YDLIDAR

YDLIDAR X4
DEVELOPMENT MANUAL

Doc#： 01. 13. 000002

YDLIDAR

Sensing changes life
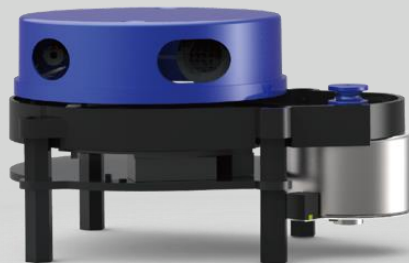
CONTENTS

WORKING MECHANISM

The system of YDLIDAR X4 (hereinafter referred to as X4) has set 3 working modes: idle mode, scan mode, and stop mode;

➢ **Idle mode：** When X4 is powered on, the default is idle mode. In idle mode, the X4's ranging unit does not work and the laser is not lit.

➢ **Scan mode：** When the X4 enters the scan mode, the ranging unit turns on the laser and starts working. Lidar continuously performs laser sampling on the external environment and outputs it in real time after background processing.

➢ **Stop mode：** When X4 runs wrong, for example when turning on the scanner, the laser is off, the motor does not turn, etc., X4 will automatically turn off the distance measuring unit and feedback the error code.
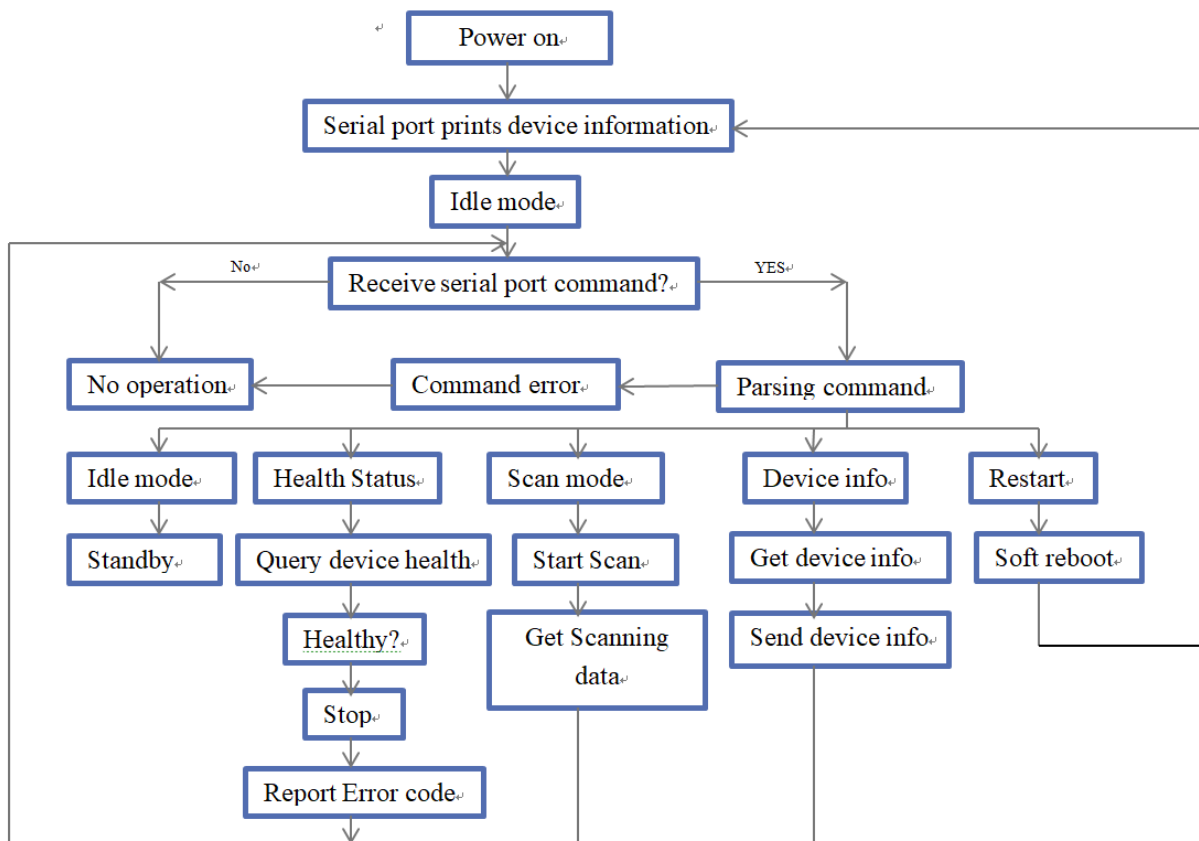
System workflow

FIG 1 YDLIDAR X4 SYSTEM WORKFLOW

SYSTEM COMMUNICATION

Communication mechanism

X4 interacts with external devices through commands and data through the serial port. When the external device sends a system command to X4, X4 will parse the system command and return the corresponding reply message. And according to the command content, to switch the corresponding working status. The external system will parse the message according to the content of the message and obtain the response data.
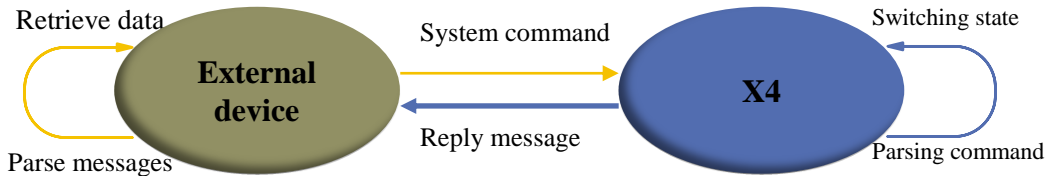

FIG 2 YDLIDAR X4 SYSTEM COMMUNICATION MECHANISM

System command

The external system can set the corresponding working status of X4 and send corresponding data by sending related system commands. The X4 system command is unified to 2 bytes. The start byte is uniformly 0xA5, and the second byte is the command content. The system commands issued by X4 are as follows:

CHART 1 YDLIDAR X4 SYSTEM COMMAND

System command		Description	Modes	Response mode
0xA5 (Start)	0x60	Start scanning and output point cloud data	Scan mode	continuous response
	0x65	Stop and stop scanning	Stop mode	No response
	0x90	Get device information (model, firmware, hardware version)	-	Single response
	0x91	Get device health status	-	Single response
	0x40	Soft reboot	-	No response

System messages

The system message is a response message that the system feeds back based on the received system command. Different system commands, system message reply mode and response content 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 it needs to send data continuously, for example when entering the scan mode.

Single reply and continuous reply messages use the same data protocol. The contents of the protocol are: start, response length, answer mode, type code and response content, and output through the serial port hexadecimal system.

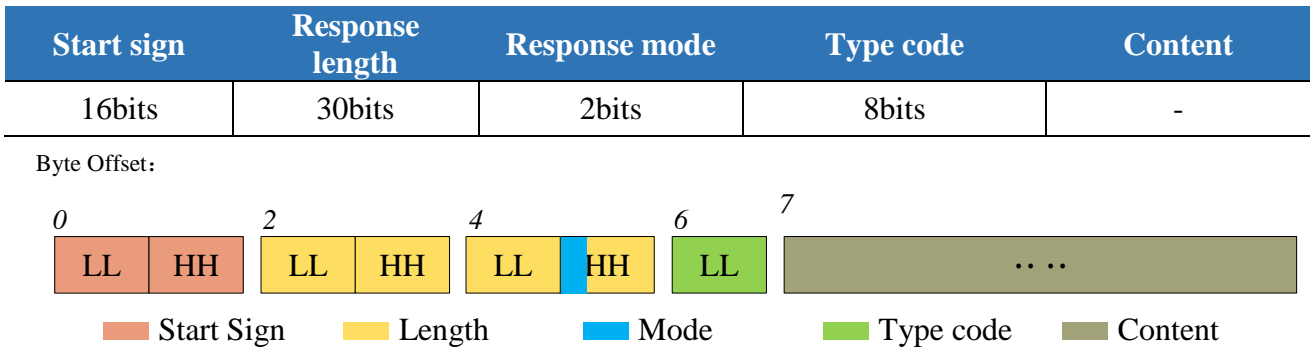**CHART 2 YDLIDAR X4 SYSTEM MESSAGE DATA PROTOCOL**

Start sign	Response length	Response mode	Type code	Content
16bits	30bits	2bits	8bits	-

Byte Offset：

FIG 3 YDLIDAR X4 SYSTEM MESSAGE DATA PROTOCOL

- ➢ **Start sign**：The X4 packet is unified as 0xA55A;
- ➢ **Response length**：The response length indicates the length of the response content. However, when the response mode is continuous, the length is infinite, so the value is invalid.；
- ➢ **Response mode**：This bit is only 2 bits, indicating that this message is a single response or continuous response. Its value and corresponding mode are as follows:

CHART 3 YDLIDAR X4 RESPONSE MODE VALUE AND CORRESPONDING MODE

Response mode value	0x0	0x1	0x2	0x3
Mode	Single response	Continuous response	Undefined	

- ➢ **Type code**：Different system commands correspond to different types of codes.
- ➢ **Content**：Different system commands, feedback different data content. The data protocol is also different.

Note 1: The X4 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.

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 user needs to parse the data in the response content according to the corresponding data protocol, such as point cloud data, device information, and the like.

Scan command [A5 60]

When an external device sends a scan command to X4, X4 goes into scan mode and feeds back point cloud data. The reply message is:

| A5 | 5A | 05 | 00 | 00 | 40 | 81 | · · · · |

Start Length Mode Type code Content

FIG 4 YDLIDAR X4 SCAN COMMAND

The 6th byte of which the high 2 is 01, so the answer mode value is 0x1, is a continuous response, ignore the response length, 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.
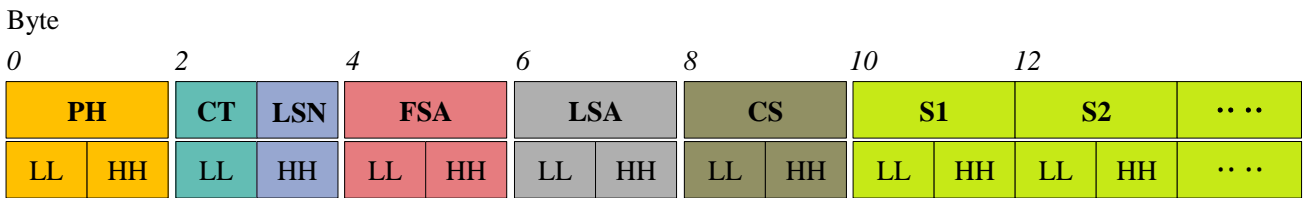
Byte

0		2		4		6		8		10		12		
PH		**CT**	**LSN**	**FSA**		**LSA**		**CS**		**S1**		**S2**		· · · ·
LL	HH	LL	HH	LL	HH	LL	HH	LL	HH	LL	HH	LL	HH	· · · ·

FIG 5 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE DIAGRAM

CHART 4 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE DESCRIPTION

Content	Name	Description
PH(2B)	Packet header	The length is 2B, fixed at 0x55AA, low in front, high in back.
CT(1B)	Package type	Indicates the current packet type. 0x00: Point cloud packet 0x01: Zero packet.
LSN(1B)	Sample quantity	Indicates the number of sample points contained in the current packet; there is only one zero point of data in the zero packet. The value is 1.
FSA(2B)	Starting 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)	Sampling data	The system test sampling data is the distance data of the sampling point.

➢ **Zero resolution:**

The zero-bit data is in a zero-bit packet with LSN = 1, that is, the number of Si is 1, and S1 = zero-distance data. FSA = LSA = zero angle data. For the analysis of the specific values of distance and angle, see the analysis of distance and angle.

➢ **Distance analysis:**

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

Si is sampling data. Sampling data is set to E5 6F. Since the system is in the little-endian mode, the sampling point S = 0x6FE5, and it is substituted into the distance solution formula, which yields Distance = 7161.25mm.

➢ **Angle analysis：**

The angle data is stored in FSA and LSA. Each angle data has the following data structure. C is the check digit and its value is fixed at 1.

Starting angle solution formula： $Angle_{FSA} = \frac{Rshiftbit(FSA,1)}{64} + AngCorrect_1$
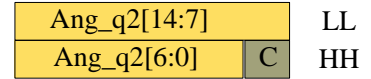

FIG 6 ANGLE DATA STRUCTURE

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

Middle angle solution formula： $Angle_i = \frac{diff(Angle)}{LSN-1} * (i-1) + Angle_{FSA} + AngCorrect_i$

AngCorrect is an angle correction value, and its calculation formula is as follows. Tand^(-1) is an inverse trigonometric function, returning the angle:

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

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

$Rshiftbit(data, 1)$ indicates that the data is shifted right by one bit. diffAngle represents the clockwise angle difference from the start angle to the end angle. LSN indicates the number of packets sampled in this frame.

Assume that the 4th to 8th bytes of the packet are 28 E5 6F BD 79，$Distance_1 = 1000$，$Distance_{LSN} = 8000$，∴ LSN = 0x28 = 40(dec)，FSA = 0x6FE5，LSA = 0x79BD，

$Angle_{FSA} = 223.78° + AngCorrect_1 = 223.78° - 6.7622° = 217.0178°$

$Angle_{LSA} = 243.47° + AngCorrect_{LSN} = 243.47° - 7.8374° = 235.6326°$

$diff(Angle) = 18.6148°$，According to this, the angle data of each sample point in the data packet of this frame can be obtained.

➢ **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

$CS = XOR_1^{end}(C_i)$ $i = 1,2,…,end$
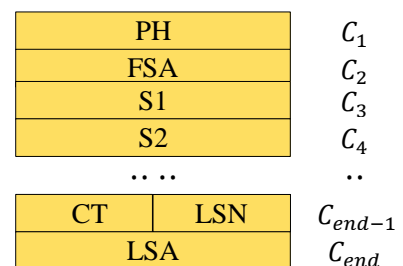
XOR_1^{end} is an XOR formula that represents an XOR of the number of elements in the element from subscript 1 to end. But the XOR satisfies the commutative law, and the actual solution may not need to follow the XOR order of this article.

Stop command [A5 65]

When the system is in the scanning state, X4 has been sending out point cloud data. If you need to close the scan at this time, you can send this command to stop the system from scanning. After sending the stop command, the system will be in standby state. At this point, the device's ranging unit is in low power mode and the laser is off.

The command is unresponsive, so the system will not reply with any message after receiving the command.

Device Information [A5 90]

When an external device sends a Get Device Information command to A4 (A5 90), X4 will feedback the device's model, firmware version, and hardware version, and the device's factory serial number. The reply message is:

A5	5A	14	00	00	00	04	. . . .

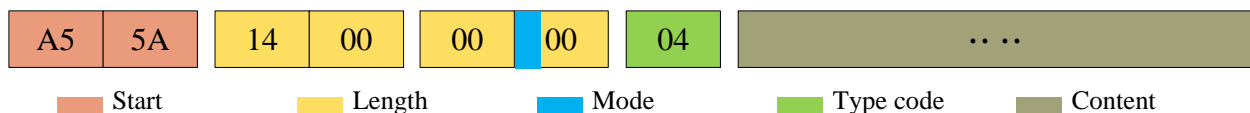Start | Length | Mode | Type code | Content

FIG 8 YDLIDAR X4 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:

Byte offset

0	1	2	3	4	5	..	19

Model | Firmware version | Hardware version | Serial number

FIG 9 YDLIDAR X4DEVICE INFORMATION RESPONSE CONTENT DATA STRUCTURE

➢ **Model number**：One byte device model, such as the X4 model code 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.

Health status [A5 91]

When the external device sends the Get Device Health Status command (A5 91) to X4, X4 will feedback the device's status code. The reply message is:

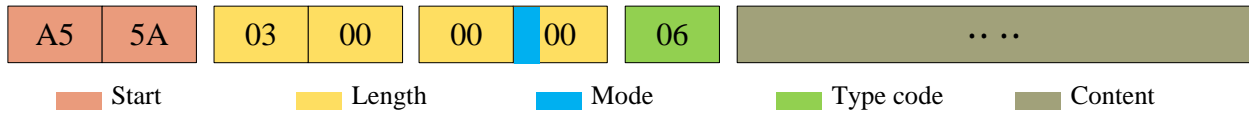| A5	5A	03	00	00	00	06	· · ··
Start		Length		Mode		Type code	Content

FIG 10 YDLIDAR X4 DEVICE HEALTH

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

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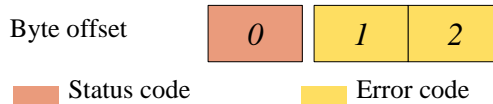
Byte offset

0	1	2
Status code	Error code	

FIG 11 YDLIDAR X4 DEVICE HEALTH STATUS

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

Restart command [A5 40]

When the external device sends the Get Device command to A4 (A5 40), X4 will start a soft reboot and the system will restart. This command does not answer.

POWER CONTROL

In the X4 external interface, the relevant control interfaces (M_EN, M_SCTP) and the power control interface (DEV_EN) of the motor are provided. The user can set the three control signals to control the power consumption of the device.

Standby control

For the convenience of users, the default value of the X4 control signal (please refer to the data sheet) does not achieve the lowest power consumption. Therefore, when users need to debug the lowest power standby state, M_EN and DEV_EN need to be further controlled as follows: M_EN = 0V, DEV_EN = 0V.

In this way, the motor and ranging functions are turned off, and the entire system is in the lowest power standby state.

Motor speed control

Users can change the scanning frequency to meet the needs according to actual needs. By changing the input voltage of the M_SCTP pin or changing the duty cycle of the input PWM signal, the motor speed can be controlled (for specific control methods, refer to the data sheet).