Application Note

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Content

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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 AG 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 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 combines the positive attributes of traditional wire-wound nickel 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 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 damages. The welded 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:

$$\alpha = \frac{R_{100} - R_0}{100 \times R_0} \quad [K^{-1}]$$ according to the DIN 43760 (formerly) numerical value of $0.00618\ K^{-1}$.

Generally, the value is defined in 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 polynomial:

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

	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

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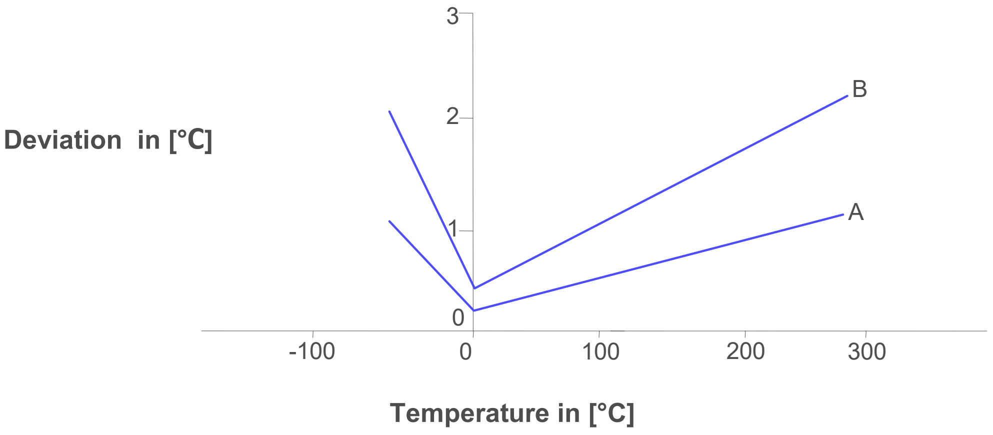
1) customer-specific characteristic curve (e.g. Balco) available

6. Tolerance classes formerly DIN 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 guaranteed up to +260 °C.



7. Applied Current

The current applied is highly dependent on the application and leads to self-heating effects and temperature measuring errors is $\Delta T = P/E$ (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

8. 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 $\Delta T = P/E = R \text{ x } I^2/E$.

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

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 surrounding medium.

Dimensions number	Sensor size	Response time in seconds						Self-heating			
	L x W x H / H2 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	
232	2	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
H: Sensor height (without connections)
H2: 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.

10. Operating Conditions

Nickel temperature sensors are built based on relatively robust materials: polymer or 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. The use of bare sensors in a long-term humid environment as well as in aggressive atmospheres must be avoided; the same applies to the direct dipping of the sensor into liquids. Potential problems can also occur due to residuals of fluxes. Hence, accurate rinsing is recommended for Nickel sensors. Furthermore, mechanical pressure on the sensors, e.g. caused by hard or strong post-curing casting compounds should be avoided.

11. Dimensions Tolerances

Sensor width (W) ±0.2 mm
Sensor length (L) ±0.2 mm
Sensor height (H2) ±0.2 mm
Sensor height (H) ±0.1 mm
Wire length ±1.0 mm (5 mm to 30 mm)
Wire length > 30 mm, tolerances on request

12. Storage

Nickel 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 precausions 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 precausions:

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

13. Additional Documents

	Document name:	
	English:	German:
Data sheets:	DTN150_E	DTN150_D
	DTN200_E	DTN200_D
	DTN200_E	DTN200_D
	DTNSMD_E	DTNSMD_D