

# **Product Manual of TFmini**



**Mini LiDAR Module**

[www.benewake.com](http://www.benewake.com)  
Benewake (Beijing) Co., Ltd.

## Specified Product

Product model: TFmini

Product name: Mini LiDAR Module

## Manufacturer

Company name: Benewake (Beijing) Co. Ltd.

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## Product Certification



## Foreword

Dear users,

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

In the purpose of offering a better operation experience to you, we hereby write this manual for an easier and simpler operation of our product, hoping to better solve the common problems you maybe meet.

This operation manual covers the product operation introduction and common problem solutions, but it is really hard to covers all the problems you maybe meet. So if you have any further questions or problems, please feel free to consult our technical support service (support@benewake.com). We will do our best to solve any problem related to the product. If you have any other good advice or suggestion, welcome to visit our official website and offer us your feedback there (<http://benewake.com/en/mfeedback.html>), and we are looking forwards to your participation.

We are Benewake who dedicated to making the best “Robotic Eyes” worldwide!

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## 1 Attentions

### 1.1 About this Document

- This manual provides all the essential information during the usage of this product.
- Please carefully read this manual and make sure that you fully understand everything herein.

### 1.2 Usage of Product

- The maintenance work of this product is limited to the professional technician, and the product can only work with the factory spare part for ensuring the performance and safety thereof.
- This product itself has no polarity and over-voltage protection. Please properly connect and supply power as per the manuals herein.
- Operating temperature of this product is between 0°C and 60°C. Do not use it beyond this temperature range to avoid risk.
- Storage temperature of this product is between -20°C and 75°C. Do not store it beyond this temperature range to avoid risk.
- For ensuring the product performance, do not open the product shell or do any assembly or maintenance that not listed in this manual.

### 1.3 Conditions with Potential Product Failure

- The product will be subject to risk of failure if the detecting object has high reflectivity, such as the mirror or the smooth floor tile.
- The product will be subject to risk of failure if there is any transparent object between it and the detecting object, such as glass or water.
- The product will be subject to risk of failure if its transmitting or receiving lens is covered by the dust. Please keep the lens clean.
- Please do not directly touch circuit board of the product by hand as it is exposed. Please wear antistatic wrist strap or glove if necessary; Otherwise, the product will be subject to risk of failure, which is shown by failure of normal operation, and even it will be broken.

## 2 Functions and Key Parameters

### 2.1 Product Functions

TFmini is a mini LiDAR module. It is mainly capable of the function of real-time and contactless distance measurement and is featured by accurate, stable and high-speed distance measurement.



## 2.2 Principle of Distance Measurement

TFmini is based on TOF, namely, Time of Flight principle. To be specific, the product transmits modulation wave of near infrared ray on a periodic basis, which wave will reflect after contacting object. The product obtains time of flight by measuring round-trip phase difference and then calculates relative range between the product and the detection object, as shown in Figure1.

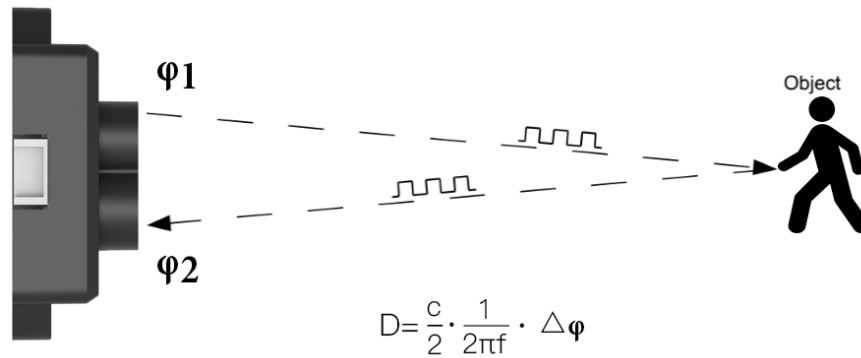


Figure 1 Schematics of TOF Principle

## 2.3 Key Characteristic Parameters

Table 1 Key Characteristic Parameters of TFmini

Description	Parameter value
Operating Range(Indoor)	0.3m~12m <sup>①</sup>
Measurement accuracy	±4cm@ (0.3-6m) <sup>②</sup>
	±6cm@ (6m-12m)
Default unit of distance	cm
Range resolution	5mm
Receiving half angle	1.15°
Transmitting half angle	1.5°
Frequency	100Hz

① Operating Range reachable under indoor standard white board condition (with reflectivity of 90%);

② A few points may be subject to an error of ±6cm due to switchover of distance measurement position within 0.3-2m.

## 2.4 Distance Measurement Characteristics

With optimization of light path and algorithm, TFmini has minimized influence from external environment on distance measurement performance. Despite that, the range of distance measurement may still be affected by the environment illumination intensity and the reflectivity of detection object. As shown in Figure 2:

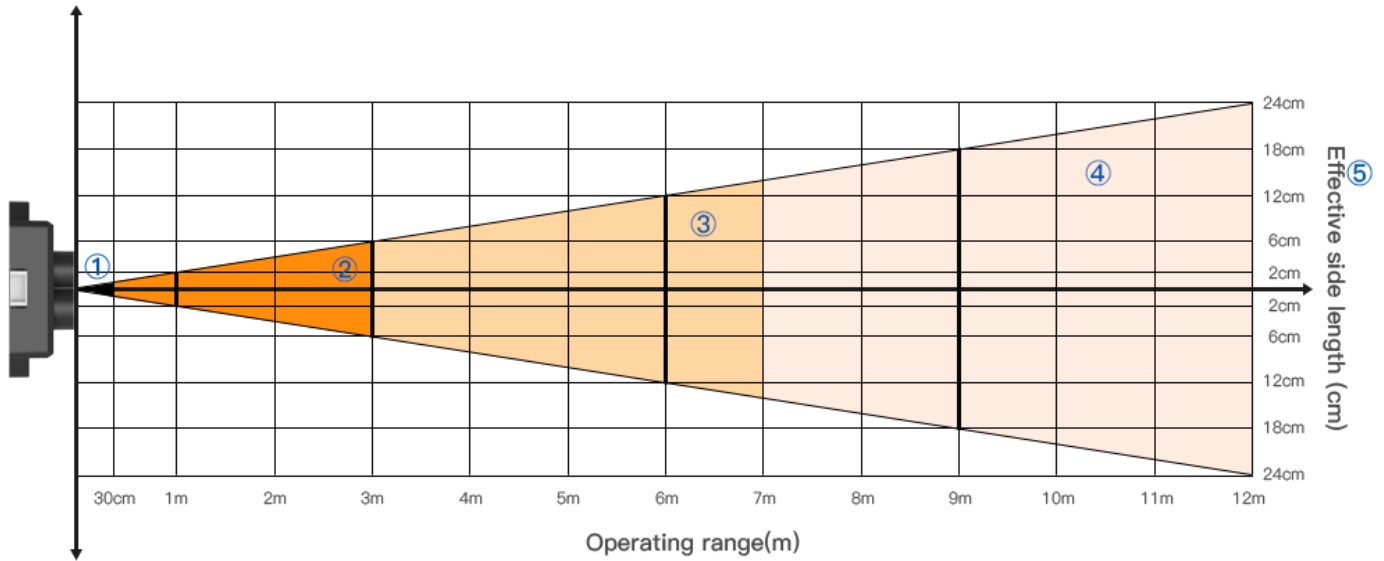


Figure 2 Schematics of Range of distance measurement and Effectiveness of the Product

- ①: Represents the detection blind area of TFmini, 0-30cm, within which the data is unreliable.
- ②: Represents the operating range of TFmini under extreme condition, which generally is 0.3-3m. Extreme condition refers to the outdoor glare (of which illumination intensity is around 100klux outdoors at noon in summer) and detection of black target (with reflectivity of 10%).
- ③: Represents the operating range of TFmini for white target under normal sunshine condition (with illumination intensity of around 70klux), which covers the range of ② and is 0.3-7m.
- ④: Represents the operating range of TFmini at the indoor environment or considerably weak ambient light environment, which is 0.3-12m.
- ⑤: Represents the Minimum side length of effective detection for TFmini at the different distances. The data will not be stable and reliable unless “the side length of detection object” is equal to or more than the Minimum side length. The Minimum side length of effective detection depends on the FOV of TFmini (the term of FOV generally refers to the smaller value between the receiving angle and the transmitting angle), which is calculated as follows:

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

In the above formula,  $d$  is the Minimum side length of effective detection;  $D$  is detecting range;  $\beta$  is the half of the value of the receiving angle of TFmini,  $1.15^\circ$ . Correspondence between the Minimum side length of effective detection and detecting range in general is given in Table 2.

Table 2 the Minimum side length of effective detection corresponding to Detecting Range

Detecting range	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m
Minimum side length	4cm	8cm	12cm	16cm	20cm	24cm	28cm	32cm	36cm	40cm	44cm	48cm





If the detection object cannot reach the Minimum side length of effective detection, as shown in Figure 3, the output (Dist) from TFmini will be a value between the actual distance values of the two objects. For a high accuracy requirements in practice, the above situation should be noticed to avoid the measurement error .

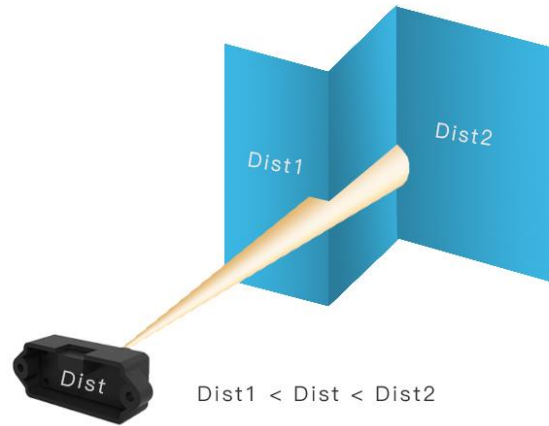


Figure 3 Distance Measurement in the case of Two Objects in Different Distances

### 3 Appearance and Structure

#### 3.1 Product Appearance

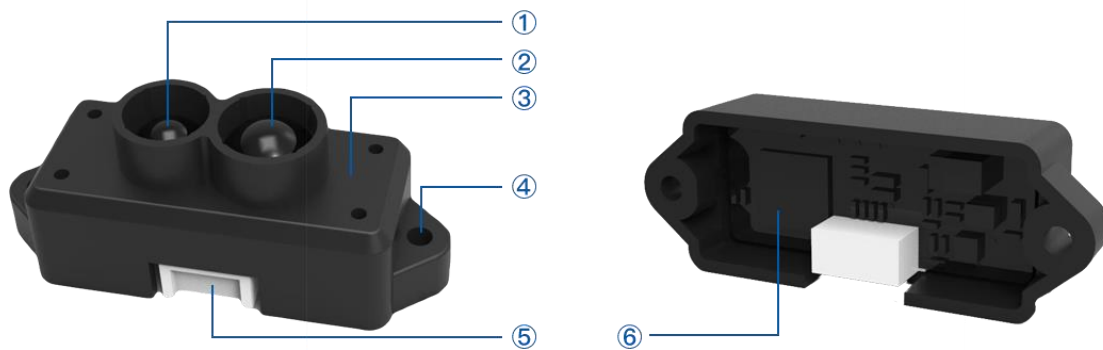


Figure 4: TFmini Product Appearance

- ① Transmitting lens
- ② Receiving lens
- ③ Enclosure, made of ABS+PC
- ④ Mounting hole is 2.35mm through hole. ST2.9 self-tapping screw is recommended for mounting and fixing.
- ⑤ Connecting terminal, GH1.25-4p SMT type; And along with the product there is a 10cm long connecting wire.
- ⑥ Circuit board, without covering enclosure at the rear of product.



### 3.2 Production Structure

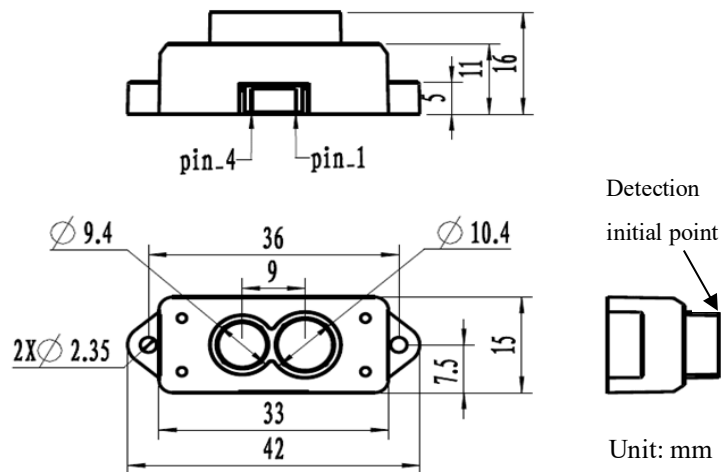


Figure 5 Constructional Drawing of TFmini

## 4 Electrical Characteristics

Table 3: Major Electrical Parameters of TFmini

Description	Parameter value
Power supply voltage	5V
Average current	≤120mA
Peak current	800mA
Average power	≤0.6W
Communication level	LVTTL (3.3V)

This product has no overvoltage nor polarity protection, so please make sure that connection and power supply are normal. The fluctuation of the power supply voltage in a range of  $\pm 0.1V$  is allowable.

Average current varies along with the operating modes of the product in two patterns, more specifically, its current is around 70mA under short distance mode and it is around 120mA under long distance mode. Please make sure that the power supply current meets the peak current of 800mA. In case of insufficient power supply current, the product maybe can't work normally.

## 5 Line Sequence and Data Communication Protocol

### 5.1 Description about Line Sequence and Connection

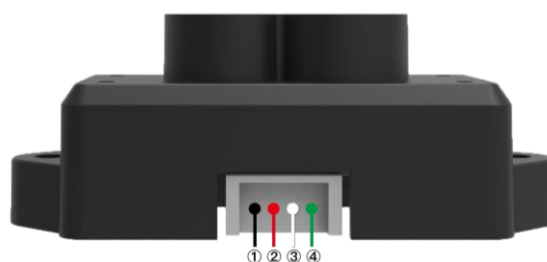




Table 4: The Function and Connection Description of each pin

No.	Pin	Function	Corresponding connection item
①	GND	Power supply	Power Ground
②	+5V	Power supply	Positive pole of power supply
③	TXD	Transmitting	RXD
④	RXD	Receiving	TXD

Type of connecting terminal: GH1.25-4P. The product includes a 10cm long connecting wire, the other end of which is a conventional 1.25-4p terminal (Molex510210400). The user may extend this wire as he/she needs. In order to ensure effective data transmission, it is recommended that the length of the connecting wire welded by the user should be less than 1m.

## 5.2 Data Communication Protocol

TFmini adopts the serial port data communication protocol, as given in Table 5.

Table 5 Data Communication Protocol of TFmini

Communication interface	UART
Default baud rate	115200
Data bit	8
Stop bit	1
Parity check	None

## 5.3 Data Output Format and Code

TFmini is available with two formats of data output, namely, the standard data output format and the Pixhawk data format, both of which can be mutually switchable via the instruction command.

- **Standard data output format (default):**

Data structure: each data package is 9 Byte, including the distance information (Dist), signal strength information (Strength), distance mode (Mode) and data check byte (Checksum), etc. Data format is hexadecimal (HEX). Data codes are detailed in Table 6

Table 6 Data Format and Code Explanation

Byte0 -1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8
0x59 59	Dist_L	Dist_H	Strength_L	Strength_H	Mode	0x00	Checksum
<b>Data code explanation</b>							
Byte0	0x59, frame header, same for each frame						

Byte1	0x59, frame header, same for each frame
Byte2	Dist_L distance value lower by 8 bits
Byte3	Dist_L distance value higher by 8 bits
Byte4	Strength_L low 8 bits
Byte5	Strength_L high 8 bits
Byte6	Mode, distance mode, represented respectively by 02 (short distance) and 07 (long distance), automatically switchable by default.
Byte7	Spare byte, 00 by default
Byte8	Checksum is the low 8 bits of the cumulative sum of the numbers of the first 8 bytes.

- **Serial port Pixhawk data format**

The data output is in the format of character string and its unit is m(meter). For example, if the measurement distance is 1.21m, the string 1.21 will be output, followed by the escape character `\r\n`.

#### 5.4 Descriptions of default Output Data

**Dist:** Represents the output of the distance value detected by TFmini, with the unit in cm by default. This value is interpreted into the decimal value in the range of 0-1200. In the practice, if the signal strength value- $Strength < 20$  (which is settable), the value of Dist will be deemed as unreliable and FFFF will be output by default (-1 in case of Pixhawk data format). If  $Strength \geq 20$  and actual distance  $> 12m$ , the default output value of Dist will be 1,200(cm).







**Strength:** Represents the signal strength with the default value in the range of 0-3,000. After the distance mode is set, the longer the distance measurement distance is, the lower the signal strength will be; the lower the reflectivity is, the lower the signal strength will be. It is recommended that the value of Dist be deemed reliable if Strength is within the range of 20-2,000, which is adjustable by the user at his/her own discretion depending upon the scenarios of application.

**Mode:** The parameter used to indicate distance mode of the product. There are two modes, namely, 02 and 07, which is short-distance and long-distance operating mode respectively. The default automatic switchover logic is as the follows: if the value of signal strength is less than a certain value (generally being 70-120) under 02 distance mode, then the distance mode is switched to 07 automatically, in which case the value of Strength will be significantly increased; if the value of signal strength is more than a certain value (generally being 1,200-1,600) under 07 distance mode, the distance mode is switched to 02, in which case the value of Strength will be significantly decreased.



## 6 Quick Test Procedures

### 6.1 Required Tools of Product Test

					
TFmini	Data wire	TTL - USB converter	USB cable	PC	PC software

### 6.2 Test Procedures

#### ① Download the PC software

Please download the PC software of TFmini at our official website (<http://www.benewake.com/en/down.html>).

Caution: please shut down any anti-virus software before uncompressing the PC software. Otherwise, maybe the software is deleted as virus. The software is only runnable under Windows environment for the time being. Please refer to Attachment 1 - Product manual of TF PC software.

#### ② Connection of the hardware

Connect “TFmini”, "data wire”, “TTL - USB board” and “USB cable” as shown in Figure 6. Make sure there is no loose connection. Then connect “USB cable” with “PC”.



Figure 6 Schematic Diagram of Correct Connection

#### ③ Connection to the PC software and data output

Open the PC software and select “①Benewake TFmini” and select automatically recognized occupied serial port (here it is “②COM9”), as shown in Figure 7

Then click “CONNECT”. Upon successful connection, The continuous images of the output data will be



displayed in area “④ TIME LINE CHART” on the right. Besides, 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.

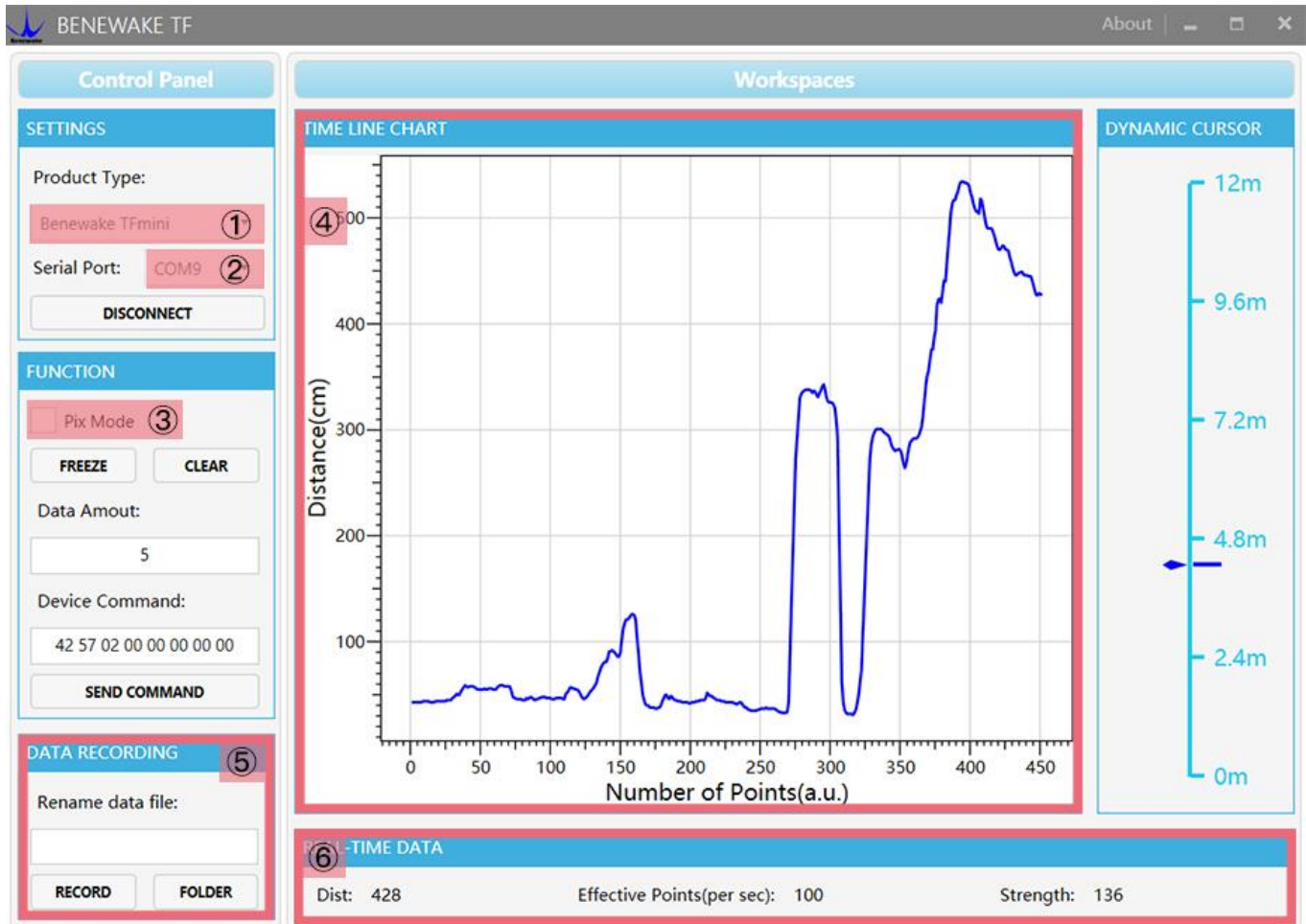


Figure 7 PC software Interface and Display

Notes:

- If no data is available in area “④TIME LINE CHART”, please check the line connection and line sequence. When TFmini is successfully powered on, there will be a red indicator light inside transmitting lens viewing from the front.
- If the user want the TFmini output in the Pixhawk format, please select “③Pix Mode” at first, otherwise area “④TIME LINE CHART” will not output the right data image normally. After Pix Mode is checked, the unit of distance will be changed into m automatically.
- The value of distance output Dist may vary with the output unit, which is cm by default. If the unit of distance is changed to the unit-mm via an instruction, and the PC software will be unable to identify it, and so the unit of “④TIME LINE CHART” will still be cm. For example, the actual TFmini measurement is 1m, the distance value of TFmini is 1000 in mm, the value read by the PC software also is 1000, but the unit will not change and still display cm.

## 7 Descriptions on User-defined Parameter Configuration

### 7.1 Function Overview

The function of user-defined configuration of product parameters is hereby enabled for more flexible settlement of your problems by TFmini. User may modify original parameters by sending relevant instructions, such as output data format and output cycle, etc. Upon successful configuration, the configured parameters will be saved in Flash without the need of reconfiguration for reboot in the event of power failure.

Please modify product configuration depending upon your actual demands. Do not frequently try irrelevant instructions so as to prevent incorrect sending of instruction which many cause unnecessary loss. Please make sure to make the configuration as per the instructions listed herein. Do not send unstated instruction.

### 7.2 Code Format of Configuration Instruction

Caution: All configuration instructions are sent as hexadecimal digits (HEX).

Table 7 Format and Details of Instruction Code

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x42	0x57	0x02	DD	EE	FF	GG	HH
Instruction code explanation							
Byte0-1	0x42 0x57, frame header, same for each frame						
Byte2	0x02 by default						
Byte3	The instructions are 0x00 by default during sending Upon the completion of sending instruction, there will be an echo, of which 0x01 represents success; 0xff represents error instruction; 0x0f represents error input parameter						
Byte4-5	EE FF double byte parameter, EE is low 8 bit; FF is high 8 bits						
Byte6	GG single byte parameter						
Byte7	HH instruction code						

### 7.3 General Parameter Configuration and Description

Before setting the relevant parameters of TFmini, user needs to establish the connection between TFmini and PC at first. About the connection details, refer to the test connection given in [6.2](#). User can send the relevant configuration-related instructions to the product via TFmini PC software or other serial port debugging software. The user may also send relevant instruction by himself via his upper computer.



- a) Enter configuration mode by the command: 42 57 02 00 00 00 01 02

Echo: 42 57 02 01 00 00 01 02, indicating successful sending;

- b) Configure product parameters by the command: 42 57 02 00 EE FF GG HH (Table 8)

Echo: 42 57 02 01 00 00 01 02, indicating successful sending;

- c) Exit configuration mode by the command: 42 57 02 00 00 00 00 02

Echo: 42 57 02 01 00 00 00 02, indicating the successful input of the command;

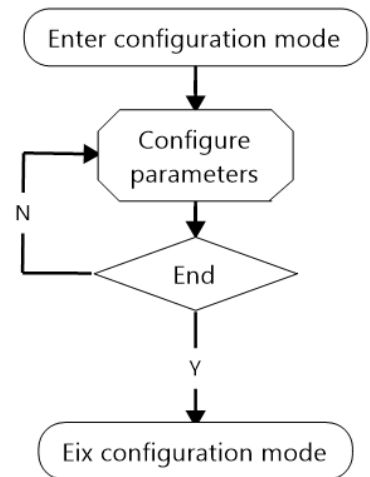


Figure 8 Flow Chart of General

Table 8 General Parameter Configuration and Description

S.N.	Configurable items	List of commands	Description	Default
①	Output data format	42 57 02 00 00 00 01 06	Standard format, as show in in Table 6	√
		42 57 02 00 00 00 04 06	“Pixhawk” data format	/
②	Data output cycle	42 57 02 00 EE FF 00 07	EE FF: setting of output cycle (ms) it must be the integral multiple of 10ms	10ms/ 100Hz
③	Unit of distance	42 57 02 00 00 00 00 1A	Output unit of distance data is mm	/
		42 57 02 00 00 00 01 1A	Output unit of distance data is cm	√
④	Detection pattern	42 57 02 00 00 00 00 14	Automatic detection pattern	√
		42 57 02 00 00 00 01 14	Fix detection pattern	/
	Distance mode	42 57 02 00 00 00 02 11	Short distance mode, applicable for 0-5m	
		42 57 02 00 00 00 07 11	Long distance mode, applicable for 1-12m	
⑤	Setting of range limit	42 57 02 00 00 00 00 19	Range limit disabled	/
		42 57 02 00 EE FF 01 19	Range limit enabled EE FF: threshold of ranging limit (mm)	Range limit: 12m
⑥	lower limit of signal strength threshold	42 57 02 00 EE 00 00 20	EE: setting of the lower limit of signal strength threshold. If the real signal is lower than the set threshold, “FF FF” will be output as the distance value which means invalid.	minimum threshold 20(DEC)
⑦	upper limit of signal strength threshold	42 57 02 00 EE FF GG 21	EE FF: setting of the maximum signal strength threshold GG: output distance value (cm)	/

### Explanation:

- ① The standard data output format is given in Table 6. “Pixhawk” data format is mainly used for the connection of Pixhawk, under which the data output is decimal string.



- ② This configuration is mainly used for the adjustment of the output frequency of product. Note that the value of EE FF must be integral multiple of 10; otherwise the command will be invalid. The output frequency is 100Hz (one output per 10 ms ) at max, and the minimum frequency is one output per 65530 ms. This configuration will not affect the real detection frequency of the hardware, but it only represents the frequency of data output. So the goal of power saving can't be achieved by the means of such instruction.
- ③ The unit of distance output generally is cm by default and can be modified into mm. With the unit modified into mm, the distance change at level of mm is available, allowing the product to be applicable for the scenario with a single detection object and high accuracy requirement.
- ④ TFmini is built in with two distance modes which are automatically switchable by default. As there is a larger error during the automatic switchover of the two modes, the user may choose fixed detection pattern if there are high accuracy requirement within the limited measurement range. During the usage, please input the command for the fixed detection pattern at first and then send configuration instruction of the distance mode. The long/short distance mode configuration will become invalid once the TFmini starts the automatic switchover of distance modes.
- ⑤ The range output limit is 12 meters and it is enabled by default. When the limit is disabled, the measurement data in the range of 0-15m can be output. However, the data above 12m is fitting data with significant error. So the range limit are modifiable by the user depending upon the demands. Upon the modification, the set threshold will be output if the measurement data more than such threshold
- ⑥ The setting of minimum signal strength threshold will be valid only if ⑤ is enabled, and it is 20 by default, which means that the distance value will output FF FF if the Strength is less than 20. The user may increase such threshold in order to improve reliability of the distance measurement value. But note that the maximum threshold should be no more than 80; otherwise the LiDAR may not operate normally. Correspondingly the threshold may be decreased in order to improve the measurement range of TFmini.
- ⑦ The setting of the maximum signal strength threshold will be valid only if ⑤ is enabled. Such function is used when the user wants to set a fixed value for the near distance object detection. For e.g.:If the user has to use the TFmini within its blind area, this command can be input and then the output value of the blind area will be set to a fixed value in order to maintain a stable data.

#### 7.4 Special Parameter Configuration Procedures and Description

The procedures of special parameter configuration are same as the general parameter configuration, without the need of sending the instruction for exiting configuration. The procedures are as follows:

a) Enter the configuration mode to send: 42 57 02 00 00 00 01 02

Echo: 42 57 02 01 00 00 01 02, indicating successful sending;



b) Send configuration instruction, sending: 42 57 02 00 EE FF GG HH (for detailed instruction, refer to Table 9)

Echo: 42 57 02 01 EE FF GG HH with the detailed value corresponding to the sent instruction

Table 9 Special Parameter Configuration and Description

S.N.	Configurable items	List of instructions	Description	Default
⑧	Setting of baud rate	42 57 02 00 00 00 GG 08	The baud rate corresponding to GG is shown in Table 10	115200
⑨	Setting of trigger source	42 57 02 00 00 00 01 40	Internal trigger, 100Hz by default	√
		42 57 02 00 00 00 00 40	External trigger	/
	Externally trigger setting	42 57 02 00 00 00 00 41	command for one single measurement	
⑩	Reset	42 57 02 00 FF FF FF FF	All settings are reset to the default	/

### Explanation:

- ⑧ Setting of baud rate. The user may configure it upon his own communication demand.
- ⑨ There are two trigger modes for the measurement of TFmini. The default one is the internal trigger by the timer with one measurement per 10ms. The user may modify this mode into the external trigger mode which allows the TFmini to start the distance measurement by an external trigger instruction . Please note that the trigger frequency of TFmini should in no way be more than 80Hz as the maximum.
- ⑩ Reset of default configuration. By sending such instruction, all adjustable configurations will be reset back to the default configurations. Please use it with caution.

Table 10 Corresponding List of Baud Rate Settings

<b>GG</b>	0x00	0x01	0x02	0x03	0x04	0x05	0x06
<b>Baud rate</b>	9600	14400	19200	38400	56000	57600	115200
<b>GG</b>	0x07	0x08	0x09	0x0a	0x0b	0x0c	/
<b>Baud rate</b>	128000	230400	256000	460800	500000	512000	/

## 8 Remote Upgrading

TFmini supports the remote upgrade. When the user's product cannot satisfy the current application requirements and Benewake website has relevant firmware upgrades, the user may upgrade the product firmware via remotely upgrading the PC software .

The PC software may obtain the program version number and the product serial number by remote upgrade, and it assess whether the product needs to be upgraded. The firmware for the upgrade is contained in the zip file, and the PC software can automatically select the relative firmware for upgrade.

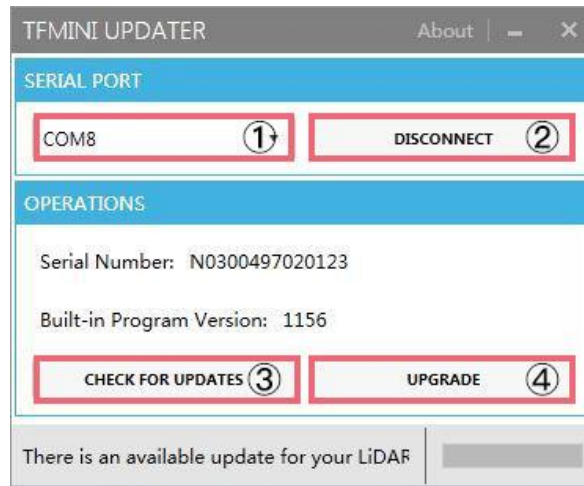


Figure 8 Firmware Upgrade PC software of TFmini

The tools for the firmware upgrade of TFmini are mostly the same as the [Quick Test Procedures](#) , which requires one TTL-USB board to connect the TFmini with PC.

Upon successful connection, open the PC software for the remote upgrade. Select appropriate port. Here it is “①COM8”. Click “② CONNECT” to connect the TFmini with the PC software. Click “③ CHECK FOR UPDATES”. The software window will show the product number and firmware version of this product, and besides it will give an upgrade prompt . However, in case of some old versions of this product, the software maybe can’t show the product number and version information, but it still supports the function of firmware upgrade. Then click “④UPGRADE” to complete upgrade.

**Caution:** please confirm that the communication bit rate of this product is 115200 before the firmware upgrade, as TFmini will be unable to upgrade at other bit rates.

## 9 Faults: Causes and Troubleshooting

**(1) Distance value occasionally will abruptly change into a fixed value beyond the range during normal operation.**

**Cause:** The different test environments (reflectivity of detected object, disturbance of ambient light, etc.) will affect the signal strength of TFmini. For a reliable and stable measurement data, the algorithm elimination is internally used for TFmini. In case of the insufficient signal strength, TFmini will feedback an extreme range, 12m, as a special symbol under the default condition. This value is not measurement data of TFmini, which is only used to prompt the user that such data is unreliable.

**Troubleshooting:** please use such value as the trigger signal of some unreliable data, and it will ensure that your system can use other reliable data for further assessment and decision-making if there are some unreliable data.

## (2) Significant error between the output distant value of LiDAR and actual distance

**Cause ①:** Incorrect interpretation of the data communication protocol of TFmini.

**Troubleshooting:** check data communication interpretation means. In case of such error, please check the data format to adjust interpretation means.

**Cause ②:** Due to the physical principles of TFmini, the above phenomenon is likely to occur if the detection object is the material with high reflectivity (such as mirror, smooth floor tile, etc.) or transparent substance (such as glass and water, etc.)

**Troubleshooting:** Please avoid use of this product under such circumstance in practice.

**Cause ③:** Lens of the product are covered by the foreign matter.

**Troubleshooting:** please use dry dust-free cloth to gently remove the foreign matter

## (3) TFmini fails to output data

**Cause:** The product will be strictly inspected before leaving our factory, ensuring that all the shipped products can work normally. However, some abnormal working matters maybe still occur because of incidents during the transportation or use.

**Troubleshooting:** Check whether the power supply is normal; check whether the voltage is within rated voltage range. If power supply is normal, there will be a red light inside the transmitting lens of TFmini.

Check TFmini with correct connection sequence and reliable connection.

Check whether the data interpretation is correct. Please carry out the interpretation as per the data format specified herein.

If the problem persists, please contact our technical support.

## (4) There is no data output when LiDAR is connected to PC software.

**Cause ①:** The PC software only supports the Windows operation system for the time being

**Troubleshooting:** Use the PC supporting Windows operation system.

**Cause ②:** TTL - USB board is poorly connected.

**Troubleshooting:** Check the TTL -USB board with the correct and reliable connection with TFmini and PC.

**Cause ③:** Driver of serial port is not correctly installed.

**Troubleshooting:** Plug and unplug USB cable again. Try to reinstall the driver or directly download and

install a driver from the internet.

If the PC software still work abnormally, please contact our technical support.

## 10 QA

Q1: Is TFmini available with 3.3V or other power supply voltage?

A1: Sorry, it is not available for the time being. The Standard power supply of TFmini is 5V. If you have any further requirement, please contact our sales person to consult a customization design matter.

Q2: TFmini will heat up after operating for a while. Is it broken?

A2: This is the normal operating condition of the product. The temperature of the chip and circuit board will slightly up after a continuous operation, which is a normal case.

Q3: Can TFmini be connected with Arduino or Raspberry Pi for use?

A3: Yes, it can. TFmini adopts serial communication protocol so that it can connect to any control board supporting serial port communication.

## Contact

### Headquart

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## Attachment 1: Specifications of TF Series PC software

This PC software only supports the Windows operating system for the time being, and besides it is applicable to any TF series products of Benewake but the output of those products is limited to the serial port communication protocol. Detailed operations are as below.

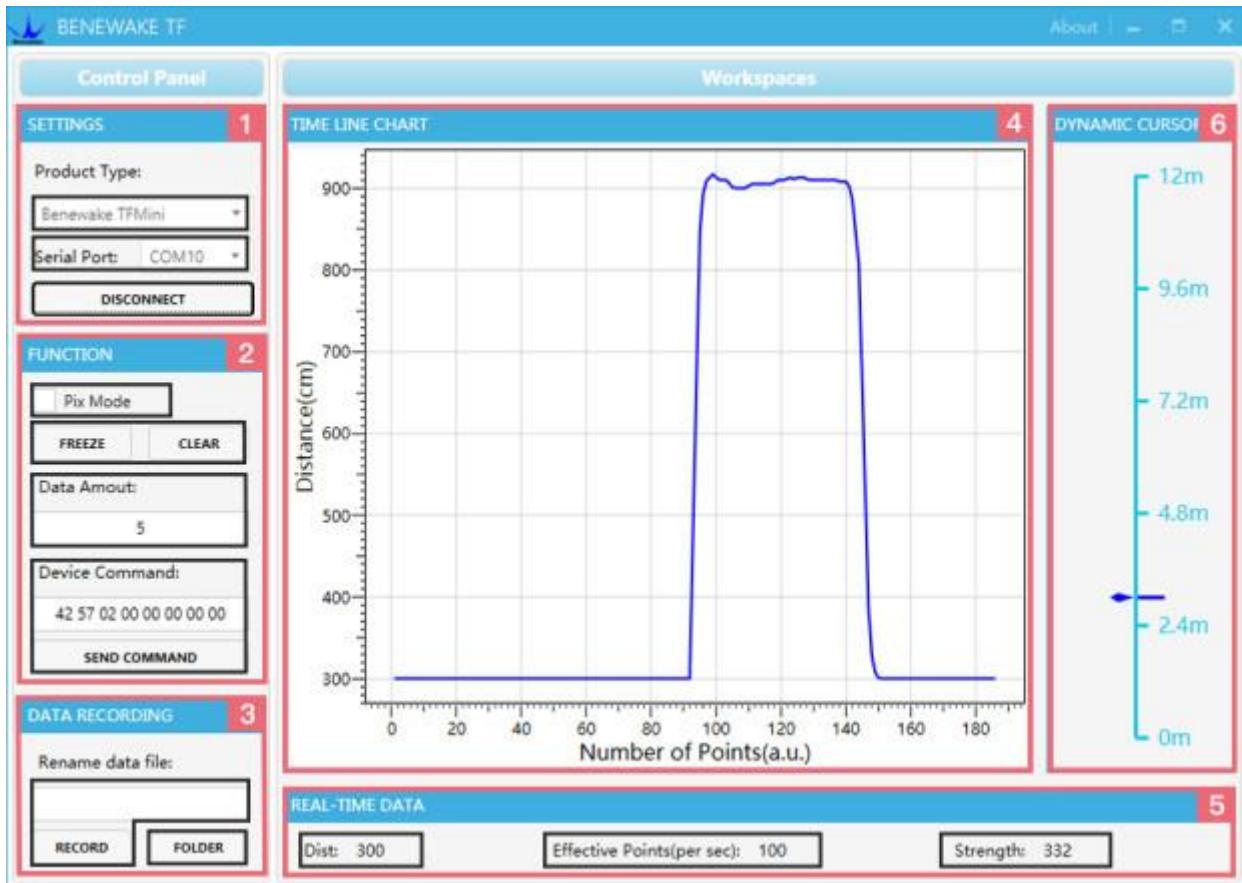


Figure 1: Interface of TF Series PC software

### 1 Product Type/Serial Port Control Zone [SETTINGS]

Product Type Selection: connect the LiDAR via TTL-USB board to the PC. As shown in the figure, we use our TFmini product and just select 'Benewake TFMini'.

Serial port communication: in the PC select the right serial port number corresponding to the LiDAR.

CONNECT/DISCONNECT: Click [CONNECT] button to establish the connection with LiDAR. Click [DISCONNECT] button to terminate the connection.

### 2 Function Zone [FUNCTION]

Pix Mode selection: in case of Pixhawk version, PIX mode will be enabled after selecting. It is default output format if no selecting PIX mode.

FREEZE/CLEAR PAUSE/CLEAR button: After clicking [FREEZE], the PC software will be paused to

make it easier to analyze the curve in [4]; after clicking [CLEAR], the plotted curve in [4] will be cleared and the plotting will be restarted.

Data Amount, 5 by default, e.g.: upon receipt of every five data, the PC software will output one averaged data of the 5 data. The number of the data can be modified depending upon the actual requirement (the value is preferable to be  $\geq 5$  to prevent the PC software from lagging). After entering the value, send a command by pressing “Enter” key on the keyboard.

Device Command, the text box for the configuration instruction: The instructions of hexadecimal serial port can be sent to TFmini via this window. It should be noted that the “Enter” key should be clicked after inputting the command, and then click the [SEND COMMAND] in the below.

### **3 Data Recording Zone [DATA RECORDING]**

Record data toolbar: name the data file which needs to be saved in this text window and then press “Enter” key after naming, and then press [RECORD] button. The data will be saved in the file. Click the [FINISHED] button if the user want to the terminate data recording.

[FOLDER] , open the folder where the data file is saved.

### **4 Data Curve Display Zone [TIME LINE CHART]**

The PC software will draw the continuous distance measurement curves based on the received data, where y-coordinates represent the current distance data while x-coordinates represent those effective data.

### **5 Real-time Data Display Zone [REAL-TIME DATA]**

Dist Distance measurement value: expressed in cm by default.

Effective data (per sec): indicates effective data refreshed by TF per each second.

Strength Signal strength: under pix mode, Strength is 0 by default in the absence of strength input.

### **6 Range Cursor [DYNAMIC CURSOR]**

Distance values are displayed in real-time way depending upon the current product type.

## Attachment 2: Development Routine of TFmini in Arduino

In this routine, UNO and DUE board is taken as example, which is mainly for the user to quickly familiarize himself with our LiDAR and thus save the time of the product development.

For detailed introduction and tutorial of Arduino, please refer to following two websites:

Chinese website: <http://www.arduino.cn/>

English official website: <https://www.arduino.cc/>

### Step 1: Hardware Connection

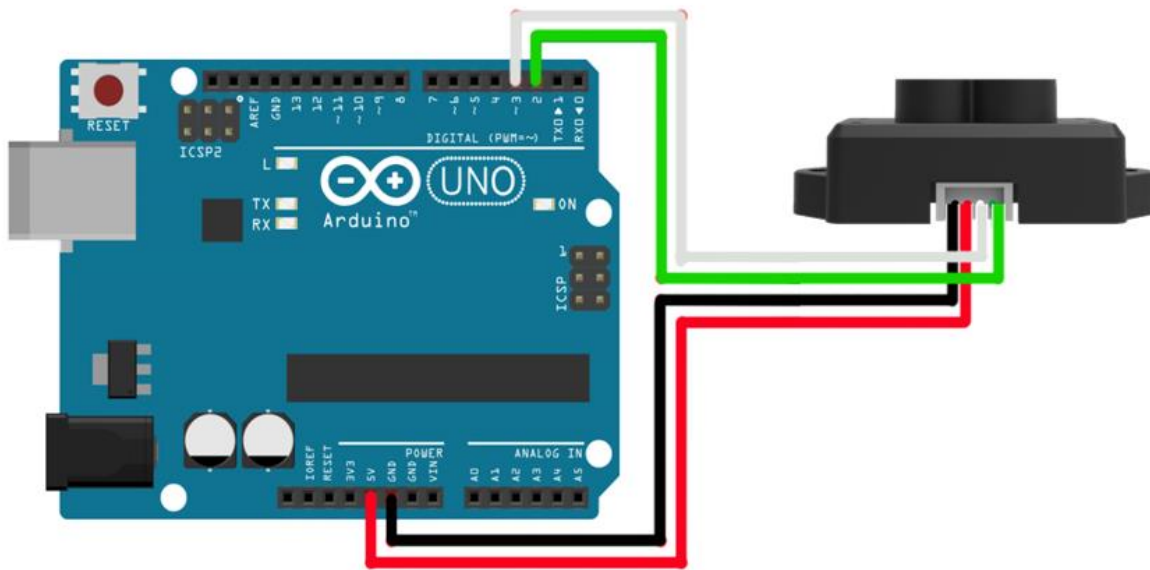


Figure 1: Schematic Diagram of Connection between TFmini and UNO Board

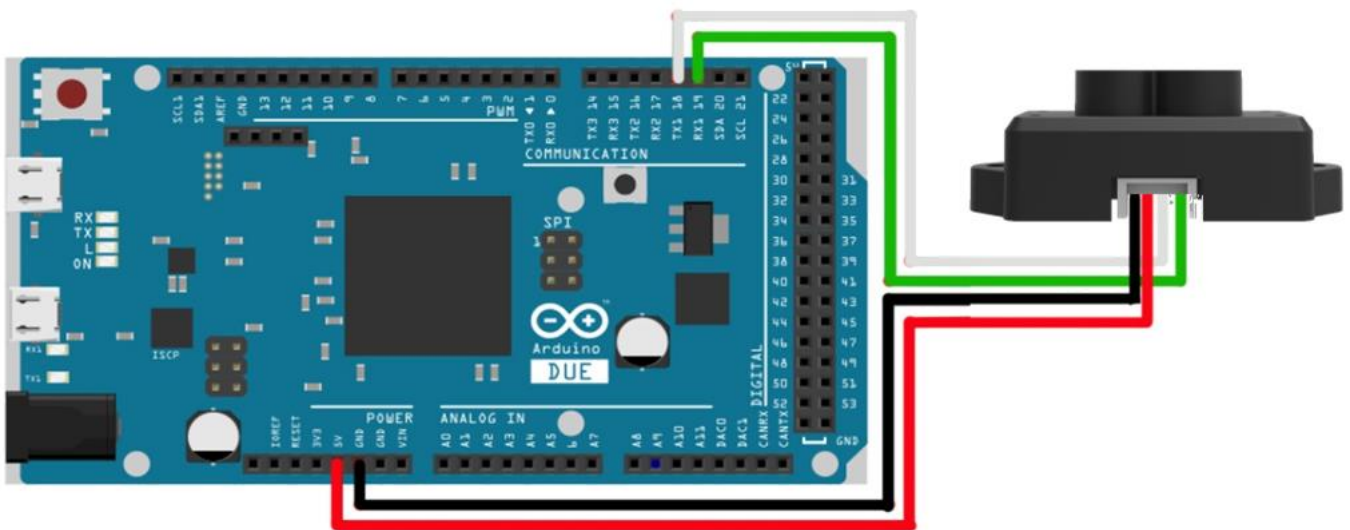


Figure 2: Schematic Diagram of Connection between TFmini and DUE Board



## Step 2: Program Compilation

At least two serial ports of Arduino are required for achievement of this routine function with one for receiving data of LiDAR and the other for outputting data to PC for display. The user may either copy following code and paste it in the IDE program editing window or directly open relevant enclosed file.

/\* this program is the interpretation routine of standard output protocol of TFmini product on Arduino. For details, refer to Product Specifications.

For Arduino boards with only one serial port like UNO board, the function of software visual serial port is to be used.

```
*/  
  
#include<SoftwareSerial.h>//header file of software serial port  
SoftwareSerial Serial1(2,3); //define software serial port name as Serial1 and define pin2 as RX and pin3  
as TX  
/* For Arduinoboard with multiple serial ports like DUEboard, interpret above two pieces of code and  
directly use Serial1 serial port*/  
int dist;//actual distance measurements of LiDAR  
int strength;//signal strength of LiDAR  
int check;//save check value  
int i;  
int uart[9];//save data measured by LiDAR  
const int HEADER=0x59;//frame header of data package  
void setup()  
{  
  Serial.begin(9600);//set bit rate of serial port connecting Arduino with computer  
  Serial1.begin(115200);//set bit rate of serial port connecting LiDAR with Arduino  
}  
void loop()  
{  
  if (Serial1.available())//check if serial port has data input  
  {  
    if(Serial1.read()==HEADER)//assess data package frame header 0x59
```

```
{
uart[0]=HEADER;
if(Serial1.read()==HEADER)//assess data package frame header 0x59
{
uart[1]=HEADER;
for(i=2;i<9;i++)//save data in array
{
uart[i]=Serial1.read();
}
check=uart[0]+uart[1]+uart[2]+uart[3]+uart[4]+uart[5]+uart[6]+uart[7];
if(uart[8]==(check&0xff))//verify the received data as per protocol
{
dist=uart[2]+uart[3]*256;//calculate distance value
strength=uart[4]+uart[5]*256;//calculate signal strength value
Serial.print("dist = ");
Serial.print(dist);//output measure distance value of LiDAR
Serial.print('\t');
Serial.print("strength = ");
Serial.print(strength);//output signal strength value
Serial.print('\n');
}
}
}
}
}
```

### Step 3: Viewing of Data

Download the program into Arduino board and open the monitor for the serial port. Then real-time distance values as well as the the corresponding signal strength can be viewed, as shown in Figure 3.

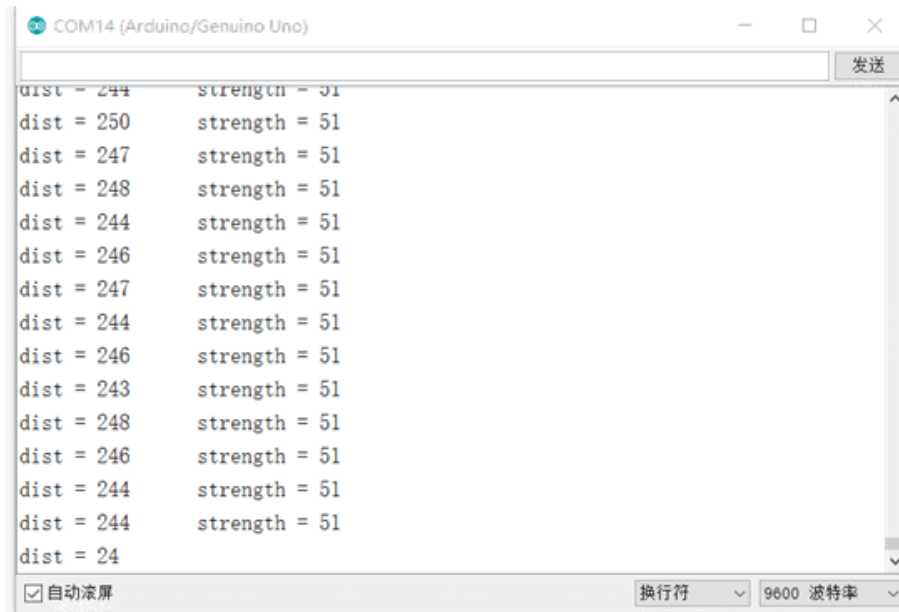


Figure 3 Display of LiDAR's Data on Monitor for Serial Port

In addition, data curve can be viewed in the curve plotter for serial port , however, the above code regarding the printing of serial port (Serial.print) should be modified:

```
// Serial.print("dist = ");
Serial.print(dist);//output measure distance value of LiDAR
Serial.print(' ');
// Serial.print("strength = ");
Serial.print(strength);//output signal strength value
Serial.print('\n');
```

Reinterpret and download the program into Arduino board and open the curve plotter. Then two curves including the dist and strength can be viewed, as shown in Figure 4.

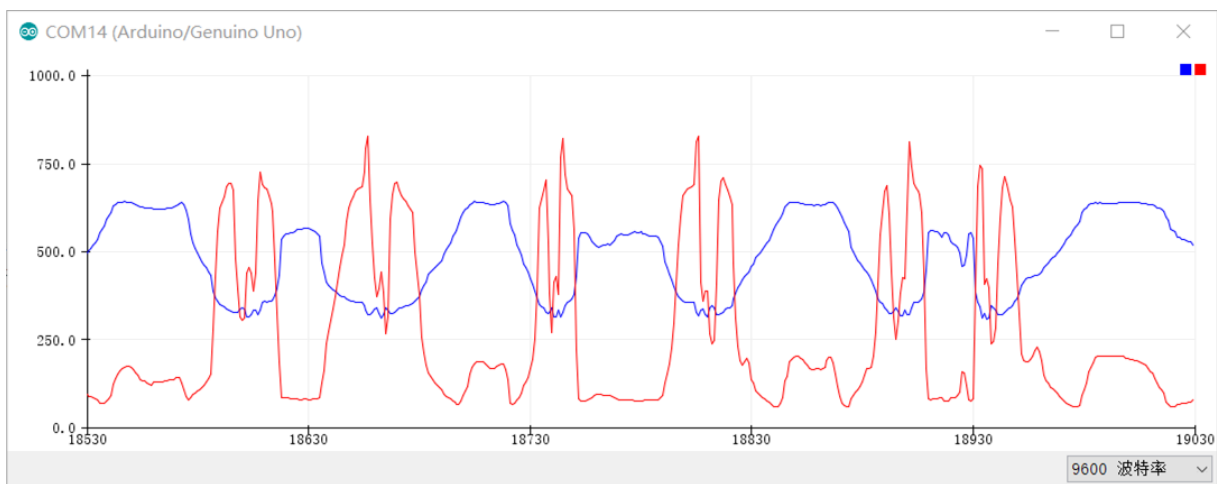


Figure 4 Curves of LiDAR's Data on Curve Plotter for Serial Port



## Attachment 3: Application of TFmini in Pixhawk

Pixhawk is the upgrade of APM and PX4, of which APM uses conventional 8-bit SCM with limited arithmetic capability. While the PX4 is a transitional product starting to use STM32F4. Pixhawk is more refined and reliable flight control system developed from PX4. For the details of this series of the open source flight control system, refer to <http://ardupilot.org/>. This website reliably introduces Pixhawk in details, and thus it is much helpful for the user to learn and familiarize himself with the flight control system.

TFmini can be connected with Pixhawk for use. By selecting Pixhawk data output format, the TFmini can directly be connected with the serial port of Pixhawk, and also it can connect with other communication interfaces (e.g. I<sup>2</sup>C) of Pixhawk via appropriate adaptors. TFmini can be used in flight device for altitude holding. It is recommended that Pixhawk adopts ArduCopter V3.3.3-V3.4.6 firmware.

Example for connecting Pixhawk:

### a) Connect TELEM2 interface of Pixhawk

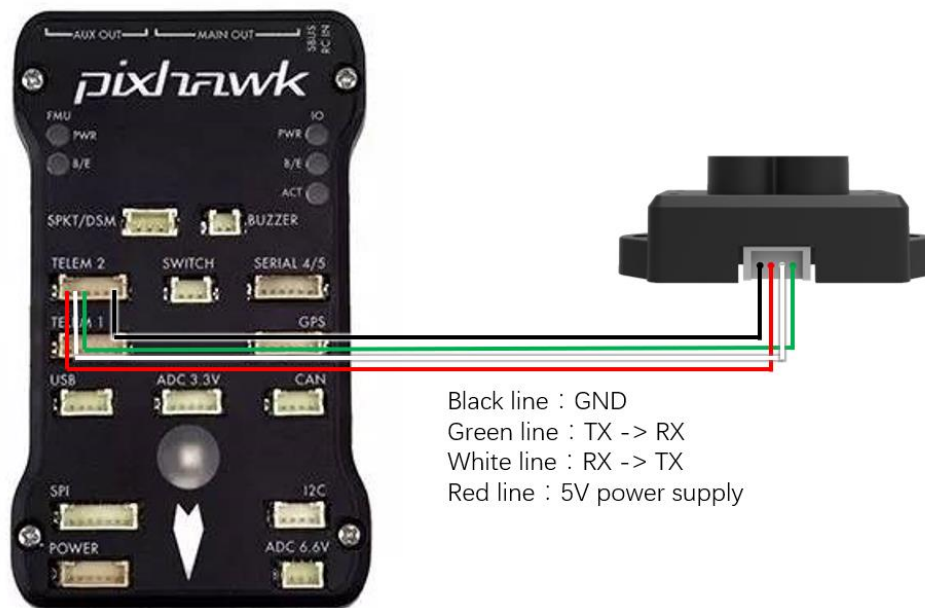


Figure 1: Schematic Diagram of Connecting TFmini with TELEM2 (Serial Port 2) of Pixhawk

### Configuration Descriptions of Mission Planner

Connect the flight control board to MP, Select [Full Parameter List] in the left from the below bar-[CONFIG/TUNING] . Find and modify the following parameters:

SERIAL2\_PROTOCOL = 9 (Lidar)

SERIAL2\_BAUD = 115

RNGFND\_TYPE = 8 (LightWareSerial)



RNGFND\_SCALING = 1

RNGFND\_MIN\_CM = 30

RNGFND\_MAX\_CM = 1200

RNGFND\_GNDCLEAR = 15 (expressed in cm, depending upon mounting height of the module)

Upon setting of these parameters, click [Write Params] on the right of the software to finish.

If the error message “**Bad Lidar Health**” appears, please check if the connection is correct and the power supply is normal.

**b) Connection with SERIAL4/5 interface of Pixhawk**

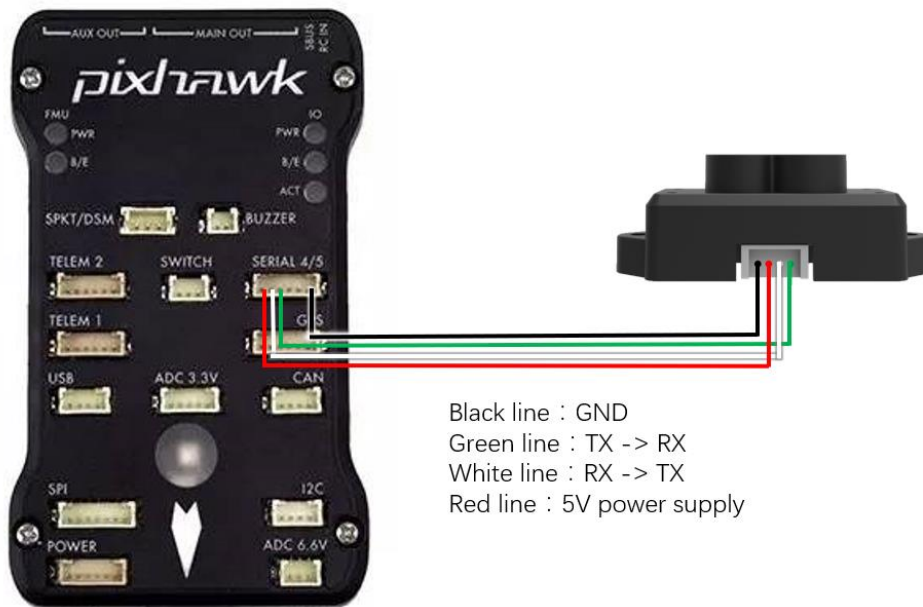


Figure 2 Schematic Diagram of Connecting TFmini with SERIAL4/5 Interface (Serial Port 4/5) of Pixhawk

**Configuration Descriptions of Mission Planner**

Connect flight control board to MP, Select [Full Parameter List] in the left from the below bar [CONFIG/TUNING] . Find and modify following parameters:

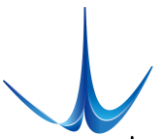
SERIAL4\_PROTOCOL = 9 (Lidar)

SERIAL4\_BAUD = 115

RNGFND\_TYPE = 8 (LightWareSerial)

RNGFND\_SCALING = 1

RNGFND\_MIN\_CM = 30



RNGFND\_MAX\_CM = 1200

RNGFND\_GNDCLEAR = 15 (expressed in cm, depending upon mounting height of the module)

Upon setting of these parameters, click [Write Params] on the right of the software to finish.

