# 8x8 Thermopile Array Module

## OTPA-8-CI25

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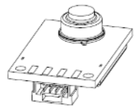


The OTPA-8 series is an 8x8 thermopile array module having a digital output through I2C interface for ease of infrared image processing. The application of OTPA-8 series includes occupancy sensing, gesture control, home security and smart appliance.

The OTPA-8 series is ideal for customers who require their products that can meet time to market with a moderate startup cost.

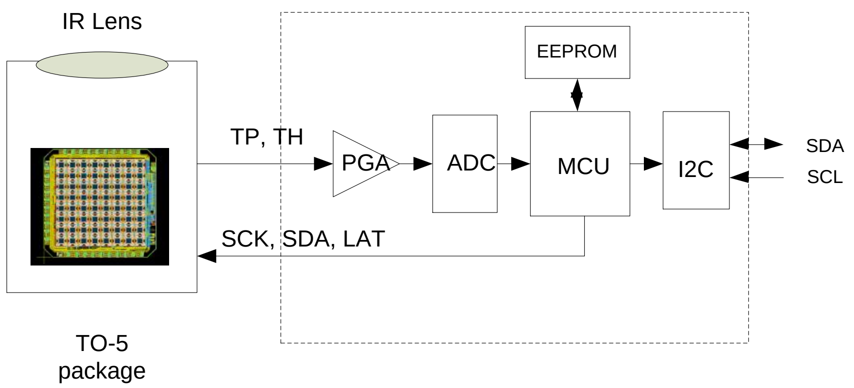
### Features and Benefit

- Factory pre-calibrated
- Low cost and small footprint
- Integrated with infrared optics
- Output reading in ℃ unit directly

### Application Examples

- White goods
- Energy management
- Building automation
- Intrusion detection

### Functional Block Diagram

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## Absolute Maximum Ratings

| Parameter | Symbol | Min | Typ | Max | Unit | Remarks / Conditions |
|---|---|---|---|---|---|---|
| Storage temperature | $T_{Storage}$ | -40 | | 100 | ℃ | |
| Power supply | $V_{Max}$ | | | 6.5 | V | |
| I/O pin | $V_{SCL}$ $V_{SDA}$ | -0.3 | | 6.5 | V | |
| ESD (Human Body Mode) | $ESD_H$ | | | 2 | kV | |
| ESD (Machine Mode) | $ESD_M$ | | | 200 | V | |

## Electrical and Mechanical Characteristic

| Parameter | Symbol | Min | Typ | Max | Unit | Remarks / Conditions |
|---|---|---|---|---|---|---|
| **Operating Conditions** | | | | | | |
| Operating voltage | $V_D$ | 4.5 | 5 | 5.5 | V | |
| Operating current | $I_D$ | - | 8.0 | - | mA | $V_{DD}$ = 5.0 V, with I2C communication. |
| **Data Communication** | | | | | | |
| Electrical interface | | | I2C | | | |
| Interface speed | | | 100 | | KHz | |
| Slave address | | | 68 | | hex | 7 bits addressing |
| **Physical Interface** | | | | | | |
| Physical connection interface | | SM04B-GHS-TB equivalent | | | | |

## Thermopile Array Characteristic (CI25 model)

| Parameter | Symbol | Min | Typ | Max | Unit | Remarks / Conditions |
|---|---|---|---|---|---|---|
| Effective number of pixels | | | 64 | | pixels | 8 x 8 = 64 pixels |
| NETD | | | 0.2 | | ℃ | @2fps |
| Frame rate | | | 2 | | fps | |
| Field of view | $FOV_X$ $FOV_Y$ | | 48 48 | | degrees | |

## Thermometer Sensing Characteristics (CI25 model)

| Parameter | Symbol | Min | Typ | Max | Unit | Remarks / Conditions |
|---|---|---|---|---|---|---|
| **Ambient Temperature Reading Characteristics** | | | | | | |
| Temperature range | $T_{Amb\_rge}$ | -20 | | 85 | ℃ | |
| Resolution of reading | $T_{Amb\_res}$ | | 0.05 | | ℃ | $T_{amb}$=25℃ |
| **Object Temperature Reading Characteristics** | | | | | | |
| Temperature range | $T_{Obj\_rge}$ | -20 | | 120 | ℃ | |
| Resolution of reading | $T_{Obj\_res}$ | | 0.05 | | ℃ | $T_{obj}$=25℃ |
| **Temperature Calibrated Range** | | | | | | |
| Object temperature accuracy[*1] | $T_{Acc}$ | -- | ±2 | | ℃ | $T_{amb}$=25℃, $T_{obj}$=50℃<br>Distance to blackbody: 22cm<br>Emissivity: 95% |

Note

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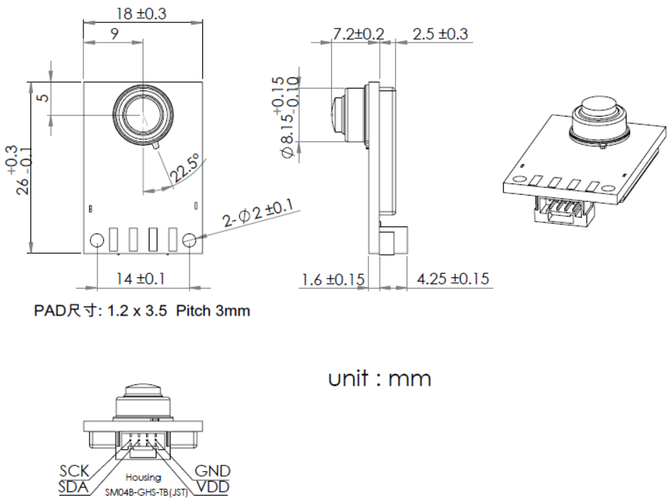
* 1: It is applicable to the sensor area of the center four pixels.

* 2: The calibration distance can be customized to meet specific application.

## Mechanic Drawing and Pin Assignment

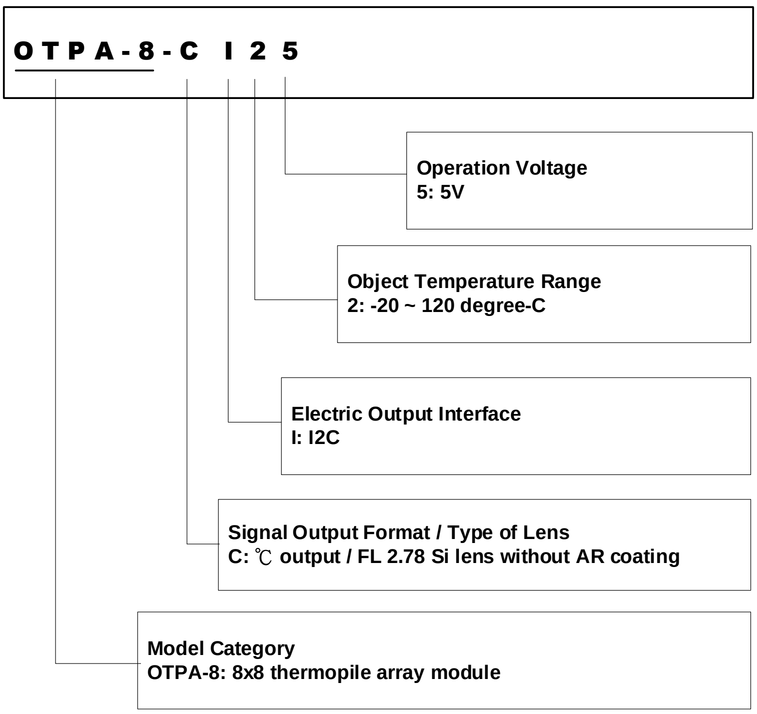
**- CI25**




## Ordering Information

OTPA-8-CI25 8x8 Thermopile Array Model

**OTPA model number example**



## Data communication protocol for OTPA-8 series

This application note is applicable to OTPA-8 series thermopile array module. The OTPA-8 series is an 8x8 thermal image sensor, which has 64 pixels of sensing elements.

OTPA-8 series provides I2C data communication interface and plays a slave role on communicating to outside controller. The Figure 1 shows an example of typical hardware connection to outside controller.

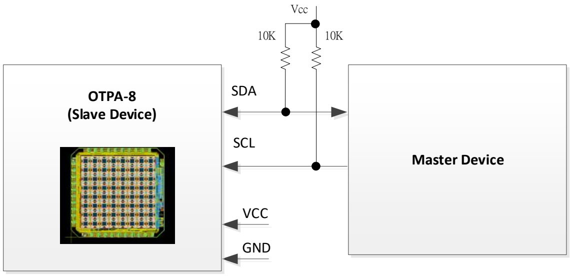



Figure 1. Data communication with I2C interface

1. I2C interface parameters
   - I2C address: 68H (slave, 7-bits addressing)
   - Data rate: 100 KHz (max.)

2. Readout command format (master to slave)
   The readout command consists of three data bytes, which are denoted as "ADR", "CMD", and "NUL" in sequence. Please see table below.

   Table 2. Dtat format of readout command

| Byte sequence | Syntax |
|---|---|
| Byte 1 | ADR |
| Byte 2 | CMD |
| Byte 3 | NUL |

   There are two types of readout commands, one is a command for readout data without HDPE compensation and the other is with HDPE compensation. Please see Table 3 and Table 4 respectively.

Table 3. Readout command for without HDPE compensation **(typical application)**

| Byte sequence | Syntax | Value | Description |
|---|---|---|---|
| Byte 1 | ADR | D0H | Write data to I2C address 68H |
| Byte 2 | CMD | **4CH** | Data readout request command |
| Byte 3 | NUL | 00H | Null byte |

Table 4. Readout command for with HDPE compensation

| Byte sequence | Syntax | Value | Description |
|---|---|---|---|
| Byte 1 | ADR | D0H | Write data to I2C address 68H |
| Byte 2 | CMD | **4AH** | Data readout request command |
| Byte 3 | NUL | 00H | Null byte |

3. Response format (slave to master)
   After receiving a readout command from the master device, the slave device wills response it a data packet consisting of 141 bytes. The responding data packet includes 9

bytes of header, 4 bytes of ambient temperature reading, and 128 bytes of object temperature reading.

Table 5. Contents of response data packet

| Byte sequence | Description |
|---|---|
| Byte 1~9 | header |
| Byte 10~13 | ambient temperature |
| Byte14~141 | object temperature |

3.1 Contents of packet header **(Byte 1~9)**

The packet header contains background information of the data packet, such as array size and packet sequence number. See Table 6 for details.

Table 6. Details of header bytes

| Byte sequence | Syntax | Value | Description |
|---|---|---|---|
| Byte 1 | STX | 02H | Delimiter: start of header |
| Byte 2 | RESP | 4CH<br><br><br>4AH | Indicates this data packet is a response to a readout command for **without** HDPE compensation.<br>Indicates this data packet is a response to a readout command for **with** HDPE compensation. |
| Byte 3 | n/a | n/a | (Reserved) |
| Byte 4 | ASDS | xxH | Bit[7:4] TP array size<br>- 0001: 8x8<br>- 0010: 16x16 (reserved)<br>- Others: (reserved)<br>Bit[3:0] Sequence of data packet<br>- 0000: the 1st data packet<br>- 0001: the 2nd data packet<br>- …<br>- 1111: the 16th data packet<br>(note: this sequence is used to identify whether the reading data packet is an updated one.) |
| Byte 5 | XOR_H | xxH | XOR error detection code, high byte<br>(Please see Section 5 for more details) |
| Byte 6 | XOR_L | xxH | XOR error detection code, low byte<br>(Please see Section 5 for more details) |
| Byte 7~8 | n/a | n/a | (Reserved) |
| Byte 9 | EXT | 03H | Delimiter: stop of header |

3.2 Ambient temperature reading **(Byte 10~13)**

The ambient temperature reading is embedded in in Byte 12 and Byte 13 in the data packet.

Table 7. Details of ambient temperature bytes

| Byte sequence | Syntax | Value | Description |
|---|---|---|---|
| Byte 10 | AMB_H | xxH | High byte of ambient temperature reading |
| Byte 11 | AMB_L | xxH | Low byte of ambient temperature reading |
| Byte 12 | n/a | n/a | (Reserved) |
| Byte 13 | n/a | n/a | (Reserved) |

According to the contents of Byte 10 (AMB_H) and Byte 11 (AMB_L), we can calculate the exact ambient temperature reading by the follow equation:

$T_{AMB}$ = ***[(AMB_H*256 + AMB_L) – 27315]/100***

where

(1) The $T_{AMB}$ represents sensor's ambient temperature reading, which unit is degree-C;

(2) The valid decimal digits are at the second decimal place.

***$T_{AMB}$ calculation example:***

AMB_H (Byte 10) = 0x74

AMB_L (Byte 11) = 0x89

$T_{AMB}$ = (0x74 * 256 + 0x89 - 27315) / 100 = 25.18℃

3.3 Object temperature reading **(Byte 14~141)**

The object temperature readings can be read from 64 sensing elements. The pixel coordinate of each sensing elements is defined as Figure 3.

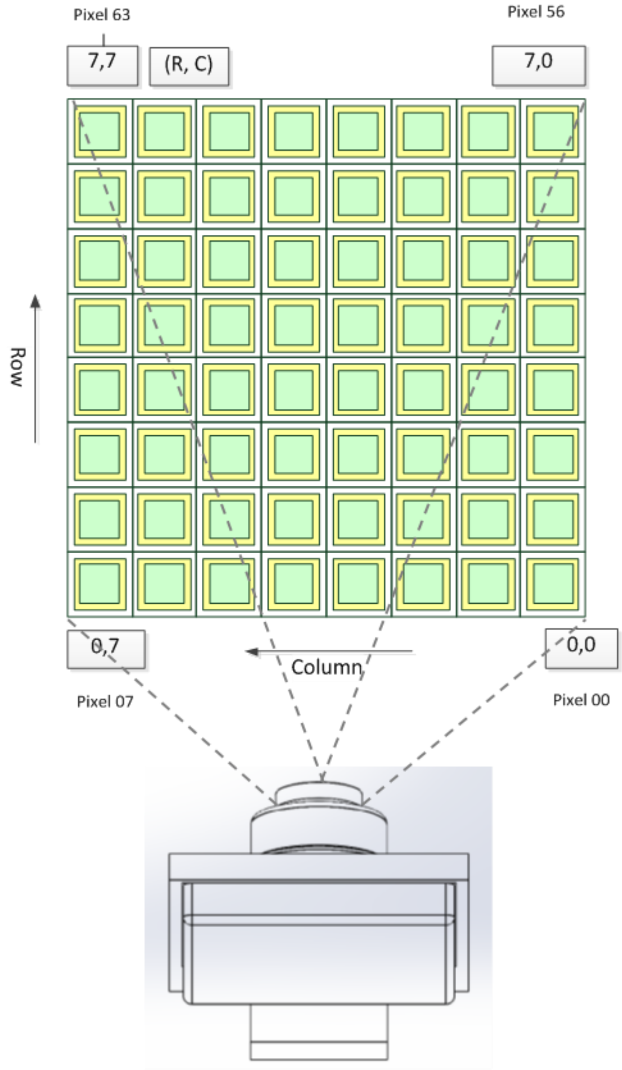



Figure 3. The coordinate of sensing elements

Each pixel's temperature reading is embedded in two data bytes in data packet. The relationship between reading byte sequence and pixel's coordinate is shown as Table 8 and Table 9.

Table 8. Relationship between reading bytes and object pixels

| **Byte 14** | **Byte 15** |
|---|---|
| Pixel 1 (Hi-byte) | Pixel 1 (Low-byte) |

………………….

| **Byte 140** | **Byte 141** |
|---|---|
| Pixel 64 (Hi-byte) | Pixel 64 (Low-byte) |

Table 9. Details of object temperature bytes

| **Byte sequence** | **Syntax** | **Value** | **Description** |
|---|---|---|---|
| Byte 14 | OBJ1_H | xxH | High byte of object temperature of pixel 1 |
| Byte 15 | OBJ1_L | xxH | Low byte of object temperature of pixel 1 |
| Byte 16 | OBJ2_H | xxH | High byte of object temperature of pixel 2 |
| Byte 17 | OBJ2_L | xxH | Low byte of object temperature of pixel 2 |
| … | OBJn_H | xxH | High byte of object temperature of pixel n |
| … | OBJn_L | xxH | Low byte of object temperature of pixel n |
| Byte 140 | OBJ64_H | xxH | High byte of object temperature of pixel 64 |
| Byte 141 | OBJ64_L | xxH | Low byte of object temperature of pixel 64 |

The exact object temperature reading for each pixel can be calculated by the following equation:

***$T_{OBJn}$ = [(OBJn_H*256 + OBJn_L)-27315]/100  (The 'n' is varied from 1 to 64),***

where

(1) The $T_{OBJn}$ represents the n's pixel temperature reading, which unit is degree-C;
(2) The valid decimal digits are at the second decimal place.

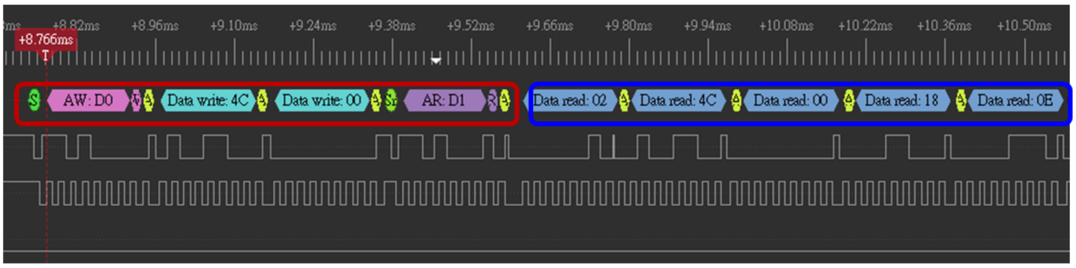
***$T_{OBJ1}$ (pixel 1) calculation example:***

OBJ1_H (Byte 14) = 0x76
OBJ1_L (Byte 15) = 0x73
$T_{OBJ1}$ = (0x76 * 256 + 0x73 -27315) / 100 = 30.08℃

4. Guide to software programming

4.1 Example of data readout

Send 'D0' '4C' '00'  'D1' '(141 bytes of clock)'
; readout command
; 'D0': write data to I2C address 68H
; '4C': data readout command
; '00': null byte
; 'D1': read data from I2C address 68H
; (141 bytes of clock): to get 141 bytes of data




Send ‘D0’ ‘4C’ ‘D1’ command

Send “141 bytes of clock” and get “141 bytes of data”

5. Error detection for data communication

In order to ensure the master side receive a correct dataset, a XOR error detection mechanism is built in OTPA-8PM4-CIA5. The XOR calculation covers Byte 14 to Byte 141.

Pixel reading data is a word length (16 bits) data, which consists of two bytes data in the data communication process. Please see Table 10.

Table 10. Relationship between pixel word and pixel byte

| Pixel word | Pixel Hi Byte | Pixel Low Byte |
|---|---|---|
| Pixel_1 | Byte 14 | Byte 15 |
| Pixel_2 | Byte 16 | Byte 117 |
| | … | |
| Pixel_63 | Byte 138 | Byte 139 |
| Pixel_64 | Byte 140 | Byte 141 |

Before sending pixel data to master side, the slave side will calculate a 16 bits XOR error detection code. The XOR code will be divided into XOR_H byte and XOR_L byte, and then to be stored in the Byte_5 and the Byte_6 which locate on the header of response packet that was described on Section 3.

The XOR calculation process looks like as follows.

```
int xor16pc=0;
for (int j=0;j<64;j++){//handling 64 pixel data
  int Pixel_x = (buffer[13+j*2]*256+buffer[13+j*2+1]);
  xor16pc=xor16pc^Pixel_x;   //16 bits XOR calculation
}
XOR_H = xor16pc/256;
XOR_L = xor16pc%256;
```

On the master side, it can do the similar calculation process and compare the calculation result with the Byte_5 and Byte_6 on the data packet header.

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