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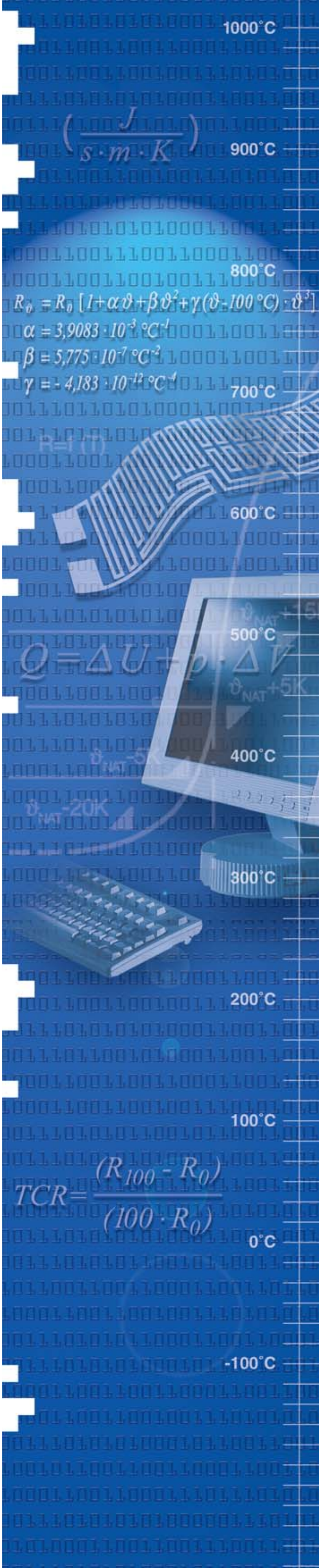
SENSOTHERM®



1000°C
900°C
800°C
700°C
600°C
500°C
400°C
300°C
200°C
100°C
0°C
-100°C
$\alpha = 3{,}9083 \cdot 10^{-3}\,°C^{-1}$
$\beta = 5{,}775 \cdot 10^{-7}\,°C^{-2}$
$\gamma = -4{,}183 \cdot 10^{-12}\,°C^{-4}$
$TCR = \frac{(R_{100} - R_0)}{(100 \cdot R_0)}$

Platin sets Standards

Platinum has been used for over 100 years as a temperature sensing material. Mainly because of its high stability and its typical characteristics as a precious metal: chemical resistance, thermal stability, reproducibility of electrical resistance behaviour. The resistance thermometer of highly pure platinum made it necessary to expand the international temperature scale (ITS) for a wider range in 1927. In the 1970ies, the development of thin film technology opened up entirely new dimensions for advanced temperature measuring techniques: conventional platinum wire-wound sensors in ceramic or glass body were substituted with platinum temperature sensors (PTS) in thin film technology. The flat type of construction proved to be superior in regard to the technical properties and price especially for the application on mass markets.

The Company

In 1985, the Murata electronics group began developing thin film platinum sensors. SENSOTHERM® Temperatursensorik GmbH was founded in the process of a management buy-out of the business branch as an independent company, well established on the market. Today, SENSOTHERM® Temperatursensorik GmbH is one of the leading producers of temperature sensors in thin film technology – platinum (PTS) as well as nickel (NTS) temperature sensors. At the Nuremberg head quarters, several million sensors are being produced per year.

Strategic Orientation

All the company's strategic efforts of the past have been directed to meet the customers' needs at a max. Great investments have been made to increase the production depth in order to be able to offer special semi finished products, individually designed for the customers' applications. Sensor types with primary housing of the highest quality and attractive price. Our customers benefit to the full from the cost advantages of foreign production sites.

Future Partnership

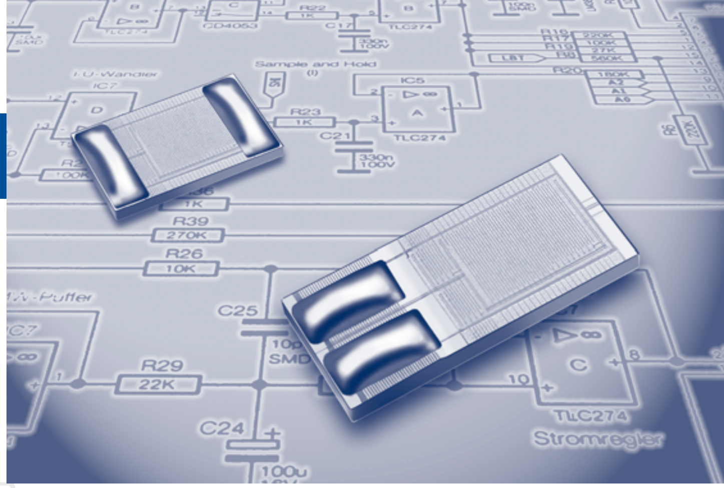
Based on our know how in the field of special development and modern production technique, the company's future is built on its flexibility and efficiency to meet any specific requirements of individual applications. Subsequently followed by individual solutions processed for mass productions to be positioned on the market. In the future, the development is going to progress far beyond conventional temperature sensors. For the development and production of new sensors for, e.g. measuring pressure, dew point, or quality of air, SENSOTHERM® offers the basis for important processes, due to the company's experiences in the fields of thick & thin film techniques. The strategic goal of SENSOTHERM® has always been the cooperation with innovative companies on their way into the future.

Quality from the beginning

The premise for the company's steady growth has always been to live quality, consistently and on a daily basis: quality as a process oriented way in regard to any company functions.

The high quality claim results from the increasing strategic meaning of sensor technology and customer solutions. Above all, quality means contributing to the customers' economic success. Parallel to the founding of the company, a quality management system was established which guarantees the demands of ISO 9001/2000. In regard to production and quality management, the company follows international standards (such as DIN EN). Processes, production flows and products are strictly controlled and consistently documented.
A maximum of transparency and traceability is therefore achieved.

Markets



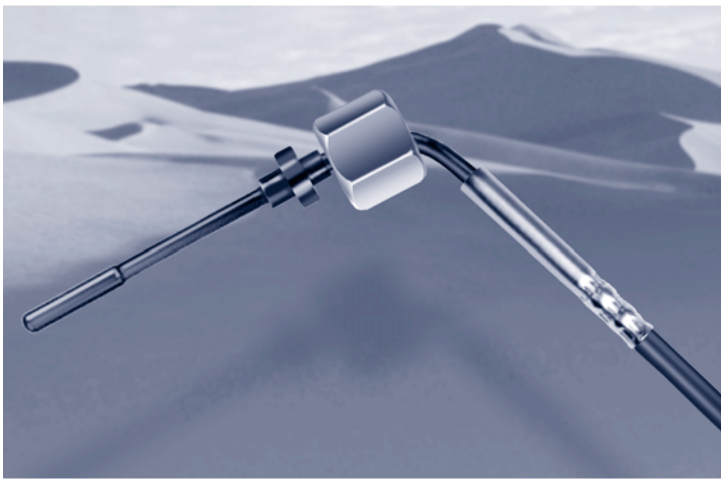
High quality and yet low cost platinum temperature sensors (PTS) are the result of many years of experience in development and production in thin film technology. For many years SENSOTHERM® has been delivering onto mass markets which are subject to a high price sensibility on the one hand and highest quality demands on the highest levels, on the other. This is true especially for the automotive industry and heating & air conditioning industries, as well as white goods. The sensors, well positioned in industrial processing techniques, are becoming increasingly important to modern medical systems.

Applications and Products

In the automotive industry sensors are not only required for controling lower temperature ranges but high temperature sensors up to 1000°C have become standard components in most modern motor management systems. Integrated into exhaust after clearing systems, high temperature sensors have taken over important functions, such as optimization of motor efficiency, reduction of exhaust gas emissions and regeneration of soot particle filters. In developing the temperature sensor, SENSOTHERM® closely cooperated with a well known system provider for the automotive industry.

While SENSOTHERM® developed a thin film element adjusted to the specific application, the provider designed the suitable housing and carried out the sensor assembly. The result is a series tested, high temperature sensor including a Pt200 measuring element. The sensor is hermetically sealed in a closed tube and thus resistant against aggressive environments as exhaust gases, contaminants, suspended matters, moisture, salt fog and aggressive fluids. Obviously, the sensor is ideally suitable for industrial process control applications (equipments and systems).

In a lower temperature range, yet of similarly high demands on the sensor quality, there are various applications in the field of energy supply. For the measuring of heat quantities, the requirements for exact records of energy consumption are high relative accuracies and long term stability. This is valid for both industry and private households. The demands for stability and accuracy of the sensors are: max 0,1 K relative stability to each other in a defined range of, e. g., 0C° to 130C° for many years.

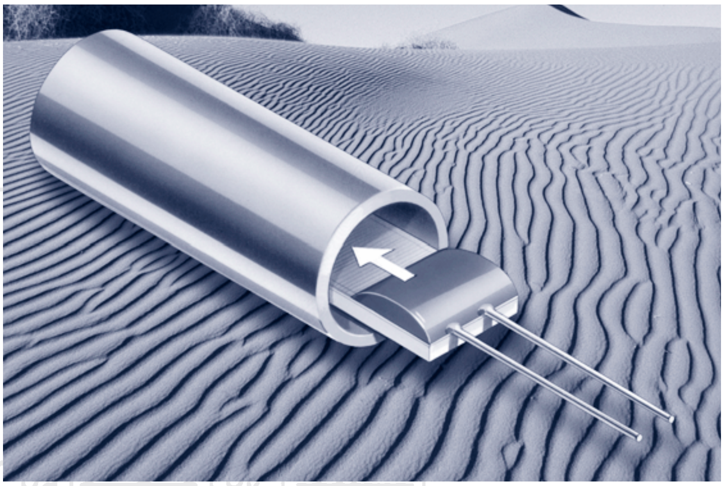


High temperature sensors for application up to 1000°C

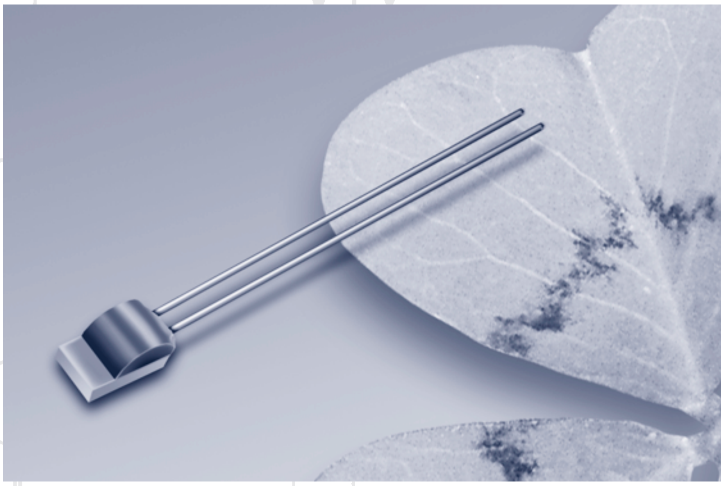
Precision And Reliability – These are terms which have become more and more important in private households. The white woods are confronted with very high quality demands.

Electronic control units, connected to high precision sensors control baking ovens, cooking zones (up to 250°C), pyrolysis processes (550°C) and the charging of storage heatings (650°C). In low temperature ranges up to 250°C, the PTS are superior to capillary tubes, rod dilation controls and thermistors not only technically but also in regard to price. Especially at higher temperatures, the use of such controlling components is critical respectively no longer accepted.

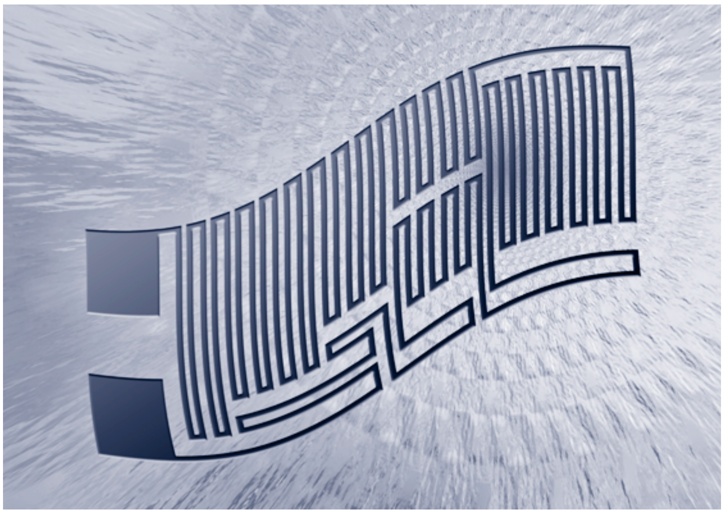
The latest development stage of thin film technology makes platinum temperature sensors a low-price, yet high performance product. An alternative to NTC, PTC and KTY semiconductors, they more and more gain ground on the mass market.



Sensors are offered in a primary housing, embedded in a small ceramics tube.



Precision en miniature: the SENSOTHERM® "Pico", 1,22 X 1,6 mm X 1,4 mm (l x w x h), designs in 100 Ω and 1000 Ω.



A new process allows the application of carrierless platinum structures onto different materials. Advantages are, e. g. the extreme flexibility of the structure, the optimum use of the platinum characteristics in direct contact with the medium to be measured and simple handling during the manufacturing of the sensor: This individually applicable structure is directly integrated into the automatic production process. In addition, the sensor element as a free structure integrated into a frame allows the detection of even the vaguest signals. Thus, the sensor element is predisposed to a use in flow techniques, for instance.

Construction and Selection

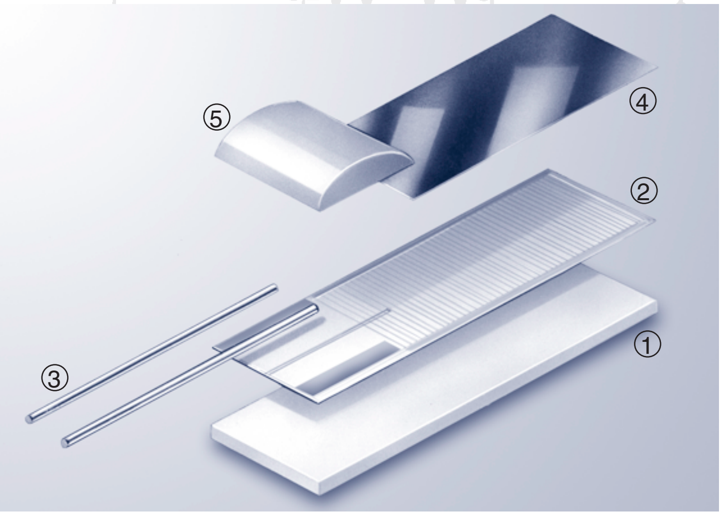
The production process used by SENSOTHERM® corresponds with the most recent production standards in thin film technology. Methods as photolithographic structuring and laser trimming increase the quality, minimizing rejects. Platinum temperature sensors (PTS) in thin film technology consist of meandering films of platinum, deposited on a ceramics substrate sealed with a glass cover.
The connecting wires are fixed onto the sensor with a glass ceramics paste. Corresponding to the application and specification, different variations are available.

The varying parameters of the sensors are:

- principle value of resistance
- geometry
- tolerance class
- temperature coefficient
- connecting technique
- primary housing
- operation temperature

Characteristics

Platinum temperature sensors in thin film technology (PTS) have an internationally standardized characteristics



1 = ceramics substrate
2 = platinum film
3 = connecting wire
4 = glass cover
5 = glass protection and fixing of connecting wires

curve according DIN EN 60751. This means less efforts needed in obtaining the sensors because of the interchange ability of the standardized items. The standardization and linearity of the output signals allow a simplified electronic data processing. The temperatures vary from –50°C to 600°C, optional from –200°C to 1000°C. In such a wide temperature range PTS shows a high measuring accuracy and long term stability. All standard SENSOTHERM sensors are available in the tolerance classes DIN B and DIN A (see page 8.) and in class T (1/3 DIN B), P (1/5 DIN B) and Z (1/10 DIN B). Sensors with a greater deviation belong to tolerance class C: twice DIN B. Different aging factors may influence the accuracy and reproducibility of the measuring signals. Thus long term stability plays an important role for the evaluation of the sensor quality.

The specific precious metal characteristics of platinum, the special SENSOTHERM® processing technology and an advanced choice of materials guarantee reproducible PTS values in various fields of use even after many years. The platinum sensors are almost insensitive to temperature shock.
The standard PTS are manufactured according to the desired sensitivity of the signals with a nominal resistance of 100, 500 or 1000 Ω. The principle values and tolerances of resistances of a 100 Ω sensor element are increased by factor 5 or 10. According to the customers‘ demand specific resistances, e. g., 50 Ω or 200 Ω are available.

Measuring Principles, Basic Values and Tolerances

The electrical resistance of the platinum temperature sensor varies in correlation to temperature. This correlation can be described by a mathematical polynominal (see. page 8).
The characteristic curvature is almost linear.

The temperature coefficient (TCR) describes the average inclination of polynominal between 0°C and 100°C, i.e. the relative mean alteration of the Ω values parallel to the change of temperature. Following the DIN EN 60751 the typical TK for a PTS is 3850ppm/°C, i.e. an increase of resistance from 100 Ω to 138,5 Ω (see page 9). Beyond this, sensors with differing temperature coefficients, e.g. 3750 pp/C, 3500 ppm/°C or adapted to customer specific values, can be delivered.

High relative precision

Certain applications need the use of sensors with a high relative precision. Therefore PTS can be selected into closely matched sensor pairs.In a defined temperature range the relative deviation can be limited to e.g. 0,1 K or 0,05 K. It is possible to select with lower or higher tolerances on customer request.

Self-Heating

Platinum sensors are passive electronic components. The measurement current leads to self-heating and therefore to error in measurement. The induced error is dependent upon the magnitude of the measuring current, the size of the sensor element and the thermal contact between PTS and the surrounding medium. The relevant recommended current is specified for each type in the datasheet.

Response Time

The time needed for the PTS to response to a step change in temperature of a flowing medium is very short (see page 9). For each type typical characteristics for water and air are specified in the datasheets .

The wire

As a standard the connecting wires can be offered as follows: platinum coated nickel, silver, nickel and pure platinum. In addition different varieties for special applications and customers needs, e.g. gold or gold-palladium can be offered.

Mechanical stress and connecting technique

Due to the compact construction platinum sensors have an extremely high vibration and shock resistance. As an assembled component they withstand standard tests without any problems. According to the requirements of MIL- and IEC-standards the pull strengths of the different wire connections are tested during the production process.

Technical Data

Principal resistance values and tolerances

$$R_\vartheta = R_0\,(1+\alpha\,\vartheta+\beta\,\vartheta^2)$$
$$\alpha = 3{,}9083 \cdot 10^{-3}\ °C^{-1}$$
$$\beta = 5{,}775 \cdot 10^{-7}\ °C^{-2}$$
(valid for $\vartheta > 0$)

$$R_\vartheta = R_0\,[1+\alpha\,\vartheta+\beta\,\vartheta^2+\gamma\,(\vartheta-100\,°C)\cdot\vartheta^3]$$
$$\alpha = 3{,}9083 \cdot 10^{-3}\ °C^{-1}$$
$$\beta = 5{,}775 \cdot 10^{-7}\ °C^{-2}$$
$$\gamma = -4{,}183 \cdot 10^{-12}\ °C^{-4}$$
(valid for $\vartheta < 0$)

According to this the accepted maximum deviations for class B are ± 0,3 °C and ± 0,12 Ω at 0 °C (see tab. 1 and tab. 2)

temper-ature	resistance values Pt 100	permitted deviation of Pt 100 tolerance class B	
		resistance 1)	temperature
-50 °C	80,31 Ω	± 0,22 Ω	± 0,6 °C
0 °C	100,00 Ω	± 0,12 Ω	± 0,3 °C
100 °C	138,50 Ω	± 0,30 Ω	± 0,8 °C
200 °C	175,84 Ω	± 0,48 Ω	± 1,3 °C
300 °C	212.02 Ω	± 0,64 Ω	± 1,8 °C
400 °C	247,04 Ω	± 0,79 Ω	± 2,3 °C
500 °C	280,90 Ω	± 0,93 Ω	± 2,8 °C
600 °C	313,59 Ω	± 1,06 Ω	± 3,3 °C

1) For Pt-sensors with a R_0 of 500 and 1000 Ohm, the principal resistance values must be multiplied by a factor of five- and ten respectively.

Tab. 1) Principal resistance values of Pt-100

tole-rance	limited deviation in [°C]
T	$0{,}10\,°C + 0{,}0017 \cdot \vartheta$ (°C)
A	$0{,}15\,°C + 0{,}002 \cdot \vartheta$ (°C)
B	$0{,}30\,°C + 0{,}005 \cdot \vartheta$ (°C)
C	$0{,}60\,°C + 0{,}007 \cdot \vartheta$ (°C)

Tab. 2)
Calculated limit values and permitted deviations in correlation to temperature

Z (= 1/10 DIN B)
P (= 1/5 DIN B)
T (= 1/3 DIN B)
C (= 2-times DIN B)

tolerance classes	resistance Ro at 0°C	temperature coefficient TC at 0°C to +100°C	temperature range
Z	Ro ± 0,012%	3850 ppm/°C ± 2 ppm/°C	-50°C...+200°C
P	Ro ± 0,024%	3850 ppm/°C ± 3 ppm/°C	-50°C...+200°C
T	Ro ± 0,04%	3850 ppm/°C ± 4 ppm/°C	-50°C...+400°C
(DIN) A	Ro ± 0,06%	3850 ppm/°C ± 5 ppm/°C	-50°C...+400°C
(DIN) B	Ro ± 0,12%	3850 ppm/°C ± 13 ppm/°C	-50°C...+600°C
C	Ro ± 0,24%	3850 ppm/°C ± 13 ppm/°C	-50°C...+600°C

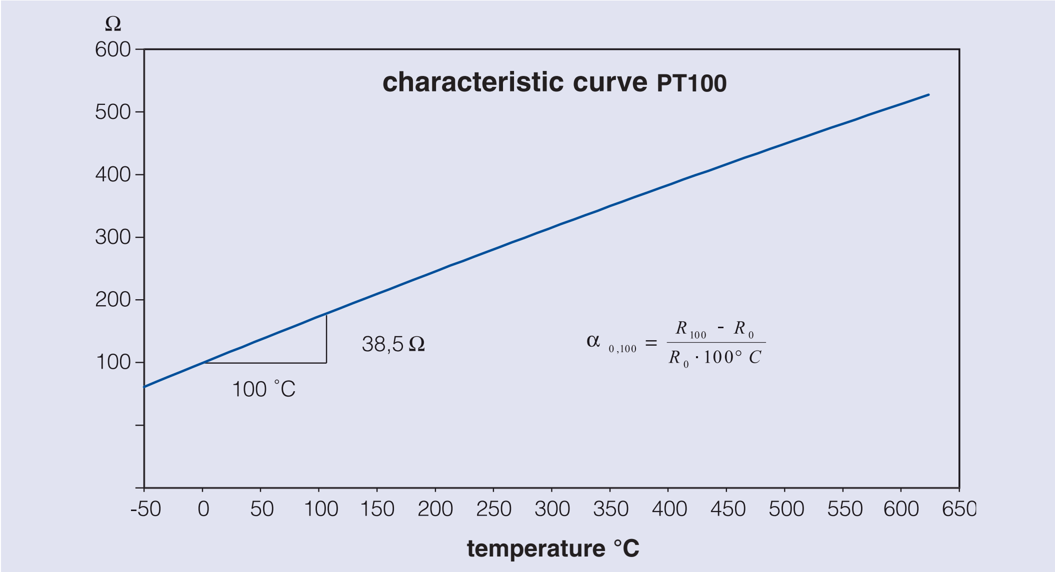
Tab. 3) Specification of the tolerance classes

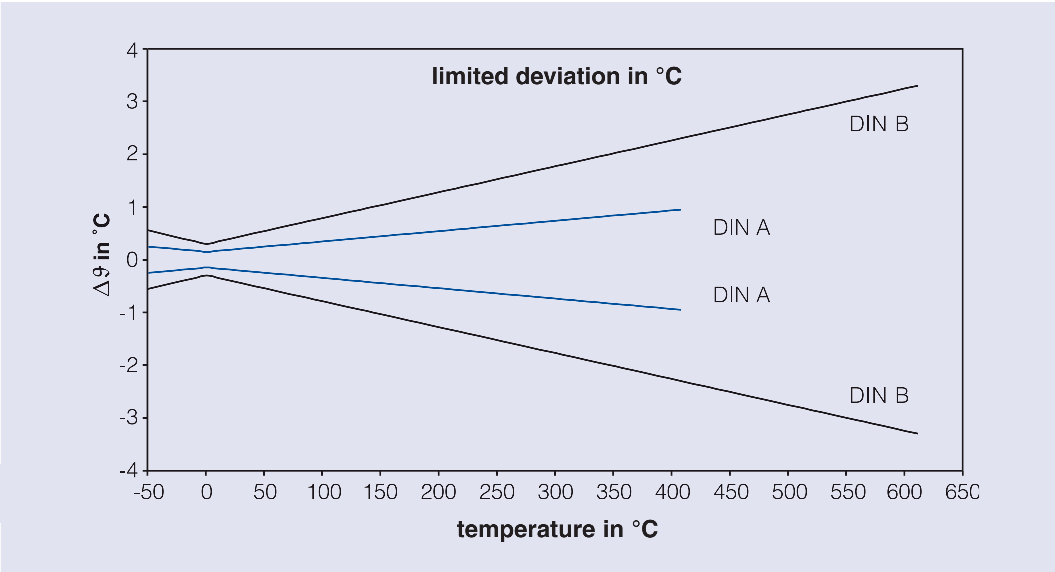
Temperature coefficient (TC) and tolerances

$$TC = \frac{(R_{100} - R_0)}{(100 \times R_0)}$$

$TC_{0,100}$ = 3850 ppm/°C.

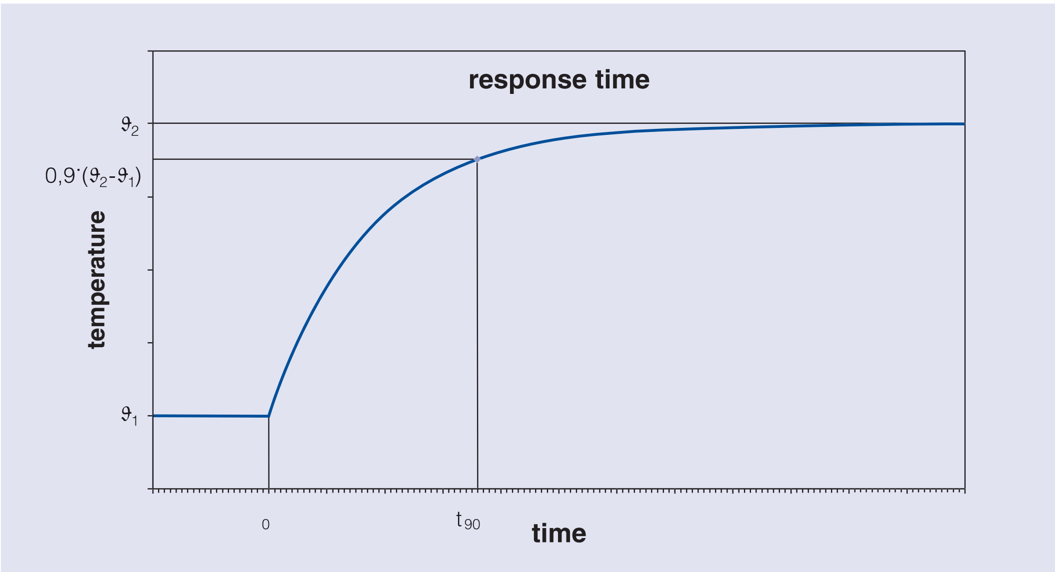
Permitted deviation according DIN B: ± 13 ppm/°C (see tab. 3).





Response time

The response time $t_{0,9}$ is the time the sensors need to respond to 90 % of the change in temperature between ϑ_1 und ϑ_2. The measurements will be done in water with a flowrate of 0,4 m/sec and in air with 1 m/sec: $t_{0,9}$ (water 0,4 m/sec) $t_{0,9}$ (air 1m/sec). For the different response times see data sheets.



Overall view platinum sensors

Sensor type	dimensions (B×L×H) in mm	principal resistance value at 0°C 100 Ω	500 Ω	1000 Ω	temperature range (DIN B) soldering pads	Ag-wire	Ni-wire	PtNi-wire	Pt-wire
PTFA	2,9 x 10,0 x 1,4	o	o	o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTFB*	2,0 x 10,0 x 1,4/1,1	o	o	o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTFC	2,0 x 2,4 x 1,4	o	o	o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTFD	2,0 x 5,0 x 1,4/1,1	o	o	o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	-50°C~+850°C*
PTFE	3,9 x 5,0 x 1,4	o	o	o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	
PTFF	2,0 x 4,0 x 1,1	o	o	o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTFM	1,2 x 4,0 x 1,1	o	o	o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTFN	1,7 x 5,0 x 1,1	o				-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	
PTFP*	1,2 x 1,6 x 1,1	o		o		-50°C~+300°C	-50°C~+550°C	-50°C~+600°C	
PTNB	2,0 x 10,0 x 0,6/0,9	o	o	o	-50°C~+150°C				
PTND	2,0 x 5,0 x 0,9	o	o	o	-50°C~+150°C				
PTNK*	3,8 x 7,8 x 0,9	o	o	o	-50°C~+150°C				
PTOD*	1,6 x 3,2 x 0,9	o	o		-50°C~+150°C				
PTSB*	2,4 x 10,0 x 1,4	o	o	o	Solid pins -50°C~+150°C				
PTSE	3,7 x 6,0 x 1,4	o	o	o	Solid pins -50°C~+150°C				
PTRA*	Ø 4,5 x 13,0	o	o	o			-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTRB	Ø 2,8 x 13,0	o	o	o			-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTRC	Ø 2,3 x 8,0	o	o	o			-50°C~+550°C	-50°C~+600°C	
PTRN*	Ø 2,2 x 7,5	o	o	o			-50°C~+400°C	-50°C~+400°C	
PTDA*	Ø 4,5 x 13,0	o	o	o			-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*
PTDB	Ø 2,8 x 13,0	o	o	o			-50°C~+550°C	-50°C~+600°C	-50°C~+750°C*

Tab. 4) overall view platinum sensors

*see figures page 11

Tab. 5)
Attachement of additional lead wires

	soft soldering	hard soldering (brazing)	resistance welding	laser welding	crimping
PtNi-wire	possible - good	very good	very good	very good	good
Ni-wire	partial (2mm)	very good	possible - good	good-very good	good
Ag-wire	good-very good	possible - good	possible	not suitable	very good
Pt-wire	good	very good	very good	very good	very good

Order code system:

PT	F	C	101	B	000
1	2	3	4	5	6

1 **abbreviation for "platinum"**

2 **shape** (D = double, F = flat, N = chip with soldering pads single sided, R = round, S = solid pins, O = SMD-like type)

3 **size** (e.g.: C = 2,0 mm x 2,4 mm)

4 **resistance values** (**101** = **10** · 10-$^{\mathbf{1}}$ = 100 Ω, 501 = 500 Ω, 102 = 1000 Ω)

5 **tolerance** (e.g.: B = class B according DIN IEC 751)

6 **standard types:** 000, special types: according to specific applications of customer

Please always indicate type of wires required

Advantages of Platinum

in high performance applications:

- Wide temperature ranges from -200°C up to 1000°C
- High precision, i.e. small deviations standardised according DIN EN 60751
- Excellent long time stability, i.e. low drift during many years typically 0,1 K at 0°C
- International standardization and platinums linearity allow a minimum cost of electronic development and easy interchangeability and ease of replacement

Carrierless platinum structures

For each sensor exists an individual data sheet

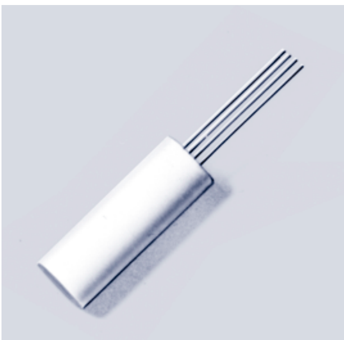
PTFB

PTFP

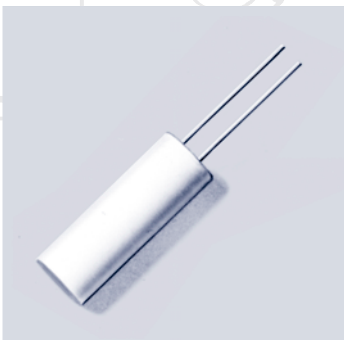
PTNK

PTOD

PTSB

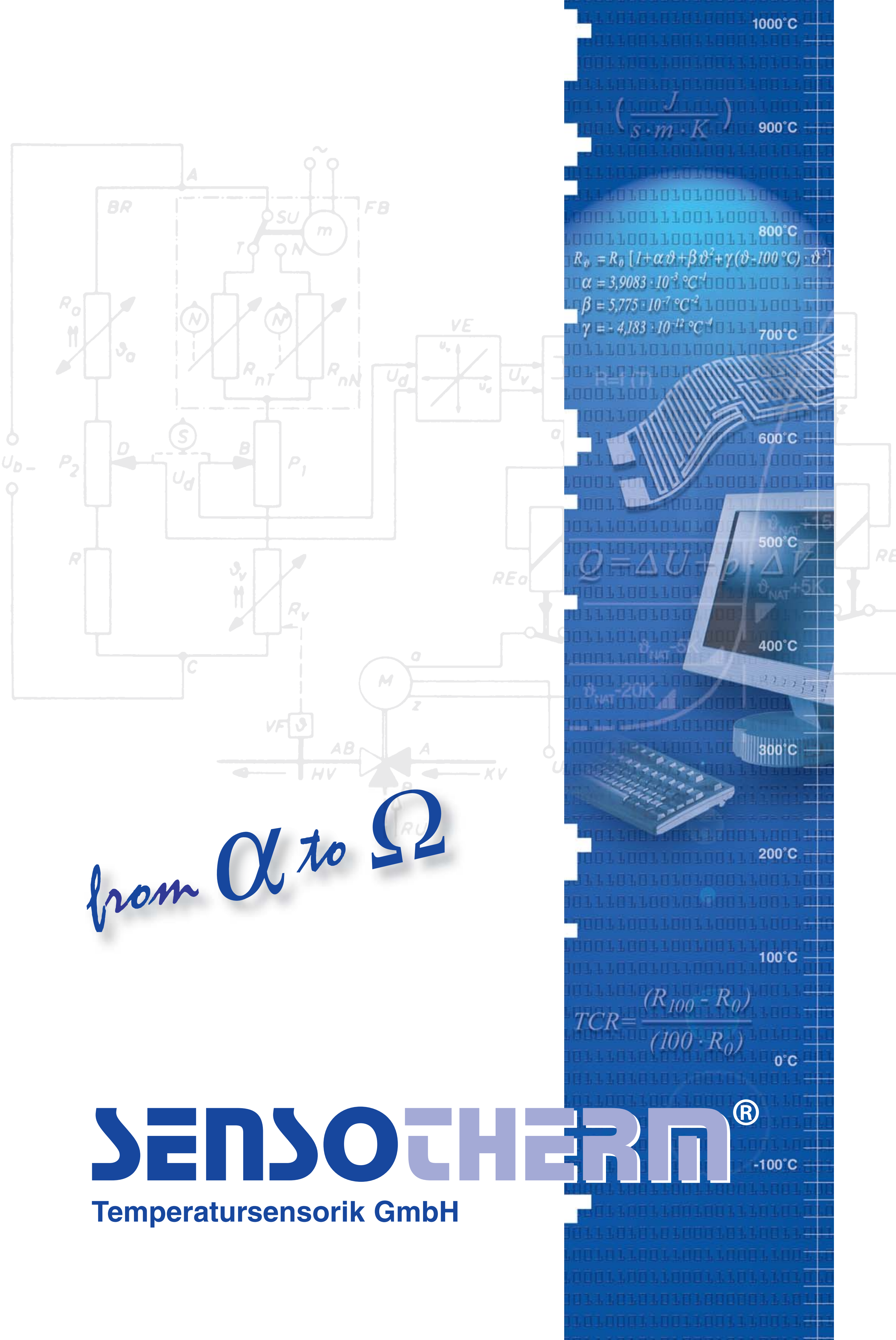


PTDA (ceramic tube)



PTRA (ceramic tube)

PTRN (metal tube)



from α to Ω

SENSOTHERM®

Temperatursensorik GmbH