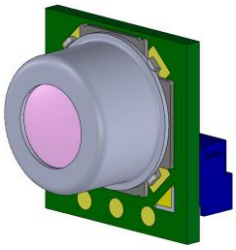
MEMS Infrared Thermal Sensor

MMS702M22A Datasheet

DESCRIPTION



MMS702 is an infrared sensor using MEMS thermopile technology. It is a multi-pixel type with an array of eight elements arranged in a single row, and can acquire temperature in each angular region divided over a wide range of angles. This sensor can measure surface temperature of objects without touching them by capturing infrared radiation from the objects. The product outputs digital values of surface temperature of objects. 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℃

- Eight elements in a single row, so pinpoint temperatures can be acquired over a wide angle.
  - Viewing angle: over 50 degrees (5.5 degrees per element)

- 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.
  - High temperature accuracy using unique calibration technology

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BLOCK DIAGRAM

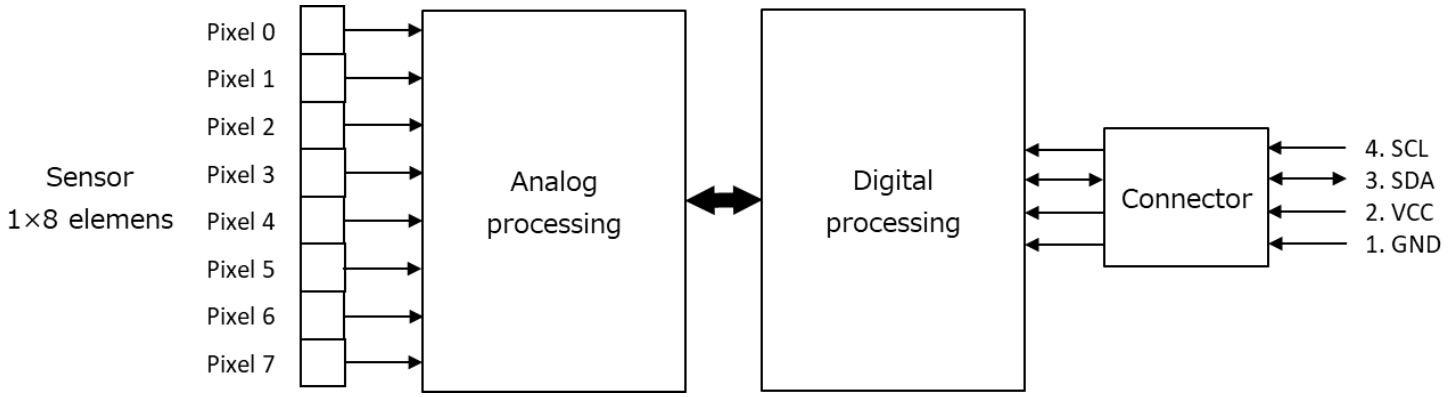


Fig. 1 Block Diagram

PIN CONFIGURATION

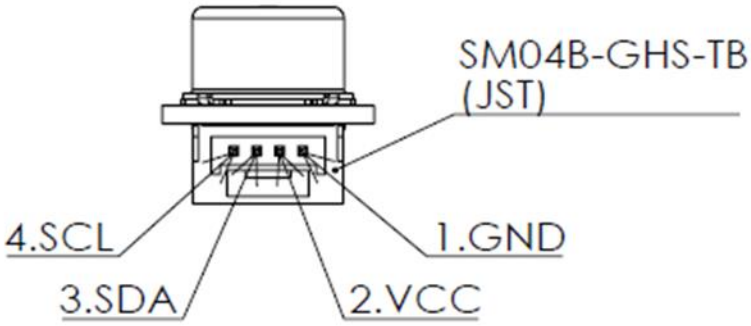


Fig. 2 Pin Configuration（Top View）

Table 1 Pin Table

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

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ABSOLUTE MAXIMUM RATINGS

(Unless otherwise specified, ambient temperature (Ta) =25°C)

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		100	°C	note[1]
Operating Temperature	To	-20		100	°C	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

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CHARACTERISTICS

Electrical characteristics

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

Item	Symbol	Min.	Typ.	Max.	Unit	Remark
Input Voltage	VIL	0.0	-	0.2 x Vcc	V	SCL, SDA Terminal
	VIH	0.8 x Vcc	-	Vcc	V	SCL, SDA Terminal
Output Voltage	VOL	0.0	-	0.2 x Vcc	V	SCL, SDA Terminal IOL = 200uA
Current Consumption	-	-	5.0	10.0	mA	

Operating characteristics

Item		Typ.	Unit	Remark
Temperature accuracy	Calibration point	±1.5	℃	note[2]
	Test point	±3.0	℃	note[3]
Output of Object temperature range		5 to 100	℃	
Output of Ambient temperature range		-20 to 100	℃	

Field of view (FOV) characteristics

Item	Pixel No	Center of FOV note[4]	FOV note[5]	Unit	Remark
Direction X	Pixel 0	24.5	5.5 (each pixel)	degree	
	Pixel 1	17.5			
	Pixel 2	10.5			
	Pixel 3	3.5			
	Pixel 4	-3.5			
	Pixel 5	-10.5			
	Pixel 6	-17.5			
	Pixel 7	-24.5			
Direction Y	Pixel 0	0	5.5	degree	

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note[2]: Accuracy of the object temperature is guaranteed by our equipment at following conditions:
(1)Ta=25℃, Tx=25℃ (2)Ta=25℃, Tx=45℃ (3)Ta=45℃, Tx=45℃
where Ta is the ambient temperature and Tx is the object temperature.

note[3]: Accuracy of the object temperature is guaranteed by our equipment at following condition:
(4)Ta=45℃, Tx=25℃

note[4]: Definition of Center of FOV: Central angle is defined as the difference between the angle of sensor maximum output and the optical axis. (Refer to Fig. 3 Center of FOV)

note[5]: Definition of FOV: The field of view is defined as angle range obtained 50% or more sensor output relative maximum output. (Refer to Fig. 4 FOV characteristics)

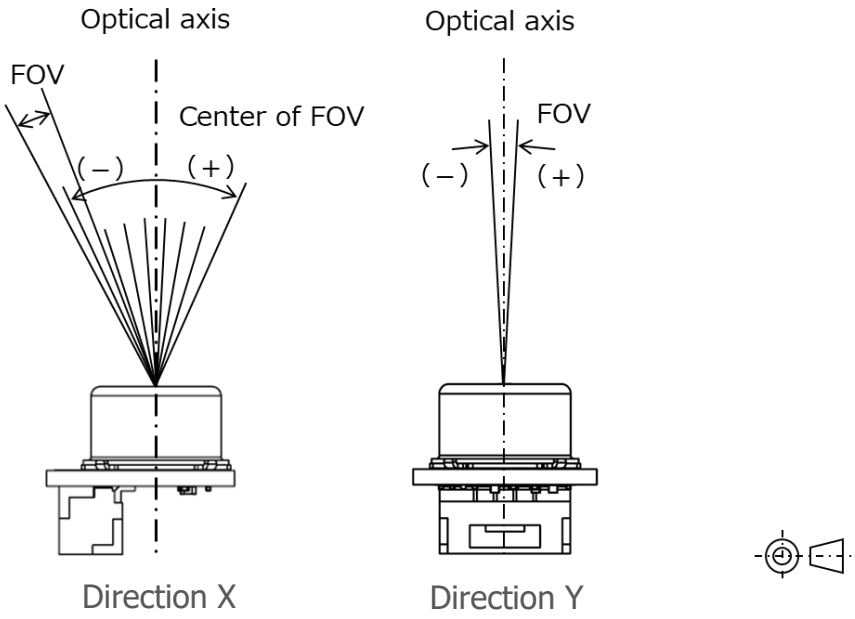


Fig. 3 Center of FOV

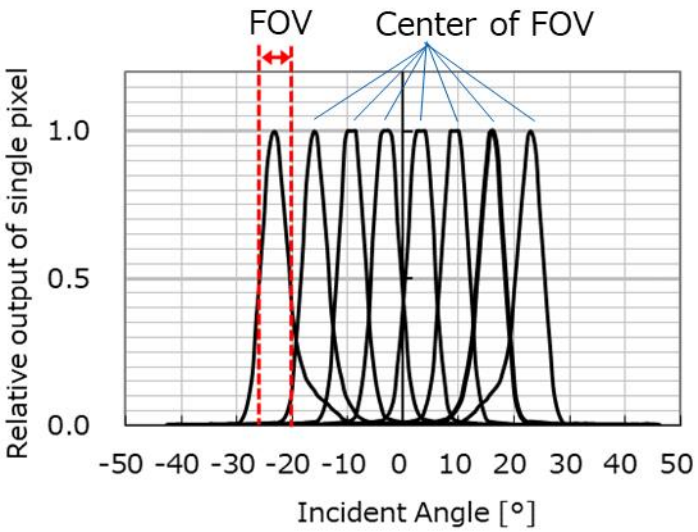


Fig. 4 FOV characteristics

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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 (Pixel 0 to Pixel 7) and output data corresponding to the ambient temperature (PTAT)
Output format	Binary data with Most Significant Bit (MSB) first
Slave Address	0x4D (0b100_1101)

The slave address 0x0A (0b000_1010) is reserved for this product. To avoid communication conflicts, other devices with the slave address 0x0A are prohibited on the same bus.

Initialization

Initialization is required at every time turn on the power.
Send and receive commands as shown below.

Slave Address	Write/ Read	Command Address	Data [High]	Data [Low]	PEC
0x4D	W	0x02	0x00	0x01	0x1B
0x4D	W	0x05	0x90	0x3A	0x4D
0x4D	W	0x03	0x00	0x03	0x7E
0x4D	W	0x03	0x00	0x07	0x62
0x4D	W	0x02	0x00	0x00	0x1C
0x4D	R	0x02	0x00*	0x00*	0x45
0x4D	R	0x05	0x90*	0x3A*	0x02
0x4D	R	0x03	0x00*	0x07*	0x50

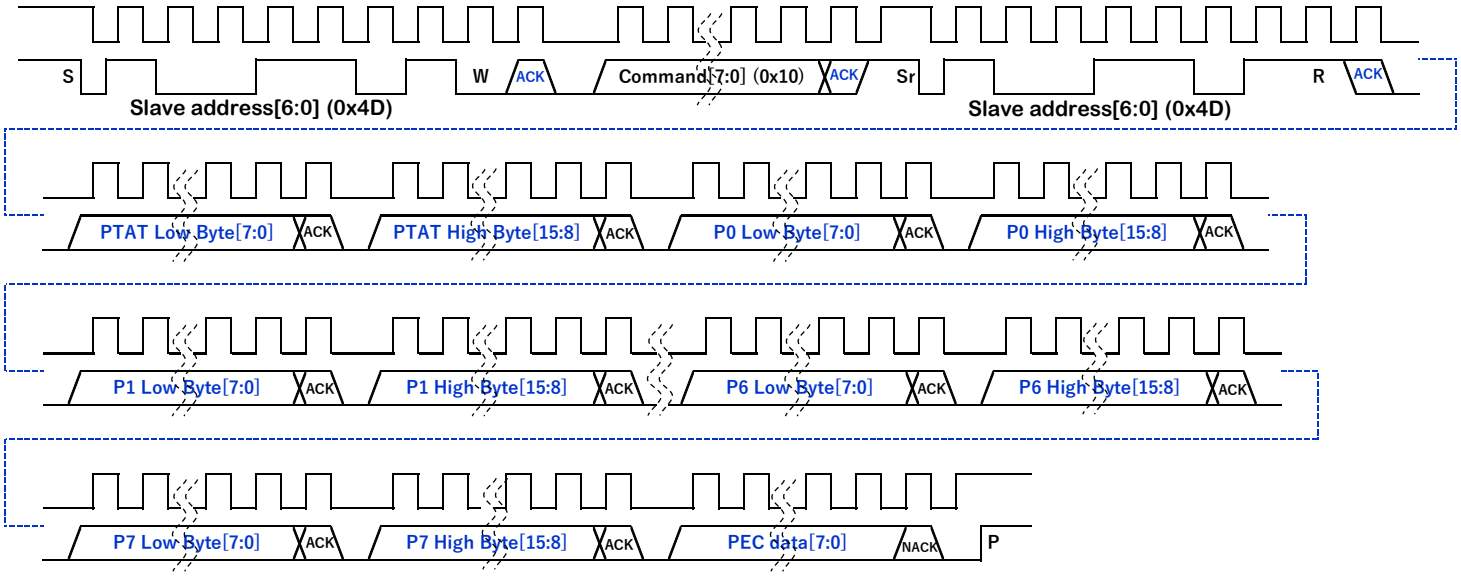
* Check if written correctly（optional）

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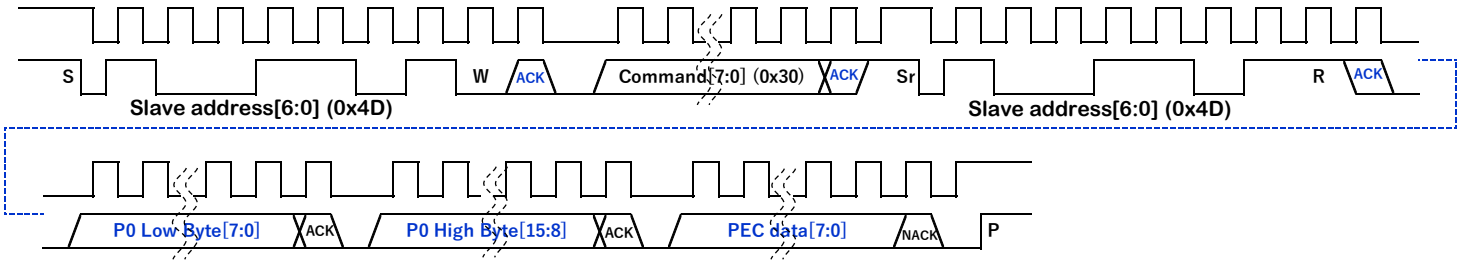
Sending and receiving data timing diagram

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



Black: master to slave, Blue: slave to master

Ex.) Individual sensor output (Command: 0x30)



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.

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Command list

List of commands for reading output data

Command	Function
0x10	Output the ambient temperature (PTAT) and the object temperature (from Pixel 0 to Pixel 7) only once, in that order
0x11	Output the data of the ambient temperature (PTAT) only once
0x30	Output the data of the object temperature (Pixel 0) only once
0x31	Output the data of the object temperature (Pixel 1) only once
0x32	Output the data of the object temperature (Pixel 2) only once
0x33	Output the data of the object temperature (Pixel 3) only once
0x34	Output the data of the object temperature (Pixel 4) only once
0x35	Output the data of the object temperature (Pixel 5) only once
0x36	Output the data of the object temperature (Pixel 6) only once
0x37	Output the data of the object temperature (Pixel 7) only once
0x00 – 0x0F 0x80 - 0xFF	Do not issue these commands. note[6]

note[6]: These commands are reserved word, so please do not send them.

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.

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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 Pixel 0 (8bits)
- High Byte of Pixel 0 (8bits)
- Low Byte of Pixel 1 (8bits)
- High Byte of Pixel 1 (8bits)
- Low Byte of Pixel 2 (8bits)
- High Byte of Pixel 2 (8bits)
- Low Byte of Pixel 3 (8bits)
- High Byte of Pixel 3 (8bits)
- Low Byte of Pixel 4 (8bits)
- High Byte of Pixel 4 (8bits)
- Low Byte of Pixel 5 (8bits)
- High Byte of Pixel 5 (8bits)
- Low Byte of Pixel 6 (8bits)
- High Byte of Pixel 6 (8bits)
- Low Byte of Pixel 7 (8bits)
- High Byte of Pixel 7 (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 Pixel 0).

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(11) Calculate CRC-8 of the result of (10).
(12) Take an XOR of (11) and (High Byte of Pixel 0).
(13) Calculate the result of (12) by CRC-8.
(14) Take an XOR of (13) and (Low Byte of Pixel 1).
(15) Calculate CRC-8 of the result of (14).
(16) Take an XOR of (15) and (High Byte of Pixel 1).
(17) Calculate the result of (16) by CRC-8.
(18) Take an XOR of (17) and (Low Byte of Pixel 2).
(19) Calculate CRC-8 of the result of (18).
(20) Take an XOR of (19) and (High Byte of Pixel 2).
(21) Calculate the result of (20) by CRC-8.
(22) Take an XOR of (21) and (Low Byte of Pixel 3).
(23) Calculate CRC-8 of the result of (22).
(24) Take an XOR of (23) and (High Byte of Pixel 3).
(25) Calculate the result of (24) by CRC-8.
(26) Take an XOR of (25) and (Low Byte of Pixel 4).
(27) Calculate CRC-8 of the result of (26).
(28) Take an XOR of (27) and (High Byte of Pixel 4).
(29) Calculate the result of (28) by CRC-8.
(30) Take an XOR of (29) and (Low Byte of Pixel 5).
(31) Calculate CRC-8 of the result of (30).
(32) Take an XOR of (31) and (High Byte of Pixel 5).
(33) Calculate the result of (32) by CRC-8.
(34) Take an XOR of (33) and (Low Byte of Pixel 6).
(35) Calculate CRC-8 of the result of (34).
(36) Take an XOR of (35) and (High Byte of Pixel 6).
(37) Calculate the result of (36) by CRC-8.
(38) Take an XOR of (37) and (Low Byte of Pixel 7).
(39) Calculate CRC-8 of the result of (38).
(40) Take an XOR of (39) and (High Byte of Pixel 7).
(41) Calculate the result of (40) by CRC-8. The result is used as the PEC value.

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Communication time out

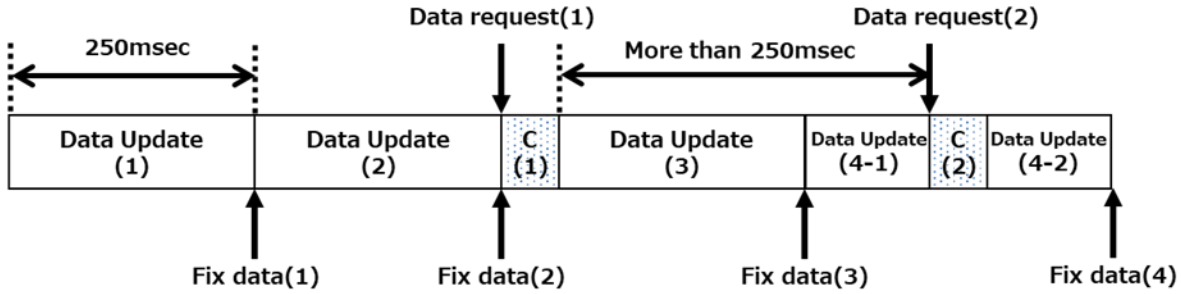
If SCL or SDA Low input continues for min. 22.8 ms and max. 70 ms, a communication timeout occurs. The process is disabled and this product enters a state waiting for a new command to be received.

Data update period

The period of computation process (data update) is Max.250ms.
The computation process stops in the communication time.
Please wait at least 500ms after completing the initial settings before acquiring data. Also, take more than 250ms period from end of communication to start of 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.



C : Communication

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TYPICAL APPLICATION CIRCUIT

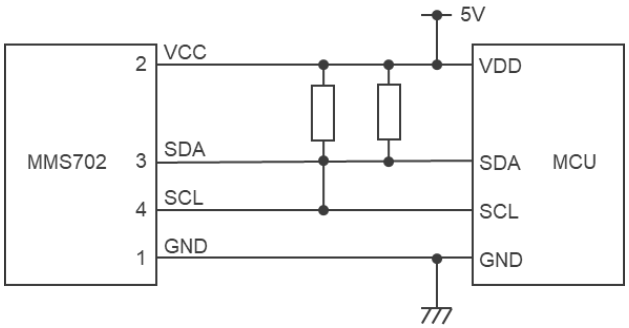


Fig. 5 Case of connecting to MCU operating at 5V

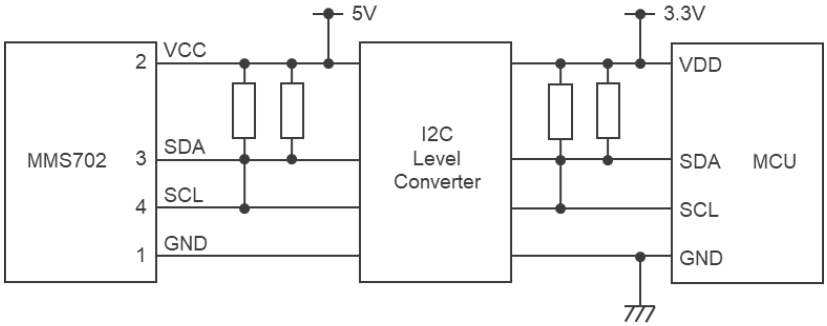
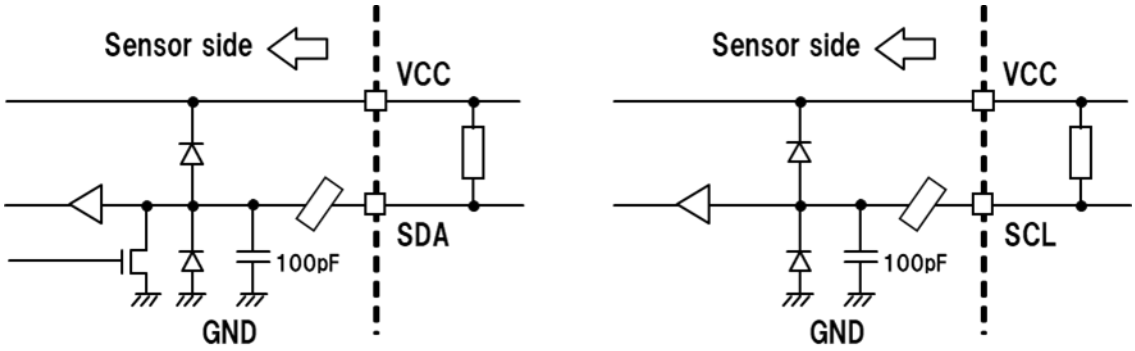


Fig. 6 Case of connecting to MCU operating at 3.3V via I2C level converter

Internal circuits of the I2C terminals (SCL and SDA) are shown below. A pull-up resistor must be connected to each of the SCL and SDA pins, and a resistance of about 3kΩ to 7kΩ is recommended. 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.



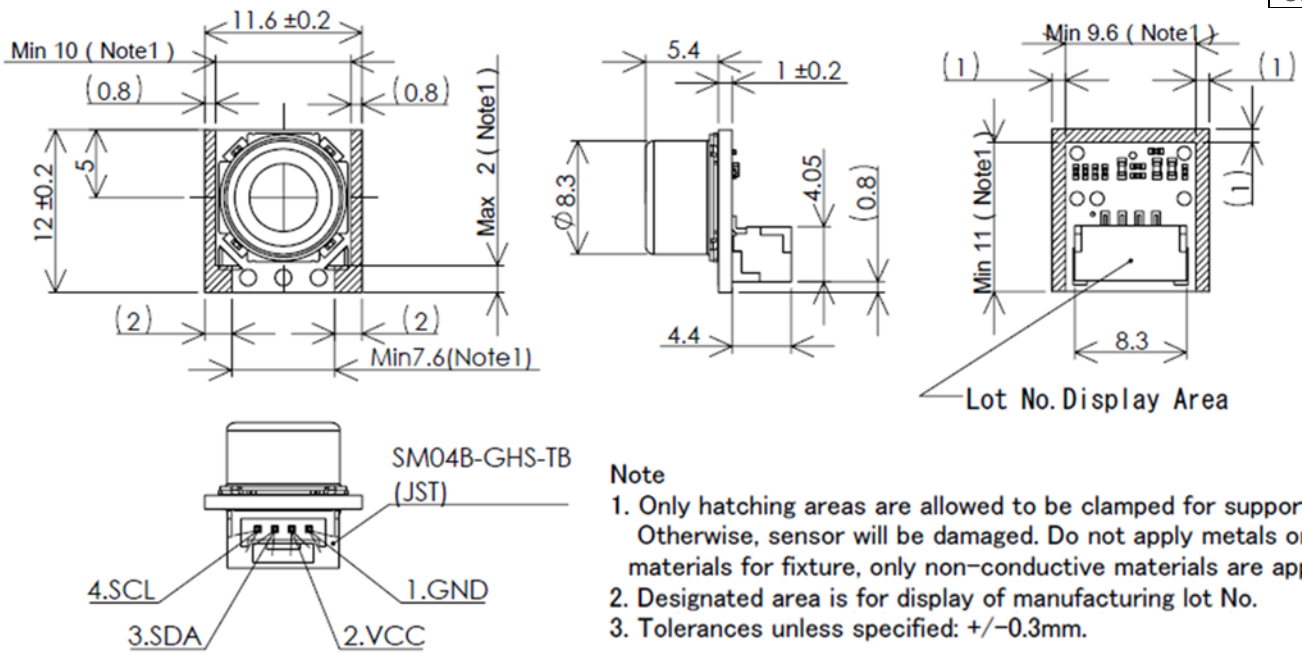
note[7]: The SDA terminal and the SCL terminal are connected to GND with a 100pF capacitor respectively. Please check that there are no problems with data transmission before use.

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DIMENSIONS

UNIT	mm



Note

1. Only hatching areas are allowed to be clamped for supporting or fixing. Otherwise, sensor will be damaged. Do not apply metals or conductive materials for fixture, only non-conductive materials are applicable.
2. Designated area is for display of manufacturing lot No.
3. Tolerances unless specified: +/−0.3mm.

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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.
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- This product is not designed as a component of equipment or devices that require a high degree of reliability, may affect the life or body, or could damage the property (space systems, submarine repeaters, nuclear power controllers, infrastructure controllers, medical equipment, military devices, units related to the control and safety of transport equipment (automobiles, trains, aircraft, etc.), traffic signaling equipment, disaster / crime prevention units, or the like). In the case where this product is used in these applications, Mitsumi does not bear any responsibility. If the product is used as a component of the above equipment or devices, Mitsumi shall not be liable for any damage caused thereby. It is the customer's responsibility to carry out the necessary safety design for the customer's hardware, software and systems.
- Before using this product, even when it is not used for the applications written previous paragraph, 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.

Precautions for Foreign Exchange and Foreign Trade Control Act

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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 specification, it shall be settled by the consultation between both parties promptly.
- Mitsumi assures only the products in wafer if they are delivered in wafer state. Mitsumi does not bear any responsibility for the defect which occurs during or after assembly process.

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.
- This specification is written in Japanese and English. The Japanese text is the original and the English text is for reference purposes. If any question arises, Japanese text shall prevail.

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ADDITIONAL NOTES

- Do not use, transport or store this product in the following environments:
  - Environments with water, oil, chemicals or solvents
  - Outdoor
  - Locations subject to direct sunlight or ultra-violet rays
  - Environments with corrosive gases (chlorine, sulfide gas, ammonia gas, etc.)
  - Locations where icing or condensation may occur
  - Environments with extreme temperature changes
  - Locations of high impact shock and vibration (Including dropping or throwing down during transportation, using products that have been dropped, ultrasonic cleaning, pushing or prodding with hard objects, etc.)
  - Dusty environments

- 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.
- 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 connect this product with the power supply switched OFF.
- Please make sure correct wiring connection when attaching this product.
- 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.
- If the parts of this product are damaged, they may fall. Please take measures to prevent falling off.
- Please do not reuse this product from discarded mounted applications.

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Strategy Engineering Department Semiconductor Business Division
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