EPCOS

PTC thermistors as limit temperature sensors

SMD, EIA case sizes 0603 and 0805, standard series

Series/Type:

Date: November 2010

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 B59601A* and B59604* (file number E69802)
- Lead-free tinned terminations

Options

- Other T_{sense} or resistance values on request

Delivery mode

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

General technical data

Max. operating voltage		V_{max}	32	V DC
Minimum operating temperature	($V \leq V_{max}$)	T_{min}	−40	°C
Maximum operating temperature	($V \leq V_{max}$)	T_{max}	125 °C or $T_{sense,1}$ +25 °C whichever is higher	°C

Electrical specifications and ordering codes

Case size 0603

R_R ($V \le V_{max}$) Ω	ΔR_R %	$T_{sense,1}$ (@ 4.7 kΩ) °C	R ($T_{sense,1}$ +10 °C) kΩ	Ordering code
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	75 ±3	-	B59601A0075B062
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
470	±50	135 ±3	≥ 40	B59601A0135B062

Note:
In order to limit self heating effects the electrical power during measurement should be below 4 mW for case size 0603.

Electrical specifications and ordering codes

Case size 0603 and 0805

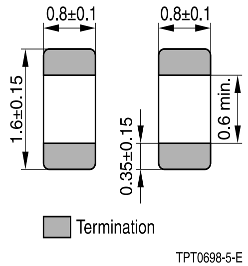
R_R ($V \leq V_{max}$) Ω	ΔR_R %	T_{sense} °C	R ($T_{sense,1}$ −5°C) kΩ	R ($T_{sense,1}$ +5°C) kΩ	R ($T_{sense,1}$ +15°C) kΩ	Ordering code
EIA case size 0603, high ohmic types						
10000	±50	120	≤ 4700	≥ 4700	-	B59604A0085A062
10000	±50	130	≤ 4700	≥ 4700	-	B59604A0090A062
EIA case size 0603, tight resistance tolerance types						
110	±15	70	≤ 1.1	≥ 1.1	-	B59602A0055B062
470	±15	55	≤ 4.7	≥ 4.7	-	B59603A0055A062
470	±15	85	≤ 4.7	≥ 4.7	-	B59603A0085A062
470	±15	105	≤ 4.7	≥ 4.7	-	B59603A0105A062
EIA case size 0805, standard types						
680	±50	70	≤ 5.7	≥ 5.7	≥ 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 case size 0603 and below 6 mW for case size 0805.

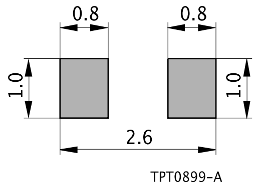
1) R ($T_{sense,1}$ +25 °C)

Dimensional drawings in mm

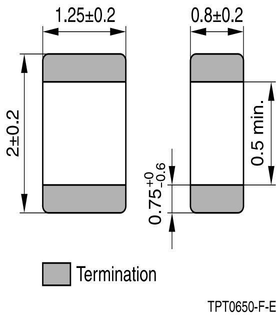
EIA case size 0603



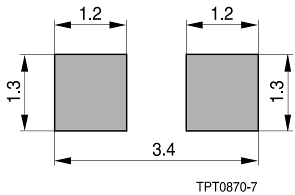
Solder pad



EIA case size 0805



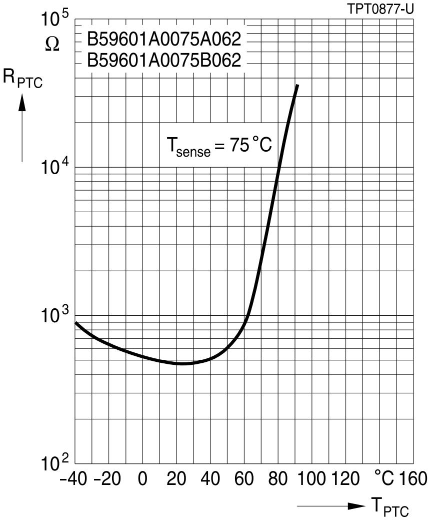
Solder pad

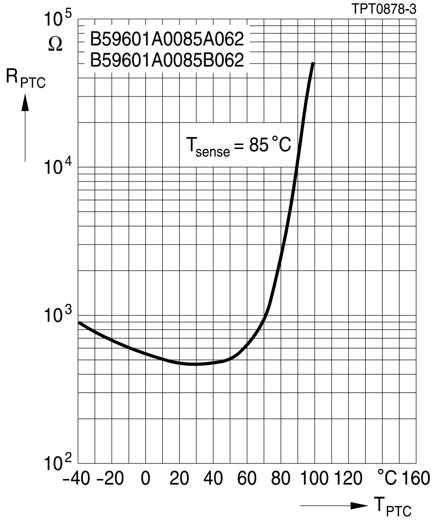


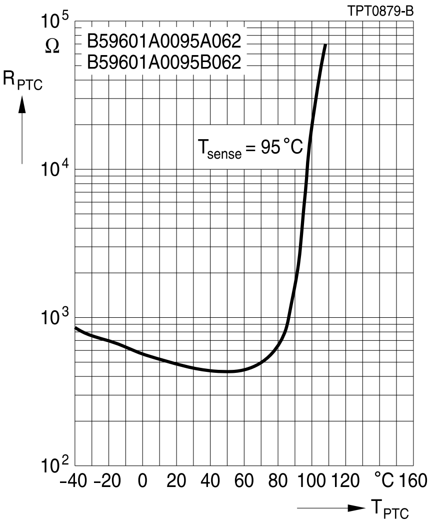
Recommended maximum dimensions (mm)

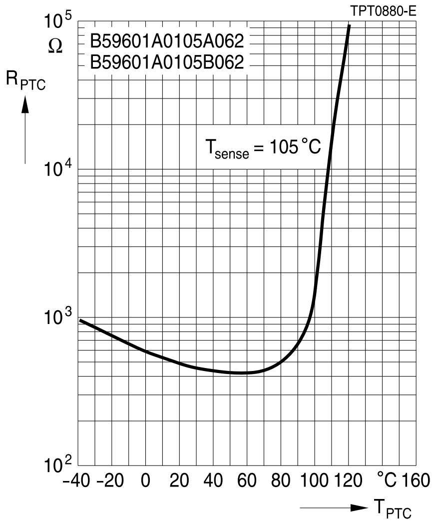
Characteristics (typical) for type A601

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



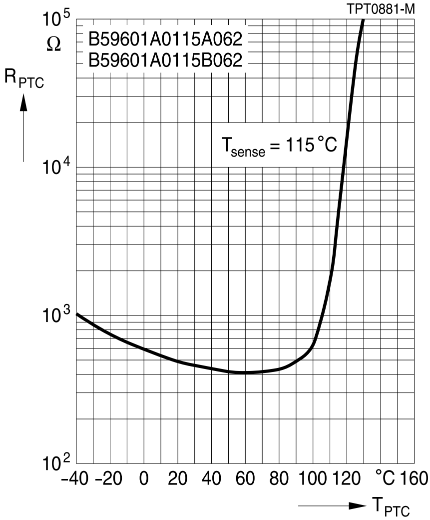


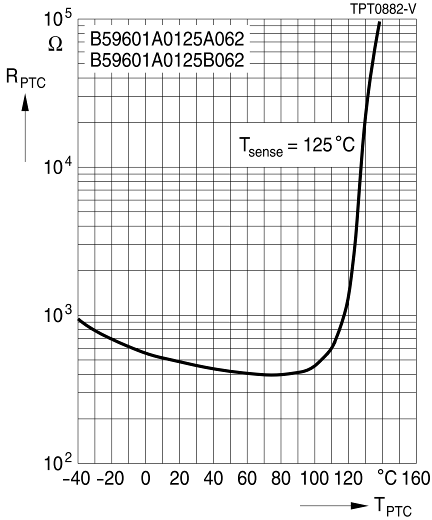


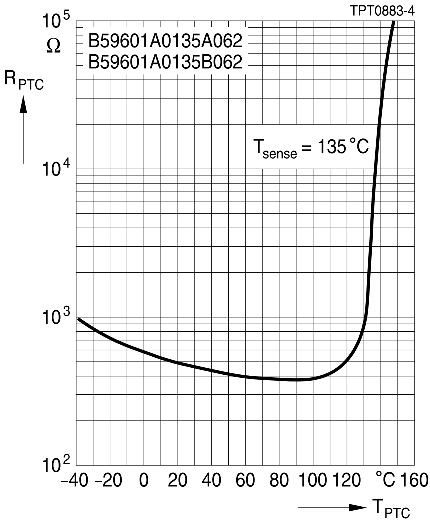


Characteristics (typical) for type A601

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

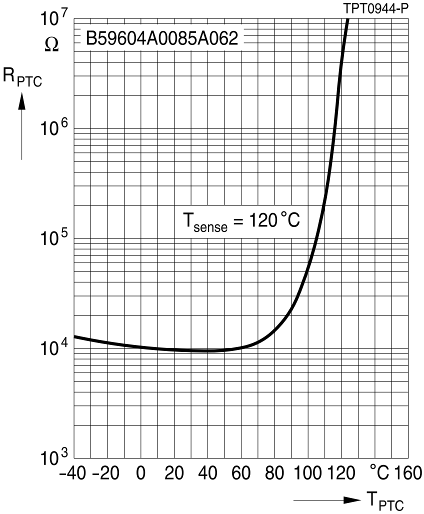


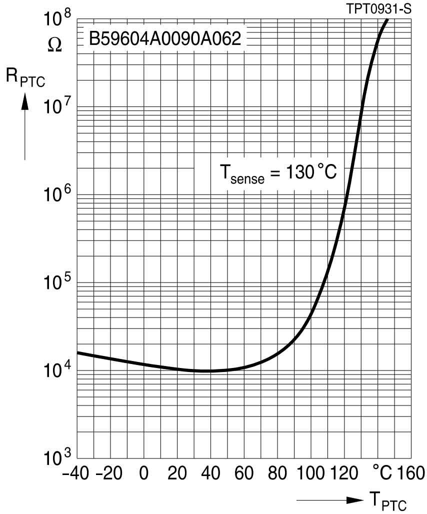




Characteristics (typical) for type A604

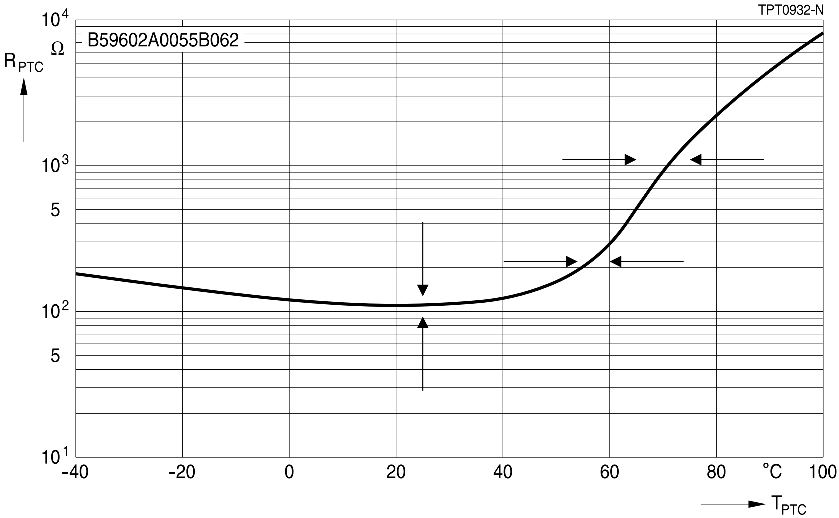
PTC resistance R_{PTC} versus PTC temperature T_{PTC}
(measured at low signal voltage)

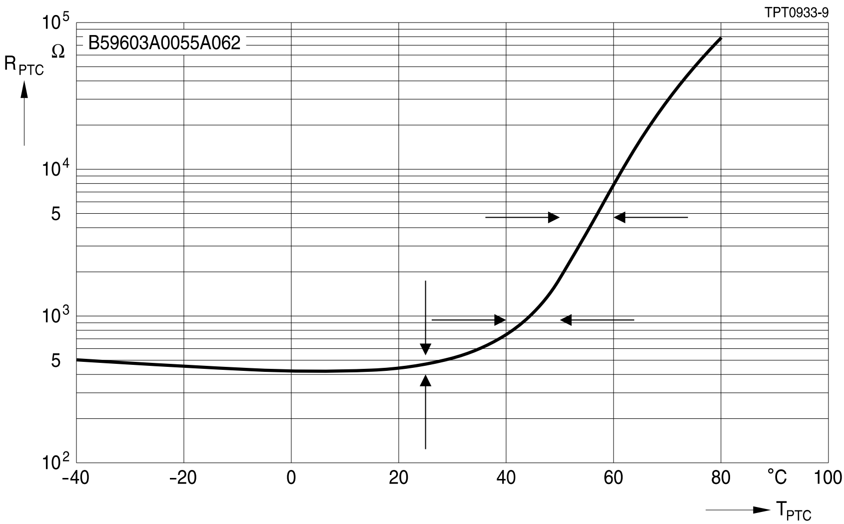




Characteristics (typical) for type A602 and A603

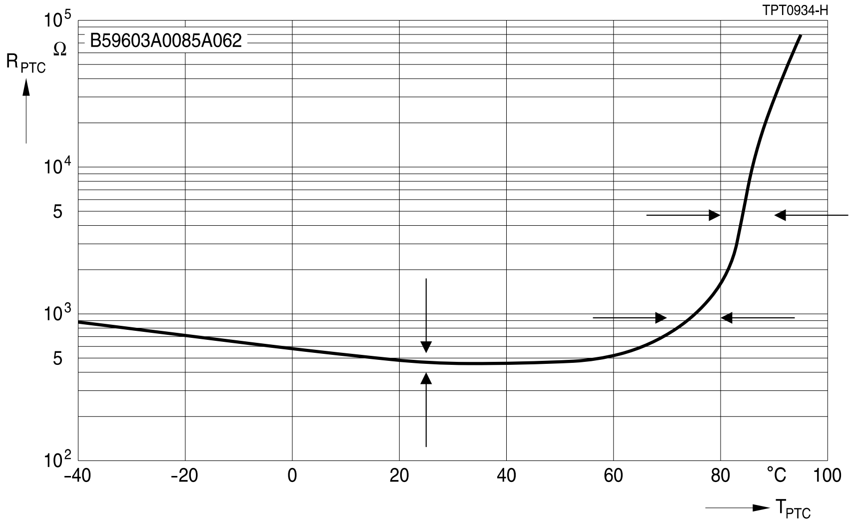
PTC resistance R_{PTC} versus PTC temperature T_{PTC}
(measured at low signal voltage)

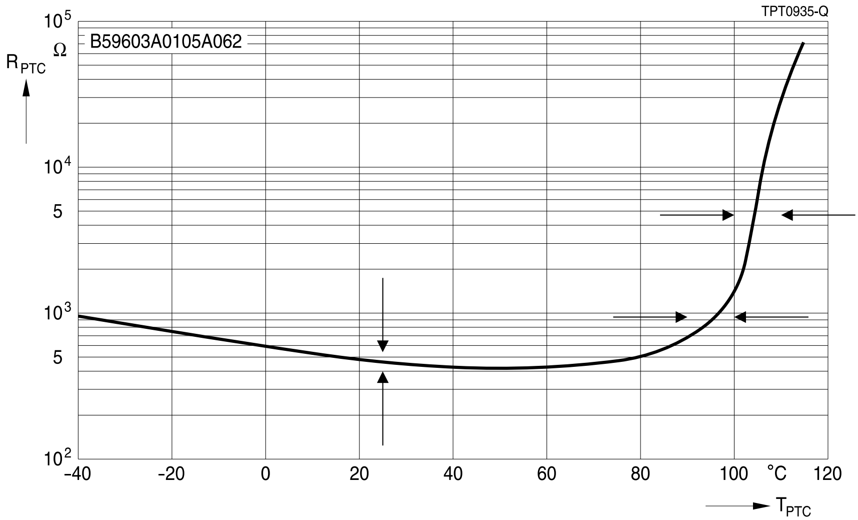




Characteristics (typical) for type A603

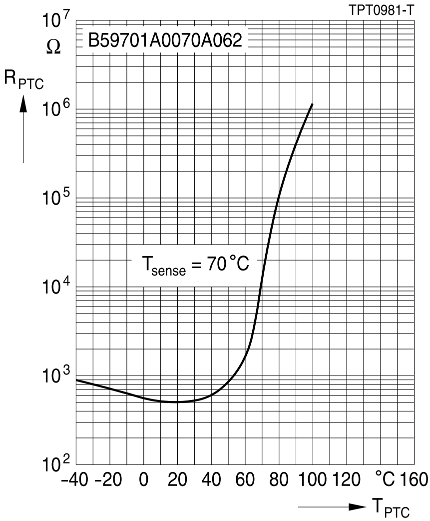
PTC resistance R_{PTC} versus PTC temperature T_{PTC}
(measured at low signal voltage)

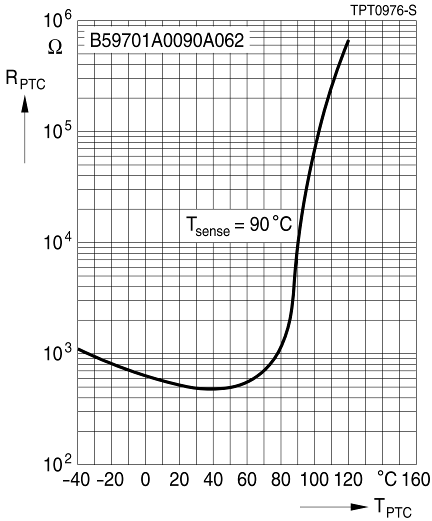


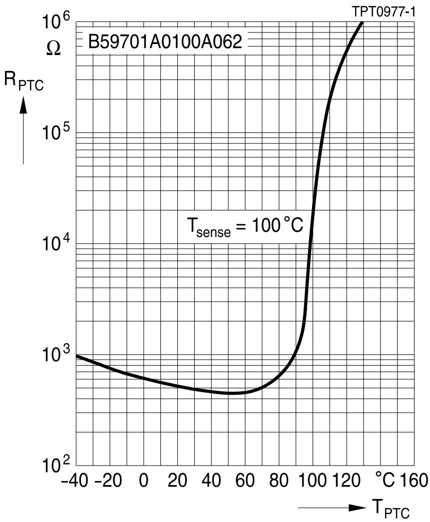


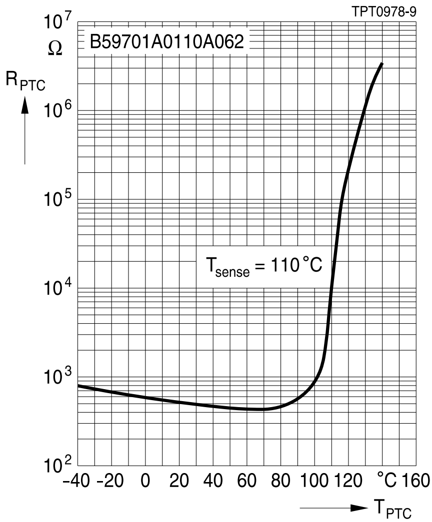
Characteristics (typical) for type A701

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



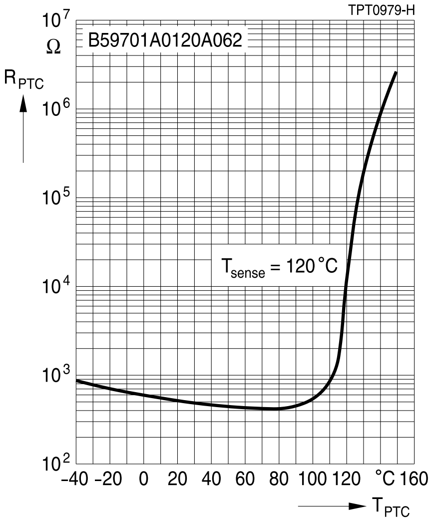


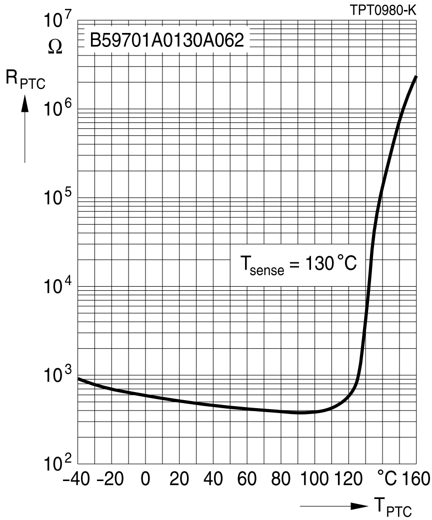


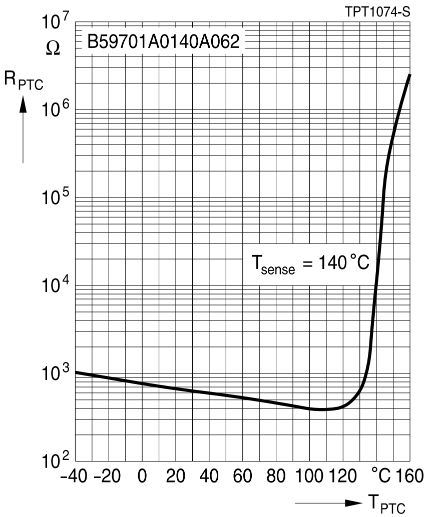


Characteristics (typical) for type A701

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







Reliability data

Test	Standard	Test conditions	$\lvert\Delta R_{25}/R_{25}\rvert$
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}/T_{op} T = 85 °C 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	< 10%
Rapid change of temperature	IEC 60738-1	$T_{LCT} = -25$ °C, $T_{UCT} = 125$ °C Number of cycles: 5 Test duration: 30 min Test according to IEC 60068-2-14, Test Na	< 10%
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	< 5%
Bump	IEC 60738-1	Pulse shape: half-sine Acceleration: 50*g* Pulse duration: 1ms; 6 x 3 pulses Test according to IEC 60068-2-29	< 5%
Climatic sequence	IEC 60738-1	Dry heat: $T_{UCT} = 125$ °C Test duration: 16 h Damp heat first cycle Cold: $T_{LCT} = -25$ °C Test duration: 2 h Damp heat 5 cycles Tests performed according to IEC 60068-2-30	< 10%
Bending test	EN 130000/4.35	Components reflow-soldered to test board Maximum bendig: 2 mm	< 5%
Adhesive strength on PCB		Shearing of the component soldered on PCB by a force of 5 N is normal to components longitudinal axis	No visible damage

Mounting instructions

1 Soldering

1.1 Leaded PTC thermistors

Leaded PTC thermistors follow the solderability requirements of IEC 60068-2-20.

During soldering, care must be taken that the thermistors are not damaged by excessive heat. The following maximum temperatures, maximum time spans and minimum distances have to be observed:

	Solder containing lead (SnPb 60/40)	Lead-free solder (Sn96.5Ag3Cu0.5)
Solderability	Solder bath temperature 230 °C Soldering time 3 s	Solder bath temperature 245 °C Soldering time 3 s
Resistance to soldering heat	Soldering iron temperature 350 °C Soldering time 3 s	Solder bath temperature 260 °C Soldering time 10 s

Distance to thermistor has to be ≥6 mm. Under more severe soldering conditions the resistance may change. Soldering conditions for wave soldering are given in chapter 1.4.1.

1.2 Leadless PTC thermistors

In case of PTC thermistors without leads, soldering is restricted to devices which are provided with a solderable metallization. The temperature shock caused by the application of hot solder may produce fine cracks in the ceramic, resulting in changes in resistance.

In addition, soldering methods should be employed which permit short soldering times.

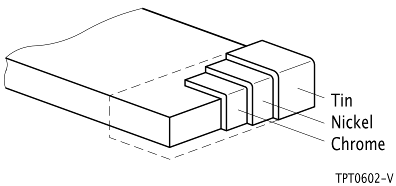
Soldering conditions for wave soldering are given in chapter 1.4.1.

1.3 SMD PTC thermistors

The notes on soldering leadless thermistors also apply to the SMD versions (refer to IEC 60068-2-58). Soldering conditions for wave soldering are given in chapter 1.4.1., for reflow soldering in chapter 1.4.2.

1.3.1 Chrome/nickel/tin terminations

(Sizes 0402, 0603, 0805, 1210)



As shown in the figure above, the terminations consists of three metallic layers. A primary chrome layer provides for good electrical contact. "Leaching" is prevented by a nickel barrier layer. The outer tin coating prevents corrosion of the nickel and ensures good component solderability.

1.3.2 Test methods for wetting and resistance to soldering heat

a) Solder bath method according to IEC 60068-2-58

Applicable for SMD components with wire or tag terminations. In case the SMD-component does not have a completely closed housing, only the wires or tags may be immersed into the solder bath.

	Lead-free solder (Sn96.5Ag3Cu0.5)	Solder containing lead (SnPb 60/40)
Wetting test	Bath temperature 250 °C Soldering time 3 s	Bath temperature 215 °C Soldering time 3 s
Resistance to soldering heat	Bath temperature 260 °C Soldering time 10 s	Bath temperature 260 °C Soldering time 10 s

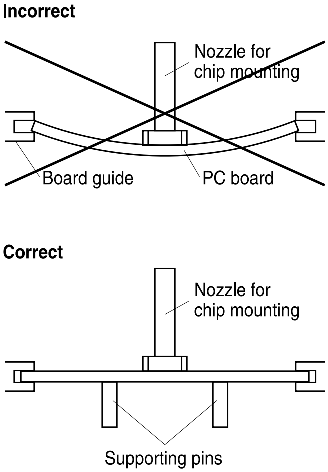
b) Solder reflow method according to IEC 60068-2-58

Applicable for chip-style SMD components. Reflow temperature profile is stated in IEC 60068-2-58, 8.1.2.1 for wetting test and 8.1.2.2 for resistance to soldering heat test.

	Lead-free solder (Sn96.5Ag3Cu0.5)	Solder containing lead (SnPb 60/40)
Wetting test	Peak temperature 225 ... 235 °C Duration maximum 20 s	Peak temperature 215 °C Duration maximum 10 s
Resistance to soldering heat	Peak temperature 245 ... 255 °C Duration maximum 20 s	Peak temperature 235 °C Duration maximum 30 s

1.3.3 Placement and orientation of SMDs on PCB

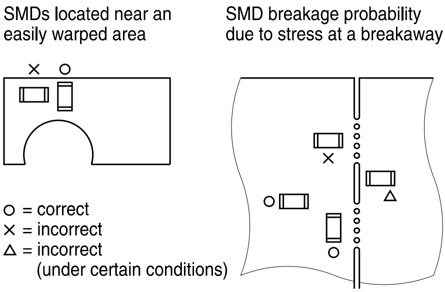
a) Component placement



KKE0267-U-E

It is recommended that the PC board should be held by means of some adequate supporting pins such as shown left to prevent the SMDs from being damaged or cracked.

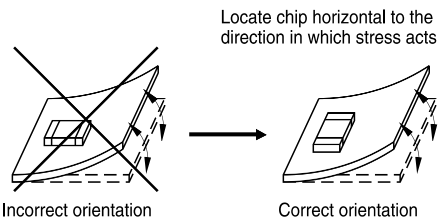
b) Cracks



KKE0268-3-E

When placing a component near an area which is apt to bend or a grid groove on the PC board, it is advisable to have both electrodes subjected to uniform stress, or to position the component's electrodes at right angles to the grid groove or bending line.

c) Component orientation



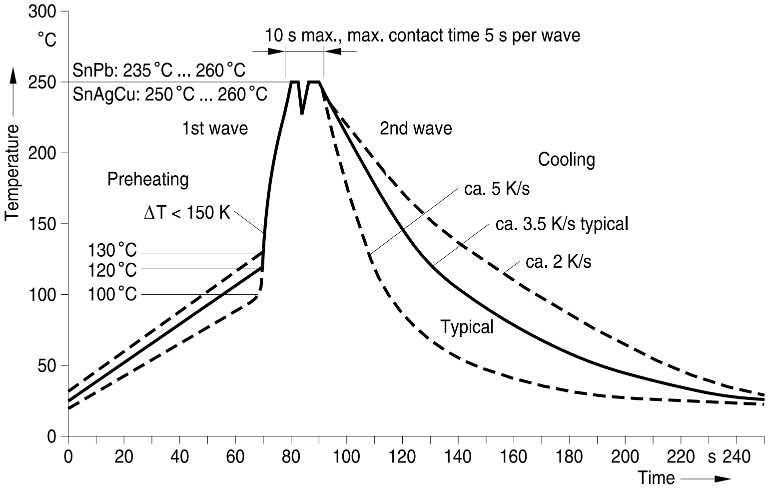
KKE0269-B-E

Choose a mounting position that minimizes the stress imposed on the chip during flexing or bending of the board.

1.4 Soldering profiles

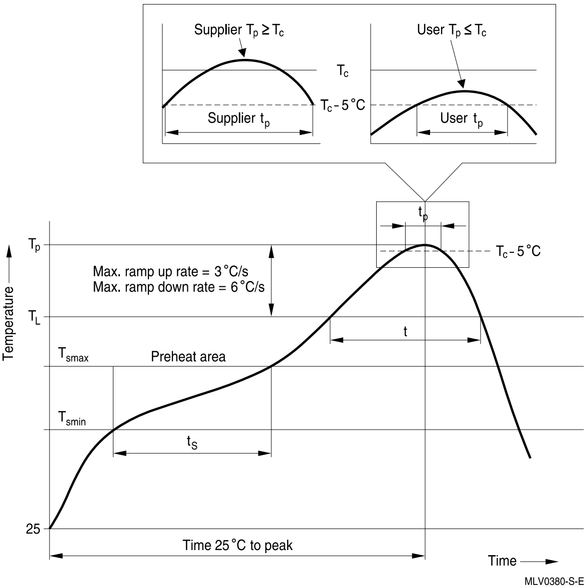
1.4.1 Wave soldering

Recommended temperature profile for wave soldering following IEC 61760-1. Applicable for leaded PTCs and selected SMD PTCs (case sizes 3225 and 4032 as well as superior series for case sizes 0402, 0603 and 0805 limit temperature sensors).



1.4.2 Reflow soldering

Recommended temperature characteristic for reflow soldering following JEDEC J-STD-020D

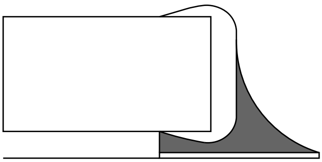


Profile feature		Sn-Pb eutectic assembly	Pb-free assembly
Preheat and soak - Temperature min - Temperature max - Time	 T_{smin} T_{smax} t_{smin} to t_{smax}	 100 °C 150 °C 60 ... 120 s	 150 °C 200 °C 60 ... 180 s
Average ramp-up rate	T_{smax} to T_p	3 °C/ s max.	3 °C/ s max.
Liquidous temperature Time at liquidous	T_L t_L	183 °C 60 ... 150 s	217 °C 60 ... 150 s
Peak package body temperature	T_p [1]	220 °C ... 235 °C [2]	245 °C ... 260 °C [2]
Time (t_P) [3] within 5 °C of specified classification temperature (T_c)		20 s [3]	30 s [3]
Average ramp-down rate	T_p to T_{smax}	6 °C/ s max.	6 °C/ s max.
Time 25 °C to peak temperature		maximum 6 min	maximum 8 min

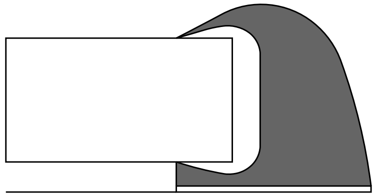
1) Tolerance for peak profile temperature (T_P) is defined as a supplier minimum and a user maximum.
2) Depending on package thickness. For details please refer to JEDEC J-STD-020D.
3) Tolerance for time at peak profile temperature (t_P) is defined as a supplier minimum and a user maximum.

Note: All temperatures refer to topside of the package, measured on the package body surface.
Number of reflow cycles: 3

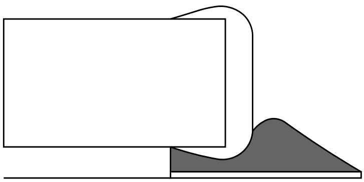
1.4.3 Solder joint profiles for PTC theristors with chrome/nickel/tin terminations



Good solder joint TPT0808-M-E



Too much solder
Pad geometry too large KKE0071-A-E



Poor wetting KKE0072-I-E

2 Storage of PTC thermistors

PTC thermistors should be soldered after shipment from EPCOS within the time specified:
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

The parts are to be left in the original packing.

Storage temperature:	−25 ... + 45 °C
Relative humidity:	≤ 75% annual average, ≤ 95% on 30 days in a year

The solderability of the external electrodes may be deteriorated if SMDs are stored where they are exposed to high humidity, dust or harmful gas (hydrogen chloride, sulfuric acid gas or hydrogen sulfide).

Do not store SMDs where they are exposed to heat or direct sunlight. Otherwise, the packing material may be deformed or SMDs may stick together, causing problems during mounting.

After opening the factory seals, such as polyvinyl-sealed packages, it is recommended to use the components as soon as possible.

3 Conductive adhesion

An alternative to soldering is the gluing of thermistors with conductive adhesives. The benfit of this method is that it involves no thermal stress. The adhesives used must be chemically inert and suitable for the temperatures arising at the surface of the termistor.

4 Clamp contacting

Pressure contacting by springs is required for applications involving frequent switching and high turn-on powers. Soldering is not allowed for such applications in order to avoid operational failure in the long term. PTC thermistors for heating and motor starting have metallized surfaces for clamp contacting.

5 Robustness of terminations

The leads meet the requirements of IEC 60068-2-21. They may not be bent closer than 4 mm from the solder joint on the thermistor body or from the point at which they leave the feedthroughs. During bending, any mechanical stress at the outlet of the leads must be removed. The bending radius should be at least 0.75 mm.

Tensile strength:	Test Ua1: Leads ∅ ≤ 0.5 mm = 5 N ∅ > 0.5 mm = 10 N
Bending strength:	Test Ub: Two 90°-bends in opposite directions at a weight of 0.25 kg.
Torsional strength:	Test Uc: severity 2 The lead is bent by 90° at a distance of 6 to 6.5 mm from the thermistor body. The bending radius of the leads should be approx. 0.75 mm. Two torsions of 180° each (severity 2).

When subjecting leads to mechanical stress, the following should be observed:

Tensile stress on leads
During mounting and operation tensile forces on the leads are to be avoided.

Bending of leads
Bending of the leads directly on the thermistor body is not permissible.

A lead may be bent at a minimum distance of twice the wire's diameter +2 mm from the solder joint on the thermistor body. During bending the wire must be mechanically relieved at its outlet. The bending radius should be at least 0.75 mm.

Twisting of leads
The twisting (torsion) by 180° of a lead bent by 90° is permissible at 6 mm from the bottom of the thermistor body.

6 Sealing and potting

When thermistors are sealed or potted, there must be no mechanical stress through differing thermal expansion in the curing process and during later operation. In the curing process the upper category temperature of the thermistor must not be exceeded. It is also necessary to ensure that the potting compound is chemically inert.

Sealing and potting compounds may degenerate the titanate ceramic of PTC thermistors and lead to the formation of low-ohmic conduction bridges. In conjunction with a change in dissipation conditions due to the potting compound, local overheating may finally damage the thermistor.

Therefore sealing and potting should be avoided whenever possible.

7 Cleaning

You may use common cleaners based on organic solvents (eg dowanol or alcohol) to clean ceramic and solder joints.

For sufficient cleaning flux must be completely removed.

Solvents may cause plastic encapsulations to swell or detach. So be sure to check the suitability of a solvent before using it.

Caution is required with ultrasonic processes. If the sound power is too high, for example, it can degrade the adhesive strength of the terminal metallization or couse the encapsulation to detach.

After cleaning drying is promptly necessary.

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 °C ... +45 °C, relative humidity ≤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.

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).

Symbols and terms

A	Area
C_{th}	Heat capacity
f	Frequency
I	Current
I_{max}	Maximum current
I_R	Rated current
I_{PTC}	PTC current
I_r	Residual currrent
$I_{r,oil}$	Residual currrent in oil (for level sensors)
$I_{r,air}$	Residual currrent 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
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}
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
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_{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
$\boxed{e}$	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.

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, EPCOS is 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 an EPCOS product with the properties described in the product specification is suitable for use in a particular customer application.
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