

TF-Luna Instruction Manual

TF-Luna LiDAR Module

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

Product information

Model: TF-Luna

Full name: TF-Luna LiDAR Module

Manufacturer

Company: Benewake (Beijing) Co. Ltd.

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Certification



Foreword

Dear users,

Thanks you for choosing Benewake products, and it's our pleasure to help you with any technical question.

To have a better experience, please read this manual carefully. We try to contain all common problems and hope you find the deployment and installation easy and fun.

This manual will guide you through the installation and operation process and show you some solution of common problems. It is still possible that you encounter some difficulties that are not included, please check our support service (supprt@benewake.com) and don't hesitate to contact our support consultants or leave a message on our feedback page on our official website: <http://benewake.com/en/mfeedback.html>

We hope you enjoy our product and join our community!

We are Benewake! Our goal is to make the best "Robotic Eyes" in the world!



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0 Revisions

Version No.	History	Date
A00	Original	2020.1.15
A03	<ol style="list-style-type: none">1. Old serial port formats are removed.2. Module size and related pictures are updated.3. More description of function.4. I2C interface is now available.5. Power supply voltage up to 3.7V-5.2V is now supported.	2020.3.15

1 Cautions

1.1 About document

- This manual provides all essential information you may need during the usage of this product.
- Please read this manual carefully before using this product and make sure that you are fully understand the contents of the manual.

1.2 About product

- The product can only be maintained and repaired by qualified professionals, and only original spare parts are permitted to use for performance and safety reasons.
- This product DO NOT have polarity and over-voltage protection at all. Please wire and supply power according to the instructions.
- The working temperature of the product is from -10°C to 60°C , please do not use it outside this temperature range to avoid risk and damage.
- The storage temperature of the product is from -20°C to 75°C , please do not store it outside this temperature range to avoid risk and damage.
- For safety and performance, please DO NOT open the product casing or remove the IR-pass filter.

1.3 Common errors and other notes

- Detecting object with high reflectivity, such as mirrors, smooth floor tiles, and calm milk liquid.
- Blocking the product with any transparent objects, such as water or glasses.



- The product's lenses may be covered by dusts or dirt which may affect results, so please keep those lenses clean.
- The exposed circuit board is electrostatic sensitive. Please do not touch the circuit board of the product barehanded. Please use ESD wrist strap or antistatic gloves to ground yourself if any operation is necessary; Otherwise, the product may be damaged by static electricity.

2 Principle description and key parameters

2.1 Ranging Principle

TF-Luna is using Time of Flight (TOF) principle to measure distance, and it periodically emits near infrared modulated waves. TF-Luna calculates the time by measuring the phase difference between the original wave and the reflection wave and uses that time to get relative distance, as shown in *Figure 1*.

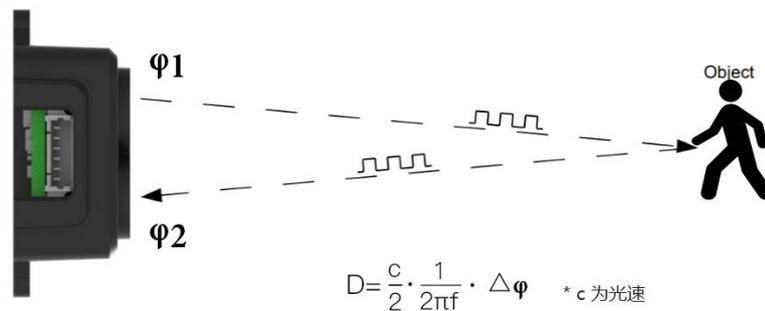


Figure 1: Schematics of TOF Principle

2.2 Basic Characteristic Parameters

Table 1: Parameters specification of TF-Luna

Description	Parameter value
Operating range	0.2m~8m ^①
Accuracy	±6cm@ (0.2-3m) ^②
	±2%@ (3m-8m)
Measurement unit	cm (Default)
Range resolution	1cm
FOV	2° ^②
Frame rate	1~250Hz (adjustable) ^③

① Operating range measured indoor based on a standard whiteboard with reflectivity 90% .

② This is theoretical, real value may be different.

③ 100Hz as default and only any factor (500/n, n can be any integer in [2, 500]) of 500Hz are available.



2.3 Repeatability

TF-Luna's ranging accuracy is positively correlated with the strength value (amp) and negatively correlated with the output frame rate (frequency). The tables below show the standard deviation (STD) using 100Hz output rate. These values are for reference only, various testing environments may give different results.

Table 1 STD Amp correlation

Amp	100	200	400	1000	≥2000
STD	3cm	3cm	2cm	1cm	0.5cm

Table 2 STD Dist correlation with 90% diffuse reflectance object

Dist	200cm	400cm	600cm	800cm
Std	0.5cm	1cm	1.5cm	2cm

2.4 Ranging characteristics

TF-Luna minimize the impact of external environment on ranging performance by optimizing light path and algorithm.

TF-Luna’s ranging dead zone is 20 cm or closer. Any distance output less than 20 cm is unreliable. The operating range of black and white targets are different:

The operating range of TF-Luna detecting black target with 10% reflectivity is 0.2-2.5m; The operating range of TF-Luna detecting white target with 90% reflectivity is 0.2-8m.

The ranging data are reliable only if the reflection surface fully covers the light spot, so the diameter of the object must at least the same as the diameter of the light spot, and that diameter depends on FOV of TF-Luna. The minimum diameter of the object surface has a formula:

$$d = 2 * D \cdot \tan\beta$$

In the formula, d represents the minimum diameter, D is the distance of the object, and β is the half FOV of TF-Luna. Common values are shown in table 4 for your convenience:



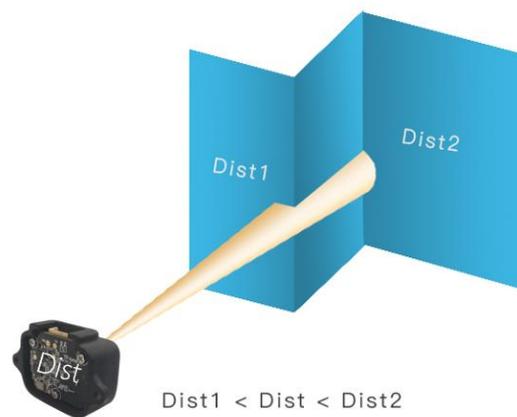


Table4 Distance and minimum diameter

Distance (D)	1m	2m	3m	4m	5m	6m	7m	8m
Minimum diameter (d)	3.5cm	7cm	10.5cm	14cm	17.5cm	21cm	24.5cm	28cm

If the light spot reaches two objects with different distances as Figure 2, the output distance value will be any value between the two actual distances of the objects, which may cause error for high-accuracy applications. Please try to avoid this situation for better accuracy and performance.

Figure 2 Detecting two objects at different location



3 Appearance and Structure

3.1 Appearance

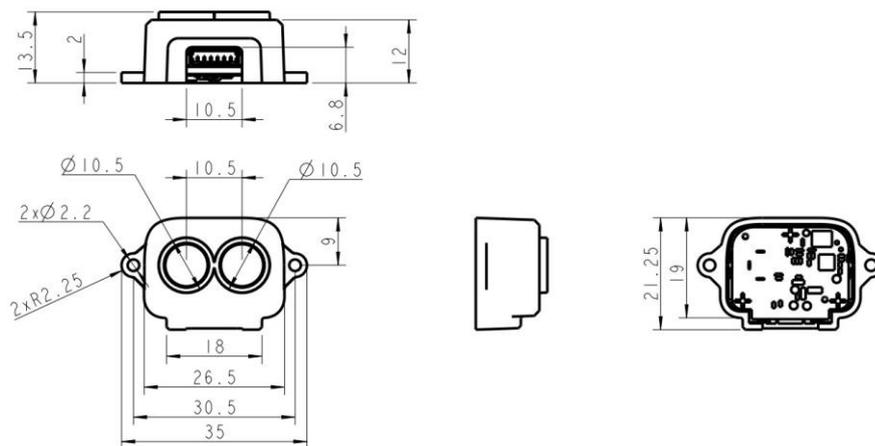


Figure 3 TF-Luna appearance and size drawing

4 Electrical Characteristics





Table 5: Major Electrical Parameters of TF-Luna

Description	Value range
Power supply voltage	3.7V-5.2V
Average current	≤70mA
Peak current	150mA
Power consumption	≤350mW
Communication signal level	LVTTTL (3.3V)

This product has no overvoltage nor polarity protection, so please make sure that the product is well connected, and the power supply voltage is inside the given range.

5 Functional Descriptions and configuration

5.1 Description about Line Sequence and Connection

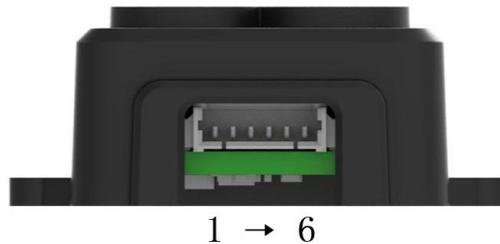


Figure 4 TF-Luna's pin numbers

Table 6: The Function and Connection Description of each pin

No.	Function	Description
1	+5V	Power supply
2	RXD/SDA	Receiving/Data
3	TXD/SCL	Transmitting/Clock
4	GND	Ground
5	Configuration Input	Ground: I2C mode /3.3V: Serial port Communications mode
6	Multiplexing output	Default: on/off mode output I2C mode: Data availability signal on but not switching value mode



5.2 Serial port Communication Protocol

Serial port Communication starts when pin 5 is disconnected or connected to 3.3v. It will set TF-Luna receiving RXD from pin 2 and sending TXD on pin 3. The serial port communication protocol is defined as follows: 8 data bits, 1 stop bit with no parity check and default baud rate of 115200 bps.

Serial port Communication Protocol data byte format:

byte	0	1	2	3~Len-2	Len-1
Description	Head(0x5A)	Len	ID	Payload	Checksum

Head: Fixed 0x5A.

Len: The length of bytes from the head byte to check-sum at the end, and it has to between 4 to 255.

ID: Indicates how to parse the Payload data.

Payload: Payload data segment, Optional.

Checksum: The lower 8 bytes of the sum from Head the Payload.

Please check **Appendix II Serial communication protocol** for more information.

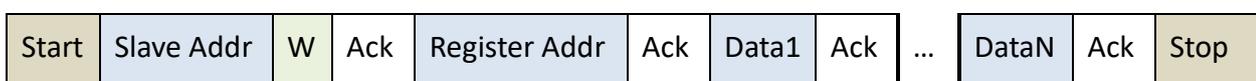
Note: Not as Checksum byte of the data frames sending from TF-Luna, those Checksum bytes that TF-Luna are not being check as default. Thus, **ANY** value is acceptable on the Checksum byte, **unless** checking of those bytes are required. Please check **“Enable/disable checksum comparison ID_FRAME_CHECKSUM_EN=0x08”** in **Appendix II Serial communication protocol** to enable the feature.

The instruction makes change immediately after sending, but the current setting is not saved and will lose after reboot. User must use **“Save current setting ID_SAVE_SETTINGS=0x11”** to save the change. The full save-current-setting11s hexadecimal string is 5A 04 11 00 in this case.

5.3 I2C communication

When pin 5 is connected to ground, TF-Luna enters I2C mode, then its pin 2 is use as SDA data and pin 3 is the SCL clock sending data. TF-Luna support up to 400kps clock speed as slave machine and its default address is 0x10. For more information about I2C register table **Appendix III I2C register table**.

Write register timing:



Read register timing:





Note that only in the read register timing: the first Stop signal is fine to be omitted, and an Ack signal is also working while replacing the last Nack signal.

In the continuous ranging mode, the host must monitor pin 6 for synchronous signal and initiate the read data operation in time. Otherwise, it may cause an error by reading and updating the data register at the same time. In multi-machine bus mode, use command to trigger reading is strongly recommended.

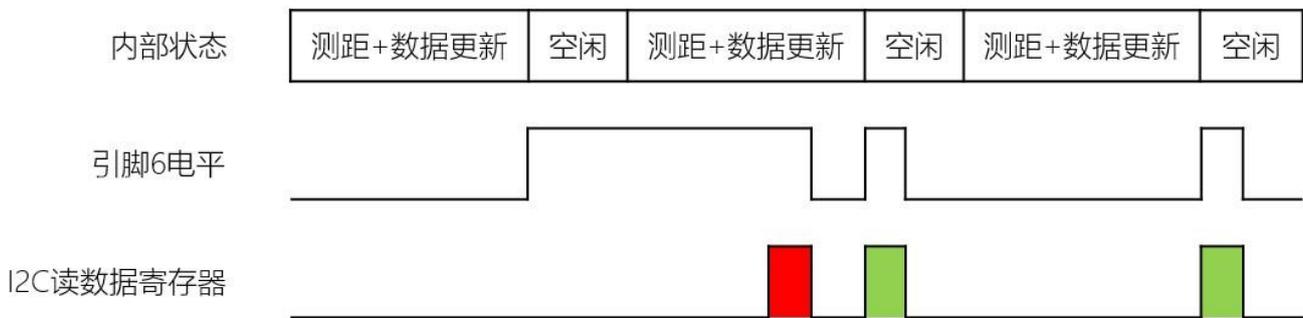


Figure 5 Timing of reading data register in I2C mode

Pin 6 is normal low level and it switches to high as soon as the data is updated. It switches to low level only if a read operation on any register is done. Therefore, I2C host must read the register when receive a high level on pin 6 in the continuous ranging mode. As the figure has shown above, the first result in red is unreliable and the rest two in green are accurate.

To writing the configuration value to the I2C register does not take effect immediately, nor will the power outage be saved, but writing 0x01 to address 0x20 will save the current register value and take effect after restarting. If the written configuration value is invalid, the register value remains valid. Generally, only writable register addresses take effect immediately after being written.

Normally write registers that are only writable are saved and start working immediately. However, changing a value of an I2C register is not. The changed value in I2C register are saved and effective after reboot only if the new value is valid and address 0x20 is written with value 0x01.





5.4 Basic data output

TF-Luna normally provide these data below:

- Distance (**Dist**): Default in centimeters.
- Signal strength (**Amp**): Distance value is unreliable when receiving signal is overexposure (Amp = 0xFFFF) or too low (Amp < 100 as 14).
- Chip Temperature (**Temp**): Celsius degree = Temp/8 - 256°C

TF-Luna supports various serial format, please check **Appendix I Serial port output format** for more information, and the default setting is 9-bytes/centimeter. Format setting is in “**Output format setting ID_OUTPUT_FORMAT=0x05**” section.

5.5 Continuous ranging mode

TF-Luna will keep tracking the distance 500 time per second, but as the customized output frequency is lower, the output may take the average. For instance, if the output frequency is 100Hz as default, then the output values are the average (arithmetic mean) of 5 previous range data. Therefore, lower output frequency gives less time of the averaging process as well as less fluctuation of the output. The highest output frequency that TF-Luna supports is 250Hz (output_frequency ≤ 250Hz), and it must be 500/n Hz (n is an integer that in the range [2, 500]). Thus, all supported values of output frequency are: 250Hz, 166Hz, 125Hz, 100Hz, ..., 2Hz, 1Hz. User can change the output frequency using “**Output frequency ID_SAMPLE_FREQ=0x03**”.

5.6 Trigger mode

TF-Luna enters trigger mode if the output frequency is set to be 0 with “**Output frequency ID_SAMPLE_FREQ=0x03**”. In this mode, TF-Luna stops measuring and outputting unless it is triggered by “**Trigger mode ID_SAMPLE_TRIG=0x04**” — in other words, TF-Luna measures and output once as soon as it receive the hexadecimal byte string 5A 04 04 00.



5.7 On/off mode

On/off mode is designed from those users only need to detect the existence of an object. TF-Luna can start this mode using “**Enable/disable on-off mode ID_ON_OFF_MODE=0x3B**” and then shows result through pin 6. Figure 7 below shows how the mode works when a high level is set to represent an object is detected.

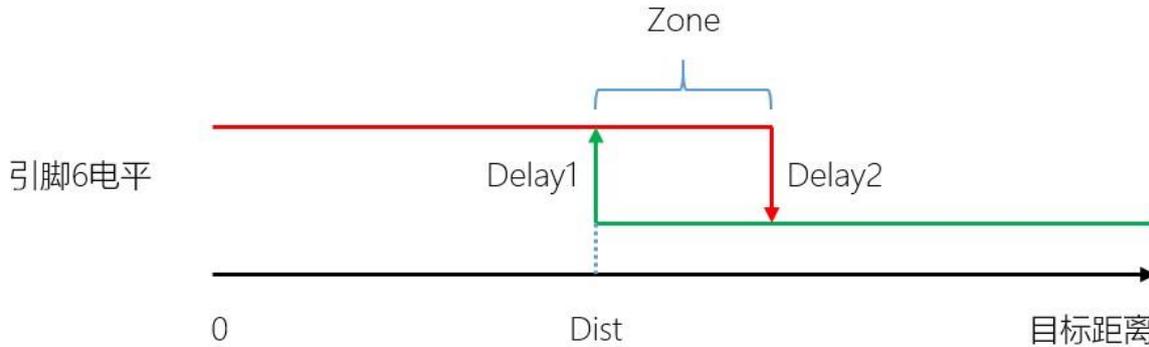


Figure 6 On/off mode that high level means closer

Zone value: If an object is detected closer than Dist, then Pin 6 outputs high-level, but only if an object is detected farther than Dist + Zone, then Pin 6 outputs low-level. When zone is set to 0, pin 6 may output up and down cause by fluctuation of the measuring when the real distance happens to be the same as Dist. That is why a proper zone value is needed to help avoid this situation by having a hysteric interval.

Delays is also supported to avoid inaccurate jumping output. Pin 6 changes its output depends on the Dist value condition and the time it last. Delay1(ms) and Delay2(ms) determine how long that approaching changes and leaving changes should wait after Dist value is already over the line.

Note: Since the Dist value is set to 0 under factory setting when no object is detected and Amp is too low, then pin 6 may have false output in the on/off mode. Please follow the instructions in **5.8 Amp threshold** to set the over-threshold value greater than Dist + Zone to avoid false output.

5.8 Amp threshold

The distance calculation may get false result if the Amp value is too low, so TF-Luna set the Dist value to dummy_dist(Default 0) when Amp is lower than amp_threshold (Default 100). If user need to change the Amp threshold value, please follow instructions in “**Amp threshold setting ID_AMP_THRESHOLD=0x22**”. Note that the final Amp threshold in TF-Luna is 10 times the value you send to it.

5.9 Distance limit

TF-Luna has a default maximum and minimum distance output: [min, max] = [0cm, 800cm]. User can change the output limits using “**Distance limit setting ID_DIST_LIMIT=0x3A**”.



Note: Any distance value lower than 20cm or greater than 800cm may be unreliable.

5.10 Power saving mode

TF-Luna supports power saving mode for power sensitive applications, it reduces its power consumption by adjusting both current level and duty cycle of the light source. With 5V power supply, TF-Luna's power consumption on **Continuous ranging mode** is about 350mW as the light source switch to highest current level and duty cycle.

When TF-Luna is on power saving mode, it dynamically adjusts the current of the light source by switching several preset current levels according to the strength (amp) of the receiving signal. Therefore, TF-Luna can get a stable amp value and save power consumption at the same time.

Users may reduce the duty cycle in different ways: to use trigger mode (about 42.5mW with 5V power supply) to turn the light source off while waiting, or to enable power saving mode. Power saving mode also turns the light source off, but it lets TF-Luna generate trigger signal periodically and automatically. The maximum sample frequency that gives TF-Luna a stable timing is 10Hz.

Please follow the format in "**Enable/disable Power saving mode (ECO) ID_LOW_CONSUMPTION=0x35**" section to enable power saving mode with listed working frequencies. The average current and power are measured with 5V power supply and the actual value might be different in various environment, especially different temperature or other power supply.

Power saving frequency	Avg current(mA)	Avg power (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
8Hz	11.3	56.5
9Hz	11.65	58.25
10Hz	12	60





5.11 Additional notes

Please check **Appendix II Serial communication protocol** for more options, such as version ID report, system software restore, baud rate configuration, etc.

6 Quick Test Guide

6.1 Required tools for testing

					
TF-Luna	Data cable	TTL to USB convertor	USB cable	PC	PC software

6.2 Steps

- ① Download and install the latest Test software

Please visit our official website (en.benewake.com) and download the Test software of TF-Luna.

Note: Please turn off any anti-virus software before uncompressing the PC software. Some anti-virus software may regard the ‘.exe’ file as virus. Also, released versions are only running on Windows systems currently.

- ② Connecting Hardware and cables



Figure 7 Schematic Diagram of Correct Connection

Please connect TF-Luna, TTL - USB converter, and USB cable properly as shown in 5. Please check





if there is any loose connection, and then plug the USB cable into your PC.

③ Open your Test software and check data output

Open the PC software and select “①TF-Luna” and select automatically recognized occupied serial port (in this case “② COM9”) as shown in Figure 6

Now click the “CONNECT” button, and a continuous images of the output data will be displayed in area “④ TIME LINE CHART” on the right if everything is connected successfully. The real-time data of the Current measure distance (Dist), effective data points per second (Effective Points) and signal strength (Strength) will be displayed in area “⑥ REAL TIME DATA” below as well.

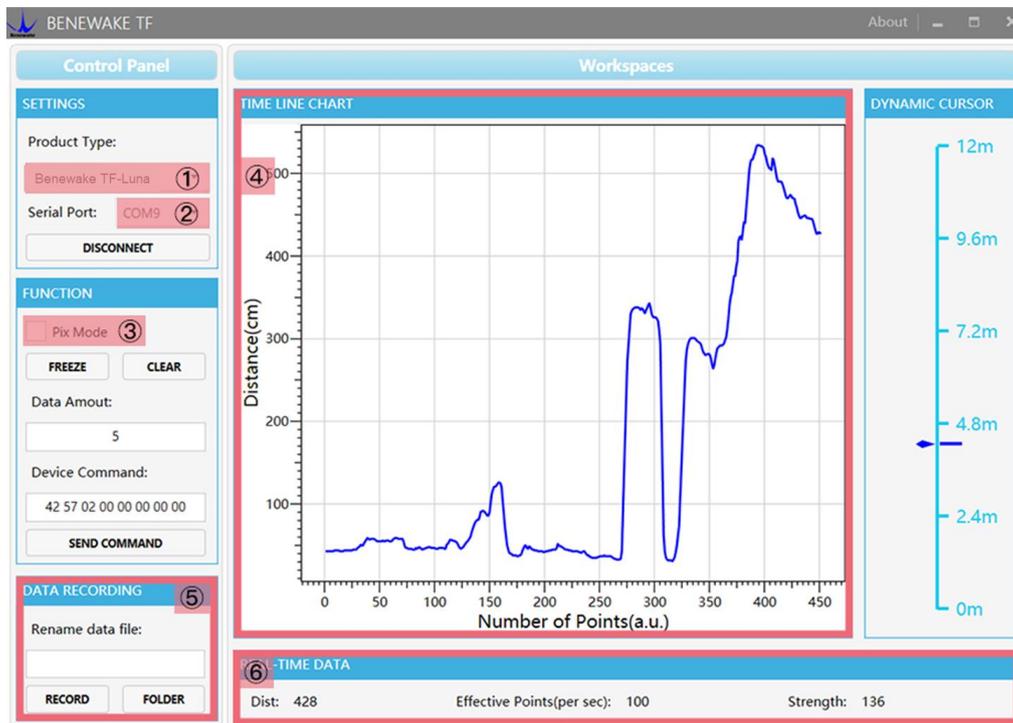


Figure 8: PC software Interface and Display

Notes:

- If nothing is displayed in area “④TIME LINE CHART”, please check the wire connection and sequence. A red LED indicator inside the transmitting lens at front will light up when TF-Luna is power-on.
- Please select “③Pix Mode” before switching TF-Luna’s outputs to Pixhawk format to avoid abnormal data display in the “④TIME LINE CHART” area. Note that selecting Pix Mode will automatically set the unit of distance to meters.
- Since TF-Luna does not pass unit information and the software always use centimeters as distance unit, the distance unit displayed in the chart remains the same as centimeter even if TF-Luna output in millimeter. For instance, suppose the actual measurement is one meter and the distance value from TF-Luna is 1000 mm, then the value read by the PC software is 1000. Thus, the



software will display 1000 with unit cm.

7 Firmware upgrade

TF-Luna allows upgrading firmware remotely when current firmware no longer support users' new requirements. Please contact us for the additional remote upgrading software if any relevant firmware upgrades are available on Benewake official website.

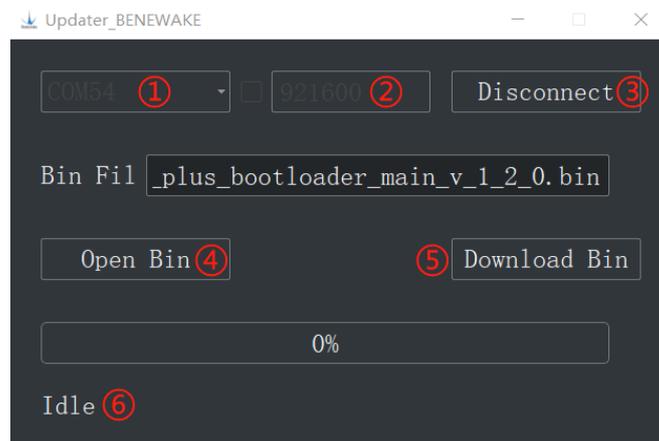


Figure 9: Firmware Upgrade PC software of TF-Luna

The tools for an upgrade are mostly the same as those in the Quick Test Guide, including a TTL/USB convertor to connect TF-Luna with PC.

Open the Updater.exe after connecting TF-Luna to your PC, and then select the correct port and baud rate, “①COM8” and “② 115200” in this case. Click “④ Open Bin” to choose the updating firmware, then the file directory will be displayed in the textbox above. Finally, click “⑤ Download Bin” to start upgrading and the upgrading information will show up in “⑥”.

Note: The full directory of the firmware files must use English letters only.

8 Appendix I Serial port output format

1. 9-byte/cm (Default)

This format is supported for any firmware after Ver. 0.0.5

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

Dist: cm

Amp: Signal strength indicator. Dist value is unreliable when Amp < 100 or Amp = 65535 (Overexposure)

Temp: Celsius temperature = Temp / 8 - 256°C

2. PIX

This format is supported for any firmware after Ver. 0.0.5





“X.YZ\r\n” is a sample ASCII string and only keep two significant digits in meter where “X.YZ” is the result.

3. 9-byte/mm

This format is supported for any firmware after Ver. 0.0.5

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

Dist: mm

Amp: Signal strength indicator. Dist value is unreliable when Amp < 100 or Amp = 65535 (Overexposure)

Temp: Celsius temperature = Temp / 8 - 256°C

4. 32-byte with timestamp

This format is supported for any firmware after Ver. 0.0.5

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

Dist: cm

Amp: Signal strength indicator. Dist value is unreliable when Amp < 100 or Amp = 65535 (Overexposure)

Timestamp: Timestamp (ms) is in small-end format

5. ID-0 output

This format is supported for any firmware after Ver. 0.0.5

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

Dist: cm

Amp: Signal strength indicator. Dist value is unreliable when Amp < 100 or Amp = 65535 (Overexposure)

Timestamp: Timestamp (ms) is in small-end format

6. 8-byte/cm

This format is supported for any firmware after Ver. 0.0.5

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

Dist: cm

Amp: Signal strength indicator. Dist value is unreliable when Amp < 100 or Amp = 65535 (Overexposure)

Timestamp: Timestamp (ms) is in small-end format

9 Appendix II Serial communication protocol

1. Version information ID_GET_VERSION=0x01

This format is supported for any firmware after Ver. 0.0.5

Downward:





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

Upward:

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

*Version: For instance, if the third, fourth, and fifth bytes are 112, 50, 9, then the version is 9.50.112

Sample instruction: [5A 04 01 00]

2. System software restore ID_SOFT_RESET=0x02

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Upward

byte	0	1	2	3	Len-1
Description	Head(0x5A)	Len	ID	*Status	Check_sum

*Status: 0 (success), otherwise (fail)

Note: Any change without “save current setting” instruction will not be saved and restore to original setting.

Sample instruction: [5A 04 02 00]

3. Output frequency ID_SAMPLE_FREQ=0x03

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Freq: Working frequency if Freq > 0, and Trigger mode if Freq = 0.

Upward

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

Freq: The current working frequency of the LiDAR

Sample instruction:

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

250Hz [5A 06 03 FA 00 00]

4. Trigger mode ID_SAMPLE_TRIG=0x04

This format is supported for any firmware after Ver. 0.0.5



Downward

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

Upward

Data frame

Sample instruction: [5A 04 04 00]

5. Output format setting ID_OUTPUT_FORMAT=0x05

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Format:

0x01 = 9-byte/cm

0x02 = PIX

0x06 = 9-byte/mm

0x07 = 32-byte with timestamp

0x08 = ID-0

0x09 = 8-byte/cm

Upward

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

Format: TF-Luna's current output format setting

Example: [5A 05 05 02 00] means PIX

6. Baud rate setting ID_BAUD_RATE=0x06

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Upward

byte	0	1	2	3~6	Len-1
Description	Head(0x5A)	Len	ID	Baudrate	Check_sum

Baudrate: TF-Luna's current baudrate.

Note: Only baud rate in [9600,921600] are supported.

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. Enable/disable output ID_OUTPUT_EN=0x07

This format is supported for any firmware after Ver. 0.0.5

Downward

byte	0	1	2	3	Len-1
Description	Head(0x5A)	Len	ID	Enable	Check_sum
Default				1	

Enable: 0 to disable, 1 to enable.

Upward

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

Example:

Enable output [5A 05 07 01 00]

Disable output [5A 05 07 00 00]

8. Enable/disable checksum comparison ID_FRAME_CHECKSUM_EN=0x08

This format is supported for any firmware after Ver. 0.0.5

Downward

byte	0	1	2	3	Len-1
Description	Head(0x5A)	Len	ID	Enable	Check_sum
Default				0	

Enable: 0 to disable, 1 to enable.

Note: Even if the Downward data checksum comparison is disabled, the valid checksum is still included in the upward data frame

Upward

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

Example:

Enable checksum comparison [5A 05 08 01 00]

Disable checksum comparison [5A 05 08 00 67]

9. I2C slave machine address configuration ID_I2C_SLAVE_ADDR=0x0B

This format is supported for any firmware after Ver. 1.0.0

Downward

byte	0	1	2	3	Len-1
------	---	---	---	---	-------



Description	Head(0x5A)	Len	ID	I2c_slave_addr	Check_sum
Default				0x10	

I2c_slave_addr: range [0x08, 0x77]

Upward

byte	0	1	2	3	Len-1
Description	Head(0x5A)	Len	ID	I2c_slave_addr	Check_sum

Example:

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

10. Restore default setting ID_RESTORE_DEFAULT=0x10

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Upward

byte	0	1	2	3	Len-1
Description	Head(0x5A)	Len	ID	Status	Check_sum

Status: 0 for success, otherwise for errors

Example:

Restore default setting [5A 04 10 00]

11. Save current setting ID_SAVE_SETTINGS=0x11

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Upward

byte	0	1	2	3	Len-1
Description	Head(0x5A)	Len	ID	Status	Check_sum

Status: 0 for success, otherwise for errors

Example: [5A 04 11 00]

12. Output product bar code ID_READ_MANU_BIN=0x12

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Upward

byte	0	1	2	3-16	Len-1
Description	Head(0x5A)	Len	ID	Bin	Check_sum



Bin: 14 byte product bar code

Example:

Send [5A 04 12 00]

Receive: U0900018010001, then the code is from the third byte to the sixteenth:

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

13. Get full-length version number ID_GET_FULL_VERSION=0x14

This format is supported for any firmware after Ver. 0.0.5

Downward

byte	0	1	2	Len-1
Description	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)	Len	ID	Name	'	Branch	'	Major version No.	'	Minor version No.	'	Revision version No.	Check_sum

Example: [5A 04 14 00]

14. Amp threshold setting ID_AMP_THRESHOLD=0x22

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Amp_Threshold: When Amp < Amp_Threshold * 10, then output Dummy_Dist instead of the result of calculation

Dummy_Dist: The output distance when Amp is too low.

Upward

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

Example:

To output 500 cm when Amp < 300 [5A 07 22 1E F4 01 00]

15. Timestamp synchronization ID_TIMESTAMP_SYNC =0x31

This format is supported for any firmware after Ver. 0.0.5

Downward

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





Std: The current std timestamp specified

Example:

To set timestamp to 1000ms [5A 08 31 E8 03 00 00 00]

16. Enable/disable Power saving mode (ECO) ID_LOW_CONSUMPTION=0x35

This format is supported for any firmware after Ver. 0.0.5

Downward

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

Sample_rate: Work frequency if Sample_rate is positive (0 to disable power saving)

Upward

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

Example:

Enable power saving mode and measure at 10Hz frequency [5A 06 35 0A 00 00]

17. Distance limit setting ID_DIST_LIMIT=0x3A

This format is supported for any firmware after Ver. 0.0.5

Downward

byte	0	1	2	3-4	5-6	7	Len-1
Description	Head(0x5A)	Len	ID	Dist_min	Dist_max	Silence	Check_sum
Default				0	800	0	

Dist_min: minimum distance output in centimeters.

Dist_max: maximum distance output in centimeters.

Silence: Not output when the distance is out of range if silence = 1. Output limit when out of range if silence = 0

Upward

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

Example:

Output limit when out of range with the minimum set to be 20cm and the maximum set to be 500cm

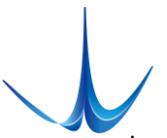
[5A 09 3A 14 00 F4 01 00 00]

18. Enable/disable on-off mode ID_ON_OFF_MODE=0x3B

This format is supported for any firmware after Ver. 1.0.0

Downward

byte	0	1	2	3	4-5	6-7	8-9	10-11	Len-1
Description	Head(0x5A)	Len	ID						Check_sum



Description	Head(0x5A)	Len	ID	Mode	Dist	Zone	Delay1	Delay2	Check_sum
Default				0	0	0	0	0	

Mode: 0 (Normal output) , 1 (On-off mode with high level output when closer) , 2 (On-off mode with low level output when closer)

Dist: critical dist value (the closer one) in centimeters.

Zone: Zone size in centimeters

Delay1: Delay time 1 in millisecond. Pin 6 switch level only if the distance detected is less than Dist and the situation last for Delay1 long.

Delay2: Delay time 2 in millisecond. Pin 6 switch level only if the distance detected is more than Dist + Zone and the situation last for Delay2 long.

Example:

Enable on-off mode with high level output when closer, and set Dist = 200cm, Zone=10cm, Delay1 = Delay2 = 1000ms:
[5A 0D 3B 01 CB 00 0A 00 E8 03 E8 03 00]

19. Enable/disable low sample rate mode ID_LOW_SAMPLE_RATE=0x3E

This format is supported for any firmware after Ver. 0.0.5

Downward

byte	0	1	2	3-6	7-10	Len-1
Description	Head(0x5A)	Len	ID	Output_period_s	One_shot_frames	Check_sum
Default				0	0	

Output_period_s: Only work when a positive number is given which means the time period of outputs are longer than one second and the output frequency is less than 1Hz.

One_shot_frames: This only work when sample_freq and output_period_s are valid. Only if output_period_s > 0, then the laser turns on every output_period_s second and then output the average output of one_shot_frames results.

Upward

byte	0	1	2	3-6	7-10	Len-1
Description	Head(0x5A)	Len	ID	Output_period_s	One_shot_frames	Check_sum

Example:

To measure once every 300 seconds and keep working for 1 second, user can let sample_freq = 1, output_period_s = 300, one_shot_frames = 1 [5A 06 03 01 00 00] [5A 0C 3E 2C 01 00 00 01 00 00 00 00]

20. Read config by id ID_GET_CONFIG_PARA=0x3F

This format is supported for any firmware after Ver. 0.0.5

Downward

byte	0	1	2	3	Len-1
Description	Head(0x5A)	Len	ID	Id	Check_sum

Id: The same as we mentioned above.

Upward: The same format of relevant Id.

Example:

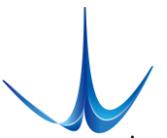
Read output frequency [5A 05 3F 03 00]



10 Appendix III I2C register table

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	--	Unit: 0.01 Celsius
0x05	R	TEMP_HIGH	--	
0x06	R	TICK_LOW	--	Timestamp
0x07	R	TICK_HIGH	--	
0x08	R	ERROR_LOW	--	
0x09	R	ERROR_HIGH	--	
0x0A	R	VERSION_REVISION	--	
0x0B	R	VERSION_MINOR	--	
0x0C	R	VERSION_MAJOR	--	
0x0D- 0x0F			--	Hold
0x10- 0x1D	R	SN	--	Production code in 14 bytes ASCII code (0x10 is the first byte)
0x1E- 0x1F				Hold
0x20	W	SAVE	--	Write 0x01 to save current setting
0x21	W	SHUTDOWN/REBOOT	--	Write 0x02 to reboot
0x22	W/R	SLAVE_ADDR	0x10	Range: [0x08, 0x77]





0x23	W/R	MODE	0x00	0x00: Continuous ranging mode 0x01: Trigger mode
0x24	W	TRIG_ONE_SHOT	--	0x01: Trigger once (only on trigger mode)
0x25	W/R	ENABLE	0x00	0x00: Turn on LiDAR 0x01: Turn off LiDAR
0x26	W/R	FPS_LOW	0x64	
0x27	W/R	FPS_HIGH	0x00	
0x28	W/R	LOW_POWER	0x00	0x00: Normal 0x01: Power saving mode
0x29	W	RESTORE_FACTORY_DEFAULTS	--	Write 0x01 to restore factory default settings
0x2A	W/R	AMP_THR_LOW	0x64	Amp threshold value
0x2B	W/R	AMP_THR_HIGH	0x00	
0x2C	W/R	DUMMY_DIST_LOW	0x00	Dummy dist value
0x2D	W/R	DUMMY_DIST_HIGH	0x00	
0x2E	W/R	MIN_DIST_LOW	0x00	Minimum dist in cm, but not working on DUMMY_DIST
0x2F	W/R	MIN_DIST_HIGH	0x00	
0x30	W/R	MAX_DIST_LOW	0x20	Maximum dist in cm, but not working on DUMMY_DIST
0x31	W/R	MAX_DIST_HIGH	0x03	
0x32- 0x33				Hold
0x34- 0x3F				Hold

