

## Thermopile Sensor

### OTP-538U

Revision Date: 2009/04/16



## Introduction

The OTP-538U is a thermopile sensor in classic TO-46 housing. The sensor is composed of 116 elements of thermocouple in series on a floating micro-membrane having an active diameter of 545  $\mu\text{m}$  and with blacken surface to absorb the incident thermal infrared radiation, which induces a voltage response at output terminals. The sensor chip is fabricated by a unique front-surface bulk micromachining technology, which result in smaller size and faster to response ambient temperature change.

The IR window is a bandpass filter having its 50% cut-on wavelength at 5  $\mu\text{m}$ , and cut-down at 14 $\mu\text{m}$ . The sensor responses proportionally to the incident IR radiation and has a constant signal response up to its cut-off frequency, which is limited by the sensor thermal time constant of tens millisecond range.

The OTP-538U thermopile sensor provides nearly Johnson-noise-limited performance, which can be calculated by its ohmic series resistance. A thermistor element, with a lead connected to ground, is also provided inside the TO package for ambient temperature reference.

## Features

- Non-contact temperature detection
- Voltage output, easy to take signal
- Zero power consumption
- Wide detection temperature range

## Applications

- **Medical Application:** *Ear thermometers*
- **Home Facility:** *Microwave oven, Hair dryer, Safety system, Home security & Air conditioner*
- **Industry Application:** *Process monitor and controller, Infrared non-contact thermometers*
- **Automobile Application:** *Thermal sensing system*

## Table of Contents

### **1 General Characteristics**

- 1.1 Absolute Maximum Ratings
- 1.2 Handling Guidelines

### **2 Device Characteristics**

- 2.1 Device Descriptions
- 2.2 Sensor Characteristics
- 2.3 Signal Output Characteristics
- 2.4 Frequency Response
- 2.5 Thermistor Characteristics
- 2.6 Optical Characteristics
- 2.7 Filter Characteristics
- 2.8 Mechanic Drawing and Pin Assignment

### **3 Liability Statement**

## List of Figures

- Figure 1: Typical output voltage versus object temperature with sensor at 25° C
- Figure 2: Frequency response
- Figure 3: Field of view curve
- Figure 4: Typical spectral transmittance curve
- Figure 5: Mechanical drawing and pin assignment

## List of Tables

- Table 1: Absolute maximum ratings
- Table 2: Device characteristics
- Table 3: Thermopile sensor characteristics
- Table 4: Typical numerical data of Thermopile's output voltage (sensor at 25° C)
- Table 5: Thermistor information
- Table 6: Tabulated thermistor data
- Table 7: Optical characteristics
- Table 8: Filter parameters

## 1. General Characteristics

### 1.1 Absolute Maximum Rating

Table 1: Absolute maximum rating

| Parameter                     | Min. | Typ. | Max. | Unit |
|-------------------------------|------|------|------|------|
| Ambient Operating Temperature | -20  |      | 100  | °C   |
| Storage Temperature           | -40  |      | 100  | °C   |

### 1.2 Handling Guidelines

- Stresses above the absolute maximum ratings may cause damages to the device.
- Do not expose the sensor to aggressive detergents such as Freon, Trichloroethylene, etc.
- Avoid touching or cleaning of the window. If necessary, do cleaning only very carefully with alcohol and cotton swab.
- Hand soldering and wave soldering may be applied by a maximum temperature of 260° C for a dwell time less than 10 s. Reflow soldering is not recommended.

## 2. Device Characteristics

### 2.1 Device Descriptions

The materials of OTP-538U are lead-free and fully complied with the RoHS regulations.

Table 2: Device characteristics

| Parameter              | Description  |
|------------------------|--|
| Cap                    | Metal cap with integrated IR window                          |
| Header                 | TO 46  |
| Leads                  | (3 isolated + 1 ground) pins with solderable gold coating    |
| Filter                 | Si-based IR filter   |
| Insulation gas sealing | The sensor is sealed hermetically in a nitrogen environment. |

### 2.2 Sensor Characteristics

Table 3: Thermopile sensor characteristics

| Parameter                    | Min                 | Typ                 | Max                 | Unit                    | Conditions   |
|------------------------------|---------------------|---------------------|---------------------|-------------------------|--|
| Output Voltage               | 0.77                |                     | 1.44                | mV                      | T <sub>amb.</sub> =25°C<br>T <sub>obj.</sub> =50°C |
| Sensitivity                  | 70                  | 85                  | 100                 | V/W                     | *  |
| TC of sensitivity            | 0.10                | 0.11                | 0.12                | %/K                     | Typical  |
| Sensitivity area in diameter | ---                 | 545                 | ---                 | μm                      |  |
| Resistance of thermopile     | 50                  | 65                  | 80                  | KΩ                      | 25°C   |
| TC of resistance             | ---                 | 0.09                | ---                 | %/K                     | Typical  |
| Time constant                | ---                 | 16                  | ---                 | ms                      | *  |
| Noise voltage                | 28                  | 32                  | 36                  | nV/Hz <sup>1/2</sup>    |  |
| NEP                          | 0.28                | 0.36                | 0.48                | nW/Hz <sup>1/2</sup>    |  |
| Normalized detectivity (D*)  | 1.0*10 <sup>8</sup> | 1.3*10 <sup>8</sup> | 1.7*10 <sup>8</sup> | cm*Hz <sup>1/2</sup> /W | *  |

Notes: \* All optical performances are measured at 1 Hz chopper frequency using a blackbody radiator of 500K temperature with filtered spectrum ranging from 5 to 14 μm. Distance between packaged thermopile and blackbody is 11cm.

2.3 Signal Output Characteristics

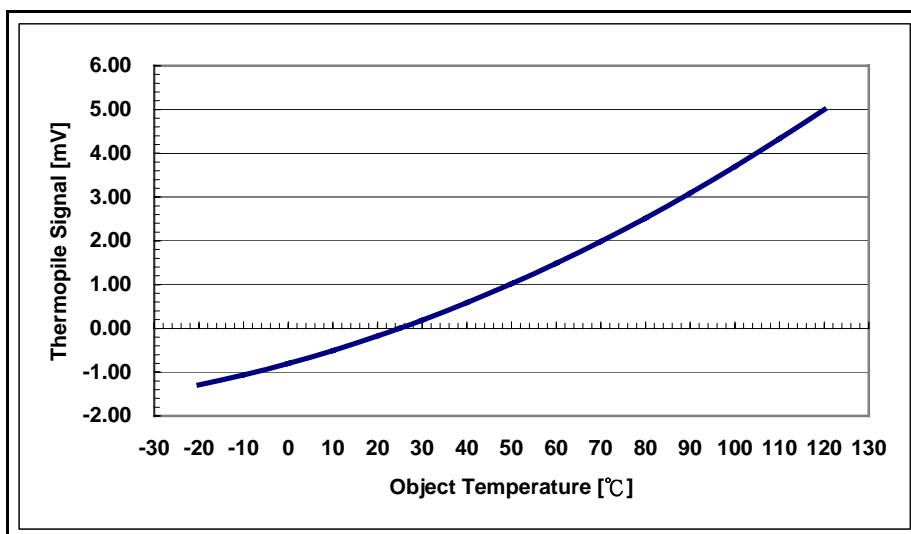


Figure 1: Typical output voltage versus object temperature with sensor at 25° C.

Table 4: Typical numerical data of Thermopile's output voltage (sensor at 25° C)

| Temp. (°C) | V_out (mV) | Temp. (°C) | V_out (mV) |
|------------|------------|------------|------------|
| -20        | -1.29      | 50         | 1.02       |
| -10        | -1.06      | 60         | 1.49       |
| 0          | -0.80      | 70         | 1.99       |
| 10         | -0.51      | 80         | 2.52       |
| 20         | -0.18      | 90         | 3.09       |
| 25         | 0.00       | 100        | 3.69       |
| 30         | 0.19       | 110        | 4.33       |
| 40         | 0.59       | 120        | 5.00       |

Note: Blackbody source size: 250 x 250mm  
Distance from sensor to source: 110mm

2.4 Frequency Response

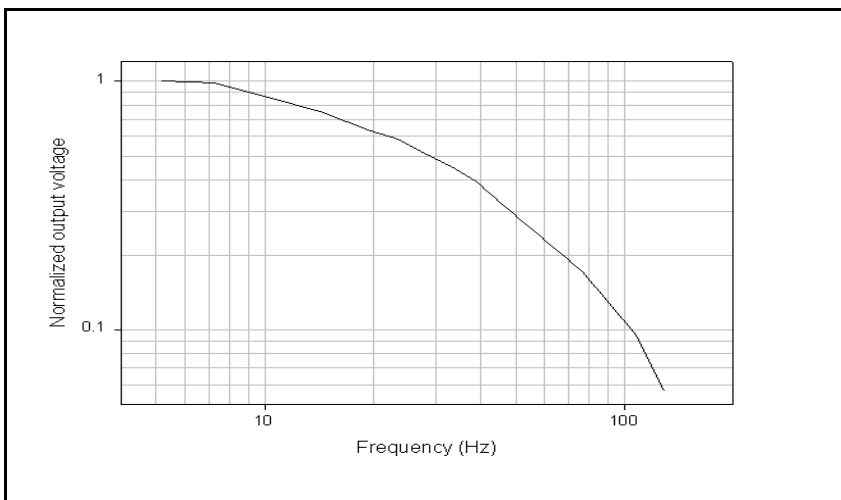


Figure 2: Frequency response

2.5 Thermistor Characteristics

Table 5: Thermistor information

| Parameter     | Min  | Typ  | Max  | Unit | Conditions |
|---------------|------|------|------|------|------------|
| Resistance    | 97   | 100  | 103  | KΩ   | 25°C       |
| $\beta$ value | 3944 | 3964 | 3984 | K    | 0°C/50°C   |

Table 6: Tabulated thermistor data

| Temp.(°C) | Resistance (KΩ) |        |       |
|-----------|-----------------|--------|-------|
|           | Min             | Center | Max.  |
| -20       | 882.3           | 919.7  | 957.9 |
| -15       | 668.9           | 696.3  | 724.2 |
| -10       | 511.7           | 532.0  | 552.5 |
| -5        | 394.8           | 409.8  | 425.1 |
| 0         | 307.0           | 318.3  | 329.8 |
| 5         | 240.5           | 249.1  | 257.7 |
| 10        | 189.8           | 196.3  | 202.9 |
| 15        | 150.7           | 155.7  | 160.7 |
| 20        | 120.5           | 124.4  | 128.3 |
| 25        | 97.0            | 100.0  | 103.0 |
| 30        | 78.32           | 80.83  | 83.34 |
| 35        | 63.61           | 65.72  | 67.83 |
| 40        | 51.96           | 53.73  | 55.51 |

| Temp.(°C) | Resistance (KΩ) |        |       |
|-----------|-----------------|--------|-------|
|           | Min             | Center | Max.  |
| 45        | 42.68           | 44.18  | 45.69 |
| 50        | 35.23           | 36.50  | 37.78 |
| 55        | 29.23           | 30.31  | 31.41 |
| 60        | 24.36           | 25.29  | 26.23 |
| 65        | 20.41           | 21.20  | 22.01 |
| 70        | 17.17           | 17.85  | 18.55 |
| 75        | 14.51           | 15.10  | 15.70 |
| 80        | 12.31           | 12.82  | 13.34 |
| 85        | 10.48           | 10.93  | 11.38 |
| 90        | 8.960           | 9.347  | 9.742 |
| 95        | 7.685           | 8.023  | 8.369 |
| 100       | 6.615           | 6.911  | 7.214 |
| 105       | 5.712           | 5.972  | 6.238 |

2.6 Optical Characteristics

Table 7: Optical characteristics

| Parameter     | Min | Typ | Max | Unit   | Conditions           |
|---------------|-----|-----|-----|--------|----------------------|
| Field of view |     | 66  |     | degree | At 50% target signal |

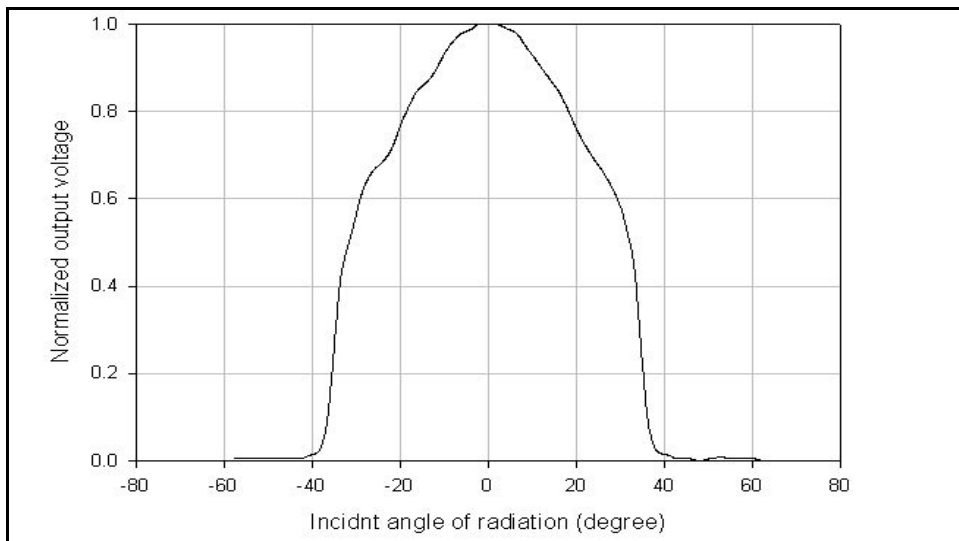


Figure 3: Field of view curve

2.7 Filter Characteristics

Table 8: Filter parameters

| Parameter         | Min | Typ | Max | Unit          | Conditions                    |
|-------------------|-----|-----|-----|---------------|-------------------------------|
| Cut on wavelength | 4.7 | 5.0 | 5.3 | $\mu\text{m}$ | At 25°C,<br>50% transmittance |

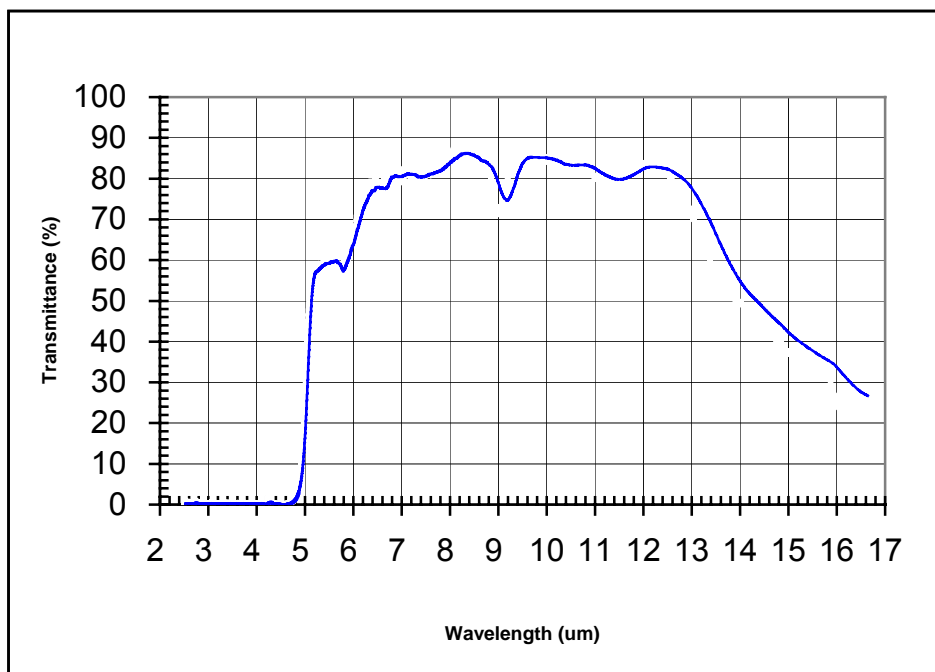


Figure 4: Typical spectral transmittance curve

2.8 Mechanic Drawing and Pin Assignment

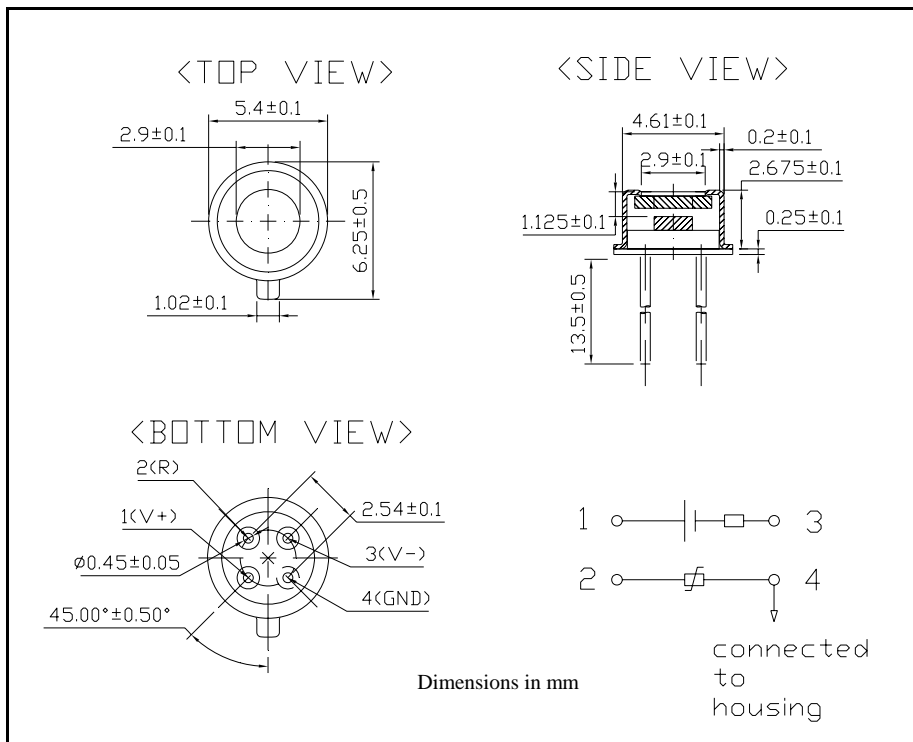


Figure 5: Mechanic drawing and pin assignment

3. Liability Statement

The contents of this document are subject to change without notice and customers should consult with Oriental System Technology (OST) sales representatives before ordering. Customers considering the use of OST thermopile devices in applications where failure may cause personal injury or property damage, or where extremely high levels of reliability are demanded, are requested to discuss their concerns with OST sales representatives before such use. The Company’s responsibility for damages will be limited to the repair or replacement of defective product. As with any semiconductor device, thermopile sensors or modules have a certain inherent rate of failure. To protect against injury, damage or loss from such failures, customers are advised to incorporate appropriate safety design measures into their product.