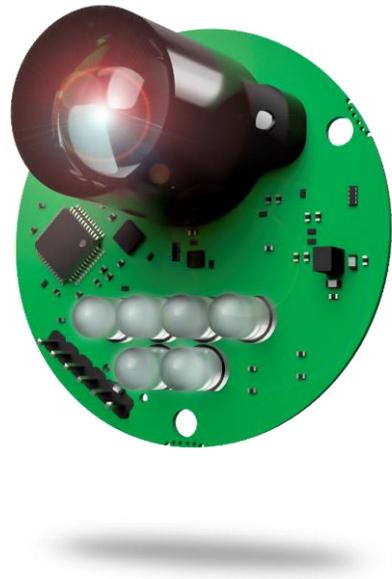


LeddarTech[®]

MASTERING LIDAR SENSOR TECHNOLOGY



LeddarOne

USER GUIDE

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

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1. Introduction

The Leddar™One enables developers and integrators to make the most of Leddar™ technology through integration in systems requiring detection and ranging. The Leddar™One Module is a more compact and low-cost alternative that brings valuable sensing intelligence to a whole new range of finished products.

1.1. Description

The Leddar™One package contains the sensor module with the following features:

- 3° conic beam
- Beam height: 3°
- Real-time data acquisition (through serial port)
- 3.3V UART or RS-485 link for measurement acquisition
- Leddar™ Software
 - Leddar™ Configurator
 - Module configuration
 - Real-time display of detection and measurement data
 - Data recording and logging.
 - Leddar™ Enabler SDK

Complete C example demonstrating parameter configuration and data acquisition using the MODBUS protocol over the serial link.

The following is a description of the main components of the Leddar™One.

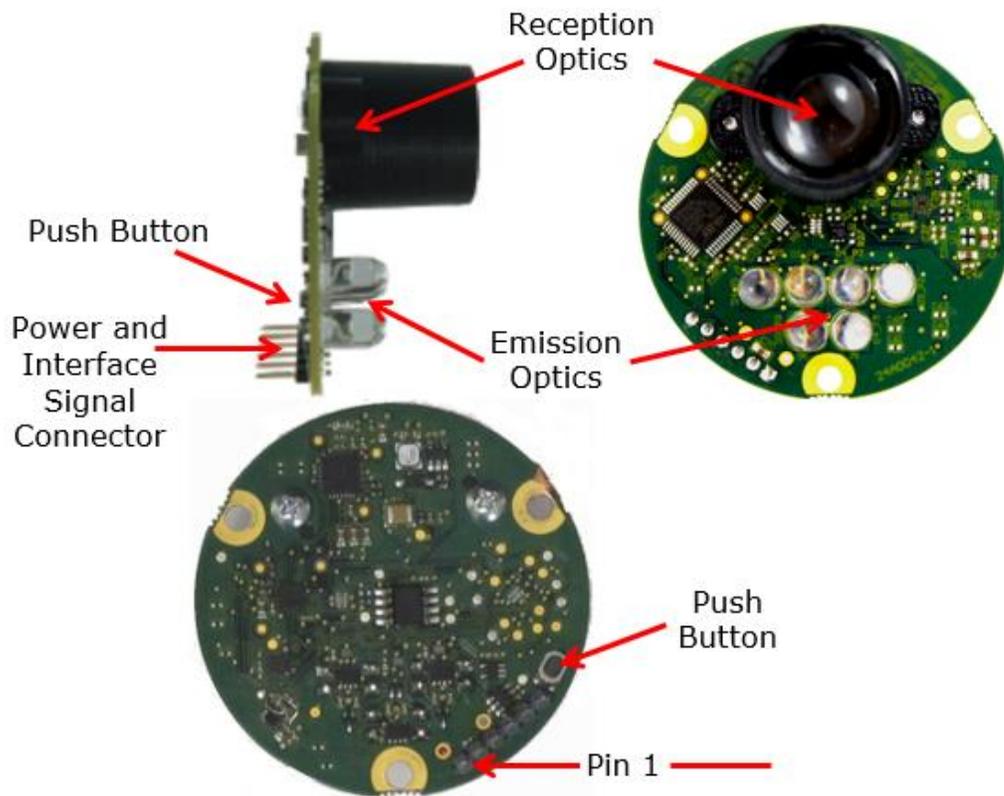


Figure 1: Leddar™ One Module (3° optics)

The power and interface signals are included on a six-pin standard 0.1" pitch header with the following pinout:

Table 1: Pinout of the Power and Interface Signals Header

Pin – Function	Description
1 – GND	Ground.
2 – IRQ	Interrupt Signal, active high. Set when a new measurement is available, reset when data read from Modbus link.
3 – Supply	5V
4 – RX or RS-485+	Serial port input.
5 – TX or RS-485-	Serial port output.
6 – RESET_N	This is a pulled-up input that must be pulled down below 0.8 V for at least 350 ns and then released to reset the processor.

The pin 1 position is shown in **Figure 1**.

Push Button

The push button at the right of the six-pin interface has three functionalities:

Table 2: Push Button Functionalities

Description	Action
Short press during sensor operation	Software reboot
Short press at power up (less than 10 seconds)	Reset sensor configuration. The button must be pressed before powering the sensor and released once power is applied.
Long press at power up (more than 10 seconds)	<p>Upload a binary file at power-up.</p> <p>WARNING: It is recommended to use the Leddar™ Configurator software for upgrading the module firmware. Firmware upgrade using the following procedure should be performed only when instructed by LeddarTech's technical support.</p> <p>A PC with a serial terminal program supporting the YMODEM protocol must be available. It must be set to 115200 bauds, 8 data bits, 1 stop bit and no parity and connected to the serial port.</p> <p>The button must be pressed before applying power and then continuously held for at least 10 seconds, until the text "<i>Waiting... (press 'a' to abort)</i>" appears in the terminal.</p> <p>You can then start the YMODEM transfer of the firmware file. Once the transfer is completed, either "<i>Successful!</i>" or "<i>Failed!</i>" will appear. On success the sensor will automatically start.</p>

Leddar™ One Architecture

The following diagram presents the architecture of the module.

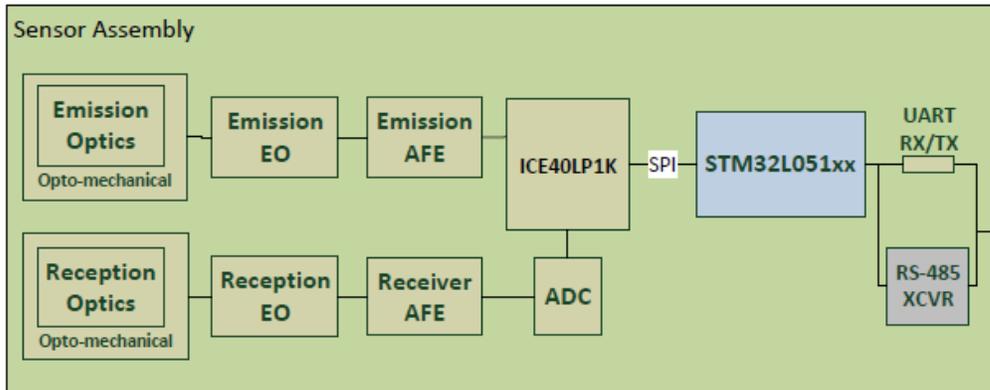


Figure 2: Working Diagram

The Leddar™ One module includes the photodetector, LEDs, MCU, the controller for LED pulsing and data acquisition. Data acquisition is performed at a sampling frequency of 72131 Hz (44 MHz/610).

The Leddar™ One module processes the acquired data and produces measurements at a configurable measurement rate. The measurements provide the distance of detected objects in the conic beam.

Note: *The sensor measurement rate varies according to the oversampling and accumulation settings.*

LED pulsing and receiver data acquisition timing is controlled by the FPGA. A temperature sensor located near the LEDs is used to implement temperature compensation on the ranging results.

The MCU recovers the waveforms from the FPGA, performs full waveform analysis, and generates detection and ranging data. The data can be acquired and displayed in software through the serial port.

1.2. Underlying Principles

Created by LeddarTech, LEDDAR™ (light-emitting diode detection and ranging) is a unique sensing technology based on LED illumination (in either the visible or the infrared spectrum) and the time-of-flight of light principle. The LED emitters illuminate the area of interest (pulsed at high frequency) and the single channel sensor receiver collects the backscatter of the emitted light and measures the time taken for the emitted light to return back to the sensor. A single photodetector is used and provides a full-beam sensing module. Full-waveform analysis enables detection and distance measurement of multiple objects in the beam, provided that foreground objects do not fully obscure objects behind them. Oversampling and accumulation techniques are used to provide extended resolution and range.

Figure 3 illustrates the illumination area and detection segments of the Leddar™One module.

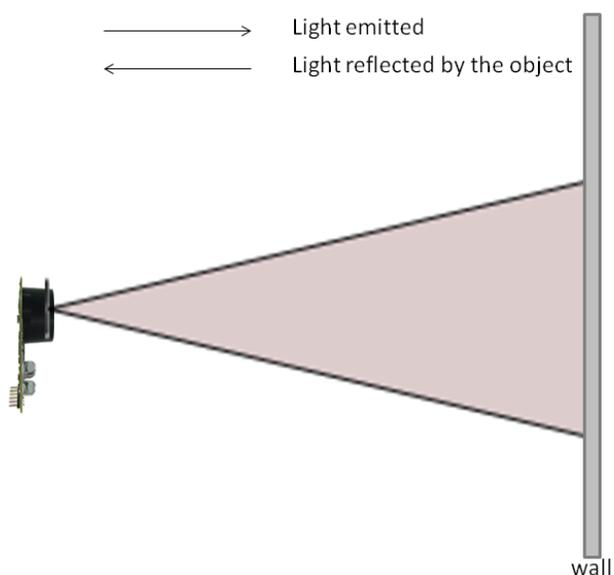


Figure 3: Illumination Area and Detection Zone

The core of Leddar™ sensing is the pulsing of diffused light, collection of reflected light (including oversampling and accumulation), and full-waveform analysis. The light source type, the number of light sources, the illumination and reception beam, and the number of photodetectors can all be tailored to fit specific application requirements such as detection range, beam and spatial resolution.

1.3. Signal Processing Algorithm Overview

The conceptual overview of the sensor signal processing algorithm is shown in Figure 4:

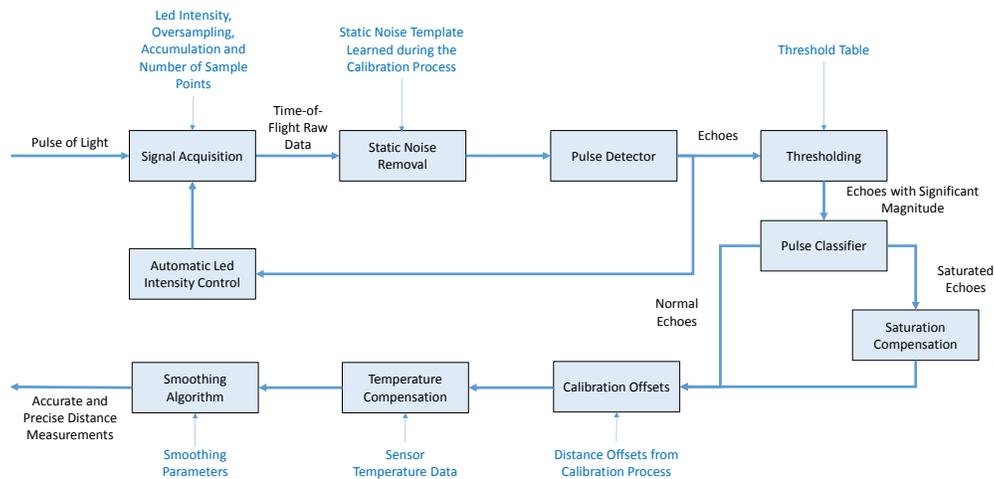


Figure 4: Leddar™ Signal Processing Algorithm Overview

1.3.1. Signal Acquisition

The signal acquisition module samples the signal of the photodiode element using a patented oversampling and accumulation strategy to maximize the signal resolution and the signal to noise ratio. It provides the light intensity received by the sensor as a function of the time (corresponding to distance knowing the speed of light) also called full-waveform signal. This full-waveform signal allows the use of advanced signal processing techniques to extract the distances of the objects and other useful information about the scene.

1.3.2. Static Noise Removal

The static noise removal algorithm removes, as its name indicates, the static noise in the full-waveform signal induced by undesirable light reflections due to sensor enclosure or electromagnetic interferences. This algorithm increases drastically the distance measurement accuracy and linearity. The static noise shape is learned during a calibration procedure during which the waveform of the signal is captured while the reception lens of the sensor is shielded from the backscattered light. The sensor comes with a static noise factory calibration. However, the default calibration can be updated by the user using Leddar™ Configurator, see Section 4.4.12 for more details.

1.3.3. Pulse Detection

The objects in the sensor field of detection create a particular signature in the full-waveform signal called pulses. The pulse detector analyzes the full-waveform signal in order to recognize

these pulses and compute their distance. By nature, time-of-flight sensor using full-waveform analysis is able to detect several distinct objects with a single photodiode element.

The detected pulses have specific amplitudes based on their distance from the sensor and on the reflectivity of the objects. It is well known that pulses of small amplitudes do not lead to accurate and precise distance measurements. Consequently, the algorithm removes all pulses with amplitudes under a given threshold. This threshold depends on the acquisition settings of the sensor, see Section 5.5.2 for more details.

1.3.4. Saturation Compensation

The algorithm classifies the detected pulses based on their shape. The LeddarOne™ determines which pulses are saturated and which have a normal shape. It is noted that other families of the products have more advanced classification technology such as merged object discrimination. Saturated pulse occurs when the signal backscattered by the object is so strong that the full-waveform signal is clipped. If not treated, this phenomenon creates an important degradation of the distance measurement accuracy. It is why a saturation compensation algorithm is executed when saturated pulses are detected. This innovative algorithm uses a sophisticated approach to provide a distance measurement accuracy better than 10 cm even with a strongly clipped signal.

1.3.5. Temperature Compensation

The signal processing algorithm also embeds an advanced temperature compensation scheme which attenuates the distance measurement drift over large and sudden sensor temperature changes. With this algorithm, the distance measurements stabilize inside 1 cm in less than 10 seconds on cold sensor startup. The temperature compensation also ensures optimal accuracy over the full operating temperature range.

1.3.6. Smoothing

The smoothing algorithm reduces the distance measurement jitter. It can be seen as a recursive average filter which continuously adapts its cutoff frequency (or averaging history length) as a function of the current measurement noise. This innovative algorithm increases the precision of the device (decreases the standard deviation of the measurements). The level of smoothing of the algorithm can be adjusted to fit the requirements of the user applications, please see Section 3.3.2 for more details.

1.3.7. Automatic LED Intensity Control

The automatic LED intensity control adjusts the intensity of the LEDs in real time in order to maintain optimal pulse magnitudes at all times. For instance, if pulses become suddenly saturated, the sensor will decrease automatically the intensity of the LEDs to a level that ensures an optimal distance measurement accuracy.

2. Getting Started

2.1. Setup

To configure the sensor and see measurements the Leddar™ Configurator software must be installed. This software is available for download at www.leddartech.com/support. Once you have downloaded the file, simply double-click on it and follow on-screen instructions.

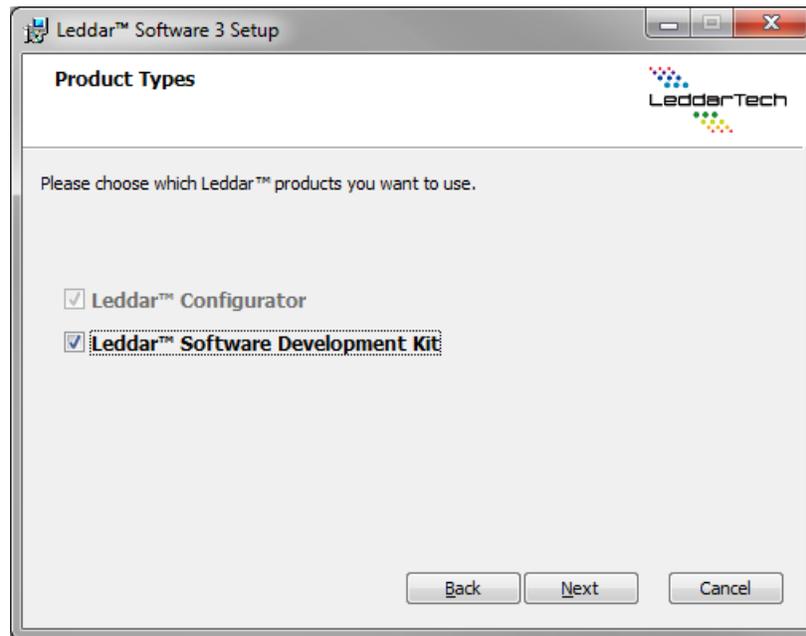


Figure 5: Leddar™ Software Setup Dialog Box

The installer creates an icon on the computer desktop and in the Start menu.

2.2. Connecting to the Module

Once the installation is completed, you can connect to the module.

To connect to the module:

1. On the computer desktop, double-click the Leddar™ Configurator icon.
2. In Leddar™ Configurator, click the connect button ().

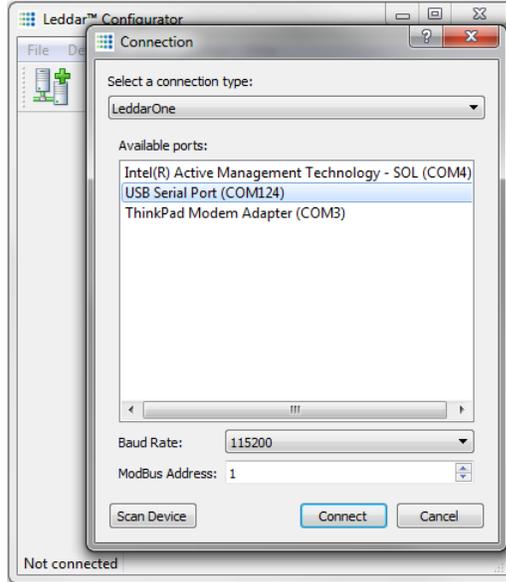


Figure 6: Connecting to a Device

3. In the **Connection** window, select your serial port and click **Connect**.

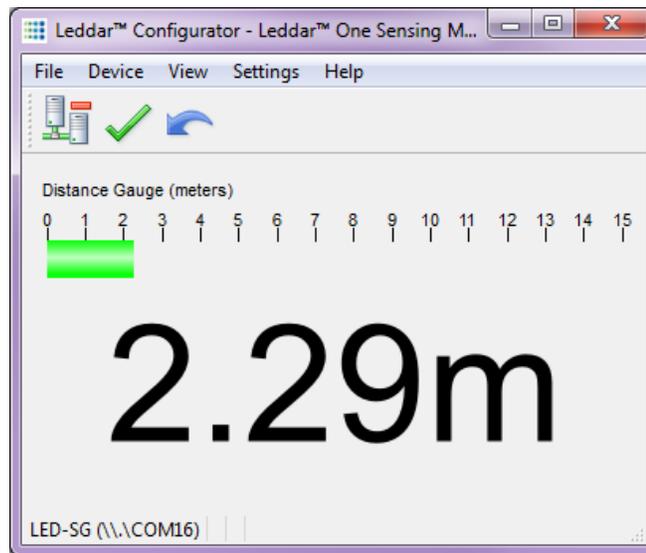


Figure 7: Connection Window

The main window displays the detections (green bar) in the distance gauge.

3. Measurement and Settings

3.1. Distance Measurement

Distance is measured from the surface of the module PCB.

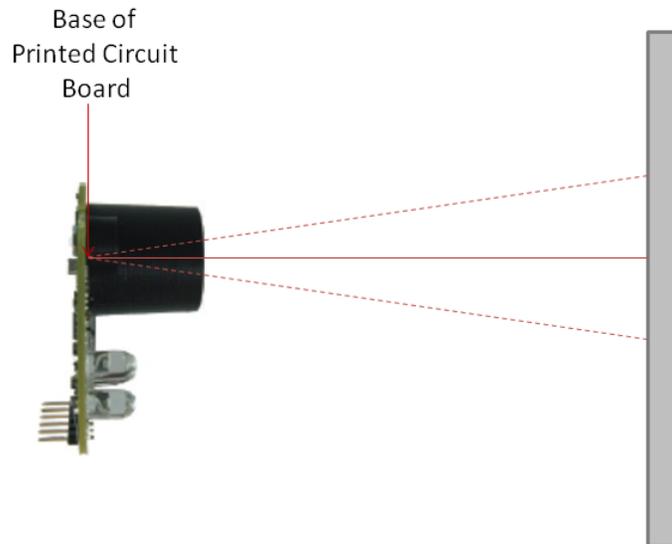


Figure 8: Distance Measurement

The dashed lines illustrate the full-beam and the solid line indicates the distance measured by the sensor.

3.2. Data Description

Measurement data can be displayed in the **Raw Detections** window (**View** menu > **Raw Detections**).

The screenshot shows a window titled 'Raw Detections' with a table of data. The table has columns for 'Seg', 'Distance', 'Amplitude', and 'Flags'. The first row contains the values 1, 2.289, 31.8, and 1. The window also has several input fields for filtering data: Min Amplitude (0.0), Max Amplitude (1024.0), Min Distance (0.0), and Max Distance (100.0).

	Seg	Distance	Amplitude	Flags
1	1	2.289	31.8	1
2				
3				
4				
5				
6				
7				
8				

Figure 9: Raw Detections Dialog Box

An object crossing the beam of the sensor is detected and its distance is measured. A measurement contains distance, amplitude, a flag bit field and the segment of the detection. The latter applies to multiple-segment modules and is fixed for the Leddar™One. The quantity of light reflected back to the sensor by the object generates the amplitude. The stronger the reflection, the higher the amplitude.

Table 3: Raw Detection Field Description

Field	Description
Segment	Beam segment in which the object is detected (Always 1 for the Leddar™One)
Distance	Distance of the detected object from the sensor
Amplitude	Quantity of light reflected by the object and measured by the sensor
Flag	Always 1 for the Leddar™One

3.3. Acquisition Settings

Acquisition settings allow you to define parameters to use for detection.

To open the **Acquisition Settings** dialog box, on the **Device** menu, point to **Configuration** and click **Acquisition...**

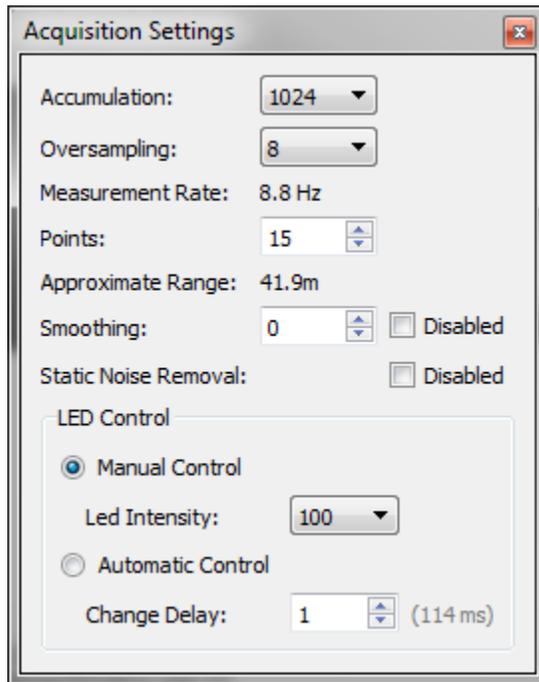


Figure 10: Acquisition Setting Dialog Box

To apply the changes, click the apply button (✓) in the main window.

Table 4: Sensor Setting Description

Parameters	Descriptions	Effects
Accumulations	Number of accumulations	Higher values enhance range, reduce measurement rate and noise.
Oversampling	Number of oversampling cycles	Higher values enhance accuracy/precision/resolution and reduce measurement rate.
Points	Number of base sample points	Determines maximum detection processing range.
Smoothing	Distance measurement smoothing	<p>Smooths the sensor measurements. The behavior of the smoothing algorithm can be adjusted by a value ranging from -16 to 16. Higher values enhance the sensor precision but reduce the sensor reactivity. The smoothing algorithm can be deactivated by checking the Disabled check box or entering -17 in the smoothing field.</p> <p>The measurement stabilization algorithm is advised for application that need to measure slowly moving objects with a high precision. The application requiring to quickly track moving objects, the stabilization should be configured with a value lower than 0 or simply deactivated.</p>
Static Noise Removal	Disabling of the static noise removal algorithm	The static noise in the full-waveform signal is removed using predefined static noise templates. These templates are determined during the calibration process. The calibration of the static noise can be conducted by the user if required. The static noise removal disabling checkbox is only available with the integrator license. This algorithm is enabled by default.
LED Control	LED power control options	Selects between manual & automatic power control. In manual mode, the following approximate relative LED intensity can be selected: 10%, 20%, 35%, 55%, 75%, and 100%. In automatic, LED power is adjusted according to incoming detection amplitudes. The current LED power level is visible in the Device State window.

* Distance measurements of objects detected with a low signal or saturated signal may have lower accuracy and precision. It is recommended to set the LED intensity to a level that will provide a strong signal for the typical object and range. Note that setting the LED intensity below 100% will reduce the detection range.

3.3.1. LED Intensity

There are a total of 6 supported LED power levels. Their approximate relative power is as follows: 10%, 20%, 35%, 55%, 75% and 100%.

The change delay defines the number of frames required before allowing the sensor to increase or decrease by one the LED power level. For example, with the same change delay, the maximum rate of change (per second) of the LED power will be two times higher at 17.6 Hz than at 8.8 Hz.

NOTE: Since the change delay parameter is a number of measurements, the delay will vary if the measurement rate is changed (through modification of the accumulation and oversampling parameters).

Keeping the sensor in automatic LED power mode ensures it adapts to varying environments. Close range objects may reflect so much light they can saturate the sensor, reducing the quality of the measurements. This mode will adapt the light output within the change delay setting to reach the optimal amplitude. On the other hand, low amplitudes provide lower accuracy and precision. The automatic LED power mode will select a LED intensity that provides the highest intensity that avoids the saturation conditions.

NOTE: When a strongly reflective or near object is present in the field of view while monitoring farther distances, the automatic adjustment will reduce the effective range of the sensor (reduce LED intensity) and may prevent detection of long range or low reflectivity objects. For these applications, manual mode with LED power set to 100% may be a better setting.

3.3.2. Smoothing

The smoothing algorithm increases the precision of the measurements at the cost of the sensor reactivity. The algorithm works by averaging consecutive measurements over a given time history. The history length of the filter is continuously adapted as a function of the current measurement noise level. It also changes according to the oversampling and accumulation settings. The smoothing level of the algorithm can also be adjusted by a parameter ranging from -16 to 16. Select the **Disabled** check box or set the value at -17 to disable smoothing. Higher values increase the sensor precision but reduce the sensor reactivity. An example of the behavior of the measurement smoothing algorithm is depicted in **Figure 11** below.

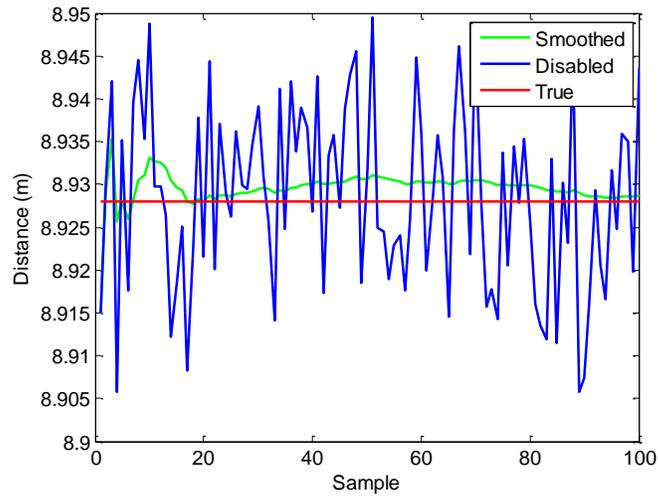


Figure 11: Measurement Stabilization Example

The red line represents the true target distance, the blue curve corresponds to the target distance measured by the sensor without stabilization, while the green curve is the stabilized measurements. One could notice that the measurement precision (standard deviation) is dramatically improved by the stabilization algorithm.

NOTE: *The smoothing algorithm is recommended for applications that need highly precise measurements of slowly moving objects. For applications that tracks quickly moving objects, it is advised to decrease the value of the stabilization parameter or to disable the stabilization algorithm. Select the **Disabled** check box or set the value at -17 to disable smoothing.*

3.4. Measurement Rate

The sensor acquires a base input waveform at a rate of 72131 Hz (44 MHz/610). Multiple acquisitions are used to perform accumulations and oversampling and generate a final waveform that is then processed to detect the presence of objects and measure their position.

The final measurement rate is therefore:

$$\text{Measurement rate} = \frac{\text{Base Rate}}{\text{accumulations} * \text{oversampling}}$$

For example, with 256 accumulations and an oversampling value of 8:

$$\text{Measurement rate} = \frac{72131}{256 * 8} = 35.22 \text{ Hz}$$

Table 5 below presents the measurement rate for typical values of accumulations and oversampling.

Table 5: Measurement Rate

Accumulation	Oversampling	Measurement rate (Hz)
4096	8	2.20
2048	8	4.40
1024	8	8.81
512	8	17.61
256	8	35.22
128	8	70.44
4096	4	4.40
2048	4	8.81
1024	4	17.61
512	4	35.22
256	4	70.44
128	4	140.88

3.5. Serial Port Settings

Two settings are available to adjust data acquisition through the 3.3 V UART or RS-485 link. The baud rate can be configured to the desired value. Parity, data bits and stop bits are fixed at None, 8, 1.

A baud rate of 115200 is recommended to provide the best data transfer rate and measurement rate up to 50 Hz. The following serial port settings are configurable.

Table 6: Serial Port Setting Description

Parameter	Value
Baud Rate	9600, 19200, 38400, 57600, 115200 bps
Modbus Address	1 to 247

3.6. Modbus Protocol

The 3.3 V UART link or RS-485 port on the sensor uses the Modbus protocol. This section describes the commands that are implemented.

For more information on the Modbus protocol, please visit www.modbus.org.

Report Server ID (function code 0x11)

This function returns information on the sensor in the following format:

Table 7: Report Server ID Message Description

Offset	Length	Description
0	1	Number of bytes of information (excluding this one). Currently 0x33 since the size of information returned is fixed.
1	8	Serial number as an ASCII string
9	1	Run status 0: OFF, 0xFF:ON. Should always return 0xFF, otherwise the sensor is defective.
20	11	The software part number as an ASCII string
31	11	The hardware part number as an ASCII string
39	8	The full firmware version as 4 16-bit values
43	4	The firmware 32-bit CRC
47	2	The FPGA version
49	4	Device option flags (LeddarTech internal use)
51	2	Device identification code

Write Configuration (function code 0x46)

This function writes the current configuration registers to permanent memory. There is no data in input or output.

Read Input Register (function code 0x4)

Here are the registers implemented for this command:

Table 8: Read Input Register Description

Address	Description
20	Least 16 significant bits of timestamp.
21	Most significant 16 bits of timestamp.
22	Temperature in 1/256 th of a Celsius
23	Number of detections

24	Distance in millimeters of first detection
25	Amplitude of first detection
26	Distance in millimeters of second detection
27	Amplitude of second detection
28	Distance in millimeters of third detection
29	Amplitude of third detection

Note that as per the Modbus protocol, register values are returned in big-endian format.

The timestamp is a 32-bit unsigned value giving the number of milliseconds since the sensor was started.

Distance and amplitude are 0 for a detection that is not present (for example if register 23 is 1, registers 26 to 29 will all be 0).

Read Holding Register (function code 0x3), Write Register (function code 0x6) and Write Multiple Register (function code 0x10).

Here are the registers implemented for these commands:

Table 9: Read Holding Register Description

Address	Description
0	Accumulation Exponent (0-12). This register contains the power of 2 of the number of accumulation. For example, if this register contains 10, 1024 accumulations will be performed.
1	Oversampling exponent (0-3). This register contains the power of 2 of the number of oversampling. For example, if this register contains 3, 8 oversampling will be performed.
2	Base sample count (2-15)
4	LED power in percentage of the maximum. Only possible values are: 20, 35, 55, 75 and 100.
29	The serial port baud rate. Possible values: 0: Default (115200) 1: 9600 2: 19200 3: 38400 4: 57600 5: 115200
30	Modbus device address (1 to 247, default to 1)

Note that as per the Modbus protocol, register values are returned in big-endian format.

A request for a register that does not exist will return error code 2. Trying to set up a register to an invalid value will return error code 3. If an error occurs while trying to execute the function, error code 4 will be returned.

See Section 3.3 and 3.5 for an explanation of settings.

3.7. SDK

If you select the Leddar™ Enabler Software Development Kit during installation, an example program in C will be installed in the Examples subfolder of the installation folder. This program implements the Modbus communication with the Leddar™One sensor module.

The example is heavily commented and easy to understand. It is a command-line application. It can be used in Windows with VisualStudio 2008 (or later) with the provided solution. It can be used in Linux with the provided Makefile (as long as development tools are installed).

4. Leddar™ Configurator

Leddar™ Configurator provides configuration parameters and operation functionalities for the Leddar™One Sensing Module.

4.1. Installing Leddar™ Configurator

See section 2.1 for guidelines regarding installation of Leddar™ Configurator. Once the installation is completed, you can connect to the sensor.

4.2. Connecting to the Module

To configure the sensor, you must first connect to it.

To connect to the sensor:

1. In Leddar™ Configurator, click the connect button .

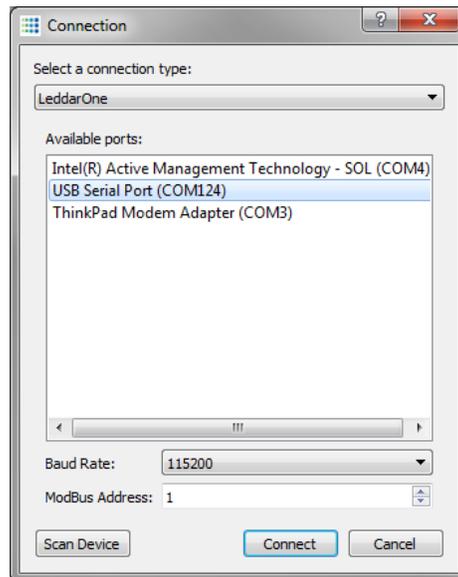


Figure 12: Connecting to a Device

2. In the **Connection** dialog box, select the serial port that you want to establish a connection with and click **Connect**.

The device has default serial port parameters. Once connected, you can modify the baud rate or/and ModBus Address (see section 4.4.1).

3. The Leddar™ Configuration main window changes to display sensor information.

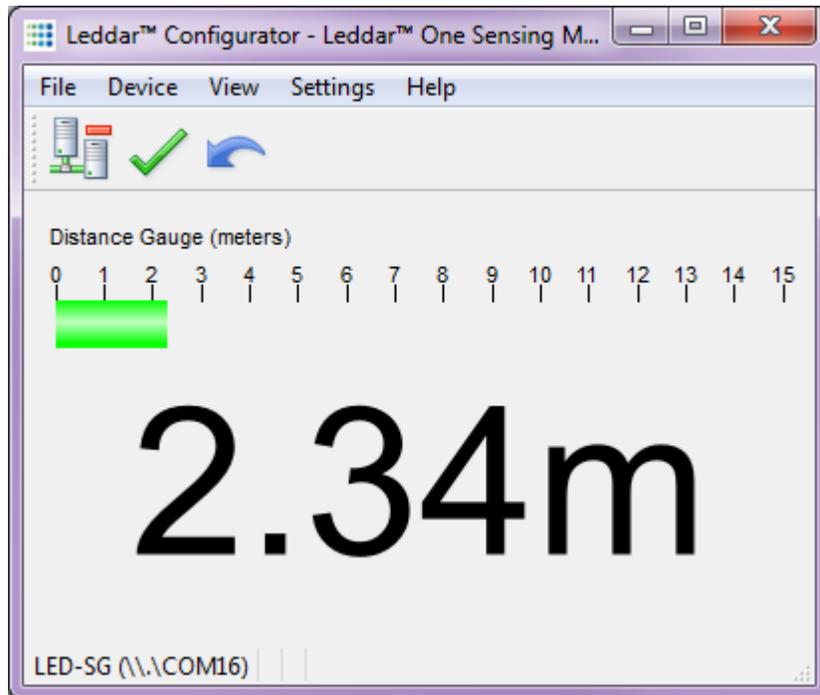


Figure 13: Leddar™ Configurator Main Window

4.3. Leddar™ Configurator Main Window

This section describes the elements of the Leddar™ Configurator main window.

At the top of the window are the menu bar and the toolbar.

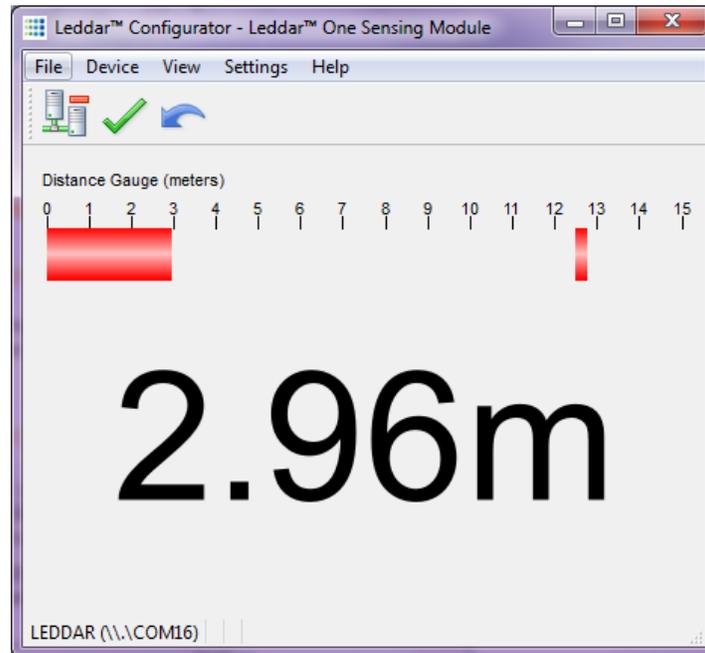


Figure 14: Leddar™ Configuration Main Window

The main area displays the distance of the first detection in numerical form as well as in a bar in a distance gauge. If present, the second and third detections will be displayed as thin bars in the gauge (as shown in Figure 14).

The distance gauge is color-coded to represent the detection quality:

- yellow for a weak detection
- green for a good detection
- red for a saturated detection.

See section 3.3 for guidelines regarding low and saturated detections

4.3.1. Menu Bar

This section presents, in the form of a table, the parameters and functionalities you can access through the menus and commands.

Table 10: Menu Bar Description

File	Device	View
Replay	Disconnect	State
Save Configuration	Configuration	Raw Detections
Load Configuration	Acquisition	
Start Recording	Communication	
Start Data Logging	Action	
Quit	Reset	
	Update	
	Calibration (only with integrator license)	

Settings	Help
Preferences	User Guide
Licenses	About

4.3.2. Toolbar

The toolbar includes several buttons for quick access to common actions.

Connect/Disconnect

Click the connect button  to open the **Connection** dialog box which allows you to select the device to connect with; it turns to disconnect  once you are connected. Clicking this button once connected will close the connection.

Apply

Click the apply button  to send the changes you made to the parameters to sensor. Until this button is clicked changes are local to the PC and do not affect sensor behavior.

Undo

Click the undo button  to erase all the changes you have made to the parameters since the last applied action or connection.

4.4. Using Leddar™ Configurator

This section presents the procedures to view, configure, and analyze detections from the sensor using Leddar™ Configurator.

4.4.1. Configuring Serial Port

The sensor serial port settings are configurable.

To open the **Communication Settings** dialog box, on the **Device** menu, point to **Configuration** and click **Communication**.

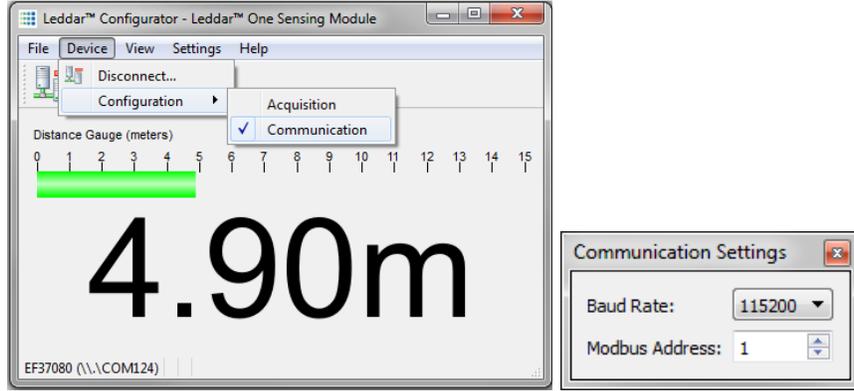


Figure 15: Device Menu for the Communication Configuration

The numbers are modified by using the arrows or by entering the value manually.

Table 11: Sensor Serial Port Setting Description

Parameters	Values
Baud Rate	Transmission rate of 9600, 19200, 38400, 57600, or 115200 bps
Address	Modbus device address 1 to 247

4.4.2. Acquisition Settings

The acquisition settings allow to define the signal acquisition parameters.

To open the **Acquisition Settings** dialog box, on the **Device** menu, point to **Configuration** and click **Acquisition**. See section 3.3 for a complete description of each setting.

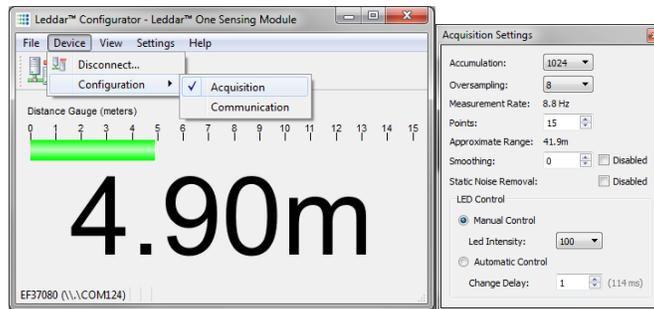


Figure 16: Device Menu and Acquisition Settings Dialog Box

To apply the changes, click the apply button  in the Leddar™ Configuration main window.

4.4.3. Saving and Loading a Configuration

The software configuration for a device can be saved to a file. This allows to save a configuration and restore it in case of system failure or in case the user wants to revert to earlier settings.

To save a configuration:

On the **File** menu, click **Save Configuration**. A filename and then a comment to help when reloading the file will be asked to the user. The comment can be left blank.

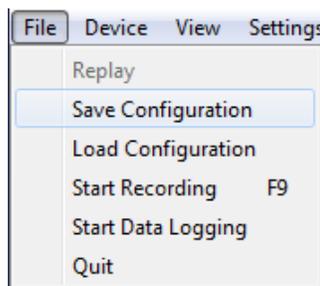


Figure 17: File Menu

To load a configuration:

On the **File** menu, click **Load Configuration** and then select a file. Once the file is selected, information on the file will be displayed and the user will be asked if this configuration can be sent to the device.

4.4.4. Configuring Detection Records

Detection records provide a playback of detections recorded by a device. This visual information can be useful for verification, troubleshooting, or training purposes. Detection records allow for a full data playback stored in a *.lfl file that can later be reloaded and replayed.

To configure the detection record:

1. On the **Settings** menu, click Preferences.

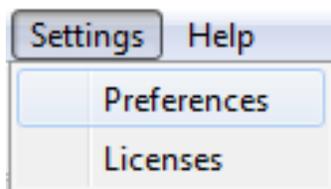


Figure 18: Settings Menu

2. Expand the Recording category and click on Recorder to display the recording parameters. It is noted that a connection to a sensor must be active for the Recording category to be available.
3. In the **Directory** dialog box, select the path where you want to save the record file.

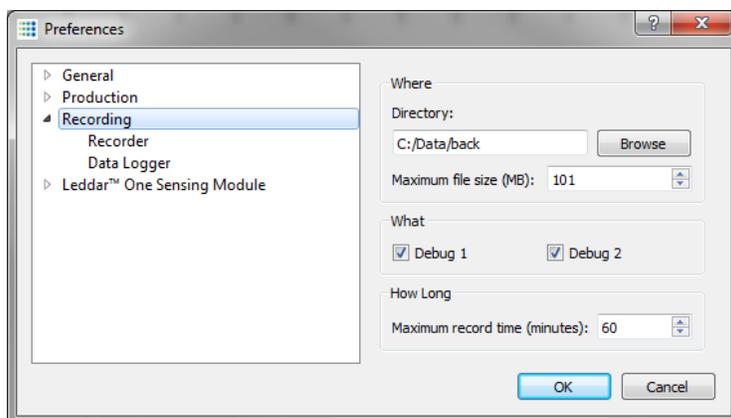


Figure 19: Record Settings Dialog Box

4. In the **Maximum file size** box, set the maximum file size by using the arrows or by entering the value manually.
The recording stops for the current file once it reaches the maximum file size and automatically switches the recording to another file. This is to keep record files of manageable sizes.
5. Under **What**, select the **Debug** check boxes if the recording is to share with LeddarTech technical support. This records additional data and results in larger log files. It is not otherwise recommended to enable this option.

6. Under **How Long**, next to **Maximum record time**, determine the length of time for a single log file by using the arrows or by entering the value manually.
7. Click **OK** to save the settings.

To start a recording:

1. Connect to the sensor for which you want to make a detection record.
2. On the **File** menu, click **Start Recording**.

OR

On the computer keyboard press the <F9> key.

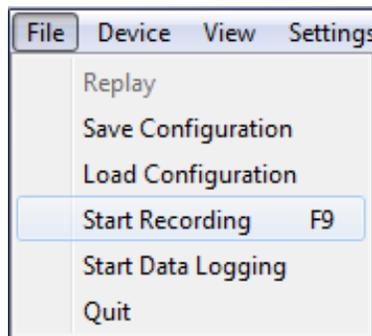


Figure 20: File Menu

To stop a recording manually:

On the **File** menu, click **Stop Recording**.

OR

On the computer keyboard press the <F9> key.

4.4.5. Using Detection Records

Once you have completed a recording, you can review it and extract part of the recording.

The **Record Replay** dialog box offers the same functions as a regular video player: there is a stop button, a play button, and frame-by-frame forward and backward buttons.

The **Position** slider lets you move directly to a desired position.

The **Playback Speed** slider lets you adjust the speed of the recording playback; faster is to the left.

The **Start**, **End**, and **Extract** buttons allow you to select a portion of the recording and extract it for further reference or analysis.

To play a record:

If you are connected to a device, disconnect from the device.

OR

Open another Leddar™ Configuration software main window.

1. On the **File** menu, click **Replay**.

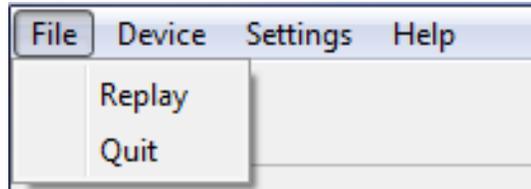


Figure 21: File Menu

2. In the **Record Replay** dialog box, click the browse button to select a file.

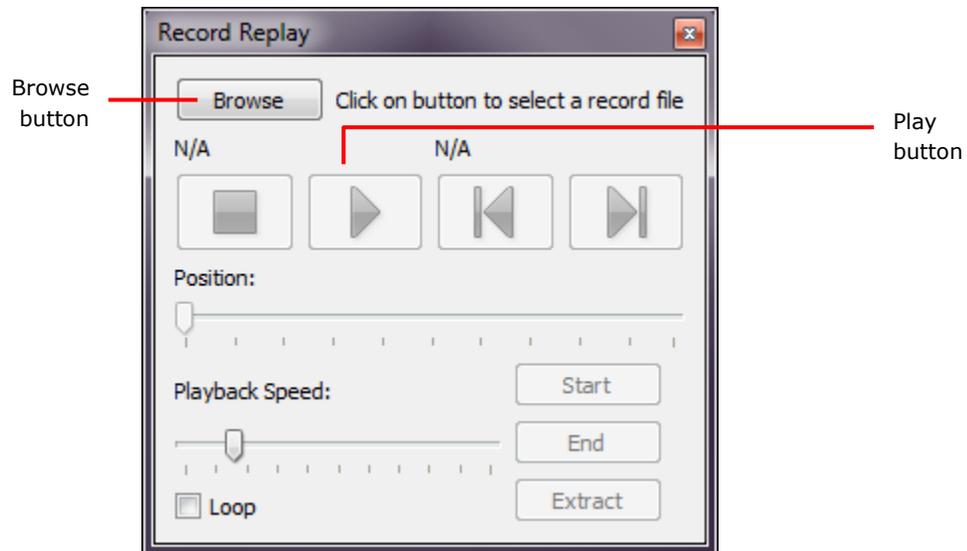


Figure 22: Record Replay Dialog Box

3. Click the play button to start the playback.

To extract a record file segment:

1. Set the **Position** slider to the position where you want the file segment to start and click the **Start** button.
2. Set the **Position** slider to the position where you want the file segment to stop and click the **End** button.

OR

Play the record and stop it at a position of interest and then click the **Start** button; restart playing the record and stop it again at a position of interest and click the **Stop** button.

Click the Extract button to extract and save that file segment.

4.4.6. Data Logging

The data logging function is used to output data to a text file. This file can be imported in a software application, such as Microsoft Excel, for offline analysis.

The duration of the logging is indicated in the status bar.

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

Table 12: Data Log Field Description

Time (msec)	Segment [Always 1]	Amplitude [0 128]	Distance (m)	Status
422530	1	127.42	6.95	1

- The time of the detection is 422530 milliseconds from the time the sensor was started.
- The location of the detection is segment 1.
- The amplitude of the detection is 127.42, which is very high (big, near, or reflective object). Note: Typically, the range of amplitude is between 0 and 128 but if the signal is saturated, the range can exceed 128.
- The distance of the detection is 6.95 meters.
- The status is always 1.

To use the data logging function:

1. On the **Settings** menu, click **Start Data Logging...**

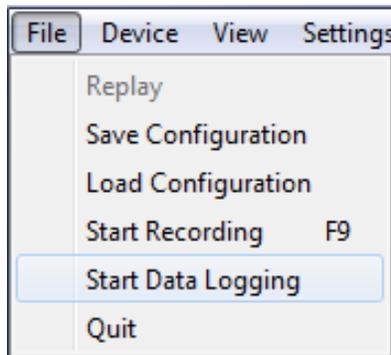


Figure 23: Setting Menu

2. In the **Directory** dialog box, click the browse button to select the path where you want to save the log and click **OK**.

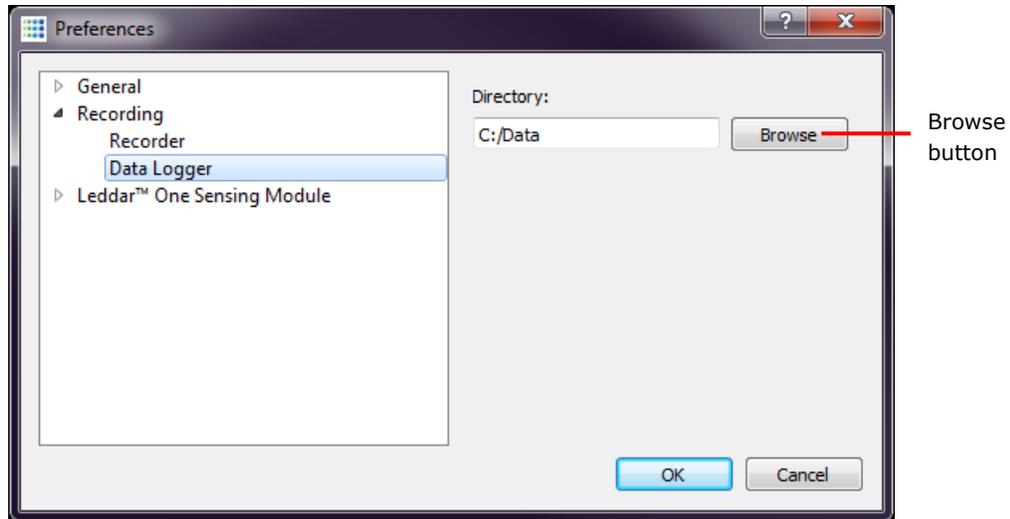


Figure 24: Data Log Setting Dialog Box

3. On the **File** menu, click **Start Data Logging**.



Figure 25: File Menu

4. To stop recording, on the **File** menu, click **Stop Data Logging**.

A .txt file is saved in the selected directory

4.4.7. Raw Detection

The **Raw Detections** dialog box allows you to view detection values in many ways. It provides filters to isolate detection parameters.

To open the **Raw Detections** dialog box, on the **View** menu, click **Raw Detections**. **Figure** presents an example of raw detections. Only the detections that meet the amplitude and distance settings appear in the list.

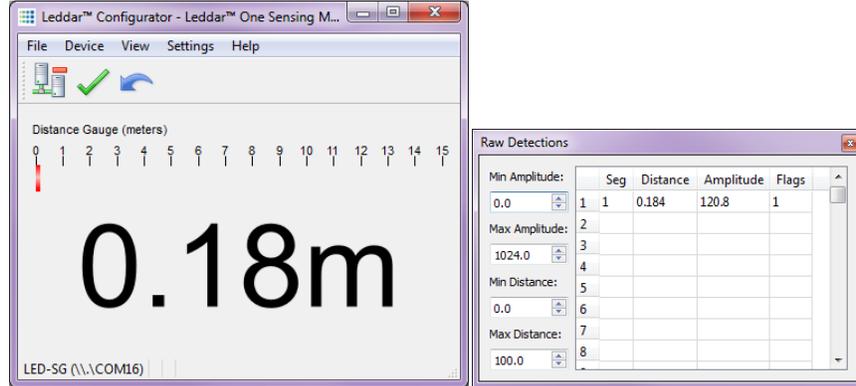


Figure 26: Example of Raw Detection Dialog Box

The following is a description of the parameters available in the **Raw Detections** dialog box.

Min and Max Amplitude

The value entered in the **Min Amplitude** box will filter detections with amplitude lower than that value. For example, if the minimum amplitude is set to 5, only the detections with amplitude of 5 and more will be displayed.

The value entered in the **Max Amplitude** box will filter detections with an amplitude lower than that value. For example, if the maximum amplitude is set to 8, only the detections with amplitude of 8 and lower will be displayed.

Min and Max Distance

The value entered in the **Min Distance** box will filter detections at a distance smaller than that value. For example, if the minimum distance is set to 10, only the detections at a distance of 10 and more will be displayed.

The value entered in the **Max Distance** box will filter detections at a distance greater than that value. For example, if the maximum distance is set to 20, only the detections at a distance of 20 and less will be displayed.

Segment Column

The **Segment** column lists the segment for which there is a detection according to the filters used. The segment numbers are read from left to right starting at 1. Since the Leddar™One sensor has only 1 segment, this value will always be one.

Distance and Amplitude Columns

The **Distance** column displays the distance of the detection and the **Amplitude** column displays its amplitude.

Flag Column

The **Flag** column displays a number that represents a detection type.

See section 3.2 for a description of the measurements data including flags.

4.4.8. Update

This option allows you to update the firmware in your sensor. It should be used only under the supervision of a LeddarTech support technician.

4.4.9. Preferences

Preferences are used to change various settings related to the display of the Leddar™ Configurator software.

The **Preferences** dialog box is opened by clicking the **Preferences** command on the **Settings** menu.

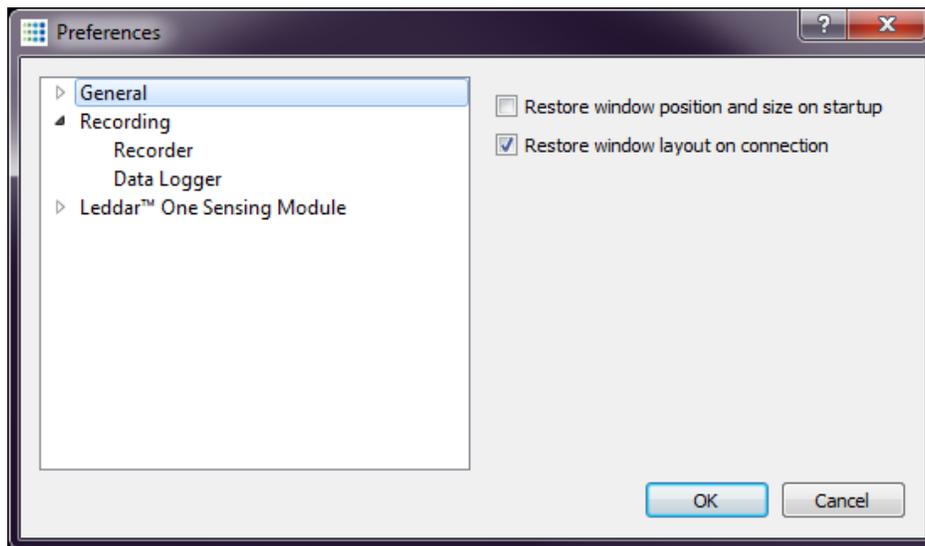


Figure 27: Preference Dialog Box

Under **General** → **Windows**, click on “**Restore window position and size on startup**” checkbox in order to keep the Leddar™ Configurator position and size on startup or click on “**Restore window layout on connection**” in order to keep the Leddar™ Configurator layout on connection.

Under **General** → **Leddar™ One Sensing Module**, some parameters of the main window can be modified.

Select “**Show all detections**” in order to display multi-detection in the distance gauge.

4.4.10. License Manager

Some features need an activation key. Contact LeddarTech for more information.

4.4.11. Device State

Information about a device is accessible by clicking the **Device State** command on the **View** menu.

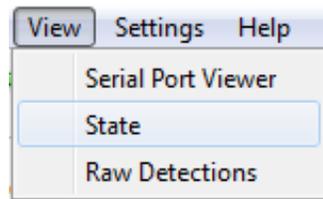


Figure 28: View Menu

The **Device State** window opens.

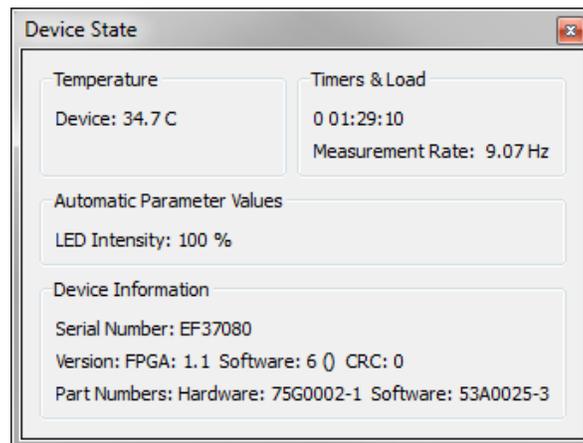


Figure 29: Device State Window

Temperature

This section indicates the temperature of the device.

Timers & Load

This feature gives the time in days, hours, minutes, and seconds since the last sensor was started and also gives the actual measurement rate.

Acquisition State

This section gives the current intensity of the LED. It is particularly useful when the device is set in automatic LED intensity, since the user can see the intensity selected by the sensor.

Serial number

The serial number of the device as assigned by LeddarTech.

Versions

- FPGA: The firmware version of the device.
- Software: The software version of the device.

Part numbers

This provides the hardware and software part numbers of a device as assigned by LeddarTech

4.4.12. Calibration of the Static Noise

The static noise of the sensor can be calibrated by the user. This feature is available with the integrator license available on request by contacting LeddarTech customer service. See Section 4.4.10 to have more details about how to add a new license to Leddar™ Configurator.

NOTE: *When the calibration is completed, the user cannot roll back to the factory calibration.*

To perform the calibration, a shield must be beforehand installed on the reception optics to block scattered light as it is shown in the following figure:



Figure 30: LeddarOne™ with Light Shielding Installed on its Lens

If the light shield is not correctly installed, a warning message will be prompted to the user before the execution of the calibration. This message can be ignored to continue the calibration process. The message should be ignored only if the user wants to improve the accuracy when the sensor is used inside a custom enclosure. For instance, a glass located in front of the sensor can create light reflections degrading the sensor accuracy. The impact of these reflections can be attenuated using the static noise removal algorithm. Thereafter, under **Device** → **Calibrate**, click on **“Calibrate...”**

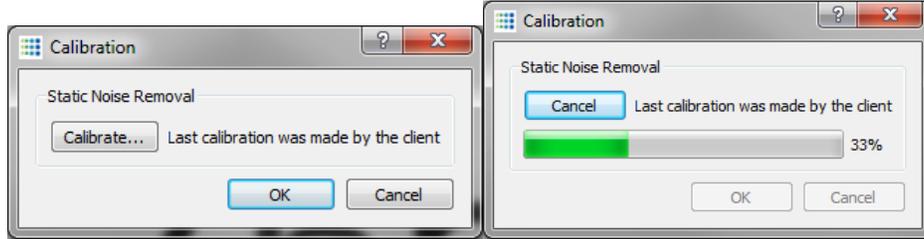


Figure 31: Calibration Window

A progress bar will show the progression of the calibration. It should take about 1 minute to execute the calibration. The calibration can be canceled at any time by clicking on “**Cancel**.”

5. Specifications

5.1. General

Table 13: General Specifications

LED pulse rate	72.131 kHz
Photodetector size	1 mm ²
Measurement rate	2.2, 4.4, 8.8, 17.6, 35.2, 70.4 Hz.
3.3V UART link	2-wire, half-duplex, 9600 to 115200 BPS
RS-485	2-wire, half-duplex, 9600 to 115200 BPS
Operating temperature	-45 °C to +85 °C

5.2. Mechanical

Table 13: Mechanical Specifications

Diameter	50.8 mm
Depth	30.6 mm
Weight	14 g

5.3. Electrical

Table 14: Electrical Specifications

DC supply voltage	5 V
Power consumption (fully active, 100% LED intensity)	1.3 W

5.4. Optical

Table 15: Optical Specifications

Beam (half-angle @ 50%)	3°
Wavelength	850 nm (near infrared)

5.5. Performance

Table 16: Sensor Performance Summary

Performance Metrics	Values	Descriptions
Measurement Accuracy*	±5 cm	Distance measurement error.
Measurement Accuracy with Saturated Signal	±10 cm	-
Measurement Precision	5 mm (1 σ)	Standard deviation of the measured distance.
Resolution**	3 mm	Smallest distance variation detected by the sensor
Range (maximum LED intensity)	See Figure 34	-
Distance Measurement Settling Time on Cold Startup	< 10 s	-

* Using a target returning a signal stronger than 5 counts.

** Measured with a 5x7 cm reflective tape installed at 10 m from the sensor.

5.5.1. Accuracy

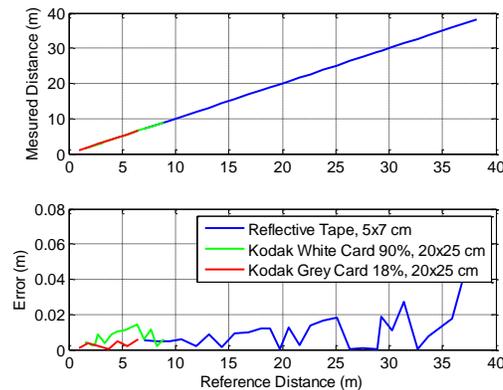


Figure 32: Accuracy versus Target Reference Distance (accumulation 256 and oversampling 8)

5.5.2. Supply Voltage Versus Accuracy

Figure 33 shows the distance measurement offset as a function of the sensor supply voltage.

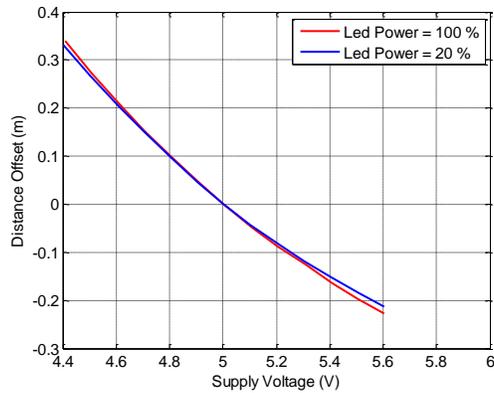


Figure 33: Accuracy versus Supply Voltage

5.5.3. Range

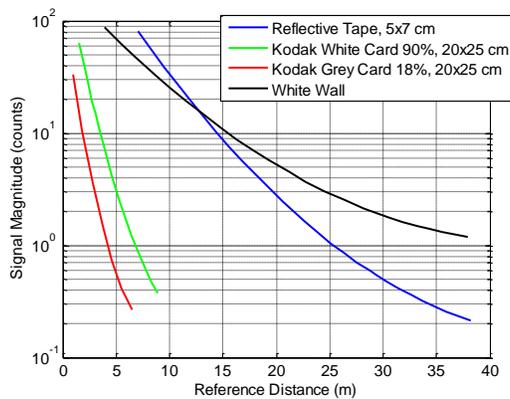


Figure 34: Signal Amplitude versus Target Reference Distance (accumulation 256 and oversampling 8)

5.5.4. Detection Threshold

The detection threshold tables are designed to provide robust detections and to minimize false detections caused by noise in the full-waveform signal. They are presented in Figure 35.

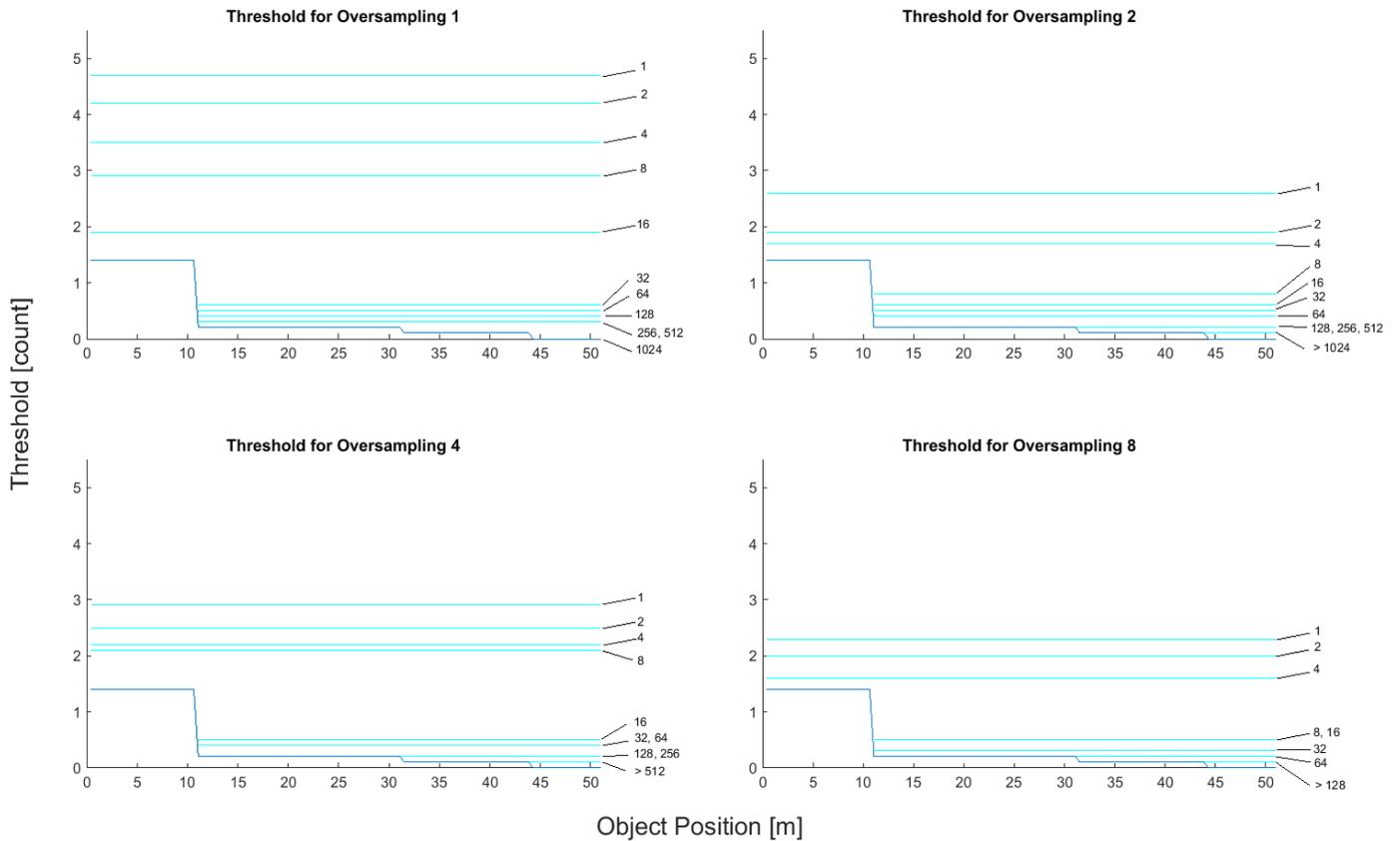


Figure 35: Threshold Tables

The multiple lines on each graph present the thresholds for a number of accumulations of 1 (top curve), 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048 and 4096 (bottom curve).

5.6. Regulatory Compliance

Table 17: Regulatory Compliance

Test Name Standards	Test Specifications	Performance Criterion	Results
Radiated Emissions FCC part 15 (2013) subpart B	Class A 30 MHz-1 GHz	N/A	Pass
Radiated Emissions CISPR11 (2009) A1 (2010)	Group 1 - class A 30 MHz-1 GHz	N/A	Pass
Radiated Emissions ICES-003 (2012)	Class A 30 MHz-1 GHz	N/A	Pass
Electrostatic Discharge Immunity IEC61000-4-2 (2008)	Contact: ± 4 kV Air: ± 8 kV	B	Pass
Radiated Electromagnetic Field Immunity IEC61000-4-3 (2006) A1 (2007) A2 (2010)	80 MHz-1000 MHz: 10 V/m 1.4 GHz-2 GHz: 3 V/m 2 GHz-2.7 GHz : 1 V/m	A	Pass
Power Frequency Magnetic Field Immunity IEC61000-4-8 (2009)	Continuous Field: 30A/m / 50 Hz & 60 Hz	A	Pass

Note: Testing results are valid for cable length less than 3 meters.

5.7. Dimensions

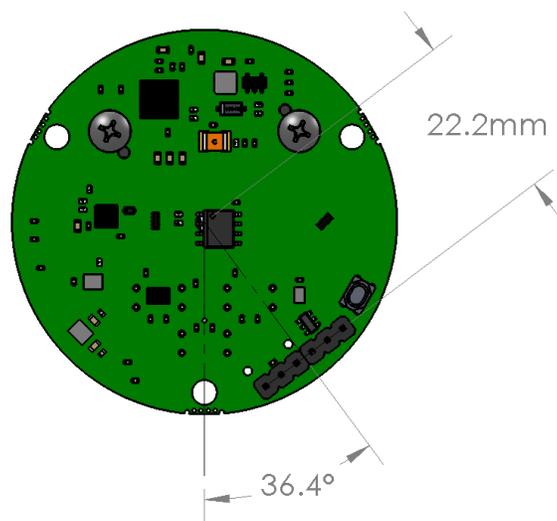
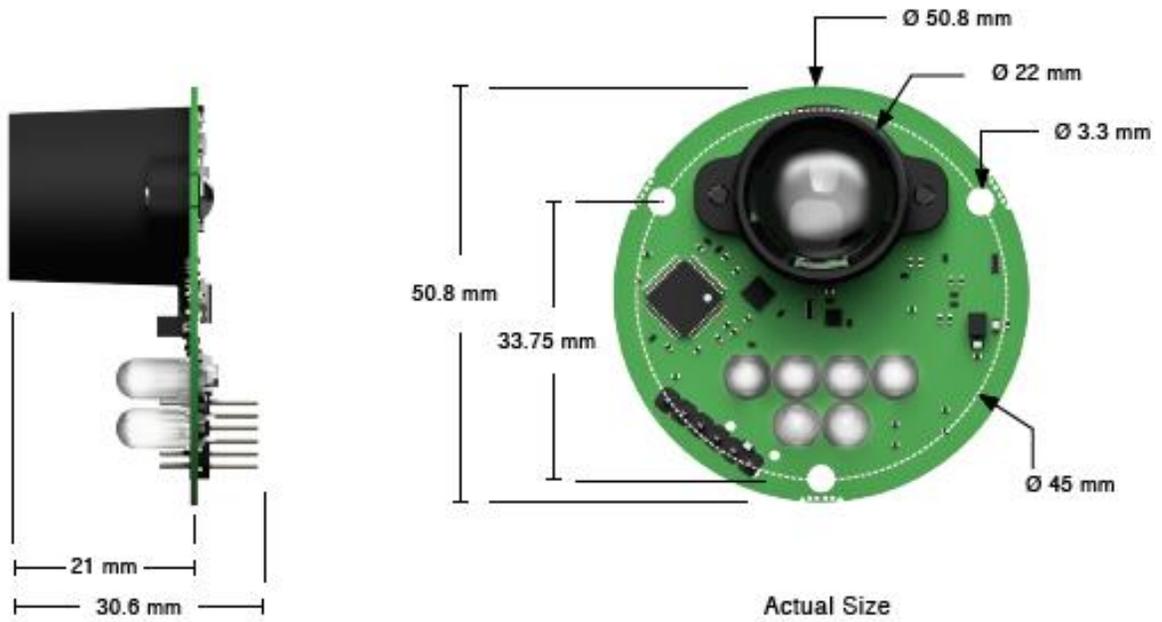


Figure 36: Dimensions

6. Technical Support

For technical inquiries, please contact LeddarTech® technical support by registering online at www.leddartech.com/support to easily:

- Follow up on your requests
- Find quick answers to your questions
- Get valuable updates

Or by contacting us at:

+ 1 418 653-9000

+ 1 855 865-9900

8:30 a.m. - 5:00 p.m. Eastern Standard Time

To facilitate the support, please have in hand all relevant information such as part numbers, serial numbers, etc.

E-mail: support@leddartech.com

LeddarTech
4535, boul. Wilfrid-Hamel, #240
Québec, QC G1P 2J7
CANADA

www.leddartech.com

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