

THERMOPILE MODULES

TPiM 1T 0136 L5.5

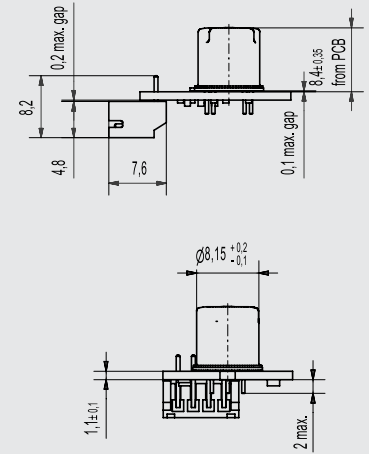
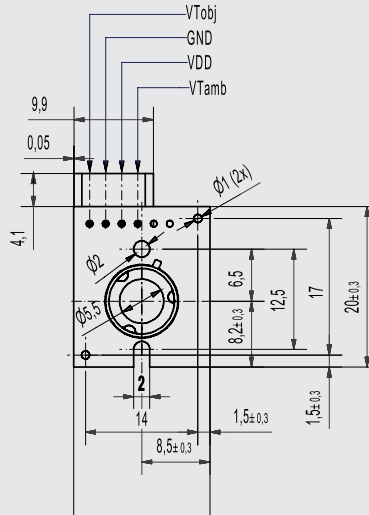
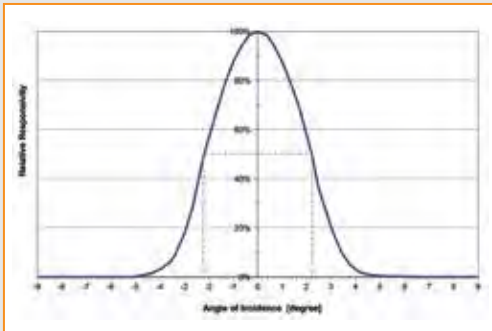
Thermopile Sensor Module with lens



The Module includes the proven concept of TPMI® in TO-5 housing with integral lens sensor on a PCB with connector for easy plug and play. It senses the thermal radiation emitted by objects and converts this to an analog voltage. The product is fully factory-calibrated for an accurate signal output over a specified temperature range and includes optional temperature compensation. The internal signal processing with 8-bit resolution of the control registers and the EEPROM technology allow for calibration as per customer requirements. The Module includes PCB with connector.

As standard two calibration ranges are provided:

- TPiM 1T 0136 L5.5 OAA250 P7 for up to 250°C
- TPiM 1T 0136 L5.5 OAA060 P7 for up to 60°C



TPiM 1T 0136 L5.5

Parameter	Symbol	TPiM 1T 0136 L5.5	Unit	Remarks
Output Voltage Swing	V_o	0.25...($V_{DD} - 0.25$)	V	
Resistive Output Load	R_L	50	k Ω	min.
Object Temp Accuracy		1.5	K	+ / -
Response Time	t_{resp}	100	ms	typ.
Supply Voltage	V_{DD}	4.5...5.5	V	
Supply Current	I_{DD}	1.5	mA	typ. ; $R_L > 1M\Omega$
Operating Temp range	T_o	-25...+100	°C	
Storage Temp range	T_s	-40...+100	°C	
ESD tolerance		2.5	kV	Human body model
Field of View, typ.	FoV	4.5	°	at 50% intensity points
Distance to Spot size ratio	D:S	11:1	Degrees	at 50% intensity points

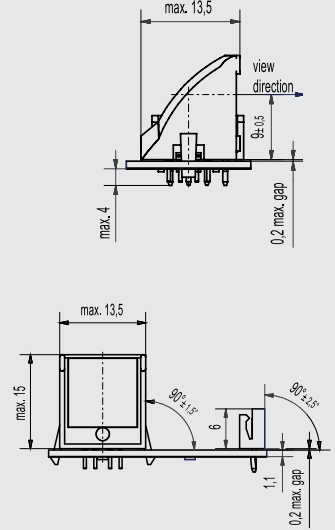
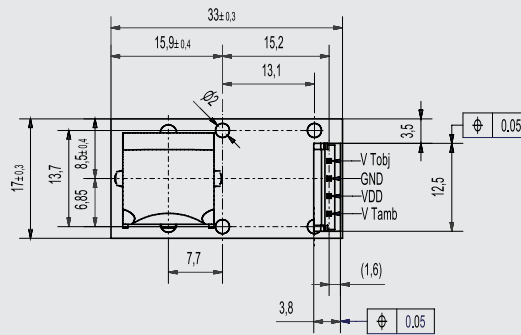
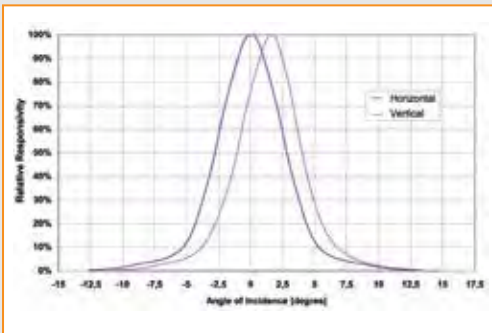
TPM 1T 0134 M

Thermopile Sensor Module

The Module includes the proven concept of TPMI® in TO-5 housing serving as aperture on a PCB with connector for easy plug and play. The product is fully factory-calibrated for an accurate signal output over a specified temperature range and includes optional temperature compensation. The Module includes PCB with connector and is available with reflector allowing narrow field of view, either to right, left or front side.

As standard calibration we provide:

- TPM 1T 0134 OAA140 P6 M for up to 140°C



TPM 1T 0134 M

Parameter	Symbol	TPM 1T 0134 M	Unit	Remarks
Output Voltage Swing	V_o	0.25...(VDD - 0.25)	V	
Resistive Output Load	R_L	50	k Ω	min.
Object Temp Accuracy		1.5	K	+ / -
Response Time	t_{resp}	100	ms	typ.
Supply Voltage	V_{DD}	4.5...5.5	V	
Supply Current	I_{DD}	1.5	mA	typ. ; $R_L > 1M\Omega$
Operating Temp range	T_o	-25...+100	°C	
Storage Temp range	T_s	-40...+100	°C	
ESD tolerance		2.5	kV	Human body model
Field of View, typ.	FoV	5.5	°	at 50% intensity points
Distance to spot size ratio	D:S	-	Degrees	

The Thermoelectric Effect

The thermoelectric effect (or Seebeck-effect) is known as reverse to the Peltier-effect. By applying a temperature difference to two junctions of two dissimilar materials A and B, a voltage U , which is proportional to the temperature difference is observed.

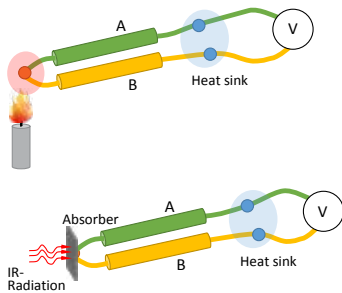


Fig 7: The Seebeck effect

Detector Design

Leopoldo Nobili (1784 - 1835) first used the thermoelectric effect for IR radiation measurement using a "pile" of Bismuth and Antimony contacts. The measure of this effect is called the thermoelectricor Seebeck-coefficient.

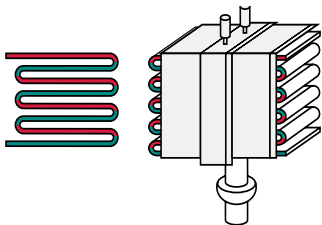


Fig 8: Nobili's Thermopile

For most conducting materials this coefficient is rather low, only few semiconductors possess rather high coefficients. Since the voltage of a single thermoelectric cell is very low, lots of such cells arranged in a series connection achieve a larger signal, making a "pile" of thermo-elements.

Excelitas Thermopile Design

Our thermopile sensors are based on silicon micromachining technology. The central part of a silicon chip is removed leaving only a $1\mu\text{m}$ thin layer (membrane) of $\text{SiO}_2/\text{Si}_3\text{N}_4$, which has low thermal conductivity. Onto this membrane thin conductors of two different thermoelectric materials (to form thermocouples) are deposited.

Both conductors have junctions alternatively in the center of the membrane (hot junctions) and on the bulky part of the silicon substrate (cold junctions). A special IR-absorption layer covers the hot junctions forming the sensors sensitive area.

When exposed to infrared radiation, the absorbed energy leads to a temperature difference between "hot" and "cold" contacts. According to the thermoelectric coefficient of the thermocouples a signal voltage is generated.

The Thermopile Construction

The sensor chip is mounted in good thermal contact into a housing with infrared filter sealing the sensor chip from the environment. The infrared filter serves as window with spectral properties. Excelitas's product portfolio includes detectors of various housings as well as integrated sensors which include temperature compensation and calibration to specified measurement ranges. We further provide unique construction models with improved thermal shock performance, referred to as ISO-thermal sensor types.

Thermopile Detectors do not require mechanical chopper to sense infrared, they offer simple solutions to infrared measurements.

Thermopile Characteristics

The most important properties of the Thermopile Sensor are its responsivity, noise, field-of-view and response time.

Responsivity

The responsivity shows low-pass characteristics with a cut off at approximately 30 Hz. Responsivity is measured in Volt per Watt by means of a defined black body radiator. Responsivity data is usually cited with respect to the active detector area, given without the infrared filter. The data shows responsivity tested at 1 Hz electrical frequency.

Noise

The noise of the detector is dominated by the Johnson noise due to the resistance of the thermopile. Noise is given as RMS value in $\text{nV}/\sqrt{\text{Hz}}$.

Sensitivity

The data tables do also mention sensitivity, as a characteristic output voltage versus target temperature at 25°C environment temperature. The data are given with standard IR filter and specified at 25°C ambient temperature and different object / blackbody temperatures, e.g. 40°C $S(25/40)$ and 100°C $S(25/100)$. Sensitivity is dependent upon the field-of-view of the detector construction. An example can be seen below for selected thermopile detector series.



Fig 8: Sensitivity curves

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Ambient Temperature Reference

As temperature reference the thermopile detectors include a thermistor which senses the internal temperature.

For exact measurements, the temperature of the detector housing (cold thermopile contacts) must be known. A 100 kOhm thermistor inside the detector housing serves as the ambient temperature reference.

The dependence of the resistance on temperature can be approximated by the following equation:

$$R_T = R_R \cdot e^{B \cdot \left(\frac{1}{T} - \frac{1}{T_R} \right)}$$

RT	NTC resistance in Ω at temperature T in K
RR	NTC resistance in Ω at rated temperature TR in K
T	Temperature in K
TR	Rated temperature in K
B	B value, material-specific constant of NTC thermistor
e	Euler number (e = 2.71828)

The actual characteristic of an NTC thermistor can be roughly described by the exponential relation. This approach, however, is only suitable for describing a restricted range around the rated temperature or resistance with sufficient accuracy. For practical applications, a more precise description of the real R/T curve is required. Either more complicated approaches (e.g. the Steinhart-Hart equation) are used or the resistance / temperature relation is given in tabulated form.

The Field-of-View

The most common use of thermopile detectors is non-contact temperature sensing. All target points within

the field-of-view will contribute to the measurement signal. To meet requirements of different applications, Excelitas offers a broad range of sensors with different windows and optics. The field-of-view data describes the dependence of signal from incident angles.

DigiPile® Sensors

Excelitas DigiPile was the first digital output Thermopile Sensor to reach the market, enabling direct connection to a microprocessor and streamlining integration. The Excelitas DigiPile line of Thermal IR Detectors are designed specifically for non-contact temperature measurement and are available in traditional TO-46 and TO-5 metal housings, as well as our SMD (Surface Mount Device) models in an ultra-compact, ceramic-type package.

Our DigiPile sensors feature a highly sensitive ADC input stage, which does not require further amplification, enabling easier integration into customer applications. The DigiPile sensors are available in an ISO-thermal package suited for applications such as ear thermometry.

CaliPile® Sensors

The CaliPile sensors represent the latest innovation in IR sensing. The only one of its kind, the CaliPile is a multifunction thermal infrared sensor. In addition to traditional non-contact temperature measurement capabilities, CaliPile sensors offer motion detection and presence monitoring across short to medium ranges. To enable these individual functions, the internal circuit combines data storage with calibration data and a number of digital filters. With selectable frequency filters and levels, the CaliPile enables users to set the product into different operating modes. The CaliPile receives calibration data to support temperature-related processing and output. Depending on the model, the sensor is calibrated for an object temperature range up to

200°C. Customers can use a maximum temperature setting to set the trigger level as the interrupt function will alert users when the level is exceeded.

Applications for the CaliPile Series include short-range presence detection with no additional lens requirements, non-contact temperature measurement and overheating protection. It is ideally suited for IoT and smart-home products, lighting and printer sensing, and general industry thermal IR detection.

Thermopile Modules

With its range of Thermopile Modules, Excelitas offers plug-and-play function and streamlined systems integration. The TPMI® modules include the thermopile sensor mounted on a PCB with a connector. The PCB caters to features such as voltage regulation and a noise-reduction filter.

The ISO-thermal module includes integrated temperature compensation for a defined temperature environment and the calibration to a certain object temperature range. TPMI Modules are offered as programmed per customer request, in addition to standard versions. For requirements of defined spot sizes, Excelitas offers sensors with a field-of-view defined by optical apertures, internal lenses or external mirror optics.

Applications for Thermopile Sensors

Thermopile Sensors have been designed for non-contact temperature measurement. The signal of the sensor follows the radiation energy receipt by the sensor. This enables measuring surface temperatures without contact.

For industrial process controls, thermopile sensors are used to remotely monitor temperature as overheating protection. Thermopiles are also suited for domestic appliances such as food monitoring during defrosting, warming-up or cooking. Typical medical applications are body and skin temperature measurement, e.g. forehead and ear thermometry.