SLAMTEC

2019-03-21 rev.0.5

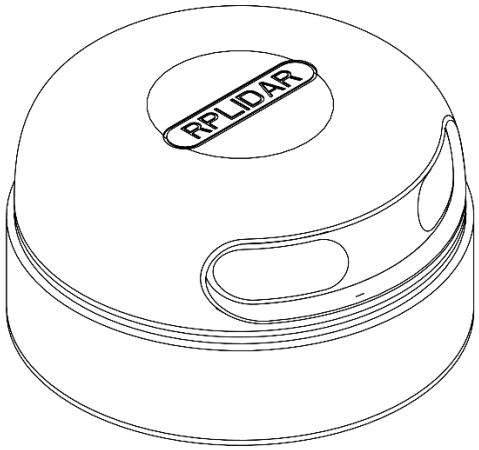
RPLIDAR A2

Low Cost 360 Degree Laser Range Scanner

Introduction and Datasheet

Model: A2M6

OPTMAG 4K



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The RPLIDAR A2 is the latest generation low cost 360 degree 2D laser scanner (LIDAR) solution developed by SLAMTEC. It can reach 8000 samples of laser ranging per second[①] with high rotation speed. And equipped with SLAMTEC patented OPTMAG technology, it breakouts the life limitation of traditional LIDAR system so as to work stably for a long time.

RPLIDAR A2M6 is the enhanced version of 2D laser range scanner(LIDAR). The system can perform 2D 360 degree scan within a 18-meter range （16-meter range of A2M6-R3 and the belowing momels）. The generated 2D point cloud data can be used in mapping, localization and object/environment modeling.

The typical scanning frequency of the RPLIDAR A2 is 10hz (600rpm). Under this condition, the angular resolution will be 0.45°. And the actual scanning frequency

① R1 and R2 models only support the radar 4k times per second ranging frequency, R3 models need to update the firmware to 1.24 to support 8k times per second ranging frequency.

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can be freely adjusted within the 5-15hz range according to the requirements of users.

The RPLIDAR A2 adopts the low cost laser triangulation measurement system developed by SLAMTEC, which makes the RPLIDAR A2 has excellent performance in all kinds of indoor environment and outdoor environment without direct sunlight exposure. Meanwhile, before leaving the factory, every RPLIDAR A2 has passed the strict testing to ensure the laser output power meet the standards of FDA Class I.

System connection

The RPLIDAR A2 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 will rotate and scan clockwise. And users can get the range scan data via the communication interface of the RPLIDAR and control the start, stop and rotating speed of the rotate motor via PWM.

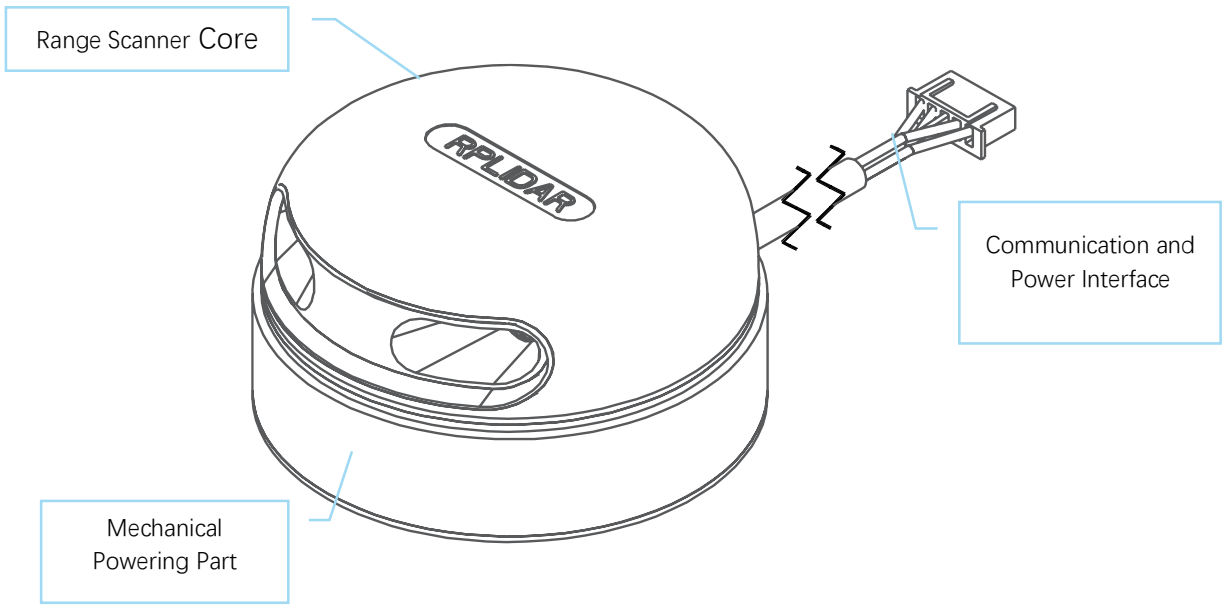


Figure 1-1 RPLIDAR System Composition

The RPLIDAR A2 comes with a rotation speed detection and adaptive system. The system will adjust the angular resolution automatically according to the actual rotating speed. And there is no need to provide complicated power system for

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RPLIDAR. In this way, the simple power supply schema saves the BOM cost. If the actual speed of the RPLIDAR is required, the host system can get the related data via communication interface.

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

Mechanism

The RPLIDAR A2 is based on laser triangulation ranging principle and adopts the high-speed vision acquisition and processing hardware developed by SLAMTEC. The system ranges more than 8000 times per second.

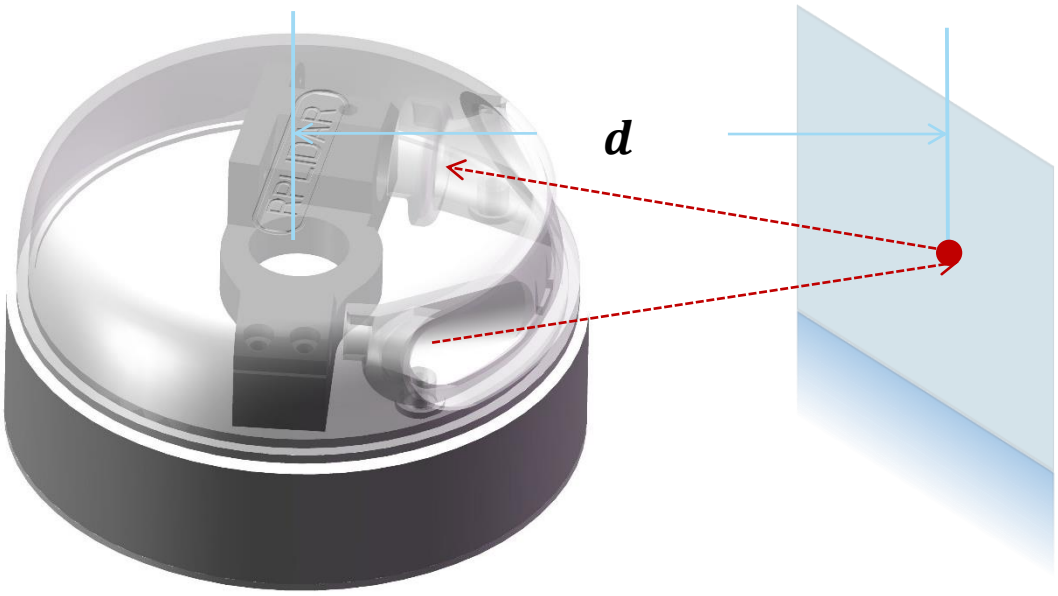


Figure 1-2 The RPLIDAR Working Schematic

During every ranging process, the RPLIDAR emits modulated infrared laser signal and the laser signal is then reflected by the object to be detected. The returning signal is then sampled by vision acquisition system in RPLIDAR and the DSP embedded in RPLIDAR starts processing the sample data and outputs distance value and angle value between object and RPLIDAR via communication interface.

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

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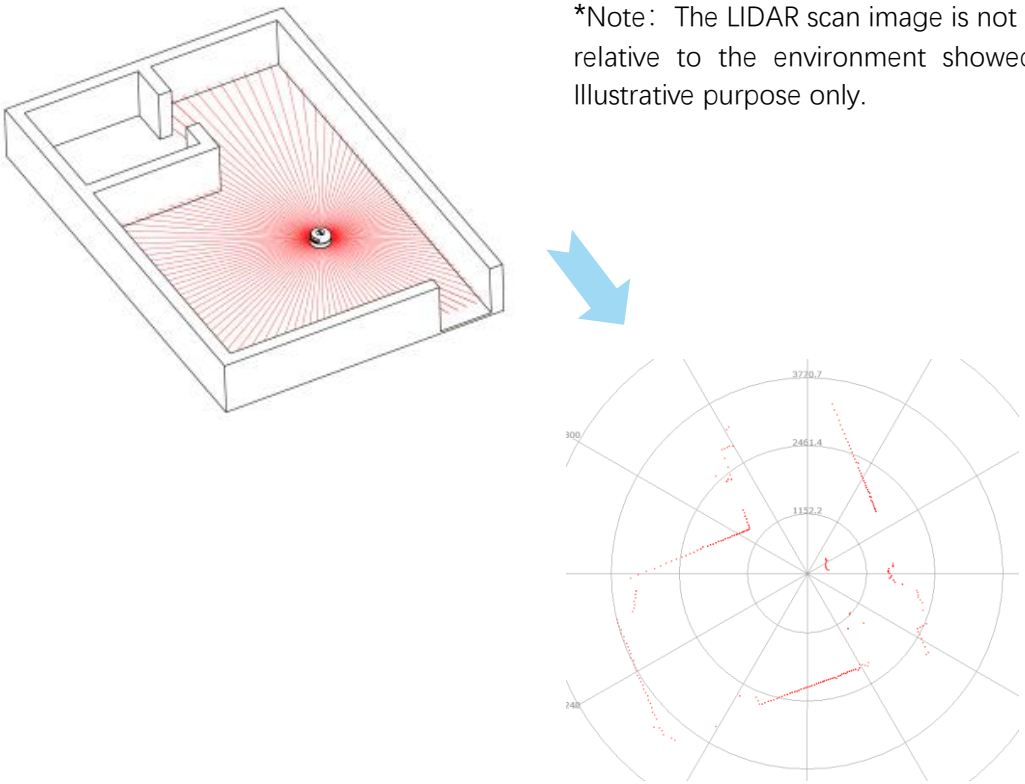


Figure 1-3 The Obtained Environment Map from RPLIDAR Scanning

Safety and Scope

The RPLIDAR A2 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 its safety to human and pets, and it reaches Class I laser safety standard. Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.



Class I

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

The modulated laser can effectively avoid the interference from ambient light and sunlight during ranging scanning process, which makes RPLIDAR work excellent in all kinds of indoor environment and outdoor environment without sunlight.

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Data Output

During the working process, the RPLIDAR will output the sampling data via the communication interface. And each sample point data contains the information in the following table. If you need detailed data format and communication protocol, please contact SLAMTEC.

Data Type	Unit	Description
Distance	mm	Current measured distance value between the rotating core of the RPLIDAR and the sampling point
Heading	degree	Current heading angle of the measurement
Start Flag	(Bool)	Flag of a new scan
Checksum		The Checksum of RPLIDAR return data

Figure 1-4 The RPLIDAR Sample Point Data Information

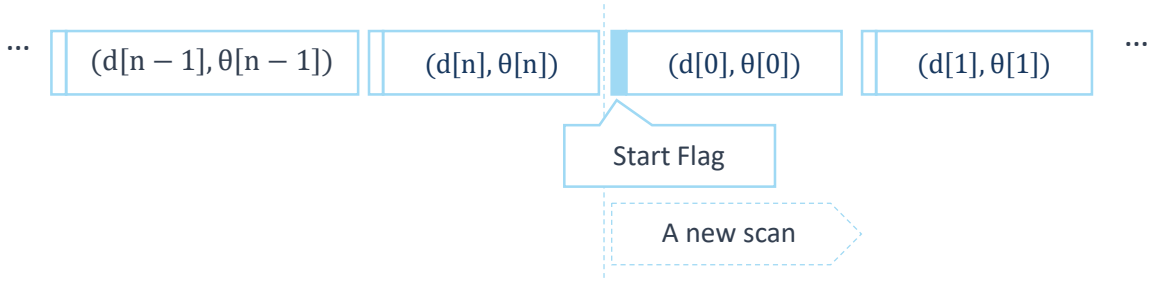


Figure 1-5 The RPLIDAR Sample Point Data Frames

The RPLIDAR outputs sampling data continuously and it contains the sample point data frames in the above figure. Host systems can configure output format and stop RPLIDAR by sending stop command. For detailed operations please contact SLAMTEC.

High Speed Sampling Protocol and Compatibility

The RPLIDAR A2 supports 3 scan modes:

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Legacy mode is compatible with the legacy RPLIDAR A1 protocol, which makes it easy to replace previous model of RPLIDAR. In this mode, RPLIDAR can only retrieve 2000 samples per second, and have a distance limit of 16 meters.

Express mode requires SDK or driver update. The RPLIDAR works at 4000 samples per second and having a distance limit of 16 meters.

Boost mode is the latest scan mode, which supports 8000 samples per second and has no distance limit for RPLIDAR A2 series.

Application Scenarios

The RPLIDAR can be used in the following application scenarios:

- General robot navigation and localization
- Environment scanning and 3D re-modeling
- Service robot or industrial robot working for long hours
- Home service /cleaning robot navigation and localization
- General simultaneous localization and mapping (SLAM)
- Smart toy's localization and obstacle avoidance

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Measurement Performance

- For Model A2M6 Only

Item	Unit	Min	Typical	Max	Comments
Distance Range	Meter(m)	0.2	A2M6-R3 and the belowing models -	16	Based om white objects with 70% reflectivity
			A2M6-R4 -	18	
Angular Range	Degree	-	0-360	-	-
Scan Field Flatness	Degree	-1.5		1.5	
Distance Resolution	mm	-	<0.5	-	<1.5 meters
			<1% of the distance		All distance range*
Angular Resolution	Degree	0.45	0.9	1.35	10Hz scan rate
Sample Duration	Millisecond(ms)	-	0.125	-	-
Sample Frequency	Hz	2000	8000	8010	
Scan Rate	Hz	5	10	15	The rate is for a round of scan. The typical value is measured when RPLIDAR takes 400 samples per scan

Figure 2-1 RPLIDAR Performance

Note: The measurement resultion changes along with distance in the triangulation ranging system.

Laser Power Specification

- For Model A2M6 Only

Item	Unit	Min	Typical	Max	Comments
Laser wavelength	Nanometer(nm)	775	785	795	Infrared Light Band
Laser power	Milliwatt (mW)	-	3	5	Peak power
Pulse length	Microsecond(us)	60	87	90	-
Laser Safety Class	-	-	FDA Class I	-	-

Figure 2-2 RPLIDAR Optical Specification

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Note: the laser power listed above is the peak power and the actual average power is much lower than the value.

Optical Window

To make the RPLIDAR A2 working normally, please ensure proper space to be left for its emitting and receiving laser lights when designing the host system. The obscuring of the host system for the ranging window will impact the performance and resolution of RPLIDAR A2. If you need cover the RPLIDAR A2 with translucent materials or have other special needs, please contact SLAMTEC about the feasibility.

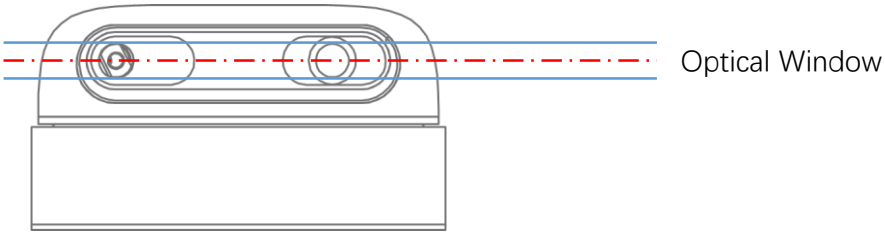


Figure 2-3 RPLIDAR Optical Window

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

Coordinate System Definition of Scanning Data

The RPLIDAR A2 adopts left-handed coordinate system. The dead zone 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 rotating clockwise. The detailed definition is shown in the following figure:

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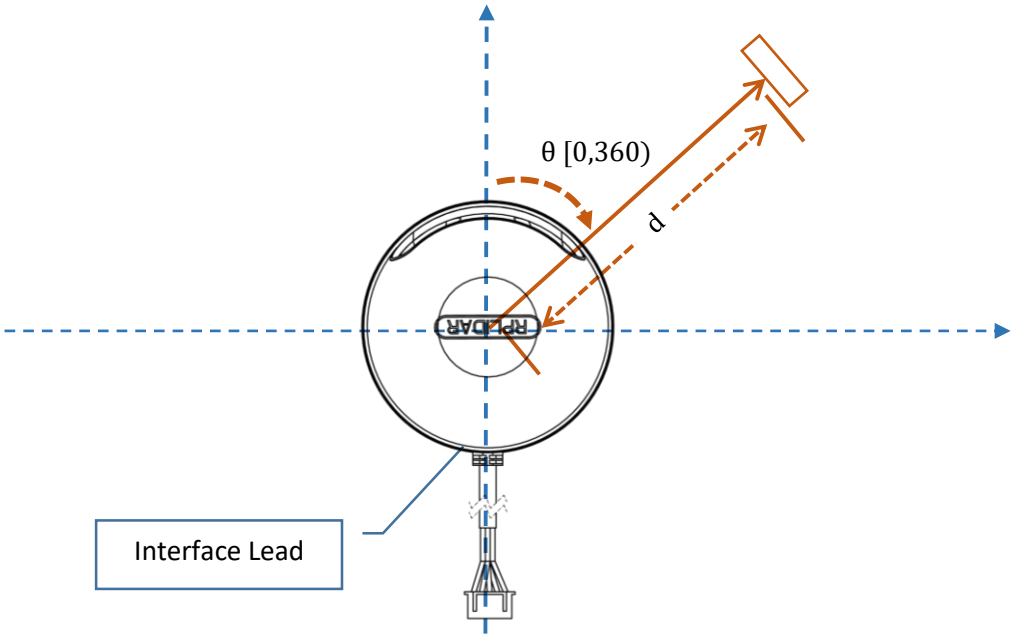


Figure 2-4 RPLIDAR Scanning Data Coordinate System Definition

Communication interface

The RPLIDAR A2 uses separate 5V DC power for powering the range scanner core and the motor system. And the standard RPLIDAR A2 uses XH2.54-5P male socket. Detailed interface definition is shown in the following figure:

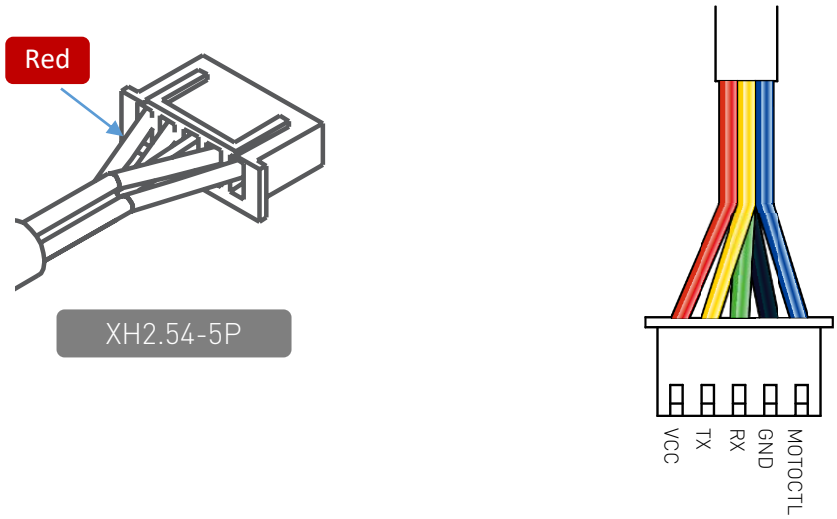


Figure 2-5 RPLIDAR Power Interface Definition

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Color	Signal Name	Type	Description	Min	Typical	Max
Red	VCC	Power	Total Power	4.9V	5V	5.5V
Yellow	TX	Output	Serial port output of the scanner core	0V	3.3V	3.5V
Green	RX	Input	Serial port input of the scanner core	0V	3.3V	3.5V
Black	GND	Power	GND	0V	0V	0V
Blue	MOTOCTL	Input	Scan motor /PWM Control Signal (active high, internal pull down)	0V	3.3V	5V

Figure 2-6 RPLIDAR External Interface Signal Definition

Power Supply Interface

RPLIDAR A2 takes the only external power to power the range scanner core and the motor system which make the core rotate. To make the RPLIDAR A2 work normally, the host system needs to ensure the output of the power and meet its requirements of the power supply ripple.

- For Model A2M6 Only

Item	Unit	Min	Typical	Max	Remark
Power Voltage	V	4.9	5	5.5	If the voltage exceeds the max value, it may damage the core
Power Voltage Ripple	mV	-	20	50	High ripple may cause the core working failure.
Inrush Current	mA			2500*	
System Start Current	mA	-	-	1500	The system startup requires relatively higher current.
Power Current	mA	TBD	200	220	5V Power，power off
		TBD	450	600	5V Power，power on

Figure 2-7 RPLIDAR Power Supply Specification

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Note: When the lidar is connected to the power supply, there is a process of charging the input capacitor. The maximum transient current of charging can reach 2500mA. After stable operation, the working current does not exceed 600mA.

Data communication interface

The RPLIDAR A2 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	Comments
Band rate	bps	-	115200	-	-
Working mode	-	-	8N1	-	8n1
Output high voltage	Volt (V)	2.9	-	3.5	Logic High
Output low voltage	Volt (V)	-	-	0.4	Logic Low
Input high voltage	Volt (V)	1.6*	-	3.5	Logic High
Input low voltage	Volt (V)	-0.3	-	0.4	Logic Low

Figure 2-8 RPLIDAR Serial Port Interface Specifications

Note: the RX input signal of A2M6 is current control type. In order to ensure the reliable signal identification inside the system, the actual control node voltage of this pin will not be lower than 1.6v.

Scanner Motor Control

The RPLIDAR A2 is embedded with a motor driver which has speed tuning feature. Users can control the start, the stop and the rotating speed for the motor via MOTOCTL in the interface. MOTOCTL can be supplied using PWM signal with special frequency and duty cycle, and in this mode, the rotating speed is decided by the duty cycle of the input MOTOCTL PWM Signal.

The following table describes the requirement for the input PWM signal of MOTOCTL:

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Item	Unit	Min	Typical	Max	Comments
High level voltage	V	3.0V	3.3V	5V	-
PWM frequency	Hz	24,500	25,000	25,500	Square Signal
Duty cycle range	-	0%	60%*	100%	Typical value is the duty cycle of high pulse width when the scanner frequency is at10hz

Figure 2-9 RPLIDA Specification for PWM Signal of MOTOCTL

Note: the typical value is tested when the scanner rotating frequency is 10Hz. With the same rotating speed, the PWM duty cycle of every RILIDAR A2 may vary slightly. If a precise rotating speed is required, users can perform a closed-loop control.

If the host system only need to control the start and stop of the motor, please use the direct current signal in high level and low level to drive MOTOCTL. Under this condition, when the MOTOCTL is the low level signal, the RPLIDAR A2 will stop rotating and scanning; when the MOTOCTL is the high level signal, the RPLIDAR A2 will rotated at the highest speed.

MISC

- For Model A2M6 Only

Item	Unit	Min	Typical	Max	Comments
Weight	Gram (g)	TBD	190	TBD	
Temperature range	Degree Celsius (℃)	0	20	45	

Figure 2-10 RPLIDAR MISC Specification

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To ensure the laser of RPLIDAR always working in the safety range (<3mW) and avoid any other damage caused by device, the RPLIDAR comes with laser power detection and sensor healthy check feature. It will shut down the laser and stop working automatically when any of the following errors has been detected.

- Laser transmit power exceeds limited value
- Laser cannot power on normally
- Scan speed of Laser scanner system is unstable
- Scan speed of Laser scanner system is too slow
- Laser signal sensor works abnormally

The host systems can check the status of the RPLIDAR via the communication interface and restart the RPLIDAR to try to recover work from error.

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SLAMTEC provides Framegrabber graphical debugging interface terminal for A2M6-R3 and the belowing models， as figure 4-1. And, SLAMTEC provides the Framegrabber plugin in RoboStudio for testing and debugging for A2M6-R4， as figure 4-2.In addition, SLAMTEC also provides SDK development kit under x86 windows, x86 Linux, arm Linux and other platforms. Please contact SLAMTEC for detail information.

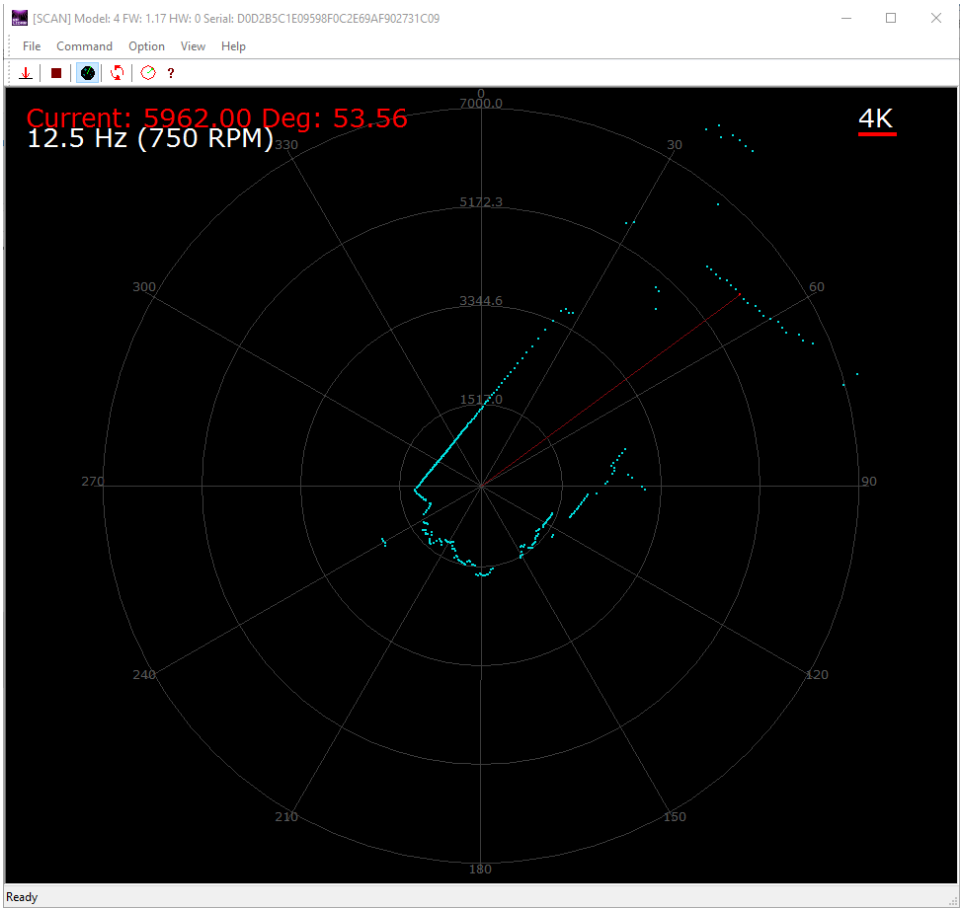


Figure 4-1 The Debugging GUI of RPLIDAR A2M6-R3 and the belowing models

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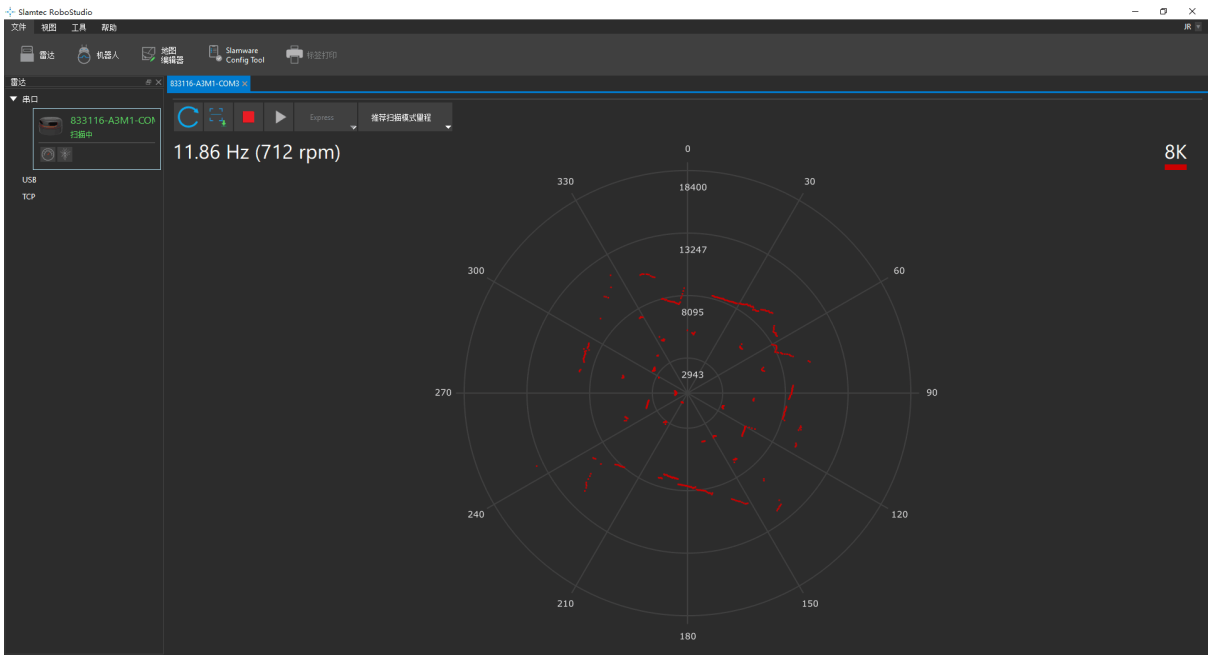


Figure 4-2 the Framegrabber Plugin in RoboStudio

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The mechanical dimensions of the RPLIDAR A2 are shown as below:

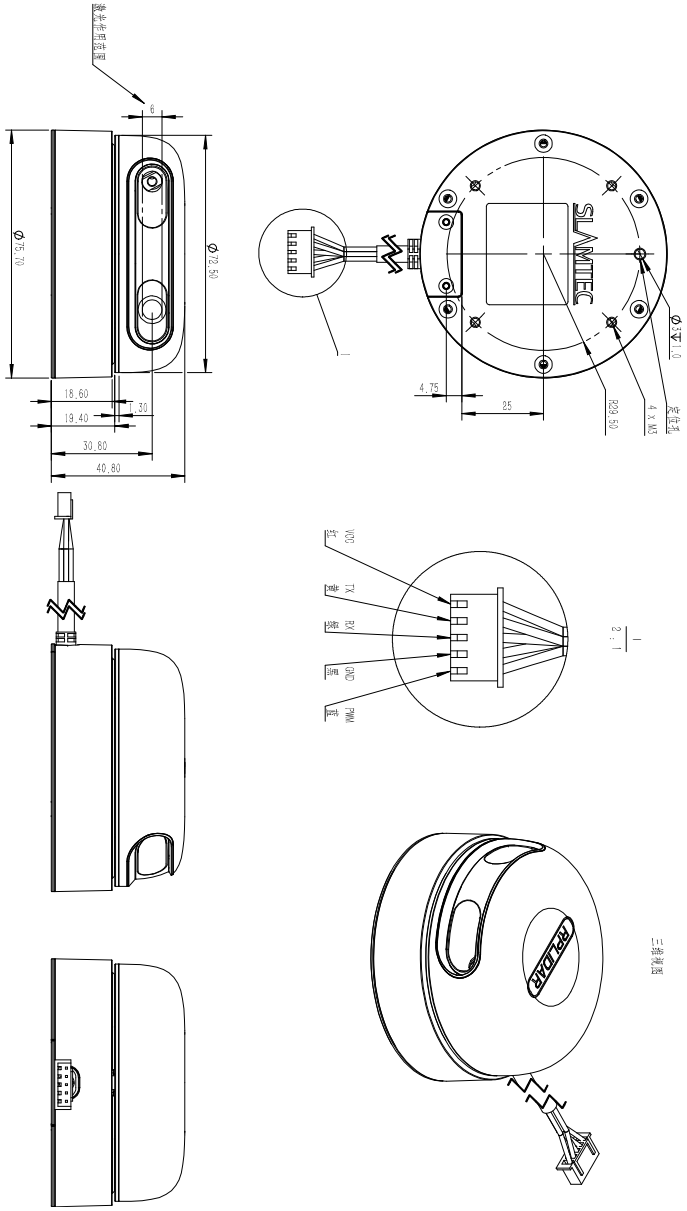


Figure 5-1 RPLIDAR Mechanical Dimensions

Note: the 4 * M3 screws in the bottom should be no longer than 4mm, or the internal module would be damaged.

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Date	Version	Description
2016-08-12	0.1	Initial Version A2M5/A2M6
2018-02-05	0.2	Alteration A2M6 models support 8K scan frequency. Add A2M6-R4 model
2018-09-26	0.3	Added product laser safety instructions and warnings, and last page product production instructions.
2019-02-14	0.4	Added a description of scan field flatness in Figure 2-1. The maximum value of system startup current in table 2-7 is changed to 2500 mA.
2019-03-21	0.5	The maximum value of system startup current in table 2-7 is changed to 1500 mA. Adds the maximum inrush current of 2500 mA in table 2-7.

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Manufacturer: SHANGHAI SLAMTEC CO., LTD.

Address: D-501 Shengyin Tower, 666 Shengxia Rd., Shanghai, China

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