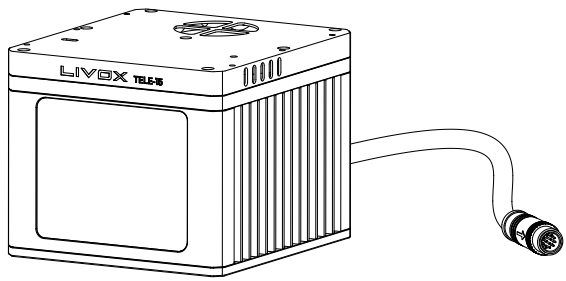
# Livox Tele-15

## User Manual v1.2

2020.11




LIVOX LiDAR

**Searching for Keywords**

Search for keywords such as “FOV” and “mount” to find a topic. If you are using Adobe Acrobat Reader to read this document, press Ctrl+F on Windows or Command+F on Mac to begin a search.

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## Using this Manual

### Legend

Warning  Important  Hints and Tips  Explanation

### Downloading Documents

Visit the link below to download the latest Livox Tele-15 User Manual and other documents related to the Livox Tele-15.

www.livoxtech.com/Tele-15

### Downloading Livox Viewer

Visit the link below to download Livox Viewer and Livox Viewer User Manual.
www.livoxtech.com/Tele-15

### Downloading Livox SDK

Visit the link below to download the Livox SDK:
https://github.com/Livox-SDK

# Contents



# Product Profile

## Introduction

Livox Tele-15 (hereinafter referred as “Tele-15”) features a long detection distance, high precision, and high reliability, and can be used for multiple applications including autonomous driving, rail traffic, mapping, and security.

High FOV Coverage: The Tele-15 utilizes Livox’s unique non-repetitive scanning technology and multi-laser and multi-APD DL-Pack technology. This ensures a high-density point cloud which is approximately five times denser than the Livox Mid-40 within the same period.

High Detection Range: Tele-15 has an extremely high signal-to-noise ratio due to its advanced photoelectric design. With a luminance of 100 kilolux, the high sensitivity function can detect objects with a 10% reflectivity at up to 320 meters away.

High Reliability: The Tele-15 offers enhanced reliability as the cutting-edge design works normally without rotating internal electronic devices such as the transmitter and receiver. The Tele-15 has undergone rigorous reliability testing required by the automotive industry. In addition, the Tele-15 has achieved an IP67 waterproof and dustproof rating under GB 4208-2008 and IEC 60529 standards. Note the included cables do not meet the same standards.

Environmental Adaptation: The built-in tag information helps users identify the type and accuracy of the low noise. Tele-15 avoids interference caused by strong environment light and filters most noise caused by sunlight. When the environment temperature exceeds 65° C (149° F), the noise filter ability decreases. Even with a luminance of 100 kilolux, the Tele-15 boasts a low noise rate lower than 0.01%.

Built-in IMU Module: The model of the build-in inertial measurement unit (IMU) is BMI088. The push frequency of the IMU is 200 Hz.

User-friendly Livox Viewer: Livox Viewer is a Windows software specially designed for Livox LiDAR sensors. It displays and records real-time point cloud data, replays point cloud videos, and analyzes the 3D point cloud data. Users can set product parameters and calibrate extrinsics using Livox Viewer. The simple interface makes Livox Viewer easy to use.

Livox SDK: A software development kit (SDK) is provided to help develop customizable applications using the data acquired from point cloud data. Livox SDK supports Windows/Linux/Mac OS/ROS.

⚠
- This distance can be reached when the target object reflects 50% or more of incident light (e.g., grey concrete walls and roads have a reflectivity range from 15% to 30%) in an environment with a temperature of 25° C (77° F). The default maximum detection range is 500 meters. However, with customized firmware, the maximum detection range can be increased to up to 1,000 meters. Contact Livox at https://www.livoxtech.com/contact if you require detection beyond 500 meters.
- Before using for the first time, remove the screen protector from the optical window.

## Product Characteristics

The Tele-15 utilizes Livox’s unique non-repetitive scanning technology and multi-laser and multi-APD DL-Pack technology. This ensures a high-density point cloud which is approximately five times denser than the Livox Mid-40 within the same period. Over time, the coverage inside the FOV increases significantly and reveals more detailed information of the surroundings.

Figure 1.2.1 displays the point cloud data of the Tele-15 inside the FOV within 0.1s. In the center of the FOV, the scanning density is as dense as traditional 300-line LiDAR sensors. In other areas of the FOV, the scanning density is significantly denser than 100-line LiDAR sensors. Within Tele-15’s FOV, the overall scanning density rivals traditional 128-lines LiDAR sensors within 0.1s.

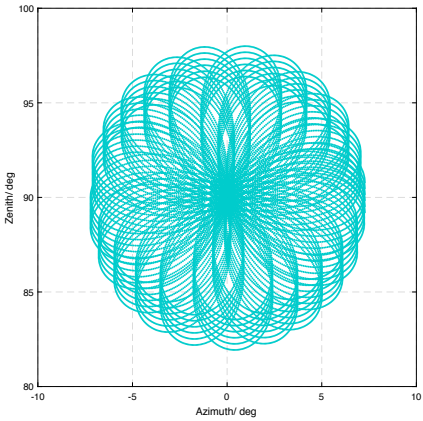



Figure 1.2.1 Point cloud patterns of the Tele-15 within 0.1 s

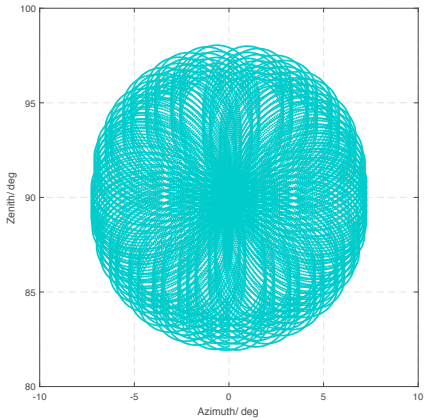



Figure 1.2.2 Point cloud patterns of the Tele-15 within 0.2 s

According to the definition of the Livox coordinate system, the angle range is 0° to 360°, so -10° to 0° is the same as 350° to 360°.

Figure 1.2.3 displays the FOV coverage of the Tele-15 compared with other non-Livox LiDAR sensors that use common mechanical scanning methods. The diagram shows that when the integration time is 0.1 seconds, the FOV coverage of the Tele-15 is approximately 99%, higher than the 128-line LiDAR sensor.

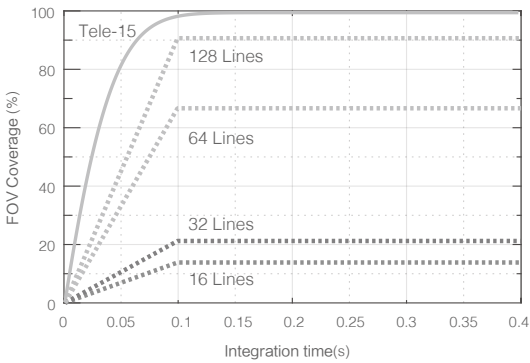



Figure 1.2.3 The FOV coverage of the Tele-15 and non-Livox LiDAR sensors using common mechanical scanning methods. The 16-line non-Livox LiDAR sensor has a vertical FOV of 30°, the 32-line non-Livox LiDAR sensor is 41°, the 64-line non-Livox LiDAR sensor is 27°, and the 128-line non-Livox LiDAR sensor has a vertical FOV of 40°.

The performance of the scanning method is defined by the FOV coverage, which is calculated as the fraction of FOV illuminated by laser beams. The FOV coverage (C) can be calculated with the following formula:

$$C = \frac{\text{Total area illuminated by laser beams}}{\text{Total area in FOV}} \times 100\%$$

Refer to the official Livox website for more information about how the FOV coverage is calculated.

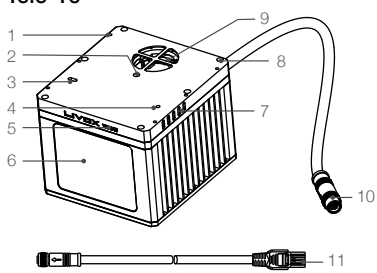
Table 1.2.1 Point cloud specifications

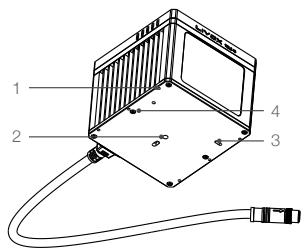
| | |
|---|---|
| Laser Wavelength | 905 nm |
| Laser Safety | Class 1 (IEC 60825-1:2014) (Safe for eyes) |
| Detection Range (@100 klx) | 320 m @ 10% reflectivity, 500 m @ 50% reflectivity |
| FOV | 14.5° (Horizontal) × 16.2° (Vertical) |
| Range Precision (1σ) | < 2 cm (5 to 70 m), < 4 cm (70 to 120 m) @ 10% reflectivity<br>< 2 cm (5 to 220 m), < 4 cm (220 to 380 m) @ 80% reflectivity |
| Angular Precision (1σ) | < 0.03 ° |
| Beam Divergence | 0.02° (Horizontal) × 0.12° (Vertical) |
| Point Rate | 240,000 points/s (first or strongest return)<br>480,000 points/s (dual return) |
| False Alarm Ratio (@100 klx) | < 0.01% |

⚠
- Tested with a Lambertian target in an environment with a temperature of 25° C (77° F), under 100 kilolux conditions with high sensitivity function enabled. The actual environment may differ from the testing environment. The figure listed is for reference only. The performance may decrease in extreme environments such as those with foggy weather, that cause strong vibration, or where the temperature is -40° C (-40° F) or 85° C (185° F).
- The built-in high sensitivity function increases the detection range of Tele-15, especially of small objects with low reflectivity. The high sensitivity function is enabled by default and can be disabled via Livox Viewer or SDK. When the environment temperature exceeds 65° C (149° F), Tele-15 reduces the sensitivity to ensure measurement accuracy. Objects with a reflectivity of 50% can be detected at a range of up to 500 meters in an environment within a temperature range of -40° to 85° C (-40° to 185° F).
- Vicinity Blind Zone: Objects that are within 2.5 meters cannot be measured precisely. When the distance from an object is less than 0.3 meters, an occlusion warning is sent by error code. The point cloud data may be distorted to a varying extent when the target object is within a range of 2.5 to 5 meters. Contact Livox for support if you require to detect objects within this range.

## Overview

### Livox Tele-15



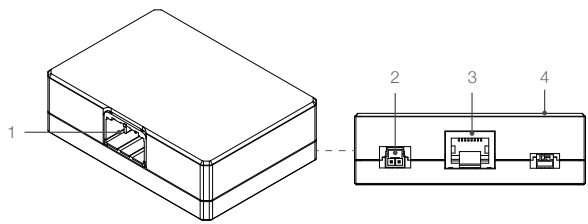

1. M3 Mounting Holes
   Make sure to use the correct screws when mounting.
2. 1/4 Inch Mounting Hole
   Can be mounted on a tripod or other bases outfitted with a 1/4 inch screw.
3. Locating Hole 1
4. Locating Hole 2
5. Self-Dissipation Module
   The self-dissipation module is removable. If it is removed, make sure that the temperature of the LiDAR shell does not exceed 85° C (185°

F). It is recommended to operate the Tele-15 in an environment with a temperature lower than 65° C (149° F). An external thermal dissipation system can also be designed. Otherwise, the Tele-15 may enter the over temperature error status and stop working. The self-dissipation module is not designed to be mounted and detached several times. Only remove the self-dissipation module when necessary.

6. Optical Window
   The laser passes through the optical window and scans objects in the FOV.
7. Air Outlet
   The air outlet allows warm air to exit the self-dissipation module. Make sure there are at least 10 millimeters between the air outlet and the nearest objects.
8. Self-Dissipation Module Screws
   Six black M2.5 screws are used to secure the self-dissipation module. If the self-dissipation module is detached, make sure to store the screws properly for future use.
9. Air Inlet/Fan
   The fan enables airflow to cool the LiDAR. Make sure there are at least 10 millimeters between the air inlet and the nearest objects.
10. M12 Aviation Connector
    The M12 aviation connector is used to connect the Livox Converter 2.0. It also can be modified by users. Refer to the Cables section for information on signal definition. When the Tele-15 is connected to the external power source directly, make sure the output voltage range of the external power source is within the working voltage range of the Tele-15.
11. Conversion Cable

### Livox Converter 2.0



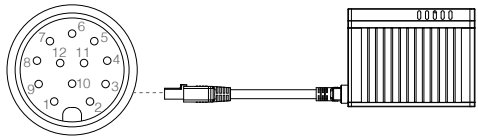

1. LiDAR Connector Port
   A JAE MX34012NF1 type connector port used to connect to the Tele-15. The mating connector is JAE MX34012SF1 LiDAR.
2. Power Port
   Connects to an external power supply. When the Tele-15 is connected to Livox Convertor 2.0, users can use a power supply of 9 to 30 V. The connector type is MOLEX 1053313-1102. The mating connector is MOLEX 105307-1202.
3. Ethernet Port
   An RJ45 type Ethernet connector is used to connect to Ethernet cables.
4. Sync Port
   The 3-pin sync port supports 3.3V LVTTL sync signal input. Refer to Table 2.2.2 for more information. The mating connector of the sync port connector is Famfull 9.510A0-003-1R0, and JST GHR-03V-S is also compatible.

# Connectors

## M12 Aviation Connector

The Tele-15 uses the high-reliability M12 aviation connector (male). It is a M12 12P A-code fully shielded male connector that meets the IEC61076-2-101 standard and has an IP rating of IP67. When the M12 aviation connector is used with the conversion cable, users can connect the Tele-15 to the Livox Connector 2.0 for connecting power and transmitting data and control signals. Users can also replace the conversion cable with a cable of their own in order to improve the waterproof and dustproof protection of the Tele-15. The mating connector is a M12 12P A-code fully shielded female connector.



### Conversion Cable

To connect the Tele-15 to the Livox Converter 2.0, users can use this cable or a cable of their own.

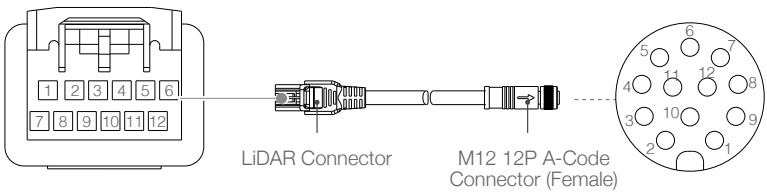



Figure 2.1.1 Conversion Cable

Below is more information on the Livox Tele-15 M12 aviation connector and the aviation and converter connector cable.

Table 2.1.1 Conversion Cable description

| LiDAR Connector Pin | M12 Aviation Connector Pin | Signal | Type | Description | Color |
|---|---|---|---|---|---|
| 1 | 1 | Power+ | Power | DC10V-15V | Blue/white |
| 7 | 9 | Power+ | Power | DC10V-15V | Blue |
| 2 | 2 | Ground | Power | Ground | Silver bare wire |
| 8 | 3 | Ground | Power | Ground | Silver bare wire |
| 3 | 4 | Ethernet-TX+ | Output | 100BASE-TX, TX+ | Orange/white |
| 4 | 5 | Ethernet-TX- | Output | 100BASE-TX, TX- | Orange |
| 9 | 6 | Ethernet-RX+ | Input | 100BASE-TX, RX+ | Green/white |

| | | | | | |
|---|---|---|---|---|---|
| 10 | 7 | Ethernet-RX- | Input | 100BASE-TX, RX- | Green |
| 5 | 8 | Ground | Power | Ground | Silver braided wire |
| 11 | 10 | Ground | Power | Ground | Silver braided wire |
| 12 | 11 | Sync- | Input | RS485_B, Pulse Per Second | Grey |
| 6 | 12 | Sync+ | Input | RS485_A, Pulse Per Second | Grey/white |

### Sync signal description

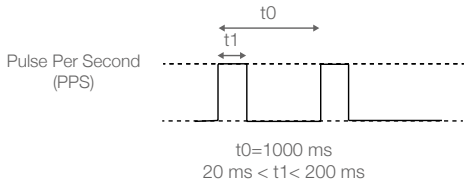



Figure 2.1.2 Sync signal description

*Refer to the Software Development Kit (SDK) section for more information about the sync signal.

## Power Cable and Sync Cable

The Tele-15 cables package includes two power cables and two sync cables.

### Power Cable

Connect “A” to the power port of the Livox Converter 2.0 and connect “B” to an external DC power supply. The connector type of this power cable is MOLEX 105307-1202.

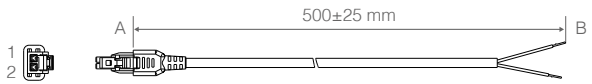



Figure 2.2.1 Power cable

Table 2.2.1 Power cable description

| Pin | Signal | Type | Description | Color |
|---|---|---|---|---|
| 1 | Power+ | Power | DC 9 - 30 V (max 30 V) | Red |
| 2 | Ground | Power | Ground | Black |

### Sync cable

Connect “A” into the sync port of the Livox Converter 2.0 and connect “B” to the sync signal. The sync cable has a 3-pin connector. The connector type is Famfull 9.510A0-003-1R0, which is compatible with JST GHR-03V-S type connectors. Refer to the Data Synchronization section for more information.

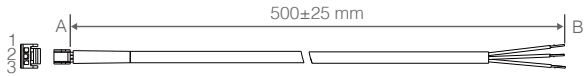



Figure 2.2.2 Sync cable

Table 2.2.2 Sync cable description

| Pin | Signal | Type | Description | Color |
|---|---|---|---|---|
| 1 | Ground | Power | Ground | Black |
| 2 | Sync+ | Input | 3.3 V LVTTL, Pulse Per Second | Blue |
| 3 | Reserved | Reserved | Undefined | White |

## Ethernet Port

The Livox Converter 2.0 supports 100BASE-TX standard RJ45 Ethernet port. The Tele-15 uses two twisted pairs to send and receive data.

# Mounting the Livox Tele-15

## Effective Field of View (FOV) Range

As shown below, the Tele-15 has a horizontal FOV of 14.5° and a vertical FOV of 16.2°. When mounting a Livox LiDAR sensor, make sure that the FOV is not blocked by any objects. Visit www.livoxtech.com/Tele-15 to download the 3D models of the Tele-15 and its FOV.

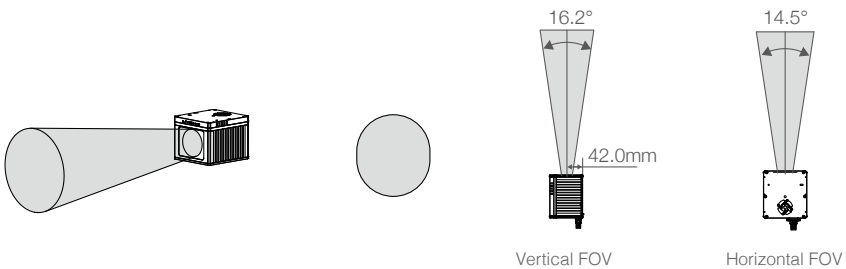



Figure 3.1.1 Effective FOV of the Tele-15

## Mounting Notice

Read and understand the following warnings before mounting the Tele-15.

1. Before use, remove the screen protector from the optical window.
2. Significant dust and stains on the optical window will affect the performance of the Tele-15 LiDAR sensor. Follow the instructions in the Maintenance section to clean the optical window using compressed air, isopropyl alcohol, or a lens cloth.
3. When mounting the Tele-15, the field of view must not be blocked by an object, including glass.
4. When mounting the Tele-15, make sure there is enough space for ventilation for the air inlet and air outlet. Allow at least 10 millimeters from the nearest objects.
5. There are no restrictions on which direction the Tele-15 can be installed. The top or bottom surface can be used to mount the Tele-15. It is recommended that the surface is parallel to the ground when mounting.
6. The Tele-15 cannot bear any extra payload. Otherwise, the reliability of the product cannot be guaranteed.
7. The 1/4 inch mounting hole is only recommended for use with the tripod and other platforms in situations where the surface is static.

## Removing the Self-Dissipation Module

Located on the top of the Livox Tele-15 is the self-dissipation module. Users are able to detach the self-dissipation module. However, make sure to prepare an alternative dissipation system so that the Livox Tele-15 can work properly without the self-dissipation module. Otherwise, the highest working temperature of Livox Tele-15 may be decreased when the self-dissipation module is detached. The self-dissipation module is not designed to be mounted and detached repeatedly. Only remove the self-dissipation module if necessary.

To remove the self-dissipation module, remove the six M2.5 screws using the provided hex screwdriver and then detach the module. If you need to re-install the self-dissipation module, make sure the connectors on the top of the Livox Tele-15 and the self-dissipation module are aligned, and secure the self-dissipation module using six black M2.5 screws.

When the self-dissipation module is detached, make sure to attach the provided rubber seal to the fan connector on the top of the Livox Tele-15. Make sure that the temperature of the LiDAR shell does not exceed 85° C (185° F). It is recommended to operate the Tele-15 in an environment with a temperature lower than 65° C (149° F). An external thermal dissipation system can also be designed.

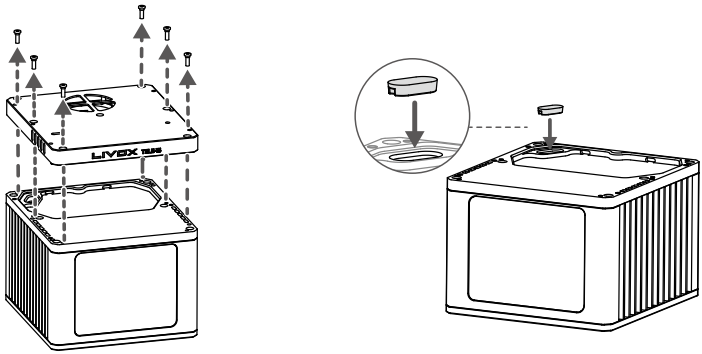


Figure 3.3.1 Removing the Self-Dissipation Module

## Dimensions

### Livox Tele-15 (with the self-dissipation module)

Refer to the dimensions and the mounting holes in the diagram below to mount or embed the Livox Tele-15 to or in an appropriate place on the target base. When the self-dissipation module is attached to the Livox Tele-15, the Livox Tele-15 can be mounted on the target base using M3 screws or outfitted with ¼ inch mounting holes.

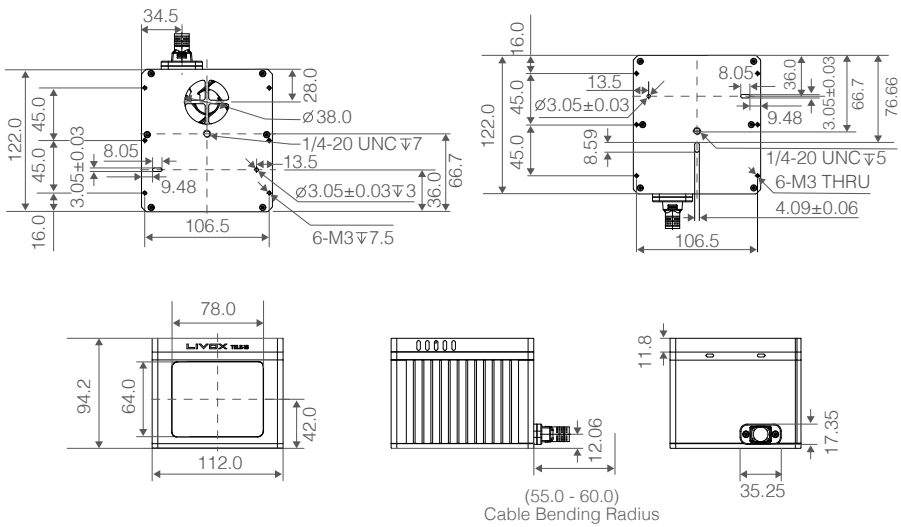



Figure 3.4.1 The Tele-15 Dimensions with Self-Dissipation Module
(refer to Appendix 1)

Unit: mm

Table 3.4.1 The Tele-15 Weight & Dimensions (with self-dissipation module)

| | |
|---|---|
| Weight | Approx. 1800 g (includes a cable with an approx. length and weight of 1.3 m and 160 g) |
| Dimensions | 112 × 94.2 × 122 mm |

### Livox Tele-15 (without the self-dissipation module)

Refer to the dimensions and the mounting holes in the diagram below to mount or embed the Livox Tele-15 to or in an appropriate place on the target base.

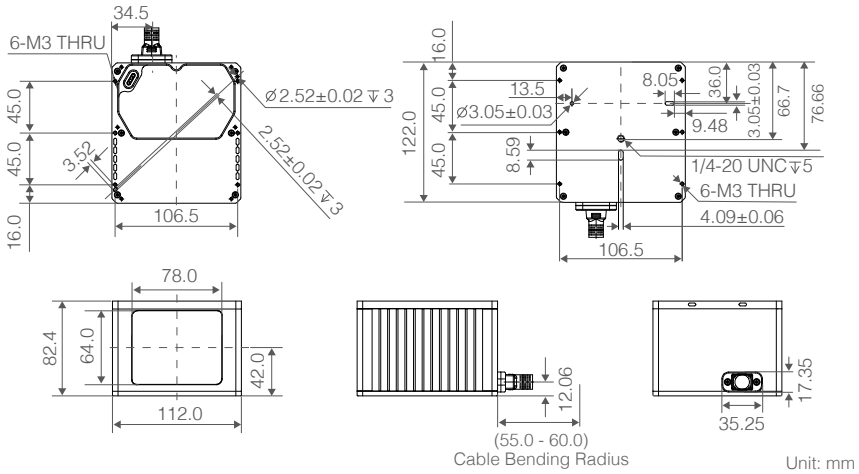



Figure 3.4.2 The Tele-15 Dimensions without Self-Dissipation Module
(refer to Appendix 2)

Table 3.4.2 The Tele-15 Weight & Dimensions (without self-dissipation module)

| | |
|---|---|
| Weigh (with cable) | Approx. 1700 g |
| Dimensions | 112 × 82.4 × 122 mm |

### Livox Converter 2.0

Refer to the dimensions below to mount the Livox Converter 2.0.

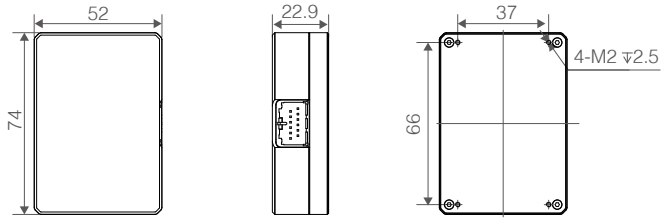



Figure 3.4.3 Livox Converter 2.0 Dimensions
(refer to Appendix 3)

Unit: mm

Table 3.4.3 Livox Converter 2.0 Weight & Dimensions

| | |
|---|---|
| Weight | Approx. 88 g |
| Dimensions | 74 × 52 × 23 mm |

## Getting Started

### External Power Supply

The working voltage range of the Tele-15 is from 10 to 15 V. When an extension cable is required, make sure to increase the output voltage of the external power source due to the extra voltage reduction. Make sure the maximum voltage does not exceed 15 V. The minimum working voltage should be increased in a low temperature environment. Note that the power cable may generate voltage fluctuation where the voltage exceeds 15 V in some scenarios such as if the power cable is interfered with or other devices connected to another power source in the parallel circuit suddenly power off. In such situations, the Tele-15 may not work normally or may even become damaged.

In an environment where the temperature is 25° C, the working power of the Tele-15 is 12 W. The working power of the Tele-15 varies at different temperature. Below shows the relationship between the temperature of the environment and the working power of the Tele-15.

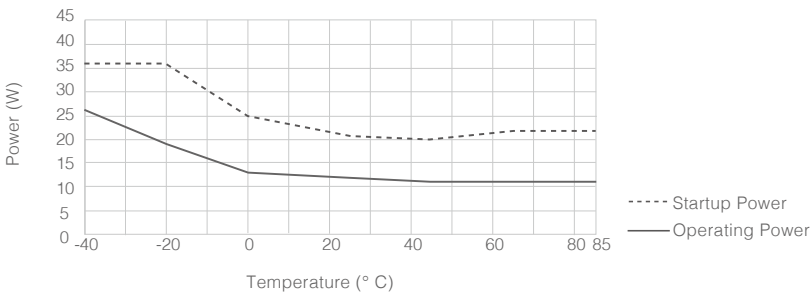



Figure 4.1.1 The working power of the Tele-15 at varying temperatures

## Connection

The Tele-15 uses a compact and reliable electrical connector for power supply as well as control signal and data transmission. Refer to the Cables section for more information about the connector. The Livox Converter 2.0 integrates a LiDAR port, a sync port, a power port, and an Ethernet port. To ensure optimal performance, it is recommended to always use a Livox Converter 2.0.

The Tele-15 supports two IP modes: dynamic IP address mode and static IP address mode. All Tele-15 LiDAR sensors are set to static IP address mode by default with an IP address of 192.168.1.1XX (XX stands for the last two digits of the Livox Tele-15 LiDAR sensor's serial number). The default subnet masks of the Livox Tele-15 LiDAR sensors are all 255.255.255.0, and their default gateways are 192.168.1.1. Directly connect the Livox Tele-15 to the computer before using for the first time. The static and dynamic IP addresses are connected in different ways. 1.The static IP address is connected by default and in this mode, the Tele-15 can be connected to a computer directly. Any static IP address can be set for the Tele-15 through Livox Viewer or SDK. 2. To connect to the dynamic IP address, make sure the Tele-15 is switched to dynamic IP mode by using the Livox Viewer or SDK. In dynamic address mode, the addresses are assigned to the Tele-15 using dynamic host configuration protocol (DHCP).

### Static IP address :

1. Follow the steps to set the IP address of your computer to static IP address:

Windows system

a. Click to enter in the Network and Sharing Center under Control Panel.

b. Click the network you are using, and click "Properties".

c. Double click "Internet Protocol Version 4 (TCP/IPv4)".

d. Set the static IP address of the computer to 192.168.1.50 and the subnet mask to 255.255.255.0. Click "OK" to complete.

Ubuntu-16.04 system

The IP address of the computer can be configured by using the ifconfig command at the terminal. The configuration code is as below:

~$ sudo ifconfig enp4s0 192.168.1.50 (replace "enp4s0" with the network port name of the computer)

2. Connect the Tele-15, Livox Converter 2.0, external power source, and computer by following Figure 4.2.1.

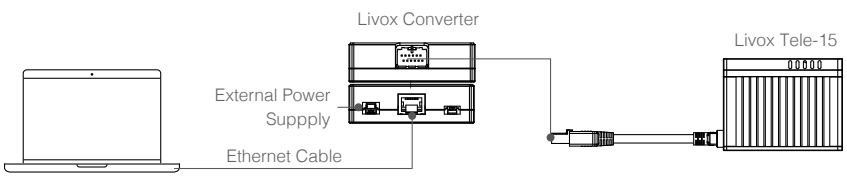



Figure 4.2.1 Connecting using static IP address

a. Connect the Tele-15 to the Livox Converter 2.0.

b. Connect the Livox Converter 2.0 to your computer using an Ethernet cable.

c. Connect the Livox Converter 2.0 to an external power source.

⚠
- If multiple Tele-15 LiDAR sensors are set to static IP addresses, make sure all the Tele-15 LiDAR sensors have different IP addresses and use a switchboard to connect them to the computer.
- Launch Livox Viewer after the Tele-15 is connected. Click the device that the static IP address should be altered. Click ⚙ to open the settings page and set the static IP address of the Tele-15.
- If more than six Tele-15 LiDAR sensors are required, use a kilo mega switchboard. Otherwise, data may get lost and there may be connection failures.

**Dynamic IP address:**

1. Follow Figure 4.2.1 to connect the Tele-15, Livox Converter 2.0, external power source, and computer.

2. Run Livox Viewer, click ⚙ to open the settings page, and set the IP address of the Tele-15 to dynamic IP address.

3. Disconnect the Tele-15, Livox Converter 2.0, external power source, and computer.

4. Follow the steps to set the IP address of your computer to dynamic IP address:

Windows system

a. Click to enter the Network and Sharing Center under Control Panel.

b. Click the network you are using, and click “Properties”.

c. Double click “Internet Protocol Version 4 (TCP/IPv4)”.

e. Select “Obtain an IP address automatically” and “Obtain DNS server address automatically”, then click “OK” to complete.

Ubuntu-16.04 system

a. Click to open “Network”.

b. Click “IPv4”, and then click “Automatic (DHCP)”. Click “Apply” to complete.

5. Connect the Tele-15, Livox Converter 2.0, router, computer, and external power supply by following Figure 4.2.2.

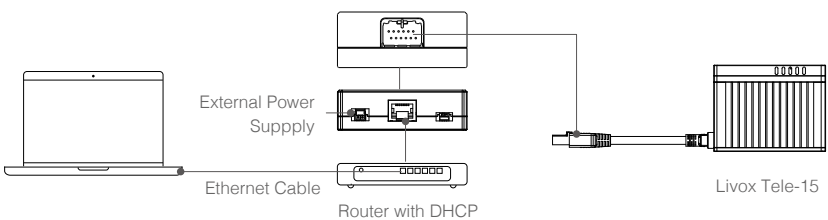



Figure 4.2.2 Connecting using dynamic IP address

a. Connect the Tele-15 to the Livox Converter 2.0.

b. Connect the computer and the Livox Converter 2.0 to the router using Ethernet cables. Make sure both the Livox Converter 2.0 and the computer are connected to the LAN port on the router.

c. Connect the Livox Converter 2.0 to an external power source.

- If more than six Tele-15 LiDAR sensors are required, use a kilo mega router.
- The broadcast number for each LiDAR sensor can be viewed in the Device Manager of Livox Viewer or the SDK. For the Tele-15, the broadcast number will be its serial number ending in an additional “1”.

# Usage

## Coordinates

The Tele-15 has a built-in IMU. The coordinates of the point cloud O-XYZ and of the IMU O'-X'Y'Z' are defined as below:

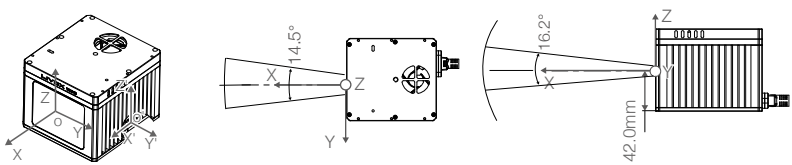



Figure 5.1.1 Coordinates of the Tele-15

The origin O' of IMU coordinates is defined in the point cloud coordinates as (-84.7, -42.5, -35.3) (Unit: mm).

## Output Data

The output information of Livox Tele-15 LiDAR sensors includes point cloud data and IMU data. Both point cloud data and IMU data have timestamp and status codes, while point cloud data also has the target reflectivity, coordinates, and tag information.

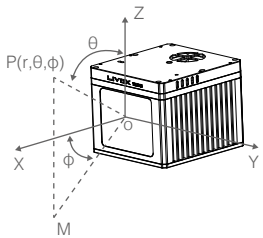
### Point Cloud Data

A point cloud is the collection of the points where the surface of an object was detected in the FOV of the LiDAR sensor. Each point contains the following information.

Target reflectivity: 0 to 255. 0 to 150 corresponds to the reflectivity within the range of 0 to 100% in the Lambertian reflection model. 151 to 255 corresponds to the reflectivity of target objects with retroflection properties.

Coordinates: Can be expressed as Cartesian coordinates (x, y, z) and Spherical coordinates (r, θ, ϕ). The relationship between Cartesian and Spherical coordinates is shown in the figure below. When there is no object within the detective range or the object is placed outside the detective range, the coordinates of the point cloud will be expressed as (0, 0, 0) in Cartesian coordinates and as (0, θ, ϕ) in Spherical coordinates.




x= r×sin(θ)×cos(ϕ)
y = r×sin(θ)×sin(ϕ)
z = r×cos(θ)

Figure 5.2.1.1 Relationship between Cartesian coordinates and Spherical coordinates

Tags: Indicates the return type of the laser and if the point detected is a noise. The format of the tag is as shown below:

| bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|
| Reserved | | Return number:<br>00:return 0<br>01:return 1<br>10:return 2<br>11:return 3 | | Point property based on intensity:<br>00:Normal<br>01:High confidence level of the noise<br>10:Moderate confidence level of the noise<br>11:Reserved | | Point property based on spatial position:<br>00:Normal<br>01:High confidence level of the noise<br>10:Moderate confidence level of the noise<br>11:Low confidence level of the noise | |

Each tag is composed of one byte. In this byte, bit7 and bit6 are Group 1, bit5 and bit4 are Group 2, bit3 and bit2 are Group 3 while bit1 and bit0 are Group 4.

Group 2 indicates the return sequence of the sampling point. Featuring a coaxial optical path, the Tele-15 itself will generate a laser return even if there is no detectable object around. This return is recorded as return 0. After that, if there is any object within the detectable range, the first laser that returns to the Tele-15 is recorded as return 1, and then return 2, and so on. If the object is too close to the Tele-15, such as 1.5 m away, the first effective return will be merged into return 0, and be recorded as return 0.

Group 3 indicates if the sampling point is a noise based on the intensity of the return. Normally, the intensity of the returns of the noises generated due to the interference of atmosphere particles such as dust, rain, fog, and snow is quite low. Therefore, the noises are divided into two categories based on the intensity of the return received. "01" stands for low intensity of the return, indicating that the samples

have a high possibility of being noises such as dust. "10" stands for moderate intensity of the return, indicating that the samples have a moderate possibility of being noises such as rain and fog. The lower the confidence level of the sample is, the lower the possibility that it is a noise.

Group 4 indicates if the sampling point is a noise based on its spatial position. Normally, when the Tele-15 LiDAR sensors detect two close objects, there will be some thread-like noises between the two objects. The noises are divided into three categories. The lower the confidence level of the noise is, the lower the possibility that it being a noise is.

### Timestamp

Both point cloud data and IMU data have timestamp information. There are three ways to synchronize data with the Tele-15: IEEE 1588-2008, Pulse Per Second (PPS), and GPS. When the three ways are used simultaneously, the synchronization priority is IEEE 1588-2008 > GPS > PPS.

IEEE 1588-2008: IEEE 1588-2008 is the Precision Time Protocol (PTP) enabling precise synchronization of clocks in measurement by Ethernet. Livox LiDAR sensors support UDP/IPV4 two-step PTP as well as the following messages: Sync, Follow_up, Delay_req, and Delay_resp.

PPS: PPS uses the sync cable for data synchronization. Refer to the Cables section for more information. The synchronization logic is shown in the figure below. The pulse interval in PPS is 1s (t0 = 1000 ms) while the continuous time of high-level voltage is from 20 ms to 200 ms. The rising edge of PPS resets the timestamp to zero, so the timestamp of the point cloud data indicates the duration between the point cloud sampling and the PPS rising edge.

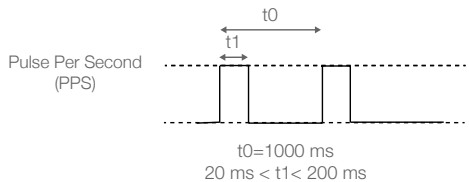



Figure 5.2.2.1 Pulse Per Second

GPS: The GPS module outputs and transmits PPS signal and UTC time to the Tele-15 to synchronize the data. The PPS signal is sent to the Tele-15 via the sync cable and the UTC time is sent to the Tele-15 via SDK. Refer to the SDK Communication Protocols section for more information about commands. The logic of the UTC Time and PPS signal command are shown below. The timestamp of the point cloud data stands for the UTC sampling time of the point cloud once GPS synchronization is in use.

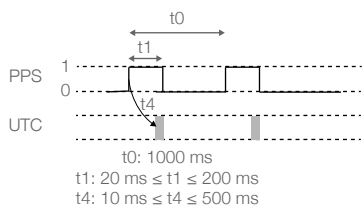



Figure 5.2.2.2 UTC Time Commands

### Status Codes

Both point cloud data and IMU data have status codes information. The status codes display the current working status of the Tele-15 LiDAR sensors. By checking the status codes, users can see the temperature status, voltage status, motor status, dust warning, service life warning, and PPS signal status. Status codes can be viewed in Livox Viewer or in the SDK. Refer to the Livox Viewer User Manual for more information about how to check status codes.

| Status | Description |
|---|---|
| Temperature status | Indicates if there is any temperature abnormality. Temperature status includes normal, warning, and error. |
| Voltage status | Indicates if there is any internal voltage abnormality. Voltage status includes normal, warning, and error. |
| Motor status | Indicates if there is any internal motor abnormality. Motor status includes normal, warning, and error. |
| Dust warning | Indicates if a significant amount of dust is detected on the optical window, if the optical window is covered by objects, or if there is an object less than 0.3 meters away from the LiDAR sensor. |
| Service life warning | Indicates if the LiDAR sensor is nearing the end of its service life. The LiDAR sensor can still work for a short period once this warning appears. It is recommended to replace the LiDAR sensor once this warning appears. |
| PPS signal status | Indicates whether the PPS sync signal is working normally. |

## Working States & Working Modes

The working states of the Livox Tele-15 includes initializing, normal, standby, power saving, and error.

| Working states | Description |
|---|---|
| Initializing | The LiDAR sensor is powering on. |
| Normal | The LiDAR sensor is powered on and working normally. |
| Standby | The LiDAR sensor is powered on, but the laser beams are not active. |
| Power saving | All components are powered off apart from the communication module. |
| Error | The LiDAR sensor will enter error status when an error is detected and all the components are powered off apart from the communication module. |

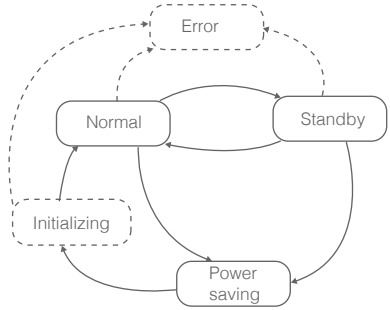



Figure 5.3.1 Relationship between the different working states

The Tele-15 also has three working modes: Normal, Standby, and Power Saving. These modes can be set in Livox Viewer and SDK.

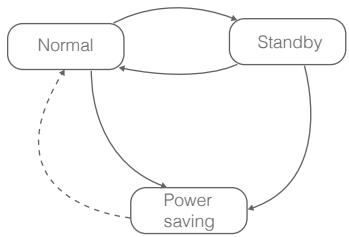



Figure 5.3.2 Relationship between the different working modes available in Livox Viewer

## Dual Return Mode

The Tele-15 can be set to Dual Return mode using Livox Viewer or SDK. The Tele-15 can generate a point cloud of up to two returns in Dual Return mode, which has a point rate of 480,000 points per second.

To set the return mode, run Livox Viewer after the Tele-15 is connected. Click the desired device under the device manager page. Click ⚙ to select the return mode.

## IMU

Tele-15 has a built-in IMU providing the altitude data of the Tele-15.

The push frequency of the IMU can be set using Livox Viewer or SDK. Setting the IMU push frequency is the same as setting the return mode of the LiDAR sensor.

### Software Development Kit (SDK)

Besides using Livox Viewer to check real-time point cloud data, users can also use the SDK or the ROS to apply the point cloud and IMU data acquired from Livox LiDAR sensors to different scenarios.

#### SDK Communication Protocol

With the SDK Communication Protocol, users can learn how to customize the Livox LiDAR sensors. The SDK Communication Protocol encompasses the following three types of data:

Control Command Data: Configuration and query of LiDAR parameters and status information.

Point Cloud Data: Point cloud data generated by LiDAR.

IMU Data: IMU data generated by the built-in IMU.

All data is stored in little-endian format.

Visit http://www.livoxtech.com/sdk to learn more information about SDK communication protocol, Livox SDK API reference, and ROS Toolkit.

## Storage, Transportation, and Maintenance

### Storage

The storage temperature range for the Livox Tele-15 is from -40° to 90° C (-40° to 194° F). Keep Livox Tele-15 LiDAR sensors in a dry and dust-free environment.

- Make sure the Tele-15 LiDAR sensors are not exposed to environments containing poisonous or corrosive gases or materials.
- DO NOT drop Livox Tele-15 LiDAR sensors and be careful when placing a LiDAR sensor in storage or taking it out of storage.
- If a Tele-15 LiDAR sensor is not to be used for more than three months, regularly check the sensors and connectors for abnormalities.

### Transportation

Before transportation, place Livox Tele-15 LiDAR sensors in a suitable box for transportation and make sure it is secure.

Make sure to place foam inside the transportation box and that the box is clean and dry.

DO NOT drop Tele-15 LiDAR sensors and always be careful when carrying a LiDAR sensor.

### Maintenance

In normal conditions, the only maintenance required for the Livox Tele-15 is to clean the optical window of the LiDAR sensor. Dust and stains on the optical window can negatively affect the performance of the LiDAR sensor.

First, check the surface of the optical window to see if cleaning is necessary. If it is necessary to clean, follow the steps below:

1. Use compressed or canned air:

DO NOT wipe a dusty optical window, as it will only cause more damage. Dust the optical window with compressed or canned air before wiping the optical window. Note that if the optical window has no visible stains afterward, it is not necessary to wipe it also.

2. Wipe the stains:
   DO NOT wipe using a dry lens tissue, as it will scratch the surface of the optical window.
   If the optical window is still dirty, a mild soap solution can be used to gently wash the window. Repeat Step 2 to remove any remaining soap residue.

## Troubleshooting

The table below shows you how to troubleshoot and resolve common issues with Livox Tele-15 LiDAR sensors. If the issue persists, contact Livox.

| Issue | Solution |
| --- | --- |
| Cannot detect the LiDAR sensor | • Make sure that all cables are correctly wired.<br>• Make sure the voltage and power supply is suitable. The voltage should be between 10 and 15 V. If a Livox Converter 2.0 is in use, make sure the power supply has a voltage range between 10 and 15 V.<br>• Make sure that the LiDAR sensor is not connected to other software.<br>• Make sure the LAN is selected.<br>• Make sure no security software is installed that would block Ethernet broadcasts.<br>If the issues persists, try to turn off all firewalls and search again.<br>Confirm the packet outputs for all connected devices using another application (e.g., Wireshark). |
| Cannot connect to the detected LiDAR sensor / Cannot start sampling | • Make sure that all cables are correctly wired.<br>• Make sure the voltage and power supply is suitable. The voltage should be between 10 and 15 V. If a Livox Converter 2.0 is in use, make sure the power supply has a voltage range between 10 and 15 V.<br>If the issue persists, reboot the LiDAR sensor and restart the software. |
| No data received | Confirm the packet outputs for all connected devices using another application (e.g., Wireshark). |

## After-Sales Information

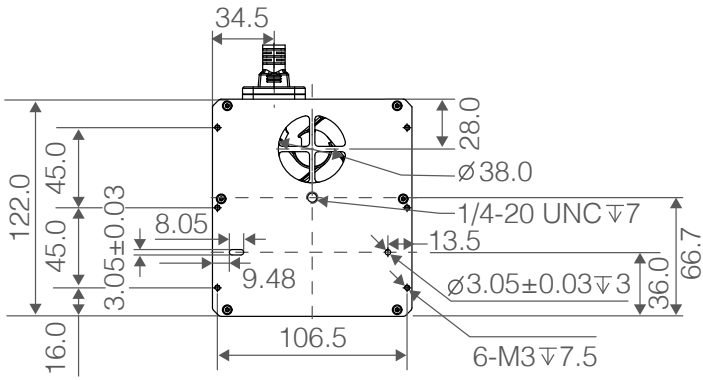
Visit www.livoxtech.com/support to check the after-sales policy and warranty conditions for Livox LiDAR sensors.

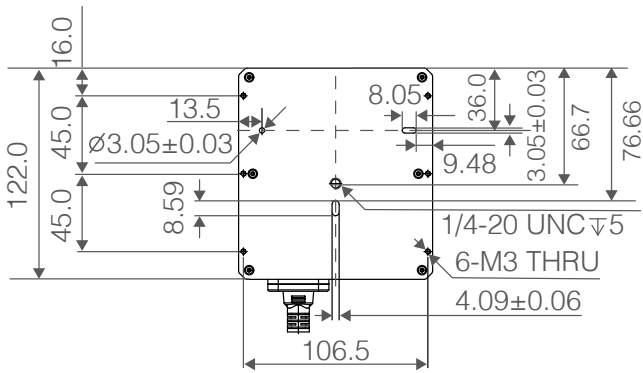
# Appendix

## Appendix 1

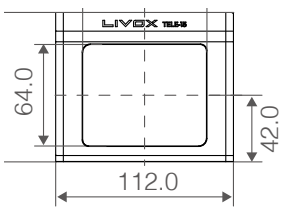
Livox Tele-15 Dimensions with Self-Dissipation Module (Unit: mm)



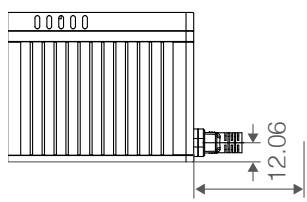

Top View



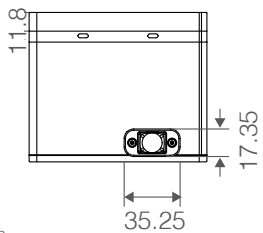

Bottom View




Front View



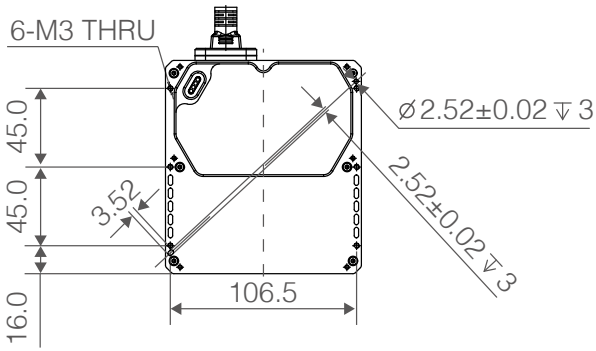

Side View Cable Bending Radius



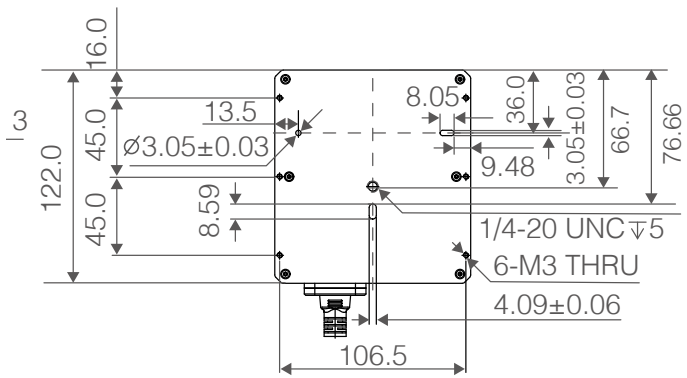

Rear View

## Appendix 2

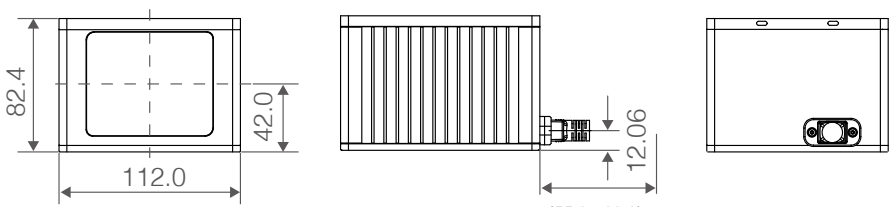
Livox Tele-15 Dimensions without Self-Dissipation Module (Unit: mm)




Top View




Bottom View



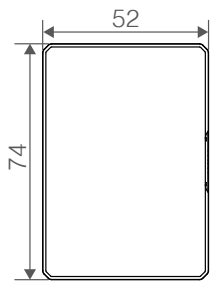

Front View

Side View

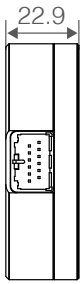
Rear View

## Appendix 3

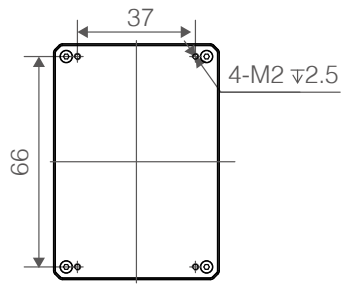
Livox Converter 2.0 Dimensions (Unit: mm)




Top View




Side View




Bottom View

## Specifications

| | |
|---|---|
| Model | TELE-15 |
| Laser Wavelength | 905 nm |
| Laser Safety① | Class 1 (IEC 60825-1:2014) (safe for eyes) |
| Detection Range (@100 klx) | 320 m @ 10% reflectivity<br>500 m @ 50% reflectivity |
| FOV | 14.5° (horizontal) × 16.2° (vertical) |
| Range Precision (1σ) | < 2 cm (5 to 70 m), < 4 cm (70 to 120 m) @ 10% reflectivity<br>< 2 cm (5 to 220 m), < 4 cm (220 to 380 m) @ 80% reflectivity |
| Angular Precision (1σ) | < 0.03° |
| Beam Divergence | 0.02° (horizontal) × 0.12° (vertical) |
| Point Rate | 240,000 points/s (first or strongest return)<br>480,000 points/s (dual return) |
| Data Latency | ⩽ 2 ms |
| Data Port | 100 Mbps Ethernet |
| Data Synchronization | IEEE 1588-2008, PPS, GPS |
| False Alarm Ratio (@100 klx)② | < 0.01% |
| IMU | Built-in IMU model: BMI088 |
| Operating Temperature Range | -40° to 85° C (-40° to 185° F) (with self-dissipation module) |
| Storage Temperature Range | -40° to 90° C (-40° to 194° F) |
| IP Rating | IP67③ |
| Power | 12 W (typical), 36 W (startup) |

| | |
|---|---|
| Power Supply Voltage Range | Livox Tele-15: 10 ~ 15 V DC (recommended 12 V DC and 36 W or higher)<br>Livox Converter 2.0: 9 ~ 30 V DC |
| Noise | 40 cm omnidirectional < 50 dB (without fan) |
| Dimensions | 112 × 94.2 × 122 mm (with self-dissipation module)<br>112 × 82.4 × 122 mm (without self-dissipation module) |
| Weight | Approx. 1.8 kg (with self-dissipation module)<br>Approx. 1.7 kg (without self-dissipation module) |

① The beam divergence of the Livox Tele-15 is 0.02° (horizontal) × 0.12° (vertical). The divergence of the embedded laser, however, is approximately 25.2° (horizontal) × 8° (vertical), which was measured at full width at half maximum. The maximum peak power of the embedded laser may exceed 70 W. In order to avoid being injured by the laser, DO NOT disassemble the Livox Tele-15.

② The false alarm ratio of the noise created by the stray light in a test environment of 100 klx at a temperature of 25° C (77° F).

③ The Livox Tele-15 has an overall IP rating of IP67 (not including Livox Converter 2.0 and cables).