

# **PTC thermistors as inrush current limiters**

Leaded disks, uncoated

**Series/Type:** B5975\*/ B5977\*

**Date:** April 2014

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## Inrush current limiters

### Leaded disks, uncoated

#### Applications

- Inrush current limiter (charging resistor) for smoothing and DC link capacitors
- To replace high-power fixed resistors for capacitor charging

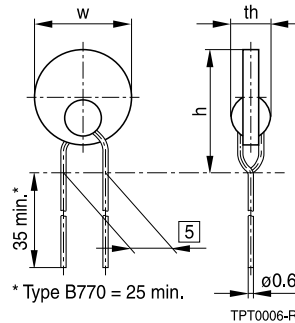
#### Features

- Self-protecting in case of malfunction of short-circuit relay or internal short circuit of capacitor
- Inrush current limiters are not damaged when directly connected to  $V_{max}$  even without additional current limitation
- Marking: Type, manufacturer's logo, reference temperature in °C and date code YYWW
- UL approval to UL 1434 with  $V_{max} = 420$  V and  $V_R = 380$  V (file number E69802)
- VDE approval for selected types (licence number 104843 E)
- RoHS-compatible

#### Delivery mode

- Cardboard strips

#### Dimensional drawing



#### Dimensions in mm

| Type | $w_{max}$ | $h_{max}$ | $th_{max}$ |
|------|-----------|-----------|------------|
| B750 | 12.5      | 16.5      | 5.0        |
| B751 | 12.5      | 16.5      | 7.0        |
| B752 | 12.5      | 16.5      | 7.0        |
| B753 | 12.5      | 16.5      | 7.0        |
| B754 | 12.5      | 16.5      | 7.0        |
| B755 | 12.5      | 16.5      | 7.0        |
| B770 | 8.5       | 12.0      | 7.0        |
| B771 | 8.5       | 12.0      | 7.0        |
| B772 | 8.5       | 12.0      | 7.0        |
| B773 | 8.5       | 12.0      | 7.0        |



#### General technical data

|                               |                         |          |          |        |
|-------------------------------|-------------------------|----------|----------|--------|
| Operating cycles at $V_{max}$ | (charging of capacitor) | $N_c$    | > 50000  | cycles |
| Switching cycles at $V_{max}$ | (failure mode)          | $N_f$    | > 10     | cycles |
| Operating temperature range   | ( $V = 0$ )             | $T_{op}$ | -40/+125 | °C     |
| Operating temperature range   | ( $V = V_{max}$ )       | $T_{op}$ | -20/+85  | °C     |

#### Electrical specifications and ordering codes

| Type | $V_{max}$ | $V_{link,max}$ | $R_R$    | $\Delta R_R$ | $T_{ref}$<br>(typ.) | $C_{th}$ | $\tau_{th}$ | Approvals |   | Ordering code   |
|------|-----------|----------------|----------|--------------|---------------------|----------|-------------|-----------|---|-----------------|
|      | V AC      | V DC           | $\Omega$ | %            | °C                  | J/K      | s           |           |   |                 |
| B750 | 260       | 360            | 25       | ±25          | 115                 | 1.0      | 100         | X         | X | B59750B0120A070 |
| B751 | 260       | 360            | 50       | ±25          | 115                 | 1.4      | 120         | X         | X | B59751B0120A070 |
| B752 | 260       | 360            | 80       | ±25          | 115                 | 1.4      | 120         | X         | X | B59752B0120A070 |
| B753 | 440       | 620            | 120      | ±25          | 115                 | 1.4      | 120         | X         | X | B59753B0120A070 |
| B754 | 440       | 620            | 150      | ±25          | 115                 | 1.4      | 120         | X         | X | B59754B0120A070 |
| B755 | 560       | 800            | 500      | ±25          | 110                 | 1.4      | 120         | X         | X | B59755B0115A070 |

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| Type | $V_{\max}$ | $V_{\text{link,max}}$ | $R_R$    | $\Delta R_R$ | $T_{\text{ref}}$ | $C_{\text{th}}$ | $\tau_{\text{th}}$ | Approvals   |   | Ordering code   |
|------|------------|-----------------------|----------|--------------|------------------|-----------------|--------------------|---|---|-----------------|
|      | V AC       | V DC                  | $\Omega$ | %            | (typ.)<br>°C     | J/K             | s                  |  |  |                 |
| B770 | 260        | 360                   | 70       | ±25          | 120              | 0.4             | 70                 | X   | X   | B59770B0120A070 |
| B771 | 260        | 360                   | 120      | ±25          | 120              | 0.6             | 80                 | X   | X   | B59771B0120A070 |
| B772 | 260        | 360                   | 150      | ±25          | 120              | 0.6             | 80                 | X   | X   | B59772B0120A070 |
| B773 | 440        | 620                   | 500      | ±25          | 120              | 0.6             | 80                 | X   | X   | B59773B0120A070 |

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**Reliability data**

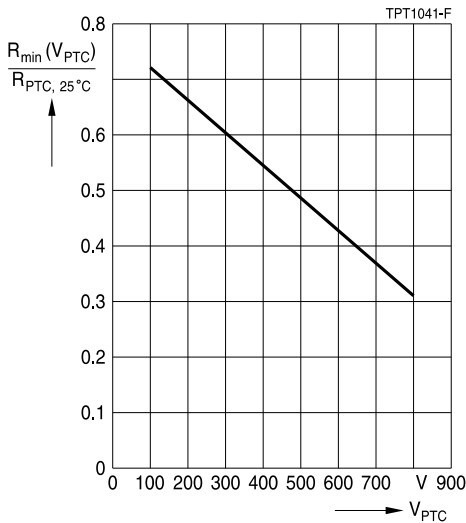
| Test                           | Standard    | Test conditions   | $ \Delta R_{25}/R_{25} $ |
|--------------------------------|-------------|---|--------------------------|
| Electrical endurance, cycling  |             | Room temperature, $V_{\text{link,max}}$<br>applied energy $< C_{\text{th}} \cdot (T_{\text{ref}} - T_A)$<br>Number of cycles: 100 000   | < 25%                    |
| Electrical endurance, constant | IEC 60738-1 | Storage at $V_{\text{max}}/T_{\text{op,max}} (V_{\text{max}})$<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   | < 10%                    |
| Rapid change of temperature    | IEC 60738-1 | $T_1 = T_{\text{op,min}} (0 \text{ V})$ , $T_2 = T_{\text{op,max}} (0 \text{ V})$<br>Number of cycles: 5<br>Test duration: 30 min<br>Test according to IEC 60068-2-14, test Na  | < 10%                    |
| Vibration                      | IEC 60738-1 | Frequency range: 10 to 55 Hz<br>Displacement amplitude: 0.75 mm<br>Test duration: 3 × 2 h<br>Test according to IEC 60068-2-6, test Fc   | < 5%                     |
| Climatic sequence              | IEC 60738-1 | Dry heat: $T = T_{\text{op,max}} (0 \text{ V})$<br>Test duration: 16 h<br>Damp heat first cycle<br>Cold: $T = T_{\text{op,min}} (0 \text{ V})$<br>Test duration: 2 h<br>Damp heat 5 cycles<br>Tests performed according to IEC 60068-2-30 | < 10%                    |

## Inrush current limiters

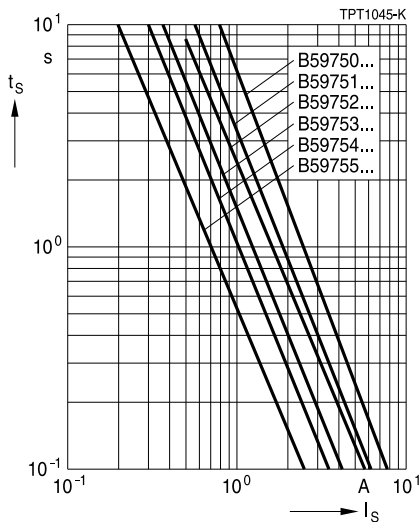
### Leaded disks, uncoated

#### Characteristics

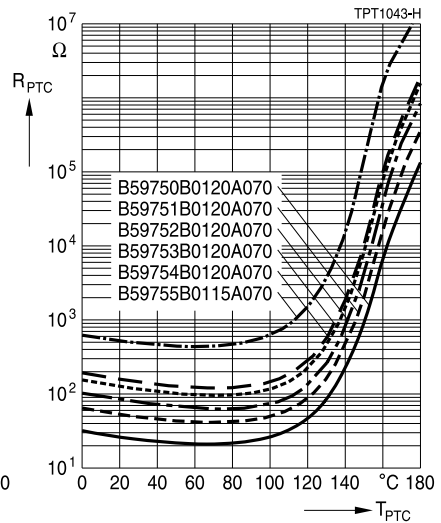
Minimum resistance of PTC thermistors versus applied voltage (pulsed)



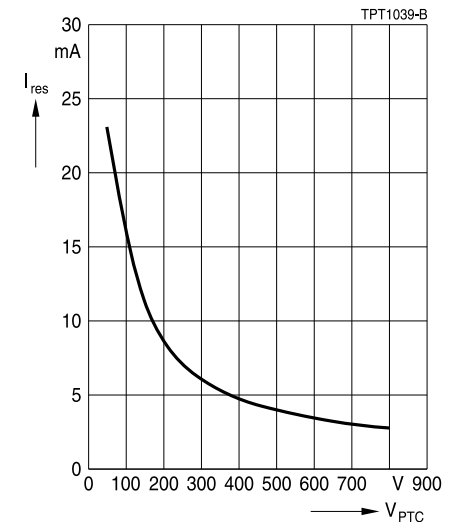
Switching time  $t_s$  versus switching current  $I_s$  (measured at 25 °C in still air)



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



Residual current in high-ohmic state  $I_{res}$  as function of applied voltage  $V_{PTC}$ , typical (measured at 25 °C in still air)

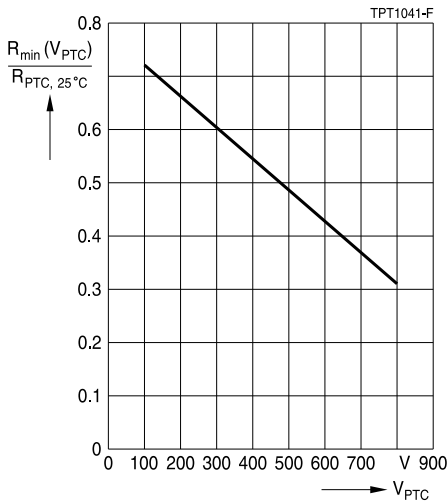


## Inrush current limiters

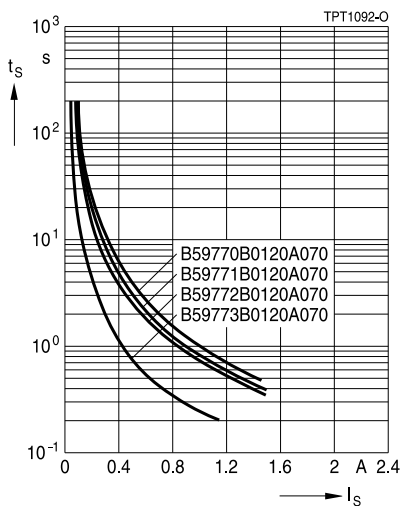
### Leaded disks, uncoated

#### Characteristics

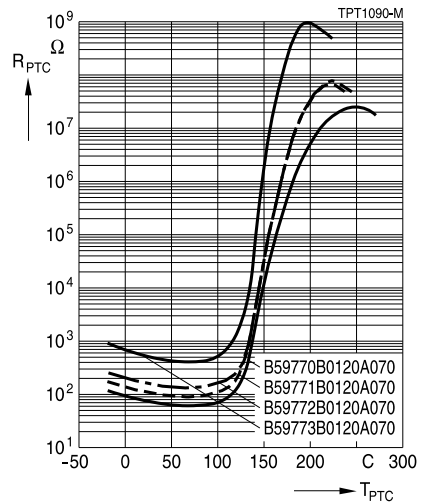
Minimum resistance of PTC thermistors versus applied voltage (pulsed)



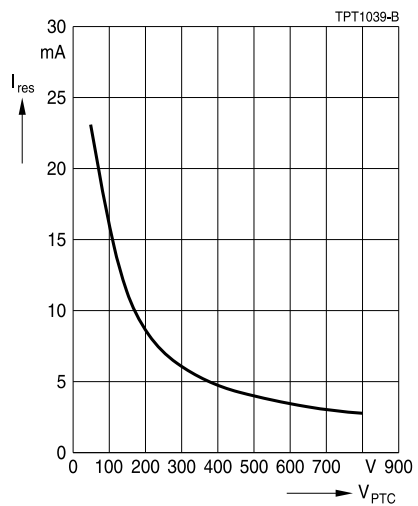
Switching time  $t_s$  versus switching current  $I_s$  (measured at 25 °C in still air)



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



Residual current in high-ohmic state  $I_{res}$  as function of applied voltage  $V_{PTC}$ , typical (measured at 25 °C in still air)



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#### Calculation of the number of required PTC elements

Number of required PTC elements (connected in parallel) as function of capacitance and charging voltage of smoothing or DC link capacitor:

$$N \geq \frac{C \cdot V^2}{2 \cdot C_{th} \cdot (T_{ref} - T_{A,max})}$$

|                    |  |
|--------------------|--|
| N                  | Number of required PTC thermistors connected in parallel |
| C                  | Capacitance of smoothing or DC link capacitor in F       |
| V                  | Charging voltage of capacitor in V                       |
| C <sub>th</sub>    | Heat capacity in J/K                                     |
| T <sub>ref</sub>   | Reference temperature of PTC in °C                       |
| T <sub>A,max</sub> | Expected maximum ambient temperature in °C               |

In case of large N values the resulting resistance of the parallel PTC network might be too low for effective limitation of the charging current. In this case a combination of series and parallel connected PTC thermistors can be used.

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## Cautions and warnings

### General

- EPCOS 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 EPCOS 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 before storage.
- 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 0402, 0603, 0805 and 1210: 12 months

### Handling

- PTCs must not be dropped. Chip-offs must not be caused during handling of PTCs.
- 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.



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#### 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 of the clamping contacts pressing against the PTC must be 10 N.
- 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 EPCOS AG.

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#### 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                                      |
| $\Delta R_R$    | 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 $R_{25}$                                 |
| T               | Temperature   |
| t               | Time  |
| $T_A$           | Ambient temperature                                   |

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|                |  |
|----------------|--|
| $t_a$          | Thermal threshold time   |
| $T_C$          | Ferroelectric Curie temperature                                |
| $t_E$          | Settling time (for level sensors)                              |
| $T_R$          | Rated temperature  |
| $T_{sense}$    | 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                           |
| $\alpha$       | Temperature coefficient  |
| $\Delta$       | Tolerance, change  |
| $\delta_{th}$  | Dissipation factor   |
| $\tau_{th}$    | Thermal cooling time constant                                  |
| $\lambda$      | Failure rate   |
| $e$            | Lead spacing (in mm)   |

### Abbreviations / Notes

**SMD** Surface-mount devices

\* To be replaced by a number in ordering codes, type designations etc.

+ To be replaced by a letter

All dimensions are given in mm.

The commas used in numerical values denote decimal points.

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