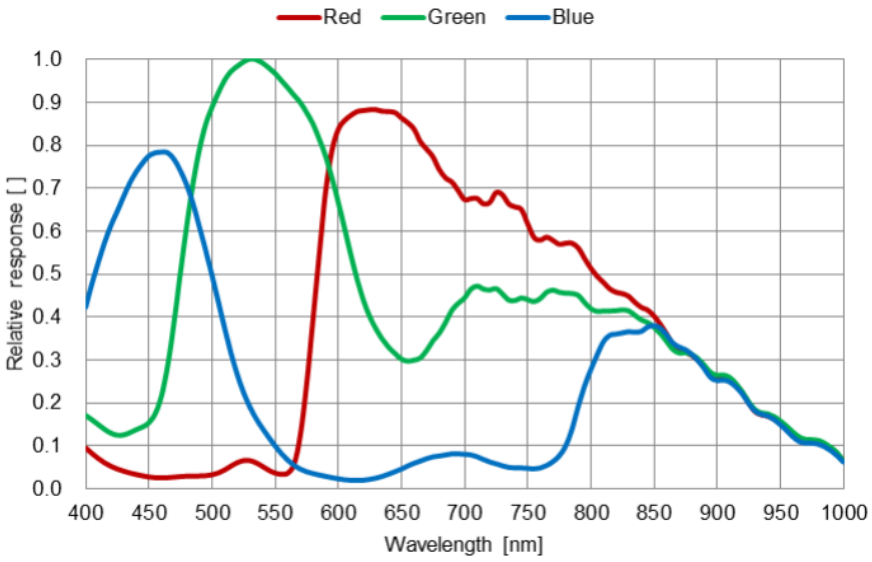
		IMX565	**IMX567**
Sensor	Technology	CMOS	
	Optical Format	1/1.1"	1/1.8"
	Resolution	4096 x 3008	2432 x 2064
	Framerate (full resolution)	42 fps	96 fps
	Partial Scan	Yes	
	Color	Monochrome or Bayer pattern	
	Pixel Size	2.74 µm × 2.74 µm	
	A/D Converter	10-bit, with linear or compressed mapping to 8 bit	
	Analog Gain	0 … 24 dB	

Trigger	Trigger Modes	Free Run, SW-Trigger, HW-Trigger via *RTCC*
	Exposure Indicator output	Yes

Total Quantum Efficiency – Monochrome sensor



Color Filter Response – Color sensor



Note:

The use of an IR cut-off filter in the optical path is necessary to obtain good color separation when using light with an NIR component.

5.3 Gpixel GL7004

Overview:

- High-speed quad color line sensor: 4096 x 4 (RGBW)
- Global Shutter
- Automatic black level correction
- Shading Correction
- Lookup Table for 10-bit to 8-bit mapping

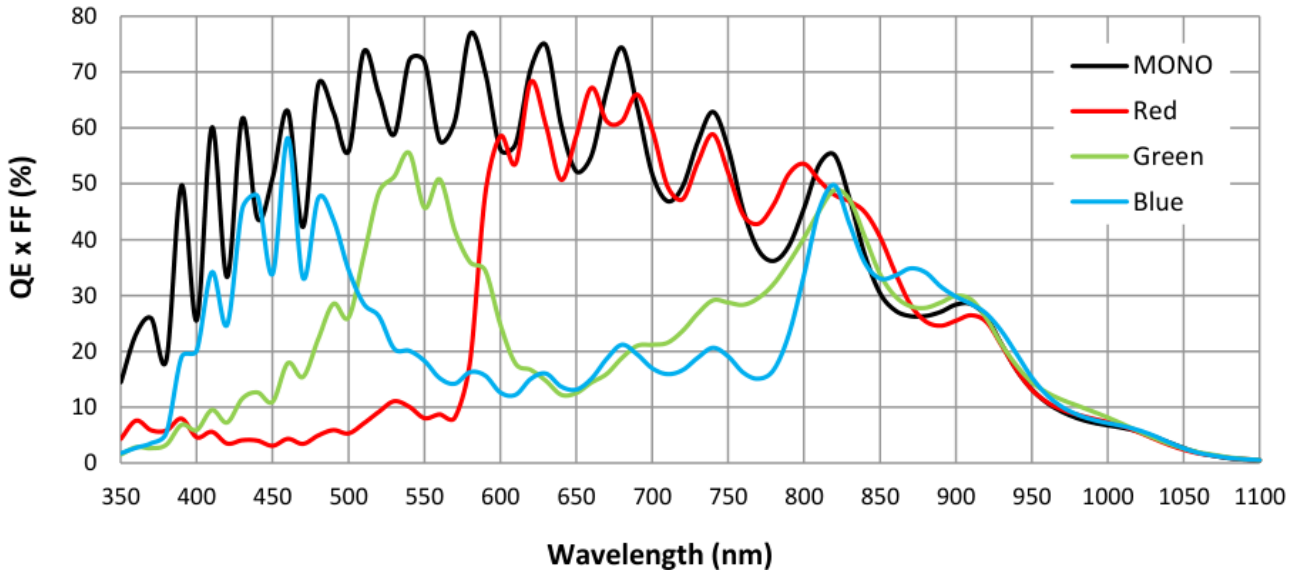
Sensor	Technology	CMOS
	Optical Format	APS-C
	Resolution	4096 x 4 (RGBW) Active lines are selected depending on the pixel format.
	Line rate (full width)	Single line (W): 211 kHz Tripple line (RGB): 70 kHz Quad line (RGBW): 53 kHz
	Pixel size	7 µm × 7 µm
	A/D converter	10-bit
	Analog gain	x1 … x4
	Other features	Horizontal flipping, adjustable readout direction

Characteristics		Analog Gain x1	Analog Gain x4
	Conversion factor	0.09 DN / e^-	0.34 DN / e^-
	Full well capacity	10.5 ke^-	2.7 ke^-
	Max. SNR	40.2 dB	34.3 dB
	Temporal dark noise	8.8 e^-	4.3 e^-
	Dynamic Range	61.5 dB	55.9 dB
	QE @ 580 nm	76.8 %	
	DSNU (full scale)	3.3 e^-	2.6 e^-
	PRNU (full scale)	1.4 %	2.1 %

FPGA processing	Automatic offset correction	Based on dedicated black pixels
	Shading correction	Gain value for each sensor pixel
	Digital gain	x1 … x4 (for each sensor line / color)
	Line delay	Adjustable for compensation of physical displacement of the sensor lines.
	Binning	Horizontal: off / 2 / 4 Vertical: off / 2

Trigger	Trigger Modes	Free Run, Trigger via *RTCC*
	Exposure Indicator output	Yes

Spectral Response



6 Mechanical Drawings

6.1 Vision Cam XM2 – Standard model

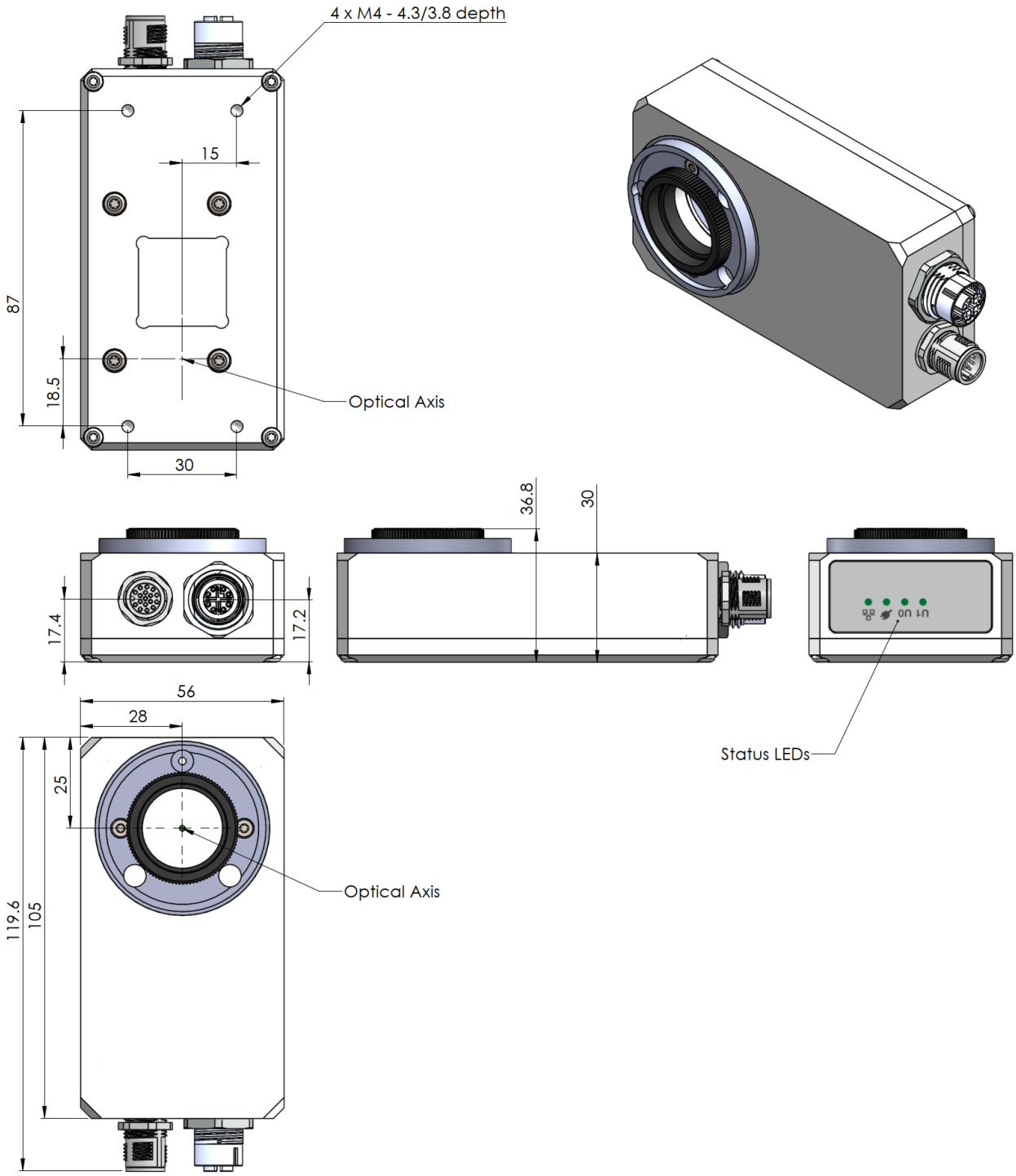


Figure 4: Dimensions for the *Vision Cam XM2* (standard model)

6.2 Vision Cam XM2 – D-Sub model

A D-Sub connector is provided for the following *VisionCam XM2* models:

- *VisionCam XM2* "Line Scan" with RS-422 interface: D-Sub 15HD
- *VisionCam XM2* with optional RS-232 interface: D-Sub 9

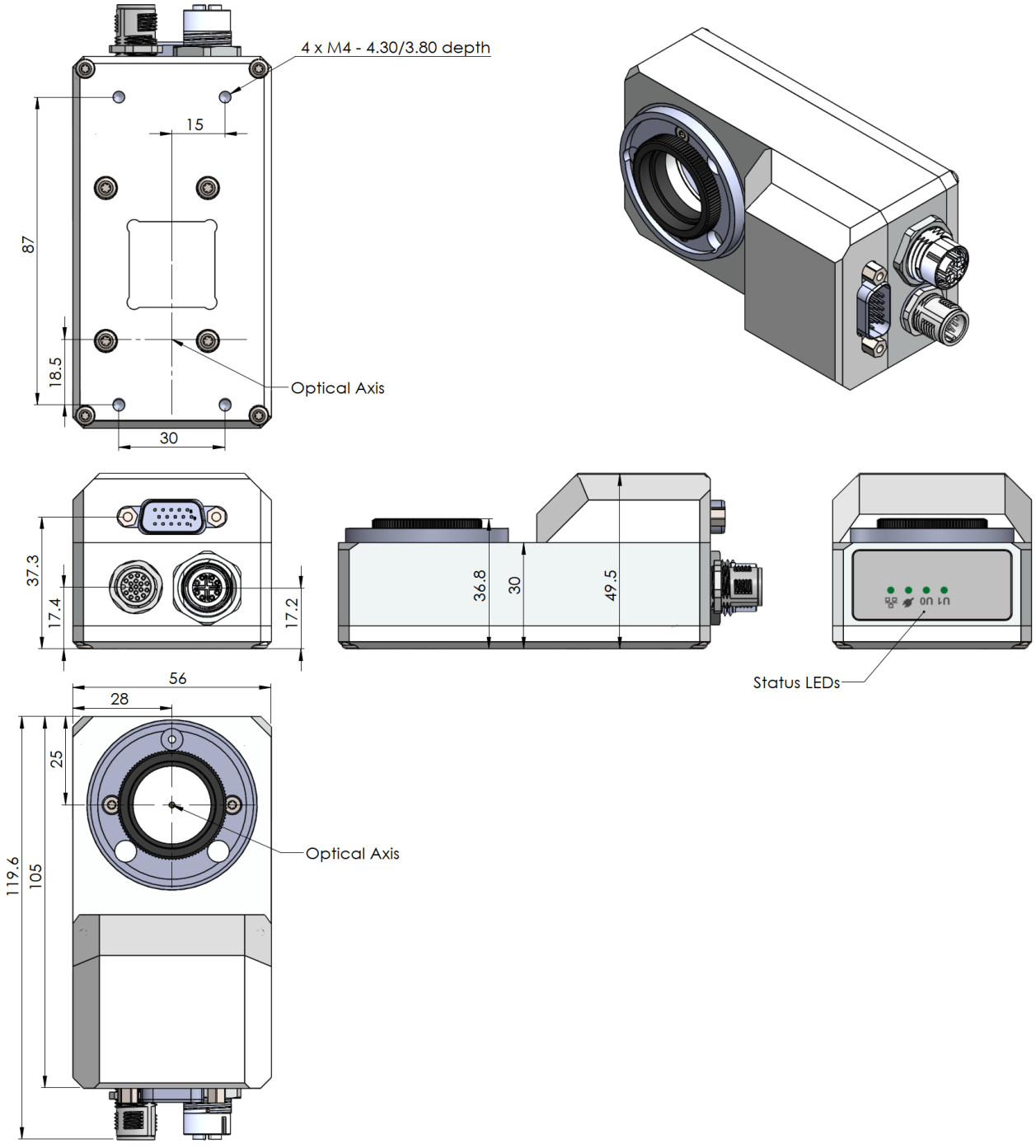
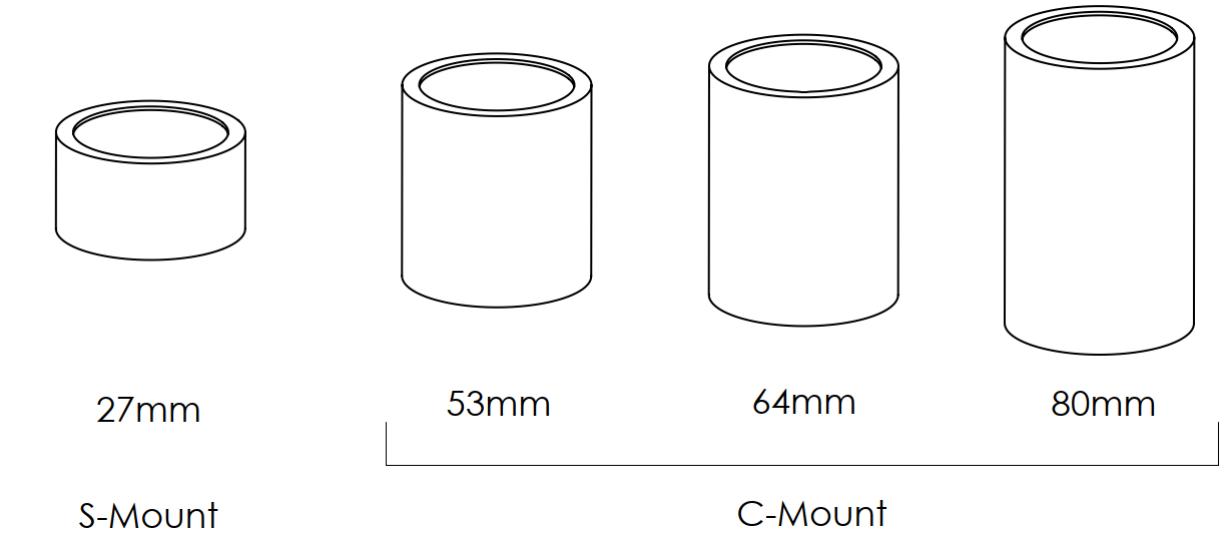


Figure 5: Dimensions for the *Vision Cam XM2* with D-Sub connector

6.3 Vision Cam XM2 – Lens tubes



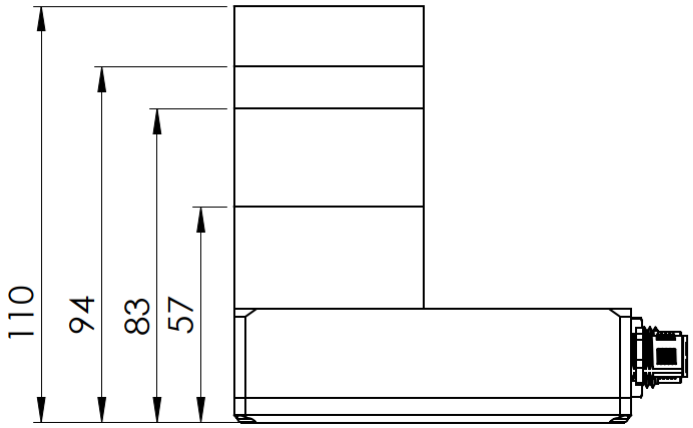


Figure 6: Available tube heights for the *Vision Cam XM2*

6.4 Vision Cam LM2

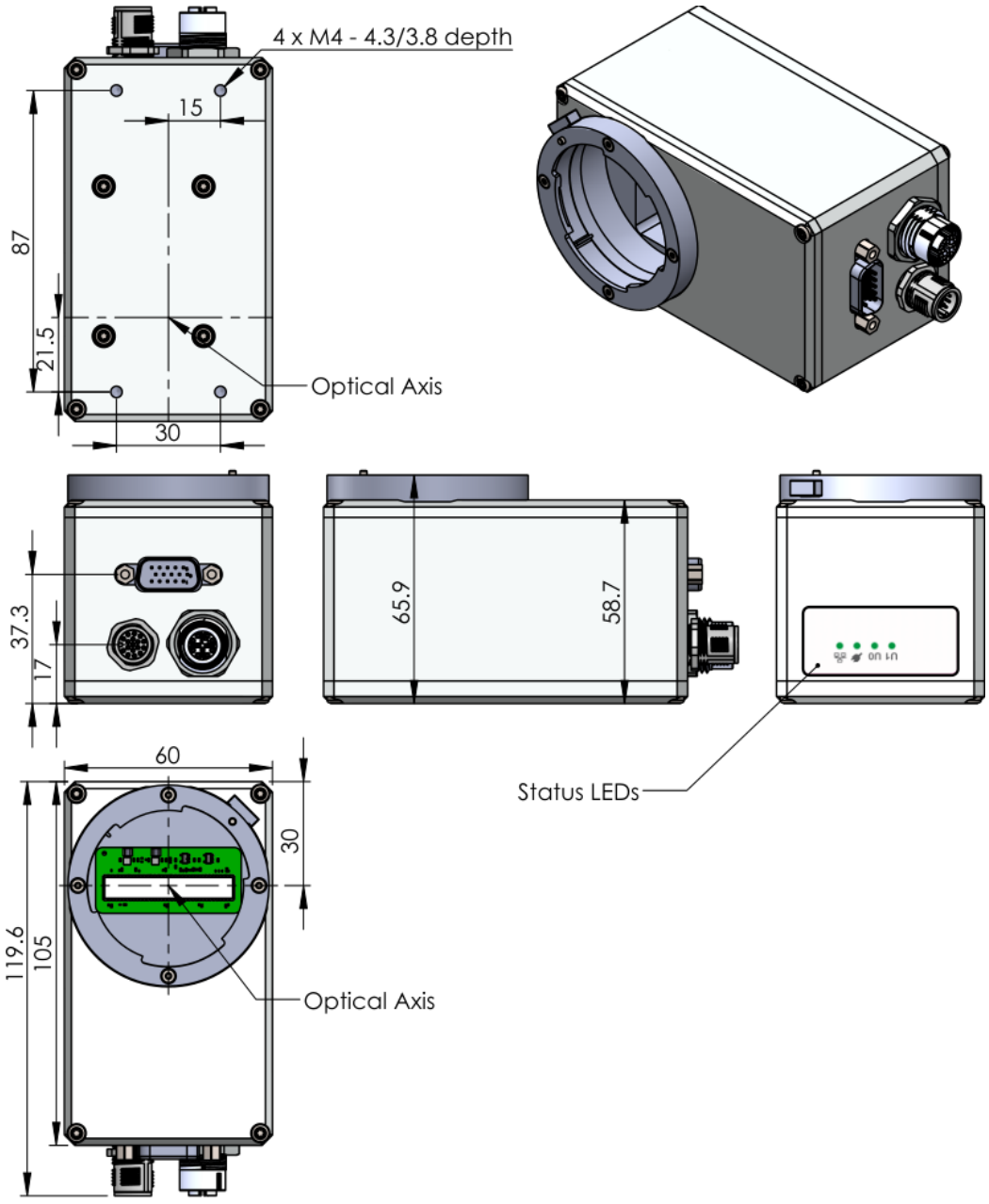


Figure 7: Dimensions for the *Vision Cam LM2*

7 Thermal Considerations

Ensuring specified quality, producing reproducible results, and maintaining flawless operation depend on many factors, among which one is operating temperature. Reliable operation requires observing the maximum limit of thermal stress imposed on the electronic components. Thermal zones and trip points are used to throttle or shutdown the system when the temperature of internal units reaches certain values.

The relationship between the environment temperature and the internal thermal zones depends on many parameters and should therefore be verified by the user:

- Utilization of hardware units by the application (CPU, GPU, sensor, …)
- Selection of the Orin Power Mode: each mode provides a different power budget by limiting the number of CPU cores used and the frequency for CPU, GPU and other SoC units
- Mechanical mounting situation
- Environment: temperature and air flow

More information about thermal trip points and Jetson Power Modes can be found in the *Vision Cam XM2* Linux OS documentation available at https://api.imago.tech:

- Thermal considerations
- Jetson Power Modes

7.1 Mechanical mounting recommendations

Heat dissipation depends on the following factors:

- Temperature difference between the device, connected components and the environment
- Mount shape and material
- The thermal properties of the installation the device is mounted to
- Air flow

Heat conduction occurs on surfaces that are in contact with other components of the system. On the remaining surfaces, the heat is dissipated from the camera by means of radiation and convection.

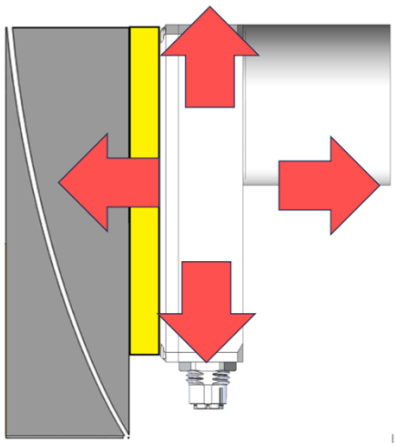


Figure 8: Heat dissipation

7.1.1 Material

High-conductive material is ideal, as it helps transferring the heat away from the device, whereas low-conductive material impedes heat dissipation. Select a well-conducting material such as aluminum, copper, or brass. Stainless steel (A2, A4 or SUS) is less suitable. Insulating materials like plastic or wood are not recommended.

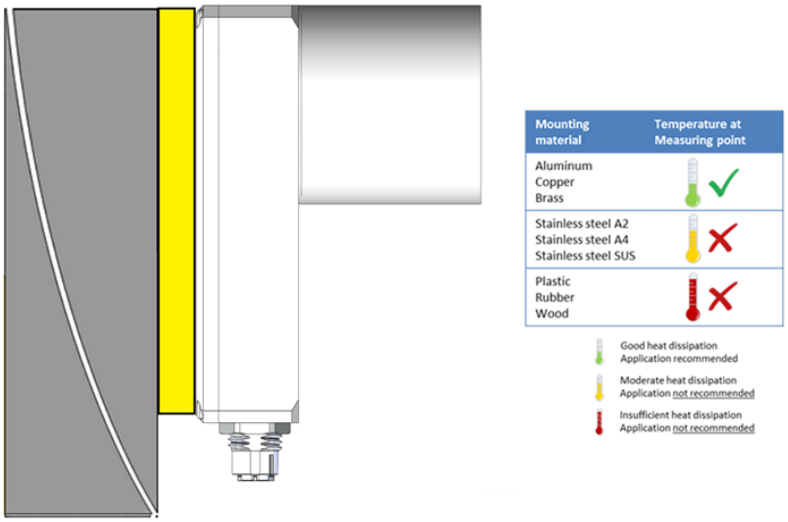


Figure 9: Material choice for the *Vision Cam XM2* holder

For applications where insulating materials are unavoidable, additional cooling may be necessary, e.g. by using active cooling.

7.1.2 Geometry / Contact Surface

Another factor which significantly influences heat dissipation is the geometry of the mounting fixture. The contact surface area has a direct effect on thermal resistance and therefore heat dissipation. Therefore, a good choice of the holder material does not guarantee good thermal conduction. The shape of the material should also be designed carefully.

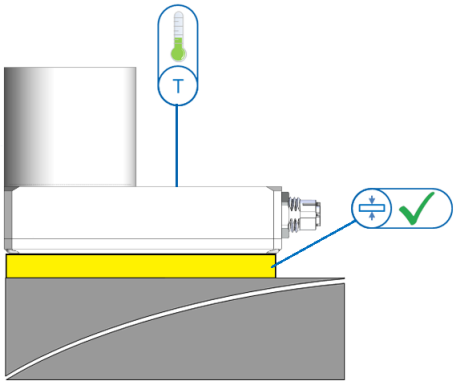


Figure 10: Large contact surface improve heat dissipation

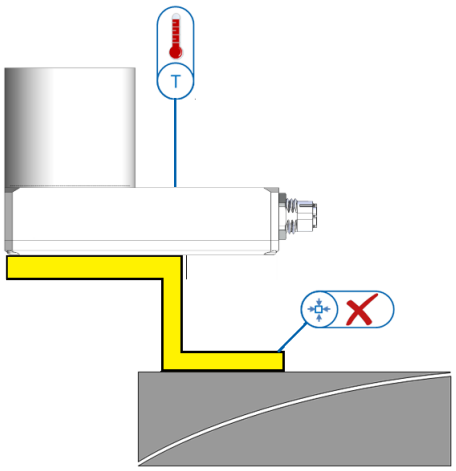


Figure 11: Small contact surface hamper efficient heat dissipation

7.1.3 Material Thickness

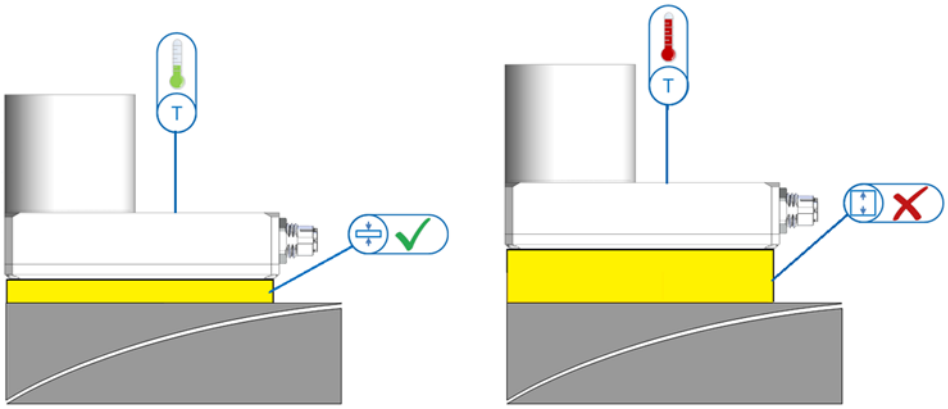


Figure 12: Material thickness influence heat dissipation, thicker holder extends heat dissipation path

Shorter conduction path between the device and installation results in better heat dissipation. Thin materials transport heat much faster than thick ones, therefore a mounting fixture should be as thin as possible.

7.1.4 Length

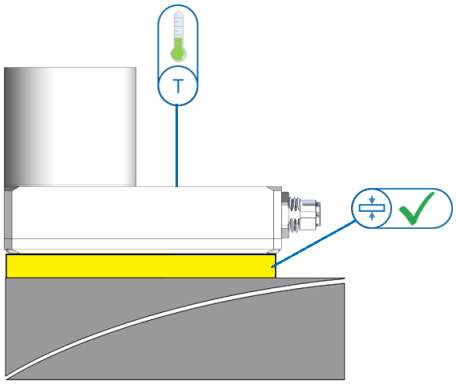


Figure 13: Short holders aid fast head dissipation with conductive surfaces

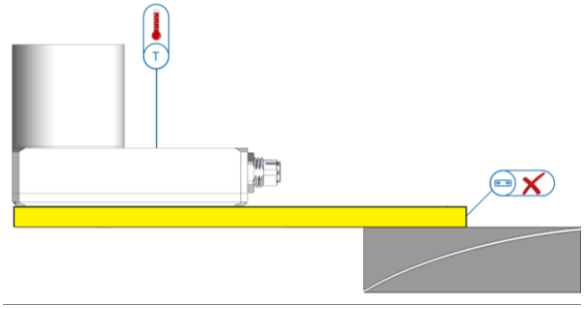


Figure 14: Long holders prevent fast heat dissipation due to extended heat path

Conductive path between the device and high-conductive surfaces must be kept as short as possible.

But thermal connection to low-conductive surfaces might benefit from thicker and longer holder designs. The latter might seem counterintuitive, but allow improving heat dissipation by

1. Absorbing and shortly retaining a certain amount of heat which
2. dissipates via the larger surface.

7.1.5 Summary

1. Efficient heat dissipation is crucial for correct operation of the *Vision Cam.*
2. The contacting surface area should be as large as possible.
3. When a holder is mounted onto high-conducting surface, the setup benefits from shorter heat path to the surface (thinner and shorter holder).
4. When a holder is mounted onto low-conducting surface, the setup benefits from longer heat path to the surface (thicker and longer holder).
5. Heat sinks or active cooling is not necessary for most applications if the camera mount is designed properly.

8 Support

Finally, if you have any open questions, the IMAGO support team is happy to assist you in any cases. For direct contact to the support, please use our ticket system: https://imago.freshdesk.com

The SDK documentation is available online: https://api.imago.tech

Visit the IMAGO Download Portal to get access to the latest documentation and Linux releases: https://www.imago-technologies.com/technical-documentation

9 History

Revision	Date	Changes
1.5	March 2025	Add *VisionCam LM2* with Gpixel GL7004
1.4	December 2024	Add Sony IMX56x models
1.3	August 2024	Update chapters *Thermal Considerations* and *RS-232*
1.2	February 2024	Add section *Thermal Considerations*
1.1	September 2023	Add missing information in section *Operating Conditions* Add mechanical drawing of Encoder Version.
1.0	July 2023	Initial release