XT-M60

60 Lines Solid-State Flash Lidar

Product Manual

2025-01

About the manual

■ Using tips

· Please be sure to read the manual carefully before use the product, and operate the product following the instruction to avoid product damage, damage to other property, personal injury or violation of warranty terms

· This manual does not contain the product authentication information, please check the authentication information at the bottom of the product brand, and query the corresponding certification reminder.

· If this laser lidar products is used as part of your product, please provide this manual to your product expectation users, or provide the acquiring methed of the manual.

■ Access

Please acqurie the latest version of manual through the following ways:

· Contact sales staff or corresponding sales channel staff of Toffuture

· Contact technical support of Toffuture: info@toffuture.com

■ Technical support

If the manual can't solve the problems, please contact us through the following way:

info@toffuture.com

■ Legend

· Warning: be sure to follow the safety instructions or the correct operation method.

· Attention: supplementary information, for better usage of the product

Safety warning

■ Laser safety

	Laser Safety
	This product will emit unvisible laser during operation, please avoid eye damage during opertaion. This product pass the Class 1 safety level and will obtain the human eye safety CB certification, according to the EN60825 requirement, it will not damage the human eye and body during noraml operation. Please use the product correctly!(Avoid direct view to the Lidar)

Attention: This product havn't obtain the human eye safety CB certification, please pay attention to the laser impact to the human eye safety; For another product series XT-S240 Pro already obtained the human eye safety CB certification

Human eye sefaty

This is the laser product,in order to protect the user, it's strongly recommended that avoiding the direct view to the laser through the magnifying equipment(like microscope and any kind of magnifying lens) during prodect operation.
This product have no power switch, it will operate once the power is connected;
During the product operation, the whole light cover can be treated like the laser emit area, direct look to the light cover could be treated like the direct view to the laser during operation.

■ High temperature

Avoid direct contact with the products shell during the product operation or right after the product

opertation.

Please check the working temperature within the chapter "technical parameter" of the user manual, avoid the working environment which exceed the working temperature.
Operating in the environment like high/low temperature, strong vibration, heavy fog etc. might reduce the XT-M60 performance.

In addition, long working time in the high tempareture environment might impact the product performance or even damage the product.
It's strongly recommended that user add radiating precaution to make sure the shell temperature won't exceed 60 degree.

If the product temperature is too high, it will trigger the high temperature self-protection mechanism, XT-M120 will send out the high temperature warning, if the temperature is too high, XT-M120 will stop the operation, and restart only after the temperature reach the normal level.

Recommand storage environment:
Dry and ventilated environment, temperature 23±5℃, humidity 30%~70%.

■ Abnormal stop

If occure the following circumstances, please immediately stop using the product and contact the

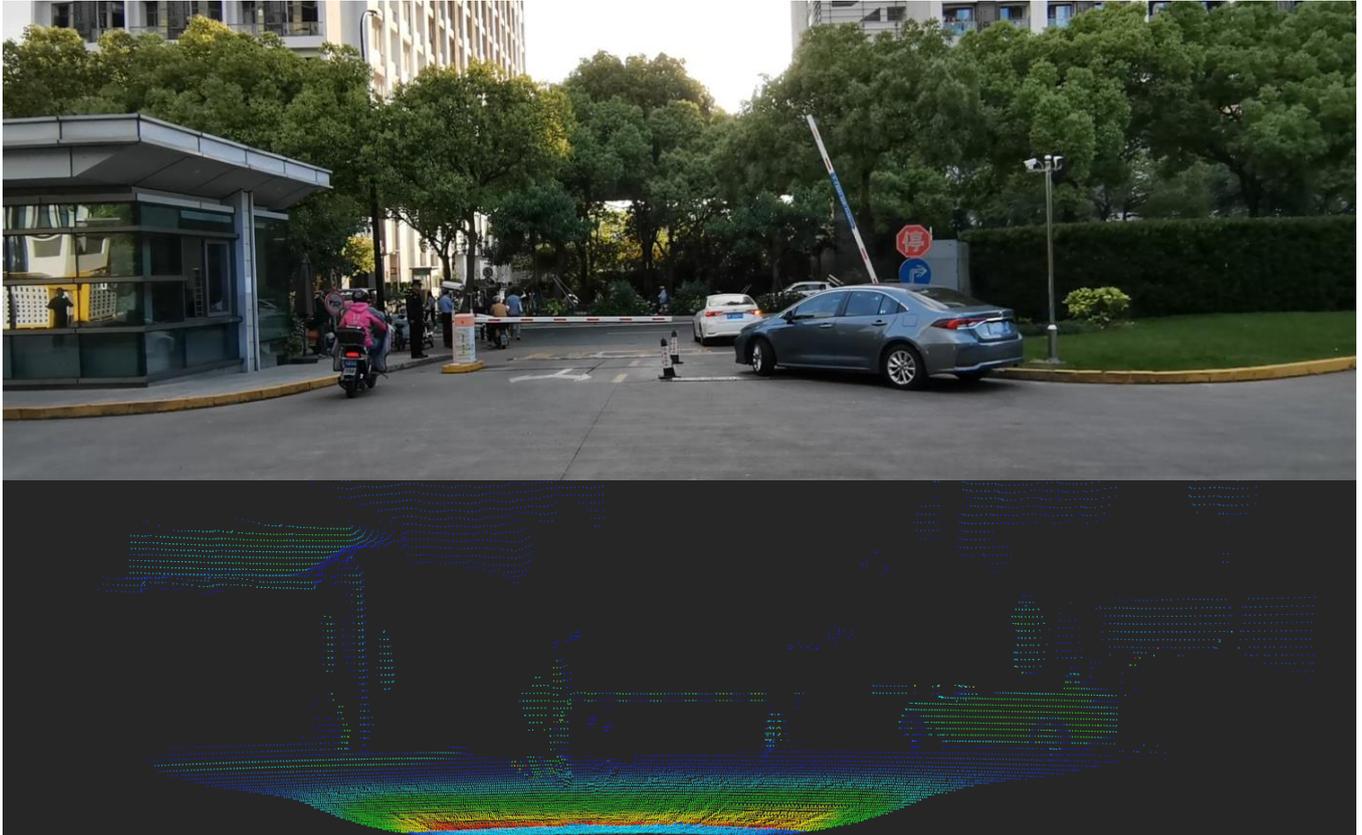Toffuture or corresponding sales channel staff of Toffuture:

· Suspect product failure or damage, for example, the product have obvious noise, smell or smoke

· User or people around feel any discomfort of themselves

· Abnormal running equipment in the surrounding environment

■ Disassembly prohibited

Without the written consent of Toffutre, disassembly is explicitly prohibited of this product.

Product introduction

XT - M60 is a cost-effective, safe and reliable pure solid state flash blind detection lidar. It can be widely used in industry of engineering machinery, unmanned aerial vehicle, intelligent traffic areas, such as AGV, UAV, intelligent security robot, vehicle blind detect and corner lidar etc.

Product highlights

Solid State :   No mechanical parts, reliable
The ultra small size :   65 mm * 38 mm * 45 mm
120 Line :   The equivalent of 60 lines, 9600 pixels/frame Angular
AngularResolution: 0.75 ° * 0.75 °
Anti-blooming: In the 100Klux sunlight environment can work properly and provide
                               stable point cloud
Multiple images: 3D point cloud, depth, the infrared gray, incredible figure, etc
Multiple interfaces: Waterproof interface
Waterproof dustproof :   IP67
Automotive Grade: Mature silicon semiconductor technology, reliability, consistency, stability,
                               security, high integration, simple structure, low fault rate and meet the
                               mass demand of clients

1、The product features

1.1Working principle

The distance measurement principle is the Flight Time measurement (Time of Flight).

1) Emit ultrashort laser pulses.

2) Laser reach the object and reflection, photosensitive receiver receives the reflected light.

3) By measuring the flight time of the laser in the air, we can accurately calculate the distance between target object and the sensors.

ToF is the abbreviation of Time - of - Flight, the Flight Time of light, essentially it is one kind of depth range camera to provied the high quality depth image, ToF, the structure light and the eyes constitute three mainstream of 3D visual technology.

iToF is the abbreviation of indirect Time - of - Flight, dToF is the abbreviation of direct Time - of - Flight.

For iToF, it has high resolution, high accuracy performance. On the other side, for dToF, it has high sensitivity and long detection range. For differnet application, different technical approach could be taken.

$$d = c*t/2 \qquad \begin{array}{l} \text{d: Distance} \\ \text{c: Speed of Light} \\ \text{t: Fly time of the laser pulse} \end{array}$$

Figure1.1 ToF distance calculation formula

1.2 Technical parameters

Product series	Scene	Product Name	Viewing Angle Fov1	Viewing Angle Fov 2	Frame Rate	Optical Wavelength	Average Power	SDK	Output Data	Angular Resolution	Measuring Distance	Dustproof Waterproof	Volume mm	Weight	Power Supply	Operation Temperature
M series (medium to long distance)	Medium And High Speed	M60	120x45°	130°x52°	1-30 Frame	940nm	6w	C++ /Linux /Ros1&2	Infrared image Depth image, 3D Point cloud	0.75°H x0.75°V (160x60)	15m@50% 7m@10% Outdoor (0.3~20m Indoor)	IP67	65x35x45	123g	12-24V@3A Aviation Interface	-40°to85°
Customized Products	Low Middle High	M Series	106°x30° 60°x45° 32°x24°	110°x30° 58°x49° 40°x30°	1-40 Frame		6-12w			60-240 Line	30\50\100m	Customized	TBD	TBD	TBD	TBD

Special Reminder：

1．FOV1, represent the field of view of the image receiver side, which is the angleof the output image and 3D point cloud. Using FOV1 as the parameter for image, software, algorithm, point cloud related applications.

2．FOV2 represent the field of view of the laser emitter, due to light interference and multi-path interference, FOV2 must be larger than FOV1. Using FOV2 as the parameter for the photology, structure, machinery and installation related applications.

3． Marked on the 3D models, application and question related to mould making and precisemechanical structure, please contact the technical support for confirmation to avoid unnecessary lost. Thank you!
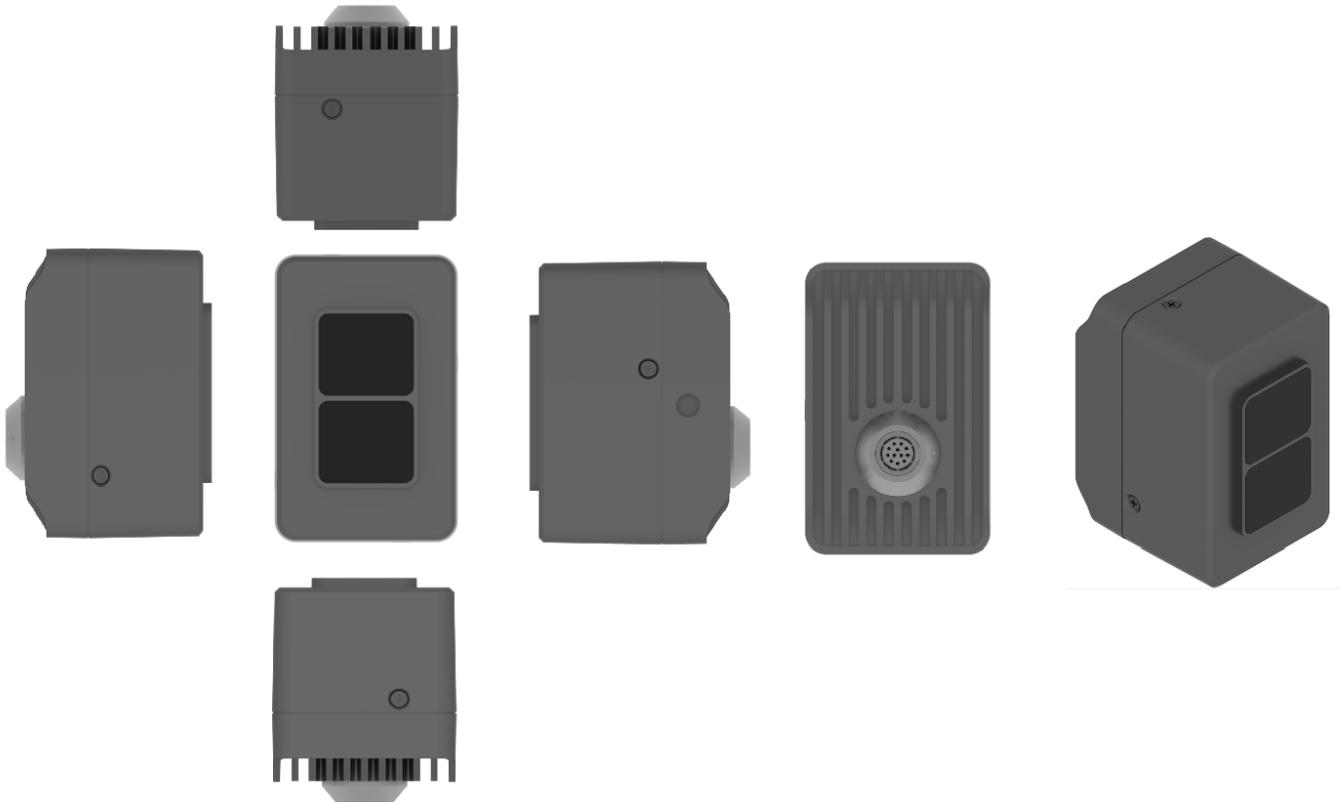
2、Products mechanical structure
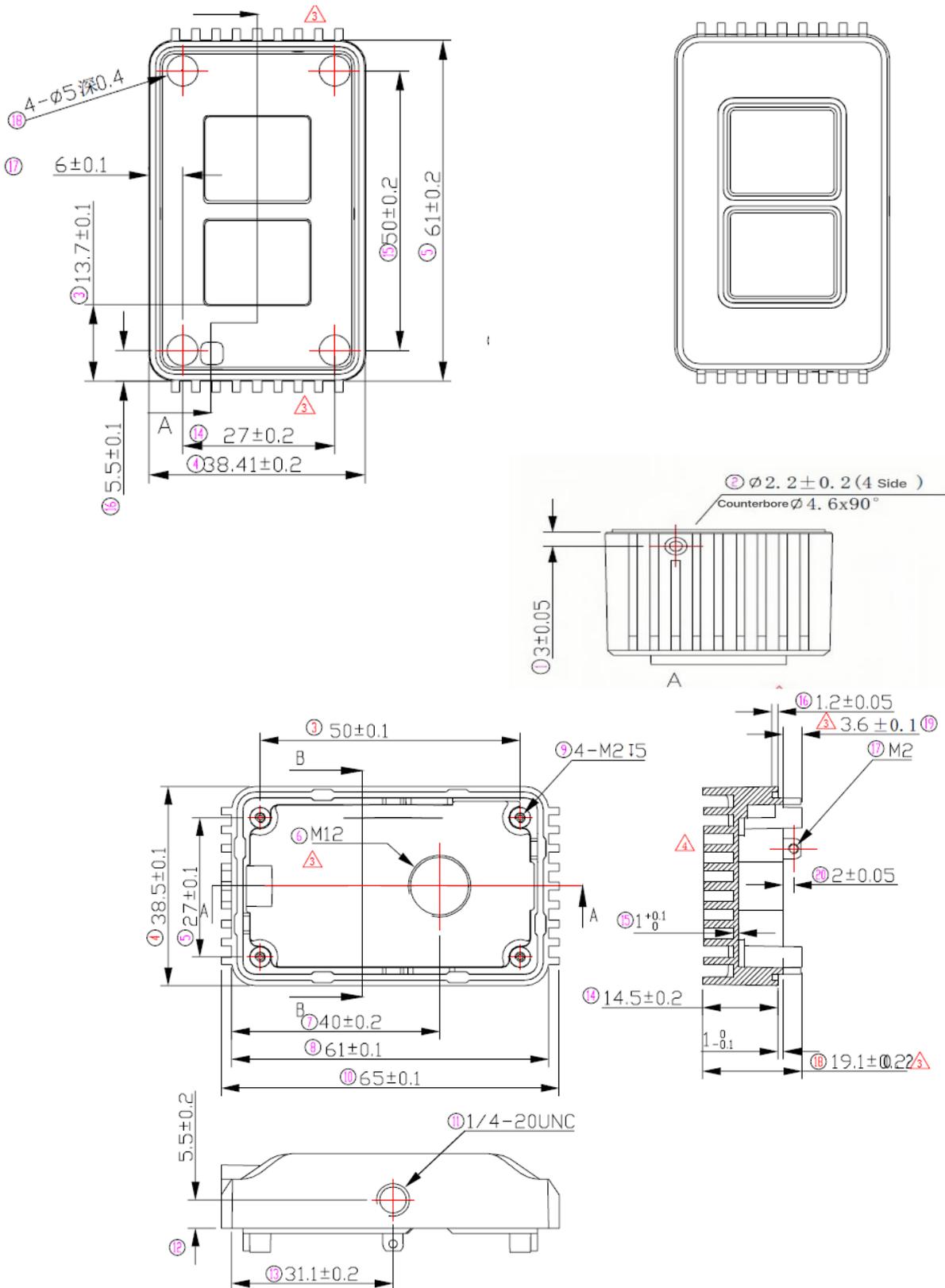
3、Product six views

Product shell

·The products are mainly made of metal, glass and copper clad, internal contain sensitive electronic components, must avoid dropping, burning and other improper operation.Once the product experience falling or burnning, please stop using immediately, and contact Toffuture for technical support.

·Avoid extrusion or puncture of the product. If the shell is damaged, please stop using immediately.

·Before active the product, please ensure that the product has been firmly fixed, and avoid the external force (such as the impact, wind, flying rock, etc.) which might move the product from a fixed position.

Light mask of the shell

·Do not touch the mask, lest the mask with fingerprints or dirt. If the mask is not clean already, please follow the decirbed methed in the section "instrument maintenance" of instructions to clean.

·Please avoid contact with hard or sharp object for scratches in the mask. Please stop using the product with serious scratches since it may affect the product performance.

High temperature

During the products operation or a certain period of time after the product operation, the product shell may be in high temperature condition, please note that：

·Avoid direct skin contact with the product shell, which might casuing the skin burned.

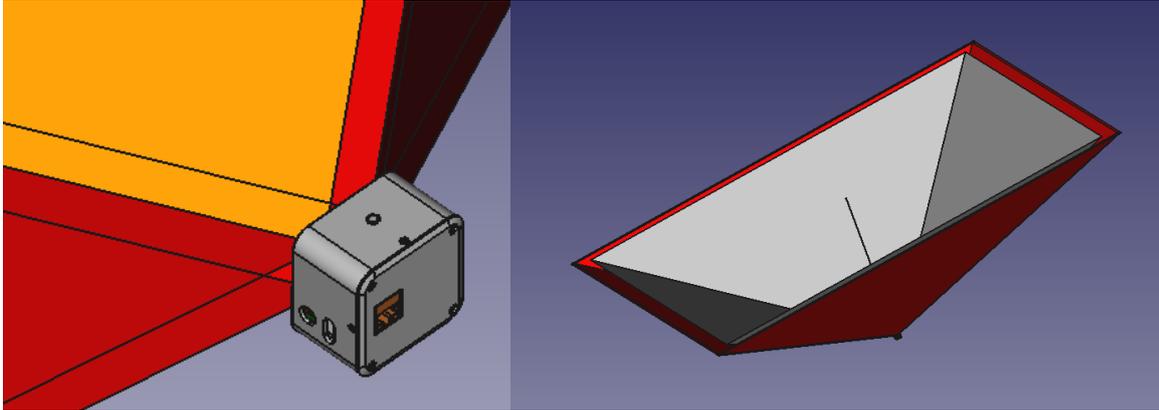·Avoid direct contact with product shell using combustible materials , which might cause a fire.

4、Installation Angle

4.1 Effective field of view (FOV) Angle range

XT - M60 Pro FOV is 120° x 45 °, pay attention to the FOV range, avoid blocking and interference.

Contact the agent or info@toffuture.com for the FOV 3D model of the mechanical installation.

4.2 Field of view(FOV) detection range

The following model server the purpose to convenient customers to intuitive understand the detection range covering by the product (spherical coordinates) under different FOV and distance measuring range,in order to select a better corresponding FOV of products for different applications.

FOV	106°＊80°	72°＊58°	106°＊30°	60°＊45°	32°＊24°
Measurement Range（@5m）	13.3m＊8.4m	7.3m＊5.5m	13.3m＊2.7m	5.8m＊4.1m	2.9m＊2.1m
Measurement Covered Area	111.4 ㎡	40.3 ㎡	35.6 ㎡	23.9 ㎡	6.1 ㎡
Measurement Range（@10m）	26.5m＊16.8m	14.5m＊11.1m	26.5m＊5.3m	11.5m＊8.3m	5.7m＊4.3m
Measurement Covered Area	445.4 ㎡	161.1 ㎡	142.2 ㎡	95.7 ㎡	24.4 ㎡
Measurement Range（@20m）	53.1m＊33.6m	29.1m＊22.2m	53.1m＊10.7m	23.1m＊16.6m	11.5m＊8.5m
Measurement Covered Area	1781.6 ㎡	644.4 ㎡	568.9 ㎡	382.6 ㎡	97.5 ㎡

For more detail, check below：
http://www.toffuture.com/xzzl→FOV Coverage Area.xlsx

4.3 Module installation angle

Look forward from the back side of the module, install the module on the tripod, aviation plug on the right side(red circle)

4.4 Coordinate

4.4.1 Camera mode(default):

Camera defined that the oppsite side of the lidar data cable(avaition plug) is the front side. "Z" point to the front side of the lidar, "X" point to the left side of the lidar, "Y" point to the sky.
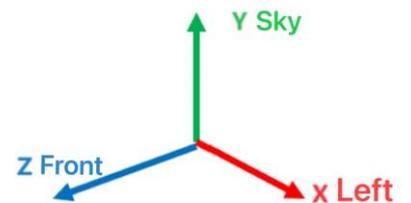
4.4.2 Lidar mode(Car):

Car defined that the oppsite side of the lidar data cable(avaition plug) is the front side. "X" point to the front side of the lidar, "Y" point to the left side of the lidar, "Z" point to the sky.

5、Installation and operation

The power supply

·Recommend to use power supply cable and power adapter offered by Toffture.
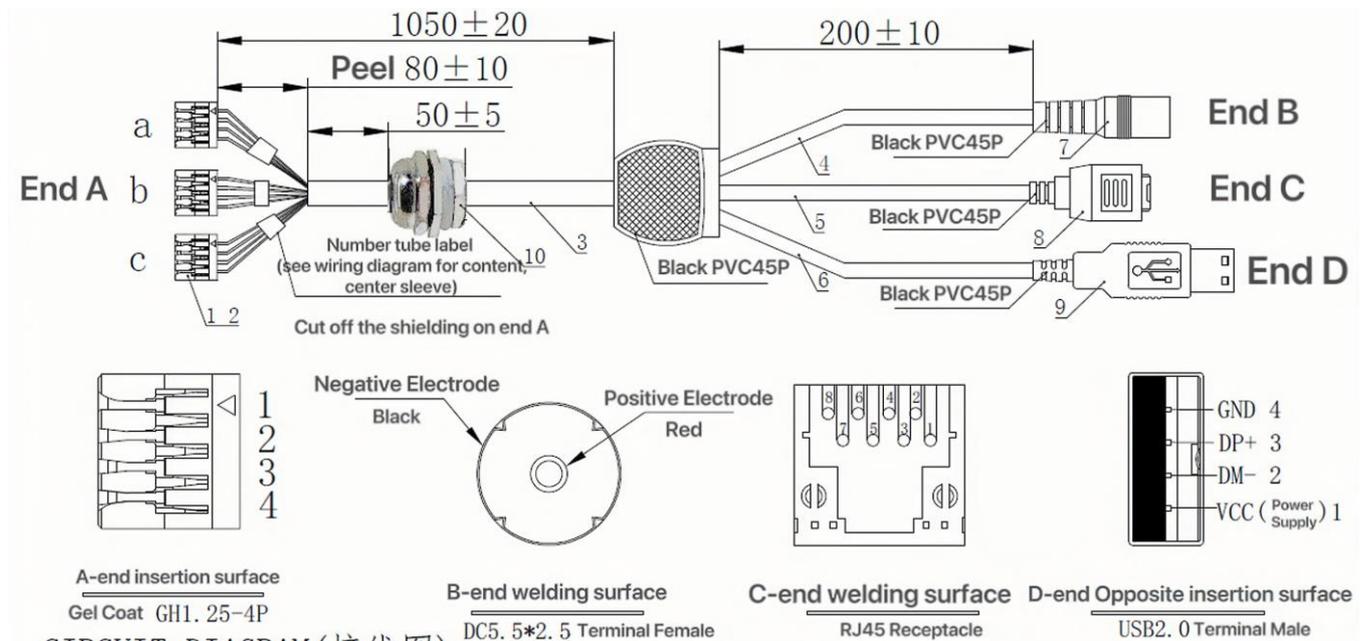
• For the customer design, configuration or selected power supply system (including cables) by themselves, please follow the relevant electrical parameters in the instructions, or contact the Toffuter for technical support. Using damaged cable, adapter or the power supply which dose not meet the requirement is forbidden.

• It's recommend to use the cable and power adaptor provided by ToFFuture

Power Supply: Delippo	Website	
19V 3.42A stable version	https://item.jd.com/100049765921.html https://m.tb.cn/h.gN2RnKYC1UDVUDv?tk=39VP34LBdYc	
12V 3A low voltage supply and small version	https://item.jd.com/100047619867.html	

It's forbidden to used the adaptor or cable which doesn't meet the requirement.

Waterproof plug

• M12 plug line sequence and pin definition as below:

2. CIRCUIT DIAGRAM (Wiring Diagram)

	End A			Number Management Content	Definition
Twisted Pair	a-1 white	1 orange	End C	Network Interface	TD_P
	a-2 black	2 orange white			TD_N
Twisted Pair	a-3 white	6 blue			RD_P
	a-4 grey	7 blue white			RD_N
Twisted Pair	b-1 white	2 white	End D	USB	DM
	b-2 purple	3 green			DP
Twisted Pair	b-3 white	4 black			GND
Twisted Pair	c-1 white	red / rush pith	End B	DC Power Supply	GND
	c-2 green				GND
Twisted Pair	c-3 white	black / rush pith			V+
	c-4 yellow				V+
		shell / shield			

Electrical interface

·Before power on, please make sure that the electrical outlet is dry and has no dirt. Please do not power on the product in the humid environment

·Please strictly follow the connector plug operation instructions. If you have already found abnormal interface (such as pin skewed, cable breakage and screw loosening, etc.), please stop using the product and contact Toffuture for technical support.

·Before you plug connector, please disconnect the power supply. Hot plug can lead to damage.

6、Component description

1. Lower baffle Vcsel launch window, light through the window for launch, detect the objects within FOV range.

2. Upper baffle is sensor receiving window, receiving the reflected light reflected from the object.

3. Waterproof Interface, which has:

a.100 BasT card, provide laser lidar data output

b. DC interface, power 12V - 25V (current above 5A)

c. USB interface, USB with laser lidar data output

4. M2 screws, outside the module using this Type of screw

5. Universal 1/4 threaded hole

7、Data output

This protocol is based on TCP/UDP

default lidar TCP port: 7787

default UDP port:7687

7.1 Three different types of communication data：

- Video data with large data flow，

  Due to the consideration of the real time requirement, UDP protocol has be chosen. UDP data is transmitted by the lidar and accpeted by the upper computert.

- lidar command interaction，

  Due to the requirement of the clear result of the excution interaction and the small amout of the data,TCP protocol has be chosen to secure the interaction integrity.

- Debug log information reported by lidar，

  In order to make sure the upper computer recevied the debug log data, and with the small amount of the data flow, TCP protocol has be chosen.

7.2 Checking the connection between the lidar and upper computer:

- Option 1: Checking the heartbeat by checking the TCP conection
- Option 2: Upper computer send the command in certian period, check the time of the last received command by the lidar

7.3 Communication packet format(based on TCP/UDP/USB) packet format definition

Start	data packet size	data	End
4Bytes(0x7EFFAA55)	4Bytes	0-500000	4Bytes(0XFF7E55AA)

Start	data packet size	Cmd ID	Command data	Response code	DevState	Protocol version number	End
4Bytes(0x7EFFAA55)	4Bytes	1Byte	0-500000	1 Byte	1 Byte	1 Byte	4Bytes(0XFF7E55AA)

Using the network order(big endian as the byte oreder of the data。

Using the little endian for the storage in lidar and upper computer

TCP/UDP level has the checksum for the network data, as the reslt the XT packet doesn't contain the checksum。

Dividing one frame data into multiple UDP packets to transfer(20 bytes packet header + 1400 bytes data), Becacuse each network packet size is smaller than MTU

USB frame data packet is continuous and complete, no need to seperate the packet.

7.4 Data flow

cmdid	Image Type	Frame SN	Resolution	Image Data	Frame Info
1 Bytes	1 Byte	2 Bytes	4 Bytes	0-500 K Bytes	N Bytes
Fixed value:251	0:Depth+Amplitude 1:Depth 2:Grayscale	Incremental value	2 Byte Width 2 Byte Hight	According to the ImageFlag indicated in the ImageInfo, distributed all kinds of pixel data	Please checkthe detail abou the FrameInfo_t in SDK cmdstructs.h The third to fourth last byte is the structure size, the second last byte is the DevState:(cehck chapter 1.8) The last byte is the protocal version number

```
#pragma pack(push, 1)  // 设置字节对齐为 1
struct FrameInfo_t{
    uint32_t magicToken;//0x33CCAA50
    uint8_t  endianType;
    uint8_t  sn[29];
    uint8_t  fw[19];
    uint8_t  lensparameters[40];

    //配置
    uint8_t  imageflags;// bit0:dist b1:amp b2:level b3:gs16bit b4:dcs  b5:gs8bit
    uint8_t  hdrmode;
    uint8_t  levelused_bit;
    uint8_t  freq[5];
    uint16_t integtime[5];
    uint16_t integtimegs;
    uint16_t roix[2];
    uint16_t roiy[2];
    uint16_t miniAmp;
    uint8_t  channel;
    uint8_t  binning;
    uint8_t  reduce;
    uint8_t  vcsel;
    uint8_t  fps;
    uint8_t  reserver1[8];

    //信息
    uint8_t  unit_div;//全局的距离单位: 默认50米量程是1mm,     100米量程为2mm,     200米量程为4mm
    uint16_t width;
    uint16_t height;
    uint16_t temperature[2];//0是sensor温度,   1是灯板温度
    uint8_t  timesync_type;//0 tick, 1 //PPS+GPS , 2 ptp
    uint8_t  timesync_state;//0 丢失,   1: 在线
    uint64_t timestamp[5];//各档位的时间戳
    int32_t  ptpoffsetus;
    uint8_t  reserver2[6];
    uint8_t  version;

    uint32_t crc32;
    uint16_t infosize;
    uint8_t  devstate;
    uint8_t  ptclversion;
};
#pragma pack(pop)  // 恢复原始的对齐方式
```

7.5 Command list：

Name	CmdID
Test communication	0
Start	1
Stop	2
Set IP address	3
Request device infomration	4
Request configuration information	5
Set integration time	8
Set new signal amplitude	9
Set HDR	10
Reset	13
Restore the factory setting	14
Request module inner configuraiton	18
Set UDP target IP	19
Set multiple modulation frequency	27
Set ROI	51
Set modulation frequency	52
Set max frame rate	56
Trace output	209
Frame output	251

7.6 Command type：

Notice:

For every command, the command data is followed by the 0x00(fixed pattern) 0x01(command format version)

For every command response, the data is followed by the command reture code and device status code and 0x03(command response version)

Below description only contain the command data detail, command response code and device status code are universal, no more detail about that.

7.6.1 Test communication: 0

command format:

only contain the command ID, no command data.

response format:

Command ID (1 Byte)	Fixed data (1 Byte)
0	1

7.6.2 Start: 1

command format:

Command ID (1 Byte)	Output type (1 Byte)	Continuous measurment (1 Byte)
1	1:Depth 2:Depth+Amplitude 3: Grayscale	0:single measurement 2:continuous measurement

Response format:
Only contain the command ID, no command data.

7.6.3 Stop: 2

command format:
Only contain the command ID, no command data.

Response format:
Only contain the command ID, no command data.

7.6.4 Set IP Address: 3

command format:

Command ID (1 Byte)	IP Data (12 Byte)
3	IP: 4 Bytes Mask:4 Bytes Gate: 4 Bytes

Response format:
Only contain the command ID, no command data.

7.6.5 Request Deviec Info: 4

command format:
Only contain the command ID, no command data.

Response format:

Command ID (1 Byte)	Configuration structure data (N Byte)
4	Check DevInfo_t struct in the SDK cmdstructs.h

```
//设备信息结构
#pragma pack(push, 1)   // 设置字节对齐为 1
struct DevInfo_t{
    uint32_t    magicToken;//0x33CCAA51
    uint16_t    size;
    uint8_t     version;
    uint8_t     sn[28];
    uint8_t     fw[18];
    uint8_t     bootver[18];
    uint8_t     ip[12];
    uint8_t     mac[6];
    uint16_t    chipid;
    uint16_t    waferid;
    uint32_t    udpDestIp;
    uint16_t    udpDestPort;
    uint8_t     timesync_type;
    uint8_t     timesync_state;
    uint8_t     errorcode;
    uint8_t     calibrated;//0 没标定， 1 部分标定， 2: 都有标定 ， 3:  多标定
    uint32_t    poweronCount;//上电次数
    uint32_t    runTimes;//运行时长 小时
    uint32_t    illumTimes;//发光时长 分钟 每累计30分钟存一次
    uint8_t     reserver[10];
};
#pragma pack(pop)   // 恢复原始的对齐方式
```

7.6.6 Request Configuration Info: 5

command format:
Only contain the command ID, no command data.

Response format:

Command ID (1 Byte)	Configuration Struct Data (N Byte)
5	Check DevCfg_t struct in the SDK cmdstructs.h

```
#pragma pack(push, 1)  // 设置字节对齐为 1
struct DevCfg_t{
    uint32_t    magicToken;//0x33CCAA52
    uint16_t    size;
    uint8_t     version;
    uint8_t     endiantype;
    uint8_t     imageflags;// bit0:dist b1:amp b2:level b3:gs16bit b4:dcs  b5:gs8bit
    uint8_t     hdrmode;
    uint8_t     freq[5];
    uint16_t    integtime[5];
    uint16_t    integtimegs;
    uint16_t    roix[2];
    uint16_t    roiy[2];
    uint16_t    miniAmp;
    uint8_t     channel;
    uint8_t     binning;
    uint8_t     reduce;
    uint8_t     setfps;
    uint8_t     usefps;
    uint8_t     vcsel;
    uint8_t     timesync_type;//0 auto
    uint8_t     ptpdomain;
    uint8_t     bautorun;
    uint8_t     bdhcp;
    uint8_t     bcut_filteron;
    uint16_t    cutIntDist[3][2];
    uint8_t     reserver[18];
};
#pragma pack(pop)  // 恢复原始的对齐方式
```

7.6.7 Set Intergration Time: 8

command format:

Command ID (1 Byte)	Data (8 - 12 Byte)
8	1st uint16 : Int time 1 2nd uint 16 : Int time 2 3rd uint 16 : Int time 3 4th uint 16 : Int time grayscale 5th uint 16 : Int time 4 6th uint 16 : Int time 5

Response format:
Only contain the command ID, no command data.

7.6.8 Set Min Signal Amplitude: 9

command format:

Command ID (1 Byte)	Data (2 Byte)
9	uint16 : Min signal amplitude

Response format:
Only contain the command ID, no command data.

7.6.9 Set HDR: 10

command format:

Command ID (1 Byte)	HDR type (1 Byte)
10	0 : turn off HDR 1 : turn on HDR

Response format:
Only contain the command ID, no command data.

7.6.10 Reset: 13

command format:
Only contain the command ID 13, no command data.

Response format:
No response.

7.6.11 Restore the factory setting: 61

command format:
Only contain the command ID 61, no command data.

Response format:
Only contain the command ID, no command data

7.6.12 Request module inner configuration: 18

command format:
Only contain the command ID 18, no command data.

Response format:

Command ID (1 Byte)	Data (36 Byte)
18	float32 order: float fx; float fy; float cx; float cy; float k1; float k2; float k3; float p1; float p2;

7.6.13 Set UDP Target IP: 19

command format:

Command ID (1 Byte)	Data (6 Byte)
19	4 Byte IP 2 Byte port

Response format:
Only contain the command ID, no command data.

7.6.14 Set Multiple Modulation Frequency: 27

command format:

Command ID (1 Byte)	Output type (5 Byte)
27	every byte is for different value 0: 24 M 1: 12 M 3: 6M 7: 3M 15: 1.5M

Response format:
Only contain the command ID, no command data.

7.6.15 Set ROI: 51

command format:

Command ID (1 Byte)	Output type (8 Byte)
51	uint16 type order X0 Y0 X1 Y1

Response format:
Only contain the command ID, no command data.

7.6.16 Set Modulation frequency: 52(this command will set all HDR to same frequency)

command format:

Command ID (1 Byte)	Data (1 Byte)
52	0：12M 1：6M 2：24M 3：3M 4：1.5M

Response format:
Only contain the command ID, no command data.

7.6.17 Set Max Frame Rate: 56

command format:

Command ID (1 Byte)	Data(1 Byte)
56	0-50

Response format:
Only contain the command ID, no command data.

7.7 Device state code

0x00	Device disconnected
0x01	Device initialization
0x02	Device dile
0x03	continuous image output
0x04	CSI communication error
0x05	I2C communication error
0x06	tempreture too low
0x07	tempreture too high
0x08	frame rate decrease due to high tempreture
0x09	frame stop due to high tempreture
0x0A	can't find TOF
0x0B	can't find external clock
0x0C	can't find tempreture IC
0x0D	can't find frimware
0x0E	Bootloader mode
0x0F	unknow error
0x10	abnormal supply voltage
0x11	abnormal supply current
0x12	RAM error
0x13	Flash error
0x14	calibration unfinished
0x15	no module internal configuration
0x16	no MAC address
0x17	no SN number
0x18	no tempreture coefficient
0x19	calibraiton on going

7.8 Command response code

0x00	OK
0x01	unknow command
0x02	device busy
0x03	device refuse
0x07	active report
0x08	command format error
0x09	command data error
0x0E	unknown error
0x0F	command time out

7.9 Device notification command list

7.9.1 DevInfo change

Device use command ID 4 to submit notification. After received the notification, upper computer send "request device info" command to get the device information.

7.9.2 DevCfg change

Device use command ID 5 to submit notification. After received the notification, upper computer send "request device configuraion" command to get the device configuraion.

7.9.3 Date info output

Device use command ID 209 to submit string trace output info.
command format:

Command ID (1 Byte)	String (Max 255 Byte)
209	String

Version History

Version	Description	Data
V1.0	First Version	20241114
V2.0	Frimware, upper computer and SDK V2.0 new structure	202501