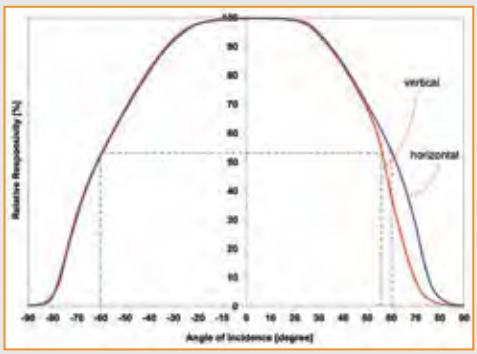
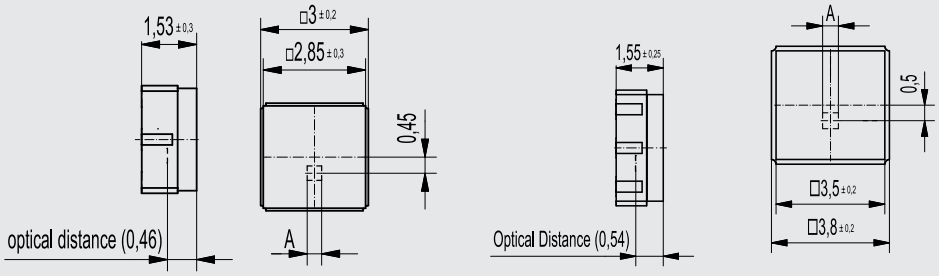
TPiS 1S 1051 • TPiS 1S 1252

DigiPile® Sensors, SMD

The DigiPile Sensor features a Thermopile sensing chip connected to an internal ADC which provides for amplification and digital conversion. Housed in a specially designed SMD carrier with optical window, the DigiPile offers two different versions of sensing chips.

The SMD type DigiPile provides for a Thermopile with digital 17-bit output. As many other types, this detector is offered with our patented ISOthermal performance. Within the bit stream the thermopile signal is followed by another signal given by an internal temperature reference diode. With the digital output, low interference of electric disturbance is achieved. These features enable optimum designs for a wide range of temperature measurement applications. With TPiS 1S 1051 we provide the smallest housing and smallest thermopile chip available. With TPiS 1S 1252 the housing is slightly larger due to a higher sensitivity thermopile chip to provide enhanced performance.





TPiS 1S 1051 - TPiS 1S 1252

Parameter	Symbol	TPiS 1S 1252	TPiS 1S 1051	Unit	Remarks
Operating Conditions					
Operating Voltage	V_{DD}	2,4…3,6	2,4…3,6	V	
Supply Current	I_{DD}	max. 15	15 max.	µA	V_{DD} = 3.3 V
Operating Temperature	T_o	-20…70	-20…70	°C	Parameters may vary from specified values with temperature dependence.
Storage Temperature	Ts	-40…100	-40…100	°C	
Thermopile Characteristics					
Sensitive Area	A	0,51 x 0,51	0,4 x 0,4	mm²	Absorber area
Sensitivity (T_{det} 25 °C / T_{obj} 40 °C)	S_{40}	400	210	counts/K	
Sensitivity (T_{det} 25 °C / T_{obj} 100 °C)	S_{100}	530	280	counts/K	
Noise of TP		8	8	counts	Tobj = 40°C, Tamb =25°C
Time Constant	t	45	15	ms	
Ambient Temperature Sensor Characteristics					
Sensitivity of Tamb		90	90	counts/K	Linear for Tamb from 0°C to 90°C
Count @ Tamb = 25°C		7000…9400	7000…9400	counts	Range
Optical Characteristics					
Field of View	FoV	120	120 / 116	Degree	At 50% intensity points
Electrical Characteristics					
ADC Resolution Tobj		17	17	Bits	Max Count = 2^{17}
ADC Resolution Tamb		14	14	Bits	Max Count = 2^{14}
ADC Sensitivity of Tobj		0,7…0,9	0,7…0,9	µV/count	
ADC Offset Tobj		64000…65000	64000…65000	counts	Range

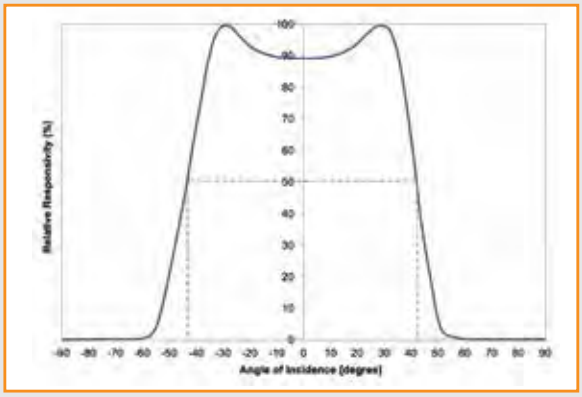
TPiS 1T 1252B • TPiS 1T 1254 • TPiS 1T 1256 L5.5

DigiPile® – ISOthermal Thermopile Sensors

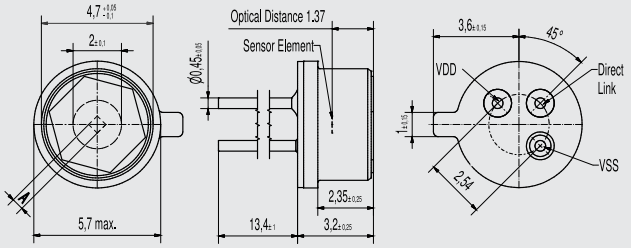
As continuation of Excelitas' focus on innovation and digitization the DigiPile is a Thermopile with digital 17-bit output. The complete range of detectors is offered with our patented ISOthermal performance. Within the bit stream the thermopile signal is followed by another signal given by an internal temperature reference diode. With the digital output, low interference of electric disturbance is achieved. These features enable optimum designs for ear and forehead thermometry.

TPiS 1T 1252B, TPiS 1T 1254, TPiS 1T 1256 L5.5

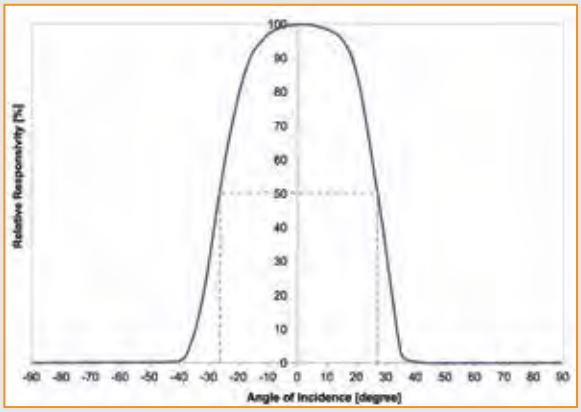
Parameter	Symbol	TPiS 1T 1252B	TPiS 1T 1254	TPiS 1T 1256 L5.5	Unit	Remarks
Operating Conditions						
Operating Voltage	V_{DD}	2,4…3,6	2,4…3,6	2,4…3,6	V	
Supply Current	I_{DD}	15 max.	15 max.	15 max.	µA	V_{DD} = 3.3 V
Operating Temperature	T_o	-20…70	-20…70	-20…70	°C	Parameters may vary from specified values with temperature dependence.
Storage Temperature	T_s	-40…100	-40…100	-40…100	°C	
Thermopile Characteristics						
Sensitive Area	A	0,51 x 0,51	0,51 x 0,51	0,51 x 0,51	mm^2	Absorber area
Sensitivity (T_{det} 25 °C / T_{obj} 40 °C)	S_{40}	290	150	67	counts/K	
Sensitivity (T_{det} 25 °C / T_{obj} 100 °C)	S_{100}	370	200	85	counts/K	
Noise of TP		8	8	8	counts	Tobj = 40°C, Tamb =25°C
Time Constant	t	45	45	45	ms	
Ambient Temperature Sensor Characteristics						
Sensitivity of Tamb		90	90	90	counts/K	Linear for Tamb from 0°C to 90°C
Count @ Tamb = 25°C		7000…9400	7000…9400	7000…9400	counts	Range
Optical Characteristics						
Field of View	FoV	84	56	5	Degree	At 50% intensity points
Electrical Characteristics						
ADC Resolution Tobj		17	17	17	Bits	Max Count = 2^{17}
ADC Resolution Tamb		14	14	14	Bits	Max Count = 2^{14}
ADC Sensitivity of Tobj		0,7…0,9	0,7…0,9	0,7…0,9	µV/count	
ADC Offset Tobj		64000…65000	64000…65000	64000…65000	counts	Range



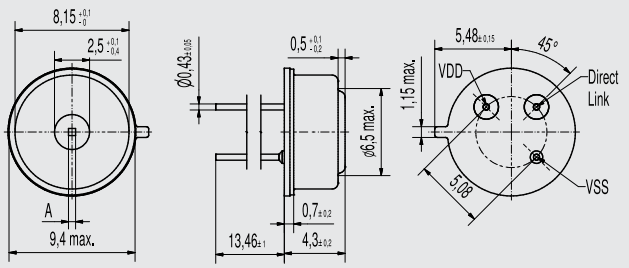
FoV TPiS 1T 1252B



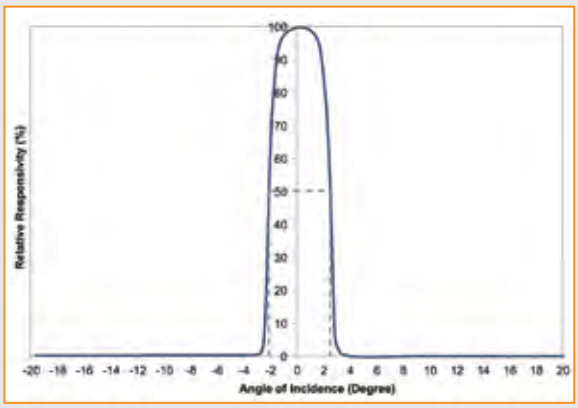
TPiS 1T 1252B



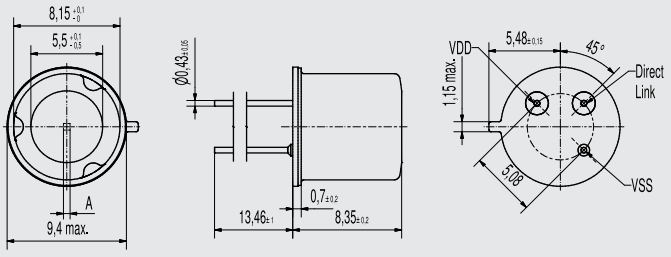
FoV TPiS 1T 1254



TPiS 1T 1254



FoV TPiS 1T 1256 L5.5



TPiS 1T 1256 L5.5

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.

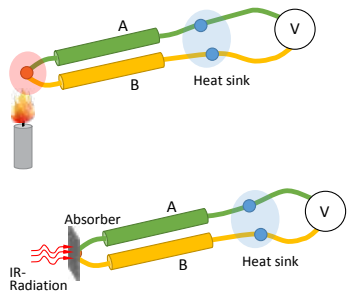


Fig 7: The Seebeck effect

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.

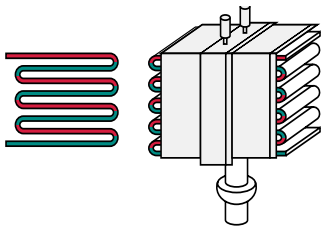


Fig 8: Nobili's Thermopile

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.

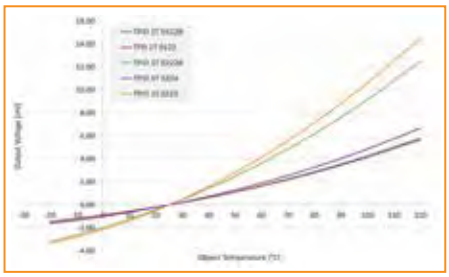


Fig 8:Sensitivity curves

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.