



ANALOG INFRARED THERMOPILES

Non-Contact Temperature Sensors

The TS3xx thermopiles are unique temperature sensors able to measure a wide range of surface temperatures without making physical contact to the object of interest. The sensor consists of a chip having an array of micro-thermocouple elements, a reference ambient temperature sensor, an infrared filter window, all contained in a hermetically sealed metal enclosure. The sensor provides a voltage output that is proportional to the thermal infrared energy entering the sensor through the filter window.

All objects above absolute zero emit thermal energy that is proportional to their temperature. The temperature of the object can be determined by measuring the intensity of this emitted energy. A very broad measurement temperature range is achieved because the measurement is non-contact, meaning the sensor does not have to be in physical contact with the object being measured.

The use of a TO-5 or TO-18 type enclosure and crystalline optical filter window provides a rugged. The filter window has a selective either longwave pass or band pass characteristic that allows thermal energy to enter the sensor but blocks unwanted radiant energy such as near IR and visible light.

The non-contact nature of this sensor makes it easy to measure the temperature of moving objects or surfaces where direct contact of traditional temperature sensors would be difficult, impossible, or surfaces hot enough to damage the sensor package.

Features

- -40 to 300°C measurement range
- High accuracy after compensation and calibration
- Built-in temperature reference
- Hermetic enclosure
- TO-5 or TO-18 package sizes
- Infrared filter window

Applications

- Non-contact measurements
- Medical thermometry
- Industrial production lines
- Remote surfaces

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Absolute Maximum Ratings

Absolute maximum ratings are limiting values of operation and storage. They should not be exceeded initially or during operation. If exceeded, instantaneous catastrophic failure can occur. Even if the device continues to operate satisfactorily, service life may be considerably shortened.

Parameter	Symbol	Min	Typ	Max	Unit	Notes/Conditions
Storage temperature	T _{stor}	-20		+85	°C	Dry
ESD rating	ESD	-2		+2	kV	Human Body Model
Humidity	Hum	0		95	%RH	Non-condensing

Product Family Variants

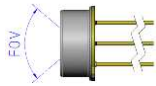
Major differences between the products in the family

Product Model Number	Package	Field of View (50% of max sensitivity)	Voltage Sensitivity ⁽¹⁾	Filter Bandpass	Internal Reference Temperature Sensor
TS305-11C55	TO-5 can	88°	7.0mV	>5.5µm	NTC thermistor, 100kΩ at 25°
TS318-11C55	TO-18 can	110°	8.4mV	>5.5µm	NTC thermistor, 100kΩ at 25°
TS318-1B0814	TO-18 can	110°	5.0mV	8-14µm	Nickel RTD, 1000Ω at 0°C

⁽¹⁾T_{amb} = +25°C, T_{obj} = +100°C, FOV totally filled

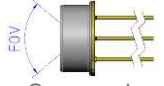
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Operational and Optical Parameters - P/N TS305-11C55 (TO-5)

Parameters	Symbol	Min	Typ	Max	Unit	Notes/Conditions
Thermopile voltage response	V_{tp}	4.9	7.0	9.1	mV	$T_{amb} = +25^{\circ}\text{C}$, $T_{obj} = +100^{\circ}\text{C}$, Totally filled FOV
Temperature coefficient of voltage response	TCV_{tp}	-0.37	-0.45	-0.53	%/K	$T_{amb} = +25^{\circ}\text{C}$ to $+75^{\circ}\text{C}$ $T_{obj} = +100^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
Thermopile resistance	R_{tp}	40	70	100	k Ω	$T_{amb} = +25^{\circ}\text{C}$
Temperature coefficient of thermopile resistance	TCR_{tp}	-0.02	-0.06	-0.10	%/K	$T_{amb} = +25^{\circ}\text{C}$ to $+75^{\circ}\text{C}$
Thermopile response time	t_{63}	7	12	17	ms	
Noise equivalent voltage	NEV		45		nV/ $\sqrt{\text{Hz}}$	$T_{amb} = +25^{\circ}\text{C}$
Reference ambient temperature sensor resistance (NTC thermistor)		95	100	105	k Ω	$T_{amb} = +25^{\circ}\text{C}$
NTC beta value	β	3943	3955	3967	K	$T_{amb} = 0^{\circ}\text{C}$ to $+50^{\circ}\text{C}$
Absorber area			0.8x0.8		mm	
Field of view	FOV		88		degrees	At 50% of maximum signal  See graph
Filter transmission range			≥ 5.5		μm	See graph
Filter window transmission efficiency		77.0			%	7.5 to 13.5 μm
				0.1	%	Average $\leq 4.0\mu\text{m}$
				0.5	%	Average 4.0 to 5.0 μm
				1.0	%	Absolute $\leq 4.0\mu\text{m}$

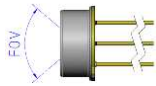
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Operational and Optical Parameters - P/N TS318-11C55 (TO-18)

Parameters	Symbol	Min	Typ	Max	Unit	Notes/Conditions
Thermopile voltage response	V_{tp}	6.3	8.4	10.5	mV	$T_{amb} = +25^{\circ}\text{C}$, $T_{obj} = +100^{\circ}\text{C}$, Totally filled FOV
Temperature coefficient of voltage response	TCV_{tp}	-0.37	-0.45	-0.53	%/K	$T_{amb} = +25^{\circ}\text{C}$ to $+75^{\circ}\text{C}$ $T_{obj} = +100^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
Thermopile resistance	R_{tp}	40	70	100	k Ω	$T_{amb} = +25^{\circ}\text{C}$
Temperature coefficient of thermopile resistance	TCR_{tp}	-0.02	-0.06	-0.10	%/K	$T_{amb} = +25^{\circ}\text{C}$ to $+75^{\circ}\text{C}$
Thermopile response time	t_{63}	7	12	17	ms	
Noise equivalent voltage	NEV		45		nV/ $\sqrt{\text{Hz}}$	$T_{amb} = +25^{\circ}\text{C}$
Reference ambient temperature sensor resistance (NTC thermistor)		95	100	105	k Ω	$T_{amb} = +25^{\circ}\text{C}$
NTC beta value	β	3943	3955	3967	K	$T_{amb} = 0^{\circ}\text{C}$ to $+50^{\circ}\text{C}$
Absorber area			0.8x0.8		mm	
Field of view	FOV		110		degrees	At 50% of maximum signal  See graph
Filter transmission range			>5.5		μm	See graph
Filter window transmission efficiency		77.0			%	7.5 to 13.5 μm
				0.1	%	Average $\leq 4.0\mu\text{m}$
				0.5	%	Average 4.0 to 5.0 μm
				1.0	%	Absolute $\leq 4.0\mu\text{m}$

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Operational and Optical Parameters - P/N TS318-1B0814 (TO-18)

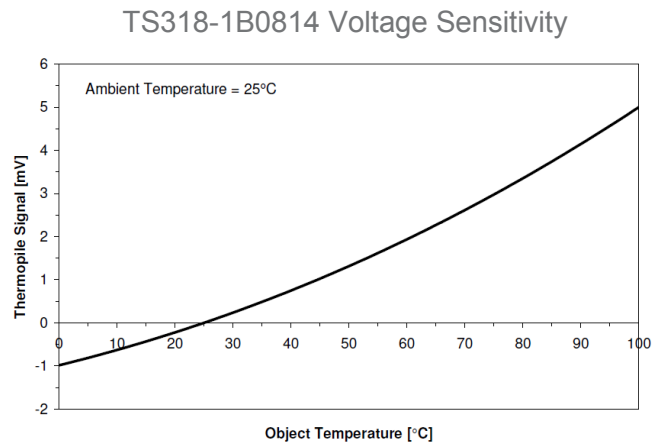
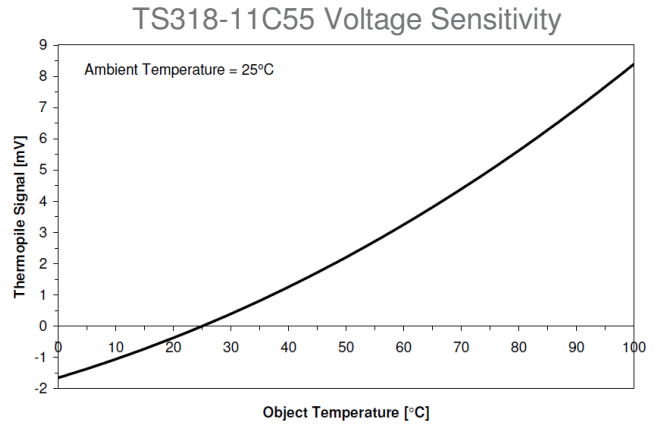
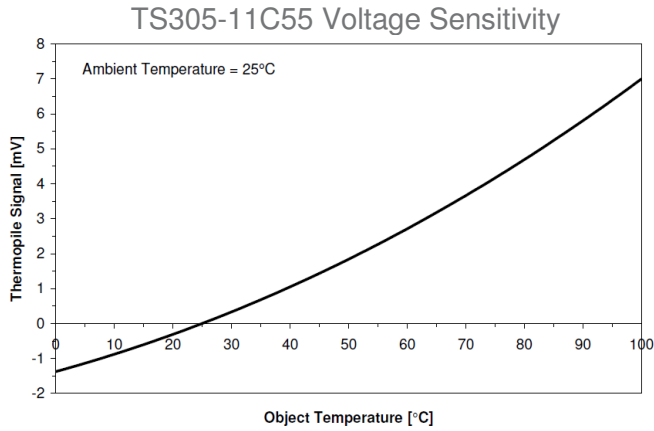
Parameters	Symbol	Min	Typ	Max	Unit	Notes/Conditions
Thermopile voltage response	V_{tp}	3.7	5.0	6.3	mV	$T_{amb} = +25^{\circ}\text{C}$, $T_{obj} = +100^{\circ}\text{C}$, Totally filled FOV
Temperature coefficient of voltage response	TCV_{tp}	-0.37	-0.45	-0.53	%/K	$T_{amb} = +25^{\circ}\text{C}$ to $+75^{\circ}\text{C}$ $T_{obj} = +100^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
Thermopile resistance	R_{tp}	40	70	100	k Ω	$T_{amb} = +25^{\circ}\text{C}$
Temperature coefficient of thermopile resistance	TCR_{tp}	-0.02	-0.06	-0.10	%/K	$T_{amb} = +25^{\circ}\text{C}$ to $+75^{\circ}\text{C}$
Thermopile response time	t_{63}	7	12	17	ms	
Noise equivalent voltage	NEV		45		nV/ $\sqrt{\text{Hz}}$	$T_{amb} = +25^{\circ}\text{C}$
Reference ambient temperature sensor resistance (NTC thermistor)		996	1000	1004	Ω	$T_{amb} = 0^{\circ}\text{C}$
Ni-RTD	TC_{Ni}	6028	6178	6328	ppm/K	$T_{amb} = 0^{\circ}\text{C}$ to $+100^{\circ}\text{C}$
Absorber area			0.8x0.8		mm	
Field of view	FOV		110		degrees	At 50% of maximum signal  See graph
Filter transmission range			8 to 14		μm	See graph
Filter window transmission efficiency		75.0			%	9.0 to 13 μm

Environmental Parameters

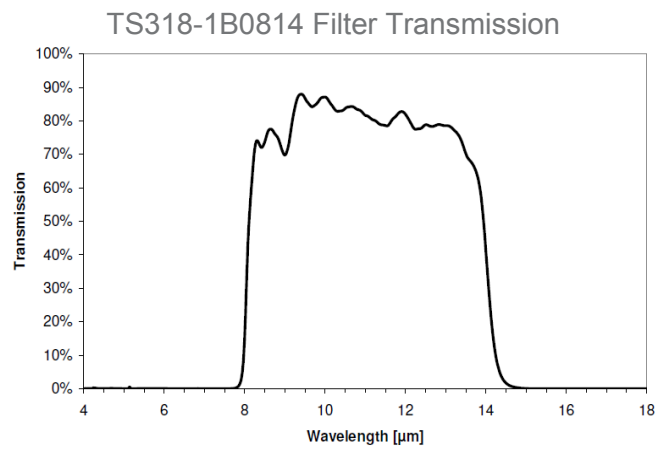
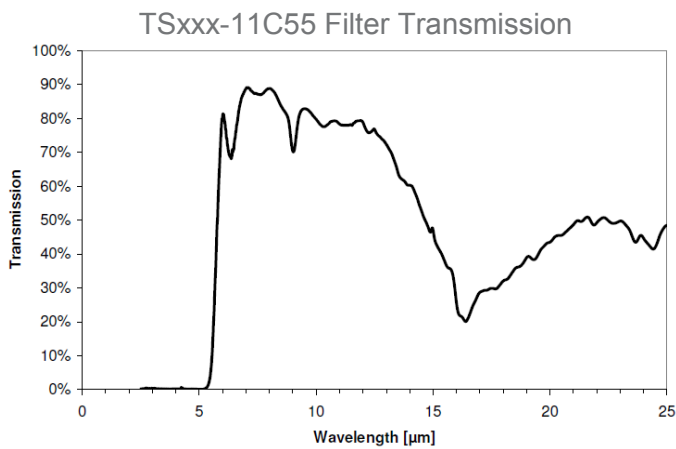
Parameter	Symbol	Min	Typ	Max	Unit	Notes/Conditions
Operating temperature range	T_{amb}	-20		85	$^{\circ}\text{C}$	Continuous
Operating temperature range		-20		100	$^{\circ}\text{C}$	Maximum one hour
Humidity	RH	0		95	%	Non-condensing

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Sensitivity and Field of View (FOV)

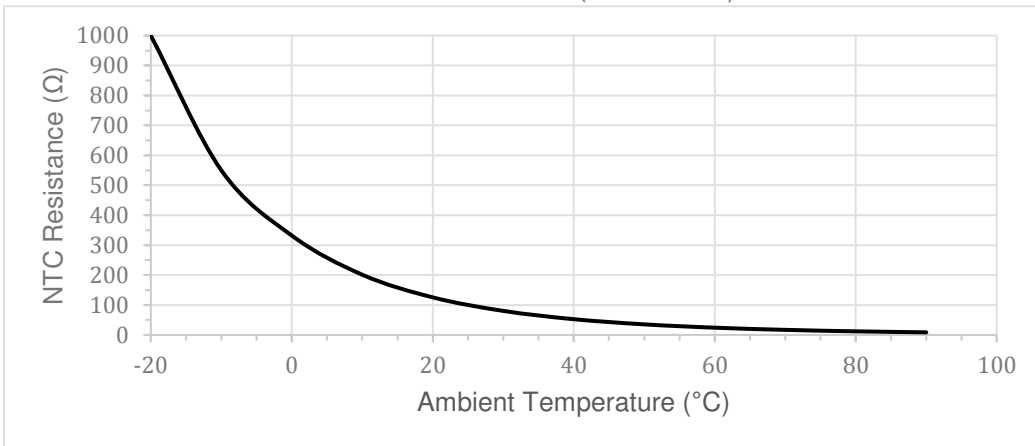


Filter Window Bandpass Characteristics

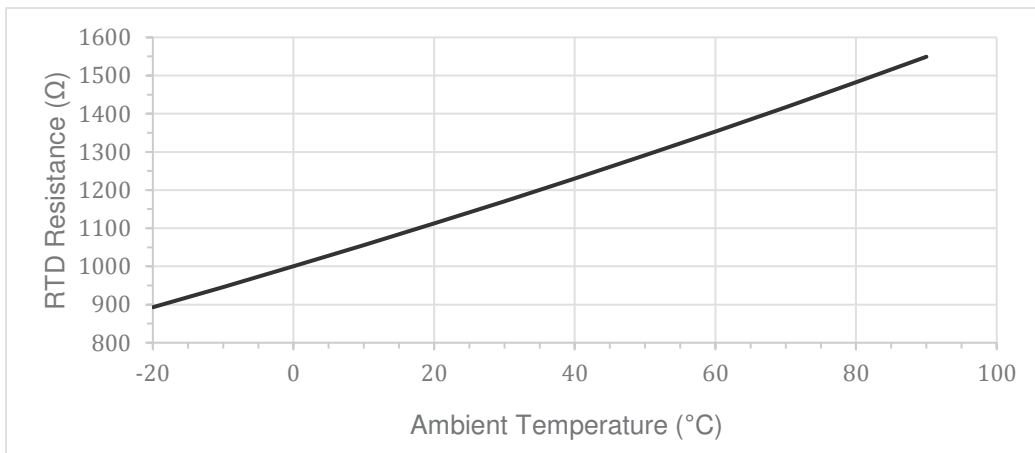


Reference Temperature Sensor Performance

TSxxx-11C55 (Thermistor)

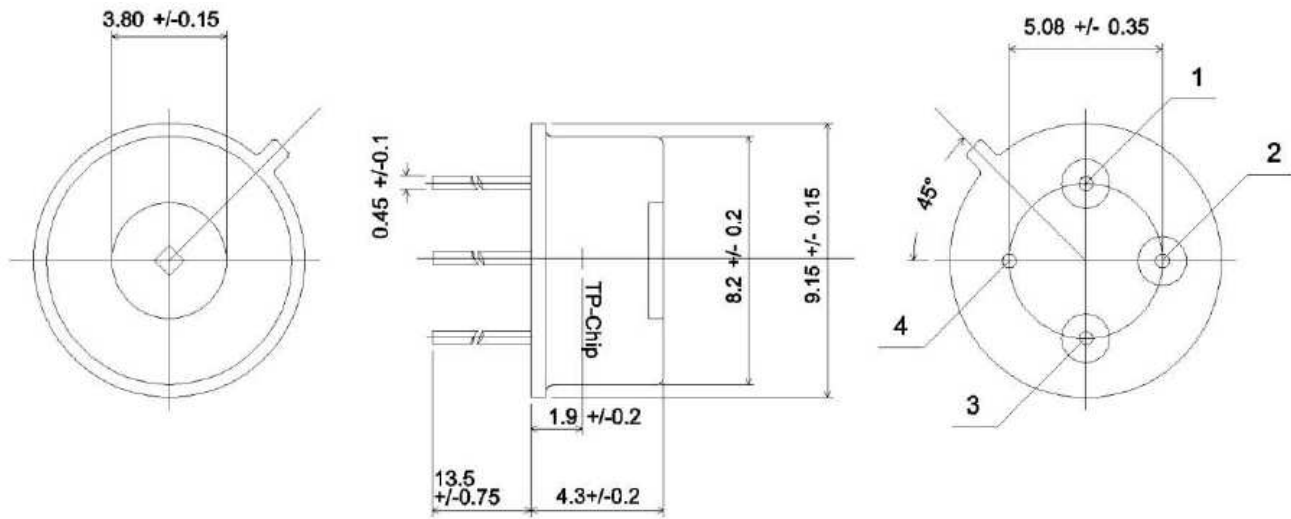


TS318-1B0814 (RTD)

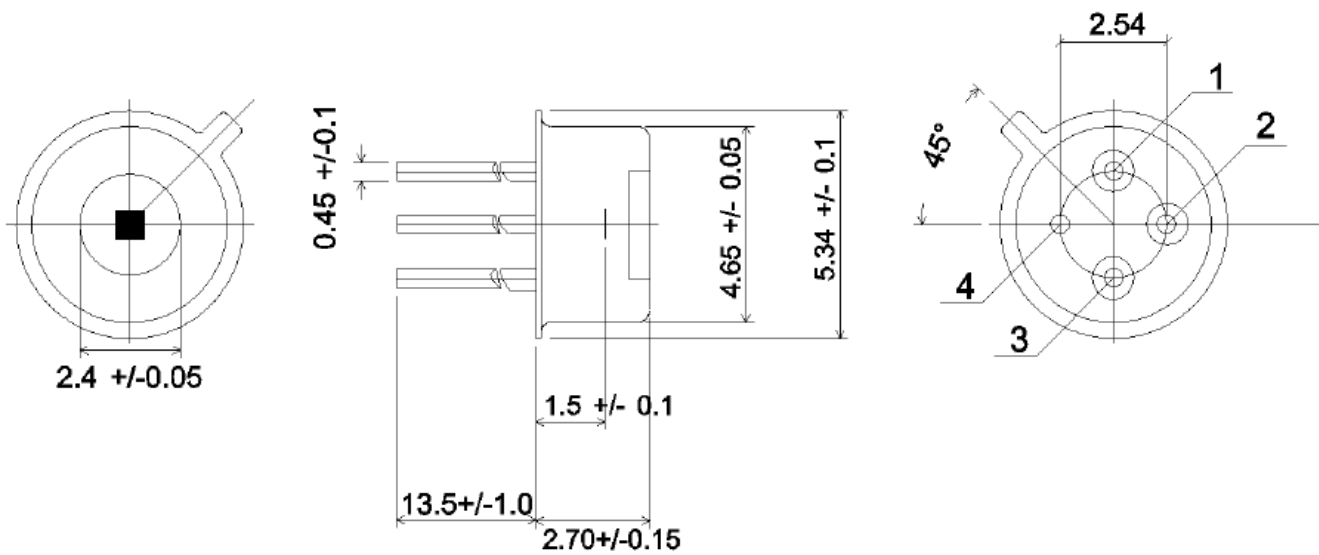


Mechanical Dimensions

TS305-11C55



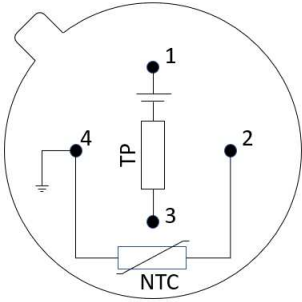
TS318-xxxxx



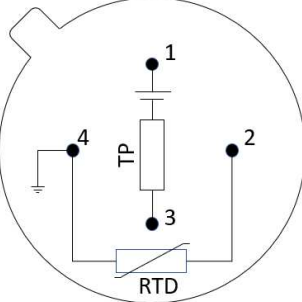
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Internal Schematics and Pin Connections

TSxxx-11C55

PIN	Connection	Schematic
1	Thermopile (+)	 <p>Bottom View</p>
2	NTC Thermistor	
3	Thermopile (-)	
4	Ground	

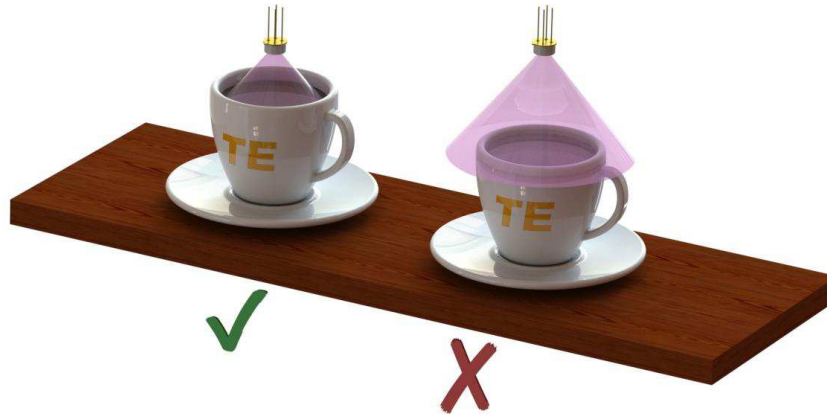
TS318-1B0418

PIN	Connection	Schematic
1	Thermopile (+)	 <p>Bottom View</p>
2	RTD Temperature Sensor	
3	Thermopile (-)	
4	Ground	

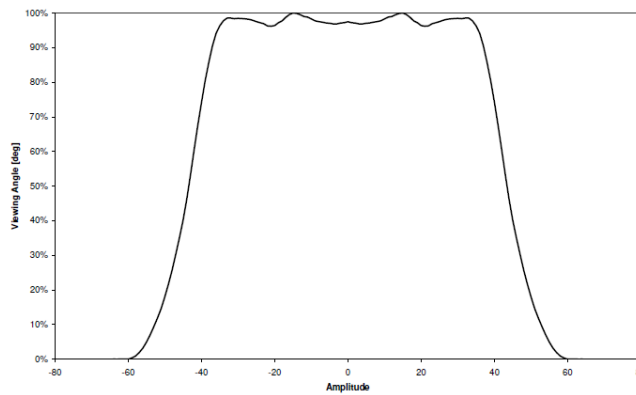
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Field of View

The thermopile's field of view must be directed to the object surface of interest. The distance to the surface or the surface diameter must be adjusted to ensure that the complete sensors field of view is covered by the object, see example on the left in the picture below.

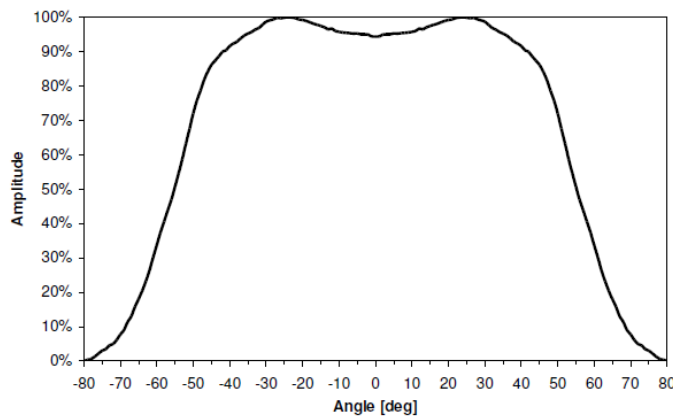


TS305-11C55
FOV = 88°



Distance / mm	Min. Diameter / mm
10	24
20	43
30	62
40	82
50	101
100	198
200	391
300	584
400	777
500	970

TS318-xxxxxx
FOV = 110°



Distance / mm	Min. Diameter / mm
10	35
20	70
30	104
40	139
50	173
100	346
200	693
300	1039
400	1386
500	1732

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Direct Sunlight

Sun light radiation which is transmitted through a glass window may influence the measurement accuracy. To avoid this, the thermopile sensor is equipped with a long wavelength filter. Due to not ideal filter characteristics a small portion of radiation will be added to the radiation of the object.

Touching the Sensors Cap

User should avoid touching the sensors cap. There will still be a measurement deviation after changing the sensors temperature rapidly.

Emissivity

Every object is transmitting infrared energy that is dependent to its temperature. The emissivity is the ratio of the radiated power by an object to the radiation of an ideal black body. Common materials like liquids, clothes, human skin, foods have emissivity factors >0.90 and therefore they can be measured very accurately without altering the sensors specification. For accurate measurements the correct emissivity of the object has to be taken into account.

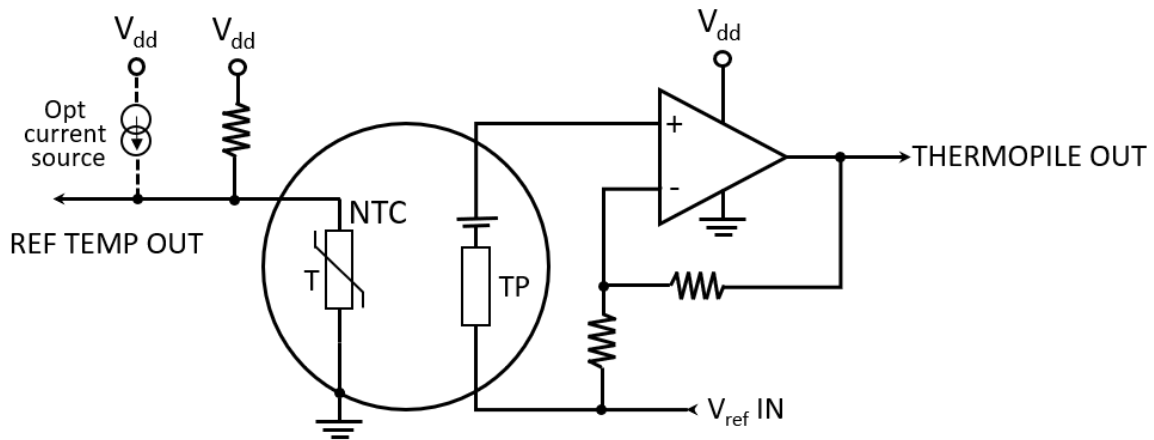
Emissivity of Common Materials

Material	Emissivity
Aluminum	
Polished	0.10 – 0.05
Oxidized	0.10 – 0.40
Rough	0.10 – 0.30
Anodized	0.60 – 0.95
Asphalt	0.90 – 1.00
Brass	
Polished	0.05
Oxidized	0.50 - 0.60
Burnished	0.30
Ceramic	0.90 – 0.95
Copper	
Polished	0.10
Oxidized	0.20 – 0.80
Foods	0.85 – 1.00
Gold	0.05
Glass	
Plate	0.90 – 0.95
Fused quartz	0.75

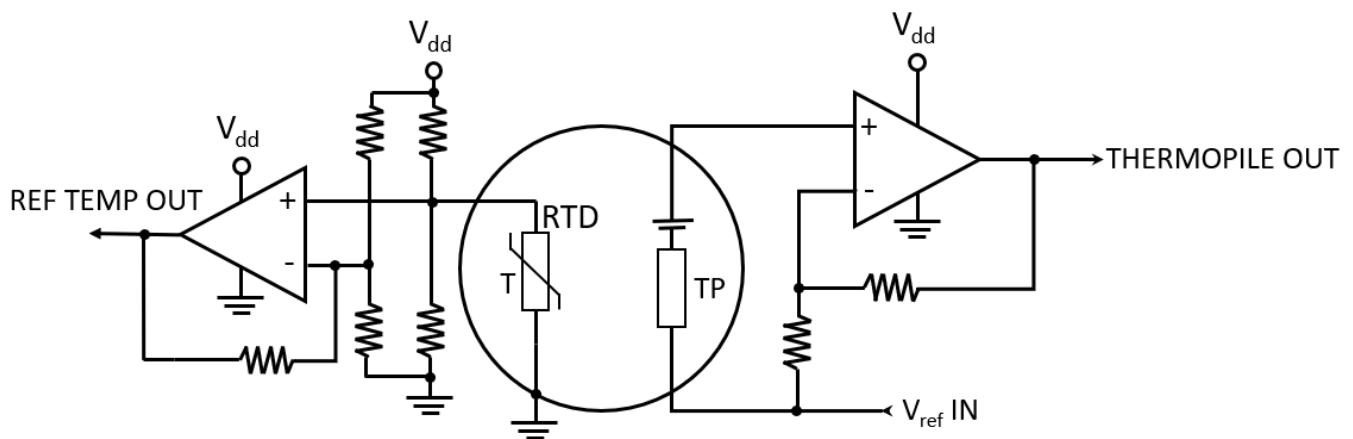
Material	Emissivity
Human Skin	0.99
Iron	
Polished	0.20
Oxidized	0.50 - 0.95
Rusted	0.50 – 0.70
Paint	
Aluminum paint	0.50
Bronze paint	0.80
On metal	0.60 – 0.90
On plastic, wood	0.80 – 0.95
Paper	0.85 – 1.00
Plastic	0.95 – 1.00
Stainless Steel	
Polished	0.10 – 0.15
Oxidized	0.45 - 0.95
Water	
Liquid	0.90 – 0.95
Ice	0.95 – 1.00
Snow	0.80 – 1.00

Circuit Examples

These circuits illustrate simple ways to interface directly to the thermopile and reference temperature sensor outputs. Additional signal processing and circuitry are required to provide an accurate temperature measurement of the target surface. A complete discussion and examples of this additional signal processing are shown in the application notes referenced on the last page of this data sheet.



Interface to NTC Referenced Thermopile

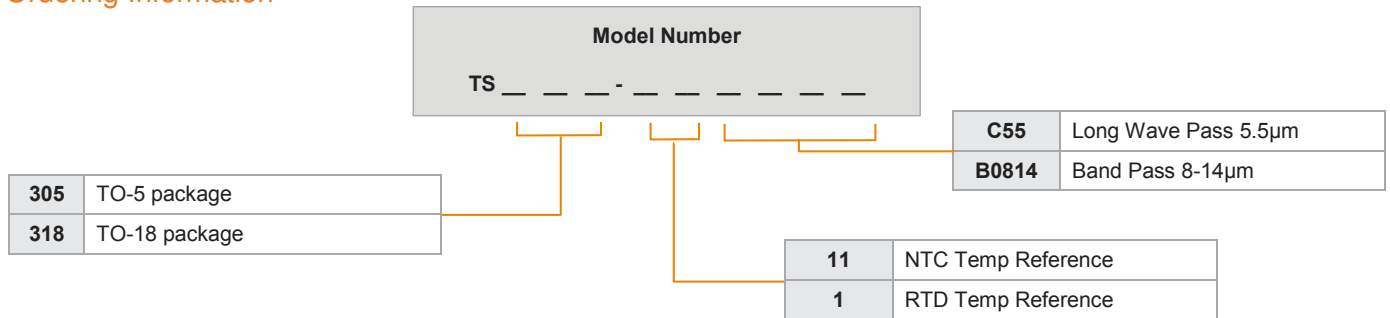


Interface to RTD Referenced Thermopile

Due to the very low output voltage levels of thermopiles (μV to mV), the op-amp should have low input offset voltage, low drift, low input bias and leakage current, and low noise performance. Calibration of the internal temperature reference is required to obtain the best overall system accuracy.

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Ordering Information



Available Configurations

Product Model Number	Part Number	Package	Field of View (50% of max sensitivity)	Voltage Sensitivity ⁽¹⁾	Filter Bandpass	Internal Reference Temperature Sensor
TS305-11C55	G-TPCO-033	TO-5 can	88°	7.0mV	>5.5µm	NTC thermistor, 100kΩ at 25°C
TS318-11C55	G-TPCO-032	TO-18 can	110°	8.4mV	>5.5µm	NTC thermistor, 100kΩ at 25°C
TS318-1B0814	G-TPCO-031	TO-18 can	110°	5.0mV	8-14µm	Nickel RTD, 1000Ω at 0°C

⁽¹⁾T_{amb} = +25°C, T_{obj} = +100°C, FOV totally filled

Application Notes

[Thermopiles Sensor for Contactless Temperature](#)

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NORTH AMERICA
Tel +1 800 522 6752

EUROPE
Tel +31 73 624 6999

ASIA
Tel +86 0400 820 6015

te.com/sensors

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