

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_{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_{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 whichever is higher ¹⁾ | °C |

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

Sensors
Limit temperature sensors, EIA case sizes 0402, 0603, 0805
Standard series
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Electrical specifications and ordering codes
EIA case sizes 0402 and 0603

| R_R ($V \leq V_{max}$) Ω | ΔR_R % | $T_{sense,1}$ (@ 4.7 k Ω) $^{\circ}C$ | $T_{sense,1}$ (@ 4.7 M Ω) $^{\circ}C$ | R ($T_{sense,1} + 10^{\circ}C$) k Ω | Ordering code |
|--|-------------------|---|---|--|-----------------|
| EIA case size 0402, high ohmic types | | | | | |
| 10000 | ± 50 | - | 130 ± 5 | - | B59404A0130A062 |
| EIA case size 0603, standard types | | | | | |
| 470 | ± 50 | 75 ± 5 | - | - | B59601A0075A062 |
| 470 | ± 50 | 85 ± 5 | - | - | B59601A0085A062 |
| 470 | ± 50 | 95 ± 5 | - | - | B59601A0095A062 |
| 470 | ± 50 | 105 ± 5 | - | - | B59601A0105A062 |
| 470 | ± 50 | 115 ± 5 | - | - | B59601A0115A062 |
| 470 | ± 50 | 125 ± 5 | - | - | B59601A0125A062 |
| 470 | ± 50 | 135 ± 5 | - | - | B59601A0135A062 |
| EIA case size 0603, tight temperature tolerance types | | | | | |
| 470 | ± 50 | 85 ± 3 | - | ≥ 15 | B59601A0085B062 |
| 470 | ± 50 | 95 ± 3 | - | ≥ 40 | B59601A0095B062 |
| 470 | ± 50 | 105 ± 3 | - | ≥ 40 | B59601A0105B062 |
| 470 | ± 50 | 115 ± 3 | - | ≥ 40 | B59601A0115B062 |
| 470 | ± 50 | 125 ± 3 | - | ≥ 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
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Electrical specifications and ordering codes
EIA case sizes 0603 and 0805

| R_R ($V \leq V_{max}$) Ω | ΔR_R % | T_{sense} $^{\circ}C$ | T (@ $2 \cdot R_R$) $^{\circ}C$ | T (typ.) (@ R_{min}) $^{\circ}C$ | R ($T_{sense,1}$ $-5^{\circ}C$) $k\Omega$ | R ($T_{sense,1}$ $+5^{\circ}C$) $k\Omega$ | R ($T_{sense,1}$ $+15^{\circ}C$) $k\Omega$ | Ordering code |
|---|-------------------|----------------------------|---|--|--|--|---|-----------------|
| EIA case size 0603, tight resistance tolerance types | | | | | | | | |
| 110 | ± 15 | 70 | 57 ± 3 | 15 | ≤ 1.1 | ≥ 1.1 | - | B59602A0055B062 |
| 470 | ± 15 | 55 | 45 ± 5 | 5 | ≤ 4.7 | ≥ 4.7 | - | B59603A0055A062 |
| 470 | ± 15 | 85 | 75 ± 5 | 40 | ≤ 4.7 | ≥ 4.7 | - | B59603A0085A062 |
| 470 | ± 15 | 105 | 95 ± 5 | 55 | ≤ 4.7 | ≥ 4.7 | - | B59603A0105A062 |
| EIA case size 0805, standard types | | | | | | | | |
| 680 | ± 50 | 70 | - | - | ≤ 5.7 | ≥ 5.7 | $\geq 40^{1)}$ | B59701A0070A062 |
| 680 | ± 50 | 90 | - | - | ≤ 5.5 | ≥ 13.3 | ≥ 40 | B59701A0090A062 |
| 680 | ± 50 | 100 | - | - | ≤ 5.5 | ≥ 13.3 | ≥ 40 | B59701A0100A062 |
| 680 | ± 50 | 110 | - | - | ≤ 5.5 | ≥ 13.3 | ≥ 40 | B59701A0110A062 |
| 680 | ± 50 | 120 | - | - | ≤ 5.5 | ≥ 13.3 | ≥ 40 | B59701A0120A062 |
| 680 | ± 50 | 130 | - | - | ≤ 5.5 | ≥ 13.3 | ≥ 40 | B59701A0130A062 |
| 680 | ± 50 | 140 | - | - | ≤ 5.5 | ≥ 13.3 | ≥ 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) $R(T_{sense,1} + 25^{\circ}C)$

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)

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.



SMD

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

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



SMD

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

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



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)



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)



SMD

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

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



Sensors
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Reliability data

| Test | Standard | Test conditions | $ \Delta R_{25}/R_{25} $ |
|--------------------------------|-------------|---|--------------------------|
| Electrical endurance, cycling | IEC 60738-1 | Room temperature: I_{smax} , V_{max} ; Number of cycles: 100 | < 20% |
| Electrical endurance, constant | IEC 60738-1 | Storage at V_{max} and $T_{op,max}$ (@ V_{max}) Test duration : 1000 h | < 25% |
| Damp heat | IEC 60738-1 | Temperature of air: 40 °C Relative humidity of air: 93% Duration: 56 days Test according to IEC 60068-2-78 | < 20% |
| Rapid change of temperature | IEC 60738-1 | $T_{LCT} = T_{op,min}$, $T_{UCT} = T_{op,max}$ Number of cycles: 5 Test duration: 30 min Test according to IEC 60068-2-14, test Na | < 20% |
| Vibration | IEC 60738-1 | Frequency: 10 - 55 - 10 Hz Displacement amplitude: 0.75 mm Test duration: 3 × 2 h Test according to IEC 60028-2-6, test Fc | < 20% |
| Shock | IEC 60738-1 | Pulse shape: half-sine Acceleration: 400 m/s ² Pulse duration: 6 ms; 6 x 5000 pulses Test according to IEC 60068-2-27, test Ea | < 20% |
| Climatic sequence | IEC 60738-1 | Dry heat: $T_{UCT} = 125$ °C Test duration: 16 h Damp heat first cycle Cold: $T_{LCT} = -40$ °C Test duration: 2 h Damp heat 5 cycles Tests performed according to IEC 60068-2-30 | < 20% |
| Bending test | IEC 60738-1 | Components reflow-soldered to test board Maximum bendig: 2 mm 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 $T = 260 - 0/+5$ °C, $t_{Peak} = 30 \dots 40$ s Pb-free soldering 3 times Test according to IEC 60068-2-58 | < 20% |

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 $-25\text{ °C} \dots +45\text{ °C}$, 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.

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

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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 |
| ΔR_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 |
| ΔR_{25} | Tolerance of R_{25} |

Sensors
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| | |
|---|--|
| T | Temperature |
| t | Time |
| T _A | Ambient temperature |
| t _a | Thermal threshold time |
| T _C | Ferroelectric Curie temperature |
| t _E | Settling time (for level sensors) |
| T _R | Rated temperature @ 25 °C or otherwise specified in the data sheet |
| T _{sense} | Sensing temperature |
| T _{op} | Operating temperature |
| T _{PTC} | PTC temperature |
| t _R | Response time |
| T _{ref} | Reference temperature |
| T _{Rmin} | Temperature at minimum resistance |
| t _S | Switching time |
| T _{surf} | Surface temperature |
| UCT | Upper category temperature |
| V or V _{el} | Voltage (with subscript only for distinction from volume) |
| V _{c(max)} | Maximum DC charge voltage of the surge generator |
| V _{F,max} | Maximum voltage applied at fault conditions in protection mode |
| V _{RMS} | Root-mean-square value of voltage |
| V _{BD} | Breakdown voltage |
| V _{ins} | Insulation test voltage |
| V _{link,max} | Maximum link voltage |
| V _{max} | Maximum operating voltage |
| V _{max,dyn} | Maximum dynamic (short-time) operating voltage |
| V _{meas} | Measuring voltage |
| V _{meas,max} | Maximum measuring voltage |
| V _R | Rated voltage |
| V _{PTC} | Voltage drop across a PTC thermistor |
| α | Temperature coefficient |
| Δ | Tolerance, change |
| δ _{th} | Dissipation factor |
| τ _{th} | Thermal cooling time constant |
| λ | Failure rate |
| e | Lead spacing (in mm) |

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2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified**. In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or lifesaving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
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