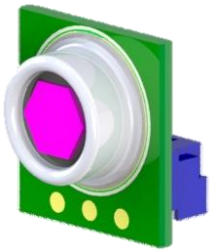
MEMS Infrared Thermal Sensor

MMS701L11A Datasheet

DESCRIPTION



MMS701 is an infrared sensor using MEMS thermopile technology. This sensor can measure surface temperature of objects without touching them by capturing infrared radiation from the objects. The product outputs a digital value of surface temperature of object. I2C is adopted for the interface. Temperature of the sensor itself can also be measured.

FEATURES

- Low noise level
  - Noise-equivalent temperature difference (NETD): below 0.06℃
- Temperature value is directly available.
  - Digital output of temperature values compensated by ambient temperature. Easy for rapid application engineering.
- Easily mountable with a connector.
  - No need to prepare dedicated board for the sensor.
- Good temperature accuracy even at in sub-zero temperatures.
  - For reference, +/-2.0℃ at -10℃

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BLOCK DIAGRAM

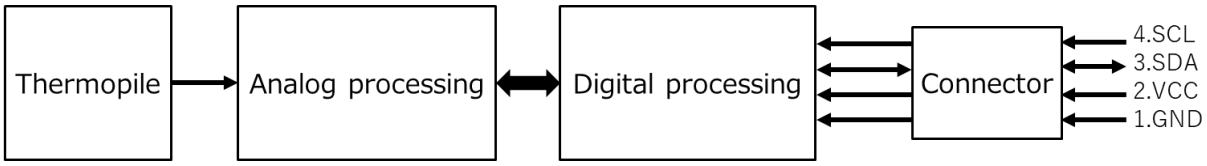


Figure 1 Block Diagram

PIN CONFIGURATION

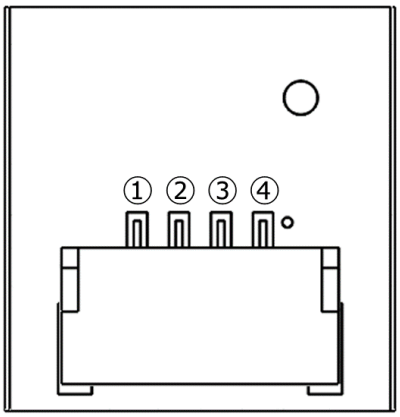


Figure 2 Pin Configuration（Top View）

Table 1 Pin Table

Pin No.	Pin Name
1	GND
2	VCC
3	SDA
4	SCL

ABSOLUTE MAXIMUM RATINGS

(Unless otherwise specified, ambient temperature (Ta) =25℃)

Item	Symbol	Min.	Max.	Unit	Remark
Power-supply Voltage	Vcc	-0.2	6.0	V	
Voltage at I/O	-	-0.3	Vcc	V	SCL, SDA terminal

RECOMMENDED OPERATING CONDITIONS

Item	Symbol	Min.	Typ.	Max.	Unit	Remark
Operating Voltage	Vcc	4.5	5.0	5.5	V	
Storage Temperature	Ts	-40		80	℃	Note[1]
Operating Temperature	To	-40		80	℃	Note[1]
Storage Humidity	Hs	20		95	%RH	Note[1]
Operating Humidity	Ho	20		95	%RH	Note[1]

Note[1] : With no icing or condensation

CHARACTERISTICS

Electrical characteristics

(Unless otherwise specified, Vcc=5V, ambient temperature (Ta) =25℃)

Item	Symbol	Min.	Typ.	Max.	Unit	Remark
Input Low Voltage	VIL	0.0	-	0.2 x Vcc	V	SCL, SDA Terminal
Input High Voltage	VIH	0.8 x Vcc	-	Vcc	V	SCL, SDA Terminal
Output Low Voltage	VOL	0.0	-	0.2 x Vcc	V	SCL, SDA Terminal IOL = 200uA
Current Consumption	-	-	3.5	7.0	mA	

Operating characteristics

Item		Typ.	Unit	Remark
Field of view	X-axis	25	degree	Note[2]
	Y-axis	25	degree	Note[2]
Temperature accuracy	Calibration point	±1.5	℃	Note[3]
	Test point	±3.0	℃	Note[4]
Output of Object temperature range (P0)		-40 to 80	℃	Refer to Figure 4
Output of Ambient temperature range (PTAT)		-40 to 80	℃	Refer to Figure 4

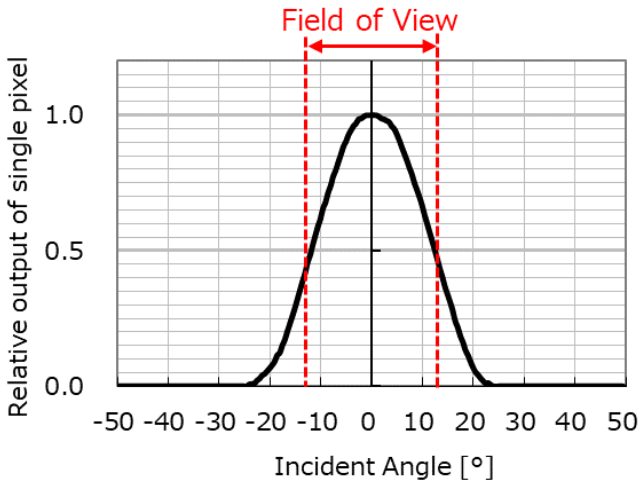


Figure 3 FOV Characteristic

Note[2] : The angular range in which 50% or more of the sensor's maximum output is obtained is defined as field of view (FOV). Please refer to Figure 3.

Note[3] : Accuracy of the object temperature is guaranteed by our equipment at following conditions:
(1)Ta=5℃, Tx=5℃ (2)Ta=5℃, Tx=25℃ (3)Ta=25℃, Tx=25℃
where Ta is the ambient temperature and Tx is the object temperature.

Note[4] : Accuracy of the object temperature is guaranteed by our equipment at following condition:
(4)Ta=25℃, Tx=5℃

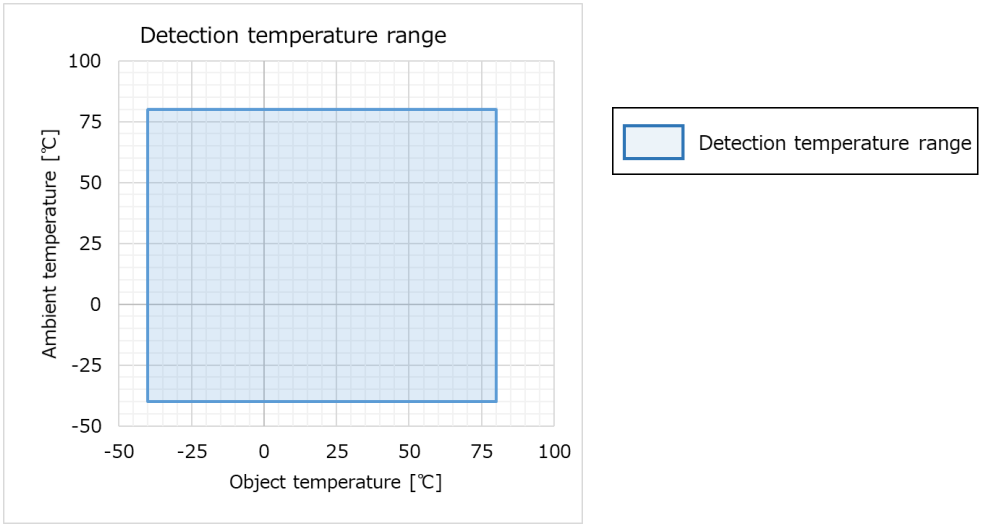


Figure 4 Detectable temperature range (for reference)

SERIAL COMMUNICATION INTERFACE

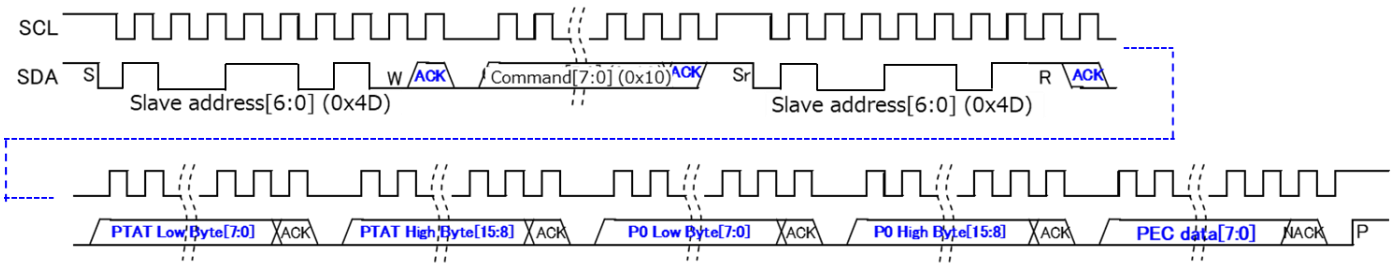
Overview of the communication function

The communication specification of this product is based on I2C protocol (SMBus compatible). This product works as a slave and has a 7-bit slave address according to the I2C specification. SCL is the clock input line and SDA is the serial data input/output line.

Item	Description
Communication method	I2C specification (SMBus compatible)
Communication speed	Max. 100kHz
Data length	8 bits
Packet Error Checking (PEC)	CRC-8 polynomial: X^8 + X^2 + X^1 + 1
Output data	Output data corresponding to the object temperature (P0) and output data corresponding to the ambient temperature (PTAT)
Output format	Binary data with Most Significant Bit (MSB) first
Slave Address	0x4D (0b100_1101)

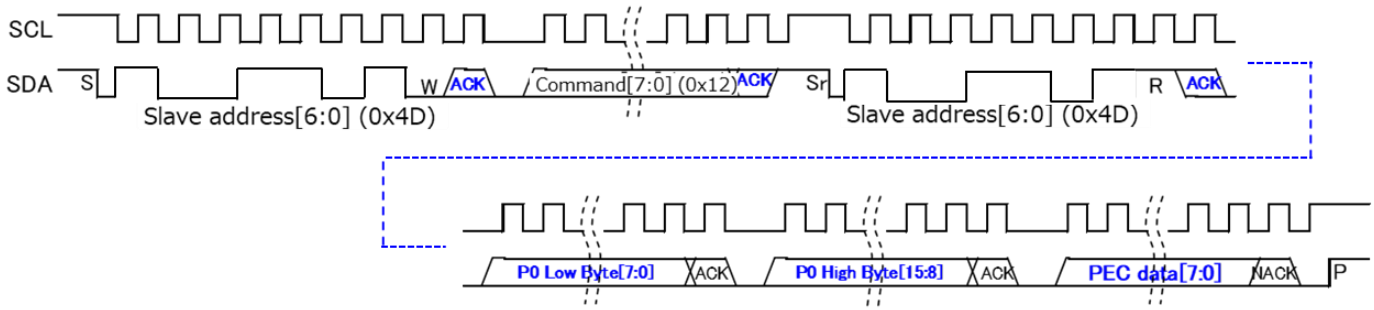
Sending and receiving data timing diagram

Ex.) Continuous sensor output (Command: 0x10)



Black: master to slave, Blue: slave to master

Ex.) Individual sensor output (Command: 0x12)



Black: master to slave, Blue: slave to master

Description of the symbols

"S"	: Start Condition
"Address"	: Slave address of this product
"W"	: Write (0)
"R"	: Read (1)
"ACK"	: Acknowledge (0)
"NACK"	: No acknowledge (1)
"Command"	: Refer to section "Command list"
"Sr"	: Repeat Start Condition
"PEC"	: Packet Error Code
"P"	: Stop Condition

When this product receives Stop Condition, both SCL and SDA terminals become high impedance, and this product waits for commands from the master.

Command list

List of commands for reading output data

Command	Function
0x10	Output the ambient temperature (PTAT) and the object temperature (P0) only once, in that order
0x11	Output the data of the ambient temperature (PTAT) only once
0x12	Output the data of the object temperature (P0) only once
0x00 0x01 0x04 0x06 0x07 0x7F - 0xFF	Do not issue these commands. Note[5]

Note[5] : Only used by the manufacturer. If these commands are issued, the internal state of the product will change, and therefore operation is not guaranteed.

The format of ambient temperature and object temperature

Output of ambient temperature and object temperature are both 10 times the value of the detected temperature [°C] as 16-bit binary data.

Command Sequence Diagram

Low Byte Data D7→D0	ACK	High Byte Data D15→D8	ACK

Data format of ambient temperature and object temperature

High Byte								Low Byte							
D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

Note: Since data is output from the MSB, the High Byte is output in the order D15 to D8, and Low Byte in the order D7 to D0.

Sign
Bit D15 of ambient temperature and object temperature is a sign bit. A negative number is expressed by 2's complement.
Ex.)
In the case where D15 is "0": 250 (High Byte data = 0x00, Low Byte data = 0xFA)
In the case where D15 is "1": -250 (High Byte data = 0xFF, Low Byte data = 0x06)

Example of output data
The detected temperature [°C] is obtained by converting the 16-bit binary output data into decimal and dividing by 10.
Ex.)
If the output data is 0x0131, the detected temperature is 305 / 10 = 30.5[°C].

When NACK is received
When this product receives NACK from a master, it is in the same state as if it had received Stop Condition.

PEC (Packet Error Checking)

This product supports Packet Error Checking (PEC) based on SMBus specification. PEC data is transmitted as the final byte of transmitted data. PEC byte is calculated based on CRC-8 method with $X^8+X^2+X^1+1$ polynomial. An example of the PEC byte calculation is shown below.

Target data
- Slave Address + W (8bits)
- Command (8bits)
- Slave Address + R (8bits)
- Low Byte of PTAT (8bits)
- High Byte of PTAT (8bits)
- Low Byte of P0 (8bits)
- High Byte of P0 (8bits)

Example of calculating PEC value (Continuous sensor output)
(1) Calculate CRC-8 of (Slave Address + W).
(2) Take an exclusive OR (XOR) of (1) and Command.
(3) Calculate CRC-8 of the result of (2).
(4) Take an XOR of (3) and (Slave Address + R).
(5) Calculate CRC-8 of the result of (4).
(6) Take an XOR of (5) and (Low Byte of PTAT).
(7) Calculate CRC-8 of the result of (6).
(8) Take an XOR of (7) and (High Byte of PTAT).
(9) Calculate CRC-8 of the result of (8).
(10) Take an XOR of (9) and (Low Byte of P0).
(11) Calculate CRC-8 of the result of (10).
(12) Take an XOR of (11) and (High Byte of P0).
(13) Calculate the result of (12) by CRC-8. The result is used as the PEC value.

Communication time out

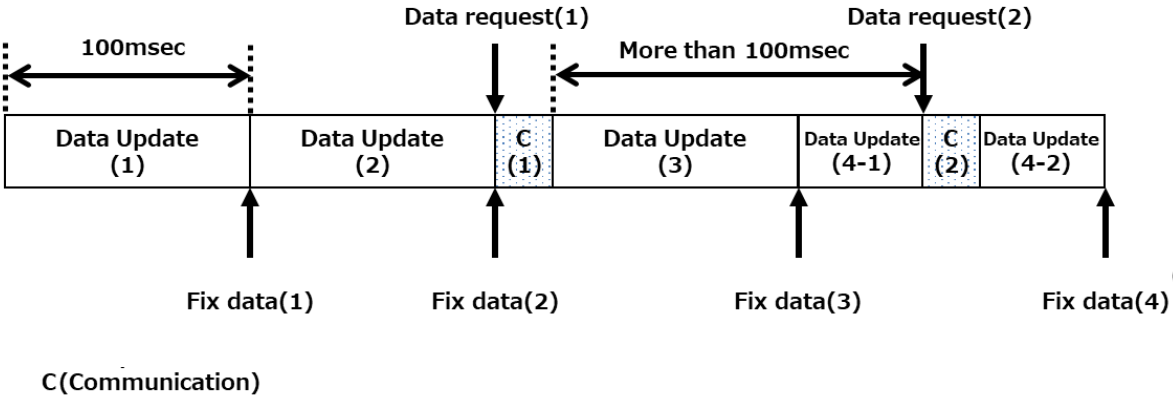
If SCL or SDA Low input continues for min. 22.8 ms and max. 70 ms, a communication timeout occurs. The process is disabled and this product enters a state waiting for a new command to be received.

Data update period

The maximum data processing time of this sensor is 100 ms. Data processing is stopped during communication. For this reason, please take more than 100ms between the end of communication and the start of the next communication.

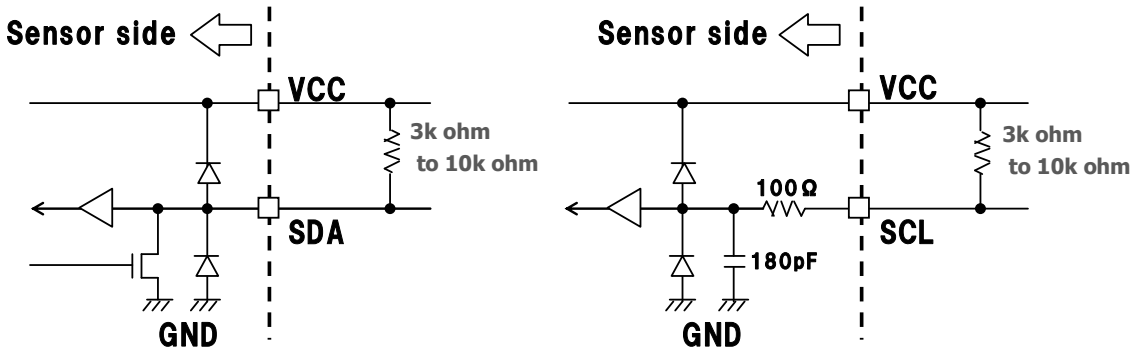
Example of output data (Figure below)

- If a data request (1) is made **after** data update (2), the updated data "Fix data(2)" is output.
- If a data request (2) is made **during** data update (4), the previous data "Fix data(3)" is output.



Communication terminal

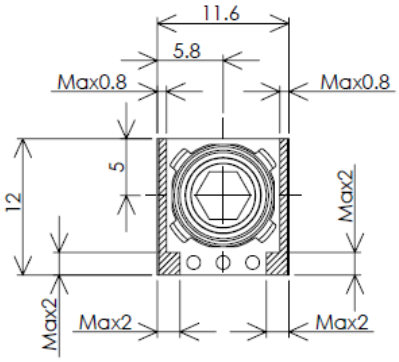
Internal circuits of the I2C terminals (SCL and SDA) are shown below. A pull-up resistor must be connected to the SCL and SDA terminals respectively. Depending on the user's environment, in most cases the pull-up resistor is about 3 kΩ to 10 kΩ. The pull-up voltage should be the same as or lower than VCC. If the pull-up voltage is higher than VCC, the circuit may be damaged.

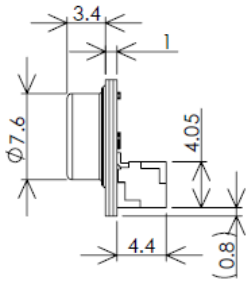


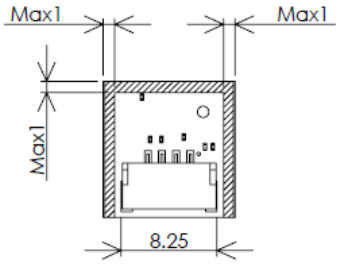
Note : The SCL terminal is connected to GND with a 180 pF capacitor. Please check that there are no problems with data transmission before use.

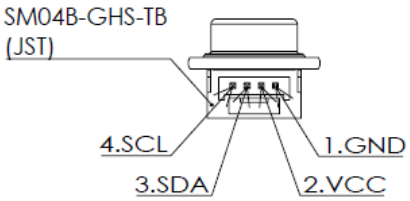
DIMENSIONS

UNIT	mm









Hatched areas are holdable areas. Only insulating materials should be used for holding parts, no metal be used.

NOTES

Safety Precautions

- Though Mitsumi Electric Co., Ltd. (hereinafter referred to as "Mitsumi") works continually to improve our product's quality and reliability, semiconductor products may generally malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of this product could cause loss of human life, bodily injury, or damage to property, including data loss or corruption. Before customers use this product, create designs including this product, or incorporate this product into their own applications, customers must also refer to and comply with (a) the latest versions or all of our relevant information, including without limitation, product specifications, data sheets and application notes for this product and (b) the user's manual, handling instructions or all relevant information for any products which is to be used, or combined with this products. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. Mitsumi assumes no liability for customers' product design or applications.
- This product is intended for applying to computers, OA units, communication units, instrumentation units, machine tools, industrial robots, AV units, household electrical appliances, and other general electronic units.
- If you have any intentions to apply this product to the units related to the control and safety of transportation units (vehicles, trains, etc.), traffic signaling units, disaster-preventive & burglar-proof units, or the like, contact our sales representatives in advance.
- Don't apply this product to any aeronautical & space systems, submarine repeaters, nuclear power controllers, medical units involving the human life, or the like.
- Before using this product, even when it is not used for the usage written above, notify and present us beforehand if special care and attention are needed for its application, intended purpose, environment of usage, risk, and the design or inspection specification corresponding to them.
- If any damage to our customer is objectively identified to be caused by the defect of this product, Mitsumi is responsible for it. In this case, Mitsumi is liable for the cost limited to the delivery price of this product.

Application considerations during actual circuit design

- The outline of parameters described herein has been chosen as an explanation of the standard parameters and performance of the product. When you actually plan to use the product, please ensure that the outside conditions are reflected in the actual circuit and assembling designs.
- Before using this product, please evaluate and confirm the actual application with this product mounted and embedded.
- To investigate the influence by applied transient load or external noise, It is necessary to evaluate and confirm them with mounting this product to the actual application.
- Any usage above the maximum rating may destroy this product or shorten the lifetime. Be sure to use this product under the maximum rating.
- If you continue to use this product highly-loaded (applying high temperature, large current or high voltage; or variation of temperature) even under the absolute maximum rating and even in the operating range, the reliability of this product may decrease significantly. Please design appropriate reliability in consideration of power dissipation and voltage corresponding to the temperature and designed lifetime after confirming our individual reliability documents (such as reliability test report or estimated failure rate). It is recommended that, before using this product, you appropriately derate the maximum power dissipation (typically, 80% or less of the maximum value) considering parameters including ambient temperature, input voltage, and output current.

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- If you export or take products and technologies in this document which are subject to security trade control based on the Foreign Exchange and Foreign Trade Act to overseas from Japan, permission of the Japanese government is required.

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- If a use of this product causes a dispute related to the industrial property rights of a third party, Mitsumi has no liability for any disputes except those which arise directly from the manufacturing and manufacturing method of our products.

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- No responsibility is assumed by us for any consequence resulting from any wrong or improper use or operation, etc. of this product.

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- Any part of the contents contained herein must not be reprinted or reproduced without our prior permission.
- In case of any question arises out of the description in this document, it shall be settled by the consultation between both parties promptly.

ATTENTION

- This product is designed and manufactured with the intention of normal use in general electronics. No special circumstance as described below is considered for the use of it when it is designed. With this reason, any use and storage under the circumstances below may affect the performance of this product. Prior confirmation of performance and reliability is requested to customers.
  - Environment with strong static electricity or electromagnetic wave
  - Environment with high temperature or high humidity where dew condensation may occur
- This product is not designed to withstand radioactivity, and must avoid using in a radioactive environment.

ADDITIONAL NOTES

- Please review in advance in your actual equipment before using sensor. The above-mentioned characteristics may not exhibit, depending on the mounted location and the ambient environment.

- Please do not use the sensor in environments where dust, water, oil, solvents, cleaning solution or other contaminants are likely to adhere to the sensor cover. Otherwise, the temperature may not be measured correctly.

- Do not use, transport or store this product in the following environments:
  - Environments with water or oil
  - Outdoor
  - Locations subject to direct sunlight or ultra-violet rays
  - Environments with corrosive gases (chlorine, sulfide gas, ammonia gas, etc.)
  - Environments with extreme temperature changes
  - Locations where icing or condensation may occur
  - Locations of high impact shock and vibration

- About handling
  - Please do not touch the sensor cover with bare hands.
  - Please do not apply an electrical load exceeding the absolute maximum rating, even momentarily. This may cause damage to the circuit. Please install protection circuits as necessary to ensure that the absolute maximum ratings are not exceeded.
  - This product is a precision instrument. Please do not drop or give excessive force or shock to the product, as the product will malfunction or change its characteristics.
  - Please consider a proper method to remove static electricity.
  - Please install this product with the power supply switched OFF.
  - Please fix this product so that the optical axis does not shift.
  - Please fix this product so that it will not be deformed. Please ensure that the resist on the substrate is not peeled off.
  - Please use the specified connector (GHR-04V). Please avoid soldering directly to the connector pins.

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