

USER MANUAL

Cube 1, Cube 1 Outdoor
Cube Range 1

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DESCRIBED PRODUCTS

Cube 1, Cube 1 Outdoor, Cube Range 1

LEGAL INFORMATION

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DOCUMENT HISTORY

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1 About this document

1.1 General information

This document describes the installation and operation of the Cube 1 and Cube Range 1 LiDAR sensors manufactured by Blickfeld GmbH. It provides important information regarding the use of said products and is intended for qualified personnel that is familiar with the local work safety regulations and general safety regulations applicable for the application area.

For better readability, those products will be referred to as Cube in this manual when all product variants are concerned in the same way. Where differences between the two products exist, they will be referred to by their respective type names explicitly. Schematic drawings that depict the Cube 1 also apply to the Cube Range 1 unless specified otherwise.

IMPORTANT NOTICE

This manual contains all of the information necessary to safely mount, install and start up the Cube. Therefore, read and follow the safety and warning notes before beginning work.

1.2 Symbols and signal words

SAFETY NOTES / WARNING NOTES

Structure of the safety and warning notes in this user manual:



Type and source of danger

Possible consequences

- Avoidance measures

EXAMPLE**Laser radiation warning**

If the Cube is not operated correctly, the optical radiation may injure the eyes and skin.

- Never open the protective housing of the Cube.
- Never intentionally look into the optical component of the Cube while the Cube is switched on.





MEANING OF THE SIGNAL WORDS

Meaning of the signal words in this user manual:

Safety symbol	Signal word	Meaning
	Danger	This signal word is used to indicate an imminently dangerous situation which, if not prevented, will lead to serious injury or death.
	Warning	This signal word is used to indicate a potentially dangerous situation which, if not prevented, may lead to death or serious injury.
	Caution	This signal word is used to indicate a potentially dangerous situation which, if not prevented, may lead to light to moderate injury.
	Attention	The signal word without a warning sign is used to indicate the potential danger of property damage.

MEANING OF THE WARNING SYMBOLS

The following warning symbols indicate sources of danger:

Symbol	Meaning
	General warning symbol.
	Warns of life-threatening electrical voltage.
	Indicates a potential danger due to laser radiation. Failure to observe the safety notes can lead to serious injury, especially to the eyes.
	Caution, hot surface! Hot surfaces that could cause skin burn may be present during and immediately after operation.

1.3 Abbreviations

Abbreviation	Description
BSL	Blickfeld Scanner Library
DHCP	Dynamic Host Configuration Protocol
EN	European Norm
FoV	Field-of-view
GUI	Graphical User Interface
LAN	Local Area Network
LiDAR	Light Detection and Ranging
MEMS	Micro-Electro-Mechanical Systems
PoE	Power over Ethernet
ROS	Robot Operating System
VTU	Visualization Toolkit for Unstructured grids

Tab. 1 List of abbreviations

2 Safety information

2.1 Intended use

The Cube was designed for continuous measurement of 3D point cloud data. This enables contact-free measurement of distances and contours of the objects in the field-of-view of the Cube.

Any use that deviates from the specifications in this user manual could lead to injury or damage.

AREAS OF APPLICATION

Typical areas of application include:

- Detection and counting of objects or persons
- Traffic monitoring
- Robot technology
- Intrusion detection
- UAV- and ground-based mapping
- Logistics and process automatization
- Filling level measurement and asset management
- Geographical surveying

2.2 Unintended use

The Cube may only be operated within the value range defined in the technical data (see 3.10 on page 27). The user of the Cube must comply with all local regulations for the operation of laser devices. Despite its high robustness compared to other LiDAR technologies, the Cube is a precise optical measuring device and must be handled with care.


Blickfeld assumes no liability for damage and danger caused by unintended or incorrect use. Any use of the Cube outside of the defined technical specifications and requirements described in this manual is considered unintended use. Any procedure performed in violation or in neglect of the instructions in this manual is considered incorrect use.

- The Cube is not permitted to be used in potentially explosive or corrosive environments.
- The indoor variants CUBE1-IH and CURA1-IH are not permitted to be used in wet environments.
- The Cube is not a safety component within the scope of the Machinery Directive (2006/42/EC) or comparable regulations, which are related to functional safety.
- The product is not suited for applications that cannot tolerate the loss of functionality of the sensor.
- The use of accessories that are not supplied or authorized by Blickfeld is at your own risk.
- Strong shaking or vibrations, e.g. due to dropping of the Cube, can permanently damage the optical components. Blickfeld cannot be held liable for any damage.
- Do not use the Cube in the close proximity of strong magnetic fields.
- Do not open the housing. Blickfeld cannot be held liable for damage caused by the manipulation or modification of the Cube that extends beyond the installation and maintenance instructions described in this document.
- The Cube is not a handheld device. Always mount the Cube safely and stably.
- In the unlikely event that unusual phenomena such as abnormal noise, unstable scan pattern behavior or vastly unusual performance characteristics occur during operation, put the device out of operation and contact support@blickfeld.com for further instructions.
- Never try to operate the Cube if an obvious damage of the device is discernible.
- Avoid touching the optical aperture and do not press against it using hands or tools.
- Make sure that the used personnel are qualified and trained for all tasks related to installing, operating, maintaining, and disposal of the device.

2.3 Particular hazards and safety instructions

The Cube is a scanning LiDAR sensor with a built-in laser that emits pulses of laser beams with a wavelength of 905 nm. Radiation of this wavelength is invisible to the human eye but can still pose a danger to the eyes and skin if the exposure level exceeds the limits applicable to Class 1 laser products.

The Cube is designated as Class 1 laser product and thus not dangerous to the human eye during all procedures of operation specified in this manual.

Explanatory label	Description
 A rectangular label with a black border. Inside, it says "CLASS 1 LASER PRODUCT" in bold, followed by "EN/IEC 60825-1 2014" in a smaller font.	Laser class explanatory label Class 1 laser product according to EN/IEC 60825-1 Ed. 3 2014.

Caution – use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

The Cube incorporates a class 3B embedded laser. Any modifications to the Cube or incorrect use can increase the level of risk of exposure to hazardous quantities of invisible laser radiation, which may pose a danger to the eyes and skin. Therefore, strictly observe the following safety notes. Further information on the non-accessible internal laser of the Cube can be found in section 3.10 on page 27.



Invisible laser radiation!

- Never open the protective housing of the Cube.
- Never intentionally look into the optical component of the Cube from close distance while the Cube is switched on.
- No service or repair work may be performed except by authorized Blickfeld personnel.
- Only use the accessories specified or authorized by Blickfeld.
- Adhere to the applicable national regulations on optical radiation protection.

⚠ WARNING**Electrical voltage!**

Inside the protective housing, hazardous voltages are present in the energized state. Electrical voltage can lead to serious injury or death.

- Never open the protective housing of the Cube.
- The power supply equipment must meet all requirements set forth in the technical specification and the electrical installation instructions in this manual.
- Custom electrical installations must be carried out by qualified electricians.
- Never try to operate the Cube if an obvious damage of the device or its protective enclosure is discernible.
- Adhere to the national and regional regulations and requirements applicable for work on electrical systems.

Additionally, for the indoor variants CUBE1-IH and CURA1-IH:

- These Cube variants have an ingress protection rating of IP40 according to IEC 60529 and were designed for indoor use. Do not use them in wet environments or under conditions that could cause condensation.
- Use the power supply unit and power cable supplied with the Cube or comparable hardware that complies with the relevant national standards for electrical safety.

⚠ CAUTION**Hot surface!**

During and shortly after operation the mounting surface of the Cube can be hot enough to potentially cause skin burn. Avoid contact of the skin with this surface during operation or let the sensor cool down after operation.

3 Product description

3.1 Model numbers

The different LiDARs of the Cube 1 product family have an 8-digit model number associated to them, which is built up according to the following scheme: CUxx1-yy, where xx and yy are variant-specific as detailed in the following table:

CU	xx1	-yy
CU: Cube 1 product line	BE1: Cube 1 RA1: Cube Range 1	-IH: Indoor variant -OV: Outdoor variant

Example: CUBE1-IH is the indoor variant of Cube 1.

3.2 Product overview

The Cube consists of a laser detection module and a combination of two beam deflection units. All components are mounted on a robust base and enclosed in a rugged housing.

As seen from the front of the Cube (see Fig. 1), the left side has two connections for the power supply and for the Ethernet. The right side has three threaded holes that can be used to mount the Cube either on the supplied mounting bracket or on a prepared mount.

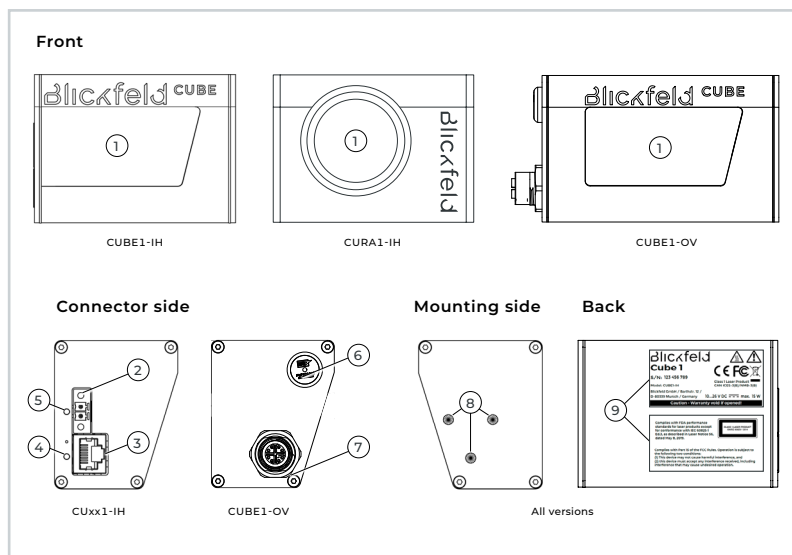


Fig. 1 Cube overview. Cube 1 front (top left), Cube Range 1 front (top center), Cube 1 Outdoor front (top right), connector side (bottom left), mounting side (bottom center), back side (bottom right).

- 1 Optical aperture (front)
- 2 Power connector
- 3 Ethernet connector
- 4 Function LED
- 5 Power LED
- 6 Vent
- 7 M12 Industrial Ethernet connector
- 8 3 x M5 x 0.8 mm threaded holes on mounting side
- 9 Device labels

3.3 Materials

Part	Material	Color
Housing	Aluminum	Black anodized
Optical window (Cube 1)	Acrylic glass (opaque)	Black
Front lens (Cube Range 1)	N-BK7 glass	Transparent

Tab. 2 List of enclosure materials

3.4 Device labels

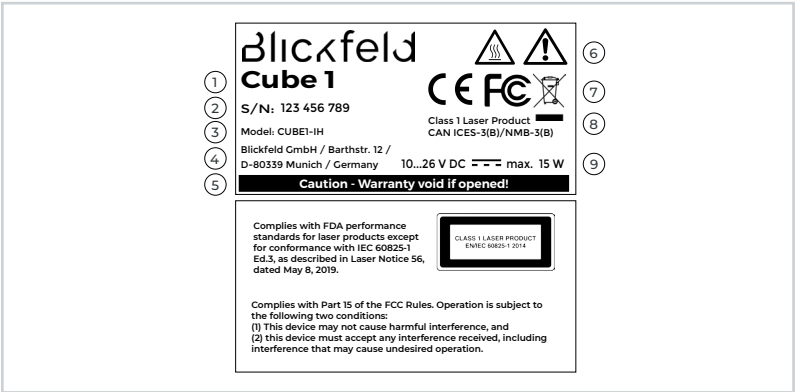


Fig. 2 Device labels. Labels are printed white on black on the device.

- 1 Product name
- 2 9-digit serial number
- 3 Model number
- 4 Manufacturer identification
- 5 Caution! Do not open protective housing
- 6 Caution: Hot surface! Warning symbol: Read operating instructions!

- 7 Conformity/certification marks; WEEE symbol
- 8 Laser class designation; equipment authorization under ISSED ICES-Gen
- 9 Voltage supply rating; max. power rating

3.5 Function description

The Cube operates with solid state LiDAR technology. A laser source generates laser pulses that hit MEMS-based silicon mirrors as shown in Fig. 3. Every Cube contains two MEMS beam deflection units, which together form the scanner. They are oriented perpendicularly with respect to each other and thus allow the deflection of the beam in two perpendicular directions. The first mirror deflects the beam in the vertical, the second one in the horizontal direction. When the scanner is running, both mirrors perform oscillating rotational movements. This simultaneous movement of both mirrors defines the trajectory for the laser beam and creates the “eye-shaped” scan pattern that is typical for the Cube (see Fig. 4). If the laser pulse hits objects in the field-of-view (FoV) of the Cube, these will reflect the laser beam. The portion of the reflected light that reaches the Cube is registered by a photo detector. Then, the distance to the object is calculated from the runtime difference between emission of the laser pulse and reception of the reflection by the time-of-flight principle.

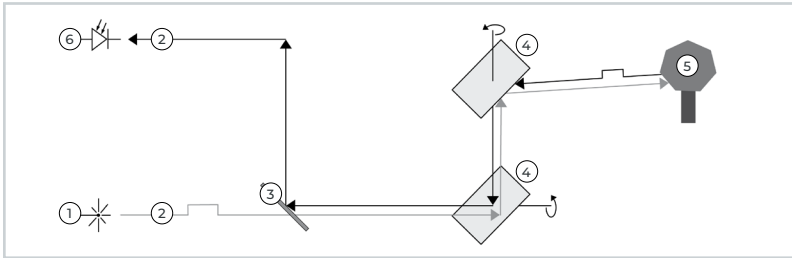


Fig. 3 Cube function description

- 1 Laser source
- 2 Laser pulse
- 3 Beam splitter
- 4 Beam deflection unit
- 5 Object in field-of-view
- 6 Detector

3.5.1 Laser source

In the Cube, the laser source is a collimated laser diode with a wavelength of 905 nm. The emitted laser beam has a collimation of 0.4° for Cube 1 and 0.24° for Cube Range 1. The laser is controlled in such a way that a regular pattern results in the point cloud with the configured horizontal resolution. The pulse energy is adapted dynamically for the horizontal angular resolution on the basis of the laser class 1 limitation described in IEC 60825-1:2014. As a result, the achievable range of the Cube is lower when the horizontal resolution is configured fine and it is higher when the horizontal resolution is chosen coarse.

3.5.2 Field-of-view

The Cube continuously scans the surroundings using two scanners in the form of MEMS mirrors. They deflect the laser beam horizontally and vertically to measure a scene in two dimensions. The maximum deflection angles in the horizontal and the vertical direction define the field-of-view. If the horizontal scanner deflects the laser by $\pm 35^\circ$, for example, this corresponds to a horizontal FoV of 70° .

3.5.3 Scan pattern

In the Cube, one of the scanners oscillates with a constant amplitude and generates the horizontal FoV. The second scanner, which is responsible for the vertical deflection, changes its amplitude continuously so that the entire vertical field-of-view of the Cube is scanned and measured. The resulting scan pattern can be seen in Fig. 4. The scan pattern consists of vertically arranged, individual scan lines. Their angular spacing is calculated by dividing the vertical FoV by the number of scan lines. For example, a vertical FoV of 30° and 100 scan lines yields a vertical resolution of 0.3° .

One complete scan across the full FoV is called a frame. Because the vertical scanner has to return to its initial amplitude before a new frame can start, every scan of one complete frame consists of a so-called up-ramping phase and a down-ramping phase. During the up-ramping phase the vertical scanner increases its deflection amplitude while during the down-ramping phase it decreases.

The frame rate depends on the number of scan lines. It describes how often the total scene is scanned per second. The installed beam deflection unit permits a scan rate of 500 scan lines/s. In the above example, this results in a frame rate of $500/100 \text{ 1/s} = 5 \text{ Hz}$. Fig. 4 illustrates the relationship between the number of scan lines and the frame rate. The figure shows scan patterns with different numbers of scan lines. The more scan lines are configured, the longer it takes to measure a complete frame.

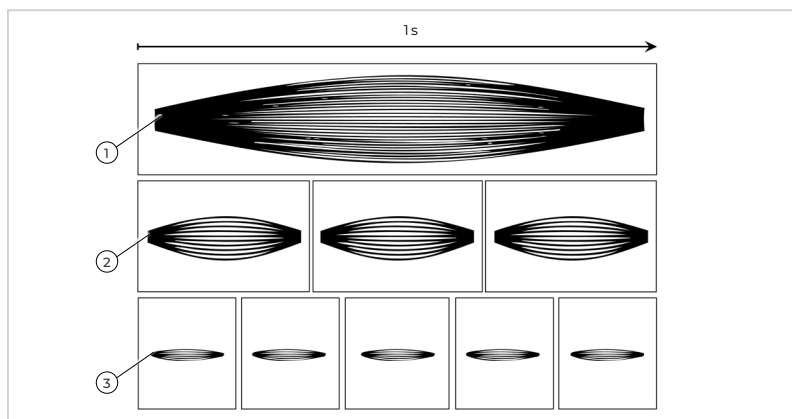


Fig. 4 Scan pattern

- 1 30 scan lines, 1 Hz
- 2 10 scan lines, 3 Hz
- 3 6 scan lines, 5 Hz

The scan pattern of the Cube is highly configurable and can be optimized for different applications. For instance, the resolution can be adjusted by changing the number of scanlines and the horizontal angular spacing. The scan pattern can be configured manually in the WebGUI or programmatically using the Blickfeld API (Blickfeld scanner library (BSL)). The following parameters are available:

- The number of scan lines in the down-ramping and the up-ramping phases.
- Vertical and horizontal FoV.
- Angle spacing (horizontal)
- Frame mode: Up, Down, Combine or Separate.
- Type: Equidistant pulsing or Interleave.

Note that it is not possible to independently configure the frame rate, since the frame rate depends on the number of scanlines and the mirror's resonance frequency. Of the five parameters listed above, the number of scanlines, and the frame mode have an immediate effect on the achieved frame rate.

Point cloud data can be recorded during the up- and down-ramping phases. The frame mode setting determines whether ranging measurements are performed during one of either phases or during both. Four settings are available:

1. Only up

The laser pulses only during up-ramping phase, meaning that the point cloud contains only scanlines from the up-ramping phase. The data from the down-raping phase is discarded.

2. Only down

The laser pulses only during down-ramping phase, meaning that the point cloud contains only scanlines from the down-ramping phase. The data from the up-ramping phase is discarded.

3. Combine up and down

Laser pulses during both phases and the point cloud contains both, scanlines from the up- and from the down-ramping phase.

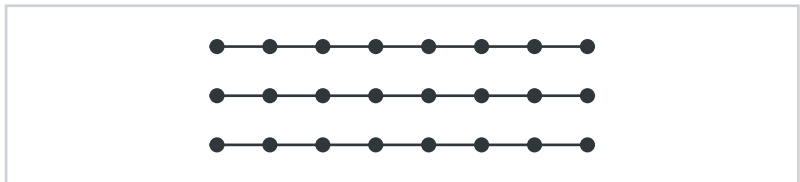
4. Separate

Up- and down-ramping phases are provided as separated frames, which effectively doubles the frame rate.

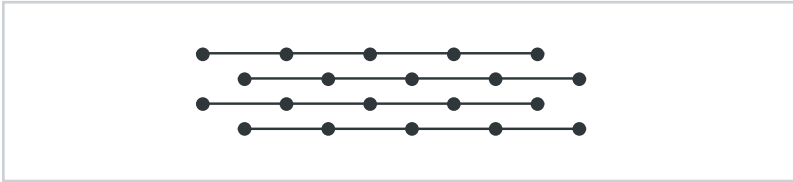
When using the only-up or only-down modes, one will usually configure the minimum possible number of scan lines in the phase that is discarded in order to maximize the frame rate.

The pulse pattern type setting controls the location of the measurement points along subsequent scan lines. Two modes are available:

- **Equidistant horizontal angle:** Laser pulses are sent out at the same horizontal angles for each scan line. The resulting pulse pattern looks like this:



- **Interleave:** Laser pulses are shifted by half the angle spacing for every other scanline, which creates the following pattern:



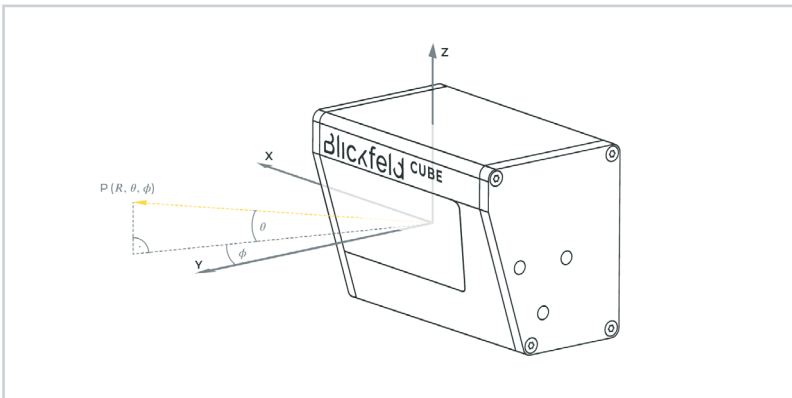
3.6 Coordinate system

The LiDAR point cloud data contains the Cartesian coordinates (x, y, z) of all detected echoes per frame. Additionally, the coordinates are available in spherical coordinates (R, θ, ϕ) , where R is the distance from the sensor, θ is the elevation angle, and ϕ the azimuthal angle. The definitions of the two coordinate systems are depicted in Fig. 5. The following relationships apply for converting between the coordinate systems:

$$x = R \times \cos\theta \times \sin\phi$$

$$y = R \times \cos\theta \times \cos\phi$$

$$z = R \times \sin\theta$$



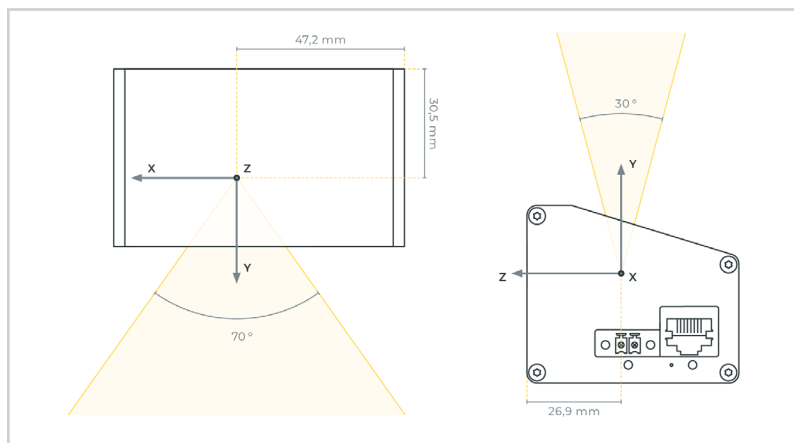


Fig. 5 Cube coordinate system. Definitions and measurements of the origin location are identical for Cube Range 1

3.7 Electrical connection (CUxx1-IH only)

The indoor variants CUxx1-IH are designed for an input voltage of 12 V DC. A 2-pin Phoenix Contact plug with type designation 1817615 is used for the power supply. The connector pin-assignment on the sensor side is shown in Fig. 6.

The outdoor variant CUBE1-OV uses Power over Ethernet (PoE) instead of a dedicated power supply connector. Please see section 3.9.1 for further details.

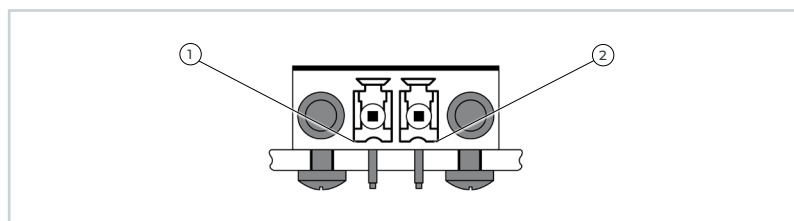


Fig. 6 Cube electrical interface pin assignment (device side)

- 1 GND
- 2 Supply voltage: +12 V DC

3.8 Thermal properties

During normal operation at room temperature, consumption is approx. 9 W. During the startup procedure, peak values of 13 W can occur.

The heat is primarily output on the mounting side of the Cube. To achieve optimal performance, especially at higher ambient temperatures, we recommend mounting the Cube on a prepared mount that can dissipate the generated heat.

3.9 Data interface

3.9.1 Ethernet interface

For connection and data transmission to a computer, a Gigabit Ethernet interface is used. Cube indoor variants are equipped with a standard RJ45 socket with a standard pin assignment (as per TIA-568B).

Cube outdoor variants instead have an IP65-rated M12 round connector (as per IEC 61076-2-109). The connector is supplied with a protective cap, which must be removed before the electrical installation. When no cable is connected to the Cube and during storage, please put the cap back onto the connector.

	Cuxx1-IH	CUBE1-OV
Standard	TIA-568B	IEC 61076-2-109
Connector geometry	RJ45	Round, M12x1
Coding	not applicable	X-coded
Number of pins	8	8
Ingress Protection rating	IP40	IP65

Tab. 3 Ethernet receptacle (CUxx1-IH & CUBE1-OV).

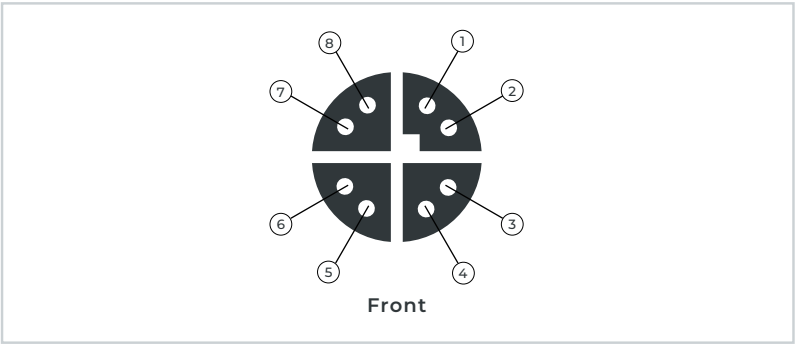


Fig. 7 Pinout of the M12 Ethernet receptacle on the sensor (CUBE1-OV only). For the pin assignment, see table below.

Signals	Pin Assignment	
1/10 Gbit	M12 X-coded	color coding (TIA-568B)
BI_DA+	1	White/orange
BI_DA-	2	Orange
BI_DB+	3	White/green
BI_DB-	4	Green
BI_DC+	5	White/blue
BI_DC-	6	Blue
BI_DD+	7	White/brown
BI_DD-	8	Brown
Shield	Housing	Housing

Tab. 4 M12 Ethernet receptacle pin assignment for the CUBE1-OV in conjunction with Figure 7.

3.9.2 Time synchronization

The Cube supports the NTPv4 and PTPv2 protocols for synchronization of the Cube's onboard clock over the network.

3.9.3 Point cloud output

The primary data output of the Cube is a 3D point cloud, which is refreshed at a certain frame rate that depends on the configured resolution and field-of-view. The point cloud is the collection of registered laser pulse reflections caused by objects within the field-of-view. The distance to these objects is determined via the time-of-flight principle and combined with the deflection angle information from the laser scanner to give the exact return locations in the three spatial coordinates (X, Y, Z). For every received echo the following information are available:

Data field	Description	Data type
ID	Unique identifier for every received echo.	unit32
Cartesian coordinates	Coordinates (x, y, z) relative to the Cube from which the echo has been received.	float
Distance	Distance from the Cube to where the target has been located.	float
Intensity	Relative intensity of the reflected light pulse.	unit32

Tab. 5 LiDAR output data provided for every received echo

Additionally, the data listed in Tab. 6 are available for every measurement angle.

Data field	Description	Data type
Timestamp offset	Specifies the start of each ranging measurement with respect to the absolute start time of the corresponding frame in ns.	unit64

Data field	Description	Data type
Elevation angle	Elevation angle under which the measurement was performed.	float
Azimuthal angle	Azimuthal angle under which the measurement was performed.	float
Ambient light level	Provides a relative measure of the near infrared light intensity in that part of the scene. For instance, objects illuminated directly by the sun will show high ambient light values while darkness will show low values.	unit32

Tab. 6 LiDAR data output provided for every measurement angle

Apart from the high-quality 3D point cloud data, the Cube outputs data of the integrated inertial measurement unit (IMU), timing data, and device status data. For a full overview of the retrievable data, please visit the user documentation of the Blickfeld Scanner Library under docs.blickfeld.com/cube/latest/bsl_index.html.

3.10 Technical specifications

OPTICAL PERFORMANCE ^a

	Cube 1	Cube Range 1
Typical application range	1.5 – 75 m	5 – 150 m
Detection range	250 m (> 30 m for 10 % reflectivity target, pixel-filling, 100 klux, 90 % detection rate, false positive rate < 0.2 %, 0.6° horizontal angular spacing)	250 m (> 50 m for 10 % reflectivity target, pixel-filling, 100 klux, 90 % detection rate, false positive rate < 0.2 %, 0.4° horizontal angular spacing ^b)

	Cube 1	Cube Range 1
Maximum field-of-view (Horizontal x vertical)	70° x 30°	18° x 12°
Vertical resolution	5 – 400 scan lines per frame ^c (user-configurable)	5 – 200 scan lines per frame ^c (user-configurable)
Horizontal resolution	0.4° – 1.0° (user-configurable)	0.24° – 0.4° (user-configurable)
Scan rate	> 500 scan lines per second	
Frame rate	1.5 – 50 Hz (dependent on configured scan lines and vertical field-of-view) Examples: <ul style="list-style-type: none"> • 70° x 30°, 200 scan lines, min. 2.5 Hz. • 70° x 30°, 50 scan lines, min. 10 Hz. • 70° x 8°, 16 scan lines, min. 30 Hz. 	2.5 – 50 Hz (dependent on configured scan lines and vertical field-of-view) Examples: <ul style="list-style-type: none"> • 18° x 12°, 200 scan lines, min. 2,5 Hz. • 18° x 12°, 32 scan lines, min. 15 Hz. • 18° x 10°, 20 scan lines, min. 25 Hz.
Number of returns	3 ^d	3

^a Measured at 25 °C, 60 % rel. humidity, single return. Performance may deviate outside of these reference conditions.

^b The effective detection range drops at the edges of the field-of-view.

^c For less than 26 scan lines (Cube), respectively 18 scan lines (Cube Range) a reduced vertical field-of-view must be configured (see frame rate).

^d Starting from a distance of 5 m. Only single returns at closer distances.

LASER

	Cube 1	Cube Range 1
Laser class	Class 1 laser product eye safe (EN/IEC 60825-1:2014, Ed. 3) Complies with FDA performance standards for laser products except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.	
Wavelength	905 nm	
Beam divergence	0.4° Examples: • 10 m: 0.07 m x 0.07 m • 50 m: 0.35 m x 0.35 m	0.24° Examples: • 10 m: 0.04 m x 0.04 m • 100 m: 0.38 m x 0.38 m

OUTPUT

Connection	TCP/IP over Gigabit Ethernet (1000BASE-T)
LiDAR output	Distance, intensity, and Cartesian coordinates per return; Azimuth angle, elevation angle, and timestamp in ns per acquisition
On-device data processing	Smart background subtraction and pose correction transformation; Filters: Distance, Noise, Intensity, Neighbor
IMU output	>1 kHz sampling rate; 3-axis accelerometer, 3-axis gyroscope

CONTROL INTERFACE

Configuration interface	Cross-platform graphical web interface with interactive 3D point cloud visualization and recording feature.
Control & stream interface	TCP connection with Blickfeld protocol; C++ library and Python package as client software interface; ROS drivers available on request
Time synchronization	NTPv4 and PTPv2 (IEEE 1588)

MECHANICAL / ELECTRICAL

Power consumption	CUxx1-IH (Indoor): Typ. 8.5 W (max. 13 W) CUBE1-OV (Outdoor): Typ. 9 W (max. 13 W)
Operating voltage	CUxx1-IH (Indoor): Recommended: 12 V DC Absolute maximum ratings: 10 V – 26 V DC CUBE1-OV (Outdoor): Power over Ethernet Type 1 PD (IEEE 802.3af): 37 – 57 V DC
Dimensions (H x W x D); Weight	CUBE1-IH: 60 x 82 x 50 mm; ca. 275 g CURA1-IH: 60 x 82 x 86 mm; ca. 385 g CUBE1-OV: 60 x 97 x 50 mm; ca. 330 g
Data connector	CUxx1-IH (Indoor): RJ45 CUBE1-OV (Outdoor): 8-pin M12 Industrial Ethernet connector, X-coded (DIN EN 61076-2-109)

Power connector	CUxx1-IH (Indoor): Phoenix Contact 1817615 Compatible power supply connector: Phoenix Contact 1845219 CUBE1-OV (Outdoor): Not available (Power over Ethernet)
Electromagnetic compatibility	EN 61326-1:2013 • Emissions: CUxx1-IH (Indoor): Class B (residential environments) CUBE1-OV (Outdoor): Class A (commercial environments) • Immunity: Table 2 (Industrial Applications) FCC (47 CFR) Part 15 Subpart B CUxx1-IH (Indoor): Class B digital device CUBE1-OV (Outdoor): Class A digital device ISED ICES-Gen CUxx1-IH (Indoor): CAN ICES-3(B) / NMB-3(B) CUBE1-OV (Outdoor): CAN ICES-3(A) / NMB-3(A)
Electrical safety	EN 61010-1:2010 + A1:2019 + A1:2019/AC:2019
Protection class	III (SELV)
Overvoltage category	I

OPERATIONAL

Operating ambient temperature (mounted)	-30 °C – 60 °C
Storage temperature	-30 °C – 60 °C
Humidity	Max. 85 % at 30 °C, non-condensing
Altitude	4000 m above sea level
Ingress protection (EN 60529:1991/ A2:2013/AC:2019-02)	CUxxI-IH (Indoor): IP40 CUBEI-OV (Outdoor): IP65
Pollution degree	2
Impact protection	IK06 according to IEC 62262*

*The product has been tested and confirmed to be safe under the following conditions:

- Rated impact energy: 1 Joule.
- The housings of the product were cooled down to -30 °C and tested within the first 10 minutes after cooling.
- A steel sphere with a mass of 500 g ± 25 g and a diameter of ca. 50 mm was dropped onto the product from a height of 200 mm.

4 Installation

4.1 Scope of delivery

Each Cube delivery contains the following parts:

- Ordered variant of the Cube
- This user manual

4.2 Mounting

The Cube must only be operated after it has been installed to a stable mounting base. Always use the M5 tapped holes on the side of the Cube for this purpose. Blickfeld offers a suitable mounting bracket, which provides a ¼"-20 UNC threaded hole for use with standard photography tripods or security camera mounts (see Fig. 8).

If a custom mounting base is used, it should be designed in a way that the heat of approx. 9W generated by the Cube is dissipated. The main thermal load is transferred via the mounting side. Make sure that the interfaces of Cube and mounting material are free from debris and use a thermal interface material for better heat conductivity if necessary.

The Cube can be mounted in any orientation. Fine adjustment of the device orientation can be performed while looking at the point cloud output after putting the Cube into operation.

Choose the mounting position such that the Cube's field-of-view is not obstructed and observe the operational and storage temperature limits. For best performance, avoid mounting configurations where the Cube would receive direct reflections from sunlight. Make sure that the device is only accessible for trained personnel.



Hot surface!

During and shortly after operation the mounting surface of the Cube can be hot enough to potentially cause skin burn. Avoid contact of the skin with this surface during operation or let the sensor cool down after operation.

ATTENTION

Strong magnetic fields can damage the Cube.

Do not place the Cube in the immediate vicinity of sources of strong magnetic fields.

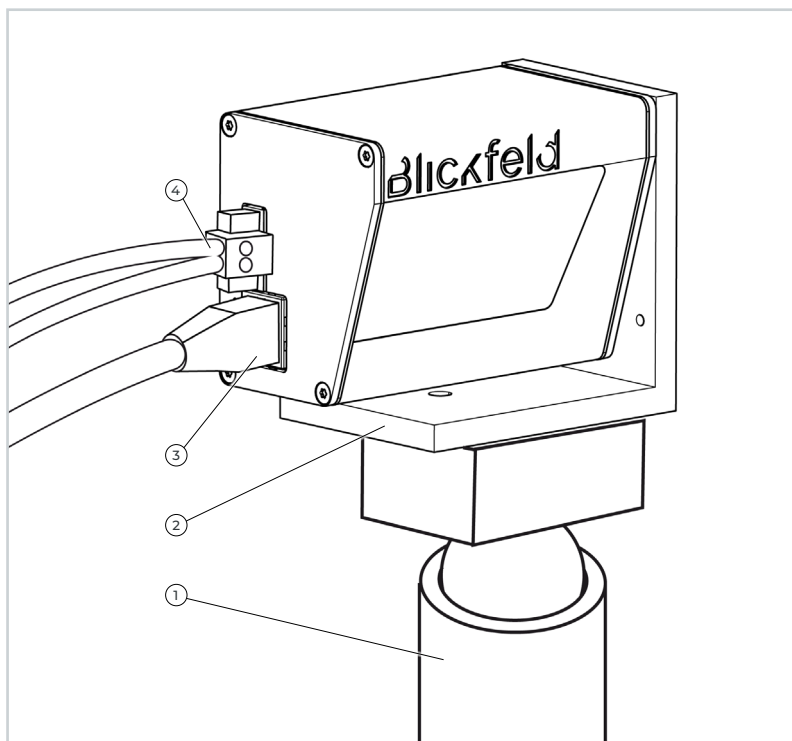


Fig. 8 Example of the Cube mounted on a tripod using the supplied mounting bracket

- 1 Stand (not included)
- 2 Mounting bracket (available from Blickfeld)
- 3 Ethernet cable
- 4 Power cable (only indoor variants)

4.3 Electrical installation / cabling

ATTENTION

An incorrect electrical connection can damage the Cube or other connected devices.

- Do not switch on the supply voltage until all other cable connections have been properly established.
- If the Cube is used with an unshielded data cable or with any other than the voltage supply recommended by Blickfeld, compliance of the system with the specified performance standards regarding electromagnetic compatibility (EMC) can no longer be guaranteed.
- Secure the power cable to the Cube using the locking screws on the connector to prevent accidental disconnection (applies to indoor variants only).
- For Cube outdoor variants, use an Ethernet cable that is IEEE 802.3af-compliant (at least Cat. 5_E). When bundling cables, obey the applicable regulations and technical guidelines regarding the number of cables and required wire cross-sections.

WARNING



Warning of electrical voltage!

An incorrect electrical installation may result in operational faults and may increase the risk for injury or damage due to hazardous electrical currents.

- Custom electrical installations must be carried out by qualified personnel.
- Adhere to the national and regional regulations and requirements applicable for work on electrical systems.

For the data connection a shielded Ethernet cable of Cat. 5_E or higher is required. The electrical installation differs depending on the Cube variant. Please follow the appropriate instructions for indoor or outdoor variants below.

ELECTRICAL INSTALLATION OF CUBE INDOOR VARIANTS

Proceed as follows to connect the Cube to the cables and establish operating readiness:

- 1 Connect the output cable of the voltage supply to the Cube while in the deenergized state.
 - 2 Secure the plug-in connectors by tightening the locking screws.
 - 3 Connect the Cube to the Local Area Network or directly to a computer using an Ethernet cable.
- The Cube is ready to start up.

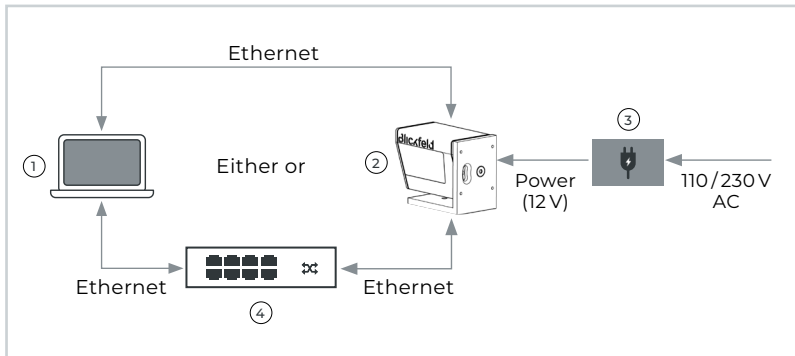


Fig. 9 Wiring diagram (indoor variants)

- 1 Computer
- 2 Cube
- 3 Power supply unit
- 4 Switch

If a different voltage supply is used than the one recommended by Blickfeld or delivered with the Cube, the following instructions apply:

- The voltage supply circuit connected to the Cube must be configured as a safety extra-low voltage (SELV) circuit.
- Observe the minimum and maximum voltage ratings as well as the maximum power consumption of the Cube as defined in the technical specifications.

- Use cables with suitable wire cross sections that comply with the applicable standards for electrical safety.
- Use the voltage supply connector specified in this manual and do not modify the connector on the Cube nor open the protective housing to access the internal electronics.

ELECTRICAL INSTALLATION OF CUBE OUTDOOR VARIANT USING POWER OVER ETHERNET (POE)

For operating the Cube outdoor devices, Power over Ethernet must be available. The corresponding networking equipment must support Type 1 powered devices (IEEE 802.3af).

Proceed as follows to connect the Cube to the cables and establish operating readiness:

- 1 Connect the Ethernet cable to a suitable PoE injector or PoE switch.
 - The Cube will start up as soon as PoE is available.

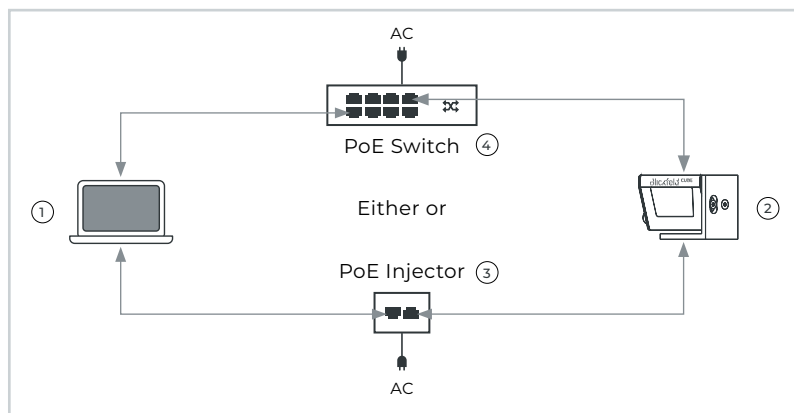


Fig. 10 Wiring diagram (outdoor variants)

- 1 Computer
- 2 Cube
- 3 PoE Injector
- 4 PoE Switch

5 Operation



Instead of reading through the instructions in this section, you can alternatively watch the tutorial videos, which are available on the Blickfeld website. Scan the QR code to access the web site on your mobile device. They cover the initial setup of the Cube, the features of the WebGUI point cloud viewer and the configuration of the scan pattern.

5.1 Powering up the Cube

For Cubes with PoE feature, no further steps for powering up are required.

Proceed as follows to put the Cube without PoE feature into operation:

- 1 Make sure that the Cube is mounted and the electrical and data connections are established as described in the previous section.
- 2 Switch on the power supply.

Note

After switching on the power to the Cube, it can take up to 60 seconds until the Cube is ready for use.

5.2 Connecting to the WEBGUI for the first time

The Cube provides a web graphical user interface available during operation (Fig. 11 on page 40). It can be opened in a normal web browser by a computer in the same network (no additional software or driver installation is necessary). The WebGUI can be used to monitor the status of the device and configure the network and scan settings. Additionally, the LiDAR point cloud can be viewed live and the recording function can be controlled. The Cube supports the automatic assignment of the IP address (DHCP), as is customary in company networks for example, but can also be addressed via a static fallback IP.

CONNECTION VIA A NETWORK WITH AUTOMATIC IP ADDRESS ASSIGNMENT

If you connect the Cube to a network with automatic IP address assignment, proceed as follows to establish a connection with the Cube:

- 3 Open an Internet browser such as “Mozilla Firefox” oder “Google Chrome”.
- 4 Go to the address “http://cube-hostname/”, in which “cube-hostname” is an identifier assigned to the Cube. The factory-set hostname that must be used when connecting for the first time is “cube-xxxxxxx”, where xxxxxxxx is the 9-digit serial number of the device. You will find the serial number on the device’s type label.
 - You are now connected to the WebGUI of the Cube. You can now change the host name used to address the Cube in the WebGUI if you wish.

DIRECT CONNECTION

If you are not connecting the Cube to a network with an automatic IP address assignment or if you have connection problems, proceed as follows to establish a connection between the computer and the Cube:

Note

The preset static IP configuration of the Cube is:

- IP address: 192.168.26.26 (fallback IP)
- Subnet mask: 255.255.255.0 (/24)

- 3 Open the system settings on your computer.
- 4 Navigate to the network settings.
- 5 Open the TCP/IPv4 settings.
- 6 Set your IP address to static and assign your IP settings according to the following scheme:
 - IP address: 192.168.26.X
 - Subnet mask: 255.255.255.0 (/24)

Note

The last position of the IP address, marked with an “X”, must be between 1 and 254 and must not be “26”.

- 7 Open an Internet browser such as “Mozilla Firefox” oder “Google Chrome”.
- 8 Open the address “http://192.168.26.26/”.
 - You are now connected to the WebGUI of the Cube.

Fig. 11 shows the landing page of the WebGUI. Visit the WebGUI documentation pages at docs.blickfeld.com/cube/latest/web_gui_index.html for a more detailed description of the WebGUI functions.

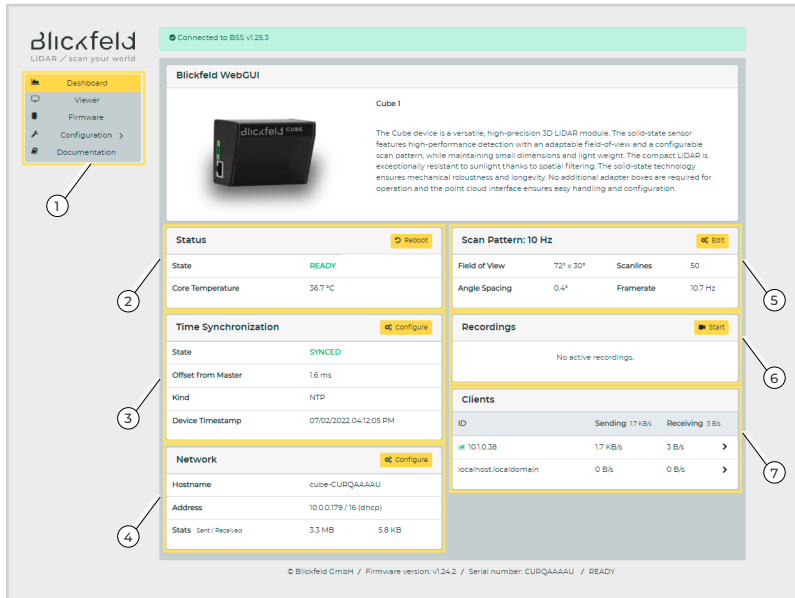


Fig. 11 WebGUI Dashboard*

- 1 Sidebar menu
- 2 Device status overview and reboot button
- 3 Time synchronization status display
- 4 Network status display
- 5 Active scan pattern display
- 6 List of active recording sessions and shortcut for starting of recordings
- 7 List of connected clients

* Subject to change.

Note

If the Cube is used in an unmanaged network, it is strongly recommended to change the networking mode of the Cube to static and configuring a custom IP address different from the fallback IP. This can be done conveniently using the WebGUI. In particular when using more than one Cube in the same network, unique IP addresses must be configured!

5.3 Starting LiDAR operation

Once the connection to the Cube is established, the sensor will be in an idle state, signaled by the state indicator reading "READY". LiDAR operation will start automatically as soon as a data stream is requested by a client. Such a data stream can be requested simply by opening the Viewer tab within the WebGUI (select "Viewer" from the side bar), which brings up a new view for visualizing the LiDAR data coming from the sensor. The state indicator will now show "RUNNING".

5.4 Stopping LiDAR operation

Always make sure that the Cube scanner is stopped before switching off the power supply to the Cube. A stopped scanner is indicated by the device status reading "READY", which is displayed on the dashboard of the WebGUI. Alternatively, the status can be requested via the Blickfeld Scanner Library (BSL). If the scanner status reads "RUNNING", the scanner is still operating.

The Cube automatically stops LiDAR measurements and the scanner once all data streams have been closed. This can be achieved by stopping all active recordings and closing the WebGUI viewer in the browser.

5.5 Configuring the sensor

Most sensor settings can be configured using the WebGUI configuration menu. The following settings are available:

- Network settings
- Time synchronization settings
- Scan pattern settings

For the powerful scan pattern generator, a tutorial video is available. Please follow the link at the beginning of this chapter.

Pre-processing algorithms such as Background Subtraction, Neighbor Filter, and coordinate transformation can be accessed via the WebGUI Viewer.

All of the above settings can alternatively be configured via the Blickfeld Scanner Library (BSL). Some features are only available via the BSL, for instance frame synchronization between multiple Cubes. Please consult the API documentation under docs.blickfeld.com/cube/latest/bsl_index.html for further details.

5.6 Troubleshooting of the WebGUI connection

Problem	Possible cause	Measure
A connection cannot be established between the computer and the Cube.	No power connection	<ul style="list-style-type: none">• Check the power LED on the Cube.• If it does not light up: check the power connection.
	The Cube is in error state.	<ul style="list-style-type: none">• Check the function LED on the Cube.• If it does not light up or lights up red: restart the Cube with a power cycle.• The function LED still does not light up or lights up red: contact Blickfeld.

Tab. 7 Troubleshooting of the WebGUI connection

Note

Cube outdoor variants do not provide power and function LEDs. In order to verify whether the Cube is powered, you can use the activity LED on the Ethernet port of your network equipment to which the Cube is connected. If the LEDs on that Ethernet port are dark, the Cube is not powered or is in a fault state. Please verify that the Power over Ethernet of your system is working, otherwise contact Blickfeld support.

5.7 Additional software tools

Software tools, firmware updates and the online documentation of the Cube can be accessed at www.blickfeld.com/resources. Tab. 8 gives an overview of the available tools.

Tool	Function
Blickfeld Point Cloud Recorder	The Blickfeld Point Cloud Recorder is used to record and convert point clouds. It supports the VTU format, among others.
Blickfeld Scanner Library (BSL)	The Cube can be controlled via a programming interface (the so-called “Blickfeld Scanner Library”, or BSL). It supports the C++ and Python programming languages. Visit github.com/Blickfeld/blickfeld-scanner-lib to download the BSL. You will also find instructions for installing the Python package there.
Robot Operating System (ROS) Drivers	This is a programming interface for applications that use the Robot Operating System (ROS/ROS 2).

Tab. 8 Software tools

Blickfeld Percept is Blickfeld's innovative and easy-to-use perception software. It empowers everyone to translate data from Blickfeld's LiDAR sensors into actionable insight for real-world applications. Please visit www.blickfeld.com for further information.

When further analysis and advanced visualization of recorded data is required, ParaView can be used. ParaView is an open-source, multi-platform data analysis and visualization application, which can be downloaded free of charge from www.paraview.org.

6 Service and Maintenance

6.1 Service and repair information

Note

The Cube contains no parts serviceable by the user. Any repair procedures may only be performed by Blickfeld authorized technicians. Do not open the sensor under any circumstance.



Danger of injury due to laser beam

- If the Cube is not operated correctly, the optical radiation may injure the eyes and skin.
- Do not open the housing. The housing may only be opened by authorized Blickfeld personnel. Contact Blickfeld if repairs are necessary.

6.2 Cleaning

For maximum performance, the optical window of the Cube must be checked regularly for contamination. Clean the window, if necessary, using a microfiber cloth dampened with a mild window cleaner. The housing may be cleaned in the same way.

Note

The window consists of a special plastic material. Note the following when cleaning:

- Avoid touching the window with your fingers.
- Do not use aggressive cleaning agents or solvents.
- Do not use paper towels for cleaning as these may scratch the material.
- Avoid using a scratching or rubbing motion on the window.

7 Storage and disposal

7.1 Storage

Provide for the following ambient conditions during storage:

Permissible storage temperature	-30 °C – 60 °C
Relative humidity	Max. 85 % at 30 °C, non-condensing

Tab. 9 Ambient conditions for storage

If possible, store the sensor components in their original packaging in a dry location. If the original packaging is no longer available, cover the Cube (to protect it against dust) and store it in a dry location.

7.2 Disposal

Dispose of the Cube and the cables in an environmentally friendly manner according to the local ordinances, regulations and laws applicable at the time of disposal.

INFORMATION ON THE WEEE DIRECTIVE 2012/19/EU FOR CUSTOMERS WITHIN THE EU



The product is marked with the crossed-out wheeled bin symbol, also known as WEEE symbol. It indicates that end users are legally obliged to dispose of these appliances separately from unsorted municipal waste, i.e. old appliances must be disposed of separately from household waste. Instead, this device as well as any electronic parts included in the delivery must be disposed of in the appropriate separate waste collections.

Make sure to erase any personal data such as IP addresses or device names that may be stored on the decommissioned devices to prevent misuse.

For disposal, customer located in Germany have the option to return decommissioned devices to Blickfeld. Please contact support@blickfeld.com for further information.

8 Customer service / support

Please do not send devices to Blickfeld without having been requested to do so. Contact the Blickfeld Support via support@blickfeld.com for technical support or repair requests.

Blickfeld GmbH
Barthstr. 12
80339 Munich, Germany

Tel.: +49 89 230 69 35 00
E-mail: support@blickfeld.com
Website: www.blickfeld.com

9 Compliance information

9.1 EU Declaration of Conformity

The EU Declaration of Conformity can be downloaded from www.blickfeld.com/resources/.

9.2 REACH information

Blickfeld LiDAR scanners employ piezoelectric actuators made from lead zirconate titanate (PZT) for beam steering. PZT is a substance of very high concern (SVHC) listed in the Authorization Candidate list under article 59 of the European Union REACH Regulation (EC) No 1907/2006.

In accordance with Article 33.1 of REACH, Blickfeld discloses the presence of lead zirconate titanate (CAS-No. 12626-81-2) in excess of 0.1% (w/w) in the final product. Under normal use, the material cannot be released into the environment and is of no harm to the user. Do not open the product's enclosure or machine the product.

More information regarding REACH can be found on the Blickfeld website under www.blickfeld.com

9.3 FCC compliance information

The Supplier's Declaration of Conformity (SDoC) under 47 CFR §2.906 can be downloaded from www.blickfeld.com/resources/.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.