innovative Sensor Technology
physical · chemical · biological

Application Note

RTD Nickel Sensors

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Content

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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. Innovative Sensor Technology 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 i 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 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 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 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 IEC60751, 2008-07 numerical value of 0.00618 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

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

5. Temperature Characteristic Curve [2)]

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

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

Nickel ND (6180 ppm/K)	Nickel NL (5000 ppm/K)	Nickel NJ (6370 ppm/K)	Nickel NA (6720 ppm/K)
A = 5.485 x 10^{-3} [$°C^{-1}$]	4.427 x 10^{-3} [$°C^{-1}$]	5.64742 x 10^{-3} [$°C^{-1}$]	5.88025 x 10^{-3} [$°C^{-1}$]
B = 6.65 x 10^{-7} [$°C^{-2}$]	-5.172 x 10^{-6} [$°C^{-2}$]	6.69504 x 10^{-6} [$°C^{-2}$]	8.28385x 10^{-6} [$°C^{-2}$]
C = 0	-5.585 x 10^{-12} [$°C^{-4}$]	5.68816 x 10^{-9} [$°C^{-3}$]	0
D = 2.805 x 10^{-12} [$°C^{-4}$]	0	0	7.67175 * 10^{-12} [$°C^{-4}$]
E= 0	0	0	0
F=-2 x 10^{-17} [$°C^{-6}$]	0	0	1.49 * 10^{-16} [$°C^{-6}$]

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

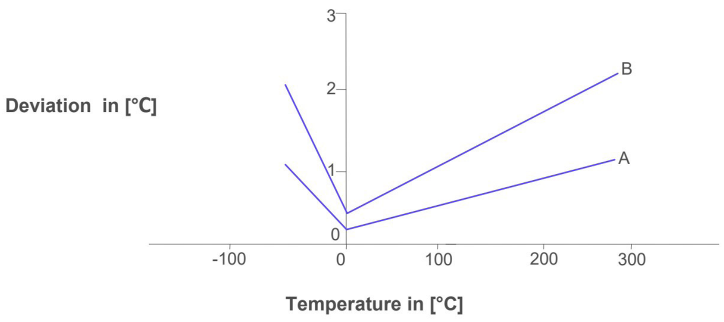
2) customer-specific characteristic curve (e.g. Balco) available

6. Tolerance classes formerly DIN 43760

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

Class	± limit deviations in °C		iST 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 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

$\Delta T = R \times I^2 \times E \times 1000$

[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)]
232 thin substrate	0.9	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	0.9	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
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

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 vary.

10. Operating Conditions

Nickel temperature sensors are built based on 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) ±0.3 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

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 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 precausions:

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

13. Additional documents

	Document name:
Data Sheets:	DTN150_E
	DTN200_E
	DTN_SMD_E
	All documents are available for dowload on iST's website. Go to www.ist-ag.com/download