RPLIDAR C1

Low-cost 360 Degree Laser Range Scanner

Introduction and Datasheet

Model: C1M1-R2

5K

Contents

The RPLIDAR C1 is a next-generation low-cost 360 degree 2D laser scanner (LIDAR) solution developed by SLAMTEC. It can take up to 5000 samples of laser ranging per second with high rotation speed. Equipped with contactless power and signal transmission technology, it breaks the life limitation of traditional LIDAR systems to work stably for a long time.

The RPLIDAR C1 can perform a 2D 360-degree scan within a 12-meter range and and the range blind area can be as low as 0.05-meter, which can easily realize the scanning and ranging of objects at various distances and cope with obstacles in the environment. RPLIDAR C1 has a compact appearance for easy embedding in various applications, and it has ultra-low noise and low vibration. RPLIDAR C1 can be used in sweeping robot, education ROS car, commercial robot, low-speed park unmanned vehicle, and parking lot detection. Therefore, it can be widely applied in many consumer-oriented business scenarios.

The typical scanning frequency of RPLIDAR C1 is 10Hz (600rpm). With the 10Hz scanning frequency, the sample rate is 5KHz, and the angular resolution is 0.72°.

Due to the accumulation of a new generation of fusion ranging technology developed by SLAMTEC, RPLIDAR C1 can output 2.5D multi-dimensional information, including position information data and additional reflectivity data. Meanwhile, before leaving the factory, every RPLIDAR C1 has passed strict testing to ensure the laser output power meets the eye-safety standard of IEC-60825 Class 1.

System Composition and Connection

The RPLIDAR C1 consists of a range scanner core and the mechanical powering part, which makes the core rotate at a high speed. When it functions normally, the scanner core will rotate and scan clockwise. Users can get the range scan data via the communication interface of the RPLIDAR.
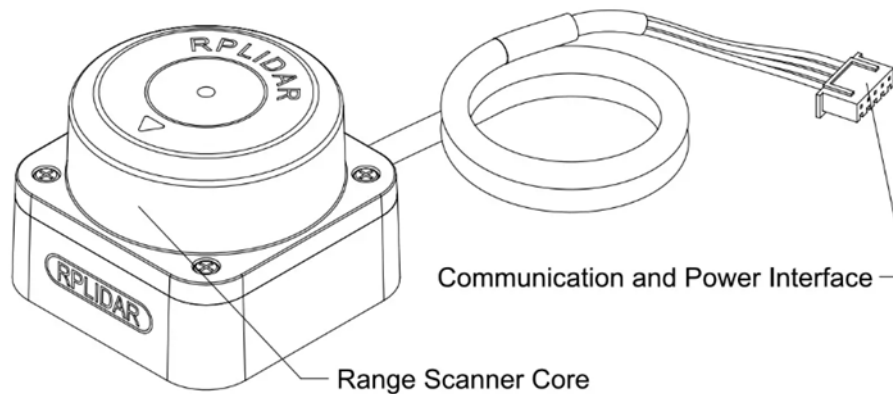
Figure 1-1 RPLIDAR C1 System Composition

The RPLIDAR C1 comes with a rotation speed detection and adaptive system. The system automatically adjusts the angular resolution according to the rotating speed. And there is no need to provide a complicated power system for the RPLIDAR. In this way, the simple power supply schema saves the BOM cost.

The detailed specification of the power and communication interface can be found in the following sections.

Mechanism

The RPLIDAR C1 is based on the laser flight-of-time (TOF) ranging principle and combined with the high-speed laser acquisition and high-precision fusion algorithm developed by SLAMTEC. It can perform high-precision and high-resolution ranging movements up to 5000 times per second. During every ranging process, the RPLIDAR emits modulated infrared laser signal, which is then reflected by the object to be detected. The returning signal is then sampled by the laser acquisition system in RPLIDAR, and the processor embedded in RPLIDAR starts processing the sample data and outputs the distance value and angle value between the object and RPLIDAR via the communication interface.
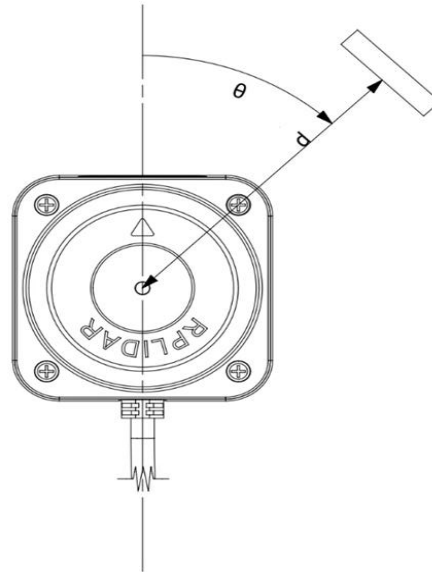
Copyright (c) 2009-2013 RoboPeak Team
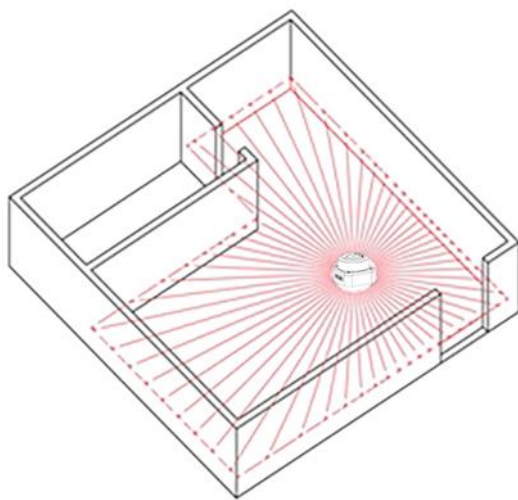Copyright (c) 2013-2023 Shanghai Slamtec Co., Ltd.

Figure 1-2 The RPLIDAR C1 Working Schematic

When driven by the motor system, the range scanner core will rotate clockwise and perform the 360-degree scan for the current environment.

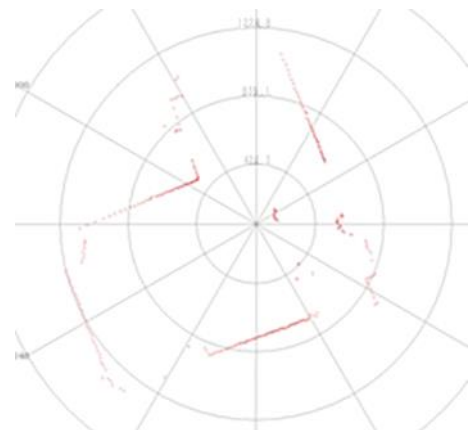*Note: The LIDAR scan image is not directly relative to the environment shown here. Illustrative purposes only.

Figure 1-3 The Environment Map Obtained from RPLIDAR Scanning

Safety and Scope

Class I

The RPLIDAR system uses a low-power infrared laser as its light source and drives it by using modulated pulse. The laser emits light in a very short time frame which can ensure the safety of humans and pets, and it reaches the Class I laser safety standard. Complies with 21 CFR 1040.10 and 1040.11, except for deviations pursuant to IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.

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

Data Output

During the working process, the RPLIDAR will output the sampling data via the communication interface. The sample point data per frame contains the information in the following table. For the specific data format, refer to the the corresponding communication protocol documents provided on the download and support page of the official website .

Data Type	Unit	Description
Distance Value	mm	Current measured distance value between the rotating core of the RPLIDAR and the sample point
Angle	Degree	Angle of the current sample point relative to the orientation of the RPLIDAR
Start Signal	(Boolean value)	Flag of a new scan
Checksum	-	Checksum of the data returned by the RPLIDAR

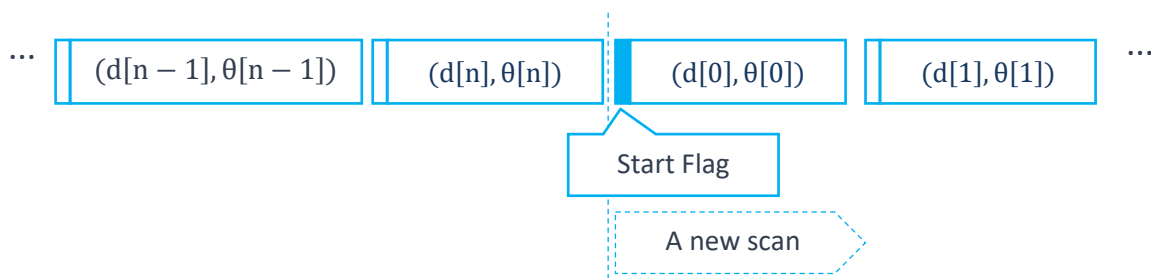*Figure 1-4 The RPLIDAR Sample Point Data Information*

Figure 1-5 The RPLIDAR Sample Point Data Frames

The RPLIDAR outputs sample data continuously, and it contains the sample point data frames in the above figure. The host system can configure the output format and stop the RPLIDAR from outputting data by sending a control command. For the specific operation, refer to the documents provided on the download and support page of the official website or contact SLAMTEC.

Protocol Compatibility

The RPLIDAR C1 adopts traditional sampling protocols and the high-speed sampling protocol for outputting the 5000 times per second laser range scan data. The RPLIDAR C1 is compatible with all communication protocols used by previous RPLIDAR S Series products and the traditional sampling protocol (standard) of the A Series products, users can directly in place of previous RPLIDAR models and use it in the original system.

In order to properly display the LIDAR model, the user must update the corresponding SDK or rewrite the original driver, please refer to https://github.com/Slamtec/rplidar_sdk for details.

Application Scenarios

The system can be used in the following application scenarios:

- General simultaneous localization and mapping (SLAM)

- Environment scanning and 3D re-modeling

- Service robots or industrial robots working for long hours

- Navigation and localization of home service/cleaning robots

- General robot navigation and localization

- Localization and obstacle avoidance of smart toys

Measurement Performance

For Model C1M1-R2 Only

Item	Detail
Distance Range[1]	White object: 0.05-12 meters (under 70% reflection) Black object: 0.05-6 meters (under 10% reflection)
Sample Rate[2]	5KHz
Scanning Frequency[3]	8~12Hz, 10Hz@typical
Angular Resolution	0.72°@typical
Scan Field Flatness	0°~1.5° (can be customized)
Communication Interface	TTL UART
Communication Speed	460800
Accuracy[4]	±30mm
Resolution	15mm
Degree of Protection	IP54
Ambient Light Limit	40,000lux

Figure 2-1 RPLIDAR Performance

Note:

[1] If the target distance is <0.05m or >12m, the lidar can detect and output point cloud data. Because the detection accuracy cannot be guaranteed, this data is only for reference.

[2] Sample Rate fluctuation is less than 1%.

[3] When the lidar is stationary, the scanning frequency fluctuation is less than 5%.

[4] Tested in an environment at a temperature of 25°' C (77"F) with a target object that has a reflection of 10~90%, if the reflection of a target object exceeds the standard value (<10% or >90%), the accuracy of point cloud data might decrease slightly.

Laser Power Specification

For Model C1 Only

Item	Unit	Min	Typical	Max	Remarks
Working Wavelength	Nanometer (nm)	895	905	915	Infrared Light Band
Laser Power	Watt (W)	-	20	-	Peak power
Pulse Length	Nanosecond (ns)	-	1.4	-	-
Laser Safety Class	-	-	IEC-60825 Class 1	-	-

Figure 2-2 RPLIDAR Optical Specification

*Note: The laser power is the peak power, and the actual average power will be much lower than this value.

Optical Window

To make the RPLIDAR C1 work normally, ensure proper space is left for emitting and receiving laser lights when designing the host system. The ranging window is partly obscured by the host system, which will impair the performance and resolution of the RPLIDAR C1. If you need to cover the RPLIDAR with translucent materials or have other special needs, please contact SLAMTEC to learn about the feasibility.
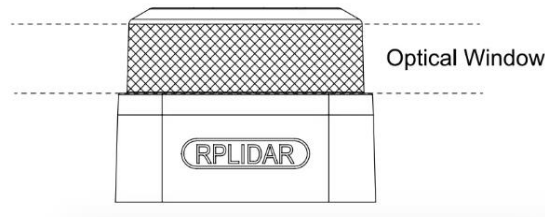
Figure 2-3 RPLIDAR Optical Window

You can check the Mechanical Dimensions chapter for detailed window dimensions.

Coordinate System Definition of Scanning Data

The RPLIDAR C1 adopts a coordinate system of the left hand. The dead ahead of the sensors is the x-axis of the coordinate system; the origin is the rotating center of the range scanner core. The rotation angle increases as the device rotates clockwise. The detailed definition is shown in the following figure:
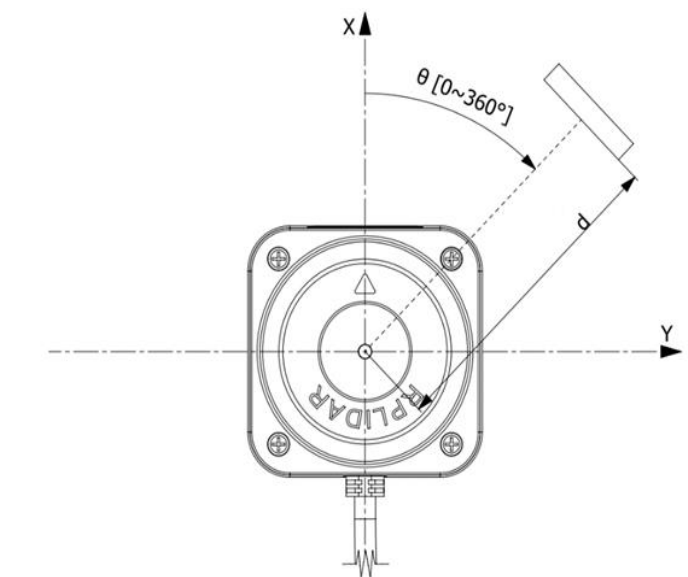

Figure 2-4 RPLIDAR C1 Scanning Data Coordinate System Definition

Communication Interface

The RPLIDAR C1 uses separate 5V DC power to power the ranging system and the motor system. And the standard RPLIDAR C1 uses an XH2.54-5P male socket. The detailed interface definition is shown in the following figure:
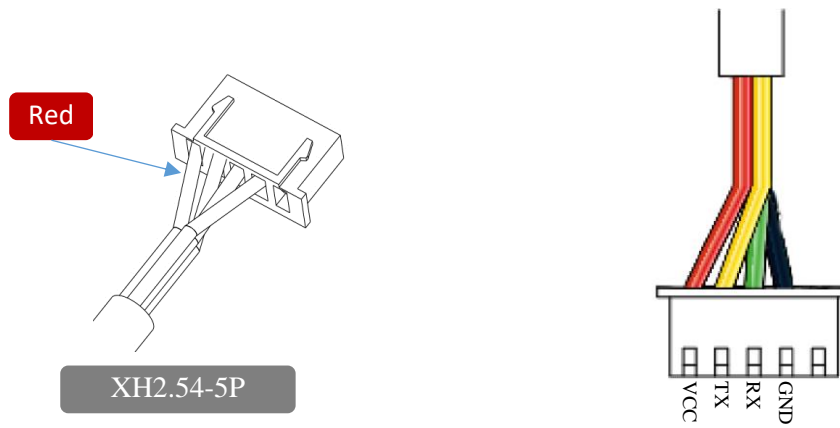
XH2.54-5P

VCC TX RX GND

Figure 2-5 RPLIDAR Power Interface Definition

Color	Signal Name	Type	Description	Min	Typical	Max
Red	VCC	Power	Total Power	4.8V	5V	5.2V
Yellow	TX	Output	Serial port output of the scanner core	0V	/	3.5V
Green	RX	Input	Serial port input of the scanner core	0V	/	3.5V
Black	GND	Power	GND	0V	0V	0V

Figure 2-6 RPLIDAR C1 External Interface Signal Definition

Power Supply Interface

The RPLIDAR C1 takes the only external power to power the range scanner core and the motor system, which makes the core rotate. To make the RPLIDAR C1 work normally, the host system needs to ensure the output of the power and meet its requirements of the power supply ripple.

For Model C1 Only

Item	Unit	Min	Typical	Max	Remarks
Power Voltage	V	4.8	5	5.2	If the voltage is not enough, the measurement will not be accurate.
Power Voltage Ripple	mV	-	-	150	Excessive power supply noise may cause increased lidar radiation.
System Start Current	mA	-	800	-	The system startup requires a relatively higher current.
Power Current	mA	-	230	260	5V Power, 10Hz scanning frequency

Figure 2-7 RPLIDAR Power Supply Specification

*Note: An insufficient power supply may lead to inaccurate range measurement and insufficient motor speed during cold start. It is recommended to provide a sufficient power supply to the lidar. The voltage measured at the external interface of the lidar is more than 5V when the lidar is working normally.

Data Communication Interface

The RPLIDAR C1 takes the 3.3V-TTL serial port (UART) as the communication interface. The table below shows the transmission speed and the protocol standard.

Item	Unit	Min	Typical	Max	Remarks
Baud Rate	bps	-	460800	-	-
Working Mode	-	-	8 data bits, 1 stop bit, no parity check	-	8n1
Output High Voltage	V	2.9	3.3	3.5	Output signal with high voltage
Output Low Voltage	V	-	-	0.4	Output signal with low voltage
Input High Voltage	V	2.4	3.3	3.5	Input signal with high voltage
Input Low Voltage	V	0	-	0.4	Input signal with high voltage

Figure 2-8 RPLIDAR Serial Port Interface Specifications

Scanner Motor Control

The RPLIDAR C1 is embedded with a closed motor control system that can control the rotation speed accurately. Users can change the rotation speed of the motor by sending a motor speed setting command to the RPLIDAR.

*Note: However, the motor can't start or stop alone, and its working state depends on the laser scan command. If you want to control the rotation speed of the lidar, provide a sufficient power supply to the lidar.

Miscellaneous

For Model C1 Only

Item	Unit	Min	Typical	Max	Remarks
Weight	Gram (g)	-	110	-	
Working Temperature Range	Degree Celsius (ºC)	-10	25	40	
Storage Temperature Range	Degree Celsius (ºC)	-20	25	60	

Figure 2-9 RPLIDAR Miscellaneous Specification

The RPLIDAR C1 comes with laser power detection and sensor health check logic to avoid damage to the device due to malfunction and to ensure that the laser always works within the safety range during its operation. To avoid damage to the device and others, the RPLIDAR C1 will shut down the laser and stop scanning automatically when any of the following errors has been detected.

- The scan speed of the laser scanner system is unstable

- The scan speed of the laser scanner system is too slow

- The external power supply is low

The host system can check the system status via the communication interface and restart the RPLIDAR C1 to try to recover work from errors. If you have any questions, please contact after-sales support or email support@slamtec.com.

To facilitate the usage of RPLIDAR C1 in product development and speed up the development for users, SLAMTEC has provided the Framegrabber plugin in RoboStudio for testing and debugging as well as the SDK available under x86 Windows, x86 Linux, MacOS, and Arm Linux. Please contact SLAMTEC for details.
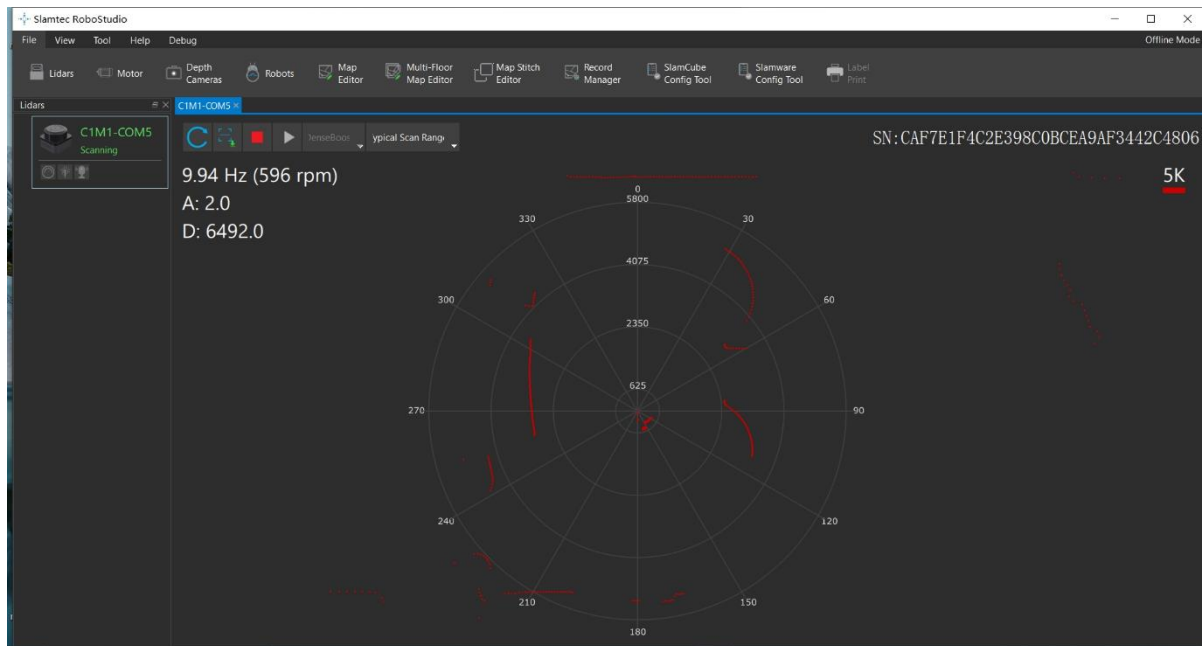

Figure 3-1 The Framegrabber Plugin in RoboStudio

The mechanical dimensions of the RPLIDAR C1 are shown below:

*Note:

1. The depth of 4*M2.5 screws in the bottom should be no longer than 4mm. Otherwise, the internal components will be damaged.

2. Dimension unit: mm; tolerance: ±0.2
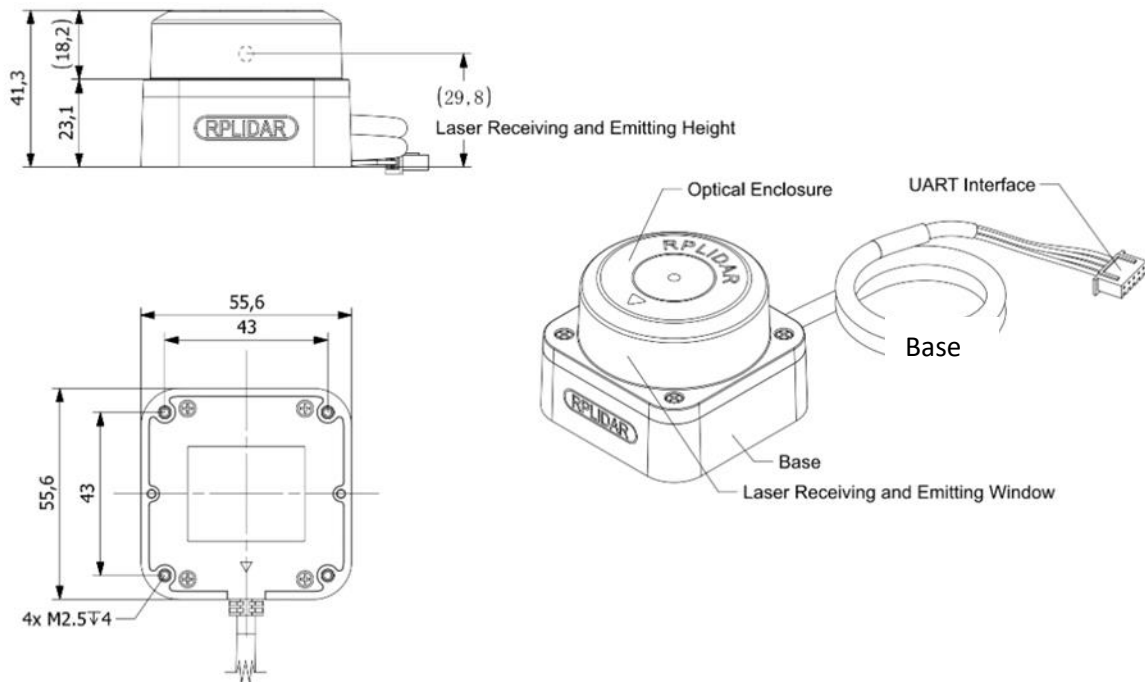
Figure 4-1 RPLIDAR C1 Mechanical Dimensions

Revision History

Date	Version	Description
2023-10-13	1.0	Initial version for C1

Image and Table Index

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