

G1 DEVELOPMENT MANUAL



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1 WORKING MECHANISM

The YDLIDAR G1(hereinafter referred to as G1) system has 4 working modes: idle mode, scan mode, stop mode, Power-down protection mode.

- **Idle mode:** When G1 is powered on, the default mode is idle mode. In idle mode, the G1's ranging unit does not work and the laser is not light.
- **Scan mode:** When G1 is in scanning mode, the ranging unit turns on the laser. When the G1 starts to work, it continuously samples the external environment and outputs it in real time after background processing.
- **Stop mode:** When G1 runs with an error, such as turning on the scanner, the laser is off, the motor does not rotate, etc. G1 will automatically turn off the distance measuring unit and feedback the error code.
- **Power-down protection mode:** In this mode, Lidar needs to continuously receive the scan commands with a less than 3 second's transmission interval so that it will keep working. If the Lidar does not receive a continuous scan command, the system will automatically stop. This mode is not enabled by default.

1.1 System Workflow

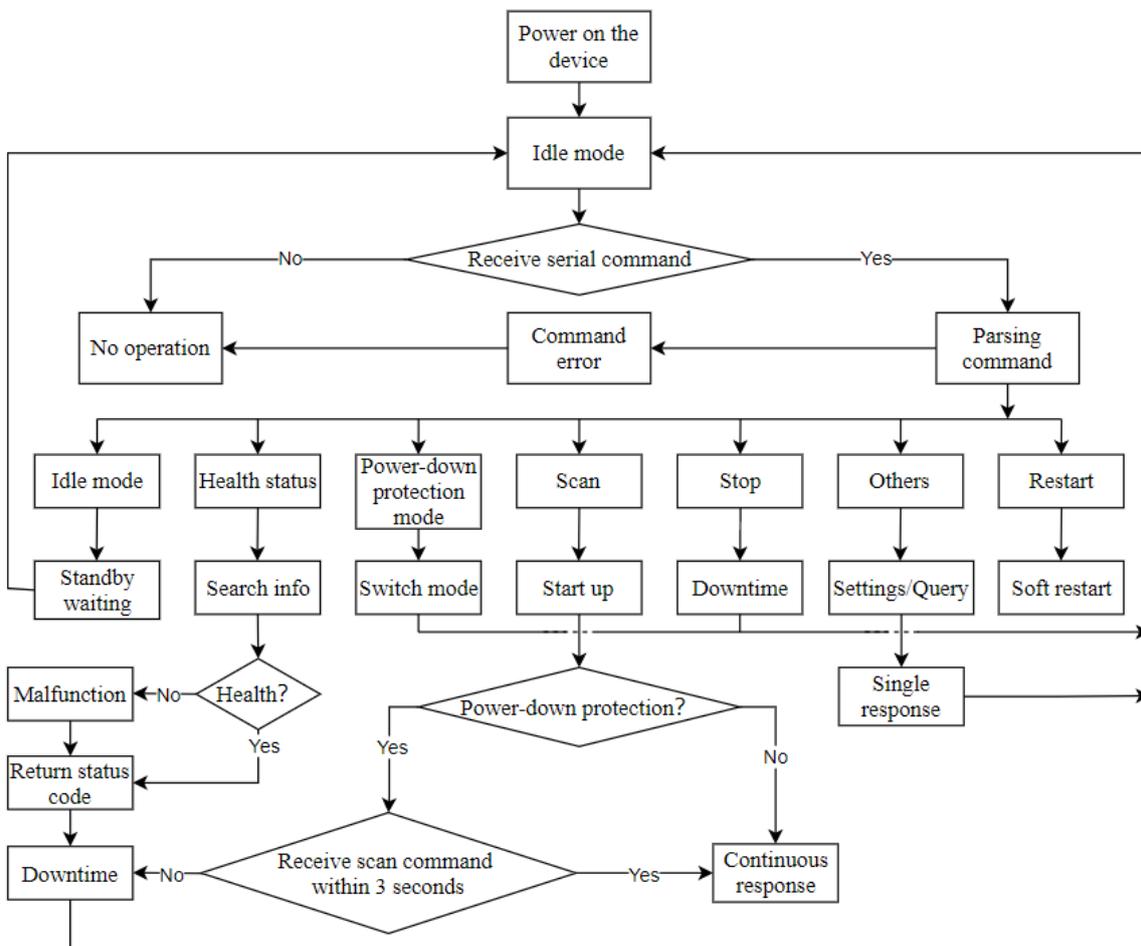


FIG 1 YDLIDAR G1 WORKFLOW

2 SYSTEM COMMUNICATION

2.1 Communication Mechanism

G1 uses the serial port to interact with external devices for commands and data. When an external device sends a system command to G1, G1 resolves the system command and returns a corresponding reply message. According to the command content, G1 switches the corresponding working status. According to the content of the message, the external system can parse the message and obtain the response data.

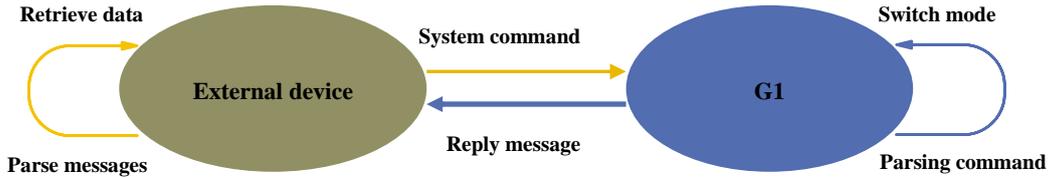


FIG 2 YDLIDAR G1 SYSTEM COMMUNICATION

2.2 System Command

By sending relevant system commands, the external system can set the corresponding working status of G1 and obtain corresponding data. The system commands of G1 consist of two bytes. The first byte is 0xA5 and the second byte is the command content. The system commands issued by G1 are as follows:

CHART 1 YDLIDAR G1 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
	0xD1	Get the currently set ranging frequency	No Single response
	0xD9	Power-down protection mode switch (off by default)	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 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 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 G1 SYSTEM MESSAGE DATA PROTOCOL

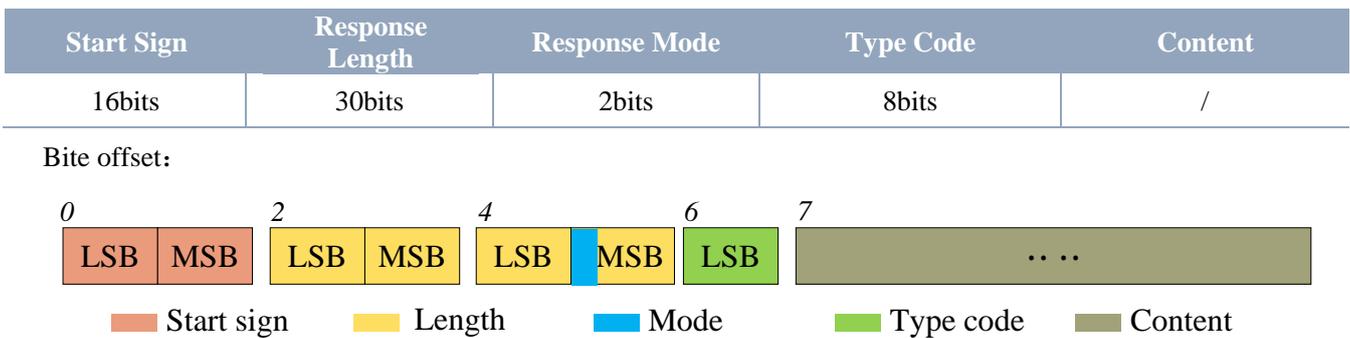


FIG 3 YDLIDAR G1 SYSTEM MESSAGE DATA PROTOCOL

- **Start sign:** G1'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 G1 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 G1 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 G1, G1 goes into scan mode and feeds back point cloud data. The reply message is:

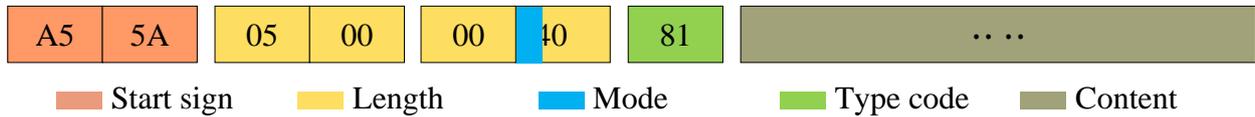


FIG 4 YDLIDAR G1 SCAN COMMAND

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:

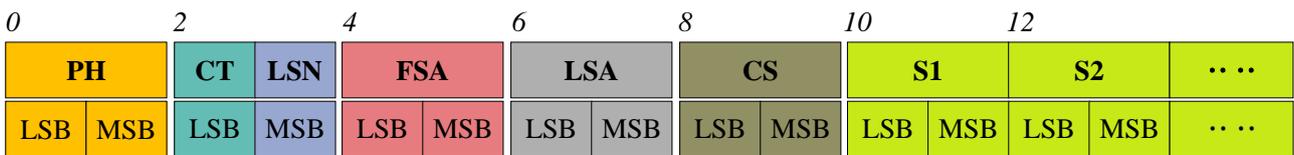


FIG 5 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE

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)	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)] see CT information analysis
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(2B)	Sample data	The sampling data of the system test is the distance data of the sampling point, and the interference flag is also integrated in the LSB of the Si node

➤ **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 reserved bit. When CT[bit0]=1, CT[bit(7:1)] stores the speed information, when CT[bit0]=0, The future version of CT[bit(7 :1)] will be used for other purposes, so in the process of parsing CT, only the starting frame of bit(0) is required to be judged.

➤ **Speed analysis**

The data protocol of G1 carries the speed. When CT[bit0]=1, the speed information is stored in CT[bit(7:1)]:

$$\text{When CT[bit0]=1, } F = \frac{Rshiftbit (CT,1)}{10}$$

➤ **Interference identification flag**

G1 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 G1 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.

➤ **Distance analysis**

Distance solution formula:

$$\text{Distance}_i = Di[5: 0] + Di[13: 6] * 64 \quad \text{The unit is mm.}$$

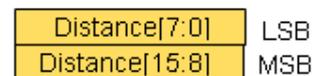


FIG 6 S NODE DATA

Among them, D_i is the first and second byte data of the sampled data S_i . Set the sampling data as E4 6F. Since the system is in little-endian mode, the sampling point $D = 0x6FE4$ is substituted into the Distance solution formula to obtain the Distance=7161mm.

At the same time, $IS = \text{bitand}(0xE4, 3) = 0$, so the signal at this sampling point has no interference. Among them, bitand is Bitwise AND operation.

➤ **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. There are two levels of angle analysis: first-level analysis and second-level analysis. The first-level analysis obtains the initial value of the angle, and the second-level analysis corrects the initial value of the angle. The specific process is as follows:

First-level analysis:

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

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



FIG 7 ANGLE DATA STRUCTURE SCHEMATIC

Intermediate angle solution formula:

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

$\text{Rshiftbit}(data, 1)$ means shifting the data to the right by one bit. $\text{diff}(Angle)$ 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.

Second-level analysis:

Angle correction formula: $Angle_i = Angle_i + \text{AngCorrect}_i \quad (i = 1,2, \dots, LSN)$

Among them, AngCorrect is the angle correction value, and its calculation formula is as follows, tand^{-1} is the inverse trigonometric function, and the angle value is returned:

IF $Distance_i == 0$ $\text{AngCorrect}_i = 0$

ELSE $\text{AngCorrect}_i = \text{tand}^{-1}\left(21.8 * \frac{155.3 - Distance_i}{155.3 * Distance_i}\right)$

Assuming that the 4th to 8th bytes in the data packet are 28 E5 6F BD 79, so $LSN = 0x28 = 40(\text{dec})$, $FSA = 0x6FE5$, $LSA = 0x79BD$, and the first-level solution formula is brought into:

$$Angle_{FSA} = 223.78^\circ, Angle_{LSA} = 243.47^\circ, \text{diff}(Angle) = 19.69^\circ$$

$$Angle_i = \frac{19.69^\circ}{39} * (i - 1) + 223.78^\circ \quad (i = 2,3, \dots, 39)$$

Assuming that in this frame of data, Distance₁ = 1000, Distance_{LSN} = 8000, and the second-level calculation formula is brought into it, we get:

$$AngCorrect_1 = -6.7622^\circ, AngCorrect_{LSN} = -7.8374^\circ, \text{ so:}$$

$$Angle_{FSA} = Angle_1 + AngCorrect_1 = 217.0178^\circ$$

$$Angle_{LSA} = Angle_{LSA} + AngCorrect_{LSA} = 235.6326^\circ$$

In the same way, Angle_i (i = 2,3, ..., LSN - 1) can be obtained in turn.

➤ **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:

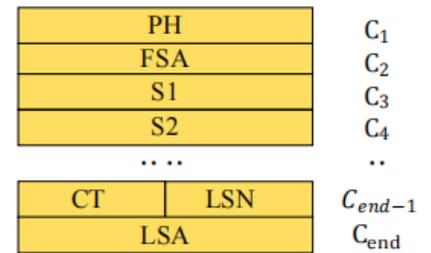


FIG 8 CS XOR SEQUENCE

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

XOR₁^{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.

➤ **CT information analysis**

Since a circle of point cloud is composed of an initial data packet and multiple point cloud data packets, in the G1 data protocol, the CT[bit(7:1)] of these data packets carries different information in each circle.

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

CHART 5 DESCRIPTION OF CT CARRYING INFORMATION

Index	G1
0(Zero pack)	CT = (Freq*10) <<1
1	CT = (CusVerMajor<<6)+(CusVerMinor<<1)
2	CT = Production debugging information
3	CT = Health<<1
Subsequent index	CT = Production debugging information

Thereinto:

Freq: scanning frequency (Hz)

CusVerMajor: user major version

CusVerMinor: user minor version

CusVersion = Major. Minor, this information is used to make lidar version compatibility

Health: Health information, where each bit of Health corresponds to the health status of different modules, as follows:

```
1 typedef enum{
2   SensorHealth=0,          //bit0: sensor abnormal, when bit0=1, sensor sampling signal is abnormal
3   EncodeHealth,          //bit1: Encode abnormal, when bit1=1, lidar cannot rotate or the angle
                           jumps
4   REFHealth,             //bit2: Pwr abnormal, when bit2=1, weak wireless power supply voltage
5   PDHealth,              //bit3: PD abnormal, when bit3=1, the laser is burned out or short-
                           circuited
6   LDHealth,              //bit4: LD abnormal, when bit4=1, abnormal laser power
7   DataHealth,           //bit5: data abnormal, when bit5=1, there is no effective point in the
                           lidar scanning circle, and it is blocked
8   HealthStatue_Tail     //bit6: reserve
9 }HealthStatue_Enum;
```

FIG 9 INFORMATION DESCRIPTION OF HEALTH BIT AND CORRESPONDING MODULES

Note1: When the Health existence 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.

Production debugging information

A considerable part of the CT bytes store more debugging information, this part of information stores some related parameters of the lidar, such as working mode, corresponding code disc information, ranging mode, etc.

Since this part of information only relates to production debugging, this information is temporarily not open, and users can use it as a reserved place.

➤ 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, G1 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 6 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: $Freq \lll 1 + 1$	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 calibration
18 }
19 val_crc8 = GetCrc8(&PtrPKG->CT, val_crc8, 0x8C); // verification result is stored in val_crc8
20 *****/

```

FIG 10 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.

3.2 Stop Command [A5 65]

When the system is in the scan mode, G1 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 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), G1 will feedback the device's model, firmware version, and hardware version, and the device's factory serial number. The reply message is:

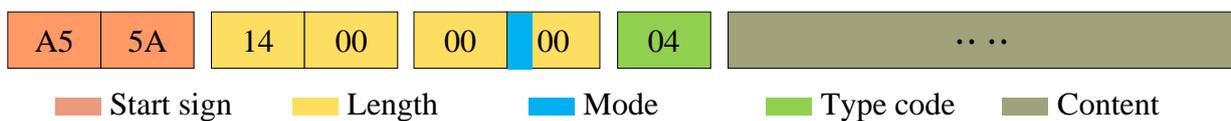


FIG 11 YDLIDAR G1 DEVICE INFORMATION

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 12 YDLIDAR G1 DEVICE INFORMATION RESPONSE CONTENT DATA STRUCTURE

- **Model number:** One byte device model, such as the model code of G1 is 19;
- **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 G1, G1 will give back the status code of the device. The reply message is:

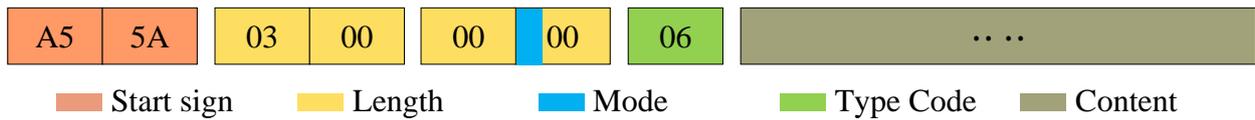


FIG 13 SCHEMATIC DIAGRAM OF YDLIDAR G1 LIDAR EQUIPMENT HEALTH STATUS MESSAGE

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:

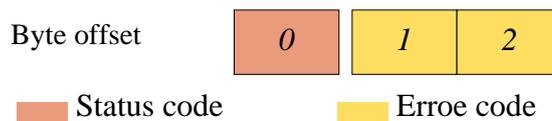


FIG 14 SCHEMATIC DIAGRAM OF DATA STRUCTURE OF HEALTH STATUS RESPONSE CONTENT OF YDLIDAR G1 EQUIPMENT

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

CHART 7 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.

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

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

G1 provides multiple command interfaces for scanning frequency settings to increase or decrease the system scan frequency.

CHART 8 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:

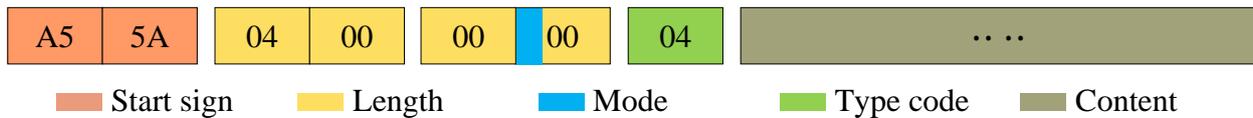


FIG 15 YDLIDAR G1 SCAN FREQUENCY SETTING MESSAGE

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 Ranging Frequency Acquisition [A5 D1]

This command is used to obtain the ranging frequency of the system. The message structure and response content of this command are as follows:

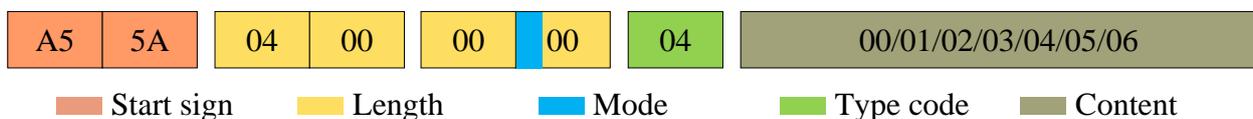


FIG 16 YDLIDAR G1 RANGING FREQUENCY SETTING MESSAGE

According to the protocol analysis: response length = 0x00000001, response mode = 0x0, type code = 0x04.

That is, the number of bytes in the response content is 1; this response is a single response, and the type code is 04. The response content of this command corresponds to the system ranging frequency, as follows:

CHART 9 RANGING FREQUENCY SETTING RESPONSE CONTENT DESCRIPTION

Response Content	0x00	0x01	0x02	0x03	0x04	0x05	0x06
Ranging frequency (KHz)	4	5	8	9	10	16	18

3.8 Power-down Protection Switching [A5 D9]

If the lidar power supply and external equipment is not a shared power supply system, please turn on the power-down protection mode to protect the Lidar.

Under this model, the scan command needs to be sent continuously and the transmission interval should be less than 3s. If the command is sent interrupted or the transmission interval is too long, the system will judge that the control terminal has been powered down, which will trigger the power failure protection and stop the Lidar. This command is a switch command. The message of the command is as follows:

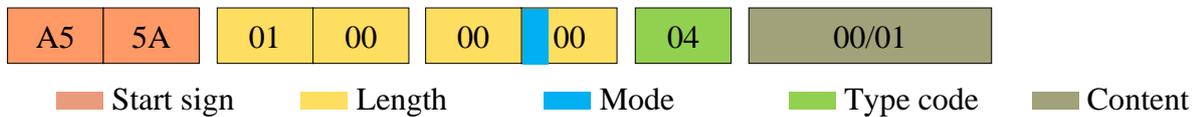


FIG 17 YDLIDAR G1 POWER-DOWNPROTECTIONMESSAGE

According to the protocol resolution: response length = 0x00000001, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 1. This response is a single response and the type code is 04.

The response content of the command corresponds to the power-on protection mode being turned on and off, 00 means that the power-down protection is enabled, and 01 means that the power-down protection is turned off.

Note: In the power-down protection mode, the message structure of the scan command changes slightly. Only when the scan command is sent for the first time in the stop state, there will be a complete message structure. There is no start flag in the subsequent scan command. The response length, response mode, and type code are only the response content.

3.9 Restart Command [A5 40]

When an external device sends a restart device command (A5 40) to G1, G1 enters a soft reboot and the system restarts. This command does not answer.

3.10 Motor Speed Control

The G1 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

During command interaction with G1, Except for the stop command (A5 65), other commands cannot be interacted in the scan mode, which may easily lead to message parsing errors.

5 REVISE

Date	Version	Content
2019-12-03	1.0	Compose a first draft
2021-07-22	1.1	Modify data protocol