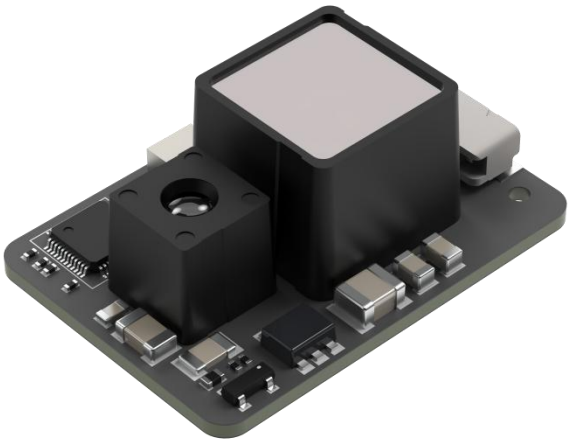
Benewake

TFS20-L User Manual



Preface

This user manual contains the introduction, use and maintenance of TFS20-L LiDAR. Please read this manual carefully before formal use, and strictly follow the steps described in the manual during use to avoid product damage, property loss, personal injury or/and violation of product warranty terms.

If you encounter problems that cannot be solved during use, please contact Benewake staff for assistance.

Contact Details

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Disclaimer

The TFS20-L product is constantly being improved, and its specifications and parameters will undergo iterative changes. Please refer to the official website for latest version.

Contents

1 Product Overview

This chapter mainly introduces the measuring principle, technical specifications, structural description, equipment coordinates and field of view distribution of the TFS20-L LiDAR.

1.1 Measuring principle

TFS20-L is a miniaturized single-point LiDAR module that measures distance based on direct measurement of time of flight (dToF). The laser at the transmitting end collimates and emits a pulsed laser signal through the transmitting lens. After being reflected by the object being measured, the echo signal enters the receiving lens and is detected by the high-sensitivity SPAD detector at the receiving end. The time difference between the transmission and echo signals can be calculated, and the distance between the object being measured and the LiDAR can be calculated based on the speed of light.

1.2 Technical specifications

Table. 1: Technical specifications

Performance Parameter	
Detection Range	0.2-20m@90% reflectivity@0Klux, 0.2-15m@90% reflectivity@100Klux 0.2-12m@10% reflectivity@0Klux, 0.2-9m@10% reflectivity@100Klux
Accuracy①	±6cm(0.2~6m), 1%(≥6m)
Repeatability②	2cm(0.2~6m) @1 σ
Frame rate	0/ 20 / 50 / 100 (default) / 250Hz
Ambient light resistance	100KLux
Laser Parameters	
Light source	VCSEL
Central wavelength	905nm
FoV	<2°
Eye safety	Class 1 Eye-safe [EN60825]
Mechanical/Electrical	
Average power consumption	≤0.43W
Peak current③	130mA@3.3V
Power supply	DC 3.3±9%V

Communication level	LVTTL (3.3V)
Operating temperature	-20℃ ~ +60℃
Storage temperature	-20℃ ~ +85℃
Dimensions	TYP. 21.0 x 15 x 7.87mm³
Weight	1.35g
Connector	0.8mm-6P (Model: WF08006-01207)
Protection Level	N/A
Communication Protocol	
Communication Interface	UART/IIC

NOTICE

① The accuracy is based on 25℃, 90% reflectivity condition, and any changes in environmental conditions may cause changes in the measurement results.

② The repeatability is based on 25℃ indoors and 90% reflectivity condition, and any changes in environmental conditions may cause changes in the measurement results.

③ The peak current is measured at room temperature.

1.3 Structural appearance

The overall appearance of the LiDAR is as shown in the figure below:

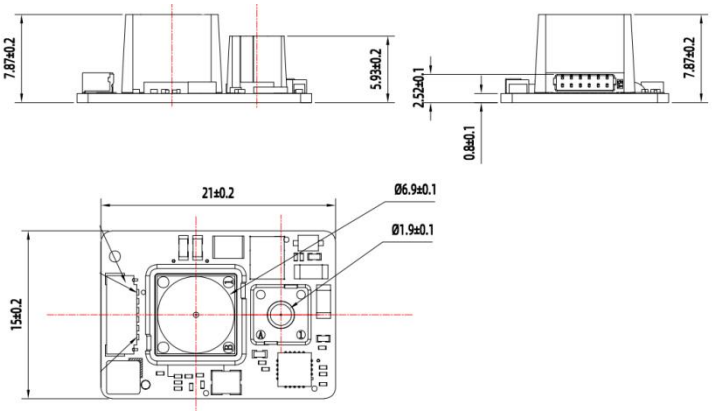


Figure. 1: TFS20-L Dimensions

2 Hardware Interface and Protocol

This section introduces the hardware and protocol information of TFS20-L LiDAR.

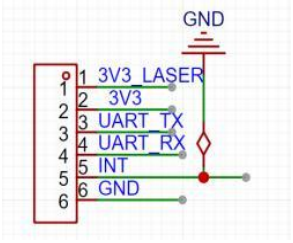
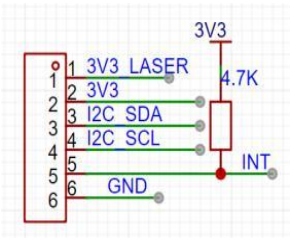
2.1 Pin sequence description

The connector terminal model is WF08006-01207, and the terminal spacing is 0.8mm.

Figure. 2: TFS20-L pin sequence

Pin number	Function	Explanation
1	3V3 Laser	Laser power supply
2	3V3GND	
3	UART_TX/I2C_SDA	Transmit / Data
4	UART_RX/I2C SCL	Receive / Clock
5	GPIO	Communication chip select
6	GND	Ground

The module supports two communication modes: UART and IIC. However, when powered on, only one interface can be selected for operation.

UART	IIC
	
Connect the INT pin to ground when powering on.	When powered on, the INT pin needs to be pulled up with a 4.7K resistor or left floating.

2.2 Serial data communication

Table. 2: Characteristics of UART

Parameter	Default	Configurability
Baud rate	115200	Configurable
Data bit	8	Non-configurable
Stop bit	1	Non-configurable
Parity	None	Non-configurable

NOTICE

The baud rate can be set to 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600. The default baud rate of TFS20-L is 115200. When the wrong baud rate is configured, it is reset to 115200.

2.3 Serial port output format

Each data packet consists of 9 bytes of hexadecimal numbers, see the following table for details:

Table. 3: Data-packet Format

Byte0-1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8
0x59 59	Dist_L	Dist_H	Strength_L	Strength_H	Temp_L	Temp_H	Checksum
Data code explanation							
Byte0	0x59, frame header, same for each frame						
Byte1	0x59, frame header, same for each frame						
Byte2	Dist_L distance value low 8 bits						
Byte3	Dist_H distance value high 8 bits						
Byte4	Strength_L low 8 bits						
Byte5	Strength_H high 8 bits						
Byte6	Temp low 8 bits						
Byte7	Temp high 8 bits						
Byte8	Checksum is the lower 8 bits of the cumulative sum of number of first 8 bytes						

2.4 I2C Communication

Pull up a 4.7K resistor on pin 5 or leave it hanging,TFS20-L enters I2C mode, then its pin 3 is used as SDA data and pin 4 is the SCL clock sending data.

TFS20-L supports up to 400kps clock speed as slave machine and its default address is 0x10. For more information about I2C register table refer to Appendix I2C register table.

Note:

1. Firmware version V1.4.6 and above supports I2C communication. If the firmware version is lower than V1.4.6 or if there are any communication issues, please upgrade the firmware or contact technical support.

2. In this document, the address of I2C slave device is a 7-bit value with value range [0x08, 0x77] ([08, 119] in decimal). For the first byte after I2C releases a start signal, the 7-bit address should be shifted leftward for one bit (i.e. multiplied with 2), and then filled with the read-write sign on the lowest bit. For TF-Luna, the default address of slave device is 0x10, the address for write operations is 0x20, and the address for read operations is 0x21.

After a write operation on the I2C register, it takes TFS20-L some time to process. If users need to read the value from the register for validation purposes, we recommend waiting for 100ms after the write operation, prior to the next read operation.

Write register timing:

Start	Slave Addr	W	Ack	Register Addr	Ack	Data1	Ack	...	DataN	Ack	Stop

Read register timing:

Start	Slave Addr	W	Ack	Register Addr	Ack	Stop

Start	Slave Addr	R	Ack	Data1	Ack	...	DataN	Nack	Stop

3 Custom Configuration

3.1 Frame definition

Customers can customize some parameters of TFS20-L, such as data frame format, frame rate, etc., which can be changed by sending specific commands. All parameters will be saved in Flash after successful configuration, and there is no need to configure them again when powering on again.

Please follow specific formats and rules when configuring parameters and avoid sending random commands.

Note: All configuration commands are sent in hexadecimal (HEX).

Table. 4: TFS20-L command format

Byte0	Byte1	Byte2	Byte3 ~ ByteN-2	ByteN-1
Head	Len	ID	Payload	Checksum
Command encoding explanation				
Byte0	Header: Fixed to 0x5A			
Byte1	Len: The length of the command frame (unit: Byte)			
Byte2	ID: Identifies the function of each command			
Byte3-N-2	Data: Different meanings and lengths in different ID command frames			
ByteN-1	Checksum: the lower 8 bits of the sum of the first N-2 bytes			

3.2 Custom configuration

TFS20-L released several configuration parameters. These parameters, such as data format, frame rate, could be modified by certain command. All the parameters will be stored in flash after configured successfully and customers don't need to configure again when restart.

Please change the parameter according to certain requirements and do not frequently try irrelevant instructions. Please configure the product according to the requirements of the datasheet and don't send unstated command.

To set the relevant parameters of TFS20-L, first connect TFS20-L to PC. For the connection method, refer to sub-section 4.2. Send relevant

configuration instructions to the sensor through TF GUI software or other serial port debugging software; customers can also send relevant instructions through their own serial port tools.

After sending the parameter configuration instructions, the power needs to be turned off and settings are saved as default.

Table. 5: General Parameter Configuration and Description

Description	Command	Response	Remarks	Default settings
Firmware version	5A 04 01 5F	5A 07 01 V1 V2 V3 SU	Version V3.V2.V1	/
Frame rate①	5A 04 01 5F	5A 06 03 LL HH SU④	Only supports 0/20/50/100/250 Hz	100Hz
Instruction trigger mode	5A 04 04 62	Data packet	After setting the output frame rate to 0, you can trigger the sensor through this command	/
Output format	5A 05 05 01 65	5A 05 05 01 65	Standard 9 bytes (cm)	√
	5A 05 05 06 6A	5A 05 05 06 6A	Standard 9 bytes (mm)	/
Output control③	On: 5A 05 07 01 67 Off: 5A 05 07 00 66	Same as command	/	Enabled
Modify baud rate②	5A 08 06 H1 H2 H3 H4 SU	Same as command	Set the baud rate Example: 256000(DEC)=3E800(HEX), H1=00, H2=E8, H3=03, H4=00	115200
Enable checksum	On: 5A 05 08 01 68	Same as command	Enable	√

	Off: 5A 05 08 00 67		Disable	/
Signal strength low threshold and low threshold output value	5A 07 22 XX LL HH 00	Same as command	Example: After Strength≤100, the Dist output value is changed to 1200. XX=100/10=10(DEC)=0A(HEX) 1200(DEC)=4B0(HEX) LL=B0，HH=04	When Strength is less than 300, the Dist output value is 500

CAUTION

① This command is mainly used to adjust the output frequency of the sensor. The default value of the output frequency is 100Hz, and custom configuration is supported, supporting frequencies are 0, 20, 50, 100, and 250Hz.

② The baud rate can be set to 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600. The default baud rate of TFS20-L is 115200. When the wrong baud rate is configured, it is reset to 115200.

③ An enable data-output command must be sent each time the power is turned on.

④ 'SU' stands for checksum and puts the lower 8 bits into the command.

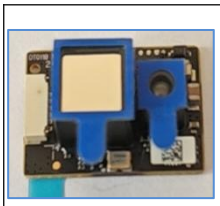
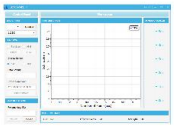
For example, to change the baud rate to 460800, first change 460800 to HEX (0x00 07 08 00), then calculate the checksum to 0x77, and you can get the following instruction - 5A 08 06 00 08 07 00 77.

⑤ There is no need to send the save settings command. Sending a specific configuration command will take effect and be saved immediately.

Do not send the command that is not in the list above.

4 Quick Test Guide

4.1 Tools required for test

				
TFS20-L	TTL-USB converter	USB cable	PC	Test Software

4.2 Test procedures

(1) Download the test software

Download the latest version of test software for TFS20-L from Benewake official website:
https://en.benewake.com/DataDownload/index_pid_20_lcid_99.html

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

(2) Connection of the hardware

Figure. 3: LiDAR and PC interfacing

Connect "TFS20-L", "TTL-USB board" and "USB cable". Make sure there is no loose connection. Then connect "USB cable" with "PC". As shown in the above image.

(3) Connection with software

Run GUI software, select "① TFmini/TFmini-S" and select automatically recognized communication port (here it is "② COM9"), choose the right baud rate (here it is "③ 115200"), as shown in the following image.

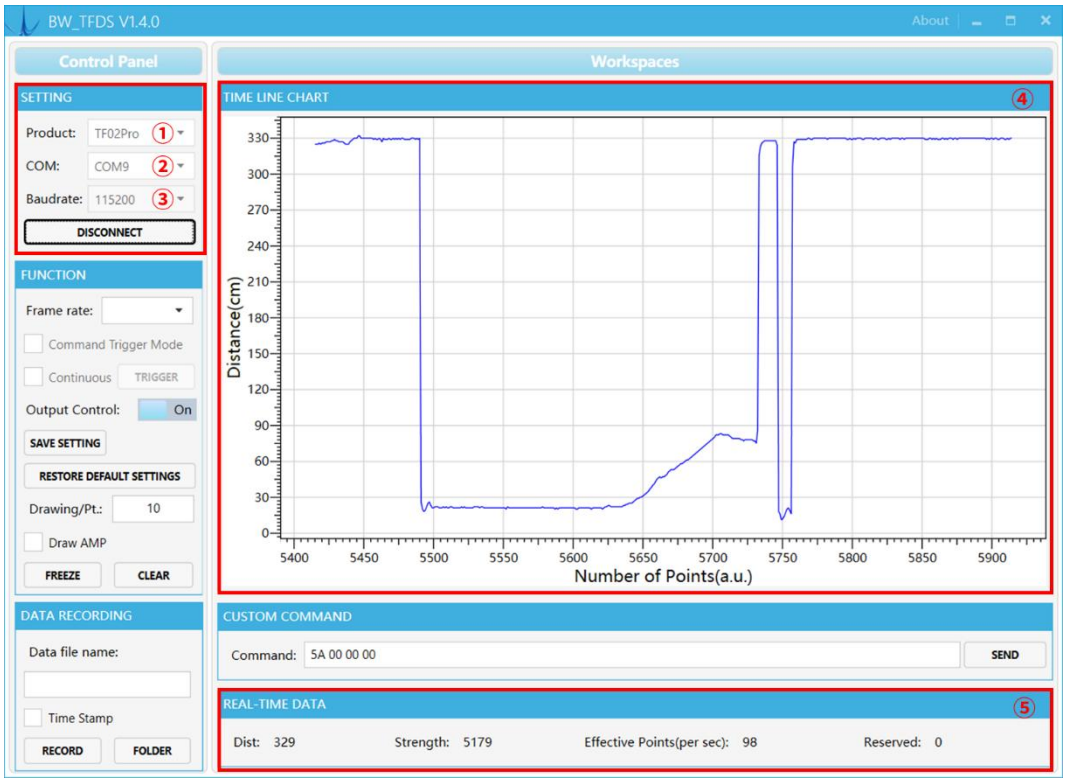


Figure. 4: GUI software and LiDAR interfacing

Then click "CONNECT". Upon successful connection, the continuous graph of the output data will be displayed in area "④ TIME LINE CHART". Besides, the real-time data of the current measured distance (Dist), effective data points per second (Effective Points) and signal strength (Strength) will be displayed in area "⑤ REAL TIME DATA".

Note

①If no data is available in area "④TIME LINE CHART", please check the wire connection and sequence. When TFS20-L is successfully powered on, there will be a faint red light inside transmitting lens viewing from the front using mobile phone camera or any other IR light detecting device.

②The 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 with specific command, 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 TFS20-L measurement is 1m, the distance value of TFS20-L is 1000 in mm, the value read by the PC software also is 1000, but the unit will not change and still display cm.

5 Q&A

① After the LiDAR is connected to the host computer, there is no data output.
Cause-1: TTL-USB board connection is bad.
Solution: Check whether the connection between TTL-USB board, TFS20-L and PC is correct and reliable.
Cause-2: The serial port driver is not installed correctly.
Solution: Re-plug the USB cable and try to re-install the driver, or search the Internet for the driver to download and install. If you still cannot use the host computer normally, please contact our technical support.

② TFS20-L will heat up after working for a period of time.
Explanation: This is the normal working state of the product. After the chip and circuit board continue to work, slight heating is normal.

③ TFS20-L has no data output.
Cause-1: The V1.4.0 version does not output data by default when powered on, and you need to send an output enable command (as mentioned in Table 5).
Solution: Send the output enable command 5A 05 07 01 67 after powering on.
Cause-2: 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.
Solution: Check whether the power supply is normal and whether the voltage is within the rated voltage range. If the power supply is normal, there should be a faint red light in the TFS20-L transmitting lens.
Check whether the wiring sequence of TFS20-L is correct and whether the connection is reliable.
Check whether the data parsing is correct. Please parse it according to the data format described in the manual.
If the problem is still not solved, please contact technical support.

④ Does TFS20-L support ultra-low power mode?
Answer: No, it does not support. The current standby power consumption is about 145 mW. The average power consumption is about 430 mW. If powered by a 10000mAh battery, it can last about 6 days.

Appendix 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	--	
0x08-0x09	R	ERROR_LOW	--	Hold
0x0A	R	VERSION_REVISION	--	Revised version
0x0B	R	VERSION_MINOR	--	Minor version
0x0C	R	VERSION_MAJOR	--	Major version
0x0D-0x0F			--	Hold
0x10-0x1D	R	SN	--	Production code in 14 bytes ASCI 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	0x01	0x00: Turn off LiDAR 0x01: Turn on LiDAR
0x26	W/R	FPS_LOW	0x64	
0x27	W/R	FPS_HIGH	0x00	
0x28	W/R			HOLD
0x29	W	RESTORE_FACTORY_DEFAULTS	--	Write 0x01 to restore factory default settings
0x2A	W/R	AMP_THR_LOW	0x2C	Amp threshold value
0x2B	W/R	AMP_THR_HIGH	0x01	
0x2C	W/R	DUMMY_DIST_LOW	0xFF	Dummy dist value
0x2D	W/R	DUMMY_DIST_HIGH	0xFF	
0x2E	W/R	MIN_DIST_LOW	0x00	Minimum dist in mm, but not working on DUMMY_DIST
0x2F	W/R	MIN_DIST_HIGH	0x00	
0x30	W/R	MAX_DIST_LOW	0xFF	Maximum dist in mm, but not working on DUMMY_DIST
0x31	W/R	MAX_DIST_HIGH	0xFF	
0x32-0x3B			--	Hold
0x3A-0x3F	R	SIGNATURE	--	'TFS20-L'