

## **PTC thermistors as limit temperature sensors**

SMD, EIA case sizes 0402, 0603, 0805,  
standard series

**Series/Type:**      **B59404, B59601, B59602,  
B59603, B59701**

**Date:**              April 2020

## Sensors

### Limit temperature sensors, EIA case sizes 0402, 0603, 0805

### Standard series

#### SMD

#### Applications

- DC/DC converters
- Home appliances
- Dimmers
- Electronic ballasts
- Over-temperature protection of power components
- Secondary protection of battery packs
- SMPS
- Notebooks

#### Features

- Fast and reliable response
- Suitable for reflow soldering only
- Compliant to RoHS directive 2002/95/EC
- UL approval to UL1434 for B59404A\* and B59601A\* (file number E69802)
- Lead-free terminations (tinned), except case size 0402

#### Options

- Other  $T_{\text{sense}}$  or resistance values on request

#### Delivery mode

- Blister tape (EIA case size 0805) or cardboard tape (EIA case sizes 0402 and 0603), 180-mm reel with 8-mm tape, taping to IEC 60286-3
- Packing unit: 4.000 pcs. for EIA case sizes 0603 and 0805, 10.000 pcs. for EIA case size 0402

#### General technical data

|                               |                           |                     |                                                                             |      |
|-------------------------------|---------------------------|---------------------|-----------------------------------------------------------------------------|------|
| Max. operating voltage        |                           | $V_{\text{max}}$    | 32                                                                          | V DC |
| Minimum operating temperature | $(V \leq V_{\text{max}})$ | $T_{\text{op,min}}$ | −40                                                                         | °C   |
| Maximum operating temperature | $(V \leq V_{\text{max}})$ | $T_{\text{op,max}}$ | 125 °C or $T_{\text{sense},1} + 25$ °C<br>whichever is higher <sup>1)</sup> | °C   |

1)  $T_{\text{op,max}} = 140$  °C for B59404A0130A062

## Sensors

### Limit temperature sensors, EIA case sizes 0402, 0603, 0805

### Standard series

#### SMD

### Electrical specifications and ordering codes

#### EIA case sizes 0402 and 0603

| $R_R$<br>( $V \leq V_{max}$ )<br>$\Omega$             | $\Delta R_R$<br>% | $T_{sense,1}$<br>(@ 4.7 k $\Omega$ )<br>$^{\circ}\text{C}$ | $T_{sense,1}$<br>(@ 4.7 M $\Omega$ )<br>$^{\circ}\text{C}$ | $R$<br>( $T_{sense,1} + 10^{\circ}\text{C}$ )<br>k $\Omega$ | Ordering code   |
|-------------------------------------------------------|-------------------|------------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------|-----------------|
| EIA case size 0402, high ohmic types                  |                   |                                                            |                                                            |                                                             |                 |
| 10000                                                 | $\pm 50$          | -                                                          | 130 $\pm 5$                                                | -                                                           | B59404A0130A062 |
| EIA case size 0603, standard types                    |                   |                                                            |                                                            |                                                             |                 |
| 470                                                   | $\pm 50$          | 75 $\pm 5$                                                 | -                                                          | -                                                           | B59601A0075A062 |
| 470                                                   | $\pm 50$          | 85 $\pm 5$                                                 | -                                                          | -                                                           | B59601A0085A062 |
| 470                                                   | $\pm 50$          | 95 $\pm 5$                                                 | -                                                          | -                                                           | B59601A0095A062 |
| 470                                                   | $\pm 50$          | 105 $\pm 5$                                                | -                                                          | -                                                           | B59601A0105A062 |
| 470                                                   | $\pm 50$          | 115 $\pm 5$                                                | -                                                          | -                                                           | B59601A0115A062 |
| 470                                                   | $\pm 50$          | 125 $\pm 5$                                                | -                                                          | -                                                           | B59601A0125A062 |
| 470                                                   | $\pm 50$          | 135 $\pm 5$                                                | -                                                          | -                                                           | B59601A0135A062 |
| EIA case size 0603, tight temperature tolerance types |                   |                                                            |                                                            |                                                             |                 |
| 470                                                   | $\pm 50$          | 85 $\pm 3$                                                 | -                                                          | $\geq 15$                                                   | B59601A0085B062 |
| 470                                                   | $\pm 50$          | 95 $\pm 3$                                                 | -                                                          | $\geq 40$                                                   | B59601A0095B062 |
| 470                                                   | $\pm 50$          | 105 $\pm 3$                                                | -                                                          | $\geq 40$                                                   | B59601A0105B062 |
| 470                                                   | $\pm 50$          | 115 $\pm 3$                                                | -                                                          | $\geq 40$                                                   | B59601A0115B062 |
| 470                                                   | $\pm 50$          | 125 $\pm 3$                                                | -                                                          | $\geq 40$                                                   | B59601A0125B062 |

#### Note:

In order to limit self heating effects the electrical power during measurement should be below 2 mW for EIA case size 0402 and below 4 mW for EIA case size 0603.

## Sensors

### Limit temperature sensors, EIA case sizes 0402, 0603, 0805

### Standard series

## Electrical specifications and ordering codes

### EIA case sizes 0603 and 0805

| $R_R$<br>( $V \leq V_{max}$ )                        | $\Delta R_R$ | $T_{sense}$      | $T$<br>(@<br>$2 \cdot R_R$ ) | $T$<br>(typ.)<br>(@ $R_{min}$ ) | $R$<br>( $T_{sense,1}$<br>$-5^\circ\text{C}$ ) | $R$<br>( $T_{sense,1}$<br>$+5^\circ\text{C}$ ) | $R$<br>( $T_{sense,1}$<br>$+15^\circ\text{C}$ ) | Ordering code   |
|------------------------------------------------------|--------------|------------------|------------------------------|---------------------------------|------------------------------------------------|------------------------------------------------|-------------------------------------------------|-----------------|
| $\Omega$                                             | %            | $^\circ\text{C}$ | $^\circ\text{C}$             | $^\circ\text{C}$                | $\text{k}\Omega$                               | $\text{k}\Omega$                               | $\text{k}\Omega$                                |                 |
| EIA case size 0603, tight resistance tolerance types |              |                  |                              |                                 |                                                |                                                |                                                 |                 |
| 110                                                  | $\pm 15$     | 70               | $57 \pm 3$                   | 15                              | $\leq 1.1$                                     | $\geq 1.1$                                     | -                                               | B59602A0055B062 |
| 470                                                  | $\pm 15$     | 55               | $45 \pm 5$                   | 5                               | $\leq 4.7$                                     | $\geq 4.7$                                     | -                                               | B59603A0055A062 |
| 470                                                  | $\pm 15$     | 85               | $75 \pm 5$                   | 40                              | $\leq 4.7$                                     | $\geq 4.7$                                     | -                                               | B59603A0085A062 |
| 470                                                  | $\pm 15$     | 105              | $95 \pm 5$                   | 55                              | $\leq 4.7$                                     | $\geq 4.7$                                     | -                                               | B59603A0105A062 |
| EIA case size 0805, standard types                   |              |                  |                              |                                 |                                                |                                                |                                                 |                 |
| 680                                                  | $\pm 50$     | 70               | -                            | -                               | $\leq 5.7$                                     | $\geq 5.7$                                     | $\geq 40^{1)}$                                  | B59701A0070A062 |
| 680                                                  | $\pm 50$     | 90               | -                            | -                               | $\leq 5.5$                                     | $\geq 13.3$                                    | $\geq 40$                                       | B59701A0090A062 |
| 680                                                  | $\pm 50$     | 100              | -                            | -                               | $\leq 5.5$                                     | $\geq 13.3$                                    | $\geq 40$                                       | B59701A0100A062 |
| 680                                                  | $\pm 50$     | 110              | -                            | -                               | $\leq 5.5$                                     | $\geq 13.3$                                    | $\geq 40$                                       | B59701A0110A062 |
| 680                                                  | $\pm 50$     | 120              | -                            | -                               | $\leq 5.5$                                     | $\geq 13.3$                                    | $\geq 40$                                       | B59701A0120A062 |
| 680                                                  | $\pm 50$     | 130              | -                            | -                               | $\leq 5.5$                                     | $\geq 13.3$                                    | $\geq 40$                                       | B59701A0130A062 |
| 680                                                  | $\pm 50$     | 140              | -                            | -                               | $\leq 5.5$                                     | $\geq 13.3$                                    | $\geq 40$                                       | B59701A0140A062 |

### Note:

In order to limit self heating effects the electrical power during measurement should be below 4 mW for EIA case size 0603 and below 6 mW for EIA case size 0805.

1)  $R(T_{sense,1} + 25^\circ\text{C})$

## Sensors

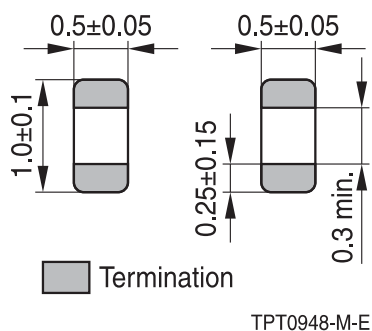
### Limit temperature sensors, EIA case sizes 0402, 0603, 0805

### Standard series

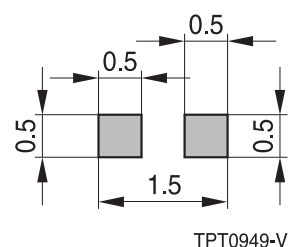
#### SMD

#### Dimensional drawings in mm

##### EIA case size 0402

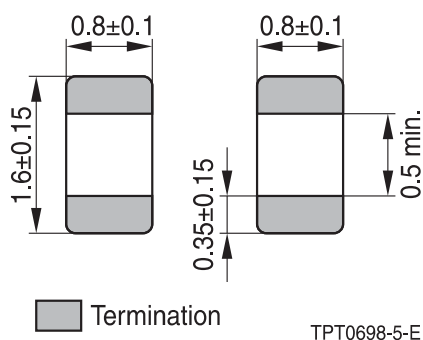


##### Solder pad

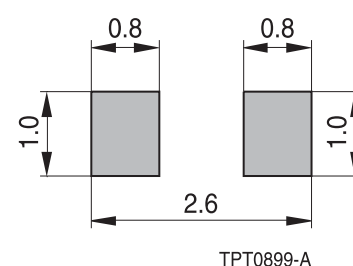


#### Recommended maximum dimensions (mm)

##### EIA case size 0603

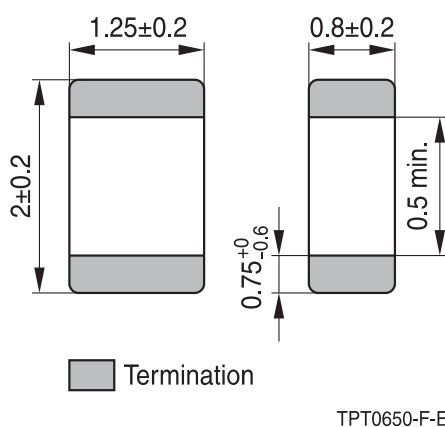


##### Solder pad

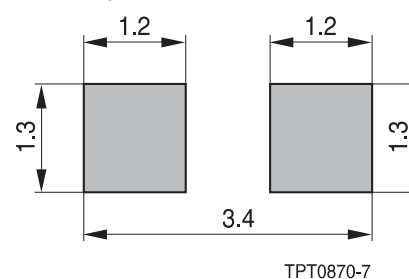


#### Recommended maximum dimensions (mm)

##### EIA case size 0805



##### Solder pad



#### Recommended maximum dimensions (mm)

# Sensors

Limit temperature sensors, EIA case sizes 0402, 0603, 0805

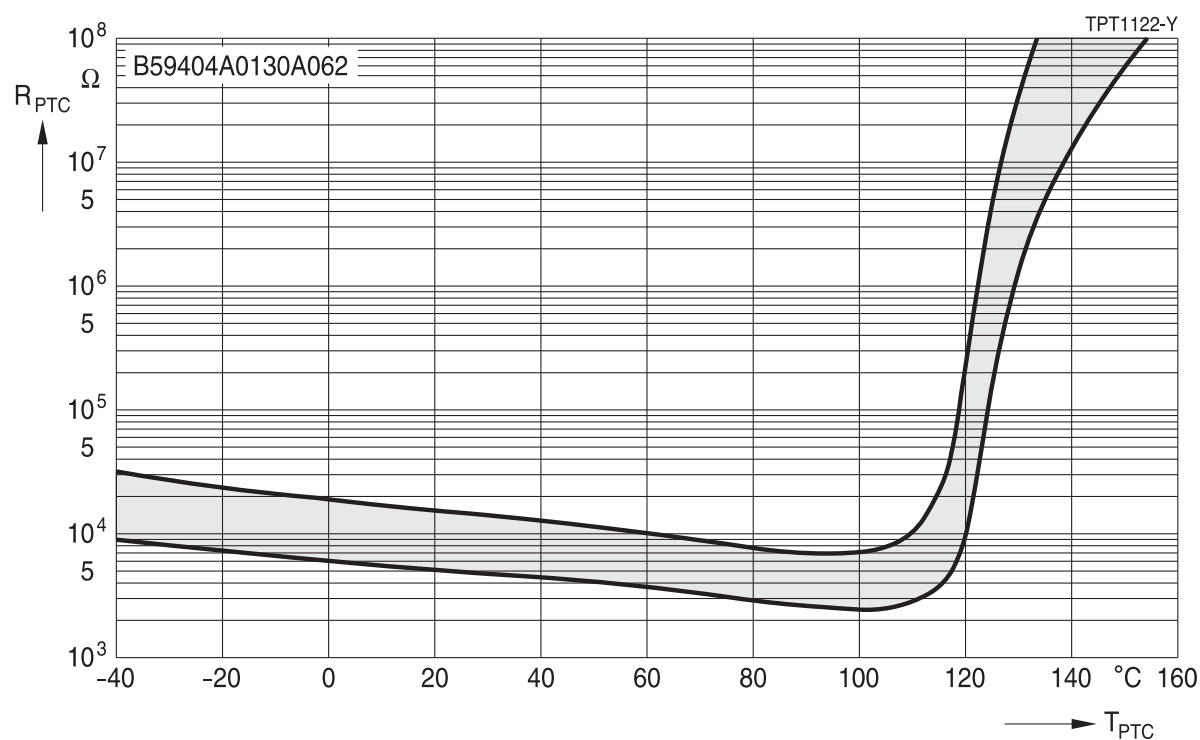
Standard series

## SMD

### Characteristics (typical) for B59404A\*, EIA case size 0402

PTC resistance  $R_{PTC}$  versus PTC temperature  $T_{PTC}$  (measured at low signal voltage).

$R_{min}$  and  $R_{max}$  values are typical values for reference only.



# Sensors

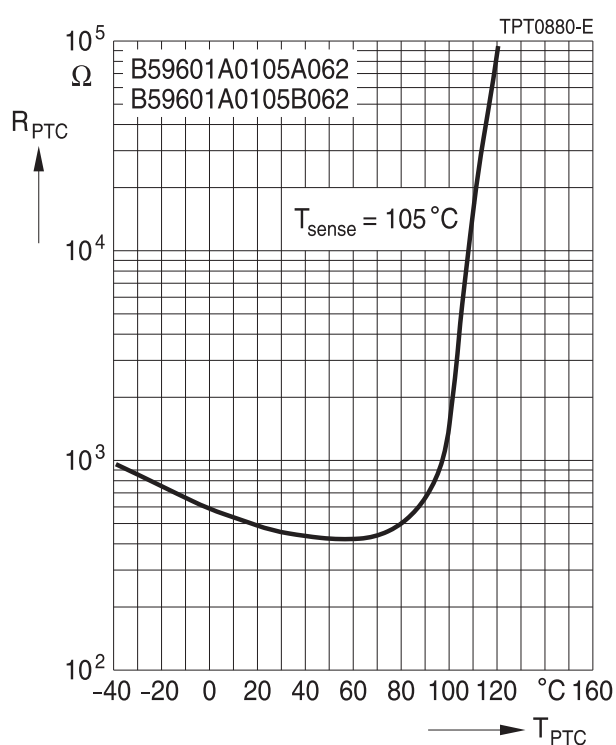
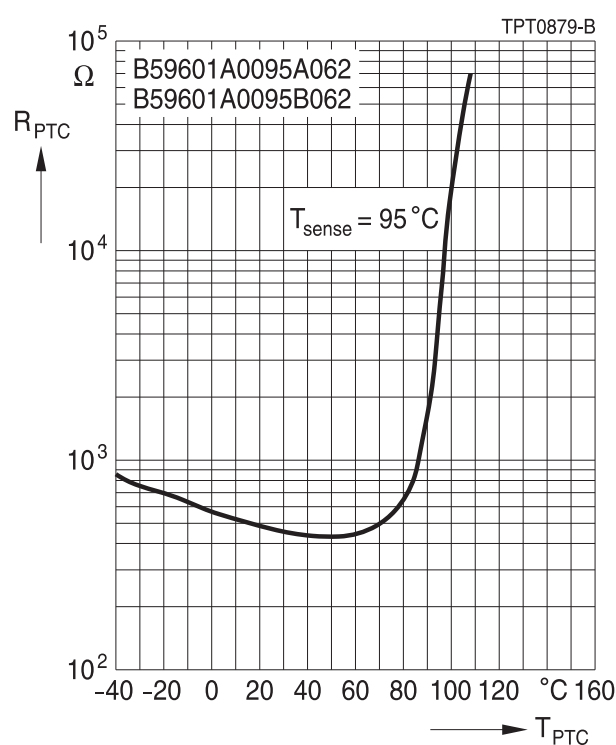
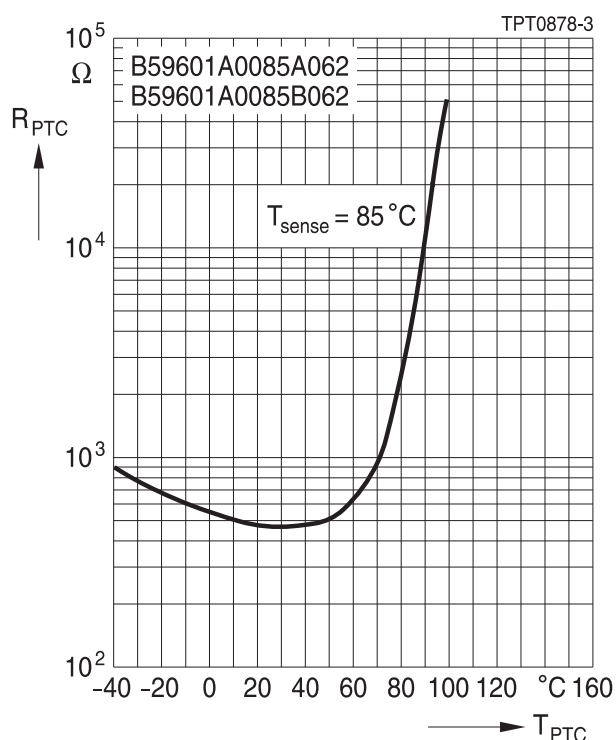
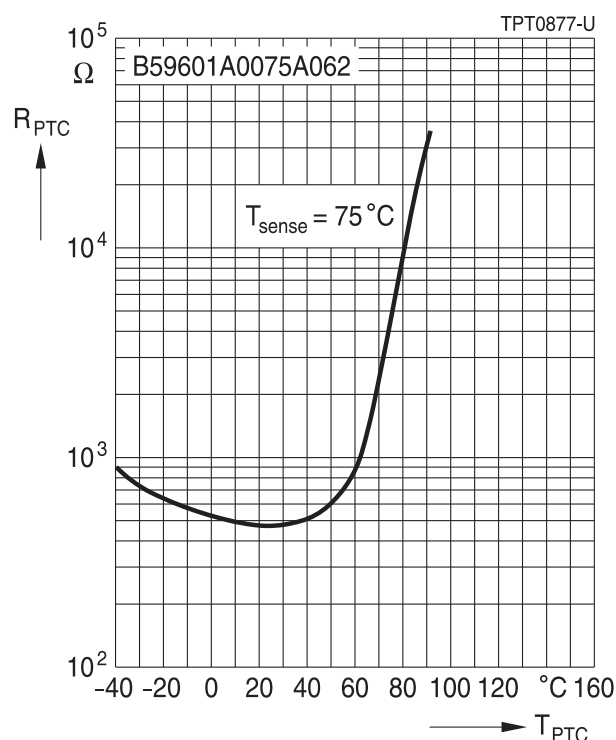
## Limit temperature sensors, EIA case sizes 0402, 0603, 0805

## Standard series

### SMD

### Characteristics (typical) for B59601A\*, EIA case size 0603

PTC resistance  $R_{PTC}$  versus PTC temperature  $T_{PTC}$   
(measured at low signal voltage)



# Sensors

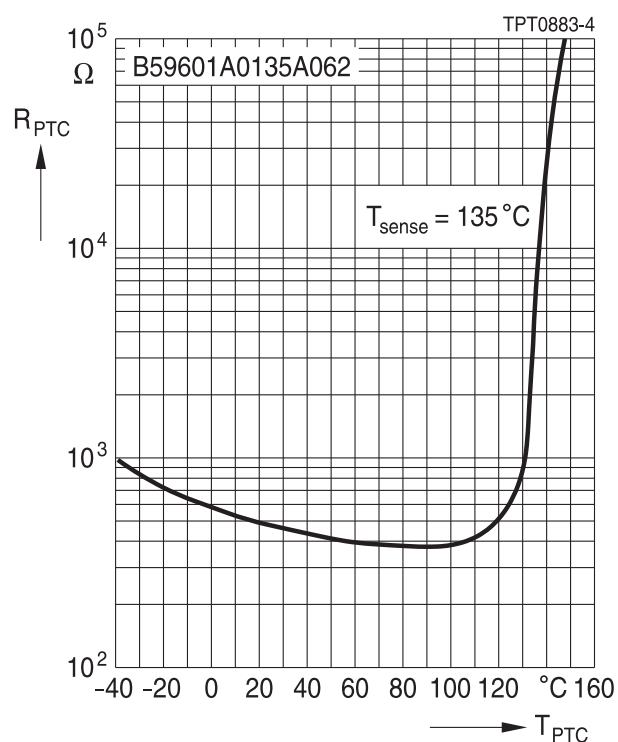
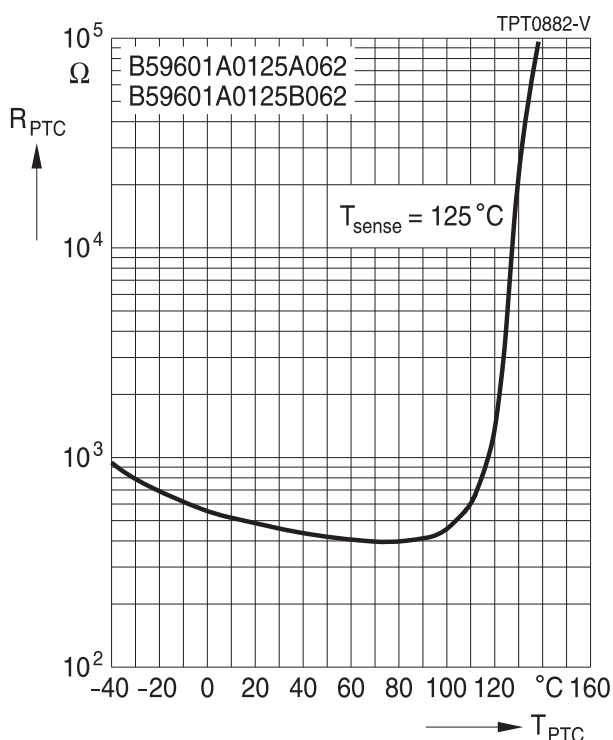
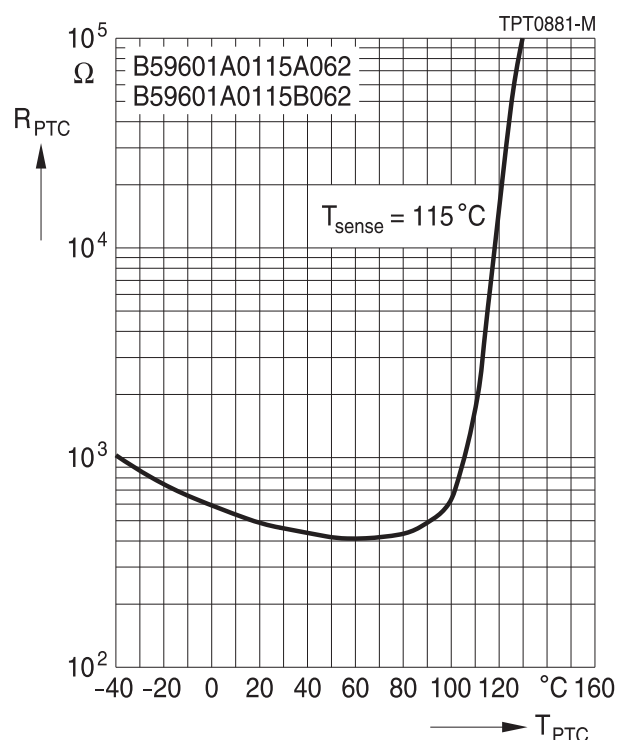
## Limit temperature sensors, EIA case sizes 0402, 0603, 0805

## Standard series

### SMD

### Characteristics (typical) for B59601A\*, EIA case size 0603

PTC resistance  $R_{PTC}$  versus PTC temperature  $T_{PTC}$   
(measured at low signal voltage)



# Sensors

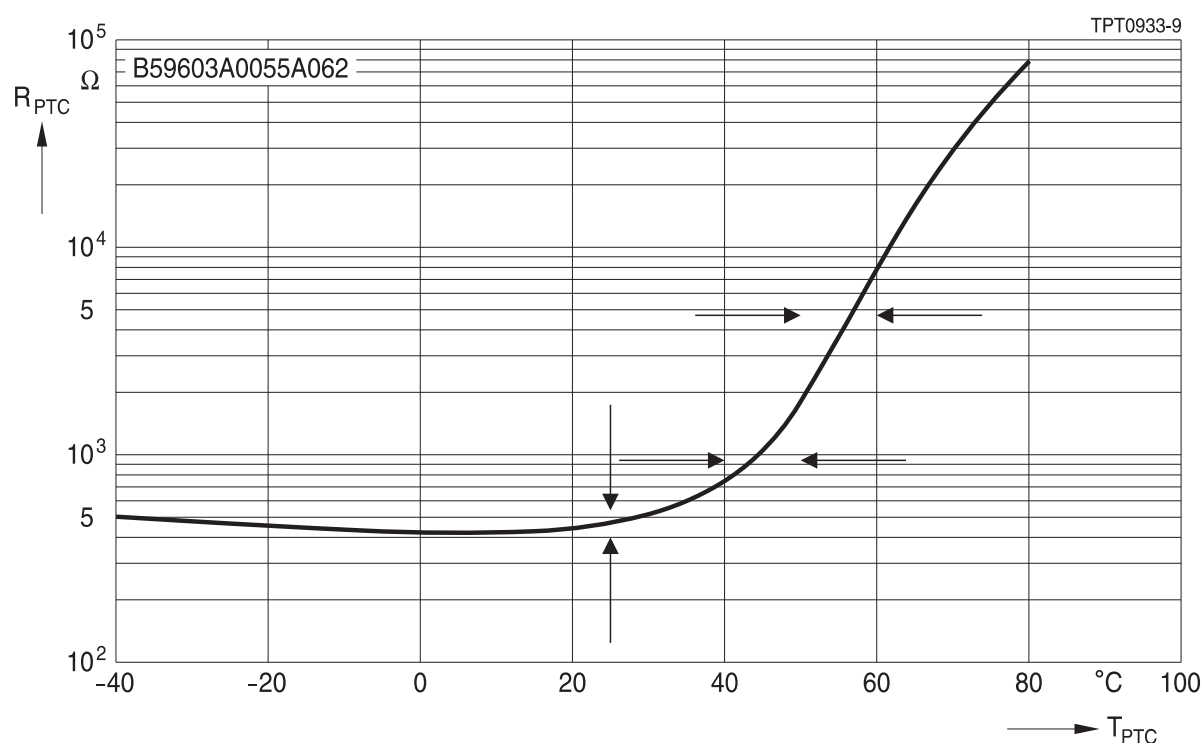
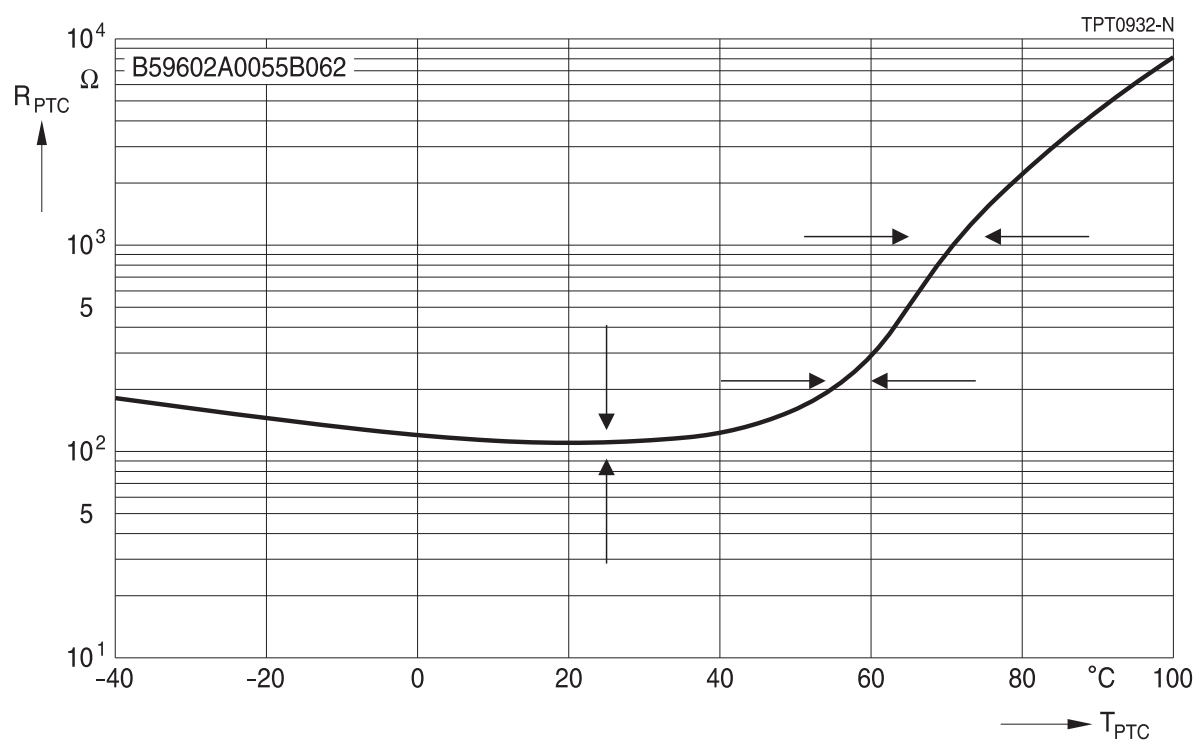
Limit temperature sensors, EIA case sizes 0402, 0603, 0805

Standard series

## SMD

### Characteristics (typical) for B59602A\* and B59603A\*, EIA case size 0603

PTC resistance  $R_{PTC}$  versus PTC temperature  $T_{PTC}$   
(measured at low signal voltage)



# Sensors

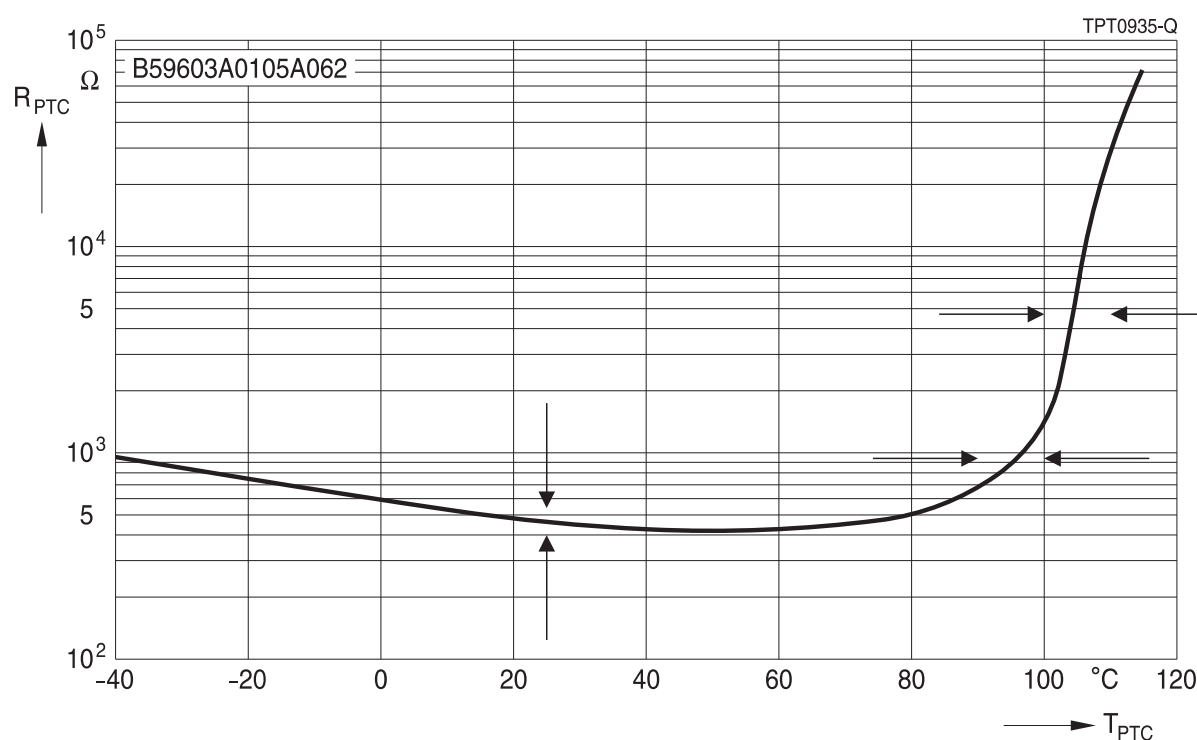
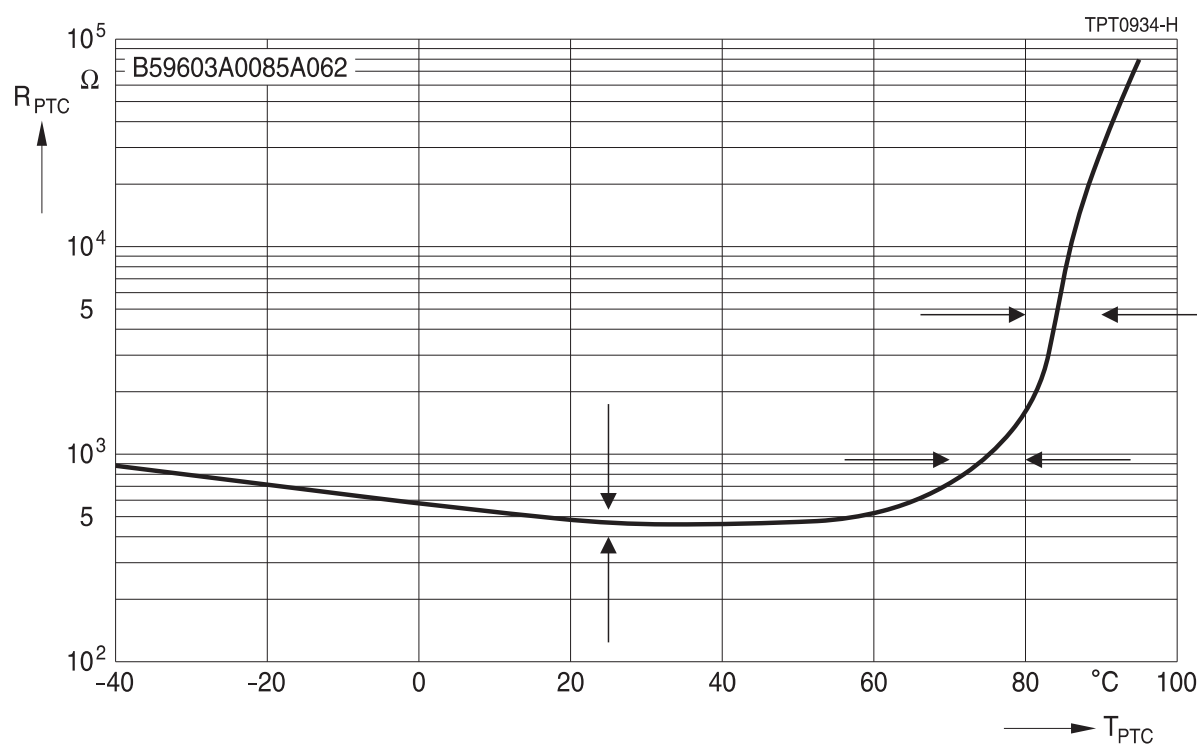
Limit temperature sensors, EIA case sizes 0402, 0603, 0805

Standard series

## SMD

### Characteristics (typical) for B59603A\*, EIA case size 0603

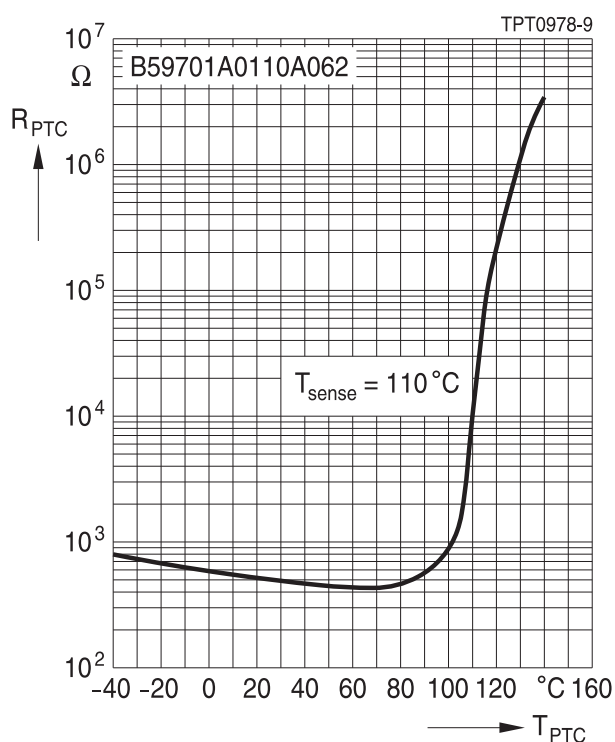
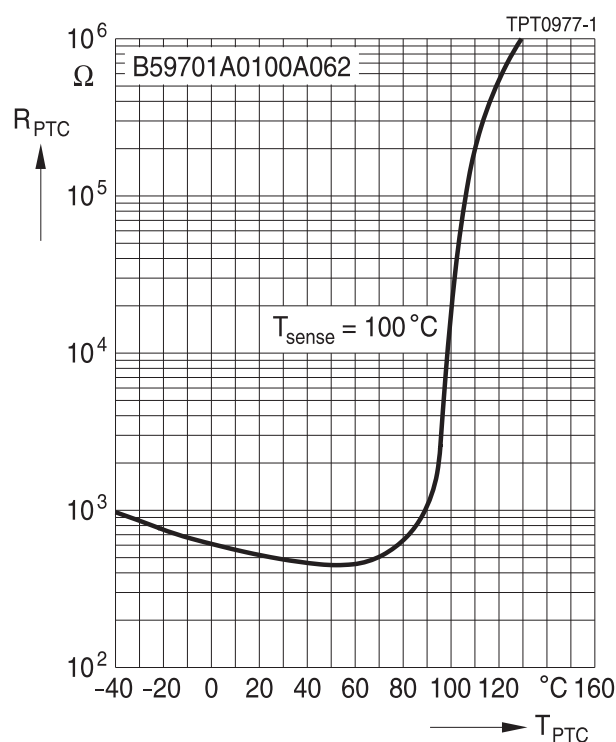
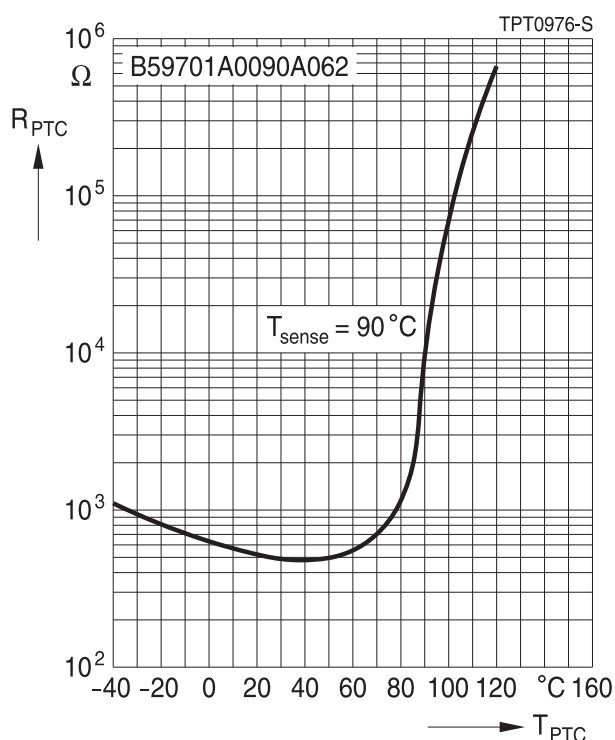
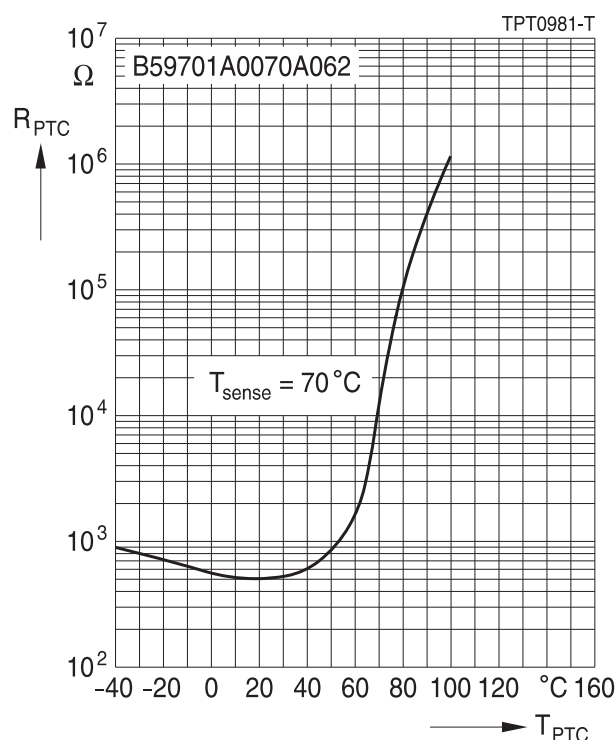
PTC resistance  $R_{PTC}$  versus PTC temperature  $T_{PTC}$   
(measured at low signal voltage)



**SMD**

**Characteristics (typical) for B59701A\*, EIA case size 0805**

PTC resistance  $R_{PTC}$  versus PTC temperature  $T_{PTC}$   
(measured at low signal voltage)



Sensors

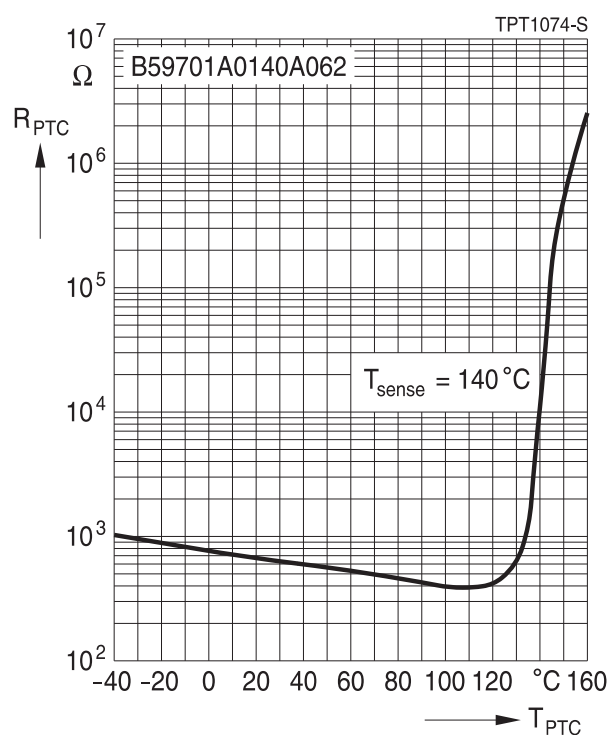
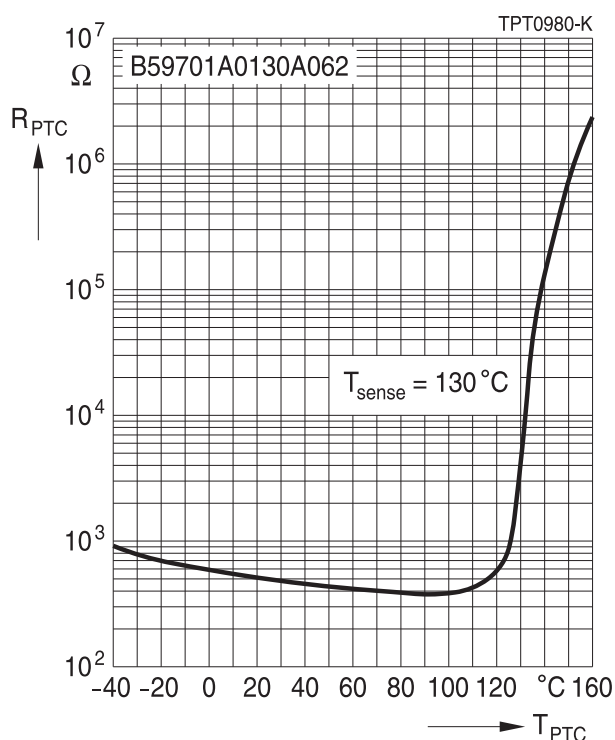
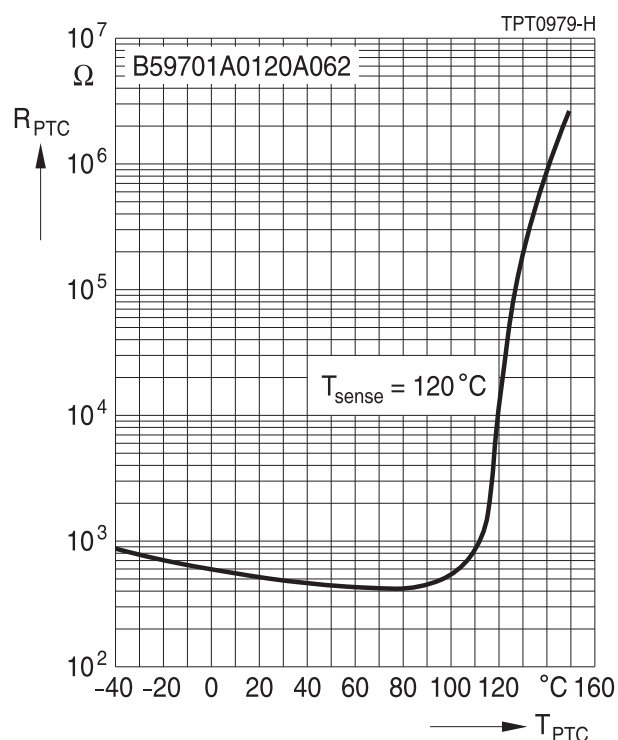
Limit temperature sensors, EIA case sizes 0402, 0603, 0805

Standard series

SMD

Characteristics (typical) for B59701A\*, EIA case size 0805

PTC resistance  $R_{PTC}$  versus PTC temperature  $T_{PTC}$   
(measured at low signal voltage)



## Sensors

Limit temperature sensors, EIA case sizes 0402, 0603, 0805

Standard series

### SMD

#### Reliability data

| Test                           | Standard    | Test conditions                                                                                                                                                                                     | $ \Delta R_{25}/R_{25} $ |
|--------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Electrical endurance, cycling  | IEC 60738-1 | Room temperature: $I_{smax}$ , $V_{max}$ ;<br>Number of cycles: 100                                                                                                                                 | < 20%                    |
| Electrical endurance, constant | IEC 60738-1 | Storage at $V_{max}$ and $T_{op,max}$ (@ $V_{max}$ )<br>Test duration : 1000 h                                                                                                                      | < 25%                    |
| Damp heat                      | IEC 60738-1 | Temperature of air: 40 °C<br>Relative humidity of air: 93%<br>Duration: 56 days<br>Test according to IEC 60068-2-78                                                                                 | < 20%                    |
| Rapid change of temperature    | IEC 60738-1 | $T_{LCT} = T_{op,min}$ , $T_{UCT} = T_{op,max}$<br>Number of cycles: 5<br>Test duration: 30 min<br>Test according to IEC 60068-2-14, test Na                                                        | < 20%                    |
| Vibration                      | IEC 60738-1 | Frequency: 10 - 55 - 10 Hz<br>Displacement amplitude: 0.75 mm<br>Test duration: 3 × 2 h<br>Test according to IEC 60028-2-6, test Fc                                                                 | < 20%                    |
| Shock                          | IEC 60738-1 | Pulse shape: half-sine<br>Acceleration: 400 m/s <sup>2</sup><br>Pulse duration: 6 ms; 6 x 5000 pulses<br>Test according to IEC 60068-2-27, test Ea                                                  | < 20%                    |
| Climatic sequence              | IEC 60738-1 | Dry heat: $T_{UCT} = 125$ °C<br>Test duration: 16 h<br>Damp heat first cycle<br>Cold: $T_{LCT} = -40$ °C<br>Test duration: 2 h<br>Damp heat 5 cycles<br>Tests performed according to IEC 60068-2-30 | < 20%                    |
| Bending test                   | IEC 60738-1 | Components reflow-soldered to test board<br>Maximum bendig: 2 mm<br>Test according to IEC 60068-2-21, test Ue                                                                                       | < 20%                    |
| Shear test                     |             | Shearing of the component soldered on PCB by a force of 5 N normal to components longitudinal axis                                                                                                  | No visible damage        |
| Resistance to soldering heat   | IEC 60738-1 | Reflow soldering<br>$T = 260 - 0/+5$ °C, $t_{Peak} = 30 \dots 40$ s<br>Pb-free soldering 3 times<br>Test according to IEC 60068-2-58                                                                | < 20%                    |

## Sensors

### Limit temperature sensors, EIA case sizes 0402, 0603, 0805

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#### SMD

## Cautions and warnings

### General

- TDK Electronics thermistors are designed for specific applications and should not be used for purposes not identified in our specifications, application notes and data books unless otherwise agreed with TDK Electronics during the design-in-phase.
- Ensure suitability of thermistor through reliability testing during the design-in phase. The thermistors should be evaluated taking into consideration worst-case conditions.

### Storage

- Store thermistors only in original packaging. Do not open the package prior to processing.
- Storage conditions in original packaging: storage temperature  $-25\text{ }^{\circ}\text{C} \dots +45\text{ }^{\circ}\text{C}$ , relative humidity  $\leq 75\%$  annual mean, maximum 95%, dew precipitation is inadmissible.
- Avoid contamination of thermistors surface during storage, handling and processing.
- Avoid storage of thermistor in harmful environment with effect on function on long-term operation (examples given under operation precautions).
- Use thermistor within the following period after delivery:
  - Through-hole devices (housed and leaded PTCs): 24 months
  - Motor protection sensors, glass-encapsulated sensors and probe assemblies: 24 months
  - Telecom pair and quattro protectors (TPP, TQP): 24 months
  - Leadless PTC thermistors for pressure contacting: 12 months
  - Leadless PTC thermistors for soldering: 6 months
  - SMDs in EIA sizes 3225 and 4032, and for PTCs with metal tags: 24 months
  - SMDs in EIA sizes 1210 and smaller: 12 months

### Handling

- PTCs must not be dropped. Chip-offs must not be caused during handling of PTCs.
- The ceramic and metallization of the components must not be touched with bare hands. Gloves are recommended.
- Avoid contamination of thermistor surface during handling.

### Soldering (where applicable)

- Use rosin-type flux or non-activated flux.
- Insufficient preheating may cause ceramic cracks.
- Rapid cooling by dipping in solvent is not recommended.
- Complete removal of flux is recommended.
- Standard PTC heaters are not suitable for soldering.

## Sensors

Limit temperature sensors, EIA case sizes 0402, 0603, 0805

Standard series

### SMD

#### Mounting

- Electrode must not be scratched before/during/after the mounting process.
- Contacts and housing used for assembly with thermistor have to be clean before mounting. Especially grease or oil must be removed.
- When PTC thermistors are encapsulated with sealing material, the precautions given in chapter "Mounting instructions", "Sealing and potting" must be observed.
- When the thermistor is mounted, there must not be any foreign body between the electrode of the thermistor and the clamping contact.
- The minimum force and pressure of the clamping contacts pressing against the PTC must be 10 N and 50 kPa, respectively. In case the assembly is exposed to mechanical shock and/ or vibration this force should be higher in order to avoid movement of the PTC during operation.
- During operation, the thermistor's surface temperature can be very high. Ensure that adjacent components are placed at a sufficient distance from the thermistor to allow for proper cooling at the thermistors.
- Ensure that adjacent materials are designed for operation at temperatures comparable to the surface temperature of thermistor. Be sure that surrounding parts and materials can withstand this temperature.
- Avoid contamination of thermistor surface during processing.

#### Operation

- Use thermistors only within the specified temperature operating range.
- Use thermistors only within the specified voltage and current ranges.
- Environmental conditions must not harm the thermistors. Use thermistors only in normal atmospheric conditions. Avoid use in deoxidizing gases (chlorine gas, hydrogen sulfide gas, ammonia gas, sulfuric acid gas etc), corrosive agents, humid or salty conditions. Contact with any liquids and solvents should be prevented.
- Be sure to provide an appropriate fail-safe function to prevent secondary product damage caused by abnormal function (e.g. use VDR for limitation of overvoltage condition).

This listing does not claim to be complete, but merely reflects the experience of TDK Electronics.

#### Display of ordering codes for TDK Electronics products

The ordering code for one and the same product can be represented differently in data sheets, data books, other publications, on the company website, or in order-related documents such as shipping notes, order confirmations and product labels. **The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products.** Detailed information can be found on the Internet under [www.tdk-electronics.tdk.com/orderingcodes](http://www.tdk-electronics.tdk.com/orderingcodes).

## Sensors

Limit temperature sensors, EIA case sizes 0402, 0603, 0805

Standard series

### SMD

## Symbols and terms

| Symbol          | Term                                                  |
|-----------------|-------------------------------------------------------|
| A               | Area                                                  |
| C               | Capacitance                                           |
| $C_{th}$        | Heat capacity                                         |
| f               | Frequency                                             |
| I               | Current                                               |
| $I_{max}$       | Maximum current                                       |
| $I_R$           | Rated current                                         |
| $I_{res}$       | Residual current                                      |
| $I_{PTC}$       | PTC current                                           |
| $I_r$           | Residual current                                      |
| $I_{r,oil}$     | Residual current in oil (for level sensors)           |
| $I_{r,air}$     | Residual current in air (for level sensors)           |
| $I_{RMS}$       | Root-mean-square value of current                     |
| $I_S$           | Switching current                                     |
| $I_{Smax}$      | Maximum switching current                             |
| LCT             | Lower category temperature                            |
| N               | Number (integer)                                      |
| $N_c$           | Operating cycles at $V_{max}$ , charging of capacitor |
| $N_f$           | Switching cycles at $V_{max}$ , failure mode          |
| P               | Power                                                 |
| $P_{25}$        | Maximum power at 25 °C                                |
| $P_{el}$        | Electrical power                                      |
| $P_{diss}$      | Dissipation power                                     |
| $R_G$           | Generator internal resistance                         |
| $R_{min}$       | Minimum resistance                                    |
| $R_R$           | Rated resistance @ rated temperature $T_R$            |
| $\Delta R_R$    | Tolerance of $R_R$                                    |
| $R_P$           | Parallel resistance                                   |
| $R_{PTC}$       | PTC resistance                                        |
| $R_{ref}$       | Reference resistance                                  |
| $R_S$           | Series resistance                                     |
| $R_{25}$        | Resistance at 25 °C                                   |
| $R_{25,match}$  | Resistance matching per reel/ packing unit at 25 °C   |
| $\Delta R_{25}$ | Tolerance of $R_{25}$                                 |

## Sensors

### Limit temperature sensors, EIA case sizes 0402, 0603, 0805

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#### SMD

|                                                                 |                                                                    |
|-----------------------------------------------------------------|--------------------------------------------------------------------|
| T                                                               | Temperature                                                        |
| t                                                               | Time                                                               |
| T <sub>A</sub>                                                  | Ambient temperature                                                |
| t <sub>a</sub>                                                  | Thermal threshold time                                             |
| T <sub>C</sub>                                                  | Ferroelectric Curie temperature                                    |
| t <sub>E</sub>                                                  | Settling time (for level sensors)                                  |
| T <sub>R</sub>                                                  | Rated temperature @ 25 °C or otherwise specified in the data sheet |
| T <sub>sense</sub>                                              | Sensing temperature                                                |
| T <sub>op</sub>                                                 | Operating temperature                                              |
| T <sub>PTC</sub>                                                | PTC temperature                                                    |
| t <sub>R</sub>                                                  | Response time                                                      |
| T <sub>ref</sub>                                                | Reference temperature                                              |
| T <sub>Rmin</sub>                                               | Temperature at minimum resistance                                  |
| t <sub>S</sub>                                                  | Switching time                                                     |
| T <sub>surf</sub>                                               | Surface temperature                                                |
| UCT                                                             | Upper category temperature                                         |
| V or V <sub>el</sub>                                            | Voltage (with subscript only for distinction from volume)          |
| V <sub>c(max)</sub>                                             | Maximum DC charge voltage of the surge generator                   |
| V <sub>F,max</sub>                                              | Maximum voltage applied at fault conditions in protection mode     |
| V <sub>RMS</sub>                                                | Root-mean-square value of voltage                                  |
| V <sub>BD</sub>                                                 | Breakdown voltage                                                  |
| V <sub>ins</sub>                                                | Insulation test voltage                                            |
| V <sub>link,max</sub>                                           | Maximum link voltage                                               |
| V <sub>max</sub>                                                | Maximum operating voltage                                          |
| V <sub>max,dyn</sub>                                            | Maximum dynamic (short-time) operating voltage                     |
| V <sub>meas</sub>                                               | Measuring voltage                                                  |
| V <sub>meas,max</sub>                                           | Maximum measuring voltage                                          |
| V <sub>R</sub>                                                  | Rated voltage                                                      |
| V <sub>PTC</sub>                                                | Voltage drop across a PTC thermistor                               |
| α                                                               | Temperature coefficient                                            |
| Δ                                                               | Tolerance, change                                                  |
| δ <sub>th</sub>                                                 | Dissipation factor                                                 |
| τ <sub>th</sub>                                                 | Thermal cooling time constant                                      |
| λ                                                               | Failure rate                                                       |
| <span style="border: 1px solid black; padding: 0 2px;">e</span> | Lead spacing (in mm)                                               |

## Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application**. As a rule, we are either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether a product with the properties described in the product specification is suitable for use in a particular customer application.
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## Important notes

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