TOPPAN

Engineering Sample

3D Time of Flight Camera *senSPure*™ C11U User's Guide

Overview

TOPPAN's 3D ToF (Time of flight) camera *senSPure*™ C11U is a 3D range measurement camera using a short-pulse hybrid ToF sensing method that allows reliable 3D detection without motion artifacts. It incorporates an in-house developed 3D ToF sensor optimized for a short-pulse light source and a sophisticated range calculation algorithm (Depth Engine) in the camera itself. Camera operation modes are available to suit various operating environments, including standard mode, high dynamic range (HDR) mode that can simultaneously capture low- and high-reflectivity objects, and high-speed mode at a maximum of 120 fps. Additionally, the camera has strong tolerance to ambient light, which allows it to be used in 100,000 lux environments, an interference suppression function among ToF cameras, and the camera body is designed to be IP67 certified dustproof and waterproof, thus making it the ideal ToF camera for FA, service robots, and autonomous mobile robot applications that require object recognition, obstacle detection, and more. This product provides a multi-OS dedicated SDK (TOPPAN ToF SDK) to facilitate ToF camera control to support user application development.

This product complies with Eye Safety class 1 laser product of IEC 60825-1:2014 and EN 50689:2021.

Features

- 3D ToF camera using TOPPAN's unique short pulse hybrid ToF sensing method.
- High ambient light tolerance (100,000lx) by dynamic ambient light suppression operation.
- Dynamic range extension (HDR) mode for ToF signal range
- 120fps high-speed mode for capturing fast-moving object.
- Support for multiple ToF cameras in the same space without ToF signal interferences.
- IP67 dustproof and waterproof for the camera body
- Dedicated SDK for multi-OS

Product code

- TPSC1AS1Z

Application

- Robotics
- Autonomous mobile robot camera
- Gaming
- Monitoring/Surveillance

Contents

1. Precautions and Agreements for use

Icons and Their Meanings

	Prohibited Action	Indicates operations or handling methods that must not be performed.
	Warnings and Safety Precaution	Indicates practices that must be followed without fail. Improper handling may result in personal injury or property damage.

Essential Precautions

Precautions for models using the I/F Hub

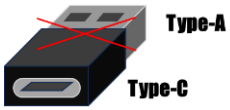
Prohibited

Prohibitions

To ensure safe and proper usage of this product and to prevent potential device failure, please refrain from the following actions:

- The ToF camera unit and ToF camera I/F Hub are designed as an integrated system; do not disconnect the dedicated connection cable between them. Detaching this cable may compromise the dust and water resistance of the camera unit. Additionally, the ToF camera connector has a specific orientation, so take care not to connect the dedicated cable from the I/F Hub in the wrong direction, as incorrect connection may lead to failure of the ToF camera or any connected devices.
- Do not connect the detached dedicated cable to any devices other than the ToF camera unit. Doing so may cause malfunction of the camera I/F Hub or any connected equipment.

- Do not use a USB Type-C to Type-A adapter to connect the supplied USB cable to a PC's USB Type-A port, as this violates USB Type-C standards and may cause device failure.



- Before installing the ToF camera into equipment or a system, ensure that the power supply adapter is turned off. First, connect the power plug from the adapter to the power input port on the ToF camera I/F hub. Only after this should the power cord of the adapter be connected to the outlet. Connecting the cables in the wrong order may result in permanent damage to the device or its components.

Precautions for Using the Camera

	**Eye Safety caution** Do not look directly into the camera under operation. The camera device emits highly concentrated non-visible infrared light. It can be hazardous to the human eye. Direct eye exposure to the laser beam during operation, especially at close range, may cause severe eye damage. When using the device, follow the safety precautions given in IEC 60825-1:2014, EN 50689:2021. Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.
 **Hot Surface**	**High Temperature caution** The surface of the casing may become hot during operation. Please be cautious, as prolonged contact with the skin may cause low-temperature burns.

Terms of Use and Agreement

Definition of Terms

The terms used in this document are defined as follows:

1. *senSPure*™ Series: C11U
2. Instruction Manuals, etc.: Documents related to the *senSPure*™ Series, including instruction manuals, delivery specifications, catalogs, and similar materials.

Notes on Descriptions

Please understand the following regarding the content described in the Instruction Manuals, etc.:

1. The rated values and performance values are those obtained under specific test conditions and do not guarantee the values obtained under combined conditions of these ratings and performances.
2. Reference data is provided as supplementary information and does not always guarantee stable operation within the referenced range.
3. Usage examples are provided for reference purposes only and are not guaranteed.
4. Due to improvements or company circumstances, the production of the *senSPure*™ Series may be discontinued, or its specifications may be changed without prior notice.

Precautions for Use

When using the *senSPure*™ Series, please adhere to the following:

1. Follow all usage conditions, operating environments, handling methods, precautions, prohibitions, and other guidelines described in the Instruction Manuals, etc., for the *senSPure*™ Series.
2. User is responsible for confirming the suitability of the product for their specific constraints and determining whether to use the *senSPure*™ Series.
3. Ensure that the *senSPure*™ Series is properly powered and installed for its intended purpose within your system.
4. When using the *senSPure*™ Series, please: 1) Allow sufficient margin for rated values and performance., 2) Implement redundant designs to minimize risks in case of product failure.), 3)

Incorporate safety measures into the overall system., 4) Perform regular maintenance on both the *senSPure*™ Series and your system.

5. The *senSPure*™ Series is designed and manufactured as a general-purpose product for industrial applications. Therefore, the following uses are not intended and are excluded from warranty coverage:
   A) Applications requiring high safety standards (e.g., nuclear control equipment, aviation equipment, railway systems, medical devices, safety devices, or other applications where human life or safety may be at risk).
   B) Applications requiring high reliability (e.g., 24-hour continuous operation systems).
   C) Applications in harsh environments (e.g., equipment exposed to chemical contamination or electromagnetic interference).
   D) Applications under conditions or environments not described in the Instruction Manuals, etc.
6. Do not use the *senSPure*™ Series for applications involving automotive installations (including motorcycles).

Warranty Conditions

Warranty Coverage

- This warranty covers only initial defects in the product (malfunctions or significant cosmetic defects at the time of product arrival).
- Failures or malfunctions that occur during use, or damages resulting from the use of this product, are not covered by the warranty.

Warranty Period

- We will only provide support for initial defects confirmed within 30 days of product arrival.

Warranty Service Details

- If an initial defect is confirmed, we will replace the product with an identical product.

However, the following cases are excluded from the warranty:

A) Use outside the intended purpose of the *senSPure*™ Series.
B) Use that does not comply with the conditions, ratings, performance, operating environments, handling methods, precautions, or prohibitions described in the Instruction Manuals, etc.
C) Modifications or repairs made by parties other than our company.
D) Issues caused by software programs provided by third parties.
E) Causes unforeseeable at the time of shipment based on the scientific and technical standards of the time.
F) Other causes not attributable to our company or the product itself (including natural disasters and other acts of force majeure).

Disclaimer

- We are not responsible for any damages arising from failure to adhere to the handling procedures described in this chapter and the Instruction Manuals.
- We are not liable for any damages resulting from the use of this product, including data loss, opportunity loss, profit loss, incidental, indirect, or consequential damages of any kind.
- We reserve the right to change the specifications of this product without notice. The product may also be discontinued without prior notice.

Export Control

When exporting the *senSPure*™ Series or technical documents related to the *senSPure*™ Series, or providing them to non-residents, please comply with the export control laws and regulations of Japan

and all relevant countries. Should the user violate these laws or regulations, we may be unable to provide the *senSPure*™ Series or related technical documents.

Safety Precautions

⚠ Prevention of Fire, Electric Shock, and Other Hazards

The following actions may cause fire, electric shock, injury, or malfunction.

- Do not use the product if it is cracked or damaged.
- Do not insert foreign objects into connectors or openings.
- Do not touch the product or connected cables with wet hands.
- Do not disassemble, repair, or modify the product.

If you notice abnormal heat, odors, or other irregularities during use, stop using the product immediately.

⚠ Installation Precautions

- Do not install the product in unstable locations, as this may cause accidents, injuries, or malfunctions.
- Do not use the product in environments exceeding the rated temperature and humidity range or where condensation occurs, as this may cause internal component damage or deterioration.
- Avoid high-temperature, high-humidity, or UV-exposed environments for prolonged periods.
- Do not install the product in areas with strong electric or magnetic fields, as this may cause malfunctions.
- Avoid corrosive, flammable, or explosive gas environments.
- Implement proper protective measures against constant water exposure or splashing of liquids other than water.
- Ensure sufficient heat dissipation during installation and avoid placing the product near heat sources.
- Secure the product firmly during installation to prevent loosening, which may affect measurement data.
- This product is intended for fixed use. Do not use it handheld.

Others

- Do not twist or apply excessive mechanical stress or shock to the product, as it may lead to failure or degraded performance.
- For safety, installation and wiring should be done by qualified personnel.
- Do not drop the product during installation; doing so may cause failures or reduced performance.
- Dispose of this product in accordance with the applicable laws and regulations of your country or region. For details, please contact the relevant local authority or waste disposal service.

General Precautions

⚠ Notes on the ToF Camera Principle

- This product measures distance using laser light. Do not intentionally look into the laser aperture for extended periods or at close range. (This product guarantees CLASS 1 LASER PRODUCT in accordance with IEC60825-1 Ed.3:2014 and EN 50689:2021.)
- Do not expose the sensor to powerful lasers or strong direct sunlight for extended periods, as the lens may focus the light and damage the sensor.

- Due to the nature of ToF cameras, performance may vary depending on the environment or sensor drive settings. In particular, the sensing accuracy may be affected for the following types of objects:
  - Highly reflective surfaces (e.g., mirrors, glossy items).
  - Low-reflectivity objects (e.g., black surfaces).
  - Materials that allow infrared light to pass through (e.g., high-transparency glass, plastics).

⚠ Handling Precautions

The following actions may affect product operation, performance, or functionality:

- When installing the product, use an ESD-controlled environment and wear anti-static gloves to prevent electrostatic damage.
- Do not touch the lens or laser light source. If dirty, clean gently with a soft cloth to avoid scratching the surface. Avoid using solvents or chemical wipes.
- For cleaning the product or I/F Hub, use a soft cloth or sponge. For heavy dirt, use a damp cloth.
- Do not use products that have been subjected to strong impacts, such as drops. Avoid touching sharp or exposed internal parts of damaged products.
- Do not pull on cables connected to the product.
- Do not connect or disconnect cables while the product is powered on.
- Do not forcibly insert non-standard connectors.
- The product generates heat during operation. Ensure sufficient heat dissipation to prevent the surrounding temperature from exceeding the rated range.
- If abnormalities are observed during use, stop using the product immediately.

⚠ Storage Conditions After Unpacking

To prevent deterioration of the product, we recommend the following storage conditions:

Temperature:	0 to 40°C
Humidity:	60%RH or lower, with no condensation even under low-temperature/high-humidity environments.
Atmosphere:	No harmful gases (e.g., acids, alkalis) that could significantly corrode electronic components or wiring.
Other:	Do not expose the product to direct sunlight or strong UV radiation.

Notes on Intended Use

⚠ Notes on Intended Use

- Do not use this product for automobiles (including motorcycles), aerospace equipment, trunk communication equipment, nuclear control equipment, life-support systems, or similar applications requiring extremely high reliability.
- This product is not designed for security purposes or guaranteed for safety.
- When using this product, respect portrait rights and privacy rights of individuals who may be captured by the camera and ensure no infringement of copyright laws or other regulations occurs.
  - Do not use this product for applications that may cause harm or damage to human life, body, or property.
  - This product is intended for fixed installations. Do not hold it by hand during operation.

Prohibited Actions

- This product is precisely assembled. Do not disassemble or modify it.
- Do not remove the product label.
- The firmware included in this product is protected by intellectual property rights. Do not engage in the following actions, either directly or through a third party:
  - Extracting the firmware from the camera body
  - Reverse engineering, such as disassembling or decompiling the firmware
- Do not reproduce, copy, transcribe, or modify the documents without authorization.
- Do not share the documents with third parties.
- Do not transfer the documents to third parties.
- Do not grant third party permission to use the documents.
- If it becomes necessary to disclose or provide the documents to a third party, please consult the manufacturer.

Other Information

SDK for This Product

This SDK software contains both Open-Source Software ("OSS") and proprietary software owned by our company. The copyrights of the OSS remain with their respective holders and must be adhered to in accordance with their individual license terms. Please refer to the related documentation file provided with this SDK or the respective websites for details on these license terms. In the event of any conflict between this agreement and the OSS license terms, the OSS license terms shall prevail.
For details on the SDK and its usage conditions, please refer to the “TOPPAN ToF SDK API Reference Manual” and other relevant documents.

Trademarks for Identification

Product names, company names, or other proper nouns mentioned in this document or related documents are the property of their respective owners. TM (™) and R (®) marks may be omitted in this document. These names are used solely for identification and explanation without intent to infringe upon any rights.

2. ToF camera system overview

2-1. Hardware system

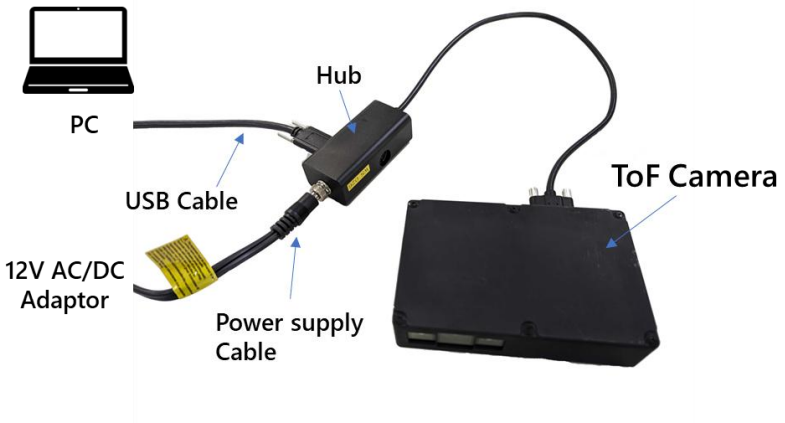


Figure 1. Hardware system overview

The 3D ToF camera is equipped with TOPPAN's original 3D ToF sensor TPHT4030, a lens, a bandpass filter and 2 VCSEL light sources with a target light wavelength of 940 nm. The power supply of the 3D ToF camera and the communication with the host computer are handled by the attached ToF camera I/F Hub.

On the host computer, the TOPPAN ToF Viewer software controls the ToF camera itself, and infrared (IR) amplitude (intensity) and depth information can be acquired and displayed in real time.

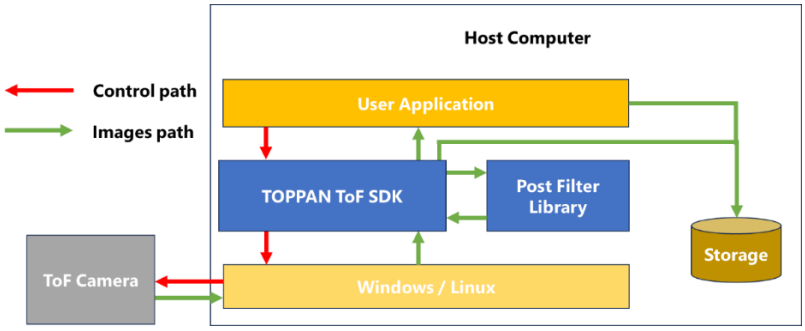


Figure 2. System Overview in the Host Computer

Table 1. Recommended environment for Host computer

Name	Performance
OS	Windows 11/10 64 bit Linux Ubuntu 20.04 LTS 64 bit
CPU	4 core or better
Operating frequency	2 GHz or better (base clock)
RAM	8 GB or more
Display	Full-HD or more
Interface	USB3.1 (Gen1) port (Type C)

Note: When processing with multiple threads and high frame rates using the Pipeline Framework, a host computer environment with a high operating frequency and many CPU cores is recommended due to the high load placed on the host PC.

2-2. Key specifications for ToF camera unit

Table 2. Key specification

Name	Specification
Product model	*senSPure*™ C11U
Dimension	29 x 120 x 77 mm (ToF camera body) 75 x 25 x 35 mm (ToF camera I/F Hub)
Weight	320 g (ToF camera body) 110 g (ToF camera I/F Hub)
ToF sensor	TPHT4030 (TOPPAN original 3D ToF sensor)
ToF sensing method	Short pulse type hybrid ToF method
Number of Active pixels	640 × 480 pixels
Working range	0.5 ~ 7 m
Light source	2×VCSEL (λ=940 nm) [class 1 laser product: (IEC 60825-1:2014, EN 50689:2021)]
Depth noise (repeatability)	≤ 1% (@distance, 30fps typical) ***Note1***
Distance accuracy	≤ 1% (@distance, 30fps typical) ***Note1***
Frame rate	15fps, 30fps 60fps (Standard mode) Max.120fps (High speed mode) HDR mode (15fps, 30fps, 60fps)
Ambient light tolerance	Max. 100,000lx
Camera FoV	90° (H) x 67° (V) * Lens Specifications
USB port (I/F Hub)	USB3.1 Gen1 (Port: Type C)
Communication protocol	UVC1.5
Camera synchronization signal	Hardware trigger (primary and secondary connections) ***Note2***
Power	12V/<3A (Typ. 10W)
Dustproof Waterproof Standard	IP67@Camera Body (See *Figure 47*)
Warming up time	10min (typ.) ***Note3***
Ambient temperature TA ***Note4***	Operating condition: -25°C ~ 60°C Storage condition: -40°C ~ 80°C
Development environment	Windows 11/10, Linux (Ubuntu20.04 LTS 64 bit), ROS2 Jetson AGX Orin (Linux Ubuntu 20.04 LTS / JetPack 5.0.1)
Software	TOPPAN ToF SDK, TOPPAN ToF Viewer

Note: This is technical specifications of the C11U(ES) product. For mass-produced products, specifications are subject to change without notice due to performance or quality improvement.

Note[1]: Test environment and standard conditions. Since the distance measurement by ToF sensing depends on the reflection of the modulation light emitted by the ToF camera, the measurement result may be affected by environmental factors and the reflectivity of the object.

Note[2]: For specifications of the connection terminals, refer to the section of ***7-8. External synchronization trigger signal information***.

Note[3]: It varies depending on the camera's installation environment and settings.

Note[4]: Ambient temperature guaranteed for operation

3. Contents

The contents of this product are as follows.

Table 3. Contents list of this product

No.	Name	Description
1	ToF camera body	3D ToF Sensor Camera Body
2	ToF camera I/F Hub	Connection Hub (Power supply, data communication, external trigger integrated type)
3	Power supply adaptor	DC 12V/3.3A *Please prepare a power cable suitable for your country.
4	USB cable	Camera Output (Type C) - PC Connection (Type C)
5	Software	TOPPAN ToF Camera SDK for C11U
6	Documentation	User's Manual, SDK Manuals

ToF camera [1] + I/F Hub [2]

Power supply adaptor [3]

USB3.0 Cable [4]

Figure 3. Contents

Includes ToF camera main unit, dedicated ToF camera I/F Hub, USB3.0 cable (Type-C), power supply adapter, software (electronic data), and documentation (electronic data). The software and documentation are distributed as digital files.

The contents of this product may vary depending on the sales format.

⃠ Prohibited

- The ToF camera unit[1] and ToF camera I/F Hub[2] are designed as an integrated system; do not disconnect the dedicated connection cable between them. Detaching this cable may compromise the dust and water resistance of the camera unit. Additionally, the ToF camera connector has a specific orientation, so take care not to connect the dedicated cable from the hub in the wrong direction, as incorrect connection may lead to failure of the ToF camera or any connected devices.
- Do not connect the detached dedicated cable to any devices other than the ToF camera unit. Doing so may cause malfunction of the hub or any connected equipment. If it has been removed, please contact the manufacturer through the seller.
- Do not use a USB Type-C to Type-A adapter to connect the supplied USB cable to a PC's USB Type-A port, as this violates USB Type-C standards and may cause device failure.
- Before installing the ToF camera into equipment or a system, ensure that the power supply adapter is turned off. First, connect the power plug from the adapter to the power input port on the ToF camera I/F hub. Only after this should the power cord of the adapter be connected to the outlet. Connecting the cables in the wrong order may result in permanent damage to the device or its components.

3-1. Camera layout

Figure 4. ToF Camera configuration (Appearance)

Caution!

- The Status LED window also functions as an internal pressure adjustment valve for the enclosure via a specialized sheet. Do not block this window.

3-2. Dimensions

The dimensions of the ToF camera and the ToF camera I/F Hub are shown below.

3-2-1. ToF camera body

Unit: mm

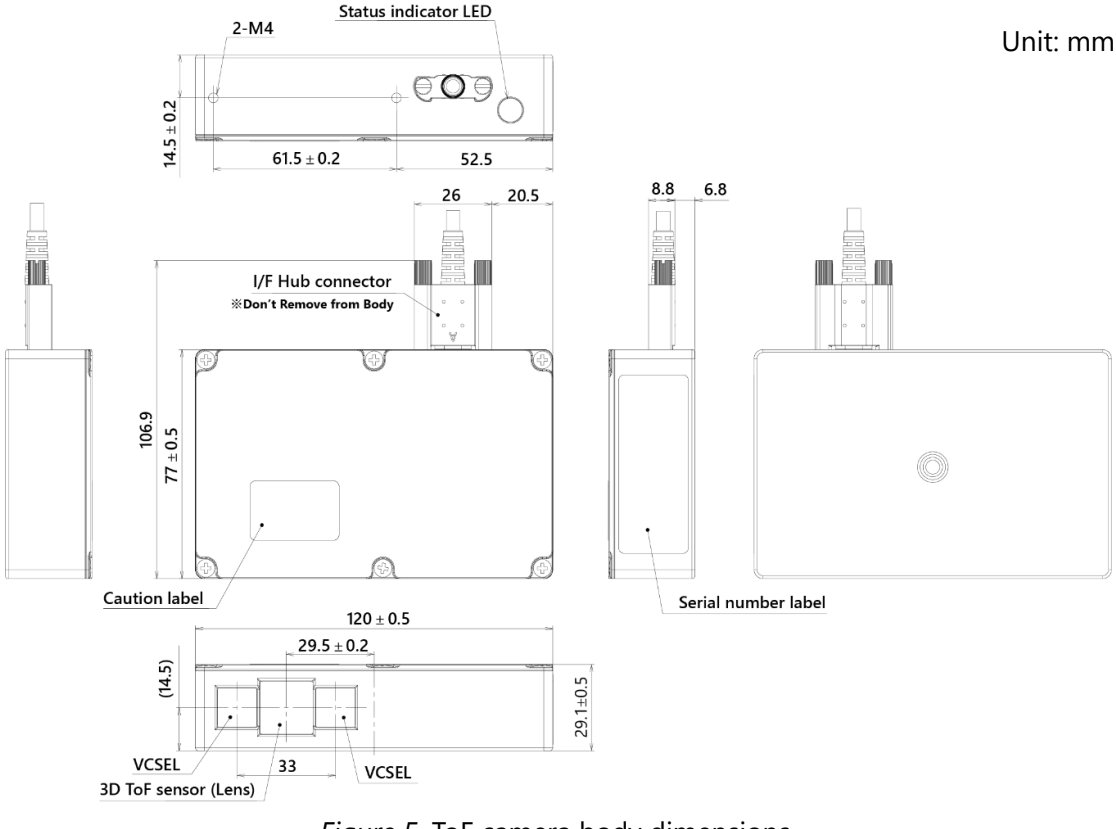


Figure 5. ToF camera body dimensions

3-2-2. ToF camera I/F Hub

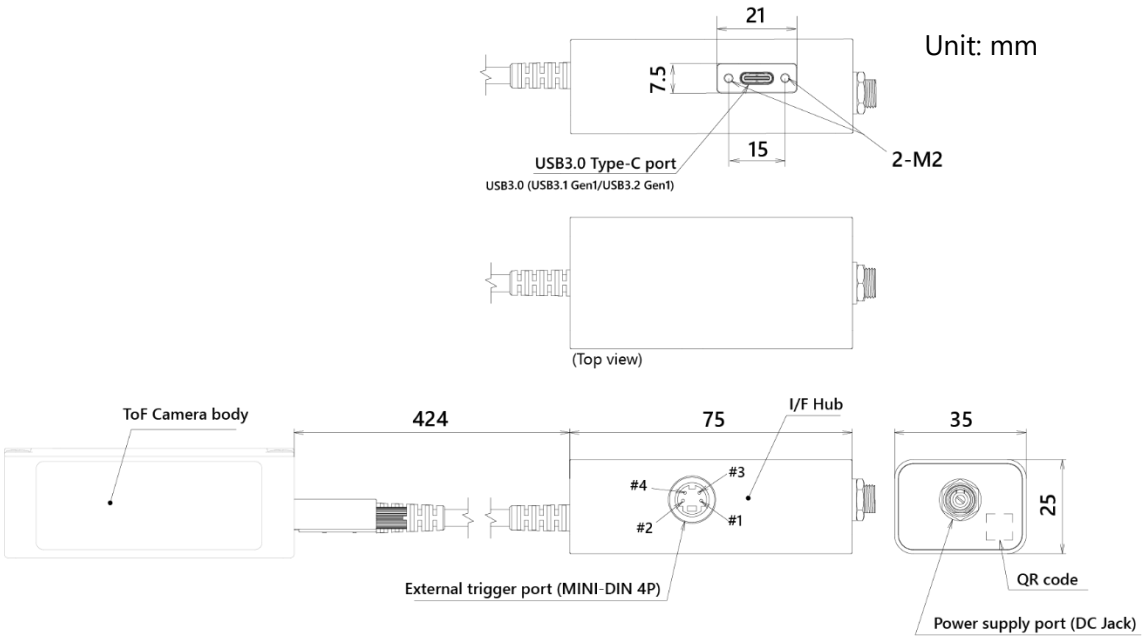


Figure 6. ToF camera I/F Hub dimensions

3-3. Camera coordinates

The camera coordinates is shown below.

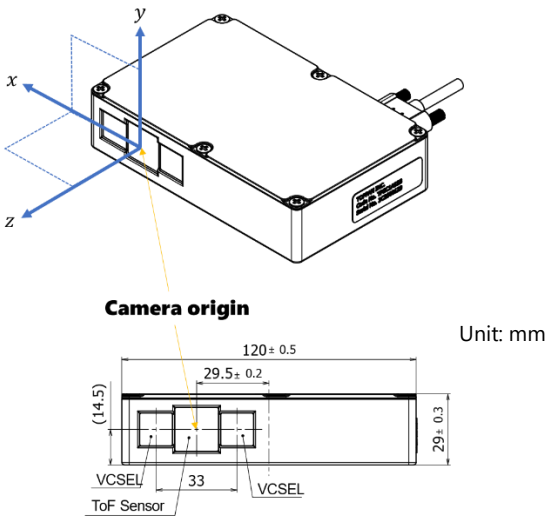


Figure 7. Camera coordinates

3-4. Label

The label position of the ToF camera is shown below.

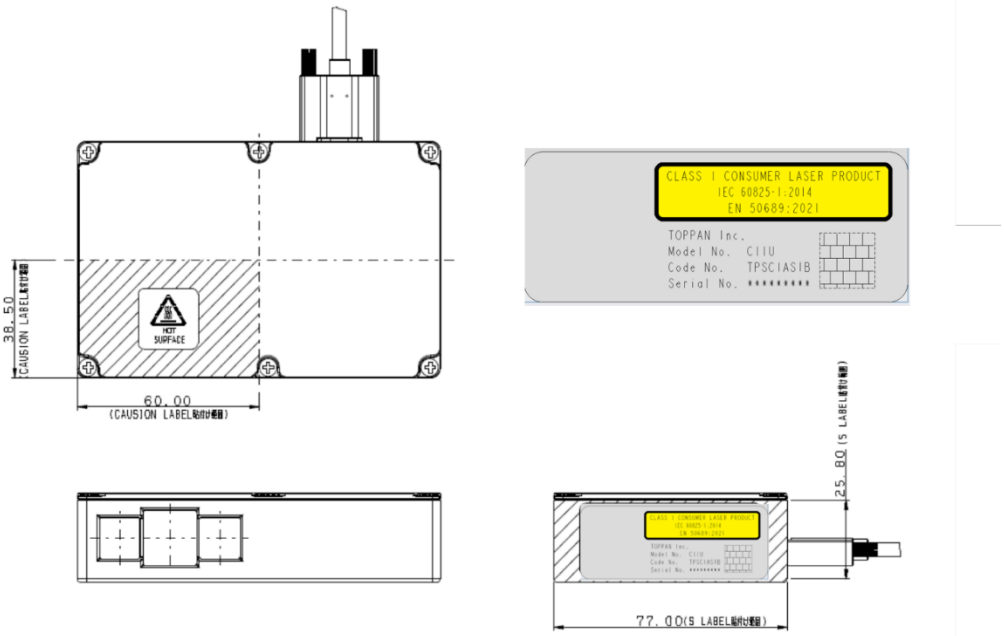


Figure 8. Label position

4. Quick start guide

4-1. Software environment setup (Common)

When the software provided as TOPPAN ToF Viewer using TOPPAN ToF SDK is deployed, the directory structure will be as follows. Hereafter, please replace the parts indicated as {SDK path} with the directory where the provided software is extracted. Additionally, the directory path for extraction must not contain Japanese characters or other multibyte characters.
For downloading and installing the software necessary for the environment setup, a network environment is required. Please ensure you have an internet connection available.

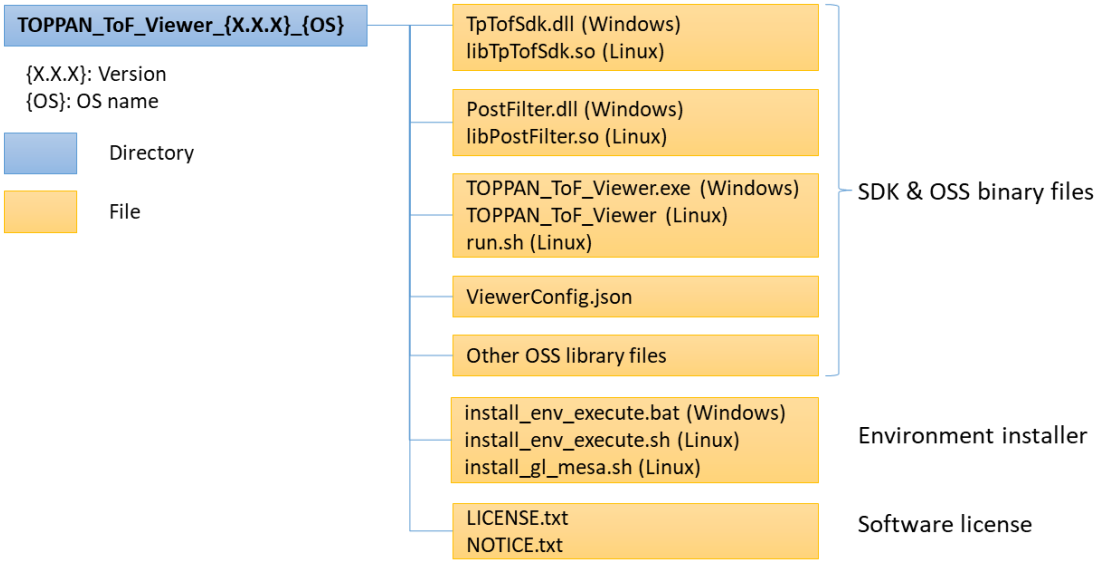


Figure 9. TOPPAN ToF SDK software

The contents of each file are as follows.

Table 4. TOPPAN ToF Viewer software

File name	Description
TpTofSdk.dll libTpTofSdk.so	Library file of TOPPAN ToF SDK
PostFilter.dll libPostFilter.so	Extension library file linked with TOPPAN ToF SDK, etc.
TOPPAN_ToF_Viewer.exe run.sh	Executable file of TOPPAN ToF Viewer using TOPPAN ToF SDK, etc.
ViewerConfig.json	Setting file of TOPPAN ToF Viewer
install_env_execute.bat install_env_execute.sh install_gl_mesa.sh	Files for environment installation
Other OSS library files	OSS Binary files(DLL), etc.
LICENSE.txt	License terms
NOTICE.txt	Third-party Notices: OSS License terms

4-1-1. Software installation for Windows

This SDK uses the following software for the Windows environment.
Please refer to "***4-1-1-1. Installation procedure (Windows)***" for the required software installation.

Table 5. Software list (for Windows)

Group	Software	Usage
Package management	chocolatey	Development environment construction
Image processing	OpenCV (Ver: 4.5.5)	Used in the SDK library
C++ extension	boost (Ver: 1.74)	Used in the SDK library
USB driver	Windows SDK	Used in the SDK library
Image reception	EWCLIB (Ver: 2.8)	Used in the SDK library
	Windows SDK 6.1	
Execution environment	Visual C++ Redistributable	For running the sample viewer in an environment where MS Visual Studio is not installed
Graphics	GLFW (Ver: 3.3.2)	Used in the TOPPAN ToF Viewer
GUI tool	Dear ImGui (Ver: 1.88)	Used in the TOPPAN ToF Viewer
	imgui-filebrowser (Commit ID: cfccc2a)	
Japanese font	IPA fonts (Ver: 003.03)	Used in the TOPPAN ToF Viewer

4-1-1-1. Installation procedure (Windows)

***STEP1*. Package management: chocolatey**

Use chocolatey as a package management tool on Windows OS. Go to below and follow the installation instructions to install the chocolatey.
https://chocolatey.org/install#individual

***Note*[1]**: Normally, you should select "*Individual*" to install the software.
***Note*[2]**: After selecting "*Individual*," start *Windows PowerShell* with administrator privileges. Copy the specified command to install chocolatey described in the procedure. Paste the command into the *Windows PowerShell* console and press the [Enter] key to execute it.
Note*[3]**: See "9-6. Note of chocolatey installation step***" for details.

***STEP2*. OSS(boost)**

Use chocolatey to install OSS (boost) referenced in this SDK.
Start a command prompt with administrator privileges and execute the following command to install.

```
cd {SDK path}
.\install_env_execute.bat
```

***STEP3*. Visual C++ Redistributable package**

If Visual C++ 2019 Redistributable Package (X64) is not installed in your environment, download and install the package from the following Microsoft website.
https://learn.microsoft.com/ja-jp/cpp/windows/latest-supported-vc-redist?view=msvc-170

Note: Architecture (X64); Download URL [https://aka.ms/vs/17/release/vc_redist.x64.exe]

4-1-2. Software installation for Linux/Ubuntu

This SDK uses the following software for the Linux/Ubuntu environment.
Please refer to "***4-1-2-1. Installation procedure (Linux/Ubuntu)***" for the required software installation.

Table 6. Software list (for Linux/Ubuntu)

Group	Software	Usage
Package management	Advanced Package Tool	Development environment construction
Image processing	OpenCV (Ver:4.2.0)	Used in the SDK library
C++ extension	boost (Ver:1.71)	Used in the SDK library Used in the TOPPAN ToF Viewer
Image reception	Video for Linux2 (V4L2)	Used in the SDK library
USB communication	libusb (Ver:1.0.23)	Used in the SDK library
Execution environment	GLFW (Ver:3.3.2)	Used in the TOPPAN ToF Viewer
Graphics	Mesa 3D (Ver:9.0.1)	Used in the TOPPAN ToF Viewer
GUI tool	Dear ImGui (Ver:1.88)	Used with TOPPAN ToF Viewer
	imgui-filebrowser (Commit ID: cfccc2a)	
Japanese font	IPA fonts (Ver:003.03)	Used in the TOPPAN ToF Viewer

4-1-2-1. Installation procedure (Linux/Ubuntu)

STEP1. **OSS**

Install OSS(OpenCV, boost, libusb, GLFW, IPA fonts) referenced in this SDK. Start terminal and install using the following command.

```
cd {SDK path}
./install_env_execute.sh
```

After executing the command, 99 usb-C11U.rules is generated in/lib/udev/rules.d/.

STEP2. **OpenGL driver**

If the OpenGL driver is not installed on your PC, install the OpenGL driver using the following command.

```
./install_gl_mesa.sh
```

4-1-3. Software installation for Jetson AGX Orin

This SDK uses the following software for the Jetson AGX Orin environment.
Please refer to "***4-1-3-1. Installation procedure (Jetson AGX Orin)***" for the required software installation.

Table 7. Software list (for Jetson AGX Orin)

Group	Software	Usage
Package management	Advanced Package Tool	Development environment construction
Image processing	OpenCV (Ver:4.2.0)	Used in the SDK library
C++ extension	boost (Ver:1.71)	Used in the SDK library

		Used in the TOPPAN ToF Viewer
Image reception	Video for Linux2 (V4L2)	Used in the SDK library
USB communication	libusb (Ver:1.0.23)	Used in the SDK library
Graphics	GLFW (Ver:3.3.2)	Used in the TOPPAN ToF Viewer
GUI tool	Dear ImGui (Ver:1.88)	Used in the TOPPAN ToF Viewer
	imgui-filebrowser (Commit ID: cfccc2a)	
Japanese font	IPA fonts (Ver:003.03)	Used in the TOPPAN ToF Viewer

4-1-3-1. Installation procedure (Jetson AGX Orin)

***STEP1* OSS**

Install OSS(boost, libusb, GLFW, IPA fonts) referenced in this SDK. Start Terminal and install by the following command.

```
cd {SDK path}
./install_env_execute.sh
```

After executing the command, 99 usb-C11U.rules is generated in/lib/udev/rules.d/.

4-2. TOPPAN ToF SDK Viewer application

This product includes the ToF Camera Viewer using TOPPAN ToF SDK, which is dedicated to TOPPAN ToF camera and is provided for the purpose of demonstrating and evaluating the performance of our ToF sensor and camera module.

The TOPPAN ToF Viewer is compatible with Windows, Linux/Ubuntu. Before use, it is necessary to install the software suitable for each environment. Please refer to "***4-1. Software environment setup (Common)***" for the software installation procedure.

An overview of the functions of TOPPAN ToF Viewer is shown below.

Table 8. TOPPAN ToF Viewer

Function	Description
Camera control	Controls the camera device.
File Save	Save the depth/IR output data.
File Play	Play back the file saved by the "Record" function.
Post Filter Settings	Setting of the post filter processing.
Post-processing setting	Set post-processing settings in SDK such as point cloud conversion.
Image and point cloud display	Display depth/IR image and point cloud data.
Snapshot	Save post-processed depth/IR images and point cloud data using the Snapshot function

The startup of TOPPAN ToF Viewer window is shown below.

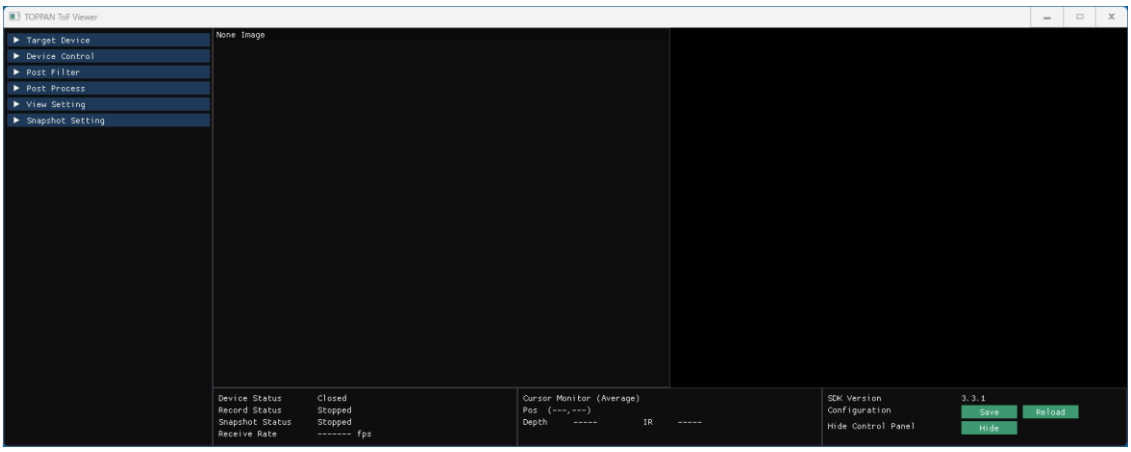


Figure 10. TOPPAN ToF Viewer window

4-2-1. Run TOPPAN ToF Viewer (Windows)

Click "TOPPAN_ToF_Viewer.exe" in the following folder containing the TOPPAN ToF Viewer software for Windows to start TOPPAN ToF Viewer.

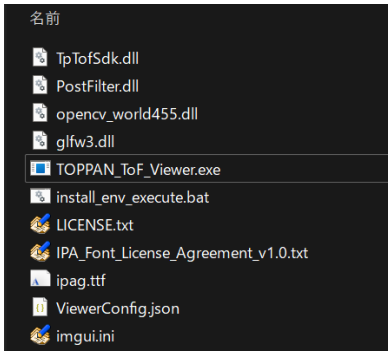


Figure 11. TOPPAN ToF Viewer folder (Windows)

4-2-2. Run TOPPAN ToF Viewer (Linux/Jetson AGX Orin)

Execute the shell script file "run.sh" in the folder containing the TOPPAN ToF Viewer software for Linux/Ubuntu to start TOPPAN ToF Viewer.

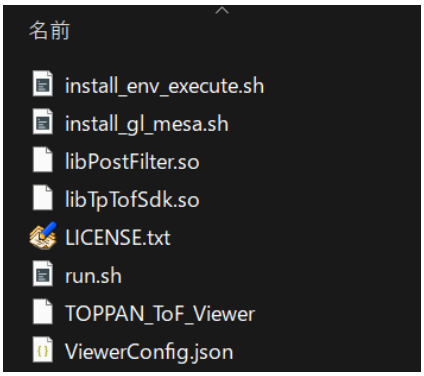


Figure 12. TOPPAN ToF Viewer folder (Linux/Ubuntu)

Execute the following command on Terminal to start TOPPAN ToF Viewer.

```
./run.sh
```

4-3. Camera startup

***STEP1*. Start camera power supply (Cable connection order)**

1. Refer to *Figure 1*, connect the ToF Camera I/F Hub to the PC using a USB cable.
2. Ensure that the power supply adapter is powered off. First, insert the power plug from the power supply adapter into the power supply port on the I/F Hub. Make sure the plug is fully inserted, then tighten the lock ring securely.
3. After completing the above, connect the power cord attached to the adapter to the wall outlet to supply power.

The LED on the back of the camera turns red when power is supplied, and then turns green to indicate that the camera has been successfully activated.

***STEP2*. Camera connection and activation**

Refer to *Figure 13*, start the TOPPAN ToF Viewer, and select "C11U" from "Target Device" in the left menu.

If not listed, press “Reload” to check the connection. After selection, wait a moment, then press “Start Capture.”

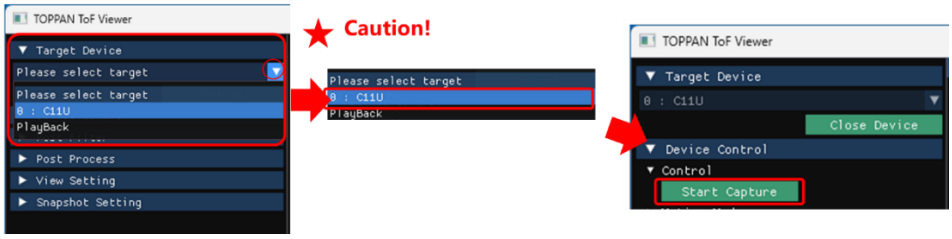


Figure 13. From Device Selection to “Start Capture”

Caution!

- When initial selecting a camera device after launching this application, the VCSEL will emit light for approximately 3 seconds for internal camera calibration. Please do not look into the VCSEL windows of the connected ToF camera during the internal camera calibration period.
- The "Start Capture" button will be enabled after the internal camera calibration is complete.

When the ToF camera starts operating successfully, the Depth and IR images from the ToF camera are displayed in real time as shown in *Figure 14*.

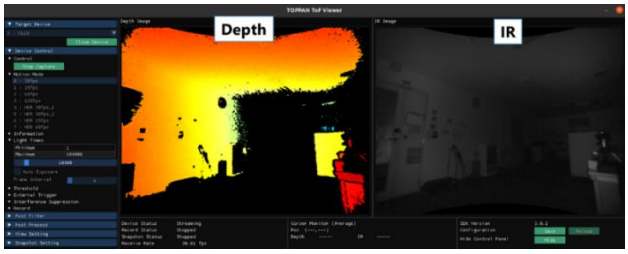


Figure 14. Depth image (left) and IR image (right)

***STEP3.* Adjusting Light Times**

When the IR and Depth images are noisy by weak signals (normally dark in IR image), please adjust “**Light Times**” to improve image quality. For an explanation of "Light Times," see”***6. Overview of short-pulse ToF sensing operation***” and “***7-2-2. Device Control operation (when Camera device is selected)***”.

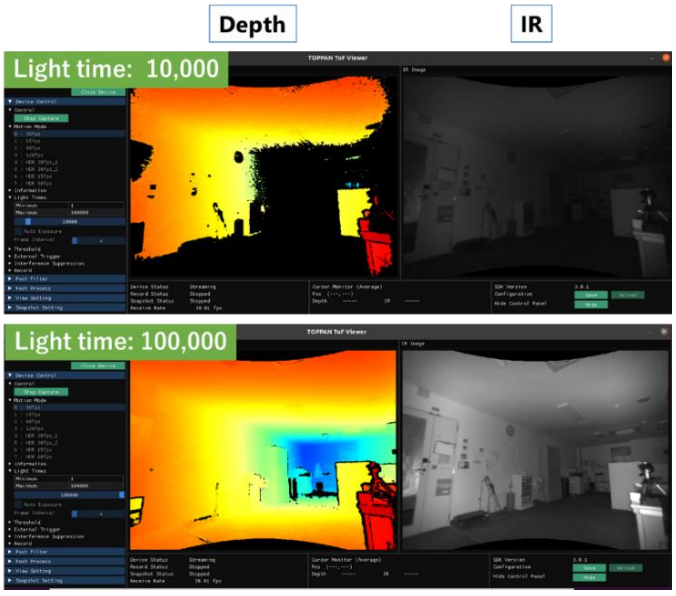


Figure 15. Changing “Light Times” affects depth sensing performance

Note: The “left mouse button press + slide” or “Ctrl key + left mouse button press” to enter values can be used for setting.

STEP4. **PostFilter Setting**

The PostFilter in the TOPPAN ToF Viewer is a function that applies filtering to IR and depth images; see “***7-2-4. Post Filter functions***”.

By Default)

Bilateral Filter : *Enable*
Flying Pixel Filter : *Enable*

4-4. Camera stop and power off

Click the “Close Device” button in the “Target Device” label to close the target device.

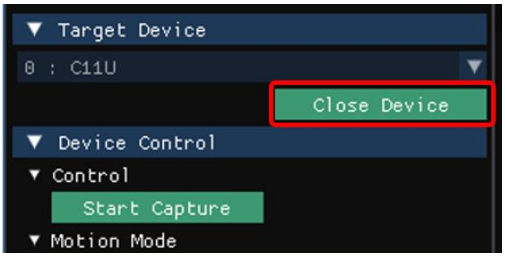


Figure 16. Closing the target device

Press the [×] button in the upper right of the window to close TOPPAN ToF Viewer. After turning off the camera power by unplugging the power cord from the outlet, disconnect the power cable from the ToF camera I/F Hub. Also check the status LED on the back of the camera to make sure that the LED is off.

⚠ ***Caution!***

- If a device is already selected, make sure to press the “Close Device” button for the device in use before exiting the application. If the application is not properly shut down, the device may not power down correctly, and the VCSEL light source may continue to emit even after the application is closed. Additionally, this could result in erratic behavior from the PC.

5. Camera operating mode

The ToF camera can operated in the following operating modes described in *Table 9*.

As shown in *Figure 17*, the operating modes are displayed in the "Motion Mode" list in the "Device Control" label. After selecting a mode, start camera mode configuration. Once configuration is complete, click "Start Capture".

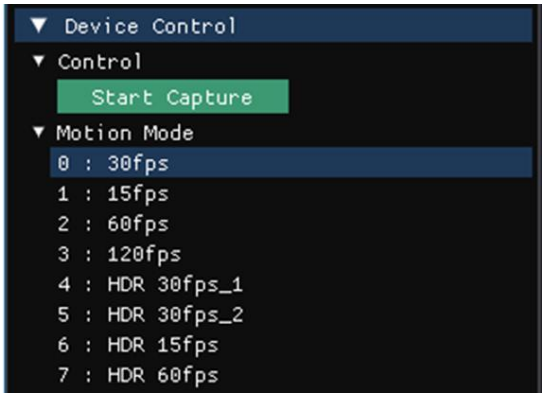


Figure 17. List of camera operating mode

Table 9. Motion mode

No.	Mode name	FPS	Max. Light Times		Function
0	**30fps**	**30**		**100,000**	**30fps mode (Default)**
1	15fps	15		200,000	15fps mode
2	60fps	60		45,000	60fps mode
3	120fps	120		13,000	120fps mode
4	HDR 30fps_1	30	10,000	100,000	Line binning HDR*Note1*
5	HDR 30fps_2	30	50,000	100,000	Line binning HDR *Note1*
6	HDR 15fps	15	50,000	200,000	Line binning HDR *Note1*
7	HDR 60fps	60	9,000	45,000	Line binning HDR *Note1*

Note[1] : "HDR (Line binning HDR)" captures a depth data with different "Light times"(fixed value) for each line of the pixel array in a 3D ToF sensor and combines them to generate HDR data. Although the final depth result data is upscaled to VGA resolution, but the actual resolution in the vertical direction is reduced due to line-by-line binning.

6. Overview of short-pulse ToF sensing operation

The 3D ToF camera of this product calculates distance using the short-pulse ToF method. As shown in, *Figure 18* this method repeatedly emits short-pulse ToF light within a single frame, integrates the returned light signal from the object onto the 3D ToF sensor, and then calculates the distance based on the integrated signal.

The “Integration time” (light integration time) is defined as the product of the number of repeated light emissions “Light Times” per frame and its unit of integration cycle “UIC”, and it affects sensing performance such as maximum measurement range and distance measurement accuracy (see *Figure 15*). Generally, when the “Integration Time” is long, distance measurement can be performed over long distances. However, under conditions where the reflectance of the object is high or the object is close, there is a possibility of distance measurement failure due to signal saturation.

The “Integration time” of the ToF camera can be adjusted in the “Light Times” item of the TOPPAN ToF Viewer (see *Table 13*, item 6).

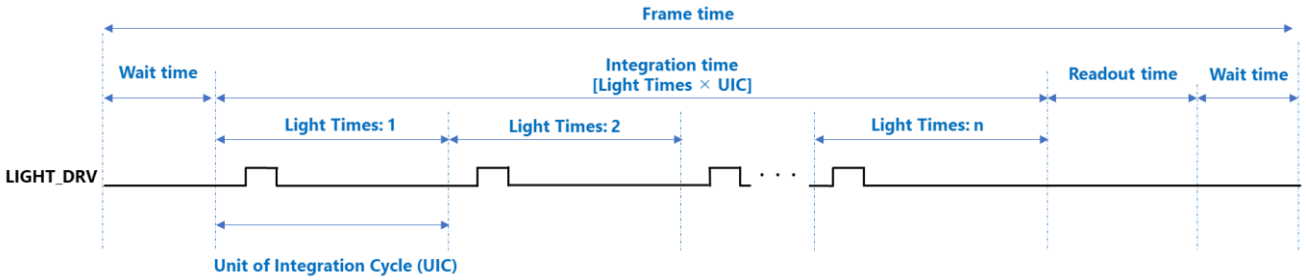


Figure 18. Definition of the “Integration Time” and the “Light Times” per frame

7. ToF camera viewer

7-1. GUI window structure

When you start TOPPAN ToF Viewer, the following GUI window is displayed.

Figure 19. TOPPAN ToF Viewer window GUI

Table 10. TOPPAN ToF SDK viewer panels

No.	Name	Description
①	Main window panel	Window in which each panel is drawn.
②	Control panel	Control and setting for ToF camera and sensor.
③	Image display panel	Displays depth/IR images or point cloud data.
④	Status display panel	Displays camera status, received frame rate, etc.

7-2. Control panel

The control panel displays related functions separated by labels, as shown in *Figure 20*. The items in each label can be expanded by clicking the label name.

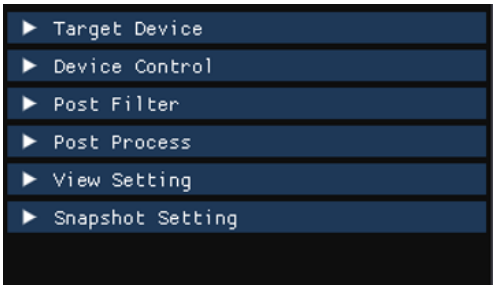


Figure 20. Control panel label overview

Table 11. Label name and description at Control panel

Name	Description
Target Device	Selecting target devices to control (including PlayBack)
Device Control	Control the device selected in "Target Device"
Post Filter	Post filter settings
Post Process	Settings for post-processing (Lens-based conversion, etc.)
View Setting	Settings for screen display
Snapshot Setting	Settings for saving images after post-processing (Refer to "***7-6. Snapshot function (Saving Snapshot data)***")

7-2-1. Target Device selection

Select the target device (camera device or PlayBack) to be used. The following table function can be performed in the "Target Device" label.

Table 12. Description of the functions in the Target Device

No.	Function	Description
①	Target Device	Select the target device to be used from the list of connected camera devices or file playback (PlayBack). *You cannot select the device while the device is open.
②	Reload	Search for the connected camera devices again.
③	Close Device	Quit the selected camera device or file playback. To use the device again, re-select the device from ①.

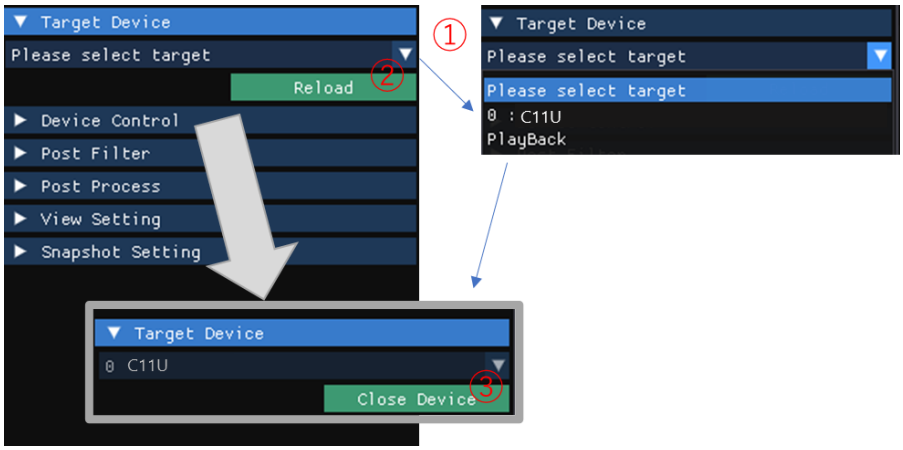


Figure 21. Flow of the target device selection

7-2-2. Device Control operation (when Camera device is selected)

This controls the camera device selected in "Target Device". The "Device Control" operation is different whether a camera device or a playback device is selected. When a camera device is selected in "Target Device", the following operations can be performed.

⚠ ***Caution!***

- When initial selecting a camera device after launching this application (See ★ *Figure 13*), the VCSEL

will emit light for approximately 3 seconds for internal camera calibration. Please do not look into the VCSEL windows of the connected ToF camera during the internal camera calibration period.

- The "Start Capture" button will be enabled after the internal camera calibration is complete.

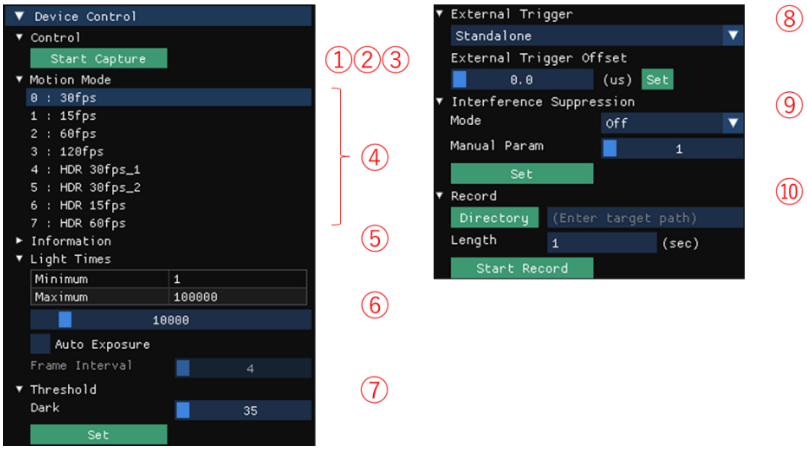


Figure 22. Device Control (when a camera device is selected) functions

Table 13. Description of Device Control (when a camera device is selected) functions

No.	Function		Description
①	Control		Control image output from the camera device.
	②	Start Capture	Start image output from the camera device. The setting is changed to "Stop Capture" when streaming starts.
	③	Stop Capture	Stop image output from the camera device. The setting is changed to "Start Capture" when streaming stops. *Always press "Stop Capture" to stop the ToF camera.
④	Motion Mode		Select the operation mode. The operation mode setting is available during the camera capture is stopped.
⑤	Information		Device and operation mode information are displayed.
⑥	Light Times		The number of light pulse emitting is changed. The AE function can be turned on or off. the frame interval of updating AE control. (This value can be changed only when the AE function is active.) *HDR modes are fixed values.
⑦	Threshold		Slide to change the Dark (the lower ineffective threshold of IR). After changing the value, press the Set button to reflect the change.
⑧	External Triger		"master"(Primary) and "slave"(Secondary) modes can be selected. The offset value of external trigger (Pulse width) is changed by the slider bar. This value is reflected by pressing the Set button. * When selecting Slave in this application, it is set to 86400 counts (equivalent to 24 hours). The waiting time per count may vary depending on the host computer environment.
⑨	Interference Suppression		The setting of Interference suppression is changed. When using multiple ToF cameras, specify different "Manual Params" for each. The changes will be applied by pressing the Set button.
⑩	Record		Record the depth and IR data from the camera outputs. See "***7-5. Record function (Saving Streaming data)***" and "***7-2-3. Device Control operation (when PlayBack is selected)***".

	Directory	Press to open the file browser and select the target directory to be saved the record data.
	Length	Specify the recording time (seconds). Do not set this to 0 seconds or leave it blank.
	Start Record	Press to start recording data. "Stop Record" is displayed during the recording.
	Stop Record	Press to stop recording data. "Start Record" is displayed after finished the recording.

[Remark] Direct Input in Text Box Using "Ctrl" Key and Left Click

In the TOPPAN ToF Viewer, you can input arbitrary values directly into a text box by using a combination of the "Ctrl" key and a left-click.

Example) "⑥ Light Times" etc.

7-2-3. Device Control operation (when PlayBack is selected)

When "Playback" is selected in the "Target Device", the following operations can be performed. This feature allows for the replay of data that was previously recorded using the "Record" function.

Figure 23. Device Control (when PlayBack is selected) functions

Table 14. Description of Device Control (when PlayBack is selected) functions

No.	Function	Description
①	Target Path	Set the directory path of the files to be played.
	Directory	Specify the directory of the playback target file path.
②	Control	Playback configuration
	Start Capture	Start the playback of the files. After playback begins, the button text changes to "Stop Capture".
	Stop Capture	Stop the playback of the files. After playback stops, the button text changes back to "Start Capture".
	Pause	Pause or resume the playback. *While paused, "Slow Play" and "Fast Play" operations are disabled.
	Slow Play	Decrease the playback speed. Playback speed can be decreased within the range of 4x speed → 3x speed → 2x speed → normal speed

		→ ½ speed → ⅓ speed → ¼ speed relative to the recorded frame rate. However, speeds below 10fps cannot be set.
	Fast Play	Increase the playback speed. Playback speed can be increased within the range of ¼ speed → ⅓ speed → ½ speed → normal speed → 2x speed → 3x speed → 4x speed relative to the saved frame rate. However, speeds above 120fps cannot be set.
	Jump Backward	Rewind the playback position by the number of seconds specified in “jump_time” in “ViewerConfig.json”.
	Jump Forward	Fast forward the playback position by the number of seconds specified in “jump_time” in “ViewerConfig.json”.
	Jump	Change the playback position to the specified time when pressed.
	Time Slider	Display the total playback duration of the files in the directory and the current playback position. The playback position can be specified using the slider. It can also be set by "left-click + slide" or by "Ctrl key + left-click to input a value."
	Playing Framerate	Display the playback frame rate of the target file. If "Slow Play" or "Fast Play" changes the playback speed, display the adjusted playback frame rate.
③	Motion Mode	Display the recorded operation mode information.
④	Information	Display the information about the camera configuration and the current operation mode.

7-2-4. Post Filter functions

Within the "Post Filter" label, settings for the post-filter processing applied to the ToF camera output can be configured.

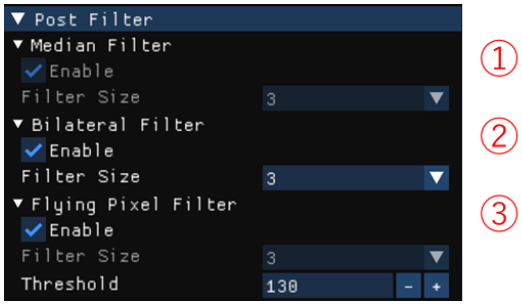


Figure 24. Post Filter functions

Table 15. Description of Post Filter functions

No.	Name	Description
①	Median Filter	Configures the median filter function for Depth and IR images.
	Enable	Enable: This function is always enabled.
	Filter Size	Filter Size: Default: 3 (fixed)
②	Bilateral Filter	Configure the bilateral filter function for Depth and IR images.
	Enable	Set the bilateral filter function to be enabled or disabled.
	Filter Size	Select the filter size. Filter Size: Default: 3

③	Flying Pixel Filter	Configure the flying pixel filter function applied to Depth and IR images. When the flying pixel filter within the camera device is enabled, this function's settings are disabled.
	Enable	Set the flying pixel filter function to be enabled or disabled.
	Filter Size	Select the filter size. Filter Size: Default: 3
	Threshold	Adjust the strength of flying pixel processing by setting the filter threshold. ＊Default: 130

7-2-5. Post Process functions

Within the "Post Process" label, operations for configuring the post-processing settings conducted within the SDK can be performed.

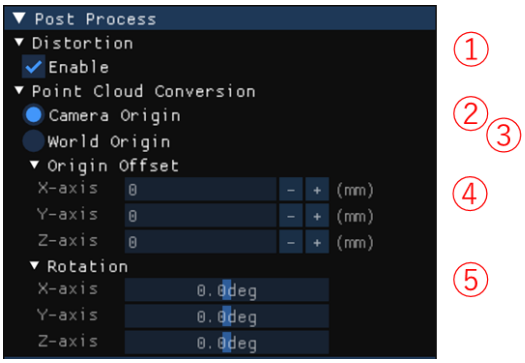


Figure 25. Post Process functions

Table 16. Description of Post Process functions

No.	Name		Description
①	Distortion		Enable or Disable the distortion correction function for the Depth image and IR image.
②	Point Cloud Conversion		Configuration of the point cloud transformation settings
	③	Camera Origin	Set the transformation method of the point cloud transformation function to camera coordinate transformation.
		World Origin	Set the transformation method of the point cloud transformation function to world coordinate transformation.
④	Origin Offset		Configure the origin position offset in world coordinates. Relative positions of the X, Y, and Z axes to the camera coordinate origin must be specified. This setting is only available when "World Origin" is selected.
⑤	Rotation		Configure the rotation angle for the point cloud coordinate axes. This setting is only available when "World Origin" is selected.

7-2-6. View Setting functions

Set the display configurations in TOPPAN ToF Viewer.

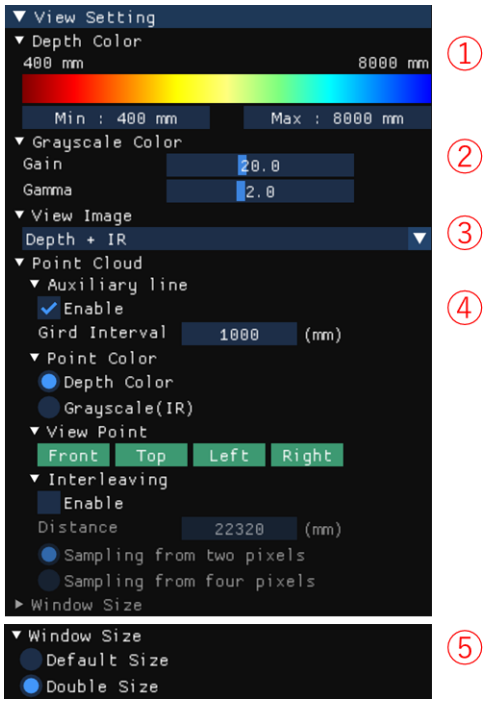


Figure 26. View Setting functions

Table 17. Description of View Setting functions

No.	Name			Description
①	Depth Color			Configure the display colors for depth images and point clouds.
		Color Gradation		The display color indicates the range within the current operating mode's measurement range. The range between Min and Max settings will be shown as a gradient.
		Min		Set the minimum value for the gradient range. ＊Adjustable Min. range is up to "Max. range – 8".
		Max		Set the maximum value for the gradient range. ＊Adjustable max. range is from "Min. range + 8" to the limit.
②	Grayscale Color			Configure the display colors for IR image.
		Gain		Adjust the gain correction coefficient for IR image. ＊Adjustable Range: 0.1 to 50.0
		Gamma		Adjust the gamma correction coefficient for IR and RAW images. ＊Adjustable Range: 0.1 to 5.0
③	View Image			Choose the type of image to display on the screen. Select the combination of images to display from the drop-down list.
④	Point Cloud			Configure the point cloud display settings.
		Auxiliary line		Configure settings for auxiliary lines (FOV/Grid lines) displayed on the point cloud display screen.
			Enable	Auxiliary lines will be drawn when enabled.
			Grid Interval	Adjust the spacing of grid lines. ＊Adjustable Range: 100 to 10,000
		Point Color		Set the display color for points on point cloud.

		Depth Color	Configure the display color of points based on their distance values (Z-axis). Each point will be displayed in the color set by the Depth Color.
		Grayscale	IR amplitude data will be applied as the display color of points.
	View Point		Set the viewpoint of point cloud display
		Front	Change the viewpoint to behind the camera.
		Top	Change the viewpoint to the top view.
		Left	Change the viewpoint to the left-side view.
		Right	Change the viewpoint to the right-side view.
	Interleaving		Set the point cloud thinning display. ＊This function is not be reflected in the output data.
		Enable	Enable the point cloud thinning display function.
		Distance	Set the maximum distance for point cloud thinning. Thinning will be applied to points within this distance. [mm]
		Sampling from two pixels	Display 1 pixel for every 2 pixels in the horizontal and vertical directions of the camera pixels.
		Sampling from four pixels	Display 1 pixel for every 4 pixels in the horizontal and vertical directions of the camera pixels.
⑤	Window Size		Change the size of the window. This option is available only when no device is selected.
	Default Size		(Default) Display at the pixel size of the display screen.
	Double Size		Display at twice the pixel size of the display screen. Recommended when using high-resolution monitors such as 4K monitors.

[Remark] Depth Color Gradient Specifications

Min. and Max. values are reset to the initial range for each operation mode when the Target Device or Motion Mode is selected. *Table 18* shows the specifications for drawing with depth values.

Table 18. Color gradation specifications for Depth Color

Specification	Depth Color
Saturation (IR value saturation)	White
Depth color Less than or equal to Min.	Same color as Min.
Depth color More than or equal to Max.	Same color as Max.
Invalid value (Less than or equal to IR lower limit)	Black

[Remark] Window Size (when using a high-resolution monitor)

When using a high-resolution monitor, such as a 4K display, it is recommended to set "⑤ Window Size" to "Double Size". Please ensure that you change the "⑤ Window Size" setting before connecting the camera, as shown in *Figure 13*.

7-3. Image display panel

The Depth image, IR image, and Point Cloud data are displayed on the image display panel shown in *Figure 19*. Select the combination of image types to display from the “Control Panel” by navigating to “View Setting” → “View Image”.

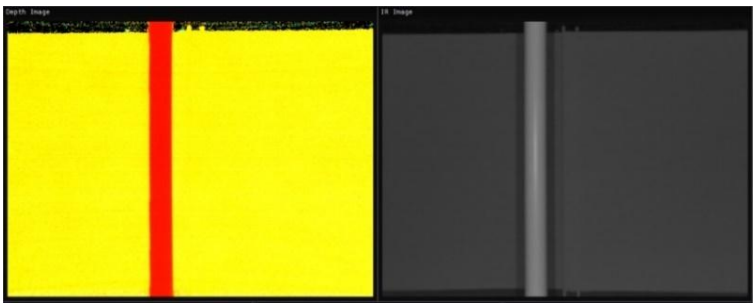


Figure 27. Depth Image (left), IR Image (right)

7-3-1. Screen control for Point cloud 3D image

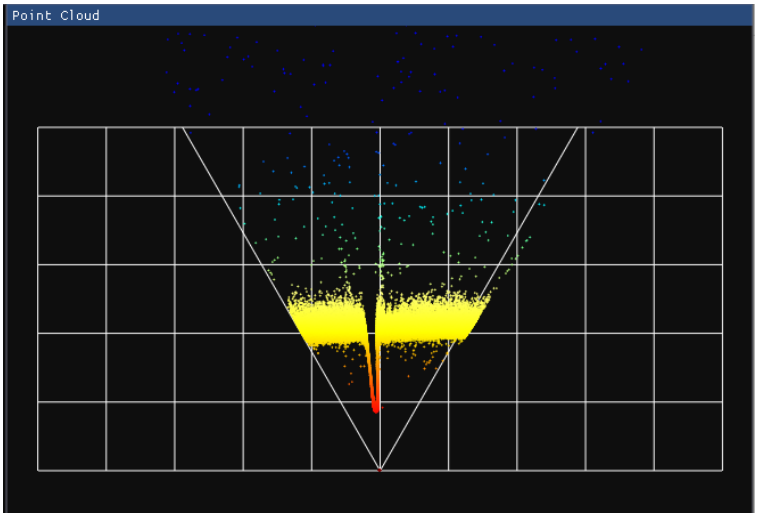


Figure 28. Depth Point Cloud 3D Image

You can display the point cloud data by selecting “Point Cloud” from the control panel under “View Setting” → “View Image”. On the Point Cloud display screen, you can change the viewpoint using mouse operations.

Table 19. Mouse operations and Behavior in the Point cloud screen

Mouse Operation	Behavior
Left button + drag	Rotate the coordinate system.
Right button + drag	Pan the coordinate system.
Scroll wheel rotation	Zoom the coordinate system (scroll up: zoom out, scroll down: zoom in).
Middle button press	Reset the rotation, panning, and zoom states.

7-4. Status display panel

The status display panel shown in *Figure 19* shows various statuses and reception frame rate.

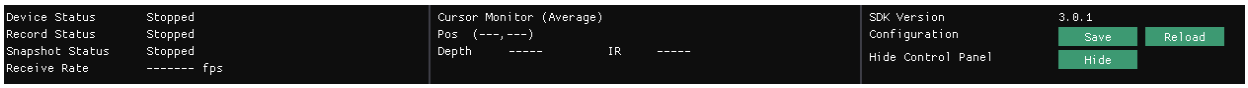


Figure 29. Status display panel

Table 20. Description of status display panel

No.	Display		Description
①	Device Status		Display the image reception status.
②	Record Status		Display the status of the file-saving function.
③	Snapshot Status		Display the status of the Snapshot function.
④	Receive Rate		Display the image reception frame rate.
⑤	Cursor Monitor		Display the pixel average value at the cursor position on the image display. The unit for Depth images is millimeters (mm).
⑥	SDK Version		Display the TOPPAN ToF SDK version.
⑦	Configuration		Save and reloads the TOPPAN ToF Viewer settings.
		Save	Save the TOPPAN ToF Viewer settings to a JSON file.
		Reload	Reload the TOPPAN ToF Viewer settings.
⑧	Hide Control Panel		Hide or re-displays the “Control Panel”.
		Hide	Hide the control panel.
		Show	Show the control panel.

7-4-1. Device status information

Table 21. Device status information to be displayed

Display	Description
Closed	Device is unselected
Stopped	Image output streaming is stopped
Streaming	Image output streaming is started
Pause	Image output streaming is paused
Fast	Double speed playback status
Slow	Slow playback status
Stopped (Timeout)	Image output streaming is stopped by timeout error

7-4-2. Record status information

Table 22. Record status information to be displayed

Display	Description
Stopped	Recording is stopped
Recording	Recording
Finished	Recording is finished successfully
Failed (Disk full)	Recording is failed (Disk full)

7-4-3. Snapshot status information

Table 23. Snapshot status information to be displayed

Display	Description
Stopped	Snapshot is stopped
Snapshot	Snapshot data is acquired successfully

7-4-4. Display information of cursor position values

When the cursor is placed over depth and IR image on the image display panel, information at the cursor's position is shown.

Table 24. Display information of cursor position values to be displayed

Display	Description
Pos	Display the (X, Y) coordinates on the image. "—" indicates out of range.
Depth	Display the average Depth value. "—", "65535", and "0" indicate invalid values.
IR	Display the average IR value. "—", "65535", and "0" indicate invalid values. Saturation is “32768”

7-5. Record function (Saving Streaming data)

“Record” function captures and saves streaming data of depth and IR images that can be played back in the TOPPAN ToF Viewer.

7-5-1. Configuration of “Record” function

This function is operated from the control panel by navigating to “Device Control (when the camera device is selected)” → “Record”.

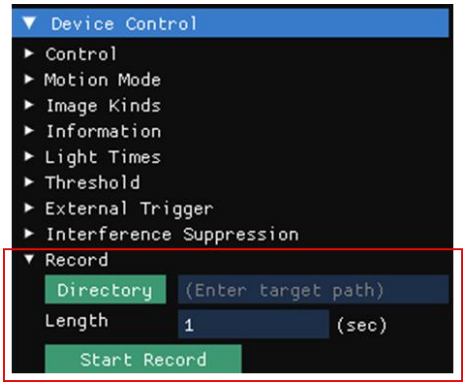


Figure 30. Record function

Table 25. Description of Record function

Name		Description
Record		Recording to save the depth and IR output images as a streaming data.
	Directory	Open the file browser upon clicking, allowing the directory for saving files to be specified.
	Length	Specify the recording duration (in seconds). Ensure that it is not set to 0 seconds or left blank.
	Start Record	Begin Recording upon clicking. After starting, the button changes to "Stop Record."
	Stop Record	Stop Recording when clicked during recording. After stopping, the button changes back to "Start Record."

7-5-2. Directory structure of the recorded data

The recorded data is stored in the directory specified under "Directory" (referred to as "Record Top" in *Figure 31*) according to the following structure. "YYYYMMDD_HHMMSS" represents the date and time when saving started.

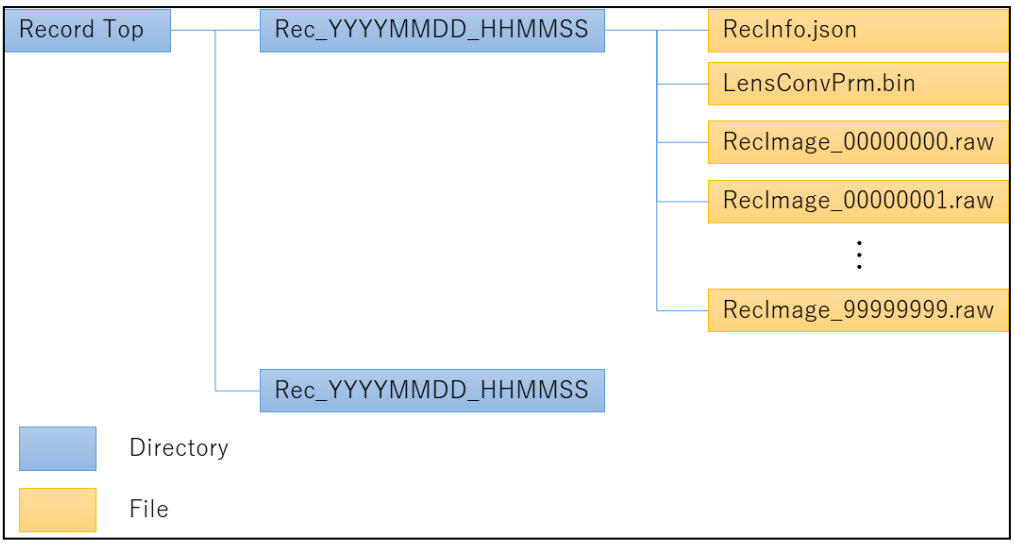


Figure 31. Directory structure of the recorded data

7-5-3. Files Output file information of the record function

7-5-3-1. RecInfo.json

This file contains information about the data generated by the Record function, including recording details, camera settings, and post-processing information at the time of output.

Table 26. RecInfo.json information

Parameter	Description
Version	Format version information
major	Major Version
minor	Minor Version
revision	Revision
Record	Recording information
rec_frames	Number of frames recorded
packing_frames	Number of frames per file
Device	Device information
hw_kind	Hardware model number Upper 16 bit: Sensor model number Lower 16 bit: Lens model number
serial_no	Device serial number
map_ver	Camera setting MAP version
major	Major Version
minor	Minor Version
revision	Revision
adjust_no	Adjustment number
firm_ver	Camera firmware version
major	Major Version
minor	Minor Version
revision	Revision
ld_wave	Light source wavelength [nm]
ld_enable	Light source information (number of lights)
correct_calib	Calibration correction revision
PostFilt	Post-filter information
cam_med_flit	Median filter status
cam_fly_p_filt	Flying pixel filter status information
Lens	Lens system conversion parameters
sens_w	Sensor width [pixel]
sens_h	Sensor height [pixel]
focal_len	Focal length (fixed-point: 12-bit integer part, 20-bit fractional part)
thin_w	Horizontal thinning factor (1 / thin_w)
thin_h	Vertical thinning factor (1 / thin_h)

	crop_x	X-coordinate position of image cropping from sensor pixels [pixel]
	crop_y	Y-coordinate position of image cropping from sensor pixels [pixel]
	dist[]	Distortion correction parameters [fx, fy, cx, cy, k1, k2, p1, p2, k3] (fixed-point: 1-bit sign, 16-bit integer, 47-bit fractional)
	cam_planar	Orthogonal coordinate transformation status information
	cam_dist	Distortion correction status information
	lens_calib	Lens calibration revision
Fov		FoV (Field of View) information
	horz	Horizontal field of view [degree × 100]
	vert	Vertical field of view [degree × 100]
Mode		Operation mode information
	id	Operation mode ID
	Images []	Image type information (Types of images included in the Record output data)
	kind	Image type “string” ="Depth," "IR" No use; "RAW G1," "RAW G2," "RAW G3," "RAW G4"
	width	Image width [pixel]
	height	Image height [pixel]
	active_start []	Active pixel start position [X coordinate, Y coordinate]
	active_w	Active pixel width [pixel]
	active_h	Active pixel height [pixel]
	bpp	Size per pixel [byte]
	range	Range information
	min	Minimum range [mm]
	max	Maximum range [mm]
	fps	Reception frame rate [fps × 100]
	range_calib	Range calibration revision

7-5-3-2. RecImage.raw

The RecImage_XXXXXXXX.raw files contain the recorded image data in binary format (little-endian). The “XXXXXXXX” in the file name is a zero-padded decimal number (00000000–99999999). When the number of frames in a single file reaches the packing_frames value specified in RecInfo.json, the data is split into a new file, and the "XXXXXXXX" in the file name increments. Each RecImage_XXXXXXXX.raw file contains multiple frames of image data (from 1 to packing_frames) within a single file.

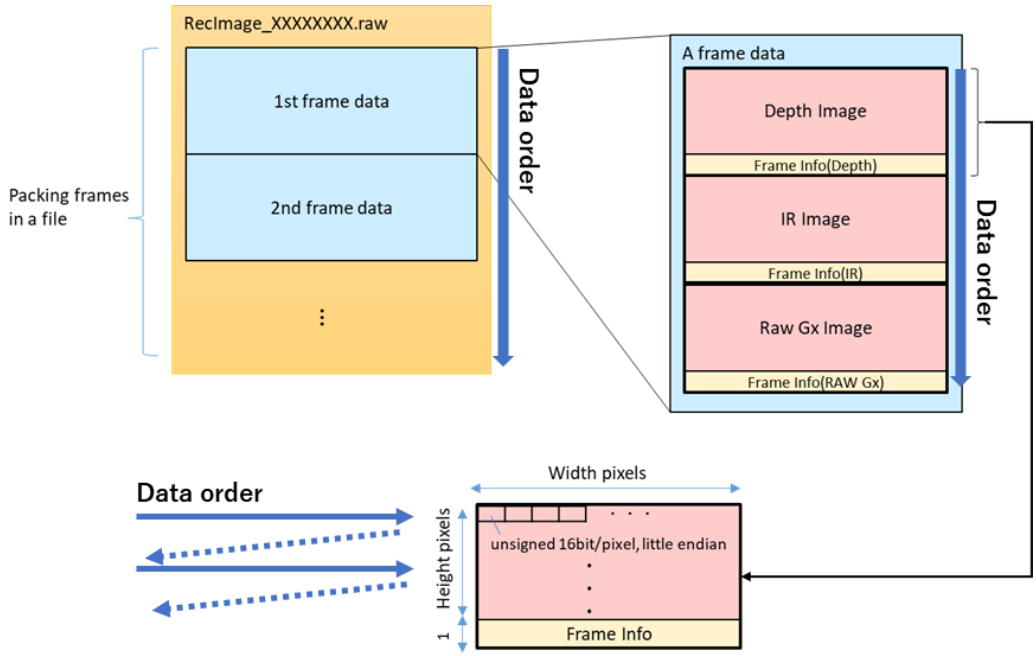


Figure 32. Binary data structure in RecImage.raw format

Table 27. Binary data structure in RecImage.raw format

Parameter	Description
File type	16-bit unsigned (Little-endian)
File extension	.raw
File header	None
Frame info	1 row (every single image)
Image data array	Refer to "***7-7. Output data array information***"
Image data Info	RecInfo.json

Note: The position of Frame Info (1 row) stores additional information for each image.
Note: The unit for each pixel in the Depth image is millimeters (mm).
Note: When [Depth + IR] is selected under Image Kinds, "Depth + Frame Info (Depth)" and "IR + Frame Info (IR)" alternate.

7-6. Snapshot function (Saving Snapshot data)

This function allows for the capture and saving of snapshots of output data after post-processing. Unlike "Record," which continuously records frame data for a specified duration, Snapshot captures and saves Depth average and deviation data for a specified number of frames directly to the PC's memory at the time of capture. Subsequently, the data can be output to the specified directory using "Save Snapshot".

7-6-1. Configuration of "Snapshot" function

The snapshot function can be operated from "Snapshot Setting" label.

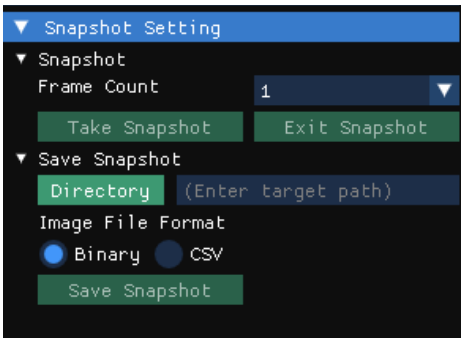


Figure 33. Snapshot Setting

The parameters to be configured are described below:

Table 28. Description of snapshot settings

No.	Display		Description
①	Snapshot		Configure the snapshot settings.
	②	Frame Count	Set the number of frames for calculating time-directional average and standard deviation of the Depth image.
	③	Take Snapshot	Capture a snapshot.
	④	Exit Snapshot	Release a captured data and quit the snapshot function
⑤	Save Snapshot		Configure the file saving settings for the captured snapshots.
	⑥	Directory	Open a file browser to specify the directory for saving the files.
	⑦	Image File Format	Select the file format for saving Depth and IR images.
	⑧	Save Snapshot	Save the files of the captured snapshot data.

Note: Data capturing flow: "Take Snapshot" (capture) → "Save Snapshot" (save) → "Exit Snapshot" (end).

7-6-2. Directory structure of the snapshot data

The snapshot data are stored in the directory specified under “Directory” (referred to as “Snapshot Top” in *Figure 34*) with the following structure. “YYYYMMDD_HHMMSS” represents the date and time when saving started.

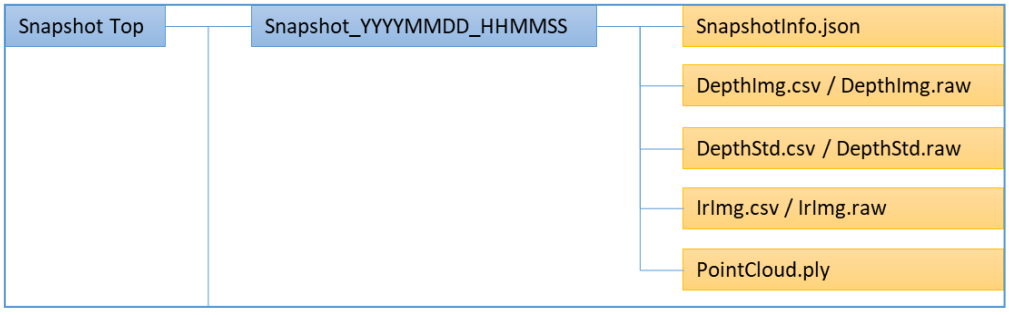


Figure 34. Directory structure of the snapshot data

7-6-3. Description of Output file information of the snapshot function

7-6-3-1. DepthImg file

This file saves an image averaged over time from the Depth image. It can be saved in Binary format (DepthImg.raw) or CSV format (DepthImg.csv). The unit for each pixel is millimeters (mm). If the Depth image is not output from the camera device, this file will not be saved.

7-6-3-2. DepthStd file

This file saves an image of the standard deviation calculated over time from the Depth image. It can be saved in Binary format (DepthStd.raw) or CSV format (DepthStd.csv). The saved values are 10 times the calculated result. However, if the value multiplied by 10 exceeds 16 bits, it is capped at 0xFFFF. The unit for each pixel is mm × 10. If the Depth image is not output from the camera device or if the number of frames used to calculate the standard deviation (Frame Count) is 1, this file will not be saved.

7-6-3-3. IrImg file

This file saves the IR image at the time of snapshot capture (first frame). It can be saved in Binary format (IrImg.raw) or CSV format (IrImg.csv). If the IR image is not output from the camera device, this file will not be saved.

7-6-3-4. Binary files (.raw) data format

The data format for the raw files saved in Binary format (DepthImg.raw, DepthStd.raw, IrImg.raw) is as follows:

Table 29. Binary data structure for snapshot (.raw) files

Parameter	Description
File type	16-bit unsigned (Little-endian)
File extension	.raw
File header	None
Image data array	Refer to "***7-7. Output data array information***"
Image data Info	SnapshotInfo.json

7-6-3-5. CSV files (.raw) data format

The CSV format is a restructured version of Binary data, designed for easier visualization.

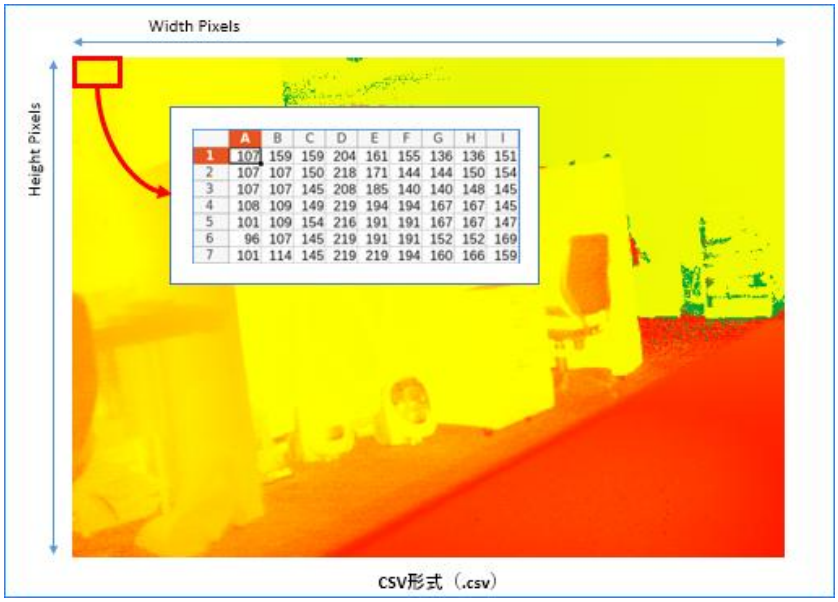


Figure 35. Visualized CSV format (.csv) data format by a spreadsheet application

7-6-3-6. Point cloud file (.ply) data format

Point Cloud data (one frame) is saved as a file in Polygon File Format (PLY). The saved point cloud file includes point cloud information and color data based on the "Point Color" settings in the "View Setting" section. Points with invalid depth values are excluded from the saved file.

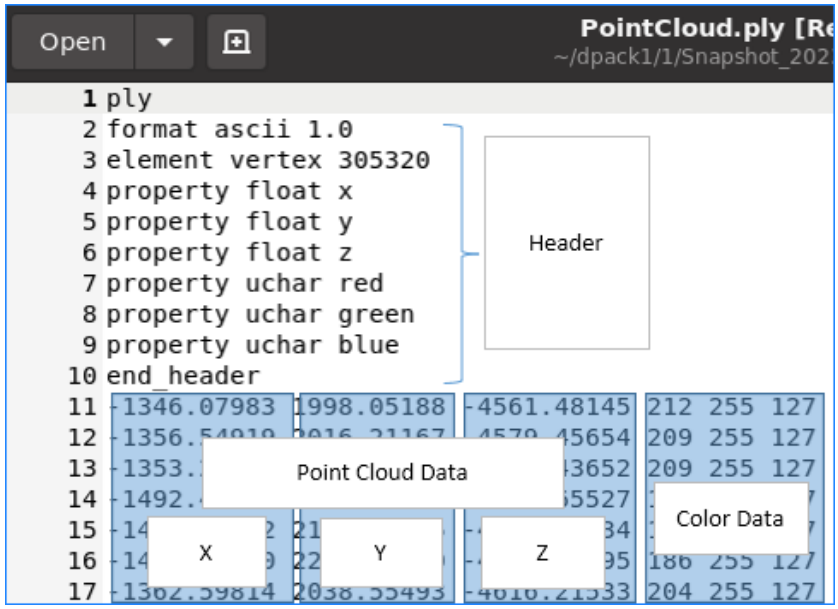


Figure 36. Point cloud file (.ply) data format

7-6-3-7. SnapshotInfo(.json) file

The SnapshotInfo.json file contains information about the snapshot output, camera settings at the time of output, and post-processing details.

Table 30. SnapshotInfo.json information

Parameter	Description
Snapshot	Snapshot information
frame_count	Number of frames used for average and standard deviation calculation
Device	Device information
hw_kind	Hardware model number Upper 16 bit: Sensor model number Lower 16 bit: Lens model number
serial_no	Device serial number
adjust_no	Adjustment number
firm_ver	Camera firmware version
major	Major Version
minor	Minor Version
revision	Revision
ld_wave	Light source wavelength [nm]
ld_enable	Light source information (number of lights)
correct_calib	Camera calibration correction revision
Lens	Lens system conversion parameters
cam_planar	Planar conversion parameter of SDK input data (excluding Viewer settings)
cam_dist	Distortion correction of SDK input data (excluding Viewer settings)
lens_calib	Lens calibration revision
Fov	FoV information
horz	Horizontal field of view [degree × 100]
vert	Vertical field of view [degree × 100]
Mode	Operating mode information
id	Operating mode ID
description	Operating mode description
Images []	Image format information
kind	Image type “string” = "Depth," "IR" No use; "RAW G1," "RAW G2," "RAW G3," "RAW G4"
width	Image width [pixel]
height	Image height [pixel]
active_start []	Image width [pixel]
active_w	Image height [pixel]
active_h	Active pixel start position [X coordinate, Y coordinate]
bpp	Active pixel width [pixel]
range	Range information
min	Minimum range [mm]
max	Maximum range [mm]
fps	Reception frame rate [fps × 100]
range_calib	Range calibration revision

PostFilt		Post-filter processing information
	med_filt	Median filter application status for Depth and IR images (Viewer settings) true: Applied false: Not applied
	fly_p_filt	Flying pixel filter application status for Depth images (Viewer settings) true: Applied false: Not applied
PostProcess		Post-processing information
	Planar	Planar conversion status for Depth image (Viewer settings) true: Applied false: Not applied
	Distortion	Distortion correction status for Depth and IR images (Viewer settings) true: Applied false: Not applied
	PointCloud	Point cloud information
	origin	Point cloud transformation type 0 : Camera origin 1 : World origin
	offset[]	Point cloud transformation origin position (when World Origin) [X offset, Y offset, Z offset]
	rotation[]	Point cloud transformation rotation angles (when World Origin) [X axis rotation, Y axis rotation, Z axis rotation]

7-7. Output data array information

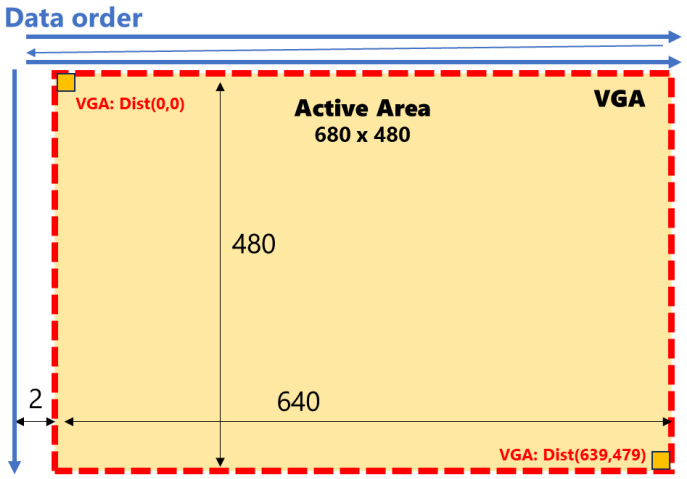


Figure 37. VGA Output data array information

Note: The output data of IR/Depth includes the Active Area.

7-8. External synchronization trigger signal information

The specifications of the external synchronization trigger signal are shown below.

7-8-1. Connector I/O Specification

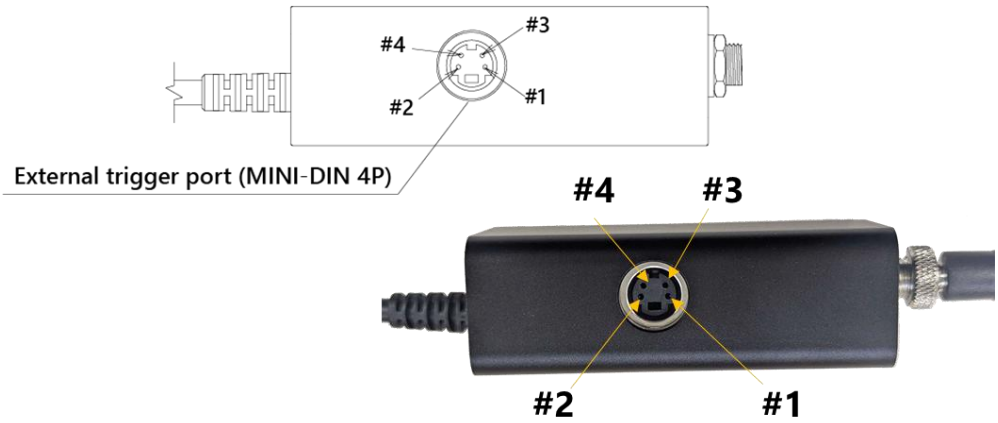


Figure 38. Triger connector pin number information

The following table shows the pin assignment of the external trigger terminal (mini-DIN-4P) for camera synchronization.

Table 31. External trigger connector pin assignment (mini-DIN-4P)

Pin No.	Name	Type	Description	When being unused
1	V33A	3.3V Power	3.3V digital power terminal (Generated from USB VBUS)	Open
2	EX_VD_I	Digital In	External trigger **input** signal from Secondary device for frame synchronization (3.3V system)	Open
3	EX_VD_O	Digital Out	External trigger **output** signal from Secondary device for frame synchronization (3.3V system)	Open
4	GND	Ground	Digital ground terminal	Open

Notes:

1. When connecting cameras together, pin 2 must be connected as input and pin 3 as output. For this reason, straight MINI-DIN 4P cables cannot be used. Therefore, prepare the converter board shown in ***Figure 39*. Example of a conversion board (PCB) for parallel** camera connection.
2. The ToF camera and the ToF camera I/F Hub are shipped connected - once the I/F Hub is removed from the camera, the dust and waterproof function of the camera itself is lost, do not remove it.

7-8-2. Parallel camera connection diagram

The circuit wiring diagram for parallel connection of ToF cameras is shown below. When connecting cameras, pin #2 must be used as input and pin #3 as output.

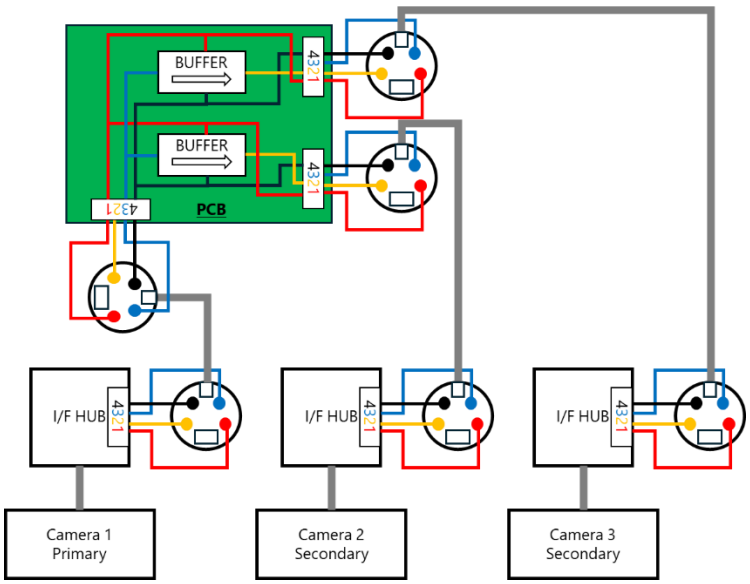


Figure 39. Example of a conversion board (PCB) for parallel camera connection

7-8-3. Trigger signal Input/Output Specification

The input and output specifications for the external trigger signal are detailed below. The signal is input and output through *a Schmitt-trigger buffer IC (TI SN74LVC2G17)* operating at a 3.3V system. For detailed IC specifications, please refer to the product datasheet from TI.

Table 32. When set to Primary operation; EX_VD_O

Name	Min.	Typ.	Max.
Frame period (tp)	8.3msec @120fps	33.3msec @30fps	66.7msec @15fps
Pulse width (PW)	37nsec	-	37nsec+25.5µsec
Rise time (tr)	-	-	15.5nsec
Fall time (tf)	-	-	18.9nsec

Note: The pulse width (PW) can be set arbitrarily in the label shown in *Figure 22*-⑧.

Table 33. When set to Secondary operation; EX_VD_I

Name	Min.	Typ.	Max.
Frame period (tp)	8.33msec (120fps)	33.33msec (30fps)	66.67msec (15fps)
Pulse width (PW)	-	37nsec	-
L to H Threshold (VT)	1.47V	1.54V	1.61V

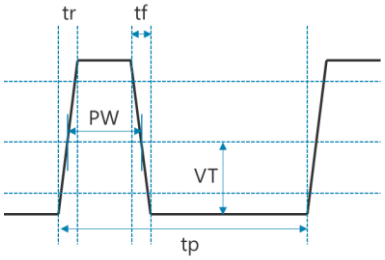


Figure 40. Definition of the external trigger pulse waveform

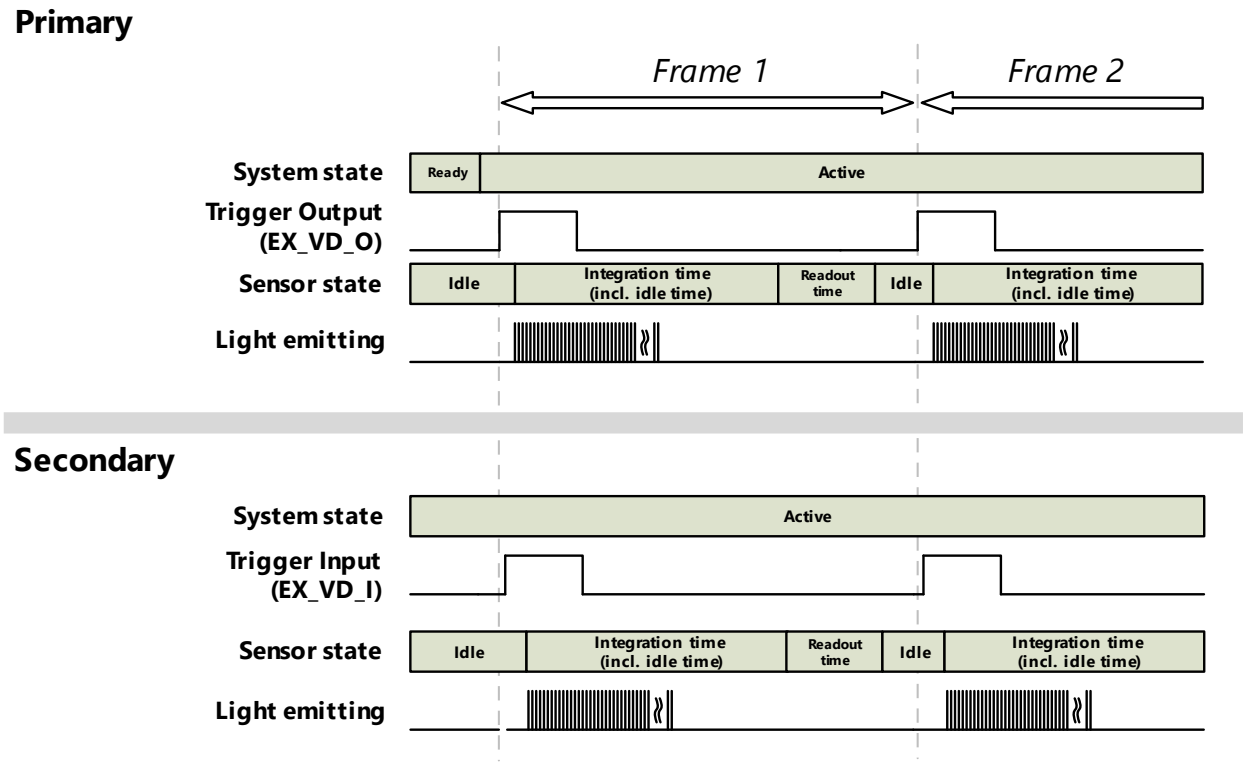


Figure 41. Primary / Secondary timing chart

7-9. Camera error information

When camera errors occur during various operations, a popup error message will be displayed.

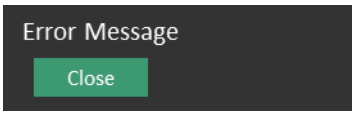


Figure 42. Error message information

Table 34. Error message list

Error message	Related label	Remark
Viewer configuration is not existed	Load Configuration	The GUI configuration file is missing.
Camera device is not connected.	Target Device	The selected device is not connected.
Failed to access “XXX”.	Target Device	Unable to retrieve information from the selected device (XXX is the device name).
	Device Control (Camera)	Register Read/Write failed (XXX is the device name for register control).
Failed to change “XXX”.	Device Control (Camera)	Failure to change Motion Mode or Image Kinds.
“XXX” is over the range.	Device Control (Camera)	The emission count setting exceeds the maximum limit.
Record directory is not existed	Device Control (Camera)	The target directory path does not exist when pressing the Start Record button.
Record Length must over 0 sec	Device Control (Camera)	The recording time is set to 0 when pressing the Start Record button.
Record Length is over	Device Control (Camera)	The recording time exceeds the maximum allowable duration when pressing the Start Record button.
Record target storage is full	Device Control (Camera)	Insufficient storage space in the target storage when pressing the Start Record button.
Record is finished	–	Recording has completed for the specified duration after starting.
Reached End of record file	–	Playback has reached the end of the file.
Snapshot directory is not existed	Snapshot Setting	The target directory path does not exist when pressing the Save Snapshot button.
Snapshot target storage is full	Snapshot Setting	Insufficient storage space in the target storage when pressing the Save Snapshot button.
Saving snapshot is finished	Snapshot Setting	Snapshot data saving has completed after starting the Save Snapshot process.
Time out receiving image	–	Timeout occurred while receiving an image due to a halt in reception.
Receiving Buffer is empty	–	High load processing state leading to insufficient reception buffer.

8. TOPPAN ToF SDK API specifications

For the TOPPAN ToF SDK API specifications specific to this product (ES), please refer to the following related documents.

Table 35. TOPPAN ToF SDK Related Documents

Related Document	Content
TOPPAN ToF SDK Development Environment Setup Guide	Instructions for setting up the TOPPAN ToF SDK software environment
TOPPAN ToF SDK API Reference Manual	API specifications for the TOPPAN ToF SDK library

9. Appendix

9-1. Product label information

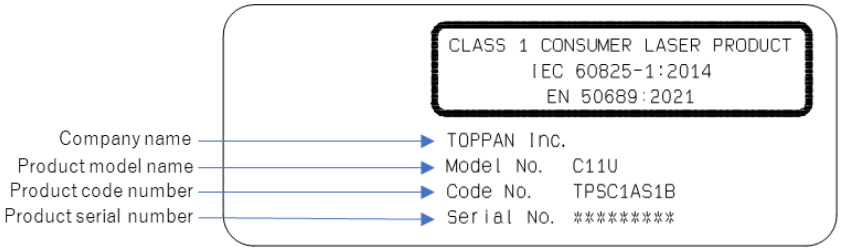


Figure 43. Product label

Serial number example：Serial No. 4A4ZW1001

9-2. Reference drawing for ToF camera mount

The following is a reference drawing of a camera mount attachment fixture that connects to a camera tripod or similar device for fixing a ToF camera.

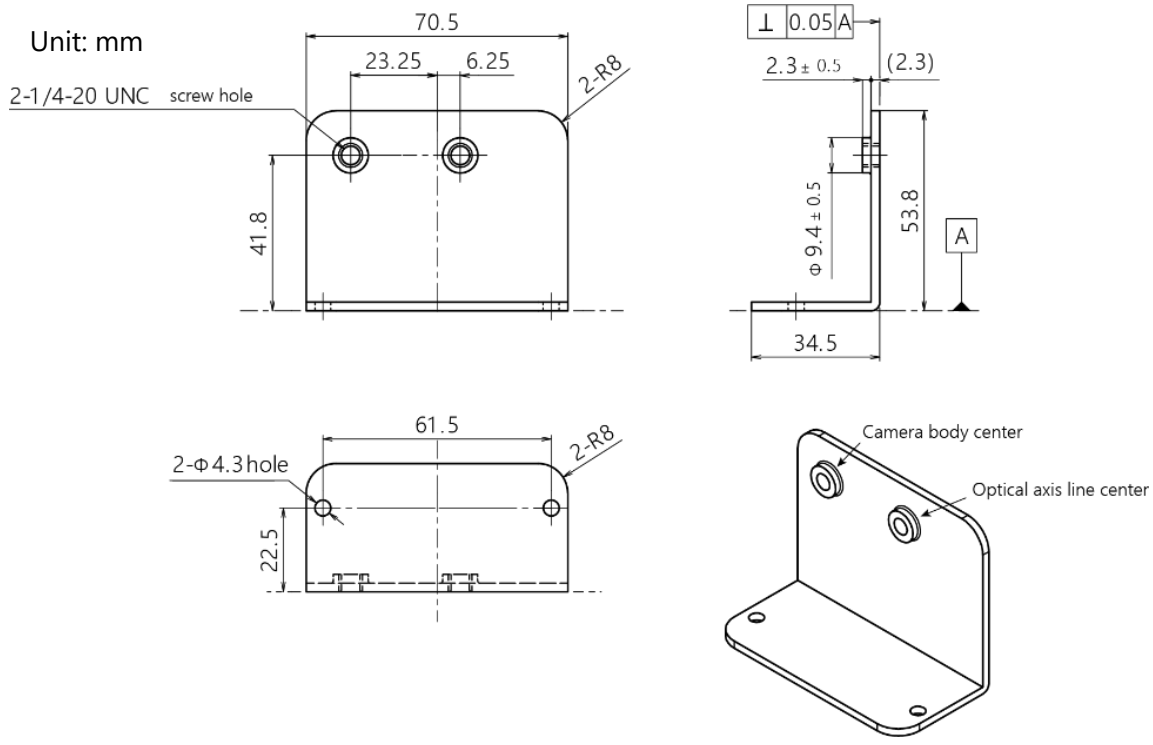


Figure 44. Camera mounting jig (Reference)

9-3. External DC power source usage

When supplying DC power without using the included AC power supply adapter, ensure that the polarity, set voltage, and current are correct.

Caution!

- Incorrect settings for polarity, voltage, or current may damage the device. Always check the polarity and voltage values with a multimeter or related tool before use.
- DC power supply specification
  Voltage: 12V
  Current: <3A

The power connector of the I/F Hub uses the following component with a locking mechanism.

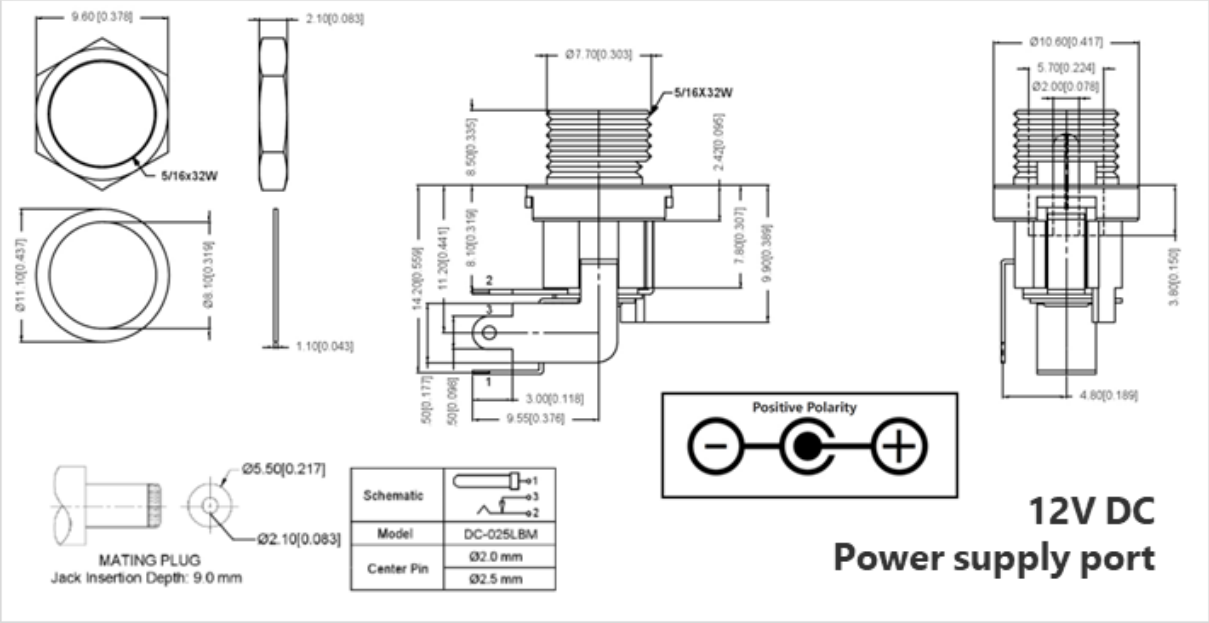


Figure 45. I/F Hub power connector part specifications

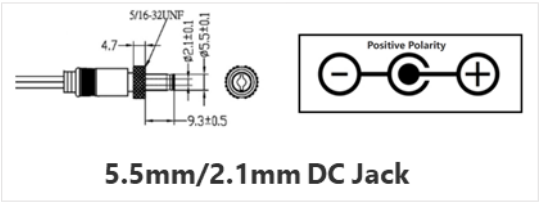


Figure 46. DC jack specification of included power adapter

9-4. Dust and water protection IP rating

This product meets the IP67 dust and water protection rating within the area indicated by the red dashed lines, including the ToF camera body.

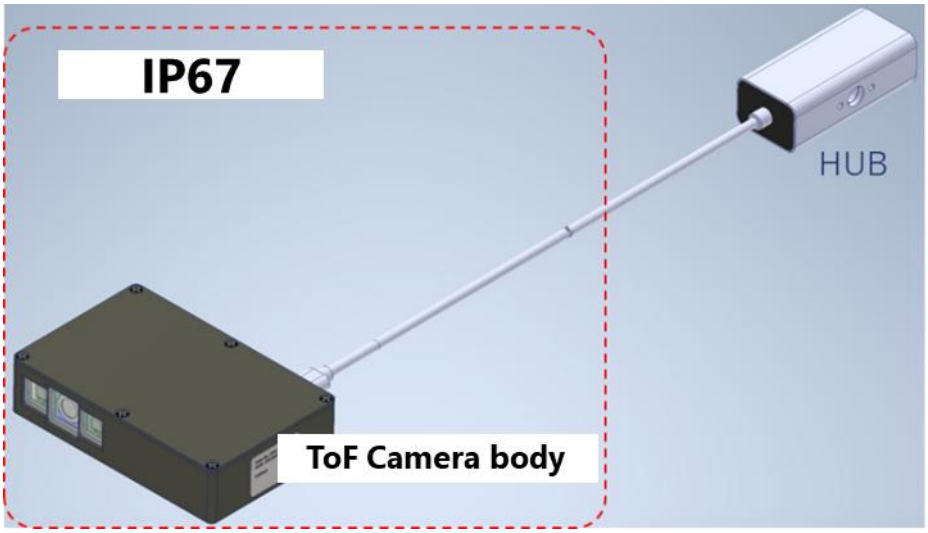


Figure 47. Coverage area (red dotted) of IP67 standard

9-5. Camera cleaning and maintenance guide

- When cleaning the ToF camera body and camera I/F Hub housing, ensure the camera is powered OFF.
- Perform cleaning in an environment with minimal static electricity and use anti-static measures such as anti-static clothing or wristbands.
- Use a soft, lint-free cloth for cleaning.
- Clean the cover glass and connector areas only if they affect camera performance, and handle with care to avoid damage.
- If the cover glass is dirty, use a soft cloth and avoid using solvents or chemical wipes. Clean carefully to avoid scratching the surface.
- For persistent dirt on areas other than the cover glass, use a small amount of distilled water on a fiber material, and ensure the camera is completely dry before use.
- Do not remove the labels from the camera housing.

9-6. Note of chocolatey installation step

Here are some additional notes for installing the package management software “chocolatey”. Please refer to the official website for the latest information on the software's terms of use and installation procedures.

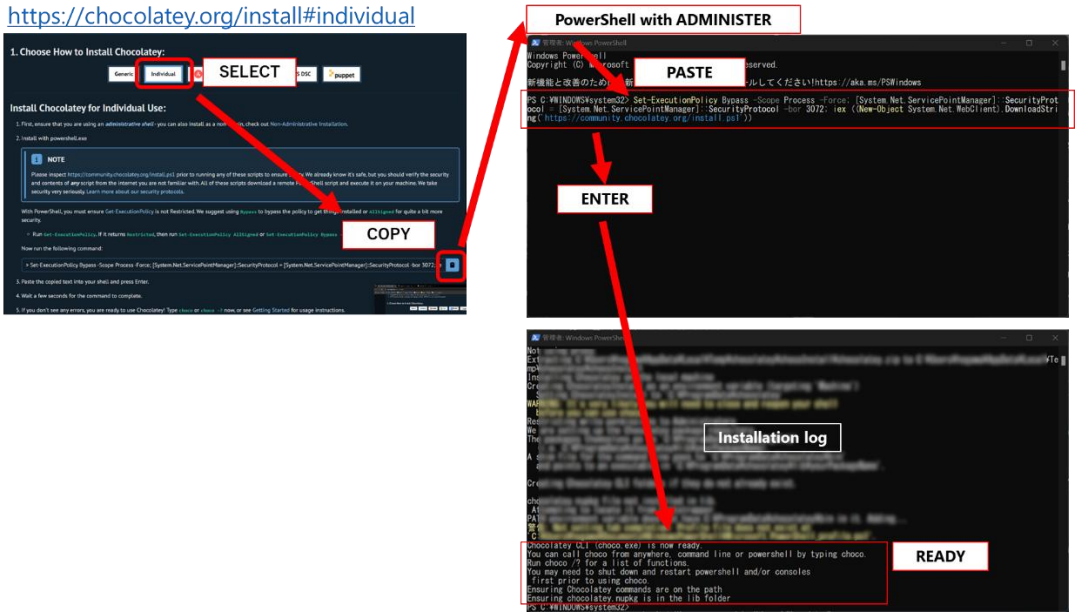


Figure 48. chocolatey installation step

10. Document history

Date	Version	Comment
YYYY/MM/DD	-.--	
2024/09/20	1.00	1. Initial Release for TPSC1AS1B WS product document
2024/10/29	1.01	1. Usage precautions updated: added notes regarding the connection between the ToF camera and the ToF camera hub. 2. ToF camera product name decided as “C11U” updated product name references. 3. Modified minor typos.
2025/01/17	1.02	1. Revised the description of “1. Precautions for use: Eye Safety caution”. 2. Revised “Table 2. Key specification: Light source”. [class 1 laser product: (IEC 60825-1:2014, EN 50689:2021)] 3. Modified minor typos
2025/01/31	1.03	1. Added the section 3.4 Label 2. The figure numbers have been updated.
2025/03/31	1.10	Initial release for C11U ES product version
2025/04/18	1.11	1. Revised Table 5, 6, 7 Correction of software versions used. 2. Revised Fig.9 Correction of TOPPAN ToF Viewer software configuration 3. Modified Fig.37 Correction of VGA output data array information. 4. Revised Table 2. Key specification: Warming up time 30min(typ.) -> 10 min(typ.), Development Environment. 5. Modified minor typos
2025/06/26	1.12	1. Added/Revised prohibitions regarding power cable connection ・Chapter 1 Prohibited table- Precautions for use with models that use an I/F HUB ・Chapter 3 Prohibited descriptions in the contents ・Chapter 4-3. Startup the camera - STEP 1. Start camera power supply (Cable connection order) ・Chapter 4-4. Stopping the camera and turning it off: Revised description. 2. Chapter 3-1. Camera configuration: Added the caution for the Status LED window 3. Modified minor typos

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