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YDLIDAR GS5 DEVELOPMENT MANUAL

www.ydlidar.com

Shenzhen EAI Technology Co.,Ltd.

CONTENTS

1 WORKING MECHANISM

1.1 Mode

The YDLIDAR GS5(hereinafter referred to as GS5) system has 2 working modes: idle mode, scan mode.

- **Idle mode:** When GS5 is powered on, the default mode is idle mode. In idle mode, the GS5's ranging unit does not work and the laser is not light.
- **Scan mode:** When GS5 is in scanning mode, the ranging unit turns on the laser. When the GS5 starts to work, it continuously samples the external environment and outputs it in real time after background processing.

1.2 Measuring Principle

GS5 is a short-range solid-state lidar with a range of 50-1000mm. It is mainly composed of a line laser and a camera. After the one-line laser emits the laser light, it is captured by the camera. According to the fixed structure of the laser and the camera, combined with the principle of triangulation distance measurement, we can calculate the distance from the object to the GS5. According to the calibrated parameters of the camera, the angle value of the measured object in the lidar coordinate system can be known. As a result, we have obtained the complete measurement data of the measured object.

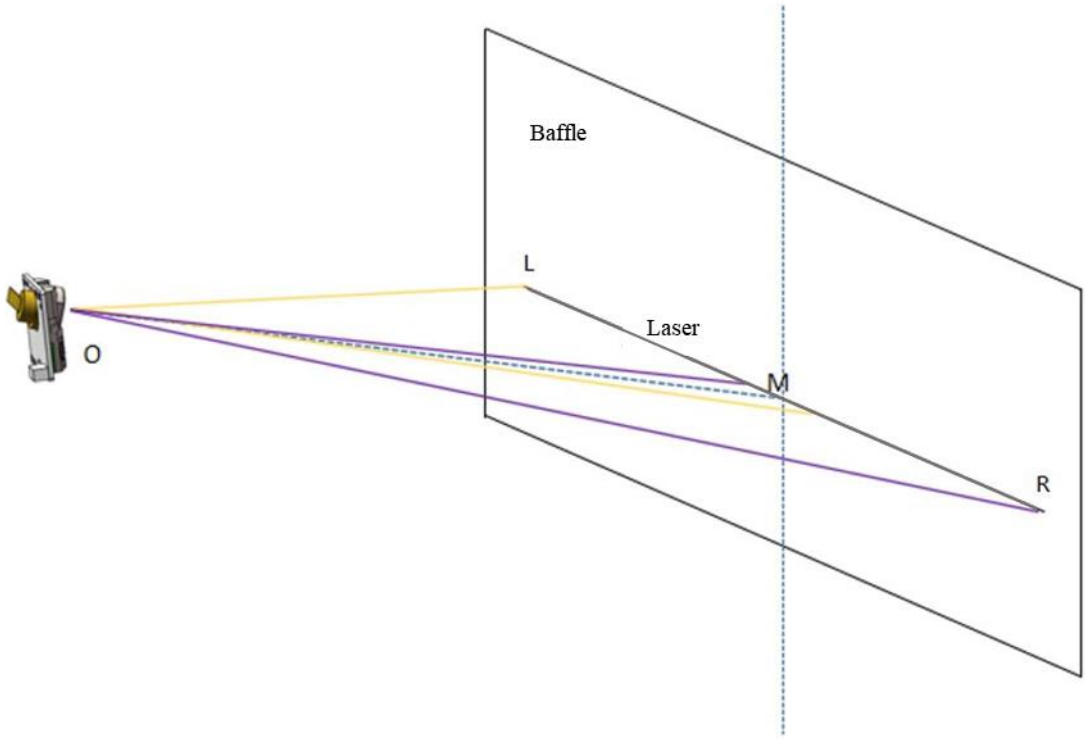


FIG 1 YDLIDAR GS5 MEASUREMENT DIAGRAM

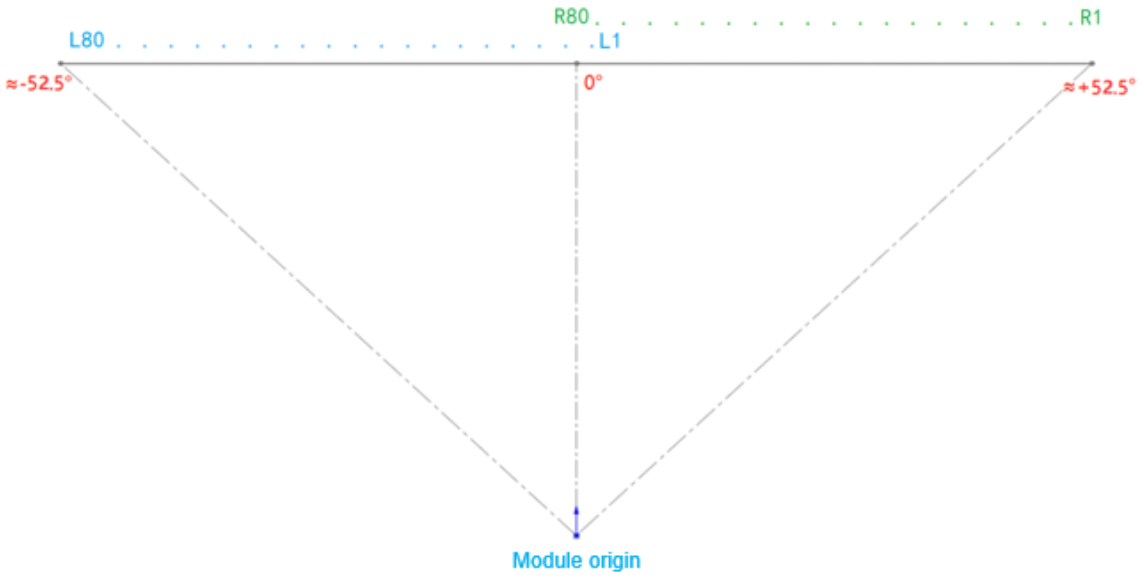


FIG 2 YDLIDAR GS5 OUTPUT POINT CLOUD ANGLE DIAGRAM

With the mod punctuation as the coordinate origin, the front is the direction of the coordinate system 0 degree, and the angle increases clockwise. The Angle and distance calculated by the SDK are all represented in the coordinate system clockwise.

2 SYSTEM COMMUNICATION

2.1 Communication Mechanism

GS5 communicates commands and data with external devices through the serial port. When an external device sends a system command to GS5, GS5 resolves the system command and returns a corresponding reply message. According to the command content, GS5 switches the corresponding working status. Base on the content of the message, the external system can parse the message and obtain the response data.

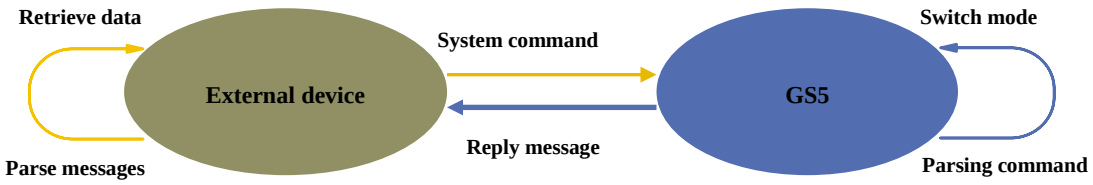


FIG 3 YDLIDAR GS5 SYSTEM COMMUNICATION

2.2 System Command

The external system can set the corresponding working status of GS5 and send corresponding data by sending related system commands. The system commands issued by GS5 are as follows:

CHART 1 YDLIDAR GS5 SYSTEM COMMAND

System command	Description	Mode switching	Answer mode
0x60	Obtaining the Device Address	Stop mode	Single response
0x61	Obtaining device parameters	Stop mode	Single response
0x62	Obtaining version Information	Stop mode	Single response
0x63	Start scanning and output point cloud data	Scan mode	Continuous response
0x64	Stop device, stop scanning	Stop mode	Single response
0x67	Soft restart	/	Single response
0x68	Set the serial port baud rate	Stop mode	Single response
0x69	Set the edge mode (anti-noise mode)	Stop mode	Single response

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. Continuous 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: packet header, device address, packet type, data length, data segment and check code, and are output through the serial port hexadecimal system.

CHART 2 YDLIDAR GS5 SYSTEM MESSAGE DATA PROTOCOL

Packet header	Device address	Packet type	Response length	Data segment	Check code
4 Bytes	1 Byte	1 Byte	2 Bytes	N Bytes	1 Byte

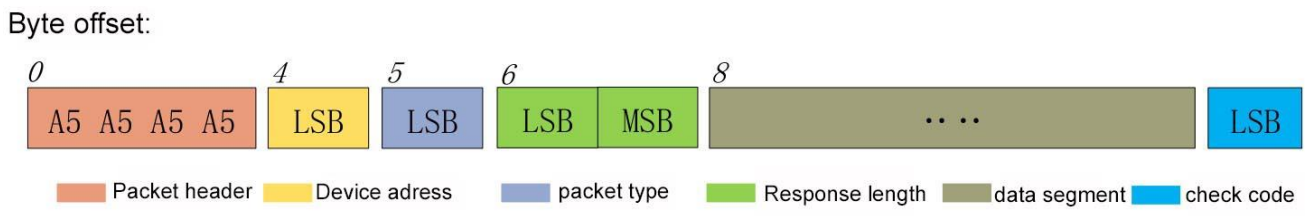


FIG 4 YDLIDAR GS5 SCHEMATIC DIAGRAM OF SYSTEM MESSAGE DATA PROTOCOL

- **Packet header:** The message packet header for GS5 is marked 0xA5A5A5A5.
- **Device address:** The reserved bit is the device address of the GS5, which is currently fixed as 0x01, 0x02, 0x04;
- **Packet type:** See chart 1 for the types of system commands.
- **Response length:** Represents the length of the response

- **Data segment:** Different system commands respond to different data content, and their data protocols are different.
- **Check code:** check code.

Note: The GS5 data communication adopts the small-endian mode, low order first.

3 DATA PROTOCOL

3.1 Obtain the Device Address Command

When an external device sends this command to GS5, GS5 returns a device address packet, the message is:

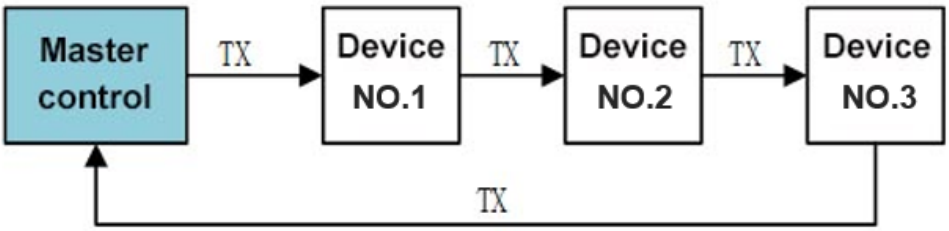
Command sending:

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	0x00	0x60	0x00	0x00	0x60

Command reception:

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	0x0*	0x60	0x00	0x00	LSB

In cascading, if N devices (up to 3 supported) are threaded, the command returns N answers at 0x01, 0x02, 0x04, corresponding to 1-3 modules respectively.



Definition: The address of module 1 is 0x01, module 2 is 0x02, and module 3 is 0x04.

3.2 Obtain version information Command

When an external device sends this command to GS5, GS5 will return its device parameters, and the message is:

Command sending:

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	0x00	0x62	0x00	0x00	0x62

Command reception:

Packet header				Adress	Command type	Data length		Data segment		Check code
0xA5	0xA5	0xA5	0xA5	0x0*	0x62	0x13	0x00	Version Number	SN Number	LSB

In the case of cascading, if N (maximum 3) devices are connected in series, this command will return N responses, where the address is the address of the last device.

The version number is 3 bytes length, and the SN number is 16 bytes length.

3.3 Obtain Device Parameter Command

When an external device sends this command to GS5, GS5 will return its device parameters, and the message is:

Command sending:

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	0x00	0x61	0x00	0x00	0x61

Command reception:

Packet header				Adress	Command type	Data length		Data segment	Check code
0xA5	0xA5	0xA5	0xA5	0x0*	0x61	0x09	0x00	Device parameters	LSB

The data segment includes the parameters of the corresponding devices, which are distributed as follows:

K0		B0		K1		B1		Bias
LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB

In cascading, if N devices (up to 3 supported) are threaded, the command returns N answers, corresponding to the parameters of each device.

The K and B received by the protocol are of uint16 type, which need to be converted to float type and then divided by 10000 before being substituted into the calculation function.

d_compensateK0 = (float)K0/10000.0f；

d_compensateB0 = (float)B0/10000.0f；

d_compensateK1 = (float)K1/10000.0f；

d_compensateB1 = (float)B1/10000.0f；

Bias is of type int8, which needs to be converted to float type and divided by 10 before substituting into the calculation function.

bias = (float)Bias /10.

3.4 Scan Command

When an external device sends this command to GS5, GS5 will return its device parameters, and the message is:

Command sending: (Send address 0x00, cascade or not, will start all devices)

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	0x00	0x63	0x00	0x00	0x63

Command reception: (In cascading cases, this command only returns one response, and the address is the largest address, for example: No.3 device are cascaded, and the address is 0x04.)

Packet header				Adress	Command type	Data length		Data segment	Check code
0xA5	0xA5	0xA5	0xA5	0x0*	0x61	0x09	0x00	Device parameters	LSB

Next, GS2 continuously outputs the point cloud data series, with the following frame structure:

Packet header				Adress	Command type	Data length		Data segment	Check code
0xA5	0xA5	0xA5	0xA5	0x0*	0x63	0x42	0x01	Point cloud data	LSB

The data segment is the point cloud data scanned by the system, which is sent to the serial port in hexadecimal to the external device according to the following data structure. The data length of the whole packet is 322 Bytes, including 2 Bytes of environmental data and 160 ranging points (S1-S160), each of which is 2 Bytes, the upper 5 bits are intensity data, and the lower 11 bits are distance data. The unit is mm.

ENV		S1		S2		·· ··	S160	
LSB	MSB	LSB	MSB	LSB	MSB	·· ··	LSB	MSB

FIG 5 SCHEMATIC DIAGRAM OF THE DATA STRUCTURE OF THE SCAN COMMAND RESPONSE CONTENT

3.5 Stop Command

When the system is in the scanning state, GS5 has been sending point cloud data to the outside world. To disable the scanning at this time, send this command to stop the scanning. After sending the stop command, the module will reply to the response command, and the system will enter the standby sleep state immediately. At this time, the ranging unit of the device is in low power consumption mode, and the laser is turned off.

Command sending: (send address 0x00, no matter whether cascading or not, all devices will be closed).

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	0x00	0x64	0x00	0x00	0x64

Command reception:

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	0x0*	0x64	0x00	0x00	LSB

In the case of cascading, if N (maximum 3) devices are connected in series, this command will only return a response, where the address is the address of the last device, for example: if 3 devices are cascaded, the address is 0x04.

3.6 Set The Baud Rate Command

When the external device sends this command to GS5, the output baud rate of GS5 can be set.

Command sending: (sending address 0x00, only supports setting the baud rate of all cascaded devices to be the same), the message is:

Packet header				Adress	Command type	Data length		Data segment	Check code
0xA5	0xA5	0xA5	0xA5	0x00	0x68	0x01	0x00	baud rate (1 Bytes)	LSB

Command reception:

Packet header				Adress	Command type	Data length		Data segment	Check code
0xA5	0xA5	0xA5	0xA5	0x0*	0x68	0x01	0x00	baud rate (1 Bytes)	LSB

Among them, the data segment is the baud rate parameter, including four baud rates (bps), respectively: 230400, 512000, 921600, 1500000 corresponding to code 0-3 (note: the three-module serial connection must be ⩾921600, the default is 921600).

In the case of cascading, if N devices (maximum support 3) devices are connected in series, the command will return N responses, corresponding to the parameters of each device, and the addresses are: 0x01, 0x02, 0x04.

After setting the baud rate, need to soft restart the device.

3.7 System Reset Command

When an external device sends this command to GS5, GS5 will enter a soft restart, and the system will reset and restart.

Command sending: (sending address, can only be the exact concatenated address: 0x01/0x02/0x04)

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	Address	0x67	0x00	0x00	LSB

Command reception:

Packet header				Address	Command type	Data length		Check code
0xA5	0xA5	0xA5	0xA5	Address	0x67	0x00	0x00	LSB

Address is the address of the module that needs to be configured in the cascade link.

Reset module 1: Address =0x01

Reset module 2: Address =0x02

Reset module 3: Address =0x04

4 DATA ANALYSIS

CHART 3 DATA STRUCTURE DESCRIPTION

Content	Name	Description
K0(2B)	Device parameters	(uint16) The left camera angle parameter k0 coefficient (see section 3.3)
B0(2B)	Device parameters	(uint16) The left camera angle parameter b0 coefficient (see section 3.3)
K1(2B)	Device parameters	(uint16) The right camera angle parameter k1 coefficient (see section 3.3)
B1(2B)	Device parameters	(uint16) The right camera angle parameter b1 coefficient (see section 3.3)
BIAS	Device parameters	(int8) The current camera angle parameter bias coefficient (see section 3.3)
ENV(2B)	Environment data	Ambient light intensity
Si(2B)	Distance measurement data	The lower 9 bits are the distance, the upper 7 bits are the intensity value

- **Distance analysis**

Distance calculation formula: $\text{Distance}_i = (Si\_MSB \ll 8 | Si\_LSB)$ &0x01ff, unit is mm.

Strength calculation: $\text{Quality}_i = Si\_MSB \gg 1$

- **Angle analysis**

The direction of laser emission is taken as the front of the sensor, the projection of the laser circle center on the PCB plane is taken as the origin of the coordinates, and the polar coordinate system is

established with the normal line of the PCB plane as the 0-degree direction. Following the clockwise direction, the angle gradually increases.

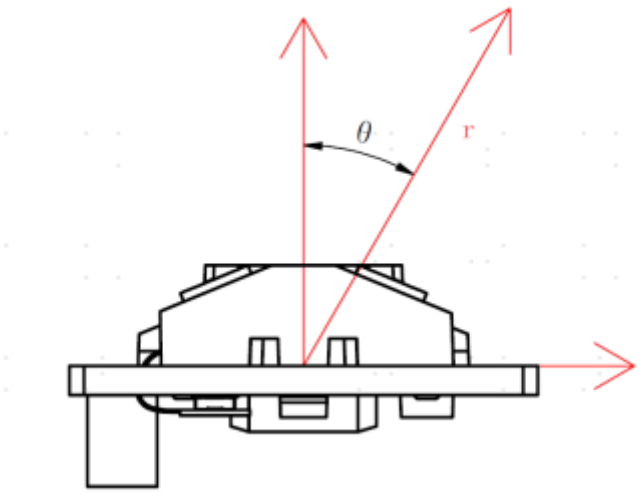


FIG 6 YDLIDAR GS5 COORDINATE SYSTEM DIAGRAM (TOP VIEW OF GS5)

To convert the original data transmitted by the Lidar to the coordinate system in the above figure, a series of calculations are required. The conversion function is as follows (for details, please refer to the SDK):

```
double pixelU = n, Dist, theta, tempTheta, tempDist, tempX, tempY;
if (n < 80)// Differentiate left and right camera data
{
pixelU = 80 - pixelU;
if (d_compensateB0 > 1) {
tempTheta = d_compensateK0 * pixelU - d_compensateB0;
}
else
{
tempTheta = atan(d_compensateK0 * pixelU - d_compensateB0) * 180 / M_PI;
}
tempDist = (dist - angle_p_x) / cos((angle_p_angle + bias - (tempTheta)) * M_PI / 180);
tempTheta = tempTheta * M_PI / 180;
tempX = cos((angle_p_angle + bias) * M_PI / 180) * tempDist * cos(tempTheta) +
sin((angle_p_angle + bias) *  M_PI / 180) * (tempDist * sin(tempTheta));
tempY = -sin((angle_p_angle + bias) * M_PI / 180) * tempDist * cos(tempTheta) +
cos((angle_p_angle + bias) *  M_PI / 180) * (tempDist * sin(tempTheta));
tempX = tempX + angle_p_x;
tempY = tempY - angle_p_y;
Dist = sqrt(tempX * tempX + tempY * tempY);
theta = atan(tempY / tempX) * 180 / M_PI;
}
else
{
pixelU = 160 - pixelU;
if (d_compensateB1 > 1)
{
tempTheta = d_compensateK1 * pixelU - d_compensateB1;
```

```
}
else
{
tempTheta = atan(d_compensateK1 * pixelU - d_compensateB1) * 180 / M_PI;
}
tempDist = (dist - angle_p_x) / cos((angle_p_angle + bias + (tempTheta)) * M_PI / 180);
tempTheta = tempTheta * M_PI / 180;
tempX = cos(-(angle_p_angle + bias) * M_PI / 180) * tempDist * cos(tempTheta) + sin(-
(angle_p_angle + bias)        * M_PI / 180) * (tempDist * sin(tempTheta));
tempY = -sin(-(angle_p_angle + bias) * M_PI / 180) * tempDist * cos(tempTheta) + cos(-
(angle_p_angle + bias)        * M_PI / 180) * (tempDist * sin(tempTheta));
tempX = tempX + angle_p_x;
tempY = tempY + angle_p_y;
Dist = sqrt(tempX * tempX + tempY * tempY);
theta = atan(tempY / tempX) * 180 / M_PI;
}
if (theta < 0)
{
theta += 360;
}
*dstTheta = theta;
*dstDist = Dist;
```

- **Check code analysis**

The check code uses single-byte accumulation to check the current data packet. The four-byte packet header and check code itself do not participate in the check operation. The check code solution formula is:

$$\text{CheckSum} = \text{ADD}_1^{end}(C_i) \qquad i = 1,2,\dots,end$$

ADD_1^{end} is the cumulative formula, it means to accumulate the numbers from subscript 1 to end in the element.

Device adress	C_1
Command type	C_2
Data length LSB	C_3
Data length MSB	C_4
Data segment LSB 0	C_5
Data segment LSB 1	C_6
…	…
Data segment MSB N	C_end

FIG 7 CHECKSUM DIAGRAM

5 OTA UPGRADE

5.1 Upgrade Workflow

Cascading upgrade prerequisites: all three modules have been assigned address using the 0x60 to avoid address conflicts that cause the upgrade to fail.
Note: During the upgrade process, each command receives a reply. The user needs to confirm the reply message and its meaning before proceeding to the next step.

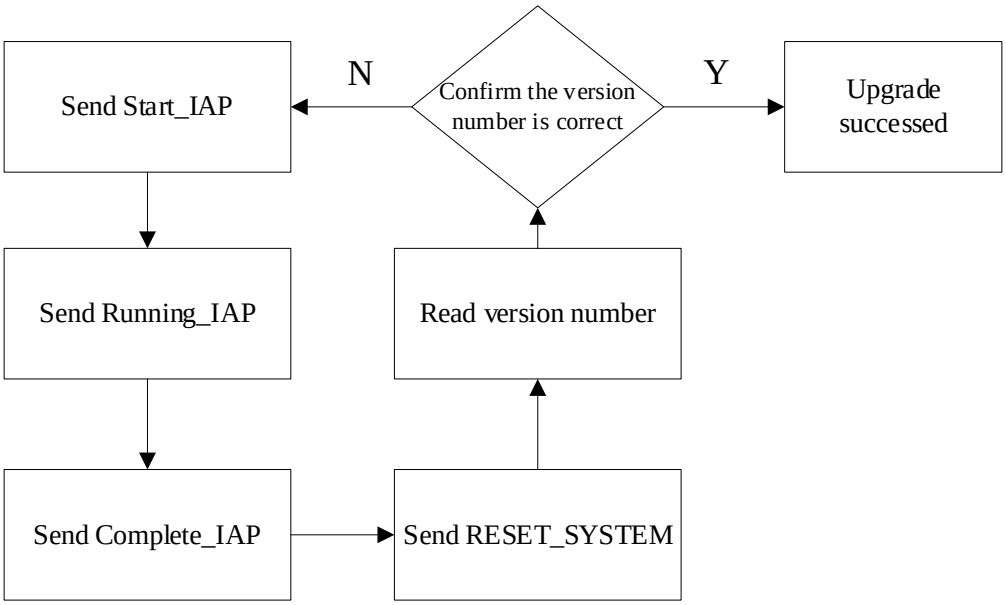


FIG 8 UPGRADE WORKFLOW

5.2 Send Protocol

CHART 4 OTA DATA PROTOCOL FORMAT (SMALL ENDIAN)

Parameter	Length (BYTE)	Description
Packet_Header	4	Data packet header, fixed as A5A5A5A5
Device_Address	1	Specifies the address of the device
Pack_ID	1	Data packet ID (data type)
Data_Len	2	Data length of data segment, 0-82
Data	n	Data, n = Data_Len
Check_Sum	1	Checksum, the checksum of the remaining bytes after the header is removed

Packet_Header				Address	Pack_ID	Data_Len		Data	Check_Sum
0xA5	0xA5	0xA5	0xA5	LSB	LSB	LSB	MSB	n Bytes	LSB

CHART 5 OTA UPGRADE INSTRUCTIONS

Instruction type	Pack_ID	Description
Start_IAP	0x0A	Send this command to start IAP after power on
Running_IAP	0x0B	Run IAP, transmit packets
Complete_IAP	0x0C	End of IAP
ACK_IAP	0x20	IAP reply
RESET_SYSTEM	0x67	Reset and restart the module at the specified address

5.3 Start_IAP Instruction

Command sending:

Packet_Header				Address	Pack_ID	Data_Len		Data	Check_Sum
0xA5	0xA5	0xA5	0xA5	LSB	0x0A	0x12	0x00	18 Bytes	LSB

Data segment Data format:

Data[0~1]: The default is 0x00;

DATA[2~17]: It is a fixed character verification code:

0x73 0x74 0x61 0x72 0x74 0x20 0x64 0x6F 0x77 0x6E 0x6C 0x6F 0x61 0x64 0x00 0x00

Refer to sending message:

A5 A5 A5 A5 01 0A 12 00 00 00 73 74 61 72 74 20 64 6F 77 6E 6C 6F 61 64 00 00 C3

Command reception: （Due to FLASH sector operations, the return delay is long and fluctuates between 80ms and 700ms)

Packet_Header				Address	ACK	Data_Len		Data	Check_Sum
0xA5	0xA5	0xA5	0xA5	LSB	0x20	0x04	0x00	4 Bytes	LSB

Receive data format:

Address: the module address;

ACK: The default is 0x20, indicating that the data packet is an acknowledgment packet;

Data[0~1]: The default is 0x00;

Data[2]: 0x0A indicates that the response command is 0x0A;

Data[3]: 0x01 indicates normal reception, 0 indicates abnormal reception;

Reference to receive:

A5 A5 A5 A5 01 20 04 00 00 00 0A 01 30

5.4 Running_IAP Instruction

Command sending:

Packet_Header				Address	Pack_ID	Data_Len		Data	Check_Sum
0xA5	0xA5	0xA5	0xA5	LSB	0x0B	0x52	0x00	82 Bytes	LSB

The firmware will be split during the upgrade, and the first two bytes of the data segment (Data) indicate the offset of this segment of data relative to the first byte of the firmware.

Data segment format:

Package_Shift		String verification code	Firmware data
Data[0]	Data[1]	Data[2]~Data[17]	Data[18]~Data[81]

Data[0~1]: Package_Shift = Data[0]+ Data[1]*256；

Data[2]~Data[17]: is a fixed string verification code:

0x64 0x6F 0x77 0x6E 0x6C 0x6F 0x61 0x64 0x69 0x6E 0x67 0x00 0x00 0x00 0x00 0x00

Data[18]~Data[81]: firmware data；

Refer to sending message:

A5 A5 A5 A5 01 0B 52 00 00 00 64 6F 77 6E 6C 6F 61 64 69 6E 67 00 00 00 00 00 + (Data[18]~Data[81]) + Check_Sum

Command reception:

Packet_Header				Address	ACK	Data_Len		Data	Check_Sum
0xA5	0xA5	0xA5	0xA5	LSB	0x20	0x04	0x00	4 Bytes	LSB

Receive data format:

Address: is the module address;

ACK: The default is 0x20, indicating that the data packet is an acknowledgment packet;

Data[0~1] : Package_Shift = Data[0]+ Data[1]*256 indicates the firmware data offset of the response. It is recommended to judge the offset as a protection mechanism when detecting the response during the upgrade process.

Data[2]=0x0B indicates that the response command is 0x0B;

Data[3]=0x01 indicates normal reception, 0 indicates abnormal reception;

Reference to receive:

A5 A5 A5 A5 01 20 04 00 00 00 0B 01 31

5.5 Complete_IAP Instruction

Command sending:

Packet_Header				Address	Pack_ID	Data_Len		Data	Check_Sum
0xA5	0xA5	0xA5	0xA5	LSB	0x0C	0x16	0x00	22 Bytes	LSB

Data segment format:

Default	String verification code	encryption flag
Data[0]~Data[1]	Data[2]~Data[17]	Data[18]~Data[21]

Data[0~1]: The default is 0x00;

Data[2]~Data[17]: It is a fixed string verification code:

0x63 0x6F 0x6D 0x70 0x6C 0x65 0x74 0x65 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00

Data[18]~Data[21]: encryption flag, uint32_t type, encrypted firmware is 1, non-encrypted firmware is 0;

Refer to sending message:

A5 A5 A5 A5 01 0C 16 00 00 00 63 6F 6D 70 6C 65 74 65 00 00 00 00 00 00 00 00 + (uint32_t encryption flag) + Check_Sum

Command reception:

Packet_Header				Address	ACK	Data_Len		Data	Check_Sum
0xA5	0xA5	0xA5	0xA5	LSB	0x20	0x04	0x00	4 Bytes	LSB

Receive data format:

Address: is the module address;

ACK: The default is 0x20, indicating that the data packet is an acknowledgment packet;

Data[0~1]: The default is 0x00;

Data[2]: 0x0C indicates that the response command is 0x0C;

Data[3]: 0x01 indicates normal reception, 0 indicates abnormal reception;

Refer to the received message:

A5 A5 A5 A5 01 20 04 00 00 00 0C 01 32

5.6 RESET_SYSTEM Instruction

Please refer to Chapter 3.8 System Reset Command for details.

5.7 OTA Upgrade Q&A

1) Q: How to judge the reset is successful after sending the reset command? Whether delay is required?
   A: The successful execution can be judged according to the response packet of the reset command; it is recommended to add a 500ms delay after receiving the response before performing subsequent operations.
2) Q: What is the possible reason for the abnormal upgrade function in the cascade state?
   A: ①Confirm whether the physical link is correct, such as whether the point cloud data of the three modules can be received; ②Confirm that the addresses of the three modules do not conflict, and you can try to reassign the addresses; ③Reset the module to be upgraded and then restart the try;
3) Q: How to deal with if the upgrade process is interrupted by a power failure and restart?
   A: Re-send the Start_IAP command to re-upgrade.
4) Q: Why is the read version number 0 after the cascade upgrade?
   A: It means that the module upgrade is unsuccessful, users need to reset the module and then upgrade again.

6 ATTENTION

1) During command interaction with GS5, except for the stop scan command, other commands cannot be interacted in scan mode, which may easily lead to message parsing errors.
2) GS5 will not automatically start ranging when power on. It needs to send a start scan command to enter the scan mode. When need to stop ranging, send a stop scan command to stop scanning and enter sleep mode.
3) Start GS5 normally, our recommended process is:
   First step:
   Send obtain the device address command to obtain the current number of cascades and configure address.
   Second step:
   Send obtain version information command to to obtain the version number.
   Third step:
   Send obtain device parameter command to obtain device parameters to obtain the angle parameters of the device for data analysis;

   Fourth step:

   Send start scan command to obtain point cloud data.

4) Suggestions for the design of light-transmitting materials for GS5 perspective windows:
   If the front cover perspective window is designed for GS5, it is recommended to use infrared-permeable PC as its light-transmitting material, and the light-transmitting area is required to be flat (flatness ≤0.05mm), and all areas in the plane should be transparent in the 780nm to 1000nm band. The light rate is greater than 90%.
5) The recommended operation procedure for repeatedly switching GS5 on and off the navigation board:
   In order to reduce the power consumption of the navigation board, if GS5 needs to be powered on and off repeatedly, it is recommended to send a stop scan command (see section 3.4) before powering off, and then configure the TX and RX of the navigation board to high impedance. Then pull VCC low to turn it off. The next time the power is turned on, first pull up VCC, then configure TX and RX as normal output and input states, and then after a delay of 300ms, perform command interaction with the line laser.
6) About the maximum waiting time after each GS2 command is sent:
   Get address: delay 800ms, get version: delay 100ms;
   Get parameters: delay 100ms, start scanning: delay 400ms;
   Stop scanning: delay 100ms, set baud rate: delay 800ms;
   Set edge mode: delay 800ms, start OTA: delay 800ms;

7 REVISE

Date	Version	Content
2023-07-24	1.0	The 1st release