LeddarTech®

Leddar™ Pixell 3D Flash LiDAR

User Guide

TF ID 019078

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Leddar™ Configurator software: this software is based in part on the work of the Independent JPEG Group.

Keep this User Guide for future reference.

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Version History

Version	Description	Date (YYYY-MM-DD)
54A0049_5.0_EN	• Updated Disclaimer information • Replaced "accuracy" with "trueness" throughout the document • Corrected 6 dead cross-references throughout the document • Section 3.3: added Table 6 • Section 4.3.4: added GET_CALIB command • Section 5.1: added demerging specifications • Section 5.3: changed PPS input voltage in Table 14 • Section 7.1.3: added External Trigger feature • Section 7.3.2: added reference to PPS input configuration • Section 10.5.2: added demerging feature • Section 10.6.3: added PULSE_MULTOBJ flag ID in Table 29 • Section 11: added hyperlinks to FibreCode drivers in Table 32 • Section 14.3: added disposal information	2021-02-05
54A0049_6.0_EN	• Changed "trueness" back to "accuracy" • Section 1.2: corrected IEC 60259 to 60529 for Water Ingress in Table 2 • Section 3.3: deleted Table 6 "Precision specifications" • Section 5.1: changed accuracy value to "±3 cm" in Table 10 and deleted "Precision" data • Section 7.3.1: added connection detail in Fig. 41 • Section 8.2: changed link for software download	2021-03-22
54A0049_7.0_EN	• Section 8.2: added link to SDK documentation • Section 9.1: added steps to bypass the Windows firewall • Section 10.5.3: added UDP option • Appendix A: added whole section • Appendix C: specified TCP/UDP options in Fig. 79-80 • Appendix C: added "UDP Data Server" section	2021-07-23

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Document Conventions

This document uses the following conventions:

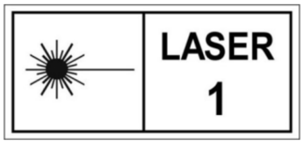
Name of menu > **name of the window**	Shows the access path to menus under each section of Leddar™ Configurator.
Arial bold	The names of buttons, menus, dialog boxes, icons, and elements of the interface are in **bold type**.
	***Note:*** *Contains helpful suggestions and references to information included within this User Guide.*
	***Warning:*** *Refers to a warning or important information to follow.*

This document uses the metric system (SI).

1. Label Explanation and Safety Information

1.1. Labels

Table 1: Explanation of labels on the sensor

Label	Location	Description
	Back of sensor	Eye safety hazard Class 1 laser product as defined by the IEC 60825-1 standard
Warranty Void If Removed	Bottom of sensor	Tamper-proof “Warranty Void” sticker applied to the sensor
MOD: PIXELL-3D-F-A1 SN: XXXXXXX MFD: Feb 2020 MADE IN CANADA www.leddartech.com	Back of sensor	Model number (MOD) Serial number (SN) Manufacturing date (MFD) Country of assembly LeddarTech website address

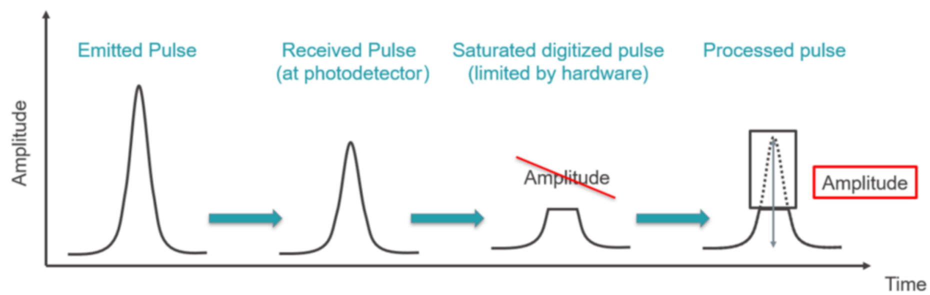
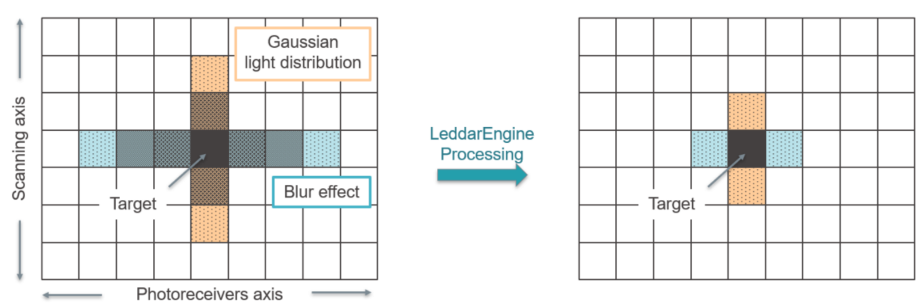
1.2. Regulatory Compliance

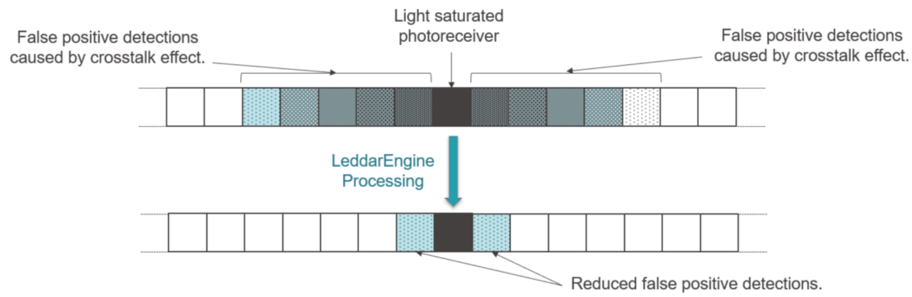
Table 2: Regulatory compliance information

Compliance Feature	Description
EMC/EMI	Complies with electromagnetic compatibility requirements as defined by IEC 61000-6-2:2016 (Immunity Standard for Industrial Environments) and IEC 61000-6-3 A1:2010 (Emission Standard for Residential, Commercial, and Light Industrial Environments).
ICES-003	Class A digital apparatus. Complies with the Canadian Interference-Causing Equipment Standard ICES-003.
Water ingress	IP67 index as defined by IEC 60529:2013
Dust ingress	Complies with Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications standard SAE J1455:2017.
Ocular safety	Complies with Class 1 laser product requirements as defined by IEC 60825-1 and FDA performance standards for laser products US 21CR1040.
CE	Compliant
RoHS	Complies with EU RoHS Directive 2011/65/EU amended 2015/863.
Shock	Complies with environmental testing / mechanical shock (endurance and collision) requirements for road vehicles standard ISO 16750-3:2003 as defined by IEC 60068-2-27:2008.
Vibration	Complies with environmental testing / sinusoidal vibration requirements for road vehicles standard ISO 16750-3:2003 as defined by IEC 60068-2-64:2008.

2. Definitions

Table 3: Definitions

Term	Definition
3D flash	3D flash is a type of LiDAR technology used by LeddarTech to provide detections in a 3D environment. The first two dimensions are the relative positions of the segments in the frame (row/line and column). The third dimension is the distance of the detection(s). LeddarTech's LiDAR technology creates optimal illumination of the field of view of a target, which is then captured in segments by the sensor detector arrays. See section 3.1 on page 22 for more details.
Amplitude	The amplitude is expressed in counts and represents the quantity of light reflected and captured by the sensor. This measure defines the strength of the digital signal.  **Fig. 1: Saturation** Saturation occurs when an object is very close to the LiDAR or has a high reflectance. The power of the received signal can be very high and saturates the analog-to-digital converter.
Channel	Synonym of "segment." See the definition of the word "segment."
Crosstalk	The phenomenon by which an optical or electrical signal transmitted in one channel creates an undesired effect in an adjacent channel. See section 0 on page 18 for more details.  **Fig. 2: Optical crosstalk**

Term	Definition
	 **Fig. 3: Electrical crosstalk**
Detection	A detection, also called "echo," is defined by distance, amplitude, channel index, timestamp, and flag.
Distance	Distance to an object measured in the segment (in meters) from the reference point. Range: 0 to Instrumented Range.
Flag	Information relative to detection quality (bit field).
FoV	Field of view
GPS	In autonomous navigation systems, the GPS provides a clock signal that can be used to synchronize various systems.
LCA	LeddarCore Automotive product family
NIR	Near-infrared light
Object	Objects, people, or animals (moving or stationary). Throughout this document, all these elements will be referred to as "objects."
Parasite ripple	A ripple that occurs following a strong detection.
PPS	Pulses per second. Signal used as a time reference by the central system to synchronize multiple sensors together with the GPS to increase the accuracy of perception.
PTP	Precision Time Protocol. Used to synchronize clocks throughout a computer network.
Segment	A vertical (V) and horizontal (H) index in the FoV. Synonym of "channel."
SoC	System on chip
Timestamp (32 bits)	Time, in milliseconds (ms), elapsed since the sensor was powered on. Range: 0 to $2^{32} – 1$. It will restart at 0 within 49 days of continuous operation.
Timestamp (64 bits)	Time elapsed since 00:00:00 UTC on January 1, 1970 (also called UNIX Time). Expressed in milliseconds (ms) by default but can be configured to be expressed in microseconds (µs) for more precision. Range: 0 to $2^{64} – 1$.

Optical and Electrical Crosstalk

In autonomous driving scenarios, a multitude of variable reflective objects may be present and will affect the performance levels of the LiDAR system. Highly reflective objects may cause detrimental effects in the detection system due to optical reflections or artefacts in the electronics. The next few paragraphs explain some of these issues and the LeddarSP's capacity to overcome them.

2.1. Optical Crosstalk

Lens flare, diffusion, and reflections may cause undesired signals, which are commonly referred to as optical crosstalk. To resolve this issue, LeddarSP uses a method that is based on a deconvolution process to reverse these effects.

The platform approach has been adopted in LeddarSP, and two chosen methods have been carefully implemented.

The first method is based on pulse deconvolution; it has the advantage of requiring a very short computation time, which optimizes the addressable pixel per second. The second method is based on trace deconvolution and requires more computing time.

Both methods' performance improvement on false detections is limited by calibration imperfections.

2.2. Electronic Crosstalk

Additionally, LeddarSP corrects photodetector and electronic imperfections in the detection. When a light pulse is received on a photodetector channel, artefacts are created in the electric signal that is generated by the adjacent photodetectors, which is commonly known as electronic crosstalk ("xtalk").

The shape and amplitude of the electronic crosstalk depend mainly on the sensor's characteristics.

The amplitude of an electronic crosstalk signal is about 40 dB below the aggressor amplitude for the pixels just next to the aggressor, decreasing gradually to reach about 60 dB from 4 pixels from the aggressor.

Both optical and electronic crosstalks are mitigated by calibration measurements in specially designed manufacturing set-ups.

The Leddar Pixell embeds LeddarEngine algorithms designed to mitigate electronic crosstalk and minimize the probability of spurious detections, providing an improvement of more than 16 dB on amplitude measurements.

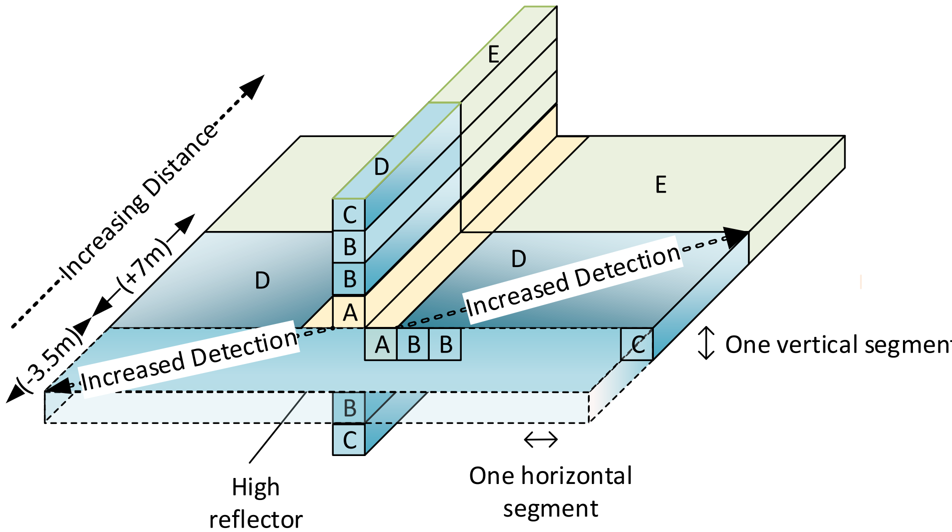
The exact performance of LeddarSP algorithms varies from unit to unit and with the scene view by the LiDAR. The reflectivity, size, and distance of objects to the LiDAR and object proximity to other objects impact the ability of the global LeddarSP algorithms to mitigate electronic crosstalk.

Therefore, with extremely strong aggressors, it is still possible to have a significant residual after a correction. This may lead to unwanted detections (i.e., false positives) or missed detections (i.e., false negatives). However, the detections in an area that have been corrected are flagged (see Table 27 on page 79); they must, therefore, be used with more caution.

The corrected area, where false positives and false negatives can occur, extends over 17 meters around the aggressor at most. The start and the end of a correction depends on the context; the start can be up to 7.7 meters before the aggressor, whereas the end can be up to 14.4 meters after the aggressor.

2.3. False Positives and False Negatives Around Reflective Events

Both modes of crosstalk inject pulse-like signals on the same photodiode array and contaminate a good number of lateral segments. Special algorithms are used to remove false positives on the same line and both sides around the strong reflector. Depending on the intensity of the reflective event, the capacity of detection on the horizontal line is limited up to 7 meters behind the reflector.



- A: Worst crosstalk effects for extremely high reflector: False positives +/- 1 segment H+V
- B: Removal of false positives generated by crosstalk, very limited detection capability, possible false negatives with improvement away from affected segment both in distance, vertically and laterally
- C: Removal of false positives up to end detectors for the head seeing the reflector, limited detection capability, possible false negatives
- D: Limited detection capability of low reflectivity target, False negatives possible from distance of reflector 7m behind To 3.5m before with improvement away from affected segment both in distance and laterally.
- E: Higher detection threshold zone with reduced range

Fig. 4: Residual crosstalk effects around a strong reflector

False positives identified as related to crosstalk are removed in zone B to D. At a greater distance, the detection range is partially reduced in zone E. In zone B to D, false negatives are expected, and their numbers will vary depending on the strength of the main reflector. In general, detection will improve away from strong reflector both laterally and vertically some segments away and in the distance. LeddarTech recommends implementing a lower responsiveness zone D (Fig. 4 above) from the distance of a flagged aggressor (Flags Sat = 3 and Xtalk = 6) extending up to a maximum of 3.5 meters ahead and 7 meters behind reflector in distance. This zone externs laterally for all segments within one of the sub-fields of view (Fig. 9), where the strong reflector is present. Inside this lower responsiveness zone, low-reflectivity targets may not always be detected while the saturation condition is present. This evaluation must be done separately for each of the eight lines.

Table 4: Distance around strong reflectors to consider for the zone

Amplitude Zone	Affected Area D (Fig. 4)
Zones I and II	≈ 1.5 m around aggressor
Zone III	≈ 3.5 m
Zones IV and V	+7 m / -3.5 m

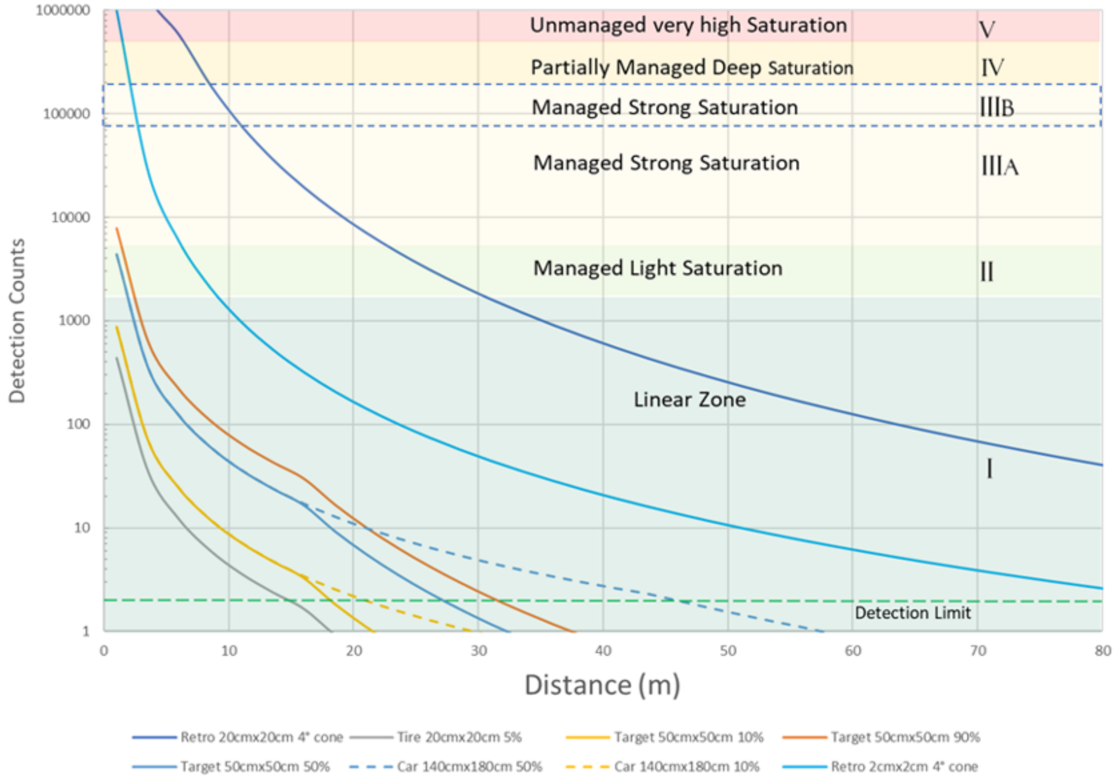


Fig. 5: Detection count vs. distance

3. Introduction

3.1. Underlying Principles and LiDAR Fundamentals

Created by LeddarTech, Leddar™ is a unique sensing technology based on laser illumination (infrared spectrum) and the principle of a light's time of flight. The laser emitters illuminate the area of interest. The multichannel sensor receiver collects the back-scattered light and measures the time taken for the light to return to the sensor.

A photodetector array is used and provides multiple detection and ranging segments. The full-waveform analysis enables the detection and distance measurement of multiple objects in each segment, as illustrated in Fig. 6, provided that foreground objects do not fully obscure objects behind them.

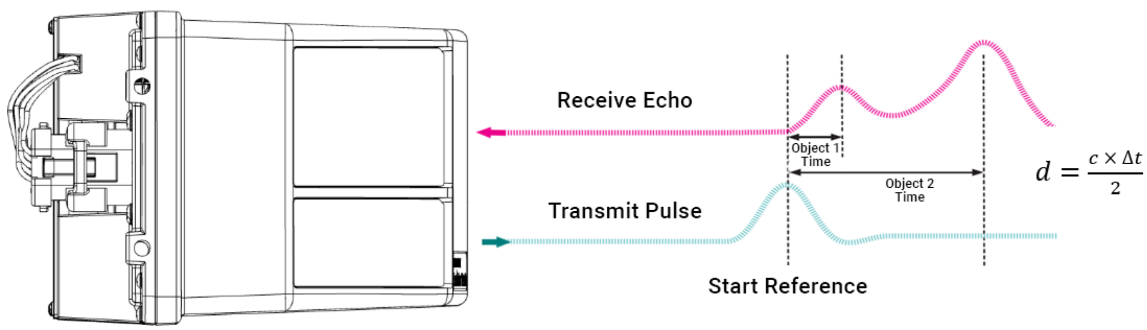


Fig. 6: Time of flight

3.2. Key Factors for Best Sensor Performance

To obtain the best operating performance, the following factors are important to consider.

Table 5: Key factors for best sensor performance

Key Factor	Description
Size of the target	The larger the target, the longer the range. The smaller the target, the shorter the range.
Reflectivity of the target	The range increases with the target's reflectivity at the emission wavelength.
Position of the target within the FoV	With centered segments, the range is higher. With outer segments, the range is lower.
Weather conditions	Inclement weather conditions such as rain, fog, snow, and dust may affect sensor performance.
Direct sunlight	Exposing the sensor to direct sunlight may affect performance levels of the illuminated portion of the FoV, which may be caused by direct sunlight.

3.3. Accuracy and Precision Based on Radar Equation

The LIDAR operates using the same detection fundamentals as conventional radars; the precision of the distance measurement depends on how strong the receiving signal is. A stronger signal will lead to a better noise ratio at the peak detector, which is directly linked to the precision of the detection. The Leddar Pixell follows a typical radar equation that links the precision with the amplitude counts of the detection. The Leddar Pixell's specification of 0.6 cm is defined at amplitude counts greater than 60 counts. Fig. 7 shows the model equation of precision, which has been taken with multiple target types.

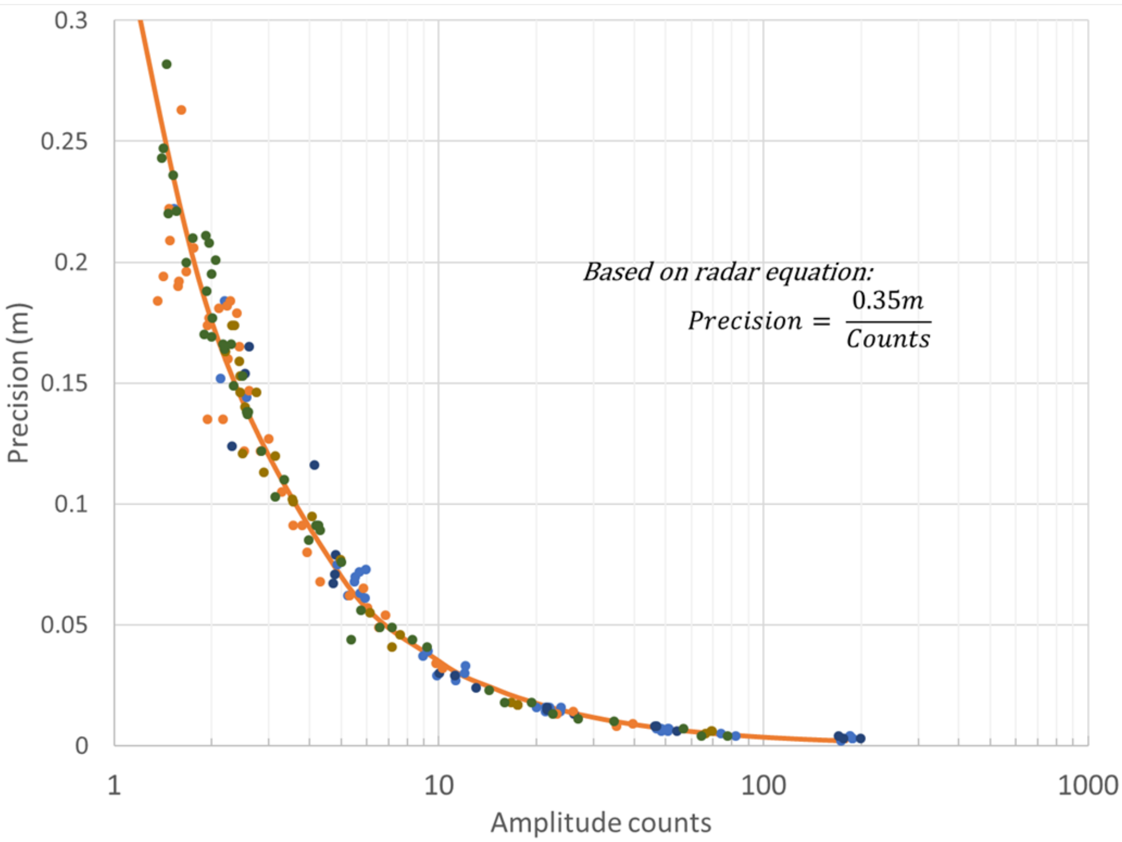


Fig. 7: Precision at low-amplitude counts

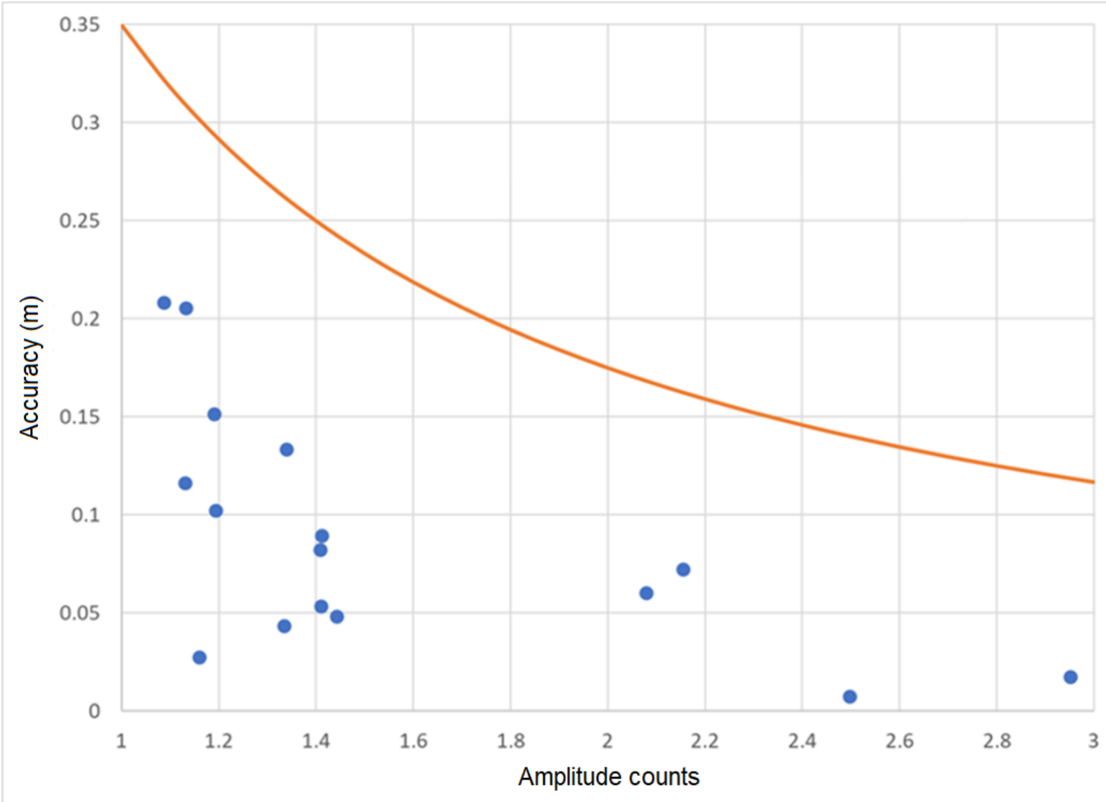


Fig. 8: Accuracy at very low-amplitude counts

Accuracy is defined as the average distance if several measurements are repeated. The accuracy specification is defined for the detection regime selected by design: SNR 9.8 dB, >90% probability of detection, and 0.0001 false alarm rate. For very low counts, the detection distance stays within the precision specification; however, the accuracy is lower because the probability of detection falls below 90%, and the peak detector has a more random behavior.

4. Intended Use and Description

This User Guide is intended for developers and integrators. This document provides information about the Leddar Pixell 3D flash LiDAR sensor (hereafter referred to as “the sensor” or “Leddar Pixell”). 3D flash technology provides detections in a 3D environment.

Using the latest 3D flash LiDAR technology, the Pixell provides more scene coverage than most scanning LiDARs, which drastically reduces dead zones. Thanks to the Pixell’ s wide horizontal FoV, four sensors will cover the entire vehicle surroundings and provide redundancy coverage in its corners. Data provided by Leddar Pixell allow for object tracking and identification of possible collisions based on object position, velocity, and directionality, without overwhelming the vehicle’s CPU with massive amounts of unnecessary data.

The Pixell has been designed using the state-of-the-art LeddarEngine™, the powerful LiDAR core for automotive and mobility applications, leveraging LeddarTech’s patented signal acquisition and processing and highly integrated SoC.

Leddar Pixell 3D flash LiDAR sensors are used to detect the presence of objects, people, and animals (whether moving or stationary). Throughout this document, all these elements will be referred to as “objects.”

The goal of this document is to help you use your sensor and Leddar Configurator so that you can achieve the best of their capabilities.

4.1. Equipment Description

Model	Leddar™ Pixell
Generation	Production unit

The Leddar Pixell sensor comes with the following software:

- Leddar Configurator
- Software Development Kit (SDK)

Fig. 9, Fig. 10, and Fig. 11 below show the sensor’s main components.

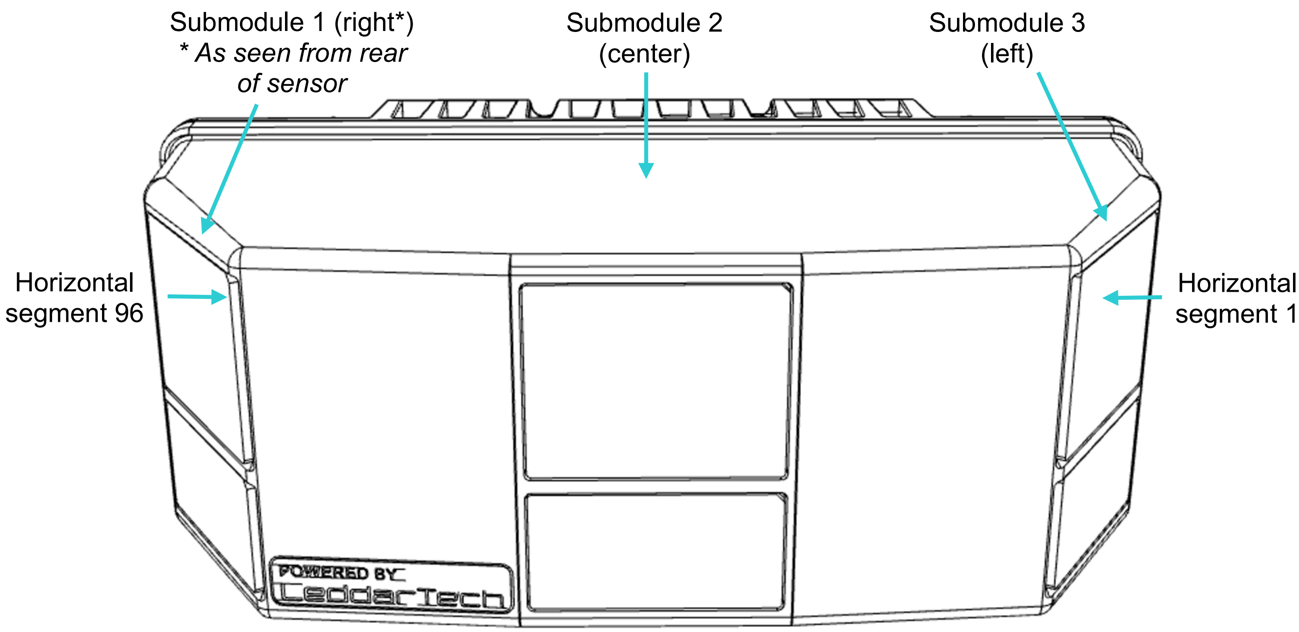


Fig. 9: Right, center, and left submodules

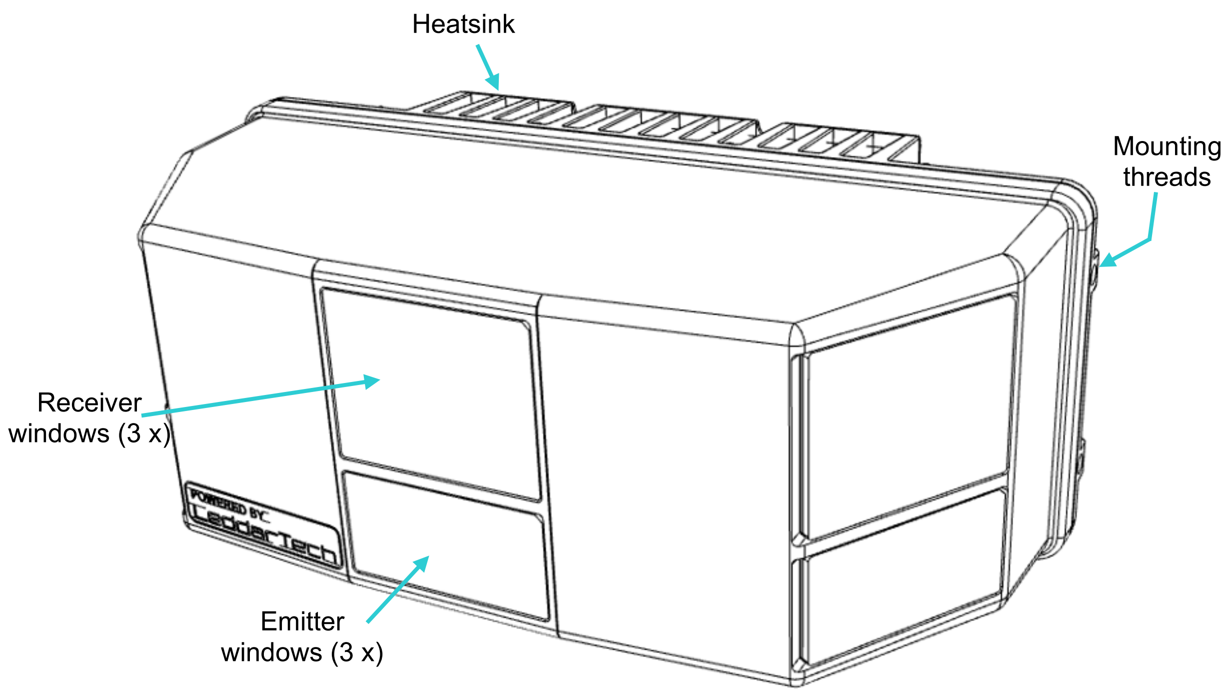


Fig. 10: Front view

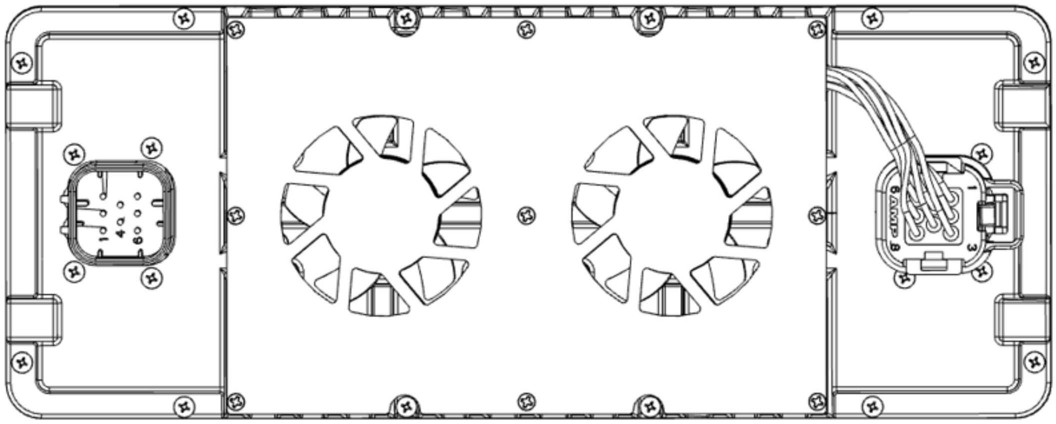


Fig. 11: Rear view

4.2. Reference Point and Coordinates

The distance is measured from the reference point (point zero).

For the left-right orientation, the reference point is located 123 mm from the sides, as seen in Fig. 12 below.

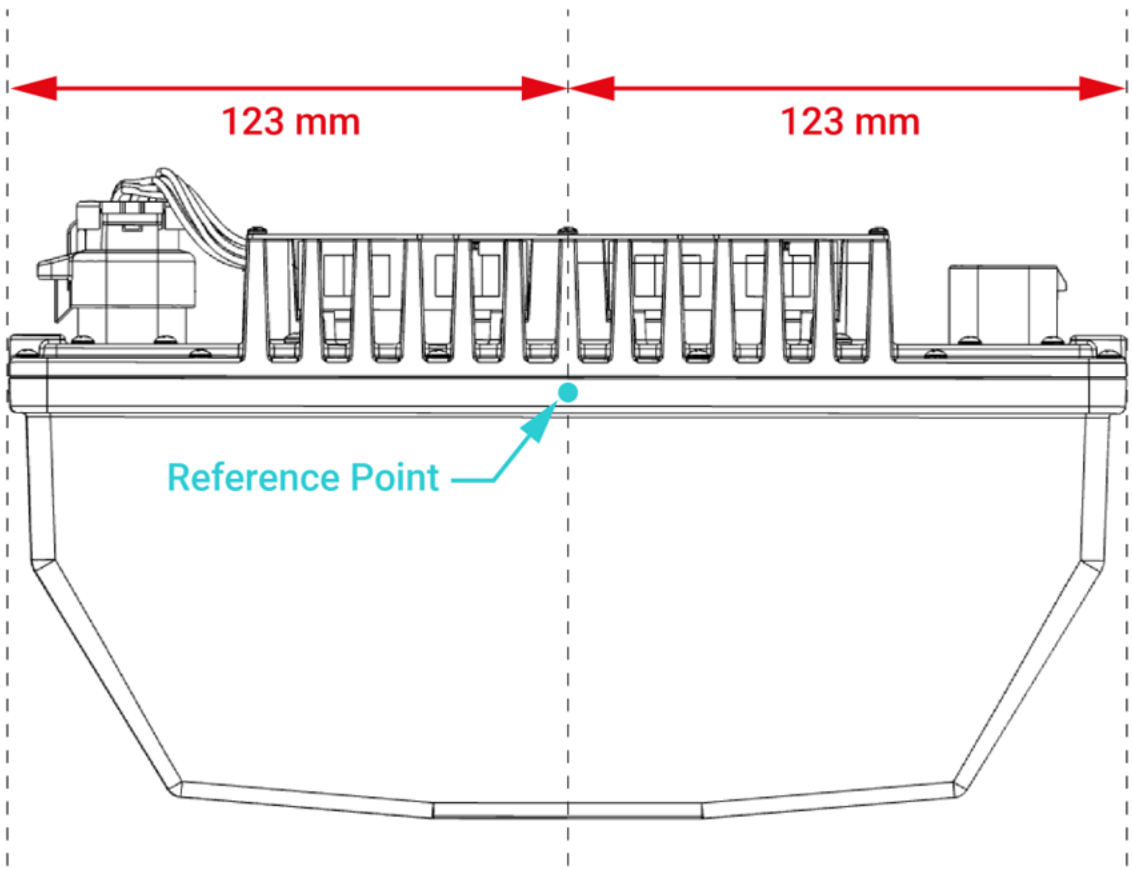


Fig. 12: Reference point (top view)

For the top-bottom orientation, the reference point is located 1 mm above the center of the mounting hole and, from there, at 7 mm inwards of the sensor, as seen in Fig. 13 below.

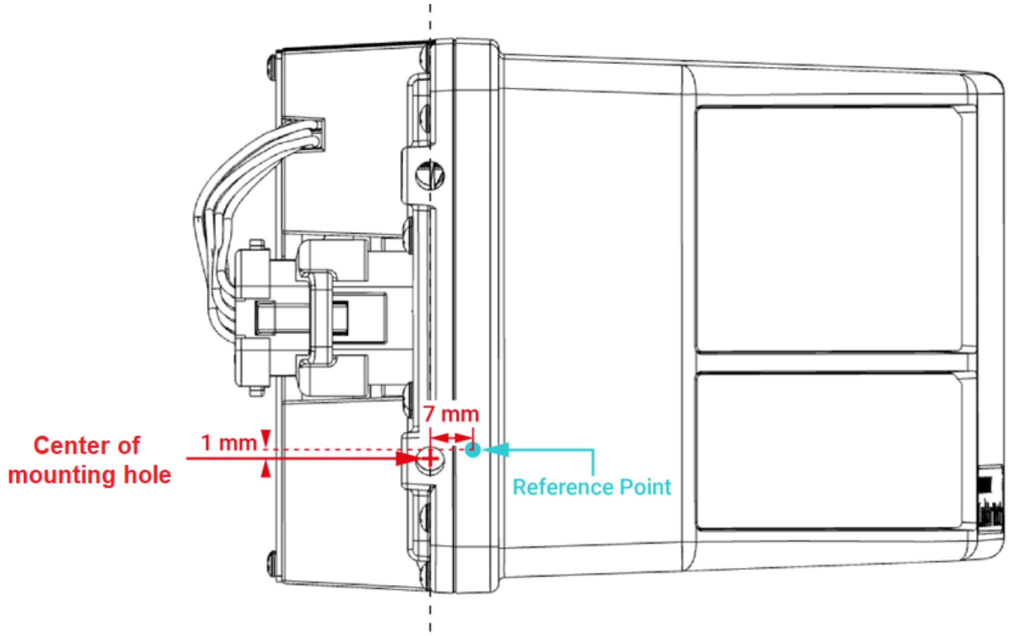


Fig. 13: Reference point (right side view)

See Appendix E on page 123 for information on converting the Leddar Pixell flash LiDAR sensor's angular data and distance reporting.

4.3. Emission Concept

This section provides information about the emission concept of the Leddar Pixell. The figures below show the representation of the horizontal FoV and the zones covered by the sensor.

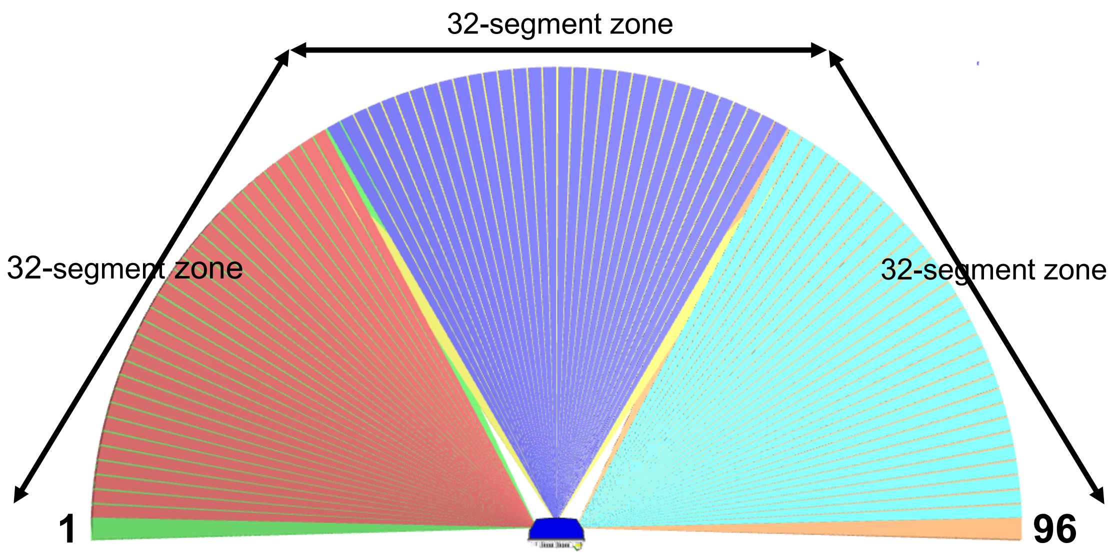


Fig. 14: Representation of the FoV resolution and segment zones

Leddar Pixell offers minimal dead zones, as seen in Fig. 15 below. This hardware configuration reduces the possibility of missing an object, as there is only a 6-cm width between the sensor windows. The width progressively reduces to completely disappear after 1 m.

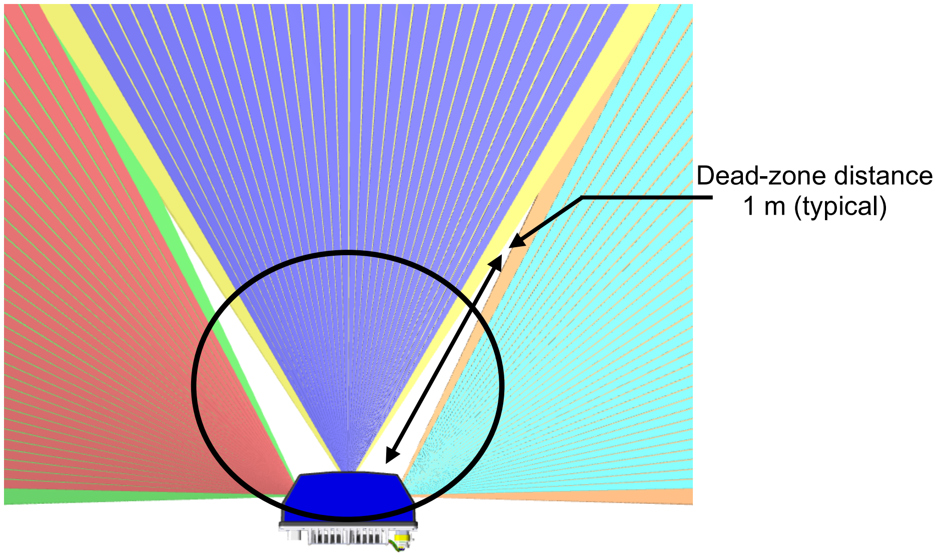


Fig. 15: Emission minimal dead zone

Depending on the distance, the overlap in the horizontal FoV varies from no overlap to up to 2 segments at long distance. This is valid for each side.

Gap left side

0	1	2	3	…	28	29	30	31
96	97	98	99	…	124	125	126	127
				…				
				…				
				…				
				…				
				…				
672	673	674	675	…	700	701	702	703

32	33	34	35	…	60	61	62	63
128	129	130	131	…	156	157	158	159
				…				
				…				
				…				
				…				
				…				
704	705	706	707	…	732	733	734	735

64	65	66	67	…	92	93	94	95
160	161	162	163	…	188	189	190	191
				…				
				…				
				…				
				…				
				…				
736	737	738	739	…	764	765	766	767

Gap right side

Fig. 16: Horizontal overlap at 7 m and <1 m

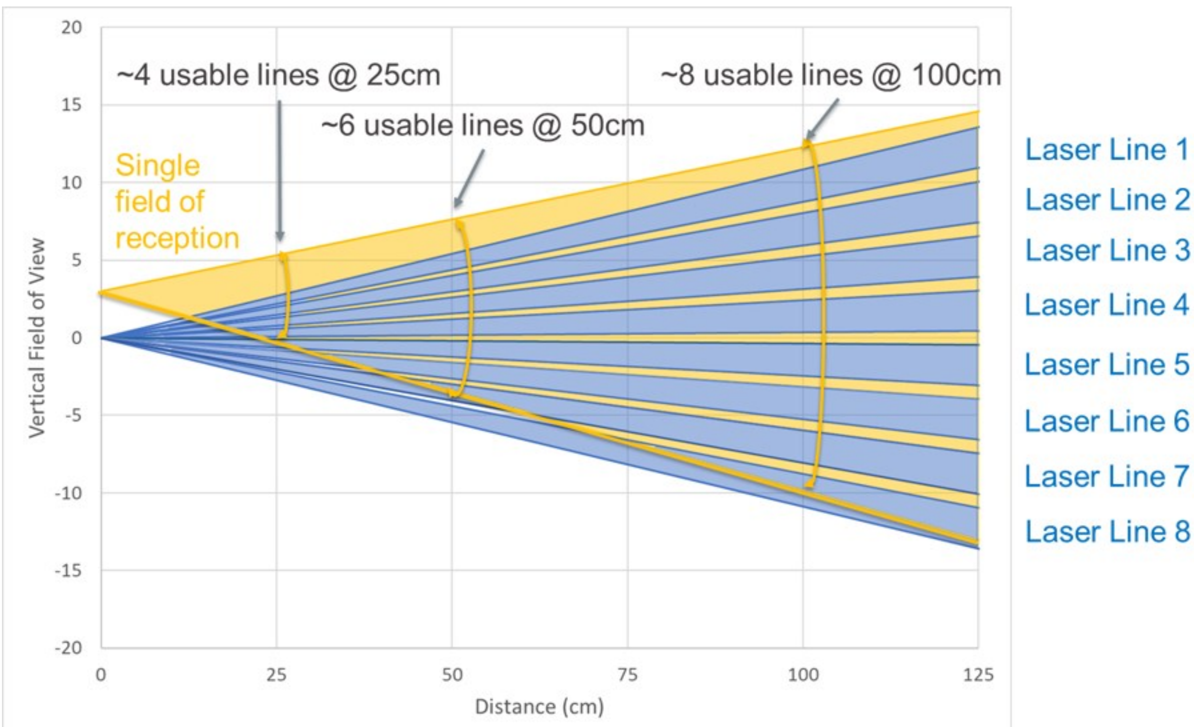


Fig. 17: Vertical emission coverage at a short distance

The Leddar Pixell uses a bi-static optical design. The spacing between the transmitter window and the receiver window (Fig. 18) creates a variable vertical overlap at close range, as shown in Fig. 17. The receiver has a single wide FoV depicted in orange in Fig. 17. The emitting section consists of 8 laser lines covering the entire horizontal FoV; however, each line scans a portion of the vertical FoV. At a very close range, only the top-emitting segments overlap with the receiving FoV.

Table 6: Usable segments vs. distance at close range

Distance	Usable Segments
25 cm	0-383 (4 lines out of 8)
50 cm	0-575 (6 lines out of 8)
100 cm	0-767 (complete FoV)

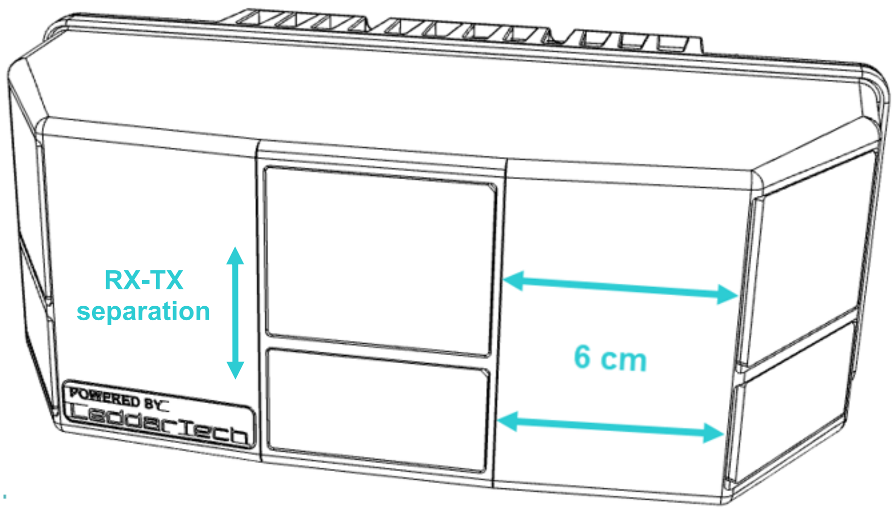


Fig. 18: Distance between two zones

The Leddar Pixell is a fusion of three laser heads; each covers approximately 60° for a total of 180°. The field width and the central angular position of each head can be read from the sensor. The positive central angle can be found in the left quadrant. Zero is at the center. The negative central angle can be found in the right quadrant.

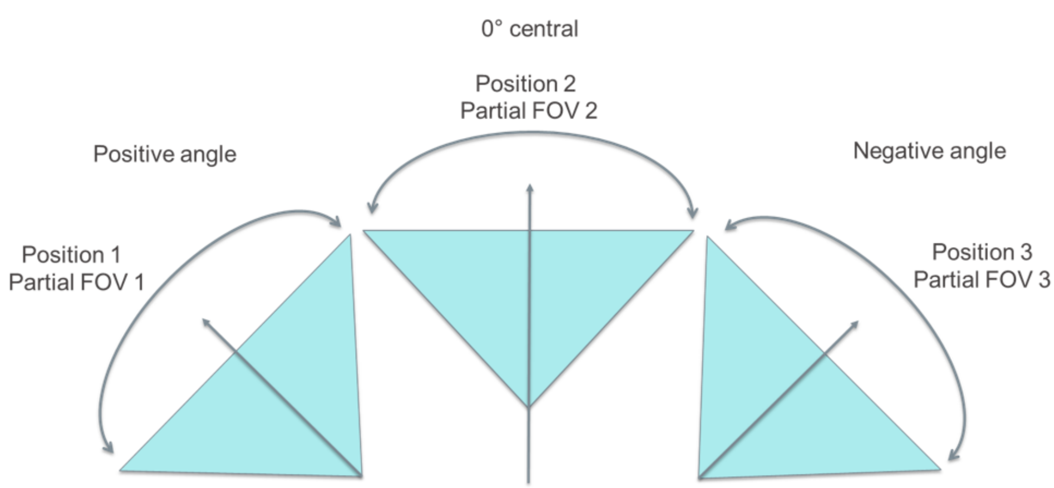


Fig. 19: Sub-FoVs, as reported

The segments overlap to minimize the dead zone between each sub-FoV, as seen in Fig. 20 below.

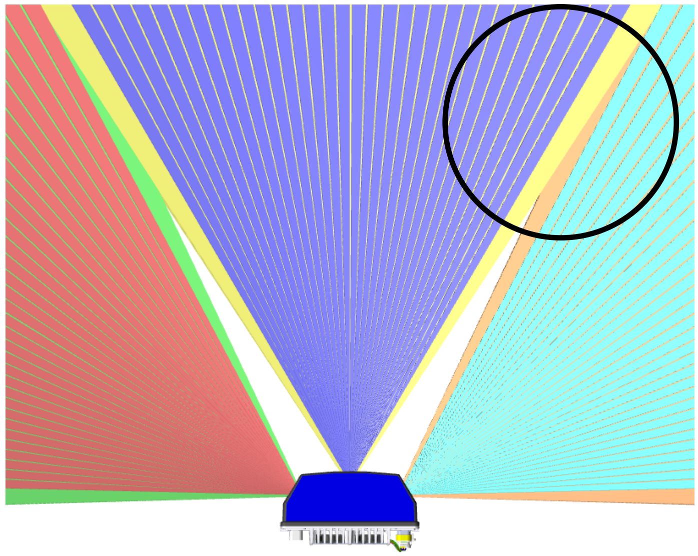


Fig. 20: Emission profile overlapping the FoV

4.3.1. Illumination Pattern

LeddarTech flash technology illuminates a wider area than other LiDAR technologies. The result is a minimal gap between vertical lines that typically measures around 0.7°. Fig. 21 illustrates the distance in degrees between two segment centers.

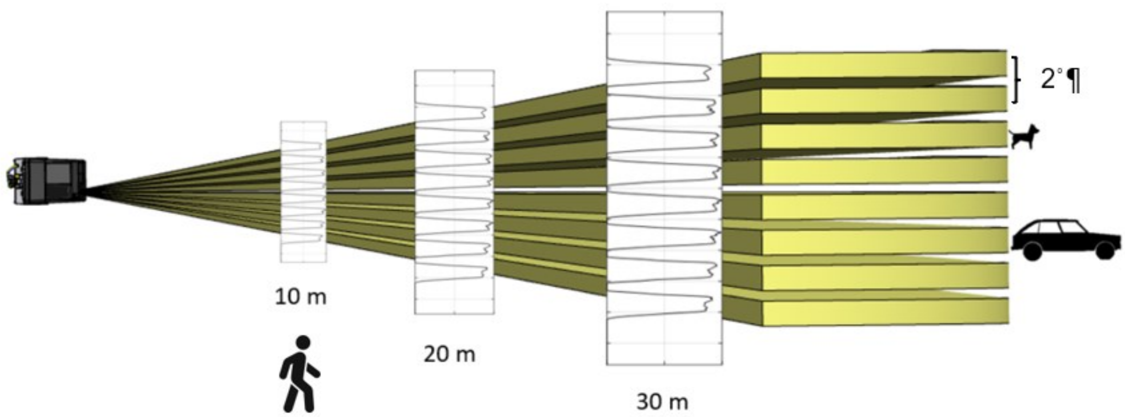


Fig. 21: Vertical FoV illumination pattern

4.3.2. Impact of Range in Vertical Gap

Because the gap between the laser lines expands in propagation with distance, there is a complex interaction for a particular size target and reflectivity and the maximum range up to where this target is detectable. Fig. 22 below shows how the amplitude of the return signal is affected for this target if aligned to the center or between two vertical lines. Loss of 50% of the normal range for this example is measured with a 50 cm x 50 cm target (50% reflectivity) if it falls totally in the vertical gap.

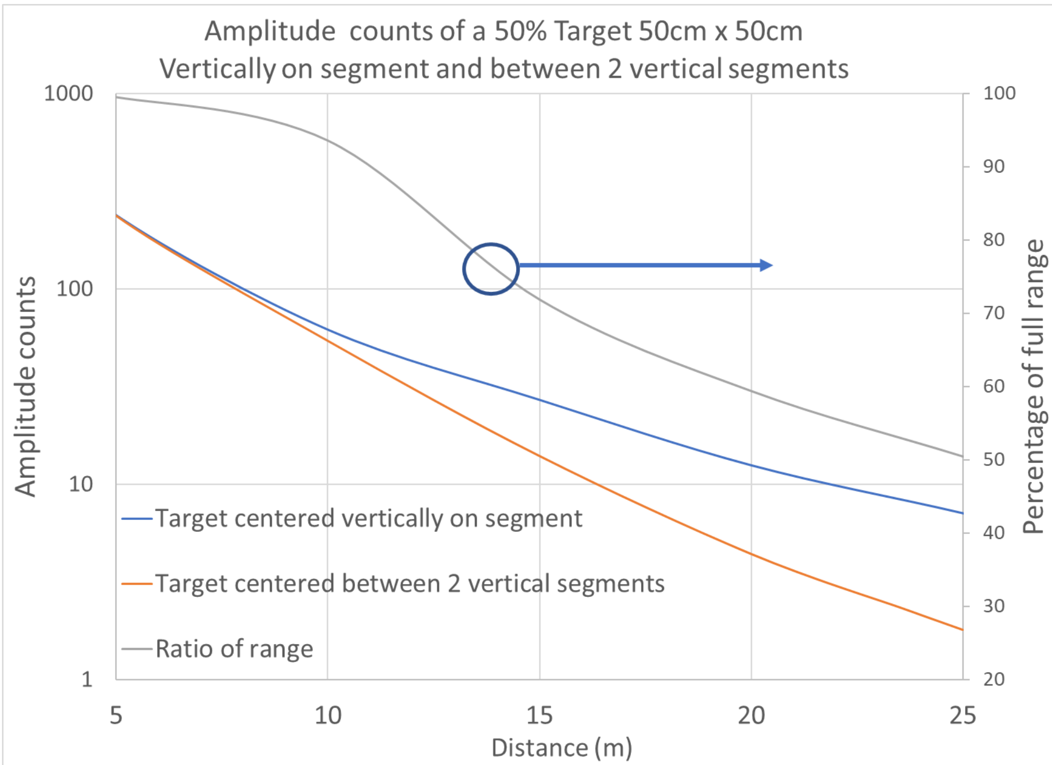


Fig. 22: Range reduction in a vertical gap

4.3.3. Channel Index

The channel index starts from 0 at the top left of the FoV and increases from left to right and from the top line to the bottom of the FoV, as shown in Table 7 on page 34. You can set the horizontal and vertical indexes in the **Raw Detections** window. See section 10.6.3 on page 78 for more details.

A channel (or segment) can be identified either by:

- its channel index, or
- its coordinates within the FoV (V Channel, H Channel) in the viewer software (Leddar Configurator). See section 10 on page 56 for more details on Leddar Configurator.

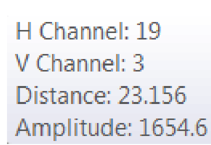


Fig. 23: Channel indexes and measurement pop-up box in Leddar Configurator

Table 7: Channel indexes

	H Segment 1	H Segment 2	…	H Segment 95	H Segment 96
V Segment 1	0	1	…	94	95
V Segment 2	96	97	…	190	191
V Segment 3	192	193	…	286	287
V Segment 4	288	289	…	382	383
V Segment 5	384	385	…	478	479
V Segment 6	480	481	…	574	575
V Segment 7	576	577	…	670	671
V Segment 8	672	673	…	766	767

Total horizontal FoV

Fig. 14 on page 28 presents a top view of the sensor that shows that each segment zone comprises 32 segments, where the horizontal segment number 1 is located on the left and the horizontal segment number 96.

The channels, also called “segments,” are identified by their coordinates within the FoV [V Segment, H Segment] from left to right and top to bottom.

4.3.4. Channel Azimuth and Elevation Angles

As seen in Table 7, each FoV segment is mapped to a unique index. To ensure optimal measurement accuracy, the channel angles, in terms of azimuth and elevation, are precisely measured for each segment after manufacturing. The reference used for these measurements is the point of maximum amplitude of the reflected light pulses, which corresponds to the center of the segment. The measurements are saved in each sensor in the form of two mapping tables: one for azimuth angles and the other for elevation angles. Each table is a one-dimensional array indexed from 0 to 767.

It is important to note that due to variability in manufacturing, the precise angles stored in the mapping tables might differ from one sensor unit to the other. Therefore, for maximum precision, it is preferable to fetch the angular mappings from each sensor independently.

To fetch those tables from the sensor, get the LT_COMM_ID_AUTO_CHANNEL_ANGLES_AZIMUT (0x2580) and LT_COMM_ID_AUTO_CHANNEL_ANGLES_ELEVATION (0x2581) configuration elements from the sensor’s configuration using the CFG_REQUEST_GET_CALIB (0x7002) command.

See Table 48 on page 112 for more information.

4.4. Sensor Alert System

4.4.1. Overview

The Leddar Pixell uses an alert system to notify you of potential problems and misuse of the sensor, along with other information about its status.

The alert system is accessible through both the Leddar Configurator software and the communication protocol.

An alert is defined by:

- an alert type
- an alert level
- a unique identifier code

There are three (3) alert levels:

Notify: This is generic system information that can be useful to you but is not problematic regarding operations or performance. No action is required from you.

Warning: The sensor is in a problematic condition that requires your attention and might require action. The sensor operation will continue, but performance might be degraded depending on the warning code. See Table 8 below.

Critical: The sensor has suffered a critical error and might have stopped operating altogether to protect itself or its surroundings (Fig. 26 on page 38). Any measurement output from the sensor in this state should not be trusted. Your immediate attention is required.

4.4.2. Alert Type List

The current alert list is minimal and is mainly used for reporting the sensor's operating state.

Table 8: Detection structure (sends echoes)

Alert Type	Type ID	Alert Level	Description
ALERT_LCA_INIT	0x00	Notify	The sensor has not finished initialization after powering up. This notification disappears after a few seconds.
ALERT_LCA_CONFIG	0x02	Notify	The sensor is currently in Self-configuration mode and has paused its measurement process. This notification disappears after a few seconds.
ALERT_LCA_ERROR	0x06	Warning	The sensor is currently in Safe mode following an error in the measurement process. ***The unit needs to be power cycled to recover from Safe mode. See section 4.5 on page 37 for more details.***

4.4.3. Access to Leddar Configurator

In the Leddar Configurator software, current active alerts can be found in **View** > **State**, next to **Sensor status:** at the bottom of the window.

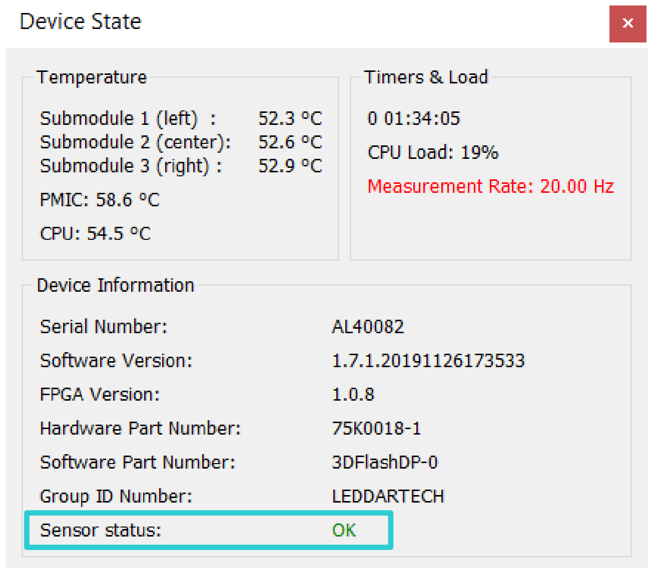


Fig. 24: Sensor status in Leddar Configurator

If the status is **OK**, there are no currently active alerts and the sensor is currently in normal operation mode.

If the status is **Notify**, **Warning**, or **Critical**, one or more alerts are currently active. The number is displayed before the status name. Hovering the cursor over the relevant word in color will display the alert information in a tooltip.

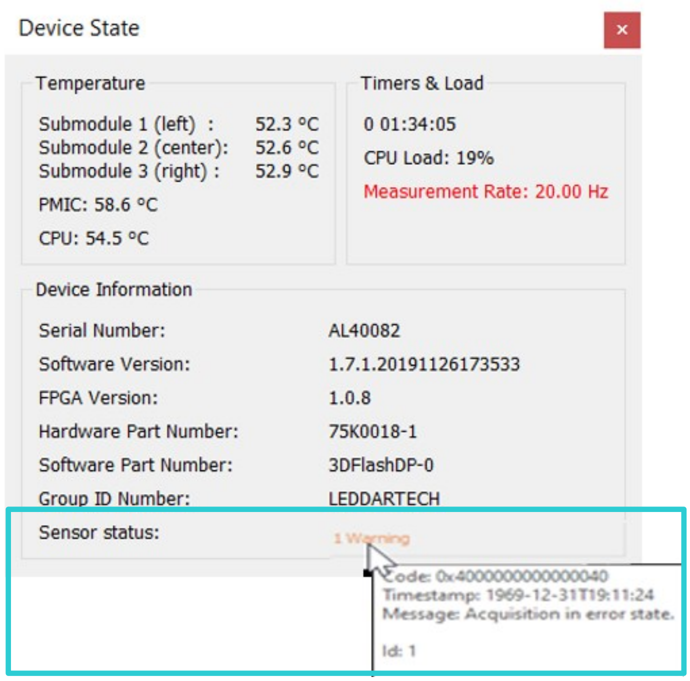


Fig. 25: Warning code example in the Device State window

4.4.4. Access to the Communication Protocol

The communication protocol allows you to fetch the currently active alerts from the sensor. To do so, the CFG_REQUEST_UPDATE request (code 0x0008, see section “Configuration Server Requests” in Appendix D “Communication Protocol”) must be made to the configuration server. See Table 43 on page 110 for the definition of the alert structure.

4.5. Sensor Operation Overview

The sensor firmware operates following an internal state machine. This section outlines the cycle of operation of this state machine.

There are three (3) main states in the sensor: Initialization, Normal Acquisition, and Safe modes.

Initialization mode: The system boots into this state when powered on. The system loads the sensor configuration and calibration from non-volatile memory. It checks whether the loaded data is coherent. It performs initial self-tests to detect faults, which lead to Safe mode. If the initialization is successful, the sensor transitions to Normal Acquisition mode automatically.

Normal Acquisition mode: This is the sensor’s main measurement acquisition and transmission mode. Lasers are flashing. Pulses are treated through signal processing algorithms and transmitted through the Ethernet communication port. Self-checks are embedded in the process to detect faults, which lead to Safe mode. If no faults are detected, the sensor remains in this mode until power is turned off.

Safe mode: The sensor has detected a critical fault that can result in damage to itself, its host, or any surrounding material or people. The conditions for the sensor to switch to Safe mode are as follows:

- Voltage at the capacitor banks too high
- Pulse repetition rate too high
- Critical supply for eye-safety hardware protection out of range
- General voltages out of range
- Lasers too hot
- CPU too hot
- Power distribution electronics too hot

When in Safe mode, the lasers are NOT flashing, the acquisition loop has stopped, and the sensor is not outputting any detections. Power consumption is reduced to a minimum. The Ethernet link is kept alive to inform you of the current status as much as possible.

The only way to exit Safe mode is to power cycle the device.

If the device has recovered from Safe mode and restarted but the critical condition is still present, the unit will return to Safe mode again.

If the unit returns to Safe mode repeatedly after you power cycle the device, power off the device and contact LeddarTech’s technical support for further troubleshooting.

A transition graph of the Leddar Pixell state machine is illustrated below.

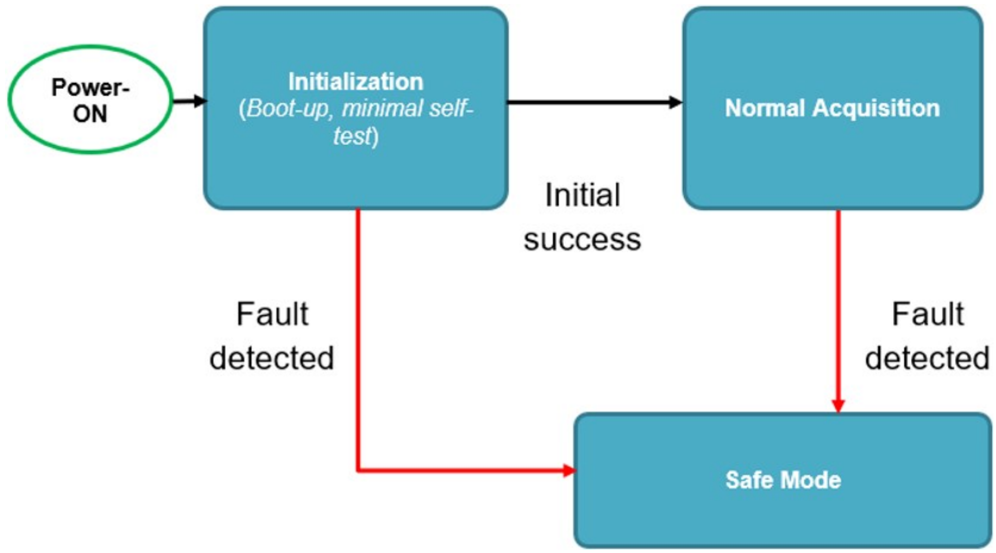


Fig. 26: Safe mode functionality

5. Specifications

5.1. General Characteristics

Table 9: Characteristics[1, 2]

Description	Value	
Number of segments (H x V)	96 x 8	
Horizontal FoV	177.5°	
Vertical FoV	16°	
Angular resolution (horizontal)	1.9°	
Angular resolution (vertical)	2.0°	
Wavelength (nominal)	905 nm	
Frame rate	20 Hz	
Accuracy[1, 3]	±3 cm	
Demerging accuracy[4]	±10 cm	
Demerging precision[4]	8 cm	
Automotive connector	Mating cycle: 10 See section 7.2 on page 48 for more details.	
Automotive Ethernet	Physical layer (PHY) compliant with 100BASE-T1 (IEEE 802.3bw). Maximum length of 30 m. Leddar Pixell does not support the 802.3bp standard.	
Maximum bandwidth	Refer to Table 16 on page 44 for more details.	
Startup time	−30 °C	+20 °C
	≤15 s	≤6 s

5.1.1. Detection Ranges

Table 10: Detection ranges

		Detection Range (m)			
Horizontal FoV (°)	**Vertical FoV (°)**	**Vehicle 10% reflectivity[5]**	**Vehicle 50% reflectivity[5]**	**Reflector 80% reflectivity[5]**	**Pedestrian 50% reflectivity[6]**
177.5	16	19	43	53	32

1 Typical specifications.

2 Environmental conditions, weather, and reflectivity level of elements in the scene may affect sensor performance.

3 Ambient test performance with a 3 σ standard deviation. Non-saturated signal without crosstalk for non-merged events.

4 Non-saturated signal without crosstalk.

5 Full pixel coverage.

6 Euro NCAP Pedestrian reference.

5.1.2. Test Conditions

Table 11: Test conditions

Test Condition	Detection Range	Description
Pedestrian **18% reflectivity**[7] 50 cm x 180 cm target	≥24 m	At the center of each 59.16° section of the horizontal FoV
	≥20 m	Everywhere else in the 59.16° section of the horizontal FoV
Vehicle **10% reflectivity**[7] 180 cm x 140 cm target	≥19.2 m	At the center of each 59.16° section of the horizontal FoV
	≥15.4 m	Everywhere else in the 59.16° section of the horizontal FoV
Vehicle **50% reflectivity**[7] 180 cm x 140 cm target	≥43 m	At the center of each 59.16° section of the horizontal FoV
	≥35 m	Everywhere else in the 59.16° section of the horizontal FoV
Reflector **80% reflectivity**	53 m	N/A

5.2. Mechanical Specifications

Table 12: Mechanical specifications[8]

Description	Value
Width	245 mm
Depth	141 mm
Height	97 mm
Section embedded in the vehicle	82 mm
Section exceeding the vehicle	60 mm
Weight	2.1 kg
Mounting holes and measurements	See Fig. 31 on page 42.

7 100 klx ambient daylight.
8 Tolerances: ±0.10 mm (linear), ±0.5° (angular).

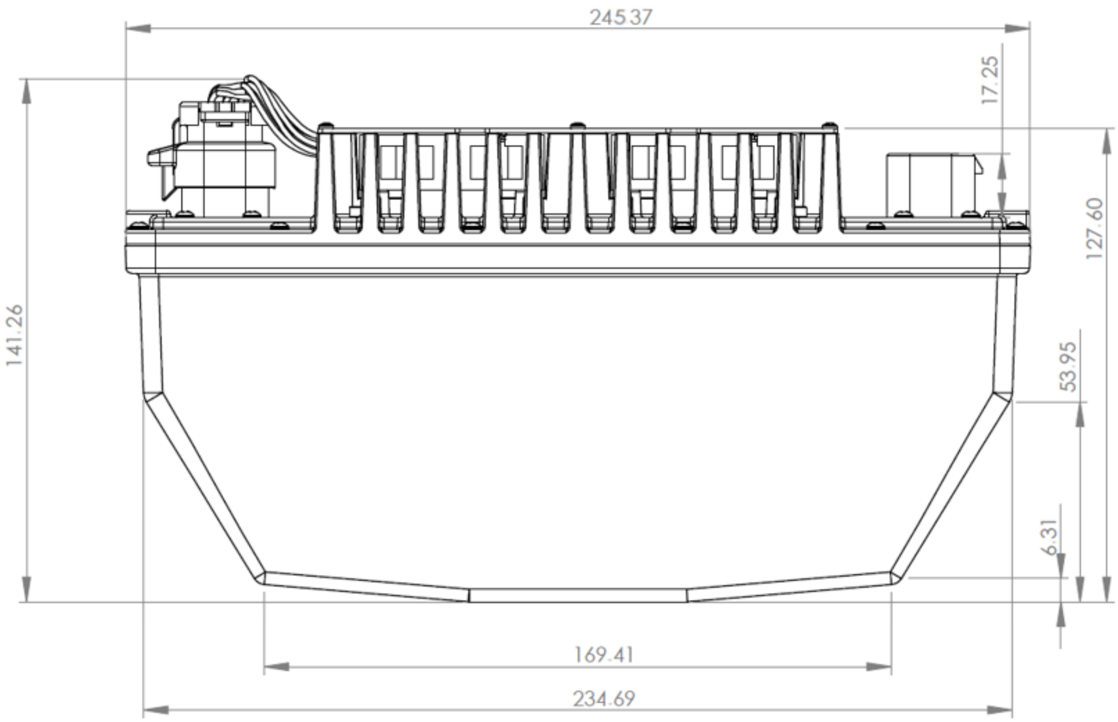


Fig. 27: Dimensions (top view)

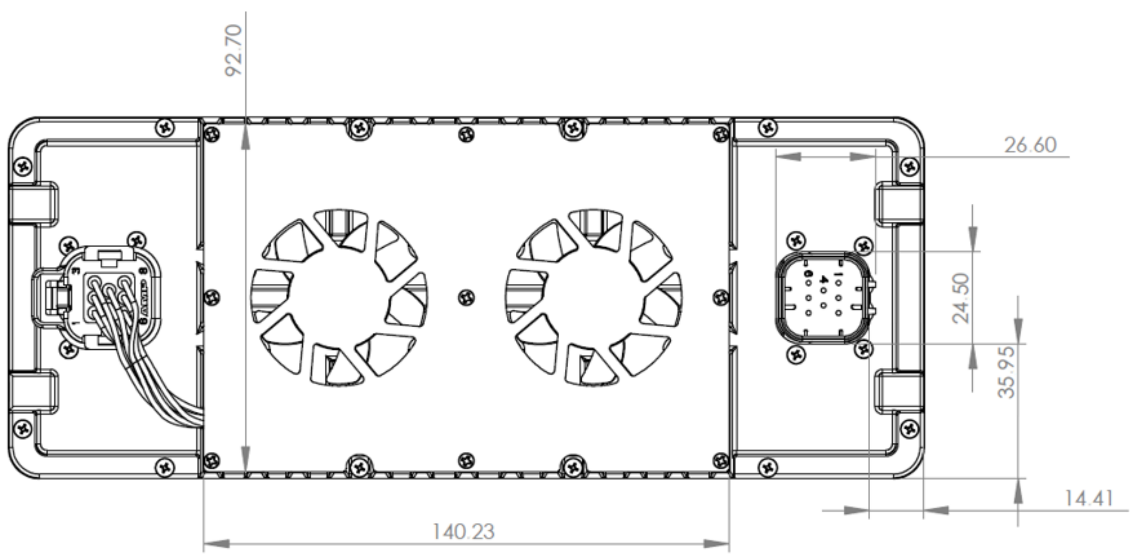


Fig. 28: Dimensions (rear view)

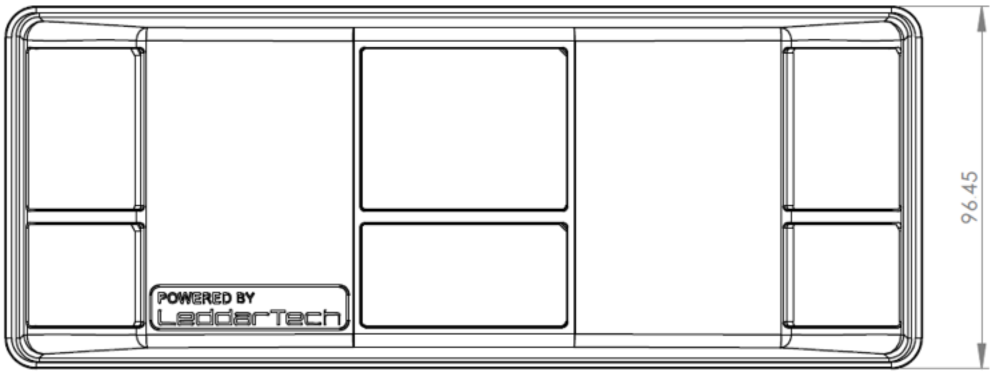


Fig. 29: Dimensions (front view)

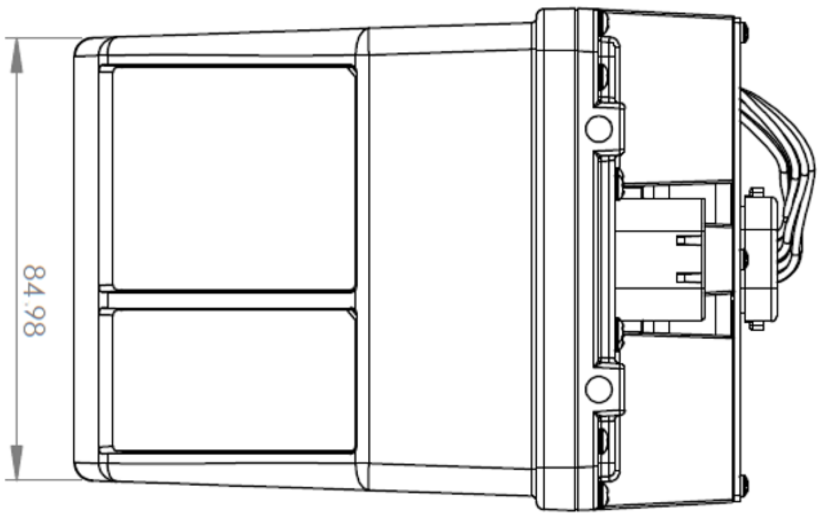


Fig. 30: Dimensions (left side view)

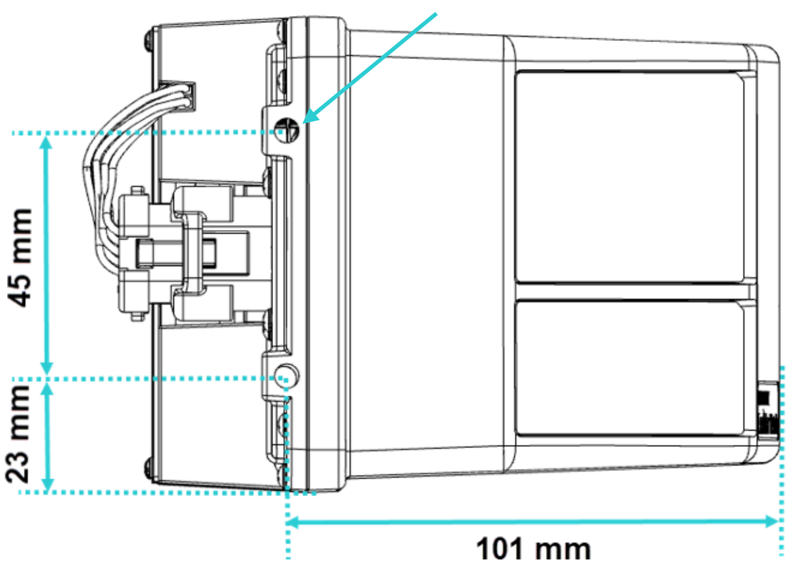


Fig. 31: Measurements and distance between mounting threads (right side view)

5.3. Electrical Specifications

Table 13: Electrical specifications

Description	Value
Power supply	11 V to 52 V Absolute minimum rating: 11.5 V
Power consumption	20 W[9]
PPS input voltage	Logic 0: <1.2 V; logic 1: 3 V to 12 V (nominal: 5 V)
PPS frequency range	0 Hz to 10 Hz for time synchronization
PPS minimum pulse width	400 ns

5.4. Environmental Specifications

Table 14: Environmental specifications

Description	Value
Operating temperature range	−30 °C to +65 °C
Storage temperature	−40 °C to +85 °C

5.5. Software System Requirements

Table 15: Leddar Configurator system requirements

Description	Value
Operating system	Windows 7 and up
Memory (RAM)	1 GB minimum
Disk space	150 MB minimum
Communication interface	Automotive Ethernet

9 Nominal power consumption at +20 °C.

5.6. Bandwidth

Table 16: Bandwidth required for communication between sensor and network[10]

Worst-Case Scenario	Bytes per Frame (Decomposed in Data Elements)		Frame Rate (FPS)
768 x 3 = 2304 detections	Header	16	At 20 FPS you need 27 777 x 20 = 555 540 bytes per second of bandwidth.
	Timestamp	12	
	Frame ID	16	
	Timestamp 32 bits	12	
	Timestamp 64 bits	16	
	Echoes sent	16	
	Distances	9224	
	Channel index	4616	
	Amplitude	9224	
	Flags	4616	
	Status	9	
	Total	**27 777**	

10 The values shown are the upper limit in case all segments have a maximum of three (3) detections. In practice, a lower bandwidth may be required since the sensor only sends out detections treated by the signal processing (valid or invalid). Characterization of the bandwidth used, in typical and worst cases, may be required for your specific application.

6. Mechanical Integration

This section provides recommendations for the mechanical integration of the Leddar Pixell.

See section 5.2 on page 40 for mounting information and section 7 on page 47 for information on connecting the sensor.

⚠	*It is strongly recommended not to install the sensor behind a window in order to maintain performance.*

As seen in Fig. 32 and Fig. 33 on next page, when installing the sensor, leave a minimum clearance of 8 mm on the top, sides, and bottom of the sensor. Leave an opening of 10 mm minimum at the back of the sensor to evacuate the heat (red arrows) properly.

You must also leave enough space for the FoV so that there is no interference with the transmission and reception of light detections. The FoV integration must span further than the 15.5° [11] vertical FoV to preserve the transmission of the outer segment of the sensor.

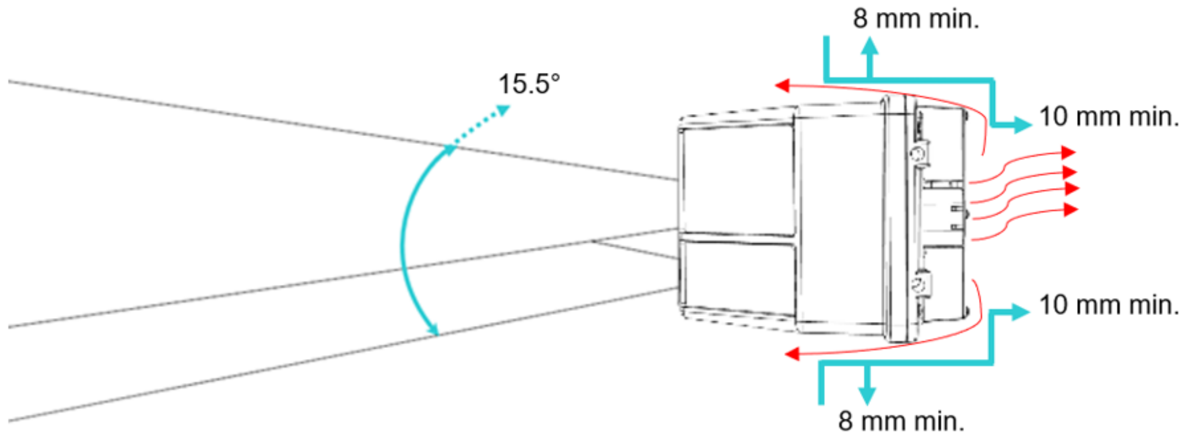


Fig. 32: Clearance required for FoV and around the sensor (side view)

[11] Typical FoV.

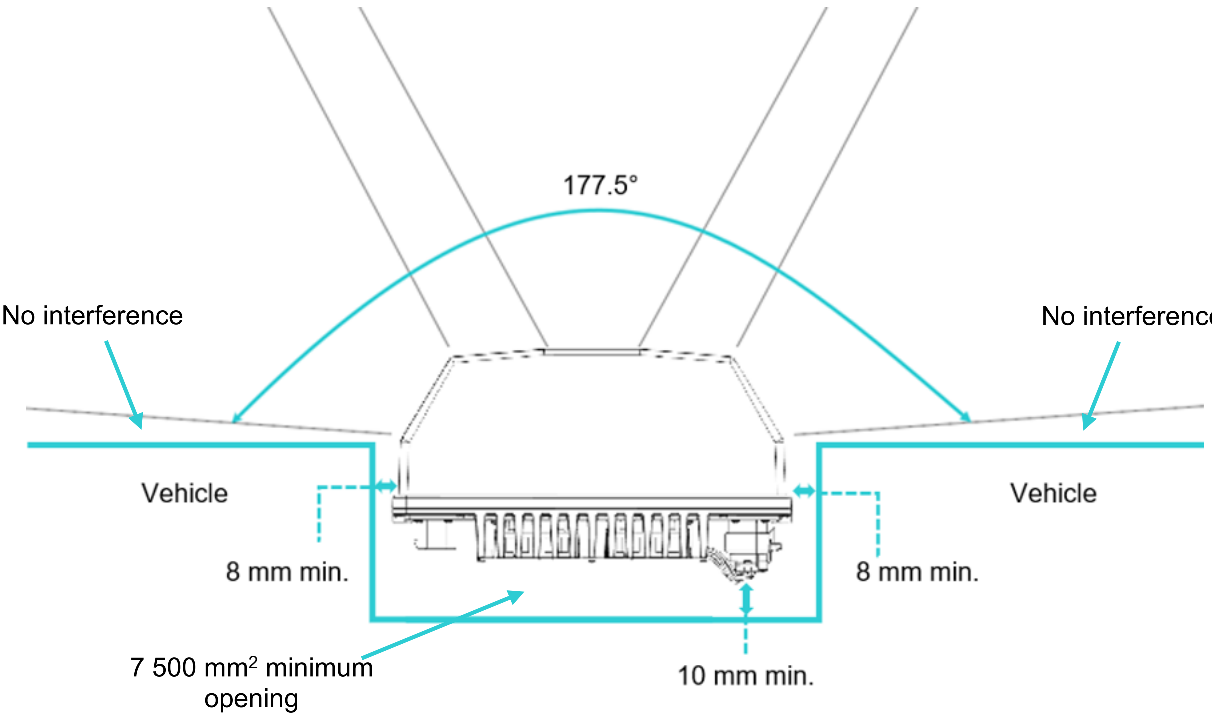


Fig. 33: Clearance size (top view)

Fig. 33 shows the minimum opening recommended at the back of the sensor to evacuate heat properly.

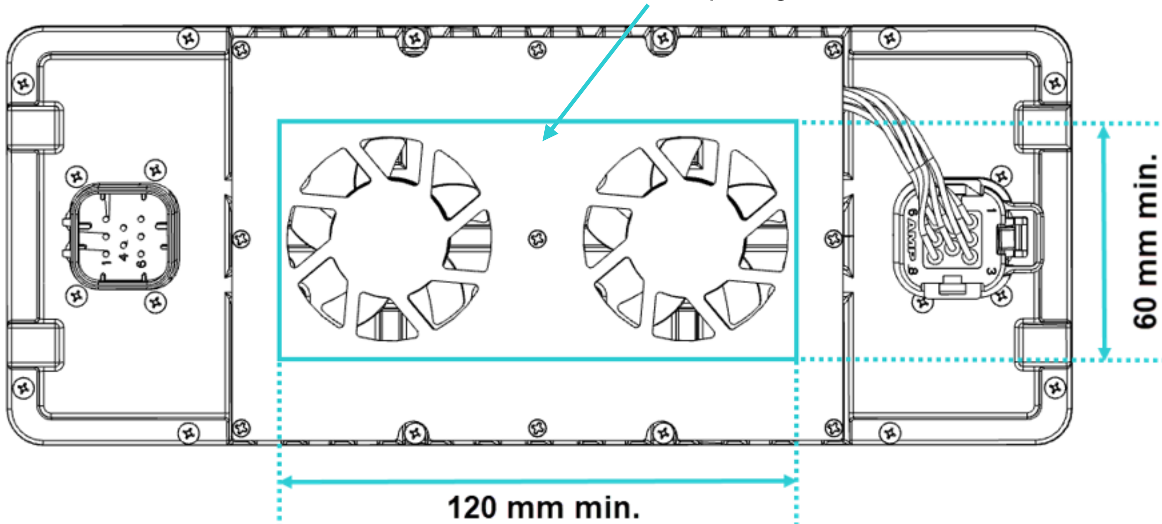


Fig. 34: Clearance size (rear view)

Make sure to leave enough space for the connectors.

7. Electronic Integration

7.1. Synchronizing the Sensors

Integrators can synchronize the clock for all the different sensors in the system to increase the perception's accuracy.

Two functionalities have been implemented: PPS and PTP.

7.1.1. GPS Pulse-per-Second Signal Input

GPSs used in autonomous navigation systems will provide a clock signal that can be employed to synchronize various systems together. The sensor must accept a "Pulse PPS" signal input and use it as a time reference.

The "Pulse PPS" signal allows each timestamp data to be synchronized with the GPS clock used in the navigation system.

LeddarTech's integration guidelines require a "Pulse PPS" synchronization signal free of data between pulses.

7.1.2. PTP Precision Time Protocol Signal Input

The Precision Time Protocol (PTP) is a protocol used to synchronize clocks throughout a computer network. The PTP is employed to synchronize networks that require precise timing but lack access to satellite navigation signals (GPS pulse-per-second signal).

LeddarTech's integration guidelines are based on the IEE 1588-2008 standard.

7.1.3. External Trigger

The **External trigger** option allows you to change the PPS input function to trigger input. The PPS input pins will be used to trigger the sensor acquisition. The physical trigger signal dictates the start of the acquisition and can be set to "Rising edge" or "Falling edge," as shown in Fig. 35 below.

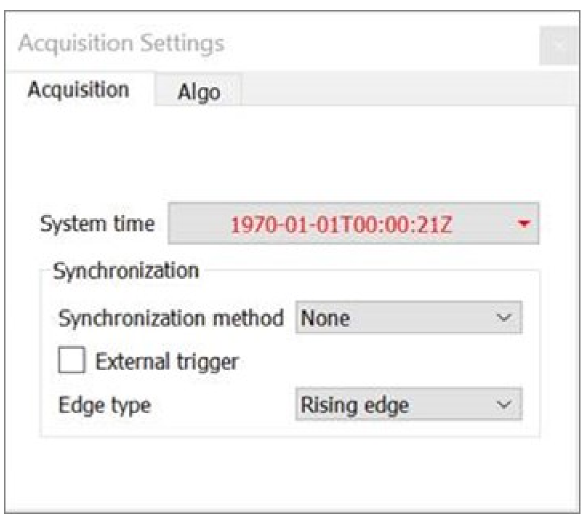


Fig. 35: Acquisition Settings, Acquisition window

7.2. Power Connector Pinout and Wiring

Table 17: Cable connection

Pin #	Function	Description
1	Ground	Power supply ground
2	ETH+	Automotive Ethernet differential pair
3	ETH-	
4	PPS- (Input)	Input for timestamp synchronization. Can be used as a trigger input.
5	PPS+ (Input)	
6	V+ (11 V-52 V)	Power supply
7	Sync+ (Out)	One pulse per second output for multi-Leddar Pixell synchronization
8	Sync- (Out)	

Recommendations on Connector Assembly

To assemble the harness, you need the following:

- One (1) automotive connector (Fig. 36). Also, refer to the pin positions in Fig. 37.
- RTV moisture-curing silicone
- Two (2) strain reliefs (Fig. 38)
- One (1) cable tie (Fig. 39)

1. Follow recommended assembly practices from AMPSEAL for this connector, referring to the instructions named “Application Specification 114-16016” available on their website.
2. Seal each exiting wire with RTV moisture-curing silicone. To ease this step, you can fill the whole rear pocket of the connector with silicone.
3. Install the strain relief (Fig. 38).
4. Install the black cable tie onto the strain relief, as shown in Fig. 40 on page 49.

Fig. 36: TE Connectivity AMP connector – Automotive connector PLG 08POS F/H BLK

Fig. 37: Automotive connector pin positions (cavity side as shown on the left)

Fig. 38: TE Connectivity AMP connector –
8 position AMPSEAL strain relief
(2 strain relief connectors required)

Fig. 39: Cable tie

	The parts and accessories shown above are recommended by LeddarTech to ensure compatibility with the Leddar Pixell connector interface. LeddarTech does not offer these parts and accessories. Contact the appropriate vendors to obtain the parts you need.

Once assembled, the connector will look as shown below.

Fig. 40: Connector assembled

7.3. Connecting the Sensor – Diagrams

This section provides information on the recommended wiring options for the sensor. Refer to Table 17 on page 48 for more details on the pinout and wiring.

7.3.1. One Sensor With the Starter Kit

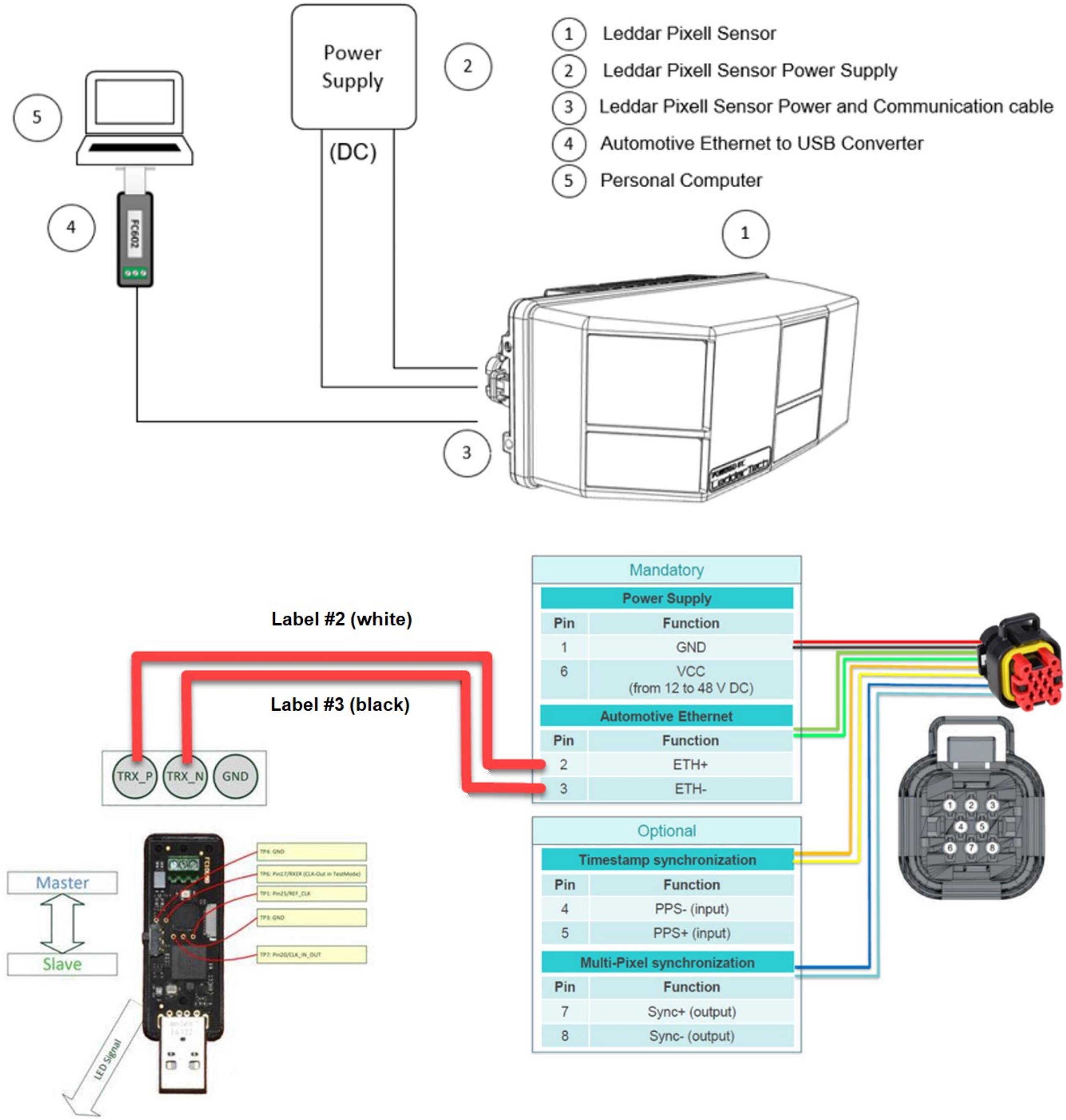


Fig. 41: One-sensor connection

You can now start using Leddar Configurator. See section 9 on page 54 and section 10 on page 56 for details. See section 11 on page 84 for more information on parts and accessories.

7.3.2. Multiple Sensors With Automotive Ethernet

Here is an example of a multiple-sensor integration. The automotive Ethernet standard is point-to-point. The physical layer is a twisted pair cable. If you do not have an ECU directly compatible with automotive Ethernet, use converters or a switch that features both standard and automotive Ethernet.

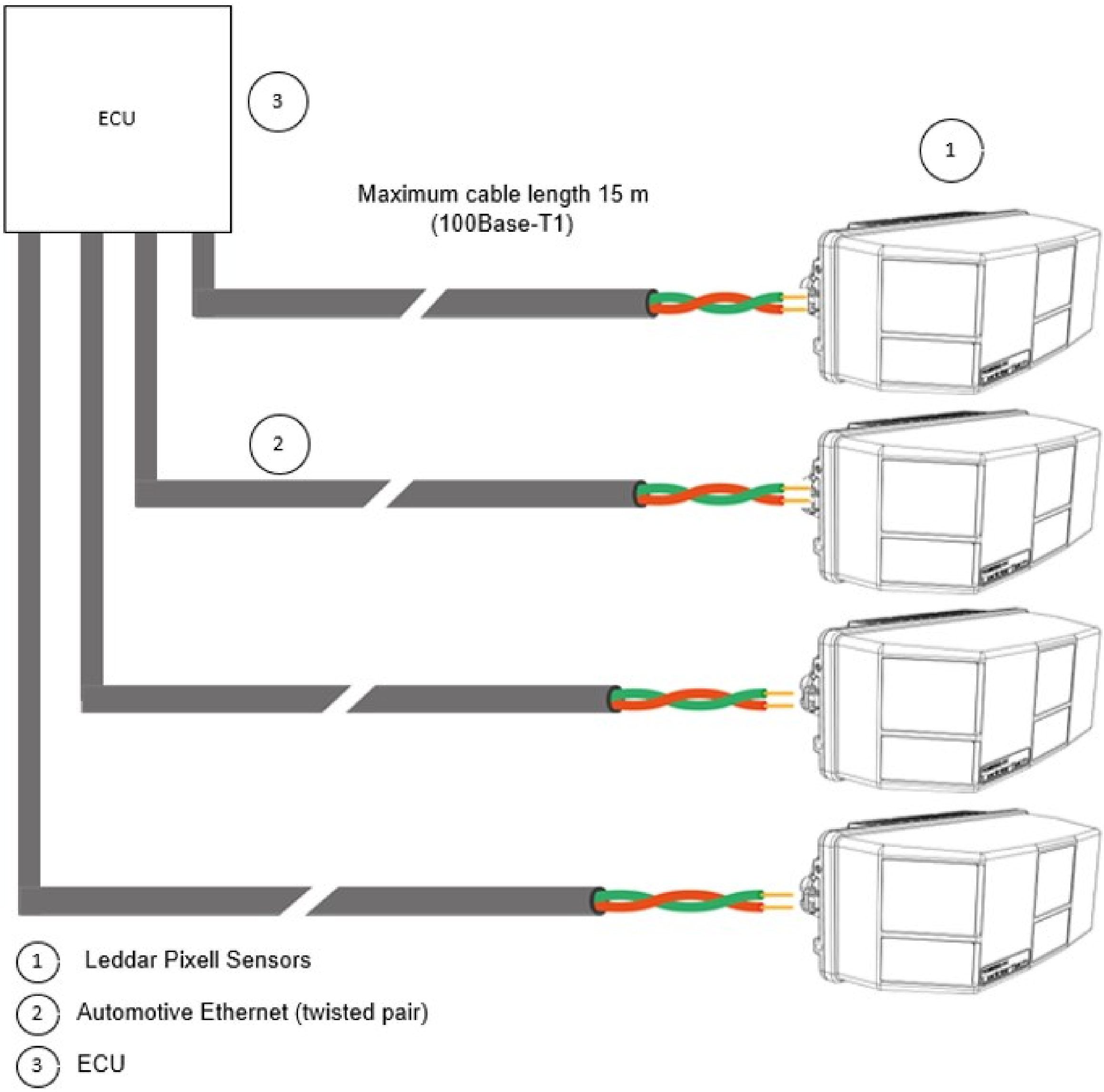


Fig. 42: Multiple-sensor connections

You can now start using Leddar Configurator. See section 9 on page 54 and section 10 on page 56 for details. See section 11 on page 84 for more information on parts and accessories.

To configure the PPS input in Trigger mode, refer to Table 46 on page 111.

8. Software Integration

There are three ways of integrating LeddarTech's LiDAR sensors within your applications:

1. Developers can build their complete applications from the ground up, based on the low-level communication protocol definition. Refer to Appendix D on page 99 for more details on the communication protocol used with the Leddar Pixell.
2. Use the Leddar SDK to accelerate your software integration and reduce the lead time associated with entirely building your application from the ground up. See section 8.2 below for more details.
3. Use the RTMaps middleware for integration with a graphical interface. See section 8.3 below.

8.1. Communication Protocol

The Leddar Pixell uses LeddarTech's proprietary data communication protocol (IP socket-based protocol), called Ipv4.

Refer to Appendix D on page 99 for more information on the sensor communication protocol.

8.2. Software Development Kit (SDK)

The Software Development Kit (SDK) allows you to integrate the sensor into your system. The SDK contains basic functions to communicate with the sensor, which will enable you to integrate the sensor faster in your system.

To obtain the software compatible with Leddar Pixell, go to www.github.com/leddartech/LeddarSDK.

To obtain the documentation relating to the Software Development Kit, go to http://sdk.leddartech.com/.

Leddar SDK Supported Platforms

LeddarTech fully supports the use of its SDK on the following platforms:

- Windows 7 and Windows 10 (32 and 64 bits)
- Linux (Ubuntu) 32 and 64 bits
- ARM (Nvidia Jetson TX2, Raspberry Pi)

Limited support is also available on other platforms. Contact LeddarTech if you want to know whether a specific platform is supported.

If you are not using the SDK on a supported platform, refer to Appendix D on page 99.

If you encounter any problem or if you have questions or concerns, contact LeddarTech support at support@leddartech.com.

8.3. RTMaps

Developed by Intempora, a Leddar™ Ecosystem partner, RTMaps 4 is an asynchronous high-performance platform designed to overcome multi-sensor challenges and allow engineers and researchers to take advantage of an efficient and easy-to-use framework for fast and robust developments.

Refer to the Application Note "Unleash the Power of LeddarTech Solid-State Scanning LiDARs with Intempora RTMaps" for assistance in using the package with this middleware. This Application Note can also be accessed at leddartech.com under **Resources** > **Resource Library** > **Document Types** > **Application Note**.

8.4. FibreCode Stick

Developed by FibreCode Embedded Solutions, the FC602 USB OABR stick represents a compact hardware interface that connects MS Windows- and Linux-based PCs with automotive Ethernet network devices and switches. Automotive Ethernet network standards OABR (OPEN Alliance BroadR-Reach) and 100Base-T1 are supported.

The FC602 USB OABR stick functions as a seamless media converter between a standard USB 2.0 interface and an automotive Ethernet network. On Windows and Linux host PCs, the USB OABR stick is detected as a standard Ethernet device.

See section 11 on page 84 and Appendix C on page 94 for more details on the driver installation.

9. Installing Leddar Configurator

1. Download LeddarInstall.exe via the provided link. Contact LeddarTech at support@leddartech.com if you did not receive the link.
2. Double-click the file to start the installation.
3. If the **Windows Security** dialog box opens, click the **Install** button to accept the installation of the drivers from LeddarTech during the process.

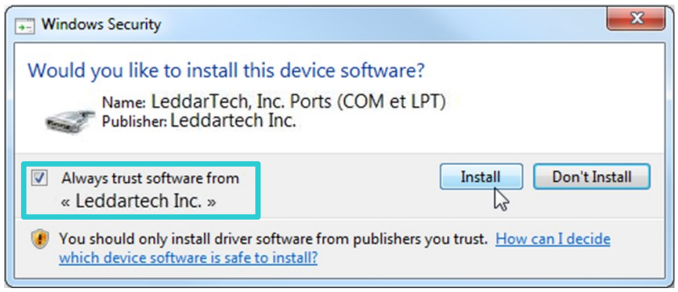


Fig. 43: Windows Security dialog box

4. Follow the steps in the **Welcome to the Leddar™ Configuration Software Setup Wizard**.

	*Refer to Appendix B on page 92 for the detailed procedure on configuring the network with a static IP.*

Connecting to Leddar Configurator

To connect your sensor to Leddar Configurator, follow the steps below.

1. On your computer desktop, click the **Leddar Configurator** icon () to open the software.
2. Click  to connect to the sensor.
3. Select **Public networks (…)** to bypass the Windows firewall.

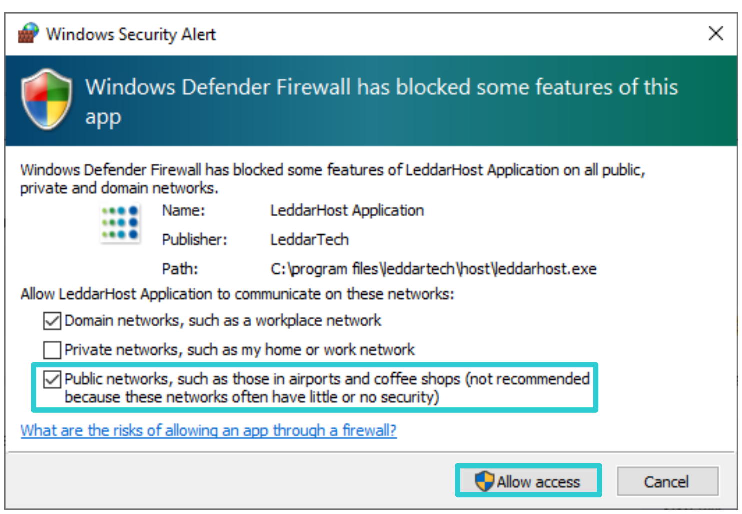


Fig. 44: Bypassing Windows firewall window

If the window above is not displayed, see Appendix A on page 90.

4. In the **Connection** window, under **Select a connection type**, select **LeddarAuto**.

The first time the sensor is connected to a computer, a few seconds are required for Windows to detect it and complete the installation.

5. a) If the sensor is automatically detected, select the available sensor from the list.

b) Otherwise, enter the IP address **192.168.0.2** and Port number **48630**.

6. Click **Connect** to connect to the available sensor.

The color of items in the list indicates the status of a sensor.

- **Black:** This sensor is available. No user is connected to it.
- **Blue:** There is a user connected to this sensor.
- **Red:** Unable to communicate. If the sensor does not respond to requests after some time, it is displayed in red.

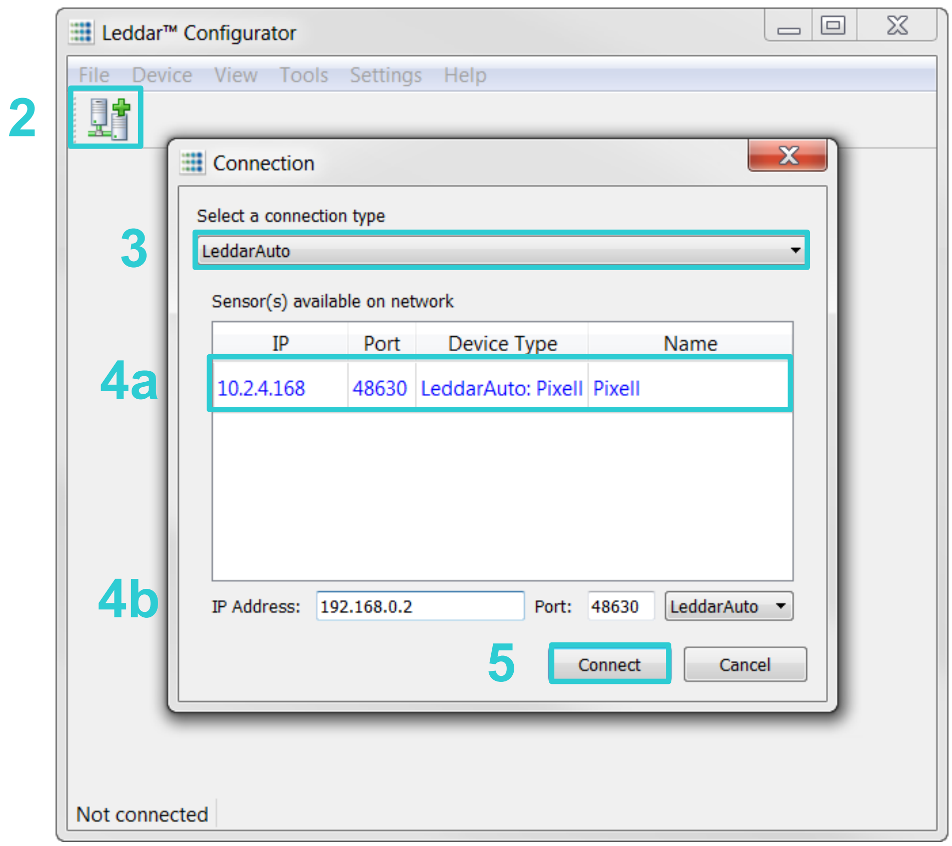


Fig. 45: Steps to connect to Leddar Configurator

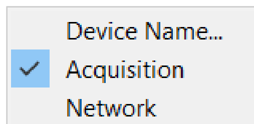
10. Leddar Configurator Software

The software allows you to view the detection measurements provided by the connected sensor. The detections may vary based on the configuration of the parameters.

⚠	*The Leddar Configurator software does not display detections flagged as "invalid."*

The main window can be resized manually or set to full-screen view. All dialog boxes that do not include a selection of action buttons at the bottom, such as **Connect**, **OK**, or **Cancel**, are dockable at the top, bottom, or right side of the main window.

When a dialog box or a window is already open, a checkmark appears next to the command on the menu.



<Alt> + click a segment to obtain the following information:

- H Channel (horizontal segment)
- V Channel (vertical segment)
- Distance
- Amplitude

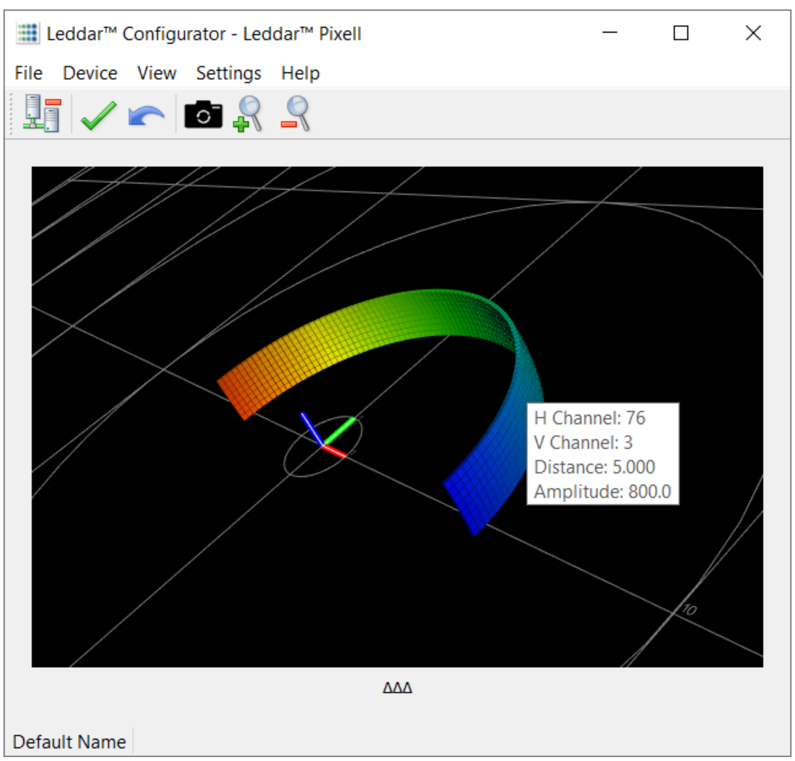


Fig. 46: Leddar Configurator software

10.1. Main Window

Once connected to the sensor, the main window of Leddar Configurator displays the following menus, toolbar, and default 3D view. See their descriptions in the sections below.

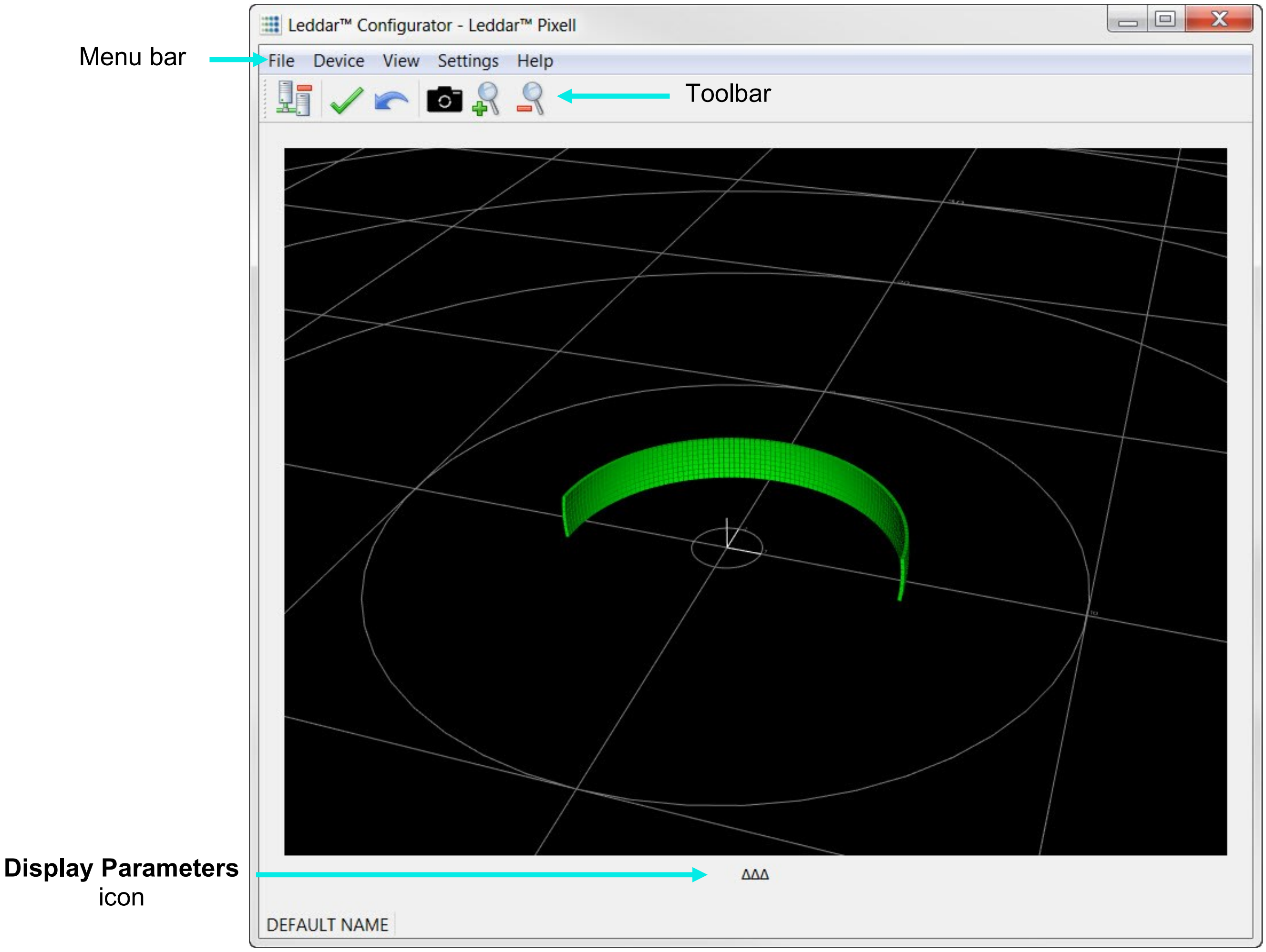


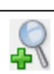
Fig. 47: Leddar Configurator main window with a 3D view example

Table 18: Main window menus and paths

Menu	Description
File	Click **File** to access the following menu options: **File** > **Replay** **File** > **Save Configuration** **File** > **Load Configuration** **File** > **Start/Stop Recording (<F9>)** **File** > **Start/Stop Data Logging** **File** > **Quit** See section 10.4 on page 66 for more details.

Menu	Description
Device	Click **Device** to access the following menu options: **Device** > **Disconnect** **Device** > **Configuration** > **Device Name…** **Device** > **Configuration** > **Acquisition** **Device** > **Configuration** > **Network** **Device** > **Action** > **Reset to factory default configuration** **Device** > **Action** > **Update** **Device** > **Debug** See section 10.5 on page 71 for more details.
View	Click **View** to access the following menu options: **View** > **Serial Port Viewer** **View** > **State** **View** > **Raw Detections** **View** > **2D Matrix Viewer** See section 10.6 on page 74 for more details.
Settings	Click **Settings** to access the following menu options: **Settings** > **Preferences** **Settings** > **Licenses** See section 10.7 on page 82 for more details.
Help	Click **Help** to access the following menu options: **Help** > **User Guide** **Help** > **About** See section 10.8 on page 83 for more details.

Table 19: Main window toolbar and Display Parameters icon

Icon	Description
 	The **Connect** icon allows you to connect to a sensor. Once connected, the **Connect** icon will change to **Disconnect**. The **Disconnect** icon will then allow you to disconnect the sensor from the system.
	The **Apply** icon allows you to confirm and apply the changes you just made to the system with respect to the sensor.
	The **Undo** icon allows you to revert to the information displayed before making your changes or before specifying parameters, for example.
	The **Reset Camera** icon allows you to select between three different types of views for the signal display: • Bird's-eye view • Top view • Front view See section 10.3.1 on page 64 for more details.
	Click **Zoom in** to zoom in the display.

Icon	Description
	Click **Zoom out** to zoom out the display.
ΔΔΔ ∇∇∇	Under the display view, click the three arrows up to see the **Display Parameters** section. Click the three arrows down to hide the **Display Parameters** section.

10.2. 3D Viewer and Parameters

Upon opening the Leddar Configurator software, the 3D view is displayed by default.

This option allows you to view the scene in a 3D environment. A colored segment represents each detection. The 3D view is configurable. See below for more details.

Click ΔΔΔ to view and modify the color and display parameters of the 3D Viewer. Once the parameters are specified according to the desired criteria, you will view the detections according to these parameters.

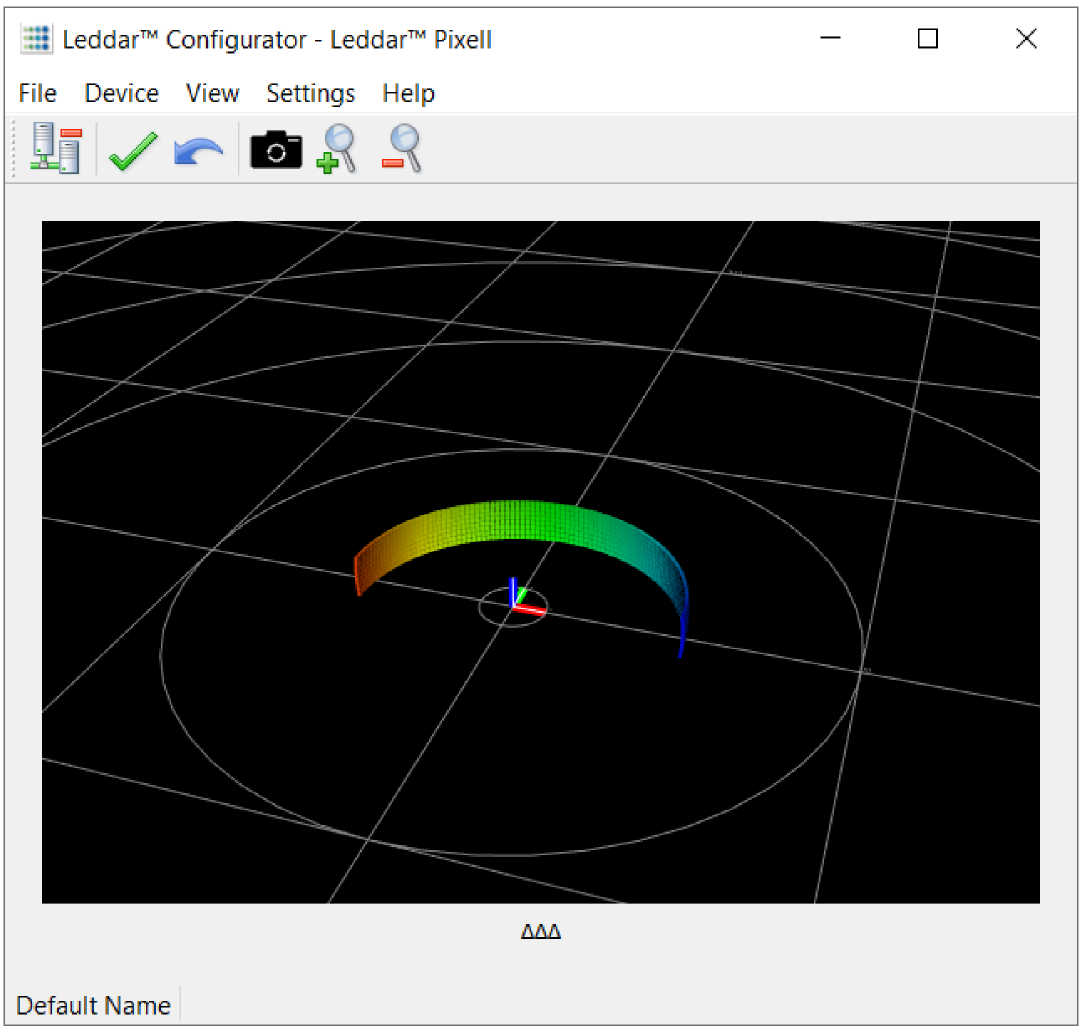


Fig. 48: 3D Viewer window

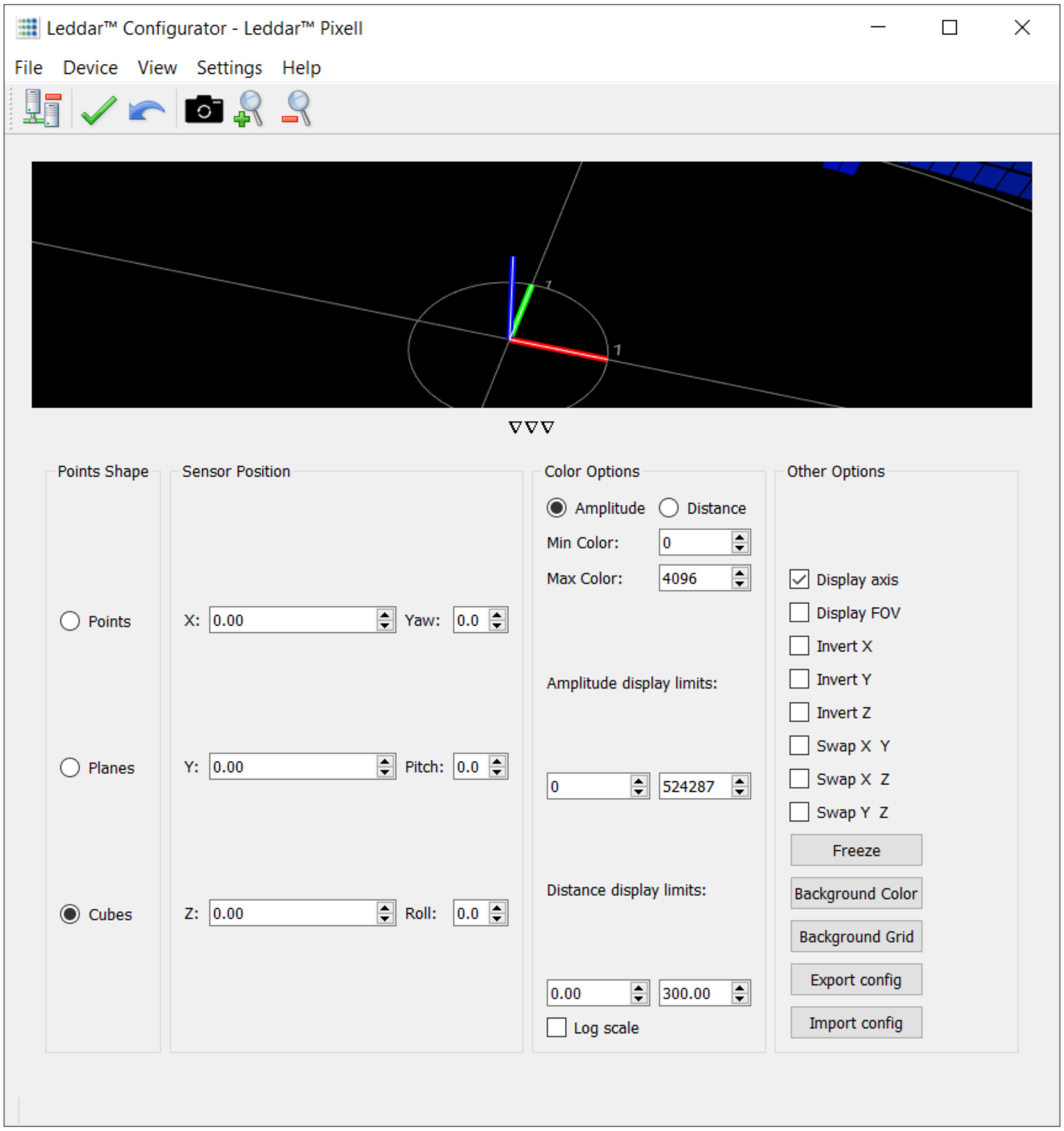


Fig. 49: 3D Viewer window and parameters

See below for the description of the **3D Viewer** window parameters section by section.

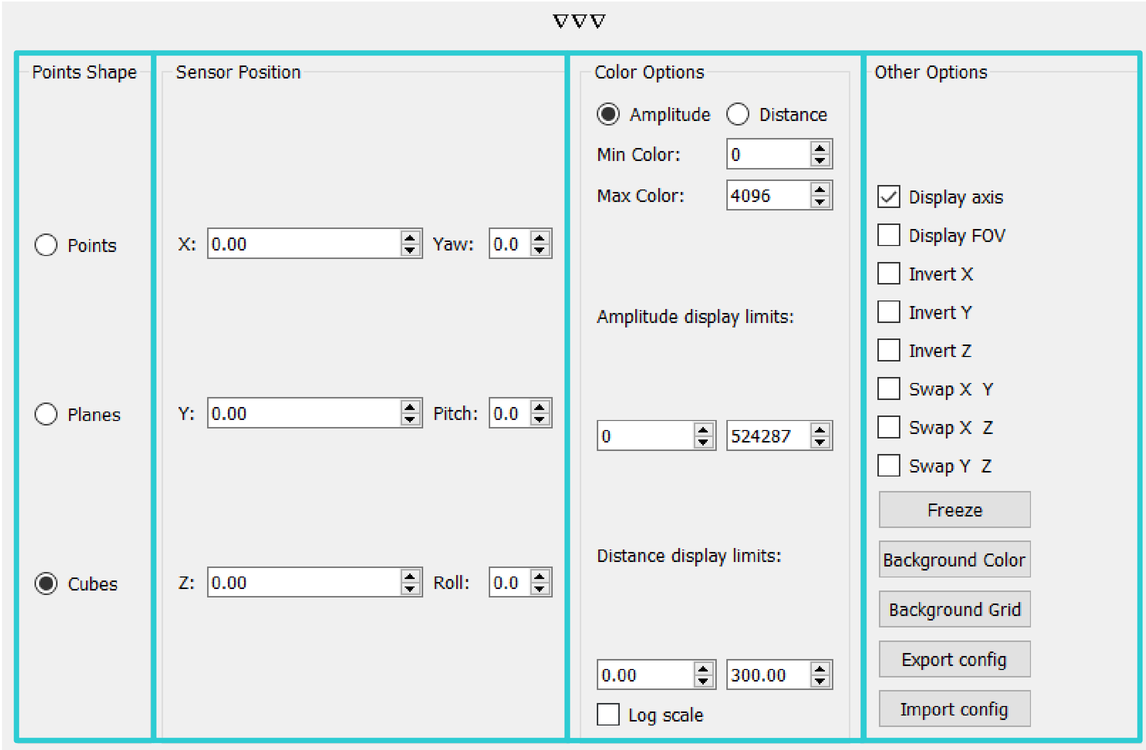


Fig. 50: 3D Viewer parameters

Click ▽▽▽ to hide the **Display Parameters** section.

Table 20: 3D Viewer parameters

Parameter/Feature	Description	Range/Value
Points Shape	This section allows you to select the points shape to display the detection scene, including the detected object. You can choose to view the scene with points, planes, or cubes. • **Points** refer to the same size points as appearing in the 3D view. • **Planes** refer to square-shaped filled segments that change depending on the distance. • **Cubes** refer to 3D shaped cubes appearing in the 3D view.	Points Planes Cubes
Sensor Position	This section allows you to specify the X, Y, and Z axes from where the sensor (sensor position) collects the detected object using the up and down arrows or by entering the exact desired values in the box. Using the up and down arrows or entering the exact desired values in the box, you can select the parameter related to: • **Yaw**, i.e., how you want to display the object around the vertical axis • **Pitch**, i.e., how you want to display the object around the horizontal axis • **Roll**, i.e., how you want to display the object around the longitudinal axis	X Y Z Yaw Pitch Roll

Parameter/Feature	Description	Range/Value
Color Options	This section allows you to change various parameters related to the color map: • Amplitude • Distance • Minimum color (Min Color) • Maximum color (Max Color) • Amplitude display limits • Distance display limits • Log scale	Varies
Amplitude **Distance**	Select the **Amplitude** or **Distance** option depending on the way you want to view the detections. If you select **Amplitude**, specify the minimum color and maximum color, and the amplitude display limits if you want to view the detections. If you select **Distance**, specify the minimum color and maximum color, and the distance display limits within which you want to view the detections.	Varies
Min Color **Max Color**	Indicates the range by which the color map may vary. Values below the specified **Min Color** will be blue and values greater than the specified **Max Color** will be red. The color of the values between these ranges will vary linearly. The maximum amplitude is 262 143 by default. Setting a value in both fields will result in a range of amplitude to display.	0 to 262 143
Amplitude Display Limits	Indicates the lower and upper limits of amplitudes to display. Detections with an amplitude value out of the range will not be displayed.	0 to 530 000
Distance Display Limits	Indicates the lower and upper limits of distances to display in meters or feet. Detections with a distance value out of the range will not be displayed. To set unit preferences, see section 10.7.1 on page 82.	0 to 300
Log Scale	Select this option to switch from a linear scale to a logarithmic scale and conversely.	N/A
Other Options	The **Other Options** section allows you to select the appropriate following options according to the desired criteria: • Display axis • Display FoV • Invert X, Y, or Z • Swap X, Y, or Z • Freeze • Background Color • Background Grid • Export Configuration • Import Configuration	Varies

Parameter/Feature	Description	Range/Value
Display Axis	Select this option to view the axis.	Varies
Display FoV	Select this option to view the FoV.	N/A
Invert X **Invert Y** **Invert Z**	Select one of these options to invert the desired axis.	N/A
Swap X Y **Swap X Z** **Swap Y Z**	Select these options to swap the X, Y, or Z axis ordinates. The coordinates will be rearranged according to the selected option.	N/A
Freeze	Click **Freeze** to view a static display of the scene.	Varies
Background Color	Click **Background Color** to change the color of the background grid.	Varies
Background Grid	Click **Background Grid** to change the background view with one of the following four options: • No grid • Polar and square grids • Grid pattern • Polar grid	Varies
Export config	Click **Export Config** to save a 3D display configuration in .lcfg format.	N/A
Import config	Click **Import Config** to restore a 3D display configuration in .lcfg format.	N/A

10.3. Changing the View and Orientation

10.3.1. Display Settings

A variety of options are available to adjust the signal display. The **Reset Camera** icon () allows you to change the type of view of the signal display. Clicking the **Reset Camera** icon moves you through the three available 3D views: Bird's-eye view, Front view, and Top view.

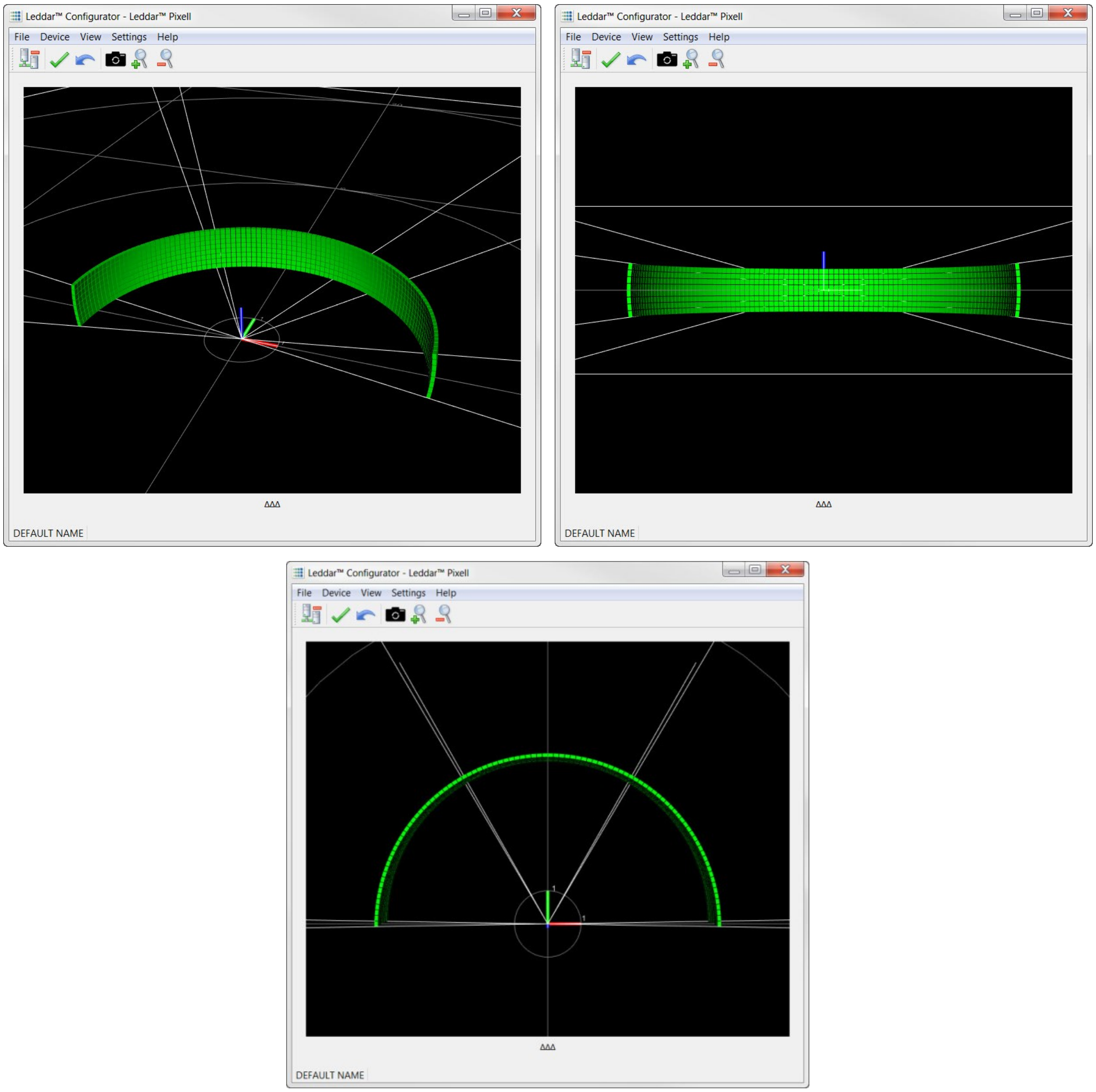
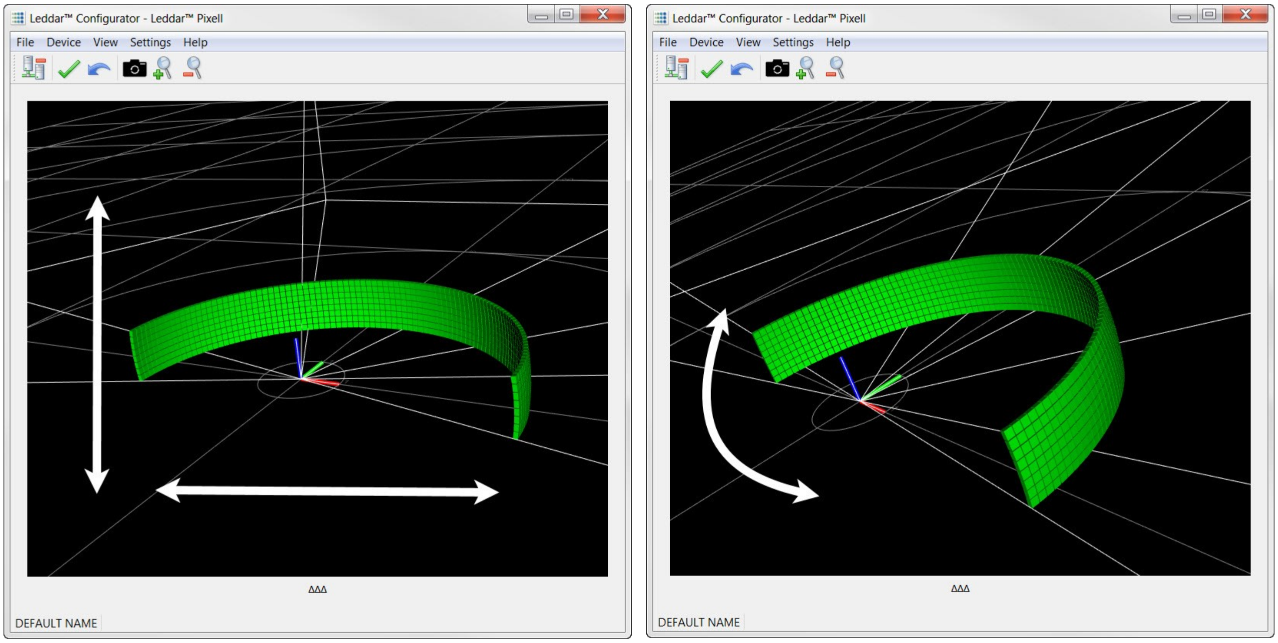


Fig. 51: 3D views (Bird's-eye, Front, and Top views, respectively)

You can view, move, and zoom the main window display in different ways according to the mouse cursor position.

You can move up, down, and sideways by clicking and dragging the display. Use the mouse cursor to point somewhere in the view; click and drag it to the desired position.



Moving the mouse to change the position *Moving the mouse to change the orientation*

Fig. 52: Signal display position and rotation

Changing the position and orientation helps you match the physical installation of the sensor. For example, if the sensor needs to be installed vertically or upside down for mechanical reasons, the axes can be reoriented to reflect its position.

10.3.2. Detection Scene Shortcuts

Mouse shortcuts allow you to change the sensor display.

- **<Shift>** + click to pan
- **<Ctrl>** + click to rotate the view in a single axis once at a time
- **<Ctrl> + mouse wheel** to zoom in or out the detection scene, or click or in the toolbar.

10.4. File Menu

Table 21: File menu options

Option	Description
Save Configuration	This option allows you to save the configuration for a specific device to a file (.lto) from the **Save as…** dialog box. This allows you to save settings and restore them in case of a system failure or to revert to earlier settings. In addition, if you have more than one sensor and you want to use the same configuration for all of them, save the configuration you want to use for all your sensors. In this case, make sure to assign a different name to all your sensors. The sensors named differently will use the same configuration. See section 10.5.1 on page 72 for more details.
Load Configuration	This option allows you to load the device configuration previously saved in the system as an .lto file. Choose the desired device configuration from the **Open** dialog box. You can also retrieve the configuration that was stored with a record file. In case of system failure, you can load a sensor configuration and use this sensor configuration to collect signal data according to a set of parameters (scanning, distance measurements, etc.) and then analyze the collected data or the information. In addition, if you have more than one sensor and you want to use the same configuration for all of them, you must load the previously saved configuration that you want to use for all your sensors. In this case, make sure to assign a different name to all your sensors. The sensors named differently will use the same configuration. See section 10.5.1 on page 72 for more details.
Start Recording **Stop Recording**	Select the **Start Recording** option (shortcut: **<F9>**) to start recording detections in an .ltl file that can later be reloaded and replayed. Select the **Stop Recording** option (shortcut: **<F9>**) to stop recording detections of the .ltl file. See section 10.4.1.2 on page 67 for more details.
Replay	Once you have completed a recording, you can review it by selecting **Replay** in the **File** menu. The **Position** slider allows you to move directly to the desired position. The **Playback Speed** slider allows you to adjust the speed of the recording playback. See section 10.4.1.3 on page 68 for more details.
Start Data Logging **Stop Data Logging**	Select the **Start Data Logging** option to start the log of receiving data or the event log of the sensor. The event log is displayed in text format. Select the **Stop Data Logging** option to stop the log of receiving data or the event log of the sensor. The event log is displayed in text format. See section 10.4.2.2 on page 71 for more details.
Quit	Select **Quit** to exit the Leddar Configurator software.

10.4.1. Recordings (.ltl File)

Detection records provide playback of detections recorded by a device. This visual information can be useful for verification, troubleshooting, or training purposes. Detection records provide a full data playback stored in an .ltl file that you can later reload and replay.

10.4.1.1. Setting up Recording Settings

Under **Settings** > **Preferences** > **Recording**, select **Recorder**.

1. Select a directory.
2. Specify a **Maximum file size** (minimum 1 MB and maximum 500 MB).
3. Select **Log debug information** only if requested by LeddarTech to activate troubleshooting information. Selecting this option activates advanced debug features and is inefficient for long recordings.
4. Specify a **Maximum record time (minutes)** (minimum 1 minute and maximum 71 582 minutes).
5. Click **OK**.

The filename of the recording will be the device name followed by the date and time of the recording.

When recording for a long period of time, an additional file is automatically created every time a recording exceeds 500 MB.

You can change the name of the file by changing the device name (see section 10.5.1 on page 72) or after the recording.

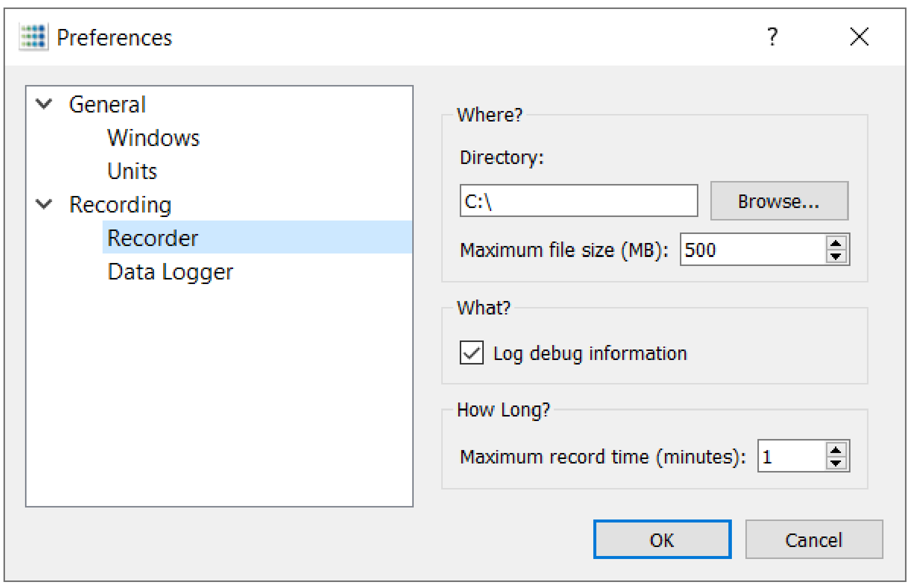


Fig. 53: Recording settings

10.4.1.2. Recording a Scene

To start recording the detection scene:

1. Under **Settings** > **Preferences** > **Recording**, specify the maximum file size and maximum record time. See section 10.4.1.1 above for more details.
2. In the **File** menu, select **Start Recording**.

A pop-up window appears where you can select the starting and ending lines for the recording. The selection ranges from 1 to 8.

If you want to record one line only, Line 4, for example, select “4” in the **Starting Line** and **Ending Line** fields, respectively.

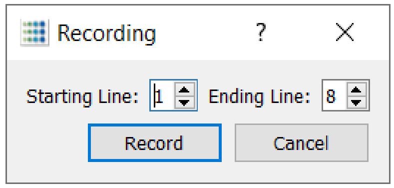


Fig. 54: Recording Starting and Ending Lines

3. Click **Record** to record a scene.

A counter starts at the bottom left of the main window next to the name of the sensor.

To stop recording the detection scene, select **Stop Recording** in the **File** menu.

10.4.1.3. Replaying a Recording

To access this function, disconnect from the sensor and click **File** > **Replay**.

Once you have completed a recording, this option allows you to review the recorded *.ltl file and extract parts.

1. Click **File** > **Replay**. The **Record Replay** window appears:

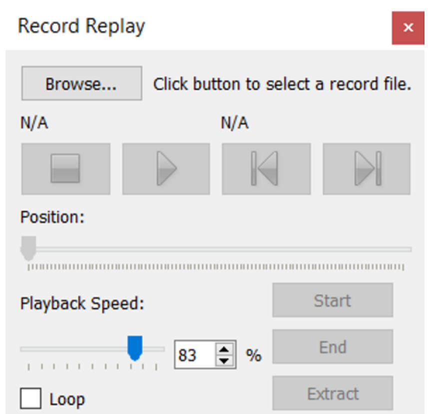


Fig. 55: Record Replay window upon opening

2. Click **Browse…** to select a file.

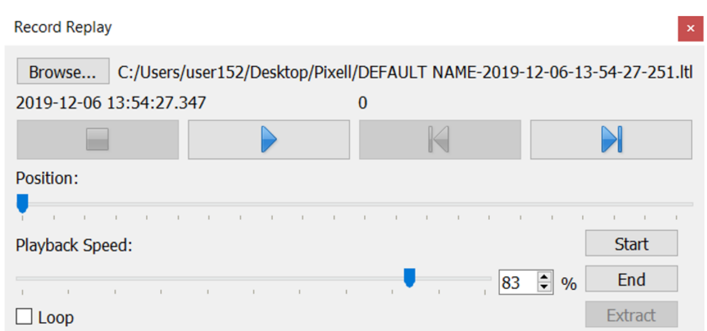
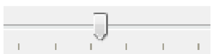
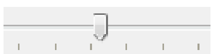


Fig. 56: Record Replay window with an open file

Table 22: Record Replay window

Button/Feature	Description
Browse…	Click **Browse…** to select the record file of the scene that you want to view again. Once selected, the name of the file will appear next to the **Browse…** button.
	Click the **Play** button to start the recording.
	Click the **Stop** button to end the recording.
 	Click the **Previous** or **Next** button to move either to the previous or to the next frame.
Position 	Move the **Position** slider to go to the desired position in the recorded file. The indication of the position is located above the **Play** and **Next** buttons, for example, 8600.
Playback Speed 	Move the **Playback Speed** slider to change the playback speed in order to see the scene or the detected object more accurately. The percentage indicates the speed of the playback, for example, 50 %.
Loop	Select this option to automatically loop back to the beginning of the recording.
Start	Click **Start** to tag the position to start the extraction.
End	Click **End** to tag the position to end the extraction.
Extract	Click **Extract** to extract a part of the scene and save it as an .ltl file. See section 10.4.1.4 below for more details.

10.4.1.4. Extracting a Scene Segment

This feature allows you to extract a segment from a previously recorded scene.

1. Click **Browse…** to select the record file to play.
2. In the **Open** window, select the desired record file and click **Open**.
3. Click  to start the playback.

To extract a record file segment:

1. Move the **Position** slider to the position to see the file segment start and click Start.
2. Move the **Position** slider to the position to see the file segment stop and click End.

Alternatively:

1. Play the record and stop it at a position of interest, then click Start.
2. Restart playing the record and stop it again at a position of interest, then click End.

3. Click  to extract and save that file segment.

   If you want to specify a different speed for the playback, enter the desired playback speed percentage or use the arrows up and down to specify the right percentage.

4. Click .

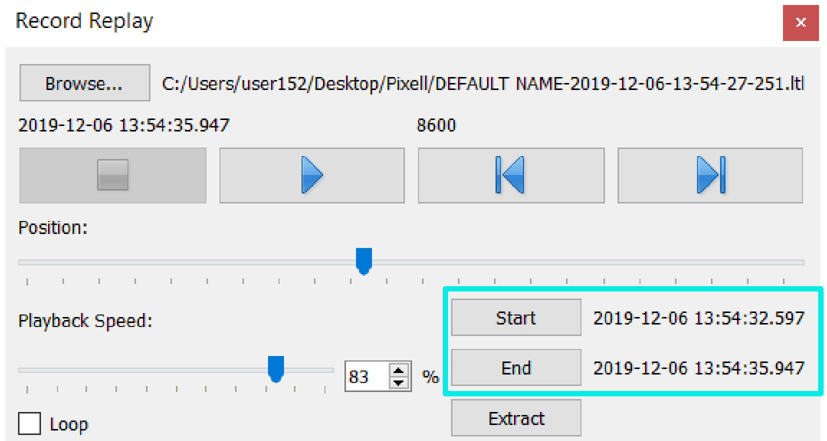


Fig. 57: Extracted segment example

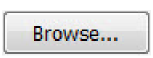
10.4.2. Data Logging (.txt File)

10.4.2.1. Setting Up Data Logging

When selecting this option, a counter will start at the bottom left of the main window next to the name of the sensor.

To set up data logging file and launch data logging:

1. To configure a .txt recording, click **Settings** > **Preferences** > **Recording** > **Data Logger**.

2. Click  to select where to save the log and click **OK**.

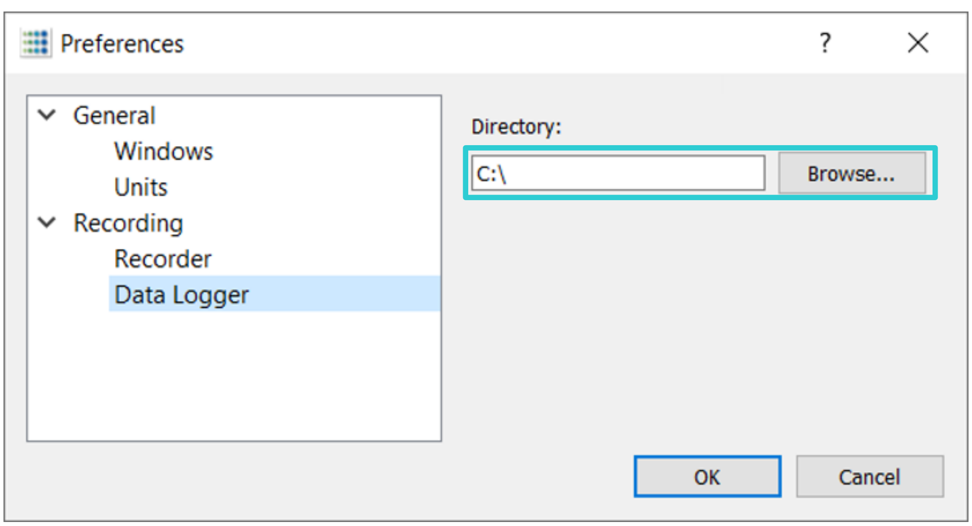


Fig. 58: Preferences window

The recording's filename will be the device name followed by the date and time of the recording. You can change the name of the file by changing the device name (see section 10.5.1 on page 72) or after the recording.

To stop data logging:

In the **File** menu, select **Stop Data Logging**.

10.4.2.2. Starting and Stopping Data Logging

To access this function, click **File** > **Start Data Logging**.

The **Data Logging** function allows you to output the data to a .txt file automatically. This file can be imported into a software application, such as Microsoft Excel, for offline analysis.

	It is recommended to change the name of the .txt file.

Each line of the generated text file contains the information related to a single detection. For example:

Time (ms)	Segment Horizontal (0 to 96), Vertical (1 to 8)	Amplitude (counts)	Distance	Status
21338	7,1	700	33.61	1

In this table:

- **Time** indicates the timestamp of the detection from when the sensor was connected to the power supply;
- **Segment** refers to the location of the detection (horizontal and vertical);
- The **Amplitude** of the detection indicates the strength of the returned signal;
- **Distance** indicates the distance of the detection in meters or feet, depending on the distance unit configured in the **Preferences** window;
- **Status** corresponds to a flag value.

10.5. Device Menu

Table 23: Device menu options

Option	Description
Device > **Disconnect…**	Click  to disconnect the sensor from the software and return to Leddar Configurator.
Device > **Configuration** > **Device Name…**	Select this option to modify the name of the sensor. See section 10.5.1 on page 72 for more details.
Device > **Configuration** > **Acquisition** > **Acqui-sition**	Select this option to manage the system time and synchronization method. See section 7.1 on page 47 for more details.
Device > **Configuration** > **Acquisition** > **Algo**	Select this option to enable or disable the demerging functionality. See section 10.5.2 on page 73 for more details.

Option	Description
Device > **Configuration** > **Network**	Select this option to access and modify the network configuration. See section 10.5.3 on page 73 for more details.
Device > **Action** > **Reset to factory default configuration**	*This action resets all settings to the factory default configuration.*
Device > **Action** > **Update**	Select this option to update the Leddar Configurator firmware. See "Firmware Update" on page 76 for more details.

10.5.1. Device Name

To access this function, click **Device** > **Configuration** > **Device Name…**.

This option allows you to view and modify the name of the sensor. When you connect to the sensor for the first time, a default name will be displayed. You can change the name of the sensor at any time with a connected device.

1. In the **Name** field of the **Device Name** dialog box, enter the new name of the sensor and click **OK**.
2. A warning message appears in red.
3. Click  in the toolbar to save your changes.

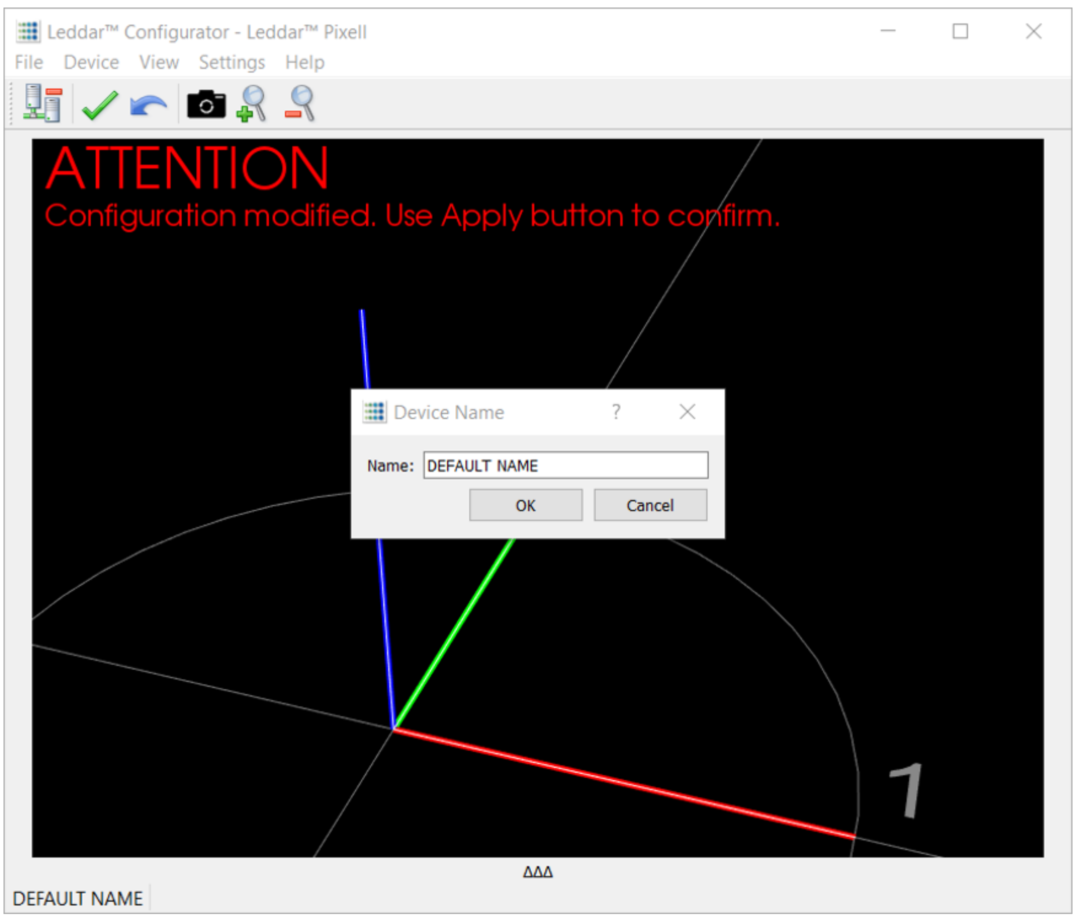


Fig. 59: Device Name window and warning message example

10.5.2. Demerging

To access this function, click **Device** > **Configuration** > **Acquisition** > **Algo**.

The Leddar Pixell integrates an algorithm that allows you to demerge pulses of operation distances higher than 0.8 meter (will vary with amplitude and pulse ratio).

The Leddar Pixell pulse demerging algorithm supports the demerging of 70 to 150 pixels in one frame with minimal effect on frame rate. The number of pixels corresponds to a scene comprised of merged objects covering 20% of the total FoV. Priority is given to the central head, line 1, segment 65, and the next other segments on the same line, and then the next line until the maximum demerging capacity is reached according to the mode of operation.

A flag has been implemented in the sensor output data, allowing you to differentiate a standard detection from a detection processed through the demerging algorithm.

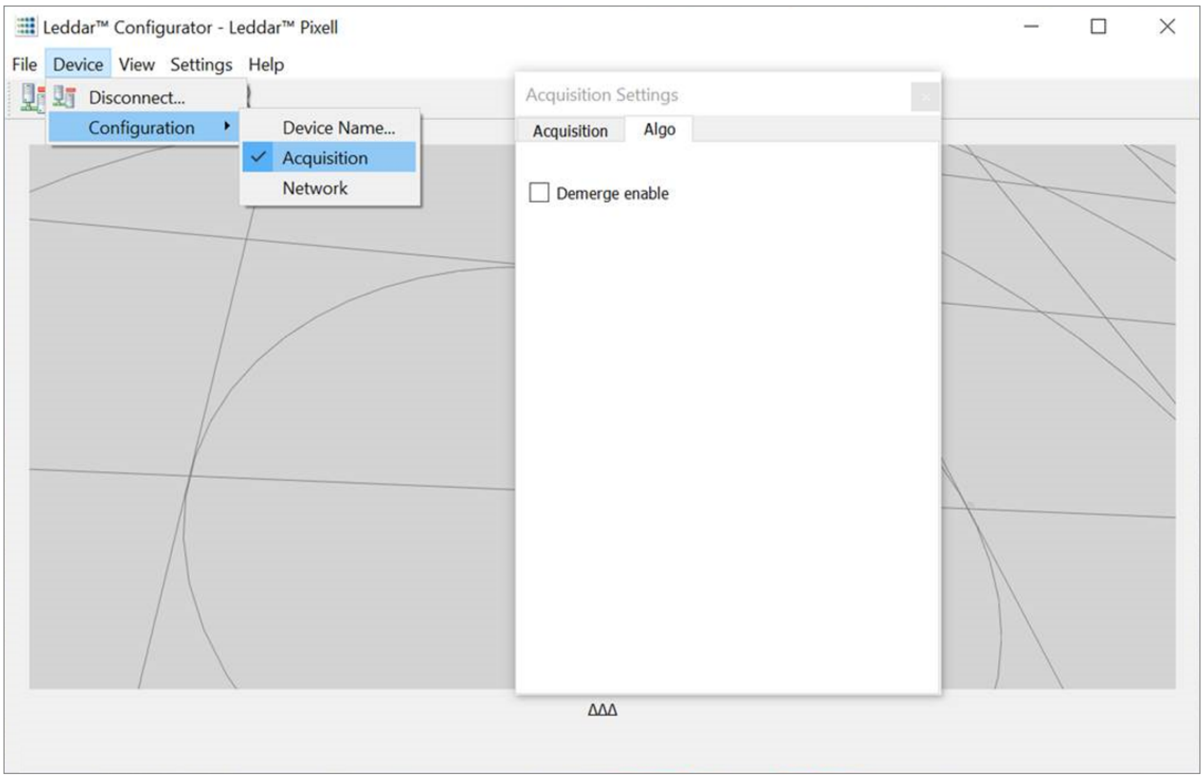


Fig. 60: Acquisition Settings, Algo window

To activate demerging, select the **Demerge enable** option.

10.5.3. Network Configuration

To access this function, click **Device** > **Configuration** > **Network**.

This window allows you to view and modify the IP configuration and communication protocol configuration. The network configuration is applied after a system reboot.

The address displayed in this window is always the latest static IP used by the sensor (default: 192.168.0.2), even if the current address is dynamically assigned. If no DHCP server is found, the sensor reverts to this address. The currently assigned address (whether dynamic or static) can be found in the **Connection** window upon a new connection (see Fig. 45 on page 55).

UDP or TCP communication mode can be selected by checking the desired option below, followed by clicking **OK** and restarting the Pixell.

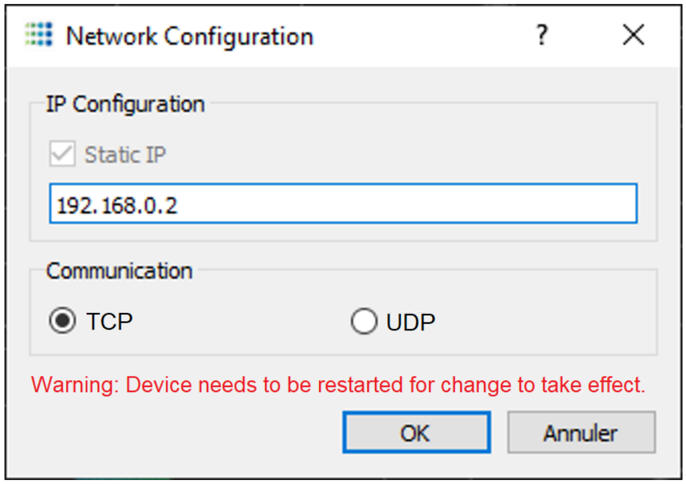


Fig. 61: Network Configuration window

A warning message will appear in the main window after changing parameters. Click ✓ in the toolbar to confirm the changes.

Table 24: Network Configuration window

Parameter	Description
Static IP	⚠ *No factory reset is possible if you lose or forget the static IP address.*
TCP	Transmission Control Protocol (data server only)
UDP	User Datagram Protocol (data server only)

10.6. View Menu

Table 25: View menu options

Menu	Description
View > **Serial Port Viewer**	Select this option to view data related to the selected serial port. This feature is not available with this version.
View > **State**	Select this option to consult various sensor information such as the sensor temperature, CPU load, sensor serial number, software version, and sensor status. See section 10.6.2 on page 75 for more details.
View > **Raw Detections**	Select this option to view the displayed data and to define the desired detection parameters. See section 10.6.3 on page 78 for more details.
View > **2D Matrix Viewer**	Select this option to view the detection scene in 2D. See section 10.6.4 on page 81 for more details.

10.6.1. Serial Port Viewer

To access this function, click **View** > **Serial Port Viewer**.

When no serial port is available, the window remains empty, as shown below.

> *This feature is not available with this version.*

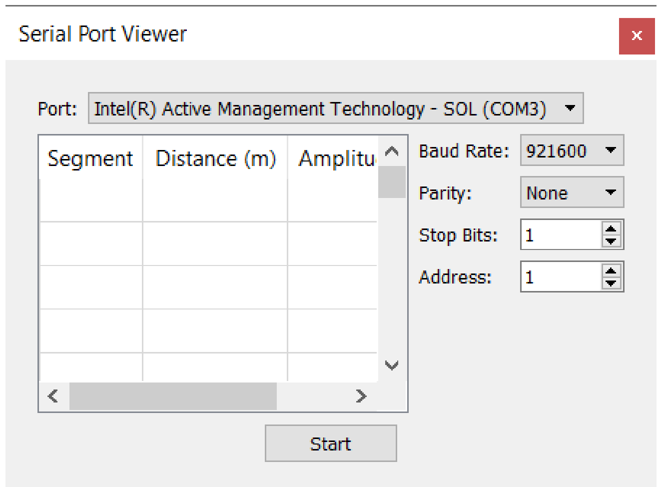


Fig. 62: Serial Port Viewer window

10.6.2. Device State

To access this function, click **View** > **State**.

This window allows you to view information about the state of the sensor.

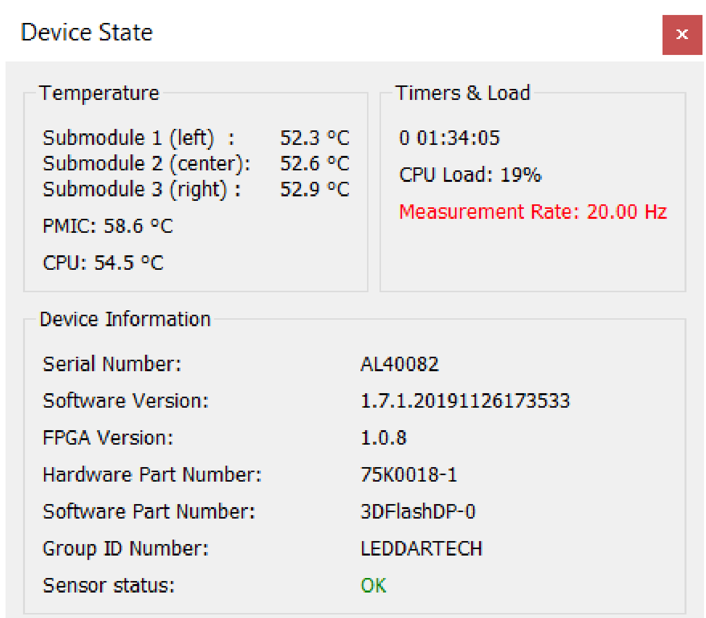


Fig. 63: Device State window

The **Measurement Rate** in red indicates a significant difference between the optimum and current measurement rates.

Table 26: Device State information

• Temperature	• Hardware part number	• Timers (operating time)
• Serial number	• Software part number	• CPU load
• Software version	• Group ID number	• Measurement rate
• FPGA version	• Sensor status[12]	

Firmware Update

To access this function, click **Device** > **Update**.

The **Code Update** window allows you to update the software from an .ltb file in the host's file system.

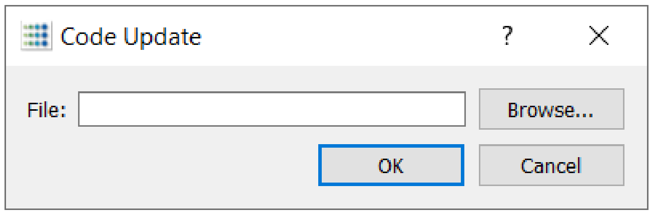


Fig. 64: Code Update window

Click **Browse...**, then select the .ltb update file provided by LeddarTech from your computer's file system. Wait for the progress bar to complete, then for the sensor to reconnect. The update is then completed.

To verify the update, click **View** > **State**. The **Device State** window opens, enabling you to verify the software version.

[12] See section 4.4 on page 36 for more details on the sensor statuses and alerts.

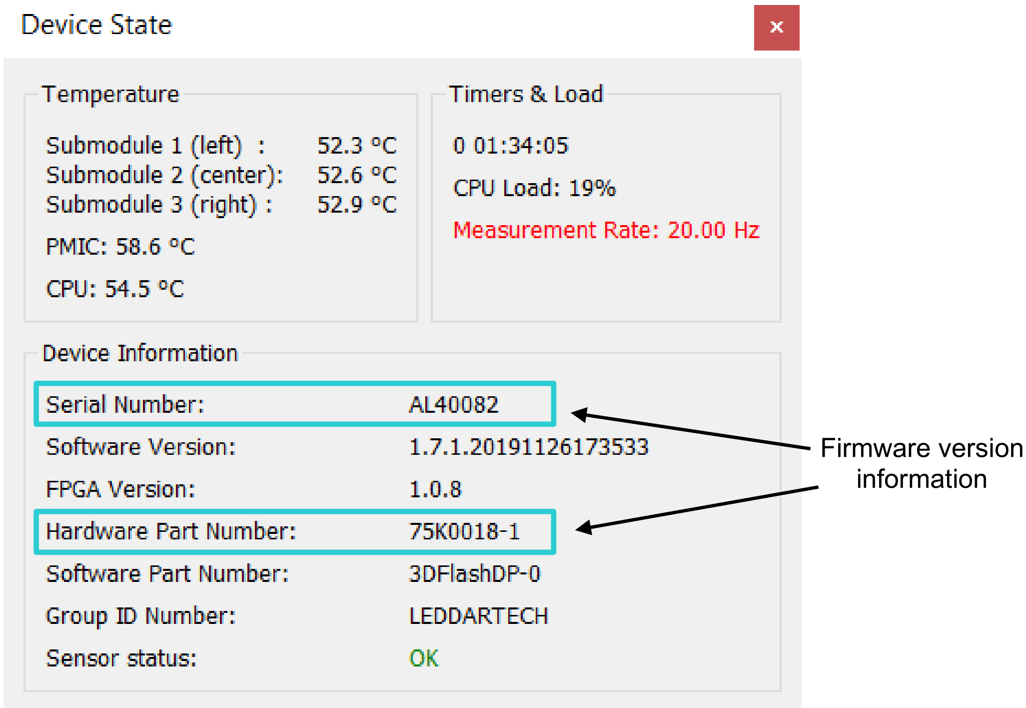


Fig. 65: Device State window

If you encounter any problem or if you have questions or concerns, contact LeddarTech support at support@leddartech.com.

10.6.3. Raw Detections

To access this function, click **View** > **Raw Detections**.

This window allows you to view detection values. It also provides filters to isolate segments and detection parameters.

An object crossing the beam of the sensor is detected and measured. This detection is qualified by its segment position, distance, and amplitude. The quantity of light reflected to the sensor by the object generates the amplitude. The bigger the reflection is, the higher the amplitude will be.

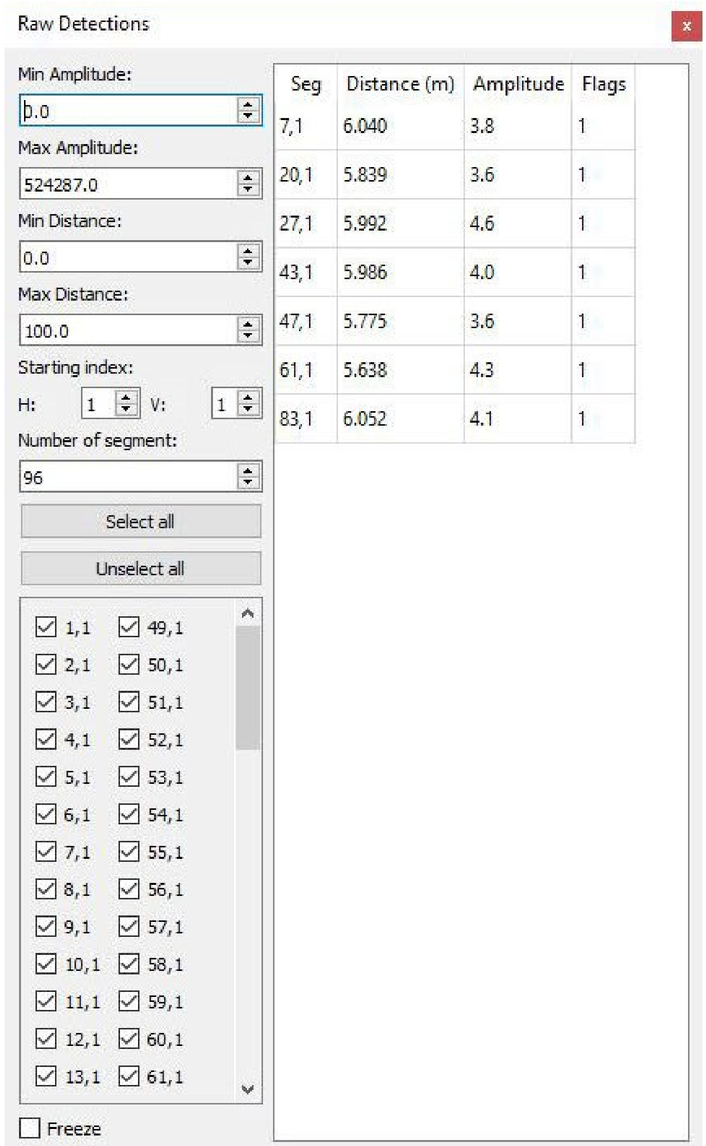
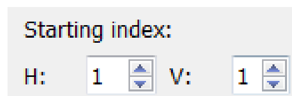
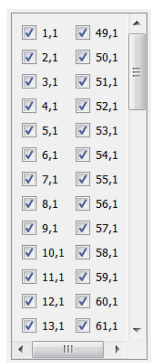


Fig. 66: Raw Detections window

Table 27: Raw Detections parameters

Parameter	Description	Range
Min Amplitude **Max Amplitude**	The value entered in the **Min Amplitude** box shows only detections of amplitude higher than or equal to that value. The value entered in the **Max Amplitude** box will show only detections of amplitude lower than or equal to that value. The maximum amplitude is 262 143 counts by default upon first use. Setting a value in both fields will result in a range of amplitude to display. The signal becomes saturated from 2047 counts to the maximum amplitude at 530 000 counts.	0 to 530 000
Min Distance **Max Distance**	Minimum and maximum distance from where to detect an object. The maximum distance is 100.0 by default.	–10 to 200
Starting Index	The vertical (V) index and horizontal (H) index correspond to a scan line index. Select a number to display that scan line. For example:  Refer to Table 7 on page 34 for more details on channel indexes.	Starting Index (V) 1 to 8 Starting Index (H) 1 to 96
Segment (Seg)	**Seg** corresponds to the segments in line and column. Select the segments that you want to display in the detection results. For example, “4,1” where 4 corresponds to a photodetector segment and 1 corresponds to a scan line. Vertical segment: 1,**X** Horizontal segment: **X**,1 	1 to 96
Freeze	Select the **Freeze** option to freeze the raw data and view the information.	N/A
Distance (m)	Position (in meters) of the detected object	Varies
Amplitude	Quantity of light reflected by the object and measured by the sensor.	0 to 1 048 576
Flags	The **Flags** parameter provides the status information that indicates the measurement type (16-bit status encoded as a bit field).	0 to 65 535

Flag Description

The following table allows you to know the status of the sensor.

Table 28: Flag value description

Bit Position	Flag ID	Description
0	Measurement status	0 = Invalid measurement 1 = Valid measurement
1	PULSE_MULTOBJ	0 = Normal measurement 1 = Measurement is the result of demerge processing (see 10.5.2 on page 73).
2	Reserved	Reserved
3	PULSE_SATURAT	0 = Normal measurement 1 = The pulse is saturated for at least 2 consecutive samples *The signal is saturated when exceeding an amplitude of 2047.* See "Saturation" in section 2.
4	Reserved	Reserved
5	Reserved	Reserved
6	PULSE_XTALK	0 = Normal measurement 1 = Measurement is the result of crosstalk ("xtalk") processing See "Crosstalk" in section 2.
7	PULSE_MODE	0 = Normal mode 1 = Mitigation mode (due to strong reflector[s] in the FoV)
8	PULSE_ORIGIN	0 = Pulse from high-range acquisition 1 = Pulse from low-range acquisition
9	Reserved	Reserved
10	PULSE_RIPPLES	0 = Normal measurement 1 = Set when parasite (electronic) ripples are detected and processed See "Parasite ripple" in section 2.
11	Reserved	Reserved
12	Reserved	Reserved
13	Reserved	Reserved
14	PULSE_RETRIEV	0 = Normal measurement 1 = Measurement is the result of a reconstructed echo from the neighboring segment
15	PULSE_INTERFERENCE	0 = Normal measurement 1 = Measurement is the result of interference processing

For example, a valid echo with saturation correction will have a flag of 9 (VALID Flag=1 + PULSE_SATURAT=8)

10.6.4. 2D Matrix Viewer and Parameters

To access this function, click **View** > **2D Matrix Viewer**.

This option allows you to view the scene in a 2D environment. A colored segment represents each detection. The 2D Matrix Viewer is configurable and can be used simultaneously as the 3D Viewer feature.

<Alt> + click a segment to obtain the following information:

- H Channel (horizontal segment)
- V Channel (vertical segment)
- Distance
- Amplitude

Click ΔΔΔ to access and configure the 2D Matrix Viewer parameters.

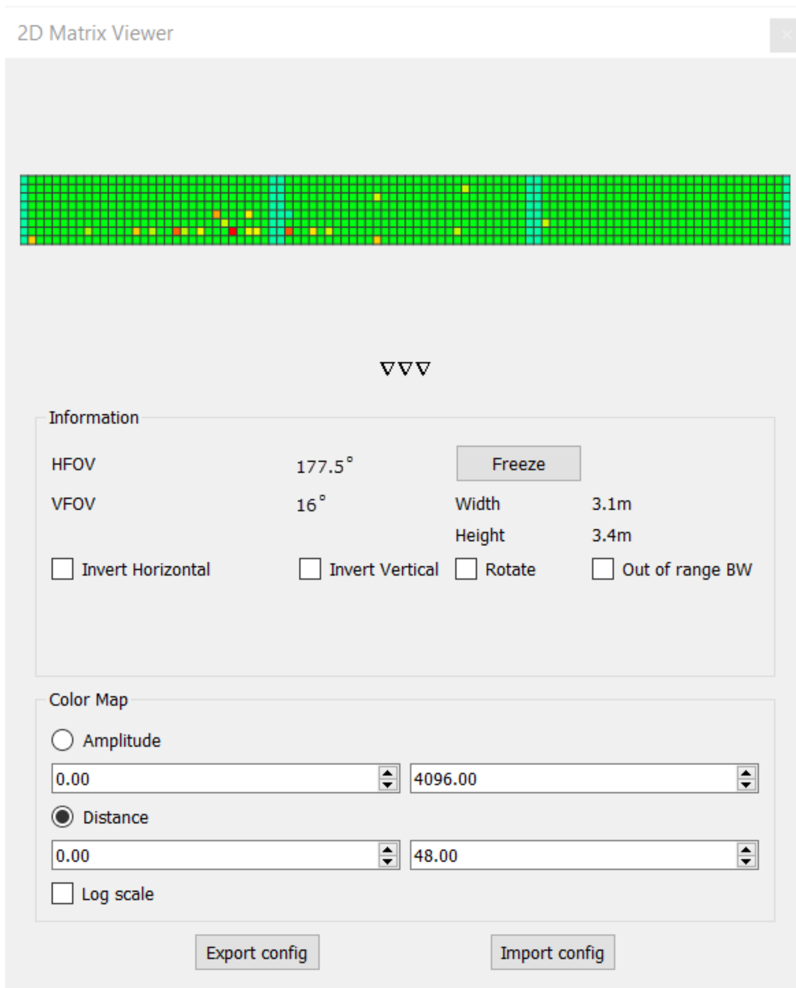


Fig. 67: 2D Matrix Viewer window and parameters

Table 29: 2D Matrix Viewer parameters

Parameter	Description	Range
HFoV	Horizontal FoV information	Varies
VFoV	Vertical FoV information	Varies
Width **Height**	Width and height of the FoV at the maximum theoretical range	Varies
Freeze	Click **Freeze** to view a static display of the scene.	N/A
Invert Horizontal **Invert Vertical**	To invert the data on a different axis, select the **Invert Horizontal** or **Invert Vertical** option.	N/A
Rotate	Select this option to rotate the image horizontally or vertically.	N/A
Out of range BW	Select this option to make all detections outside of color map settings appear in black or white.	N/A
Amplitude	Select this option to display colors on the map or grid according to amplitude. The amplitude is 4096 counts by default.	Varies
Distance	Select this option to display colors according to distance. The distance is 48.00 by default.	Varies
Log Scale	Select this option to switch from a linear scale to a logarithmic scale and conversely.	N/A
Export config	Click **Export config** to save a 2D display configuration in .lcfg format. This feature is not available with this version.	N/A
Import config	Click **Import config** to restore a 2D display configuration in .lcfg format. This feature is not available with this version.	N/A

10.7. Settings Menu

10.7.1. Preferences

To access this function, click **Settings** > **Preferences**.

This window allows you to change various settings related to window display and recording of data.

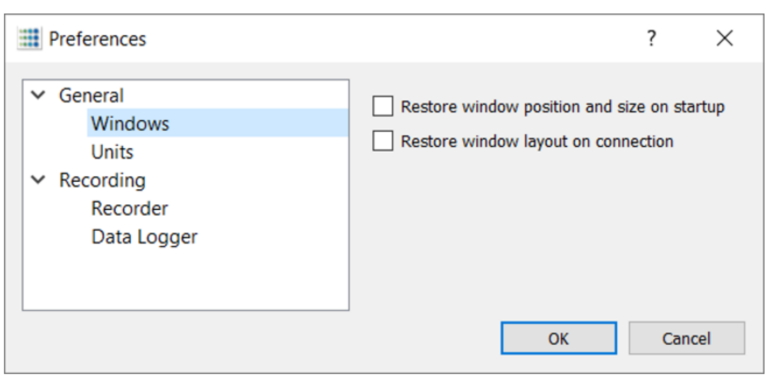


Fig. 68: Preferences window

Table 30: Preferences window options and settings

Option	Description
Windows	Select **Windows** to: • restore the window position and size upon startup • restore the window layout upon connection
Units	Select the distance unit: • Meter • Foot Select the temperature unit: • Celsius • Fahrenheit • Kelvin
Recorder	See section 10.4.1.1 on page 67 for details.
Data Logger	See section 10.4.2.1 on page 70 for details.

10.7.2. License Manager

⚠	*Do not delete or modify the content of the **License Manager** window. Contact LeddarTech support for more information.*

10.8. Help Menu

The **Help** menu includes the **User Guide** and **About** options.

10.8.1. User Guide

To access this function, click **Help** > **User Guide**.

The **User Guide** option allows you to select and consult a PDF version of a user guide directly from Leddar Configurator.

If available, select a user guide from the list to open a PDF version of the selected user guide.

10.8.2. About

To access this function, click **Help** > **About**.

The **About** option allows you to know which software version is currently used and the software part number. This information is beneficial when contacting LeddarTech Support.

11. Parts and Accessories

Part/Accessory	Part Number	Qty	Description
	PIXELL-3D-F-A2	1 x	Leddar Pixell 3D flash LiDAR

The Starter Kit socket compatibility is as follows. Refer to the table below for more parts and accessories.

- PIXELL-SK-01-US (IEC type B)
- PIXELL-SK-01-EU (IEC type E/F Hybrid)
- PIXELL-SK-01-UK (IEC type G)
- PIXELL-SK-01-CH (IEC type I)

Table 31: Starter Kit parts and accessories

Part or Accessory	Part Number	Qty	Description
Power supply[13] 	29A0014	1 x	SDI40-12-U-P5 wall plug, universal input In: 90-264 VAC Out: 12 V 3 A, 36 W, DC plug 2.1 mm x 5.5 mm x 9.5 mm, female, without power cable
Power cord[13] 	22G0001	1 x	312003-01, North American power cord, 1.8 m or 2.5 m, 10 A, IEC320-C13 plug (depending on the country)
Communication cable 	71A0047-1	1 x	External 3 m harness power and Ethernet cable with a sensor connector on one side and power connector and Ethernet/PPS wires on the other

13 Indoor use only.

Part or Accessory	Part Number	Qty	Description
Automotive Ethernet to USB converter[13] 	73A0019-1	1 x	Compact hardware interface connecting MS-Windows and Linux-based PCs with automotive Ethernet network devices and switches Windows driver: Broadway2 Windows Software Package Linux driver: Broadway2 Linux Software Package
Mounting bracket[13] 	36D0199	1 x	Installation bracket and screws (4 x M6 x 1.0 ↧ 15.00 mm) to install the sensor on a tripod
	36D0200	2 x	

For any questions or concerns, contact LeddarTech support at support@leddartech.com.

12. Troubleshooting

Problem	Required Action
Ethernet connection not available	• Verify that your computer is configured with a static IP address. • If the cabling connection seems secure, verify that the Ethernet link between the control computer and the sensor is valid using the ping command.
Sensor not detected in Leddar Configurator	• Verify the power supply of the sensor. • Disconnect from Leddar Configurator, then reconnect. • Power cycle the sensor.
No data returned	• Verify that nothing obstructs the sensor windows. • Verify if the lasers emit NIR light using a digital camera[14] or an IR laser viewing card, such as the VRC2 from Thorlabs Inc. **1.** Make sure that your sensor is powered properly. **2.** Run the camera application on your smartphone or turn on your digital camera. **3.** Center the camera's view on the laser element of the sensor. **4.** Look at your phone or camera screen and slowly move your camera around the center of the laser element to try and detect if there is either a purple beam or haze emitted from the laser, such as in Fig. 69 below.  **Fig. 69: NIR light visible by the camera**
Optical window damaged	Contact LeddarTech support.
Sensor not sending data and reporting "Safe mode" status	• A critical fault has occurred. Power cycle the sensor to reset the condition. • If the Safe mode status persists, contact LeddarTech Support.
Windows shutting down	Disable and enable the Ethernet connection in Windows.

If you still encounter any problem after reading the information above or if you have additional questions or concerns, contact LeddarTech support at support@leddartech.com.

[14] Note that some cameras (for example, iPhone cameras) have NIR filters on their main lens and will not work for this verification check.

13. Maintenance

Maintenance must be performed by a qualified maintenance technician without the need to recalibrate or dismantle the sensor from the vehicle.

⚠	*Disconnect the sensor to prevent unintended exposure to the laser beam.*

Manipulation	⚠ *Avoid touching the optical surfaces as fingerprints can permanently damage the optical coatings.*
Cleaning the windows	• Blow off dust using compressed air. • Clean the windows with a soft cloth and mild soap. ⚠ *Do not pressure wash the sensor.*

For any questions or concerns on how to safely perform maintenance operations on the Leddar Pixell, contact LeddarTech support at support@leddartech.com.

14. Disposal

14.1. Product Contents

Qty	Description
1 x	Leddar Pixell 3D flash LiDAR
1 x	Power supply
1 x	Communication cable

14.2. Product Materials

Material	Description
Plastic	Top cover, lens holder
Metal	Back of the sensor and heat sink, screws, and lens holder
Wire components	USB cable
Glass	Optical lens, receiver, and emitter windows
PCB components	Printed circuit boards inside the sensor

14.3. Disassembly Instructions

1. Remove all the screws on the back of the product.
2. Remove the top cover.
3. Remove all the screws holding the PCBs.
4. Remove the lens inside the lens holder.

Like any electronic equipment, the Leddar Pixell 3D flash LiDAR sensor contains environmentally unsustainable components. Dispose of in an environmentally responsible manner.

15. Technical Support

For technical enquiries, contact LeddarTech technical support at support@leddartech.com to easily:

- follow up on your requests
- find quick answers to questions
- get valuable updates

Also, see the contact information at the end of this document.

Please have all relevant information such as part numbers, serial numbers, and pictures to facilitate support.

Appendix A. Configuring the Windows Firewall for Leddar Configuration

1. Open the **Control Panel** window and select **Windows Defender Firewall** > **Advanced settings**.

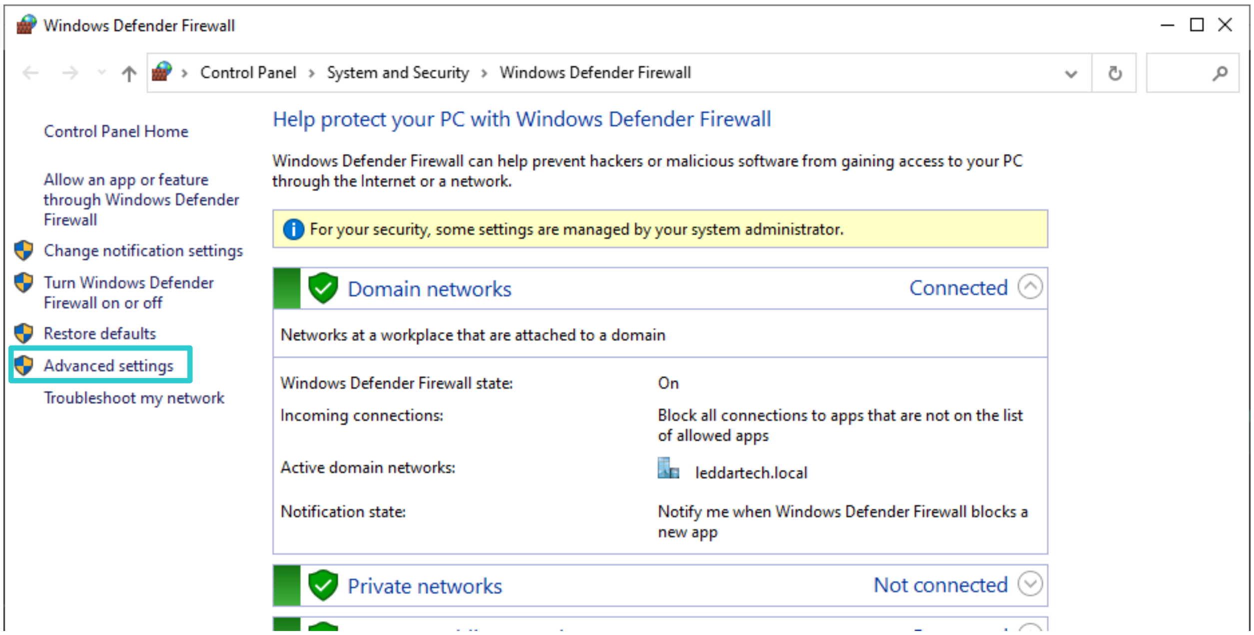


Fig. 70: Windows Defender Firewall window

2. Select **Inbound Rules**, then double-click the **LeddarHost Application** line that blocks the UDP protocol.

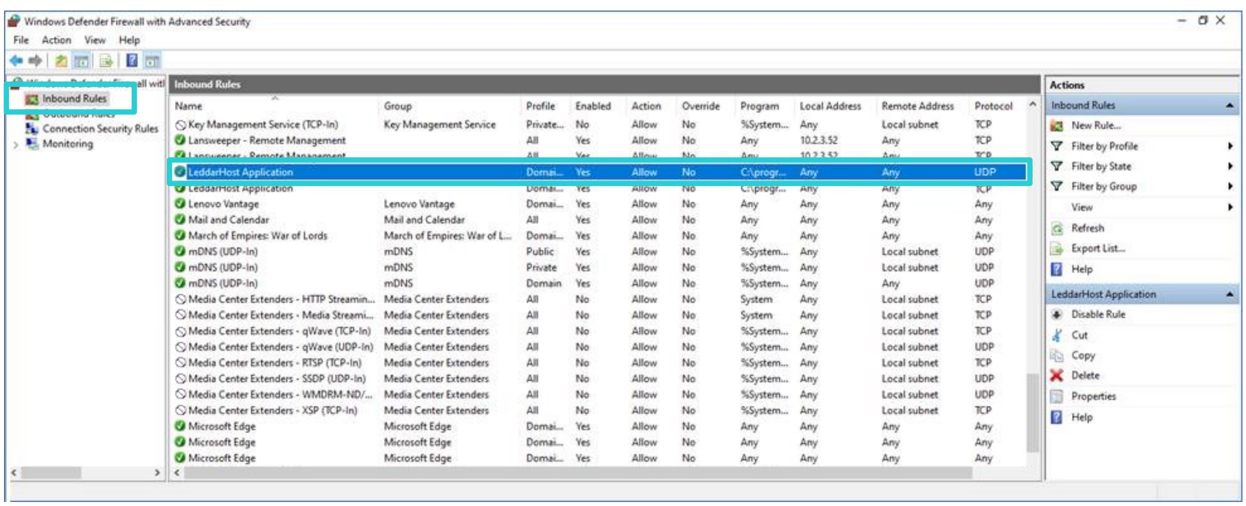


Fig. 71: Inbound Rules window

3. In the **Action** section, select **Allow the connection** option, then click **OK** to confirm.

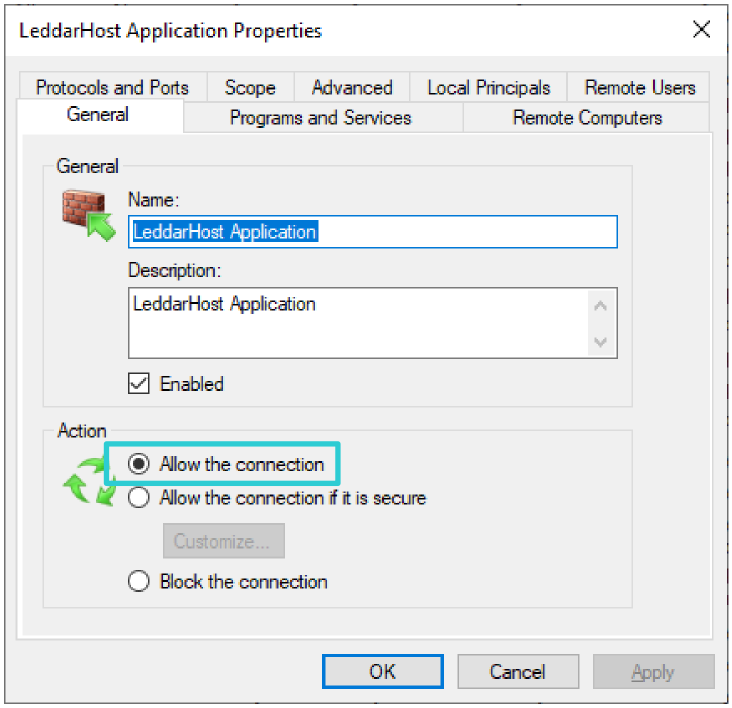


Fig. 72: LeddarHost Application Properties window

Appendix B. Static IP Configuration With Windows 7 and Up

Configuring the Network Static IP

⚠	*You will be disconnected from the Internet if you are not connected via other means.*

1. In **Control Panel** > **Network and Internet** > **Network and Sharing Center**, select **Change adapter settings**.

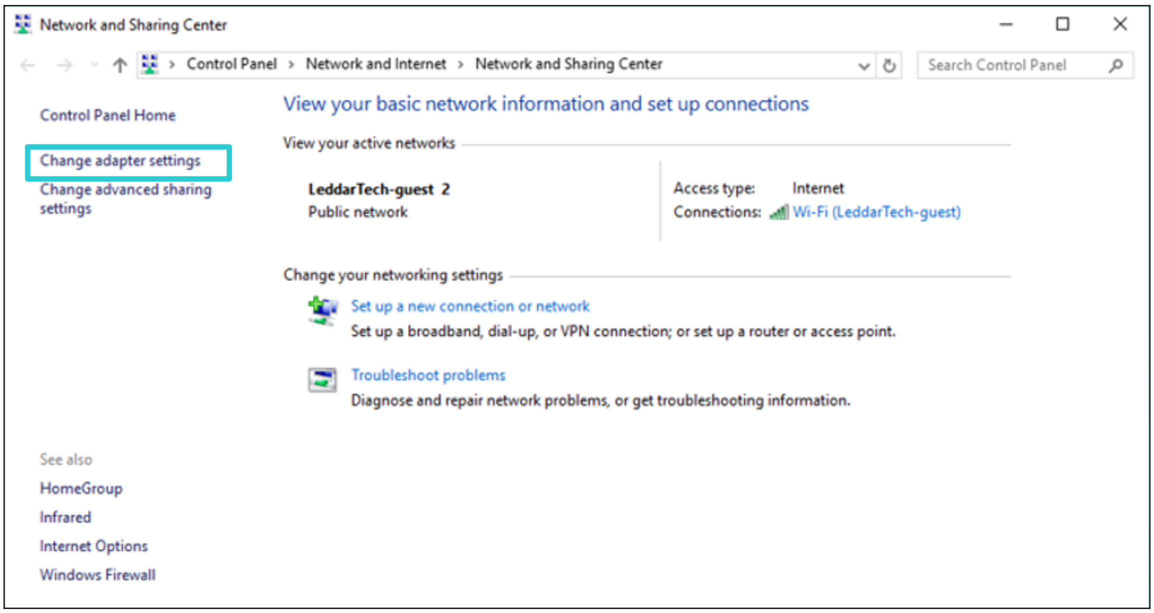


Fig. 73: Change adapter settings

2. In the **Network Connections** window, double-click **Ethernet**.

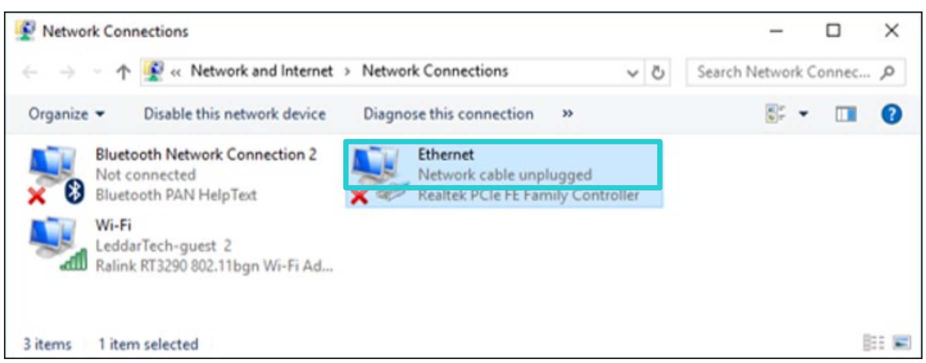


Fig. 74: Ethernet network option

3. In the **Ethernet Properties** window, select **Internet Protocol Version 4 (TCP/IPv4)**, then click **Properties**.

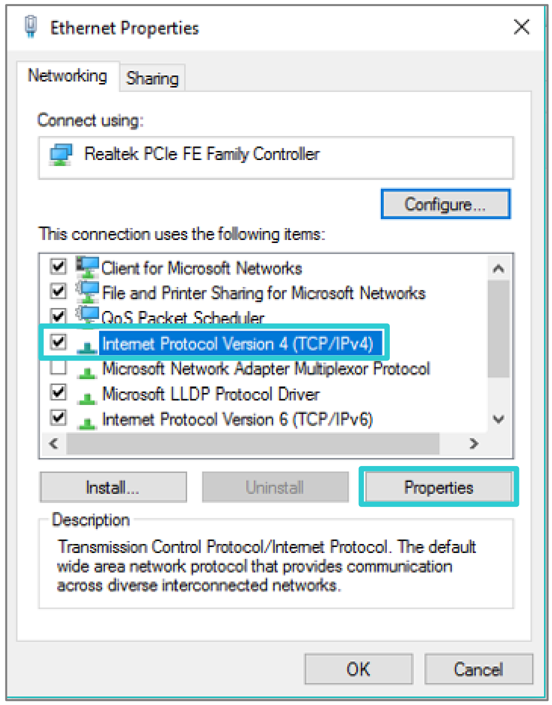


Fig. 75: Ethernet Properties window

4. Select **Use the following IP address:** and enter an IP address different from the sensor (for example, **192.168.000.100**) in the **IP address:** field.
5. Enter the same subnet mask as the sensor (**255.255.255.0** by default) in the **Subnet mask:** field.

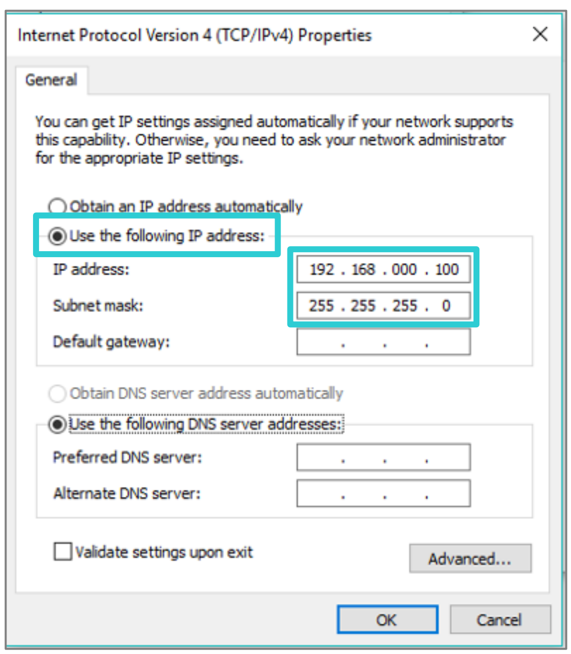
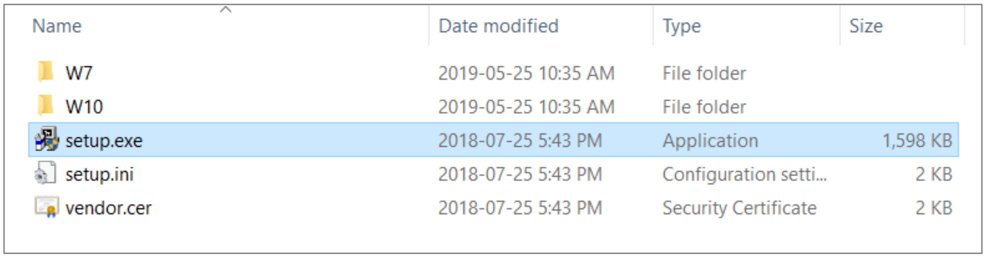


Fig. 76: IP address and Subnet mask fields

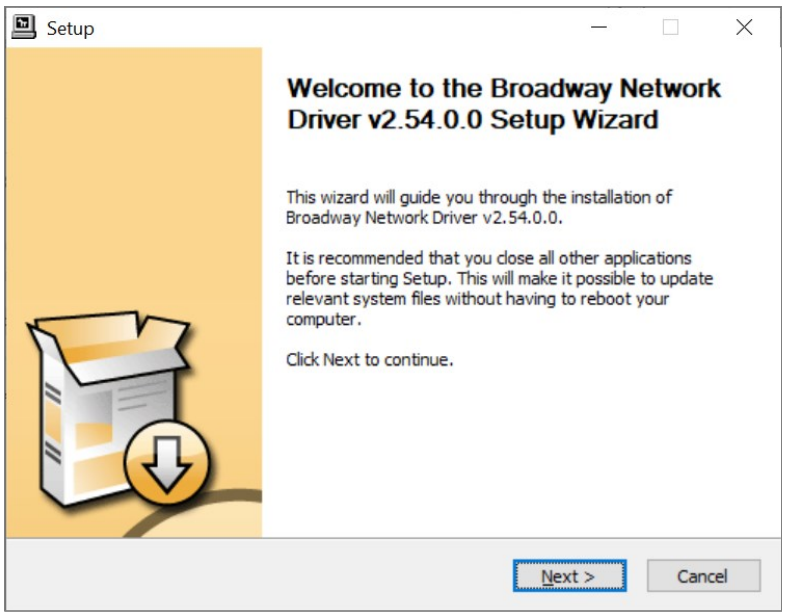
Appendix C. FibreCode Driver Installation Procedure

Install the Broadway Network Driver provided by LeddarTech.

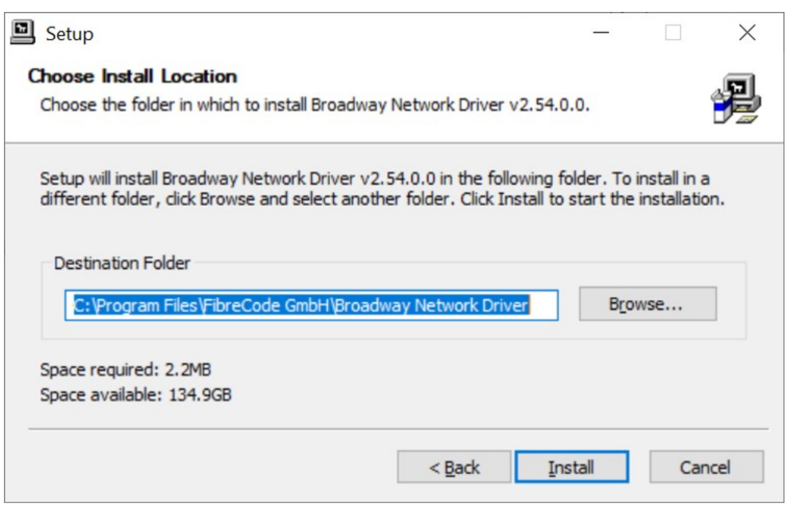


Once the Wizard is open, follow the steps below to perform the installation.

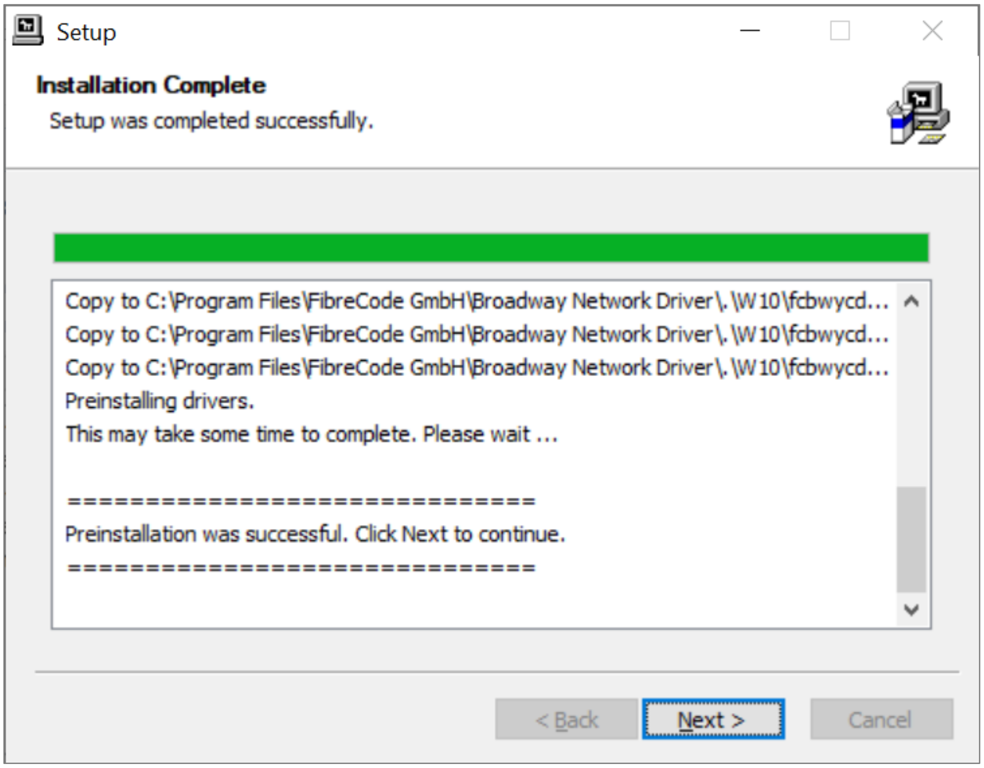
1. Click **Next**.



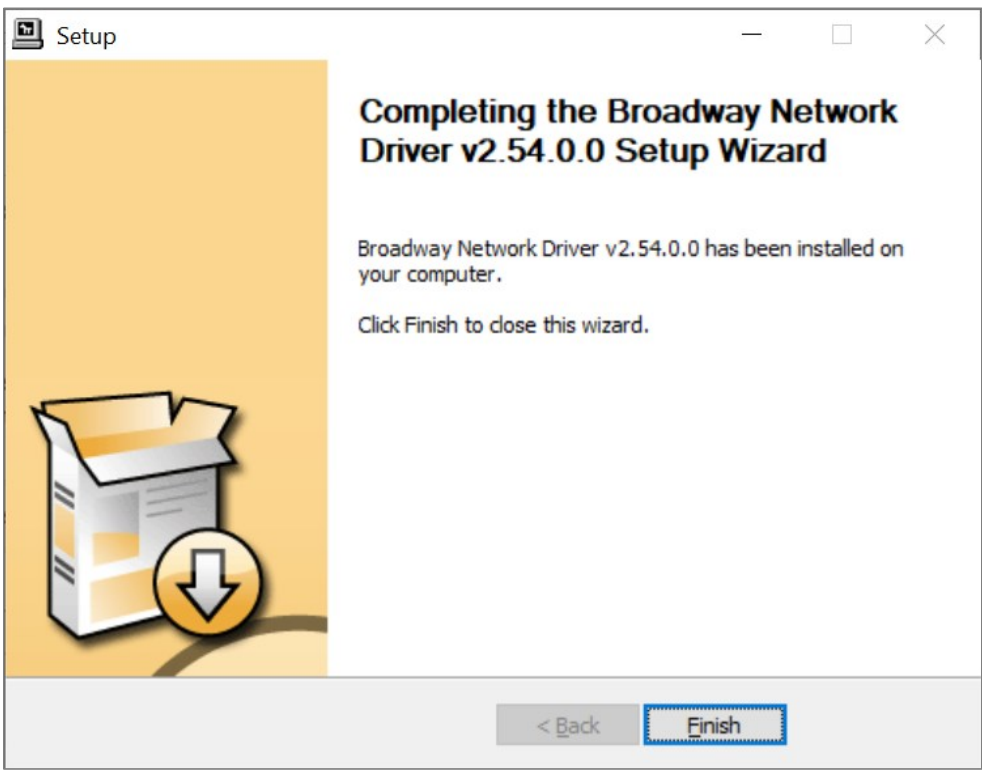
2. Select the destination folder and click **Install**.



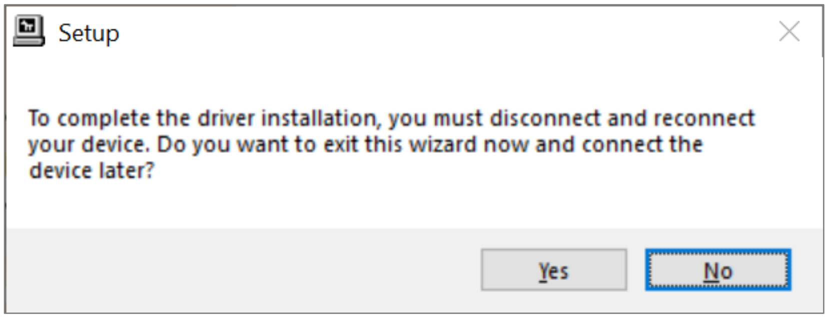
3. Once the installation of FibreCode is completed, click **Next**.



4. Click **Finish**.

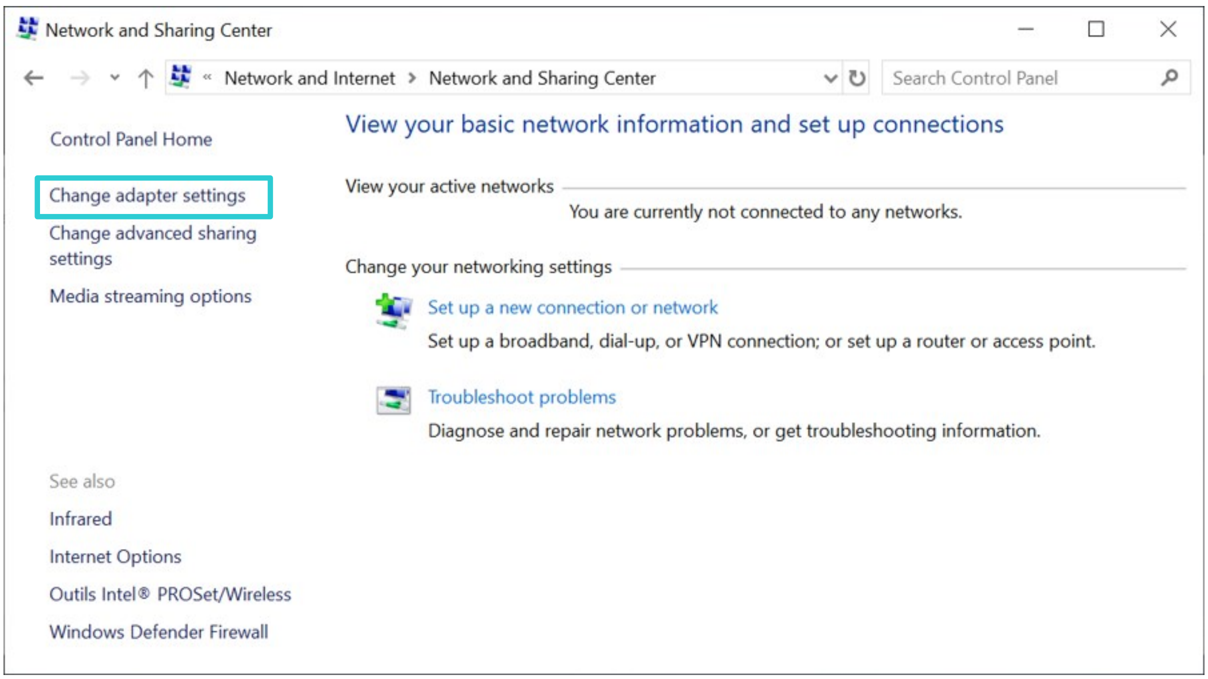


5. After the driver has been installed, click **Yes** to connect the device later.

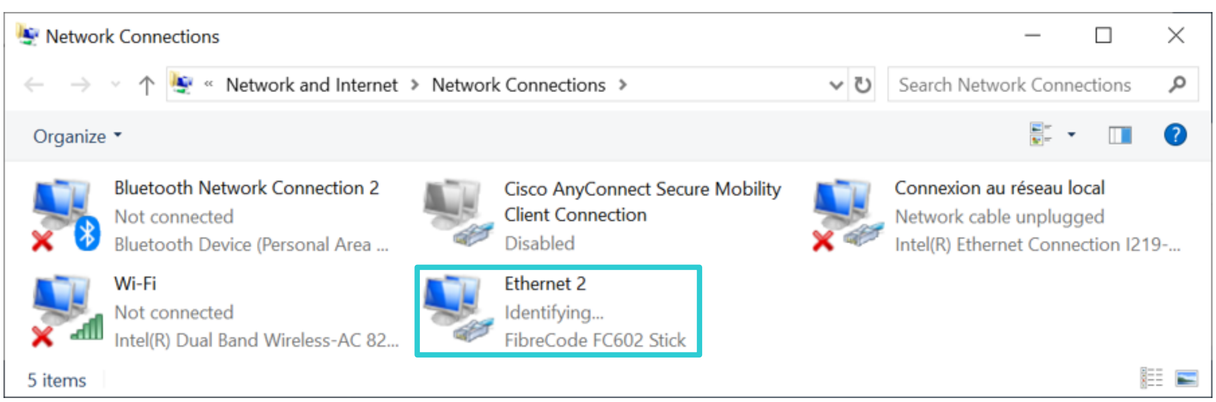


Verify that the driver is installed.

6. Open the **Control Panel** window and select **Network and Internet** > **Network and Sharing Center**, then **Change adapter settings**.

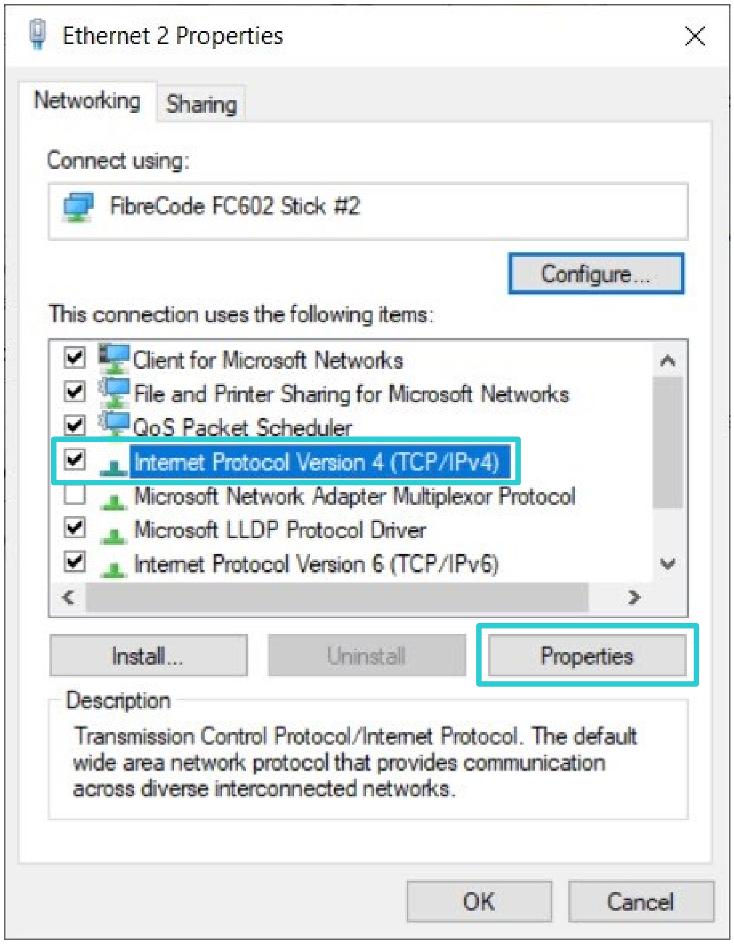


7. In the **Network Connections** windows, **FibreCode FC602 Stick** must be visible, as shown below.

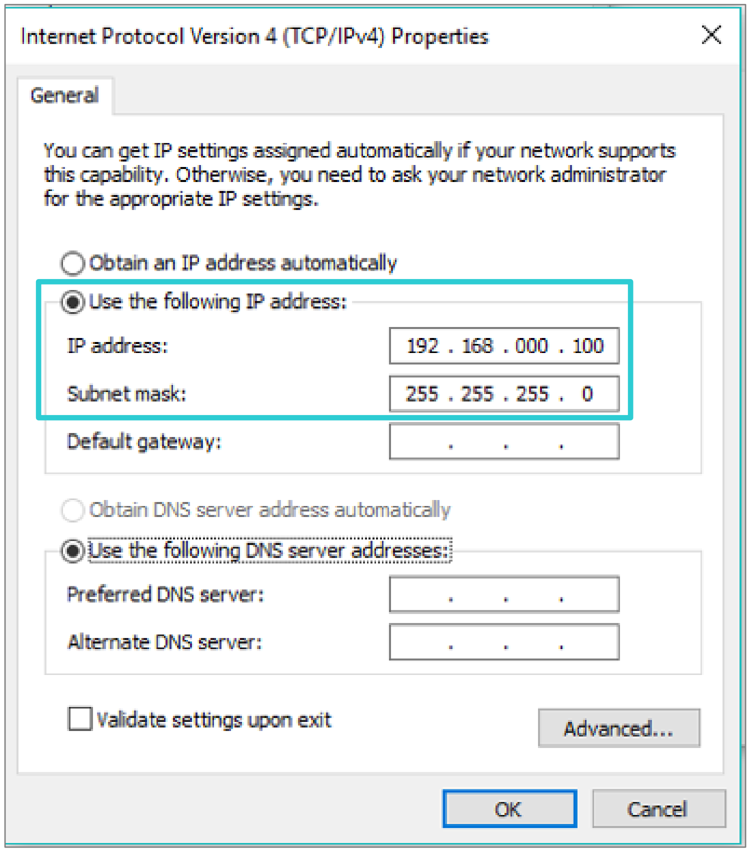


If you do not see the FibreCode driver's connection, right-click a connection and select ***Properties*** *as explained below.*

1. Select **Internet Protocol Version 4 (TCP/IPv4)** and click **Properties**.

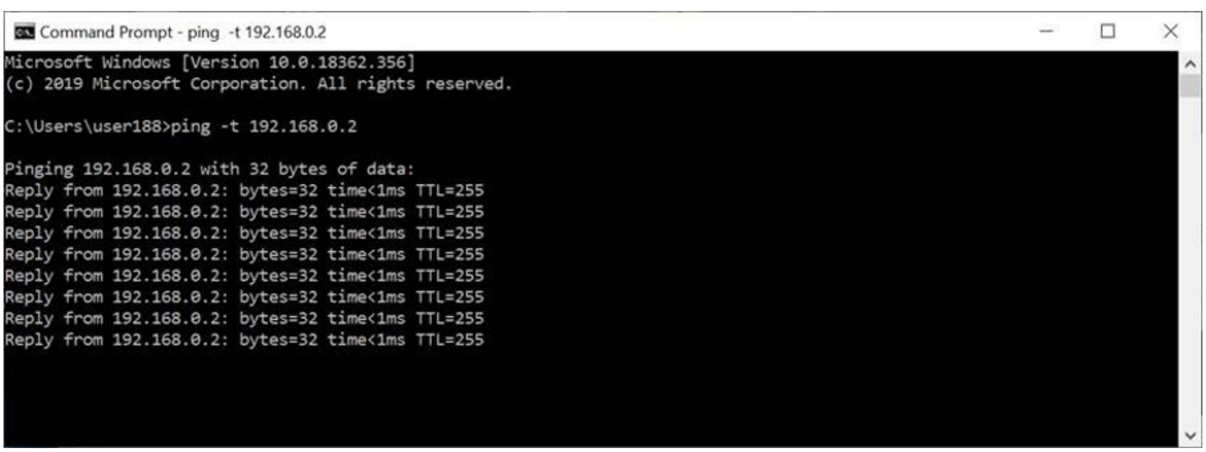


2. Select **Use the following IP address:** and enter an IP address different from the sensor (for example, **192.168.000.100**) in the **IP address:** field.
3. Enter the same subnet mask as the sensor (**255.255.255.0** by default) in the **Subnet mask:** field.



4. Click **OK**.

Verify if the connection is working by using the Command Prompt (cmd):



If the ping command does not work:

a. Disconnect and reconnect the FibreCode USB stick, or

b. Reboot Windows.

Appendix D. Communication Protocol

Introduction

This section presents the Leddar™ Ipv4 communication protocol used with the Leddar Pixell 3D flash LiDAR sensor. The protocol defines a set of communication rules that provide flexibility to support several product-specific applications.

This protocol also offers a set of generic communication requests that may be implemented partially or entirely depending on the product application and available hardware.

Architecture

The Leddar Pixell sensor uses the IPv4 protocol. Its IP address can be set automatically using a DHCP or static mode. It is divided between the three servers: identification, configuration, and data server requests.

	All ports are currently permanent and cannot be changed.

Protocol Concepts

Two major protocol concepts are used by the different servers. Both concepts involve a host and a sensor (which is independent of the client or server side). All data transmitted over the Ipv4 communication protocol is in little-endian (Intel) byte order.

Definitions

This section provides some common definitions used in those concepts (structures, constants, etc.).

Request Header Structure

All commands and data sent by the host minimally consist of a request header and may be followed by data (specific to the request).

Table 32: Request header definition

Item	Size (bytes)	Description
Server protocol version	2	Protocol version specific to each server (identification, configuration, data)
Request code	2	Used to uniquely identify the request type. Codes may be reused for different server links. Note that request code 0 is invalid.
Request size	4	Size of the complete request: header plus data.
Total	8	N/A

	The protocol version number is specific to each server, which means that protocol version 1 for a given server is not necessarily equivalent to protocol version 1 for another server.

Answer Header Structure

Some servers specify that the sensor must respond to requests with an answer. In these cases, the answer minimally consists of an answer header and may be followed by data (specific to the request).

Table 33: Answer header definition

Item	Size (bytes)	Description
Protocol version	2	Protocol version specific to each server (identification, configuration, data)
Answer code	2	Answer code used to provide feedback on the request execution
Answer size	4	Size of the complete request: header plus data
Request code	2	Code of the request the answer applies to
Reserved bytes	6	Reserved for alignment. Must be set at 0.
Total	16	N/A

Table 34: Answer codes

Error Code Name	Value	Description
OK	0x0000	Request properly handled
ERROR	0x0001	General error
FLASH_ERROR	0x0002	Error related to flash memory read or write
HARDWARE_ERROR	0x0003	Error caused by abnormal hardware operation
INVALID_DATA	0x0004	The request contained invalid data.
INVALID_REQUEST	0x0005	The request is invalid (not defined/supported).
PROTOCOL_ERROR	0x0006	Error in the protocol (invalid header or packet structure)
UNSUPPORTED_PROTOCOL	0x0007	Unsupported protocol version (as specified in the request header)
LIMITED_MODE	0x0008	The device is in a limited mode of operation and cannot service this request.
OUTPUT_SIZE_TOO_LONG	0x0009	The constructed response is larger than the maximum supported packet size.
MISSING_ELEMENT	0x000A	The request is missing a required element.
Device-specific	≥0x0100	Application-specific codes

Element Header Structure

Some protocol concepts described later make use of elements for transmitting data. Each element has a header, optionally followed by data.

Table 35: Element header definition

Item	Size (bytes)	Description
Element code	2	Unique element identifier
Element count	2	If the element data is an array, this is the length of the array.
Element size	4	Size of the element data. If the element data is an array, this is the size of a single element data entry. The full element data size is “element count” x “element size.” In all cases, the element size excludes the element header.
Total	8	N/A

Protocol Concept A – Structure-Based

A first protocol concept used by some server protocol versions is described as follows:

Host		→	Sensor	
Request header (8 bytes)	Request data		Answer header (16 bytes)	Answer data

On the Leddar Pixell, only the identification server uses this protocol concept for reasons of backward compatibility of the sensor discovery system.

In this protocol concept, the request and answer data are data structures associated with the request code. If the data structure needs to be changed over time, a new request code will be assigned. Another way of supporting new data structures is to rely on the data size specified in the request header. As long as new structures have different sizes, the right structure definition can be loaded.

A major issue with this protocol version is the difficulty to update the data format associated with a given request code. Because of this, protocol concept B is used for the configuration and data servers.

Protocol Concept B – Element Based

This second protocol concept is now preferred in newer products because of its flexibility. It is described as follows:

Host					
Request header (8 bytes)	Element 1 header (8 bytes)	Element 1 data	Element 2 header (8 bytes)	Element 2 data	(…)

↓

Sensor					
Answer header (16 bytes)	Element 1 header (8 bytes)	Element 1 data	Element 2 header (8 bytes)	Element 2 data	(…)

Both the request and answer headers have the same format as in concept A, which prevents compatibility breaks if a given server updates its protocol from concept A to concept B.

In this concept, instead of having only one set of data accompanying a given request, it is possible to have several chunks of data, called “elements.” Each element has a header that identifies the element and its accompanying data size. The element data is optional.

Here are general rules for this protocol concept:

1. There can be any number of elements following a request or answer header.
2. Usually, elements can be placed in any order in a request or answer. Therefore, if a given request needs three elements for correct execution, the sensor should never assume a given order for them, as the order could change from one firmware version to another one. If a specific order is required, it is specifically mentioned in the request’s description.
3. The elements code is unique and usually has an associated data format that will never change over time. For example, if a given element is defined as being encoded on 2 bytes, it will not change over time. If it later needs to be increased to 4 bytes, a new code will usually be created instead.
4. When the sensor receives an unsupported element with a request, it should ignore that element without throwing any error. This is an essential rule for allowing backward compatibility over time.

   For example, let’s assume a firmware version 1 that supports a given request requiring a given element specified to be on 2 bytes for correct execution. Now, let’s assume a newer firmware version 2 supports that same request but needs the element to be on 4 bytes instead of 2 bytes. In this case, a new element code would be created for that new element.

   Noteworthy here is that to support all firmware versions, the host would simply have to send the request with both elements present. In this case, the older firmware version would simply ignore the unsupported element, which is on 4 bytes, while the newer firmware version would ignore the unsupported element code that is on 2 bytes.
5. Following the rule above, it is very important for the host or sensor to always accept all elements data loads (specified by the headers) even if it does not support any element for a given request in order to prevent communication protocol errors.

Supported Server Protocols

The Ipv4 communication protocol is based on the client-server model. For all communications with a Leddar™ device, the device is the server. The client is typically a program running on a computer or processing board used for the device configuration, control, and monitoring of the Leddar device.

Currently, the Ipv4 communication protocol defines three different kinds of client-server links that fulfill three separate purposes:

- Identification
- Configuration (also for control and status monitoring)
- Real-time data transfer

Each client-server link is assigned a separate port. Note that TCP and UDP communication may be held simultaneously on the same port and separate client-server links. The packets are directed to the program according to the packet type (TCP or UDP).

The identification server is connectionless (UDP), the configuration server is connection-oriented (TCP), while the real-time data transfer (data server) can be of either type (see section 10.5.3 on page 73).

Identification Server

The identification server’s purpose is to allow a client to broadcast requests to all sensors on the network. This is useful when the client wants to list all sensors present on a given network.

The identification server on the sensor side is constantly “listening” for identification requests from clients and answers those requests when they are received.

Identification Server Protocol – Version 1 (0x0001)

There is currently only one protocol version defined in Ipv4 for the identification server. For this version, protocol concept A described in “Configuration Server Requests” on page 105 applies with the following characteristics:

1. This server uses a UDP socket.
2. The sensor’s listening port is 48620.
3. Unless otherwise specified for a given request, an answer is required.

See “Identification Server Requests” on page 105 for a list of generic requests that may be implemented.

Configuration Server

The configuration server supports one (1) connection at a time. Once connected, it listens for requests and answers them when processed.

Once connected to the configuration server, the client may send requests and wait for the answer before sending a new request. The configuration server cannot execute several requests in parallel.

Also, the configuration server connection must be kept alive by the client by sending at least one request within 60 seconds after its last request. Typically, when the client has no special request to send, a CFG_REQUEST_ECHO or CFG_REQUEST_UPDATE request is sent for keeping the connection alive.

Any protocol error will make the configuration server terminate the connection and listen for a new connection.

Configuration Server Protocol – Version 2 (0x0002)

This configuration server protocol is based on the protocol concept B described in “Data Server Requests” on page 105 with the following characteristics:

1. This server uses a TCP connection type.
2. The connection port is 48630 (by default).
3. Unless otherwise specified for a given request, an answer is required.

See “Configuration Server Requests” on page 105 for a list of generic requests supported by the Leddar Pixell. See “Communication Examples” for configuration modification examples.

TCP Data Server

The data server also supports one connection at a time and is used for real-time data transfer from the device to the client.

Typically, the data to be sent to the client must be configured through a request to the configuration server (CFG_REQUEST_SET / ELEM_DATA_LEVEL).

Data Server Protocol Version 3 (0x0003)

This data server protocol is based on the protocol concept B described in “Data Server Requests” on page 105 with the following characteristics:

1. This server uses a TCP connection type.
2. The connection port is provided by the configuration server.

3. The host sends requests (LT_COMM_DATASRV_REQUEST_SEND_ECHOES and LT_COMM_DATASRV_REQUEST_SEND_STATES).
4. The sensor answers with the corresponding data. See Table 44 and Table 45.

As previously mentioned, the packets transmitted by the data server will consist of a request header followed by a group of element headers and data. The request code identifies the type of data that is included in the packet.

See “Data Server Requests” on page 105 for a list of generic requests that may be implemented. See “Communication Examples” for configuration modification examples.

UDP Data Server

The data server supports one client at a time and is used for real-time data transfer from the device to the client.

Typically, the data to be sent to the client must be configured through a request to the configuration server (CFG_REQUEST_SET / ELEM_DATA_LEVEL).

UDP Data Server Protocol Version 3 (0x0003)

This data server protocol is based on the protocol concept B described in “Data Server Requests” on page 105 with the following characteristics:

1. This server uses a UDP socket.
2. The host’s listening port is provided by the configuration server.
3. The sensor sends the corresponding data as soon as it is available.
4. The format of the sent data is identical to a TCP data server answer (see Table 44 and Table 45).
5. The sensor stops sending when the connection with the configuration server is terminated.

Identification Server Requests

The following table defines generic requests that are available on a Leddar Pixell.

For descriptions of constants and structures, see "Constant, Structure, and Data Type Definitions."

⚠	***For all requests listed below, only relevant request and answer elements are provided. Depending on the actual product firmware version, there might be additional elements sent by the product. These additional elements should simply be ignored as they are present either for backward compatibility purposes or reserved for LeddarTech's internal use.***

Table 36: Identification server requests

Short Name	Request Code	Description	Request Data	Answer
IDT_REQUEST_IDENTIFY	0x0011	This request allows the identification of all devices present on the network. All devices supporting this request and listening on the network will answer with a structure including identification information.	N/A	struct IdtAnswerIdentifyLCAuto See Table 37.

Configuration Server Requests

The following table defines generic requests that are available on a Leddar Pixell.

For descriptions of constants and structures, see "Constant, Structure, and Data Type Definitions."

⚠	***Only relevant requests and elements are provided below. Depending on the actual product firmware version, there might be additional available requests or elements. For example, the CFG_REQUEST_GET_CONFIG request might return several additional elements not documented below. These additional requests or elements should simply be ignored as they are present either for backward compatibility purposes or reserved for LeddarTech's internal use. You should never attempt to send undocumented requests or elements to the device. Trying to do so may cause unpredictable device behavior or even permanent failure.***

Table 37: Configuration server requests

Short Name	Request Code	Description	Request Element	Answer Element
CFG_REQUEST_GET	0x0002	This is a generic request for retrieving various data from the device. The server will return all elements data requested in ELEM_LIST.	ELEM_LIST = 0x0070	See Table 46 and Table 47.
CFG_REQUEST_SET	0x0003	This is a generic request for setting various data in the device. The server will set a value for all elements provided with the request. Any value set through this request is usually lost on a device reset, with the exceptions below.	ELEM_DATA_LEVEL=0x106E	See Table 46.
CFG_REQUEST_ECHO	0x0006	This is an empty request. It is used to keep alive the connection with the configuration server.	N/A	N/A
CFG_REQUEST_UPDATE	0x0008	This request returns the device status. It can be used instead of CFG_REQUEST_ECHO to keep the connection alive.	N/A	See Table 43.
CFG_REQUEST_GET_DEVICE_INFO	0x7000	This request returns all device information data kept in non-volatile memory.	N/A	See Table 47.
CFG_REQUEST_GET_CALIB	0x7002	This request returns the channel, azimuth, and elevation angles for calibration.	LT_COMM_ID_AUTO_CHANNEL_ANGLES_AZIMUT=0x2580 LT_COMM_ID_AUTO_CHANNEL_ANGLES_ELEVATION=0x2581	See Table 48.
CFG_REQUEST_GET_CONFIG	0x7006	This request returns the shadow copy of all configuration data kept in non-volatile memory.	N/A	See Table 46.

Short Name	Request Code	Description	Request Element	Answer Element
CFG_REQUEST_SET_CON FIG	0x7007	This request sets the shadow copy of some or all configuration data kept in non-volatile memory. New data is not written to non-volatile memory until CFG_REQUEST_ WRITE_CONFIG is requested. Most of the configuration data enter into force as soon as their values are set in the shadow copy, with the exceptions below. Elements that configure the network parameters (ELEM_IP_MODE, ELEM_IP_ ADDRESS, ELEM_IP_GATEWAY, and ELEM_IP_NETMASK) do not enter into force at this time.	Same as answer elements of CFG_REQUEST_GET_CONFIG. Not all elements have to be present; only those that need to be modified must be present.	N/A
CFG_REQUEST_WRITE_C ONFIG	0x7008	This request writes configuration data currently stored in the shadow copy to non-volatile memory.	N/A	N/A
CFG_REQUEST_RESTORE _CONFIG	0x7009	This request restores the shadow copy with configuration data currently stored in non-volatile memory.	N/A	N/A
CFG_REQUEST_RESET_C ONFIG	0x7011	This request forces all device configuration data to be reset to their default factory values in the shadow copy and the non-volatile memory.	N/A	N/A

Data Server Requests

The following table defines generic requests that are available on a Leddar Pixell.

For descriptions of constants and structures, see “Constant, Structure, and Data Type Definitions.”

⚠	***For all requests listed below, only relevant request and answer elements are provided. Depending on the actual product firmware version, there might be additional elements sent by the product. These additional elements should simply be ignored as they are present either for backward compatibility purposes or reserved for LeddarTech’s internal use.***

Table 38: Data server requests

Short Name	Request Code	Description	Request Element	Answer Element
DATA_REQUEST_SEND_ECHOES	0x0020	This request asks for the last detection echoes.	N/A	See Table 44. LT_COMM_ID_FRAME_ID LT_COMM_ID_TIMESTAMP LT_COMM_ID_AUTO_TIMESTAMP64 LT_COMM_ID_AUTO_NUMBER_DATA_SENT LT_COMM_ID_AUTO_ECHOES_AMPLITUDE LT_COMM_ID_AUTO_ECHOES_DISTANCE LT_COMM_ID_AUTO_ECHOES_CHANNEL_INDEX LT_COMM_ID_AUTO_ECHOES_VALID LT_COMM_ID_STATUS
DATA_REQUEST_SEND_STATES	0x0002	This request asks for the last states.	N/A	See Table 45. LT_COMM_ID_TIMESTAMP LT_COMM_ID_SYS_TEMP LT_COMM_ID_CPU_LOAD_V2

Constant, Structure, and Data Type Definitions

This section provides element, constant, structure, and data type definitions referenced in this document.

Constants

Table 39: Constant definitions

Constant Name	Value
LT_COMM_DEVICE_NAME_LENGTH	64
LT_COMM_PART_NUMBER_LENGTH	16
LT_COMM_SERIAL_NUMBER_LENGTH	32
LT_COMM_FIRMWARE_VERSION_LENGTH	32
LT_COMM_ALERT_MSG_LENGTH	32

Structures

Table 40: struct IdtAnswerIdentifyLCAuto

Field Name	Data Type	Description
mHeader	LtComLeddarTechPublic::sLtCommAnswerHeader	Structure header - 16 bytes
mMacAddress	struct MacAddress. See Table 42.	See Table 42.
mDeviceType	uint16_t	Device type
mPartNumber[LT_COMM_PART_NUMBER_LENGTH]	char[16]	Hardware part number
mSoftPartNumber[LT_COMM_PART_NUMBER_LENGTH]	char[16]	Software part number
mSerialNumber[LT_COMM_SERIAL_NUMBER_LENGTH]	char[32]	Serial number
mFirmwareVersion[LT_COMM_FIRMWARE_VERSION_LENGTH]	char[32]	Firmware version
mDeviceName[LT_COMM_DEVICE_NAME_LENGTH]	char[64]	Device name – UTF-8 encoded
mSensorState	uint32_t	Sensor state
mDataPort	uint16_t	Port number to reach to get Leddar data

Table 41: struct IpAddress

Field Name	Data Type	Description
ADDRESS	uint8_t[4]	IP address
RESERVED	uint8_t[4]	Reserved

Table 42: struct MacAddress

Field Name	Data Type	Description
ADDRESS	uint8_t[6]	MAC address
RESERVED	uint8_t[4]	Reserved

Table 43: struct sLtCommElementAlert

Field Name	Data Type	Description
CODE	uint64_t	Alert code
TIMESTAMP	uint64_t	Alert timestamp in seconds since 00:00:00 UTC on January 1, 1970
MESSAGE	char[LT_COMM_ALERT_MSG_LENGTH]	Alert default message
CUSTOM_MESSAGE	char[LT_COMM_ALERT_MSG_LENGTH]	Alert custom message
UID	uint8_t	Alert unique ID
PADDING	uint8_t[15]	Reserved

Elements

The following tables define elements referenced in this document. If the element is an array (element count different from 1), the element data type column provides the data type of a single entry in the array. See section 2 on page 17 for more details.

Table 44: Detection structure (sends echoes)

Element Name	Element Code	Element Data Type	Description
LT_COMM_ID_FRAME_ID	0x1092	uint64_t	Unique identifier number for the current detections
LT_COMM_ID_TIMESTAMP	0x1050	uint32_t	Elapsed time in milliseconds (ms) since unit power-up when the detections occurred
LT_COMM_ID_AUTO_TIMESTAMP64	0x2721	uint64_t	Elapsed time in µs since UNIX Epoch time (00:00:00 on January 1, 1970) when the detections occurred.
LT_COMM_ID_AUTO_NUMBER_DATA_SENT	0x2501	uint32_t[2]	Index of the first detection sent and the number of detections sent by the data server. The first channel index is number 99.
LT_COMM_ID_AUTO_ECHOES_DISTANCE	0x2703	uint32_t	Echo distance
LT_COMM_ID_AUTO_ECHOES_CHANNEL_INDEX	0x2700	uint16_t	Index of the echo channel for 3D sensors
LT_COMM_ID_AUTO_ECHOES_AMPLITUDE	0x2702	uint32_t	Echo amplitude
LT_COMM_ID_AUTO_ECHOES_VALID	0x2701	uint16_t	Bit field with various information
LT_COMM_ID_AUTO_ECHOES_TIMESTAMP_UTC	0x2704	uint64_t	Elapsed time in µs since UNIX Epoch time (00:00:00 on January 1, 1970) when each waveform occurred
LT_COMM_ID_STATUS	0x0004	uint8_t	Status of the ongoing command

Table 45: State structure (sends states)

Element Name	Element Code	Element Data Type	Description
LT_COMM_ID_TIMESTAMP	0x1050	uint_32	Timestamp of related data in ms
LT_COMM_ID_CPU_LOAD_V2	0x104A	float	CPU load in percentage
LT_COMM_ID_SYS_TEMP	0x1011	LtFixedPoint	System (laser) temperature in temperature scale (divide value by temperature scale). A raw value of 0x7FFFFFFF means that there is no available temperature.
LT_COMM_ID_CPU_TEMP	0x1012	LtFixedPoint	CPU temperature in temperature scale (divide value by temperature scale). A raw value of 0x7FFFFFFF means that there is no available temperature.
LT_COMM_ID_AUTO_PMIC_TEMP	0x2720	LtFixedPoint	PMIC temperature in temperature scale (divide value by temperature scale). A raw value of 0x7FFFFFFF means that there is no available temperature.

Table 46: Configuration elements

Element Name	Element Code	Element Data Type	Description
LT_COMM_ID_DEVICE_NAME	0x22	char	The device name is defined as byte.
LT_COMM_ID_IPV4_IP_ADDRESS	0xF01	struct IpAddress	Ethernet address (IPv4)
LT_COMM_ID_AUTO_SYSTEM_TIME	0x116B	uint8_t	Set system time. 64-bit integer representing microseconds since Epoch UTC
LT_COMM_ID_AUTO_TIME_SYNC_METHOD	0x116C	uint8_t	Time synchronization method to be used: 0 = none, 1 = PTP, 2 = PPS

Table 47: Constant elements

Element Name	Element Code	Element Data Type	Description
LT_COMM_ID_HW_PART_NUMBER	0xF03	char [LT_COMM_PART_NUMBER_LENGTH]	Hardware part number
LT_COMM_ID_SERIAL_NUMBER	0xF00	char [LT_COMM_SERIAL_NUMBER_LENGTH]	Device serial number
LT_COMM_ID_IPV4_ETHERNET_ADDRESS	0x610038	struct MacAddress	MAC address. See Table 42.
LT_COMM_ID_TEMPERATURE_SCALE	0x1017	uint32	Temperature scale for fixed-point value

Element Name	Element Code	Element Data Type	Description
LT_COMM_ID_DISTANCE_SCALE	0x1003	uint32	Distance scale for fixed-point value
LT_COMM_ID_AMPLITUDE_SCALE	0x1002	uint32	Amplitude scale for fixed-point value
LT_COMM_ID_FILTERED_SCALE	0x1004	uint32	Filtered scale for fixed-point value
LT_COMM_ID_AUTO_CHANNEL_NUMBER_HORIZONTAL	0x1020	uint16	Number of horizontal channels
LT_COMM_ID_AUTO_CHANNEL_NUMBER_VERTICAL	0x1021	uint16	Number of vertical channels
LT_COMM_ID_MAX_ECHOES_PER_CHANNEL	0x1024	uint16_t	Max. number of echoes on the same channel
LT_COMM_ID_HFOV	0x01F0	float	Sensor horizontal FoV
LT_COMM_ID_VFOV	0x01F1	float	Sensor vertical FoV
LT_COMM_ID_SOFTWARE_PART_NUMBER	0x10FC	char[16]	Software part number
LT_COMM_ID_FIRMWARE_VERSION_V2	0x10EF	uint16_t[4]	Full firmware version: major.minor.release.build.
LT_COMM_ID_FPGA_VERSION	0x610016	char [LT_COMM_FPGA_VERSION_LENGTH]	FPGA version
LT_COMM_ID_DEVICE_TYPE	0x610018	uint16_t	See PROTOCOL_IDT_DEVICE_TYPE_...
LT_COMM_ID_ECHO_AMPLITUDE_MAX	0x108C	uint32_t	Max. possible echo amplitude value

Table 48: Calibration elements

Element Name	Element Code	Element Data Type	Description
LT_COMM_ID_AUTO_CHANNEL_ANGLES_AZIMUT	0x2580	LtFloat[NumberOfChannels]	Elevation angles in degrees from the center of the FoV to the center of each channel
LT_COMM_ID_AUTO_CHANNEL_ANGLES_ELEVATION	0x2581	LtFloat[NumberOfChannels]	Azimuth angles in degrees from the center of the FoV to the center of each channel

Communication Examples

Example 1: Finding Online Sensors With the Identification Server

Host: Broadcast a request to the sensor identification server. The host broadcasts this request through a UDP connection type on port 48620.

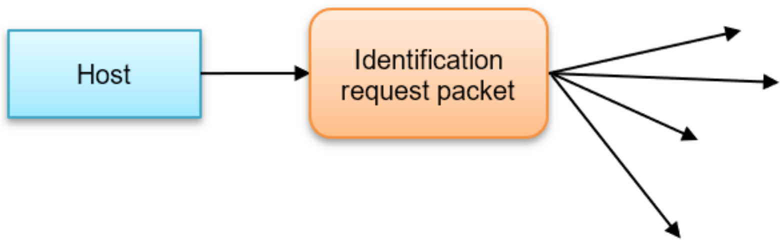


Fig. 77: Broadcast request to find online sensors

Table 49: Identification request packet

	Item	Value
Request header	Server protocol version	Identification server protocol – Version 1 = 0x0001
	Request code	IDT_REQUEST_IP_CONFIG = 0x0011
	Request size	8 bytes = 0x00000008

Sensors: All online sensors that receive the broadcast request send an identification answer packet to the host. The host will receive a stack of identification answers and must parse all sensors information for identification.

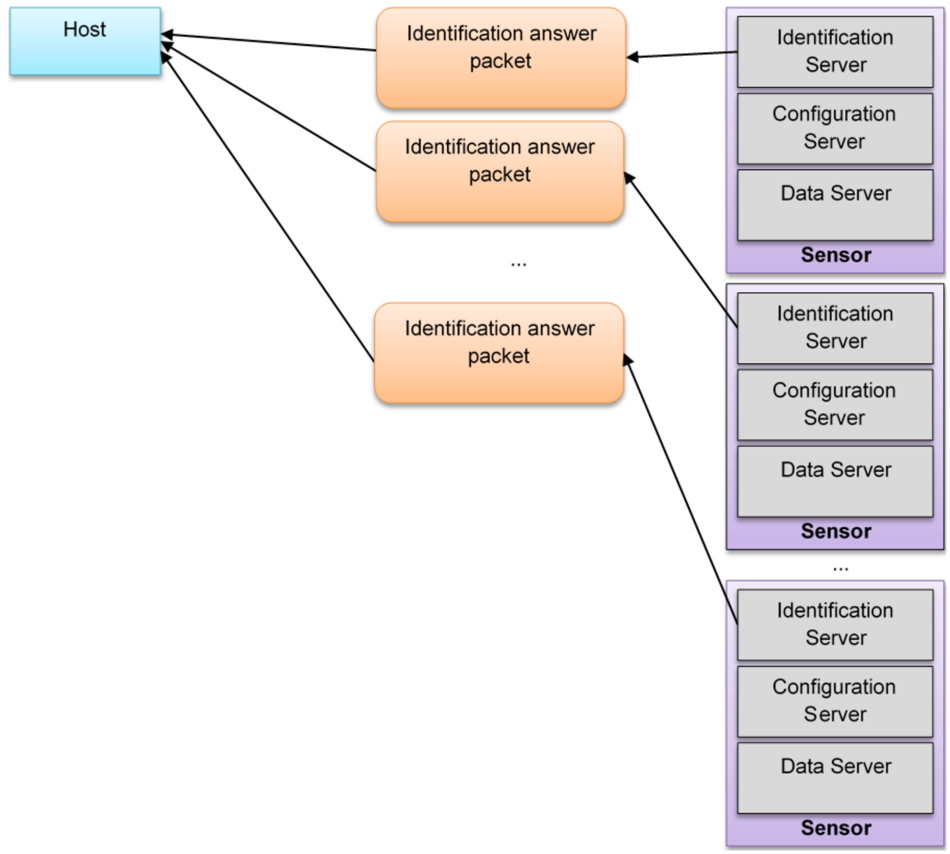


Fig. 78: Available sensor answers by an identification answer packet

Refer to “Configuration Server Protocol Version 2” and Table 39.

Table 50: Identification answer packet

	Item	Value
Answer header	Protocol version	Identification server protocol – Version 1 = 0x0001
	Answer code	OK = 0x0000
	Answer size	264 bytes = 0x00000108
	Request code	IDT_REQUEST_IP_CONFIG = 0x0011
	Reserved bytes	0x00, 0x00, 0x00, 0x00, 0x00, 0x00
Answer data	mMacAddress	8 bytes structure. See Table 42.
	mDeviceType	2 bytes
	mPartNumber[LT_COMM_PART_NUMBER_LENGTH]	16 bytes of hardware part number string
	mSoftPartNumber[LT_COMM_PART_NUMBER_LENGTH]	16 bytes of firmware part number string
	mSerialNumber[LT_COMM_SERIAL_NUMBER_LENGTH]	32 bytes of serial number string
	mFirmwareVersion[LT_COMM_FIRMWARE_VERSION_LENGTH]	32 bytes of firmware version number string
	mDeviceName[LT_COMM_DEVICE_NAME_LENGTH]	64 bytes (32 words) of UTF-8 encoded
	mSensorState	4 bytes
	mDataPort	2 bytes

Example 2: Get Detections From a Connected Sensor

Before receiving detections from the sensor, unlock the data server to send detections.

The host sends a “Set sensor data level” request to the connected sensor via the configuration server to get detections data. The host sends this request to the connected sensor through a TCP connection type to the configuration server.

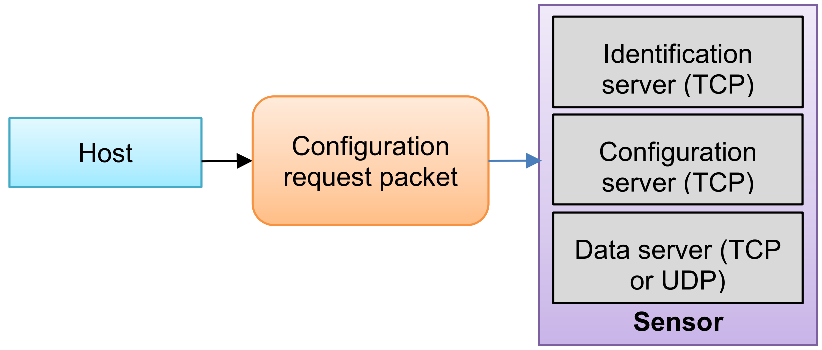


Fig. 79: Host sends a request to unlock data server

Table 51: Set sensor data level request packet

	Item	Value
Request header	Server protocol version	Configuration server protocol – Version 2 = 0x0002
	Request code	CFG_REQUEST_SET = 0x0003
	Request size	20 bytes = 0x00000014
Element header	Element code	ELEM_DATA_LEVEL = 0x106E
	Element count	1 element = 0x0001
	Element size	4 bytes = 0x00000004
Element data	ELEM_DATA_LEVEL field	Activate segment raw detections = 0x00000010

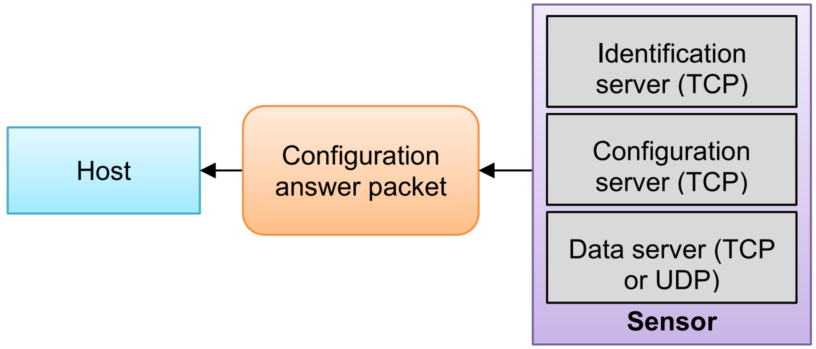


Fig. 80: Connected sensor sends a confirmation answer back to host

Table 52: Set sensor data level answer packet

	Item	Value
Answer header	Protocol version	Configuration server protocol – Version 2 = 0x0002
	Answer code	OK = 0x0000
	Answer size	16 bytes = 0x00000010
	Request code	CFG_REQUEST_SET = 0x0003
	Reserved bytes	0x00 0x00 0x00 0x00 0x00 0x00

Once the step above is completed, the host can receive detection packets from the connected sensor data server. To read detections according to the refresh rate, the host needs to send data requests periodically to read detections.

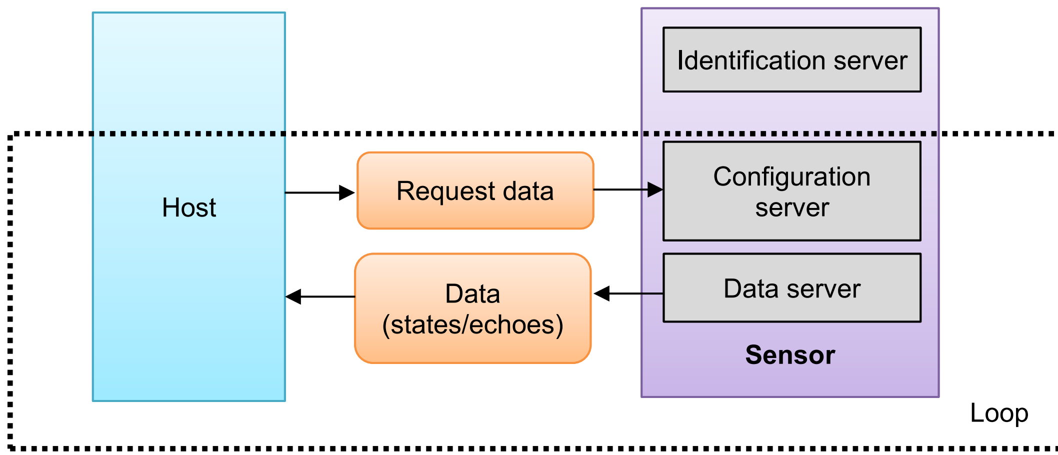


Fig. 81: Loop to get detection data periodically

Table 53: Request data request

	Item	Value
Request header	Server protocol version	Data server protocol - Version 3 = 0x0003
	Request code	DATA_REQUEST_SEND_ECHOES = 0x0020
	Request size	8 bytes = 0x0008
Element header	Element code	ELEM_DATA_LEVEL = 0x106E
	Element count	1 element = 0x0001
	Element size	4 bytes = 0x00000004
Element data	ELEM_DATA_LEVEL field	Activate segment raw detections = 0x00000010

Table 54: Data detection packet for n detections

	Item	Value
Answer header	Server protocol version	Data server protocol version 3 = 0x0003
	Request code	LT_COMM_DATASRV_REQUEST_SEND_ECHOES = 0x0020
	Request size	212 bytes = 0x000000D4
Element header	Element code	LT_COMM_ID_FRAME_ID = 0x1092
	Element count	1 element = 0x0001
	Element size	8 bytes = 0x00000008
Element data	LT_COMM_ID_FRAME_ID field	Frame unique identification number = 0x0000000000000000
Element header	Element code	LT_COMM_ID_TIMESTAMP = 0x1050
	Element count	1 element = 0x0001
	Element size	4 bytes = 0x00000004
Element data	LT_COMM_ID_TIMESTAMP field	Acquisition timestamp = 0x00000000
Element header	Element code	LT_COMM_ID_AUTO_TIMESTAMP64 = 0x2721
	Element count	1 element = 0x0001
	Element size	8 bytes = 0x00000008
Element data	LT_COMM_ID_AUTO_TIMESTAMP64 field	Acquisition timestamp = 0x0000000000000000
Element header	Element code	LT_COMM_ID_AUTO_NUMBER_DATA_SENT = 0x2501
	Element count	2 elements
	Element size	4 bytes per element = 0x00000004
Element data	LT_COMM_ID_AUTO_NUMBER_DATA_SENT field	Index of the first detection n - number of detections sent by the data server
Element header	Element code	LT_COMM_ID_AUTO_ECHOES_DISTANCE = 0x2703
	Element count	n elements
	Element size	4 bytes per element = 0x00000004
Element data	LT_COMM_ID_AUTO_ECHOES_DISTANCE field	Array of n distances words (4 bytes word) scaled at ELEM_DISTANCE_SCALE. See Example 3.
Element header	Element code	LT_COMM_ID_AUTO_ECHOES_CHANNEL_INDEX= 0x2700
	Element count	n elements
	Element size	1 byte per element = 0x00000001
Element data	ELEM_ECHOES_CHANNEL_INDEX field	Array of n segments indexes bytes. See section 2 on page 17.
Element header	Element code	LT_COMM_ID_AUTO_ECHOES_AMPLITUDE = 0x2702
	Element count	n elements
	Element size	4 bytes per element = 0x00000004
Element data	LT_COMM_ID_AUTO_ECHOES_AMPLITUDE field	Array of n amplitudes words (4 bytes word) scaled at LT_COMM_ID_FILTERED_SCALE. See Example 3.
Element header	Element code	LT_COMM_ID_AUTO_ECHOES_VALID = 0x0004
	Element count	n elements
	Element size	1 byte per element = 0x00000001
Element data	LT_COMM_ID_AUTO_ECHOES_VALID field	Array of n flags bytes

	Item	Value
Element header	Element code	LT_COMM_ID_AUTO_ECHOES_TIMESTAMP64 = 0x2704
	Element count	n elements
	Element size	8 bytes per element = 0x00000008
Element data	LT_COMM_ID_AUTO_ECHOES_TIMESTAMP64 field	Array of n detection timestamps
Element header	Element code	LT_COMM_ID_STATUS = 0x2701
	Element count	n elements
	Element size	1 byte per element = 0x00000001
Element data	LT_COMM_ID_STATUS field	0x01

For detailed information about detection, see section 2 on page 17.

Example 3: Get Constant Values From a Connected Sensor

In the following example, we want to know LT_COMM_ID_FILTERED_SCALE and LT_COMM_ID_DISTANCE_SCALE constant values to interpret incoming detection data. Requests sent by host and sensor answers will be described below.

The host sends a request to the connected sensor via the configuration server to get a list of constant values.

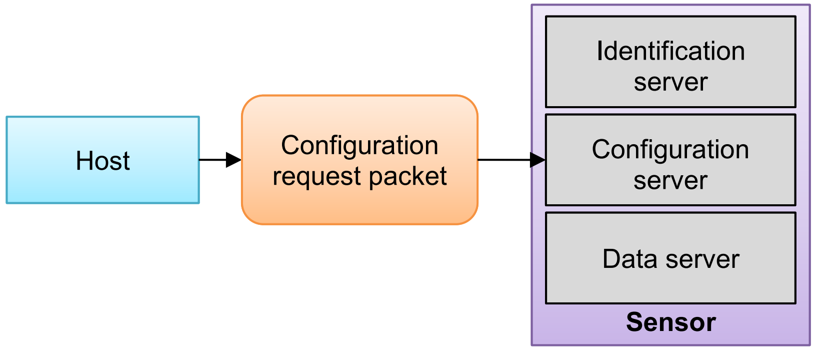


Fig. 82: Host sends a request to the configuration server

Table 55: Get elements list

	Item	Value
Request header	Server protocol version	Configuration server protocol – Version 2 = 0x0002
	Request code	CFG_REQUEST_GET = 0x0002
	Request size	20 bytes = 0x00000014
Element header	Element code	ELEM_LIST = 0x0070
	Element count	2 elements = 0x0002
	Element size	2 bytes per element = 0x00000002
Element data	List of elements	0x1004 (LT_COMM_ID_FILTERED_SCALE) 0x1003 (LT_COMM_ID_DISTANCE_SCALE)

The connected sensor sends a confirmation answer to the host.

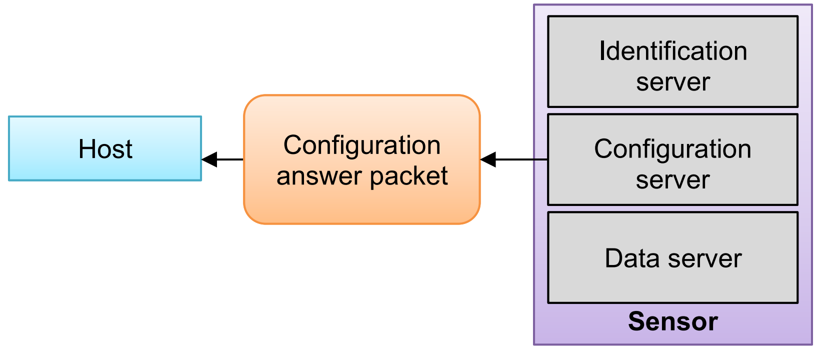


Fig. 83: Confirmation sent to host

Table 56: Constant values answer packet

	Item	Value
Answer header	Protocol version	Configuration server protocol – Version 2 = 0x0002
	Answer code	OK = 0x0000
	Answer size	40 bytes = 0x00000028
	Request code	CFG_REQUEST_GET = 0x0002
	Reserved bytes	0x00 0x00 0x00 0x00 0x00 0x00
Element header	Element code	LT_COMM_ID_FILTERED_SCALE = 0x1004
	Element count	1 element = 0x0001
	Element size	4 bytes = 0x00000002
Element data	LT_COMM_ID_FILTERED_SCALE	0x00200000
Element header	Element code	LT_COMM_ID_DISTANCE_SCALE = 0x1003
	Element count	1 element = 0x0001
	Element size	4 bytes = 0x00000002
Element data	LT_COMM_ID_DISTANCE_SCALE	0x00010000

Appendix E. Converting Leddar Pixell Flash LiDAR Sensor's Angular Data and Distance Reporting and Mapping to Real-World Coordinates Protocol

Each Leddar Pixell™ Cocoon LiDAR sensor is thoroughly calibrated on a dedicated production bench both in angular positions and in absolute distance using various traceable targets and carefully selected scenes to reach the required accuracy with precise angular mapping. The sensor comes with accessible internal data providing the angular mapping done in production. This section explains how to transform this basic internal mapping to precise Cartesian coordinates to map the "real world" as seen by the Leddar Pixell.

Mapping the Space Around the Platform with Sensor's Echoes

The Leddar Pixell sensor reports echoes using a distance and segment number where the detection has occurred for each echo in the list. The distance is a direct line-of-sight distance between the object detected and the sensor. To position this echo in space around the platform on which the sensor is installed, different ways of mapping the space could be used, as shown in Fig. 84 below.

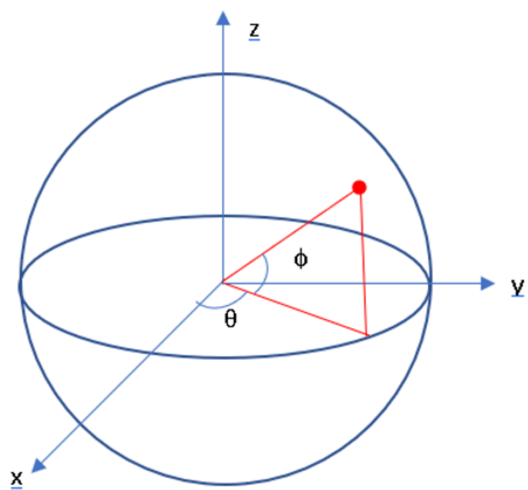


Fig. 84: Coordinates with two well-known reference systems

The red dot could be located in space using either Cartesian coordinates {x, y, z} or spherical coordinates {R, θ, ϕ}. The following equation set could be used to move from one to the other. The reference point of the Leddar Pixell sensor is the origin 0, 0, 0, with the x-axis pointing forward and the y-axis pointing to the left.

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

Equation 1: Coordinate transformation for x

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

Equation 2: Coordinate transformation for y

$$z = R\sin\phi$$

Equation 3: Coordinate transformation for z

Mechanical Positions of the Reference Point for the Leddar Pixell

The Leddar Pixell sensor is calibrated in production relative to a preferred mechanical reference point rather than the mounting holes in order to reduce variability (Fig. 85 and Fig. 86).

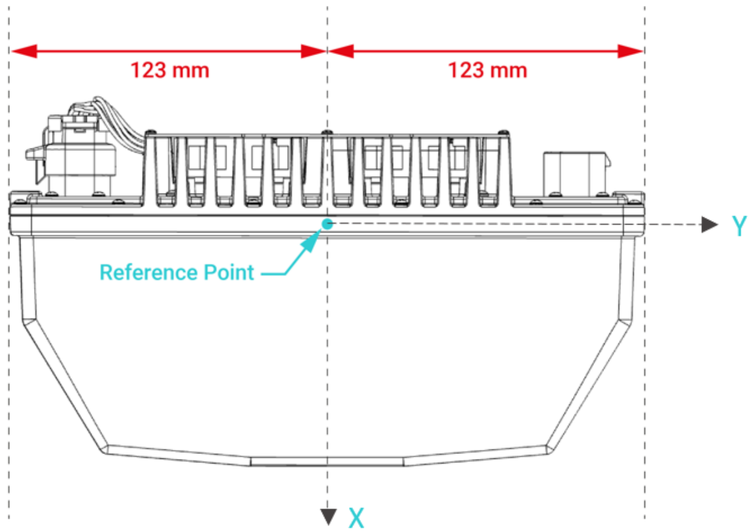


Fig. 85: Top view of the sensor showing the reference point

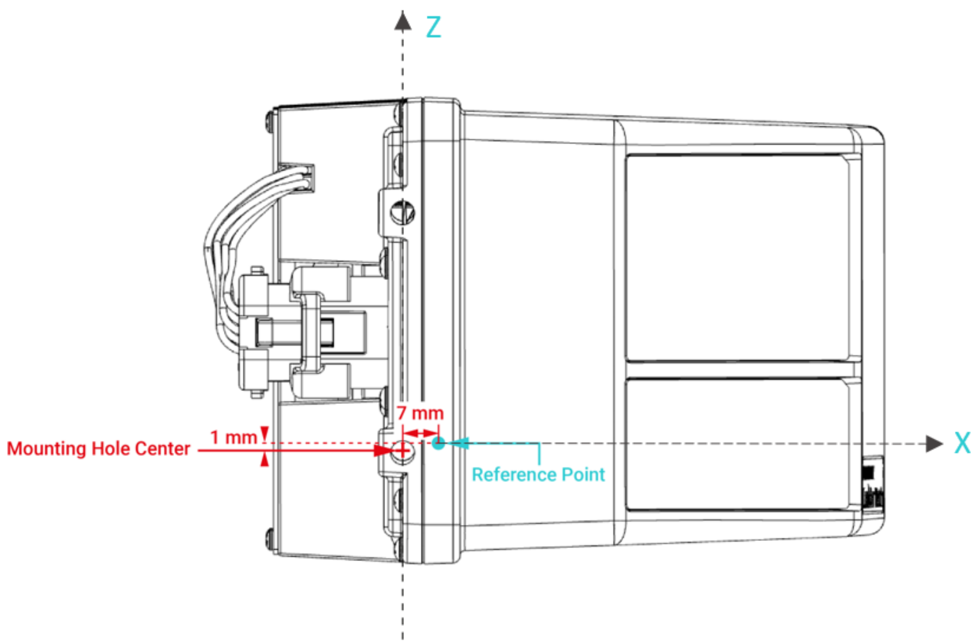


Fig. 86: Side view of the sensor showing the reference point

Information Returned From the Leddar Pixell

The Leddar Pixell sensor returns echoes tagged with a global segment number (0-767) and a distance (see section 4.3 on page 28). For each segment number, there is a general angular mapping stored in the sensor based on production data for a target at maximum range. A transformation should be applied to find the position (x, y, z) in space according to the distance of the echoes and the segment number.

Azimuth *u* and elevation *v* angles for each segment car be read once at start-up and used in the conversion equations (see section "Constant, Structure, and Data Type Definitions.")

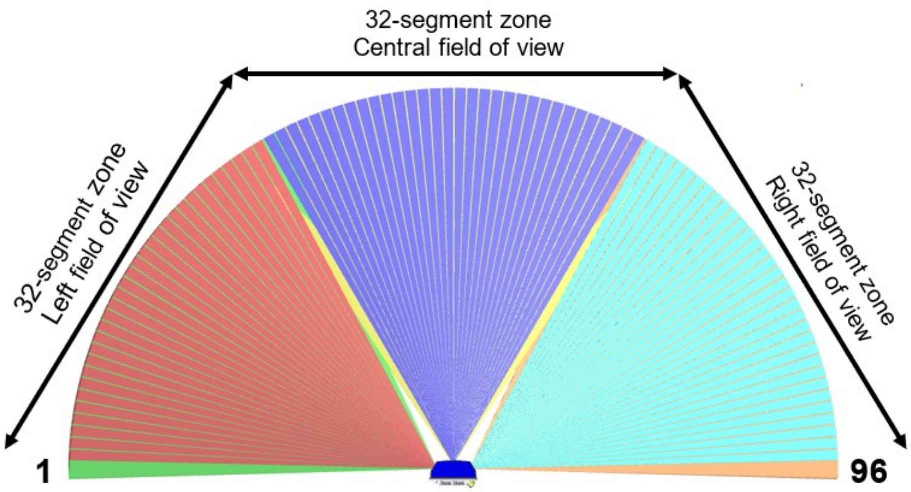


Diagram showing the three sub-fields of view

From the segment number (0-767) of an echo reported by the sensor, its field of view of origin can be found using the mathematical function modulo with 96 as argument (remainder of the division by 96). A result from this function between 0-31 points to the left field, between 32-63 points to the central field, and between 64-95 to the right field of view. This sorting is needed to select the right constants in the table below. For example, a global segment number of 505 represents local segment 25 in the left field of view (remainder of 505 divided by 96).

Mapping Using Opto-Mechanical Parameters of the Leddar Pixell

The following table lists translation values to transform the relative position of the internal sensors toward the external mechanical reference point.

Table 57: Opto-mechanical constants for each field of view

	Remainder 0-31	***Remainder 32-63***	***Remainder 64-95***
Head	Left field of view	Central field of view	Right field of view
B_x	+0.056 m	+0.0000 m	-0.056 m
B_y	+0.034 m	+0.0396 m	+0.034 m
D	-0.01562 m	-0.01562 m	-0.01562 m

Next, the field of view specific distance R_u can be evaluated using the reported distance R' from the echo, the B_x, B_y, and u, v derived from the segment number of the echo of interest.

$$R_u = R' - B_x \sin u \cos v - B_y \cos u \cos v + D \sin v$$

Equation 4: R_u calculation

Transformation to Cartesian Coordinates

From the corrected distance R_u based on actual distance of echo, fixed opto-mechanical parameters B_x, B_y, and D and internal angles u, v stored in the sensor specific for each segment, the Cartesian coordinates can be calculated.

$$x = B_y + R_u \cos u \cos v$$

Equation 5: Transformations to Cartesian x

$$y = B_x + R_u \sin u \cos v$$

Equation 6: Transformations to Cartesian y

$$z = - R_u \sin v$$

Equation 7: Transformations to Cartesian z

Those transformations should be applied to all echoes reported by the sensor.

	The way the angle v is reported by the sensor requires a minus sign in the z-axis transformation equation to conform to the universal x,y,z axis definition.

Contact LeddarTech support for sample Python code.

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