TF-Luna User Manual

Lidar module

www.benewake.com
Benewake (Beijing) Co., Ltd.

Said product

Product model: TF-Luna

Product name: TF-Luna lidar module

manufacturer

Company: Beixing (Beijing) Photon Technology Co., Ltd.

Address: No. 28, Information Road, Haidian District, Beijing, China

certified product

Preface

respected user:

Hello. Thank you for choosing Beixing Photon Technology's products. We are honored to participate in your problem-solving process.

In order to make the product use experience better, we hereby formulate product instruction manuals to help you use the product more conveniently.

And better help you solve your problem.

This manual has covered usage instructions and problem solving measures for common situations, but it still cannot guarantee that your problem can be completely solved.

question. If you encounter other problems while using the product, you are welcome to consult our technical support staff

(support@benewake.com), we are dedicated to helping you solve any problems in product use. When using the product, do you have any

If you have any comments or suggestions, you can go to the official website (http://www.benewake.com) to give us feedback. We look forward to your participation.

We are Beixing, and we are determined to make the best robot eyes!

Table of contents

1Revision history

Version revision content		release date
A01 initial version		2020.1.15
A03	1. Delete some chapters. 2. Update external dimensions. 3. Improve the function description. 4. Add I2C interface description. 5. Updated power supply voltage range: 3.7V-5.2V.	2020.3.15
A05	1. Delete "Set low sampling rate mode ID_LOW_SAMPLE_RATE=0x3E". 2. Correct the definition of I2C register 0x25. 0x00 means the radar is turned off, and 0x01 means the radar is turned on. 3. Correct the description of the I2C write register. When using I2C communication, please ensure that the firmware version Greater than or equal to V1.0.7. 4. Added Amp's description of ambient light overexposure. 5. Add ultra-low power consumption mode. 6. The unit of distance limit of I2C register 0x2E-0X31 is corrected from cm to mm. 7. Added description of single frequency mode. 8. Add filter configuration instructions. 9. Add "output with device ID" format.	2020.7.23

2 things to note

2.1 About documentation

ÿThis manual provides various information necessary for the use of the product.

ÿPlease read this instruction manual carefully before using this product and make sure you fully understand the contents of the instruction manual.

2.2 Product use

ÿ This product can only be repaired by qualified professionals, and only original spare parts can be used to ensure product performance and safety.

ÿ The product itself has no polarity protection and over-voltage protection. Please follow the instruction manual for correct wiring and power supply.

ÿ The working temperature of the product is -10ÿ~60ÿ. Please do not use it outside this temperature range to avoid risks.

ÿ The storage temperature of the product is -20ÿ~75ÿ. Please do not store outside this temperature range to avoid risks.

ÿ Please do not open the case for assembly or maintenance other than those described in this instruction manual, as this may affect the product's protective performance and cause product failure.

2.3 Product failure situations

ÿ There is a risk of failure when the product detects objects with high reflectivity, such as mirrors, smooth floor tiles, and calm milk surfaces.

ÿ When there are transparent objects, such as glass and water, between the product and the target being measured, there is a risk of failure.

ÿ When the product's transmitting and receiving window is covered with dirt, there is a risk of failure. Please keep the window clean.

ÿ Since the circuit board of the product is directly exposed, please do not touch the circuit board directly with your hands. If necessary, please wear an electrostatic bracelet or anti-static bracelet Electric gloves. Otherwise, there is a risk of product failure, which is manifested in the product not working properly.

3Principles and key parameters

3.1 Principle of ranging

TF-Luna is based on TOF (Time of Flight) principle. Specifically, the product periodically emits near-infrared light modulated waves outwards, and the modulated waves are reflected after encountering objects. The product obtains the flight time by measuring the round-trip phase difference of the modulated wave, and then calculates the relationship between the product and The relative distance between the measured targets is shown in Figure 1 .

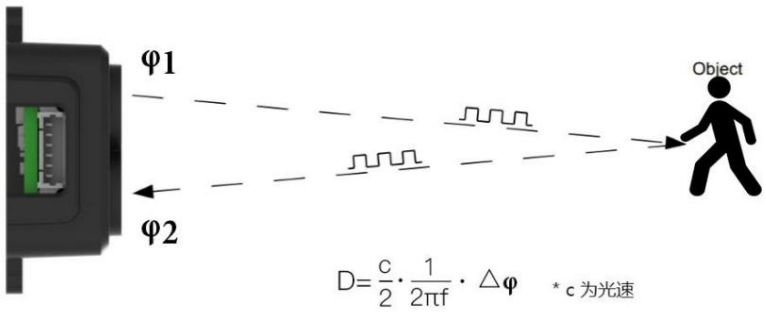


Figure 1 Schematic diagram of flight time principle

3.2 Key characteristic parameters

Table 1 TF-Luna key characteristic parameters

parameter name	Parameter value
Measuring range	0.2m~8m ÿ
Accuracy	±6cm@ÿ0.2-3mÿ
	±2%@ÿ3m-8mÿ
Default distance unit	cm
distance resolution	1cm

Signal reception angle	2° ÿ
Output frequency	1~250Hz(adjustable) ÿ

ÿThe range measurement range that can be achieved under the condition of diffuse reflection white board (90% reflectivity).

ÿThis angle is a theoretical value, and there is a certain deviation in the actual angle value.

ÿThe default value of the output frame rate is 100Hz, and custom configuration is supported. The configurable value is 500/n (n is a positive integer).

3.3 Repeat accuracy

The ranging repeatability accuracy of TF-Luna is related to the signal strength value (Amp) during measurement and the output frame rate. The larger the Amp, the higher the repeatability accuracy. The higher the degree, the lower the output frequency and the higher the repetition accuracy. The ranging repeatability is characterized by the 1ÿ standard deviation of ranging. The following is given for 100Hz When outputting frame rate, the 1ÿ standard deviation under different test conditions is for reference only. The actual standard deviation may be affected by the use environment.

Table 2 Reference value of ranging standard deviation under different Amp

Amp 100		**200**	**400**	**1000 ÿ2000**	
Std	3cm	3cm	2cm	1cm 0.5cm	

Table 3 Reference values of ranging standard deviation of 90% reflectivity diffuse reflection target at different distances

Distance	**200cm 400cm 600cm 800cm**			
Std	0.5cm	1cm	1.5cm 2cm	

3.4 Ranging characteristics

TF-Luna products have been optimized with optical paths and algorithms to minimize the impact of the external environment on ranging performance.

The ranging blind zone of TF-Luna is 0-20cm, and the data within this range is not trustworthy.

Detection capability for black (10% reflectivity) targets, measuring range is 0.2-2.5m.

Detection ability of white (90% reflectivity) targets, measuring range is 0.2-8m.

Only when the "measured target side length" is greater than or equal to the "effective distance measurement side length", the data will be stable and reliable. "Effective distance measurement side length" Determined by the field of view (the field of view generally refers to the smaller of the receiving angle and the transmitting angle), the calculation formula is:

$$d = 2 ÿ D ÿ \tan ÿ$$

Among them, d represents the effective ranging side length, D represents the detection distance, ÿ is the receiving half angle of TF-Luna 1°, and the general effective ranging The corresponding relationship between side length and detection distance is shown in Table 4:

Table 4 The effective side length of the measured target corresponding to the ranging distance

detection distance	1 m	2m	3m	4m	5 m	6m	7m	8m
efficient side length	3.5cm	7cm	10.5cm	14cm	17.5cm	21cm	24.5cm	28cm

When the side length of the measured object does not meet the effective distance measurement side length, as shown in Figure 2, the TF-Luna output measurement value (Dist) will appear abnormal.

often. If higher accuracy is required during use, such situations should be avoided as much as possible to reduce measurement errors.

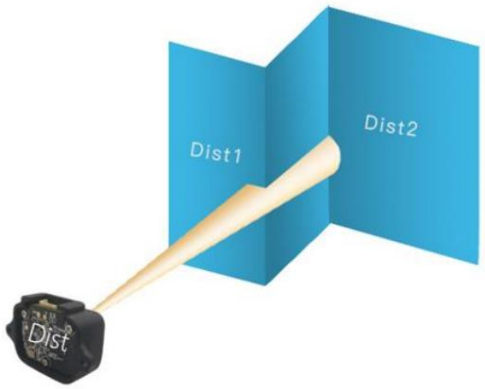


Figure 2 Detecting two objects at different distances

4Appearance and structure

4.1 Product appearance

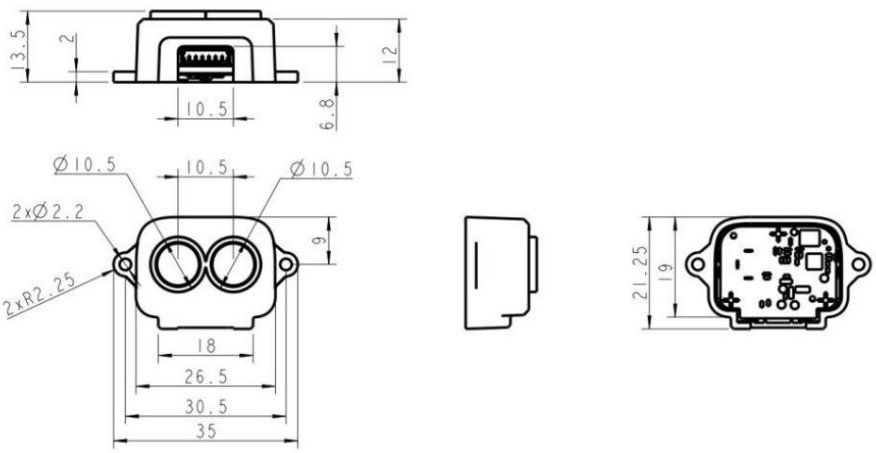


Figure 3 TF-Luna product appearance and dimensions

5 Electrical Characteristics

Table 5 TF-Luna main electrical parameters

parameter name	Parameter value
Input voltage	3.7V-5.2V
average current	ÿ70mA
Peak current	150mA
Power consumption	ÿ350mW
Communication level	LVTTLÿ3.3Vÿ

This product does not have overvoltage protection or polarity protection. Please ensure that the wiring is normal and the input voltage is within the specified range.

6Function description

6.1 Line sequence description

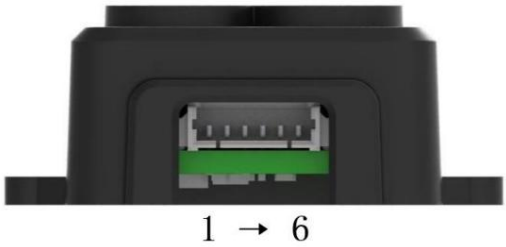


Figure 4 TF-Luna pin sequence diagram

Table 6 Pin functions and connection instructions

serial number	Function	illustrate
1	+5V	Positive pole of power supply
2	RXD/SDA	Receive data
3	TXD/SCL	send/clock
4	GND	power ground
5	Interface configuration input	Ground: Start in I2C mode Floating or connected to 3.3V: Start in serial port mode
6	Multiplex output	Switch mode function: switch output I2C mode and switch mode off: data ready indication

6.2 Serial communication

When pin 5 is left floating or connected to 3.3V, TF-Luna starts in serial communication mode, pin 2 is the serial port receiving RXD, and pin 3 Send TXD for serial port. The serial communication hardware protocol is: 8 bits for data bits, 1 bit for stop bits, no parity, and default baud rate.

115200bpsÿ

The serial communication software protocol data frame format is as follows:

Byte 0		1	2	3~Len-2	Only-1
DescriptionHead	(0x5A) Len ID			Payload	Checksum

Head: Frame header, fixed at 0x5A.

Onlyÿ Contains the length of all bytes from the frame header to Check_sum, in bytes, ranging from 4 to 255.

IDÿ Indicates how to parse Payload data.

Payload: Data segment, parsed based on ID, there may be no data segment.

Checksum: Calculate the sum of all bytes from Head to Payload, and take the lower 8 bits.

For the serial communication software protocol, see Appendix 2 Serial Communication Software Protocol.

Note: TF-Luna does not enable checksum checking for downlink data frames by default, that is, the Checksum at the end of the downlink frame can be filled in. Recharge any value. The data frame uploaded from TF-Luna contains the correct Checksum value. If users have requirements for communication reliability, You can use the "checksum switch ID_FRAME_CHECKSUM_EN=0x08" command in Appendix 2 of the serial port communication software protocol. Turn on the checksum checking function.

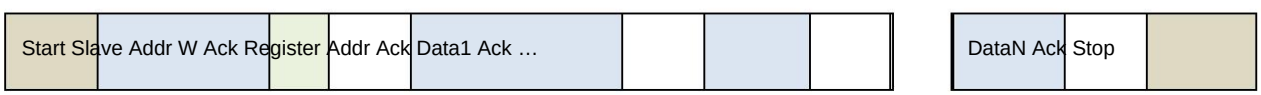
The configuration command takes effect immediately after it is issued, but will not be saved. If you need to save it after power failure, you need to send an additional message "Save current settings". ID_SAVE_SETTINGS=0x11" command: 5A 04 11 00.

6.3 **I2C** communication

When pin 5 is connected to ground, TF-Luna starts in I2C communication mode, pin 2 is the data line SDA, and pin 3 is the clock line SCL. TF-Luna serves as an I2C slave. The default slave address is 0x10 and supports a clock frequency of up to 400kbps. For a list of I2C registers see Appendix 3 **I2C** register list.

Note: The I2C slave address in this document is a 7-bit value, the available range is [0x08, 0x77], decimal [8, 119]. I2C The first byte sent after the start signal needs to shift the 7-bit address to the left by one bit (multiplied by 2), and then add the lowest bit of the read and write flag. Chi. For example, the default slave address of TF-Luna is 0x10, the write operation address is 0x20, and the read operation address is 0x21.

Write register timing:



Read register timing:

Start Slave Addr R Ack Data1 Ack …					DataN Nack Stop		

In the register reading sequence, the host does not need to generate the first Stop signal, but directly generates the second Start signal. The last Nack can also be an Ack signal.

In the continuous ranging working mode, the host must use the data ready signal generated by pin 6 of TF-Luna as a synchronization signal to initiate a data read operation within the specified timing, otherwise it may be read during the data register update period. resulting in occasional data anomalies Common problem. In multi-machine bus mode, it is recommended to use the command trigger mode to work.

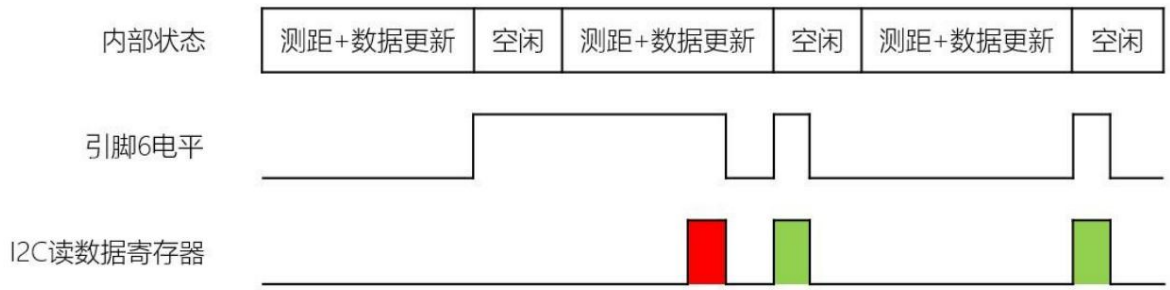


Figure 5 Schematic diagram of I2C reading data register

When the data update is completed, pin 6 switches to high level, and when the read register operation (any register) is completed, pin 6 switches to low level. In continuous operation mode, the I2C master needs to read the data register immediately after reading the pin as high level. The above timing , the data read for the first time is unreliable, and the next two times are correct reading times.

After writing the register through I2C, TF-Luna needs some time for processing to take effect. If the user needs to read back the register value To verify, it is recommended to wait 100ms after the write operation before performing the read operation.

6.4 Data output

TF-Luna mainly outputs the following data:

ÿ Distance measurement value (Dist): Default unit is cm.

ÿ Signal strength (Amp): When Amp=0xFFFF, it means overexposure; when Amp<100, the signal is too low. Distance values cannot be trusted when the signal is overexposed or too low. Under normal circumstances, the value of Amp will not be greater than 30000. When the Amp is greater than 32768, it means that TF-Luna has detected overexposure of ambient light, such as when facing the sun outdoors.

ÿ Chip temperature (Temp): The formula for converting the temperature value output by the serial port into degrees Celsius is: Temp/8-256. Note that Temp It is the chip temperature, not the ambient temperature. Normally, the chip temperature is about 20°C higher than the ambient temperature.

TF-Luna supports multiple serial port output formats. Please refer to Appendix 1 for serial port output formats. The factory default is "9 byte cm" format. Users can modify the output format through the "set output format ID_OUTPUT_FORMAT=0x05" command.

6.5 Continuous ranging mode

TF-Luna performs ranging internally at a frequency of 500Hz, and outputs after averaging multiple times according to the output frequency configured by the user. For example, with the factory default configuration of 100Hz output frequency, TF-Luna will average 5 consecutive ranging results and output them. Therefore, the lower the output frequency, the more average times, and the smaller the data volatility. The maximum output frequency supported by TF-Luna is 250Hz, and it only supports a frequency value of 500/n, where the value range of n is [2,500], that is, the user-configurable output frequency is: 250, 166, 125, 100,… 2,1 equivalent. Users can modify the output frequency through the "Set output frequency ID_SAMPLE_FREQ=0x03" command.

6.6 Command trigger mode

When the output frequency is set to 0 through the "Set output frequency ID_SAMPLE_FREQ=0x03" command, TF-Luna enters the command trigger mode. At this time, the radar no longer actively measures distance. Every time it receives a "Single trigger command ID_SAMPLE_TRIG=0x04" (5A 04 04 00), measure the distance and output it once.

6.7 Switch mode

When the user only cares about whether there is a target within a certain distance range, the switching mode of TF-Luna can be enabled through the "Set switching output mode ID_ON_OFF_MODE=0x3B" command. In this mode, detection information is represented by the high and low levels of pin 6. Figure 6 takes the near high and far low mode as an example to illustrate the working mode of the switching mode.

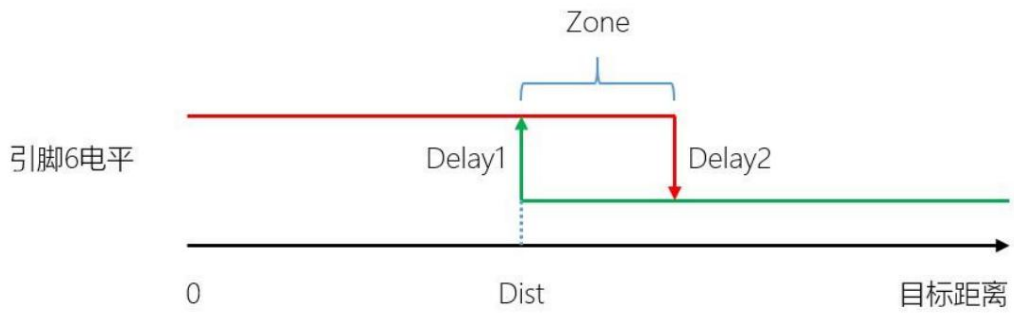


Figure 6 Switching mode of near high and far low

When Zone is set to 0, pin 6 outputs high level when the target distance is less than Dist, and pin 6 outputs when the target distance is greater than Dist. low level. If the target distance happens to be at Dist, the level of pin 6 may jump high and low frequently due to the fluctuation of ranging. You can avoid this problem by setting Zone to form a hysteresis interval. When Zone is not 0, the high-level to low-level transition will be triggered only when the target distance is greater than Dist+Zone, and the low-level to high-level transition will be triggered only when the target distance is smaller than Dist.

The switching mode supports delay setting. When Delay1 and Delay2 are not 0 and the target distance meets the jump condition, the level jump of touch pin 6 will not be triggered immediately. Only the duration of Delay1 or Delay2 ms will always meet the jump condition. Only then will the level transition of pin 6 be actually triggered.

Note that under the default settings, when the signal strength is less than the threshold, the ranging value is assigned to 0. When the user uses the switching mode, If there is no target in the distance, the signal strength is less than the threshold, making the distance value 0, causing the level of pin 6 to be consistent with the target in the near distance. At this time, you can refer to "6.8 Amp Threshold Settings" to set the distance value when the signal strength is less than the threshold to a value greater than Dist+Zone.

6.8 **Amp** threshold setting

When the signal strength is too small, the distance calculation result may be wrong. Therefore, under the TF-Luna factory default configuration, when Amp<100, the distance is forced to be assigned a value of 0. When the user has lower or higher requirements for the distance output value of TF-Luna, the Amp threshold can be appropriately adjusted by "Set AMP kick threshold ID_AMP_THRESHOLD=0x22". Note that the actual set Amp threshold is 10 times the value in the instruction.

6.9 Distance limit setting

Under the factory default configuration of TF-Luna, the minimum output is 0cm and the maximum output is 900cm. Users can use "Settings" according to actual needs Distance limit ID_DIST_LIMIT=0x3A" command to set.

Note that distance values outside the range of [20cm, 800cm] may not be reliable.

6.10 Low power mode

The power consumption of TF-Luna is determined by two factors: the light source driving current and the lighting duty cycle.

TF-Luna achieves the purpose of adapting to a large dynamic range of targets with different distances and different reflectivities by adaptively adjusting the light source driving current. When the signal strength returned to the radar is too high, it automatically switches to low-level current operation. On the contrary, when the signal strength is too low, it automatically switches to high-level current operation. The higher the current level, the greater the power consumption.

Refer to "6.5 Continuous Ranging Mode". In continuous ranging mode, TF-Luna always emits light at the highest duty cycle and does not change with the output frequency. Therefore, when TF-Luna is in continuous working mode and the current level is at the highest level, the power consumption is the largest. When powered by 5V, the power consumption is approximately 350mWÿ

Users can change the luminous duty cycle of TF-Luna in two ways. The first is to use the command trigger mode, TF-Luna It does not emit light when no ranging command is received. At this time, the power consumption is about 42.5mW (5V power supply). The actual power consumption is determined by the frequency of command triggering. Another way is to enable the low power consumption mode provided by TF-Luna. The internal working mechanism of this mode is the same as the command trigger mode, except that The trigger signal is automatically generated internally by TF-Luna. Users can set TF-Luna to enter low power mode through the "Low power mode ID_LOW_CONSUMPTION=0x35" command.

In order to ensure the internal working sequence of TF-Luna, the maximum output frequency in low power mode is 10Hz. The following table lists the reference values of average power consumption at different operating frequencies in low-power mode when powered by 5V. The actual power consumption may be affected by the ambient temperature or supply voltage. There is a difference from the reference value.

Low power mode operating frequency	Average operating current (mA)	Average power consumption (mW)
1Hz	8.85	44.25
2Hz	9.2	46
3Hz	9.55	47.75

4Hz	9.9	49.5
5Hz	10.25	51.25
6Hz	10.6	53
7Hz	10.95	54.75
8 Hz	11.3	56.5
9Hz	11.65	58.25
10Hz	12	60

6.11 Ultra-low power mode

To further reduce power consumption, TF-Luna provides an “ultra-low power mode”. In this mode, the MCU enters sleep mode. At this time

The standby power consumption of TF-Luna is about 1.5mW. Since the MCU enters sleep mode and cannot be automatically triggered like the "low power mode", it must

It must be woken up by the level change of pin 2.

6.11.1 Serial communication ultra-low power consumption mode

(1) Enter ultra-low power consumption mode

Enable ultra-low power mode through the command "Ultra-low power mode ID_ ULTRA_LOW_POWER_MODE=0x58"

mode, after this command is issued, TF-Luna stops serial port output, but does not immediately enter the ultra-low power consumption mode and needs to continue

Continue to send "Save current settings ID_SAVE_SETTINGS=0x11" and "System software reset" in sequence

ID_SOFT_RESET=0x02" command, TF-Luna enters ultra-low power consumption mode. Since the configuration has been saved,

It will enter this mode directly after powering on again.

(2) Wake-up ranging

The user sends any byte of data to TF-Luna through the serial port, which will wake up TF-Luna for a ranging measurement.

After the distance is completed, the ranging results in the specified format are sent through the serial port, and then the ultra-low power consumption mode is entered again. Figure 7 takes

115200 baud rate, 9-byte output format as an example, wake-up time is about 8.5ms.

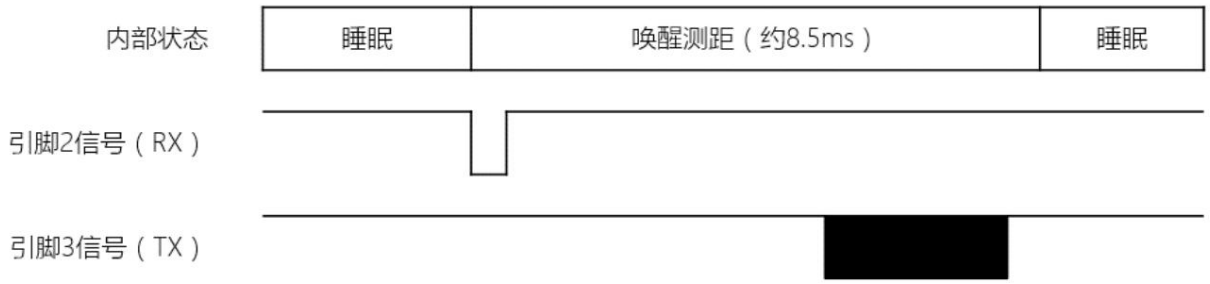


Figure 7 Serial communication ultra-low power mode timing diagram

(3) Exit ultra-low power consumption mode

Since TF-Luna's serial communication module is not enabled when it is in ultra-low power mode, it cannot exit this mode directly. TF-Luna can only respond to serial port commands within the short sequence of being awakened. Therefore, the user needs to continuously send the "disable" command of "Ultra-low power mode ID_ ULTRA_LOW_POWER_MODE=0x58" until a response from TF-Luna is received. Then the user sends the "Save current settings ID_SAVE_SETTINGS=0x11" command to ensure that the state is saved.

(4) Power consumption estimation

TF-Luna consumes about 1.5mW when sleeping, the average power consumption during wake-up is about 260mW, and the wake-up time is about 8.5ms. root According to the above calculation conditions, the average power consumption is about 3.7mW when the wake-up test is performed once every 1 second. Wake up test every 10 seconds, average The power consumption is about 1.72mW.

6.11.2 I2C communication ultra-low power mode

(1) Enter ultra-low power consumption mode

The user needs to continuously write three bytes: [0x01, 0x01, 0x02] to the 0x1F address to enter and save the ultra-low power consumption mode.

(2) Wake-up ranging

The user can try to access any valid or invalid register address (no ACK from the slave will be received), and TF-Luna will wake up when it detects the level change on pin 2. After waking up, perform a ranging and update the register

New ranging results. TF-Luna does not enter sleep mode again until the user performs a register read operation.

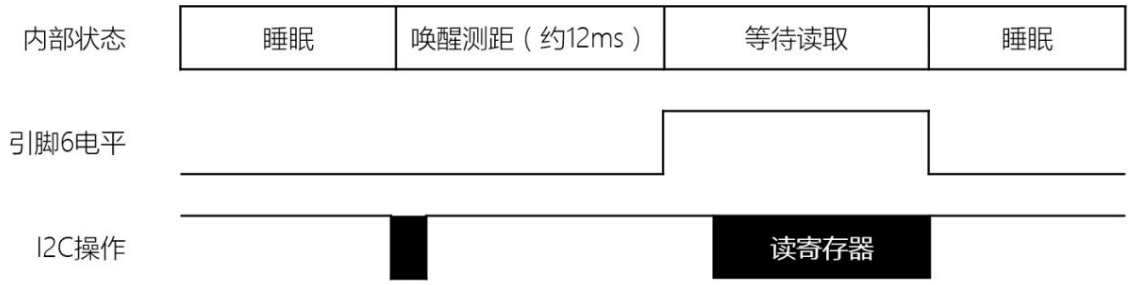


Figure 8 I2C communication ultra-low power mode timing diagram

(3) Exit ultra-low power consumption mode

Since only register reading operations can make TF-Luna enter sleep mode again, after waking up (wait for at least 6ms after triggering), directly start writing three bytes continuously to the 0x1F address: [0x00, 0x01, 0x02] to exit the super mode. Low power mode.

(4) Power consumption estimation

TF-Luna consumes about 1.5mW when sleeping, the average power consumption during wake-up ranging is about 200mW, the wake-up ranging duration is about 12ms, and the power consumption during waiting for reading is about 42.2mW, assuming a wait of 5ms. According to the above calculation conditions, the average power consumption is about 4.1mW when the wake-up test is performed once every 1 second. The average power consumption is about 1.76mW after a 10-second wake-up test.

6.11.3 Precautions

Since the MCU is in sleep state when in ultra-low power mode, it may not respond to user instructions correctly. In mode, users are not allowed to perform any command configuration operations, and are only allowed to perform two operations: "wake up ranging" and "exit ultra-low power mode". Any other configuration operations must be performed after exiting ultra-low power mode.

6.12 Single frequency working mode

TF-Luna adopts the sine wave modulation phase ranging principle, which has the problem of "periodic distance". TF-Luna works on a single frequency. The periodic distance is 15 meters. When the measurement distance exceeds 15 meters, it will start from 0 meters. If there is an object with high reflectivity at 16 meters object, TF-Luna will misjudge it as an object 1 meter away. In order to extend the cycle distance, TF-Luna enables dual-frequency working mode by default. formula, the cycle distance is greater than 65 meters, which is far beyond its own range, which can avoid the problem of "over-cycle".

However, in dual-frequency mode, the distance calculation algorithm has higher requirements on data stability. When the signal is small (AMP is less than 100), the data stability becomes worse, which may easily lead to distance calculation errors, and the final output distance will be abnormal and error. Up to tens of meters. In some application scenarios, the reflectivity of the target is very low and data with an AMP of less than 100 needs to be used. Users can configure TF-Luna to enter single frequency Operating mode. In single-frequency operating mode, when AMP is less than 100, although the stability of the data distance becomes worse, it is not prone to large abnormal values. At the same time, users need to consider that this scenario will not be affected by the "over-cycle" problem.

6.13 Other functions

To obtain the version number, reset the system software, set the serial port baud rate and other functions, users can use them according to the description in "Appendix 2 Serial Port Communication Software Protocol".

7 Quick Test Steps

7.1 Tools required for product testing

					
TF-Luna	Data cable TTL - USB board USB cable			PC software	

7.2 Test steps

(1) PC test software download

Please go to Benewake official website (http://www.benewake.com/download) to download TF-Luna host computer software.

Note: Please turn off the anti-virus software before decompressing the host computer software to avoid files in the host computer software being deleted as viruses. The host computer currently only supports running on Windows systems.

(2) Device connection

Figure 9 Diagram of correct connection

As shown in Figure 9, connect ÿTF-Lunaÿ, ÿTTL-USB adapter boardÿ and ÿUSB cableÿ, make sure there is no looseness, and then connect ÿUSB Cable' is connected to the 'computer'.

(3) Host computer connection and reading

As shown in Figure 10, open the TF host computer, select ÿÿ TF-Lunaÿ, and select the automatically recognized occupied serial port (here is ÿÿ COM9ÿÿÿ

Then, click "CONNECT" to connect to the host computer. After the connection is successful, the continuous output data image will appear in the "ÿ TIME LINE CHART" area on the right, and the "ÿ REAL TIME DATA" area below will display the current test distance (Dist), effective data volume per second (Effective Points) and signal strength in real time. (Strength).

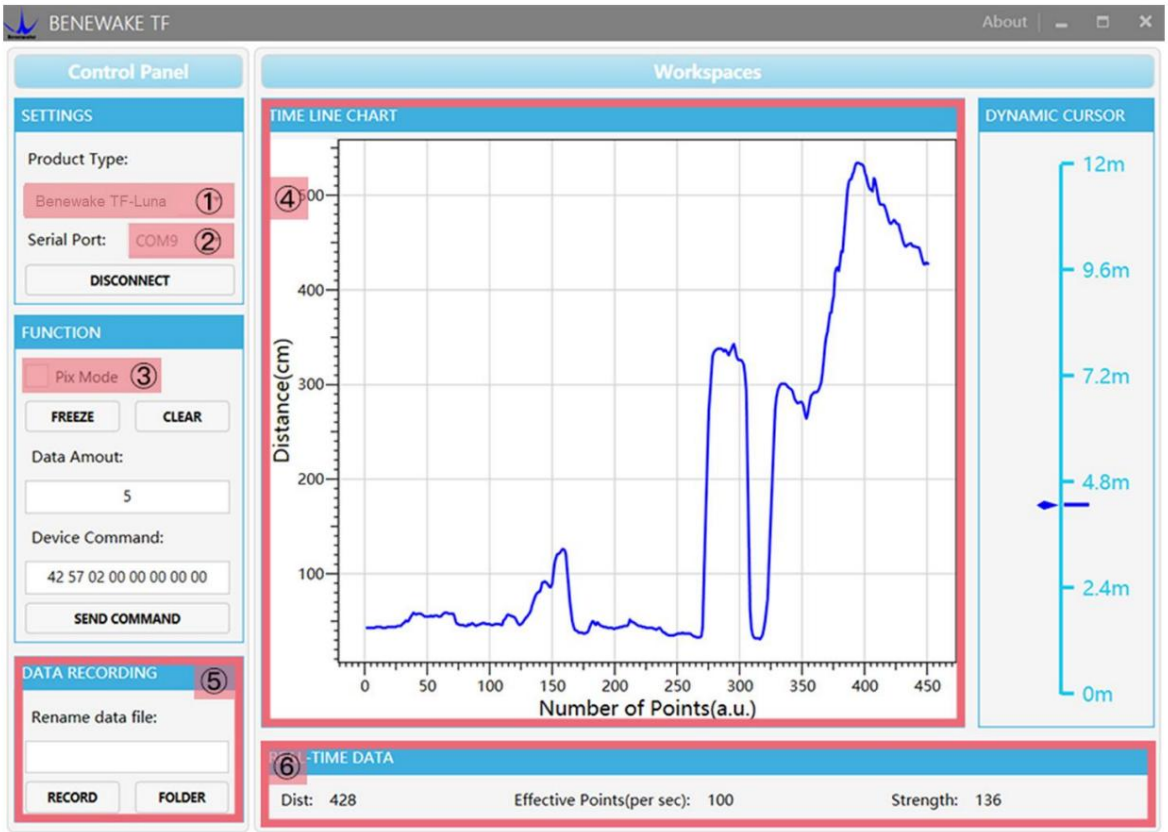


Figure 10 Host computer interface and display

Note: a)

If there is no data in the "ÿ TIME LINE CHART" area, please check the connection and line sequence. TF-Luna is powered on successfully. Look at the transmitter from the front. There will be a faint red light inside the lens.

b) If TF-Luna is output in Pixhawk format, you need to check ÿÿ Pix Modeÿ first and then ÿÿ TIME LINE CHARTÿ area will Normally output data image. After checking Pix Mode, the distance unit changes to m.

c) The distance output Dist value will be different depending on the output unit. The default unit is cm. If the distance unit of TF-Luna is modified to mm through a command, the host computer cannot distinguish it, and the unit of "ÿ TIME LINE CHART" is still cm. For example, TF-Luna The actual measurement distance is 1m, and the output is 1000 in mm. The value read through the host computer is 1000, but the value read on the host computer is 1000. The unit will not change and cm will still be displayed.

8Firmware updates

TF-Luna supports firmware updates. When the user's product cannot meet the current usage needs and BeiWake official has the corresponding firmware update, the user can update the product firmware through "TF-Luna Remote Upgrade Host Computer". Please contact technical support to obtain firmware updates.

machine.

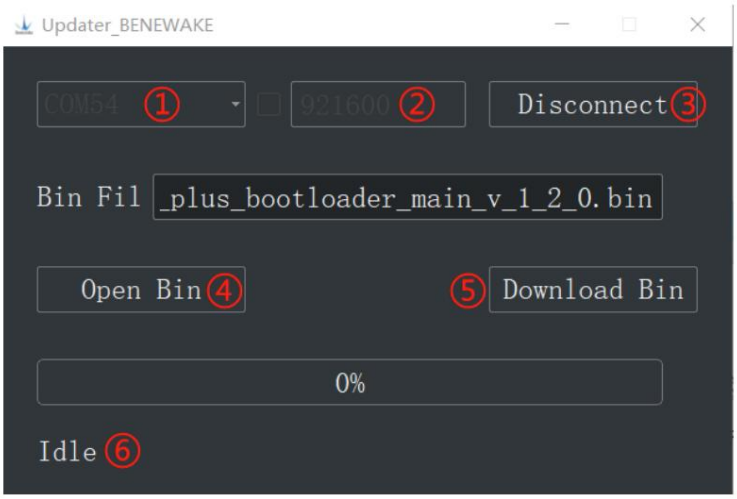


Figure 11 TF-Luna firmware upgrade host computer

The tools required for TF-Luna firmware update are basically the same as those described in the quick test steps, and a TTL-USB adapter is also required.

The board establishes the connection between TF-Luna and the computer.

After the connection is completed, open the TF-Luna firmware update host computer and select the appropriate port, here it is "ÿ COM8". In ÿÿ Enter the correct baud rate at 115200, click ÿ CONNECT to establish communication between TF-Luna and the host computer; click ÿ Open Bin to select the firmware file that needs to be updated, and the address of the firmware file will be displayed in the text box above. Then click "ÿ Download Bin" to complete the update. ÿÿÿ will display firmware update information.

Note that the firmware update host computer and firmware files need to be placed in a pure English path.

Appendix 1 Serial port output format

1. 9 bytes cm

Minimum firmware version supporting this protocol: V0.0.5.

Byte 0		1	2	3	4	5	6	7	8
Description	0x59	0x59	Dist_L	Dist_H Amp_L	Amp_H Temp_L	Temp_H Check_sum			

Distÿcmÿ

Amp: signal strength. When it is less than 100, the ranging result is unreliable. When overexposed, the value is 65535.

TempÿTemp / 8 – 256 = ÿÿ

2. PIX

Minimum firmware version supporting this protocol: V0.0.5.

X.YZ\r\n

ASCII code format, unit is meter, keep two decimal places.

3. 9 bytes mm

Minimum firmware version supporting this protocol: V0.0.5.

Byte 0		1	2	3	4	5	6	7	8
Description	0x59	0x59	Dist_L	Dist_H Amp_L	Amp_H Temp_L	Temp_H Check_sum			

Distÿmmÿ

Amp: signal strength. When it is less than 100, the ranging result is unreliable. When overexposed, the value is 65535.

TempÿTemp / 8 – 256 = ÿ

4. With 32bit timestamp

Minimum firmware version supporting this protocol: V0.0.5.

Byte 0		1	2	3	4	5	6-9	10
Description	0x59	0x59	Dist_L	Dist_H Amp_L	Amp_H Timestamp	Check_sum		

Distÿcmÿ

Amp: signal strength. When it is less than 100, the ranging result is unreliable. When overexposed, the value is 65535.

Timestamp: Timestamp, little endian format, unit ms.

5. ID0 output

Minimum firmware version supporting this protocol: V0.0.5.

Byte 0		1	2	3	4	5	6	7-10	11
Description	0x5A	Only	0x00	Dist_L	Dist_H Amp_L	Amp_H Timestamp	Check_sum		

Distÿcmÿ

Amp: signal strength. When it is less than 100, the ranging result is unreliable. When overexposed, the value is 65535.

Timestamp: timestamp, little endian format, unit ms

6. 8 bytes cm output

Minimum firmware version supporting this protocol: V0.0.5.

Byte 0		1	2	3	4-7
Description	Dist_L	Dist_H	Amp_L	Amp_H	Timestamp

Distÿcmÿ

Amp: signal strength. When it is less than 100, the ranging result is unreliable. When overexposed, the value is 65535.

Timestamp: Timestamp, little endian format, unit ms.

7. Output with device ID

Minimum firmware version supporting this protocol: V3.0.8.

Byte 0		1	2	3	4	5	6	7-10	11	12
Description	0x5A	0x0D	0x00	Dist_L	Dist_H	Amp_L	Amp_H	Timestamp	Dev_Id	Check_sum

Distÿcmÿ

Amp: signal strength. When it is less than 100, the ranging result is unreliable. When overexposed, the value is 65535.

Timestamp: Timestamp, little endian format, unit ms.

Dev_Id: Device ID, same as I2C slave address.

Appendix 2 Serial Communication Software Protocol

1. Get the version number ID_GET_VERSION=0x01

Minimum firmware version supporting this protocol: V0.0.5.

Down:

Byte 0 Description	1	2	Only-1
Head(0x5A) Len		ID	Check_sum

Uplink:

Byte 0 Description	1	2	3~5	Only-1
Head(0x5A) Len		ID	Version	Check_sum

Version: For example, the 3rd, 4th, and 5th bytes are 112, 50, and 9 respectively, indicating the version number 9.50.112.

Example:

Command[5A 04 01 00]

2. System software reset ID_SOFT_RESET=0x02

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description	1	2	Only-1
Head(0x5A) Len		ID	Check_sum

Upward

Byte 0 Description	1	2	3	Only-1
Head(0x5A) Len Status: 0 (success); non-0		ID	Status	Check_sum

(failure).

Note: Configuration items that have been modified but have not performed the "Save Current Settings" operation will be restored to their initial state.

Example:

Command[5A 04 02 00]

3. Set output frequency ID_SAMPLE_FREQ=0x03

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3~4	Only-1
Head(0x5A) Len	Default value		ID	Freq	Check_sum
				100	

Freq: Working frequency, 0 (command single trigger mode), >0 (set working frequency).

Upward

Byte 0 Description	1	2	3~4	Only-1
Head(0x5A) Len		ID	Freq	Check_sum

Freq: The actual operating frequency of the radar.

Example:

10Hz [5A 06 03 0A 00 00]

250Hz [5A 06 03 FA 00 00]

4. Single trigger instruction ID_SAMPLE_TRIG=0x04

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	Only-1
Head(0x5A)	Len Upstream		ID	Check_sum

Data Frame

Example:

Command[5A 04 04 00]

5. Set the output format ID_OUTPUT_FORMAT=0x05

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3	Only-1
Head(0x5A)	Len Default value		ID	Format	Check_sum
				0x01	

Format: 0x01 (9 bytes cm output), 0x02 (PIX output), 0x06 (9 bytes mm output), 0x07 (with 32bit timestamp), 0x08 (ID0 output), 0x09 (8 bytes cm output), 0x0A (output with device ID).

Upward

Byte 0 Description		1	2	3	Only-1
Head(0x5A)	Len		ID	Format	Check_sum

Format: The actual output format configured by the radar.

Example:

PIX output [5A 05 05 02 00]

6. Set the serial port baud rate ID_BAUD_RATE=0x06

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3~6	Only-1
Head(0x5A)	Len Default value		ID	Baudrate	Check_sum
				115200	

Upward

Byte 0 Description		1	2	3~6	Only-1
Head(0x5A)	Len Baudrate: The serial	port	ID	Baudrate	Check_sum

baud rate that the radar is actually configured to.

Description: Configurable baud rate range [9600,921600].

Example:

9600 [5A 08 06 80 25 00 00 00]

19200 [5A 08 06 00 4B 00 00 00]

38400 [5A 08 06 00 96 00 00 00]

57600 [5A 08 06 00 E1 00 00 00]

115200 [5A 08 06 00 C2 01 00 00]

230400 [5A 08 06 00 84 03 00 00]

460800 [5A 08 06 00 08 07 00 00]

921600 [5A 08 06 00 10 0E 00 00]

7. Output switch ID_OUTPUT_EN=0x07

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3	Only-1
Head(0x5A)	Len	Default value		ID	Enable	Check_sum
					1	

Enable: 0 (output is not enabled), 1 (output is enabled).

Upward

Byte 0		1	2	3	Only-1
Description	Head(0x5A)	Len	Example:	ID	Enable	Check_sum

Enable output [5A 05 07 01 00]

Turn off output [5A 05 07 00 00]

8. Checksum switch ID_FRAME_CHECKSUM_EN=0x08

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3	Only-1
Head(0x5A)	Len	Default value		ID	Enable	Check_sum
					0	

Enable: 0 (checksum is not enabled), 1 (checksum is enabled).

Note: When the checksum is disabled, the radar does not check the checksum of the downlink data frame, and the uplink data frame still contains the correct checksum bytes.

Upward

Byte 0		1	2	3	Only-1
Description	Head(0x5A)	Len	Example:	ID	Enable	Check_sum

Turn on checksum [5A 05 08 01 00]

Turn off checksum [5A 05 08 00 67]

9. Modify the I2C slave address ID_I2C_SLAVE_ADDR=0x0B

Minimum firmware version supporting this protocol: V1.0.0.

Downward

Byte 0 Description		1	2	3	Only-1
Head(0x5A) Len	Default value		ID	I2c_slave_addr Check_sum	
				0x10	

I2c_slave_addr: range [0x08, 0x77];

Upward

Byte 0 Description		1	2	3	Only-1
Head(0x5A)	Len Example:		ID	I2c_slave_addr	Check_sum

Modify to 0x20 [5A 05 0B 20 00]

10.Restore factory settings ID_RESTORE_DEFAULT=0x10

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	Only-1
Head(0x5A)	Len Upstream		ID	Check_sum

Byte 0 Description		1	2	3	Only-1
Head(0x5A)	Len Status: 0 (success) non-0		ID	Status	Check_sum

(failure).

Example:

Command [5A 04 10 00]

11.Save the current settings ID_SAVE_SETTINGS=0x11

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	Only-1
Head(0x5A)	Len Upstream		ID	Check_sum

Byte 0 Description		1	2	3	Only-1
Head(0x5A)	Len Status: 0 (success) non-0		ID	Status	Check_sum

(failure).

Example:

Command [5A 04 11 00]

12. Read the production barcode ID_READ_MANU_BIN=0x12

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	Only-1
Head(0x5A)	Len Upstream		ID	Check_sum

Byte 0		1	2	3-16	Only-1

Description	Head(0x5A)	Len		ID	Bin	Check_sum

Bin: 14-byte production barcode.

Example:

Command[5A 04 12 00]

Feedback: U0900018010001, then the 3rd to 16th bytes are:

0x55 0x30 0x39 0x30 0x30 0x30 0x31 0x38 0x30 0x31 0x30 0x30 0x30 0x31

13. Get the full version number ID_GET_FULL_VERSION=0x14

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0	Description	1	2	Only-1
Head(0x5A)	Len		ID	Check_sum

Upward

Byte 0		1	2	3-10	11	12-19	20	21-22 23		24-25 26		27-28 Len-1	
Description	Head(0x5A)	Only	ID project name (right aligned)		'.' branch name (right aligned)		'.' Main version This issue		'.' minor version This issue		'.' Correction edition book Number		Check_sone

Example:

Command[5A 04 14 00]

14.Set AMP kick threshold ID_AMP_THRESHOLD=0x22

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0	Description	1	2	3	4-5	Only-1
Head(0x5A)	Len Default value		ID	Amp_Threshold	Dummy_Dist	Check_sum
				10	0	

Amp_Threshold: The AMP kick threshold is Amp_Threshold * 10. Below this threshold, the distance value is output as Dummy_Dist.

Dummy_Dist: The distance value output by AMP when it is lower than the kick threshold, in cm.

Upward

Byte 0		1	2	3	4-5	Only-1
Description	Head(0x5A) Len		ID	Amp_Threshold	Dummy_Dist	Check_sum

Example:

The Amp threshold is 300. When Amp<300, the output is 500cm [5A 07 22 1E F4 01 00]

15. Single and dual frequency mode switching ID_ DEALIAS_EN =0x29

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0		1	2	3	Only-1

Description Head(0x5A) Len Default value			ID	Enable	Check_sum
				1	

Enable: 1 (dual frequency mode) 0 (single frequency mode).

Upward

Byte 0 Description		1	2	3	Only-1
Head(0x5A) Len			ID	Enable	Check_sum

Example:

Dual frequency mode [5A 05 29 01 00]

Single frequency mode [5A 05 29 00 00]

16. Timestamp synchronization ID_TIMESTAMP_SYNC =0x31

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3-6	Only-1
Head(0x5A) Len Default value			ID	Std	Check_sum
				0	

Std: the specified current timestamp

Example:

Specify the current time as 1000ms [5A 08 31 E8 03 00 00 00]

17. Low power mode ID_LOW_CONSUMPTION=0x35

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3-4	Only-1
Head(0x5A) Len Default value			ID	Sample_rate Check_sum	
				0	

Sample_rate: Working frequency, 0 (low power mode is not enabled), >0 (low power mode is enabled).

Upward

Byte 0 Description		1	2	3-4	Only-1
Head(0x5A) Len			ID	Sample_rate Check_sum	

Example:

Low power consumption mode 10Hz output [5A 06 35 0A 00 00]

18. Filter configuration ID_FILTER_BIT_MAP=0x39

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3	Only-1
Head(0x5A) Len			ID	Filter_bit_map	Check_sum

default value				0x03	

Filter_bit_map: Filter enable control, 1 enables, 0 disables.

Bit0 - Kalman filter

Bit1 – Median filter

Upward

Byte 0		1	2	3	Only-1
Description	Head(0x5A) Len		ID	Filter_bit_map	Check_sum

Example:

Turn off filter [5A 05 39 00 00]

Turn on filter [5A 05 39 03 00]

19.Set distance limit ID_DIST_LIMIT=0x3A

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description		1	2	3-4	5-6	7	Only-1
Head(0x5A) Len	Default value		ID	Dist_min	Dist_max	Silence	Check_sum
				0	900	0	

Dist_min: Minimum distance value output, unit cm

Dist_max: The maximum distance value output, unit cm

Silence: 0 (outputs the limit endpoint value after exceeding the distance limit), 1 (does not output after exceeding the distance limit)

Upward

Byte 0		1	2	3-4	5-6	7	Only-1
Description	Head(0x5A) Len		ID	Dist_min	Dist_max	Silence	Check_sum

Example:

The minimum output distance is 20cm, and the maximum output distance is 500cm. After the distance limit is exceeded, the output limit endpoint value [5A 09 3A 14 00 F4 01 00 00]

20. Set the switching output mode ID_ON_OFF_MODE=0x3B

Minimum firmware version supporting this protocol: V1.0.0.

Downward

Byte 0 Description		1	2	3	4-5	6-7	8-9	10-11	Only-1
Head(0x	5A)	Only	ID	Mode	Dist	Zone	Delay1	Delay2	Check_sone
default value				0	0	0	0	0	

Mode: 0 (data output mode), 1 (switch mode, near high and far low), 2 (switch mode, near low and far high)

Dist: critical value, the proximal point value of the hysteresis interval, unit cm

Zone: hysteresis interval size, unit cm.

Delay1: Anti-shake delay time 1, unit ms. When the distance changes from far to near and exceeds the near-end threshold, and Delay1 ms remains smaller than the near-end threshold, the switch will be switched.

Change the level.

Delay2: anti-shake delay time 2, unit ms. When the distance changes from near to far and exceeds the far-end threshold, and Delay2 ms remains greater than the far-end threshold, the switch will be switched.

Change the level.

Example:

Near high and far low, Dist=200cm, Zone=10cm, Delay1=Delay2=1000ms [5A 0D 3B 01 C8 00 0A 00 E8 03 E8 03 00]

21. Read the specified radar configuration ID_GET_CONFIG_PARA=0x3F

Minimum firmware version supporting this protocol: V0.0.5.

Downward

Byte 0 Description	1	2	3	Only-1
Head(0x5A) Len Id: Corresponds to this		ID	Id	Check_sum

document ID definition.

Upstream: The upstream format of the corresponding ID command frame.

Example:

Read output frequency [5A 05 3F 03 00]

22. Ultra-low power mode ID_ ULTRA_LOW_POWER_MODE=0x58

Minimum firmware version supporting this protocol: V3.0.7.

Downward

Byte 0 Description	1	2	3	Only-1
Head(0x5A) Len Enable: 1 (enabled), 0		ID	Enable Check_sum	

(disabled)

Upward

Byte 0 Description	1	2	3	Only-1
Head(0x5A) Len		ID	Enable Check_sum	

Example:

Enter ultra-low power mode [5A 05 58 01 00]

Exit the ultra-low power mode [5A 05 58 00 00]. Due to the wake-up time in the ultra-low power mode, the exit command needs to be sent several times, such as [5A 05

58 00 00 5A 05 58 00 00 5A 05 58 00 00 5A 05 58 00 00 5A 05 58 00 00]ÿ

23. Frequency calibration ID_FREQ_CNT_CALIB=0x59

Minimum firmware version supporting this protocol: V3.0.7.

Downward

Byte 0 Description	1	2	3	Only-1
Head(0x5A) Len		ID	Cmd	Check_sum

Cmd: 1 (perform frequency calibration, takes about 2 seconds), 2 (read frequency calibration parameters)

Upward

Byte 0 Description	1	2	3-4	Only-1
Head(0x5A) Len		ID	Calib_freq_cnt	Check_sum

Calib_freq_cnt: Frequency calibration parameter, a non-0 value indicates calibration is completed

Example:

Perform frequency calibration [5A 05 59 01 00]

Read frequency calibration parameters [5A 05 59 02 00]

Appendix 3 I2C register list

Address	R/W	Name	Initial Value	Description
0x00	R	DIST_LOW	-	cm
0x01	R	DIST_HIGH	-	
0x02	R	AMP_LOW	-	
0x03	R	AMP_HIGH	-	
0x04	R	TEMP_LOW	-	0.01 degrees Celsius
0x05	R	TEMP_HIGH	-	
0x06	R	TICK_LOW	-- timestamp	
0x07	R	TICK_HIGH	-	
0x08	R	ERROR_LOW	-- Error status code	
0x09	R	ERROR_HIGH	-	
0x0A	R	VERSION_REVISION	-- Revision	
0x0B	R	VERSION_MINOR	--minor version	
0x0C	R	VERSION_MAJOR	-- major version	
0x0D-0x0F			-- reserve	
0x10-0x1D	R	SN	-	Production code, ASCII code, 14 bytes, 0x10 Store the first byte
0x1E			-- reserve	
0x1F	W	ULTRA_LOW_POWER	-	0x00: Standard mode 0x01: Ultra-low power consumption mode
0x20	W	SAVE	-- Write 0x01: Save the current register value	
0x21	W	SHUTDOWN/REBOOT	-- Write 0x02: Restart	
0x22	W/R	SLAVE_ADDR	0x10 range: [0x08, 0x77]	

0x23 W/R MODE			0x00 0x00: Continuous working mode 0x01: Command trigger mode	
0x24 W TRIG_ONE_SHOT			--	0x01: Trigger a range measurement, only the command triggers Valid in mode
0x25 W/R ENABLE			0x01 0x00: radar off 0x01: Radar on	
0x26 W/R FPS_LOW			0x64 frame rate	
0x27 W/R FPS_HIGH			0x00	
0x28 W/R LOW_POWER			0x00 0x00: Standard mode 0x01: low power mode	
0x29 W RESTORE_FACTORY_DEFAULTS -- Write 0x01: Restore factory register values				
0x2A W/R AMP_THR_LOW			0x64 AMP threshold. After AMP is lower than the threshold, Distance is fixed to DUMMY_DIST	
0x2B W/R AMP_THR_HIGH			0x00	
0x2C W/R DUMMY_DIST_LOW			0x00 When AMP is lower than the distance of AMP_THR output Distance, cm	
0x2D W/R DUMMY_DIST_HIGH			0x00	
0x2E W/R MIN_DIST_LOW			0x00 minimum distance value, mm, DUMMY_DIST Not subject to this restriction	
0x2F W/R MIN_DIST_HIGH			0x00	
0x30 W/R MAX_DIST_LOW			0x20 Maximum distance value, mm, DUMMY_DIST not subject to this restriction	
0x31	W/R MAX_DIST_HIGH		0x03	
0x32- 0x3B			-- reserve	
0x3C- 0x3F	R SIGNATURE		--	'L' 'U' 'N' 'A'