

YDLDIART-MINI PLUS DEVELOPMENT MANUAL



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1 WORKING MECHANISM

The YDLIDAR T-mini Plus (hereinafter referred to as T-mini Plus) system has 3 working modes: idle mode, scan mode, stop mode, Power-down protection mode.

- **Idle mode:** When the T-mini Plus is powered on, it defaults to the idle mode. In the idle mode, the T-mini Plus 's ranging unit does not work and the laser does not light up.
- **Scan mode:** When T-mini Plus enters the scan mode, the ranging unit lights up the laser and starts to work, continuously sampling the external environment, and outputting it in real time after background processing.
- **Stop mode:** When there is an error in T-mini Plus operation, such as when scanning is turned on, the laser is not bright, the motor does not rotate, etc., T-mini Plus will automatically turn off the ranging unit and feedback the error code.

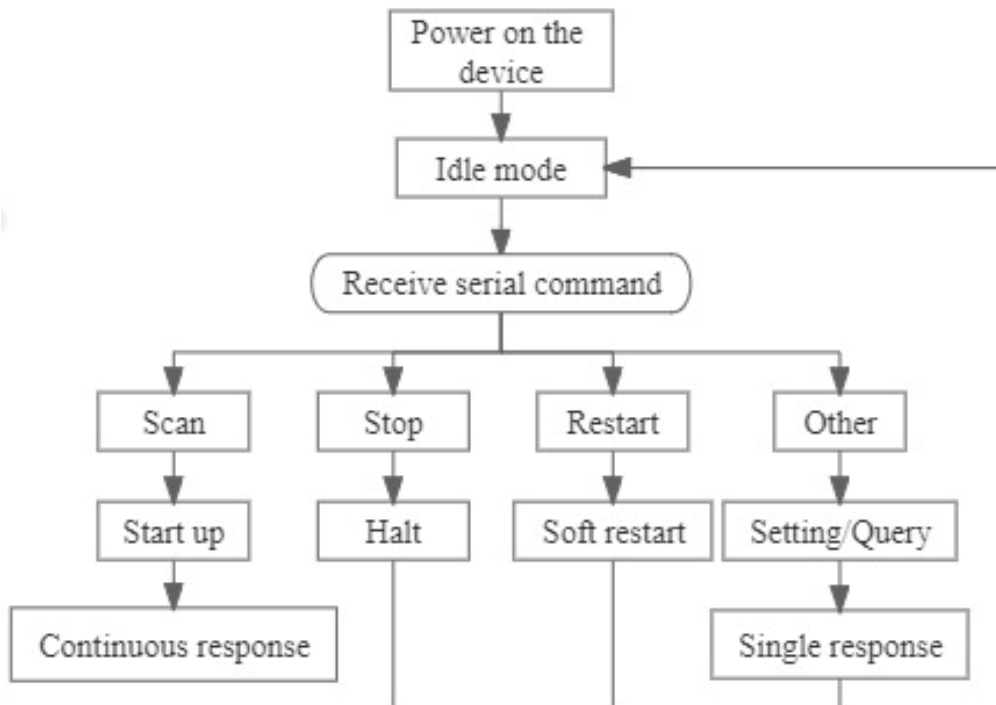


FIG 1 YDLIDAR T-MINI PLUS SYSTEM WORKFLOW

2 SYSTEM COMMUNICATION

2.1 Communication Mechanism

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

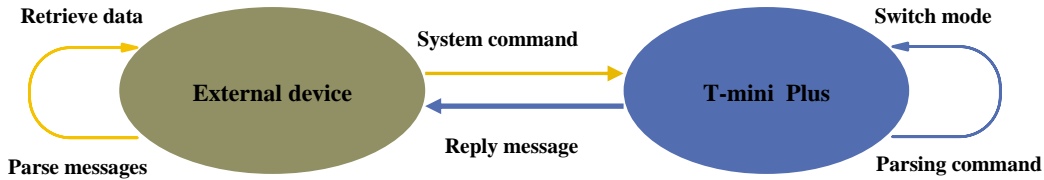


FIG 2 YDLIDAR T-MINI PLUS SYSTEM COMMUNICATION

2.2 System Command

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

CHART 1 YDLIDAR T-MINI PLUS SYSTEM COMMAND

System Command	Description	Mode Switching	Answer Mode
0xA5 (Start)	0x60	Start scanning, output point cloud data	Scan mode Continuous 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, continuous response.

No response means that the system does not return any messages. A single response 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 single response and continuous 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 T-MINI PLUS SYSTEM MESSAGE DATA PROTOCOL

Start Sign	Response Length	Response Mode	Type Code	Content
16bits	30bits	2bits	8bits	/

Byte offset:

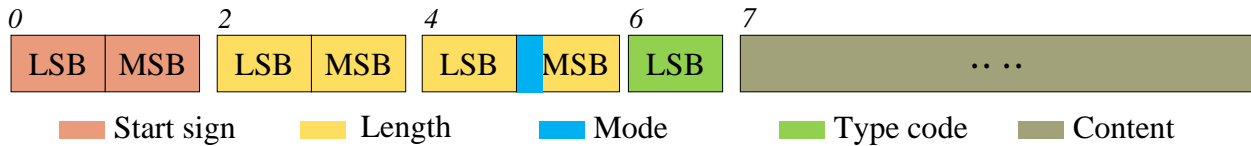


FIG 3 YDLIDAR T-MINI PLUS SYSTEM MESSAGE DATA PROTOCOL

- **Start sign:** T-mini Plus'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 continuous response. Its value and corresponding mode are as follows:

CHART 3 YDLIDAR T-MINI PLUS RESPONSE VALUE AND MODE

Mode	0x0	0x1	0x2	0x3
Response mode	Single response	Continuous 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 T-mini Plus 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 need 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 T-mini Plus, T-mini Plus goes into scan mode and feeds back point cloud data. The reply message is:



FIG 4 YDLIDAR T-MINI PLUS SCAN COMMAND

The 6th byte high 2 is 01, so the response mode takes 0x1, which is a continuous 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 :

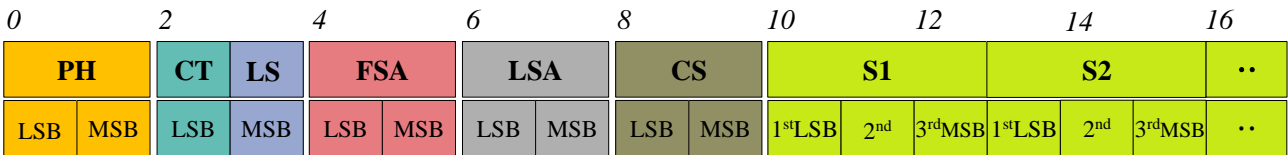


FIG 5 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE

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)	Scanning frequency&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)] means reserved bit
LSN(1B)	Sample quantity	Indicates the number of sampling points contained in the current packet. There is only one starting point of data in the start 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(3B)	Sample data	S node, used to store the sampling data and quality data of the system ranging

3.1.1 Start Bit Analysis

When CT[bit(0)] =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; for the specific value analysis of the distance and angle, please refer to the following;

When CT[bit(0)] = 0 is detected, it indicates that the packet data is a point cloud data packet.

Note: CT [bit (7:1)] is a reserved bit and will be used for other purposes in future versions. Therefore, in the process of parsing CT, only the start frame of bit (0) needs to be determined.

3.1.2 Intensity Analysis

Intensity calculation formula: $Intensity(i) = Intensity[7:0]$

The intensity represents the strength information of the laser signal, which is stored in the first byte of the Si node.

Among them, Si is sampled data, and Si(j) represents the j byte of Si. Suppose the sampling data is 64 E5 6F, so this sampling point S (1) = 0x64=100(dec),

So, Intensity=100.

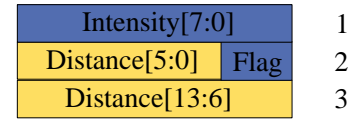


FIG 6 S-NODE DATA STRUCTURE DIAGRAM

Note: In node S, the first byte stores Intensity, and its value range is 0~255.

3.1.3 Interference Filtering

T-mini Plus integrates an interference recognition algorithm, and the points that interfere with the signal will be marked on the Flag. Users can filter the points that interfere with the signal according to the actual usage, as follows:

- 1) Flag=2, the signal has the interference of specular reflection, it is recommended to filter the ranging value of this point to filter out the interference;
- 2) Flag=3, the signal is interfered by ambient light, it is recommended to filter the ranging value of this point to filter out the interference.

Note: When filtering all the points marked by interference, the anti-noise effect of T-mini Plus is relatively good, and at the same time it will lose part of the detailed information of the point cloud. Users can choose different noise filtering strategies according to the actual use scene.

3.1.4 Distance Analysis

Distance solution formula: $Distance_i = Lshiftbit(Si(3), 6) + Rshiftbit(Si(2), 2)$

Among them, Si is the sampled data. $Lshiftbit(data, 1)$ means to shift data by one bit to the left, $Rshiftbit(data, 1)$ means to shift data by one bit to the right. Suppose the sampling data is 64 E5 6F. Since the system is in the little-endian mode, the solution to the sampling point is:

$$Distance = dec(Lshiftbit(0x6F, 6)) + dec(Rshiftbit(0xE5, 2)) = 7161mm$$

3.1.5 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: $Angle_{LSA} = \frac{Rshiftbit(LSA, 1)}{64}$

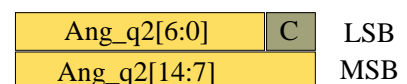


FIG 7 ANGLE DATA STRUCTURE SCHEMATIC

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 to the ending angle, and LSN represents the number of packet samples in this frame.

3.1.6 Check Code Parsing

The check code uses a two-byte XOR to verify the current data packet. The check code itself does not participate in XOR operations, and the XOR sequence is not strictly in the byte order. The XOR sequence is shown in the figure. Note that Since the sampled data *S_i* has 3 bytes, the upper 8 bits of the first byte of *S_i* need to be filled with zeros and then XORed, as shown in the figure 8 C_3 and C_5. Therefore, the check code solution formula is:

AA 55 20 13 95 A9 63 00 5A E8 01 08 B9 01 AC B8 01 F8 B6 01 88 B5 01 58 AE 01 C0 AB 01 04
 AA 01 78 A9 01 34 A9 01 C4 AD 01 34 AF 01 78 AE 01 2C AD 01 02 00 00 62 AD 01 60 AD 01
 F0 AB 01 88 AD 01 FE AD

PH		
LSB (0xAA)		MSB(0x55)
CT(0x20)		LSN(0x13)
FSA		
LSB(0x95)		MSB(0xA9)
LSA		
LSB(0x63)		MSB(0x00)
CS		
LSB(0x5A)		MSB(0xE8)
S1		
S1[1](0x01)	S1[2](0x08)	S1[3](0xB9)
...		
S _i		
S _i [1](0x01)	S _i [2](0xFE)	S _i [3](0xAD)

FIG 8 CHECK CODE PARSING DIAGRAM

$$CS=PH(0x55AA)^{LSN}.CT(0x1320)^{FSA(0xA995)^{LSA(0x0063)^{0x00}.S1[1](0x0001)}$$

$$^S1[3].S1[2](0xB908)...^{0x00}.S_i[1](0x0001)^{S_i[3].S_i[2](0xADFE)}=0xE85A$$

3.1.7 CT Information Analysis

Since a circle of point cloud is composed of a starting data packet and multiple point cloud data packets, in the data protocol of T-mini Plus, the CT[bit(7:1)] of these data packets carries different information in each circle.

➤ CT information decomposition

It is specified that the index of the initial data packet is 0, and the indexes of subsequent data packets are superimposed on this basis, and the corresponding information of CT[bit(7:1)] of each index is as follows:

CHART 5 DESCRIPTION OF CT CARRYING INFORMATION

Index	T-mini Plus
0(Zero pack)	$CT = (\text{Freq} * 10) \ll 1$
1	$CT = (\text{CusVerMajor} \ll 6) + (\text{CusVerMinor} \ll 1)$
2	CT = Production debugging information
3	CT = Health $\ll 1$
4	$CT = (\text{HardwareVer} \ll 5) + (\text{FirewareMajor} \ll 1)$
5	CT = FirewareMinor $\ll 1$
6-8	CT = Production debugging information
9	$CT = ((\text{SN_Year} - 2020) \ll 3) + (\text{SN_Number}[\text{bit}(20:19)] \ll 1)$
10	$CT = (\text{SN_Month} \ll 4) + (\text{SN_Number}[\text{bit}(18:16)] \ll 1)$
11	$CT = (\text{SN_Day} \ll 3) + (\text{SN_Number}[\text{bit}(15:14)] \ll 1)$
12	$CT = \text{SN_Number}[\text{bit}(13:7)] \ll 1$
13	$CT = \text{SN_Number}[\text{bit}(6:0)] \ll 1$
Subsequent index	CT = Production debugging information

➤ CT information description

Among them, the description and use of each carried information is as follows:

CHART 6 CT CARRY INFORMATION DESCRIPTION

Item	Description	Remarks
Freq	Scanning frequency	The user can obtain the scanning frequency
CusVerMajor	Customer version major	Users can do protocol compatibility according to the user version The current user version of T-mini Plus is: V1.0
CusVerMinor	Customer version minor	
Health	Health information	The user can parse the information and get the status of the lidar in real time
HardwareVer	Hardware version	The user can parse the information to obtain the hardware version of the lidar
FirewareMajor	Firmware major	The user can parse the information to obtain the firmware version of the lidar
FirewareMinor	Firmware minor	
SN_Year	Production serial number year	User can parse SN information for tracking lidar information $SN = \text{SN_Year} * 10^{12} + \text{SN_Month} * 10^{10} + \text{SN_Day} * 10^8 + \text{SN_Number}$
SN_Month	Production serial number month	
SN_Day	Production serial number date	
Production debugging information	Not open	This information stores production-related information and is not yet open

➤ **Health analysis**

In order to facilitate real-time monitoring of lidar health information, T-mini Plus integrates health information. Health is integrated in the CT [bit (7:1)] of the data packet with index 4. Each bit of Health represents the health status of different modules, as follows:

CHART 7 HEALTH INFORMATION DESCRIPTION

Bit	Description	Remarks
0	Sensor status: 0 normal, 1 abnormal	When this bit is abnormal, the lidar sampling sensor is abnormal and can no longer carry out normal ranging. Generally, the abnormal conditions are as follows: (1) Damaged lidar sensor
1	Encode status: 0 normal, 1 abnormal	When this bit is abnormal, the lidar angle measurement system may be abnormal. Generally, the abnormal conditions are as follows: (1) The lidar is blocked (2) Abnormal lidar optical coupler (3) Abnormal lidar code plate
2	WiPwr status: 0 normal, 1 abnormal	When this bit is abnormal, the lidar wireless power supply system may be abnormal. Generally, the abnormal conditions are as follows: (1) The wireless module is damaged
3	PD status: 0 normal, 1 abnormal	When this abnormality occurs, the lidar laser emission system may be abnormal. Generally, the abnormal conditions are as follows: (1) The laser tube is damaged (2) The laser tube terminal and pad fall off
4	LD status: 0 normal, 1 abnormal	When this abnormality occurs, the lidar laser emission system may be abnormal. Generally, the abnormal conditions are as follows: (1) The laser tube is damaged (2) The laser tube terminal and pad fall off
5	Data status: 0 normal, 1 abnormal	When this abnormality occurs, the lidar scans a circle without valid data. Generally, the abnormal conditions are as follows: (1) Lidar ranging (transmitting or receiving) is blocked (2) The lidar optical path is completely deviated, and the laser signal cannot be received

Note 1: When the Health bit is 1, the corresponding module is abnormal, and when it is 0, the corresponding module is normal.

Note 2: Due to AD resources, PwrHealth, PDHealth, and LDHealth, these 3 items are only tested once after power-on, and the subsequent status will not be updated.

Note 3: SensorHealth, EncodeHealth, DataHealth, these 3 test items are real-time test items.

➤ **CT information verification**

Since the index of each packet is not given, users can only synchronize the index of the starting packet once. If the serial port of user loses packets, the unpacking of related information (Health and user version) may be incorrect. Therefore, T-mini Plus introduces a check byte for CRC8, as follows:

- 1) Using the CRC8 check method, starting from the zero packet, CRC8 is performed on each CT until the next zero packet is received.
- 2) The check result of CRC8 is stored at the beginning of each zero-bit packet, so the data structure of the zero-bit packet can be adjusted as follows:

CHART 8 DATA STRUCTURE DESCRIPTION OF THE START PACKET WITH CHECK RESULT

Content	Designation	Byte Offset
LastCRC(1B)	CT check result of the last lap	0
PH(2B)	Packet header	1
CT(1B)	Zero packet: $Freq \ll 1 + 1$	3
LSN(1B)	Sampling amount	4
FSA(2B)	Starting angle	5
LSA(2B)	End angle	7
CS(2B)	Check code	9
Si(2B)	Sample data	$11+2*i$

CRC verification code, please refer to:

```
1 u8 GetCrc8(u8 *ptr, u8 default_crc,u8 poly) {
2   u8 crc = default_crc;
3   u8 i;
4   crc ^= *ptr;
5   for (i = 0; i < 8; i++) { //0x8c
6     if (crc & 0x01) {
7       crc = (crc >> 1) ^ poly;
8     }
9     else {
10      crc >>= 1;
11    }
12  }
13  return crc;
14 }
15 /*****
16 if(*PkgInIndex == 0){ //zero packet, index = 0
17   val_crc8 = 0; // Clear calibration result, set it to 0, start the next round of CT
18   calibration
19 }
20 val_crc8 = GetCrc8(&PtrPKG->CT,val_crc8,0x8C); // verification result is stored in val_crc8
21 *****/
```

FIG 9 CT INFORMATION VERIFICATION REFERENCE CODE

According to this method, the check result is equal to the LastCRC in the initial data packet, it is considered that there is no packet loss phenomenon in the serial port data, and the relevant information is credible, otherwise it is not credible.

Note: The CRC check result is placed at the beginning of the next round of data, that is, before the start packet. Therefore, only the start packet has a CRC check, and the data packet does not carry it.

3.2 Stop Command [A5 65]

When the system is in the scan mode, T-mini Plus always sends point cloud data to the outside. If users 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 off.

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), T-mini Plus will feedback the device's model, firmware version, and hardware version, and the device's factory serial number. The reply message is:

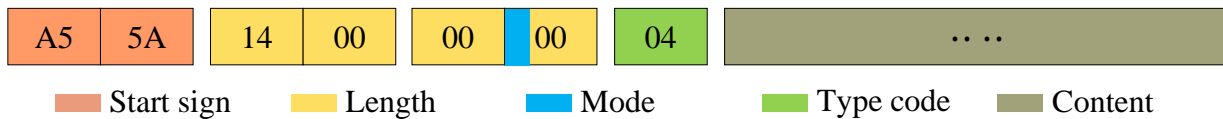


FIG 10 YDLIDAR T-MINI PLUS DEVICE INFORMATION

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 11 YDLIDAR T-MINI PLUS DEVICE INFORMATION RESPONSE CONTENT DATA STRUCTURE

- **Model number:** One byte device model, such as the model code of T-mini Plus is 151;
- **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 T-mini Plus, T-mini Plus will give back the status code of the device. The reply message is:

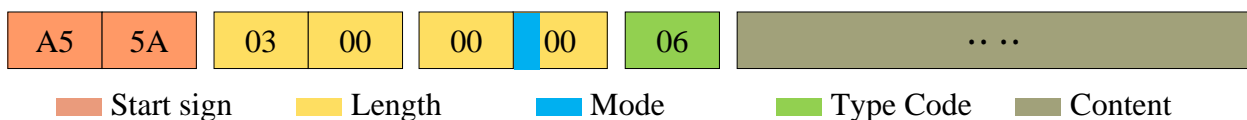


FIG 12 SCHEMATIC DIAGRAM OF YDLIDAR T-MINI PLUS LIDAR EQUIPMENT HEALTH STATUS MESSAGE

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:

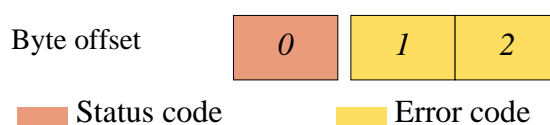


FIG 13 SCHEMATIC DIAGRAM OF DATA STRUCTURE OF HEALTH STATUS RESPONSE CONTENT OF YDLIDAR T-MINI PLUS EQUIPMENT

- **Status code:** 1 byte, each bit of this byte corresponds to the health information of different modules, details as follows:

CHART 9 HEALTH STATUS CODE BIT DESCRIPTION

Bit	Description
Bit0	Sensor status bit, used to judge the state of the image sensor:1 abnormal,0 normal
Bit1	Encode status bit, used to judge the status of the angle detection module:1 abnormal,0 normal
Bit2	WiPwr status bit, used to judge the status of the wireless power supply module:1 abnormal,0 normal
Bit3	PD status bit, used to judge the status of the laser feedback voltage:1 abnormal,0 normal
Bit4	LD status bit, used to judge the state of the laser drive current:1 abnormal,0 normal
Bit5	Data status bit, used to judge whether the lidar data is normal:1 abnormal,0 normal
Bit[6:7]	Reserved status bit

- **Error code:** 2 bytes, when there is a warning or error state, error code will output the abnormal information of the corresponding module.

Note1: When obtaining health information, users only need to pay attention to the status code, not the error code.

Note2: This information can be obtained once at the beginning of power-on, and the real-time health information of the lidar can be obtained by parsing and scanning data packets.

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

T-mini Plus provides multiple command interfaces for scanning frequency settings to increase or decrease the system scan frequency.

CHART 10 SCAN FREQUENCY SETTING COMMAND DESCRIPTION

Commands	Description
0xA509	Increase the current scan frequency of 0.1Hz
0xA50A	Reduce the current scan frequency of 0.1Hz
0xA50B	Increase the current scan frequency of 1Hz
0xA50C	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:

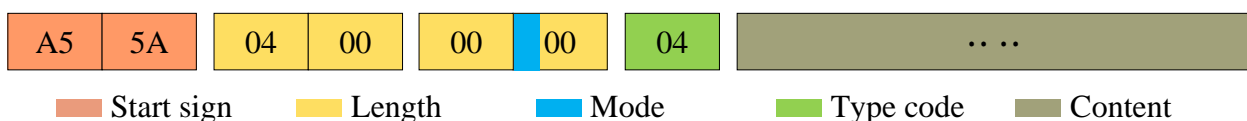


FIG 14 YDLIDAR T-MINI PLUS SCAN FREQUENCY SETTING MESSAGE

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 the external device sends the Get Restart command (A5 40) to T-mini Plus, T-mini Plus will enter a soft restart and the system restarts. There is no response to this command.

4 MOTOR SPEED CONTROL

The T-mini Plus 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.

5 ATTENTION

- 1) During command interaction with T-mini Plus, except for the stop scan command (A5 65), other commands cannot be interacted in scan mode, which may easily lead to message parsing errors.
- 2) T-mini Plus will not rotate when powered on, the user needs to send a command (A5 60) to enter the scan mode, and send A5 65 to stop the scan mode;
- 3) When T-mini Plus is blocked, the laser will be turned off, and the serial port will still output the distance measurement package (the distance in the distance measurement package is 0 at this time, that is, the invalid distance), and output Health information on the index corresponding to the CT (Encode error).
- 4) When T-mini Plus is blocked during scanning and can't find the distance at all, the health information of the point cloud data packet of the serial port will alarm for data abnormalities and other errors.

6 REVISION

Date	Version	Content
2023-12-21	1.0	The 1st release