

# RPLIDAR A2

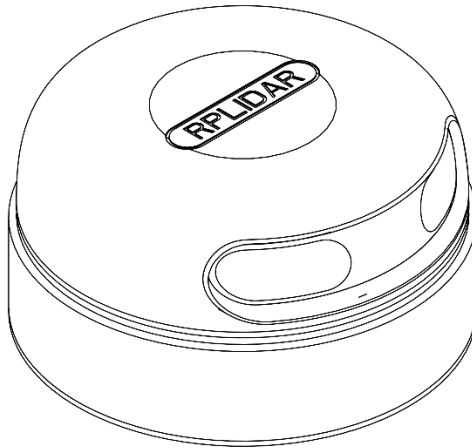
Low Cost 360 Degree Laser Range Scanner

## Introduction and Datasheet

Model: A2M7

OPTMAG

16K



|  |           |
|--|-----------|
| <b>CONTENTS</b>                                | <b>1</b>  |
| <b>INTRODUCTION</b>                            | <b>3</b>  |
| SYSTEM CONNECTION                              | 4         |
| MECHANISM                                      | 5         |
| SAFETY AND SCOPE                               | 6         |
| DATA OUTPUT                                    | 6         |
| HIGH SPEED SAMPLING PROTOCOL AND COMPATIBILITY | 7         |
| APPLICATION SCENARIOS                          | 8         |
| <b>SPECIFICATION</b>                           | <b>9</b>  |
| MEASUREMENT PERFORMANCE                        | 9         |
| LASER POWER SPECIFICATION                      | 9         |
| OPTICAL WINDOW                                 | 9         |
| COORDINATE SYSTEM DEFINITION OF SCANNING DATA  | 10        |
| COMMUNICATION INTERFACE                        | 11        |
| MISC   | 14        |
| <b>SELF-PROTECTION AND STATUS DETECTION</b>    | <b>15</b> |
| <b>SDK AND SUPPORT</b>                         | <b>16</b> |
| <b>MECHANICAL DIMENSIONS</b>                   | <b>17</b> |
| <b>REVISION HISTORY</b>                        | <b>18</b> |
| <b>APPENDIX</b>                                | <b>19</b> |
| IMAGE AND TABLE INDEX                          | 19        |



The RPLIDAR A2M7 is the next generation low cost 360 degree 2D laser scanner (LIDAR) solution developed by SLAMTEC. It can take up to 16000 samples of laser ranging per second 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.

The system can perform 2D 360-degree scan within a 16-meter range. The generated 2D point cloud data can be used in mapping, localization and object/environment modeling.

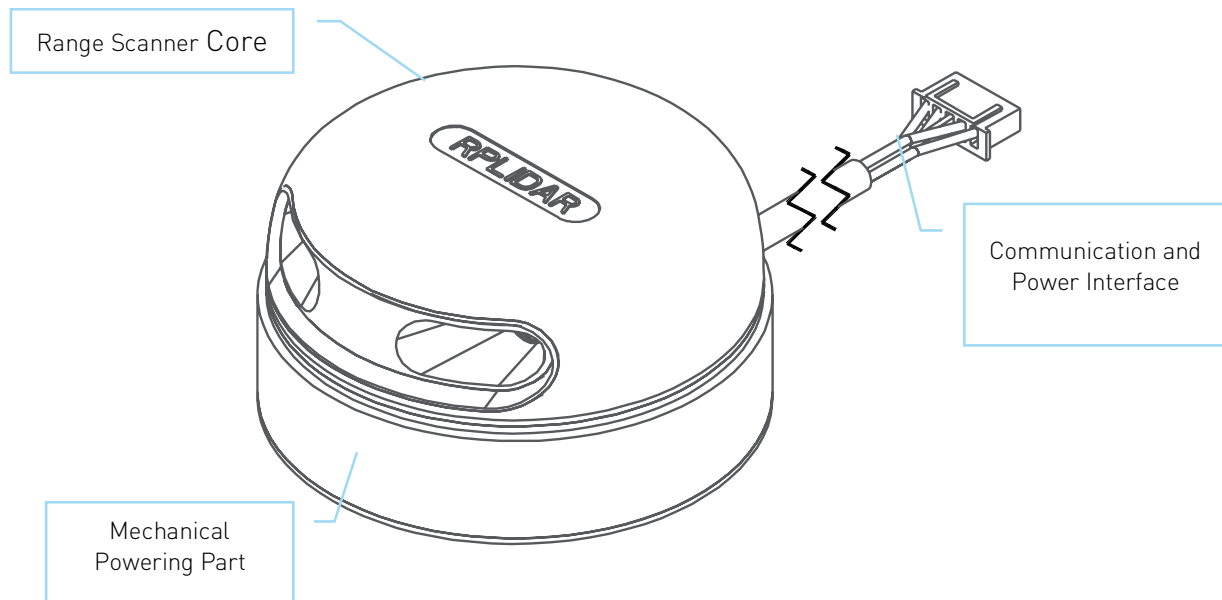
Compared with RPLIDARs in other series, RPLIDAR A2M7 has a more stable performance when detecting objects in long distance and objects in white or black alternatively, which is ideal for map building in the indoor environment within a 16-meter ranging radius. Therefore, it can be widely applied in many consumer-oriented business scenarios. RPLIDAR A2M7 under enhanced mode works with the maximum ranging radius and sampling rate to realize an optimistic mapping performance in the indoor environments.

The typical scanning frequency of RPLIDAR A2M7 is 10Hz(600rpm), and the frequency can be freely adjusted within the 5-15Hz range according to the specific requirements. With the 10Hz scanning frequency, the sampling rate is 16kHz and the angular resolution is 0.225°.

Due to the improvements in SLAMTEC hardware operating performance and related algorithm, RPLIDAR A2M7 works well in all kinds of indoor environment. Meanwhile, before leaving the factory, every RPLIDAR A2M7 has passed the strict testing to ensure the laser output power meet the eye-safety standard of IEC-60825 Class 1.

## System connection

The RPLIDAR A2M7 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.



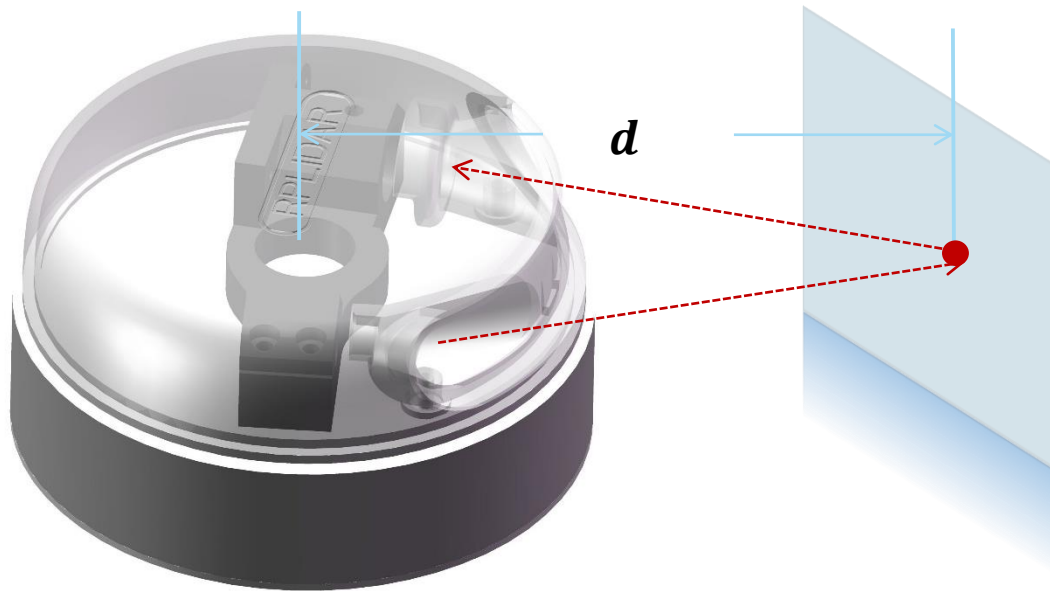
*Figure 1-1 RPLIDAR System Composition*

The RPLIDAR A2M7 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 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

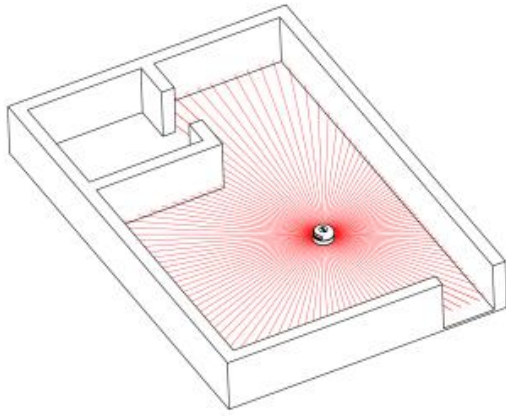
The RPLIDAR A2M7 is based on laser triangulation ranging principle and adopts the high-speed vision acquisition and processing hardware developed by SLAMTEC. The system ranges more than 16000 times per second.



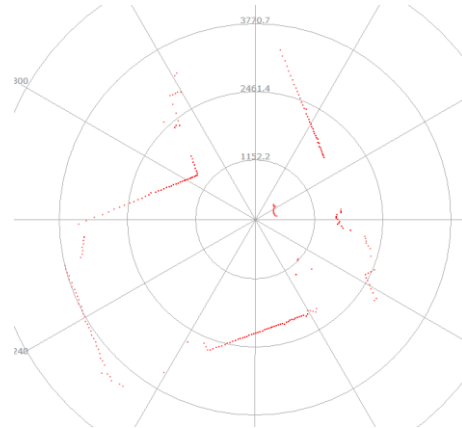
*Figure 1-2 The RPLIDAR Working Schematic*

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.



\*Note : The LIDAR scan image is not directly relative to the environment showed here. Illustrative purpose only.



*Figure 1-3 The Obtained Environment Map from RPLIDAR Scanning*

## Safety and Scope



Class I

The RPLIDAR A2M7 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 pet, 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.

**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.

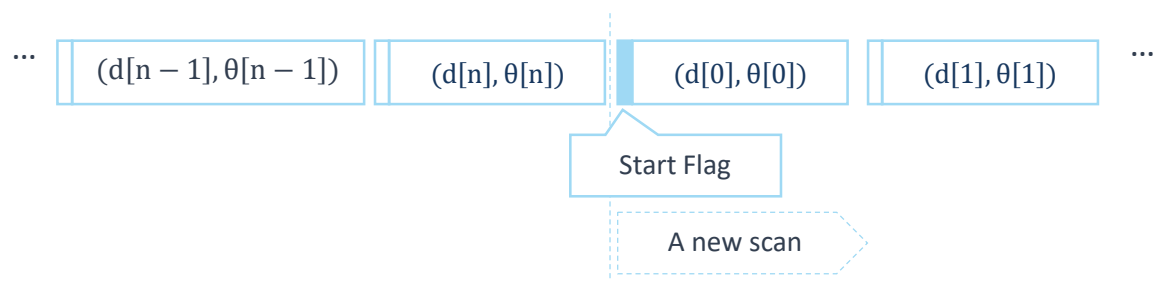
## Data Output

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 A2M7 adopts the newly extended high speed sampling protocol for outputting the 16000 times per second laser range scan data. Users are required to update the matched SDK or modify the original driver and use the new protocol for the 16000 times per second mode of RPLIDAR A2M7. Please check the related protocol documents for details.

Legacy mode is compatible with the legacy RPLIDAR series protocol, which makes it easy to replace previous model of RPLIDAR. In this mode, RPLIDAR can only retrieve 2000 samples per second.

## 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



## Measurement Performance

### ● For Model A2M7 Only

| Item                    | Performance  |
|-------------------------|--|
| Application Scenarios   | Extreme performance<br>Ideal for indoor environments with maximum ranging distance and sampling frequency. |
| Distance Range          | White object: 16 meters<br>Black object: 10 meters   |
| Sample Rate             | 16 kHz   |
| Scan Rate               | Typical value: 10 Hz (adjustable between 5 Hz-15 Hz)   |
| Angular Resolution      | 0.225°   |
| Scan Field Flatness     | ±1.5°  |
| Communication Interface | TTL UART   |
| Communication Speed     | 256000 bps   |
| Compatibility           | Support former SDK protocols   |

*Figure 2-1 RPLIDAR Performance*

Note: the triangulation range system resolution changes along with distance.

## Laser Power Specification

### ● For Model A2M7 Only

| Item               | Unit            | Min | Typical           | Max | Comments            |
|--------------------|-----------------|-----|-------------------|-----|---------------------|
| Laser wavelength   | Nanometer(nm)   | 775 | 785               | 795 | Infrared Light Band |
| Laser power        | Milliwatt (mW)  | -   | 10                | 12  | Peak power          |
| Pulse length       | Microsecond(us) | 60  | 87                | 90  | -                   |
| Laser Safety Class | -               | -   | IEC-60825 Class 1 | -   | -                   |

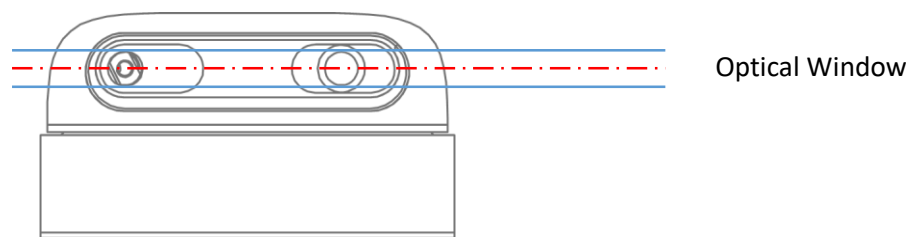
*Figure 2-2 RPLIDAR Optical Specification*

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 A2M7 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 A2M7. If you need cover the RPLIDAR A2M7 with translucent materials or have other special needs, please contact SLAMTEC about the feasibility.

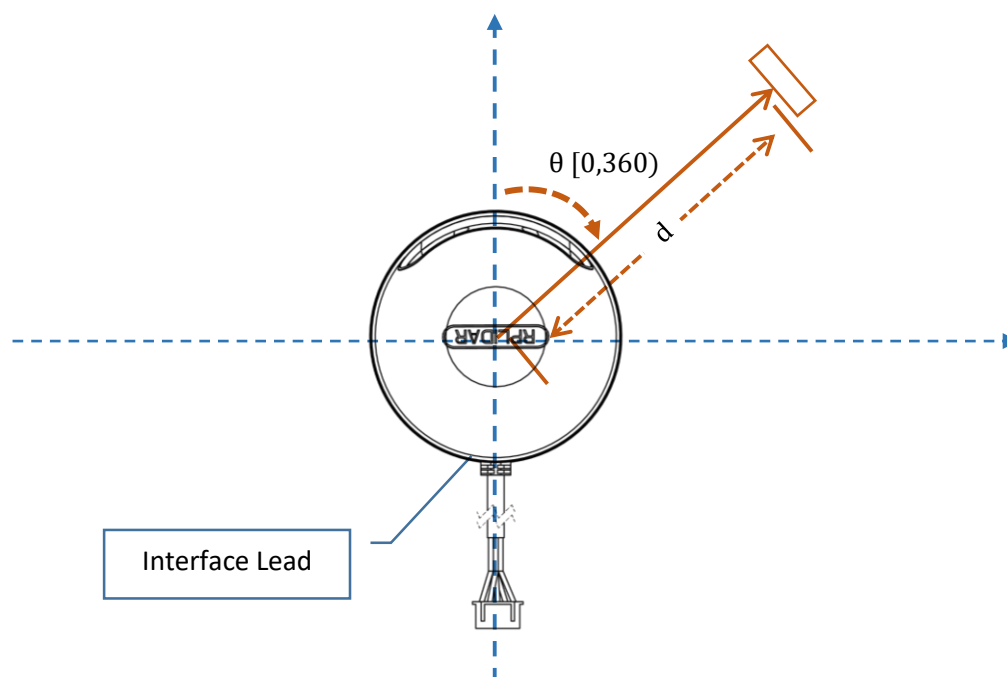


*Figure 2-3 RPLIDAR Optical Window*

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

## Coordinate System Definition of Scanning Data

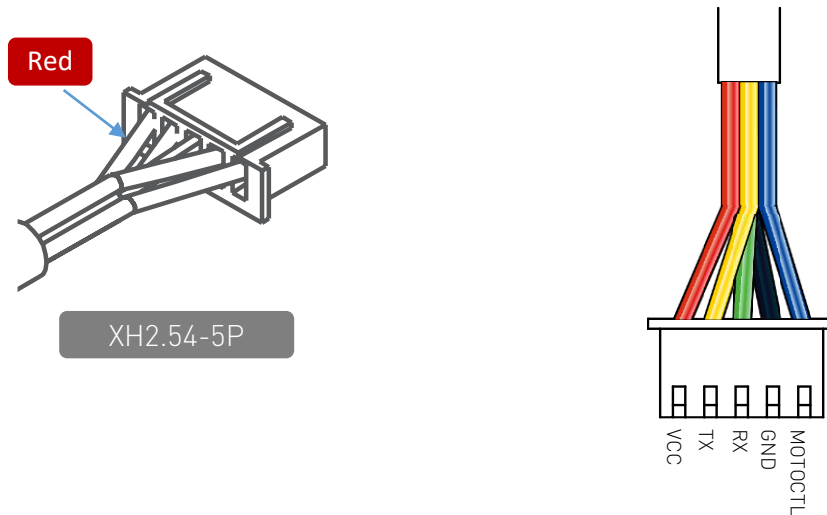
The RPLIDAR A2M7 adopts coordinate system of the left hand. The dead ahead of the sensors is the x axis of the coordinate system; the origin is the rotating center of the range scanner core. The rotation angle increases as rotating clockwise. The detailed definition is shown in the following figure:



*Figure 2-4 RPLIDAR Scanning Data Coordinate System Definition*

## Communication interface

The RPLIDAR A2M7 uses separate 5V DC power for powering the range scanner core and the motor system. And the standard RPLIDAR A2M7 uses XH2.54-5P male socket. Detailed interface definition is shown in the following figure:



*Figure 2-5 RPLIDAR Power Interface Definition*

| 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 A2M7 takes the only external power to power the range scanner core and the motor system which make the core rotate. To make the RPLIDAR A2M7 work normally, the host system needs to ensure the output of the power and meet its requirements of the power supply ripple.

● For Model A2M7 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 Current       | Start | 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*

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 A2M7 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      | -    | 256000  | -   | -          |
| 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 A2M7 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 A2M7 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:

| Item               | Unit | Min    | Typical | Max    | Comments  |
|--------------------|------|--------|---------|--------|---|
| High voltage level | 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 at 10Hz |

*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 A2M7 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 A2M7 will stop rotating and scanning; when the MOTOCTL is the high level signal, the RPLIDAR A2M7 will rotated at the highest speed.

## MISC

- For Model A2M7 Only

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

*Figure 2-10 RPLIDAR MISC Specification*

To ensure the laser of RPLIDAR always working in the safety range ( $<3\text{mW}$ ) 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.

To facilitate the usage of RPLIDAR A2 in the product development and speed up the development cycle for users, SLAMTEC has provided the **Framegrabber** plugin in RoboStudio for testing and debugging as well as the SDK available under Windows, x86 Linux and Arm Linux. Please contact SLAMTEC for detail information.

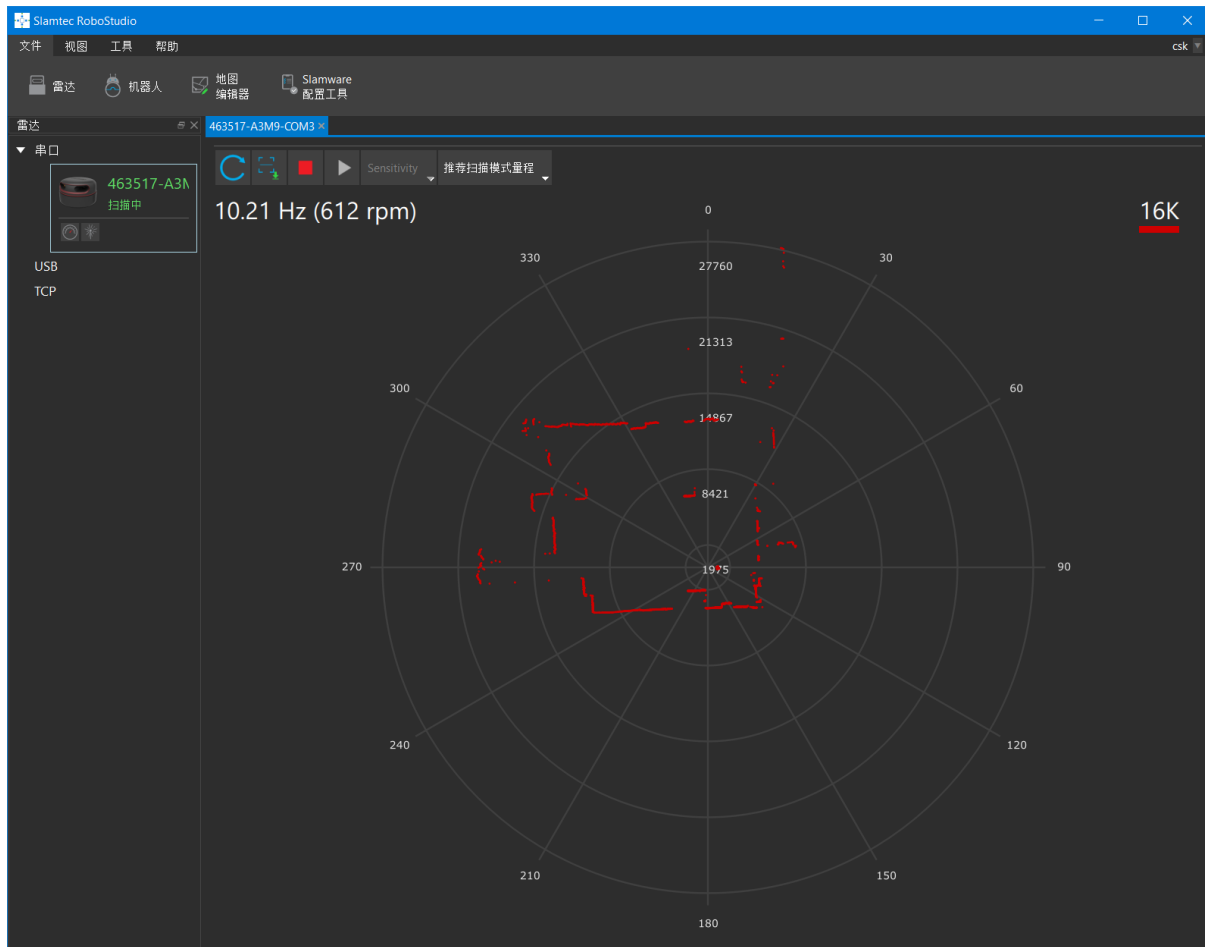
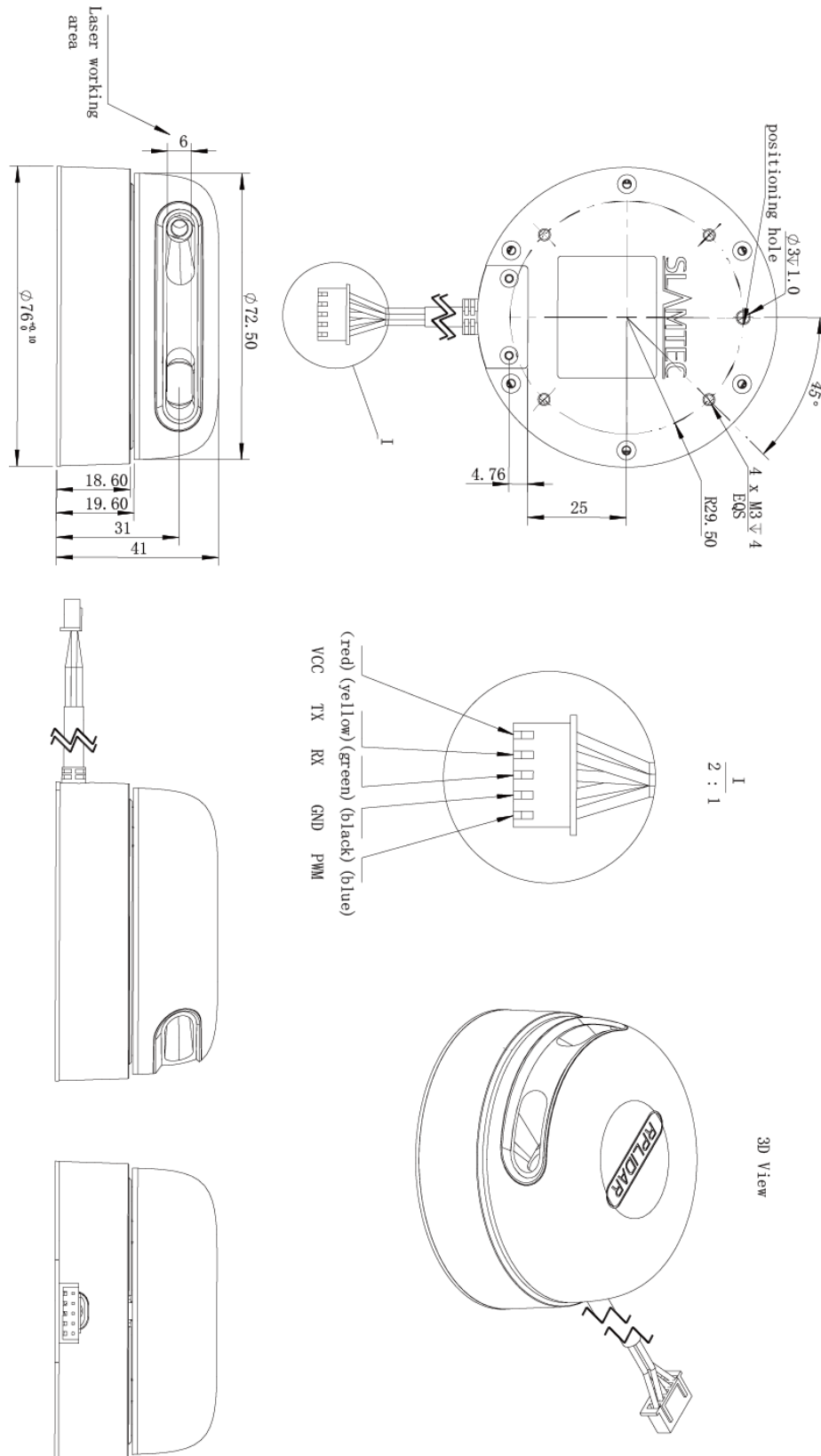


Figure 4-1 the Framegrabber Plugin in RoboStudio



The mechanical dimensions of the RPLIDAR A2M7 are shown as below:



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

| Date       | Version | Description              |
|------------|---------|--------------------------|
| 2019-04-29 | 1.0     | Initial version for A2M7 |

## Image and Table Index

|   |    |
|---|----|
| FIGURE 1-1 RPLIDAR SYSTEM COMPOSITION .....                         | 4  |
| FIGURE 1-2 THE RPLIDAR WORKING SCHEMATIC.....                       | 5  |
| FIGURE 1-3 THE OBTAINED ENVIRONMENT MAP FROM RPLIDAR SCANNING ..... | 6  |
| FIGURE 1-4 THE RPLIDAR SAMPLE POINT DATA INFORMATION .....          | 7  |
| FIGURE 1-5 THE RPLIDAR SAMPLE POINT DATA FRAMES .....               | 7  |
| FIGURE 2-1 RPLIDAR PERFORMANCE .....                                | 9  |
| FIGURE 2-2 RPLIDAR OPTICAL SPECIFICATION.....                       | 9  |
| FIGURE 2-3 RPLIDAR OPTICAL WINDOW .....                             | 10 |
| FIGURE 2-4 RPLIDAR SCANNING DATA COORDINATE SYSTEM DEFINITION.....  | 10 |
| FIGURE 2-5 RPLIDAR POWER INTERFACE DEFINITION .....                 | 11 |
| FIGURE 2-6 RPLIDAR EXTERNAL INTERFACE SIGNAL DEFINITION .....       | 11 |
| FIGURE 2-7 RPLIDAR POWER SUPPLY SPECIFICATION .....                 | 12 |
| FIGURE 2-8 RPLIDAR SERIAL PORT INTERFACE SPECIFICATIONS .....       | 13 |
| FIGURE 2-9 RPLIDA SPECIFICATION FOR PWM SIGNAL OF MOTOCTL.....      | 13 |
| FIGURE 2-10 RPLIDAR MISC SPECIFICATION .....                        | 14 |
| FIGURE 4-1 THE LIDARS PLUGIN IN ROBOSTUDIO.....                     | 16 |
| FIGURE 5-1 RPLIDAR MECHANICAL DIMENSIONS.....                       | 17 |

Manufacturer: SHANGHAI SLAMTEC CO., LTD.

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

Made in China