Application Note
RTD Platinum Sensor

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INNOVATIVE SENSOR TECHNOLOGY

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1. General Information

In many sectors, temperature measurement is one of the most important physically defined parameter to determine product quality, security and reliability. Temperature sensors are produced with different technologies to fit specific application requirements. To this end, IST has concentrated the development, manufacturing processes and materials to produce high-end thin-film temperature sensors. This know-how, partially derived from the semiconductor industry, allowing IST 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 thin-film sensors combines 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 creates an optimal price/performance ratio.

2. Construction

The temperature sensor consists of a high-purity platinum meander, photolithographically structured on a ceramic substrate. 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 Coefficent

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:

$$\alpha = \frac{R_{100} - R_0}{100 \times R_0}$$ [K^{-1}] according to the DIN EN 60751, 2009-05 numerical value of 0.00385 K^{-1}.

Generally, the value is defined in ppm/K.

This example defines 3850 ppm/K[1].

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.

$R(t) = R_0 (1 + A \times t + B \times t^2)$ 0 °C to +850 °C
$R(t) = R_0 (1 + A \times t + B \times t^2 + C \times [t-100] \times t^3)$ -200 °C to 0 °C

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

R_0 = resistance value in Ω at 0 °C
t = temperature in accordance with ITS 90

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6. Tolerance Classes DIN EN 60751 Norm

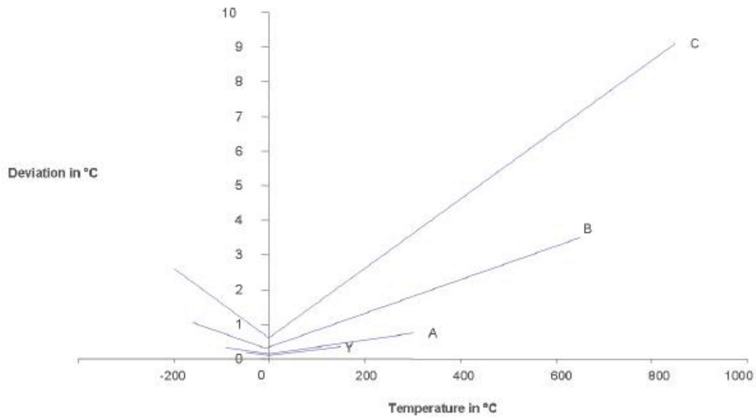
Temperature sensors are classified according to DIN EN 60751, 2009-05.

Class	± deviations in °C	IST AG reference	Temperature range of validity
DIN EN 60751 F 0.1	0.10 + 0.0017 x |t|	Y	-50 °C to +150 °C
DIN EN 60751 F 0.15	0.15 + 0.002 x |t|	A	-90 °C to +300 °C
DIN EN 60751 F 0.3	0.30 + 0.005 x |t|	B	-200 °C to +600 °C
DIN EN 60751 F 0.6	0.60 + 0.01 x |t|	C	-200 °C to +850 °C
1/5 DIN EN 60751 F 0.3	0.06 + 0.001 x |t|	K	upon request
1/10 DIN EN 60751 F 0.3	0.03 + 0.0005 x |t|	K	upon request

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

The temperature curves refers to DIN EN 60751 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 measurement point is 5 mm from the wire end. For long wires (> 20 mm) the resistance is compensated (measured at room temperature) to ensure the correct resistance at the chip edge.



7. Applied Current

The current applied is highly dependent on the application and leads to self-heating effects. Depending on the thermal transfer from the sensor into the application, the current can be increased. There is no bottom current limit for platinum thin-film sensors. The maximum current for sensors between +750 °C and +1000 °C (7W, 8W, 10W) should not exceed 1 mA.

Recommended current supplies:

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

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 $\Delta t = R \times I^2 / E$.

E = self-heating coefficient in mW/K, R = resistance in kΩ, I = measuring current in mA

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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 is depending on the sensor dimensions, the thermal contact resistance and the surounding medium.

Dimensions number	Sensor size	Response time in seconds						Self-heating			
	L x W x T/H in mm	Water (v = 0.4 m/s)			Air (v = 1 m/s)			Water (v = 0 m/s)		Air (v = 0 m/s)	
		$t_{0.5}$	$t_{0.63}$	$t_{0.9}$	$t_{0.5}$	$t_{0.63}$	$t_{0.9}$	E in mW/K	Δt in [mK][1)]	E in mW/K	Δt in [mK][1)]
161	1.6 x 1.2 x 0.25/0.8	0.05	0.08	0.18	1	1.2	2.5	12	8.3	1.8	56
308	3.0 x 0.8 x 0.25/0.6	0.08	0.1	0.25	1.2	1.5	3.5	15	6.7	2.2	46
232	2.3 x 2.0 x 0.25/0.9	0.09	0.12	0.33	2.7	3.6	7.5	40	2.5	4	25
202	2.0 x 2.0 x 0.65/1.3	0.11	0.16	0.38	3.6	4.9	10.2	32	3.1	3.2	31
216	2.5 x 1.6 x 0.65/1.3	0.12	0.18	0.42	4	5.4	11	36	2.8	3.6	28
232	2.3 x 2.0 x 0.65/1.3	0.15	0.2	0.55	4.5	6	12	40	2.5	4	25
325	3.0 x 2.5 x 0.65/1.3	0.25	0.3	0.7	5.5	7.5	16	90	1.1	8	13
516	5.0 x 1.6 x 0.65/1.3	0.25	0.3	0.7	5.5	7.5	16	80	1.3	7	14
520	5.0 x 2.0 x 0.65/1.3	0.25	0.3	0.75	6	8.5	18	80	1.3	7	14
525	5.0 x 2.5 x 0.65/1.3	0.33	0.4	0.85	6.5	9	19	90	1.1	8	13
538	5.0 x 3.8 x 0.65/1.3	0.35	0.4	0.90	7.5	10	20	140	0.7	10	10
505	5.0 x 5.0 x 0.65/1.3	0.4	0.5	1.1	8	11	21	150	0.7	11	9
102	10.0 x 2.0 x 0.65/1.3	0.33	0.4	0.85	7.5	10.5	20	140	0.7	10	10
281	13 x Ø 2.8	2.5	4.5	8	10	15	28	60	1.7	5.5	18
281*	13 x Ø 2.8	2	2.5	5.5	10	12	22	45	2.2	4	25
451	13 x Ø 4.5	8	10	22	12	22	40	85	1.2	8	13
451*	13 x Ø 4.5	5	6	14	16	18	37	60	1.7	6.5	15
SMD 1206	3.2 x 1.6 x 0.4	0.15	0.25	0.45	3.5	4.2	10	55	1.8	7	14
SMD 0805	2.0 x 1.2 x 0.4	0.1	0.12	0.33	2.5	3	8	38	2.6	4	25
FC 0603	1.5 x 0.75 x 0.4	0.08	0.1	0.25	1.8	2.2	5.5	25	4	2.5	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)
W: Sensor width

T: Sensor thickness (without connections)
H: Sensor height (incl. connections and strain relief)

10. Dimensions Tolerances

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

Sensor thickness (T) ±0.1 mm
Wire length ±1 mm (5 mm to 30 mm)
Wire length > 30 mm, tolerances on request

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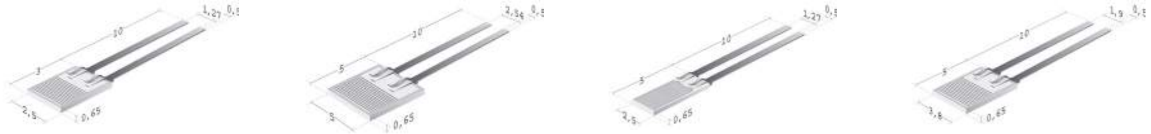
1. Sensor Construction Examples

Wire

SIL



FlipChip and SMD

Minisens and Slimsens

Long wire, insulated wire and insulated stranded wire

Inverted wire and perpendicular wire

Round ceramic housing

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