Photoneo | Focused on 3D

Photoneo 3D Sensors

User Manual

Preface

Thank you for choosing the Photoneo® 3D Sensor. Please, take a few minutes to read this manual and become familiar with the device.

For more information on our products, accessories, replacement parts, software, and services, see our website www.photoneo.com, or contact our team at Help Center.

Purpose of the Manual

This manual provides information about the installation and setup of the Photoneo 3D Sensors and is designed for engineers, installers, and electricians who possess a general knowledge of automation.

Scope of the Manual

The manual provides information about the **Alpha 3D Scanner**, **PhoXi 3D Scanner**, and **MotionCam-3D (Color)** product lines. All models will be referenced as a *"3D sensor"*. For the full reference of Photoneo products, visit the website www.photoneo.com.

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Legal Information

Warning Notice System

This user manual contains notices that should be observed to ensure personal safety, as well as prevent damage to equipment. The notices referring to personal safety are highlighted with a safety alert symbol, while notices referring only to equipment do not have a safety alert symbol. The notices are graded according to the degree of danger.

⚠ **WARNING**
Indicates that death or severe personal injury may result if proper precautions are not taken.

⚠ **CAUTION**
When a safety alert symbol is shown, it indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
When no safety alert symbol is shown, it indicates that equipment damage can result if proper precautions are not taken.

NOTICE
Indicates that an unintended result or situation can occur if the relevant information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger is used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to equipment damage.

Qualified Personnel

The device described in this documentation may be operated only by **qualified personnel**. Qualified personnel means those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with this device.

Installation, commissioning, use, decommissioning, and disposal of this device should be done following relevant documentation, in particular, its warning notices, and safety instructions.

Photoneo 3D Sensors are either Laser Class 3R or Laser Class 2 devices. More information is available in section Projection Unit Properties and Compliance with Standards sections.

Proper Use of Photoneo Products

Please note the following:

⚠ **WARNING**
Photoneo products may only be used following relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Photoneo. Proper transport, storage, installation, assembly, commissioning, operation, and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions for storage or operation of the device must be complied with. All information provided in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of Photoneo s.r.o. The remaining trademarks in this publication may be trademarks that could violate the rights of the owner when used by third parties for their purposes.

Products Overview

Photoneo provides two main families of 3D area scanning devices:

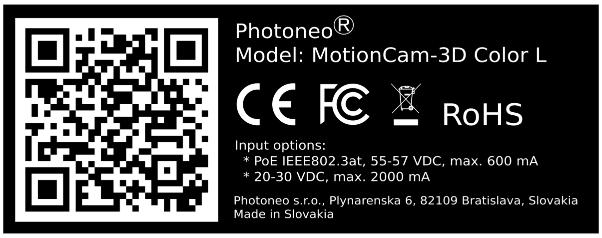
MotionCam-3D (Color) is a high-accuracy and high-resolution snapshot 3D area scanning device for large work areas that can be in arbitrary motion. The product is based on a patented CMOS sensor and Parallel Structured Light technology developed by Photoneo. It provides the scanning quality of sequential structured light devices with the ability to scan dynamic scenes.

PhoXi 3D Scanner and **Alpha 3D Scanner** use a sequential structured light projection to reconstruct the 3D surface geometry of a static scene or object at very high resolution and quality.

All Photoneo 3D sensors provide onboard calculations of the data which are provided to the user in multiple data formats: depth map, point cloud, normals, and confidence. Data are transferred to the computer running the driver software (see section PhoXi Control) via a 1Gbps Ethernet connection.

Product Identification

The device description and the manufacturer can be located on the back panel of the device.



Label with manufacturer address, product name, and model, CE, FCC, WEEE, and RoHS marks, country of origin, and input options.

Laser Device

⚠ WARNING

This device is a laser product. Do not deliberately look into the laser beam. This may cause injury to the retina. The use of protective eyewear is normally not necessary. The laser class label is present on the back of the device.

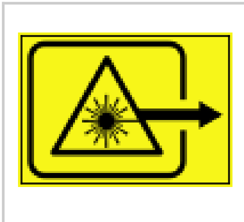
The laser projector aperture is located on the right side of the front panel of the device (Figure 1). The aperture is marked with a warning label. Do not look directly into the laser projector while the device is in use. Laser Class and Laser parameters used in our devices are discussed in the chapter Projection Unit Properties.

To avoid unauthorized contact with the scanner or unintentional viewing of the laser beam, it is recommended to locate the device in a restricted area and take measures to restrict laser light exposure to the surroundings. Although diffuse reflections are not harmful, users should remove mirrors, polished objects, and similar items from the vicinity of the scanner to avoid specular reflections.

All components of the device, including those sourced from 3rd party suppliers, conform fully with all applicable European directives and regulations.

Figure 1: Photoneo scanning device laser aperture location

Laser radiation hazard warning symbol.

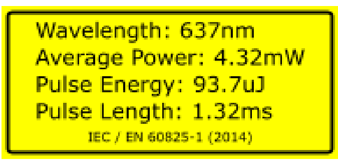


Laser aperture label. Designates the place from which laser radiation is emitted.

The device uses the following labels and warning systems. Apart from the laser aperture label, all are located on the back panel of the device.

Laser Class 3R devices

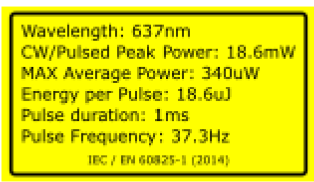
Laser radiation warning with laser class label. The serial number of the device can be found above the warning labels.



Label specifying wavelength, average power, pulse energy, and pulse length of the laser.

Laser Class 2 devices

Laser radiation warning with laser class label. The serial number of the device can be found above the warning labels.



Label specifying wavelength, average power, pulse energy, and pulse length of the laser.

Objects Suitable for Scanning

Photoneo 3D sensors are measurement devices working on the principle of optical triangulation. Modulated light projected from the projection unit is reflected by the scanned object and captured by a camera unit based on which the distance to the object is computed.

For **PhoXi 3D Scanners** and **Alpha 3D Scanners**, which operate the principle of sequential structured light, the scene must be completely static during the scan.

For **MotionCam-3D (Color)**, which uses the revolutionary and patented principle of Parallel Structured Light™, the scene can be in arbitrary movement or vibration.

As both systems rely on the reflection of projected light, objects most suitable for scanning are (including and not limited to):

- rough surface objects, for example, wood, rubber, paper, plaster, etc.,
- objects with a matte finish, such as sand-blasted aluminum, cast iron, etc.,
- molded, un-polished plastic materials,
- fruits, foods, skin, textiles, plants.

Some objects not suitable for scanning (including and not limited to):

- mirrors and polished metals,
- most liquids (e.g. water, oil),
- translucent and transparent objects (e.g. glass, transparent plastic).

Smoke and particles dispensed in the air still negatively influence the 3D data.

Scope of Delivery

- Selected model of Photoneo 3D Sensor
- Desktop PoE injector (input: 90 ~ 264 VAC, output: 33.6 W, 56 V, IEEE802.3at) with power cable (1.8 m)
- Ethernet cable M12-X male - RJ45 male, 5 m, PUR
- Quick Start Guide and Datasheet

NOTICE
Software components are needed for the operation of the scanner. See section Configuration for more information.

Installation

Guidelines for Installation

A Photoneo 3D sensor is designed to allow easy installation.

The device can be mounted[1]:

- Using a mounting plate of suitable size and 4 M4 screws.
  - This is the preferred mounting method to ensure rigid mounting of the device to avoid unwanted movement
- Using an M8 screw.
- On a tripod using a 3/8-16 UNC screw.

To install the device:

1. Mount the device using any preferred method. Refer to Dimensions and Illustrations.
2. When mounting the scanner, ensure that an appropriate scanning distance is set between the scanner and the scanned object and eliminate any potential obstacles.

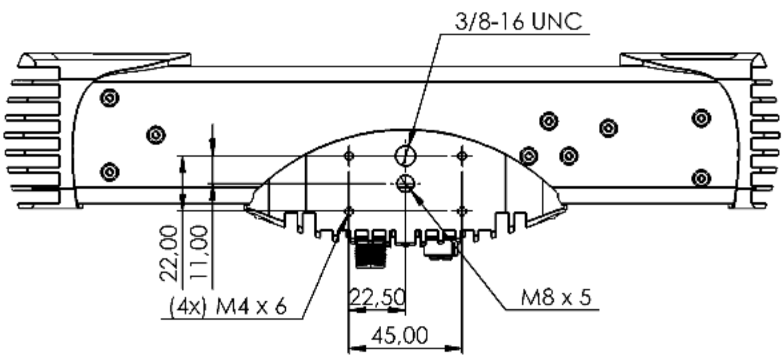


Figure 2: Mounting plate

3. Connect the device to the computer or local network and plug it into the power. See the section Powering the device & Data connection for more details.
4. Download and install the PhoXi Control application from the Photoneo webpage.
5. Run the PhoXi Control application and try to make your first scan. Please refer to the PhoXi Control user Manual at https://photoneo.com/kb/pxc.

⚠ WARNING
Hot surface warning The surface of the processing unit becomes hot to touch when the device is in use. Mount the device on a metal mounting plate that will act as a thermal bridge to dissipate the heat or use the carbon body to manipulate the device.

[1] A CAD models of the Photoneo 3D Sensors are available at: Device Resources - Photoneo

Powering the Device & Data Connection

There are two possibilities for how to power the device:

1. Using the M12-X Power over Ethernet (PoE) connector (providing both power and data connection)
2. Using the M12-A 24 V power connector to power the device and the M-12X connector for data transfer

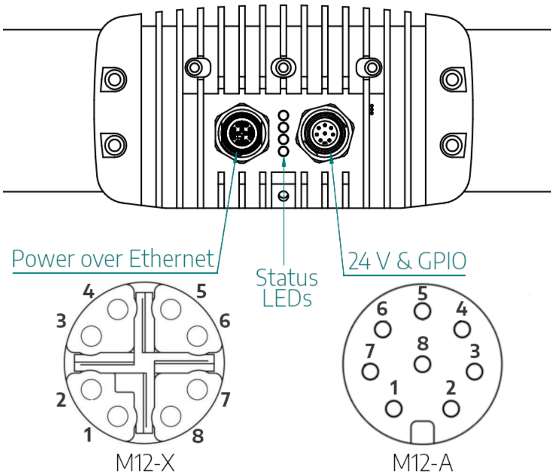


Figure 3: Back panel of the Photoneo scanning device

Powering Through PoE Connector

1. Connect 1 Gbps capable (standardly delivered) Ethernet cable to the PoE injector IN (data+power) port
2. Connect the M12-X RJ45 cable to the scanner and to the PoE injector OUT (data) port
3. Plug in the power cable of the PoE injector

NOTICE
It is recommended to use a PoE connection to power the device.

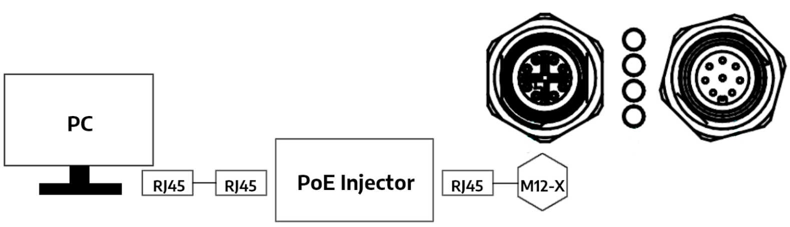


Figure 4: Connection schematics for PoE

Powering by 24 V

1. Connect the Ethernet M12-X RJ45 cable to the device and to your computer or switch

2. Connect the M12-X RJ45 cable to the device and to your computer or switch
3. Connect the M12-A cable to the device and to the adapter and plug in the 24 V power adapter
4. Alternatively, connect the M12-A cable to the device and the open-end wires to the 24 V DIN rail adapter

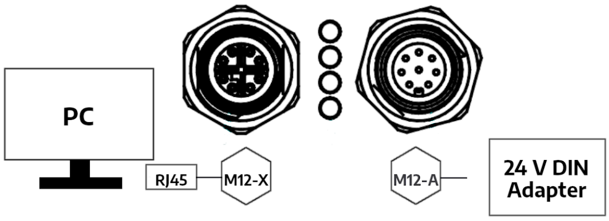


Figure 5: Connection schematics for 24 V power using DIN rail adapter

External Grounding

Safety purposes

The body of the device is constructed from conductive materials: aluminum and carbon. These materials are coated with non-conductive lacquer or anodized aluminum. However, this doesn't necessarily imply that they serve as effective electrical protective layers. Therefore, relying on them for electrical protection is not assured.

Equipotential bonding is made to protect operators against electric shock. It does not allow two different device's chassis to have different voltages on them. Connecting these chassis with a conductive wire will bring those chassis to the same voltage potential and protect the operator against electric shock (and protect against ESD as well). Voltages of both chassis will be equal and the operator won't get hurt by touching both of those devices at the same time.

The point of equipotential bonding is the ground terminal of the building. This is because the Electrical network is (in TT, TN, TNC, and TNC-S cases) tied to the ground. If a dangerous voltage appears on the device chassis, the error current will flow through the ground fault circuit interrupter (GFCI) and switch off the voltage.

EMI reduction

Even though grounding and bonding our sensor is not primarily made for EMI (Electromagnetic interference) reduction purposes, in certain cases, it can improve the EMI behavior of the device. The idea is that the conductive chassis will form a Faraday cage, which will lead the induced current by a path of the smallest impedance to the ground (it is assumed that the intrusive device is connected with the ground directly or by chassis capacity).

To achieve the smallest impedance we should follow these rules.

- The Grounding wire must be as thick and as short as possible.
- The grounding wire must be as narrow as possible.
- The grounding wire should not be tangled. If the scanner should be moving during the operation, make a half loop only to relax cable bending stress.

Try to use star topology by connecting the grounding wire of our device directly to the grounding point. Avoid connecting multiple sensors in series.

Avoid ground loops (chassis ground connected in more than one point, for example, the cable shielding and the chassis ground) as they can form loop antenna and pick up unwanted noise more effectively. If so, the chassis ground should be disconnected at one point to break the loop.

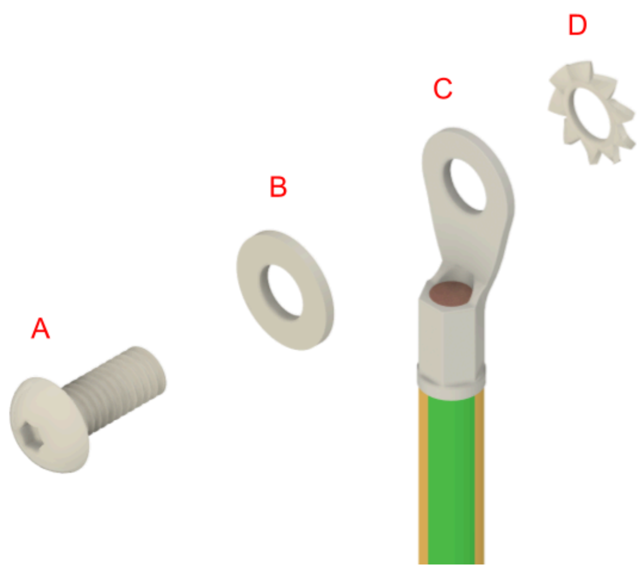
Avoid long or tangled grounding wires. They have higher inductance(and therefore impedance) and are not able to ground high frequencies properly. They can even worsen the EMI.

Required tools:

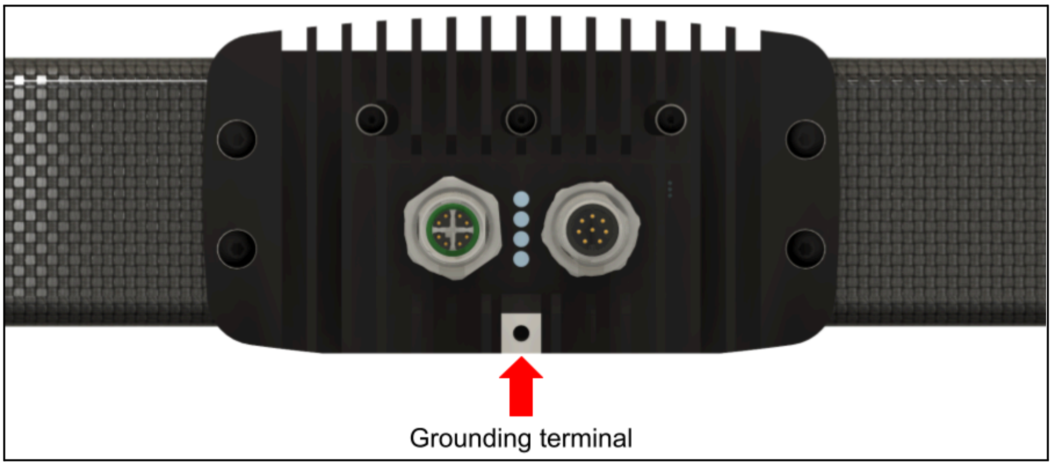
- 1x Screw M4X10mm (A) - The screw must be long enough to hold washers and lug, But not too long since the hole is blind and has limited depth.
- 1x Flat washer (4mm hole) (B) - it will make a hard support for a soft cable lug. It will improve the contact quality.
- 1x Cable lug (4mm hole) © - 2.5-6mm cable (according to the cable used). Lug will manage a good contact between our device and the cable. Lug cable size must be chosen properly, otherwise, the cable won't be holding well and contact will be poor.
- 1x Fan washer (4mm hole) (D) - this one will bite through aluminum anodization and make good conductive contact.
- Screwdriver which will fit the used screw-head.
- Lug/cable crimping tool.
- AWG11 Copper-stranded wire of the required size (the shorter the better). Use yellow/green stripe-colored wire as this is the color of a protective conductor according to IEC 60446 standard.

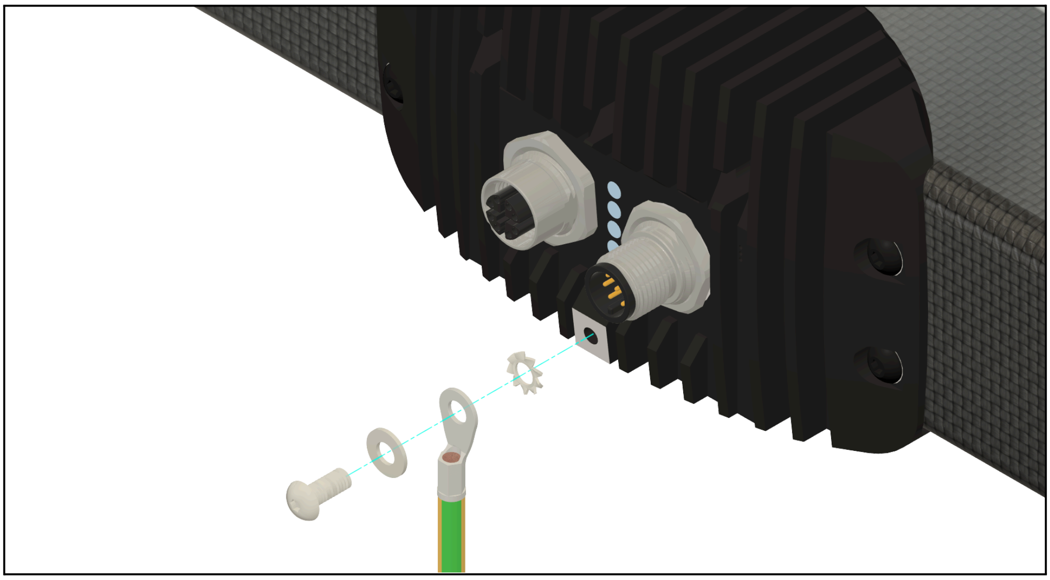
Instructions:

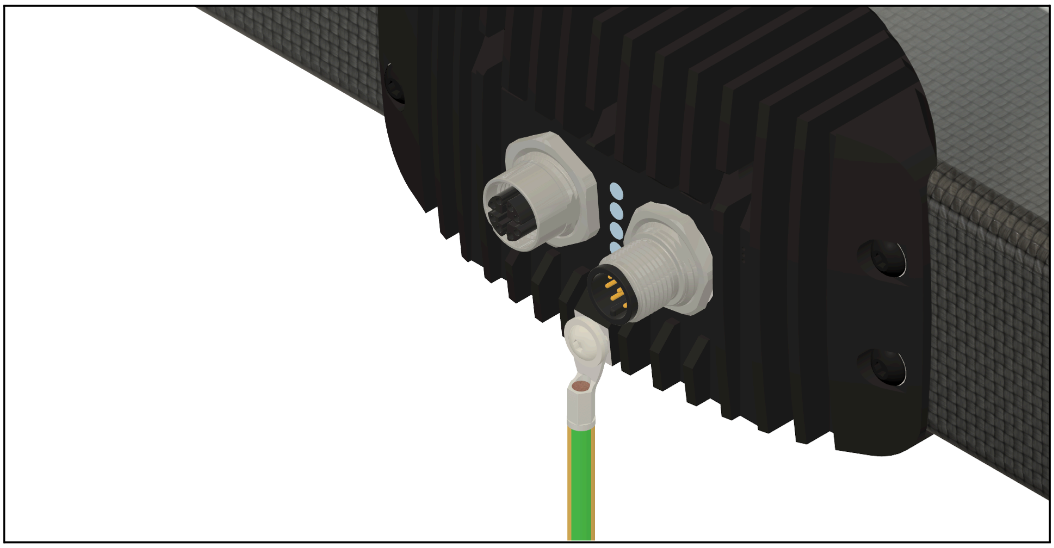
- Crimp the lug on the cable, and prepare the screw and washers according to the picture. The fan washer will be in between the scanner and the lug. Its purpose is to bite through the anodized layer and make good contact.



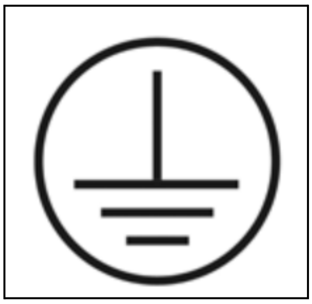
- Here is the place where the *Grounding terminal* is located. Older devices do have this terminal covered with an anodized layer (therefore it is black, not silver).







- Tight the screw at the recommended 1.3 Nm moment. The cable lug should not be able to rotate. Do not over-tighten the bolt or the thread in the aluminum body might get damaged.
- Connect the device to the grounding terminal in the building. Protective ground should be marked with the following symbol.



Protective ground symbol

Status LEDs

#	LED Name		Color	Description
1	POWER		Green Red Off	Power ON and OK Power ON, power on processing unit not OK No power
2	STATUS		Green Orange Red	Firmware ready Device occupied HW fault
3	ETH1		Flashing green Green Off	Activity on the link No activity on the link Link is down
4	ETH2		Green Off	Gigabit ethernet connected No gigabit ethernet

Figure 6: Status LEDs of a device working correctly

Supported Network Topologies

The following network topologies are supported by the Photoneo 3D sensors:

- Direct connection to a computer

Figure 7: Direct connection

- The sensor connected to a switch

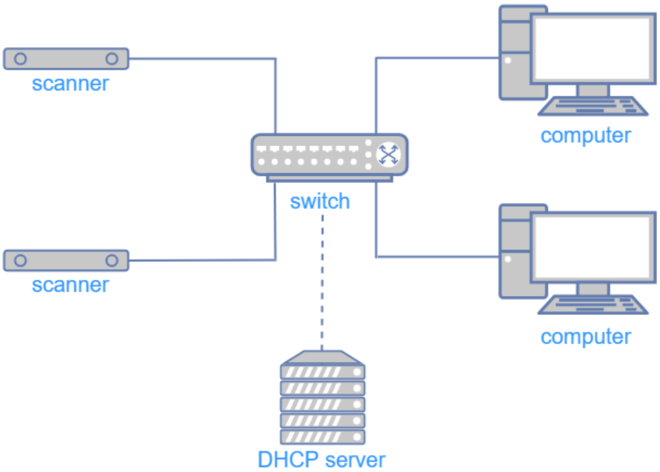


Figure 8.1: Connected to a switch

The following network topology is not supported by the Photoneo scanning device:

- The sensor connected to a router:

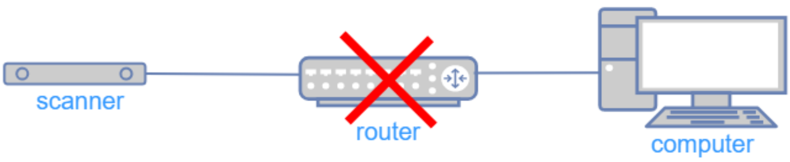


Figure 8.2: Connecting the scanner through a router is not supported

Note:

- Connecting to the scanner via WiFi is not recommended as it is slower and less reliable.

NOTICE
If several 3D sensors are connected to a computer with several ethernet adapters, using static IP addresses on different subnets is recommended.

Mounting Restrictions

Using external casing for additional Ingress Protection

To protect the device from harsh environmental conditions (high/low temperatures, dust, water jets), it is possible to use an external enclosure.

See the instructions for the IP67 enclosure developed for Photoneo 3D Sensors at
IP67 enclosure

The effect of the additional (planar) optical element (glass) in front of the device can be split into

- a small translation of the point cloud towards the scanning device when compared to the case without the presence of the additional optical element,
- a distortion, which is in most practical cases negligible.

Displacement characterization (for a glass of 3 mm thickness)	Scanner Model			
	S	M	L	XL
Translation [mm]	1.140	1.140	1.127	1.124
RMSQ of distortion [mm]	0.090	0.088	0.088	0.092
Max. distortion [mm]	0.216	0.220	0.208	0.202
Max. local relative distortion [promile]	1.9	1.4	0.7	0.4
Max. local rotation [angular minute]	9.5	6.3	3.5	1.9

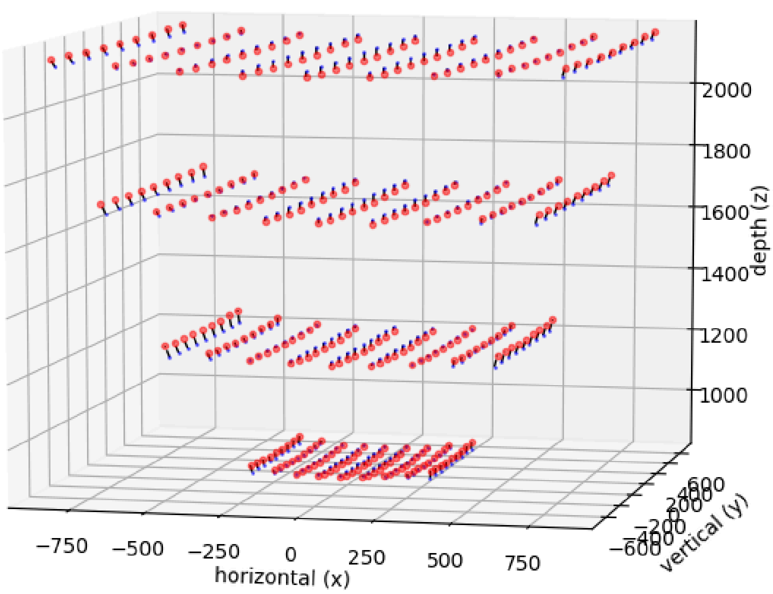


Figure 9: Point cloud distortion for scanner L with casing magnified 200 times (thickness = 3.0mm)

Movement During Scanning

In general, MotionCam-3D (Color) can be mounted on moving constructions or robotic arms, as it can capture dynamic scenes as well as static scenes. The device itself as well as the scenes can be in motion or vibrating.

It is possible to mount the PhoXi 3D Scanner on moving constructions or robotic arms, however, it is necessary to stop the movement during the acquisition. Movement of the scanner during the projection of light patterns causes a loss of quality and interferes with depth calculation. Make sure the device and the scanned area are still during the acquisition.
If vibrations are present, use a damping apparatus to isolate the scanner's mounting from the source of the vibrations. Acceleration and deceleration forces according to the scanner's environment restrictions should be taken into account when designing the mount for the scanner. The maximum acceleration allowed during operation (not including the scanning process) is up to 20 ms^{-2}.

Strong Electric Field

As a general rule, always isolate low-voltage, logic-type devices such as Photoneo 3D sensors from devices that are high voltage and generate high electrical noise. Carefully consider the routing of the wiring for the devices in the panel as well. Avoid placing low-voltage signal wires and communication cables in the same tray with AC power wiring and high-energy, rapidly-switched DC wiring.

Clearance for Cooling and Wiring

Photoneo 3D Sensor is designed to be cooled through natural convection cooling. In order to ensure adequate cooling, a clearance of at least 25 mm around the device must be allowed. When planning the placement of the Photoneo 3D Sensor, consider placing heat-generating and electronic-type devices in the cooler areas. By reducing exposure to high-temperature environments, you can extend the operating life of electronic devices considerably.

NOTICE
It is recommended to mount the device on a metal plate that will act as a thermal bridge and dissipate the heat produced by the processing unit away from the scanner.

Turning Off the Device

Before turning off the device, make sure it is not actively scanning - the device is not projecting laser patterns. Turn it off by unplugging it from power.

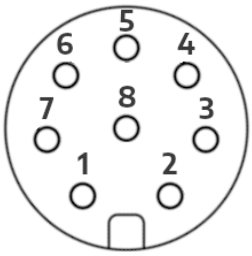
NOTICE
It is not recommended to unplug the device from the power while it is actively scanning. This is to prevent possible damage to the projection unit.

Laser Safety Interlock

NOTICE
Not all devices have the Laser Safety Interlock feature. This feature must be enabled per request at Photoneo premises before shipping.

To operate the device, it is necessary to supply a high signal (5-24V) on the Pin 8 (OPTO_IN2) on the 24V connector. If no power is present (low signal) on Pin 8 (OPTO_IN2), the projection unit will not emit light.

Please, refer to the Powering the Device & Data Connection subsection for full powering instructions. Laser Safety Interlock can be used in combination with PoE or 24V powering.



24 V connector - view from the mating side

Wire number	Color	Function
1	White	DC_IN:+ 24 V
2	Brown	**OPTO_IN2_GND: laser interlock ground**
3	Green	ground
4	Yellow	-
5	Grey	-
6	Pink	-
7	Blue	-
8	Red	**OPTO_IN2: laser interlock signal 5 - 24 V**

Configuration

Photoneo sensors can be operated via a dedicated application - PhoXi Control or other GigE Vision-compatible 3rd party applications. PhoXi Control application enables users to control Photoneo 3D Sensors manually via a GUI or by a computer program using the provided API or GenICam interface. Alternatively, Photoneo sensors can run in GigE Vision compatible mode in which PhoXi Control cannot be used.

PhoXi Control

The GUI is primarily used to set up the scanning environment, configure advanced scanner parameters, and visualize the output. In addition, the GUI can also be used as a powerful debugging tool for development with the API. Calls to the API trigger the same response in the GUI as user inputs. After triggering the scan by calling the API method, the application will execute the scan, send it as an output of the call, and display it simultaneously in the GUI.

The API serves as a central platform for building custom applications for Photoneo 3D Sensors. In order to facilitate the development process and reduce computing demands, all computations are performed on the device itself.

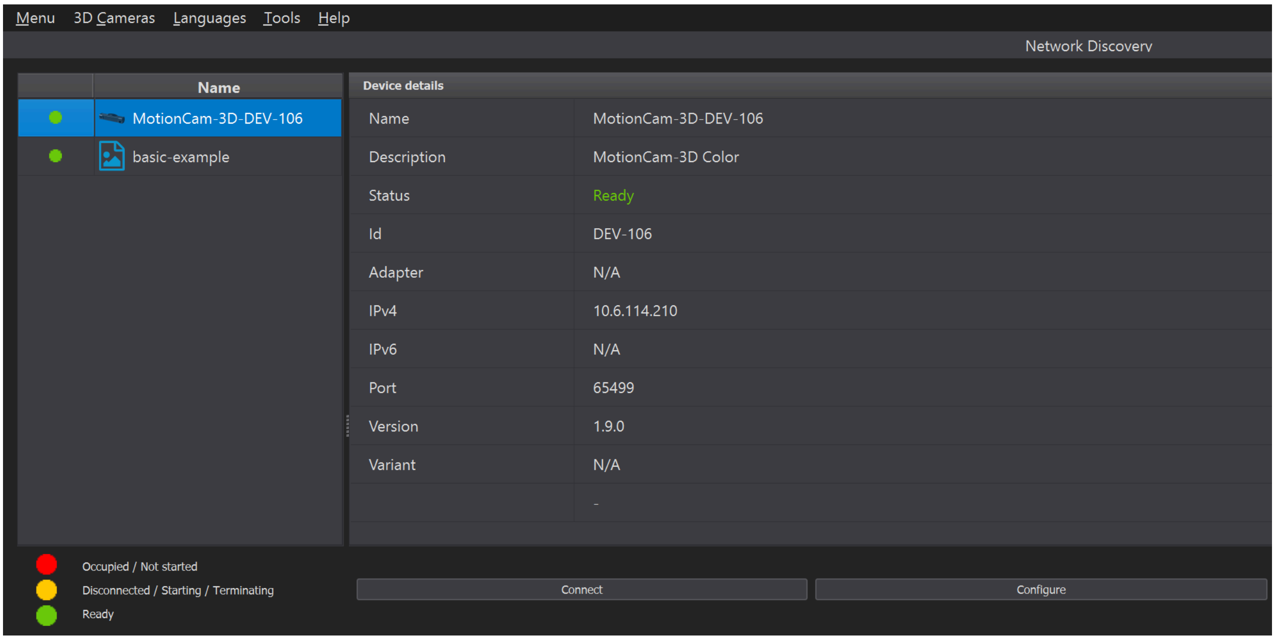
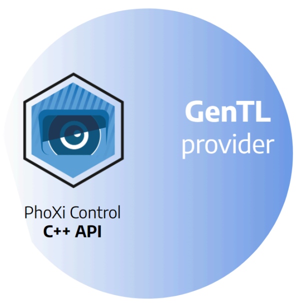


Figure 10: PhoXi Control – Network Discovery

GenICam interface

The Generic Interface for Cameras standard is the base for plug-and-play handling of cameras and devices. It was developed by the European Machine Vision Association (EMVA)



GenICam support is provided via the GenTL library that works as a wrapper around PhoXi Control C++ API. PhoXi Control has to be running to use the GenICam interface.

You can download the latest version of PhoXi Control and the PhoXi Control User Manual from our website at https://www.photoneo.com/downloads/phoxi-control/. User guides for GenICam integrations contain more detailed information and requirements for running the examples.

GigE Vision

GigE Vision is a high-speed communication protocol and interface standard that is designed for transmitting data over Ethernet networks. Third-party software with GigE support can be used to operate Photoneo 3D Sensors without a running instance of PhoXi Control.
User guides for GigE integrations contain more detailed information and requirements for running the examples.

Hardware Parameters

Powering the device

The following subsections explain different options for powering a Photoneo 3D Sensor. In case both PoE and 24 V connector (M12-A) are used to power the device, PoE is prioritized.

Power Over Ethernet Connector

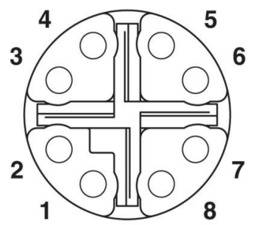


Figure 11: PoE connector pinout, view from the mating side

Connector type: M12 X coded, 1404741

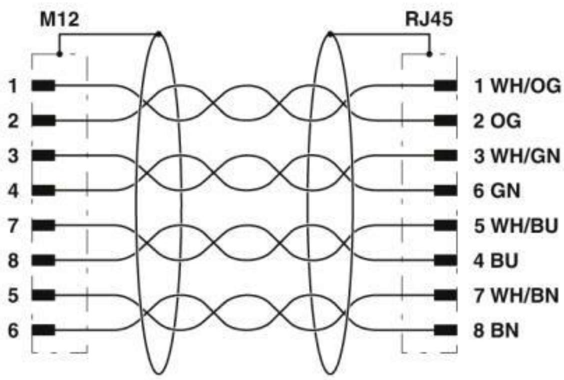


Figure 12: Contact assignments of the M12 and RJ45 plug

Powering Requirements

PoE Standard	IEEE802.3at
Operating voltage U_e DC	min. 55 V
Residual ripple maximum (% of U_e)	0.5 %
Rated operating current I_e (I_{max})	0. 360 A (0.6 A)
Minimum Power	33 W
Shielding	Fully Shielded RJ45

Transfer data rate	1 Gbit
Maximum recommended cable length	20 m

24 V Power Connector (M12-A)

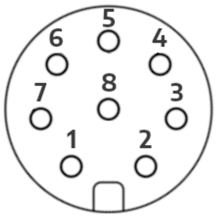


Figure 13: 24 V Power & GPIO pinout, view from the mating side

Connector type: M12 A coded, M12A-08PMMP-SF8001

Pin	Pinout	Function
1	DC_IN	+ 24 V
2	OPTO_IN2_GND	*laser interlock ground
3	GND	ground
4	OPTO_IN1	hardware trigger input signal (5 - 24 V)
5	OPTO_IN1_GND	hardware trigger input ground
6	OPTO_OUT	hardware trigger output signal (5 - 24 V)
7	OPTO_OUT_GND	hardware trigger output ground
8	OPTO_IN2	*laser interlock signal (5 - 24 V)

* Laser interlock safety feature must be enabled per request at Photoneo premises before shipping.

Powering Requirements

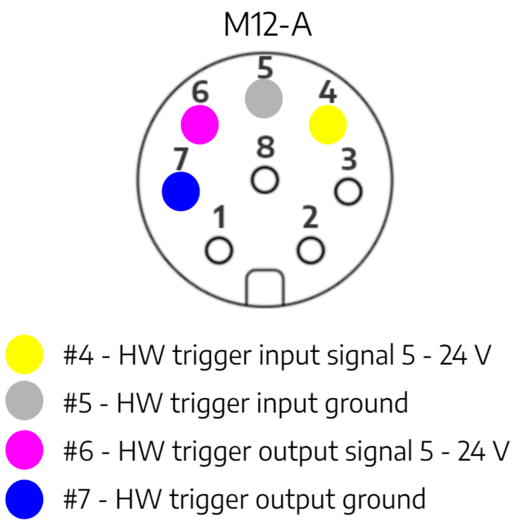
Operating DC voltage U_e (U_{min}-U_{max})	24 V (20 - 30 V)
Residual ripple maximum (% of U_e)	2 %
Rated operating current I_e (I_{max})	1 A (2 A)
Minimum Power	60 W
Maximum recommended cable length	20 m

Hardware Trigger Characteristics

Hardware trigger provides the user with means of triggering devices by external means - outside of the software environment. More information on the software configuration can be found in the PhoXi Control User Manual. This functionality is mostly used for synchronization purposes:

- With external events, such as an object arriving inside the field of view of Photoneo 3D Sensor (i.e. triggered by an optical gate)
- With other devices, such as 2D cameras, PLCs, ...
- With multiple Photoneo 3D Sensors

The hardware trigger is activated by feeding a logical signal to the specified pin of the M12-A connector. The device is also able to signal that it is currently acquiring → this signal can be read from the output pin on the M12-A connector.



View of the port on the Photoneo 3D Sensor (similar to the previous figure)

The allowed input signal voltage range is 5 - 24 V, depending on the user's requirements. The output signal needs to be read through a pull-up resistor.

To correctly connect/wire the devices together, please adhere to the following schematics for trigger input and trigger output.

Trigger Input

Circuit Characteristics

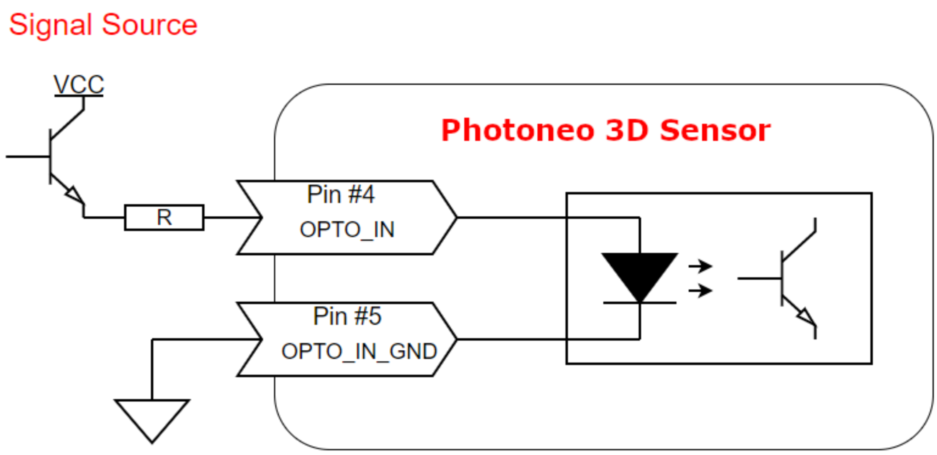
Both wiring schematics below are valid. It is recommended to

- Use $R = 0\,\Omega$ if your $VCC = 5 - 12\,V$

- Use $R = 4k7\,\Omega$ if your $VCC = 24\,V$

The trigger input can be done as a common cathode or common anode. Refer to the diagrams below.

Common Cathode



Common Anode

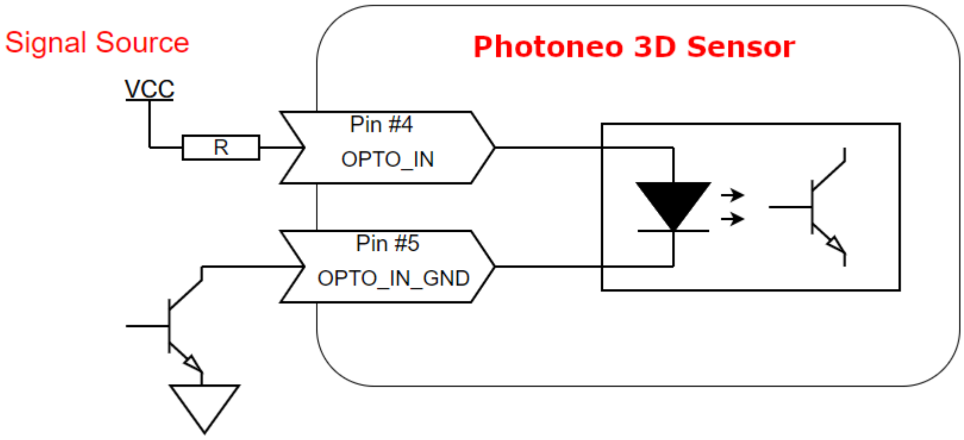


Figure 14: Trigger input wiring options

Input Signal Characteristics

The trigger input signal causes the device to start the acquisition. In the case of MotionCam-3D the trigger input signal is a transition between logic zero and logic one. Therefore the signal can be:

- Falling edge → change from logic 1 to logic 0
- Rising edge → change from logic 0 to logic 1

The choice of the signal depends on the specifics of the setup. For example, the setup for a falling edge can be:

- The input pin is kept at 24 V and it's lowered to 0 V to produce the falling edge

- The input pin is kept at 0 V and it's elevated to 24 V for a short period of time. Letting it fall back down produces a falling edge that triggers the device

Whether the device is triggered by a falling edge, rising edge, or both is controlled by a parameter called Hardware Trigger Signal.

Trigger Output

Circuit Characteristics

The trigger output is read through the VCC pull-up. Please refer to the diagram below. It is recommended to

- Use a $R = 10k\,\Omega$ resistor to read the signal (for example using a PLC)
- Use a $R = 1k6\,\Omega$ resistor when the MotionCam-3D is daisy-chained with another MotionCam-3D and your $VCC = 5 - 12\,V$
- Use $R = 4k7\,\Omega$ resistor when the MotionCam-3D is daisy-chained with another MotionCam-3D and your $VCC = 24\,V$

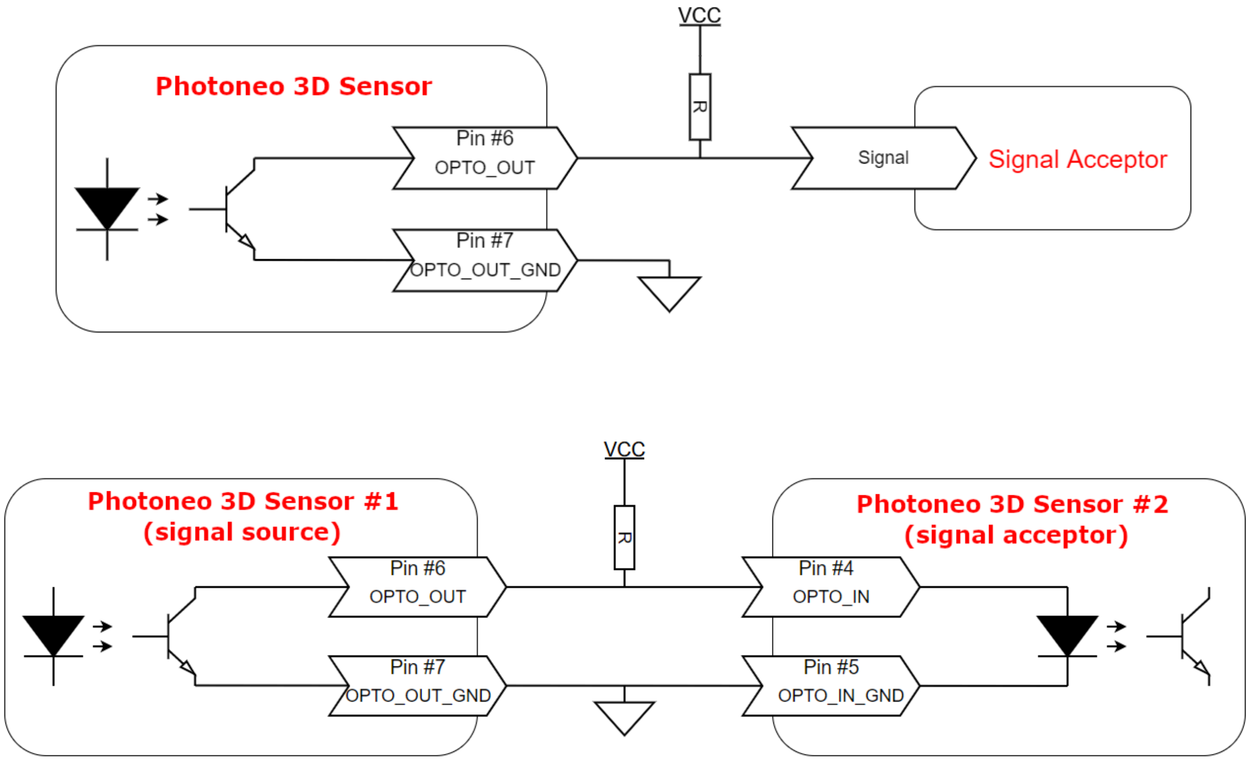


Figure 15: Recommended wiring for trigger output

Output Signal Characteristics

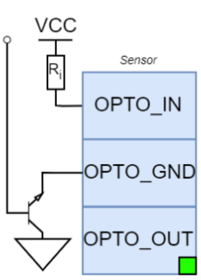
The trigger output signal is used to mark the time during which the device is in acquisition. Once the acquisition starts, the signal changes from logic 0 to logic 1. After it finishes it changes from logic 1 to logic 0.

The acquisition is defined as follows:

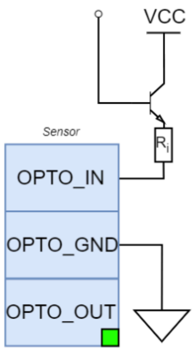
- In camera mode → the time during which the laser sweeps the scene and the 3D data are gathered.
- In scanner mode → the time it takes to project all necessary patterns as well as LED texture.

Simplified wiring schemes

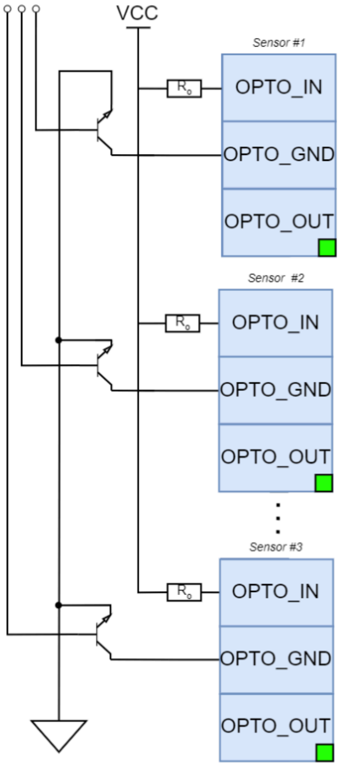
SEXT A



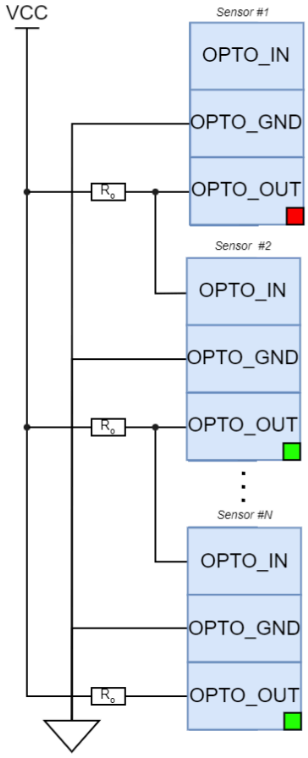
SEXT B



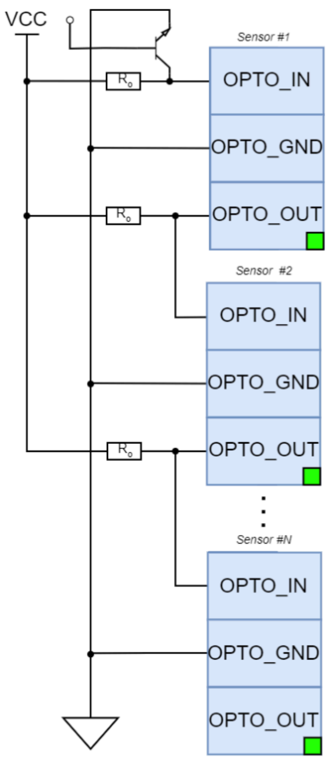
MEXT



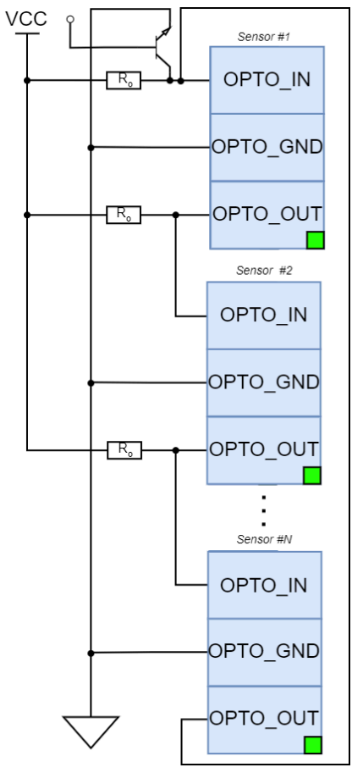
INTSEQ



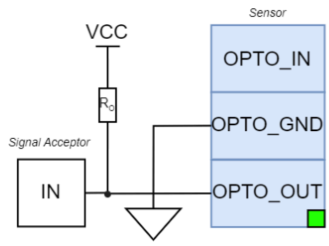
EXTSEQ



EXTDCL



OUT



HW trigger = TRUE; Freerun = TRUE (green)

HW trigger = FALSE (red)

SEXT A	Single device triggered by HW trigger - Common Cathode
SEXT B	Single device triggered by HW trigger - Common Anode
MEXT	Multiple devices triggered by HW trigger independently from each other
INTSEQ	Two or more devices triggered sequentially in a daisy chain - triggered by the Sensor #1
EXTSEQ	Two or more devices triggered sequentially in a daisy chain - Sensor #1 triggered externally
EXTDCL	Two or more devices triggered sequentially in a loop - daisy chain in a loop
OUT	Photoneo 3D Sensor output signal to another device (Signal Acceptor)

*Resistors R_i and R_o are dependent on the voltage of the power source and type of the connected devices - refer to the sections Trigger Input and Trigger Output.

Ground pin OPTO_IN_GND and OPTO_OUT_GND can be connected to the same ground (of the voltage source) - in this case, OPTO_GROUND (separate from the ground of the sensor itself).

Projection Unit Properties

Projection width horizontal	47.5° ± 1°				
Projection width vertical	36.0°± 2°				
Model	MotionCam-3D (Color) S	MotionCam-3D (Color) S+, M, M+, L, L+	PhoXi 3D Scanner XS, S	PhoXi 3D Scanner M, L, XL Alpha 3D Scanner L, XL	
Light source	Visible red light (laser)	Visible red light (laser)	Visible red light (laser)	Visible red light (laser)	
Laser class	LC3R	LC3R	LC3R	LC3R	LC2
Wavelength	639 nm	637 nm	639 nm	637 nm	637 nm
Average power	0.314 mW	4.32 mW	0.314 mW	4.32 mW	0.340 mW
Pulse energy	382 nJ	93.7 μJ	382 nJ	93.7 μJ	18.6 μJ
Pulse length	0.96 ms	1.32ms	0.96 ms	1.32 ms	1 ms

Environmental Conditions

Transport

Ambient temperature	From -20 °C to 50 °C (max gradient 10 °C/hour)
Humidity	From 0 % to 95 % non-condensing
Atmospheric pressure	From 1080 hPa to 660 hPa (corresponding to an altitude of -1000 m to 3500 m)

⚠ CAUTION
Please ensure that the device is always transported in its original casing or that it is properly cushioned for transport.

Operation

Operating temperature for optimal scanning performance	From 22 °C to 25 °C
Overall operating temperature	From 0 °C to 40 °C
Humidity	From 0 % to 95 % non-condensing
Atmospheric pressure	From 1080 hPa to 660 hPa (corresponding to an altitude of -550 m to 3500 m)
Maximum acceleration (idle)	20 ms^{-2}

NOTICE
For the correct performance of the device, make sure it has reached its operating temperature. The operating temperature is reached approximately after 45 minutes of the device being powered up or after 10 minutes of continuous scanning in the free run mode followed by 2 - 5 minutes of cool down to stabilize the temperature.

Degree of Ingress Protection

Photoneo 3D sensors have the following mechanical protection according to standard EN 60529:

- IP65 Mechanical Protection
- Completely protected against the ingress of dust (dust-tight).
- Protected against low-pressure jets of water from any direction.

Cleaning Instructions

The optical scanning device produced by Photoneo is technically advanced yet a low-maintenance device. To preserve the performance and quality of the scanning, please check and maintain its outer optical parts regularly.

The glasses covering the camera unit and the projection should not be touched by bare hands to avoid staining the glass. This could interfere with light passing through them. If the glass was touched or lightly stained by any other mechanism, wipe the glass with lint-free wipes intended for optical components.

In cases where the device is used in an environment with lots of dust, especially when the dust contains sharp or hard particles that could potentially damage the glass, clean the glasses with a specialized cleaning solution for optical components, e.g.: First Contact™ Cleaning Solution[2].

To clean the glasses:

[2] www.photoniccleaning.com/product-p/rfcr.htm

1. Coat the glass with the solution using the applicator. Make sure not to spread it to the edges. The solution immediately dries and creates a film over the glass.
2. Remove the film from the glass using peel tabs with wooden or plastic tips.
3. The film removes any dirt or particles from the glass.

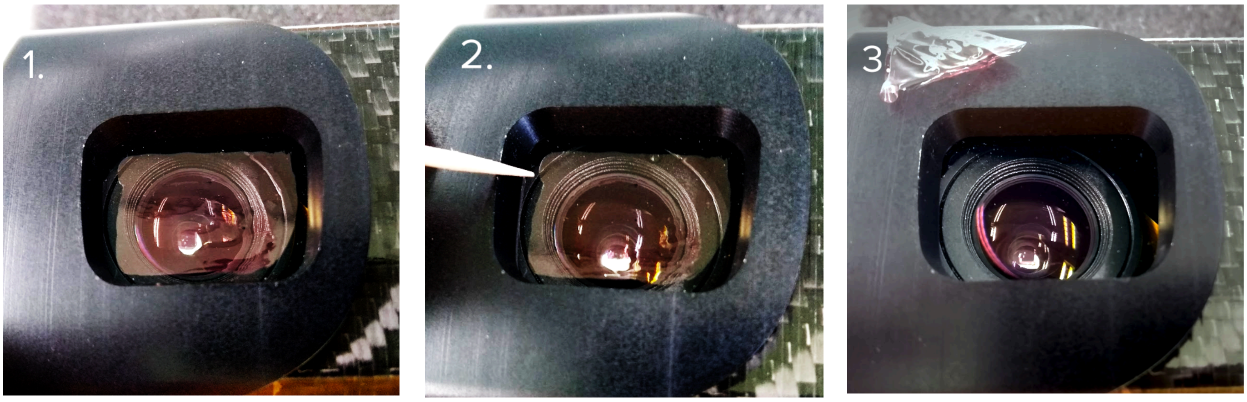


Figure 16: Cleaning process of the glass over the camera unit

Scanning Parameters

Information about the scanning range and parameters of your Photoneo 3D Sensor is available in the device datasheet. Full user manual, datasheets, CAD models, and other instructions see https://photoneo.com/downloads/device-resources/

Datasheet Parameters Explanation

3D Sensing Technology

Photoneo 3D sensor either uses sequential structured light technology or the Parallel Structured Light Technology. More information can be found in the section Objects Suitable for Scanning.

Output data

Depending on the device used for scanning, the output data structure can differ.

- 3D points (x y z)
    a. Floating numbers depicting the position of a 3D point in a given coordinate frame. The default coordinate frame has its origin in the 2D camera with the Z-axis towards the scene, the X-axis continuing to the right of the device, and the Y-axis facing downward.
- Normals (x y z)
    a. The normal vector for each 3D point can also be calculated. The normal vector is perpendicular to the area surrounding the point.
- Depth Map (z)

a. The “depth” of a point is the absolute 3D distance from the image sensor to the measured point (the ray of light that hits the surface of the object). The DepthMap is, therefore, always in the camera coordinate system and corresponds to the Z coordinate value in the point cloud.

- Color Image (RGB)
  a. A 2D RGB texture is available on the MotionCam-3D Color in both Scanner and Camera modes at different resolutions.
- Texture (grayscale intensity)
  a. A 2D grayscale texture (LED, laser, computed).
- Confidence (float)
  a. For each measured 3D point, the “confidence” value expresses certainty about the accuracy of the point measurements. For example, a confidence value of 0.12 means that the estimated error for a point measurement is 0.12 mm. This value is based on a heuristic method that considers the light conditions for each pixel.

Scanning range

The scanning range consists of 2 values which represent the minimal and maximal distance of the scanned object from the device in order to perform the 3D reconstruction. The volume bounded by intersecting planes at the distances is called a calibration volume and it is determined by the model of the Photoneo 3D sensor.

Optimal scanning distance (sweet spot)

Denotes the focus distance of the 2D camera at which theoretically the best scanning results can be obtained.

Scanning area (at sweet spot)

Size of the area that is covered at the optimal scanning distance (sweet spot).

Operation Mode / Scene

MotionCam-3D (Color) devices are able to switch between a Camera (Dynamic) mode and a Scanner (Static Mode). In the Camera mode, the device is able to capture objects in motion or the device itself can be moving without causing any motion blur. The Scanner mode requires the devices as well as the scene to be static during scanning. Additionally, all devices also support a 2D mode that outputs only 2D texture data.

Point-to-point distance (at the sweet spot)

The average distance between two neighboring points in the point cloud of a plane located in the focus distance of the camera. Alternatively, the square of the point size is the average surface sampled by a single 3D point on the plane scanned in the focus distance of the camera.

Figure 15 and Figure 16 show the point size as a function of the scanning distance. The point size linearly decreases with the distance. Therefore, it is possible to calculate the approximate point size using the *Optimal scanning distance (sweet* *spot)* and the *point-to-point distance (at the sweet spot)* values, which can be found in the datasheet. If P_s is the point size at the optimal scanning distance D_o, then we can calculate the approximate point size P at the desired distance D_d as follows:

$$P = (\frac{P_s}{D_o}) \times D_d$$

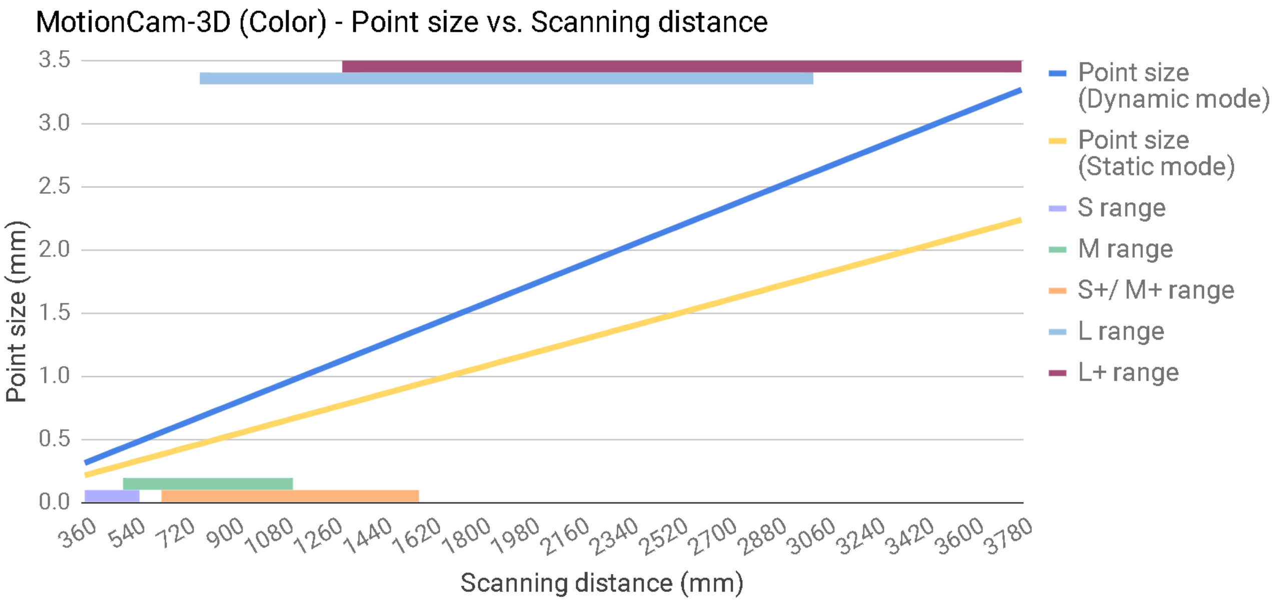


Figure 17: Relationship between scanning distance and point size for the MotionCam-3D (Color) devices

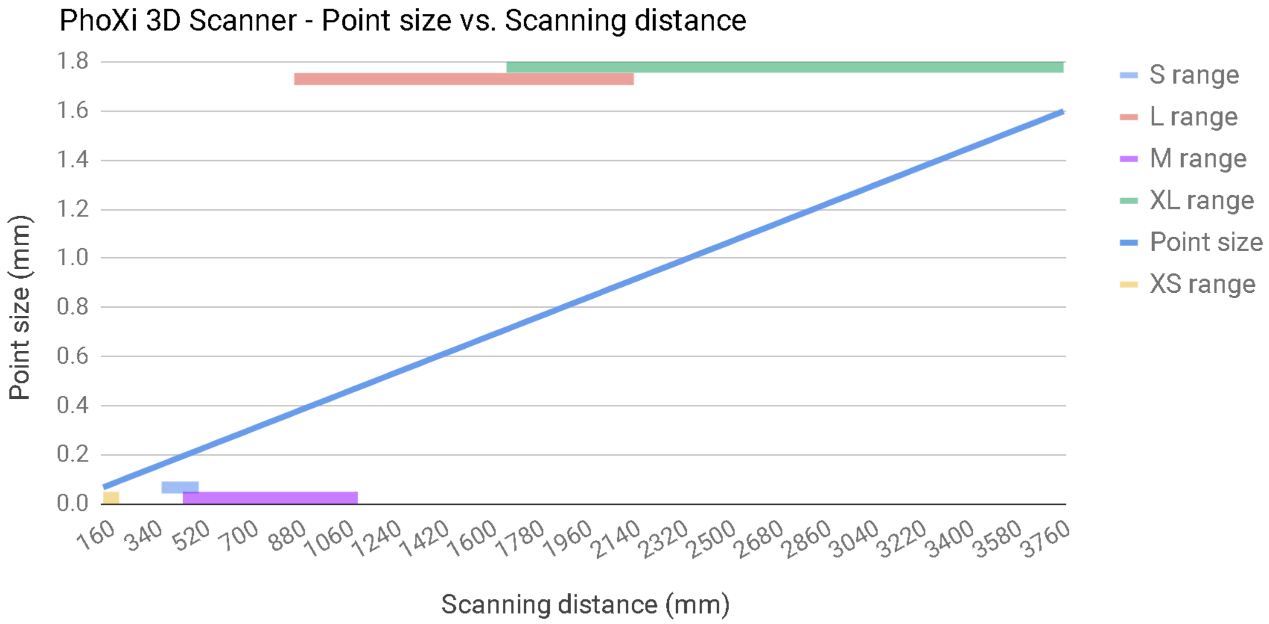


Figure 18: Relationship between scanning distance and point size for the PhoXi 3D Scanner devices

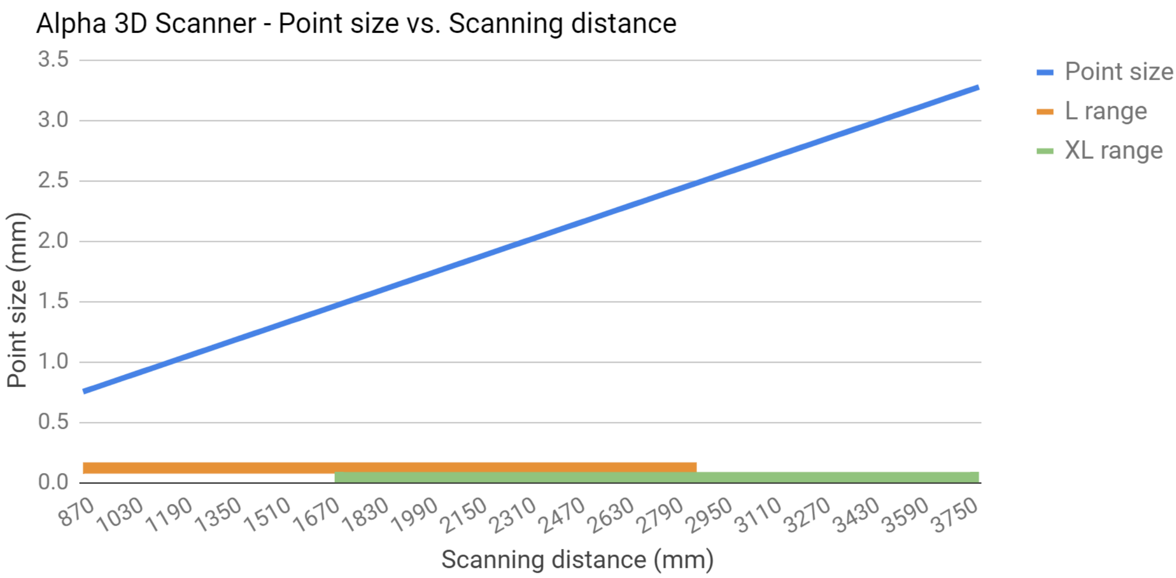


Figure 19: Relationship between scanning distance and point size for the Alpha 3D Scanner devices

Calibration accuracy (1 σ)

The accuracy of point measurement as the result of device calibration (can also be understood as space deformation). Every 3D point is determined with a certain measurement error. This measurement error is different for each point across the whole measured volume. Calibration accuracy is the standard deviation (σ) of measurement errors of all 3D points.

Temporal noise (1 σ)

The standard deviation of noise (measured on a diffuse surface with 80 percent albedo). The noise level describes the ability of the sensor to capture local surface details. The noise distribution of our sensor is similar to the Gaussian distribution.

Equivalently, temporal noise can also be defined as the average distance of the 3D points from the average Z-value of the 3D points.

FPS

Stands for Frames Per Second. FPS is used to measure frame rate – the number of consecutive full-screen images that are displayed each second.

Dimensions

This cell in the datasheet contains 3 values, which represent the length, height, and depth of the device respectively.

Baseline

It is the distance between the camera and the projection unit.

Temperature working range

Photoneo 3D sensors are designed to work within the full temperature working range, however, to achieve the stated accuracy, it is advised to keep the ambient temperatures in the optimal temperature working range.

Power

The device can be powered using a Power over Ethernet injector or 24V adapter.

Data connection

It is recommended that the device is connected to a 1 Gbit network to ensure sufficient data flow.

Depth Map Resolution

Its resolution is determined by the resolution of the 3D sensor itself.

Data Acquisition Time

Data acquisition times represent the shortest possible acquisition time and the maximum estimated acquisition time in the worst-case scenario.

Compliance with Standards

Photoneo 3D Sensors conform to the following standards and test specifications. Please note that the certification status may change without notification. Consult your local Photoneo representative if you need additional information related to the latest listing of exact approvals.

CE

Photoneo 3D Sensors satisfy requirements and safety-related objectives according to the EC directives listed below. This CE mark is supported by tests conducted by the manufacturer.

Laser Classification

The Laser class of the scanner is determined according to EN 60825-1:2014 Equipment Classification and requirements standard. The laser class was tested by an independent certification body.

Photoneo 3D Sensors are Laser Class 3R or Laser Class 2 devices. All devices are labeled according to their respective class following rules given by the harmonized standard.

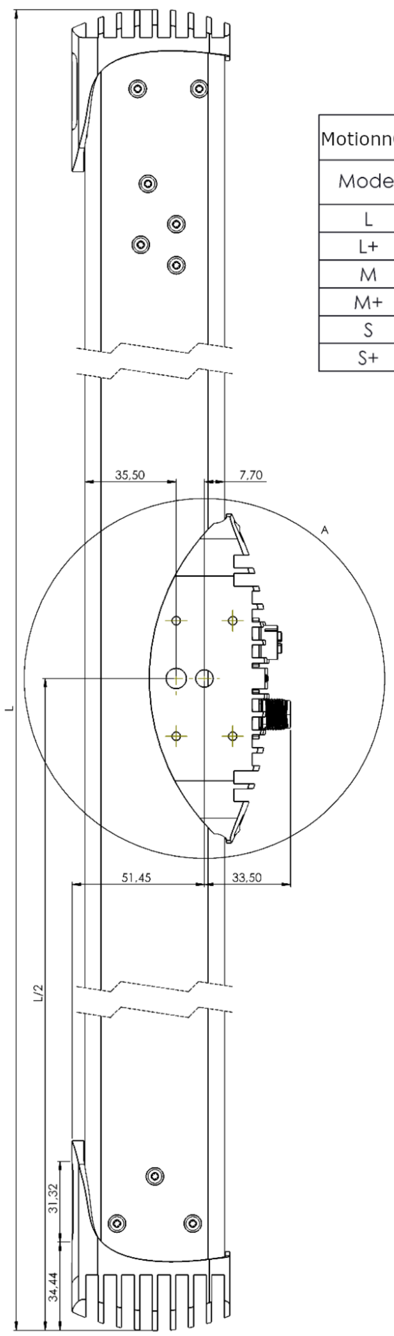
Details about the laser device used can be found in the section Projection Unit.

If necessary, please contact Photoneo for a written Declaration of Laser Class for your specific device.

Dimensions and Illustrations

MotionCam-3D Color

Bottom View: Mounting Plate



MotionnCam-3D Color	
Model	Length L
L	628
L+	628
M	428
M+	428
S	308
S+	308

Figure 19: Bottom view of MotionCam-3D Gen 3 Color

Bottom View: Detail A

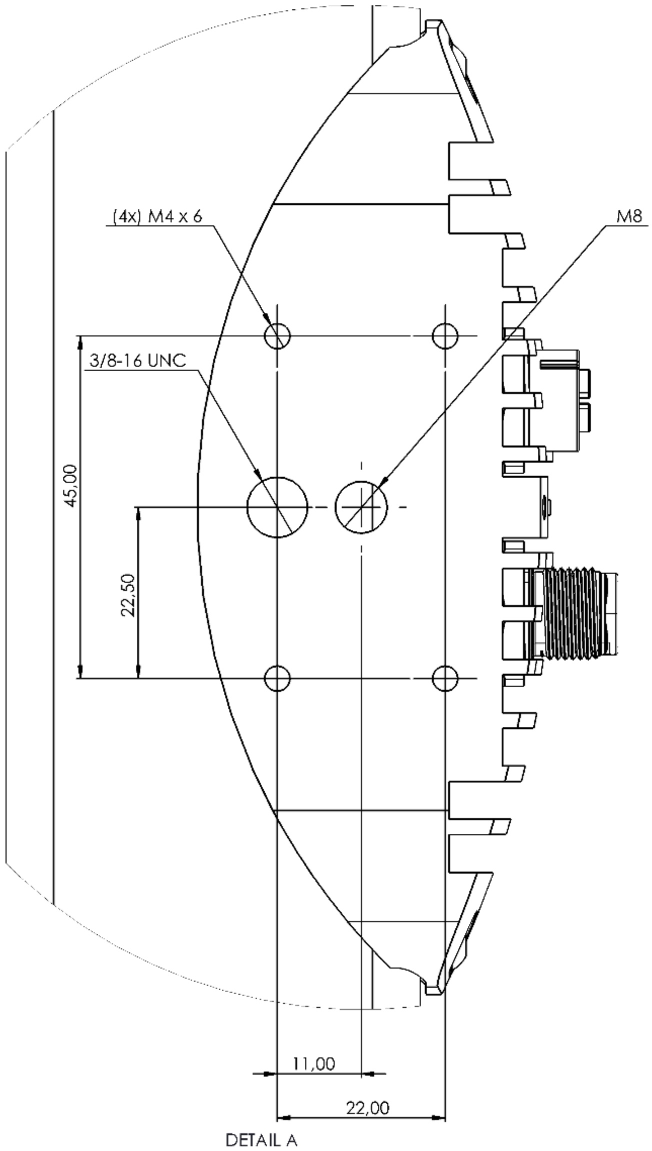


Figure 20: MotionCam-3D Gen 3 Color - Detail A

Front View: Projection Unit and Camera Unit

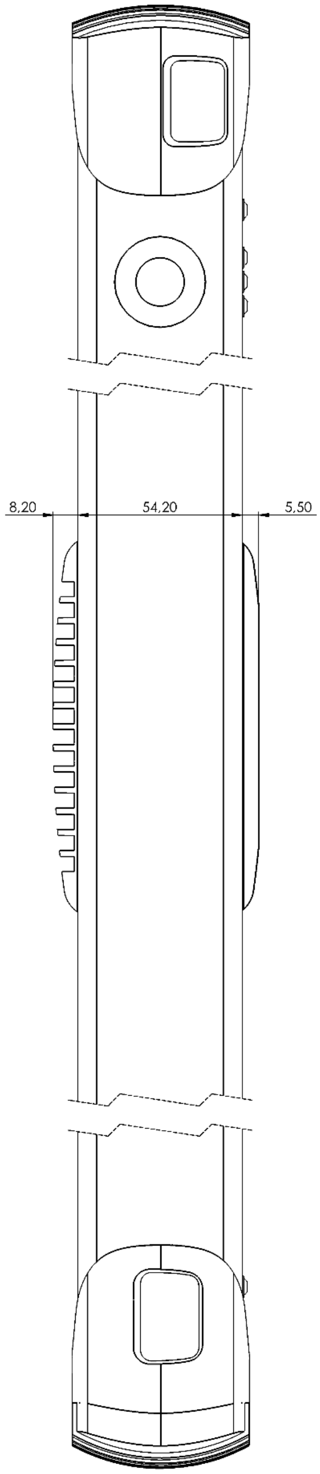
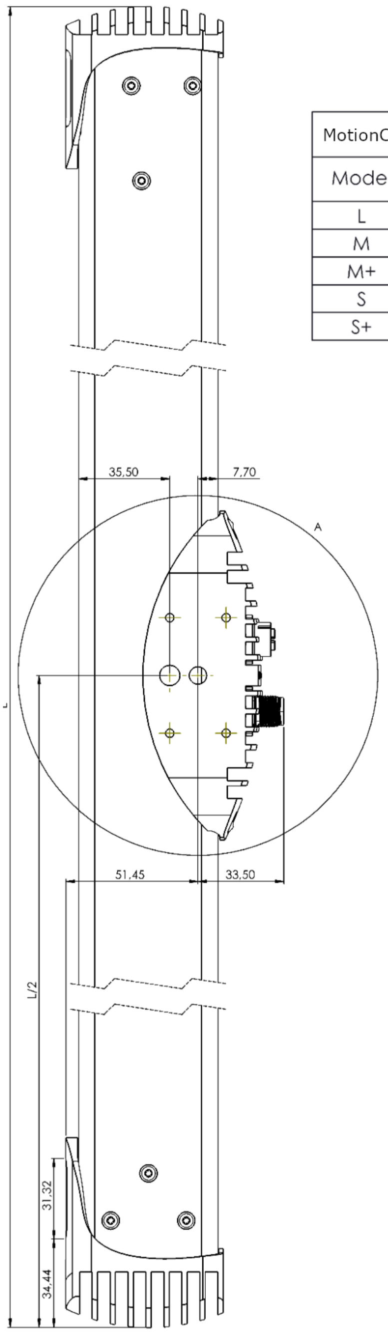


Figure 21: Projection unit and camera of MotionCam-3D Gen 3 Color

MotionCam-3D Gen 3

Bottom View: Mounting Plate



MotionCam-3D Gen 3	
Model	Length L
L	628
M	428
M+	428
S	308
S+	308

Figure 22: Bottom view of MotionCam-3D Gen 3

Bottom View: Detail A

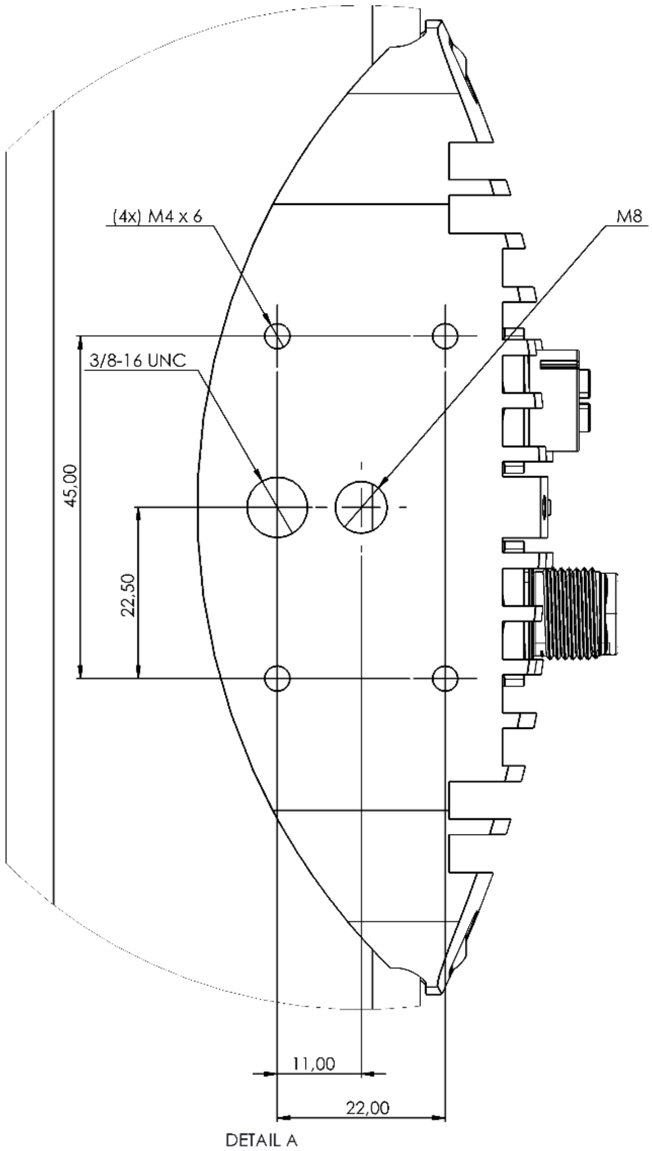


Figure 23: MotionCam-3D Gen 3 - Detail A

Front View: Projection Unit and Camera Unit

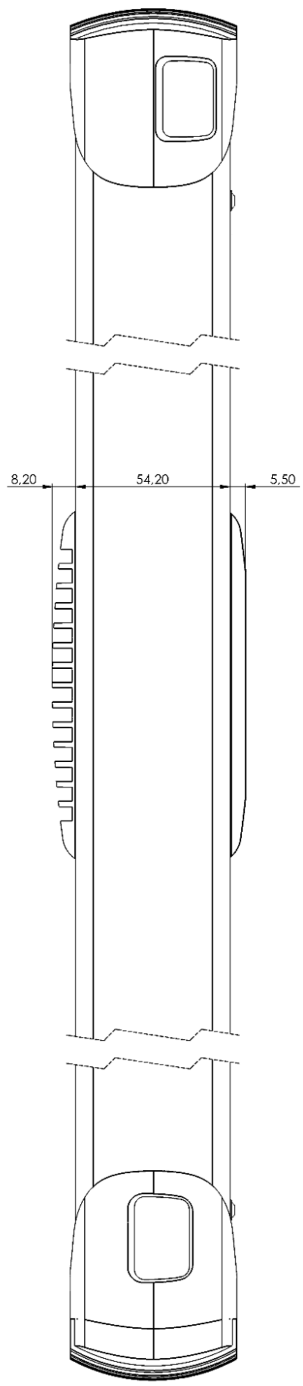


Figure 24: Projection unit and camera of MotionCam-3D Gen 3

MotionCam-3D Gen 2

Bottom View: Mounting Plate

MotionCam-3D Gen2	
Model	Length L
L	628
M	428
M+	428
S	308
S+	308

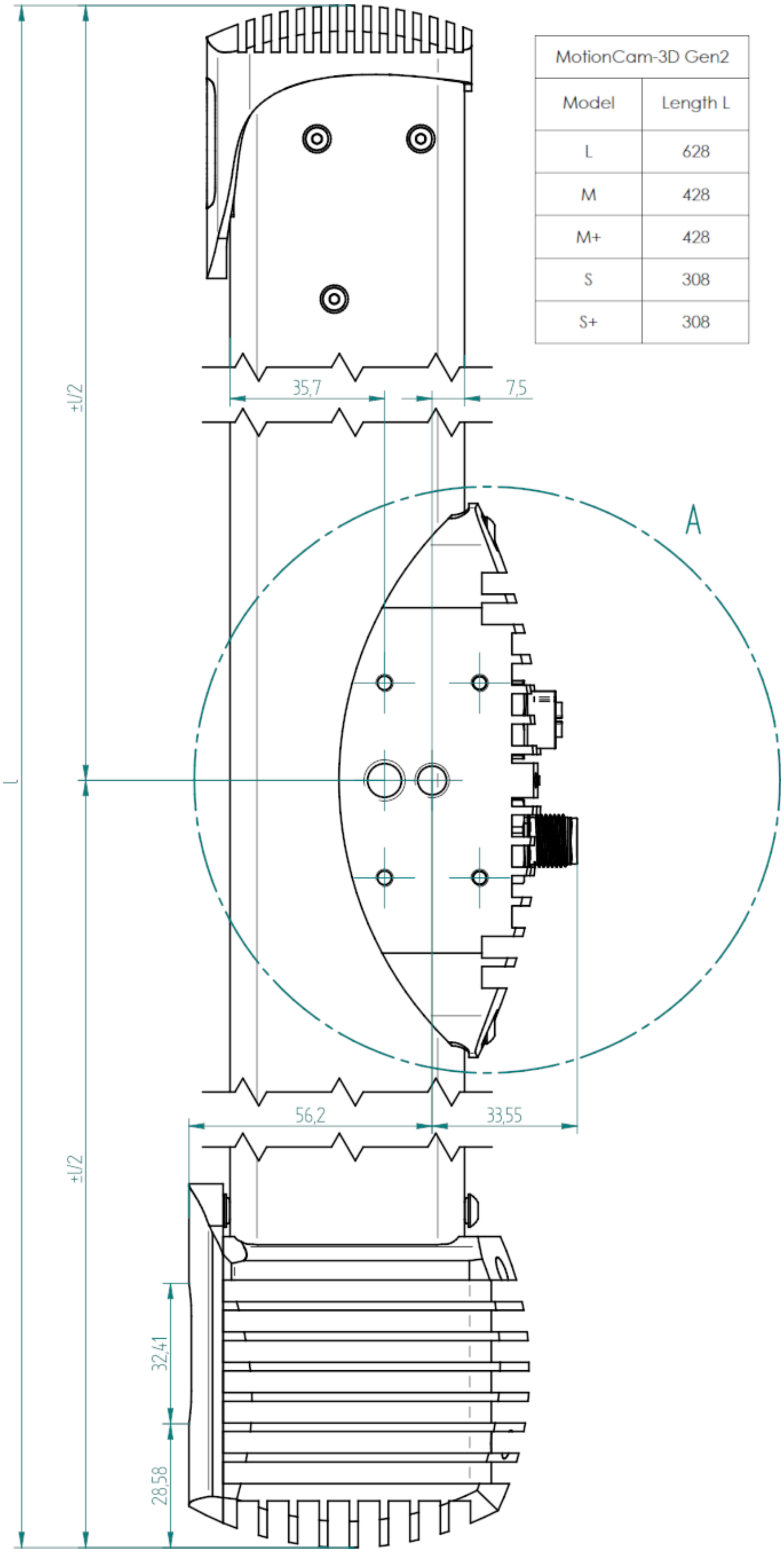


Figure 25: Bottom view of MotionCam-3D Gen 2

Bottom View: Detail A

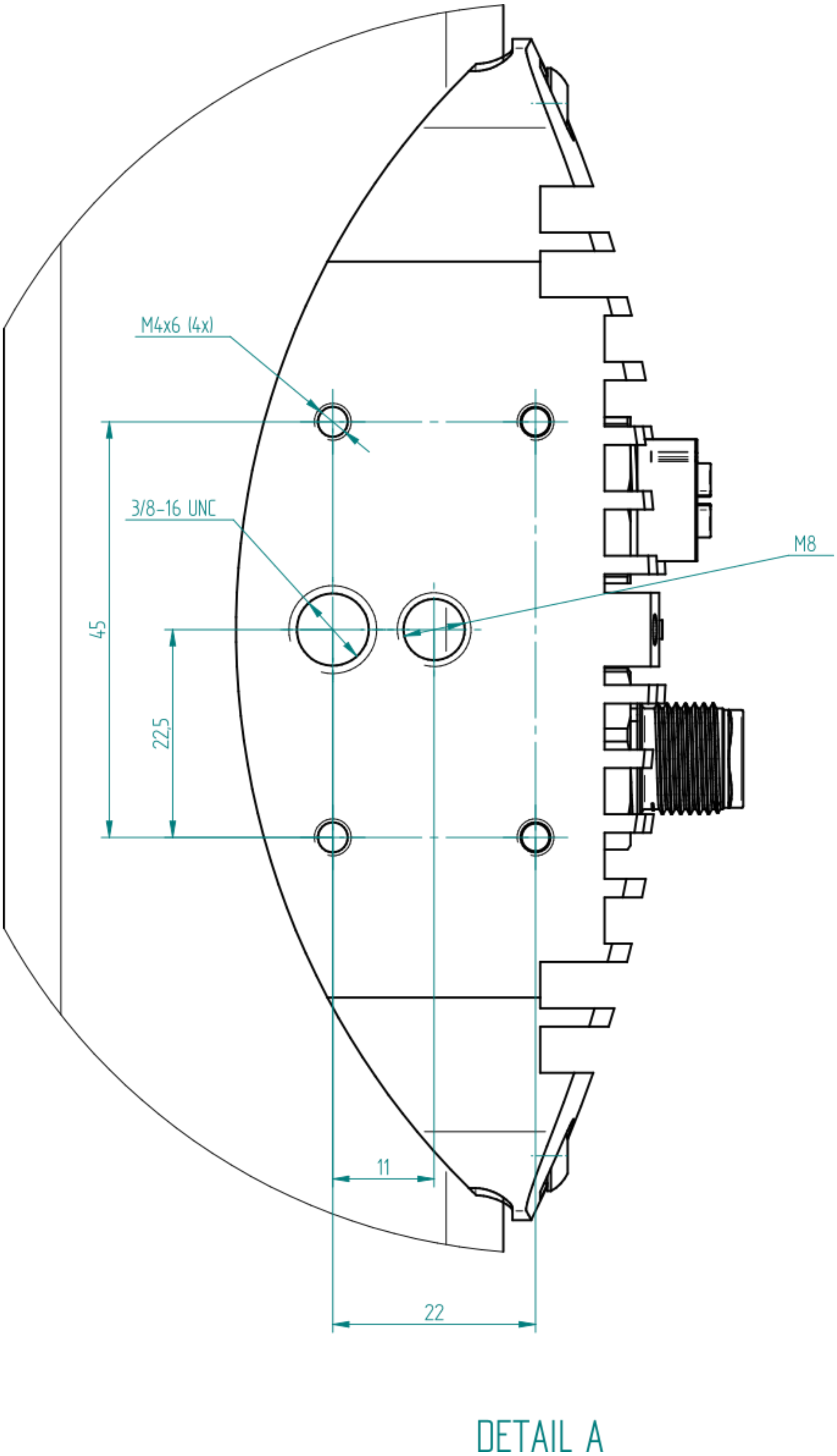


Figure 26: MotionCam-3D Gen 2 - Detail A

Front View: Projection Unit and Camera Unit

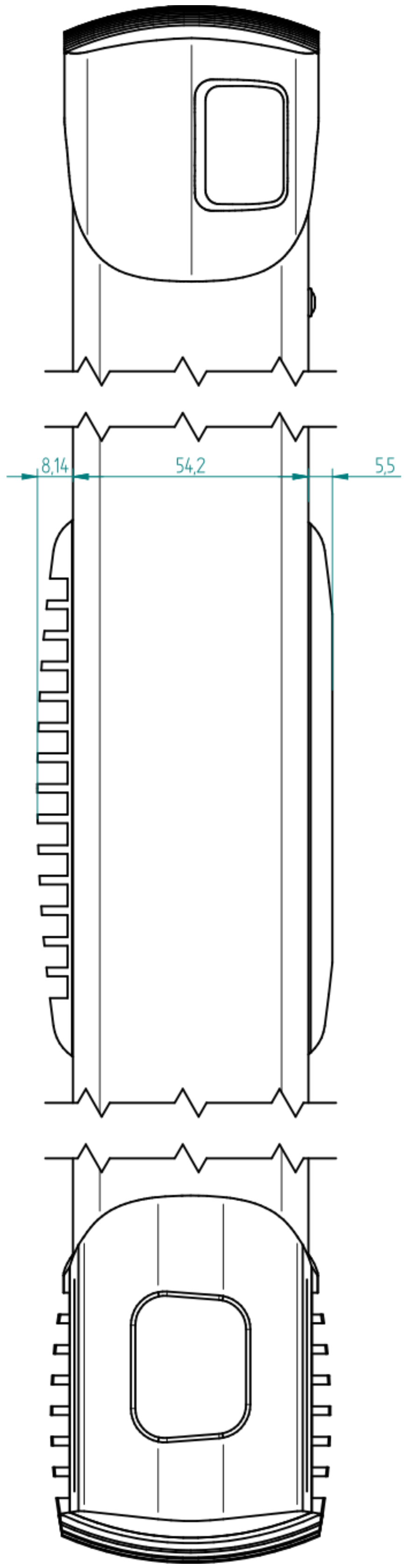
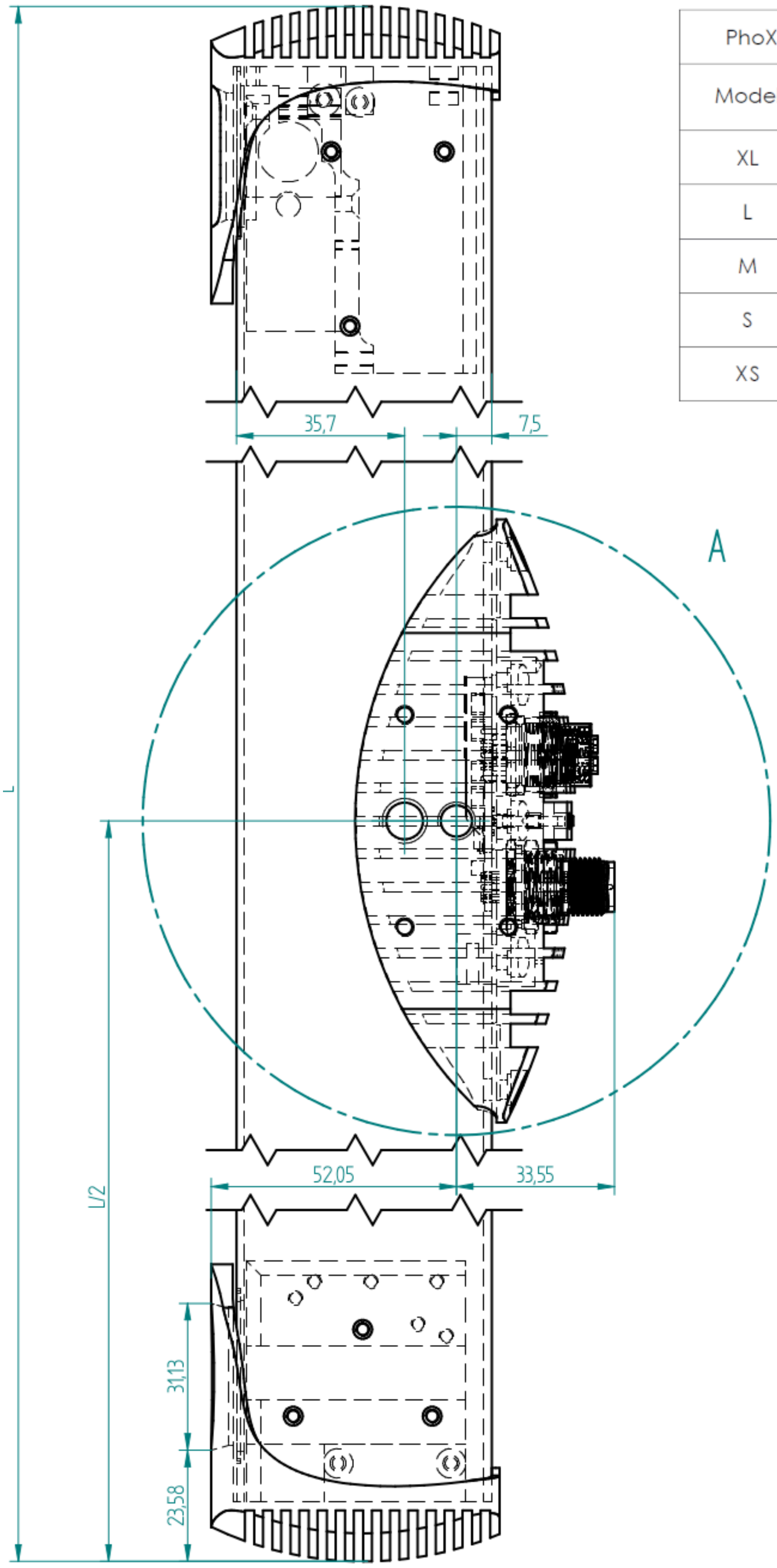


Figure 27: Projection unit and camera of MotionCam-3D Gen 2

PhoXi 3D Scanner

Bottom View: Mounting Plate



PhoXi 3D Scanner	
Model	Length L
XL	953
L	628
M	428
S	308
XS	308

Figure 28: Bottom view of PhoXi 3D Scanner

Bottom View: Detail A

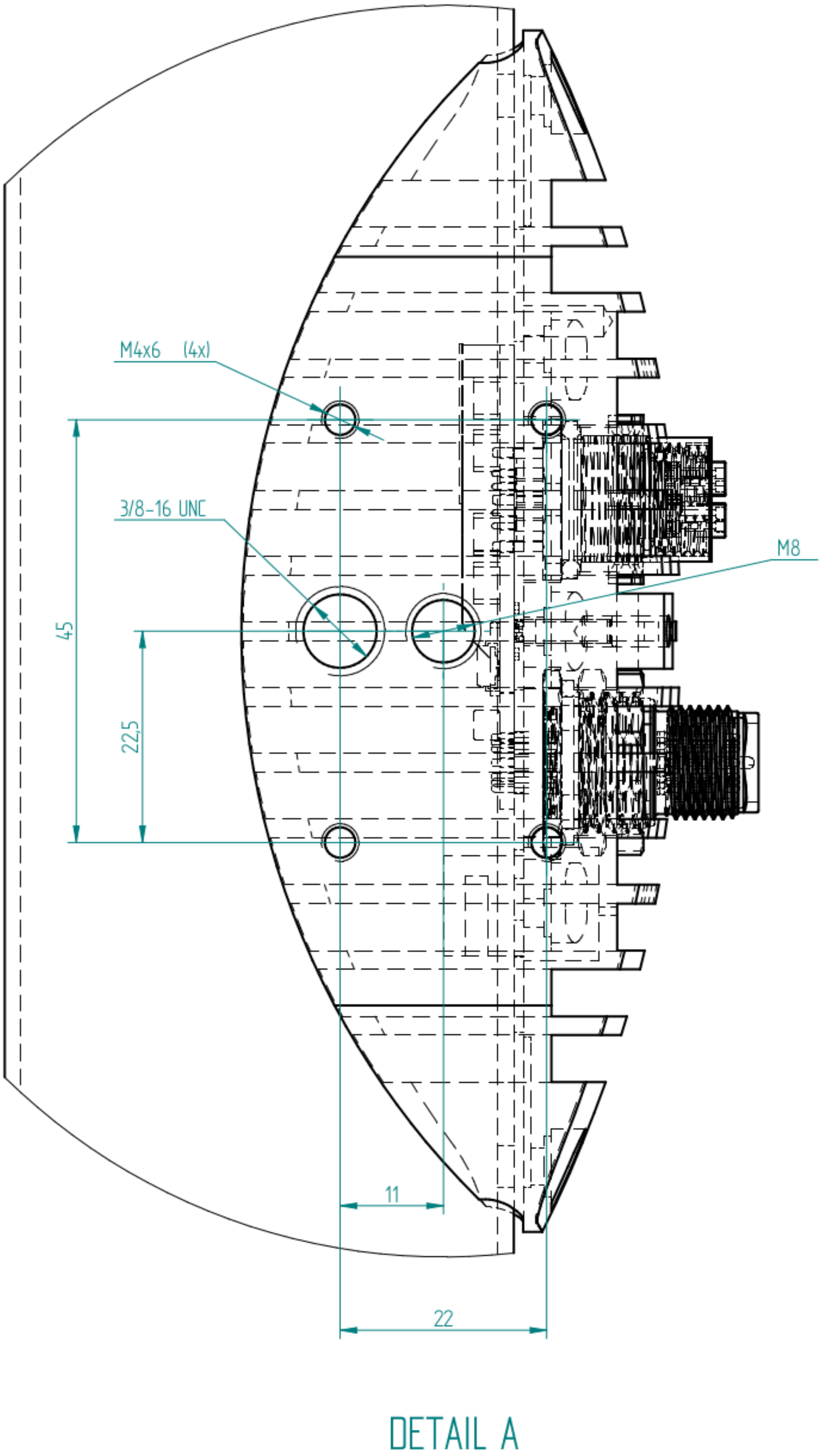


Figure 29: PhoXi 3D Scanner - Detail A

Front View: Projection Unit and Camera Unit

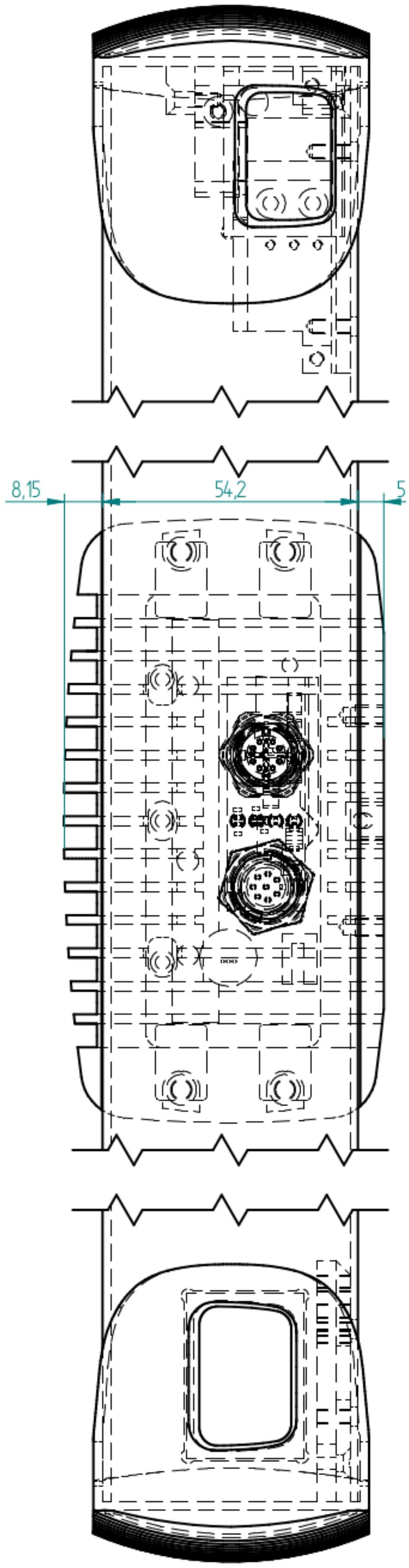
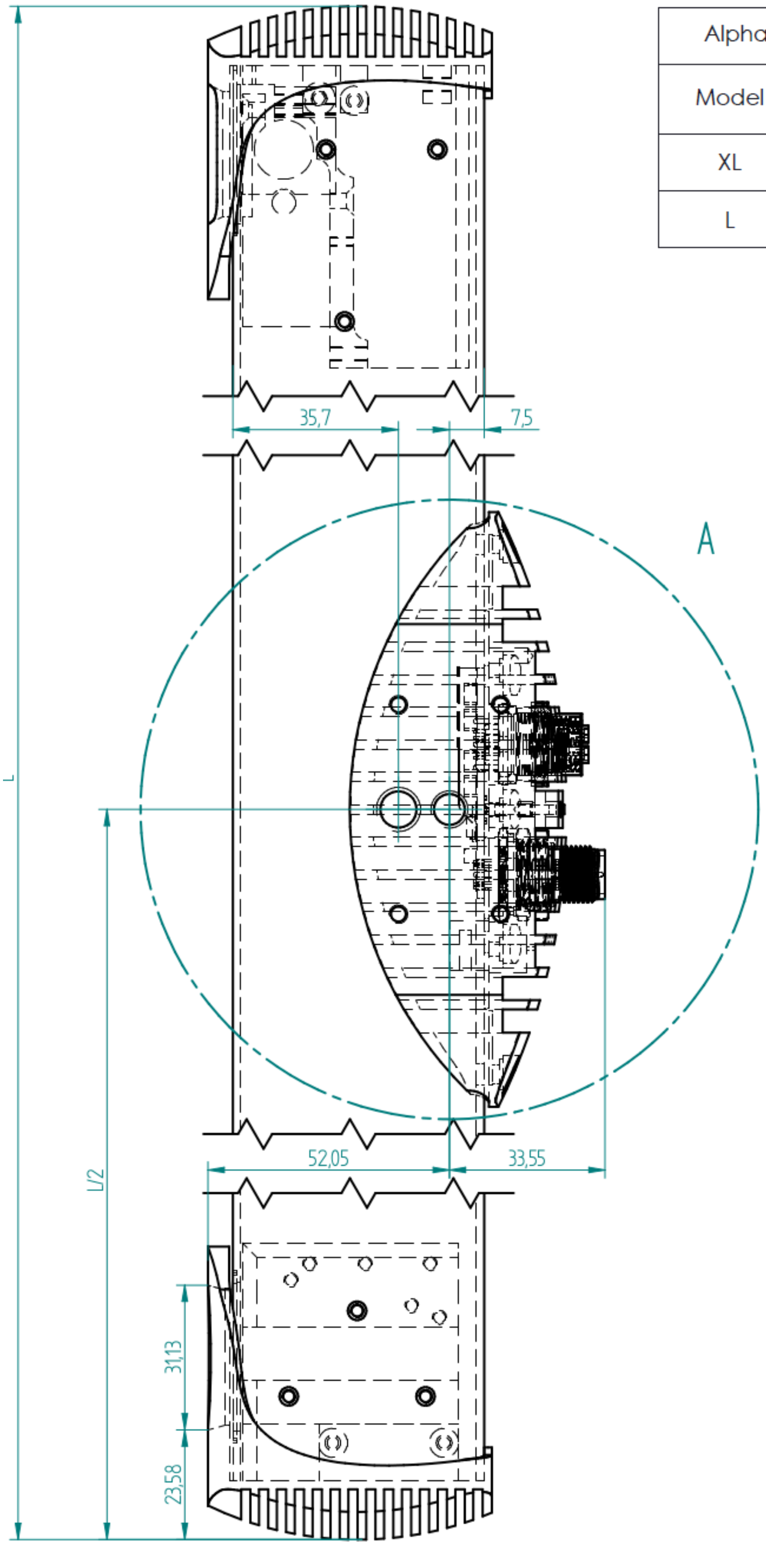


Figure 30: Projection unit and camera of PhoXi 3D Scanner

Alpha 3D Scanner

Bottom View: Mounting Plate



Alpha 3D Scanner	
Model	Length L
XL	428
L	428

Figure 31: Bottom view of Alpha 3D Scanner

Bottom View: Detail A

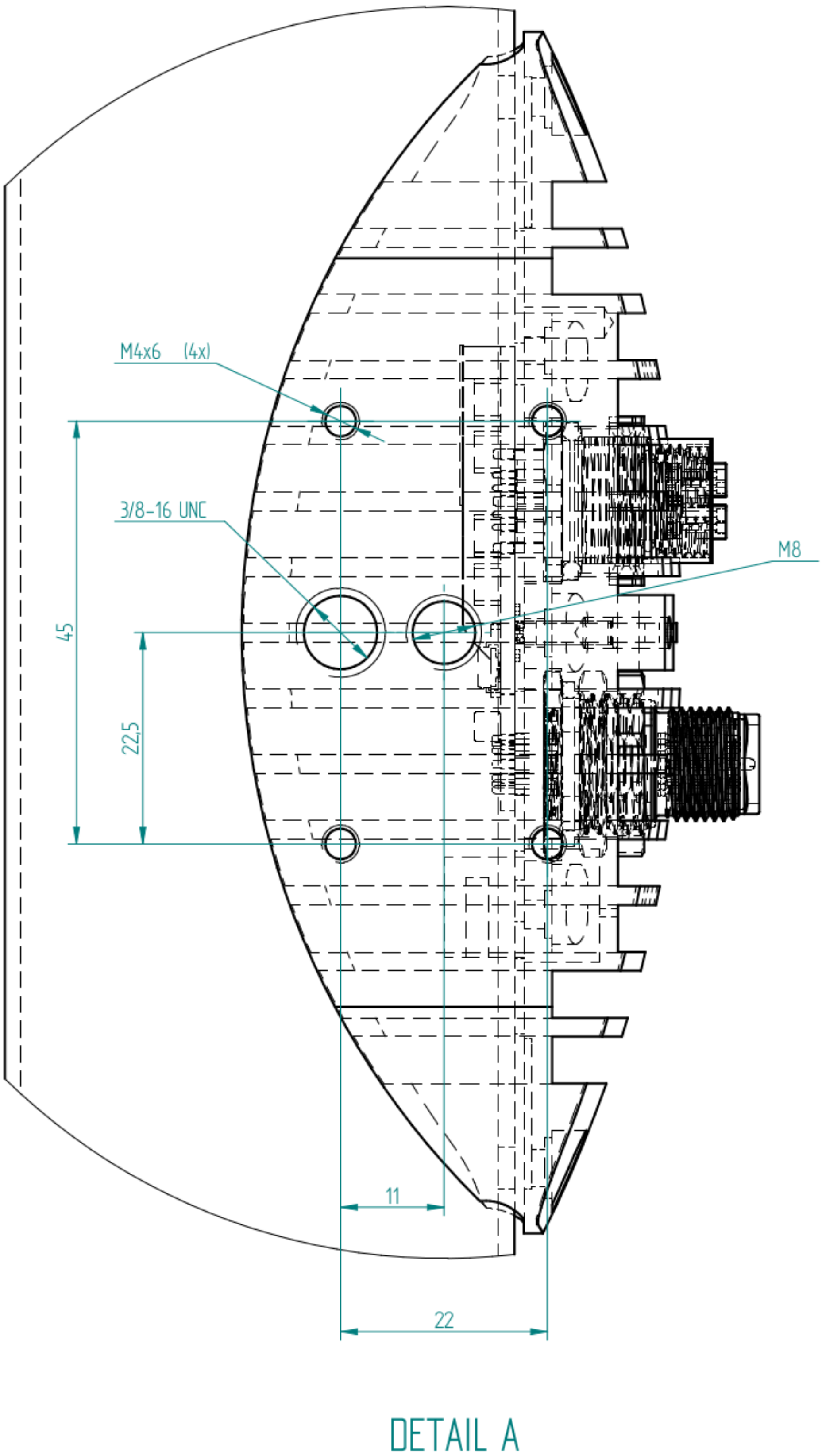


Figure 32: Alpha 3D Scanner - Detail A

Front View: Projection Unit and Camera Unit

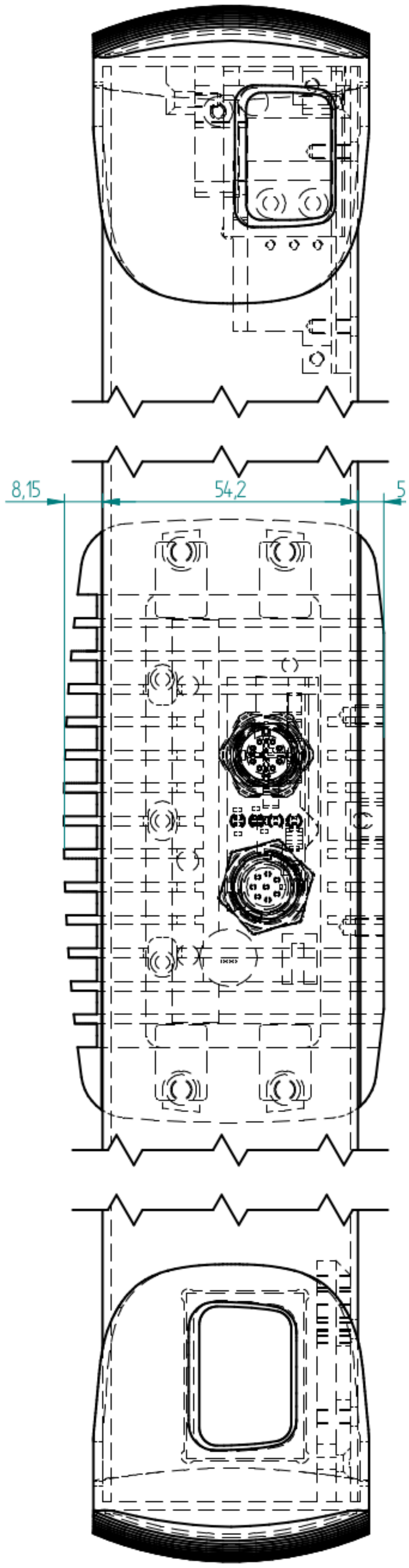


Figure 33: Projection unit and camera of Alpha 3D Scanner

Warranty

Standard 1-year warranty applies. Full warranty conditions are stated in General Terms and Conditions on the Photoneo website: www.photoneo.com/kb/terms-conditions

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