

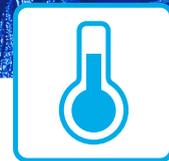


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APPLICATION NOTE

RTD Platinum Sensor





Application Note



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Application Note



RTD Platinum Sensor



1. General Information



In many sectors, temperature is one of the most important physically defined parameters to determine product quality, security and reliability. Temperature sensors are produced with different technologies to fit specific application requirements. IST AG has concentrated on the development and manufacturing of high-quality thin-film temperature sensors. This know-how, partially derived from the semiconductor industry, allows IST AG to manufacture sensors in very small dimensions. Thin-film temperature sensors exhibit a very short response time due to their low thermal mass. The technologies and processes of IST AG thin-film sensors combine the positive attributes of traditional sensors - accuracy, long-term stability, repeatability and interchangeability within a wide temperature range. The advantages of thin-film mass-production create an optimal price/performance-ratio.



2. Construction



The temperature sensor consists of a high-purity platinum meander, structured on a ceramic substrate by the use of photolithography. The resistivity is laser-trimmed and precisely adjusted to the final value. The resistive structure is covered with a glass passivation layer protecting the sensor against mechanical and chemical damages. The welded lead wires are covered with an additional fixation layer.



3. Nominal Value and Temperature Coefficient

The nominal value of the sensor is the defined value of the sensor resistance at 0 °C. The temperature coefficient α (TCR) is defined as:

$$\alpha = \frac{R_{100} - R_0}{100 \times R_0} \text{ [K}^{-1}\text{]} \text{ according to the IEC60751, 2008-07 numerical value of } 0.00385 \text{ K}^{-1}.$$

Generally, the value is defined in ppm/K.

This example defines 3850 ppm/K¹⁾.

R_0 = resistance value in Ω at 0 °C

R_{100} = resistance value in Ω at +100 °C

1) Other TCRs available upon request

4. Long-term Stability

For all sensor types up to 7W (+750 °C), the change in ohmic value after 1000 hrs is less than 0.04 % at maximum operating temperatures.

5. Temperature Characteristic Curve

The curve determines the relationship between the electrical resistance and the temperature.

$$R(T) = R_0 (1 + A \times T + B \times T^2) \quad 0 \text{ }^\circ\text{C to } +850 \text{ }^\circ\text{C}$$

$$R(T) = R_0 (1 + A \times T + B \times T^2 + C \times [T-100] \times T^3) \quad -200 \text{ }^\circ\text{C to } 0 \text{ }^\circ\text{C}$$

Platinum (3850 ppm/K)	Platinum (3911 ppm/K)	Platinum (3750 ppm/K)	Platinum (3770 ppm/K)
$A = 3.9083 \times 10^{-3} \text{ [}^\circ\text{C}^{-1}\text{]}$	$A = 3.9692 \times 10^{-3} \text{ [}^\circ\text{C}^{-1}\text{]}$	$A = 3.8102 \times 10^{-3} \text{ [}^\circ\text{C}^{-1}\text{]}$	$A = 3.8285 \times 10^{-3} \text{ [}^\circ\text{C}^{-1}\text{]}$
$B = -5.775 \times 10^{-7} \text{ [}^\circ\text{C}^{-2}\text{]}$	$B = -5.829 \times 10^{-7} \text{ [}^\circ\text{C}^{-2}\text{]}$	$B = -6.01888 \times 10^{-7} \text{ [}^\circ\text{C}^{-2}\text{]}$	$B = -5.85 \times 10^{-7} \text{ [}^\circ\text{C}^{-2}\text{]}$
$C = -4.183 \times 10^{-12} \text{ [}^\circ\text{C}^{-4}\text{]}$	$C = -4.3303 \times 10^{-12} \text{ [}^\circ\text{C}^{-4}\text{]}$	$C = -6 \times 10^{-12} \text{ [}^\circ\text{C}^{-4}\text{]}$	

R_0 = resistance value in Ω at 0 °C

T = temperature in accordance with ITS 90



6. Tolerance Classes IEC60751 Norm

Temperature sensors are classified according to IEC60751, 2008-07.



Class	± deviations in °C	Temperature range of validity in °C*	IST AG reference
IEC60751 F 0.1	$0.10 + 0.0017 \times T $	0 to +150	Y
IEC60751 F 0.15	$0.15 + 0.002 \times T $	-30 to +300	A
IEC60751 F 0.3	$0.30 + 0.005 \times T $	-50 to +500	B
IEC60751 F 0.6	$0.60 + 0.01 \times T $	-50 to +600	C
1/5 IEC60751 F 0.3	$0.06 + 0.001 \times T $	upon request	K
1/10 IEC60751 F 0.3	$0.03 + 0.0005 \times T $	upon request	K

* Customer-specific temperature range available on request

|T| is the numerical value of the temperature in °C without taking leading signs into account.

The temperature curves refer to IEC60751 standards. The values in the table are for informative purposes only. Based on the assembly method and the different measurement conditions, accuracy, self-heating and response time may vary.

The IEC 60751 requires RTD manufacturers to subtract their extended measurement uncertainty from tolerances, and the customer needs to add it. IST AG subtracts their measurement accuracy.

Tolerance class F0.3 and higher are measured in one temperature. Tolerance class F0.15 and better are measured in two temperatures with a difference of 60 °C. The electrical contact point is 5 mm from wire end. Deviations in assembly process can lead to higher uncertainty.

For wires longer than 20 mm the resistance is compensated (measured at room temperature) to ensure the correct resistance at the chip edge. Although compensated, the wire resistance adds uncertainty, and we therefore recommend four wire extensions.

For 1/3 IEC60751, 1/5 IEC60751, 1/10 IEC60751 and 3- or 4-wire sensors please contact us.

7. Applied Current

The influence of the applied current is highly dependent on how the sensor is used in the application and can lead to significant self-heating effects. In general, the applied current should be as low as possible in order to reduce self-heating effects. The following values are typically used as measurement current:

100 Ω	500 Ω	1000 Ω	2000 Ω	10000 Ω
1 mA	0.5 mA	0.3 mA	0.2 mA	0.1 mA

Higher measurement currents can be applied as long as self-heating does not change the measurement value more than the needed measurement accuracy. The maximum current for sensors between 750°C and 1000°C should not exceed 1mA.

8. Self-heating

The electric current generates self-heating resulting in errors of measurement. To minimize the error, the testing current should be kept as low as possible. The measurement error caused by self-heating is dependent on temperature error $\Delta T = R \times I^2 \times E \times 1000$

ΔT = self-heating in [K]

E = self-heating coefficient in K/mW

R = resistance in [Ω]

I = measuring current in [A]



9. Response Time

The response time is defined as the time in seconds the sensor needs to detect the change in temperature. $t_{0.63}$ describes the time in seconds the sensor needs to measure 63 % of the temperature change. The response time depends on the sensor dimensions, the thermal contact resistance and the surrounding medium.



Chip size	Response time in seconds						Self-heating			
	Water (v = 0.3m/s)			Air (v = 3 m/s)			Ice Water (v = 0 m/s)		Air (v = 3 m/s)	
	$t_{0.5}$	$t_{0.63}$	$t_{0.9}$	$t_{0.5}$	$t_{0.63}$	$t_{0.9}$	E [K/mW]	ΔT in [mK] ¹⁾	E [K/mW]	ΔT [mK] ¹⁾
3505	0.02	0.025	0.04	0.9	1.2	2.4	0.180	18.0	0.556	56
161	0.03	0.05	0.1	1	1.2	2.5	0.083	8.3	0.556	56
308	0.08	0.1	0.25	1.2	1.5	3.5	0.067	6.7	0.455	45
216	0.14	0.18	0.42	4	5.4	11	0.028	2.8	0.278	28
202	0.1	0.15	0.35	3.2	4.3	9.3	0.031	3.1	0.313	31
232 (thin substrate)	0.09	0.12	0.33	2.7	3.6	7.5	0.025	2.5	0.250	25
232	0.13	0.18	0.5	3.3	4.5	9.5	0.025	2.5	0.250	25
325	0.25	0.3	0.7	5.5	7.5	16	0.011	1.1	0.125	13
516	0.25	0.3	0.7	5.5	7.5	16	0.013	1.3	0.143	14
520	0.25	0.3	0.75	6	8.5	18	0.013	1.3	0.143	14
525	0.33	0.4	0.85	6.5	9	19	0.011	1.1	0.125	13
538	0.35	0.4	0.90	7.5	10	20	0.007	0.7	0.100	10
505	0.4	0.5	1.1	8	11	21	0.007	0.7	0.091	9
102	0.33	0.4	0.85	7.5	10.5	20	0.007	0.7	0.100	10
281	2.5	4.5	8	10	15	28	0.017	1.7	0.182	18
281*	2	2.5	5.5	10	12	22	0.022	2.2	0.250	25
451	8	10	22	12	22	40	0.012	1.2	0.125	13
451*	5	6	14	16	18	37	0.017	1.7	0.154	15
SMD/FC 1206	0.15	0.25	0.45	3.5	4.2	10	0.018	1.8	0.143	14
SMD/FC 0805	0.1	0.12	0.33	2.5	3	8	0.026	2.6	0.250	25
SMD/FC 0603	0.08	0.1	0.25	1.8	2.2	5.5	0.040	4.0	0.400	40

1) Self-heating ΔT [mK] measured with Pt100 at 1 mA applied current at 0 °C

* Two sensing elements in the same round ceramic housing

L: Sensor length (without connections)

H: Sensor height (without connections)

W: Sensor width

H2: Sensor height (incl. connections and strain relief)



10. Dimensions Tolerances

Sensor width (W) ± 0.2 mm
 Sensor length (L) ± 0.2 mm
 Sensor height (H2) ± 0.3 mm
 Sensor height (H) ± 0.1 mm

Wire length ± 1 mm (up to 30 mm)
 Wire length > 30 mm, tolerances on request



Wire length in mm	31-120	121-400	401-1000	1001-2000	2001-4000
ISO 2768-1, tolerance class V (very coarse):	± 1.5 mm	± 2.5 mm	± 4 mm	± 6 mm	± 8 mm

11. Operating Conditions

Platinum temperature sensors are built on the basis of very robust materials: a high temperature glass protects the meander, the substrate is mainly based on densely sintered high-purity alumina and the wire fixations enable a reliable strain relief of the welding points.

Unfortunately it is not possible to test the sensor behavior in all application and installation conditions. Therefore the customer needs to test the compatibility of the sensor element with the application and/or the installation conditions. With certain ceramic casting compounds for instance there can occur chemical reactions between the passivation glass and the fixation glass. Potential problems can also arise due to strong creeping polymers (e.g. uncured

silicones) or because of the reaction between plastic-based casting compounds with the plastic-based wire fixations, used for directly welded wires. The use of bare sensors in long-term humid environment as well as in aggressive atmospheres has to be avoided; the same applies to the direct dipping of the sensor into liquids. Furthermore mechanical pressure on the sensors, e.g. caused by hard or strong post-curing casting compounds should be avoided. Some epoxy-based casting compounds might become conductive above T_g and therefore cause a bypass via the sensor wires, which can lead to a lower resistance reading.

For sensors at higher temperatures (> +600 °C) oxygen access should be guaranteed in order to counter post-oxidation-effects in stainless steel housings. Alternatively the construction should be chosen in a way that no significant decrease of the oxygen partial pressure might occur in the installation. In principle, stainless steel parts should be carefully cleaned and pre-oxidized.

IST AG also offers special (customer-specific) sensors for various applications. Please don't hesitate to contact us and ask for your suitable sensor solution.

12. Storage

Platinum thin-film sensors must not be exposed to etching, corrosive or damp environments. Humidity above 70% rH and direct exposure to sunlight should be avoided.

Additional storage precautions apply to specific sensors.

In ideal circumstances, the following parameters apply:

Temp. range:	10 °C to 30 °C
Humidity:	50 +/- 10 % rH
Storage:	Neutral environment, no direct exposure to sunlight

Additional storage precautions:

Silver plated and silver wire should be packaged in an airtight wrapping to avoid tarnishing.

13. Voltage Sensitivity (e.g. ESD)

Platinum temperature sensors are passive components which cannot actively be protected against excess voltage events, such as ESD. In terms of ESD-sensitivity, they react similar to thin-film resistors. This means, that the ESD sensitivity is inherent to sensor design and is typically a function of size. But also, base resistance, meander design and special coating might have impact on ESD-sensitivity of platinum temperature sensors. ESD-induced damages of platinum RTDs a rarely observed in customer returns and are typically related to a specific assembly or application.

In case ESD-damages are observed on the customer side, we recommend taking normal ESD precautions when handling the sensors. IST AG can also support critical applications with special design and help with the selection of sensor type.

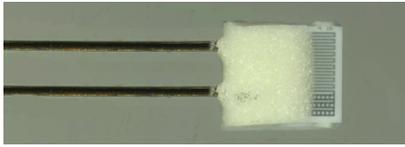


14. Sensor Construction Examples

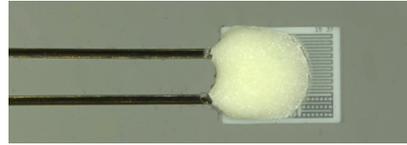


General notification

iST continuously enhances its RTD temperature sensor components to guarantee both availability and quality. Ongoing renewal and modernization of equipment and processes ensure a redundant manufacturing setup, based on identical materials and production methods. Visually, sensors may vary in their edge finish—either straight-cut or with broken edges—as illustrated in this example:



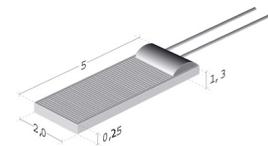
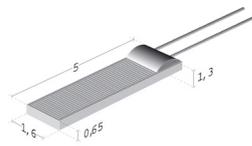
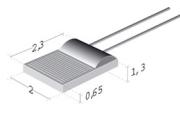
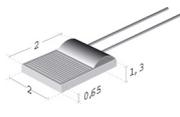
Example of an established breaking-edge sensor process



Example of a redundant sensor process with diced edge



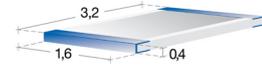
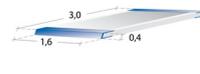
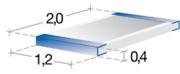
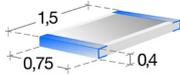
Wire



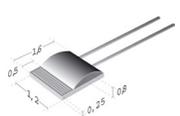
SIL



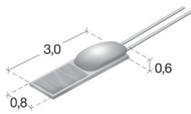
FlipChip and SMD



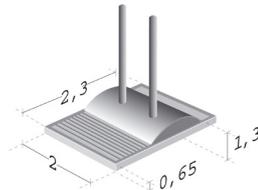
Minisens and Slimsens



Long wire, insulated wire and insulated stranded wire

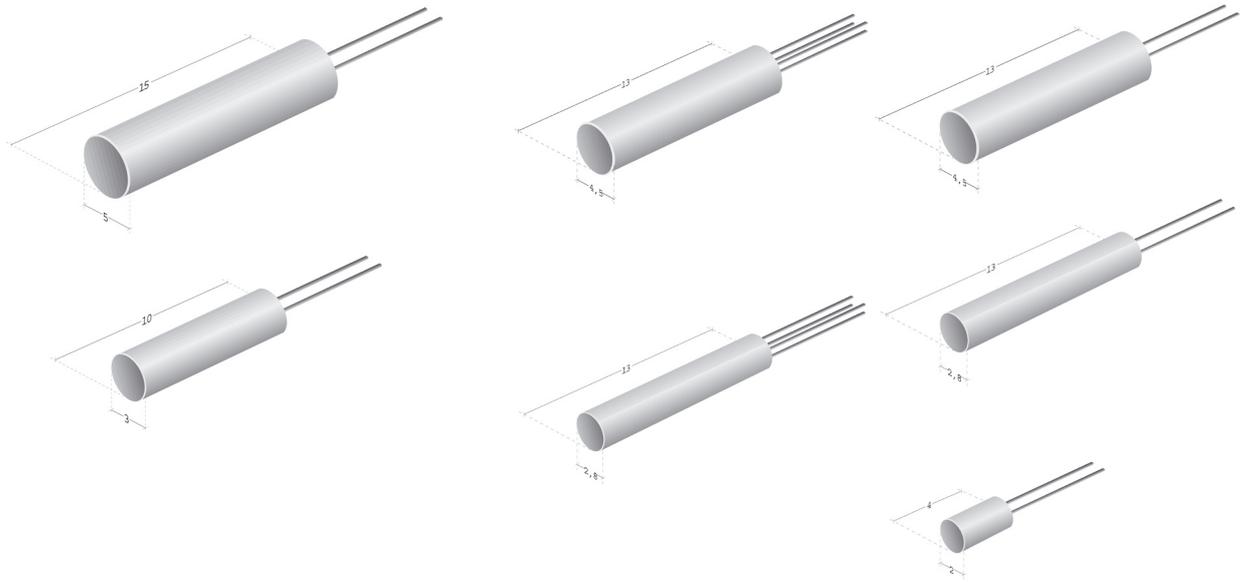


Inverted wire and perpendicular wire





Round ceramic or steel housing



15. Additional Documents

	Document name:	
Data Sheets:	DTP150_E	DTPSMD_E
	DTP200_E	DTP200_400_3-wires_E
	DTP300_E	DTP300_E
	DTP400_E	DTP500_E
	DTP600_E	DTP750_E
	DTP850_E	DTP1000_E
	DTPBondSens_E	DTPFC_E
	DTPPG_E	DTPRTPT_E
	DTPPW_E	DTPPW_4-wire_E
		DTP_Round_Housing_E

Technical specifications are subject to change without prior notice. The information contained in this data sheet has been carefully reviewed and is believed to be accurate; however, no liability is assumed for any errors or omissions. Continuous exposure to extreme operating conditions may impact product lifetime or reliability. The customer is solely responsible for assessing the suitability and fitness of the product for their specific application. This product is not designed, authorized, or warranted for use in life support or safety-critical applications. The customer agrees to hold the supplier harmless from any claims, damages, or liabilities arising from such use. No explicit or implied warranties, including but not limited to warranties of merchantability or fitness for a particular purpose, are provided. The material provided herein may not be reproduced, adapted, merged, translated, stored, or utilized in any form without prior written consent from the copyright holder. No transfer of any intellectual property rights is granted or implied. All rights reserved.



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