

TSA QUA DEVELOPMENT MANUAL



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1 WORKING MECHANISM

The YDLIDAR TSA (hereinafter referred to as TSA) system has 3 working modes: idle mode, scan mode, stop mode.

- **Idle mode:** When TSA is powered on, the default mode is idle mode. In idle mode, the TSA's ranging unit does not work and the laser is not light.
- **Scan mode:** When TSA is in scanning mode, the ranging unit turns on the laser. When the TSA starts to work, it continuously samples the external environment and outputs it in real time after background processing.
- **Stop mode:** When TSA runs with an error, such as turning on the scanner, the laser is off, the motor does not rotate, etc. TSA will automatically turn off the distance measuring unit and feedback the error code.

1.1 System Workflow

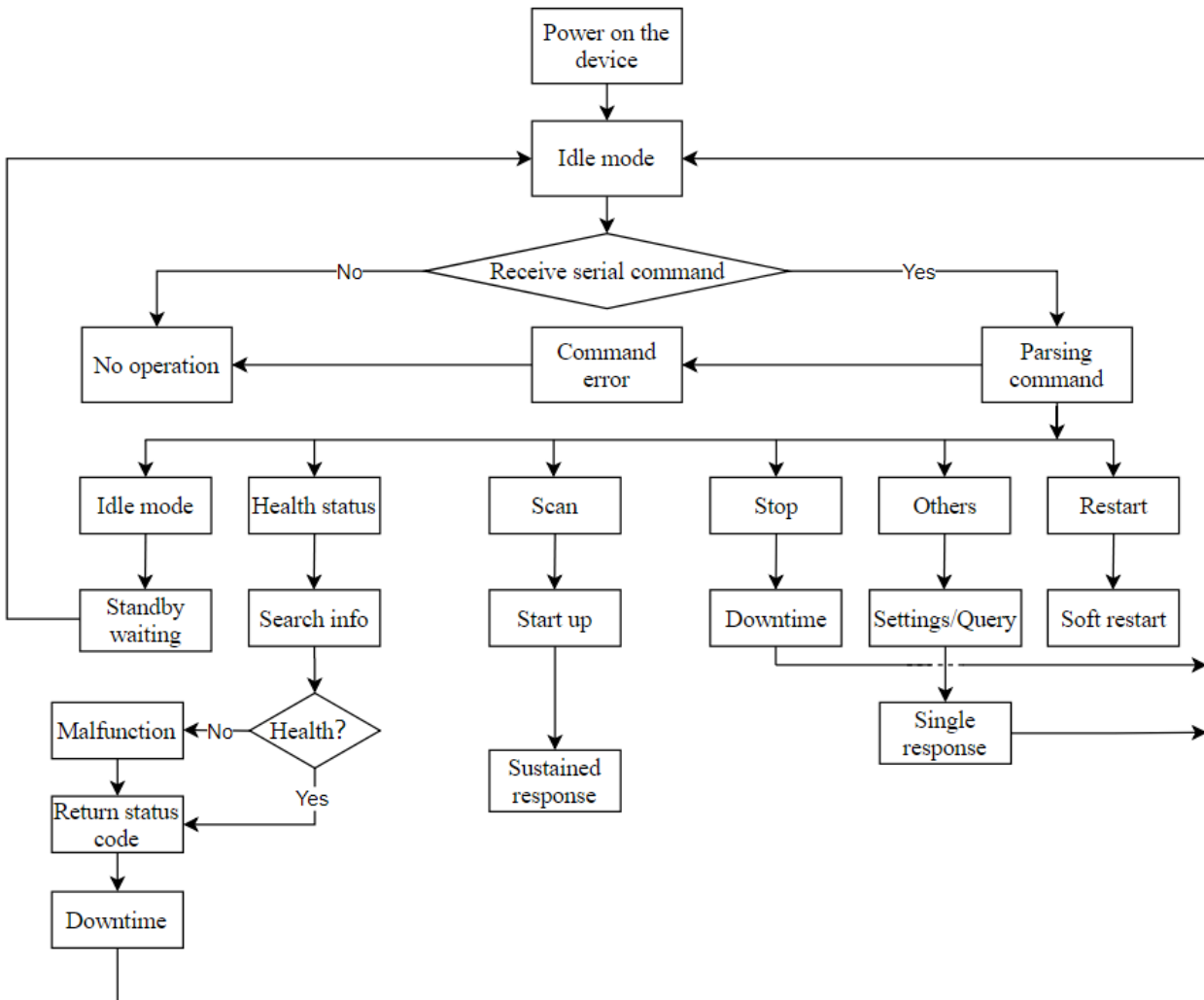


FIG 1 YDLIDAR TSA WORKFLOW

2 SYSTEM COMMUNICATION

2.1 Communication Mechanism

TSA uses the serial port to interact with external devices for commands and data. When an external device sends a system command to TSA, TSA resolves the system command and returns a corresponding reply message. According to the command content, TSA switches the corresponding working status. According to the content of the message, the external system can parse the message and obtain the response data.

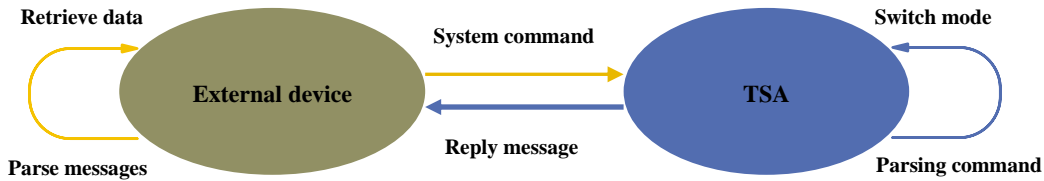


FIG 2 YDLIDAR TSA SYSTEM COMMUNICATION

2.2 System Command

By sending relevant system commands, the external system can set the corresponding working status of TSA and obtain corresponding data. The system commands of TSA consist of two bytes. The first byte is 0xA5 and the second byte is the command content. The system commands issued by TSA are as follows:

CHART 1 YDLIDAR TSA SYSTEM COMMAND

System Command	Description	Mode Switching	Answer Mode
0xA5 (Start)	0x60	Start scanning, output point cloud data	Scan mode Sustained response
	0x65	Stop and stop scanning	Stop mode No answer
	0x90	Get device information (model, firmware, hardware version)	No Single response
	0x92	Get device health status	No Single response
	0x09	Increase the current scan frequency of 0.1Hz	No Single response
	0x0A	Reduce the current scan frequency of 0.1Hz	No Single response
	0x0B	Increase the current scan frequency of 1Hz	No Single response
	0x0C	Reduce the current scan frequency of 1Hz	No Single response
	0x0D	Get the currently set scan frequency	No Single response
	0x40	Soft restart	/ No answer

2.3 System Messages

The system message is a response message that the system feeds back based on the received system command. According to different system commands, the reply mode and response content of the system message are also different. There are three kinds of response modes: no response, single response, sustained response.

No response means that the system does not return any messages. A single reply indicates that the system's message length is limited, and the response ends once. Sustained response means that the system's message length is infinite and needs to send data continuously, such as when entering the scan mode.

The one-time response and sustained response messages use the same data protocol. The contents of the protocol are: start sign, response length, response mode, type code and response content, and are output through the serial port hexadecimal system.

CHART 2 YDLIDAR TSA SYSTEM MESSAGE DATA PROTOCOL

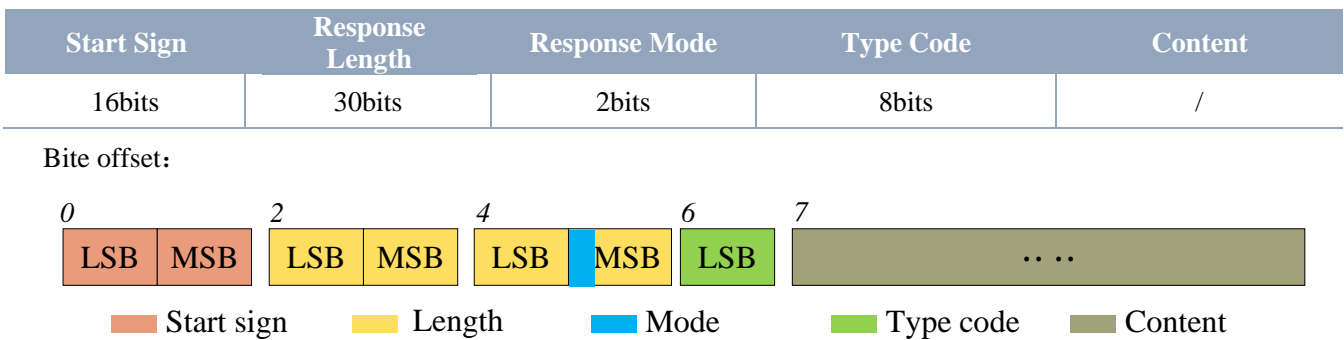


FIG 3 YDLIDAR TSA SYSTEM MESSAGE DATA PROTOCOL

- **Start sign:** TSA's message sign is unified as 0xA55A.
- **Response length:** The response length indicates the length of the response content, when the answer mode is continuous, the length should be infinite, so this value is invalid.
- **Response mode:** This bit is only 2 bits, which means this time it is a single response or sustained response. Its value and corresponding mode are as follows:

CHART 3 YDLIDAR TSA RESPONSE VALUE AND MODE

Mode	0x0	0x1	0x2	0x3
Response mode	Single response	sustained response	Undefined	

- **Type code:** Different system commands correspond to different types codes.
- **Content:** Different system commands, feedback different data content, and their data protocols are also different.

Note 1: The TSA data communication adopts the little-endian mode and the low-order mode.

Note 2: In the reply message, the lower 6 bits of the 6th byte belong to the response length and the upper 2 bits belong to the response mode.

3 DATA PROTOCOL

Different system commands have different packet contents. In the packets of different types of codes, the data protocol of the response content is also not the same. Therefore, the users needs to parse the data in the response content according to the corresponding data protocol, such as point cloud data, device information, etc.

3.1 Scan Command [A5 60]

When an external device sends a scan command to TSA, TSA goes into scan mode and feeds back point cloud data. The reply message is:

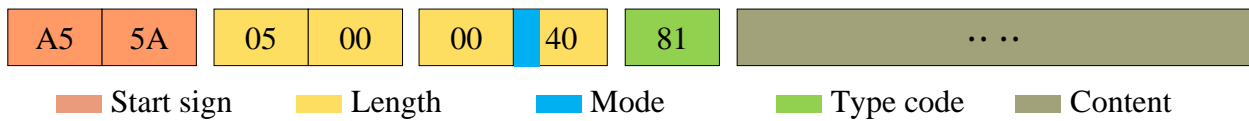


FIG 4 YDLIDAR TSA SCAN COMMAND

The 6th byte high 2 is 01, so the response mode takes 0x1, which is a sustained response, ignoring the response length, and the type code is 0x81.

The response content is the point cloud data scanned by the system. According to the following data structure, the data is sent to the external device in hexadecimal to the serial port.

Byte offset:

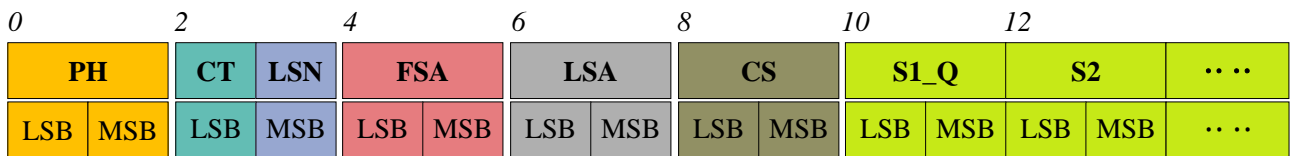


FIG 5 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE

CHART 4 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE DESCRIPTION

Content	Name	Description
PH(2B)	Packet header	2B in length, fixed at 0x55AA, low in front, high in back
CT(1B)	Package type	Indicates the type of the current packet, CT[bit(0)]=1 means the beginning of a lap of data, CT[bit(0)]=0 means point cloud data packet, CT[bit(7:1)] is reserved bit
LSN(1B)	Sample quantity	Indicates the number of sampling points contained in the current packet. There is only one zero point of data in the zero packet. The value is 1
FSA(2B)	Start angle	The angle data corresponding to the first sample point in the sampled data
LSA(2B)	End angle	The angle data corresponding to the last sample point in the sampled data
CS(2B)	Check code	The check code of the current data packet uses a two-byte exclusive OR to check the current data packet.
Si_Q(2B)	Signal quality	Received signal quality information, the larger the value, the better the signal quality
Si(2B)	Sample data	The sampling data of the system test is the distance data of the sampling point

➤ Start bit analysis

When CT&0x01=1 is detected, it indicates that the packet data is the start packet, representing the beginning of a cycle of data. In this packet, LSN=1, that is, the number of Si is 1;

When CT&0x01=0 is detected, indicates that the packet data is an intermediate data packet within a circle of data, not the starting point of a circle of data.

For the specific value analysis of the distance and angle, please refer to the following.

➤ Distance analysis

Distance solution formula: $Distance_i = Si$

Among them, Si is the sampled data. Set the sampling data as 44 1A. Since the system is in little-endian mode, the sampling point $S = 0x1A 44$ is substituted into the Distance solution formula to obtain the Distance=6724.00mm.

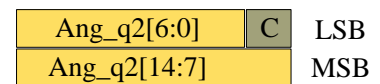


FIG 6 ANGLE DATA STRUCTURE

➤ Signal quality analysis

Signal quality calculation formula: $Quality_i = Si_Q$

Among them, Si_Q is signal quality data. Suppose the sampling data is 6F 00. Since this system is in the little-endian mode, the sampling point $S = 0x00 6F$, which is brought into the signal quality calculation formula, and the result is =111.

➤ Angle analysis

Angle data is stored in FSA and LSA, and each Angle data has the following data structure, where C is the check bit and its value is fixed to 1. The specific process is as follows:

Starting angle solution formula: $Angle_{FSA} = \frac{Rshiftbit(FSA,1)}{64}$

End angle solution formula: $Angle_{LSA} = \frac{Rshiftbit(LSA,1)}{64}$

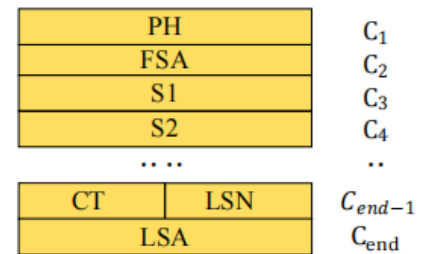
Intermediate angle solution formula:

$$Angle_i = \frac{diff(Angle)}{LSN-1} * (i - 1) + Angle_{FSA} \quad (i = 2,3, \dots, LSN - 1)$$

Rshiftbit(data, 1) means shifting the data to the right by one bit. *diff(Angle)* means the clockwise angle difference from the starting angle (uncorrected value) to the ending angle (uncorrected value), and LSN represents the number of packet samples in this frame.

➤ **Check code parsing**

The check code uses a two-byte exclusive OR to verify the current data packet. The check code itself does not participate in XOR operations, and the XOR order is not strictly in byte order. The XOR sequence is as shown in the figure. Therefore, the check code solution formula is:



$$CS = XOR_1^{en}(C_i) \quad i = 1,2, \dots, end$$

FIG 7 CS XOR SEQUENCE

XOR_1^{end} indicates the XOR of the element from subscript 1 to end. However, XOR satisfies the exchange law, and the actual solution may not need to follow the XOR sequence.

3.2 Stop Command [A5 65]

When the system is in the scan status, TSA always sends point cloud data to the outside. If you need to turn off scanning at this time, you can send this command to stop the system from scanning. After the stop command is sent, the system will be in the standby state. At this time, the ranging unit of the device is in the low power mode, and the laser is not lit.

The command is unresponsive, so the system will not respond to any messages after receiving the command.

3.3 Device Information [A5 90]

When an external device sends a Get Device Information command to (A5 90), TSA will feedback the device's model, firmware version, and hardware version, and the device's factory serial number. The reply message is:

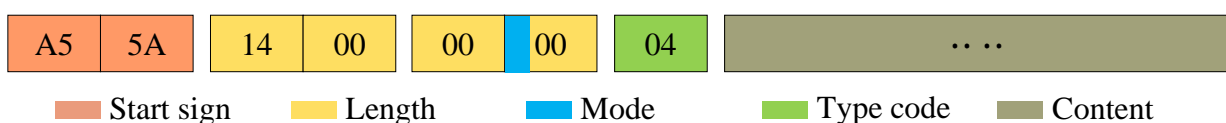


FIG 8 YDLIDAR TSA DEVICE INFORMATION

According to the protocol resolution: response length = 0x00000014, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 20. The response is a single response and the type code is 04. This type of response content satisfies the following data structure:

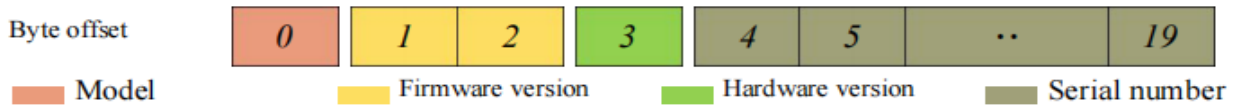


FIG 9 YDLIDAR TSADEVICE INFORMATION RESPONSE CONTENT DATA STRUCTURE

- **Model number:** One byte device model, such as the model code of TSA is 130;
- **Firmware Version:** 2 bytes. The low byte is the major version number, and the high byte is the minor version number;
- **Hardware version:** 1 byte for hardware version;
- **Serial number:** 16 bytes, the only factory serial number.

3.4 Health Status [A5 92]

When an external device sends a health status command (A5 92) to TSA, TSA will give back the status code of the device. The reply message is:

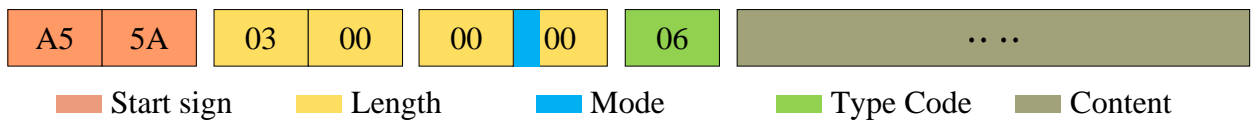


FIG 10 SCHEMATIC DIAGRAM OF YDLIDAR TSA LIDAR EQUIPMENT HEALTH STATUS MESSAGE

According to the protocol resolution: response length = 0x00000003, answer mode = 0x0, type code = 0x06.

That is, the number of response content bytes is 3. This response is a single response and the type code is 06. The type of reply content satisfies the following data structure:

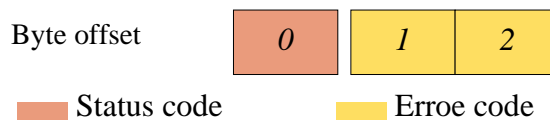


FIG 11 SCHEMATIC DIAGRAM OF DATA STRUCTURE OF HEALTH STATUS RESPONSE CONTENT OF YDLIDAR TSA EQUIPMENT

- **Status code:** 1 byte, 0x0 indicates that the device is operating normally, 0x1 indicates that the device is operating warning, and 0x2 indicates that the device is operating incorrectly.
- **Error code:** 2 bytes. When a warning or error state occurs, the specific error code will be recorded in this field. 0x00 means that the device is running without error.

3.5 Scan Frequency Setting [A5 09/0A/0B/0C]

TSA provides multiple command interfaces for scanning frequency settings to increase or decrease the system scan frequency.

CHART 5 SCAN FREQUENCY SETTING COMMAND DESCRIPTION

Commands	Description
A5 09	Increase the current scan frequency of 0.1Hz
A5 0A	Reduce the current scan frequency of 0.1Hz
A5 0B	Increase the current scan frequency of 1Hz
A5 0C	Reduce the current scan frequency of 1Hz

The above commands are the same type of commands and have the same message structure. The scan frequency setting command has the following message structure:

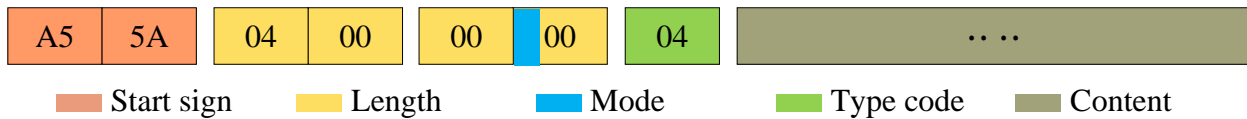


FIG 12 YDLIDAR TSA SCAN FREQUENCY SETTING MESSAGE

According to the protocol resolution: response length = 0x00000004, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 4; this response is a single response, and the type code is 04. The response content represents the currently set scanning frequency (Unit: Hz), and its solution formula is:

$$F = \frac{\text{AnswerData}}{100}$$

Among them, AnswerData is converted to decimal data for response content (little-endian mode) in Hertz (Hz)

3.6 Scan Frequency Acquisition [A5 0D]

This command is used to get the scan frequency (note that it is not a real-time frequency). The message structure and response content are consistent with the scan frequency setting command. The users can refer to the [scan frequency setting \[A5 09/0A/0B/0C\]](#). This section does not describe it.

3.7 Restart Command [A5 40]

When an external device sends a restart device command (A5 40) to TSA, TSA enters a soft reboot and the system restarts. This command does not answer.

3.8 Motor Speed Control

The TSA integrates the system's speed control into the system's command interface, not the hardware interface. Users can change the speed of the motor by adjusting the scan frequency. See the section on [Scan Frequency Setting \[A5 09/0A/0B/0C\]](#) for details. This section does not elaborate.

4 ATTENTION

When performing command interaction with TSA series lidars, except for the stop scan command (A5 65), other commands cannot be interacted in scan mode, which may easily lead to message parsing errors.

The TSA will not rotate when powered on. You need to send the command A5 60 to make it enter the scanning mode, and send A5 65 to stop it.

5 REVISE

Date	Version	Content
2020-12-02	1.0	Compose a first draft