

EPCOS Product Brief 2017

# NTC Thermistors

## NTC Element H650 for Measuring Temperatures up to 650 °C

In the past, measurement of temperatures in excess of 500 °C had primarily been based on Pt temperature sensors. TDK now presents a new NTC element for maximum operating temperatures up to 650 °C. Applications include the automotive sector, industry and domestic appliances, e.g. exhaust gas recirculation, 3D printers or ovens. The new NTC element is characterized by high resolution and an extremely robust construction. With a sensitivity  $\alpha$  of  $-0.72\%/K$  at 600 °C, this NTC element provides a significantly better resolution, and therefore

better temperature measurement, compared to Pt temperature sensors with a sensitivity of  $0.10\%/K$ . During long term testing at an average application temperature of 300 °C, the aging behavior is excellent; the typical resistance drift is in the range of  $\pm 0.2$  K.

The qualification has been based on automotive standard AEC-Q200.

Thanks to NTC technology, the use of precious metals like platinum or gold can be avoided completely.



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### Introduction

The new NTC element is based on a glass-encapsulated, high-performance perovskite ceramic with inflexible terminals made of aluminum oxide and a conducting path made of silver. The nominal temperature is 200 °C, and the tightest tolerance about  $\pm 1$  K at 200 °C.

As a design option, the NTC element can be delivered with additional lead wire for welding connections or on a lead frame as a variant that includes a connector for easier mounting, e.g. for the injection molding process.

The qualification has been based on automotive qualification AEC-Q200 and has been adapted for a maximum temperature of 650 °C, which means this NTC element is basically suitable for applications like exhaust gas recirculation. These systems are used in diesel engines in order to reduce the formation of toxic nitrogen oxide in the combustion process.

In 3D printers the new NTC element can monitor the correct temperature in the printer chamber and protect critical areas of the equipment and material against overheating.

Last but not least, high-temperature sensors are required in household appliances like ovens for catalytic cleaning.



### Electrical specification and ordering code

$R_R$ $\Omega$	$\Delta R_R/R_R$ %	$R_{25}$ $\Omega$	No. of R/T characteristic	$T_R$ $^{\circ}\text{C}$	$B_{25/200}$ K	$\delta_{th}$ mW/K	$\tau_c$ s	$C_{th}$ mJ/K	Ordering code
5000	$\pm 2$	821 970	6001	200	4113 $\pm 1\%$	approx. 1.5	approx. 10	approx. 15	B57650H0824A001



### Overview of R/T-curve characteristics and summary of resistance values between -40 °C and +650 °C

Temp. $^{\circ}\text{C}$	$R_{nom}$ $\Omega$	$\Delta R$ $\pm\%$	$\Delta T$ $\pm^{\circ}\text{C}$	$\alpha$ %/K
-40	18452000	11.0	2.0	5.6
0	2431500	8.4	1.8	4.6
25	821970	7.2	1.7	4.1
100	59902	4.4	1.5	3.0
<b>200</b>	<b>5000</b>	<b>2.0</b>	<b>1.0</b>	<b>2.1</b>
300	826.76	3.6	2.3	1.6
400	207.35	4.6	3.8	1.2
500	68.619	5.4	5.5	1.0
600	28.051	6.0	7.5	0.8
650	19.207	6.3	8.8	0.7

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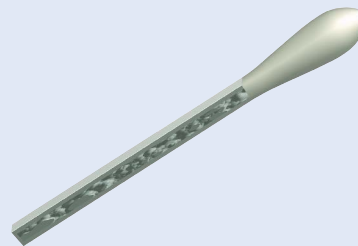
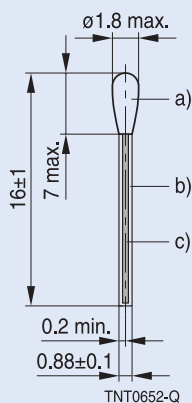
### Design

With the newly developed perovskite NTC ceramic TDK has designed a completely new NTC element. The NTC thermistor chip is connected to an alumina rod, metalized on two opposite sides. Glass encapsulation protects the NTC ceramic chip including the interconnection to the alumina rod electrodes. The electrodes and interconnections are silver-based. Furthermore, all materials of the sensor element are lead- and halogen-free and comply with all RoHS requirements without exemptions.

### The design of the H650 element in detail

#### Basic design

- a) High-temperature ceramic (inside glass encapsulation)
- b) Rigid terminals, aluminum oxide
- c) Conducting path, silver pads



The NTC element has a total length of 16 mm and a maximum diameter of 1.8 mm and is designed for measurements in an operating temperature range from  $-40\text{ °C}$  to  $+600\text{ °C}$ . The maximum temperature can be extended to  $650\text{ °C}$  for 1000 hours. The rated resistance is defined at  $200\text{ °C}$  with minimum tolerance. The specified resistance value at the rated temperature is  $5000\ \Omega$ .

This specification allows a temperature measurement accuracy of about  $\pm 1\text{ K}$  at the rated temperature of  $200\text{ °C}$ .

Besides providing high stability up to  $650\text{ °C}$ , the R/T curve allows higher sensitivity at elevated temperatures. Compared to Platinum temperature sensors with a sensitivity  $\alpha$  of  $+0.35\%/K$ , the NTC element reaches a sensitivity  $\alpha$  of  $-4.1\%/K$  at  $25\text{ °C}$ , one order of magnitude more.

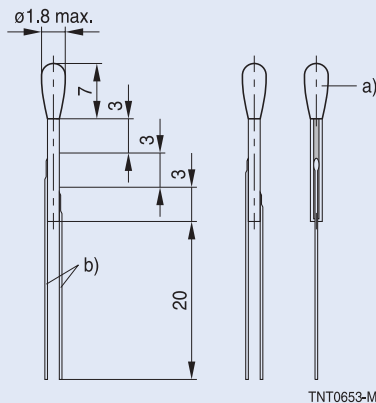
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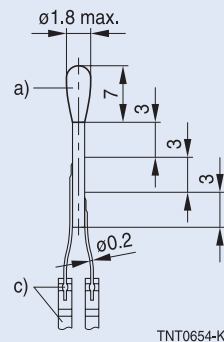
### Design options

For easier mounting and further processing, the following H650 NTC element options are available:

#### with lead wires



#### with welded-on connector



- a) NTC basic element
- b) Silver lead wire
- c) Welded NTC element on connector

The connector can be based on customer-specific requirements with regard to design and materials. Typical materials for lead-frame or connector pins are CuSn with surface treatment using tin, silver or gold.

### Qualification

The qualification has been in accordance with automotive standard AEC-Q200. The maximum temperature for testing was extended to 650 °C for the specified maximum operating temperature.

For long term testing, e.g. storage at 300 °C (10 000 hours), as an average application temperature, a typical resistance drift is in the range of about 0.2 K.

This very low variation in resistance is result of a reliable ceramic combined with a robust new design.

### Symbols and terms

Symbol		Symbol	
$B_{25/200}$	B value determined by resistance measurement at 25 °C and 200 °C	$\delta_{th}$	Dissipation factor
$R_R$	Rated resistance	$\tau_c$	Thermal cooling time constant
$\Delta R_R/R_R$	Resistance tolerance	$\tau_a$	Thermal time constant
$T_R$	Rated temperature		

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