

# **PTC thermistors as inrush current limiters**

PTC thermistors in housing

**Series/Type:** B59\*\*\*J0130A020

**Date:** March 2016

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## Inrush current limiters

### PTC thermistors in housing

#### Applications

- Inrush current limiter 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
- Encased thermistor disk with clamp contacts for high reliability
- For high pulse currents and a high number of operating cycles
- Inrush current limiters are not damaged when directly connected to  $V_{max}$  even without additional current limitation
- Flame-retardant plastic case
- Case material UL-listed
- Sn-plated lead-free solder pins
- Manufacturer's logo, type designation and date code YYWW stamped on in white (YYWWD for type J103)
- Types J213, J215, J217 and J219 qualification based on AEC-Q200, Rev. D
- UL approval for all types to UL 1434 (file number E69802)
- VDE approval for J105, J107 and J109 (licence number 40040539)
- IECQ certificate for J105, J107 and J109 (file number 101-QA-13)
- RoHS-compatible

#### Delivery mode

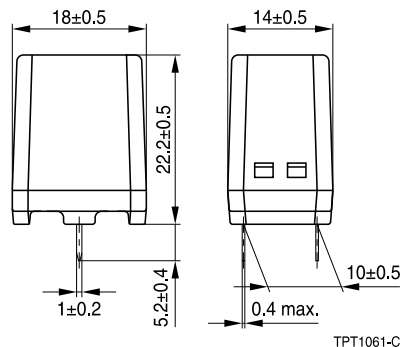
- Packed in carton box

#### General technical data

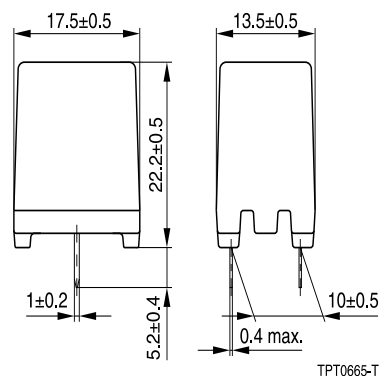
Operating cycles at $V_{max}$	(charging of capacitor)	$N_c$	> 100000	cycles
Switching cycles at $V_{max}$	(failure mode)	$N_f$	> 100	cycles
Operating temperature range	( $V = 0$ )	$T_{op}$	-40/+125	°C
Operating temperature range	( $V = V_{max}$ )	$T_{op}$	-20/+85	°C

#### Dimensional drawings

##### Type J213, J215, J217 and J219



##### Type J105, J107 and J109



Dimensions in mm

## Inrush current limiters

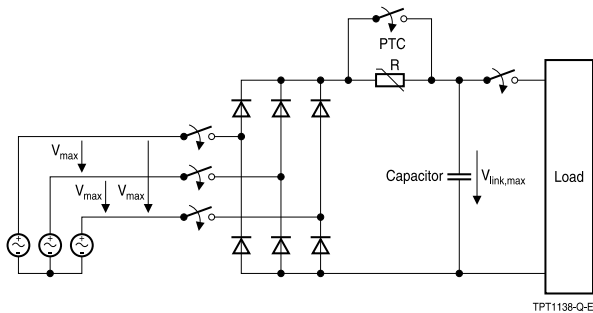
### PTC thermistors in housing

#### Electrical specifications and ordering codes

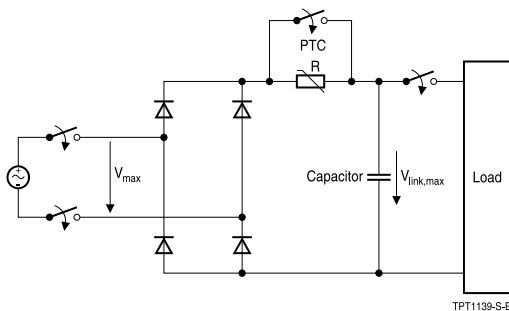
Type	$V_{max}$ V AC	$V_{link,max}$ V DC	$R_R$ $\Omega$	$\Delta R_R$ %	$T_{ref}$ (typ.) $^{\circ}C$	$C_{th}$ (typical) J/K	$\tau_{th}$ (typical) s	Circuit diagram	Ordering code
PBT plastic case, preferred types for new designs									
J213	280	400	33	25	130	1.1	140	2	B59213J0130A020
J215	280	400	22	25	130	2.3	150	2	B59215J0130A020
J217	440	620	56	25	130	2.3	150	1, 2, 3	B59217J0130A020
J219	560	800	100	25	130	2.3	150	1, 2, 3	B59219J0130A020
Phenolic resin plastic case									
J105	280	400	22	25	130	2.3	150	2	B59105J0130A020
J107	440	620	56	25	130	2.3	150	1, 2, 3	B59107J0130A020
J109	560	800	100	25	130	2.3	150	1, 2, 3	B59109J0130A020

#### Circuit diagrams

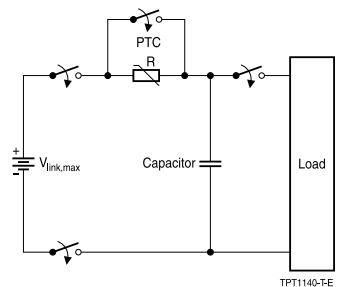
##### ① Three phases circuit



##### ② Single phase circuit



##### ③ DC circuit



## Inrush current limiters

### PTC thermistors in housing

#### 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:

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

K	K factor K = 1 for DC source K = 0.96 for 3-phase bridge rectifier K = 0.76 for single phase bridge rectifier
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.

**Inrush current limiters**
**PTC thermistors in housing**
**Reliability data**

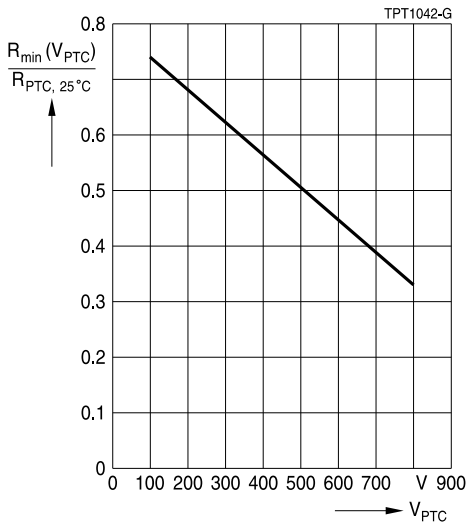
Test	Standard	Test conditions	$ \Delta R_{25}/R_{25} $
Electrical endurance, cycling		Room temperature, $V_{\text{link,max}}$ applied energy $< C_{\text{th}} \cdot (T_{\text{ref}} - T_A)$ Number of cycles: 100 000	< 25%
Electrical endurance, constant	IEC 60738-1	Storage at $V_{\text{max}}$ and $T_{\text{op,max}}$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

## Inrush current limiters

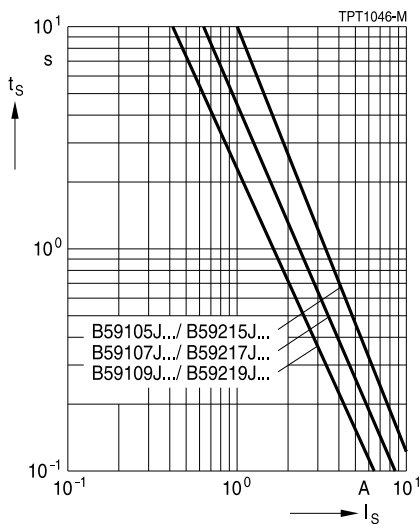
### PTC thermistors in housing

#### Characteristics

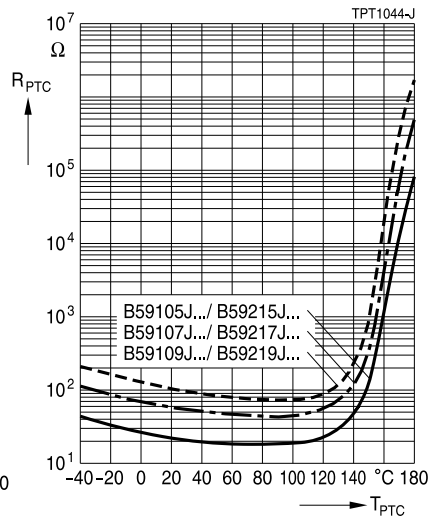
Minimum resistance of PTC thermistors versus applied voltage (pulsed)



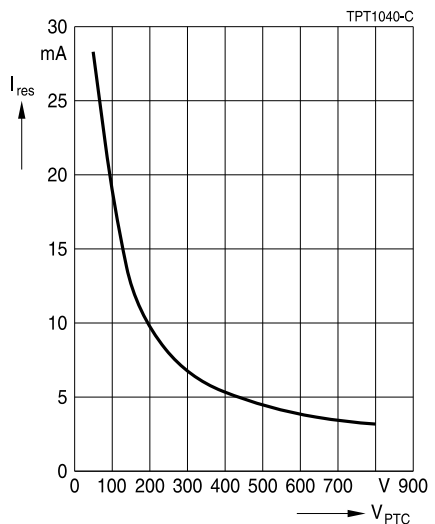
Switching time  $t_s$  versus switching current  $I_s$  (measured at 25 °C in still air)



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)

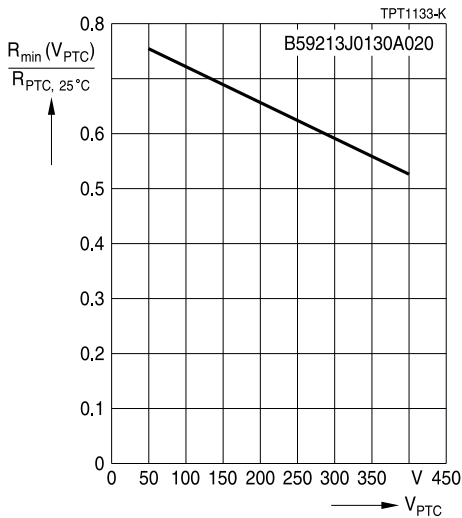


## Inrush current limiters

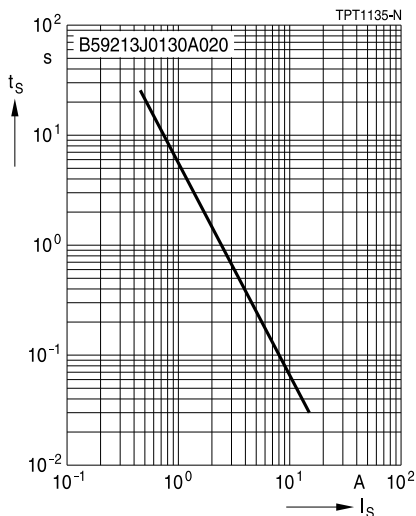
### PTC thermistors in housing

#### Characteristics for type J213

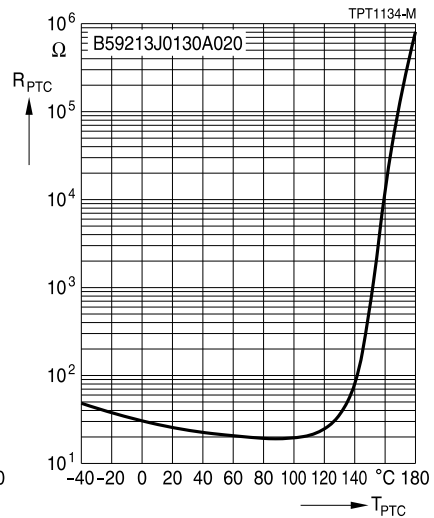
Minimum resistance of PTC thermistors versus applied voltage (pulsed)



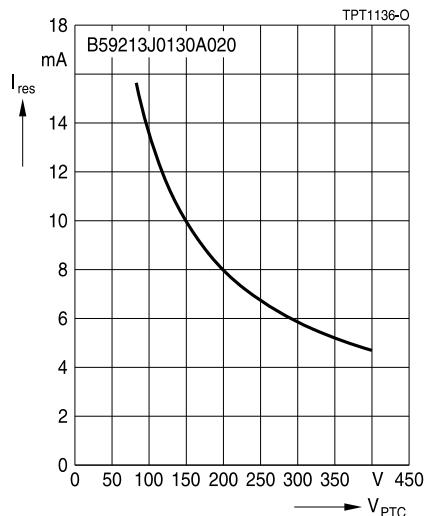
Switching time  $t_s$  versus switching current  $I_s$  (measured at 25 °C in still air)



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

### PTC thermistors in housing

## 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 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.



## Inrush current limiters

### PTC thermistors in housing

#### 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 EPCOS AG.

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## Inrush current limiters


### PTC thermistors in housing

#### 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 $R_{25}$

## Inrush current limiters

### PTC thermistors in housing

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
	Lead spacing (in mm)

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