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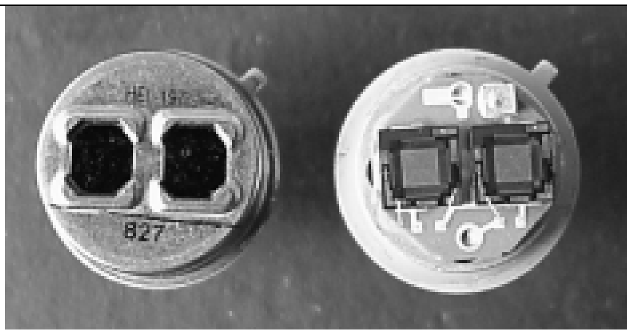
data

product note thermopile sensors

TPS 2534

Dual thermopile sensor with two spectral filters for gas detection

- **Two individual thermopiles with different infrared bandpass filters in TO-5 housing form a 2-channel detector for IR absorption (NDIR) gas sensing.**
- **Features:**
  - **Thermistor temperature reference (30 kΩ) included,**
  - **large signal.**



- **Applications:**
  - **IR absorption (NDIR) gas sensing with reference channel to monitor light source**
- **The device is available with a variety of filter combinations. The standard version employs a reference filter (G20) at the channel T1 and a gas selective filter at channel T2.**
- **Standard devices; TPS 2534 T2 T1 / device number:**
  - **CO_2, ref: TPS 2534 G2 G20 / 3197**
  - **HC, ref: TPS 2534 G5 G20 / 3196**
  - **CO, ref: TPS 2534 G1 G20 / 3195**
  - **CO, HC: TPS 2534 G1 G5 / 3198**
  - **CO_2, NO: TPS 2534 G2 G4 / 3199**
  - **Other combinations on request.**

TPS 2534: 4 pin sensor housing of TO 5 size

connections:

pin 1: thermistor;

pin 2: pos. thermopile contact T2;

pin 3: pos. thermopile contact T1;

pin 4: common ground.

Contents

1 General product description

1.1 Introduction

A thermopile device is a self generating infrared (IR) sensor having an output signal voltage directly proportional to the incident infrared (IR) radiation power and largely independent of the wavelength. An infrared bandpass filter in front of the sensor makes the device sensitive to specific gas absorption bands.

The Heimann TPS 2534 thermopile employs two thermopile chips in a single sensor housing of TO-5 package size with two independently selectable IR windows. This makes the device a 2 channel gas detector or generally speaking, a 2-channel filter spectrometer.

The employed thermopile chips have each a sensitive area of $1.2 \cdot 1.2$ mm^2 for the IR radiation. The sensor comes as a hermetically sealed and dry nitrogen filled metal housing in the size of a TO-5 package with 2 window openings and 4 pin leads. The windows are equipped with IR bandpass filters. A thermistor inside the can serves as temperature sensor and reference for the ambient.

The output voltage as a function of the chopping frequency of the incoming IR radiation corresponds to that of a low pass characteristic. The sensor acts as a voltage generator with a finite source resistance (thermopile resistance) and generates therefore no 1/f noise. Instead, only the thermal white noise resulting from the thermopile resistance is apparent on the output signal.

1.2 Name of the product; device marking

PerkinElmer TPS 2534 T2 T1 dual thermopile sensor.

TP = thermopile, S = single chips, 2 = number of chips, 5 = type of chip (here: absorber 1.2 · 1.2 mm^2), 3 = thermistor as temperature reference, 4 = identifier for cap (here: 2 square holes),

T1, T2: gas filter channels.

Device number: All PerkinElmer thermopiles have an 8 digit device number. The first 4 digits refer to the product group and the manufacturing location. For a thermopile identification therefore only the last 4 digits are relevant.

Example: The device configuration with the filter set G2 (CO_2) G20 (reference) has the 4-digit device number (Heimann Bau No.) 3197. The last three digits of this number are printed on the sensor cap (except on engineering samples). → TPS 2534 G2 G20 / 3197.

For all types of PerkinElmer thermopile engineering samples the device number is 9530 0038.

There are several standard filter configurations available. For their description please refer to chapter 4. For engineering samples with customized filter sets an additional individual data sheet is provided that states the filter position and the connection scheme.

2 Technical data

2.1 General design characteristics

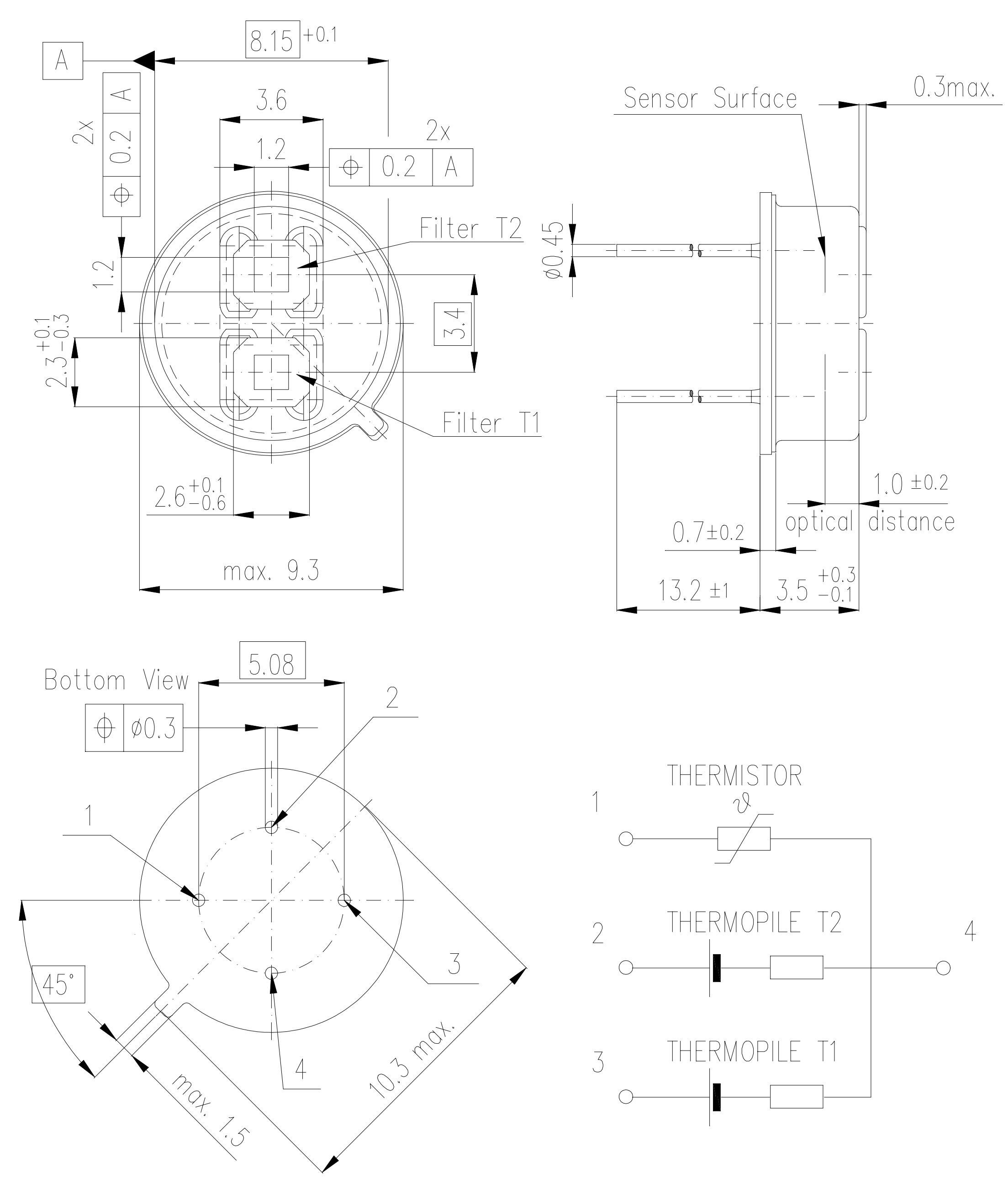
Parameter	Type
Package	TO-39
Header	Ni plated or Gold plated over Ni coating
Leads	SnPb plated over Ni coating or Gold plated over Ni coating
Cap	Nickel alloy
Filter	Silicon based with Heimann IR bandpass coatings
Temperature Reference	Thermistor 30 kΩ
Insulating Gas	Nitrogen
Sealing	The sensor is hermetically sealed to withstand a gross leaktest according to MIL Std.883 method 1014c1.
Device Marking	Manufacturer, date code (3 digits) and part number (3 digits) (except engineering samples)

2.2 Mechanical dimensions and electrical connections

The drawing No. 2/70823 defines the connections, functional block diagram and standard dimensions and tolerances.

The sensor is housed in a TO-5 can (3.5 mm height) with TO-39 base plate having 4 isolated pins. An additional thermistor of 30 kΩ (@ 25°C) is included to measure housing temperature. The connection scheme is shown in the figure. The thermopiles as well as the thermistor utilize the pin number 4 as common junction. None of the pins is connected to the sensor housing.

The cap has two windows of 2.6 x 2.3 mm^2 size each, in which two (different) infrared bandpass filters are hermetically mounted.



Allgemeintoleranzen / GENERAL TOLERANCES ±0.1

Werkstückkanten/EDGES OF WORKING-PARTS ACC. DIN 6784

Form−u.Lagetoleranzen / GEOMETRICAL TOLERANCES

	Datum / DATE	Name / NAME	Werkstoff / MATERIAL
Gez. / DRAWN BY	14.02.97	Tkocz	
Gepr. / CHECKED BY			

EG&G HEIMANN Optoelectronics

Maßstab / SCALE: 5:1

Benennung/TITLE: Dimensions and Connections TPS 2534 4−Pin Dual Element Thermopile with Thermistor

Zeichnung Nr./DRAWING NO. 2/70823

Liefervorschrift/SPECIFICATION

Ersatz für/REPLACEMENT FOR

Ersetzt durch/REPLACED BY

Index NO.	Änderung REVISION	Datum DATE	Name NAME
3	2/3763	09.06.99	Tkocz
2	−	19.03.97	Tkocz
1	−	11.03.97	Tkocz

A4.dwg

2.3 Electrical data

2.3.1 Thermopile

Parameter	Symbol	Limits			Units	Conditions
		Min	*Typ*	*Max*		
Sensitive area	*A*		1.2 · 1.2		mm^2	Absorber size
Field of view	*FOV*		90		°	refer to section 3.2
Resistance of each thermopile (TP)	$R_{THERMOPILE}$	15	40	65	kΩ	
Sensitivity	S_V		42		V/W	500 K blackbody, 1 Hz modulation, without IR filter
Time constant	τ		35		ms	this value is not checked in production
Noise voltage	V_{rms}		30		$nV / Hz^{1/2}$	r.m.s., 25°C, thermal noise
Noise equivalent power	*NEP*		0.7		$nW / Hz^{1/2}$	500 K, 1 Hz, without IR filter
Specific detectivity	*D**		$2.3 \cdot 10^8$		$cm\ Hz^{1/2}$ /W	500 K, 1 Hz, without IR filter
Temperature coefficient of TP resistance	dR_{TP} / dT		0.02	0.1	%/K	
Temperature coefficient of sensitivity	dS / dT		-0.01		%/K	typical

2.3.2 Temperature reference; thermistor

Parameter	Symbol	Limits			Units	Conditions
		Min	*Typ*	*Max*		
Resistance	R_{TH}	28.5	30	30.9	kΩ	At 25°C
BETA-Value	β	3924	3964	4004	K	Defined at 25°C / 100°C

Tabulated thermistor data:

T	Rmin1	Rmin2	Rnom	Rmax2	Rmax1	ΔTmin1	ΔTmin2	ΔTmax2	ΔTmax1
°C	Ω	Ω	Ω	Ω	Ω	°C	°C	°C	°C
-20	250577	264307	274590	284873	293111	-1.58	-0.68	0.68	1.22
-15	191113	201531	208350	215169	221420	-1.54	-0.61	0.61	1.17
-10	146923	154893	159390	163887	168669	-1.49	-0.54	0.54	1.11
-5	113827	119973	122910	125847	129535	-1.43	-0.47	0.47	1.04
0	88824	93599	95490	97381	100246	-1.37	-0.39	0.39	0.98
5	69841	73578	74730	75882	78124	-1.33	-0.32	0.32	0.93
10	55297	58241	58890	59539	61305	-1.34	-0.25	0.25	0.9
15	44016	46352	46710	47068	48470	-1.38	-0.19	0.19	0.91

T	Rmin1	Rmin2	Rnom	Rmax2	Rmax1	ΔTmin1	ΔTmin2	ΔTmax2	ΔTmax1
°C	Ω	Ω	Ω	Ω	Ω	°C	°C	°C	°C
20	35330	37196	37320	37444	38563	-1.24	-0.08	0.08	0.78
25	28500	30000	30000	30000	30900	-1.17	0	0	0.7
30	22930	24143	24250	24357	25085	-1.3	-0.11	0.11	0.82
35	18570	19556	19720	19884	20475	-1.42	-0.21	0.21	0.94
40	15118	15924	16120	16316	16799	-1.56	-0.31	0.31	1.06
45	12383	13045	13250	13455	13852	-1.7	-0.41	0.41	1.18
50	10197	10744	10950	11156	11484	-1.84	-0.51	0.51	1.31
55	8434	8888	9090	9292	9564	-1.99	-0.62	0.62	1.44
60	7010	7389	7581	7773	8001	-2.13	-0.72	0.72	1.57
65	5858	6176	6354	6532	6723	-2.25	-0.81	0.81	1.68
70	4916	5183	5349	5515	5675	-2.38	-0.92	0.92	1.79
75	4146	4372	4524	4676	4812	-2.5	-1.01	1.01	1.9
80	3508	3700	3840	3980	4095	-2.63	-1.11	1.11	2.02
85	2981	3145	3273	3401	3500	-2.77	-1.22	1.22	2.15
90	2542	2682	2799	2916	3000	-2.93	-1.34	1.34	2.29
95	2179	2299	2405	2511	2583	-3.11	-1.46	1.46	2.45
100	1873	1977	2073	2169	2231	-3.34	-1.6	1.6	2.64

Rmin1 : Minimum Thermistor Resistance resulting from the Total Tolerance
Rmin2 : Minimum Thermistor Resistance resulting from the Gradient (BETA) Tolerance
Rnom : Typical Thermistor Resistance
Rmax1: Maximum Thermistor Resistance resulting from the Total Tolerance
Rmax2: Maximum Thermistor Resistance resulting from the Gradient (BETA) Tolerance
ΔTmin1: Temperature Deviation calculated from Rmin1
ΔTmin2: Temperature Deviation calculated from Rmin2
ΔTmax1: Temperature Deviation calculated from Rmax1
ΔTmax2: Temperature Deviation calculated from Rmax2

2.4 Absolute maximum ratings; handling requirements

Parameter	Symbol	Limits			Units	Conditions
		Min	*Typ*	*Max*		
Ambient Temperature Range		-40		100	°C	Operation / Storage

Stresses above the absolute maximum ratings may cause damages to the device.

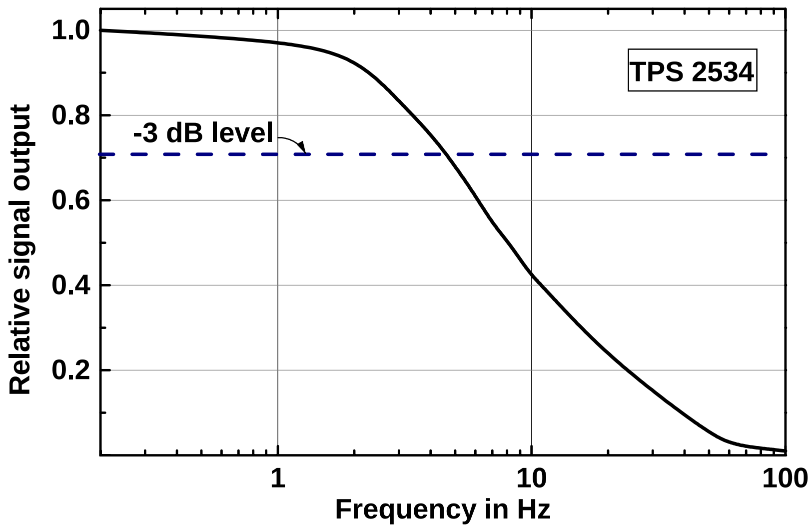
The sensor can be damaged by electrostatic discharges. Please take appropriate precautions for the handling.

Do not expose the sensors to aggressive detergents such as freon, trichlorethylene, etc. Windows may be cleaned with alcohol and cotton swab. The thermopile sensors can be damaged by electrostatic discharges. Please take appropriate precautions for the handling.

Hand soldering and wave soldering may be applied with a maximum temperature of 260°C for a dwell time less than 10s. Avoid heat exposure to the top and the window of the detector. Reflow soldering is not recommended.

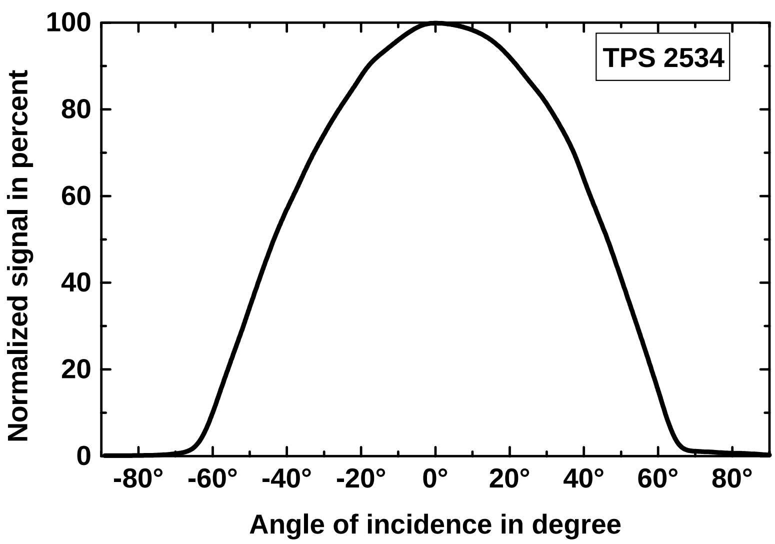
3 Typical performance characteristics

3.1 Frequency behavior of the thermopile output voltage



The figure shows the relative signal output as a function of the thermal signal chopping frequency. The -3 dB level at 71% relative output level defines the cutoff frequency f_{co} and thus the time constant τ via $\tau = 1/2\pi\ f_{co}$.

3.2 Field of view



The graph shows the thermopile response as a function of the radiation incidence angle -90...+90°. Defining the field of view as the angle range, where the relative signal drops to 50% of its maximum value, the value of 90° is derived.

3.3 Positioning in respect to other PerkinElmer thermopile sensors

From the function and properties, the PerkinElmer dual sensor is a combination of two TPS 535 thermopiles. This dual combination allows a more compact design than two single TPS 535. There is also a cost advantage. In terms of output signal and electrical properties there is almost no difference between the types TPS 535 and TPS 2534.

In most applications, the second window carries a reference filter that allows the monitoring of the IR source.

4 Sensor types

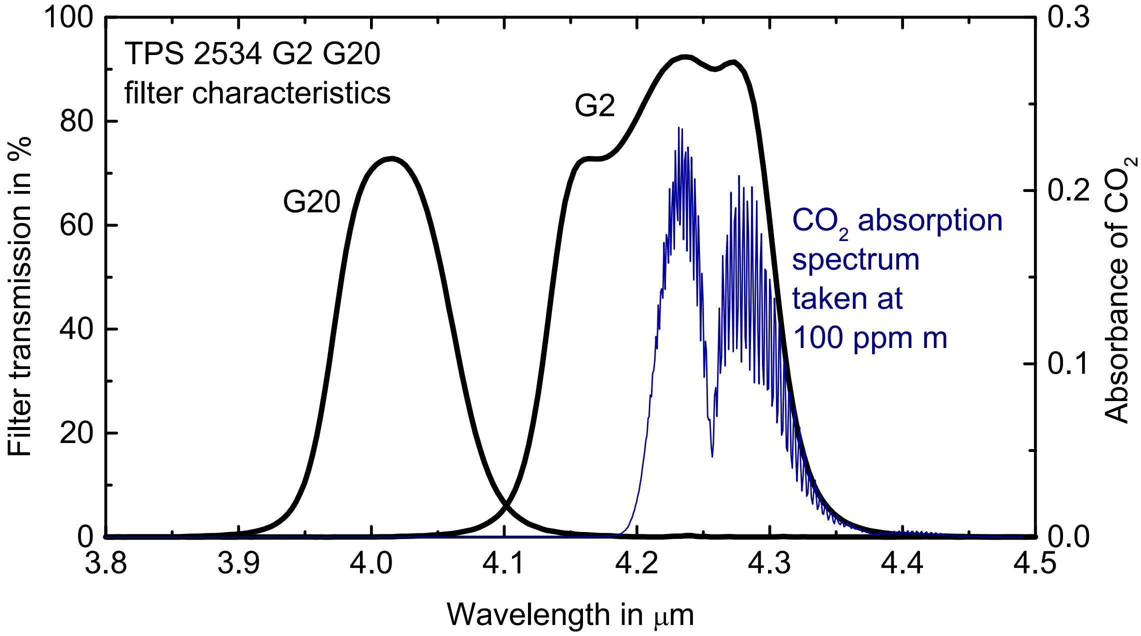
The TPS 2534 thermopile detector is available in several standard filter sets, which are described in the following sections. You can identify a sensor by the respective device number printed on the package (except engineering samples).

4.1 TPS 2534 G2 G20; device number 3197

This dual sensor is for CO_2 gas detection. The G2 filter is located in the region of the strongest CO_2 absorption. Its application is only recommended if the product of CO_2 concentration and absorption length does not exceed a value of 10000 ppm·m.

It is especially suited for air quality control devices – here the measurement range is typically 0....5000 ppm – where very short path lengths below 5 cm are employed.

For exhaust emission control, where CO_2 concentrations up to 20% appear, the path length should consequently not exceed 5 cm. If longer absorption chambers are to be employed, the filter G2.2 instead G2 has to be used. (See the PerkinElmer Optoelectronics information sheet on infrared filters.)



The graph shows the positions of the two filters G20 (channel T1) reference and G2 (channel T2) CO_2 on the wavelength scale together with the CO_2 absorption spectrum. The detailed specifications of the infrared filters are given in the table.

Filter specifications of TPS 4339 G2 G20 / 3197

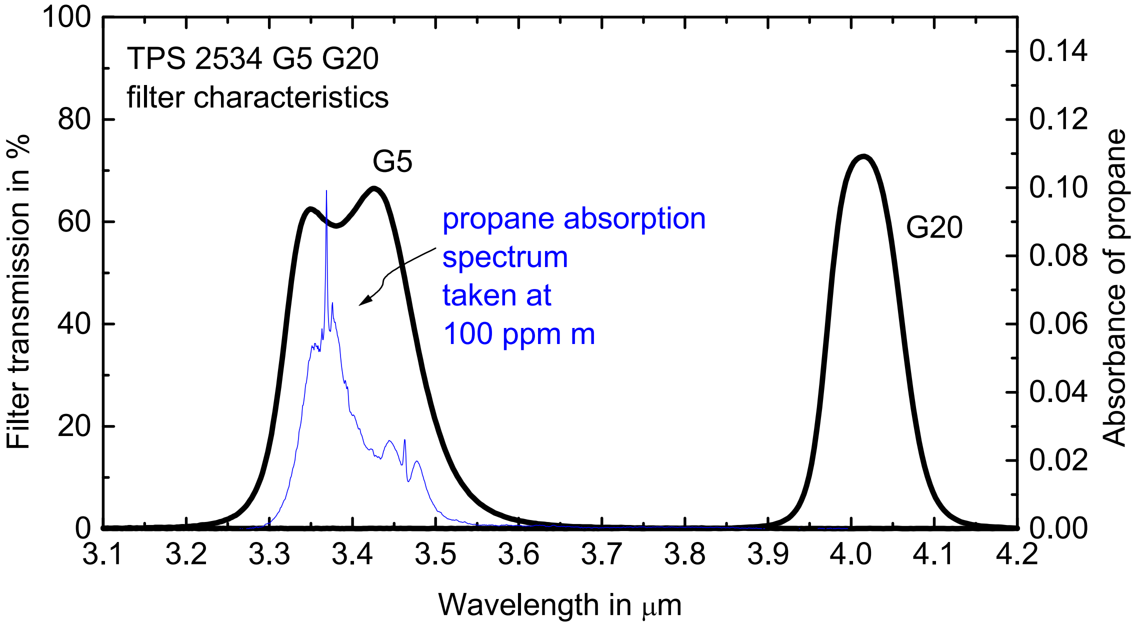
Channel number	**T1**	**T2**
Filter Identifier	**G 20**	**G2**
Matched to gas	reference	CO_2
Center wavelength (CWL)	4.0 µm	4.26 µm
CWL tolerance	±2%	±1%
Half power bandwidth (HPB)	90 nm	180 nm
HPB tolerance	±20 nm	±20 nm
HPB / CWL	2.3%	4.2%
Peak transmittance	>76%	>73%
Average transmittance from visual to bandpass region	≤0.1%	≤0.1%
Peak transmission value from visual to bandpass region	≤1%	≤1%
Peak transmittance from bandpass region to 8 µm	<1%	<1%
Typical filter thickness	0.525 mm	0.525 mm
Substrate material	silicon	silicon

4.2 TPS 2534 G5 G20; device number 3196

This dual sensor is for the detection of gaseous hydrocarbons (HC). The G5 filter is located in a region, where especially ethane and propane have their strongest absorption.

There are other HC filters available. See the PerkinElmer Optoelectronics product information on infrared filters.

The following graph shows the positions of the two filters G20 (channel T1) reference and G2 (channel T2) HC on the wavelength scale together with the propane absorption spectrum. The detailed specifications of the infrared filters are given in the table.



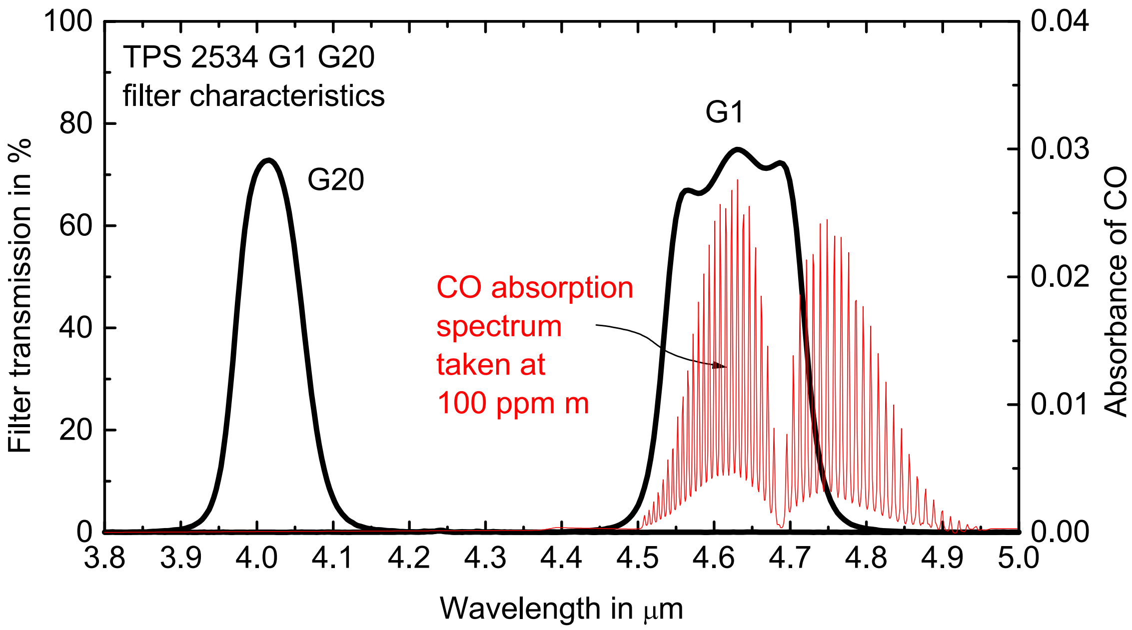
Filter specifications of TPS 2534 G5 G20 / 3196

Channel number	**T1**	**T2**
Filter Identifier	**G 20**	**G5**
Matched to gas	reference	HC (ethane, propane)
Center wavelength (CWL)	4.0 µm	3.4 µm
CWL tolerance	±2%	±2%
Half power bandwidth (HPB)	90 nm	180 nm
HPB tolerance	±20 nm	±20 nm
HPB / CWL	2.3%	5.3%
Peak transmittance	>76%	>76%
Average transmittance from visual to bandpass region	≤0.1%	≤0.1%
Peak transmission value from visual to bandpass region	≤1%	≤1%
Peak transmittance from bandpass region to 8 µm	<1%	<1%
Typical filter thickness	0.525 mm	0.525 mm
Substrate material	silicon	silicon

4.3 TPS 2534 G1 G20; device number 3195

This dual sensor is for the detection of carbon monoxide (CO). The respective G1 filter covers the R-branch of the CO absorption.

The following graph shows the positions of the two filters G20 (channel T1) reference and G1 (channel T2) CO on the wavelength scale together with the carbon monoxide absorption spectrum. The detailed specifications of the infrared filters are given in the table.



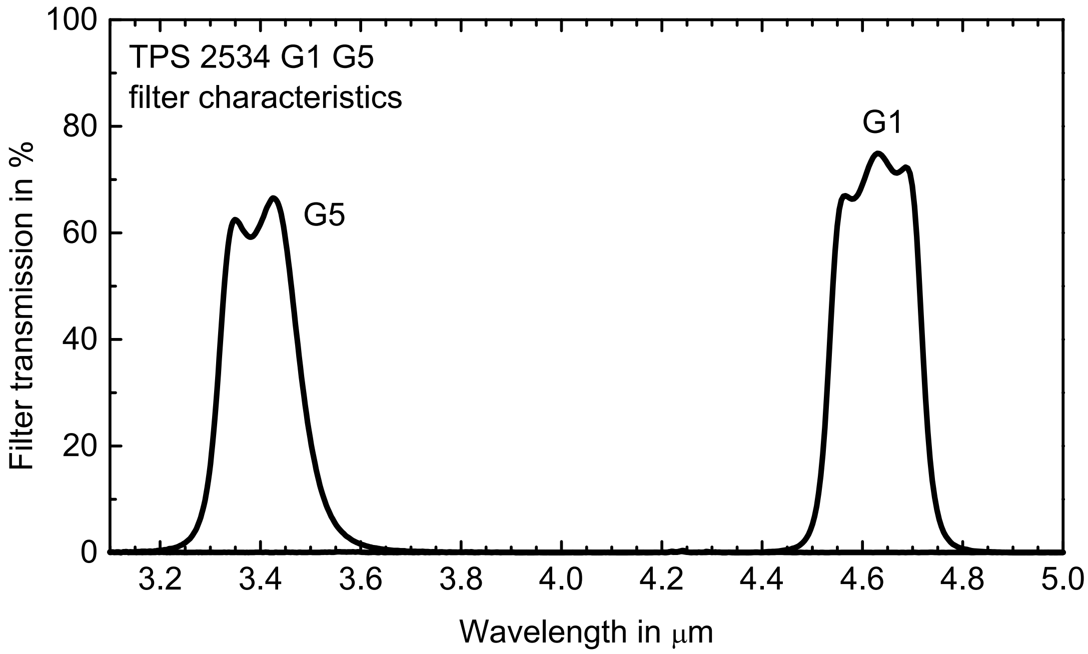
Filter specifications of TPS 2534 G1 G20 / 3195

Channel number	**T1**	**T2**
Filter Identifier	**G 20**	**G1**
Matched to gas	reference	CO
Center wavelength (CWL)	4.0 µm	4.64 µm
CWL tolerance	±2%	±1%
Half power bandwidth (HPB)	90 nm	180 nm
HPB tolerance	±20 nm	±20 nm
HPB / CWL	2.3%	4%
Peak transmittance	>76%	>73%
Average transmittance from visual to bandpass region	≤0.1%	≤0.1%
Peak transmission value from visual to bandpass region	≤1%	≤1%
Peak transmittance from bandpass region to 8 µm	<1%	<1%
Typical filter thickness	0.525 mm	0.525 mm
Substrate material	silicon	silicon

4.4 TPS 2534 G1 G5; device number 3198

This dual sensor is for the simultaneous detection of hydrocarbon through the G5 filter and carbon monoxide through the G1 filter. There is no reference channel.

The following graph shows the positions of the two filters G5 (channel T1) HC and G1 (channel T2) CO on the wavelength scale. The detailed specifications of the infrared filters are given in the table.



Filter specifications of TPS 2534 G1 G5 / 3198

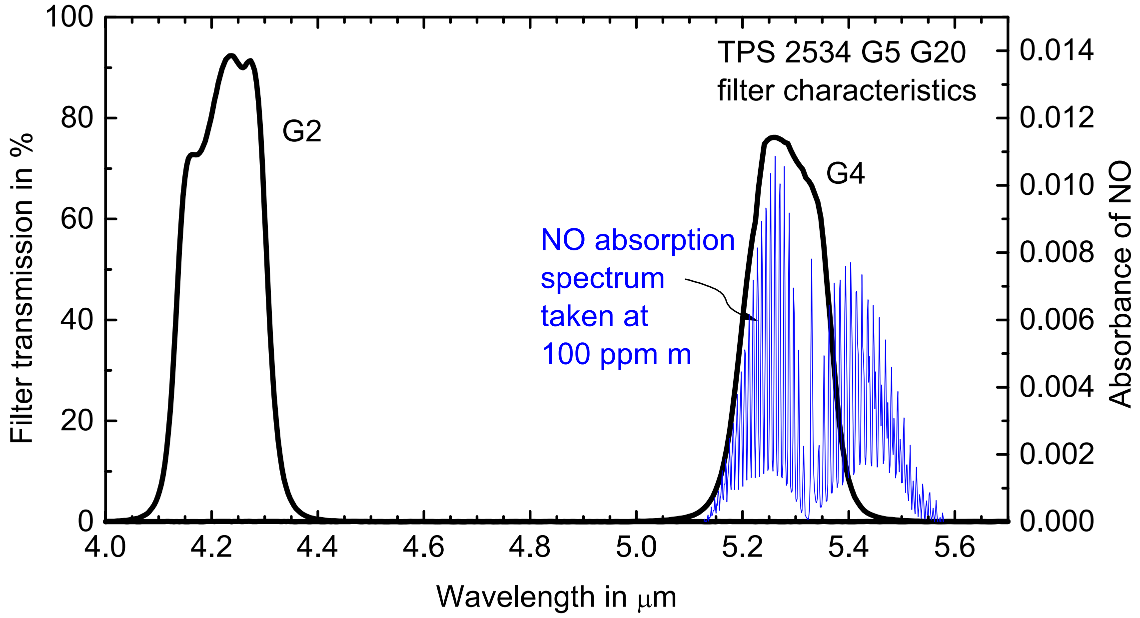
Channel number	**T1**	**T2**
Filter Identifier	**G5**	**G1**
Matched to gas	HC (ethane, propane)	CO
Center wavelength (CWL)	3.4 µm	4.64 µm
CWL tolerance	±2%	±1%
Half power bandwidth (HPB)	180 nm	180 nm
HPB tolerance	±20 nm	±20 nm
HPB / CWL	5.3%	4%
Peak transmittance	>76%	>73%
Average transmittance from visual to bandpass region	≤0.1%	≤0.1%
Peak transmission value from visual to bandpass region	≤1%	≤1%
Peak transmittance from bandpass region to 8 µm	<1%	<1%

Channel number	T1	T2
Filter Identifier	G5	G1
Typical filter thickness	0.525 mm	0.525 mm
Substrate material	silicon	silicon

4.5 TPS 2534 G2 G4; device number 3199

This dual sensor is for the simultaneous detection of nitric oxide through the G4 filter and carbon dioxide through the G2 filter. There is no reference channel. The G4 filter sits on the R-branch of the NO absorption in order to minimize the influence by water absorption.

The following graph shows the positions of the two filters G4 (channel T1) NO and G2 (channel T2) CO_2 on the wavelength scale together with the NO absorption spectrum. The detailed specifications of the infrared filters are given in the table.



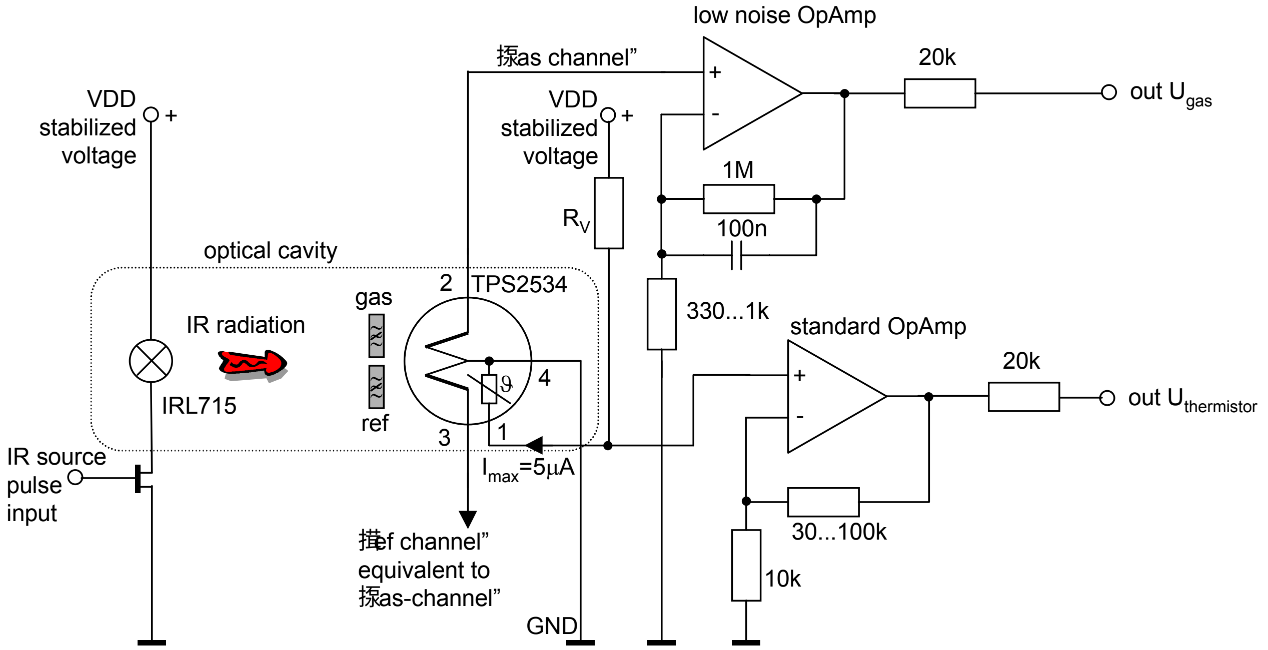
Filter specifications of TPS 2534 G2 G4 / 3199

Channel number	T1	T2
Filter Identifier	G4	G2
Matched to gas	NO	CO_2
Center wavelength (CWL)	5.3 µm	4.26 µm
CWL tolerance	±1%	±1%
Half power bandwidth (HPB)	180 nm	180 nm
HPB tolerance	±20 nm	±20 nm
HPB / CWL	3.4%	4.2%
Peak transmittance	>73%	>73%
Average transmittance from visual to bandpass region	≤0.1%	≤0.1%

Channel number	T1	T2
Filter Identifier	G4	G2
Peak transmission value from visual to bandpass region	≤1%	≤1%
Peak transmittance from bandpass region to 8 µm	<1%	<1%
Typical filter thickness	0.525 mm	0.525 mm
Substrate material	silicon	silicon

5 Application hints

A thermopile behaves as a voltage generator with an internal resistance. The output signals are very small and need amplification. The sketch below shows a standard circuit for the first signal conditioning stage in a thermopile-based IR absorption gas detector.



To amplify the thermopile signals, select a low noise operational amplifier. Recommended types are e.g. Intersil Harris ICL7650, Linear technology LT1112 (Dual) / LT1114 (Quad), or Analog Devices AD8551 / AD8552 / AD8571 / AD8572. Attention: If you do not employ a rail-to-rail amplifier, either a dual polarity power supply or a bandgap voltage is needed.

The thermistor serial resistor, R_v, has to be designed to a value to make sure, that the maximum current through the thermistor will not exceed about 5 µA. For higher values, signal fluctuations due to heating effects may occur.

6 Quality statement

PerkinElmer Optoelectronics is an ISO 9001 certified manufacturer with established SPC and TQM. All materials are checked according to specifications and final goods meet the specified tests.

All devices employing PCB assemblies are manufactured according IPC-A-610C guidelines.

7 Contact PerkinElmer Optoelectronics

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Customers considering the use of PerkinElmer Optoelectronics thermopile devices in special applications where failure or abnormal operation may directly affect human lives or cause physical injury or property damage, or where extremely high levels of reliability are demanded, are requested to consult with PerkinElmer Optoelectronics sales representatives before such use. The company will not be responsible for damage arising from such use without prior approval.

As any semiconductor device, thermopile sensors or modules have inherently a certain rate of failure. It is therefore necessary to protect against injury, damage or loss from such failures by incorporating safety design measures into the equipment.