

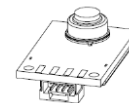
## THERMOPILE ARRAY

## OTPA-16 series

### 16x16 Thermopile Array Module

#### OTPA-16 series

Revision Date: 2021/08/06 (Rev.07)



The OTPA-16 series is a 16x16 thermopile array module having a digital output through I2C interface for ease of infrared image processing. The application of OTPA-16 series includes occupancy sensing, gesture control, home security and smart appliance.

The OTPA-16 series is ideal for customers who require their products that can meet time to market with a moderate startup cost.

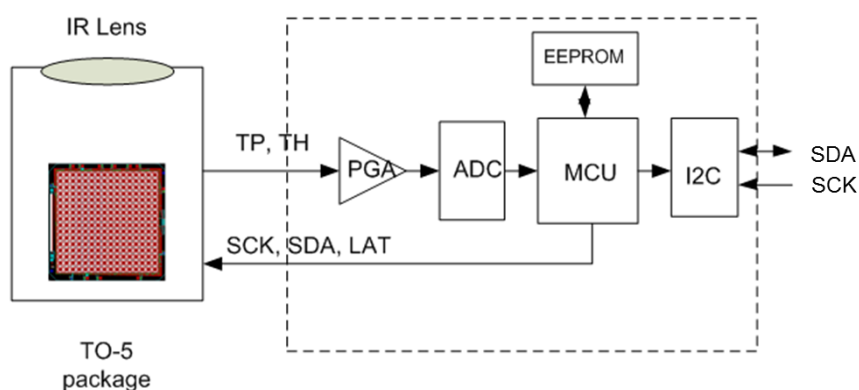
#### Features and Benefit

- Factory pre-calibrated
- Low cost and small footprint
- Integrated with infrared optics
- Output reading in  $^{\circ}\text{C}$  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 <sub>Storage</sub>	-40		100	°C	
Power supply	V <sub>Max</sub>			6.5	V	
I/O pin	V <sub>SCL</sub> V <sub>SDA</sub>	-0.3		6.5	V	
ESD (Human Body Mode)	ESD <sub>H</sub>			2	kV	
ESD (Machine Mode)	ESD <sub>M</sub>			200	V	

### Electrical and Mechanical Characteristic

Parameter	Symbol	Min	Typ	Max	Unit	Remarks / Conditions
<b>Operating Conditions</b>						
Operating voltage	V <sub>D</sub>	4.5	5	5.5	V	
Operating current	I <sub>D</sub>	-	8.0	-	mA	V <sub>DD</sub> = 5.0 V, with I2C communication.
<b>Data Communication</b>						
Electrical interface			I2C			
Interface speed			100		KHz	
Slave address			68		hex	7 bits addressing
<b>Physical Interface</b>						
Physical connection interface			SM04B-GHS-TB equivalent			

### Thermopile Array Characteristic (AI25 or CI25 model)

Parameter	Symbol	Min	Typ	Max	Unit	Remarks / Conditions
Effective number of pixels			256		pixels	16 x 16 = 256 pixels
NETD			0.4		°C	@0.5fps (-AI25 model)
Frame rate			0.5	2	fps	
Field of view	FOV <sub>X&amp;Y</sub>		72		degrees	

### Thermopile Array Characteristic (HI35 model)

Parameter	Symbol	Min	Typ	Max	Unit	Remarks / Conditions
Effective number of pixels			256		pixels	16 x 16 = 256 pixels
NETD			0.5		°C	@1fps
Frame rate			0.5	2	fps	
Field of view	FOV <sub>X&amp;Y</sub>		38		degrees	

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### Thermometer Sensing Characteristics (AI25 or CI25 model)

Parameter	Symbol	Min	Typ	Max	Unit	Remarks / Conditions
<b>Ambient Temperature Reading Characteristics</b>						
Temperature range	$T_{Amb\_rge}$	-20		60	°C	
Resolution of reading	$T_{Amb\_res}$		0.05		°C	$T_{amb}=25^{\circ}C$
<b>Object Temperature Reading Characteristics</b>						
Temperature range	$T_{Obj\_rge}$	-15		110	°C	
Resolution of reading	$T_{Obj\_res}$		0.05		°C	$T_{obj}=25^{\circ}C$
<b>Temperature Calibrated Range</b>						
Object temperature accuracy <sup>*1</sup>	$T_{Acc}$	--	$\pm 2$		°C	$T_{amb}=25^{\circ}C$ , $T_{obj}=50^{\circ}C$ Distance to blackbody: 22cm Emissivity: 95%

### Thermometer Sensing Characteristics (HI35 model)

Parameter	Symbol	Min	Typ	Max	Unit	Remarks / Conditions
<b>Ambient Temperature Reading Characteristics</b>						
Temperature range	$T_{Amb\_rge}$	0		50	°C	
Resolution of reading	$T_{Amb\_res}$		0.05		°C	$T_{amb}=25^{\circ}C$
<b>Object Temperature Reading Characteristics</b>						
Temperature range	$T_{Obj\_rge}$	0		50	°C	
Resolution of reading	$T_{Obj\_res}$		0.05		°C	$T_{obj}=25^{\circ}C$
<b>Temperature Calibrated Range</b>						
Object temperature accuracy <sup>*1</sup>	$T_{Acc}$	--	$\pm 2$		°C	$T_{amb}=25^{\circ}C$ , $T_{obj}=50^{\circ}C$ Distance to blackbody: 50cm Emissivity: 95%

#### Note

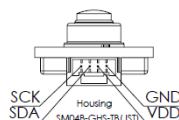
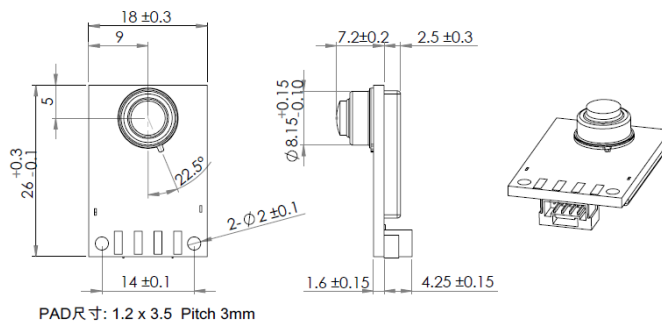
- \* 1: It is applicable to the sensor area of the center four pixels.
- \* 2: The calibration distance can be customized to meet specific application.

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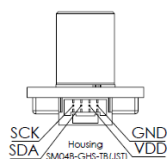
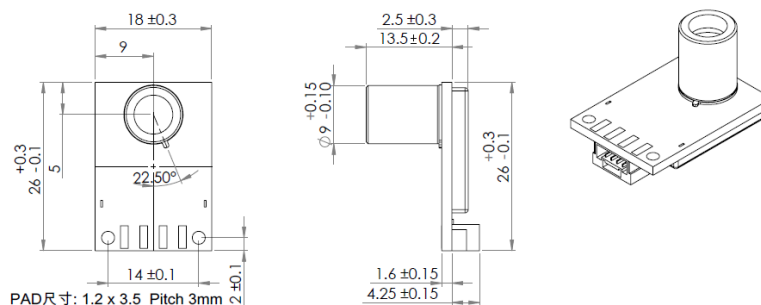
## Mechanic Drawing and Pin Assignment

### -AI25 or -CI25



unit : mm

### -HI35 model

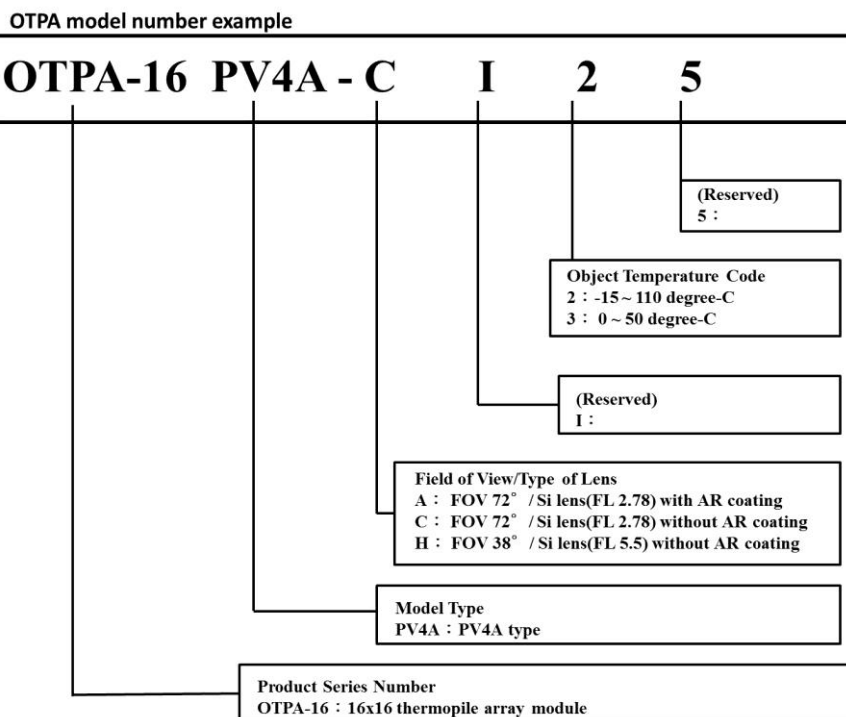


unit : mm

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**Ordering Information**



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### Data communication protocol for OTPA-16PV4A series

This application note is applicable to OTPA-16PV4A series of thermopile array module. The OTPA-16PV4A series are 16x16 thermal image sensors, one of which has 256 pixels of sensing elements. Currently the member of OTPA-16PV4A includes OTPA-16PV4A-AI15, OTPA-16PV4A-AI25 and OTPA-16PV4A-CI25. To simplified further discussion on the following sections, we use OTPA-16PV4A to represent any member of OTPA-16PV4A series in this application note.

OTPA-16PV4A provides I2C data communication interface and plays a slave role on communicating with an outside controller. The Figure 1 shows an example of typical hardware connection to outside controller.

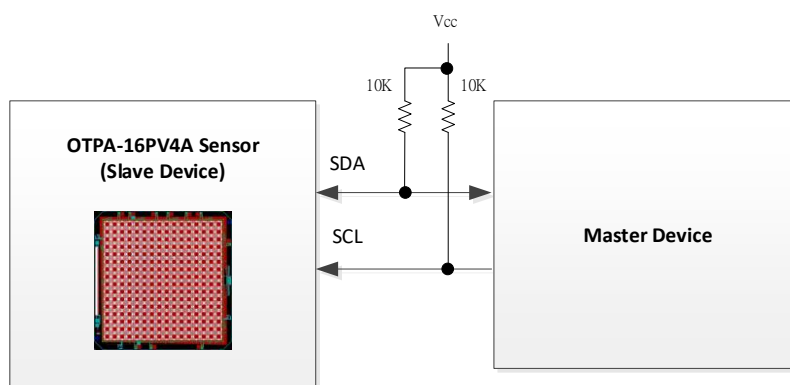


Figure 1. Data communication with I2C interface

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

There are two types of commands, which functions are described as follows:

  - Frame-rate-setting command
  - Readout command

#### 2.1 Frame-rate-setting command

The frame-rate-setting command consists of four data bytes, which are denoted as “ADR”, “CMD”, “CFG1”, and “CFG2” in sequence. The definition of each parameter is described on Table 1.

Table 1. Contents of frame-rate-setting command

Byte sequence	Syntax	Value	Description
Byte 1	ADR	D0H	Write data to I2C address 68H
Byte 2	CMD	2FH	Frame-rate-setting command
Byte 3	CFG1	xxH	Bit[7:4] (Reserved) Bit[3:0] frame rate setting <ul style="list-style-type: none"> <li>- 0100: 250ms (4 fps)</li> <li>- 0101: 500ms (2 fps)</li> </ul>

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			<ul style="list-style-type: none"> <li>- 0110: 1 sec (1 fps) [default]</li> <li>- 0111: 2 sec (0.5 fps)</li> <li>- Others: reserved</li> </ul>
Byte 4	CFG2	xxH	Bit[7:0] (Reserved)

### 2.2 Readout command

The readout command consists of three data bytes, which are denoted as “ADR”, “CMD”, and “NUL” in sequence. The definition of each parameter is described on Table 2.

Table 2. Contents of readout command

Byte sequence	Syntax	Value	Description
Byte 1	ADR	D0H	Write data to I2C address 68H
Byte 2	CMD	4EH	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 will response it a data packet consisting of 525 bytes. The responding data packet includes 9 bytes of header, 4 bytes of ambient temperature reading, and 512 bytes of object temperature reading.

Table 5. Contents of response data packet

Byte 1~9	Byte 10~13	Byte14~525
header	ambient temperature	object temperature

#### 3.1 Contents of packet header

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	4EH	Indicates this data packet is a response to a readout command.
Byte 3	n/a	n/a	(Reserved)
Byte 4	ASDS	xxH	Bit[7:4] TP array size <ul style="list-style-type: none"> <li>- 0010: 16x16</li> <li>- Others: (reserved)</li> </ul> Bit[3:0] Sequence of data packet <ul style="list-style-type: none"> <li>- 0000: the 1<sup>st</sup> data packet</li> <li>- 0001: the 2<sup>nd</sup> data packet</li> <li>- ...</li> <li>- 1111: the 16<sup>th</sup> data packet</li> </ul> (note: this sequence is used to identify whether the reading data packet is an updated one.)
Byte 5~8	n/a	n/a	(Reserved)
Byte 9	EXT	03H	Delimiter: stop of header

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3.2 Ambient temperature reading

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.

3.3 Object temperature reading

The object temperature readings can be read from 256 sensing elements. The pixel coordinate of each sensing elements is defined as Figure 3.

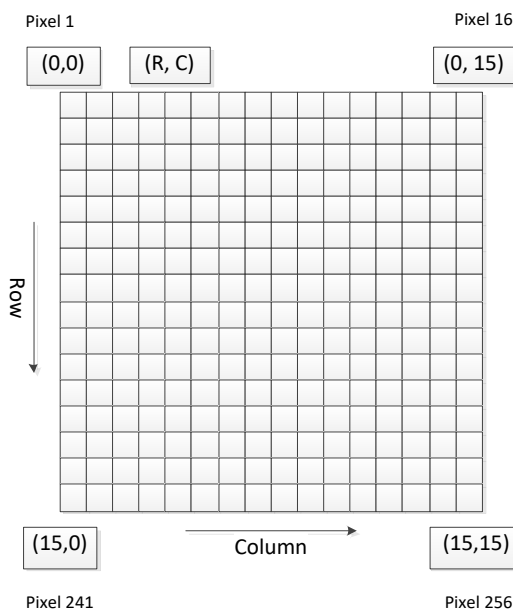


Figure 3. The coordinate of sensing elements

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

<b>Byte 14</b>	<b>Byte 15</b>
Pixel 1 (Hi-byte)	Pixel 1 (Low-byte)
.....	
<b>Byte 524</b>	<b>Byte 525</b>
Pixel 256 (Hi-byte)	Pixel 256 (Low-byte)



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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 524	OBJ256_H	xxH	High byte of object temperature of pixel 256
Byte 525	OBJ256_L	xxH	Low byte of object temperature of pixel 256

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

$$T_{OBJn} = [(OBJn\_H * 256 + OBJn\_L) - 27315] / 100 \quad (\text{The 'n' is varied from 1 to 256}),$$

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.

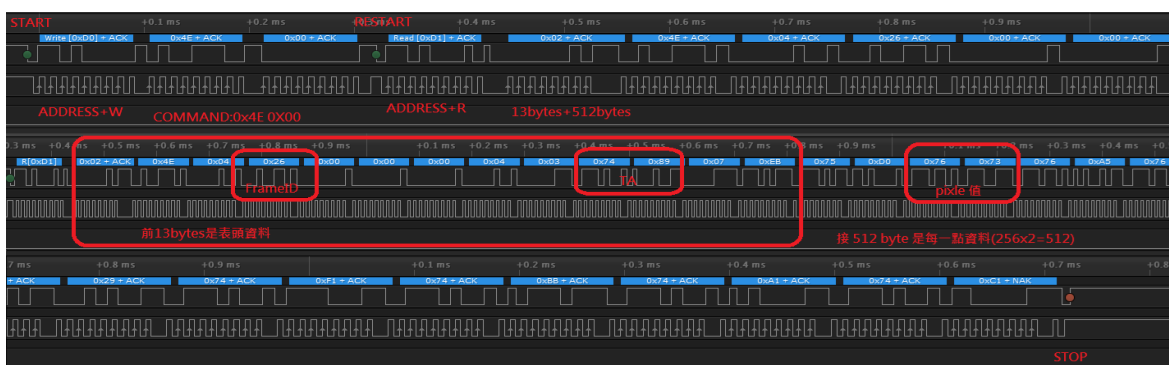
4. Guide to software programming

4.1 Example of frame-rate-setting

Send 'D0' '2F' '04' '00' ; Frame-rate-setting command  
 ; 'D0': write data to I2C address 68H  
 ; '2F': Frame-rate-setting request  
 ; '04': set frame rate to 4fps

4.2 Example of data readout

Send 'D0' '4E' '00' 'D1' '(525 bytes of clock)' ; readout command  
 ; 'D0': write data to I2C address 68H  
 ; '4E': data readout command  
 ; '00': null byte  
 ; 'D1': read data from I2C address 68H  
 ; (525 bytes of clock): to get 525 bytes of data



Example: TA = (0x74 \* 256 + 0x89 - 27315) / 100 = 25.18°C

Example: Pixel 值 = (0x76 \* 256 + 0x73 - 27315) / 100 = 30.08°C

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