Application Note
RTD Nickel Sensor

TEMPERATURE

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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, allows 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 wire-wound platinum 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 photolithographically structured nickel meander on a ceramic substrate. The resistivity is laser-trimmed and precisely adjusted to the final value. The resistive structure is covered with a polymer or glass passivation layer protecting the sensor against mechanical and chemical damages. The welded leadwires 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 43760 (formerly) numerical value of 0.00618 K^{-1}.

Generally, the value is defined in ppm/K.
This example defines 6180 ppm/K.

R_0 = resistance value in Ω at 0 °C
R_{100} = resistance value in Ω at +100 °C

4. Long-Term Stability

The change in ohmic value after 1,000 h at maximum operating temperature amounts to less than 0.1 %.

5. Temperature Characteristic Curve[1)]

The characteristic curve is defined with a polynom:

$$R(t) = R_0 (1 + A * t + B * t^2 + C * t^3 + D * t^4 + E * t^5 + F * t^6)$$

	Nickel ND (6180 ppm/K)	Nickel NL (5000 ppm/K)	Nickel NJ (6370 ppm/K)	Nickel NA (6720 ppm/K)
A	$5.485 * 10^{-3}$ [°C^{-1}]	$4.427 * 10^{-3}$ [°C^{-1}]	$5.64742 * 10^{-3}$ [°C^{-1}]	$5.88025 * 10^{-3}$ [°C^{-1}]
B	$6.65 * 10^{-6}$ [°C^{-2}]	$5.172 * 10^{-6}$ [°C^{-2}]	$6.69504 * 10^{-6}$ [°C^{-2}]	$8.28385 * 10^{-6}$ [°C^{-2}]
C	0	$5.585 * 10^{-9}$ [°C^{-3}]	$5.68816 * 10^{-9}$ [°C^{-3}]	0
D	$2.805 * 10^{-11}$ [°C^{-4}]	0	0	$7.67175 * 10^{-12}$ [°C^{-4}]
E	0	0	0	0
F	$-2 * 10^{-17}$ [°C^{-6}]	0	0	$-1.5 * 10^{-16}$ [°C^{-6}]

R_0 = resistance value in Ω at 0°C

t = temperature at ITS 90

1) custom specific characteristic curve (e.g. Balco) available

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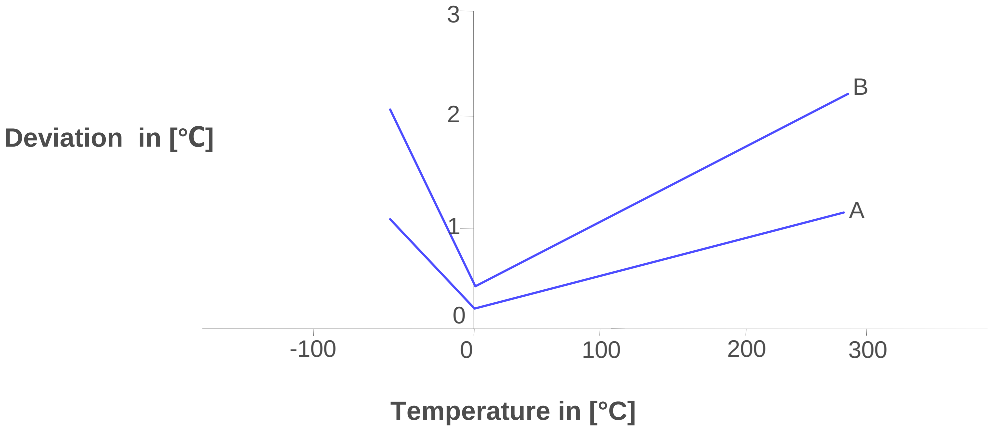
Tolerance classes formerly DIN EN 43760

Class	± limit deviations in °C		IST AG reference
	t < 0 °C	t > 0 °C	
1/2 DIN 43760	0.2 + 0.014 x |T|	0.2 + 0.0035 x |T|	A
DIN 43760	0.4 + 0.028 x |T|	0.4 + 0.007 x |T|	B

| T | is the numerical value of the temperature in °C without taking leading signs into account. The tolerances are only garanteed up to +260 °C.



6. Applied Current

The current applied is highly dependent on the application and leads to self-heating effects and temperature measuring errors is MT = P/EP (see self-heating). Depending on the thermal transfer from the sensor into the application, the current can be increased. There is no bottom current limit for nickel thin-film sensors.

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

7. Self Heating

To measure the resistance, electric current must run through the element. The current generates heat energy, resulting in errors of measurement. To minimize the error, caused by self-heating, the current should be kept as low as possible. Temperature error $\Delta t = RI^2 / E$.

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

8. 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.

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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)]
232	2.3 x 2.0 x 0.25/0.8	0.09	0.12	0.33	2.7	3.6	7.5	40	2.3	4	22.5
232	2.3 x 2.0 x 0.65/1.3	0.15	0.2	0.55	4.5	6	12	40	2.3	4	22.5
325	3.0 x 2.5 x 0.65/1.3	0.25	0.3	0.7	5.5	7.5	16	90	1	8	11.3
516	5.0 x 1.6 x 0.65/1.3	0.25	0.3	0.7	5.5	7.5	16	80	1.1	7	12.9
520	5.0 x 2.0 x 0.65/1.3	0.25	0.3	0.75	6	8.5	18	80	1.1	7	12.9
525	5.0 x 2.5 x 0.65/1.3	0.33	0.4	0.85	6.5	9	19	90	1	8	11.3
102	10.0 x 2.0 x 0.65/1.3	0.33	0.4	0.85	7.5	10.5	20	140	0.6	10	9
538	5.0 x 3.8 x 0.65/1.3	0.35	0.5	0.9	7.5	10	20	140	0.6	10	9
505	5.0 x 5.0 x 0.65/1.3	0.4	0.5	1.1	8	11	21	150	0.6	11	0.6
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	14.3
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

1) Self-heating MT[mK] was measured for Ni1000 with 0.3 mA measurement current at 0 °C

L: Sensor length (without connections)

W: Sensor width

T: Sensor thickness (without connections)

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

The values in the table are for informative purposes only. Based on the assembly method and the different measurement conditions, self-heating and response time can variate.

9. Dimensions Tolerances

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

Sensor thickness (T) ±0.1 mm
Wire length ±1.0 mm (5 mm to 30 mm)
Wire length > 30 mm, tolerances on request

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