Low Cost Non Contact Temperature Measurement by THERMOPILE MODULES

Technical Information for TPM with Mirror Optics

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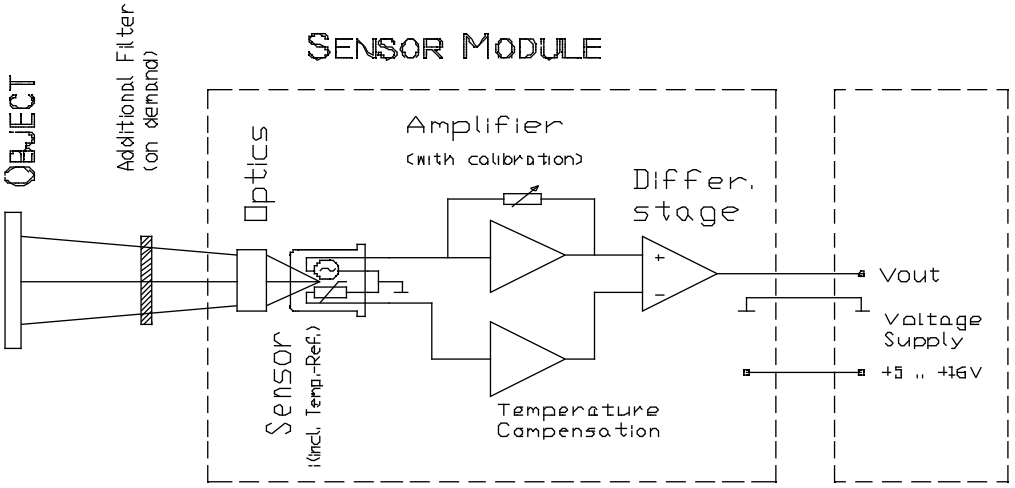
1 SCOPE

1.1 PURPOSE

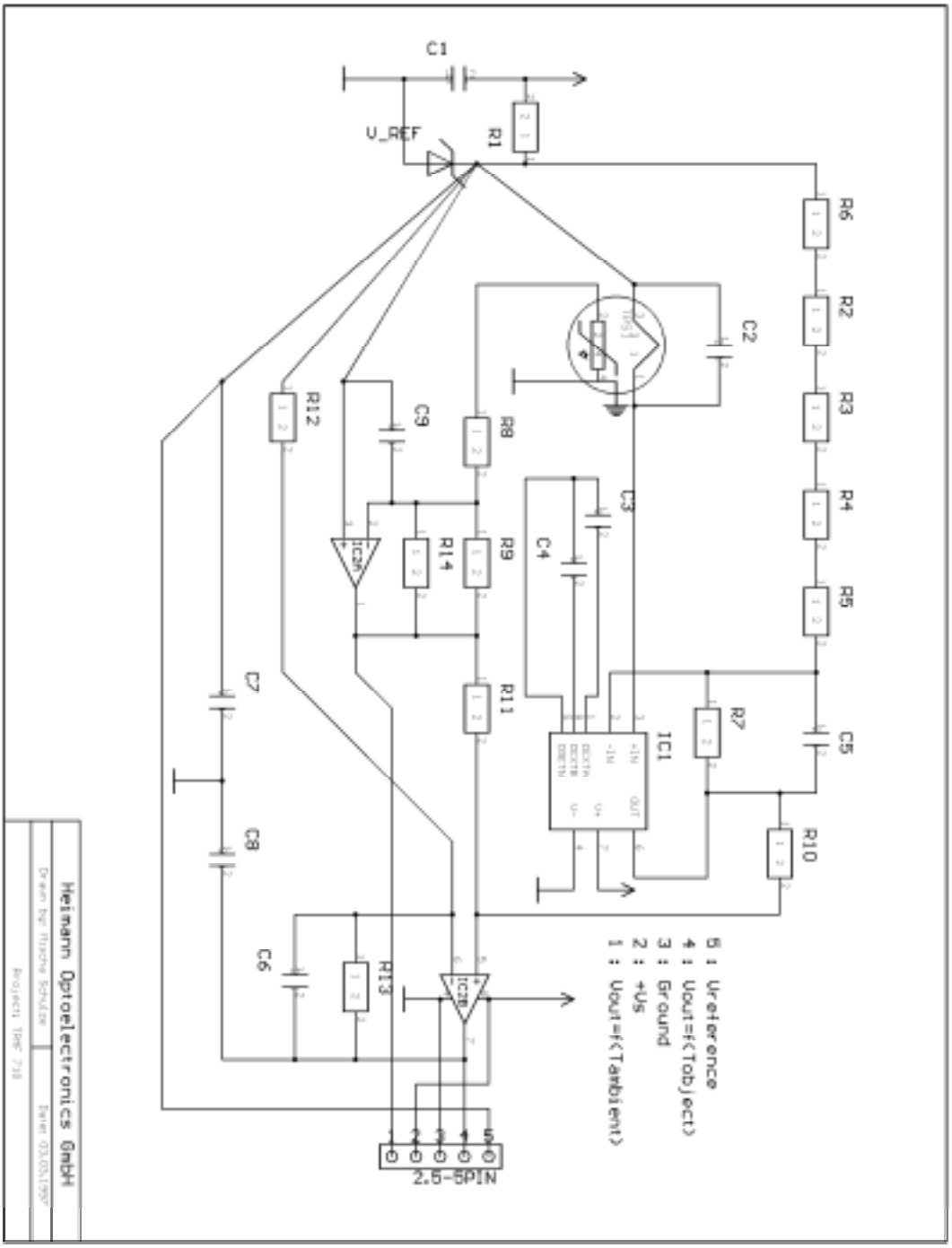
This measurement system is used for the non-contact measurement of surface temperatures based on IR-radiation. The thermopile sensor is integrated in an ambient temperature compensated module with mirror or lens optics. An additional IR-window can be used for protection against contamination and condensation. The standard system is optimised to an object emission near 95%, but it can be modified to respective application conditions.

1.2 SCHEMATIC

The following drawing shows the principle of the measurement and circuitry :



Picture 1 : Schematic of the Thermopile Module


C1
U_REF
R1
R6
R2
R3
R4
R5
C2
R12
C9
R8
C3
C4
R14
R9
R11
R7
C5
IC1
C7
C8
R10
C6
R13
2.5-5PIN
5 : Ureference
4 : Uout=f(Tobject)
3 : Ground
2 : +Us
1 : Uout=f(Tambient)
Heimann Optoelectronics GmbH

Proposed partlist according to standard type 1 :

Part	*Value*	*Package*
R1	50kΩ	SMD 0805
R2	25Ω	SMD 0805
R3	50Ω	SMD 0805
R4	100Ω	SMD 0805
R5	200Ω	SMD 0805
R6	1kΩ	SMD 0805
R7	1.5MΩ 1)	SMD 0805
R8	6.8kΩ	SMD 0805
R9	11kΩ 1)	SMD 0805
R10	10kΩ	SMD 0805
R11	10kΩ	SMD 0805
R12	10kΩ	SMD 0805
R13	10kΩ	SMD 0805
R14	-	-
C1	100nF	SMD 0805
C2	100nF	SMD 0805
C3	100nF	SMD 0805
C4	100nF	SMD 0805
C5	10nF 1)	SMD 0805
C6	100nF	SMD 0805
C7	-	-
C8	-	-
C9	-	-
IC1	ICL7650CSA	SO8
	H7650SCBA-1	SO8
	LTC1050	SO8
IC2	LM358/LM258	SO8
	LM2904	SO8
V_REF	LM4041DIM3-1.2	SOT23
	AD1580ART	SOT23
TPS1	TPS434	TO5

1) These devices are changed depending on the module type.

2 GENERAL CHARACTERISTICS

2.1 DESIGN CHARACTERISTICS

Standard Infrared Sensor	HEIMANN TPS434
Sensor Spectral Range	HEIMANN Standard Filter
Protection Filter Spectral Range	1) HEIMANN Standard Filter 2) HEIMANN G12 Filter (Uncoated Silicon)
Optics	Ellipsoid Mirror
Case	Aluminium Die Cast Box

Table 1 : Design Characteristics of the Common Module Types

Note : The additional protection filter should be used to prevent the optics against contamination and condensation. The standard types of modules work properly with the additional protection filter only.

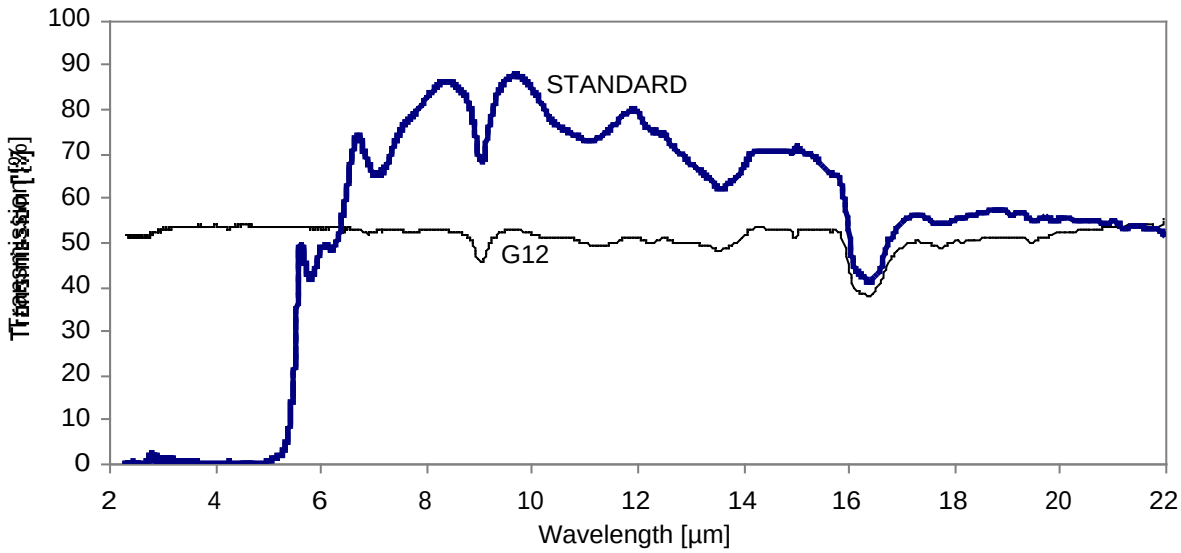


Diagram 1: Sample Filter Transmission Curve of the Standard Filter.

2.2 ABSOLUTE MAXIMUM RATINGS

Supply Voltage (Single Power Supply)	+18V
Storage Temperature Range	-40°C to 100°C

Table 2 : Absolute Maximum Ratings

2.3 OPERATING CONDITIONS

Supply Voltage (Single Power Supply)	+5V .. +16V

Output Voltage Swing	0V .. (Vsupply - 2V)
Supply Current (RL $\rightarrow\infty$) at V+ 5V	1.5 mA (typical) ; 5 mA (maximum)
Power Supply Rejection Ratio	50 dB (minimum)
Output Current (Short Circuit to Ground)	60 mA (maximum)
Response Time	20 ms (typical)
Operating Object Range	Measurements to 2000°C
Operating Ambient Range	-20°C .. 100°C

Table 3 : Operating Conditions

2.4 HANDLING REQUIREMENTS

Stresses above the absolute maximum ratings may cause damages to the device. Short circuits from the output to V+ can cause destruction's. Regarding to short circuits to ground, the maximum output current is approximately 60mA independent of V+. Continuous short-circuits at values of supply voltage in excess of +15VDC might cause destruction's.
Precautions should be taken to avoid reverse polarity of power supply. Reversed polarity of power supply results in a destroyed unit.
The module can be damaged by electrostatic discharges. Please take appropriate precautions for the handling.
Do not expose the sensor's to aggressive detergents such as freon, trichlorethylen, etc. Windows may be cleaned with alcohol and cotton swab.
Hand soldering may be applied by a maximum temperature of 300°C for a dwell time less than 10s.

2.5 APPLICATION HINTS

2.5.1 Connection Requirements

Capacitive loads which are applied directly to the outputs reduce the loop stability margin. Values of 50 pF can be accommodated using the worst-case unity gain connection. A resistive isolation should be used If larger load capacitance must be driven.

2.5.2 Ambient Temperature Compensation

The thermopile sensor converts the temperature radiation of an object surface to an electrical signal by thermocouples (Seebeck effect). The sensor output voltage is caused by the temperature difference between radiation heated (hot) junctions and cold junctions with a good thermal contact to the housing. The changing of the housing (cold junction) temperature have to be detected to get the right output signal depending on the object radiation only. The sensor module is designed to compensate the ambient (sensor) temperature changing by a hardware adjustment. Because of many physical

affects are influencing the non-contact temperature measurement based on infrared radiation, it is difficult to have the best initial adjustment for the different applications. Therefore some deviations could be found at first measuring. For all applications the optimised solution can be prepared and fixed based on the measurement in the application. Don't hesitate to contact the marketing or engineering department for support.
The temperature compensation is working right in an ambient temperature range, limited by different device parameters of the thermopile sensor and the thermistor. Please have a look to the following diagram for better understanding of the principle compensation curve. The central curve shows the deviation for an optimum working of a compensated module type 1. The other curves are showing the maximum deviation for the same module type at the specified object temperature (worst case).
The compensation of the mentioned module type is adjusted to the best fitting at 20°C to 60°C ambient temperature.

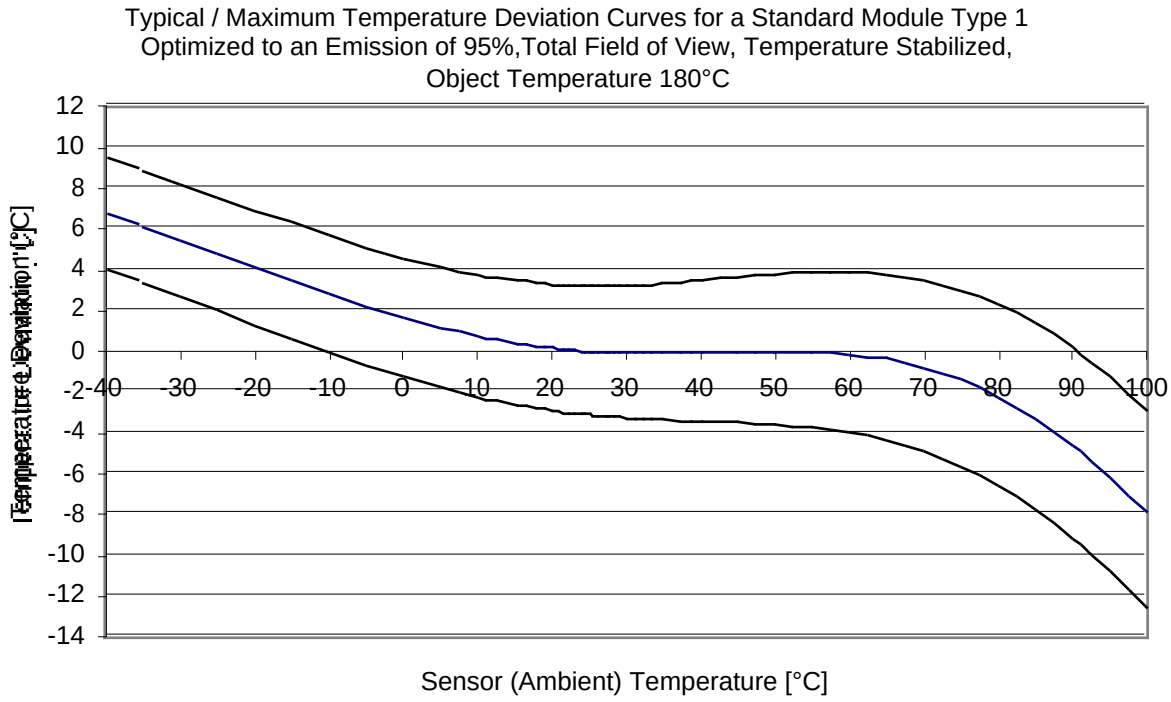


Diagram 2 : Typical and Maximum Temperature Deviation of a Module Type 1

2.5.3 Measuring Tolerances

The measuring tolerance of the sensor modules depends on the emissivity, object temperature, object size to spot size relation, temperature gradients on the sensor, device tolerances and the optimal adjustment of the ambient temperature compensation as basis for the measurement in a wide ambient range.
The following diagram shows the 'worst case' temperature tolerances at different object (black body) temperatures need to be added to the typical compensation curve for a standard module type 1.

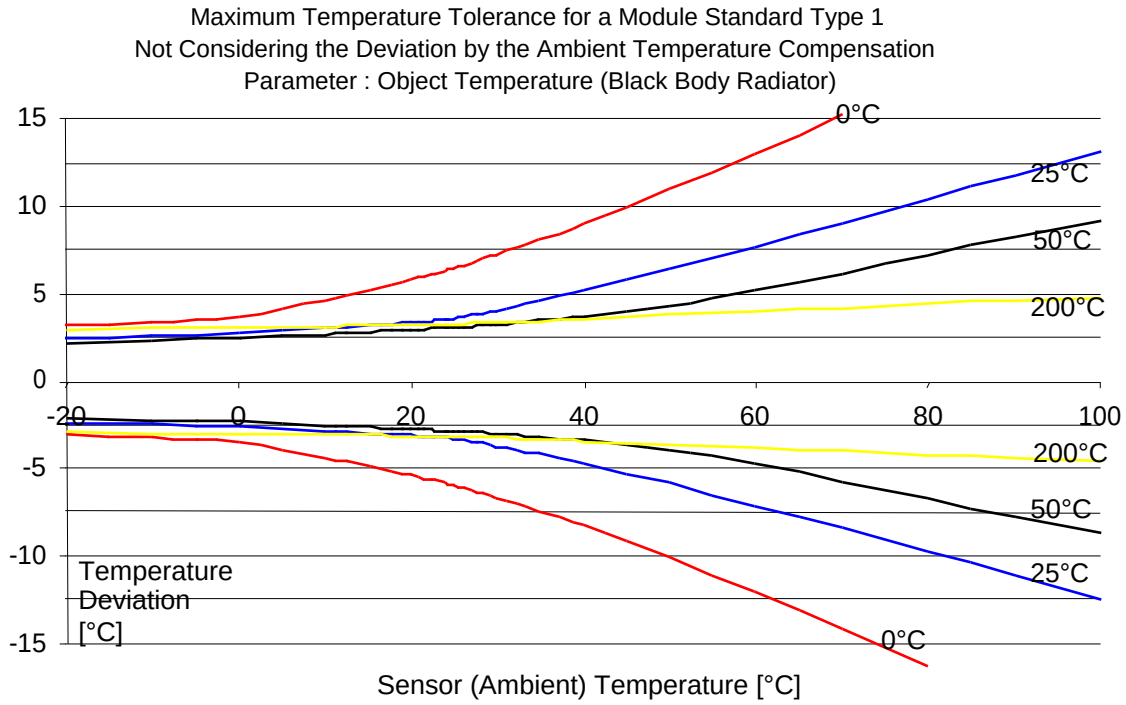


Diagram 3 : Maximum Temperature Deviation of a Module Type 1

2.5.4 Applications Adjustment

Don't hesitate to contact us, if the sensor modules show problems in your special application. The sensor module can be adjusted to the different requirements of most applications. If possible, please give following information's to allow us better support :

* Object temperature range
* Object (surface) emissivity
* Ambient temperature range
* Temperature accuracy of measurement at object and ambient temperature ranges
* Field of view (spot size and measuring distance)
* Sensor module with a special case
* Measuring data of the sensor module in your application (for the optimal adjustment of the ambient temperature compensation) like the following :

Tobject	Tambient	Vout(Tsensor)	Vout(Tobject)
:	:	:	:

The measuring conditions should be :

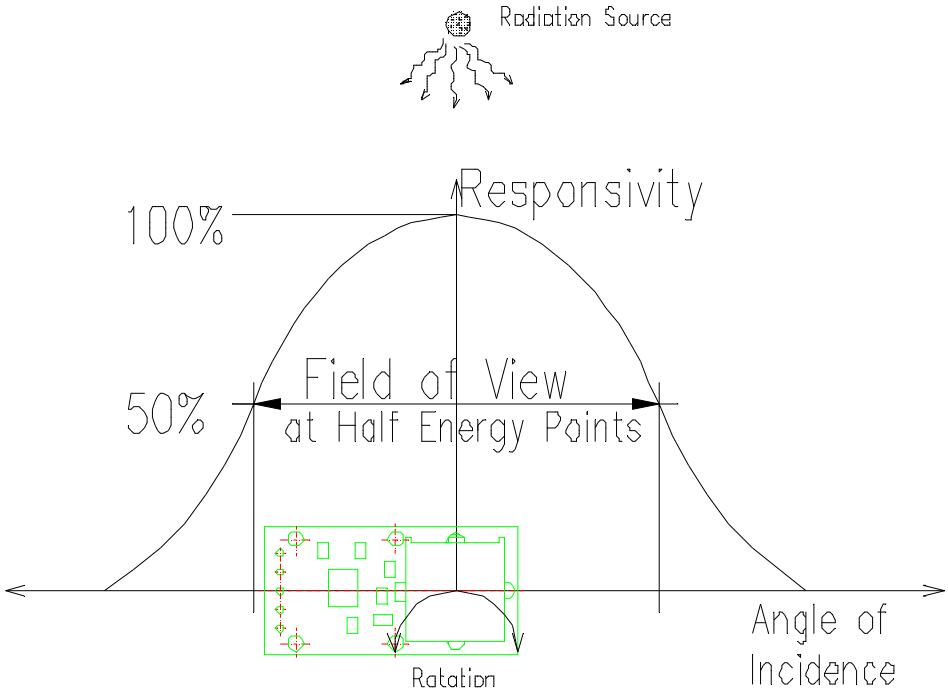
- Constant object temperature
- Constant object emissivity
- Variation of the ambient (sensor) temperature in the used range
- Measuring of the output voltages at different stabilised ambient temperatures

3 TYPE CHARACTERISTICS

3.1 OPTICAL CHARACTERISTICS

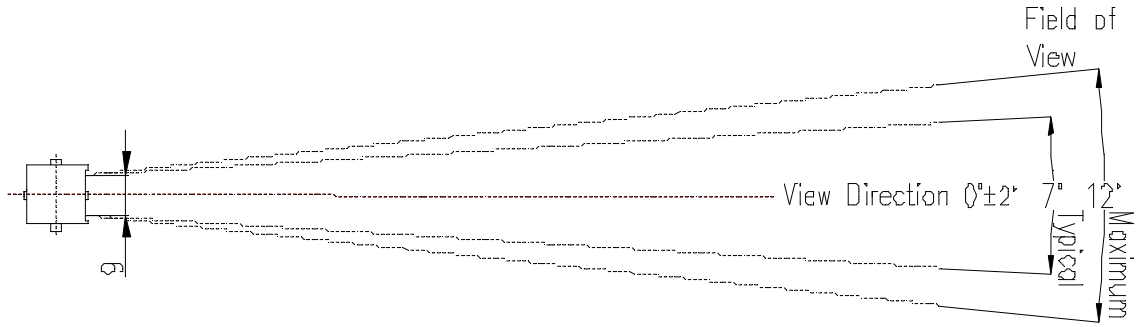
3.1.1 Definition and Measurement

The field of view is defined by the full angle at the half energy points given by the following experiment.



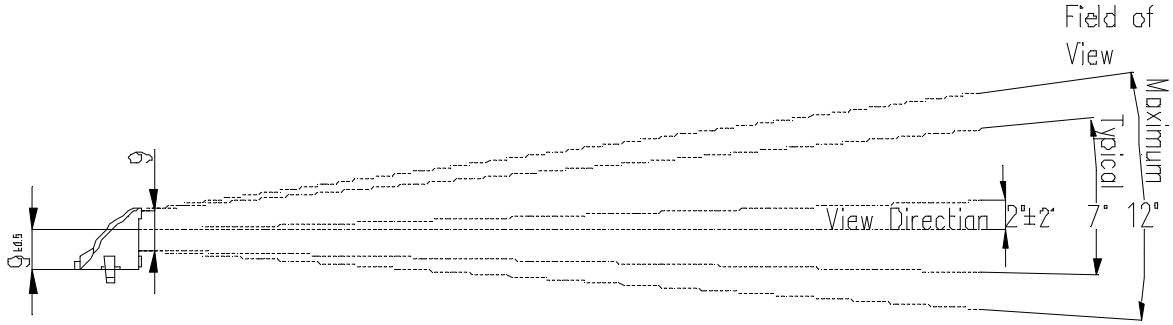
Picture 2 : Measuring of the Field of View

3.1.2 Horizontal Characteristics



Picture 3 : Horizontal Characteristics of the Mirror Optics

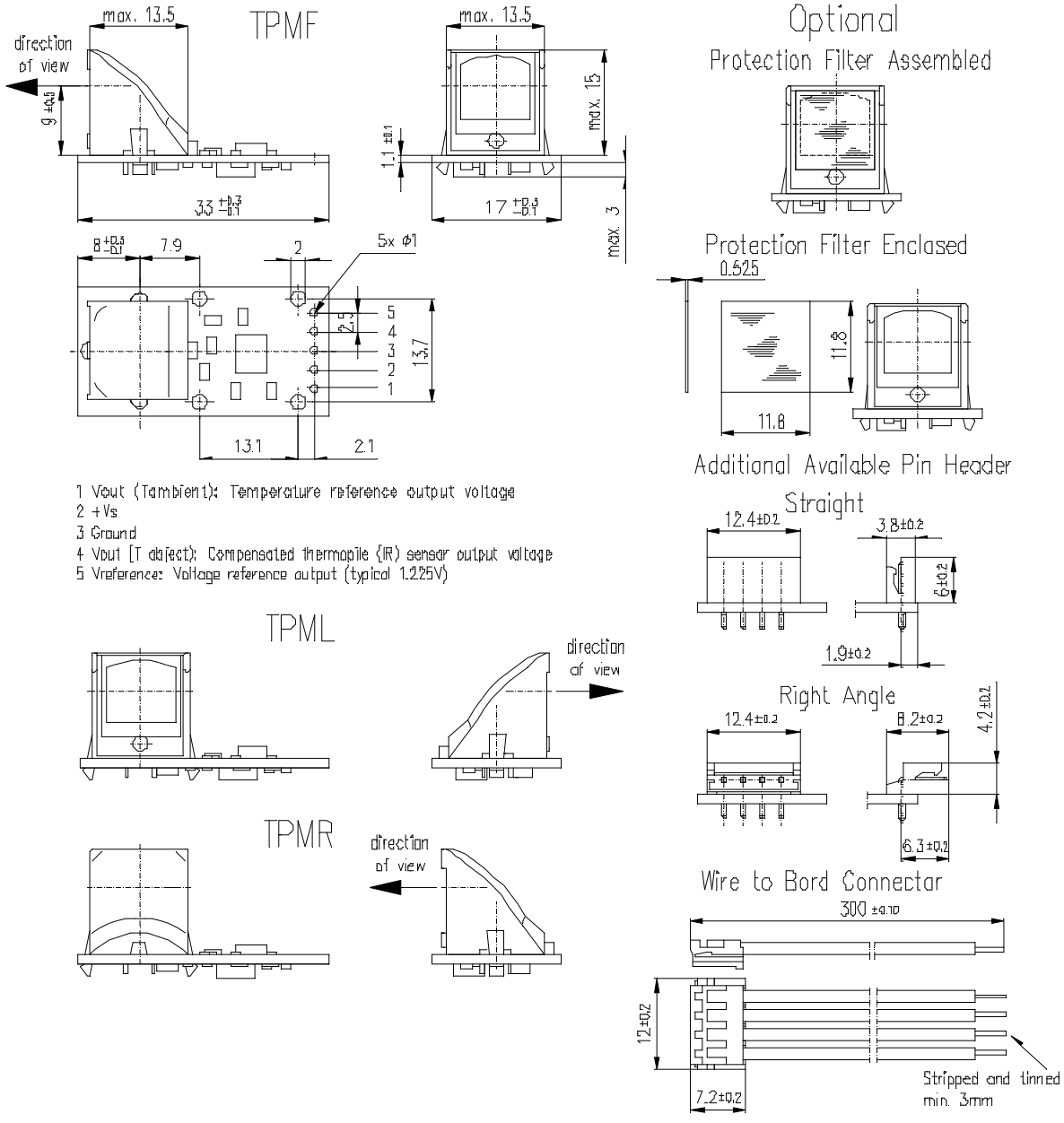
3.1.3 Vertical Characteristics



Picture 4 : Vertical Characteristics of the Mirror Optics

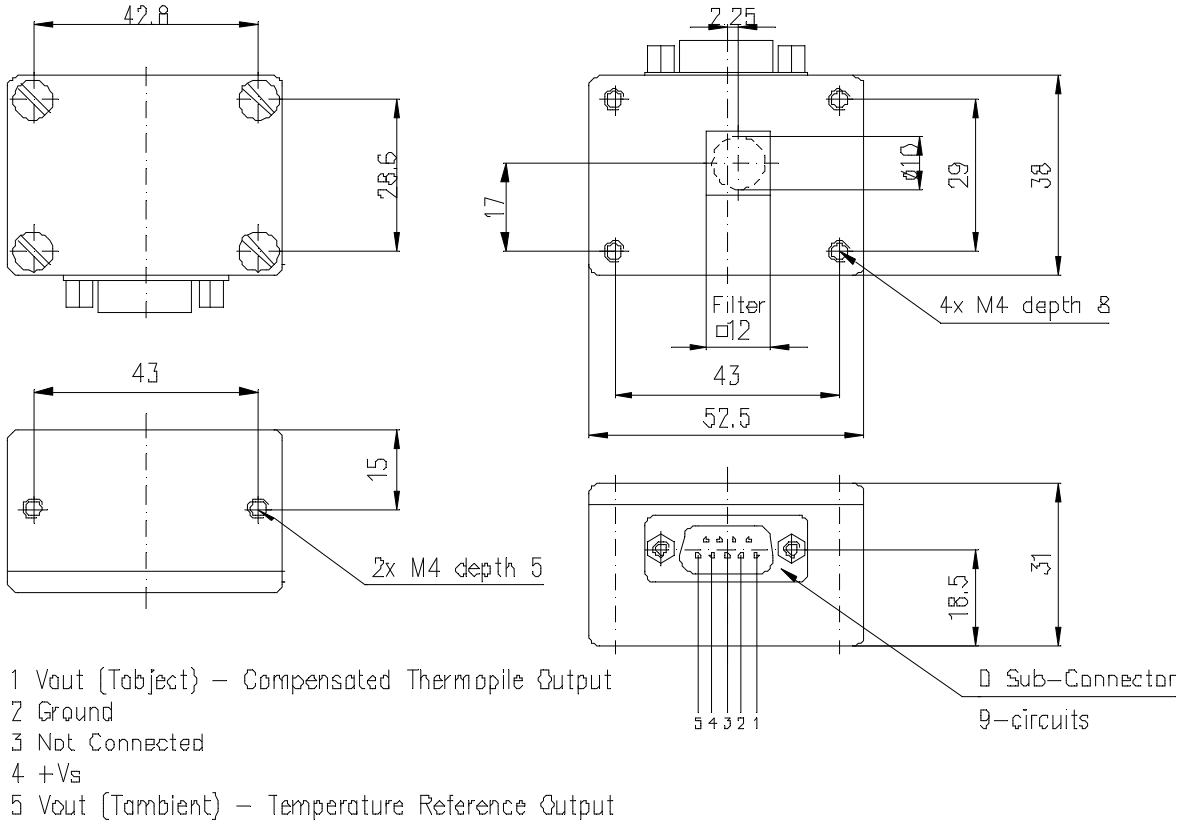
3.2 MECHANICAL CHARACTERISTICS

3.2.1 Mechanical Dimensions and Connections - Board Type



Picture 5 : Dimensions and Scheme of Connections for the Board Type Module

3.2.2 Mechanical Dimensions and Connections - Case Type



Picture 6 : Dimensions and Scheme of Connections for the Case Type Module

3.2.3 Marking

Each device is marked at the backside of the mirror optics by a label with a letter and a serial number. The letter describes the place of manufacturing. The case type is labeled at the side of the aluminim die cast box.

3.3 ELECTRICAL CHARACTERISTICS

3.3.1 Compensated Thermopile Output Voltage

The following table shows the typical voltages for different object temperatures at 25°C ambient (sensor) temperature :

The compensated thermopile output voltages are defined with a mounted protection filter, for an object emissivity larger than 99.9% and by the definition, that the target fills the whole field of view of the sensor with mirror optics.

Filter System	*Sensor Filter Type : STANDARD Protection Filter Type : STANDARD*					*Sensor Filter Type : STANDARD Protection Filter Type : G12*				
Type→	*TPM..0*	*TPM..1*	*TPM..2*	*TPM..3*	*TPM..4*	*TPM..0*	*TPM..1*	*TPM..2*	*TPM..3*	*TPM..4*
Tobject	*Vout (Tobject)*					*Vout (Tobject)*				
°C	*V*	*V*	*V*	*V*	*V*	*V*	*V*	*V*	*V*	*V*
-20	0.719	1.080	1.176	1.203	1.216	0.729	1.086	1.180	1.206	1.218
0	1.364	1.273	1.232	1.229	1.227	1.369	1.277	1.234	1.231	1.228
20	2.187	1.520	1.303	1.262	1.240	2.188	1.521	1.303	1.262	1.240
25	2.423	1.591	1.323	1.272	1.244	2.423	1.591	1.323	1.272	1.244
40	3.208	1.827	1.390	1.303	1.257	3.207	1.825	1.389	1.302	1.256
60	4.441	2.197	1.497	1.352	1.277	4.444	2.194	1.494	1.350	1.276
80	5.900	2.635	1.622	1.411	1.301	5.913	2.632	1.618	1.407	1.299
100	7.592	3.143	1.768	1.478	1.328	7.625	3.143	1.763	1.474	1.326
120	9.526	3.724	1.935	1.556	1.360	9.590	3.729	1.929	1.550	1.357
140	11.705	4.378	2.123	1.643	1.395	11.812	4.392	2.117	1.636	1.392
160	14.130	5.106	2.332	1.740	1.435	14.295	5.132	2.327	1.733	1.431
180		5.908	2.562	1.846	1.478		5.951	2.559	1.839	1.474
200		6.783	2.813	1.963	1.526		6.847	2.813	1.956	1.521
220		7.731	3.085	2.089	1.577		7.821	3.089	2.083	1.572
240		8.750	3.377	2.225	1.632		8.869	3.386	2.219	1.627
260		9.837	3.689	2.370	1.691		9.992	3.704	2.365	1.686
280		10.993	4.021	2.523	1.754		11.187	4.043	2.521	1.749
300		12.214	4.371	2.686	1.820		12.453	4.402	2.686	1.816
350			5.326	3.129	2.000			5.382	3.136	1.998
400			6.385	3.620	2.200			6.473	3.637	2.200
450			7.539	4.155	2.418			7.665	4.184	2.421
500			8.779	4.731	2.652			8.948	4.774	2.659
550			10.097	5.342	2.901			10.313	5.401	2.913
600			11.485	5.986	3.163			11.753	6.062	3.180
650			12.936	6.660	3.437			13.259	6.754	3.460
700				7.360	3.722				7.473	3.750
750				8.084	4.017				8.218	4.051
800				8.831	4.321				8.985	4.361
850				9.597	4.633				9.773	4.680
900				10.381	4.952				10.579	5.005
950				11.182	5.278				11.402	5.338
1000				11.999	5.610				12.240	5.677
1200					6.991					7.084
1400					8.438					8.557
1600					9.933					10.076
1800					11.464					11.632
2000					13.023					13.214

Table 5 : Typical Output Voltage Vout(Tobject) at Various Object Temperatures

Parameter	*Minimum ms*	*Typical ms*	*Maximum ms*
Time Constant	5	20	100

Table 6 : Response Time of the Thermopile Output

NOTE : The time constant can be measured as response to an object temperature jump (low to high or high to low) based on the following equations :

Low to High : $\Delta V = \Delta V_{\max} * \left(1 - e^{-\frac{t}{\tau}}\right)_{t=\tau} \quad \Rightarrow \quad \Delta V = \Delta V_{\max} * \left(1 - \frac{1}{e}\right)$

High to Low : $\Delta V = \Delta V_{\max} * \left(e^{-\frac{t}{\tau}}\right)_{t=\tau} \quad \Rightarrow \quad \Delta V = \Delta V_{\max} * \left(\frac{1}{e}\right)$

3.3.2 Temperature Reference Output Voltage

The following table shows the typical voltages for different ambient temperatures :

Type →	*TPM..0*	*TPM..1*	*TPM..2*	*TPM..3*	*TPM..4*
Tambient	*Vout (Tambient)*				
°C	*V*	*V*	*V*	*V*	*V*
-40	1.273	1.240	1.229	1.227	1.226
-30	1.314	1.252	1.232	1.228	1.226
-20	1.382	1.273	1.238	1.231	1.228
-10	1.490	1.306	1.247	1.235	1.229
0	1.656	1.357	1.260	1.242	1.232
10	1.896	1.430	1.280	1.251	1.236
20	2.225	1.530	1.307	1.264	1.241
25	2.423	1.591	1.323	1.272	1.244
30	2.645	1.659	1.341	1.280	1.248
40	3.149	1.813	1.382	1.300	1.256
50	3.710	1.984	1.428	1.322	1.265
60	4.292	2.162	1.475	1.344	1.274
70	4.855	2.334	1.521	1.366	1.283
80	5.370	2.491	1.563	1.386	1.291
90	5.819	2.629	1.600	1.404	1.299
100	6.195	2.744	1.631	1.418	1.305

Table 7 : Typical Output Voltage Vout(Tambient) at Various Ambient (Sensor) Temperatures

4 PACKAGING

4.1 PACKING FOR DELIVERY

The packing for the delivery of mass production devices depends on the respective order quantity.

4.2 LABELLING FOR DELIVERY

Each label contains the following information :

Name of the manufacturer, Product Group, Product type, Product number, Quantity per box, Date of packing, Place of packing

5 QUALITY

HEIMANN 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.