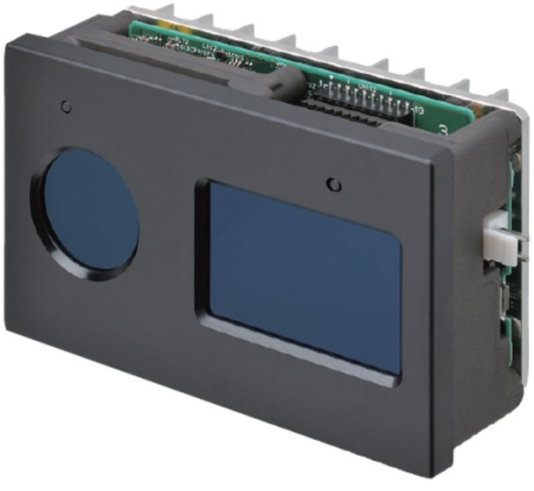
OMRON

3D TOF Sensor Module

B5L

User's Manual

3D TOF Sensor Module



E596-E1-01

Note

Unauthorized copy, replication, and/or reprint of a part or all of this manual is prohibited.

- The content of this manual is subject to change without notice for the purpose of improvement.
- If you have any question or comments, please contact our sales representative listed at the end of this manual.

Please notify the manual number described at the end of this manual as well.

Trademark

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Other company names and product names referenced in this document are trademarks or registered trademarks of each company.

Introduction

Thank you for purchasing a 3D TOF sensor module B5L.
This manual describes information necessary for using 3D TOF sensor module B5L. Please read this manual and make sure you understand the functionality and performance of the product before you attempt to use it in a control system.
Please keep this manual at hand and make it available at any time.

Intended Readers

This manual is intended for the those who must also have knowledge of electrical systems and software.

Applicable Product

This manual covers the following product.
- 3D TOF sensor module B5L (hereinafter called "this product")

Definition in this document

"This product":	Indicates "B5L-A2S-U01-010" which consists of the "main body" and "SDK". Description of "this product" refers to the whole or part of the configuration.
"Main body":	Indicates the 3D TOF sensor module.
"SDK":	Indicates the evaluation software, command specifications, sample code, and/or documentation.
"NIR":	Near-infrared

Datasheet

Can be downloaded from the following site.
Japanese:
https://www.omron.co.jp/ecb/product-detail?partNumber=B5L
English:
https://www.components.omron.com/product-detail?partNumber=B5L

Table of Contents

Warranty and Limited Warranty

Thank you for using Omron Corporation (“Omron”) products. The Terms and Conditions hereunder are applied to Omron products regardless of where they are purchased. When you place an order, you are expected to agree to the Terms and Conditions described below.

1. Definition

The definition of terms used in these Terms and Conditions are as follows:

(1) Omron products: FA system equipment, general-purpose control devices, sensors, and electronic/mechanism components under Omron brand

(2) Catalogues: Omron general catalogue, FA system equipment general catalogue, safety component general catalogue, electronic/mechanism components general catalogue and other catalogues, specifications, instructions and manuals of Omron products, including electronically provided information available on the Omron electronic components information website, etc.

(3) Usage conditions: Usage conditions, rating, performance, operating environment, handling instructions, cautions, prohibited use, etc. of Omron products described in catalogues.

(4) Customer application: Application of Omron products by customers which include embedding and/or using Omron products in their parts/components, electronic substrates, devices, equipment or systems manufactured by customers.

(5) Fitness: (a) fitness, (b) performance, (c) non-infringement of third-party intellectual property, (d) compliance with laws and regulations and (e) conformity to standards.

2. Caution on Descriptions

Attention is required to the following points on descriptions in catalogues.

(1) Rated values and performance values are the product of tests performed for separate single conditions, including but not limited to temperature and humidity. It is not intended to warrant rated values and performance values for multiple combined conditions.

(2) Reference data are provided for reference only. Omron does NOT warrant that Omron products work properly at all time in the range of reference data.

(3) Application examples are provided for reference only. Omron does NOT warrant the fitness of Omron products under such application.

(4) Omron may discontinue the production of Omron products or change the specifications of them for the purpose of improving such products or other reasons entirely at its own discretion.

3. Precautions

Please be aware of and accept the following when you introduce or use Omron products:

(1) Please use Omron products in compliance with usage conditions including rating and performance.

(2) Please confirm fitness of Omron products in your application and use your own judgment to determine the appropriateness of using them in such application. Omron shall not warrant the fitness of Omron products in customer application.

(3) Please confirm that Omron products are properly wired and installed for their intended use in your overall system.

(4) When using Omron products, please make sure to (i) maintain a margin of safety vis-à-vis the published rated and performance values, (ii) design to minimize risks to customer application in case of failure of Omron products, such as introducing redundancy, (iii) introduce system-wide safety measures to notify risks to users, and (iv) conduct regular maintenance on Omron products and customer application.

(5) Omron products are designed and manufactured as general-purpose products for use in general industrial products. They are not intended to be used in the following applications. If you are using Omron products in the following applications, Omron shall not provide any warranty for such Omron products. Even in the case of the following applications to elevator/lift equipment and medical devices, etc, some case are likely applied to an usual guarantee prescribed on next article as general-purpose products used for general industrial products. So, please contact our sales person in charge.

   (a) Applications with stringent safety requirements, including but not limited to nuclear power control equipment, combustion equipment, aerospace equipment, railway equipment, elevator/lift equipment, amusement park equipment, medical equipment, safety devices and other applications that could cause danger/harm to people’s body and life.

   (b) Applications that require high reliability, including but not limited to supply systems for gas, water and electricity,

etc., 24 hour continuous operating systems, financial settlement systems and other applications that handle rights and property.

(c) Applications under severe conditions or in severe environment, including but not limited to outdoor equipment, equipment exposed to chemical contamination, equipment exposed to electromagnetic interference and equipment exposed to vibration and shocks.

(d) Applications under conditions and environment not described in catalogues.

(6) In addition to the applications listed from (a) to (d) above, Omron products are not intended for use in automotive applications (including two wheel vehicles). Please do NOT use Omron products for automotive applications. Please contact Omron sales staff for products for automotive use.

4. Warranty Terms and Conditions

The terms and conditions for warranty of Omron products are as follows:

(1) Warranty period: One year after the purchase from Omron or Omron's agency.

(2) Coverage: Omron will provide either of the following two services for the malfunctioning Omron products at its own discretion:

(a) Free repair of malfunctioning Omron products at an Omron maintenance service location (Repair service is not available for electronic/mechanism parts.), or

(b) Free replacement of the malfunctioning Omron products with the same number of replacement/alternative products.

(3) Exceptions: Omron will not cover Omron products under its warranty if the cause of the malfunction falls under any of the following:

(a) Usage in a manner other than the original intended use for the Omron products.

(b) Usage outside of the usage conditions.

(c) Modification or repair made to the Omron products by other than Omron personnel.

(d) Software program embedded by other than Omron or usage of such software.

(e) Causes which could not have been foreseen with the level of science and technology at the time of shipping from Omron.

(f) Causes originating from other than Omron or Omron products (including force majeure such as but not limited to natural disasters).

5. Limitation of Liability

The warranty set out in these Terms and Conditions is the whole and sole liability for Omron products. There are no other warranties, expressed or implied. Omron and the distributors of Omron products are not liable for any damages which may arise from or be related to Omron products.

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Customers of Omron products shall comply with all applicable laws and regulations of Japan and/or other relevant countries with regard to security export control, when exporting Omron products and/or technical documents or providing such products and/or documents to a non-resident. Omron may not provide customers with Omron products and/or technical documents should they fail to comply with such laws and regulations.

Safety Precautions

Make sure to read these precautions for a safe use of the Product.

- The contents included are to ensure proper use of the Product and prevent harm and/or property damage to the user or other people.
- Warnings and cautions are defined as follows.

● **Definition of Warning and Caution**

⚠ **Warning**	Denotes a potentially hazardous situation which, if not avoided, may result in minor, moderate or serious injury, or death. It may also result in serious damage.
⚠ **Caution**	Denotes a potentially hazardous situation which, if not avoided, may result in minor or moderate injury, or damage.

"Damage" indicates property damage to a building, production line, household goods, other products, livestock, pets, etc.

● **Examples of indications**

	Indicates forbidden actions.
	Indicates required actions.

⚠ Warning

Regarding the use or handling of the Product

Do not use the Product for safety of life or crime prevention purposes. Do not use the Device on automobiles or other vehicles, including bikes as it may result in accidents.	

Regarding the prevention of fire, electric shock, etc.
The following will result in fire, electric shock, injury or damage if ignored.

Do not touch the Device or any connected cable during a lightning storm. Do not use the Device if it is cracked or damaged. Do not insert foreign objects in the connector or in the holes on the various parts of the Device. Do not use the Device in bathrooms or any other place where it may get in contact with water. Do not touch the Device or any connected cable with wet hands. Do not touch the electrode at the side opening of the Device during power-on. Do not disassemble, repair, or modify the Device.	
Turn the power off and stop using the Product if you notice any anomaly, including foul odor, heating, distortion or discoloration to the Device during use. Install the cables for connecting the Device in a way that would not put strong force on them, including making sure they are not crushed in a door.	

Regarding the prevention of accident or injury
The following will result in accident or injury if ignored.

Do not touch sharp parts or the exposed interior of the Device that was damaged.	

⚠ Caution

Regarding the use or handling of the Product

Make sure to follow the warnings and cautions indicated in this document when using the Product.

Regarding installation

The following will result in accident, injury or damage if ignored.

Do not install the Device in an unstable location.
Install the cables in a safe way, out of the way of hands or feet.

Regarding heating

The following will result in burns if ignored.

The Device may produce heat.
Do not touch it during power-on or shortly after powering it off

Precautions for Safe Use

Check the Product for physical damage upon opening its package.
It is recommended to wear gloves when opening the package.
Follow the indications listed below for a safe use of “the Product”.

(1) Installation Environment

There is potential internal deterioration and damage of internal parts of the Device.

- Do not use “the Product” in conditions exceeding the ratings for temperature and humidity.
- Do not use “the Product” in an environment where condensation occurs.
- Do not use “the Product” in an environment subjected to water, oil or chemicals spills.
- Do not use “the Product” in an environment subjected to corrosive, combustible or explosive gas.
- Do not use “the Product” in an environment where dust, salt or iron powder are present.

(2) Power Supply and Wiring

The following will result in fire if ignored.

- Make sure there is no faulty wiring of I/O terminals, etc.
- Do not connect the DC power supply terminal to AC power.
- Do not connect “the Product” to DC voltage above the rated capacity.
- Do not reverse-connect the DC power supply.
- Make sure to turn the Device off before removing cables.
- Make sure to check the Device and the connector pins for distortion or physical damage before connecting the Device to the Connector.
- Check the cables for physical damage.

(3) Others

- Treat “the Product” as industrial waste when disposing of it.
- Use the M4 screws on the fixing holes on the Device when fixing it.
- Make sure not to twist, bend or break the Device when fastening the screws. The following will result in accident or deterioration if ignored.
- Install “the Product” with attention being paid to dust prevention so that foreign objects will not enter during use. The following will result in short circuit or long-term reliability decline due to foreign objects if ignored.
- For safety’s sake, installation and wiring should be performed by professional technicians.
- Do not drop “the Product” during installation and use. The following will result in accident or deterioration if ignored.
- Install “the Product” after confirming that there are no people around under the place of installation.

Precautions for Correct Use

Observe the following precautions to prevent failure to operate and malfunctions, and to prevent adversely affecting the performance and function of “the Product”.

- Store the Device at a temperature of -20°C to +60°C and a relative humidity level of 35% to 85%.
- Do not touch the board mounted parts with bare hands. Discharge any static electricity from the user before use.
- Take proper measures against static electricity by using an antistatic wrist strap, etc. before handling “the Product”.
- Make sure to properly ground the connector's earth terminal in order to prevent malfunction due to noise.
- Do not use “the Product” in places where the surrounding temperature goes above the rating range.
- Do not use “the Product” in a location where it would be subjected to direct sunlight.
- Do not use “the Product” in a location subject to excessive inductive or power supply noise, such as in strong magnetic or electric fields.
- Do not use “the Product” in a location where it would be subjected to strong UV light.
- Do not use “the Product” in a location where it would be subjected to radiation.
- Sufficiently evaluate the electrical characteristics of any connection to the Device.
- If the Customer designs such structures as NIR transmission filter and installs them in front of the light-projecting part or the light-receiving part, the detection performance will deteriorate due to NIR light transmittance. Therefore, design with margins giving consideration to deviation and other factors.
- The Customer should choose the power cable and USB cable after fully validating their applicability.
- Do not strongly pull the cable connected to the Device.
- Do not reversely insert the Connector.
- Do not forcibly insert any non-standard connector.
- Do not touch the light-projecting part or the light-receiving part.
- Clean the light-projecting part or the light-receiving part if fouled. Clean with a soft and dry cloth, avoiding damage to the light-projecting part or the light-receiving part. Never use volatile solvents such as benzine and thinner or chemical wipers, etc.
- In order to improve long-term reliability of the Device, pay sufficient attention to heat emission during installation.
- Install “the Product” at a sufficient distance from surrounding heat generating parts.
- When installing “the Product”, do not block the top surface, side surface and heat sink surface of the Device. Otherwise, heat cannot be emitted.
- “The Product” generates heat during operation. Since the surrounding temperature rises due to heating, sufficient consideration should be given to heat emission so that the surrounding temperature will not go above the rating temperature range. In addition, do not fix “the Product” upside down.
- In case of instantaneous stop or power outage, when power is restored, make sure to use “the Product” after resetting.
- If abnormality occurs in received data, restart the power or reset.
- Do not peel off the QR code label. Otherwise, lot tracing of “the Product” will become impossible.
- Do not use “the Product” under conditions where it would be subjected to strong interfering light.
- If multiple units of “the Product” are used simultaneously, measurement may not be performed correctly due to the influence of NIR light transmitted from sources other than the Device.
- Before using “the Product”, fully confirm if “the Product” can be used at the actual installation location.

Caution on Usage

1) Since “the Product” is intended for assembly into other devices, single units of “the Product” are not certified by various standards in each country.
2) “The Product” is not used for crime prevention and does not guarantee safety.
3) “The Product” has face detection function. As such, the Customer shall take proper care of privacy, portrait right, copyright or any other rights of people.
4) “The Product” cannot be used for purposes that cause hazard or damage to people's life, body and asset.

Protection of Intellectual Property

Do not do or allow any third party to do the following to the “Firmware” contained in “the Product” (built-in software for operating the Device) and “SDK”.
(a) Withdrawal of the “Firmware” from the “Device”
(b) Reverse engineering of “Firmware” and “SDK”, including disassembling and decompiling, etc.

Technical information provided by OMRON is treated as OMRON’s confidential information. Do not disclose to any third party.

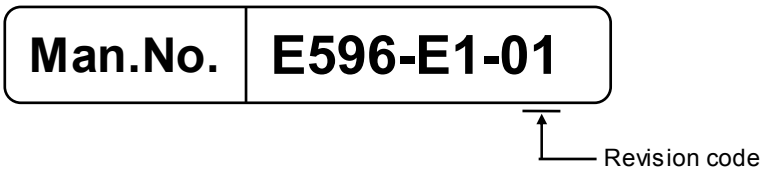
Definition of Terms

This section provides definitions of terms related to "this product".

Term	Description
TOF sensor	A sensor that measures the distance from a sensor to an object using the TOF method. TOF is an abbreviation for Time of Flight. The distance is measured by emitting light and measuring the phase difference between the emitted and reflected light.
Distance precision	Difference between the average measured value and the actual distance
Repeatability	The extent to which the measured values vary
Operation mode	- Normal mode: The HDR function is enabled and the distance is calculated based on two measurement results. - High-speed mode: The HDR function is disabled and the distance is calculated based on one measurement result. Note: HDR function: Function to make multiple measurements by changing the shutter speed.
Start-up period	Time from powering up the B5L to the point where communication becomes available
Warm-up period	Time from powering up the B5L to the point where its performance becomes stable
Distance data	The three-dimensional distance from the coordinate origin of B5L to the object.
Cartesian coordinate system	A coordinate system defined by specifying mutually orthogonal coordinate axes
Rotated Cartesian coordinate system	Cartesian coordinate system rotated around Xo, Yo, and Zo axes by the specified angle
Polar coordinate system	A coordinate system that represents the position of a point in a solid using its distance r and angle θ as well as angle φ from the origin
Amplitude data	Photo sensitivity of each pixel when the LED is emitted

Revision History

A manual revision code appears as a suffix to the catalog number on the front and back covers of the manual.



Revision Code	Revision Date	Revision Details & Pages
A	2020 Aug.	First edition

Chapter 1 Overview

1-1 Overview

This product is a built-in 3D TOF sensor module with a light source and a TOF imager that measures the distance to an object based on the phase difference between the emitted and reflected light waves.
USB I/F is used to communicate with the host to receive commands from the host and return the results of execution.

1-2 Model and System Configuration

Model

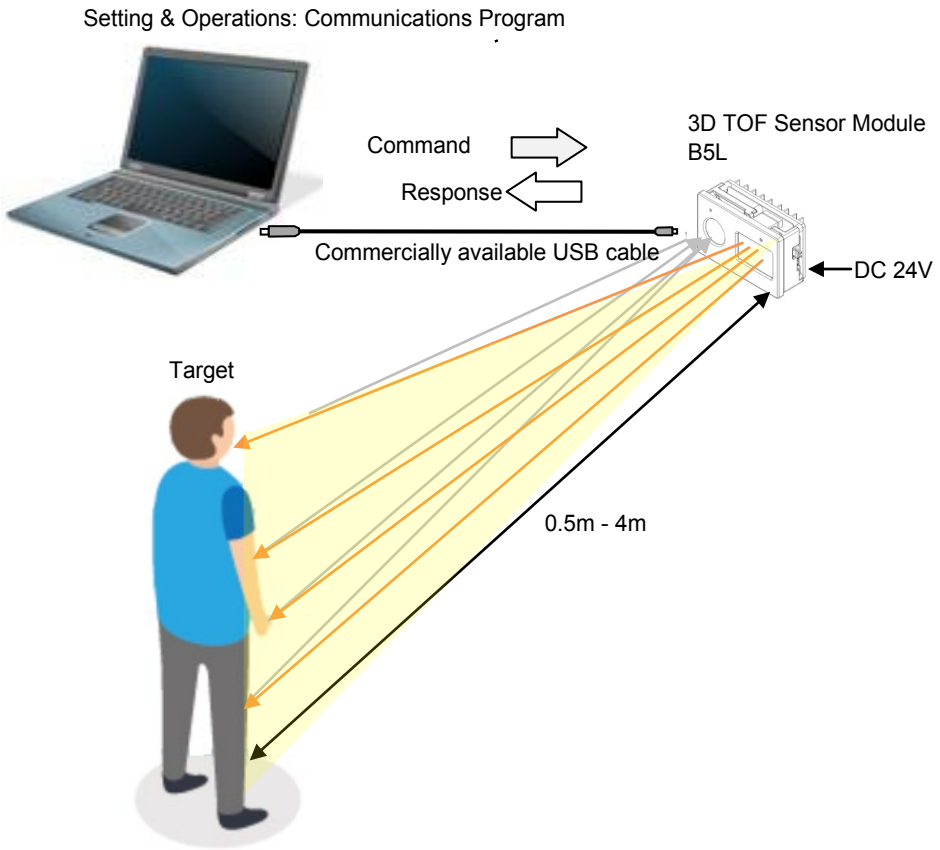
Operating range	NIR transmission filter*1	Model
0.5m to 4m	Yes (built-in)	B5L-A2S-U01-010

*1 NIR transmission filter transmits infrared rays and absorbs visible light.

Model configuration

①	②	③	④	⑤
Series	Light source	Angle of view	Communications	NIR transmission filter
B5L-A	□	□	-□01	-□□0
	2: LED, near-infrared ray of 940nm	S: 90°	-U01: USB2.0	Yes (built-in): -010

System configuration



1-3 Specifications

Ratings/Performance Specifications

Item	Specifications	Note
Operating range	0.5m to 4m	
Detection resolution	Approx. 0.3°	
Horizontal detection range (angle of view)	87° min.	
Vertical detection range (angle of view)	67° min.	
Light source	LED, near-infrared ray of 940nm	
Distance precision	±2%(±4cm) max. at 2m, center block, 10 x 10 pixel	Notes 1 & 2
Repeatability	±1%(±2cm) max. at 2m, center block, 10 x 10 pixel	Notes 1 & 2
Frame rate	10fps	Note 1
Supply voltage	DC24V ±10% 3A	
Power consumption (current consumption)	Average at measurement: 7.2W 0.3A Maximum: 72W 3A (informative)	Note 1
Ambient temperature	In use: 0 to +50°C Storage: -20 to +60°C (with no icing or condensation)	
Ambient humidity	In use & storage: 35 to 85 %RH max. (no dew condensation)	
Operating illumination environment	500lx max.	
Vibration resistance	10 to 150Hz: acceleration of 50m/s^2, double amplitude of 0.7mm max. 8 min. 3 sweeps each in X, Y, and Z directions	
Shock resistance	300m/s^2 for 3 times each in X, Y, and Z directions	
Dimensions	103 × 64.3 × 43.1 mm Approx. 108.6 x 64.3 x 43.1mm (connector included)	
Degree of protection	IEC60529 IP10	
Weight	Approx. 305 g	
Material	Frame: Aluminum die-cast Cover: Polycarbonate (PC) Filter: Acrylic resin (PMMA) Heat sink: Aluminum	
Communications	USB2.0 CDC class	
Start-up period	30 seconds max.	Note 3
Warm-up period	Approx. 30 minutes	Note 4

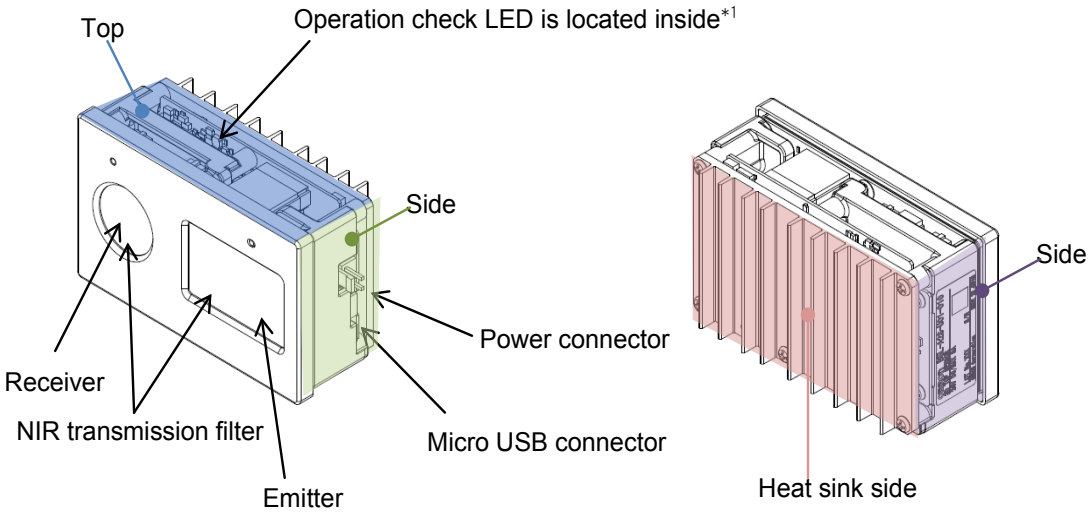
Note 1:
- When stable in OMRON's measurement environment
- Ambient temperature: 25°C
- Operation mode: Normal mode (default)
- Exposure time setting: 850 (default)
- LED emission frequency ID: 8 (default)

Note 2:
- Target object: 70% reflectivity (white paper)
- Distance precision and repeatability are based on the following conditions:
  Distance precision: Average of 100 measurements of 10 x 10 pixels in the center (10,000 data in total)
  Repeatability: Standard deviation of 100 measurements of 10 x 10 pixels in the center (10,000 data in total)

Note 3:
Time from power-on to when communications becomes available

Note 4:
Time from power-on to when the performance becomes stable

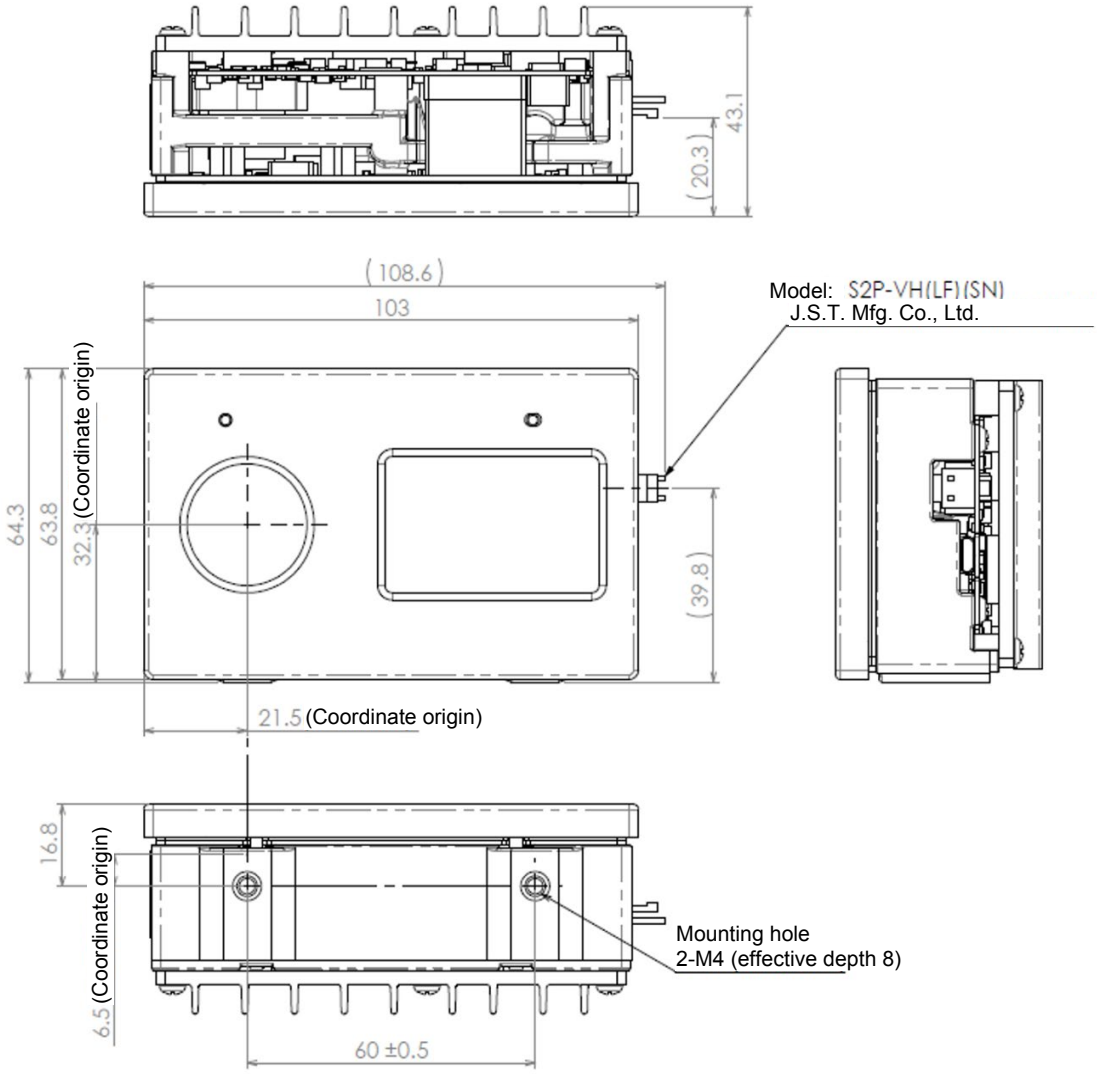
1-4 Part Names and Functions



*1: Internal LED for operation check
- No command operation (initial state):
  On startup/Under normal operation: Solid ON, On error occurrence: Flashing
- With command operation:
  On startup: Solid ON, Under normal operation/On error occurrence: Can be turned off by a command

1-5 Dimensions

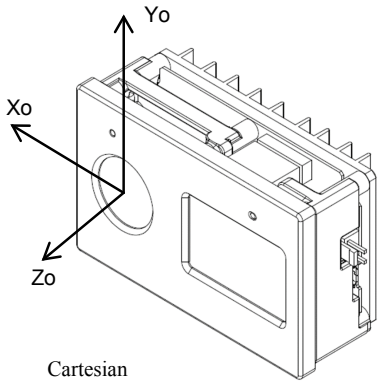
(Unit: mm) Tolerance class IT



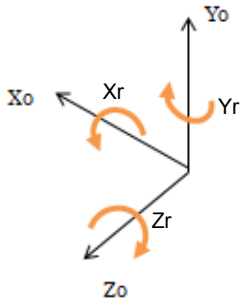
1-6 How to Measure 3D Distance by This Product

Distance data coordinate

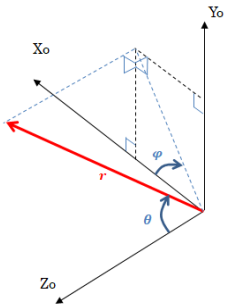
As shown below, the X coordinate is rightward of the receiver, the Y coordinate is upward of the receiver, and the Z coordinate is onward of the receiver.
The following three coordinate systems are available.
The origin of each coordinate system is the "coordinate origin" described in "1-6 Dimensions".



Cartesian



Rotated Cartesian



Polar

Output data

The following output data are available from this product.
You can specify which data to acquire by the result acquisition format setting.

Data name	Description
Distance data	The three-dimensional distance from the coordinate origin of this product to the object.
Distance data in Cartesian coordinate system	Xo, Yo, Zo: X, Y, and Z coordinates based on the origin coordinate as its origin
Distance data in rotated Cartesian coordinate system	Xr, Yr, Zr: Cartesian coordinate system rotated around Xo, Yo, and Zo axes by the angle specified by the command
Distance data in polar coordinate system	r, θ, ϕ: Polar coordinate system based on the Cartesian coordinate system
Amplitude data	Photo sensitivity of each pixel when the LED is emitted 16 bits (256 scales)

Operation mode

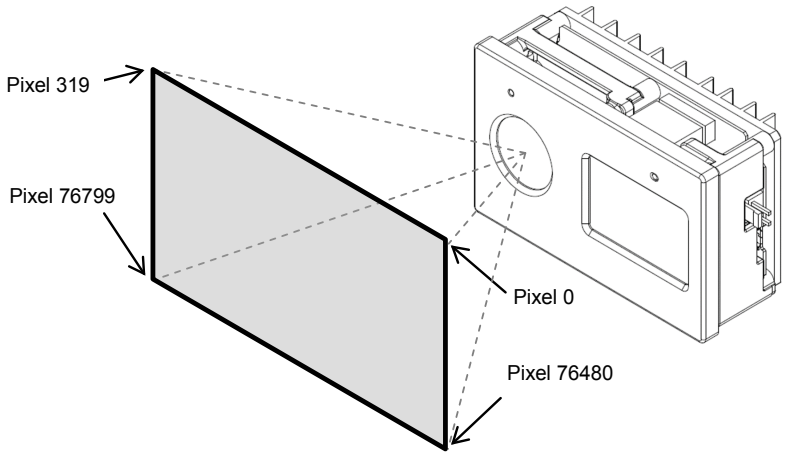
This product has the following operation modes. You can specify a mode by the operation mode setting.

Mode	Description
Normal	The HDR function is enabled and the distance is calculated based on two measurement results.
High-speed	The HDR function is disabled and the distance is calculated based on one measurement result.

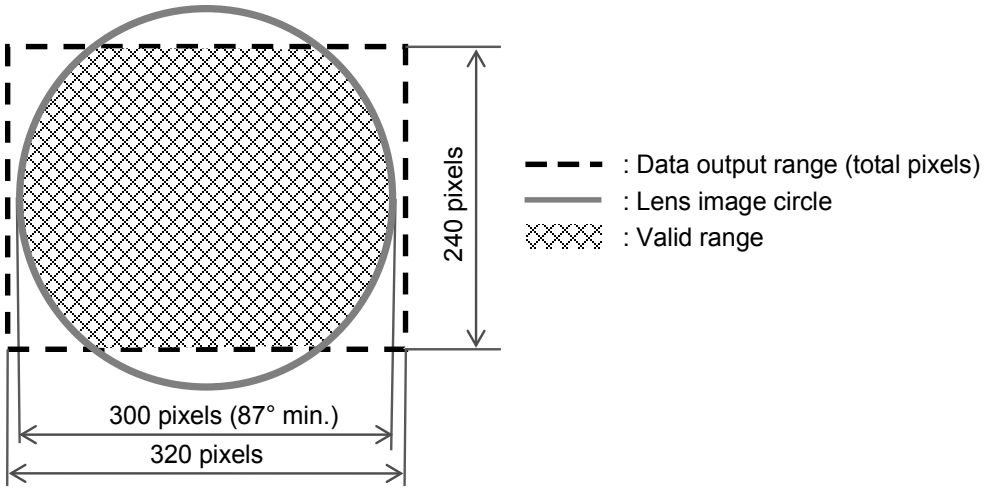
Note. HDR function: Function to make multiple measurements by changing the shutter speed

Data output sequence

The data is output in the order of 76799 to 0 from the bottom right to the top left of a 320 x 240 image. Refer to "4-4 Get Result (82Hex)" for details.



Field of View (FOV)



Software

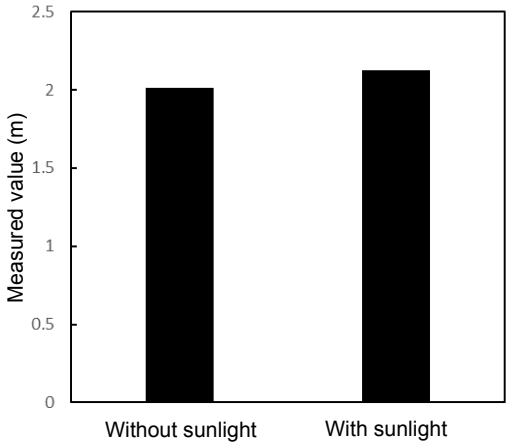
Visit the following site for the evaluation software and sample code:

- Japanese
  https://www.omron.co.jp/ecb/product-detail?partNumber=B5L
- English
  https://www.components.omron.com/product-detail?partNumber= B5L

Note 1. The sample code is for evaluation only. OMRON shall not guarantee operation of the code.
Note 2. OMRON is under no obligation to correct any errors or defects in the sample source code under any circumstances, including, but not limited to, changes in the sample code.
Note 3. OMRON does not accept inquiries about the sample code.

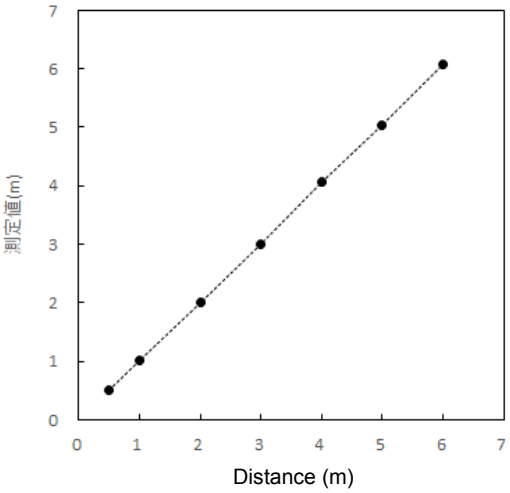
Characteristics data (informative)

● Impact of sunlight



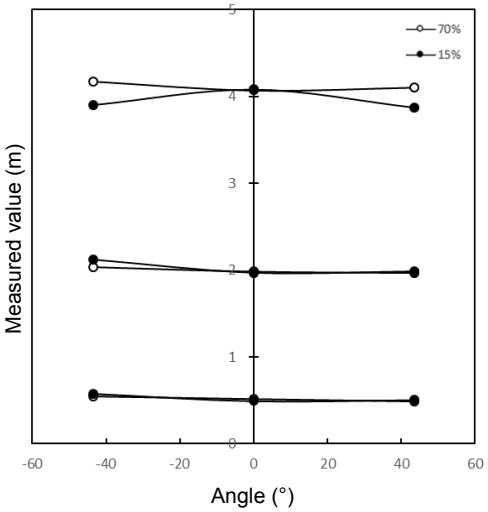
Conditions:
Target: White PP film
Angle: 0°
Measurement distance: 2m
Illuminance: 10,000lx min. with sunlight

● Distance precision

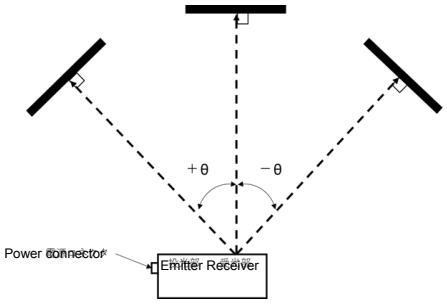


Conditions:
Target: 70% reflectivity (white paper)
Angle: 0°

● Distance precision in angle direction



Conditions:
Target: 70% reflectivity (white paper), 15% reflectivity (gray paper)
Angle: -43.5°, 0°, +43.5°
Measurement distance: 0.5m, 2m, 4m



1-7 Procedures

Step	Description	Refer to
Preparation	Check the specifications and usage	Safety Precautions, Definition of Terms Ch. 1 Overview
↓	↓	
Installation & Wiring	Installation and wiring of this product	Ch. 2 Installation & Wiring
↓	↓	
Power ON		Ch. 2 Installation & Wiring
↓	↓	
Connection check	Use the Get version command to check	Ch. 4 Command Description
↓	↓	
Initial setting	Setting by communications - Setting of operation mode - Setting of result acquisition format - Setting of parameters (measurement parameters, operation check, LED setting, communication response speed settings)	Ch. 3 Communications from Host Ch. 4 Command Description
↓	↓	
Operations	Start of distance measurement, acquisition of result, stop of measurement by communications, other acquisition when needed	Ch. 2 Installation & Wiring Ch. 3 Communications from Host Ch. 4 Command Description
↓	↓	
Power OFF		
↓	↓	
Troubleshooting		Ch. 5 Troubleshooting

Chapter 2 Installation & Wiring

2-1 Installation

Designing installation location

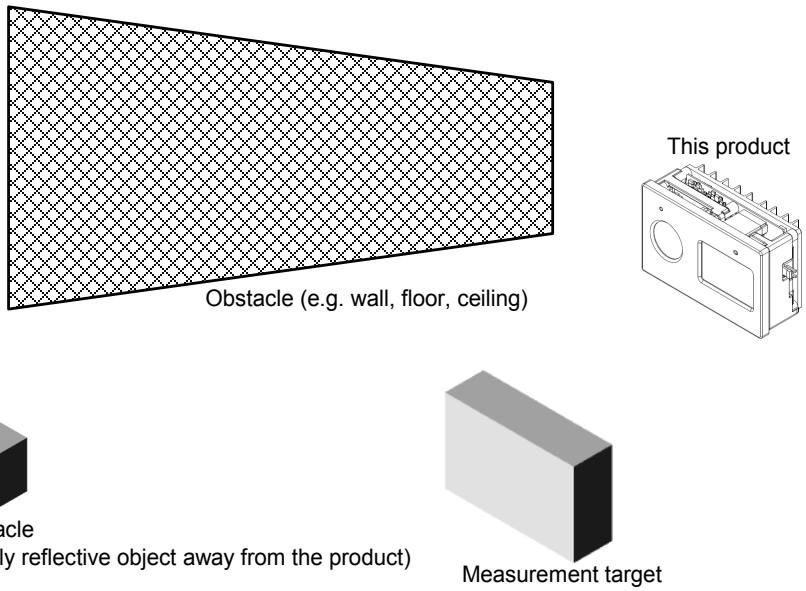
- Measurement target

  The measurement target must be within the "valid range" described in "1-7 How to measure 3D distance by this product", "Field of View".

  The following targets may not be measured correctly.
  - Highly reflective objects (e.g. mirror and shiny object)
  - Low reflective objects (e.g. black object)
  - Objects that allow light to pass through (e.g. glass and plastics with high transmission)
  - Presence of an obstacle other than the object to measure
  - When this product or an object to measure is moving or vibrating

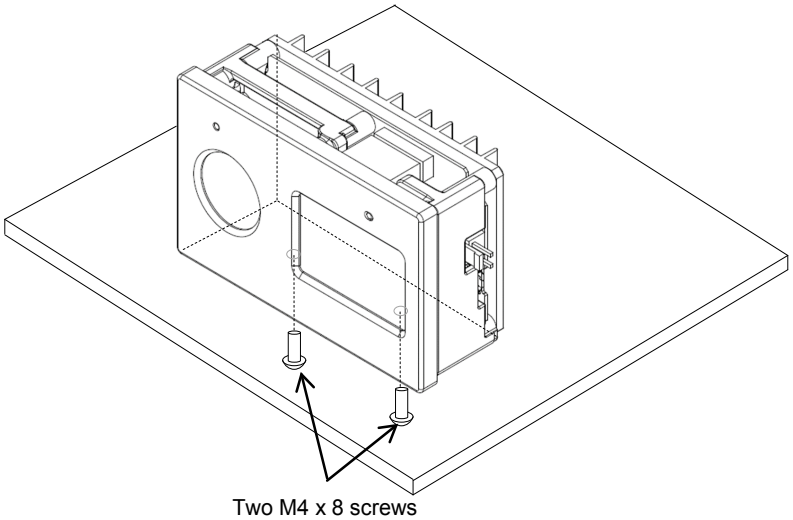
- Impact of obstacle

  Check the impact of objects other than the measurement target.
  - If there is an object (obstacle) other than the measurement target is in the vicinity of the target, the distance to the target cannot be measured accurately due to the reflected light from the obstacle.
  - Floors, walls and ceilings may have the same impact as obstacles.
  - If a transparent object such as glass and plastic is placed between this product and the measurement target, the distance to the target cannot be measured accurately.
  - Separately install a cover, if any, so that the emitted light should not be reflected by the inside surface of the cover and enter the receiver.
  - A measurement target that is highly reflective and in about 12.5 meters or farther away from the product is measured as closer.



How to install

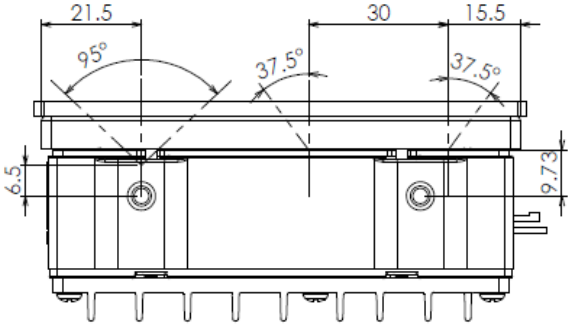
Fix two locations on the bottom using M4 screws.
Screw clamping allowance is 3 to 7mm and tightening torque is 0.91 to 1.37N-m.

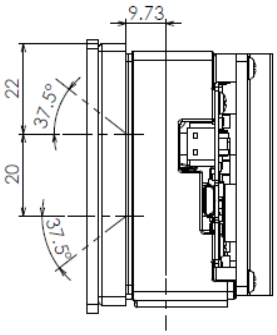


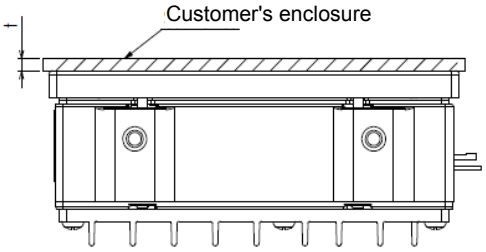
Two M4 x 8 screws

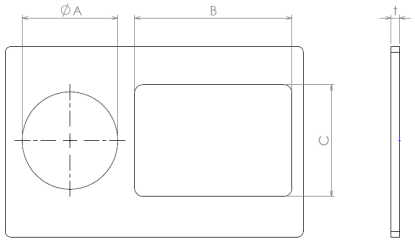
Aperture

Design the aperture of the enclosure based on the following dimensions.









Aperture size of customer's enclosure by thickness [mm]

Thickness	A	B	C
t = 1	28	44	34
t = 2	30	46	36
t = 3	32	48	38

Precautions on TOF sensor principles

This product measures the distance by emitting light and calculating based on the phase difference between the emitted and reflected light.
Also, the measurement requires time to accumulate the light received.
As a consequence precise measurement may not be available under the following conditions.

- Highly reflective objects (e.g. mirror and shiny object), low reflective objects (e.g. black object), objects that allow light to pass through (e.g. glass and plastics with high transmission)
- A measurement target is in (speed of light/source modulation frequency)/2 (= approx. 12.5m) or farther away from the product (measured as closer)
- Presence of an obstacle other than the object to measure
- When this product or an object to measure is moving or vibrating

Impact of ambient light

This product emits 940nm infrared light.
If the main body or measurement target is exposed to strong ambient light of the same wavelength band, the distance to the target cannot be measured accurately due to the effect of the ambient light.

Impact of cover

Before installing a cover, you must take into account the followings.

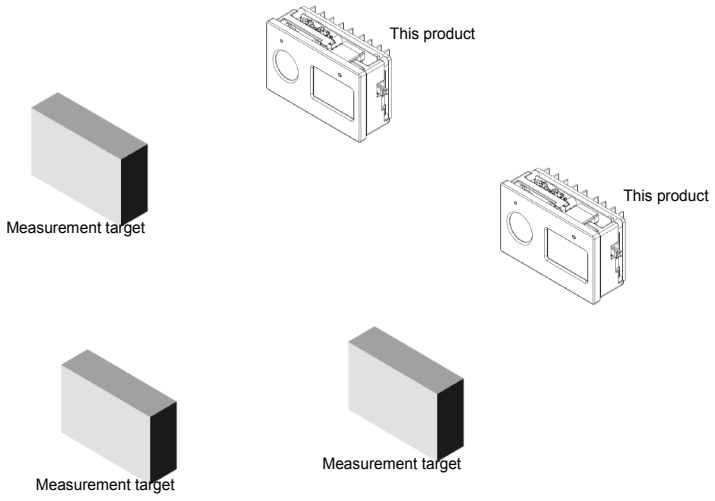
- Separately install a cover so that the emitted light should not be reflected by the inside surface of the cover and enter the receiver.
- Take into account the transmittance of the 940 nm wavelength for the cover material.
- To reduce the effect of reflection on the cover surface, apply AR coating.

Impact of heat

This product is equipped with an internal temperature sensor to stop measurement for safety reasons when the temperature exceeds a certain level.
To cover this product, you must take into account sufficient heat dissipation.

To use multiple products at the same time

If you use two or more units of this product simultaneously, configure unique LED emission frequency ID for each unit.
Refer to "4-13 LED Emission Frequency ID Setting (8EHex)" for details.
By default, the LED emission frequency ID is 8.



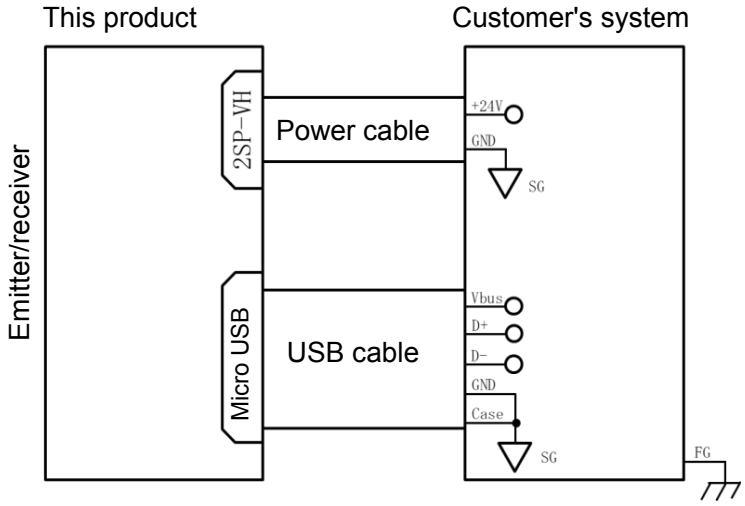
2-2 Wiring

External power supply

This product by itself does not conform to fireproof enclosure requirements.
Use a power supply that complies with IEC 62368-1 LPS (Limited Power Supply Requirements) for incorporation.

Precautions on connection configuration

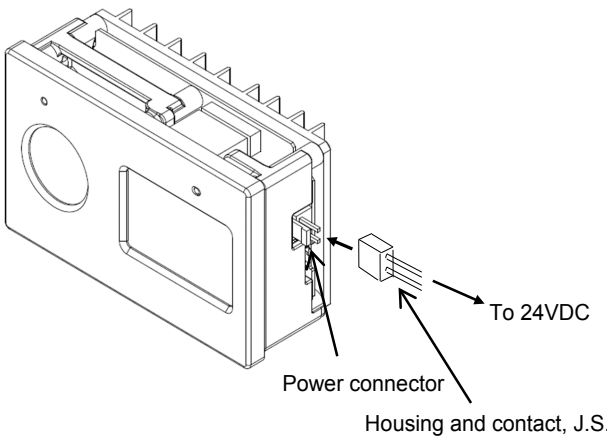
Shown below is the connection configuration.



Note 1: To obtain the limit values for radiation interference level (e.g. CISPR22 Class A), check and take measures as the product in which this product is incorporated.
Noise countermeasures for the connection lines can be expected to reduce the level of radiated noise.
Please evaluate the cable and GND connection (e.g. FG connection) before making your decision.
Note 2: Pay attention to creepage distance and other factors to prevent static electricity from being applied to any part of the enclosure other than the emitter and receiver surfaces.
Separate the mounting holes of this product from the FG.

Power supply connection

Wire the 24VDC power supply to the power connector shown below.



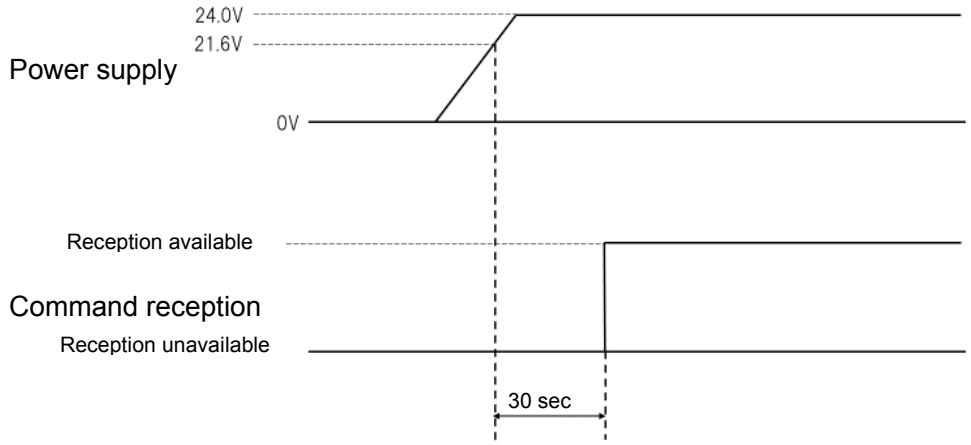
Power connector: S2P-VH (J.S.T. Mfg. Co., Ltd.)
See below for recommended counterparts.
- Housing: VHR-2M or VHR-2N (J.S.T. Mfg. Co., Ltd.)
- Contact: SVH-21T-P1.1 (J.S.T. Mfg. Co., Ltd.)

Pin #	Signal	Description
1	Vcc	Power supply DC24V±10%
2	GND	Ground (0V)

● To power on

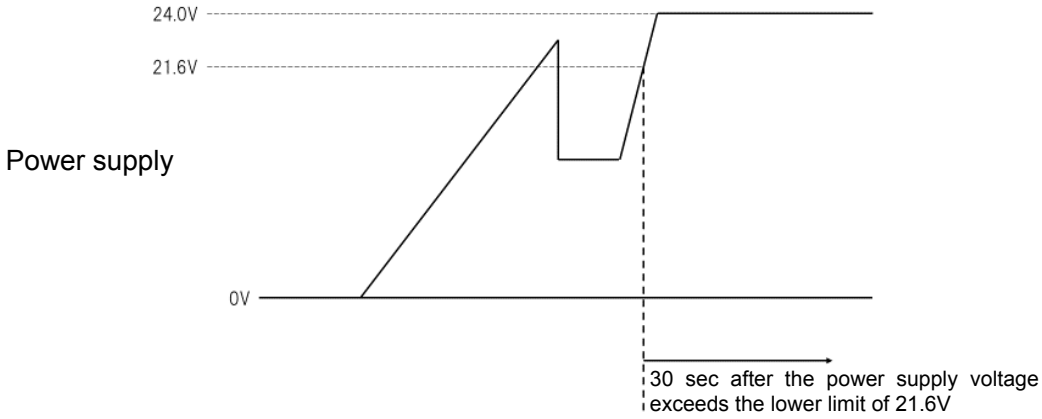
This section describes the operation flow of this product from power-on to operation start.

・ Power-ON sequence



It takes 30 seconds from when the lower limit of the power supply voltage (21.6V) is reached until the command is accepted.
After 30 seconds, use the Get version command to check the response.
Refer to "3-2 Basic Process on Host" for details.

・ If the power supply voltage momentarily falls below the lower limit of 21.6V

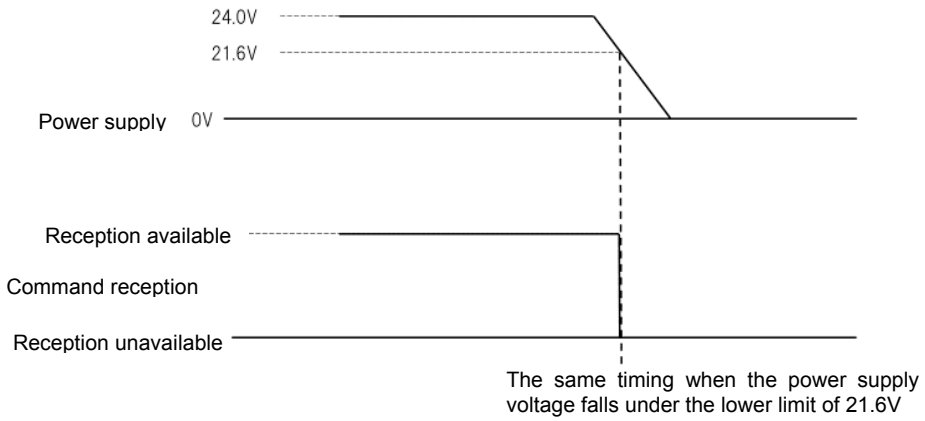


After turning on the power again, or when it is restored (when the voltage exceeds 21.6V again), start the command operation in 30 seconds.

● To power off

This section describes the operation flow of this product from the end of operation to power-off.

・ Power-OFF sequence



Execute the distance measurement stop command and turn off the power after the distance measurement is stopped.
Refer to "3-2 Basic Process on Host" for details.

Note: If the power supply voltage is dropped to 0V, do not perform the start-up sequence immediately, but wait for 5 seconds or more before turning the power back on.

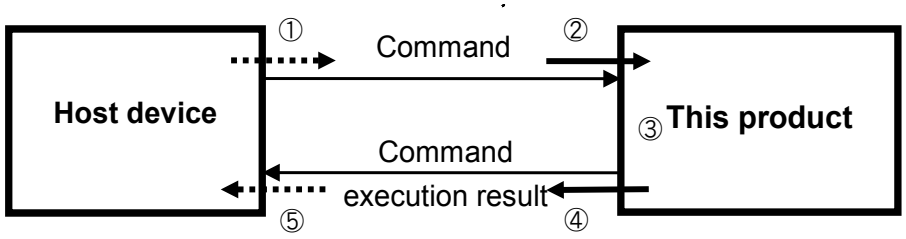
USB connection

This product is a USB device connected to the host via a USB cable.
The USB connector of this product is micro USB as shown below.
- Micro USB compliant (Vbus rating: 0.5A max.)
- Vbus power supply must be provided from the host.

Chapter 3 Communications from Host

3-1 Overview

This section describes basic communication steps between the host and this product.



①Host sends a command to this product.
②This product receives the command.
③This product executes the command.
④This product sends the execution result of the command to the host.
⑤Host receives the command execution result.

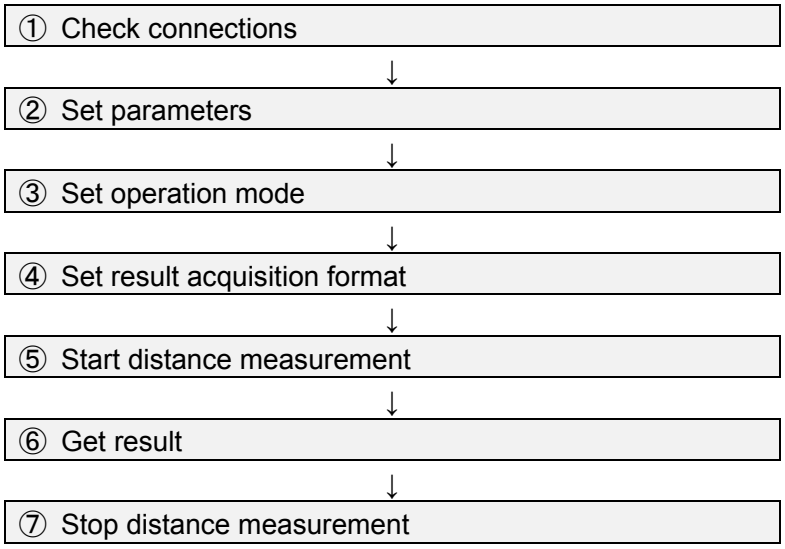
Until the host receives the execution result of the previous command, it must not send the next command. This product discards any command received while processing a command.

When a command is ended with an error, setting values are retained as they were before executing the command.

Caution
A command execution result may not be received even after a certain period of time has passed due to communication failure or other reasons. In such a case, it must be judged as communication timeout.
Refer to "3-4 Command List and Response List", "Timeout" for details of communication timeout.

3-2 Basic Process on Host

This section describes basic result acquisition process on the host that operates this product.



①Check if connection to this product is available.
Use the Get version command to check the response.
If the response cannot be checked, refer to "Chapter 2 - Installation and Wiring".

②Configure parameters.
Set the following parameters as needed.

- Exposure time/frame rate
  Time to accumulate receiving light.
  The larger this value is, the more distant object can be detected, while saturation and overflow are more likely to occur for near objects. In addition, the product generates more heat, reducing the maximum frame rate.
  Refer to "4-9 Exposure Time Setting (88Hex)" and "4-10 Get Exposure Time (89Hex)" for details.
- T3D rotation angle
  It is an angle for converting the coordinate system as seen from the camera (Cartesian coordinate system) into a coordinate system rotated to a desired angle (rotated Cartesian coordinate system).
  Refer to "4-11 T3D Rotation Angle Setting (8AHex)" and "4-12 Get T3D Rotation Angle (8BHex)" for details.
- LED emission frequency ID
  Mutual interference can be avoided when multiple units of this product are operated simultaneously.
  Refer to "4-13 LED Emission Frequency ID Setting (8EHex)" and "4-13 Get LED Emission Frequency ID (8FHex)" for details.
- MIN_AMP (for all range)
  Low amplitude (weakly reflected light) pixels make the distance output results unstable.
  For pixels with amplitude values smaller than the value set by this threshold, the distance and amplitude values are output as low amplitude values.
  Refer to "4-15 MIN_AMP (for all range) Setting (90Hex)" and "4-16 Get MIN_AMP (for all range) (91Hex)" for details.
- MIN_AMP (for close distance)
  Low amplitude (weakly reflected light) pixels at far distance make the distance measurement incorrect due to impact of close obstacles, leading to erroneous

results. This setting eliminates the problem.
For pixels with amplitude values smaller than the set value (weakly reflected light), the distance and amplitude values are output as low amplitude values.
Refer to "4-17 MIN_AMP (for close distance) Setting (92Hex)" and "4-18 Get MIN_AMP (for close distance) (93Hex)" for details.

- Enabling/disabling operation check LED
  This setting switches between enabling and disabling operation check LED.
  Refer to "4-20 Set Enabling/Disabling Operation Check LED (95Hex)" and "4-13 Get Enabling/Disabling Operation Check LED (96Hex)" for details.
- Responder speed setting (transmission size/interval)
  Response data may be occasionally lost. Adjusting the response speed by this command can prevent the loss of response data.
  If loss of response data occurred, make the transmission size smaller and the interval longer. (The setting may degrade the frame rate)
  Refer to "4-22 Response Speed Setting (97Hex)" and "4-23 Get Response Speed (98Hex)" for details.
- ENR threshold
  Occasionally the distance output at the boundary between the measurement target and the background may become unstable. This setting eliminates the problem.
  If the difference in distance between adjacent pixels is greater than the set value, the farther pixel value is output as the lower amplitude value.
  Refer to "4-24 ENR Threshold Setting (99Hex)" and "4-25 Get ENR Threshold (9AHex)" for details.

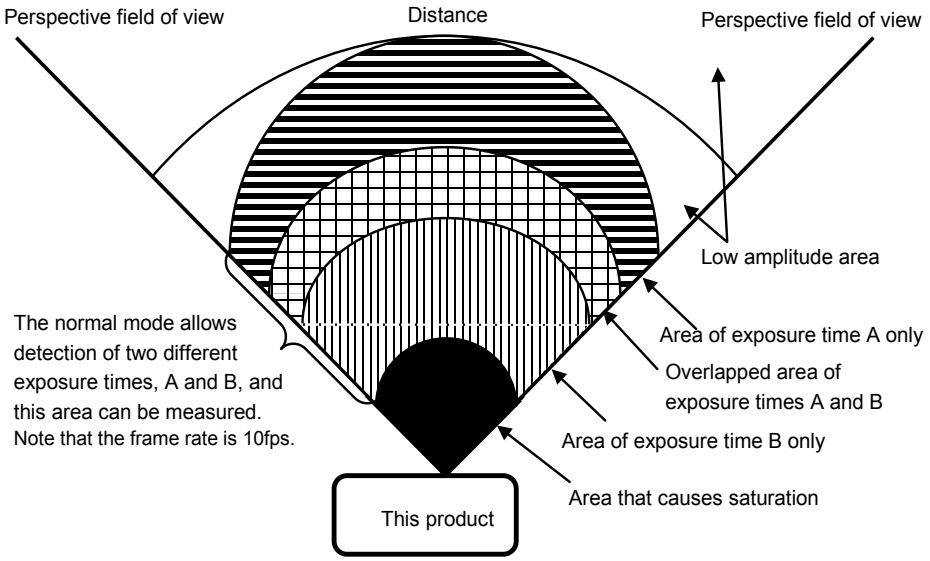
③Specify the operation mode.

Use the operation mode setting command to set the desired mode.

This product has two operation modes: Normal mode and High-speed mode.

The normal mode is the default mode. It allows wider range of measurement than the high-speed mode.

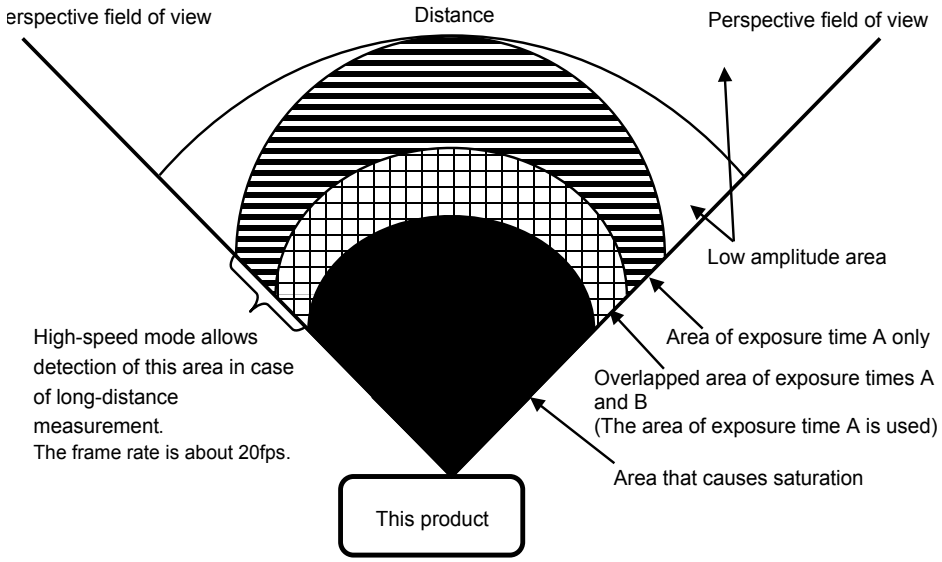
Normal mode



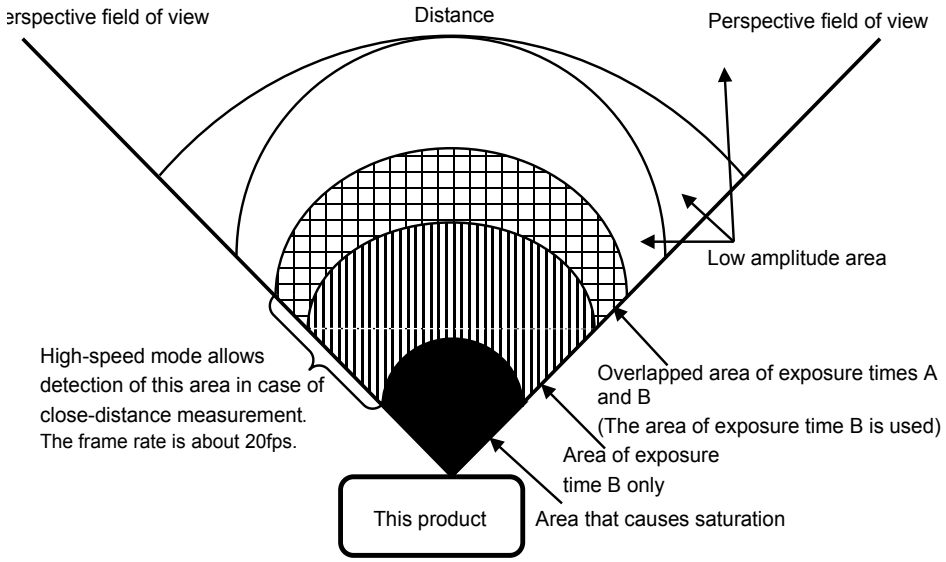
The high-speed mode increases the frame rate by about twice compared to the normal mode. You must be careful about measurement of the followings:

- When the distances to the measurement targets vary widely from close to distant
- When the reflectivity of the measurement targets vary widely from low to high

High-speed mode (long distance)



High-speed mode (close distance)



④Set the result acquisition format.

Use the Set result acquisition format command to set the desired format for results to acquire.

⑤Start measuring the distance.

Execute the Start distance measurement command to start measuring the distance.

Note: The distance measurement result cannot be acquired if distance measurement has not been started.

⑥Acquire the results.

Execute the Get result command to acquire distance measurement results.

⑦Stop the distance measurement.

Execute the Stop distance measurement command to stop measuring the distance.

- When executing the command, check the response code, and if an error occurs, perform the necessary processing according to the host application.
- Refer to "3-4 Command List and Response List", "Timeout" for command time-out period.
- If the execution result is not returned, re-send the command.
  Use the appropriate number of times (N) according to the host application.
- If the execution result is not returned yet, you may apply the following exception handlings.
  e.g.)
  - Resetting this product
  - Restarting the host device
- When the power is turned off, the distance measurement is stopped. After starting up the product next time, start from the step ⑤ of starting distance measurement.
- Even if the power is turned off, the following settings are retained.
  - Operation mode
  - Result acquisition format
  - Exposure time/frame rate
  - T3D rotation angle
  - LED emission frequency ID
  - MIN_AMP (for all range)
  - MIN_AMP (for close distance)
  - Enabling/disabling operation check LED
  - Responder speed setting (transmission size/interval)
  - ENR threshold

3-3 Command Specifications

Command format

Synchronization code	Command No.	Data length 2 bytes		Data
		MSB	LSB	

MSB: Most Significant Byte
LSB: Least Significant Byte
Data is sent starting from MSB.
e.g.) If the data length is 300 (012CHex), it is sent in the order of 01Hex - 2CHex.

Response format

Synchronization code	Response code	Data length 4 bytes				Data
		H-MSB	H-LSB	L-MSB	L-LSB	

H-MSB: Most Significant Byte (High Word)
H-LSB: Least Significant Byte (High Word)
L-MSB: Most Significant Byte (Low Word)
L-LSB: Least Significant Byte (Low Word)
Data is sent starting from H-MSB.
e.g.) If the data length is 300 (0000012CHex), it is sent in the order of 00Hex - 00Hex - 01Hex - 2CHex.
As exceptions, the following data have a different value order from the above. For details, refer to respective command description page.
- Get result command, distance & amplitude data
- Get θφ table command, θφ table data

3-4 Command List and Response List

Command list

Usage	Command No.	Command name	Command function
Connection check	00Hex	Get version	Acquires model/version
Basic setting	86Hex	Set operation mode	Sets operation mode
	84Hex	Set result acquisition format	Sets result acquisition format
Parameter setting	88Hex	Set exposure time	Sets exposure time/frame rate
	8AHex	Set T3D rotation angle	Sets rotation angle for rotated Cartesian coordinate system
	8EHex	Set LED emission frequency ID	Sets LED emission frequency ID against interference
	90Hex	Set MIN_AMP (for all range)	Sets minimum amplitude for all range
	92Hex	Set MIN_AMP (for close distance)	Sets minimum amplitude for close distance
	95Hex	Set enabling/disabling operation check LED	Sets enabling/disabling of operation check LED
	97Hex	Set response speed	Sets response speed
	99Hex	Set ENR threshold	Sets edge threshold for edge noise reduction
Operations instruction	80Hex	Start distance measurement	Emits LED and starts distance measurement
	81Hex	Stop distance measurement	Stops LED emission and stops distance measurement
	82Hex	Get result	Acquires distance result/amplitude result
Setting acquisition	87Hex	Get operation mode	Acquires operation mode
	85Hex	Get result acquisition format	Acquires result acquisition format
	89Hex	Get exposure time	Acquires exposure time/frame rate
	8BHex	Get T3D rotation angle	Acquires rotation angle for rotated Cartesian coordinate system
	8FHex	Get LED emission frequency ID	Acquires LED emission frequency ID against interference
	91Hex	Get MIN_AMP (for all range)	Acquires minimum amplitude for all range
	93Hex	Get MIN_AMP (for close distance)	Acquires minimum amplitude for close distance
	94Hex	Get θφ table	Acquires θφ table in polar coordinate system
	96Hex	Get enabling/disabling operation check LED	Acquires enable/disable operation check LED
	98Hex	Get response speed	Acquires response speed
	9AHex	Get ENR threshold	Acquires edge threshold for edge noise reduction
Status acquisition	9BHex	Get imager temperature	Acquires current imager temperature
	9CHex	Get LED temperature	Acquires current LED temperature
Other instruction	9EHex	Initialize parameters	Resets all parameters
	9FHex	Reset software	Resets this product

Response code list

Error code	Error details
00Hex	Normal end
FFHex	Undefined command - Issued when a received command is not found in the command list
FEHex	Internal error
FDHex	Illegal command - When an illegal parameter is input
FCHex	Command not executable - An execution of a command was attempted that cannot be executed during distance measurement. - An execution of a command that can be executed only during distance measurement was attempted while distance measurement is being stopped.

F9Hex	Device error (power supply)
F8Hex	Device error (imager)
F7Hex	Device error (abnormal heat generation)
F5Hex	Device error (flash write)
F4Hex	Device error (flash read)
F0Hex	Device error (others)

The error strength is in the following order (the left side has the higher strength).
FFHex > FEHex > FCHex > FDHex > F7Hex > F9Hex, F8Hex, F5Hex, F4Hex, F0Hex

If any of the device errors from F9Hex to F0Hex occurred, perform the following actions according to the error code.

(1) F8Hex/F0Hex (device error (imager/others))
Perform the followings:
- Restart this product by using the Reset software command
- Restart the host device

(2) F5Hex/F4Hex (device error (flash write/flash read))
The flash ROM data may have been corrupted. Perform the Initialize parameters command. When the Initialize parameters command is executed, the parameters are reset to the default values.
If you have changed any parameter from the default value, you need to configure the value again.

(3) F9Hex (device error (power supply))
The supply voltage to this product may be too low.
Check the supply voltage and perform the followings.
- Restart this product by turning off the power
- Restart the host device

(4) F7Hex (device error (abnormal heat generation))
Abnormal heat generation occurred due to an internal failure. Immediately turn off the power and do not turn on the power again.

Timeout

Timeout time = Maximum response time of this product + Maximum communications time between this product and host

The maximum response time is the maximum time from the completion of receiving a command to the start of sending a response. It depends on the command to execute as shown below.

Set LED emission frequency ID command : 5 seconds
Setting command other than the above : 1 second
Command other than the above : 500 milliseconds

The maximum communication time between the host and this product is system-dependent. You must set an appropriate time for the timeout time.
If the next command is issued while the command is being executed, the issued command will not be accepted, and the system will wait for normal reception after the response to the command being executed is sent.

Chapter 4 Command Description

4-1 Get Version (00Hex)

Acquires the model and version of this product.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	00Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	1DHex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Model character string (11 characters): "B5L-A2S-U01"
Major version (1-byte hexadecimal): To be updated on a major change
Minor version (1-byte hexadecimal): To be updated on a minor change
Release version (1-byte hexadecimal): To be updated on a slight modification
Revision number (4-byte hexadecimal): Used for internal management
Serial No. character string (11 characters): Identification character string for each unit

4-2 Start Distance Measurement (80Hex)

Emits LED and starts distance measurement.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	80Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

The response is returned when distance measurement has been started and the result can be acquired.
By issuing the Get result command during distance measurement, the distance and

amplitude can be acquired from this product.
If the distance measurement is being performed, the command is ended normally and the status does not change.

Shown below are commands that can be accepted during distance measurement.
- Get version
- Stop distance measurement
- Get result
- Get imager temperature
- Get LED temperature
- Reset software

Not-executable error occurs if a command other than the above is received during distance measurement.

NOTE. If an error has occurred during the initialization of this product, this command causes an error. If an error has occurred that makes distance measurement impossible during distance measurement, the measurement is immediately stopped.

4-3 Stop Distance Measurement (81Hex)

Stops LED emission and stops distance measurement.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	81Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

By issuing this command during distance measurement, the measurement is stopped.
If the distance measurement has not been started, the command is ended normally and the status does not change.

4-4 Get Result (82Hex)

Acquires the distance and amplitude results detected by this product.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	82Hex	00Hex	01Hex	00Hex (fixed)

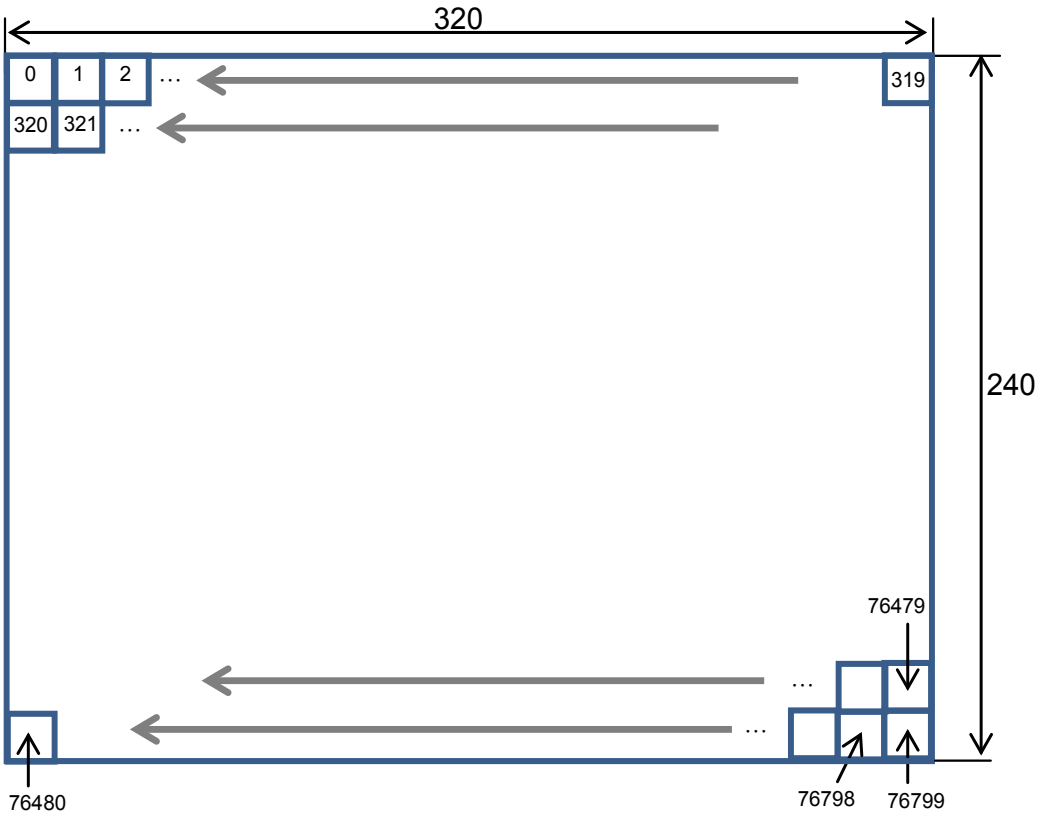
- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	See below for details				
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Returns the latest distance measurement results at the time the command is issued in the format specified in the Set result acquisition format command.

The data is output in the order of 76799 to 0 from the bottom right to the top left of a 320x240 image.



When Cartesian coordinate system or rotated Cartesian coordinate system is specified for the result acquisition format, output is in PCD format. The following PCD header is prefixed to the distance data.

```
# .PCD v.7 - Point Cloud Data file format
VERSION .7
FIELDS x y z
SIZE 2 2 2
TYPE I I I
COUNT 1 1 1
WIDTH 320
HEIGHT 240
VIEWPOINT 0 0 0 1 0 0 0
POINTS 76800
DATA binary
```

If the result acquisition format is 0000Hex: Distance Data (Polar coordinate system), returned is the distance data of 320 pixels wide and 240 pixels high with 2 bytes per pixel.

Data length				Data block
00Hex	02Hex	58Hex	00Hex	

Data block									
Distance data									
76799		76798		76797		…	0		
LSB	MSB	LSB	MSB	LSB	MSB		LSB	MSB	

If the result acquisition format is either of the followings, returned is the PCD file format data of 320 pixels wide and 240 pixels high with 2 bytes of coordinate values x, y, and z, respectively.

0001Hex: Distance data (Cartesian coordinate system)

0002Hex: Distance data (rotated Cartesian coordinate system)

The PCD header of 170 bytes is prefixed to the distance data.

Data length				Data block
00Hex	07Hex	08Hex	AAHex	

Data block													
PCD header	Distance data												
	x76799		y76799		z76799		…	x0		y0		z0	
	LSB	MSB	LSB	MSB	LSB	MSB		LSB	MSB	LSB	MSB	LSB	MSB

If the result acquisition format is 0000Hex: Distance Data (Polar coordinate system) + Amplitude data, returned is the distance data of 320 pixels wide and 240 pixels high with 2 bytes per pixel, followed by amplitude data of 320 pixels wide and 240 pixels high with 2 bytes per pixel.

Data length				Data block
00Hex	04Hex	B0Hex	00Hex	

Data block												
Distance data							Amplitude data					
76799		76798		76797		…	0		76799		76798	
LSB	MSB	LSB	MSB	LSB	MSB		LSB	MSB	LSB	MSB	LSB	MSB

Data block					
Amplitude data					
76797		…	0		
LSB	MSB		LSB	MSB	

If the result acquisition format is either of the followings, returned is the PCD file format data of 320 pixels wide and 240 pixels high with 2 bytes of coordinate values x, y, and z, respectively, followed by amplitude data of 320 pixels wide and 240 pixels high with 2 bytes per pixel.

0101Hex: Distance data (Cartesian coordinate system) + Amplitude data

0102Hex: Distance data (rotated Cartesian coordinate system) + Amplitude data

The PCD header of 170 bytes is prefixed to the distance data.

Data length				Data block
00Hex	09Hex	60Hex	AAHex	

Data block													
PCD header	Distance data							x0		y0		z0	
	x76799		y76799		z76799		…						
	LSB	MSB	LSB	MSB	LSB	MSB		LSB	MSB	LSB	MSB	LSB	MSB

Data block				
Amplitude data				
76799		…	0	
LSB	MSB		LSB	MSB

If the result acquisition format is 01FFHex: Amplitude data only, returned is the amplitude data of 320 pixels wide and 240 pixels high with 2 bytes per pixel.

Data length				Data block
00Hex	02Hex	58Hex	00Hex	

Data block							
Amplitude data							
76799		76798		76797		…	0
LSB	MSB	LSB	MSB	LSB	MSB		LSB	MSB

4-5 Set Result Acquisition Format (84Hex)

Sets the result output format.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	84Hex	00Hex	02Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Setting value	Data name
0000Hex	Distance data (polar coordinate system)
0001Hex	Distance data (Cartesian coordinate system)
0002Hex	Distance data (rotated Cartesian coordinate system)
0100Hex	Distance data (polar coordinate system) + Amplitude data
0101Hex	Distance data (Cartesian coordinate system) + Amplitude data
0102Hex	Distance data (rotated Cartesian coordinate system) + Amplitude data
01FFHex	Amplitude data

Specify the output information and coordinate system.

Output information: Distance data only
Distance data + Amplitude data
Amplitude data only

Coordinate system: Polar (r)
Cartesian (Xo, Yo, Zo)
Rotated Cartesian (Xr, Yr, Zr)

The default value is 0000Hex: Distance data (polar).
The unit of distance data is mm (millimeter).
When Cartesian coordinate system or rotated Cartesian coordinate system is specified, the distance data output is in PCD (Point Cloud Data) format.
Note: PCD (Point Cloud Data)
http://pointclouds.org/documentation/tutorials/pcd_file_format.php#pcd-file-format

The distance data output is a value as shown below in respective format.

Polar coordinate system		0 to 12499[mm]
Cartesian coordinate system	Xo	-12499 to 12499[mm]
	Yo	-12499 to 12499[mm]
	Zo	0 to 12499[mm]
Rotated Cartesian coordinate system	Xr	-12499 to 12499[mm]
	Yr	-12499 to 12499[mm]
	Zr	-12499 to 12499[mm]

The amplitude data output is a value ranging from 0 to 255.
The abnormal values are as shown below.
All of X, Y, and Z values are abnormal ones as shown below in Cartesian and rotated Cartesian coordinate systems.

Error status	Distance value	Amplitude value
Saturation	31000	511
Overflow	32000	510
Low amplitude (less than MIN_AMP)	30000	Logical OR of amplitude value and 0100Hex

- Saturation
  The receiving light level exceeds the allowable value of this product and distance measurement is unavailable.
  Adjust the exposure time shorter.
- Overflow

  Adjust the exposure time shorter.
- Low amplitude (less than MIN_AMP)
  The amplitude value is less than the specified MIN_AMP.

4-6 Get Result Acquisition Format (85Hex)

Acquires the result acquisition format currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	85Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	02Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Setting value	Data name
0000Hex	Distance data (polar coordinate system)
0001Hex	Distance data (Cartesian coordinate system)
0002Hex	Distance data (rotated Cartesian coordinate system)
0100Hex	Distance data (polar coordinate system) + Amplitude data
0101Hex	Distance data (Cartesian coordinate system) + Amplitude data
0102Hex	Distance data (rotated Cartesian coordinate system) + Amplitude data
01FFHex	Amplitude data

Acquires the output information and coordinate system being specified.

Output information: Distance data only
Distance data + Amplitude data
Amplitude data only

Coordinate system: Polar (r)
Cartesian (Xo, Yo, Zo)
Rotated Cartesian (Xr, Yr, Zr)

4-7 Set Operation Mode (86Hex)

Sets the operation mode.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	86Hex	00Hex	01Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Setting value	Data name
00Hex	Normal mode
01Hex	High-speed mode

The default value is 00Hex: Normal mode.

4-8 Get Operation Mode (87Hex)

Acquires the operation mode currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	87Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	01Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Setting value	Data name
00Hex	Normal mode
01Hex	High-speed mode

4-9 Set Exposure Time (88Hex)

Sets the exposure time and frame rate.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	88Hex	00Hex	07Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Specify the values in the order from Exposure time (2 bytes), Reserved (4 bytes), and Frame rate (1 byte). Specify 00Hex (x 4) for Reserved.

Byte position	Data name	
0	Exposure time	MSB
1		LSB
2 - 5	Reserved (00 x 4, fixed)	
6	Frame rate	

Specify the exposure time within the range shown below.
- Normal mode: 170 to 5312
- High-speed mode: 20 to 10000

Specify the frame rate within the range from 1 to 20.

If 0 is set to the frame rate, the product runs at the maximum frame rate for the specified exposure time.
If a value other than 0 is set to the frame rate, the product runs at the specified frame rate even if it can run at a higher rate. It does not run at a frame rate that exceeds the rate for the specified exposure time.

The default values are:
- Exposure time : 850
- Frame rate : 0

Note: The frame rate is the number of frames per second and is expressed in frames per second (fps).

4-10 Get Exposure Time (89Hex)

Acquires the exposure time and frame rate currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	89Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	07Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Data is returned in the order from Exposure time (2 bytes), Reserved (4 bytes), and Frame rate (1 byte). Skip the data in the Reserved block.

Byte position	Data name	
0	Exposure time	MSB
1		LSB
2 - 5	Reserved (00 x 4, fixed)	
6	Frame rate	

4-11 Set T3D Rotation Angle (8AHex)

Sets rotation angles for x, y, and z axes in the rotated Cartesian coordinate system.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	8AHex	00Hex	06Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

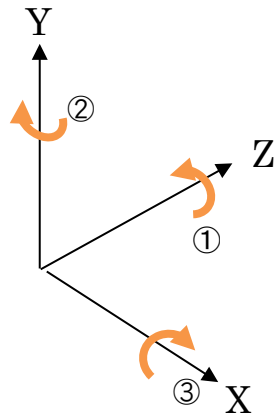
・ Data details

Specify the rotation angles in the order of x, y, and z as integers (2 bytes) ranging from 0 to 359 degree.

The angles must be specified counterclockwise.

Rotation is processed in the order from z, y, to x.

Byte position	Data name	
0	Rotation angle around x axis	MSB
1		LSB
2	Rotation angle around y axis	MSB
3		LSB
4	Rotation angle around z axis	MSB
5		LSB



The default values are 0 degrees for all.

Note: The number indicates the sequence of rotation

4-12 Get T3D Rotation Angle (8BHex)

Acquires rotation angles for x, y, and z axes in the rotated Cartesian coordinate system.

● Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	8BHex	00Hex	00Hex

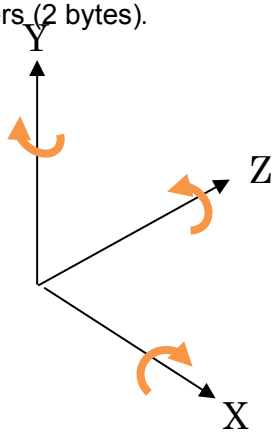
● Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	06Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

The rotation angles are acquired in the order of x, y, and z as integers (2 bytes).

Byte position	Data name	
0	Rotation angle around x axis	MSB
1		LSB
2	Rotation angle around y axis	MSB
3		LSB
4	Rotation angle around z axis	MSB
5		LSB



4-13 Set LED Emission Frequency ID (8EHex)

Sets the LED emission frequency ID for avoiding mutual interference between units of this product.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	8EHex	00Hex	01Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Specify the LED emission frequency ID from 0 to 16.
The default value is 8.

If multiple units of this product with the same LED projection frequency are operated at the same time, their emission may interfere with each other, resulting in incorrect distance measurement results.
Specifying unique LED emission frequency IDs for the units can relieve mutual interference between them.

4-14 Get LED Emission Frequency ID (8FHex)

Acquires the LED emission frequency ID currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	8FHex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	01Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Acquires the LED emission frequency ID, from 0 to 16, currently specified.

4-15 Set MIN_AMP (for all range)(90Hex)

Sets the minimum amplitude for all range.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	90Hex	00Hex	01Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Specify the minimum amplitude to judge as a valid pixel for all range in 1 byte.
If a pixel has an amplitude value smaller than the set value, it is judged as low amplitude.
The setting range is 0 to 200.
The default value is 0.

4-16 Get MIN_AMP (for all range)(91Hex)

Acquires the minimum amplitude value currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	91Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	01Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

The minimum amplitude value (for all range) currently specified is returned in 1 byte.

4-17 Set MIN_AMP (for close distance)(92Hex)

Sets the minimum amplitude for close distance.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	92Hex	00Hex	01Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Specify the minimum amplitude to judge as a valid pixel for close distance (within 1.5m) in 1 byte.

If a pixel has an amplitude value smaller than the set value, it is judged as low amplitude.

Even if you set a value smaller than the minimum amplitude for the all range, the minimum amplitude for the all range at a close distance is still valid.

The setting range is 0 to 200.

The default value is 0.

4-18 Get MIN_AMP (for close distance)(93Hex)

Acquires the minimum amplitude value currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	93Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	01Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

The minimum amplitude value (for close distance) currently specified is returned in 1 byte.

4-19 Get θφ Table (94Hex)

Acquires θ and φ tables.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	94Hex	00Hex	00Hex

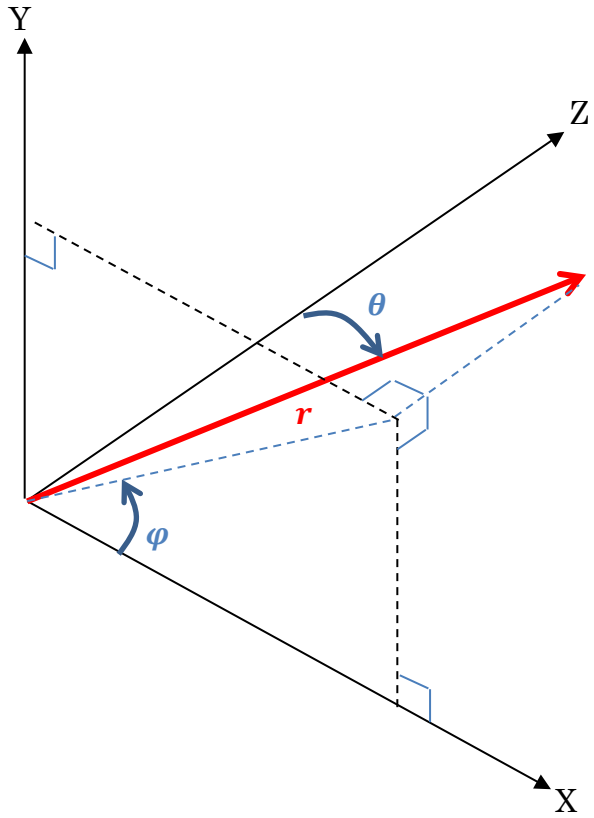
- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	04Hex	B0Hex	00Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Table data are returned in the order of θ and φ in 2 bytes per pixel.

As with distance and amplitude data, the data is output in the order of 76799 to 0 from the bottom right to the top left of a 320x240 image.



Data length				Data block
00Hex	04Hex	B0Hex	00Hex	

Data block									
θ table data									
76799		76798		76797		…	0		
LSB	MSB	LSB	MSB	LSB	MSB		LSB	MSB	

Data block									
φ table data									
76799		76798		76797		…	0		
LSB	MSB	LSB	MSB	LSB	MSB		LSB	MSB	

- Data details

The available θ table angle range is: 0≤θ<90 (degrees).
The value stored in the θ table consists of the upper 4 bits of the MSB as the approximate angle-of-view/angle-of-view judgment values and the lower 12 bits as the 12-bit fixed-point value of 0≤θ<90 [degrees].
When the upper 4 bits are all "1", the data is outside the angle of view. When they are all "0", the data is inside the angle of view.
For example, if the data at position 76799 is BE FAHex:
The value is FABEHex, which indicates:
Upper 4 bits FHex: Outside the angle of view (AOV)
Lower 12 bits ABEHex = 2750: 90 x (2750/4096) = 60 [degrees]

76799															
LSB								MSB							
BHex				EHex				FHex				AHex			
1	0	1	1	1	1	1	0	1	1	1	1	1	0	1	0
θ value (lower 8 bits)								Judgement of outside or inside the AOV				θ value (upper 4 bits)			

The available φ table angle range is: 0≤φ<360 (degrees).
The value stored in the ϕ table consists of the upper 2 bits of the MSB as fixed to 0 and the lower 14 bits as the 14-bit fixed-point value of 0≤φ<360 [degrees].
For example, if the data at position 76799 is BE 4D 19Hex:
The value is 194DHex, which indicates:
Upper 2 bits: Fixed to 0
Lower 14 bits 194DHex = 6477: 360 x (6477/16384) = 142 [degrees]

76799															
LSB								MSB							
4Hex				DHex				1Hex				9Hex			
0	1	0	0	1	1	0	1	0	0	0	1	1	0	0	1
φ value (lower 8 bits)								Fixed		φ (upper 6 bits)					

The formula for converting θ and φ from fixed-point values to degrees is as follows:
θ [degrees] = 90 x θ [fixed-point value]/4096
φ [degrees] = 360 x φ [fixed-point value]/16384

4-20 Set Enabling/Disabling Operation Check LED (95Hex)

Enables or disables the operation check LED.

When disabled, the operation check LED cannot be lit/flashing after startup.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	95Hex	00Hex	01Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Specify 0 to enable the operation check LED or 1 to disable it.

The default value is 0 (enable).

This product's status	Operation check LED status	
	Enabled	Disabled
When power is turned ON	Solid ON	Solid ON
Under normal operation	Solid ON	Not lit
Error occurred[*1]	Flashing	Not lit

The status is enabled or disabled immediately after receiving the command.

*1: A status in which this product cannot be properly started up due to an error such as a device error.

4-21 Get Enabling/Disabling Operation Check LED (96Hex)

Acquires the enabled or disabled status of the operation check LED currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	96Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	01Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

The enabled or disabled status of the operation check LED currently specified is returned in 1 byte.

4-22 Set Response Speed (97Hex)

Sets the command response speed.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	97Hex	00Hex	03Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Specify the data in the order of transmission size (1 byte) and transmission interval (2 bytes) of the response data. Specify the transmission size as either of 1, 2, 4, 8, or 16 [kilobytes] and the transmission interval within the range from 0 to 10000 [microseconds].
The default values are:
Transmission size : 16 [kilobytes]
Transmission interval : 0 [microseconds]

Byte position	Data name	
0	Transmission size	
1	Transmission interval	MSB
2		LSB

Depending on the host environment, response data may be occasionally lost. Adjusting the response speed by this command can prevent the loss of response data.
If loss of response data occurred, make the transmission size smaller and the interval longer. (The setting may degrade the frame rate)

4-23 Get Response Speed (98Hex)

Acquires the command response speed currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	98Hex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	03Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Acquires the command response speed currently specified.

Byte position	Data name	
0	Transmission size	
1	Transmission interval	MSB
2		LSB

4-24 Set ENR Threshold (99Hex)

Sets the edge threshold for ENR (edge noise reduction).
The boundary between pixels that has a larger distance than this threshold is recognized as the edge.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	99Hex	00Hex	02Hex	See below for details

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details
Specify the edge detection threshold (0 to 12499 [mm]) in 2 bytes.
Specifying 0 disables the ENR.
The default value is 0.

ENR (edge noise reduction)
When the distance difference between pixels is large (for example, when the distance between the measurement target and the background is far away), this function judges the pixel with a distance difference greater than or equal to the threshold as the boundary (edge) and outputs the distance and amplitude values of the farther pixel as the low amplitude.
Lowering the threshold makes it easier to judge an edge, but misjudgments increase when there is a large variation in distance between pixels.
You can use 500 as a guideline of the threshold to enable the ENR.

4-25 Get ENR Threshold (9AHex)

Acquires the edge threshold for ENR (edge noise reduction) currently specified.

- Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	9AHex	00Hex	00Hex	

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	02Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Acquires the edge detection threshold (0 to 12499) in 2 bytes.

4-26 Get Imager Temperature (9BHex)

Acquires the imager temperature of this product during the distance measurement.

Note: If this command is issued before the distance measurement has been started, a device error (abnormal heat generation) occurs and the distance measurement cannot be started. If this happens, turn the unit power back on or use the Reset software command to restart the unit.

● Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	9BHex	00Hex	00Hex	

● Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	08Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Current imager temperature is returned in the order of top-left, top-right, bottom left, and bottom right in 2 bytes.

The temperature [°C] of the imager is calculated by multiplying the obtained value by a factor of ten.

Top left		Top right		Bottom left		Bottom right	
MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB

4-27 Get LED Temperature (9CHex)

Acquires the LED temperature of this product during the distance measurement.

Note: If this command is issued before the distance measurement has been started, a device error (abnormal heat generation) occurs and the distance measurement cannot be started. If this happens, turn the unit power back on or use the Reset software command to restart the unit.

● Command (from host to this product)

Synchronization code	Command No.	Data length		Data
FEHex	9CHex	00Hex	00Hex	

● Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	02Hex	See below for details
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

The current LED temperature is returned in 2 bytes.

The temperature [°C] of the LED is calculated by multiplying the obtained value by a factor of ten.

4-28 Initialize Parameters (9EHex)

Initializes all parameters currently specified to the factory default values.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	9EHex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

The following parameters are initialized:

- Operation mode (normal/high-speed)
- Exposure time/frame rate
- Exposure time/frame rate
- T3D rotation angle
- LED emission frequency ID
- MIN_AMP (for all range)
- MIN_AMP (for close distance)
- Enabling/disabling operation check LED
- Responder speed setting (transmission size/interval)
- ENR threshold

If this command is executed, this product is reset and the USB connection is released. After executing this command, there is a waiting time of about 10 seconds before the next command can be accepted.

4-29 Reset Software (9FHex)

Resets this product.

- Command (from host to this product)

Synchronization code	Command No.	Data length	
FEHex	9FHex	00Hex	00Hex

- Response (from this product to host)

Synchronization code	Response code	Data length				Data
FEHex	Normal end: 00Hex	00Hex	00Hex	00Hex	00Hex	
	Error: FFHex to F0Hex	00Hex	00Hex	00Hex	00Hex	

・ Data details

Stops the distance measurement and goes back to the status after power ON.
The following parameter settings are retained.

- Result acquisition format (output information, coordinate system)
- Operation mode (normal/high-speed)
- Exposure time/frame rate
- T3D rotation angle
- LED emission frequency ID
- MIN_AMP (for all range)
- MIN_AMP (for close distance)
- Enabling/disabling operation check LED
- Responder speed setting (transmission size/interval)
- ENR threshold

If this command is executed, the USB connection is released.
After executing this command, there is a waiting time of about 10 seconds before the next command can be accepted.

Chapter 5 Troubleshooting

5-1 Troubleshooting List

Error upon setting

Problem	Internal operation check LED	Communication response code	Error description	Possible causes	Action
Command for setting cannot be executed. (Whether this product is started up or not is not recognized)	Not lit[*1]	-	This product is nor operating	The installation conditions are not met.	Check the items described in "Chapter 2 - Installation & Wiring".
				Startup error due to power supply failure.	Check the power supply connected to this product (e.g. voltage and rating).
				Startup error due to power cable connection failure.	Check the power cable connection (e.g. incomplete locking and reverse connection).
				Startup error due to temperature at installation location.	Check that the temperature of the installation environment is within the rated one.
Command for setting cannot be executed after startup.	Flashing[*1]	FFHex	Undefined command	Execution of a command not listed in the command list was attempted.	Check the command number and data length, and run the proper command.
		FDHex	Illegal command	A value configured for the command data is out of the specifications.	Check the available range for the value, and run the proper command.
		F5Hex or FEHex	Device error (flash write) or internal error	A setting value could not be set due unknown reasons.	Run the command again that caused the error.

*1: If the operation check LED has been enabled.

Error upon distance measurement start

Problem	Internal operation check LED	Communication response code	Error description	Possible causes	Action
The Start distance measurement command cannot be executed after startup.	Flashing[*1]	-	-	Either of the followings was detected when this product was started.	-
		F8Hex or F0Hex	Device error (imager) or device error (others)	Initialization error of a device in this product	- Turn the unit power back on or use the Reset software command to restart the unit. Before turning the power back on, please wait for 5 seconds or longer after powering off.

Problem	Internal operation check LED	Communication response code	Error description	Possible causes	Action
					- Restart the host device.
		F5Hex or F4Hex	Device error (flash write) or device error (flash read)	The flash ROM data may have been corrupted.	Perform the Initialize parameters command. (When the Initialize parameters command is executed, the parameters are reset to the default values. If you have changed any parameter from the default value, you need to configure the value again.) If the error occurs even after the above correction is performed, the firmware itself may have been corrupted.
		F9Hex	Device error (power supply)	The 24VDC supply voltage to this product may be too low.	- Check the supply voltage. - Turn the unit power off and back on or restart the unit. Before turning the power back on, please wait for 5 seconds or longer after powering off. - Restart the host.
		F7Hex	Device error (abnormal heat generation)	Abnormal heat generation occurred in a component in this product.	Immediately turn off the power and do not turn on the power again. Note that if the Get imager temperature command or Get LED temperature command is issued before the distance measurement has been started, this error occurs as well and the distance measurement cannot be started. If this happens, turn the unit power back on or use the Reset software command to restart the unit.
USB is not recognized.	Flashing[*1]	-	USB not recognized	The unit has not been started. Or, the host has not recognized the PC's USB port.	First, check if the unit has been successfully started. If the unit has been successfully started up but has not recognized the USB, the host driver may not have been called properly. - When the host OS is Windows 10, delete the unnecessary COM ports and then reboot this product and the host. - When the host OS is Ubuntu18, run the following command on the host after

Problem	Internal operation check LED	Communication response code	Error description	Possible causes	Action
					this product is started up. sudo modprobe usbserial vendor=0x0590 product=0x00CA

*1: If the operation check LED has been enabled.

Error during distance measurement

Problem	Internal operation check LED	Communication response code	Error description	Possible causes	Action
Command issued by the host cannot be executed.	-	FCHex	Command not executable	An execution of a command was attempted that cannot be executed during distance measurement.	An execution of a command is attempted that cannot be executed during distance measurement.
				An execution of a command (Get result command) that can be executed only during distance measurement was attempted while distance measurement is being stopped.	If this error is outputted for the Get result command, execute the Get result command after executing the Start distance measurement command.
	Flashing[*1]	F9Hex	Device error (power supply)	The 24VDC supply voltage to this product may be too low.	- Check the supply voltage. - Turn the unit power off and back on or restart the unit. Before turning the power back on, please wait for 5 seconds or longer after powering off. - Restart the host.
The distance values of X, Y, and Z are 31000 for all.	Not lit	00Hex	Saturation	The receiving light level exceeds the allowable value of this product and distance measurement is unavailable.	Use the Set exposure time (88Hex) to adjust the exposure time shorter.
The distance values of X, Y, and Z are 32000 for all.	Not lit	00Hex	Overflow	The receiving light level is too high and the distance has not been measured accurately.	Use the Set exposure time (88Hex) to adjust the exposure time shorter.
The distance values of X, Y, and Z are 30000 for all.	Not lit	00Hex	Low amplitude (less than MIN_AMP)	The amplitude value is less than the specified MIN_AMP.	Use the Set exposure time (88Hex) to adjust the exposure time longer.

*1: If the operation check LED has been enabled.

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