LeddarVu

8-Segment Solid-State LiDAR Module

USER GUIDE

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1. Introduction

The LeddarVu module enables developers and integrators to make the most of Leddar™ technology through integration in detection and ranging systems. The purpose of the LeddarVu module is to easily and rapidly be integrated in various applications.

The module can be configured to be used in very simple applications or to perform more complex tasks depending on the hardware and software settings.

1.1. Description

The LeddarVu module contains the following:

- Source and control assembly
- Receiver assembly

The module comes in two configurations:

1. SPI
2. USB, CAN and SERIAL

Depending on your configuration, they offer the following features:

- Horizontal field of view (FOV): 16°, 47.5° and 98.5°
- Vertical field of view (FOV): 0.3°, 2.25° and 3°
- 8 detection segments
- Real-time data acquisition and display (through SPI)
- SPI (Serial Peripheral Interface) for the direct link with the receiver (SPI carrier board)
- I2C interface to read the optional temperature sensor on the source module (SPI carrier board)
- Serial link interface: TTL, RS-232, RS-422, and RS-485 (USB, CAN and SERIAL carrier board)
- USB interface (USB, CAN and SERIAL carrier board)
- CAN bus interface for acquisition (USB, CAN and SERIAL carrier board)

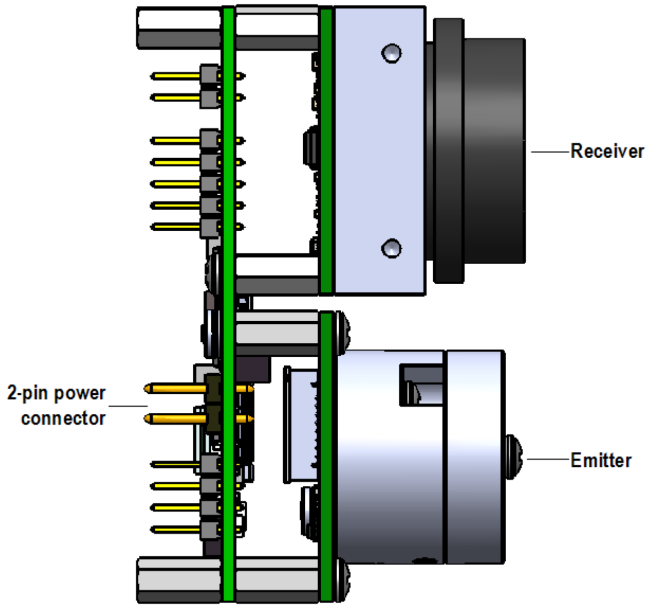


Figure 1: General elements of the LeddarVu module

Receiver assembly

The receiver assembly contains the photodetector array (8 elements), the circuit receiver, and a processor (MCU).

The module generates a full waveform per segment at its measurement rate.

NOTE: Lens coating color for 47.5° configuration may change from one sample to another from greenish to bluish, but the inherent properties of the lens are not affected in the field of application of this product.

Emitter assembly

The emitter assembly includes the emitter (LED, VSCEL, or laser), the emitter driver circuit, and the temperature sensor.

Light source pulsing is controlled by the receiver assembly since the receiver data acquisition must be synchronized with the light source pulses. The temperature sensor, located near the light source, is used to implement temperature compensation on the ranging results.

Power connection

The power connection is a 2-pin connector that provides the module with a 12 V power source.

1.2. SPI Carrier Board

The following presents the description of the SPI board.

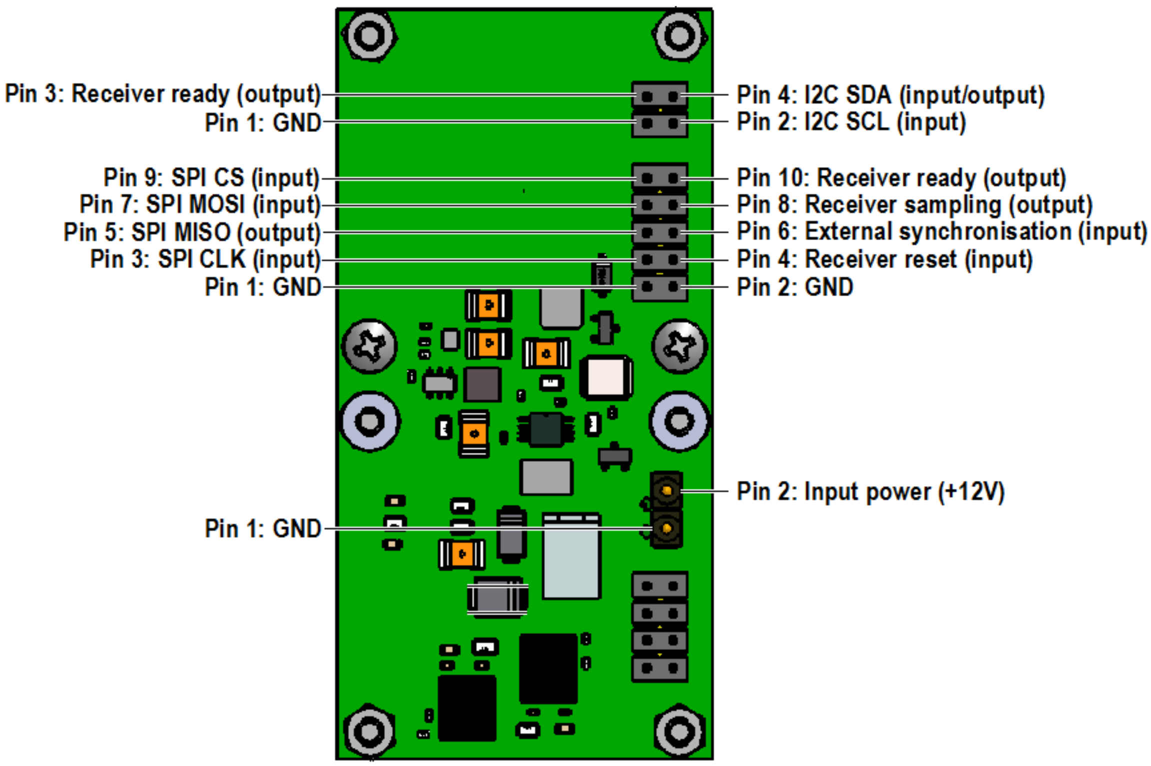


Figure 2: Board of the SPI LeddarVu module

NOTE: Power outputs can supply up to 15 mA.

1.3. USB, CAN and SERIAL Carrier Board

The following presents the description of the USB, CAN and SERIAL board.

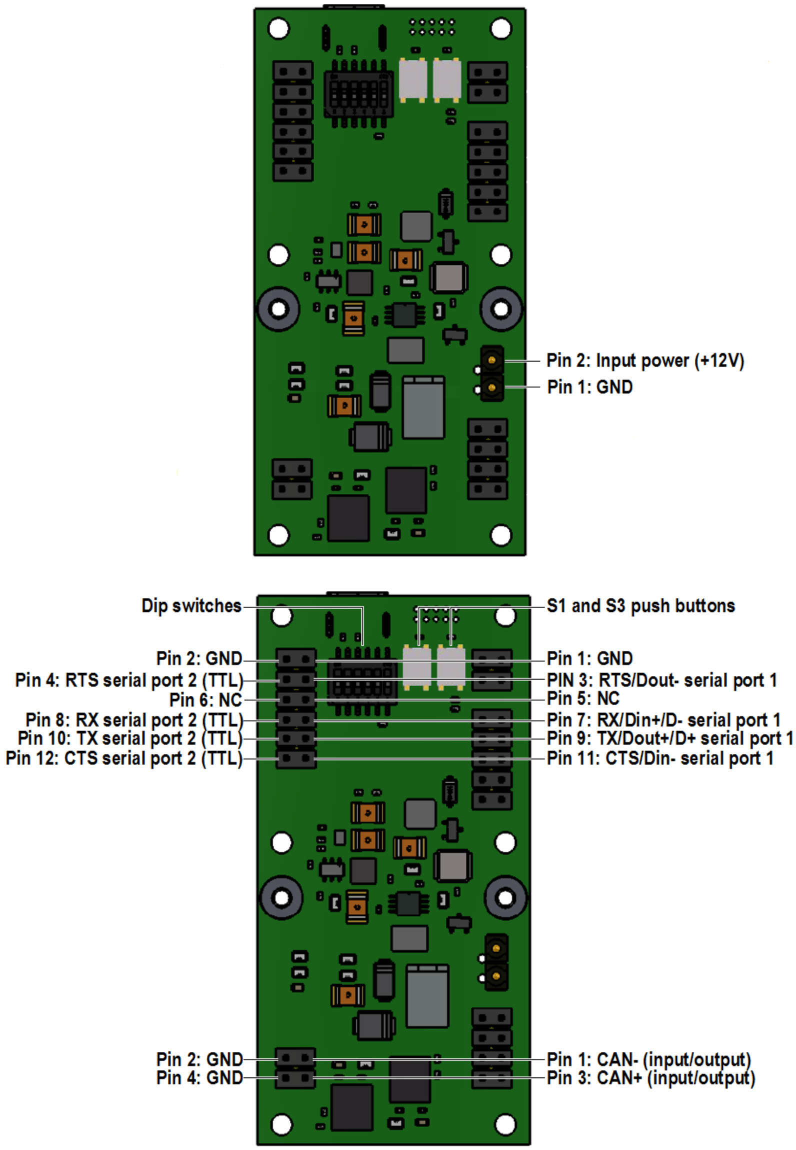


Figure 3: Board of the USB, CAN and SERIAL LeddarVu module

NOTE: Power outputs can supply up to 15 mA.

DIP Switches

The DIP switches are used for the configuration of the serial port number 1. This port is configurable to these EIA electrical interfaces for the following standard serial communication ports:

- RS-232
- RS-485 two-wire configuration
- RS-422/RS-485 four-wire configuration

Table 1: Communication port configuration (for 6 positions DIP switch)

Interface	DIP switch position					
	1	2	3	4	5	6
RS-232	OFF	OFF	ON	OFF	OFF	X
RS-485 two-wire configuration	ON	ON	OFF	ON	ON	X
RS-422 **RS-485 four-wire configuration**	ON	OFF	ON	OFF	OFF	X

NOTE: On all port configurations, the module is still a half-duplex slave.

Table 2: Communication port configuration (for 8-position DIP switch)

Interface	DIP switch position							
	1	2	3	4	5	6	7	8
RS-232	OFF	ON	OFF	OFF	OFF	X	X	X
RS-485 two-wire configuration	ON	OFF	ON	ON	ON	X	X	X
RS-422 **RS-485 four-wire configuration**	ON	ON	OFF	OFF	OFF	X	X	X

NOTES:

- DIP switch position 6 on **'ON'** position enables a 121Ω termination resistor to RS-485 two-wire configuration only (must be kept on 'OFF' position in any other configuration).
- DIP switch position 8 on **'ON'** position enables a 121Ω termination resistor to CAN port.

Configurable serial link 1

Depending on the DIP switch positions, the configurable serial link pin functionalities differ (refer to Table 3).

Table 3: Communication link configuration

Pin position	**Interface**		
	RS-232	RS-485 two-wire configuration	RS-422 RS-485 four-wire configuration
1	GND	GND	GND
3	RTS	D -	Dout -
5	NC	NC	NC
7	RX	D -	Din +
9	TX	D +	Dout +
11	CTS	D -	Din -

NOTE: If a two-wire or four-wire differential port configuration is selected, in function of your network configuration, you should put bias resistors on transmitter or receiver lines to maintain the proper idle voltage and force the line to the idle condition.

Push buttons

The S1 push button is used for a hard-reset purpose; a short press resets the module.

The S3 push button is used for special purposes (refer to Table 4).

Table 4: S3 push button functionalities

Description	Action
Long press during module operation (longer than 10 seconds)	Resets the carrier board configuration to the default values: CAN port configuration • 1Mbsp, standard frame format • Base Rx: 0x740 • Base Tx: 0x750 • No delay • Distance in cm and a max. of 96 echoes Serial link configuration • 115,200 bps, 8 bits, no parity, no flow control, 1 stop bit • Distance in cm and a max. of 40 echoes • Modbus address: 1
Press the S3 button for more than 2 seconds during startup (or after a hard reset)	Put the USB, CAN and SERIAL carrier board in bootloader mode. This feature is used to upgrade the USB, CAN and SERIAL carrier board firmware. Use the LeddarTech software tool to upgrade firmware.

1.4. Working Diagram

The working diagram explains how the module works in the standard and optional configurations.

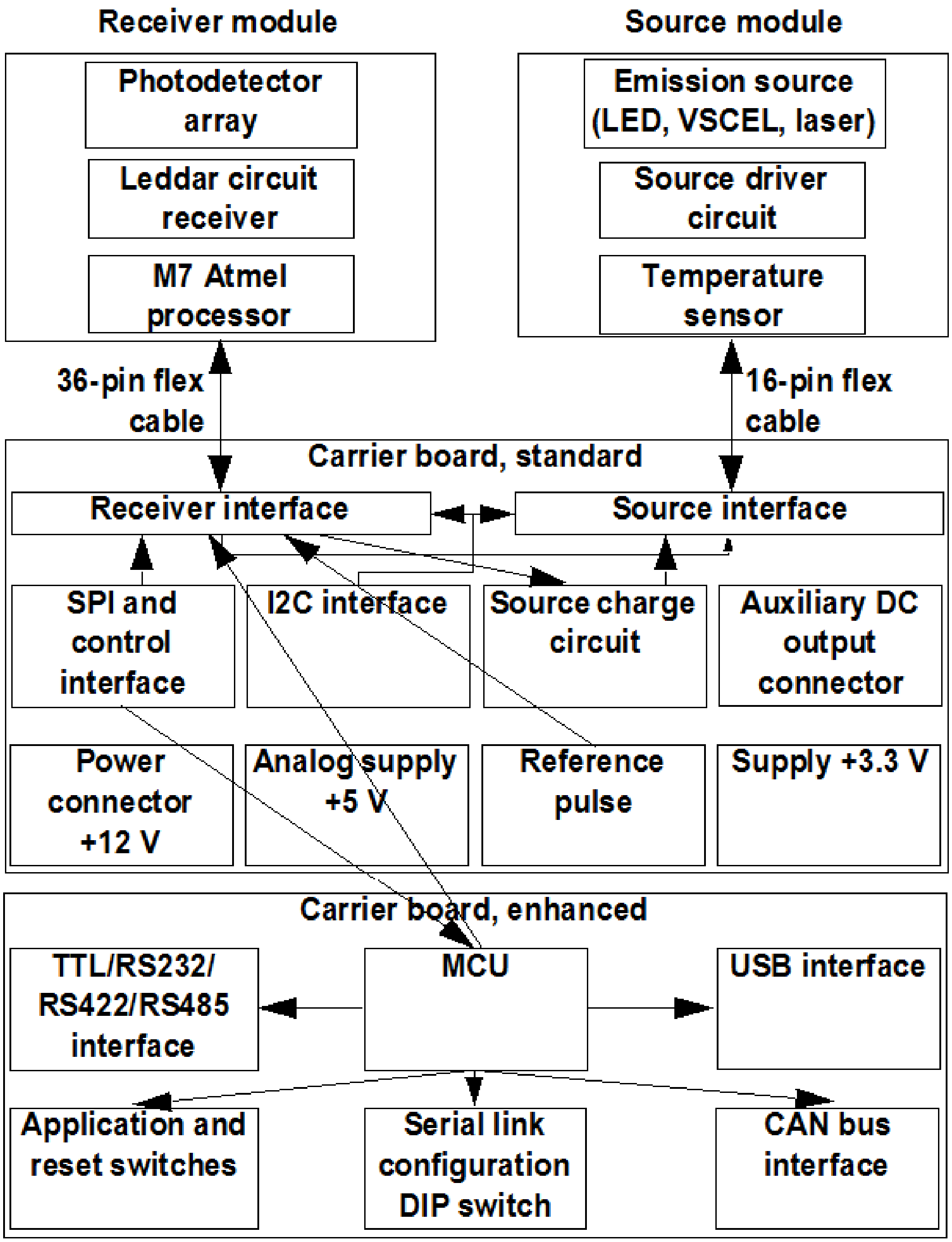


Figure 4: LeddarVu module working diagram

1.4.1. SPI Carrier Board

The SPI carrier board includes the following elements:

SPI and control interface

The SPI serial port functionalities are available via pins 3, 5, 7, and 9. The port has a standard signal level of 0 V through 3.3 V.

Table 5: SPI pin definition

Pin	Function
3	CLK (input)
4	Hard-reset (input)
5	MISO (output)
7	MOSI (input)
9	CS (input)

I2C interface

The integrated circuit (I2C) protocol is intended to allow multiple slave digital circuits to communicate with one or more master circuit. As for the SPI, it is only intended for short distance communications. The port has a standard signal level of 0 V through 3.3 V.

Power supply

The power source includes the source, the auxiliary DC output connection, the +12 V connection, the +5 V analog supply, and the +3.3 V supply.

1.4.2. USB, CAN and SERIAL Board

The optional carrier board includes the standard elements and the following ones:

Serial ports (TTL, RS-232, RS-422, and RS-485)

The TTL port is used for the short-range transmission of data. The port has a standard signal level of 0 V through 3.3 V.

The RS-232 is used for the transmission of data. It defines the signals connection between the data terminal equipment (such as a computer) and the data circuit-terminating equipment (such as a modem).

The RS-422 (ANSI/TIA/EIA-422-B), a four-wire configuration, specifies the electrical characteristics of the digital signaling circuit. It can transmit data at rates as high as 10 Mbit/s or may be sent on cables as long as 1500 meters. Some systems directly interconnect and may be used to extend the range of an RS-232 connection.

The RS-485 (ANSI/TIA/IEA-485) is a two-wire or four-wire differential serial communication port. It is often used in electrically noisy environments.

Microcontroller MCU

The source and control assembly are equipped with an MCU on the carrier board. It is provided to transmit data from the receiver module through the communication ports.

USB interface

The USB interface is a compatible 2.0, full-speed 12-MBit/s port. This interface emulates a VCP (virtual COM port) used as a serial port.

Application and reset switch

The reset switch restarts the module. This can be used as an alternative to cycling the power.

Serial link configuration DIP switches

The source and control assembly is equipped with ten DIP switches. Five of them are used to configure serial link 1 (see Figure 2 and Figure 3).

CAN bus interface

The CAN bus is implemented via a differential pair. The ISO 11898 standard describes the CAN technology. The interface has a level of 3.3 V.

2. Underlying Principles

Created by LeddarTech, LEDDAR™ (light-emitting diode detection and ranging) is a unique sensing technology based on light (infrared spectrum) and the time-of-flight of light principle. The light source illuminates the area of interest (pulsed typically at 10 kHz for the LeddarVu8 47.5° module) and the multichannel module receiver collects the backscatter of the emitted light and measures the time taken for the emitted light to return back to the module.

An 8-channel photodetector array is used and provides multiple detection and ranging segments. Full-waveform analysis enables detection and distance measurement of multiple objects in each segment, provided that foreground objects do not fully obscure objects behind them. Oversampling and accumulation techniques are used to provide extended resolution and range.

Figure 5 illustrates the illumination area and detection segments. In this case, the 8 segments provide a profile of the object in the beam. In other installations, the channels can be used to locate and track one or multiple objects in the beam.

Figure 5: 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.

3. Getting Started

This chapter presents the steps to install Leddar™ Configurator and start using the LeddarVu.

3.1. Optional Power Supply

The power supply included with the Starter Kit version of the LeddarVu8 has a pluggable terminal block that connects to the 12V header connector of the LeddarVu sensor. Location of the 12V header pin can be found on Figure 2 (LeddarVu SPI) or Figure 3 (LeddarVu USB, UART, CAN Bus).

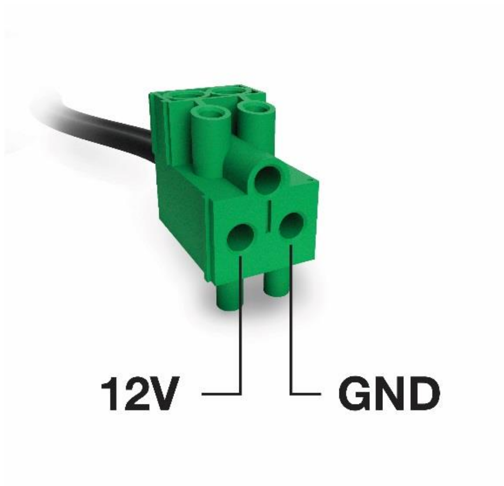


Figure 6: Optional Power Supply Terminal Block

3.2. Optional SPI cable

The table below shows the pinout of the optional SPI cable sold by LeddarTech. Refer to Figure 2 for connection information.

Table 6: Optional SPI Cable Pinout

Wire Color	Function
Black	Ground
Blue	Reset_N
Orange	SCLK
Green	MISO
Yellow	MOSI
Brown	CS#

3.3. Setup

This section presents the Leddar™ Configurator installation and the procedure to set up the LeddarVu module. All software operations are described in chapter 6.

To install Leddar™ Configurator:

1. Download the LeddarInstaller.exe file from our Web site at http://support.leddartech.com/login.
   a. If you are a new user, fill the form and click Submit.
   b. If you are a registered user, login by entering your e-mail address and password, and click Log In.
2. In the Download section, click a product and then click LeddarInstaller.exe. Double-click the file to start the installation.
3. On the computer desktop, double-click the **Leddar™ Configurator** icon.
4. In the **Welcome to the Leddar™ Software 3 Setup Wizard** dialog box, click **Next**.

Figure 7: Welcome to the Leddar™ Software 3 Setup Wizard dialog box

In the **End-User License Agreement** dialog box, read the terms of the agreement, select the **I accept the terms in the License Agreement** check box, and click **Next**.

Figure 8: End-User License Agreement dialog box

In the **Product Types** dialog box, the **Leddar™ Software Development Kit** check box is selected by default.

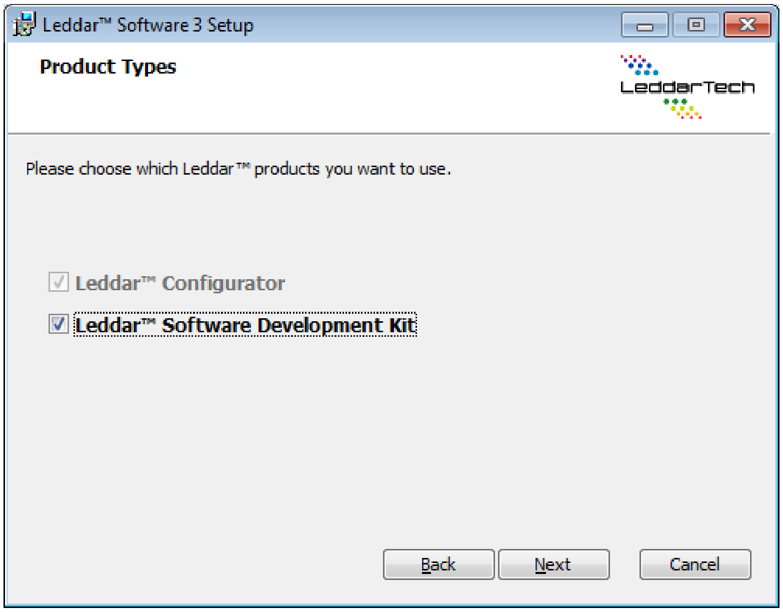


Figure 9: Product Types dialog box

1. Click **Next**.
2. In the **Destination Folder** dialog box, click **Next** to select the default destination folder.

   OR

   Click the **Change** button to choose a destination folder.
3. In the **Ready to Install Leddar™ Software 3** dialog box, click the **Install** button.
4. In the **Completed the Leddar™ Software 3 Setup Wizard** dialog box, click **Finish**.

Leddar™ Configurator creates an icon on the computer desktop.

3.4. Connecting to the LeddarVu Module

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

Once the installation is completed, you can connect to the LeddarVu module to create your configuration.

To connect to the module:

1. Connect the power cable to the module and to a power source.
2. Connect the USB cable to the module and to the computer.
3. On the computer desktop, double-click the Leddar™ Configurator icon.
4. In Leddar™ Configurator, click the connect button .

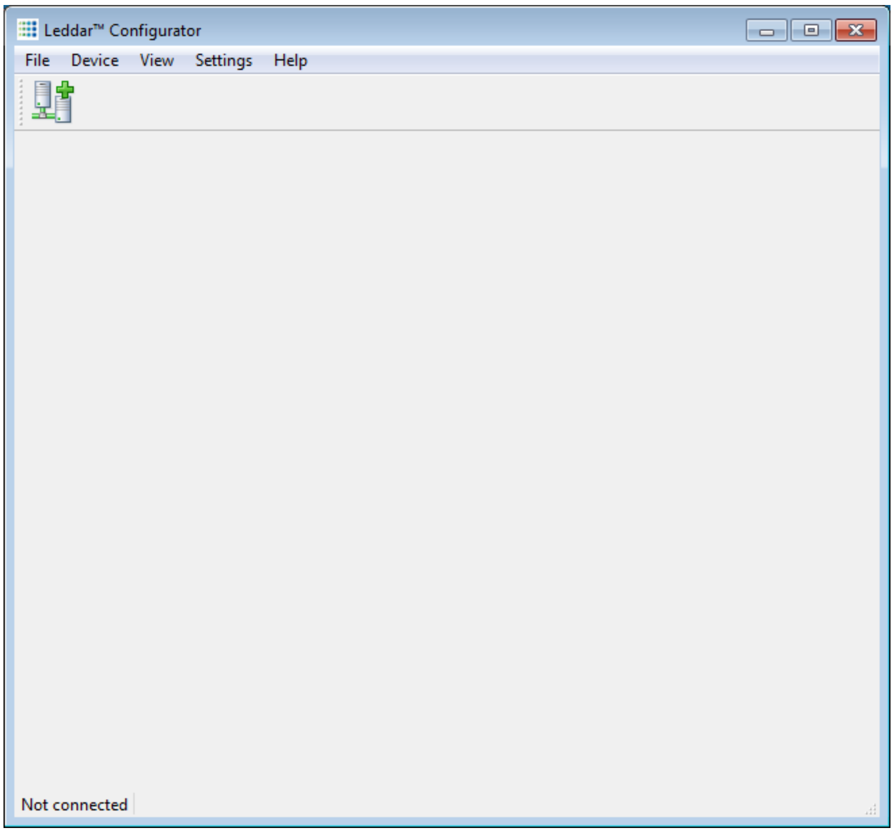


Figure 10: Connecting to a module

5. In the **Connection** dialog box, in the **Select a connection type** list, select either **LeddarVu SPI** for a standard board or **LeddarVu Serial** for an USB, CAN and SERIAL.

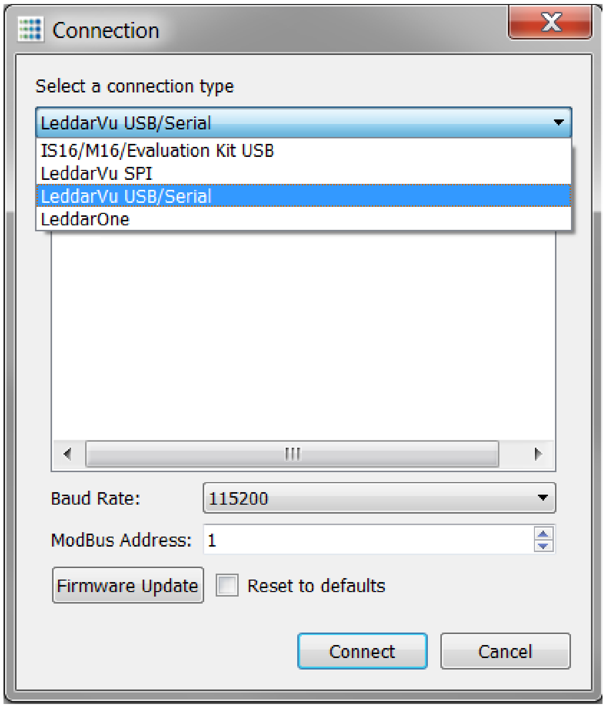


Figure 11: Connection dialog box

6. In the **Available ports** list, select the product and click the **Connect** button.

The main window displays the detections (green lines) in the segments (white lines).

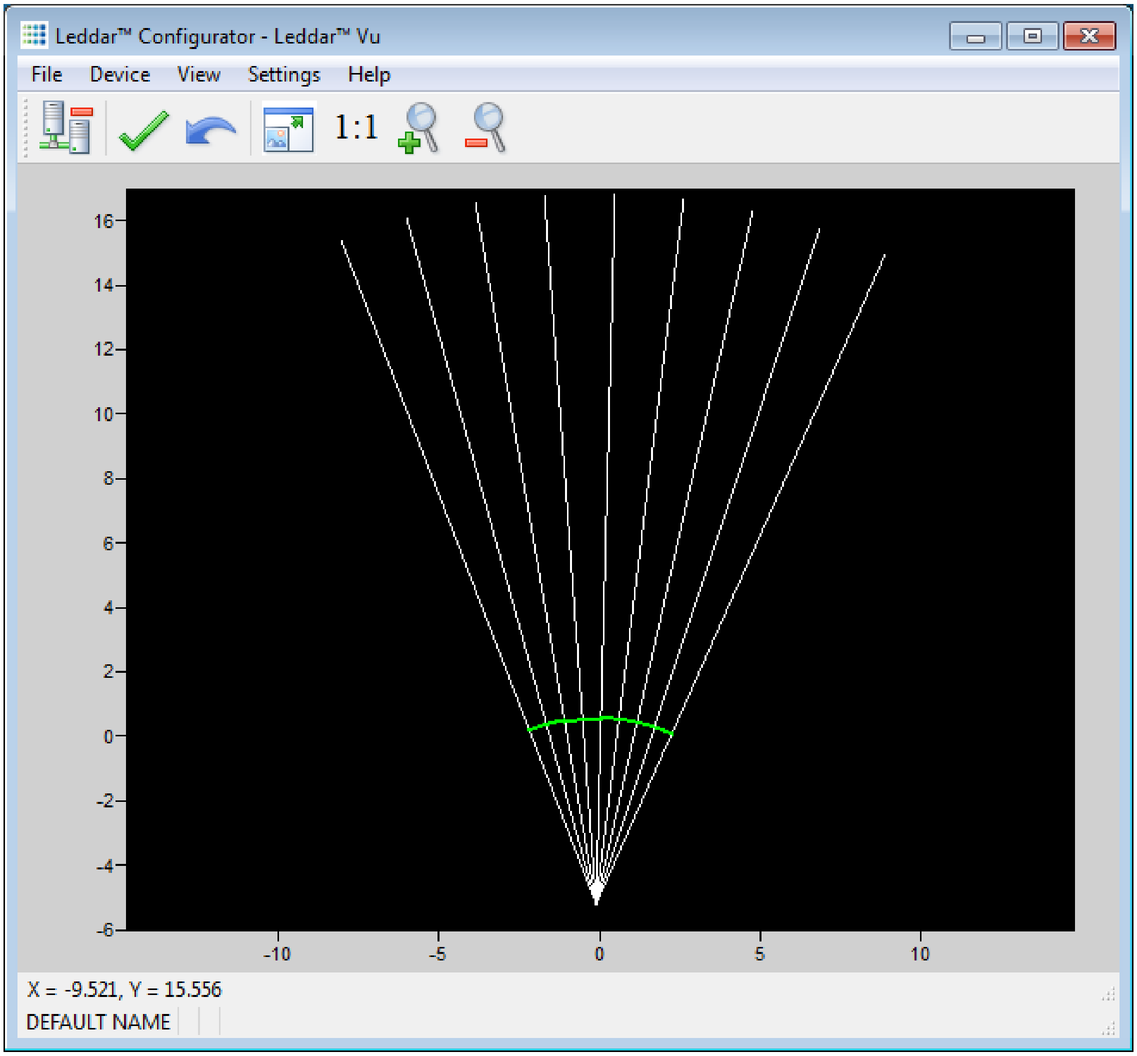


Figure 12: Main window

A complete description of Leddar™ Configurator features and parameters for the LeddarVu module can be found at chapter 6.

NOTE: Refer to Section 6 Leddar™ Configurator for details on how to use the software.

4. Measurements and Settings

This chapter presents measurements, settings, and zone definition for the LeddarVu module.

4.1. Distance Measurement

Distance is measured from the base of the standoffs for the LeddarVu module.

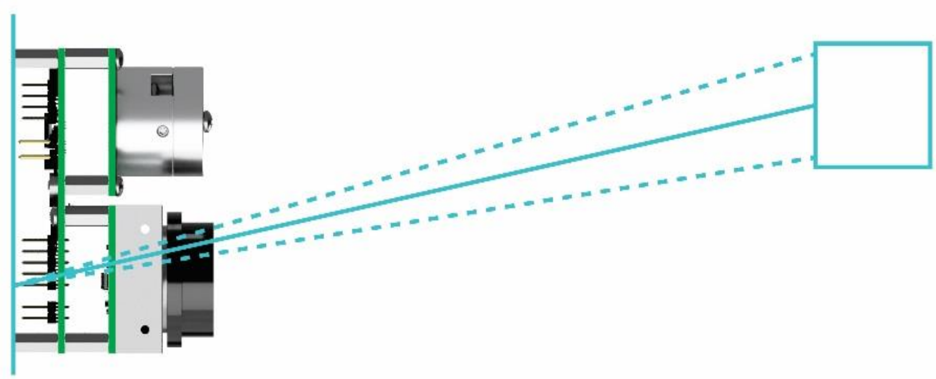


Figure 13: Distance measurement

The dashed lines illustrate 1 of the 8 segments and the solid line indicates the distance measured by the module in that segment.

4.2. Data Description

Data displayed in the **Raw Detections** dialog box allow the user to precisely define the desired detection parameters (**View** menu > **Raw Detections**).

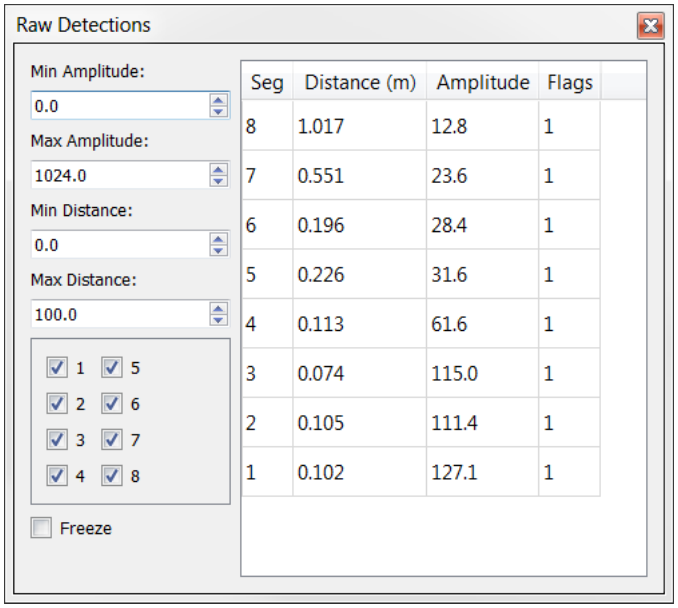


Figure 14: Raw Detections dialog box

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

The amplitude is expressed in counts. A count is the unit value of the used ADC in the receiver. The fractional of counts is caused by the accumulation to get more precision.

Table 7: Raw detection table description

Field	Description
Segment (Seg)	Beam segment in which the object is detected.
Distance	Position of the detected object.
Amplitude	Quantity of light reflected by the object and measured by the module.
Flags	8-bit status (bit field). See Table 8.

The **Flag** parameter provides the status information that indicates the measurement type.

Table 8: Flag value description

Bit position	Bit = 0	Bit = 1
0	Invalid measurement	Valid measurement
1	Normal measurement	Measurement is the result of demerge processing
2	Reserved	Reserved
3	Normal measurement	Received signal is above the saturation level. Measurements are valid (VALID is set) but have a lower accuracy and precision. Consider decreasing the light source intensity.
4	Reserved	Reserved
5	Reserved	Reserved
6	Reserved	Reserved
7	Reserved	Reserved

The **Flag** field provisions for 8 bits encoded as a bit field. Three bits are currently used. The following table presents the implemented decimal values of the status bit field.

Table 9: Status value description

Status value (decimal)	Status value (binary)	Description
1	00000001	Normal measurement (valid)
9	00001001	Saturated signal (valid)

4.3. Acquisition Settings

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

To open the **Acquisition Settings** dialog box, select **Device > Configuration** > **Acquisition**.

4.3.1. General Settings

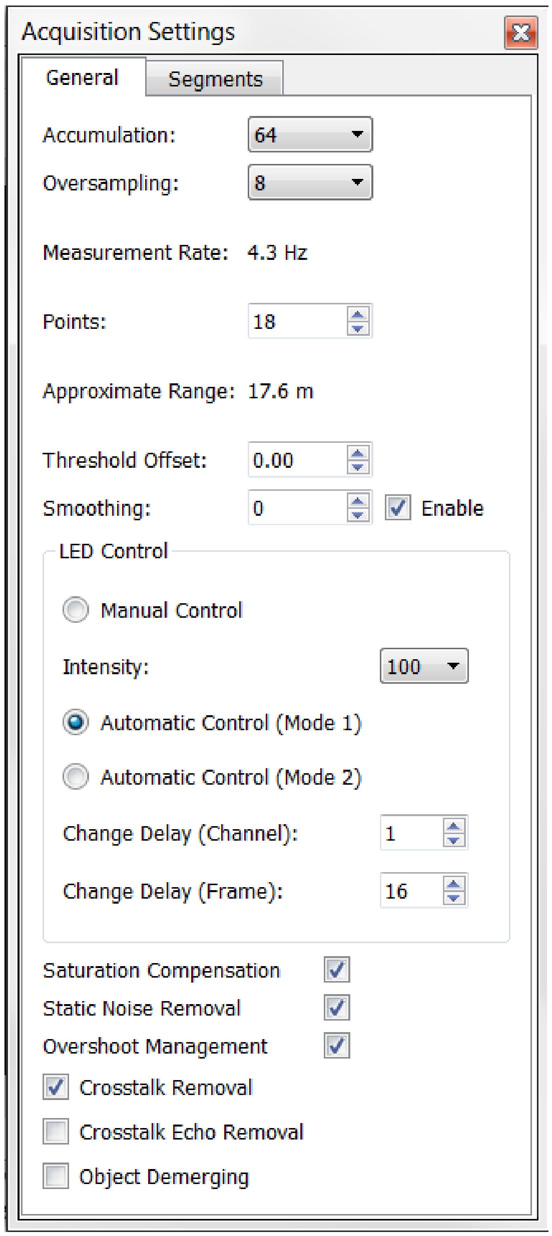


Figure 15: General tab – Acquisition Settings dialog box

To apply new acquisition settings, click .

Table 10: Acquisition settings description

Parameter	Description	Range
Accumulation	Number of accumulations. Higher values enhance the range and reduce the measurement rate and noise. When you increase the accumulation value, you reduce the noise as well as the measurement rate. Depending on your application, a reduction of the noise might be more important than a high measurement rate.	1 2 4 8 16 32 64 128 256 512 1024
Oversampling	Number of oversampling cycles. Higher values enhance the accuracy/precision/resolution and reduce the measurement rate. When you increase the accumulation value, you increase the resolution (accuracy) but you reduce the measurement rate. Depending on your application, a higher resolution might be more important than a high measurement rate.	1 2 4 8 16 32
Points	Number of base sample points. Determines the maximum detection range. The more points there are, the more they have an impact on the processing load since it impacts the number of sample points to process for each segment.	2 to 128

Parameter	Description	Range
Threshold Offset	Modification to the amplitude threshold. Higher values decrease the sensitivity and reduce the range. See below for more details.	−50.00 to 500.00
Smoothing	Object smoothing algorithm. Smooths the LeddarVu module measurements. The behavior of the smoothing algorithm can be adjusted by a value ranging from -16 to 16. Higher values enhance the module precision but reduce the module reactivity. The smoothing algorithm can be deactivated by clearing the **Enable** check box. The measurement smoothing 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 smoothing should be configured with a value lower than 0 or simply deactivated. See below for more details.	−16 to 16
Light Source Control	Light source power control options. Selects between manual and automatic power control. In automatic, light source power is adjusted according to incoming detection amplitudes. The current laser power level is visible in the **View > State > Device State** window. See below for more details.	100% 81% 53% 28% 6%
Change Delay (Channel and Frame)	Minimum delay between power changes. Smaller numbers speed up the response time of the light source power adjustment.	Channel: 0 to 8 Frame: Varies
Saturation Compensation	When selected, this parameter activates the advanced distance computation algorithm for very strong (saturated) signals. This computation uses slightly more computing power to enhance the quality of the distance measurements of saturated light pulses.	N/A
Static Noise Removal	When selected, this parameter enhances measurements by subtracting the constant electronic noise present at the beginning of signals.	N/A
Overshoot Management	When selected, this parameter improves the detection of false measurements caused by specific signal shapes. For example, this may occur when strongly reflecting objects are present in the field of view.	N/A

Parameter	Description	Range
Crosstalk Removal	Inter-segment interference noise removal. Crosstalk is a phenomenon inherent to all multiple segments time-of-flight sensors. It causes a degradation of the distance measurement accuracy of an object when one or more objects with significantly higher reflectivity are detected in other segments at a similar distance. This option enables an algorithm to compensate the degradation due to crosstalk. This algorithm increases the computational load of the LeddarVu module microcontroller. It is recommended to disable the crosstalk removal if the module is configured to run at rates higher than 50 Hz.	N/A
Crosstalk Echo Removal	When selected, this parameter can further increase accuracy by removing secondary echoes that might still be present in adjacent segments after applying the first stage of crosstalk removal.	N/A
Object demerging	Eases the discrimination of multiple objects in the same segment. Object demerging is only available for measurement rates under 5.0 Hz. Also, the accumulation value must be of 64 and the oversampling value of 8. The number of merged pulses that can be processed in each frame is also limited. A status field is available in the device state window (Leddar™ Configurator) indicating if the sensor processes all merged pulses. The measurement of demerged objects tends to be less precise than for usual detections. See below for more details.	N/A

Threshold offset

The threshold offset is a value that modifies the detection amplitude threshold.

A default detection threshold table was determined to provide robust detection and minimize false detections caused by noise in the input signal.

Figure 16 below presents the threshold table for a light source intensity of 16. This table is effective when the threshold offset value is 0.

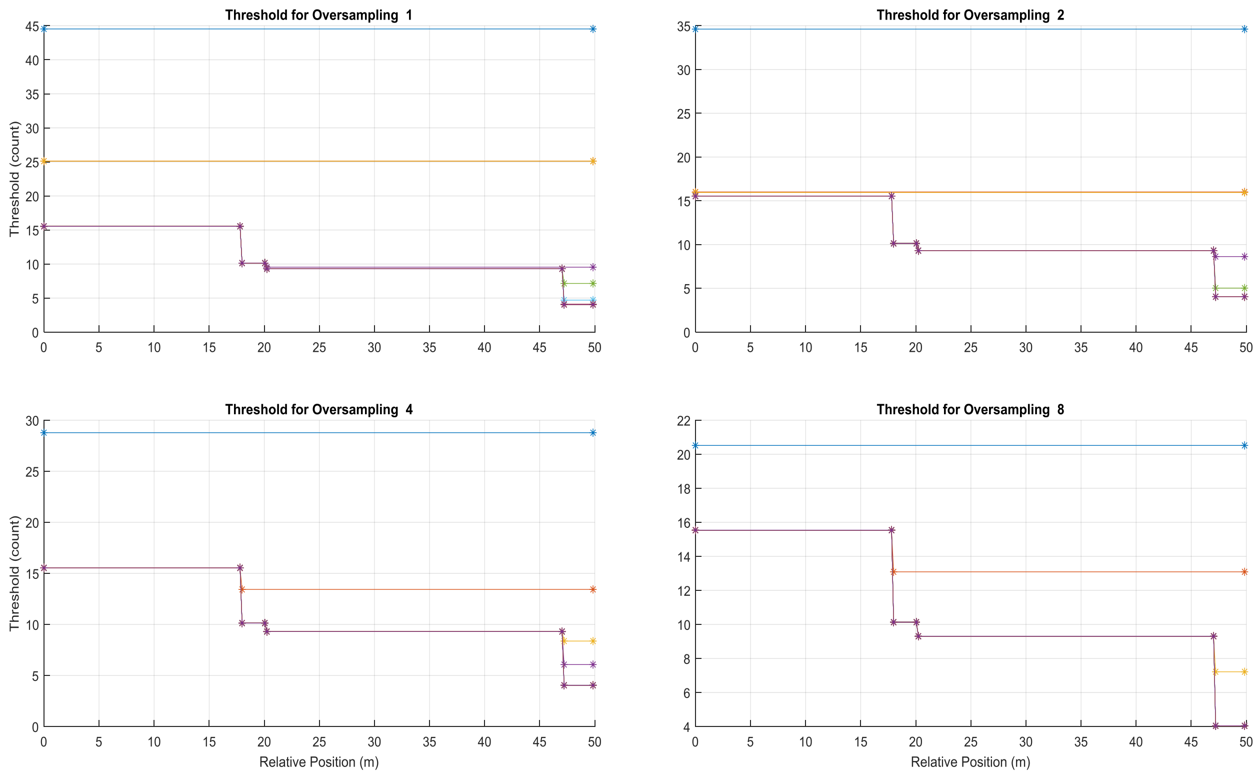


Figure 16: Detection threshold example

The multiple lines on each graph present the thresholds for numbers of accumulations of 1 (top curve), 2, 4, 8, 16, 32, 64, 128, and 256 (bottom curve). Accumulations of 512 and 1024 are also available, although not shown (provide the lowest thresholds).

The threshold offset parameter has the effect of offsetting each value in the threshold table by the selected value. This provides a means of reducing the sensitivity (positive value) or increasing the sensitivity (negative value) of the module. Increasing the value of the threshold offset allows ignoring (will not result in a measurement) signals with amplitude higher than the default threshold. Decreasing the value of the threshold offset allows measurements of amplitude signals lower than the default threshold.

NOTE: The default setting (0) is selected to ensure a very low occurrence of false measurements.

False measurements are likely to occur when reducing the threshold offset (negative values). These false measurements are very random in occurrence while true measurements will be repeatable. For this reason, it may be useful in some applications to use a higher sensitivity and filter out the false measurements at the application level. For example, this can be useful in applications that require long detection ranges or detection of small or low reflectivity targets.

Smoothing

The smoothing algorithm increases the precision of the measurement at the cost of the LeddarVu module reactivity. The history length of the filter is defined as a function of the measurement noise level. It also changes according to the oversampling and accumulation settings.

The history length of the averaging filter can also be adjusted by a parameter ranging from −16 to 16. Clear the **Enable** check box to disable smoothing. Higher values increase the module precision but reduce the module reactivity. An example of the behavior of the measurement smoothing algorithm is depicted in Figure 17.

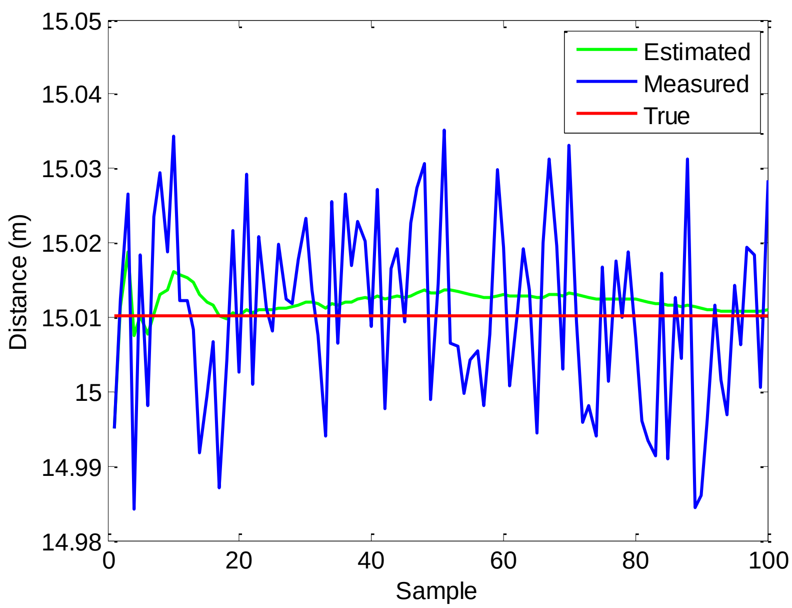


Figure 17: Measurement smoothing example

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

NOTE: The smoothing algorithm is recommended for applications that need highly precise measurements of slowly moving objects. For application that tracks quickly moving objects, it is advised to decrease the value of the smoothing parameter or to disable the smoothing algorithm.

Light Source Control

There is a total of 5 light source power levels. Their approximate relative power is evenly distributed between 0 through 100%. There were three power control mode: manual, automatic mode 1 and automatic mode 2.

With the manual mode, the light power source of the sensor is set to a fixed value. This mode can be used in a controlled environment of sensor FOV.

For automatic mode, the change delay defines the number of measurements required before allowing the LeddarVu module to increase or decrease by one the light source power level. For example, with the same change delay, the maximum rate of change (per second) of the light source power will two times higher at 12.5 Hz than at 6.25 Hz. The change delay can be set by the number of detection frame and the number of channel in saturation mode can be tolerated (automatic mode 1 only).

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 module in automatic light source power mode (default setting) ensures it adapts to varying environments. Close range objects may reflect so much light they can saturate the module, reducing the quality of the measurements. The automatic mode 1, will adapt the light output within the change delay setting (channel and frame parameter) to reach the optimal amplitude. On the other hand, low amplitudes provide lower accuracy and precision.

This automatic light source power mode will select a light source intensity that provides the highest intensity that avoids the saturation condition. The automatic mode 2, will adapt the light output within the change delay (frame parameter only) to reach at least one or more channels in saturation condition to provides the highest detection range. This mode is useful to keep a highest detection range into non-saturated channels when a strongly reflective object is detected.

NOTE: When a strongly reflective or near object is present in the field of view while monitoring farther distances, the automatic adjustment mode 1 will reduce the effective range of the module (reduce light source intensity) and may prevent detection of long range or low reflectivity objects. For these applications, the automatic mode 2 may be a better setting.

Object Demerging

The sensor can detect up to 4 objects per channel, as long as there is enough infrared light coming back from each target. There is also the possibility to activate the Active Demerging which will allow to demerge one pair of objects which closer together than normal. With the active demerging enabled, the sensor can also detect up to 4 objects per channel with the advantage of having 2 of these 4 objects to be detected while being close to each other.

When the Active demerging is disabled.

- The normal demerging will happen on any objects who are separated by at least 5 meters. This normal feature can give up to 4 detections.

When the Active demerging is enabled, the normal demerging will still occur in addition to demerge a pair of objects which are significantly closer together

- The Accumulation needs to be of 64 and higher for the active demerging to be ON
- The Oversampling need to be of 8 and higher for the active demerging to be ON
- At 8 Oversampling the demerging will happen if the two objects are separated by 90cm
- At 16 Oversampling the demerging will happen if the two objects are separated by 70cm
- At 32 Oversampling the demerging will happen if the two objects are separated by 50cm
- The accuracy of the sensor can be slightly altered on these two objects.

The active demerging will not work if one of the targets has an amplitude which is 10 times higher than the other target that is to demerge.

The minimum amplitude for targets to be demerged is of 10 counts each. There cannot be any demerging if the detection is saturated.

If the targets cannot be demerged (from normal demerging or active demerging) i.e. if they are closer than the minimum distance required if they do not meet the minimum or maximum amplitude requirement, the two detections will be averaged as only one detection. This average will be weighted by the amplitude and the range of the given detections.

4.3.2. Enabling and Disabling Segments

To open the Acquisition Settings dialog box, select **Device > Configuration > Acquisition**.

Segments are enabled by default. Deactivating a segment can target what needs to be identified in a field of view. This has an impact on the measurement rate which will be faster.

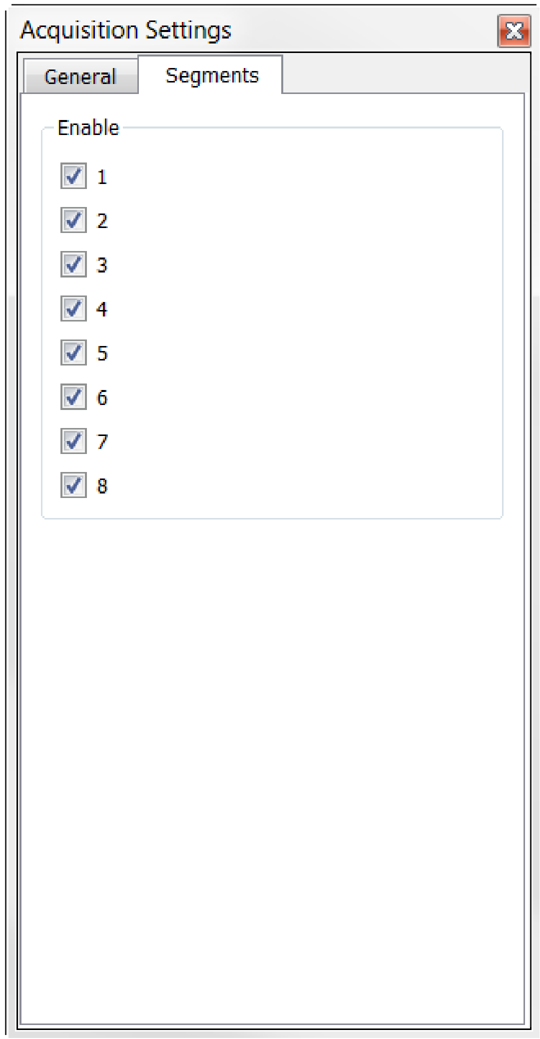


Figure 18: Segments tab – Acquisition Settings dialog box

When you uncheck segments, the corresponding segments will appear with gray square lines in the main window as shown in the image below.

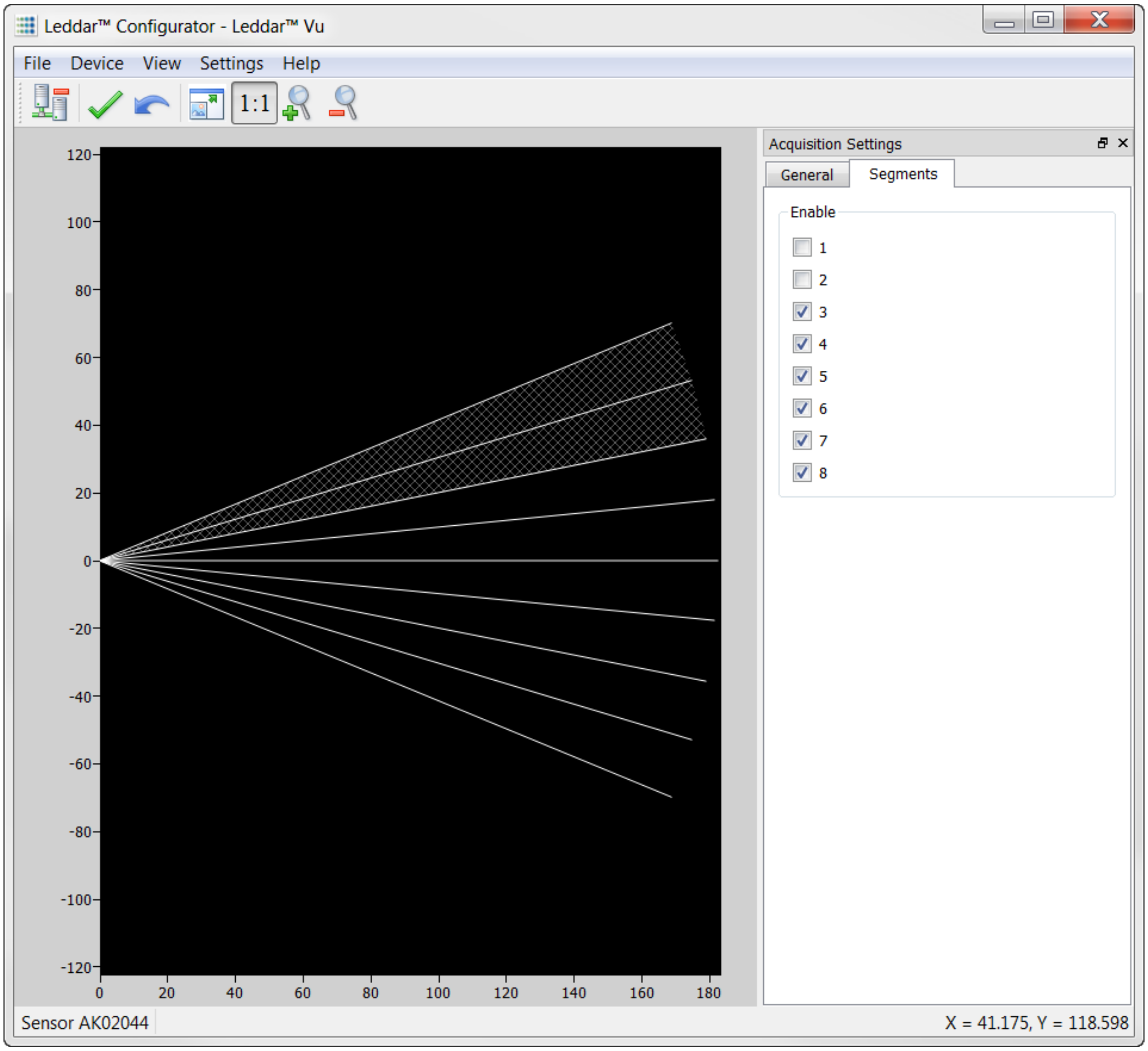


Figure 19: Disabled segments example

To apply new acquisition settings, click the apply button ✓ in the main window.

4.4. Measurement Rate

The LeddarVu module acquires a base input waveform for all segments at a rate between 10 kHz and 40 kHz, depending on the sensor field of view (see Table 11).

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.

Table 11: Base Acquisition Rate Based on the Field of View

LeddarVu8 FOV	Base Acquisition Rate
16°	10 kHz
47.5°	20 kHz
98.5°	40 kHz

Therefore, the final measurement rate is:

$$Measurement\ rate = \frac{Base\ Rate}{(Number\ of\ segments\ enabled + 1) * accumulations * oversampling}$$

For example, LeddarVu 16° with 256 accumulations and an oversampling value of 8:

$$Measurement\ rate = \frac{10000}{(8+1) * 256 * 8} = 0.5425\ \text{Hz}$$

Table 12 below presents the measurement rate for typical values of accumulations and oversampling.

Table 12: Measurement rate for LeddarVu8

Accumulation	Oversampling	Measurement Rate (Hz)		
		LeddarVu 16°	LeddarVu 47.5°	LeddarVu 98.5°
1024	8	0.1356	0.2713	0.5425
512	8	0.2713	0.5425	1.0851
256	8	0.5425	1.0851	2.1701
128	8	1.0851	2.1701	4.3403
64	8	2.1701	4.3403	8.6806
32	8	4.3403	8.6806	17.3611
1024	4	0.2713	0.5425	1.0851
512	4	0.5425	1.0851	2.1701
256	4	1.0851	2.1701	4.3403
128	4	2.1701	4.3403	8.6806
64	4	4.3403	8.6806	17.3611
32	4	8.6806	17.3611	34.7222

4.5. CPU Load

The measurement rate varies with the accumulations and oversampling settings. The higher the rate, the higher the processing load is on the source and control assembly microcontroller. The **Point** parameter, in the **Acquisition Settings** dialog box, (**Device** menu, **Configuration** > **Acquisition**) also has an impact on the processing load since it impacts the number of sample points to process for each segment.

Given the high flexibility of parameter settings, it is possible to create a processing load that exceeds the capacity of the microcontroller. When the microcontroller load is exceeded, the theoretical measurement rate will not be obtained.

The load (**CPU Load**) is displayed in the **Device State** window (**View** menu > **State**). It is recommended to verify the load when modifying the accumulations, oversampling, and point count parameters. The measurement rate will be lower than the calculated rate and the measurement period may be irregular when the load nears or reaches 100%.

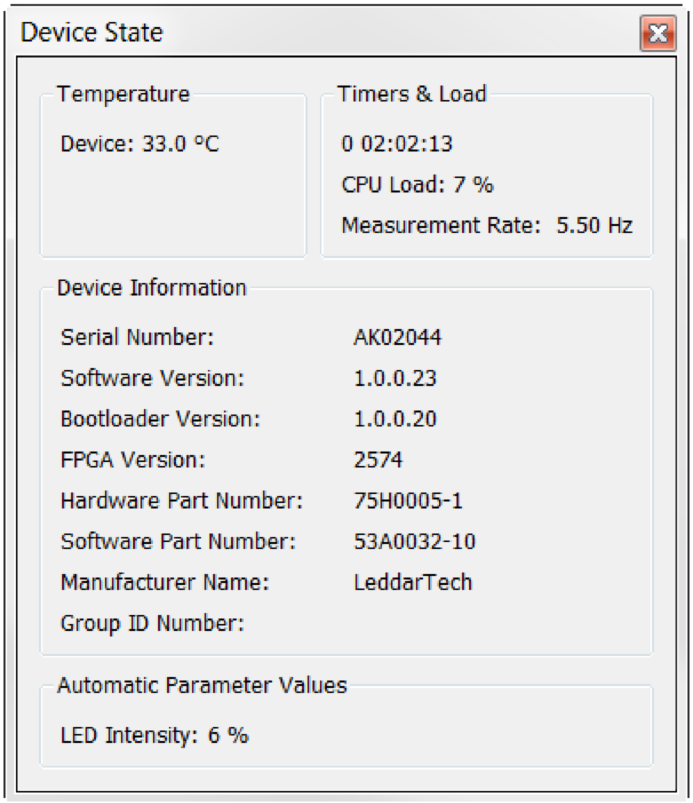


Figure 20: Device State window

5. Communication Interfaces

The interfaces and links are optional and are implemented depending on your configuration.

5.1. SPI Interface

The SPI interface on the SPI board is a direct link to the receiver module.

The SPI interface available with the USB, CAN and SERIAL board is a port connected to MCU but not implemented for the moment.

5.1.1. SPI Basics

The SPI interface uses the configuration mode 0; where, data is captured on the rising edge of the clock signal and outputted on the falling.

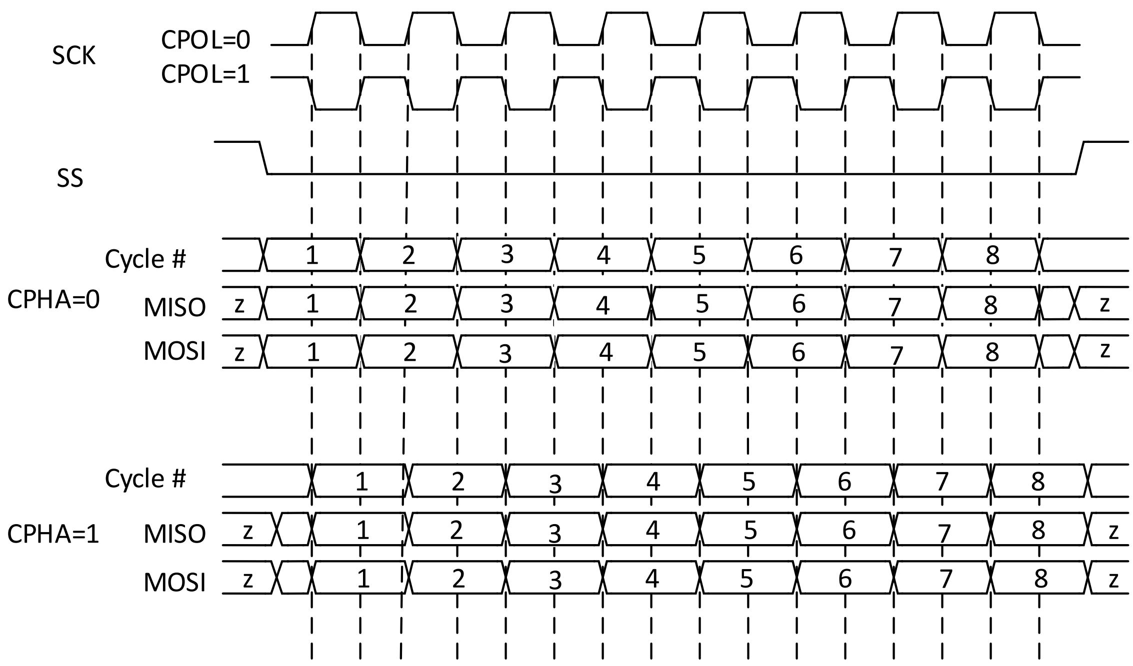


Figure 21: Standard SPI timing diagram

Table 13 below presents the basic clock signal modes.

Table 13: Basic modes

Mode	Clock Polarity CPOL	Clock Phase CPHA
0	0	0
1	0	1
2	1	0
3	1	1

5.1.2. SPI Protocol

The universal SPI protocol uses a combination of standard commands for FLASH and SRAM memories.

Each SPI packet contains a header, a payload, and a cyclic redundancy check (CRC).

The first byte of the header corresponds to an instruction opcode. It is followed by a 24-bit address and the 16-bit size of the payload. The payload contains several user-data bytes. The last 16 bits of the packet is the CRC16 (IBM) of both header and payload. The table below summarizes the structure of an SPI packet. It is noted that address and the CRC are packed with the most significant byte first while the first byte of data corresponds to the least significant byte.

Table 14: Byte offsets

Field	Opcode	Address			Size		Data			CRC16	
Byte offset	1	2	3	4	5	6	7	…	7 + n	8 + n	9 + n

The supported opcodes are presented in Table 15.

Table 15: SPI opcode commands

Mnemonic	Opcode	Operation	Description
READ	0x0B	Read data	The read command returns data from memory starting at the selected address. It needs a delay between the group containing the opcode, address, and size data, and the return data stream to let the receiver module to decode the request and get the ready data to the clock.
WRITE	0x02	Write data	The write command writes data to memory starting at the selected address and is limited to a page of 1 to 512 bytes.
CE	0xC7	Reset configuration	The reset command resets the module to the default configuration. The process is started on deassert of nCS and the write-enable flag in the status register must be asserted.
RDSR	0x05	Read status register	The read status command returns a byte of the status register and bit-field flags (refer to Table 16).
WREN	0x06	Write enabled	The write enabled command disables the write protection in order to modify any parameters.
WRDIS	0x04	Write disabled	The write disabled command enables the write protection to lock the module from any parameter changes.
SOFTRST	0x99	Software reset	The software reset command resets the receiver module.

The status register and bit flags are presented in Table 16.

Table 16: Status register

Bit	Name	Access	Description
7:2	Reserved	R/W	Future use
1	Write enable latch	R	0 = Write disabled 1 = Write enabled
0	Module ready	R	0 = Module ready 1 = Module busy (programming, erasing)

Data chronograms are represented in Figure 22 and Figure 23, and opcode and register chronograms are presented in Figure 24 and Figure 25 below.

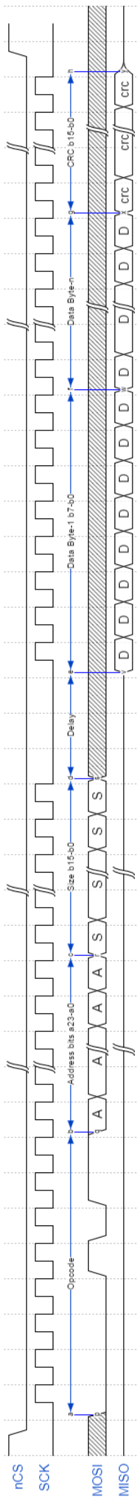


Figure 22: Read data chronogram

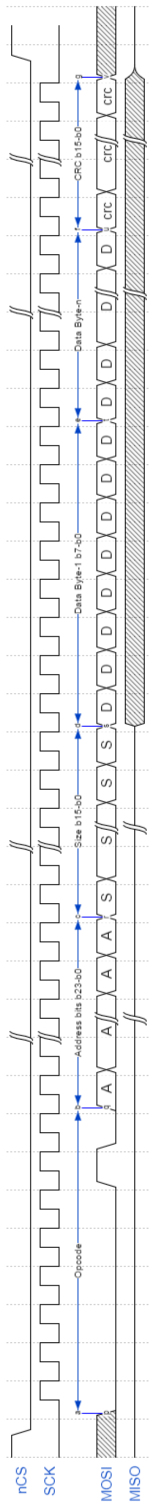


Figure 23: Write data chronogram

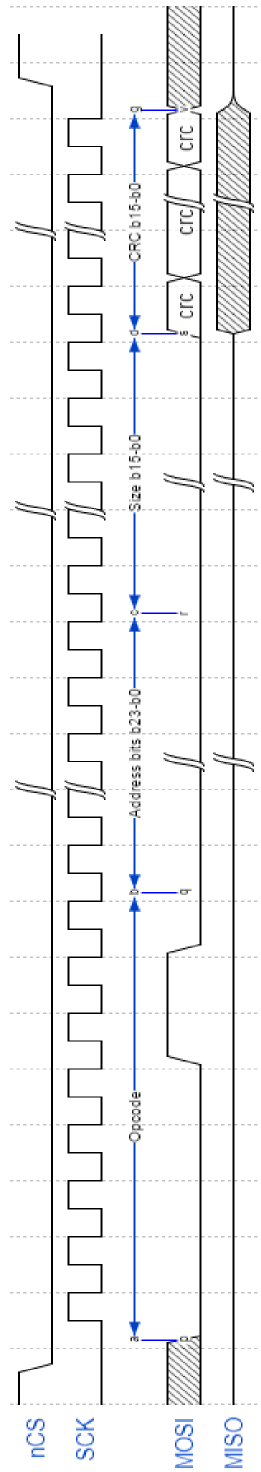


Figure 24: Single opcode chronogram (write enabled example)

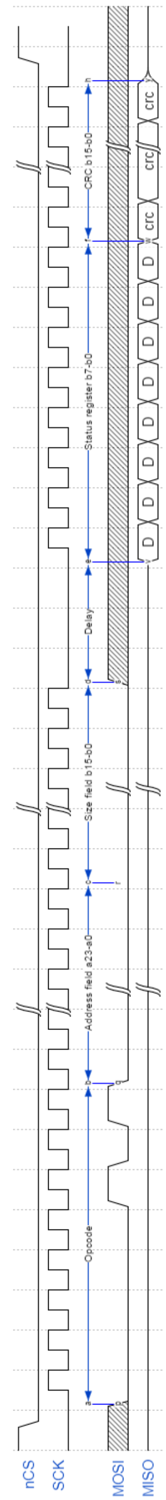


Figure 25: Read status register chronogram

5.1.3. Memory Map

The memory map is divided in four memory banks. This section presents the description of the four memory banks in a table format.

Table 17: Memory banks

Bank Number	Start Base Address	Bank Size (KB)	Access	Description
0	0x00000000	1024	R/W	Configuration data
2	0x00200000	512	R/W	Configuration data
6	0x00400000	128	Read only	General device information and constants
10	0x00480000	128	R/W	General Status
12	0x004C0000	128	R/W	LeddarVu Status
14	0x00500000	1024	Read only	Detection list
21	0x00FFFB00	1	R/W	Transaction configuration

Configuration Data

Table 18: Configuration data bank

Offset	Length	Type	Description
0	32	char	Module name as an ASCII string
32	1	uint8_t	Accumulation exponent: for example, 3 = 2^3=8
33	1	uint8_t	Oversampling exponent: for example, 3 = 2^3=8
34	1	uint8_t	Base point sample
35	4	uint32_t	Bit field of segment enabled
39	4	uint32_t	Acquisition rate of the reference pulse
43	4	float	Yaw angle of the module
47	4	float	Pitch angle of the module
51	4	float	Roll angle of the module
55	4	float	X-axis position of the module
59	4	float	Y-axis position of the module
63	4	float	Z-axis position of the module

Offset	Length	Type	Description
67	1	int8_t	Precision (smoothing): Stabilizes the module measurements. The behavior of the smoothing algorithm can be adjusted by a value ranging from –16 through 16.
68	1	uint8_t	Precision enabled
69	1	uint8_t	Saturation compensation enabled
70	1	uint8_t	Overshoot management enabled
71	4	int32_t	Sensitivity (detection threshold) setting expressed in a raw amplitude scale.
75	1	uint8_t	Light source power (0 to 100)
76	1	uint8_t	Auto light source power: 0: disabled 1: mode 1 2: mode 2
77	2	uint16_t	Auto frame average: Changes the delay in the number of measurements. This is the responsivity of the auto light source power according to the number of frames.
79	1	uint8_t	Auto detections average: Number of detections for saturation acceptance (the number of detections can be saturated to avoid decreasing the light source power when using the automatic mode). This is the responsivity of the auto light source power according to the number of detections.
80	1	uint8_t	Object demerging enabled
81	1	uint8_t	Static noise removal enabled

Product Configuration

Table 19: Product Configuration Data Bank

Offset	Length	Type	Description
0	1	uint8_t	Crosstalk Removal enabled
1	1	uint8_t	Crosstalk Echo Removal enabled

Device Information and Constants

Table 20: Device information and constants bank

Offset	Length	Type	Description
0	32	char	Module part number as an ASCII string
32	32	char	Software part number as an ASCII string
64	32	char	Module serial number as an ASCII string
96	32	char	Manufacturer name as an ASCII string
128	32	char	Group identification number as an ASCII string
160	32	char	Build date as an ASCII string
192	32	char	Firmware version as an ASCII string
224	32	char	Bootloader version as an ASCII string
256	32	char	ASIC version as an ASCII string (optionally filled in function of the module)
288	32	char	FPGA version as an ASCII string

Offset	Length	Type	Description
320	2	uint16_t	Module type 0x00000000: Invalid Device 0x00000007: M16 Evaluation Kit 0x00000008: IS16 0x00000009: M16 0x0000000A: LeddarOne 0x0000000D: LeddarVu8
322	4	uint32_t	Internal Use
326	1	uint8_t	Accumulation exponent min.
327	1	uint8_t	Accumulation exponent max.
328	1	uint8_t	Oversampling exponent min.
329	1	uint8_t	Oversampling exponent max.
330	1	uint8_t	Base point sample min.
331	1	uint8_t	Base point sample max.
332	2	uint16_t	Number of vertical segments
334	2	uint16_t	Number of horizontal segments
336	2	uint16_t	Number of reference segments
338	4	uint32_t	Base point sample distance
342	4	uint32_t	Reference segment mask: bit-field mask indicates the position of the reference segments.
346	2	uint16_t	Number of sample max.
348	1	uint8_t	Internal Use
349	4	uint32_t	Clock frequency
353	1	uint8_t	Maximum number of detections per segment
354	4	uint32_t	Distance scale
358	1	uint8_t	Raw amplitude scale bit, to which 0xd must be added (amplitude scale given in bitshift). That is raw amplitude << (scale bit + 0x0d)
359	4	uint32_t	Raw amplitude scale, to which the value 8192 must be added.
363	2	int16_t	Precision min.
365	2	int16_t	Precision max.
367	4	int32_t	Sensitivity min.
371	4	int32_t	Sensitivity max.
375	1	uint8_t	Current light source power count (max 16)
376	2	uint16_t	Auto frame average min.

Offset	Length	Type	Description
378	2	uint16_t	Auto frame average max.
380	1	uint8_t	Auto light source power percent min.
381	1	uint8_t	Auto light source power percent max.
382	1	uint8_t	Auto detections average min.
383	1	uint8_t	Auto detections average max.
384	1	uint8_t	Static noise calibration source: 0 = By end-user 1 = By factory
385	4	uint32_t	CPU load scale
389	4	uint32_t	Temperature scale

LeddarVu Device Information and Constants

Table 21: Device Information and Constants

Offset	Length	Type	Description
0	1	uint8_t	Sensor temperature scale exponent Sensor temperature scale = 2^ contents of this register

General Status

Table 22: General Status

Offset	Length	Type	Description
0	1	uint8_t	Detection ready flag: for polling mode, detections are ready to read if set to 1
37	4	uint32_t	CPU Load %CPU load = Contents of this register/CPU load scale
75	4	uint32_t	Binary CRC32

LeddarVu Status

Table 23: General Status

Offset	Length	Type	Description
0	4	uint32_t	Sensor temperature Temperature = Contents of this register/(2^ sensor temperature scale exponent)

Detection List

Table 24: Detection list bank

Offset	Length	Type	Description
0	4	uint32_t	Timestamp: in ms since the power up
4	2	uint16_t	Number of detection (N)
6	2	uint16_t	Current percentage of light source power
8	4	uint32_t	Acquisition options
12	N * detection structure size	Array of detection structure	Start of detection list array Refer to Table 25 for details.

Detection Structure Size

Table 25: Detection structure size

Offset	Length	Type	Description
0	4	uint32_t	Distance expressed in distance scale To convert to meters, the distance must be divided by the distance scale.
4	4	uint32_t	Amplitude expressed in raw amplitude scale To convert the amplitude to count, it must be divided by the amplitude scale. Amplitude = Contents of this register/(Amplitude Scale Register + 8192)
8	2	uint16_t	Segment number
10	2	uint16_t	Bit-field detection flags: Bit 0: Detection is valid (will always be set) Bit 1: Detection is the result of object demerging Bit 2: Reserved Bit 3: Detection is saturated Bit 4: Reserved Bit 5: Reserved Bit 6: Detection is within the crosstalk zone Bit 7: Reserved

Transaction Configuration

Table 26: Transaction configuration bank

Offset	Length	Type	Description
0	1	uint8_t	Secure-transaction enabled flags: 1 = Enables the CRC calculation and validation on any transaction. This flag is enabled by default. 0 = No CRC validation. The CRC field is still required in SPI protocol but can be set to any value.
1	1	uint8_t	Transaction modes: 0 = Free run. The READY pin is asserted on each ready detection frame. The host must be able to read data on time. 1 = Blocking read. On the READY pin assertion, host must read all data from traces or detections bank (data transaction control source configuration) to continue acquisition. 2 = Partial blocking read. On the READY pin assertion, host can read all data from traces of the detection bank and the acquisition is still running. Possible loss of detection frames if the host reading data is very long.
2	2	uint16_t	CRC of the last transaction
4	2	uint16_t	Bit-field information of last transactions: • All bits to 0: No transaction error • Bit-0: Access right violation • Bit-1: Invalid address • Bit-2: Command not found • Bit-3: Write disabled • Bit-4: CRC failed • Bit-5: Command execution error • Bit-6: Invalid packet
6	1	uint8_t	Data transaction control source: 0 = On trace 1 = On detections This register determines which data type will control the READY pin and manage the transaction mode.

5.1.4. SPI Operation

The SPI operation includes four parameters: SPI port configuration, speed and timing, access, and modification.

5.1.4.1. SPI Port Configuration

The SPI port must be configured in the 0 mode (see section 5.1.1 SPI Basics 45) to communicate with the receiver module.

5.1.4.2. Sensor Hard Reset

A hard-reset pin is available to reboot the sensor. The standard hard reset chronogram is shown on Figure 26 below: the nCS must not be asserted during this reset sequence. The minimum reset state time (Trst) is 1 millisecond. The minimum wait time after reset state release (Twait) is 100 milliseconds.

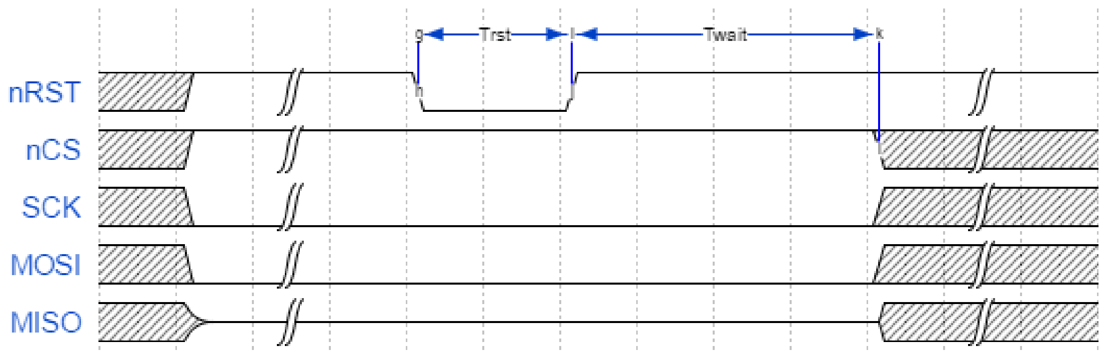


Figure 26: Standard hard reset chronogram

To prevent the receiver module to go into the bootloader mode, the port must never have all SPI input pins (nCS, MOSI and CLK) set to the low level for more than 100 milliseconds at power up or when performing a hard reset.

5.1.4.3. Speed and timing

For the read operation, a delay is needed between the header (group containing the opcode, address, and size data), and the return data stream to let the receiver module to decode the request and get the ready data to the clock. This delay can be set to 1 millisecond, during this delay, the SPI clock must be halted and the nCS must be staying asserted (see Figure 22).

The SPI clock frequency can be in the range between 500 kHz and 25 MHz.

5.1.4.4. Access

To access a parameter, you need to add a parameter offset to the associated bank start base address. Use the parameter length to get or set the whole parameter field.

5.1.4.5. Modification

To modify a parameter:

1. Disable the write protection of the module by sending the write enabled command.
2. Poll the status register to get the ready state and write enabled flag asserted.
3. Send the new parameter value.
4. Poll the status register to get the ready state.
5. Send the write disabled command (write protection) to prevent any unwanted parameter change.

NOTE: To prevent any data corruption or loss after modifying a parameter or a firmware update, the module must be in the ready state before shutting it down or doing a hard reset.

5.2. I2C Interface

The I2C interface on the SPI board is a direct link to the receiver and source modules. For the moment, only the temperature sensor is accessible. Refer to the LM75BIMM-3/NOPB temperature sensor datasheet from Texas Instruments.

The I2C interface available with the enhance board is a port connected to MCU but not implemented for the moment.

5.3. USB Interface

The USB interface available with the USB, CAN and SERIAL board is a VCP (virtual COM port) serial emulation port. This port is used as a serial link with the Modbus protocol (refer to Section 5.4 Serial Link Interface). This interface can also be used to update the USB, CAN and SERIAL board firmware in the bootloader mode.

5.4. Serial Link Interface

The serial links can be of the following electric signals: TTL, RS-232, RS-422, and RS-485.

The serial link ports use the Modbus protocol using the RTU transmission mode only. This section describes the commands that are implemented.

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

Read input register (function code 0x4)

The following table presents the registers for the read input commands.

Table 27: Read input register messages

Address	Description
1	Detection status for polling mode: 0 = Detections not ready 1 = Detections ready: this status flag is reset to 0 after reading this register
2	Number of segments (N)
11	Number of detections
12	Current percentage of light source power
13	Bit field of acquisition status: Reserved
14	Low 16 bits of timestamp (number of milliseconds since the module was started)
15	High 16 bits of timestamp
16 to 16 + N-1	Distance of first detection for each segment, zero if no detection in a segment. The distance unit is defined by the serial port parameters.
16 + N to 16 + (2*N) - 1	Amplitude of first detection for each segment times 64 (that is, amplitude = this register/64), zero if no detection in a segment
16 + (2*N) to 16 + (3*N) - 1	Flag of the first detection for each segment: Bit 0: Detection is valid (will always be set) Bit 1: Detection is the result of object demerging Bit 2: Reserved Bit 3: Detection is saturated Bit 4: Reserved Bit 5: Reserved Bit 6: Detection is within the crosstalk zone Bit 7: Reserved
16 + (3*N) to 16 + (4*N) - 1	Distance of the second detection for each segment
16 + (4*N) to 16 + (5*N) - 1	Amplitude of the second detection for each segment
16 + (5*N) to 16 + (6*N) - 1	Flag of the second detection for each segment
16 + (6*N) to 16 + (7*N) - 1	Distance of the third detection
16 + (7*N) to 16 + (8*N) - 1	Amplitude of the third detection
16 + (8*N) to 16 + (9*N) - 1	Flag of the third detection

Address	Description
16 + (9*N) to 16 + (10*N) - 1	Distance of the fourth detection
16 + (10*N) to 16 + (11*N) - 1	Amplitude of the fourth detection
16 + (11*N) to 16 + (12*N) - 1	Flag of the fourth detection
16 + (12*N) to 16 + (13*N) - 1	Distance of fifth detection
16 + (13*N) to 16 + (14*N) - 1	Amplitude of fifth detection
16 + (14*N) to 16 + (15*N) - 1	Flag of the fifth detection
16 + (15*N) to 16 + (16*N) - 1	Distance of the sixth detection
16 + (16*N) to 16 + (17*N) - 1	Amplitude of the sixth detection
16 + (17*N) to 16 + (18*N) - 1	Flag of the sixth detection

NOTE: As per the Modbus protocol, register values are returned in big-endian format.

For an example of a 0x04 Modbus function (read input register), refer to Appendix A.

Read holding register (function code 0x3), write register (function code 0x6), write multiple register (function code 0x10), and read/write multiple register (function code 0x17).

The following table presents the registers for these commands (see section 4.3 for a more detailed description of parameters).

Table 28: Read holding register message definition

Address	Description
0	Exponent for the number of accumulations (that is, if the content of this register is n, 2^n accumulations are performed)
1	Exponent for the number of oversamplings (that is, if the content of this register is n, 2^n oversamplings are performed)
2	Number of base samples
3	Reserved
4	Detection threshold as a fixed-point value with a 6-bit fractional part (that is threshold value is this register divided by 64).

Address	Description
5	Light source power in percentage of the maximum. A value above 100 is an error. If a value is specified that is not one of the pre-defined values, the closest pre-defined value will be used. Refer to the detection reading to verify the LED intensity value as seen in Table 27 and Table 31.
6	Bit field of acquisition options: Bit-0: Automatic light source power enabled Bit-1: Demerge object enabled Bit-2: Static noise removal enabled Bit-3: Precision (smoothing) enabled Bit-4: Saturation compensation enabled Bit-5: Overshoot management enabled Bit-6: Automatic light source power mode: 0: Mode 1 1: Mode 2 Bit-7: Crosstalk Removal enabled Bit-8: Crosstalk Echo Removal enabled
7	Auto light source power change delay in number of measurements
8	Reserved
9	Number of echoes for saturation acceptance: The number of echoes can be saturated to avoid decreasing the light source power in automatic mode.
10	Operation mode Write mode: 0: Stop (stop acquisition) 1: Continuous 2: Single (acquisition of a single detection frame) Read mode: 10: Stopped (sensor is stopped) 11: Continuous acquisition mode 12: Single frame busy (acquisition in progress) 13: Sensor is busy
11	Smoothing: Stabilizes the module measurements. The behavior of the smoothing algorithm can be adjusted by a value ranging from –16 through 16.
12	Low 16 bits of segment enabled: Bit-field of enabled segment
13	High 16 bits of segment enabled

NOTE: 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 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.

Report server ID (function code 0x11)

This function returns information on the LeddarVu module in the following format:

Table 29: Report server ID messages

Offset	Length	Description
0	**1**	Number of bytes of information (excluding this one). Currently 0x99 since the size of information returned is fixed.
1	**32**	Serial number as an ASCII string
33	**1**	Run status 0: OFF, 0xFF: ON. Should always return 0 FF, otherwise the module is defective.
34	**32**	The device name as an ASCII string
66	**32**	The hardware part number as an ASCII string
98	**32**	The software part number as an ASCII string
130	**8**	The full firmware version as 4 16-bit values
138	**48**	The full bootloader version as 4 16-bit values
146	**2**	The FPGA-build version
148	**4**	Internal Use
152	**2**	Module identification code (13 for LeddarVu8)

Get detections (function code 0x41)

This function returns the detections/measurements in the following format:

The first byte is the number of detections in the message. Because of the limitation on a Modbus message length, a maximum of 40 detections will be returned.

NOTE: This maximum can be configured to a lower value using the Leddar™ Configurator software (serial port configuration) or the Write Register command described below.

Following the first byte, each detection has six bytes (refer to Table 30).

Table 30: Get detection messages (detection fields)

Offset	Length	Description
0	**2**	The distance (little-endian). Distance unit is defined by serial port parameters
2	**2**	The amplitude times 64 [that is, amplitude = this field/64 (little-endian)]
4	**1**	4 bits are flags describing the measurement (all others are reserved): Bit 0 - Detection is valid (will always be set) Bit 1 - Detection is the result of object demerging Bit 3 - Detection is saturated Bit 6 - Detection is within the crosstalk zone
5	**1**	Segment number

Three more data fields follow the detection list:

Table 31: Get detection messages (trailing fields)

Offset	Length	Description
0	**4**	Timestamp of the acquisition (little-endian). The timestamp is expressed as the number of milliseconds since the device was started.
4	**1**	Current light source power as a percentage of maximum.
5	**2**	Bit-field acquisition. Reserved

For an example of a 0x41 Modbus function, refer to Appendix B.

Read module data (function code 0x42)

Table 32 and Table 33 present the request and answer codes for reading data. This function is an encapsulation of the SPI protocol. See section 5.1.3 Memory Map.

Table 32: Requests

Offset	Length	Description
0	**4**	Base address: 0x00000000 to 0x00FFFFFF (little-endian)
4	**1**	Number of bytes to read: 1 through 247

Table 33: Answers

Offset	Length	Description
0	**4**	Base address: 0x00000000 to 0x00FFFFFF (little-endian)
4	**1**	Number of bytes read: 1 through 247
5	**Nb * 1 byte**	Data

Write module data (function code 0x43)

Table 34 and Table 35 present the request and answer codes for writing data. This function is an encapsulation of the SPI protocol. See section 5.1.3 Memory Map.

Table 34: Requests

Offset	Length	Description
0	**4**	Base address: 0x00000000 to 0x00FFFFFF
4	**1**	Number of bytes written: 1 through 247
5	**Nb * 1 byte**	Data

Table 35: Answers

Offset	Length	Description
0	**4**	Base address: 0x00000000 to 0x00FFFFFF
4	**1**	Number of bytes written: 1 through 247

Send opcode command (function code 0x44)

Table 36 and Table 37 present the request and answer codes for sending the opcode. This function is an encapsulation of the SPI protocol. See section 5.1.3 Memory Map.

Table 36: Requests

Offset	Length	Description
0	**1**	Opcode, supported opcodes: Read status = 0x05 Write enabled = 0x06 Write disabled = 0x04 Reset configuration = 0x C7 Soft reset = 0x99
1	**1**	Argument: optional value (must be set to 0x00)

Table 37: Answers

Offset	Length	Description
0	**1**	Opcode
1	**1**	Return value: optional return value (read status opcode = Status value)

Get serial port settings (function code 0x45, 0x00)

Table 38, Table 39, and Table 40 present the requests and answers of the get serial port settings.

Table 38: Requests

Offset	Length	Description
0	**1**	Sub-function code: 0x00

Table 39: Answers header field

Offset	Length	Description
0	**1**	Sub-function code: 0x00
1	**1**	Number of serial port
2	**1**	Current logical serial port number (current logical serial number connected to the host used for this transaction)

Table 40: Answers serial port settings field

Offset	Length	Description
0	**1**	Logical serial port number
1	**4**	Baud rate, supported rates: 9,600 19,200 38,400 57,600 115,200
5	**1**	Date size: 8 = 8-bit size
6	**1**	Parity: 0 = None 1 = Odd 2 = Even
7	**1**	Stop bit: 1 = 1 stop bit 2 = 2 stop bits
8	**1**	Flow control: 0 = None
9	**1**	Modbus address: 1 through 247
10	**1**	Max. echoes per transactions. Used for the Get Detection command (function code 0x41), max. of 40 echoes.
11	**2**	Distance resolution: 1 = m 10 = dm 100 = cm 1,000 = mm

NOTE: This answer table is repeated by the number of available serial port.

Set serial port settings (function code 0x45, 0x01)

Table 41, Table 42 and Table 43 present the requests and answers for the set serial port settings.

Table 41: Requests header field

Offset	Length	Description
0	**1**	Sub-function code: 0x01

Table 42: Requests serial port setting field

Offset	Length	Description
0	**1**	Settings of corresponding logical serial port number to set.
1	**4**	Baud rate, supported rates: 9,600 19,200 38,400 57,600 115,200
5	**1**	Date size: 8 = 8-bit size
6	**1**	Parity: 0 = None 1 = Odd 2 = Even
7	**1**	Stop bit: 1 = 1 stop bit 2 = 2 stop bits
8	**1**	Flow control: 0 = None
9	**1**	Modbus address: 1 through 247
10	**1**	Max. echoes per transactions. Used for the Get Detection command (function code 0x41), max. of 40 echoes.
11	**2**	Distance resolution: 1 = m 10 = dm 100 = cm 1,000 = mm

NOTE: This request table can be repeated by the number of available serial ports (by using the corresponding logical port number).

Table 43: Answers

Offset	Length	Description
0	**1**	Sub-function code: 0x01

Get carrier firmware information (function code 0x45, 0x02)

Table 44 and Table 45 present the registers for the firmware information commands.

Table 44: Requests

Offset	Length	Description
0	**1**	Sub-function code: 0x02

Table 45: Answers

Offset	Length	Description
0	**1**	Sub-function code: 0x02
1	**32**	Firmware part number ASCII string
33	**8**	Firmware version in four units for format A, B, C, and D.

Get carrier device information (function code 0x45, 0x03)

Table 46 and Table 47 present the registers for the carrier device information commands.

Table 46: Requests

Offset	Length	Description
0	**1**	Sub-function code: 0x03

Table 47: Answers

Offset	Length	Description
0	**1**	Sub-function code: 0x03
1	**32**	Hardware part number ASCII string
33	**32**	Hardware serial number ASCII string
65	**4**	Option bits. For Leddar use

Get CAN port settings (function code 0x45, 0x04)

Table 48, Table 49 and Table 50 present the requests and answers of the get CAN port settings.

Table 48: Requests

Offset	Length	Description
0	**1**	Sub-function code: 0x04

Table 49: Answers header field

Offset	Length	Description
0	**1**	Sub-function code: 0x04
1	**1**	Number of CAN port

Table 50: Answers CAN port settings field

Offset	Length	Description
0	**1**	Logical CAN port number settings
1	**4**	Baud rate, supported rates: • 10,000 • 20,000 • 50,000 • 100,000 • 125,000 • 250,000 • 500,000 • 1,000,000
5	**1**	Frame format: 0 = Standard 11 bits 1 = Extended 29 bits
6	**4**	Tx base ID
10	**4**	Rx base ID
14	**1**	Maximum number of detections (measurements) returned per CAN detection message transaction: 1 through 96
15	**2**	Distance resolution: • 1 = m • 10 = dm • 100 = cm • 1,000 = mm
17	**2**	Inter-message delay 0 through 65535 milliseconds
19	**2**	Inter-cycle delay 0 through 65535 milliseconds

NOTE: This answer table is repeated by the number of available CAN port.

Set CAN port settings (function code 0x45, 0x05)

Table 51 and Table 52 present the requests and answers for the CAN port commands.

Table 51: Requests header field

Offset	Length	Description
0	**1**	Sub-function code: 0x05

Table 52: Requests CAN port settings field

Offset	Length	Description
0	**1**	Settings of corresponding logical CAN port number to set
1	**4**	Baud rate, supported rates: 10,000 20,000 50,000 100,000 125,000 250,000 500,000 1,000,000
5	**1**	Frame format: 0 = Standard 11 bits 1 = Extended 29 bits
6	**4**	Tx base ID
10	**4**	Rx base ID
14	**1**	Maximum number of detections (measurements) returned per CAN detection message transaction: 1 through 96
15	**2**	Distance resolution: 1 = m 10 = dm 100 = cm 1,000 = mm
17	**2**	Inter-message delay 0 through 65535 milliseconds
19	**2**	Inter-cycle delay 0 through 65535 milliseconds

NOTE: This request table can be repeated by the number of available CAN port (by using the corresponding logical port number).

Table 53: Answers

Offset	Length	Description
0	**1**	Sub-function code: 0x05

5.5. CAN Bus Interface

The CAN bus interface uses two default message IDs that can be modified by the user: 1856 (0x740) and 1872 (0x750).

Four message IDs are available:

Table 54: CAN message IDs

Message ID	Direction	Data Type
0x740	Rx	Request from a host
0x750	Tx	Answer to a host request
0x751	Tx	Number of detection messages
0x752 and over	Tx	Detection messages

1856 (0x740) (Rx base ID)

These are 8-byte length messages for command requests that the module monitors: the first byte (Byte 0) describes the main function and the rest of the message bytes are used as arguments. Undescribed bytes are reserved and must be set to 0.

The module answer messages are described in section 1872 (0x750) (Tx base ID).

Table 55: CAN bus request message

Function Request (Byte 0)	Function Request Description	Function Arguments (Byte 1)
1	Stop sending detections continuously	
2	Send detection once	Bit field of operation mode Bit-0: 0 = Return detection in single message mode 1 = Return detection in multiple message mode
3	Start sending detections continuously (that is, the module will send a new set of detections each time they are ready without waiting for a request).	Bit field of operation mode Bit-0: 0 = Return detection in single message mode 1 = Return detection in multiple message mode
4	Get input data (read only)	See Table 56
5	Get holding data	See Table 57
6	Set holding data	See Table 58
7	Set base address	See Table 59
8	Read module data	See Table 60
9	Write module data	See Table 61
10	Send module opcode command	See Table 62

Table 56: CAN bus request message (Get input data)

Input Data Type (Byte 1)	Input Data Description
0	Number of segments
1	Device identification and option
2 and 3	Firmware version
4 and 5	Bootloader version
6	FPGA version
7 through 12	Serial number
13 through 18	Device name
19 through 24	Hardware part number
25 through 30	Software part number

Table 57: CAN bus request message (Get holding data)

Holding Data Type (Byte 1)	Holding Data Description
0	Acquisition configuration
1	Smoothing and detection threshold
2	Light source power management
3	Distance resolution and acquisition options
4	CAN port configuration 1
5	CAN port configuration 2
6	CAN port configuration 3
7	Reserved
8	Segment enabled

Table 58: CAN bus request message (Set holding data)

Holding Data Type (Byte 1)	Holding Data Description	Argument	Argument Description
0	Acquisition configuration	Byte 2	Exponent for the number of accumulation (that is, if the content of this register is n, 2^n accumulations are performed).
		Byte 3	Exponent for the number of oversampling (that is, if the content of this register is n, 2^n oversamplings are performed).
		Byte 4	Number of base samples
1	Smoothing and detection threshold	Byte 2	Smoothing: Stabilizes the module measurements. The behavior of the smoothing algorithm can be adjusted by a value ranging from −16 to 16. Clear the **Enable** check box to disable smoothing.
		Bytes 4 through 7	Detection threshold as a fixed-point value with a 6-bit fractional part (that is, threshold value is this register divided by 64).
2	Light source power management	Byte 2	Light source power in percentage of the maximum. A value above 100 is an error. If a value is specified that is not one of the predefined values, the closest predefined value will be used. Refer to the detection reading to verify the LED intensity value as seen in Table 55 and Table 67. Note that this value is ignored if the automatic light source intensity parameter is enabled.
		Byte 3	Number of echoes for saturation acceptance: the number of echoes can be saturated to avoid decreasing the light source power when using the automatic mode.
		Bytes 4 and 5	Auto light source power changes the delay in number of measurements

Holding Data Type (Byte 1)	Holding Data Description	Argument	Argument Description
3	Distance resolution and acquisition options	Bytes 2 and 3	Distance units: • 1 = m • 10 = dm • 100 = cm • 1,000 = mm
		Bytes 4 and 5	Bit field of acquisition options: Bit-0: Automatic light source power enabled Bit-1: Demerge object enabled Bit-2: Static noise removal enabled Bit-3: Precision (smoothing) enabled Bit-4: Saturation compensation enabled Bit-5: Overshoot management enabled Bit-6: Automatic light source power mode: 0: Mode 1 1: Mode 2 Bit-7: Crosstalk Removal enabled Bit-8: Crosstalk Echo Removal enabled
4	CAN port configuration 1	Byte 2	Baud rate (kbps): 0 = 1000 1 = 500 2 = 250 3 = 125 4 = 100 5 = 50 6 = 20 7 = 10
		Byte 3	Frame format: 0 = Standard 11 bits 1 = Extended 29 bits
		Bytes 4 through 7	Tx base ID
5	CAN port configuration 2	Bytes 4 through 7	Rx base ID
6	CAN port configuration 3	Byte 3	Maximum number of detections (measurements) returned per CAN detection message transaction: 1 through 96
		Bytes 4 and 5	Inter-message delay 0 through 65535 milliseconds
		Bytes 6 and 7	Inter-cycle delay 0 through 65535 milliseconds

7	Reserved	-	-
8	Segment enabled	Bytes 4 through 7	Bit-field of the enabled segments

Table 59: CAN bus request message (Set base address)

Data Description	Argument	Argument Description
Base address	Bytes 4 through 7	Base address to access Read module date and Write module date commands (from 0x00000000 to 0x00FFFFFF)

Table 60: CAN bus request message (Read module data)

Data Description	Argument	Argument Description
Read module data	Byte 1	Data length (1, 2, or 4)
	Bytes 2 and 3	Offset from 0x0000 to 0xFFFF (final address to access is the result of the base address plus this offset). This function is an encapsulation of the SPI protocol. See section 5.1.3 Memory Map.

Table 61: CAN bus request message (Write module data)

Data Description	Argument	Argument Description
Write module data	Byte 1	Data length (1, 2, or 4)
	Bytes 2 and 3	Offset from 0x0000 to 0xFFFF (final address to access is the result of the base address plus this offset).
	Bytes 4 through 7	Data to write This function is an encapsulation of the SPI protocol. See section 5.1.3 Memory Map.

Table 62: CAN bus request message (Send module opcode command)

Data Description	Argument	Argument Description
Send module opcode command	Byte 2	Opcode This function is an encapsulation of the SPI protocol. See section 5.1.2 SPI Protocol.
	Byte 3	Optional argument (must be set to 0x00)

1872 (0x750) (Tx base ID)

These are 8-byte answer messages to the host command requests.

Table 63: CAN bus answer message

Answer Data (Byte 0)	Answer Data Description	Additional Answer Data (Byte 1 to Byte 7)
1	Answer to stop continuously sending detection requests.	Success: Return echo from the command request. Fail: All bytes, from 2 through 7, are set to 0xFF.
2	Answer to send once a detection request.	Success: Return echo from the command request. Fail: All bytes, from 2 through 7, are set to 0xFF.
3	Answer to continuously sending a detection request.	Success: Return echo from the command request. Fail: All bytes, from 2 through 7, are set to 0xFF.
4	Answer to the Get input data request.	Success: See format in Table 64 Fail: All bytes, from 2 through 7, are set to 0xFF.
5	Answer to the Get holding data request.	Success: See format in Table 58 Fail: All bytes, from 2 through 7, are set to 0xFF.
6	Answer to the Set holding data request.	Success: Return echo of the command request. Fail: All bytes, from 2 through 7, are set to 0xFF.
7	Answer to the Set base address request.	Success: Return echo of the command request. Fail: All bytes, from 2 through 7, are set to 0xFF.
8	Answer to the Read module data request.	Success: See Table 65 Fail: All bytes, from 2 through 7, are set to 0xFF.
9	Answer to the Write module data request.	Success: return echo of the command request. Fail: All bytes, from 2 through 7, are set to 0xFF.
10	Answer to the Send module opcode request.	Success: See Table 66 Fail: All bytes, from 2 through 7, are set to 0xFF.

Table 64: CAN bus answer message (Get input data)

Input Data Type (Byte 1)	Input Data Description	Argument	Arguments Description
0	Number of segments	Bytes 2 and 3	Number of segments
1	Device identification and options	Bytes 2 and 3	Device identification code (13 for LeddarVu8)
		Bytes 4 through 7	Device option flags (LeddarTech internal use)
2	Firmware version in format A, B, C, D.	Bytes 2 and 3	The firmware build version (A)
		Bytes 4 and 5	The firmware build version (B)
		Bytes 6 and 7	The firmware build version (C)
3	Firmware version in format A, B, C, D.	Bytes 2 and 3	The firmware build version (D)
4	Bootloader version in format A, B, C, D.	Bytes 2 and 3	The bootloader build version (A)
		Bytes 4 and 5	The bootloader build version (B)
		Bytes 6 and 7	The bootloader build version (C)
5	Bootloader version in format A, B, C, D.	Bytes 2 and 3	The bootloader build version (D)
6	FPGA version	Bytes 2 and 3	The FPGA version
		Byte 6	Run status 0: OFF, 0xFF: ON. Should always return 0xFF, otherwise the module is defective.
7 through 12	Serial number	Bytes 2 through 7	Serial number as an ASCII string (max. 32 bytes)
13 through 18	Device name	Bytes 2 through 7	The device name as an ASCII string (max. 32 bytes)
19 through 24	Hardware part number	Bytes 2 through 7	The hardware part number as an ASCII string (max. 32 bytes)
25 through 30	Software part number	Bytes 2 through 7	The software part number as an ASCII string (max. 32 bytes)

Table 65: CAN bus answer message (Read module data)

Data Description	Argument	Argument Description
Read module opcode command	Byte 1	Data length (1, 2, or 4)
	Byte 2	Offset
	Byte 3	
	Byte 4	Data to read
	Byte 5	
	Byte 6	
	Byte 7	

Table 66: CAN bus answer message (Send module opcode request)

Data Description	Argument	Argument Description
Send module opcode command	Byte 2	Opcode
	Byte 3	Optional argument
	Byte 4	Optional return value

1873 (0x751) (Tx base ID + 1)

These are 8-byte messages that indicates the number of detections that will be sent.

Table 67: CAN bus number of detection messages

Data	Data Return Description
Byte 0	Number of detections
Byte 1	Current light source power as a percentage of the maximum
Byte 2	Status of the bit field acquisition: Reserved
Byte 3	
Bytes 4 through 7	Timestamp of the acquisition. The timestamp is expressed as the number of milliseconds since the module was started.

1874 (0x752) (Tx base ID + 2)

These are the detection messages with flag information, which contains one detection presented in the following format:

- Data bytes 0 and 1 contain the distance in units defined by the distance-units holding data.
- Data bytes 2 and 3 contain the amplitude. This value must be divided by 64 to get the amplitude (that is, 6 bits for fractional part).
- Data bytes 4 and 5 contain the flag information as described in the table below.
- Bytes 6 and 7 contain the segment number.

Table 68: Flag information about measurements

Data	Description
Bit 0	The detection is valid (always set).
Bit 1	The detection is the result of object demerging.
Bit 2	Reserved
Bit 3	The detection is saturated.
Bit 4-5	Reserved
Bit 6	The detection within the crosstalk zone
Bit 7-15	Reserved

Detection messages can be sent in two modes: as a single message ID or a multiple message ID.

For the single message ID mode, all detection messages are sequentially sent on the same message ID; that is, 1874 (0x752).

For the multiple message ID mode, detections are send on a message IDs ranging from 1874 through the number of detections (1874 + number of detections). The range of message IDs can be limited by the maximum number of detections to output to the CAN port (defined in CAN configuration 3 holding data for a maximum configurable of 96 detections).

The following are examples of message IDs for the 1874 base (with a 19-detection frame):

- From 1874 through 1893.
- From 1874 through 1890, for a module setup with a maximum of 16 number of detections.

For an example of a LeddarVu Can Bus, refer to Appendix C.

6. Leddar™ Configurator

Leddar™ Configurator provides configuration parameters and operation functionalities for LeddarTech products.

6.1. Introduction to Configurator Software

The Configurator interface 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**, **Cancel**, etc. are dockable at the top, the bottom, or on the right side of the main window.

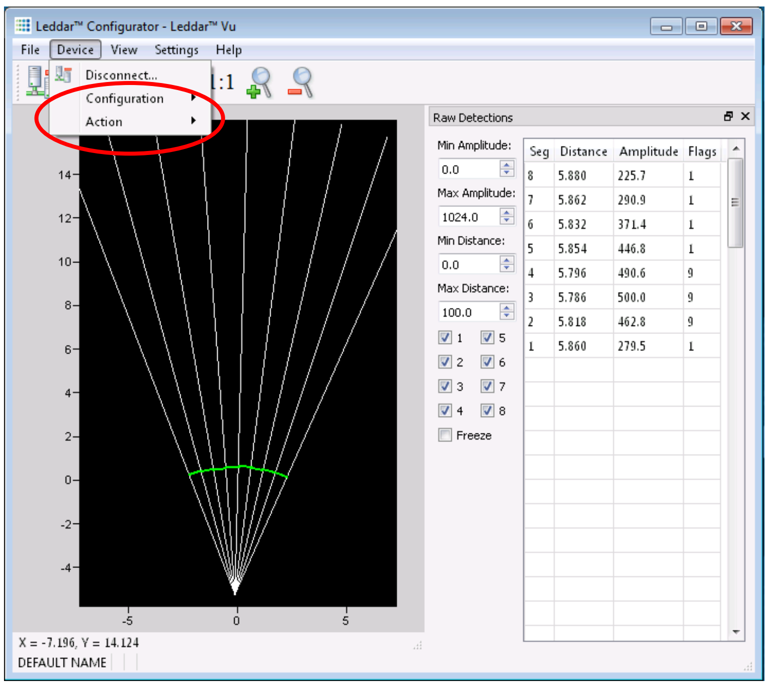


Figure 27: Raw Detections dialog box docked on the side of the main window

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

6.2. Connection Window

The following is a description of the information shown in the **Connection** dialog box.

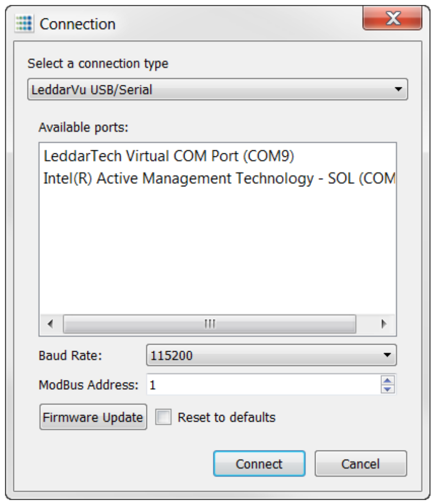


Figure 28: USB connection dialog box

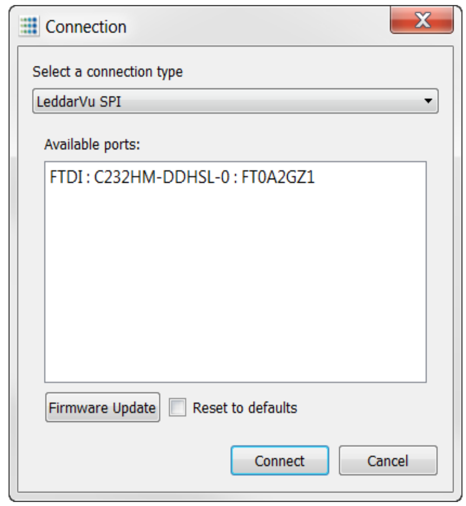


Figure 29: SPI connection dialog box

Select a connection Type

The connection type you are using. There are four connection types:

1. IS16/M16/Evaluation Kit USB
2. LeddarVu SPI
3. LeddarVu USB/Serial
4. LeddarOne

Available ports

The list of available ports displays the modules currently detected.

NOTE: The next descriptions apply to IS16/M16/Evaluation Kit USB.

Name

The device name can be modified (see section 6.4.1 Module Name).

Serial Number

The serial number of the device as assigned by LeddarTech.

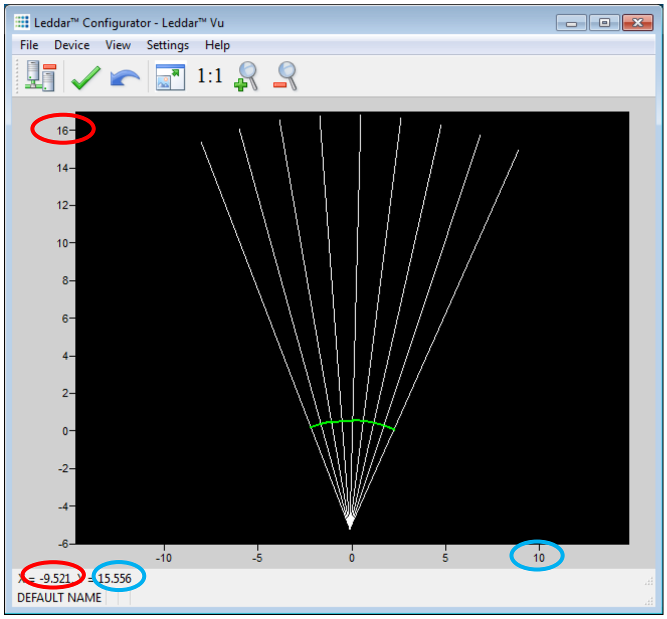
Type

The product name.

6.3. Leddar™ Configurator Main Window

After connecting to the device, the main window opens.

Vertical scale setting areas



Horizontal scale setting areas

Figure 30: Leddar™ Configurator main window

The measurements are plotted in a symbolic graph containing the 16 segments (white lines) originating from the LeddarVu module. Detections are drawn as arcs in their corresponding segments. Only valid measurements are displayed. A more detailed description of the measurements can be obtained in the **Raw Detections** dialog box (see section 6.12 Raw Detections).

The X and Y numbers displayed at the bottom are the mouse cursor position coordinates.

6.3.1. Toolbar

The toolbar includes several buttons for adjusting the view of the main window display.

6.3.2. Fit to Window

Click the fit-to-window button to adjust the LeddarVu module view to the main window.

6.3.3. Force Equal Horizontal and Vertical Scales

When the equal scaling button 1:1 is selected (button highlighted), the original ratio of the display is kept or restored. The horizontal and vertical scales will be set to the same values and the beam will be displayed in accordance with the beam properties (for example, the display will show a 47.5° beam for a 47.5° LeddarVu module).

Click the button again to change the vertical and horizontal scales independently.

NOTE: When in equal scaling mode, you cannot zoom the display horizontally or vertically, that is, holding the <Control> or <Shift> key down while zooming in or out will have no effect. The scales cannot then be modified by entering values in the fields shown in Figure 30 above.

6.3.4. Zoom in

Click the zoom in button to zoom in vertically and horizontally around the center of the display.

6.3.5. Zoom out

Click the zoom out button to zoom out vertically and horizontally around the center of the display.

6.3.6. Scale

The window opens with the default scale setting. The horizontal and vertical scales can be changed manually by entering new values in the fields accessible by clicking the areas shown in Figure 30.

To apply the changes, click anywhere in the main window.

6.3.7. Panning and Zooming

The display in the main window can be panned and zoomed in different ways. Panning and zooming is done relative to the mouse cursor position.

You can move up, down, and sideways by clicking and dragging the display.

To zoom the display in and out, use the mouse wheel alone. This has the same effect as clicking the zoom in or zoom out button respectively (see sections 6.3.4 and 6.3.5).

To zoom the display horizontally, hold down the <Control> key of the computer keyboard while using the mouse wheel.

NOTE: The equal scaling button 1:1 must be not selected (not highlighted).

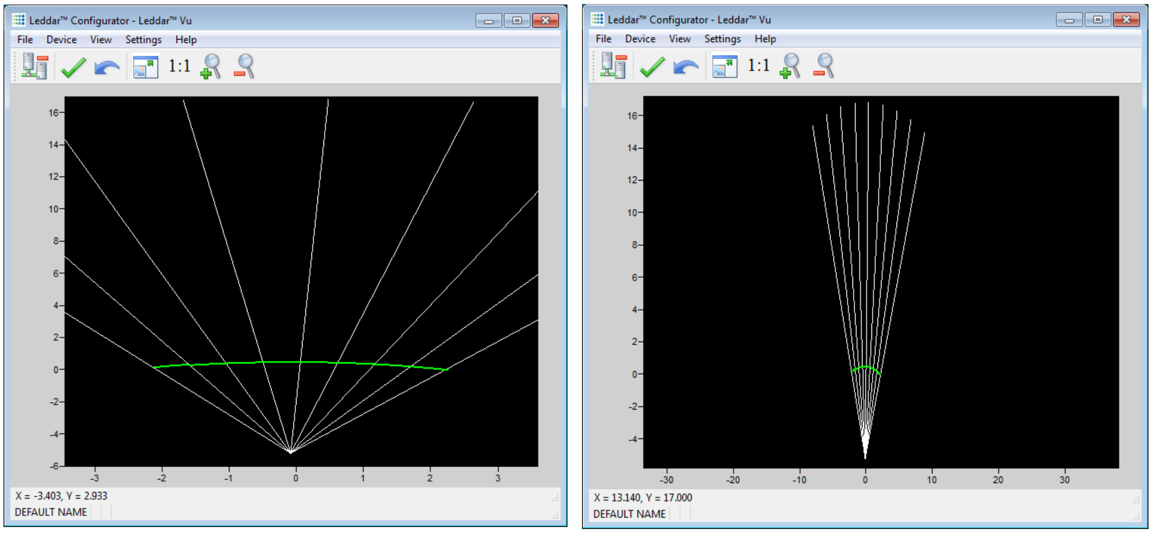


Figure 31: Zooming in *(left)* and out *(right)* horizontally

To zoom the display vertically, hold the <Shift> key down while using the mouse wheel.

NOTE: The equal scaling button 1:1 must be not selected (not highlighted).

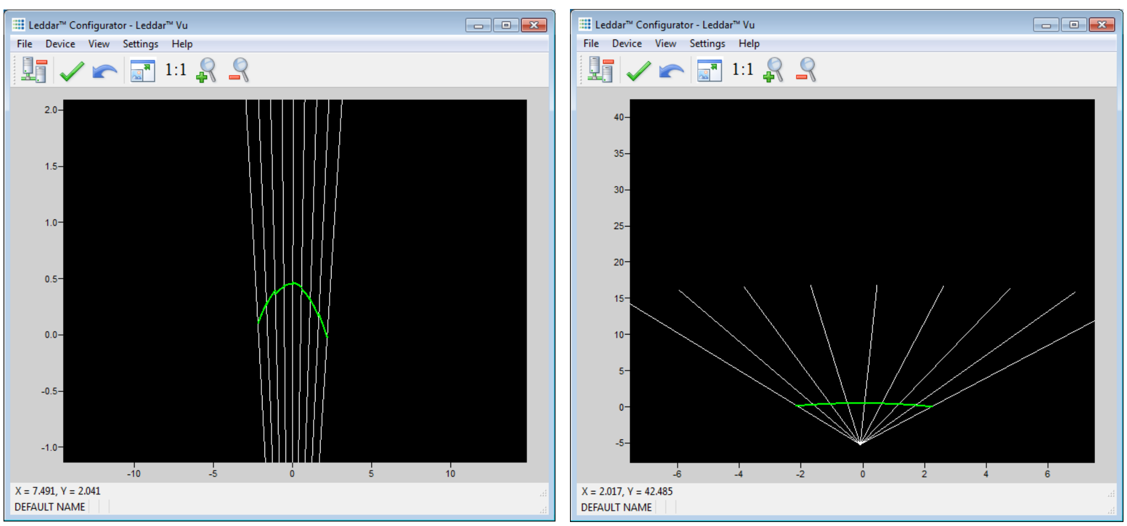


Figure 32: Zooming in *(left)* and out *(right)* vertically

The measurements of a detection point appear as a pop-up when you point to it with the mouse cursor for a more accurate assessment of the detection. Detection points are shown in the form of green lines (arcs) in the main window for visibility reasons.

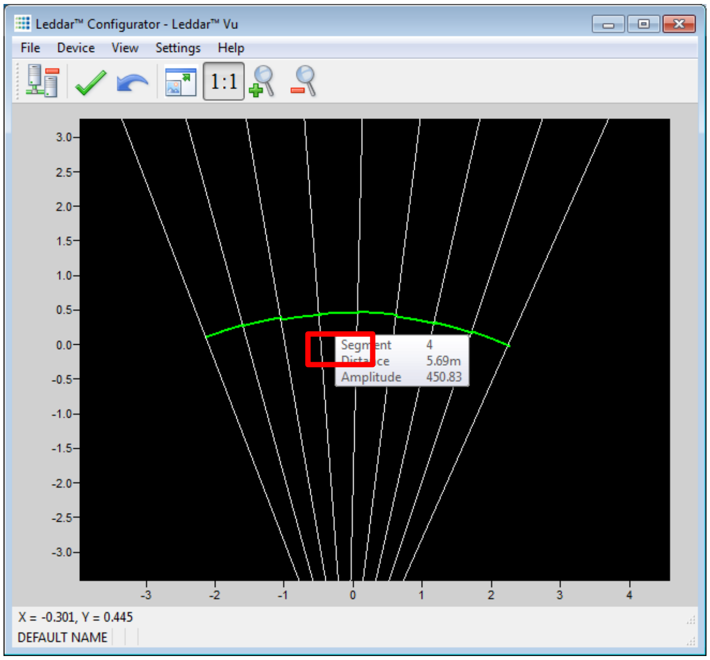


Figure 33: Detection point coordinates

6.3.8. Changing the LeddarVu Module Origin

The module origin can be modified by clicking the module origin at the bottom of the segments.

To do so, use the mouse cursor to point to the bottom of the segments (a red dot appears); click and drag it in the desired position.

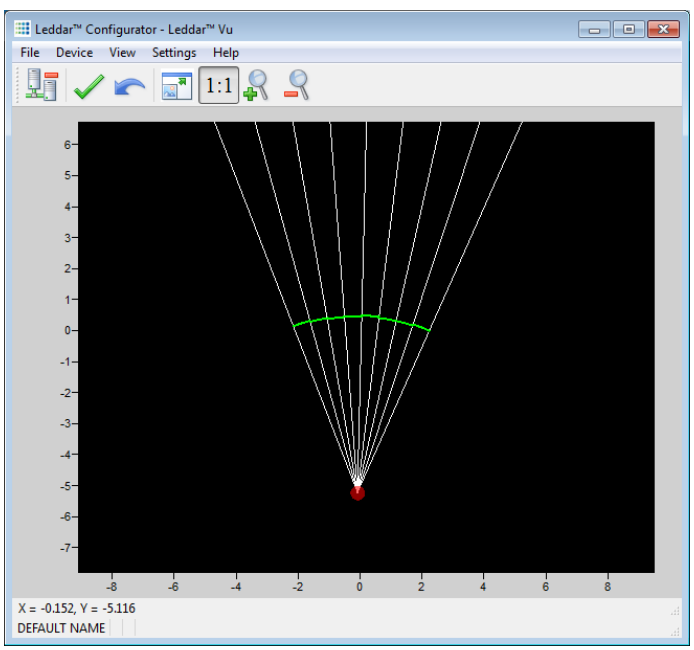


Figure 34: Dot indicator to modify the module origin

If you click and drag the module origin, its position is displayed in the status bar as shown in Figure 35.

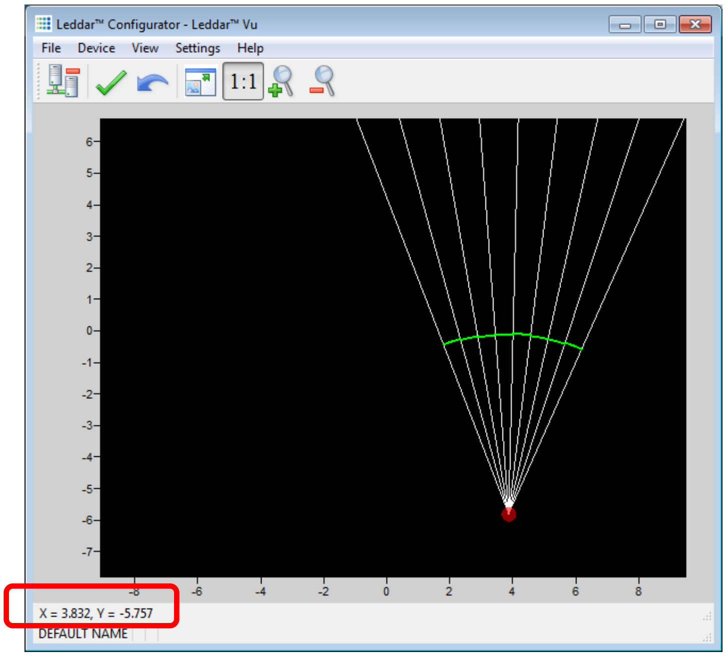


Figure 35: Module position changed

To apply the changes, click the apply button .

The origin is saved in the module and it can also be modified by editing the parameters in the module position settings window.

6.3.9. Changing the LeddarVu Module Orientation

The module origin may be rotated to match its physical position. If you do so, the main window display can better match the physical installation of the module. For example, if the module is installed above the ground, the origin can be set to reflect its position.

Use the mouse cursor to point to the top of the segments (the top turns red); click and drag it in the desired position.

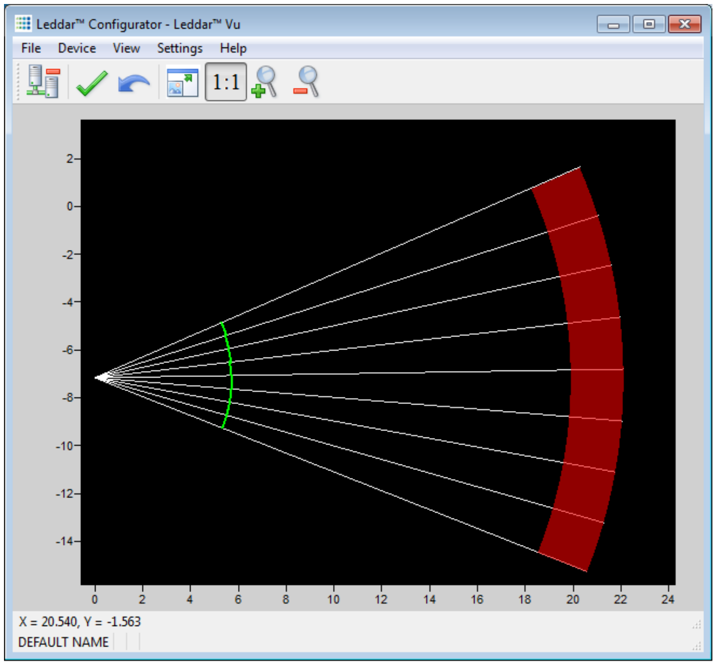


Figure 36: Red bar to rotate the module position

To apply the changes, click the apply button.

The module orientation is saved in the module and can also be modified by editing the parameters in the module position settings window.

6.4. Settings

The LeddarVu module stores many settings. Once saved in the module, these parameters are effective at each power up. The Leddar™ Configurator software loads these parameters upon each connection.

6.4.1. Module Name

When you connect to a LeddarVu module for the first time, it has a default name. You can change that name at any time.

To change the module name:

1. Connect to a module.
2. On the **Device** menu, point to **Configuration** and click **Device Name**.

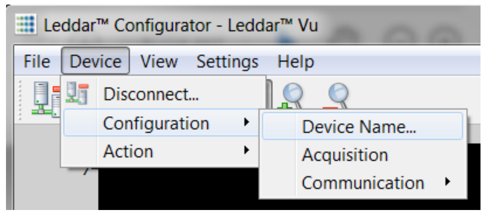


Figure 37: Device menu and the Configuration menu items

3. In the **Device Name** dialog box, in the **Name** field, type the new name of the module and click **OK**.

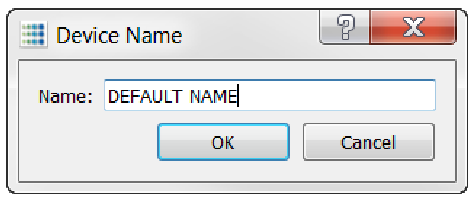


Figure 38: Device Name dialog box

4. To apply the change, click the apply button ✓ in the Leddar™ Configurator main window.

6.4.2. Acquisition Settings

The acquisition settings allow you to define parameters to use for detection and distance measurement.

To open the **Acquisition Settings** dialog box, select **Device > Configuration** > **Acquisition**.

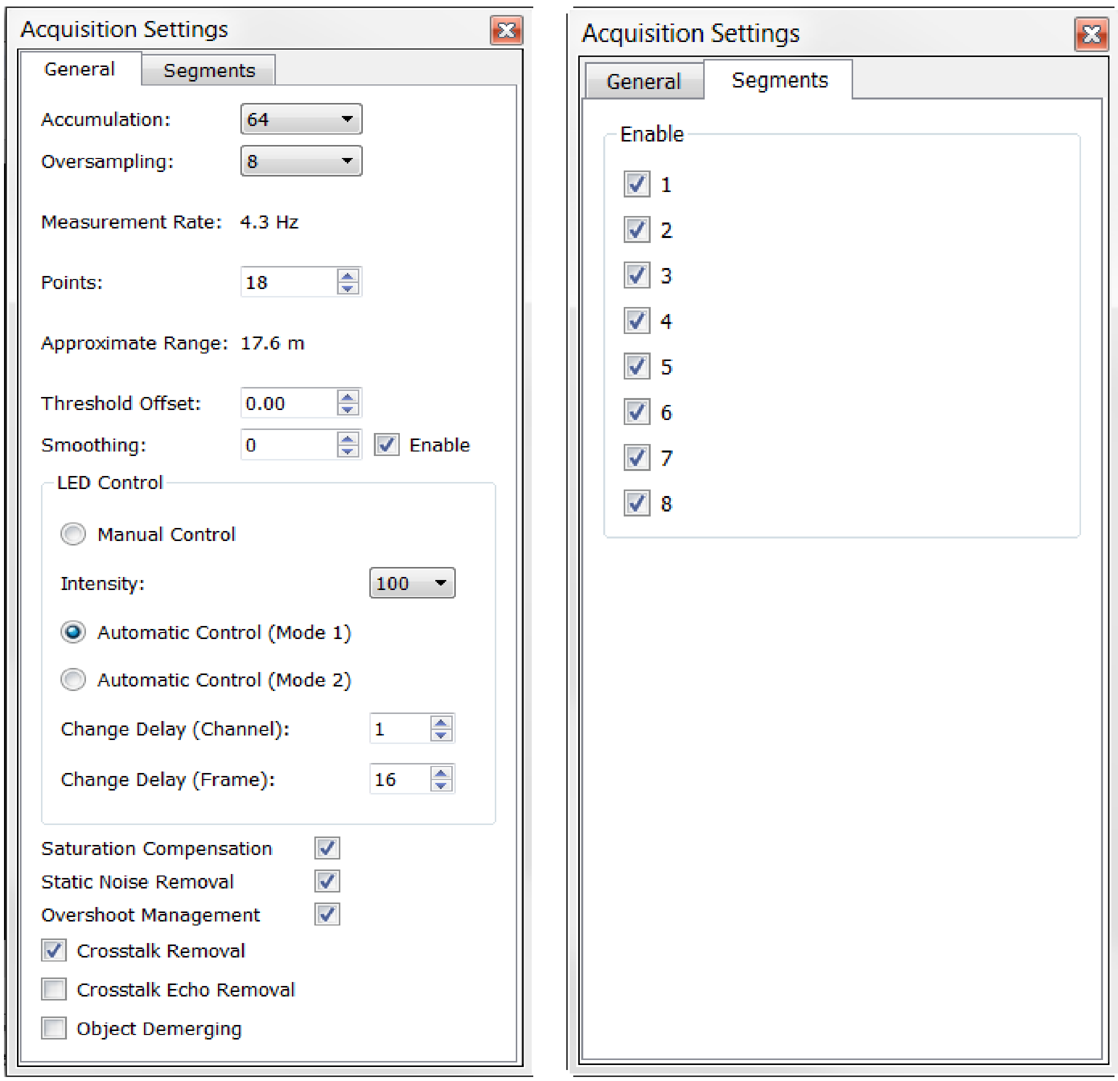


Figure 39: Acquisition Settings dialog box

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

Refer to Section 3.3 Acquisition Settings for more details on all the parameters.

6.4.3. Serial Port

The serial port settings of the USB, CAN and SERIAL board are configurable.

To configure the serial port:

1. On the **Device** menu, point to **Configuration**, point to **Communication**, and click **Serial Ports**.

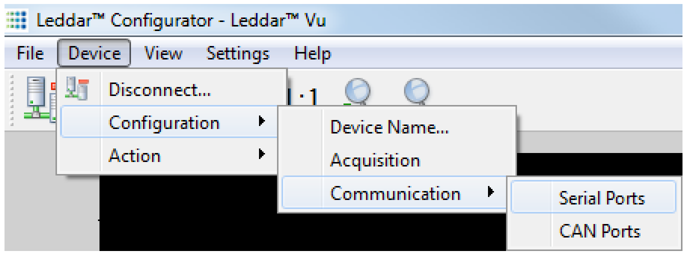


Figure 40: Device menu

2. In the **Serial Port Setting** dialog box, use the arrows or type numbers to modify the values.

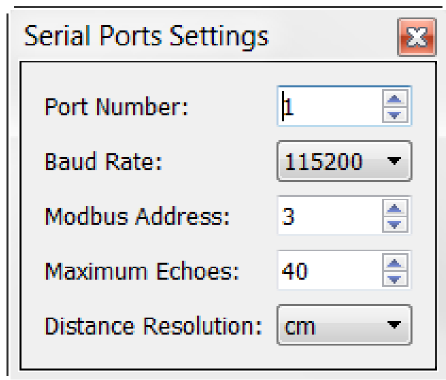


Figure 41: Serial Port Settings dialog box

Table 69 describes the serial port settings.

Table 69: Serial port setting description

Parameter	Value
Port number	Select 1 for the configurable serial link number 1. Select 2 for the TTL serial link number 2. Select 3 for the USB VCP serial link.
Baud rate	9,600 bps, 19,200 bps, 38,400 bps, 57,600 bps, 115,200 bps
Address	1 to 247
Detections	0 to 40
Distance resolution	Millimeters (mm), centimeters (cm), decimeters (dm), meters (m)

6.4.4. CAN Port

The CAN port settings of the USB, CAN and SERIAL board are configurable.

To configure the CAN port:

1. On the **Device** menu, point to **Configuration**, point to **Communication**, and click **CAN Ports**.

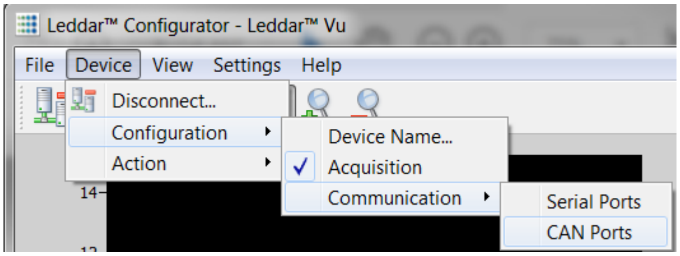


Figure 42: Device menu

2. In the **Serial Port Setting** dialog box, use the arrows or type numbers to modify the values.

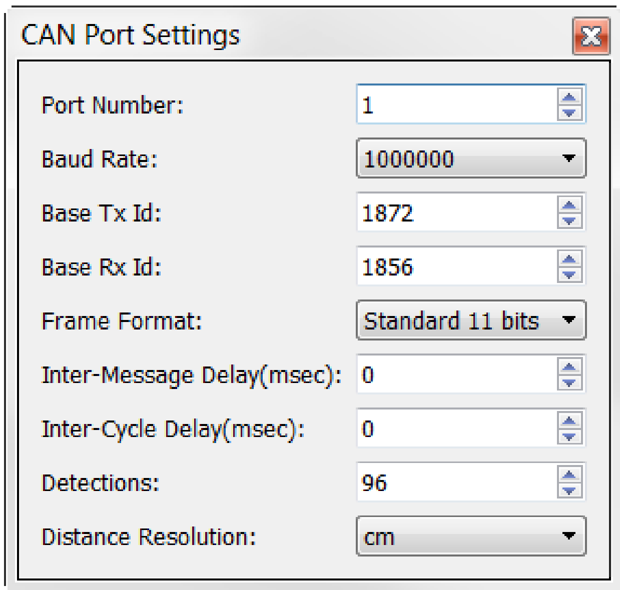


Figure 43: CAN Port Settings dialog box

Table 70 describes the CAN port settings.

Table 70: CAN port setting description

Parameter	Value
Port number	Select 1 for CAN communication
Baud rate	10,000 bps, 20,000 bps, 50,000 bps, 100,000 bps, 125,000 bps, 250,000 bps, 500,000 bps, and 1,000,000 bps
Base Tx ID	The base CAN arbitration ID used for data messages coming from the USB, CAN and SERIAL to host (see the protocol documentation).
Base Rx ID	The base CAN arbitration ID used for data messages sent to the USB, CAN and SERIAL board (see the protocol documentation).
Frame format	Standard 11 bits, Extended 29 bits
Inter-message delay	0 to 65535 milliseconds
Inter-cycle delay	0 to 65535 milliseconds
Detections	1 to 96
Distance resolution	Millimeters (mm), centimeters (cm), decimeters (dm), meters (m)

6.5. Saving and Loading a Configuration

The software configuration for a device can be saved to a file. This enables you to backup settings and restore them in case of system failure or in case you want to revert to earlier settings. You can also get the configuration that was stored with a record file.

To save a configuration:

- On the **File** menu, click **Save Configuration**.

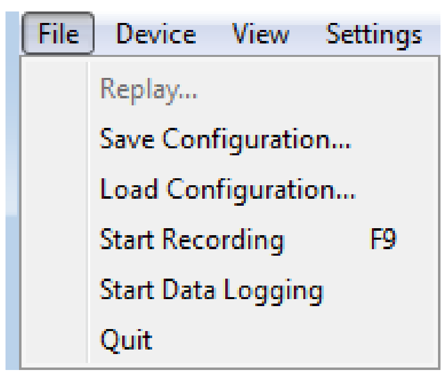


Figure 44: File menu

To load a configuration:

- On the **File** menu, click **Load Configuration**.

6.6. 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 *.ltl file that can later be reloaded and replayed.

To configure the detection record:

1. In Leddar™ Configurator, on the **Settings** menu, click **Preferences**.

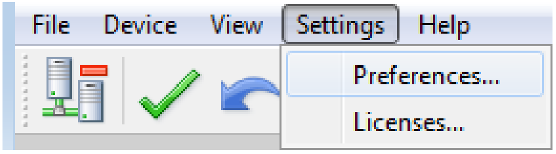


Figure 45: Settings menu

2. In the **Preferences** dialog box, click **Recording** and click **Recorder**.

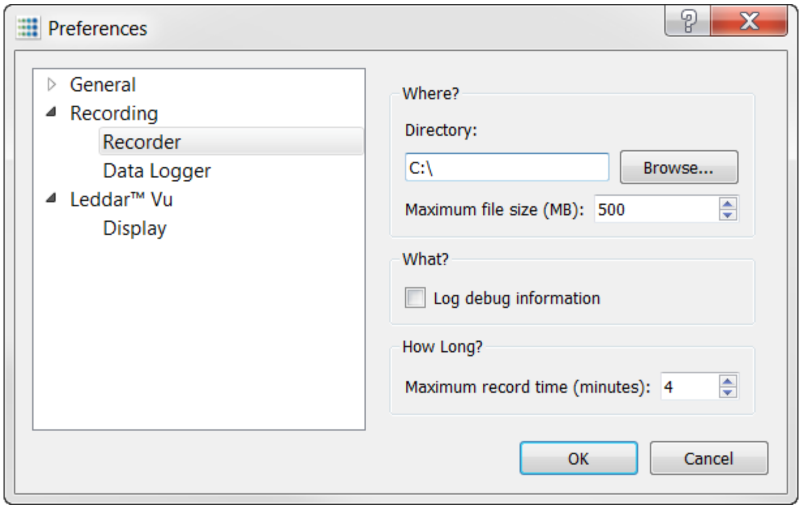


Figure 46: Preferences dialog box

3. Under **Directory**, click the **Browse** button to select the path where you want to save the detection record file.
4. In the **Maximum file size** box, set the maximum file size by using the arrows or by entering the value manually.
5. Under **What**, select the **Log debug information** check boxes.
6. Under **How Long**, next to **Maximum record time**, determine the length of time for recording by using the arrows or by entering the value manually. At the end of that period, recording will stop even if the file size has not reached its maximum.
7. Click **OK** to save the settings.

A complete description of the elements found in the **Preferences** for recording dialog box follows the next two procedures.

To start a recording:

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

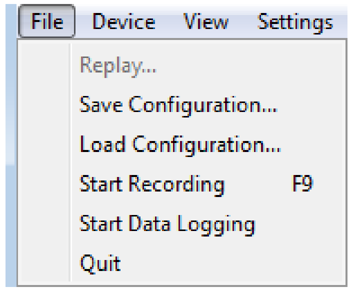


Figure 47: File menu

To stop a recording manually:

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

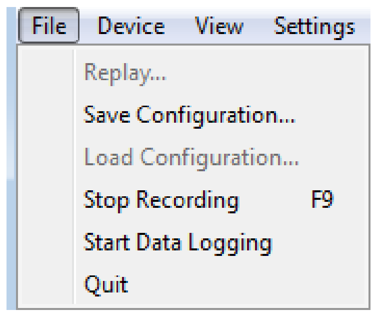


Figure 48: File menu to stop a recording

The following is a description of the elements available in the **Preferences** for recording dialog box.

Record directory

The record directory is the folder in which all record files will be saved. These files are in a proprietary format, with the extension *.ltl, and can only be opened and viewed with the Leddar™ Configurator software.

Maximum file size

Record files can be quite large. Set the maximum file size as needed. 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.

Debug

These check boxes are reserved for the use of LeddarTech technicians.

Maximum record time

The value entered as the **Maximum record time** determines the length of the time for recording. At the end of that period, recording will stop even if the file size has not reached its maximum.

6.7. 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:

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

   OR

   Open another Leddar™ Configurator main window.

NOTE: The record files can also be opened by double-clicking them.

2. On the File menu, click Replay.

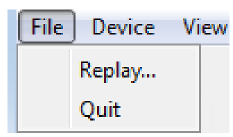


Figure 49: File menu to open a recording

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

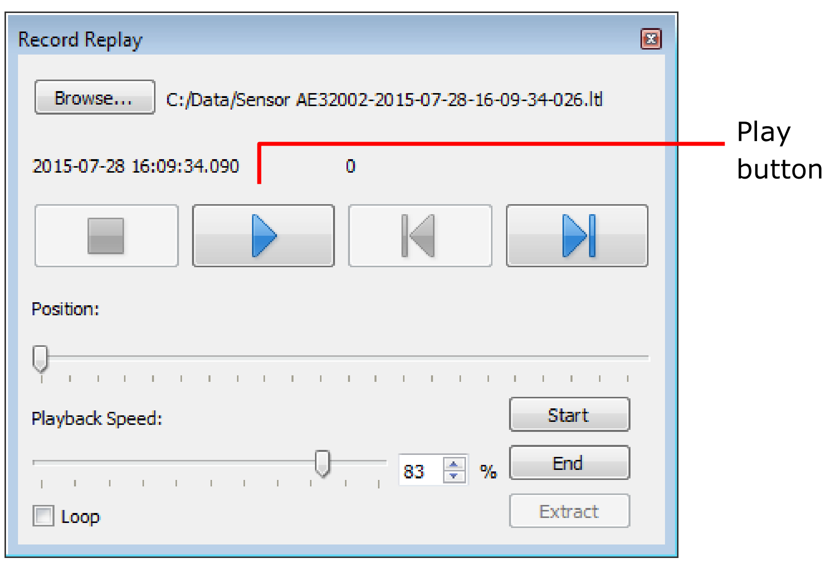


Figure 50: Record Replay dialog box

4. 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.
3. Click the **Extract** button to extract and save that file segment.

6.8. Data Logging

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

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

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

Table 71: Field description of the log text file

Time (msec)	Segment [0 15]	Amplitude [0 512]	Distance (m)	Status
12735204	7	0.9	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 (line, column).
- *Amplitude* of the detection indicates the strength of the returned signal.
- *Distance* indicates the distance of the detection in meters or in feet depending on the distance unit configured in the **Preferences** menu.
- *Status* corresponds to a flag value. Refer to Section **6.1.2 Raw Detections** for more details.

To use the data logging function:

1. In Leddar™ Configurator, on the **Settings** menu, click **Preferences**.

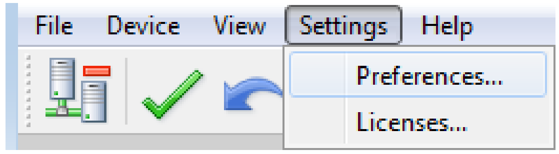


Figure 51: Settings menu

2. In the **Preferences** dialog box, click **Recording** and click **Data Logger**.

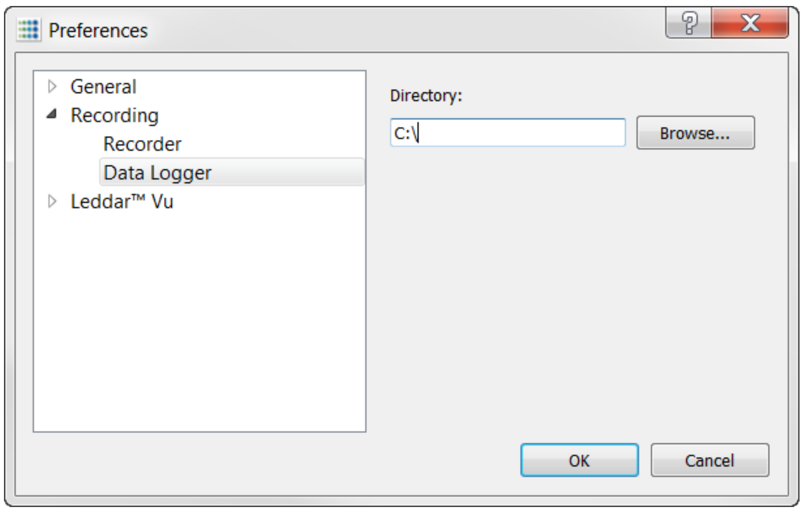


Figure 52: Preferences dialog box for logging data

3. Under **Directory**, click the browse button to select the path where you want to save the log and click **OK**.
4. On the **File** menu, click **Start Data Logging**.

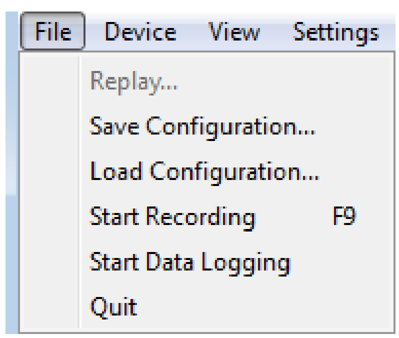


Figure 53: File menu

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

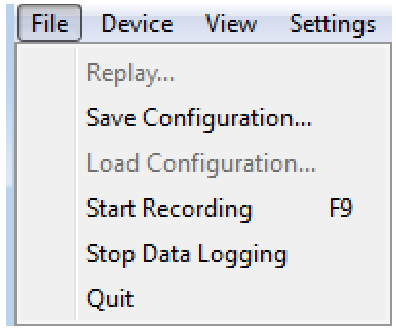


Figure 54: File menu to stop data recording

A .txt file is saved in the selected directory.

6.9. Firmware Update

Follow the steps below to update the firmware.

1. Connect the LeddarVu module to its power supply and to your computer by USB or SPI.
2. Launch Leddar Configurator and connect to your sensor.
3. You will get a prompt indicating that the carrier board firmware is outdated.

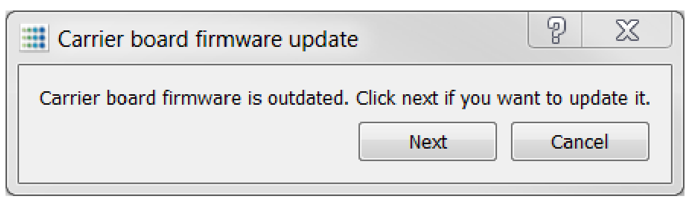


Figure 55: Carrier board firmware update

4. Follow the on-screen instructions to perform the firmware update.

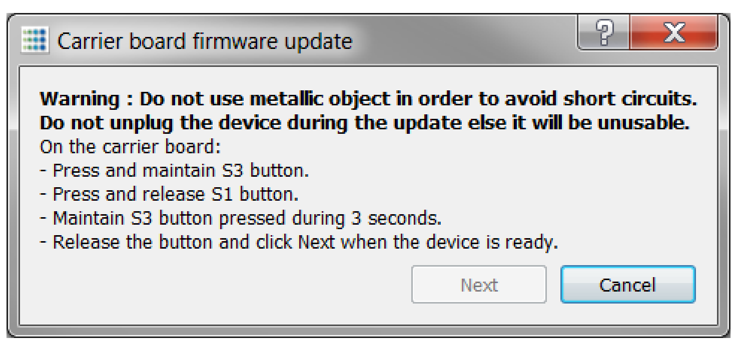


Figure 56: Carrier board firmware update warning

NOTE: Remember to maintain the S3 button pressed while you press S1. See the image below.

For reference, here are the S3 and S1 buttons:

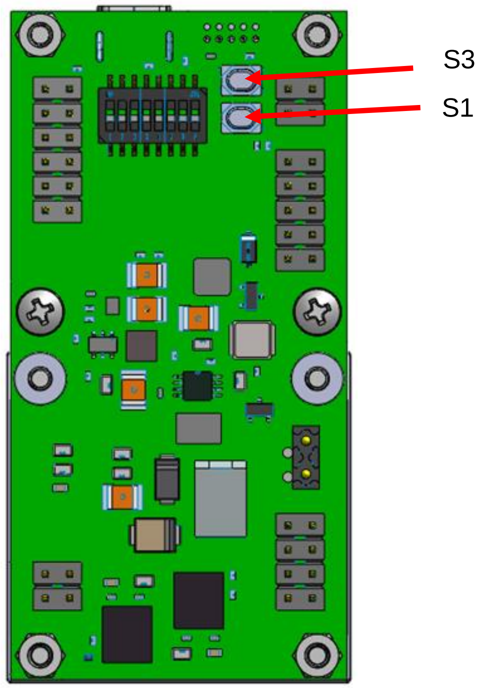


Figure 57: Carrier board S3 and S1 buttons

5. At the end of the update, you will have to power-cycle the sensor and connect again.
6. Upon the second connection, you will get a prompt saying that the software is not up to date.

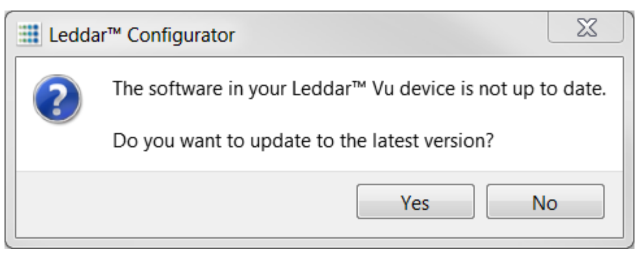


Figure 58: Updating the latest version window

7. Perform the second phase of the update, and power-cycle the sensor again.

To verify the update, on the **View** menu, click the **State** command. The **Device State** window opens, and you can verify the following versions.

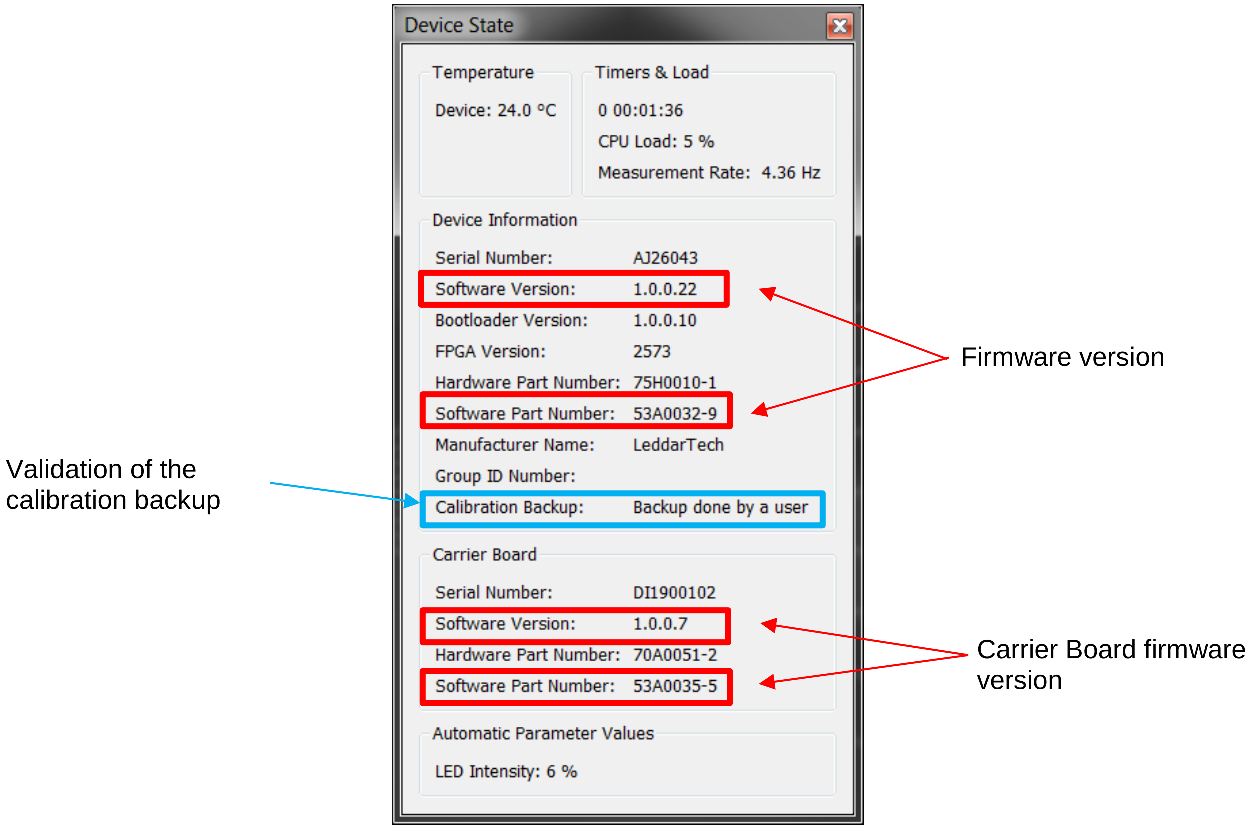


Figure 59: Device state window

8. Once the update is done, you can create a backup of your sensor's calibration and current acquisition settings. In the **Device** menu, click **Action**, **Calibration Backup**, and **Create**.

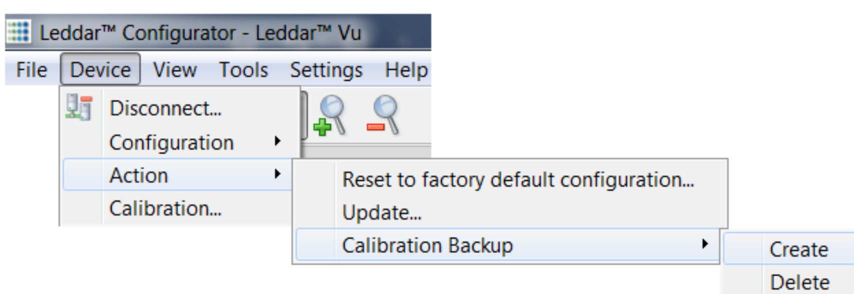


Figure 60: Steps for creating a backup

NOTE: A backup is made on all new sensors in the factory before shipping.

6.10. Device State

Information about a device is accessible when connecting to a device in the **Connection** window or by clicking the **State** command on the **View** menu.

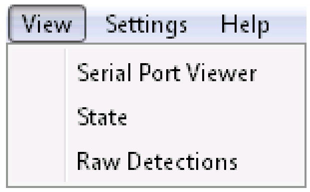


Figure 61: View menu

The **Device State** window opens.

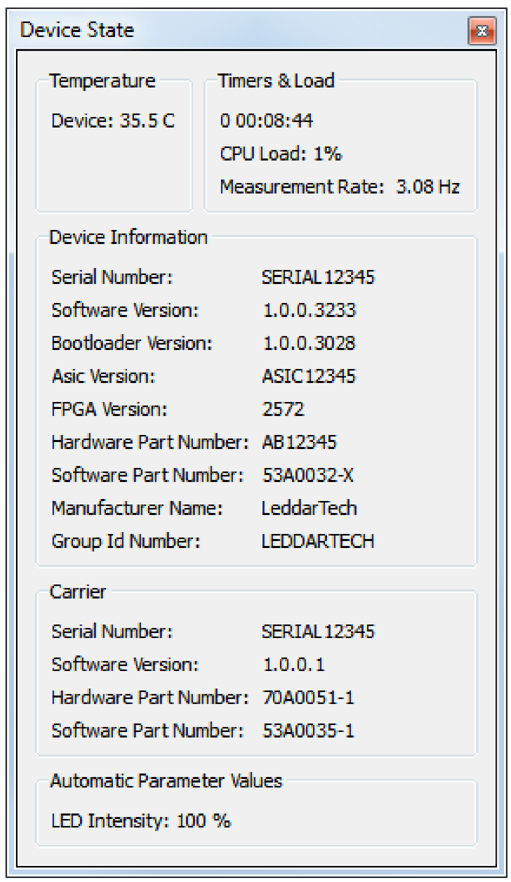


Figure 62: Device State window

General

Timers & Load

This feature gives information in days, hours, minutes, and seconds about two types of activities of a device. The first line indicates the time elapsed since the last device reset, the second since the last power cut or outage.

Measurement Rate

This parameter indicates the rate at which the module measures the speed and dimension of static or moving surfaces.

Automatic Parameter Values

This parameter indicates the intensity of the light source.

Device Information

Serial Number

This parameter indicates the serial number of the device as assigned by LeddarTech.

Software Version

This parameter indicates the software version, which is specific to the processor of your unit.

Bootloader Version

This parameter indicates the bootloader (booting instructions) version, which is specific to the processor of your unit.

Asic Version

This parameter indicates the version of the application-specific integrated circuit; the microchip designed for this special application. This field is optional in function of the receiver module type.

FPGA Version

This parameter indicates the field-programmable gate array circuit used in the device.

Hardware Part Number

This parameter indicates the hardware part number of the device as assigned by LeddarTech.

Software Part Number

This parameter indicates the software part number of the device as assigned by LeddarTech.

Manufacturer Name

This parameter indicates the name assigned to LeddarTech.

Group Id Number

This parameter indicates the end-user group unique identifier used for licensing purposes.

Carrier

Serial Number

This parameter indicates the serial number of the USB, CAN and SERIAL carrier board as assigned by LeddarTech.

Software Version

This parameter indicates the software version, which is specific to USB, CAN and SERIAL carrier board of your unit.

Hardware Part Number

This parameter indicates the hardware part number of the USB, CAN and SERIAL carrier board as assigned by LeddarTech.

Software Part Number

This parameter indicates the software part number of the USB, CAN and SERIAL carrier board as assigned by LeddarTech.

6.11. Preferences

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

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

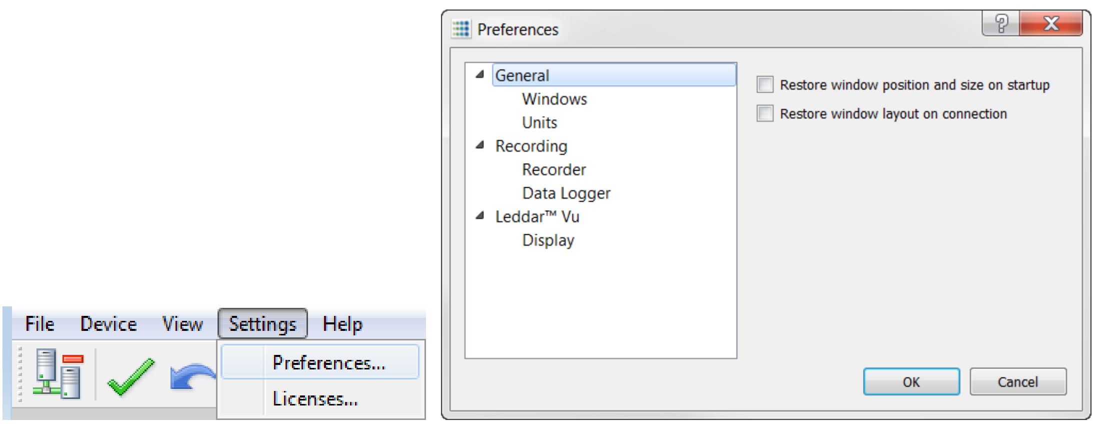


Figure 63: Settings Menu and Preferences Dialog Box

Windows

The two options allow the user to select how the content of the main window will be displayed in Leddar™ Configurator. Choices are:

- The **Restore window position and size on startup** feature starts Leddar™ Configurator at the same place on the computer desktop and at the same size it was when it was closed.
- The **Restore window layout on connection** feature connects to the Evaluation Kit at the same size it was and with all docked dialog boxes or windows that were displayed when it was closed.

Distance

The unit that is applied to distances displayed in Leddar™ Configurator.

Temperature

The unit used when displaying the temperature.

Recording

The **Recorder** parameter lets you choose how data files are recorded.

The **Data Logger** parameter lets you select a directory to store logs.

Display

The **Detection Arc Thickness** parameter allows a user to modify the pixel width of the displayed green detections arcs in the main window.

6.12. Raw Detections

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

To open the **Raw Detections** dialog box, on the **View** menu, click **Raw Detections**.

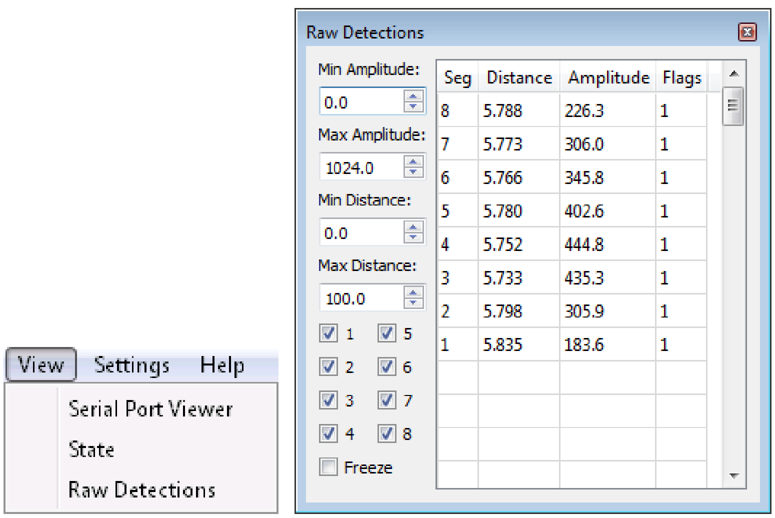


Figure 64: View menu and Raw Detections dialog box

Figure 65 presents an example of raw detections. When there is no detection in some segments, only the segments where a detection occurred appear in the list.

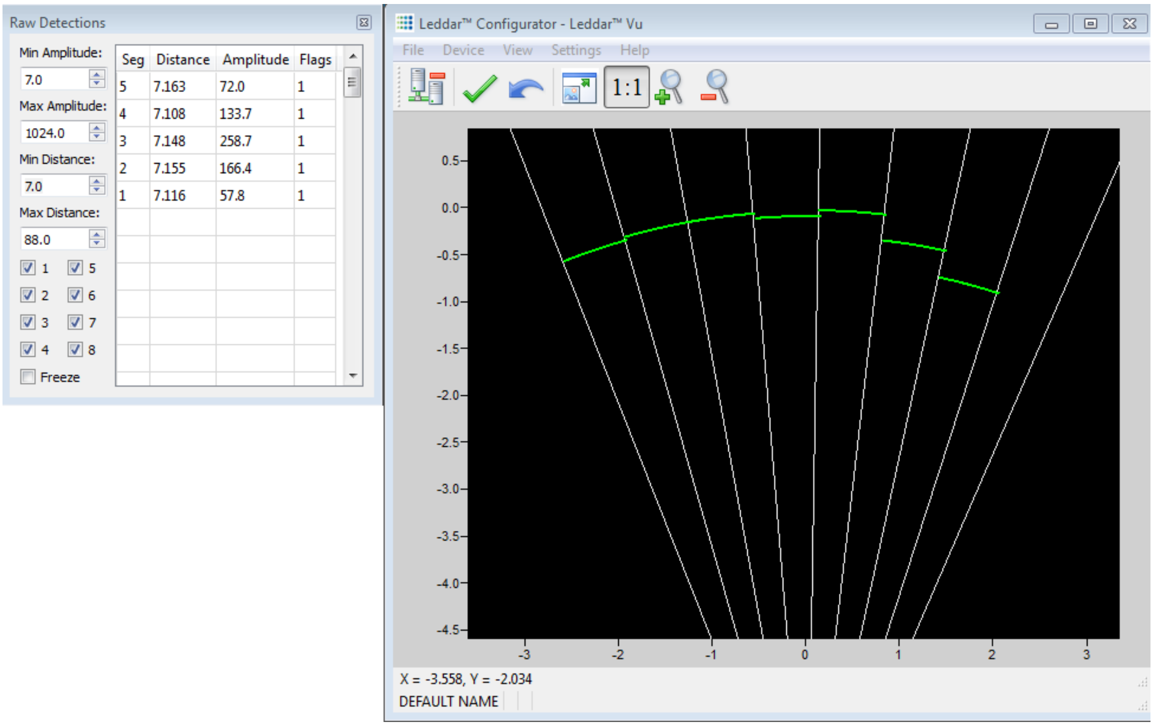


Figure 65: Example of detection filters

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 shows only detections of amplitude higher or equal to that value. For example, if the minimum amplitude is set to 5, only the detections of amplitude 5 and more will be displayed.

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

Setting a value in both fields will result in a range of amplitude to display.

Min and Max Distance

The value entered in the **Min Distance** box will show only detections at a distance greater or equal to 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 Amplitude** box will show only detections at a distance smaller or equal to that value. For example, if the minimum distance is set to 20, only the detections at a distance of 20 and less will be displayed.

Setting a value in both fields will result in a range of distance to display.

Boxes 1 to 8

Check boxes 1 to 8 allow you to select which segments to display.

Freeze

When selected, the **Freeze** parameter freezes the values displayed in the **Raw Detections** dialog box. To return to the live display, clear the check box.

Seg

The **Seg** 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.

Distance and Amplitude

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

Flags

The **Flags** column displays a number that represents a detection type. See Table 8 in section 4.1.

7. Specifications

This chapter presents the LeddarVu module specifications.

7.1. General

Table 72: General specifications

Light Source pulse rate	51.2 kHz
Photodetector array size	1 x 8
Photodetector acquisition rate	100 MHz
Measurement rate	See Table 12.
USB (optional)	2.0, 12 Mbits/s
CAN (optional)	10 to 1000 kbit/s, optional 120-Ω termination
Serial links (optional)	TTL, RS-232, RS-422, and RS-485. 2-wire, 4-wire, 9600 to 115200 BPS
Operating temperature	-40°C to +85°C

7.2. Mechanical

Table 73: Mechanical specifications

Assembly height	43.3 mm
Assembly width	35.2 mm

See section 7.6 for dimensions including optics.

7.3. Electrical

Table 74: Electrical specifications

Voltage	12 VDC ± 0.6 V
Power consumption (total)	< 2.2 W
Power output maximum current	15 mA

7.4. Optical

Table 75: Optical specifications

Wavelength	905 nm (infrared)
Laser risk group	IEC 60825-1:2014 (Third Edition); Class I laser product
Beam width and height (HFOV and VFOV)	Table 766.

Table 76: HFOV and VFOV

Horizontal FOV*	Vertical FOV*
16 ± 1°	0.3 ± 0.2°
16 ± 1°	2.25 ± 0.6°
47.5 ± 3.5°	0.3 ± 0.15°
47.5 ± 3.5°	3 ± 0.6°
98.5 ± 5°	0.3 ± 0.15°
98.5 ± 5°	3 ± 0.25°

* These parameters present the sensitivity of the module across the horizontal FOV (segment amplitude efficiency) and vertical FOV (amplitude vs. tilt). See Figure 66.

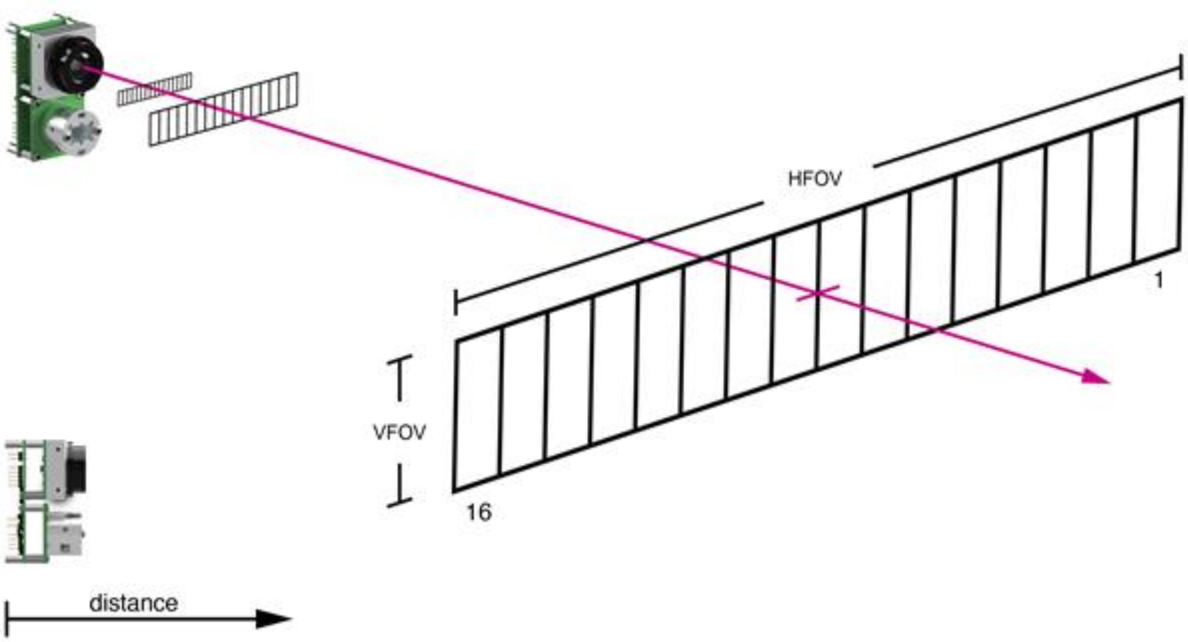


Figure 66: Horizontal field of view (HFOV) and Vertical field of view (VFOV)

7.5. Performance

Table 77: Module performances

Performance Metrics	Values
Measurement accuracy	±5 cm
Measurement precision	6 mm (amplitude >15)
Resolution	1 cm
Range (maximum light source intensity)	Varies with beam optics and target properties (see amplitude vs range figures below)
Data refresh rate	Up to 100 Hz (standard board)

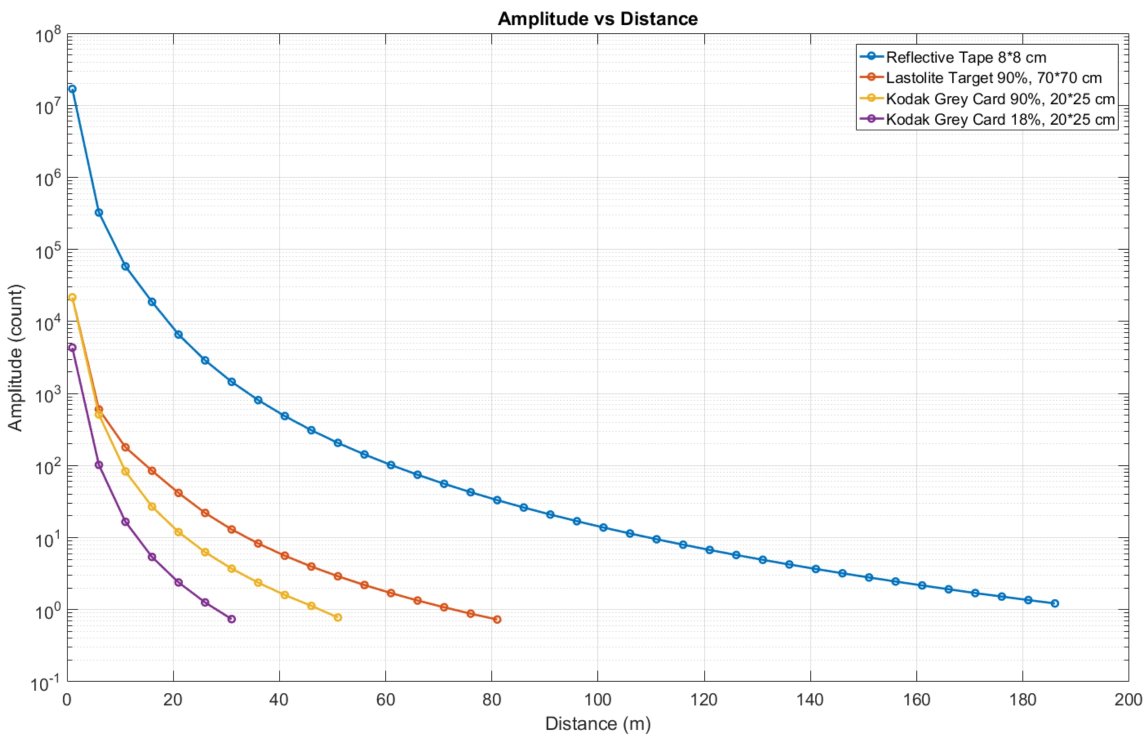


Figure 67: 16° x 0.3° (maximum intensity, 256 accumulations, and 8 oversamplings)

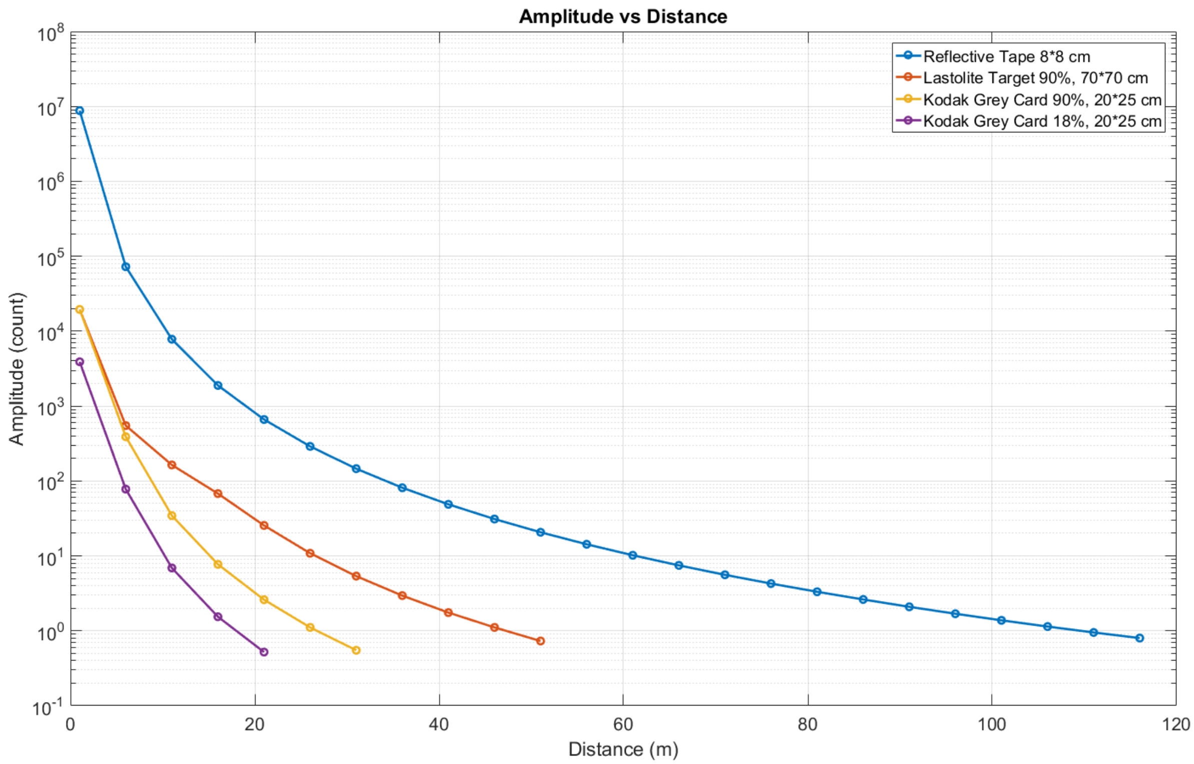


Figure 68: 16° x 2.25° (maximum intensity, 256 accumulations, and 8 oversamplings)

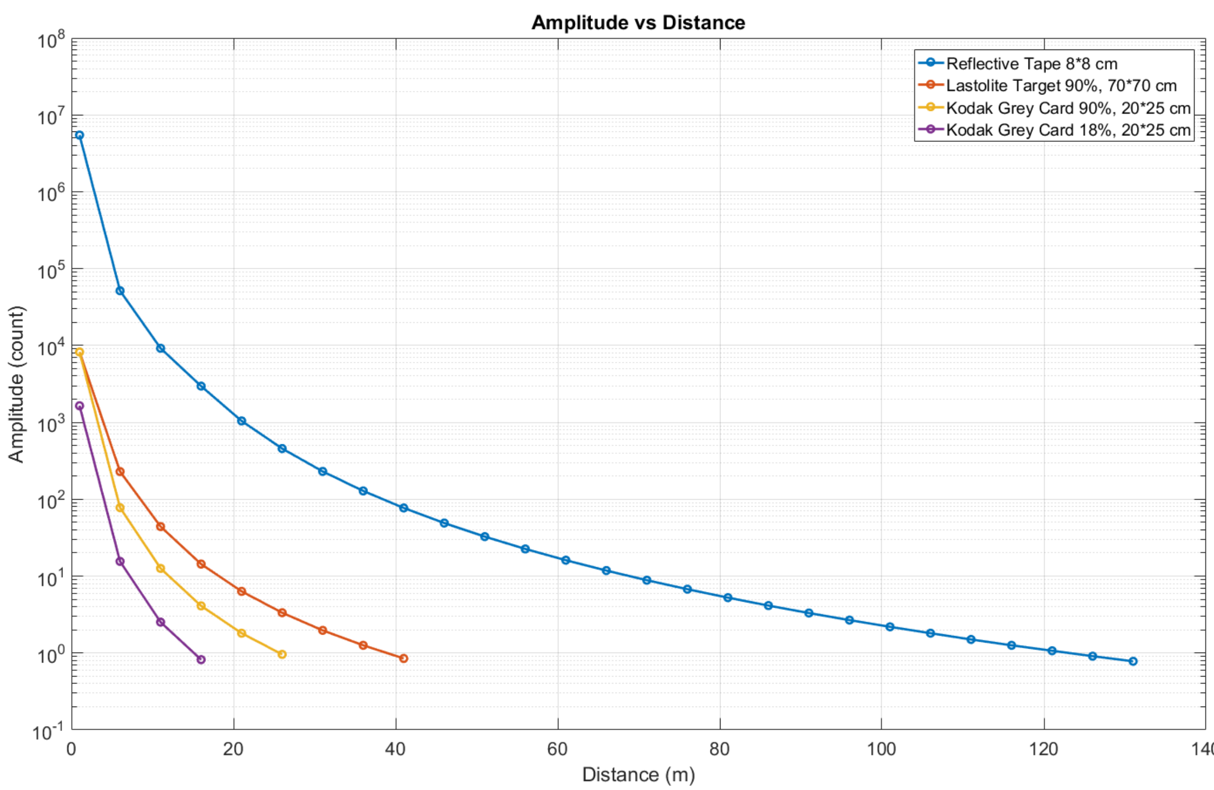


Figure 69: 47.5° x 0.3° (maximum intensity, 256 accumulations, and 8 oversamplings)

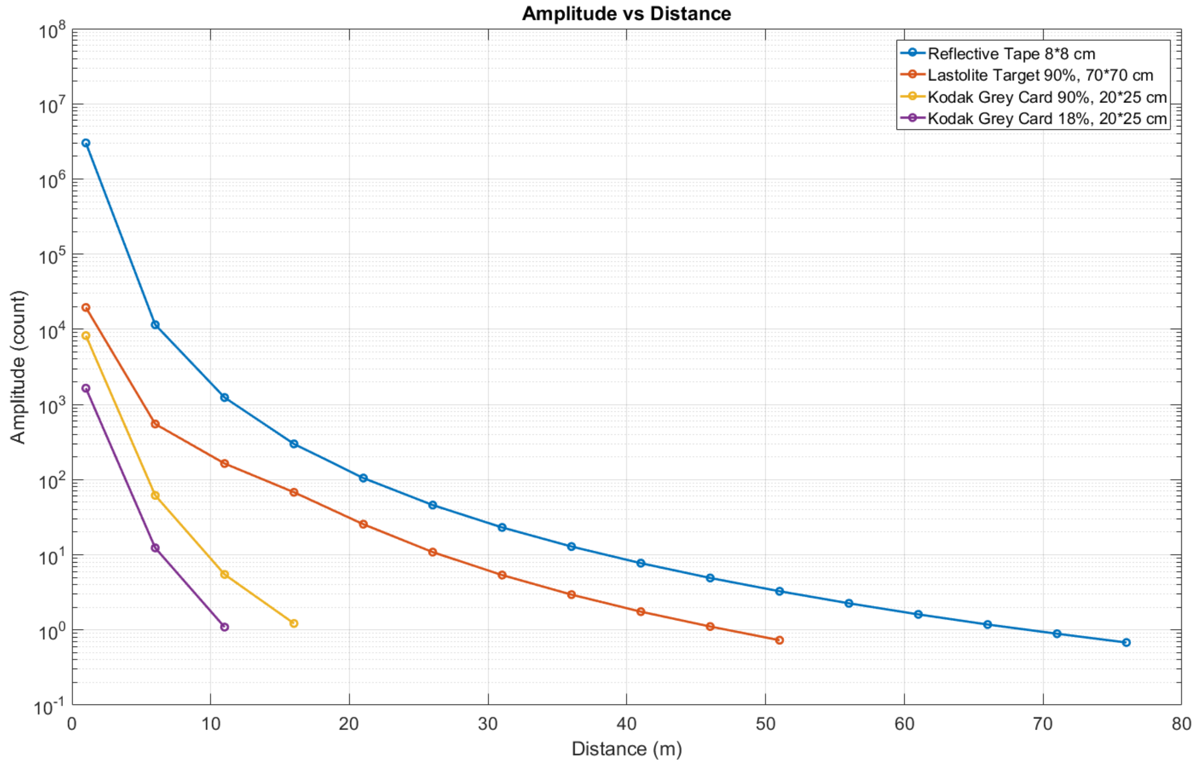


Figure 70: 47.5° x 3° (maximum intensity, 256 accumulations, and 8 oversamplings)

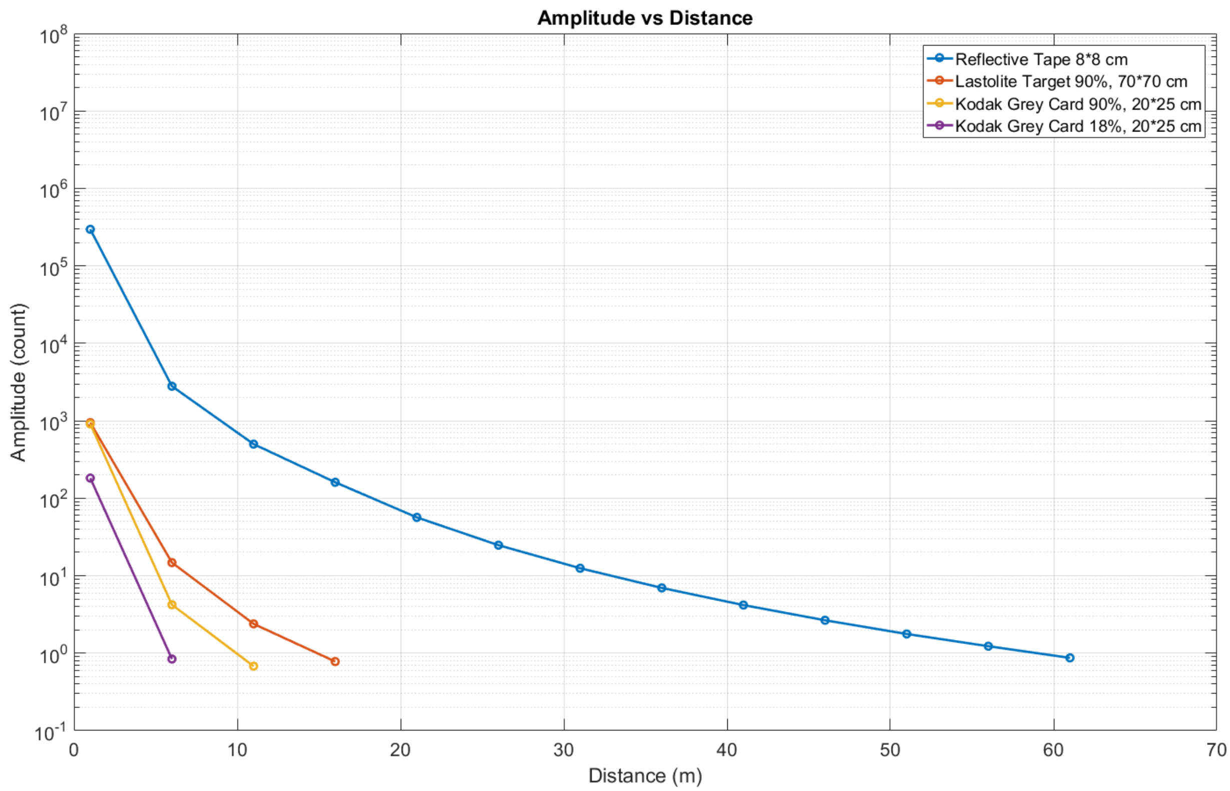


Figure 71: 99.5° x 0.3° (maximum intensity, 256 accumulations, and 8 oversamplings)

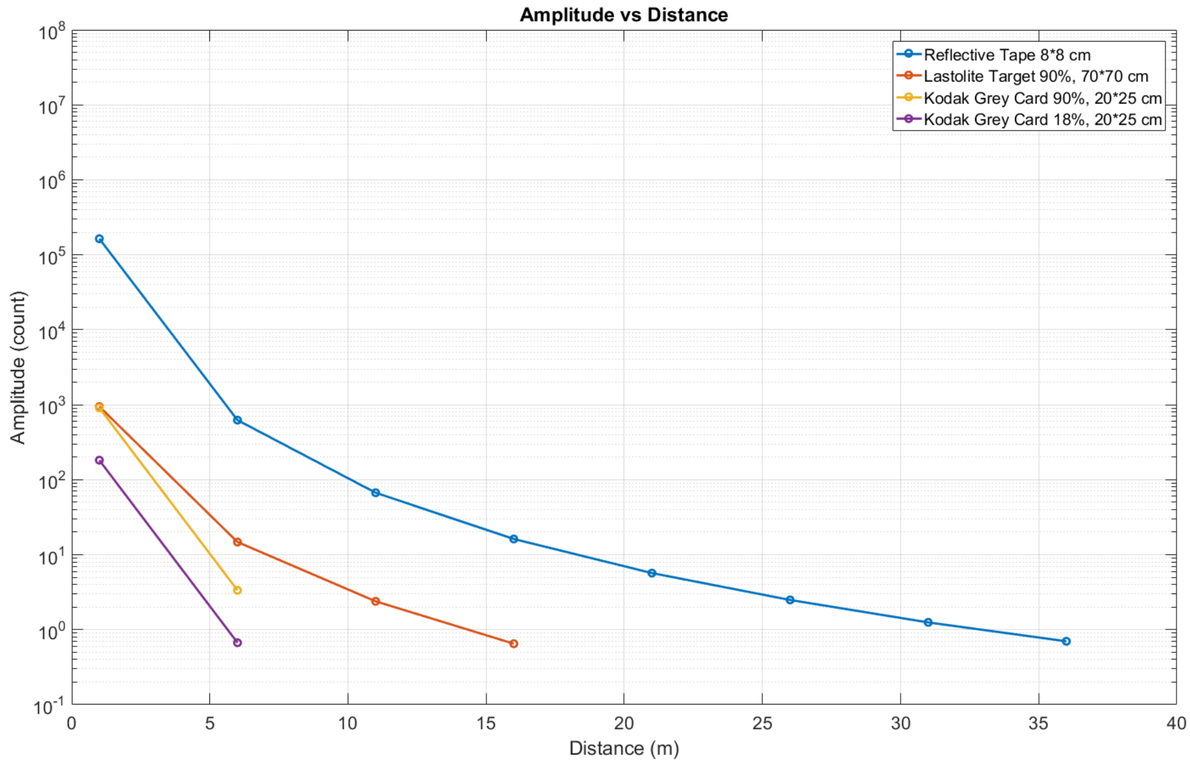


Figure 72: 98.5° x 3° (maximum intensity, 256 accumulations, and 8 oversamplings)

7.6. Regulatory Compliance and Safety

The module complies with FDA performance standards for laser products except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.

NOTE: Testing results are valid for a cable length shorter than 3 meters.

Table 78: Regulatory compliance

Test Name Standard	Test Specification	Performance Criterion	Result
Radiated emissions **FCC part 15 (2013) subpart B**	Class A 30MHz-1GHz	N/A	Pass
Radiated emissions **CISPR11 (2009) A1 (2010)**	Group 1 - class A 30MHz-1GHz	N/A	Pass
Radiated emissions **ICES-003 (2012)**	Class A 30MHz-1GHz	N/A	Pass
Electrostatic discharge immunity **IEC61000-4-2 (2008)**	Contact: ±4 kV Air: ±8 kV	C	Pass
Radiated electromagnetic field immunity **IEC61000-4-3 (2006)** **A1 (2007) A2 (2010)**	80 MHz-1000M Hz: 10 V/m 1.4 GHz – 2 GHz: 3 V/m 2 GHz - 2.7 GHz: 1 V/m	C	Pass

7.7. Dimensions

This section presents the LeddarVu module dimensions.

7.7.1. 98.5° Module

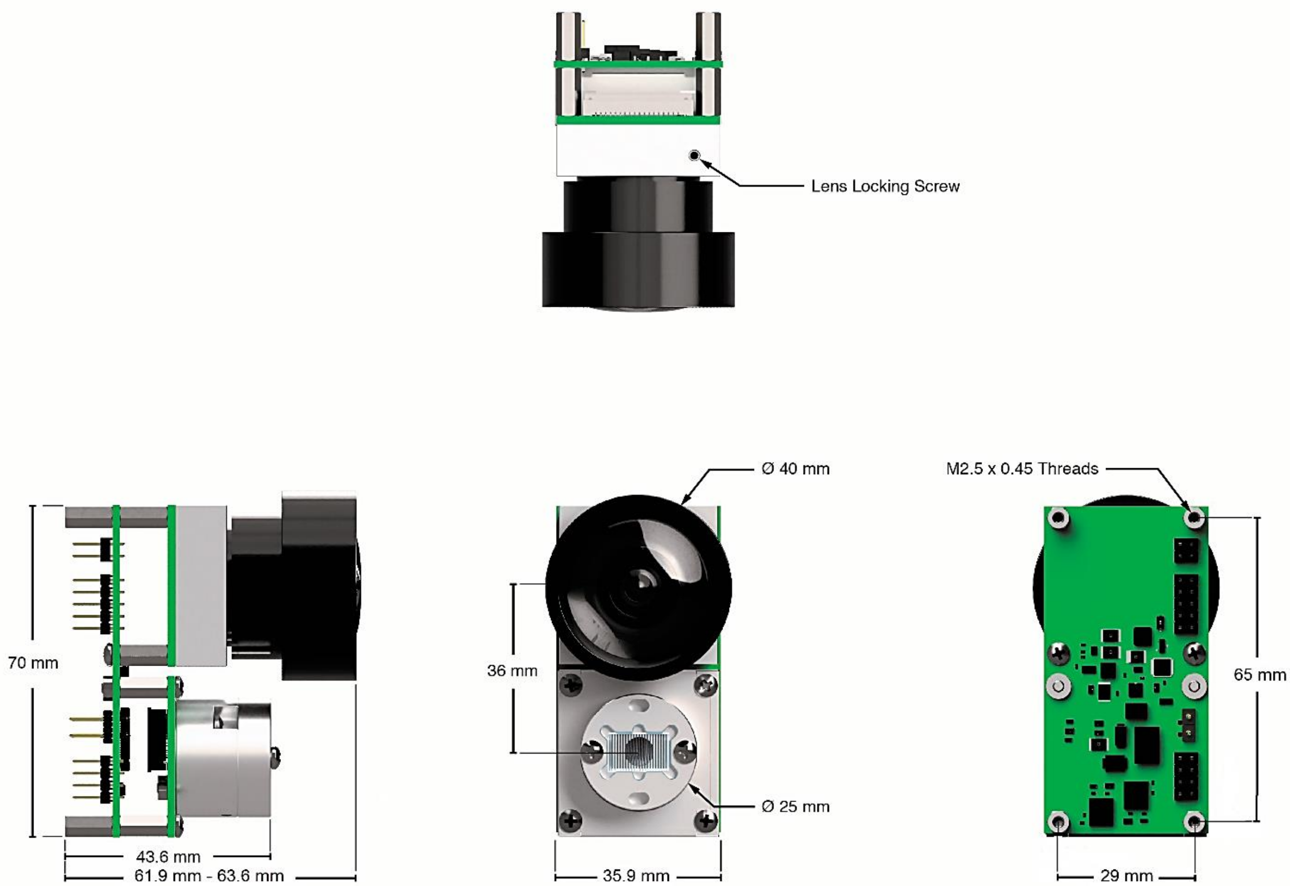
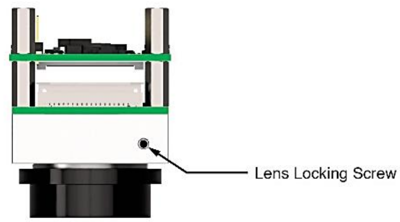


Figure 73: 98.5° module dimensions

7.7.2. 47.5° Module



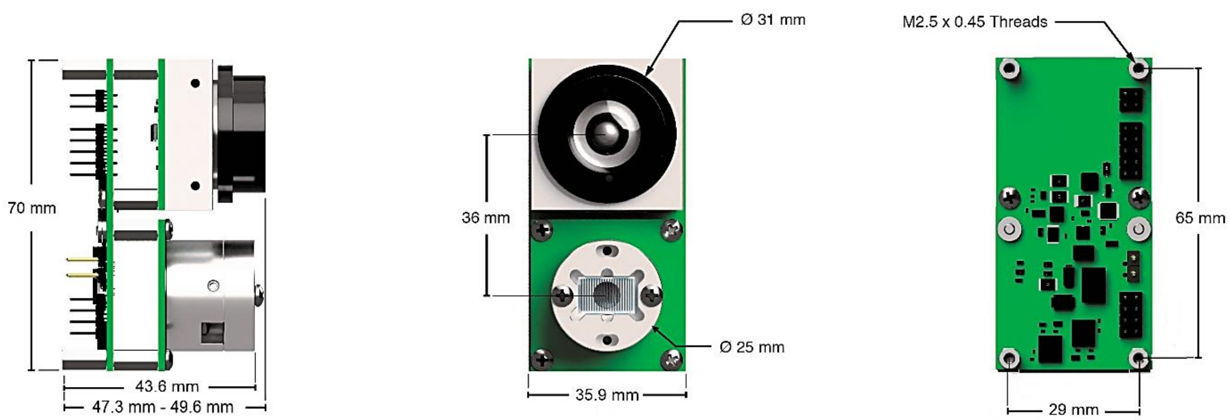


Figure 74: 47.5° module dimensions

7.7.3. 16° Module

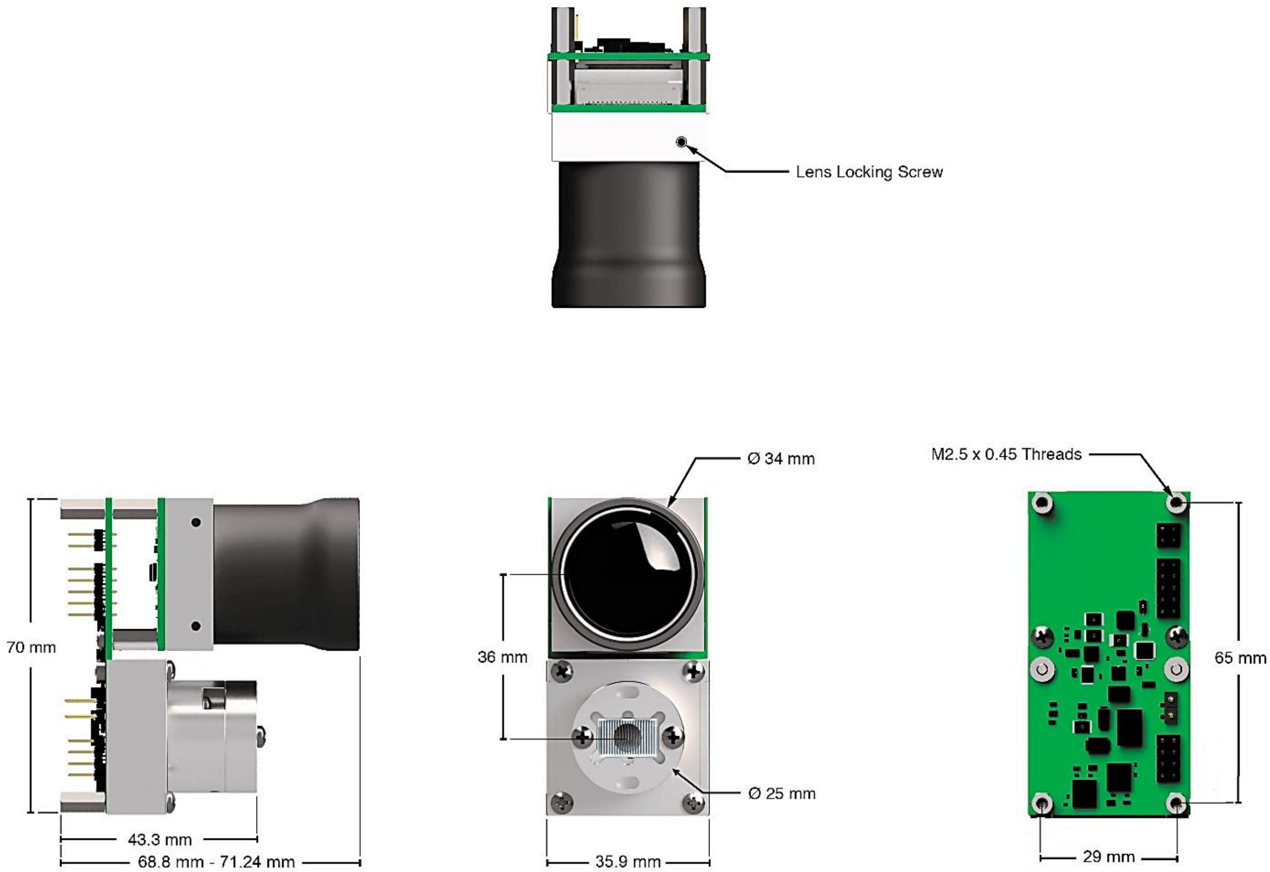


Figure 75: 16° module dimensions

8. 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 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.

E-mail

support@leddartech.com

Company address

LeddarTech Inc.
4535, boul. Wilfrid-Hamel Blvd, #240
Québec, QC G1P 2J7
Canada

www.leddartech.com

Appendix A – Example of a 0x04 function (read input register)

Transmitted message

01 04 00 01 00 27 E1 D0

Use the 0x04 command to read 39 consecutive registers starting at address 01. On device with Modbus address 01, using the CRC D0 E1.

Received message

01 04 4E 00 01 00 08 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 08 00 64 00 00 B0 F7 00 00 00 0F 00 0E 00 0C 00 0D 00 0E 00 12 00 16 00 19 5A E3 5B F5 5E 26 62 29 63 92 75 13 7C 2B 5B 66 00 01 00 01 00 01 00 01 00 01 00 09 00 09 00 01 66 6F

1, 8, 0, 0, 0, 0, 0, 0, 0, 0, 8, 100, 0, 45303, 0, 15, 14, 12, 13, 14, 18, 22, 25, 23267, 23541, 24102, 25129, 25490, 29971, 31787, 23398, 1, 1, 1, 1, 1, 9, 9, 1

Header: 1, 8, 0, 0, 0, 0, 0, 0, 0, 0, 8, 100, 0, 45303, 0

(Address 1) Status for polling mode: 1 = Detections ready

(2) Number of segments: 8 = 8 segments

(11) Number of detection: 8 = 8 detections

(12) Light source power: 100 = 100%

(14&15) TimeStamp: 45303 = 45303 ms

Distance (first detection only): 15, 14, 12, 13, 14, 18, 22, 25

(Address 16) Segment #8 = 15cm

(17) Segment #7 = 14cm

(18) Segment #6 = 12cm

(19) Segment #5 = 13cm

(20) Segment #4 = 14cm

(21) Segment #3 = 18cm

(22) Segment #2 = 22cm

(23) Segment #1 = 25cm

Amplitude (first detection only): 23267, 23541, 24102, 25129, 25490, 29971, 31787, 23398

(Address 24) Segment #8 = 23267 / 64 = 363.55 counts

(25) Segment #7 = 23541 / 64 = 367.83 counts

(26) Segment #6 = 24102 / 64 = 376.59 counts

(27) Segment #5 = 25129 / 64 = 392.64 counts

(28) Segment #4 = 25490 / 64 = 398.28 counts

(29) Segment #3 = 29971 / 64 = 468.30 counts

(30) Segment #2 = 31787 / 64 = 496.67 counts

(31) Segment #1 = 23398 / 64 = 365.59 counts

Flag (first detection only): 1, 1, 1, 1, 1, 9, 9, 1

(Address 32) Segment #8 = 1 = Valid

(33) Segment #7 = 1 = Valid

(34) Segment #6 = 1 = Valid

(35) Segment #5 = 1 = Valid

(36) Segment #4 = 1 = Valid

(37) Segment #3 = 9 = Saturation

(38) Segment #2 = 9 = Saturation

(39) Segment #1 = 1 = Valid

Appendix B – Example of a 0x41 Modbus Function

Transmitted data stream message

01 41 C0 10

Use the 0x41 command to read on device Modbus address # 01, using the CRC 10 C0.

Received data stream message

01 41 08 25 00 52 81 09 07 25 00 49 81 09 06 24 00 4F 81 09 05 25 00 05 81 09 04 29 00 A9 7D 09 03 2E 00 96 66 01 02 35 00 CC 47 01 01 39 00 64 33 01 00 F0 4C 1A 00 64 00 00 D2 EE

Get detection messages (first byte):

Modbus address: 01 hex = 1 = Address#1

Function code: 0x41 hex = 65 = function 0x41

Number of detections: 08 hex = 8 = 8 detections

Get detection messages (detection fields):

(1) 25 00 52 81 09 07:

Distance (cm): 00 25 hex = 37cm = 0.37m

Amplitude (count): 81 52 hex = 33106 / 64 = 517.28 counts

Flag: 09 hex = 9 (Saturation)

Segment #: 07 hex = 7 (Segment #8)

(2) 25 00 49 81 09 06:

Distance (cm): 00 25 hex = 37cm = 0.37m

Amplitude (count): 81 49 hex = 33097 / 64 = 517.14 counts

Flag: 09 hex = 9 (Saturation)

Segment #: 06 hex = 6 (Segment #7)

(3) 24 00 4F 81 09 05:

Distance (cm): 00 24 hex = 36cm = 0.36m

Amplitude (count): 81 4F hex = 33103 / 64 = 517.23 counts

Flag: 09 hex = 9 (Saturation)

Segment #: 05 hex = 5 (Segment #6)

(4) 25 00 05 81 09 04:

Distance (cm): 00 25 hex = 37cm = 0.37m

Amplitude (count): 81 05 hex = 33029 / 64 = 516.08 counts

Flag: 09 hex = 9 (Saturation)

Segment #: 04 hex = 4 (Segment #5)

(5) 29 00 A9 7D 09 03:

Distance (cm): 00 29 hex = 41cm = 0.41m

Amplitude (count): 7D A9 hex = 32169 / 64 = 502.64 counts

Flag: 09 hex = 9 (Saturation)

Segment #: 03 hex = 3 (Segment #4)

(6) 2E 00 96 66 01 02:

Distance (cm): 00 2E hex = 46cm = 0.46m

Amplitude (count): 66 96 hex = 26262 / 64 = 410.34 counts

Flag: 01 hex = 1 (Valid)

Segment #: 02 hex = 2 (Segment #3)

(7) 35 00 CC 47 01 01:

Distance (cm): 00 35 hex = 53cm = 0.53m

Amplitude (count): 47 CC hex = 18380 / 64 = 287.19 counts

Flag: 01 hex = 1 (Valid)

Segment #: 01 hex = 1 (Segment #2)

(8) 39 00 64 33 01 00:

Distance (cm): 00 39 hex = 57cm = 0.57m

Amplitude (count): 33 64 hex = 13156/ 64 = 205.56 counts

Flag: 01 hex = 1 (Valid)

Segment #: 00 hex = 0 (Segment #1)

Get detection messages (trailing fields):

(1) F0 4C 1A 00 64 00 00:

TimeStamp (ms): 00 1A 4C F0 hex = 1 723 632 ms = 1723 s

Light source POWER (%): 64 hex = 100 = 100%

Bit field acq. (reserved): 00 00 hex = 0

CRC (16bits Modbus) = EE D2

Appendix C – Example of a LeddarVu CAN Bus Detection Request

A request is sent to the sensor, this request is an 8 bytes message that is addressed to the message ID 0x740, the sensor then replies with multiple 8 bytes message that is addressed to the message ID 0x750 +.

There are two possible modes:

1. For example, if we want to obtain a detection frame (polling), in the mode **multiple message**, we send this request: 0x740: 02, 01, 00, 00, 00, 00, 00, 00

   The sensor will then answer with the following sequence:

   0x750: 02 01 00 00 00 00 00 00: echo of the successful request

   0x751: 08 64 00 00 41 8D 26 00: number of detections (8), led power (100%), timestamp (2526529msec)

   0x752: 77 05 8F 00 01 00 07 00: detection of the channel #7, distance (0x0577 = 1399cm), amplitude (0x008F = 143/64 = 2.2344 counts), flag info (0x0001 = valid)

   0x753: 0E 05 D3 00 01 00 06 00: detection of the channel #6

   0x754: 05 05 EC 00 01 00 05 00: detection of the channel #5

   0x755: 03 05 F9 00 01 00 04 00: detection of the channel #4

   0x756: 0D 05 F2 00 01 00 03 00: detection of the channel #3

   0x757: 1B 05 ED 00 01 00 02 00: detection of the channel #2

   0x758: 2D 05 B9 00 01 00 01 00: detection of the channel #1

   0x759: 97 05 9F 00 01 00 00 00: detection of the channel #0

2. If we want the sensor to send data streaming in the mode **simple message**, we initiate the communication with the request:
   0x740: 03, 00, 00, 00, 00, 00, 00, 00

   The sensor will then answer with the following sequence:

   0x750: 03 00 00 00 00 00 00 00: echo of the successful request

   0x751: 08 64 00 00 41 8D 26 00: detection frame N: number of detections (8), led power (100%), timestamp (2526529msec)

   0x752: 77 05 8F 00 01 00 07 00: detection of the channel #7, distance (0x0577 = 1399cm), amplitude (0x008F = 143/64 = 2.2344 counts), flag info (0x0001 = valid)

   0x752: 0E 05 D3 00 01 00 06 00: detection of the channel #6

   0x752: 05 05 EC 00 01 00 05 00: detection of the channel #5

   0x752: 03 05 F9 00 01 00 04 00: detection of the channel #4

   0x752: 0D 05 F2 00 01 00 03 00: detection of the channel #3

   0x752: 1B 05 ED 00 01 00 02 00: detection of the channel #2

   0x752: 2D 05 B9 00 01 00 01 00: detection of the channel #1

0x752: 97 05 9F 00 01 00 00 00: detection of the channel #0

0x751: 08 64 00 00 41 8D 26 00: detection frame N+1

0x752: 77 05 8F 00 01 00 07 00

0x752: 0E 05 D3 00 01 00 06 00

0x752: 05 05 EC 00 01 00 05 00

0x752: 03 05 F9 00 01 00 04 00

0x752: 0D 05 F2 00 01 00 03 00

0x752: 1B 05 ED 00 01 00 02 00

0x752: 2D 05 B9 00 01 00 01 00

0x752: 97 05 9F 00 01 00 00 00

0x751: 08 64 00 00 41 8D 26 00: detection frame N+2

0x752: 77 05 8F 00 01 00 07 00

0x752: 0E 05 D3 00 01 00 06 00

0x752: 05 05 EC 00 01 00 05 00

0x752: 03 05 F9 00 01 00 04 00

0x752: 0D 05 F2 00 01 00 03 00

0x752: 1B 05 ED 00 01 00 02 00

0x752: 2D 05 B9 00 01 00 01 00

0x752: 97 05 9F 00 01 00 00 00

To stop the data streaming, we send the request:

0x740: 01, 00, 00, 00, 00, 00, 00, 00

The sensor the responds with the following message:

0x750: 01 00 00 00 00 00 00 00: echo of the successful request

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