

# Platinum Thin-film Sensors in Operation

Described in more detail below are a few of the parameters influenced by platinum thin-film sensors during their operating time:

## Measured currents and self-heating

Current supply the platinum thin-film sensor. The resulting temperature measuring fault is given by:

$$\Delta t = P \cdot S$$

with P, the power loss =  $I^2 R$  and S, the self-heating coefficient in K/mW.

The self-heating coefficients are specified in the datasheets for the individual products. Self-heating is dependent on thermal contact between the platinum

thin-film sensor and the surrounding medium. If the heat transfer to the environment is efficient, higher measured currents can be used.

Platinum thin-film sensors set no lower limits for measured currents. They depend to a great extent on the application. We recommend:

100 Ω:	max. 1 mA
500 Ω:	max. 0.7 mA
1000 Ω:	max. 0.3 mA
2000 Ω:	max. 0.25 mA
10000 Ω:	max. 0.1 mA

## Thermal response times

The thermal response time is the time required by a platinum thin-film sensor to react to a step-by-step temperature change with a change in resistance, which corresponds to a certain percentage share of the temperature change. DIN EN 60751 recommends the use of times for a 50 % and 90 % change,  $t_{0.5}$  and  $t_{0.9}$  are indicated in the datasheets for water and air flows of 0.4 or 2.0 m/s. Conversion to other media and speeds can be carried out with the aid of the VDI/VDE 3522 manual.

## Thermo-electrical effect

Platinum thin-film sensors generate practically no electromotive power.

## Vibration and impact

Platinum thin-film sensors are solid components and as such extremely resistant to vibration and impact. The qualifying factor is normally the mounting method. Testing well mounted thin-film platinum thin-film sensors revealed:

Vibration resistance: 40 g over a range of 10 Hz up to 2 kHz  
Shock resistance: 100 g, 8 ms half sine

## General electrical parameters of the elementary sensors

Inductivity: <math><1 \mu\text{H}</math>  
Capacity: 1 to 6 pF  
Insulation: >10 MΩ at 20°C  
>1 MΩ at 500°C

High-voltage strength:  
>1000 V at 20°C  
> 25 V at 500°C

## Mechanical load capability

Platinum thin-film sensors are sensitive to mechanical loads that may, under extreme conditions, lead to a rupture or chipping of the glass cover or the ceramic substrate. Improper handling or unsuitable mounting processes may lead to permanent changes in the measuring signals.

During manufacture, the connection wires are subjected to pulling and tear resistance tests in accordance with MIL 833 and IEC 40046. In the case of nickel/platinum coated wires, the products are approved when  $F_{axial} > 8$  N (without glass ceramic connection sealing).

## Repeatability

Platinum thin-film sensors manufactured by Heraeus Sensor Technology are characterized by a high degree of repeatability of the signal.

## Accuracy tolerance classification

Heraeus Sensor Technology supplies platinum thin-film sensors in accordance with DIN EN 60751 in the accuracy tolerance classifications B and in addition

Limit variations for 100 Ω platinum sensors				
Temperature °C	Limit variations			
	Class A		Class B	
	°C	Ohm	°C	Ohm
-200	±0.55	±0.24	±1.3	±0.56
-100	±0.35	±0.14	±0.8	±0.32
0	±0.15	±0.06	±0.3	±0.12
100	±0.35	±0.13	±0.8	±0.30
200	±0.55	±0.20	±1.3	±0.48
300	±0.75	±0.27	±1.8	±0.64
400	±0.95	±0.33	±2.3	±0.79
500	±1.15	±0.38	±2.8	±0.93
600	±1.35	±0.43	±3.3	±1.06
650	±1.45	±0.46	±3.6	±1.13
700	-	-	±3.8	±1.17
800	-	-	±4.3	±1.28
850	-	-	±4.6	±1.34

Basic values for 100 Ω platinum temperature sensors as per DIN EN 60751 (TS 90)											
°C	Ω	Ω/°C	°C	Ω	Ω/°C	°C	Ω	Ω/°C	°C	Ω	Ω/°C
-200	18.52	0.432	70	127.08	0.383	340	226.21	0.352	610	316.92	0.320
-190	22.83	0.429	80	130.90	0.382	350	229.72	0.350	620	320.12	0.319
-180	27.10	0.425	90	134.71	0.380	360	233.21	0.349	630	323.30	0.318
-170	31.34	0.422	100	138.51	0.379	370	236.70	0.348	640	326.48	0.317
-160	35.34	0.419	110	142.29	0.378	380	240.18	0.347	650	329.64	0.316
-150	39.72	0.417	120	146.07	0.377	390	243.64	0.346	660	332.79	0.315
-140	43.88	0.414	130	149.83	0.376	400	247.09	0.345	670	335.93	0.313
-130	48.00	0.412	140	153.58	0.375	410	250.53	0.343	680	339.06	0.312
-120	52.11	0.409	150	157.33	0.374	420	253.96	0.342	690	342.18	0.311
-110	56.19	0.407	160	161.05	0.372	430	257.38	0.341	700	345.28	0.310
-100	60.26	0.405	170	164.77	0.371	440	260.78	0.340	710	348.38	0.309
-90	64.30	0.403	180	168.48	0.370	450	264.18	0.339	720	351.46	0.308
-80	68.33	0.402	190	172.17	0.369	460	267.56	0.338	730	354.53	0.307
-70	72.33	0.400	200	175.86	0.368	470	270.93	0.337	740	357.59	0.305
-60	76.33	0.399	210	179.53	0.367	480	274.29	0.335	750	360.64	0.304
-50	80.31	0.397	220	183.19	0.365	490	277.64	0.334	760	363.67	0.303
-40	84.27	0.396	230	186.84	0.364	500	280.98	0.333	770	366.70	0.302
-30	88.22	0.394	240	190.47	0.363	510	284.30	0.332	780	369.71	0.301
-20	92.16	0.393	250	194.10	0.362	520	287.62	0.331	790	372.71	0.300
-10	96.09	0.392	260	197.71	0.361	530	290.92	0.330	800	375.70	0.298
0	100.00	0.391	270	201.31	0.360	540	294.21	0.328	810	378.68	0.297
10	103.90	0.390	280	204.90	0.358	550	297.49	0.327	820	381.65	0.296
20	107.79	0.389	290	208.48	0.357	560	300.75	0.326	830	384.60	0.295
30	111.67	0.387	300	212.05	0.356	570	304.01	0.325	840	387.55	0.294
40	115.54	0.386	310	215.61	0.355	580	307.25	0.324	850	390.48	0.293
50	119.40	0.385	320	219.15	0.354	590	310.49	0.323			
60	123.24	0.384	330	222.68	0.353	600	313.71	0.322			

tion A and 1/3 DIN (see Table 2). Proportionally limited tolerances are calculated as

$$\Delta t = \pm 1/a (0.3^\circ\text{C} + 0.005 \text{ t})$$

with a = 1, 2 or 3

Platinum thin-film sensors can also be selected in tolerance groups with a maximum  $\Delta t = 0.1$  K over a range of 0°C to 100°C. For applications with high price sensitivity, other accuracy tolerances are also available.

## Long-term stability

The ageing effects on thin-film sensors as a result of long-term operation or temperature shock may have a negative influence on the precision and reproducibility of the sensor signal. Long-term stability is therefore of the greatest importance.

Due to the chemical stability and homogeneity of the platinum used, platinum thin-film sensors are the most stable thin-film sensors. Depending on the operating conditions, the resistance changes after 5 years of operation at 200°C are typically less than 0.04 %. The standard test conditions include

250 h, 500 h and 1000 h. However, shock tests and long-term tests can be adjusted to the customer's requirements.

## Climate and humidity

A double glass layer and a glass of ceramic fixing drops protect the sensor element reliably from environmental influences. Measurements as per IEC 71 show that climatic and humidity variations do not have an impact on the measuring accuracy of sensor elements.

## Circuit design

Platinum thin-film sensors are often fed with a continuous current, as standard in 2-lead circuitry. For energy-saving reasons (accumulator or battery operation), a switched measured current can also be used. The voltage output signal is a function of the  $R_t$  resistance. Because of the simple quadratic function of the platinum thin-film sensor characteristic curve as well as the possibility of a simple linear approximation, the linearization of the measuring symbols poses no problem.

# Color Coding

## Connection

Standard 2-lead circuits may result in a loss of precision. Therefore, 3 or 4-lead circuits are recommended:

- for longer cables, where the resistance and the temperature-dependent resistance of the cable may achieve significant values
- for platinum thin-film sensors with narrower tolerances
- if significant electromagnetic interferences exist

## Storage

Platinum thin-film sensors should not be subjected to caustic and corrosive media and atmospheres. The specific storage information for each type is to be followed.

## Cleaning

Platinum thin-film sensors are cleaned before packing and further cleaning is normally not required. Should cleaning be required after mounting, most conventional industrial processes can be used, including immersion in a liquid or bath. We recommend that residue-free cleaning agents be used.

## Handling

Platinum thin-film sensors are precision components, and should therefore be carefully handled during mounting. Metal holders, clamps or other rough gripping devices may not be used. Plastic tweezers are recommended for working with elementary sensors. The supply leads may not be bent near the body of the platinum thin-film sensor. Frequent repositioning of the supply leads should be avoided.

## Connection technology

The best results are achieved with welding processes (resistance welding, laser welding etc.) or soldering (soft, hard solder). When using hard solder, it should be ensured that the platinum thin-film sensor body is not heated above its maximum nominal temperature. In general, the soldering times for hard solder should be less than three seconds.

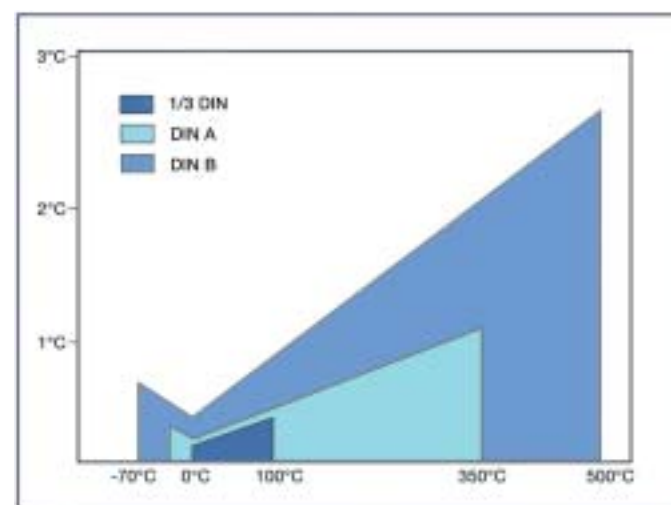
Shrinkage and ultrasonic sealing is also possible.

- When shrinkage is being carried out, it must be ensured that any electrical resistance is avoided at the connecting point.
- With ultrasonic sealing, the leads are to be bent out of the level of the platinum thin-film sensor, in order to exclude interior damage.
- For the SMD and SOT223 series, we recommend automatic further processing with wave or reflow soldering processes.

## Adhesion and embedding

When adhering, embedding, powdering or coating platinum thin-film sensors, it is important that the coefficients of thermal expansion of the different materials used agree, in order to avoid mechanical tensions that may affect the sensor signal.

The embedding materials should be chemically neutral and remain elastic after drying. The position of a connected platinum thin-film sensor should under no circumstances be subsequently corrected by sliding its body. Heraeus Sensor Technology's MR series is already recast in a ceramic casing. The SOT223 and TO92 series are cast in plastic.



Tolerances of basic values for platinum temperature sensors are specified in DIN EN 60751. The following applies:  
 Class B:  $\Delta t = \pm (0.3^\circ\text{C} + 0.005 \text{ t})$ ; Class A:  $\Delta t = \pm (0.15^\circ\text{C} + 0.002 \text{ t})$  and according to our own definition: Class 1/3 DIN:  $\Delta t = \pm 1/3 (0.3^\circ\text{C} + 0.005 \text{ t})$ , Class 2 B:  $\Delta t = \pm 2 (0.3^\circ\text{C} + 0.005 \text{ t})$

To meet the request of many customers and to enable an easier identification of the various sensor families, Heraeus Sensor Technology has introduced a clear color coding system. This ensures that the temperature application range and the resistance value of a sensor can be seen at a glance.

What is the use for you:

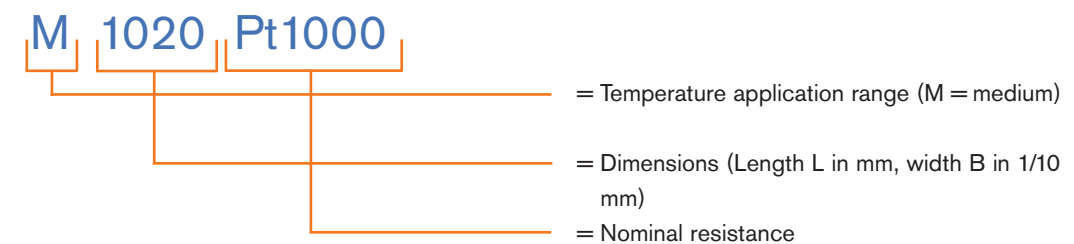
- avoiding mistakes in your production resulting in an higher quality level
- simplified logistic by easy classification

The table below indicates the meaning of the colors of fixing material and meander cover:

The color coding system			
Area	Temperature range	Color	Name
	°C		
Fixing	C (above -200°C)	light blue	Cryo temperature
	L (up to 400°C)	light blue	Low temperature
	M (up to 600°C)	blue	Medium temperature
	H (above 600°C)	white	High temperature
Resistance value			
	Ω		
Meander cover	Pt 100	transparent	
	Pt 500	pink	
	Pt 1000	blue	
	Pt 10000	white	

## Example

Sensor designation:



Concerning all products: We reserve the right to make alterations in illustrations and technical data printed. All technical data serves as a guideline and does not guarantee particular properties to any products.