TPD 1T 0122

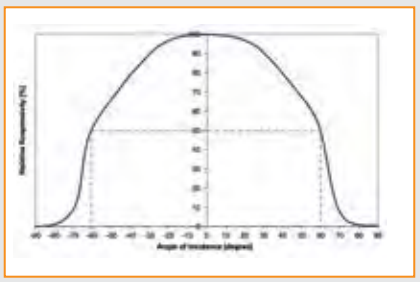
Miniature Thermopile Detector

This Thermopile Detector in TO-46 housing features a miniature housing including a sensitive chip with small optical window. The window is optically coated in the IR band 5-14µm. The housing includes a thermistor for ambient temperature compensation.

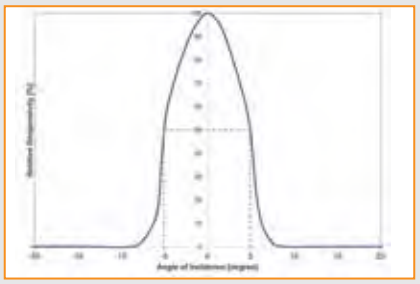
TPD 1T 0122 L3.0

Miniature Thermopile Detector with lens

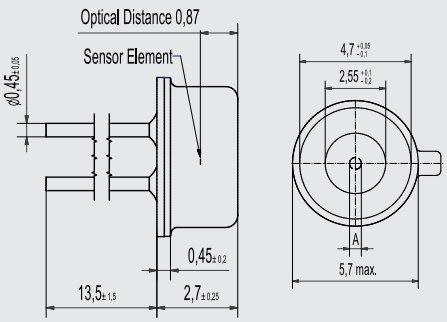
This Thermopile Detector in miniature TO-46 housing includes a focusing lens built into the smallest TO housing based thermopile detector. It includes a specially designed sensing chip and a standard internal Thermistor as temperature reference for temperature compensation. The built-in lens provides the narrow field-of-view for long-range contactless temperature measuring applications.



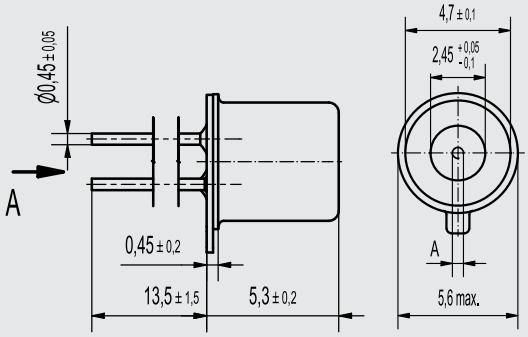
FoV TPD 1T 0122



FoV TPD 1T 0122 L3.0

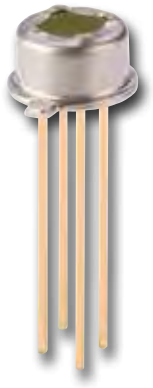


TPD 1T 0122



TPD 1T 0122 L3.0

TPD 1T 0122 L3.0 - TPD 1T 0122					
Parameter	**Symbol**	**TPD 1T 0122 L3.0**	**TPD 1T 0122**	**Unit**	**Remarks**
Sensitive Area	A	Ø 0.5	Ø 0.5	mm	Absorber Area
Thermopile Resistance	R_{TP}	85…135	85…135	kΩ	25°C
Responsivity	R	77	77	V/W	500°K / 1Hz / Without IR-filter
Sensitivity (T_{det} 25 °C / T_{obj} 40 °C)	S_{40}	18.6	43	µV/K	
Sensitivity (T_{det} 25 °C / T_{obj} 100 °C)	S_{100}	25	56	µV/K	
Time Constant	t	15	15	ms	
Noise Voltage	V_n	42	42	nV/√Hz	25°C
Specific Detectivity	D*	0.8	0.8	10^8 cm√Hz/W	25°C
Temp. Coefficient of Resistance	TC_{RTP}	0,03	0,03	%/K	
Temp. Coefficient of Responsivity	T_{CR}	-0,05	-0,05	%/K	
Field of view	FoV	10	120	Degrees	at 50% intensity points
Thermistor resistance (25°C)	R_{25}	100	100	kΩ	25 °C
Thermistor BETA-value	β	3964	3964	K	defined at 25 °C / 100 °C



TPD 1T 0223

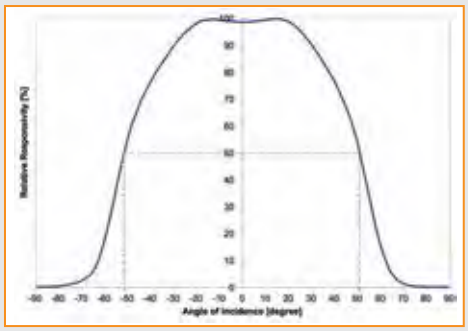
Miniature Thermopile Detector

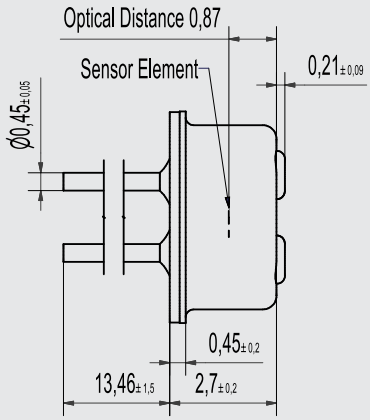
Thermopile Detector in miniature TO housing for general-purpose Detectors in 4.7 mm diameter TO-46 type housings, feature a specially-designed element configuration. The window is available as standard infrared or optional with narrow band-pass for gas-sensing applications. With the narrowband filter a square window is provided.

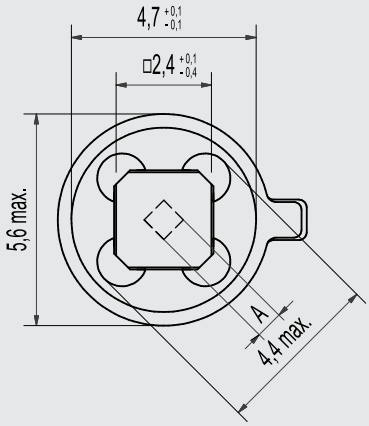
TPD 1T 0223 provides the small absorbing area, and is equipped as standard with an internal thermistor as temperature reference for ambient temperature compensation.

Features and Benefits

- Small housing
- Square window
- Filter options







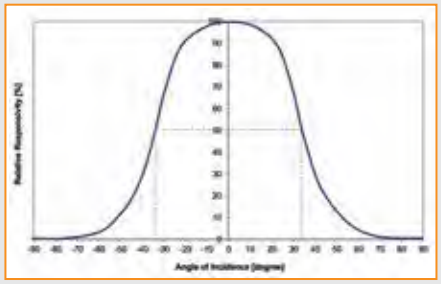
TPD 1T 0223				
Parameter	**Symbol**	**TPD 1T 0223**	**Unit**	**Remarks**
Sensitive Area	A	0.7 x 0.7	mm	Absorber Area
Thermopile Resistance	R_{TP}	50…100	kΩ	25°C
Responsivity	R	45	V/W	500°K / 1Hz / Without IR-filter
Sensitivity (Tdet 25 °C / Tobj 40 °C)	S_{40}	88	µV/K	
Sensitivity (Tdet 25 °C / Tobj 100 °C)	S_{100}	116	µV/K	
Time Constant	t	22	ms	
Noise Voltage	V_n	35	nV/√Hz	25°C
Specific Detectivity	D*	0.9	10^8 cm√Hz/W	25°C
Temp. Coefficient of Resistance	TC_{RTP}	0,03	%/K	
Temp. Coefficient of Responsivity	TC_R	-0,05	%/K	
Field of view	FoV	104	Degrees	at 50% intensity points
Thermistor resistance (25°C)	R_{25}	100	kΩ	25 °C
Thermistor BETA-value	β	3964	K	defined at 25 °C / 100 °C

TPiD 1T 0224 • TPiD 1T 0624

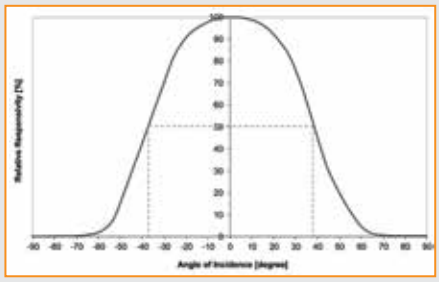
Thermopile Detectors

This Thermopile Detector in TO-39 housing offers a sensitive chip placed into the housing with aperture-type, small optical window. This family provides the ISOthermal performance for improved thermal shock resistance. Excelitas offers a range of ISOthermal Thermopile Detectors in TO-39 type housings. Our patented ISOthermal feature provides improved system performance when subjected to thermal shock conditions.

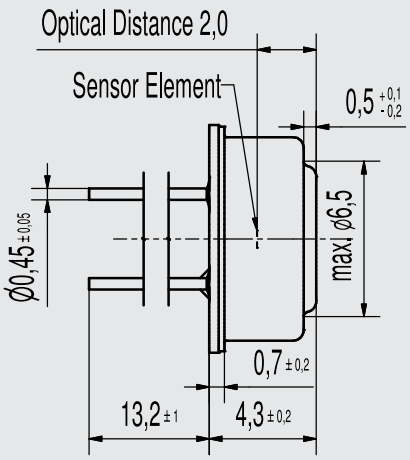
Both types are provided with round window, which also serves as aperture. All feature a specially designed element configuration, each one with different sized absorbing areas. TPiD 1T 0224 provides the smallest absorbing area, TPiD 1T 0624 offers the largest absorbing sensor area and highest sensitivity. All types are equipped as standard with internal thermistor as temperature reference for ambient temperature compensation.

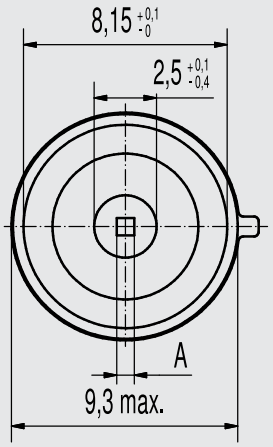


FoV TPiD 1T 0224



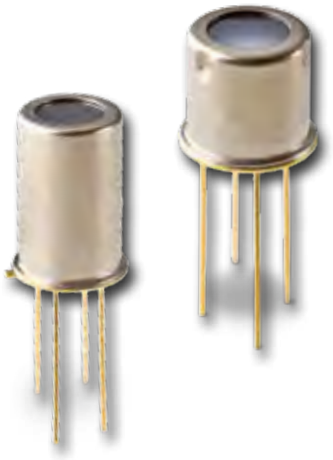
FoV TPiD 1T 0624





TPiD 1T 0224 - TPiD 1T 0624

Parameter	Symbol	TPiD 1T 0224	TPiD 1T 0624	Unit	Remarks
Sensitive Area	A	0.7 x 0.7	1.2 x 1.2	mm	Absorber Area
Thermopile Resistance	R_{TP}	50…100	50…110	kΩ	25°C
Responsivity	R	45	33	V/W	500°K / 1Hz / Without IR-filter
Sensitivity (Tdet 25 °C / Tobj 40 °C)	S_{40}	50	92	µV/K	
Sensitivity (Tdet 25 °C / Tobj 100 °C)	S_{100}	65	120	µV/K	
Time Constant	t	22	27	ms	
Noise Voltage	V_n	35	36	nV/√Hz	25°C
Specific Detectivity	D*	0.9	1.1	10^8 cm√Hz/W	25°C
Temp. Coefficient of Resistance	TC_{RTP}	0,03	0,03	%/K	
Temp. Coefficient of Responsivity	TC_R	-0,05	-0,05	%/K	
Field of view	FoV	70	76	Degrees	at 50% intensity points
Thermistor resistance (25°C)	R_{25}	100	100	kΩ	25°C
Thermistor BETA-value	β	3964	3964	K	defined at 25°C / 100°C



TPD 1T 0226 IRA • TPiD 1T 0226 L5.5

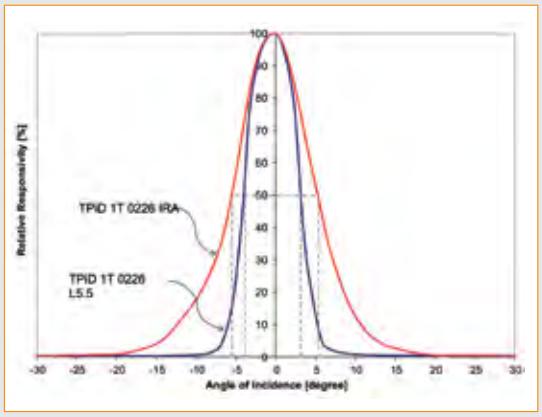
Thermopile Detector with integrated Optics

This Series of Thermopile Detectors with integrated optics offer two different alternatives: IRA type with high metal can which includes an integrated reflector for collecting the radiation receipt, or the L5.5 type with integral lens for focusing radiation towards the sensitive chip.

The IRA type thermopile is specially suited with an internal reflector that reduces the field-of-view and offers a smaller measurement "target" spot than conventional detectors without optics. Due to the reflector, the housing size is taller than other types, although the housing has the same diameter as a standard TO-5 housing.

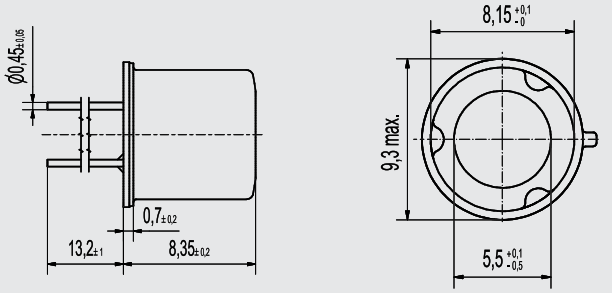
The TPiD 1T 0226 L5.5 provides the ISOthermal performance feature and integral optics. A built-in internal lens provides a field-of-view slightly sharper than the IRA type.

All versions are equipped as standard with an internal thermistor as temperature reference for ambient temperature compensation.

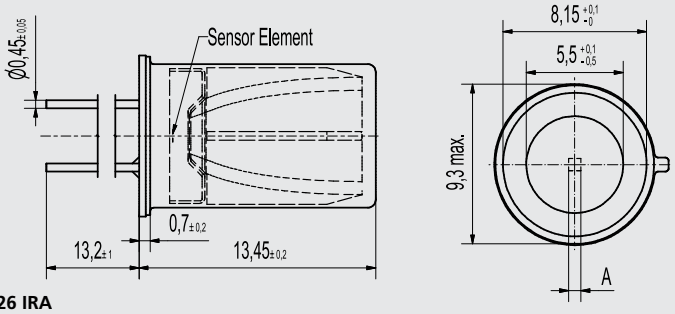


FoV TPD 1T 0226 IRA - TPiD 1T 0226 L5.5 Combined

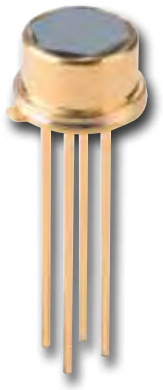
TPiD 1T 0226 L5.5



TPD 1T 0226 IRA



TPD 1T 0226 IRA - TPiD 1T 0226 L5.5					
Parameter	**Symbol**	**TPiD 1T 0226 L5.5**	**TPD 1T 0226 IRA**	**Unit**	**Remarks**
Sensitive Area	A	0.7 x 0.7	0.7 x 0.7	mm	Absorber Area
Thermopile Resistance	R_{TP}	50…100	50…100	kΩ	25°C
Responsivity	R	45	45	V/W	500°K / 1Hz / Without IR-filter
Sensitivity (T_{det} 25 °C / Tobj 40 °C)	S_{40}	20	62	µV/K	
Sensitivity (T_{det} 25 °C / Tobj 100 °C)	S_{100}	27	82	µV/K	
Time Constant	t	22	22	ms	
Noise Voltage	V_n	35	35	nV/√Hz	25°C
Specific Detectivity	D*	0.9	0.9	10^8 cm√Hz/W	25°C
Temp. Coefficient of Resistance	TC_{RTP}	0,03	0,03	%/K	
Temp. Coefficient of Responsivity	TC_R	-0,05	-0,05	%/K	
Field of view	FoV	7	15	Degrees	at 50% intensity points
Thermistor resistance (25°C)	R_{25}	100	100	kΩ	25 °C
Thermistor BETA-value	β	3964	3964	K	defined at 25 °C / 100 °C



TPiD 1T 0122B • TPiD 1T 0222B • TPiD 1T 0622B

ISOThermal Thermopile Detector

This Excelitas Thermopile Detector with ISOthermal design features a special housing concept matched with a sensitive chip and small optical window. As the industry standard for ear thermometry applications, these Thermopile Detectors are referenced as ISOThermal detectors. The patented designs provide superior performance under thermal shock conditions and thereby are best suited for the thympanon ear thermometry.

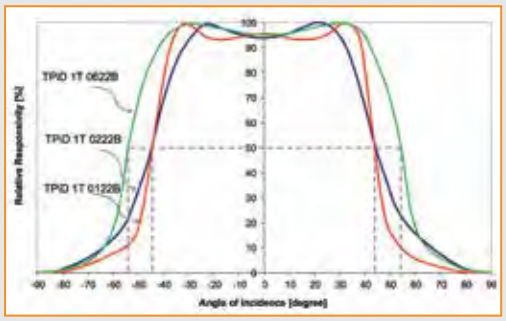
The range comprises TPiD 1T 0122B as the low cost version, whereas the versions TPiD 1T 0222B and TPiD 1T 0622B provide higher signal by high sensitive element designs and larger element area. The physical dimensions of the ISO thermal sensors are equivalent to our TO-46 sensor housings and include a special aperture. All types are equipped with an internal Thermistor as temperature reference for ambient temperature compensation.

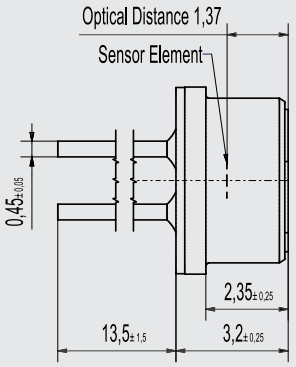
Features and Benefits

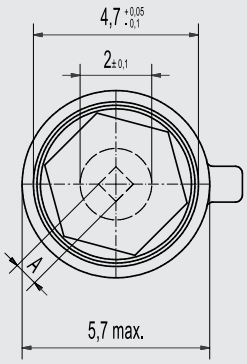
- Patented ISOThermal design
- TO-46 type housing

Target applications

- Ear thermometry







TPiD 1T 0122B, TPiD 1T 0222B, TPiD 1T 0622B

Parameter	Symbol	TPiD 1T 0122B	TPiD 1T 0222B	TPiD 1T 0622B	Unit	Remarks
Sensitive Area	A	Ø 0.5	0.7 x 0.7	1.2 x 1.2	mm	Absorber Area
Thermopile Resistance	R_{TP}	85…135	50…100	50…110	kΩ	25°C
Responsivity	R	92	60	40	V/W	500°K/ 1Hz/ Without IR-filter
Sensitivity (Tdet 25 °C / Tobj 40 °C)	S_{40}	44	95	150	µV/K	
Sensitivity (Tdet 25 °C / Tobj 100 °C)	S_{100}	58	125	200	µV/K	
Time Constant	t	15	22	27	ms	
Noise Voltage	V_n	42	35	36	nV/√Hz	25°C
Specific Detectivity	D*	1.0	1.2	1.3	10^8 cm√Hz/W	25°C
Temp. Coefficient of Resistance	TC_{RTP}	0,03	0,03	0,03	%/K	
Temp. Coefficient of Responsivity	TC_R	-0,05	-0,05	-0,05	%/K	
Field of view	FoV	90	90	110	Degrees	at 50% intensity points
Thermistor resistance (25°C)	R_{25}	100	100	100	kΩ	25 °C
Thermistor BETA-value	β	3964	3964	4092	K	defined at 25 °C / 100 °C

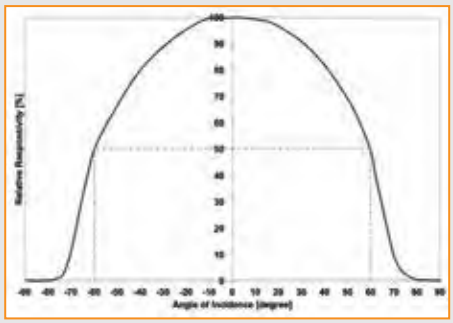
TPiD 1S 0121 • TPiD 1S 0222

Thermopile Detectors, SMD

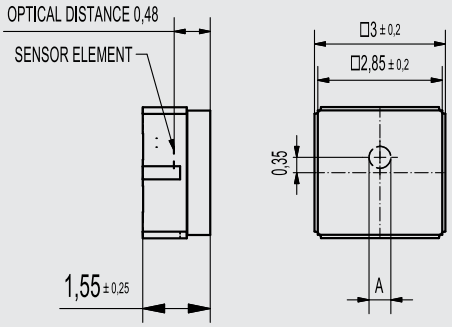
Thermopile Detectors in SMD housings offer two different sensitive chips which require different SMD housing sizes to accommodate either smaller form factor or higher sensitivity performance.

This enables standard SMT assembly processes and affords smaller host system designs. The SMD versions feature the unique ISOthermal performance for applications that are subjected to thermal shock conditions.

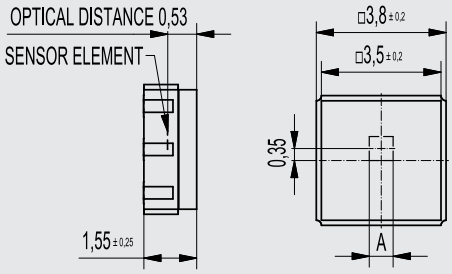
The TPiD 1S 0121 is the smallest SMD version we offer, whereas the TPiD 1S 0222 provides an element with higher sensitivity. Again, these detectors are equipped with an internal thermistor as temperature reference for Thermopile temperature compensation. All SMD parts are supplied in volume in tape & reel packaging.



FoV TPiD 1S 0121 - TPiD 1S 0222 Combined



TPiD 1S 0121



TPiD 1S 0222

TPID 1S 0121 - TPID 1S 0222					
Parameter	**Symbol**	**TPiD 1S 0121**	**TPiD 1S 0222**	**Unit**	**Remarks**
Sensitive Area	A	Ø 0.5	0.7 x 0.7	mm	Absorber Area
Thermopile Resistance	R_{TP}	85…135	50…100	kΩ	25°C
Responsivity	R	77	45	V/W	500°/ 1Hz/ Without IR-filter
Sensitivity (Tdet 25 °C / Tobj 40 °C)	S_{40}	42	107	µV/K	
Sensitivity (Tdet 25 °C / Tobj 100 °C)	S_{100}	56	142	µV/K	
Time Constant	t	15	22	ms	
Noise Voltage	V_n	42	35	nV/√Hz	25°C
Specific Detectivity	D*	0.8	1.2	10^8 cm√Hz/W	25°C
Temp. Coefficient of Resistance	TC_{RTP}	0,03	0,03	%/K	
Temp. Coefficient of Responsivity	TC_R	-0,05	-0,05	%/K	
Field of view	FoV	120	120	Degrees	at 50% intensity points
Thermistor resistance (25°C)	R_{25}	100	100	kΩ	25 °C
Thermistor BETA-value	β	4092	4092	K	defined at 25 °C / 100 °C

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.

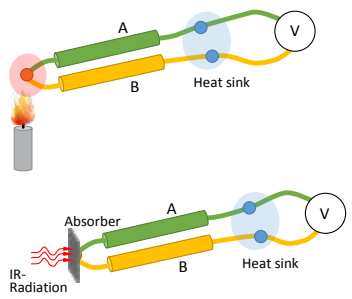


Fig 7: The Seebeck effect

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.

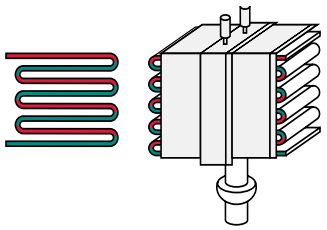


Fig 8: Nobili's Thermopile

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 1µm thin layer (membrane) of SiO2/Si3N4, which has low thermal conductivity. Onto this membrane thin conductors of two different thermoelectric materials (to form thermos-couples) 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 it's 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 nV/√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.

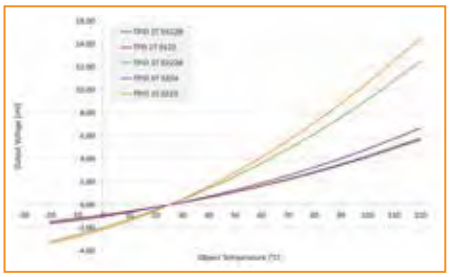


Fig 8:Sensitivity curves

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 it's 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.