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X2 DEVELOPMENT MANUAL



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1 WORKING MECHANISM

After the X2 is powered on, the system automatically starts ranging. The following is the working process of the X2 system workflow:

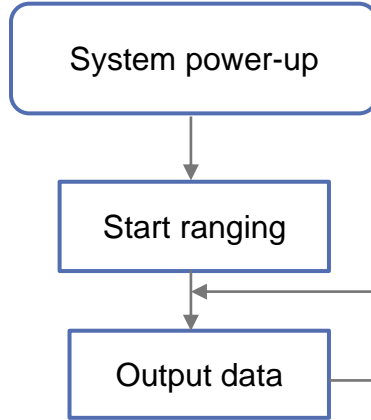


FIG 1 YDLIDAR X2 WORKFLOW

2 SAMPLING AND RANGING

After power on, the system will automatically start ranging, and at the same time it will output to the serial port a message data to start scanning: A5 5A 05 00 00 40 81. The specific meaning of this message is as follows:

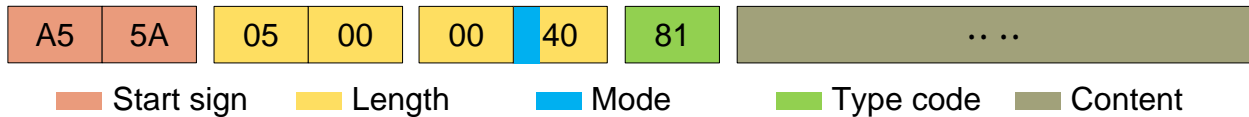


FIG 2 YDLIDAR X2 START SCAN MESSAGE DESCRIPTION

- **Start sign:** X2'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 1 YDLIDAR X2 RESPONSE VALUE AND MODE

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

- **Type code:** The type code of the start scan message is 0x81.
- **Content:** Scan data, see data protocol for details.

3 POWER-ON INFORMATION

After power-on, the system will output power-on information once, and will feedback the device model, firmware version and hardware version, as well as the factory serial number of the device. The response message is:

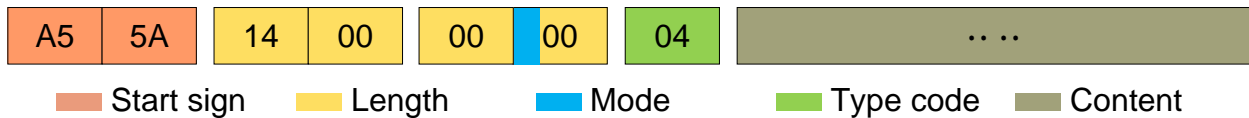


FIG 3 YDLIDAR X2 DEVICE INFORMATION MESSAGE

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

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

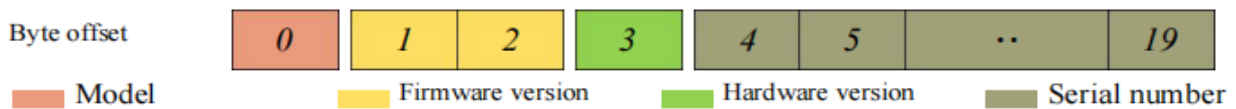


FIG 4 YDLIDAR X2 DEVICE INFORMATION RESPONSE CONTENT DATA STRUCTURE

- **Model number:** One byte device model, such as the model code of X2 is 04;
- **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.

4 DATA PROTOCOL

After the system starts to scan, it will output the scan data in the subsequent message. The data protocol is sent to the external device in hexadecimal to the serial port according to the following data structure.

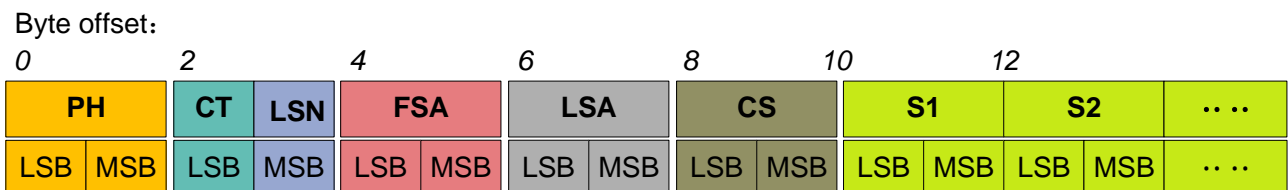


FIG 5 SCHEMATIC DIAGRAM OF THE DATA STRUCTURE OF THE SCAN COMMAND RESPONSE CONTENT

CHART 2 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 and scan frequency analysis:**

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

When CT[bit(0)] = 1 is detected, it indicates that the packet data is start packet. 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; at the same time, in the start data packet, CT[bit(7:1)] scan frequency information, $F = CT[bit(7:1)]/10$ (when CT[bit(7:1)] = 1).

Note: When CT[bit0]=0, CT[bit(7:1)] is a reserved bit, and future versions will be used for other purposes. Therefore, in the process of parsing CT, only bit(0) is required to determine the starting frame.

➤ **Distance analysis:**

Distance solution formula: $Distance_i = \frac{Si}{4}$

Among them, Si is sample data. Set the sampling data as E5 6F. Since the system is in little-endian mode, the sampling point S = 0x6FE5 is substituted into the Distance solution formula to obtain the Distance=7161.25mm.

➤ **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: $Angle_{FSA} = \frac{Rshiftbit(FSA,1)}{64}$

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

Ang_q2[6:0]	C	LSB
Ang_q2[14:7]		MSB

FIG 6 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 (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: $Angle_i = Angle_i + AngCorrect_i \quad (i = 1,2, \dots, LSN)$

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

IF $Distance_i == 0$ $AngCorrect_i = 0$

ELSE $AngCorrect_i = \tan^{-1}(21.8 * \frac{155.3 - Distance_i}{155.3 * Distance_i})$

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

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

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

Assuming that in this frame of data, $Distance_1 = 1000$, $Distance_{LSN} = 8000$, 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, $Angle_i$ ($i = 2, 3, \dots, LSN - 1$) 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:

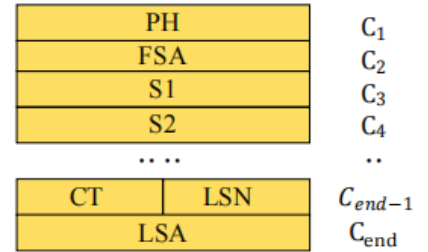


FIG 7 CS XOR SEQUENCE

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

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.

5 MOTOR SPEED CONTROL

At the same time, users can change the scanning frequency to meet their needs according to actual needs. Adjust the motor speed by changing the input voltage of the M_SCTP pin or changing the duty cycle of the input PWM signal (for specific control methods, please refer to the data sheet).

6 REVISE

Date	Version	Content
2019-04-24	1.0	Compose a first draft
2021-07-30	1.1	Modify CT information